Cottonwood Watershed – 9 Element Watershed Plan Summary

Impairments to be addressed:

Mud Creek (Bacteria)

Cottonwood River South (Bacteria, Sulfate)

Clear Creek (Sulfate)

Doyle (Sulfate)

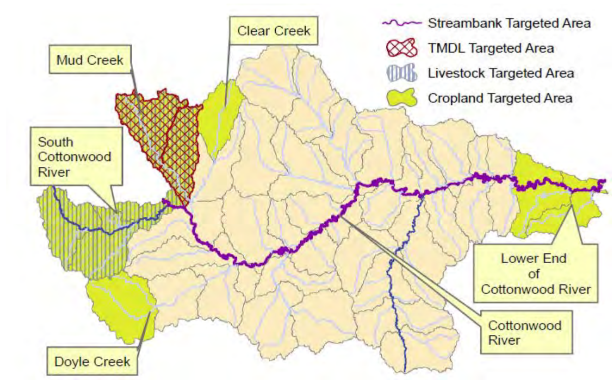
Mud Creek near Marion (Sulfate, Atrazine)

South Cottonwood River near Canada (TP)

Cottonwood River near Emporia (TP, Biology)

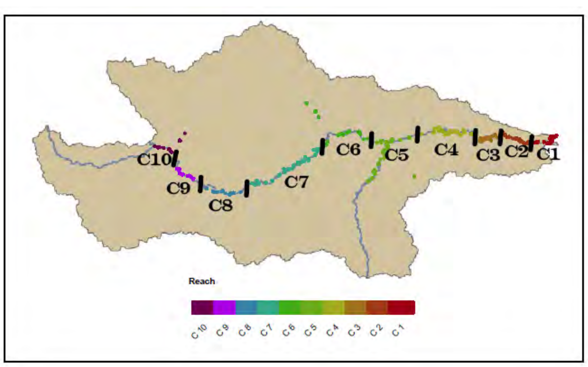
Marion County Lake (Dissolved Oxygen, Eutrophication)

Prioritized Critical Areas for Targeting BMPs



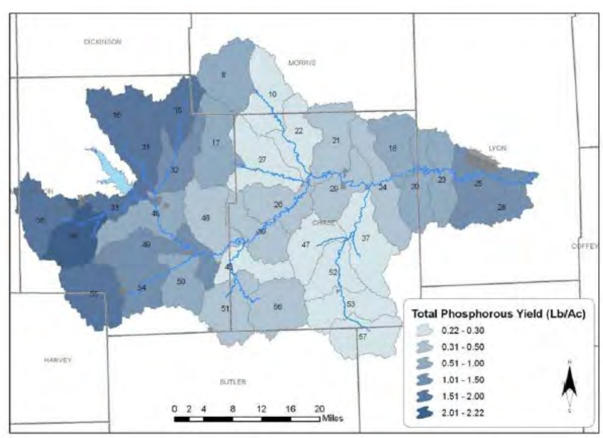
*Please note that an amendment has been approved by KDHE 10/11/12 and an additional livestock HUC 12 (11070202020050) has been added.

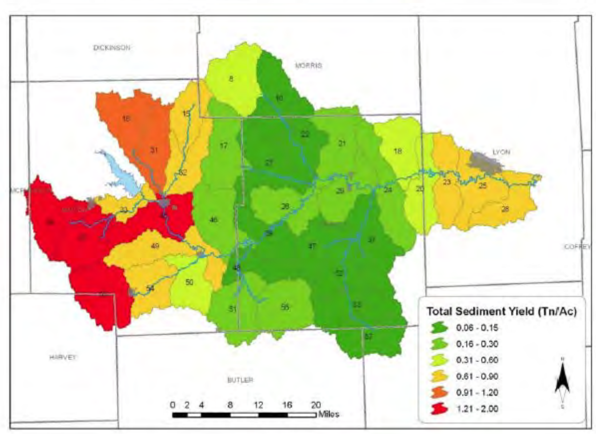
Streambank targeted areas



Targeting considerations:

- Livestock targeted areas were chosen by identifying the impaired water for bacteria and landowner knowledge.
- Cropland BMP Targeted areas were identified through SWAT (Soil and Water Assessment Tool) modeling to determine where high levels of phosphorous and sediment where coming from within the Cottonwood watershed.
- Streambank targeted areas were determined through a riparian and stream channel assessment conducted by the Kansas Water Office. This assessment identified "hot spots" along the Cottonwood River.
- High priority targeted areas were determined by where the high priority TDLS are located in the watershed.





Cottonwood Watershed – 9 Element Watershed Plan Summary

Best Management Practices and Load Reduction Goals

Best Management Practices (BMPs) to address phosphorus and sediment in the watershed where chosen by the SLT based on local acceptance/adoptability and the amount of load reduction gained per dollar spent.

Cropland BMPs

- Grasses Waterways
- No-till cultivation practice
- Vegetative Buffers
- Terraces
- Conservation crop rotation
- Establish permanent vegetation

Livestock BMPs

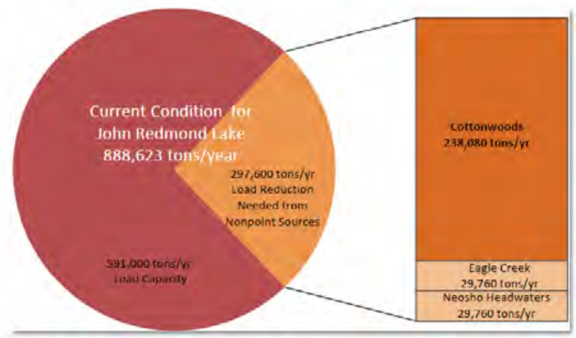
- Vegetative filter strips
- Fence off streams
- Relocate psture feeding sites
- Off strem watering sites
- Rotational grazing

<u>Phosphorus Load Reduction for Marion County Lake</u>

<u>Sediment Reduction:</u>

Required load reduction for Cottonwood from Nonpoint Sources (80% of Total load for John Redmond)

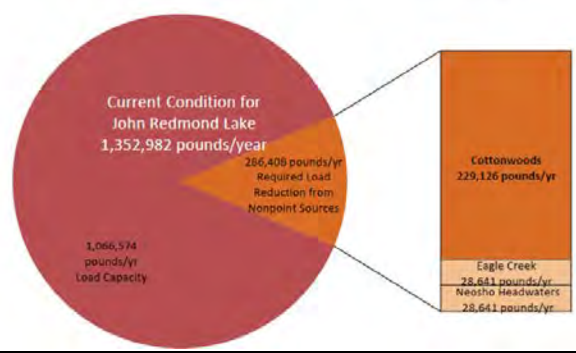
John Redmond Sediment TMDL	
Sediment Current Condition (tons)	888,623
Less Total Silt Load Capacity (tons)	591,000
Required Load Reduction from Nonpoint Sources (tons) for John Redmond Reservoir	**297,600**
Required Annual Load by Watersheds (tons/yr) to meet TMDL	
Neosho Headwaters (10% of total load reduction)	29,760
Eagle Creek (10% of total load reduction)	29,760
Required Load Reduction for Cottonwood Watershed from Nonpoint Sources (80% of Total Load for John Redmond Reservoir)	**238,080**
Total Load Reduction for John Redmond Reservoir	**297,600**



<u>Phosphorus Reducation:</u>

Required load reduxtion for Cottonwood from nonpoint sources (80% total load for John Redmond Reservoir)

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 by Watersheds (lbs/yr) to meet TMDL	
Neosho Headwaters (10% of total load reduction)	28,641
Eagle Creek (10% of total load reduction)	28,641
Required Load Reduction for Cottonwood Watershed from Nonpoint Sources (80% of Total Load for John Redmond Reservoir)	**229,126**
Total Load Reduction for John Redmond Reservoir	**286,408**



Clements stone arch bridge (1886) over the Cottonwood River
Photo courtesy of Kansas Geological Survey

COTTONWOOD RIVER

Watershed Restoration and Protection Strategy

Upper and Lower Cottonwood Watershed

Final Draft Plan July 18, 2011

Funding for the development of this plan was provided through an EPA 319 grant 2007-0028 from the Kansas Department of Health and Environment.

K-State Research and Extension Project (KSRE) Staff

Robert Wilson, Watershed Planner, Office of Local Government
Josh Roe, Watershed Economist, Department of Agricultural Economics
Susan Brown, Kansas Center for Agricultural Resources and the Environment
Aleksey Sheshukov, Watershed Modeler, Department of Biological and Agricultural Engineering

Kansas Department of Health and Environment Project Officer
Ann D'Alfonso, Watershed Management Section

Table of Contents

List of Figures

List of Tables

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.

National Pollutant Discharge Elimination System (NPDES) 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.

Nonpoint Sources (NPS): Sources of pollutants from a disperse area, such as urban areas or agricultural areas

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.

Point Sources (PS): Pollutants originating from a single localized source, such as industrial sites, sewerage systems, and confined animal facilities

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.

Water Quality Standard (WQS): Mandated in the Clean Water Act. Defines goals for a waterbody by designating its uses, setting criteria to protect those uses and establishing provisions to protect waterbodies from pollutants.

1.0 Preface

The purpose of this Watershed Restoration and Protection Strategy (WRAPS) report for the Cottonwood 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 Cottonwood River Watershed.

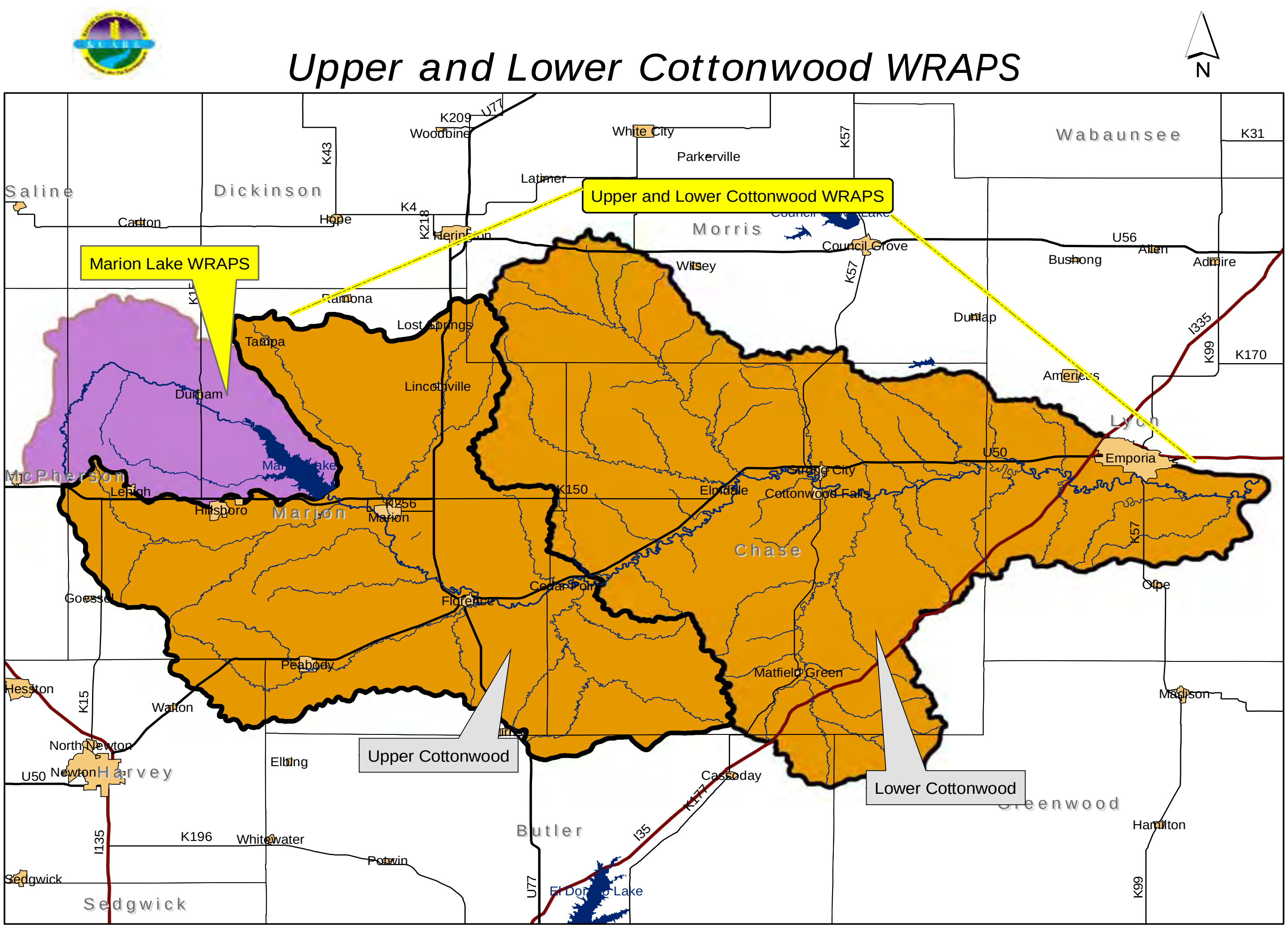
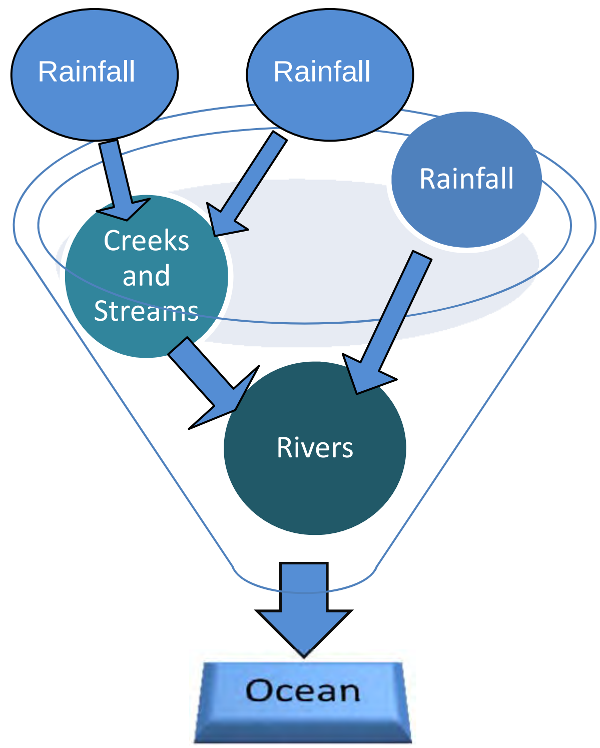


Figure 1. Map of the Upper and Lower Cottonwood Watersheds.

2.0 Background Information

2.1 What is a Watershed?

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.

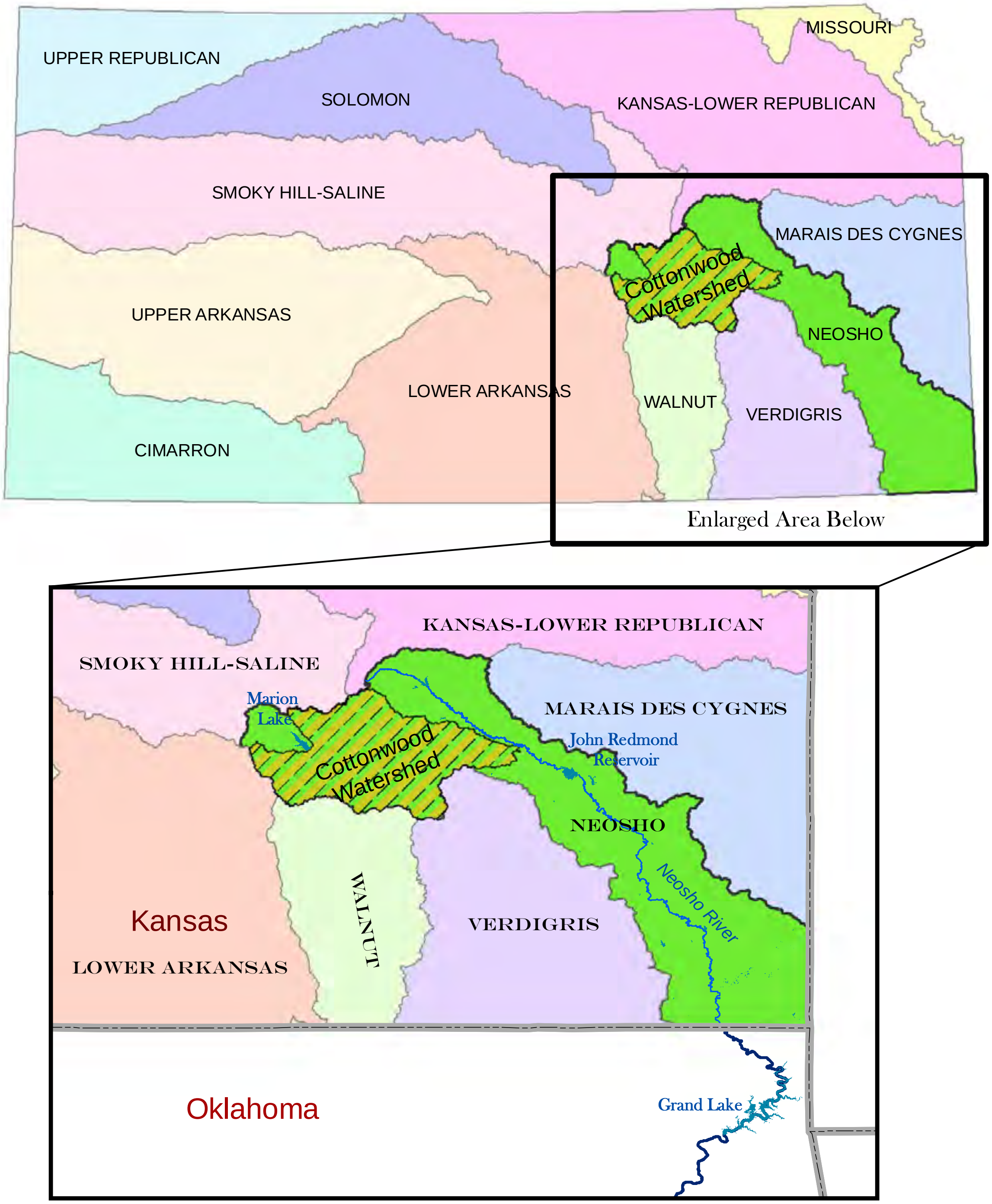


Elevation determines the watershed boundaries. The upper boundary of the Cottonwood Watershed has an elevation of 677 meters (2,221 feet) and the lowest point of the watershed, which is the confluence of the Cottonwood and Neosho Rivers, has an elevation of 200 meters (656 feet) above sea level.

2.2 Where is the Cottonwood Watershed?

The Cottonwood Watershed WRAPS project covers the area that drains the Cottonwood River and its tributaries from the dam at Marion Lake to the confluence of the Cottonwood and Neosho Rivers. One other WRAPS project is currently underway in the Cottonwood Watershed. It is the Marion Lake WRAPS which involves the drainage of Marion Lake. The area of the Marion Lake WRAPS is not included in the Cottonwood WRAPS. Refer to the illustration in Figure 1, page 11.

There are twelve river basins located in Kansas. The Cottonwood Watershed is a portion of the Neosho Basin.



2.3 Why is the Cottonwood Watershed Important?

The Neosho Basin drains the Neosho River and its tributaries into Oklahoma where it flows into the Arkansas River, through Arkansas to the Mississippi River and ultimately empties into the Gulf of Mexico. There are several dams constructed along the Cottonwood and Neosho Rivers. Marion Lake, as mentioned previously is located on the headwaters of the Cottonwood River. John Redmond Reservoir is located on the Neosho River. Grand Lake is located on the Neosho River in Oklahoma.

Grand Lake, located in northeast Oklahoma, was impounded in 1940. It contains 46,500 surface acres and is a major recreational reservoir. Three major rivers flow into Grand Lake:

- the Neosho River from Kansas,
- the Spring River from Missouri, and
- the Elk River from Missouri.

Grand Lake is a surface water supply to many communities in the area. It is also a major recreational economic resource for Oklahoma. The Neosho Basin comprises 57 percent of the total Grand Lake Watershed; therefore, it is of key importance to the overall environmental health of Grand Lake.

Grand Lake has elevated levels of phosphorus and nitrogen. This can cause algal blooms in the lake and low levels of dissolved oxygen which will be discussed later in this report. Both of these incidents will negatively impact aquatic life. According to the Grand Lake Watershed Alliance Foundation (GLWAF), the Neosho River basin can contribute phosphorus, nitrogen, sediment and bacteria into Grand Lake. Spring River may contribute to the phosphorus, nitrogen and bacteria levels, but also carries heavy metals from abandoned mining areas. Elk River is similar to the Neosho River in that it can contribute phosphorus, nitrogen, bacteria and sediment. Therefore, the water quality of Grand Lake depends on the water quality of the rivers entering it. Since the bulk of the watershed of Grand Lake lies in Kansas, it is important for the Cottonwood and the other Neosho Basin watersheds to reduce pollutants exiting their watersheds. A 30 percent reduction target has been assigned by KDHE to the outflow of each watershed in Kansas.

Grand Lake is expected to receive TMDLs in 2012. At this time, responsibilities for pollutants in the lake will be distributed to the incoming rivers. Therefore, the Neosho River Basin could receive a significant portion of the pollutant load. At that time, the SLTs for the Cottonwood Watershed will need to reevaluate the BMPs (definition below) and load reductions that are outlined later in this plan for needed corrections and alterations.

NOTE: 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.

2.4 What is a HUC?

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. The Cottonwood Watershed WRAPS project is composed of 2 HUC8s (meaning an 8 digit identifier code): the Upper Cottonwood and the Lower Cottonwood. The Upper Cottonwood HUC number is 11070202 and the Lower Cottonwood HUC number is 11070203. The first 2 numbers in the code refer to the drainage region, the second 2 digits refer to the drainage subregion, the third 2 digits refer to the accounting unit and the fourth set of digits is the cataloging unit. For example:

11070203 = Region drainage of the Arkansas, Red and White River basins
11**07**0203 = Subregion drainage of the Neosho and Verdigris Rivers in Arkansas, Kansas, Missouri and Oklahoma
1107**02**03 = Accounting unit drainage of the Neosho River basin in Arkansas, Kansas, Missouri and Oklahoma
110702**02** = Cataloging units drainage of the section of the Cottonwood River named the Upper Cottonwood
110702**03** = Cataloging units drainage of the section of the Cottonwood River named the Lower Cottonwood

As watersheds become smaller, the HUC number will become larger. HUC 8s are further divided into smaller watersheds with HUC 10 and HUC 12 delineations. The Cottonwood Watershed is divided into thirty five HUC 12 delineations.

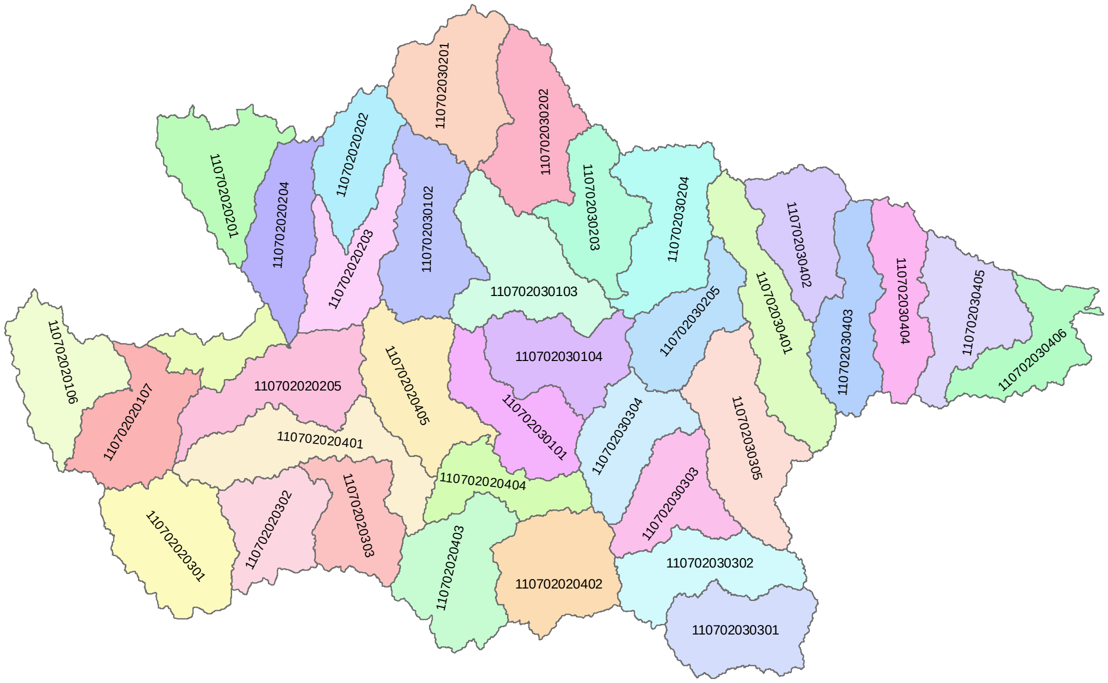


Figure 2. HUC 12 Delineations in the Cottonwood Watershed.

3.0 Watershed History

3.1 Stakeholder Leadership Team (SLT) History

The SLT was formed out of concern for the Cottonwood River and flooding events that occur along the river. Due to the size of the watershed, it was decided that two SLTs would serve the WRAPS process better than one. One group is from the Upper Cottonwood and meets in Hillsboro and Marion. The other group is from the Lower Cottonwood and meets in Cottonwood Falls. The SLTs began meeting in August of 2009. Although two different SLTs have been formed, there is one set of water quality issues and goals for the watershed.

The Cottonwood SLTs have representation from several watershed districts within the basin. The primary purpose of these taxing entities is to construct and maintain watershed structures to control flooding.

Even though there is one set of water quality issues, the SLT from the Lower portion of the watershed has desired that a greater focus be placed on flooding. The SLT hopes to slow the rate of flooding in the Cottonwood River and subsequent erosion by improving conditions in the watershed. New conservation practices will include those implemented in cropland, along streambanks and in livestock areas in addition to their desire to construct more retention structures. Watershed-wide 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. Benefits will also apply to downstream Reservoirs: John Redmond and Grand Lake. However, EPA 319 and State Water Plan funds cannot be spent on structural practices such as watershed retention structures so a complete evaluation of increased adoption, costs, and load reductions (which will be discussed later in this report) stemming from new structures is not included in this plan. The SLT does recognize that the installation of new watershed structures in the future could have a positive effect on sediment and nutrient loadings in the Cottonwood River.

In summary, there are 57 completed watershed structures and 60 planned structures within the Cottonwood Watershed. Their average retention is 520 acre-feet and average drainage area is 1,792 acres (2.8 square miles). As noted in the following map, watershed structures are generally placed on intermittent streams. For load reduction purposes, they function similar to a large pond, reducing sediment and nutrients by an average of 50 percent.

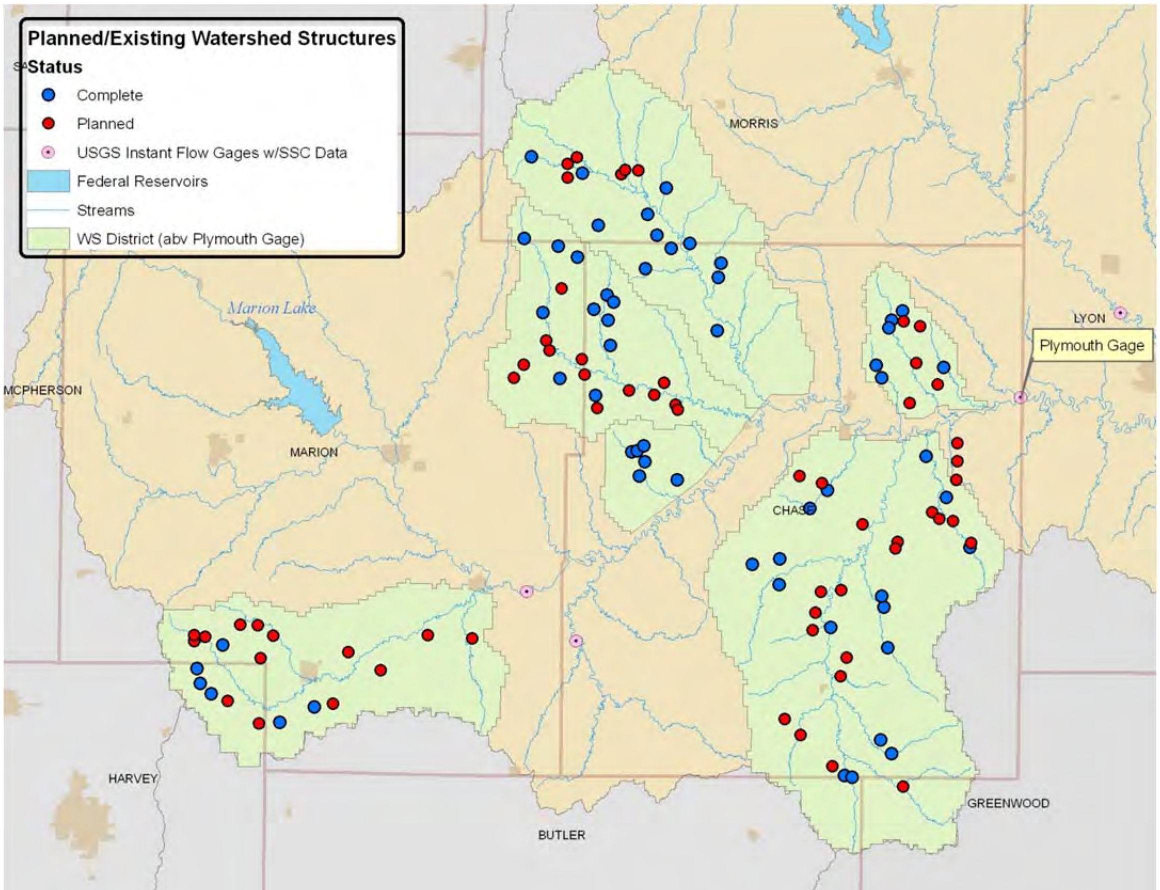


Figure 3. Current and Planned Watershed Structures in the Cottonwood Watershed. [1]

3.2 Overview

The Upper and Lower Cottonwood Watersheds are designated as Category I watersheds indicating that they are 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 Upper Cottonwood is ranked thirty-sixth in priority and the Lower Cottonwood is ranked forty-third out of ninety-two watersheds state wide.

3.3 Issues and Goals of the Upper and Lower SLTs

The charge of the SLTs has been to create a plan of restoration and protection measures for the watershed. During the time period that they have been meeting, they have had speakers and discussions to review and study watershed issues and concerns. The SLT then set **priority watershed issues and concerns.**

The SLTs have set their priority issues as (in no particular order):

1. Flooding along the Cottonwood River.
2. Streambank erosion.
3. Riparian area degradation.
4. Erosion on cropland and livestock areas.
5. Bacteria and nutrient runoff from livestock operations.
6. Sediment and nutrient runoff from cropland.

The Watershed goals as set by the SLTs are (in no particular order):

1. Achieve high-priority Total Maximum Daily Loads (TMDLs) in the watershed.
2. Protect public drinking water supplies.
3. Preserve productivity of agricultural lands.
4. Minimize impacts of flooding along the Cottonwood River by utilizing the BMPs listed in this WRAPS 9 Element Plan.
5. Protect recreational uses on rivers, streams and lakes.
6. Protect aquatic life in rivers, streams and lakes.

What is a Total Maximum Daily Load (TMDL)?

Every state assigns ***designated uses*** for each water body. These designated uses provide for:

- healthy aquatic life,
- safe contact recreation (swimming and boating),
- safe drinking water,
- safe food procurement, and
- adequate ground, irrigation, industrial, and livestock water usage.

Not meeting these uses indicates a failure to meet the Kansas ***Water Quality Standard*** (WQS). When this happens, a ***TMDL*** is developed. TMDL is a regulatory term derived from the US Clean Water Act. The TMDL will set a maximum amount of pollutant that can be discharged into a waterbody while still providing for its designated uses. It is an assessment tool that helps to identify pollutant impairments and determine the amount of pollutant in the water.

TMDLs consist of 3 parts: wasteload allocation (WLA) from point sources, load allocation (LA) from nonpoint sources, and a built in margin of safety (MOS). In this WRAPS report, we will address the LA from nonpoint sources.

The purpose of this WRAPS plan is to address these issues and concerns of the SLT, to address and mitigate current TMDLs in the watershed and to proactively improve conditions so that the impairments on the current 303d list will not reach the stage of TMDL development.

4.0 Watershed Review

4.1 Land Cover/Land Uses

The Lower Cottonwood Watershed covers 609,280 acres and the Upper Cottonwood covers 476,093 (excluding Marion Lake watershed). The entire watershed covers 1,085,373 acres. It is overwhelmingly grassland (68%). This area is part of the Flint Hills ecosystem which is part of the Tallgrass Prairie. Much of the grassland is used to summer stocker calves from May to June. Heavier than normal stocking rates are used for this short period of time. Grassland can contribute fecal coliform bacteria (FCB) 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 26 percent. Cropland can contribute nutrients from fertilizer runoff and sediment from bare crop ground that erodes during heavy rainfall events. The rest of the land uses (6%) in the watershed are urban, woodlands, water and other.

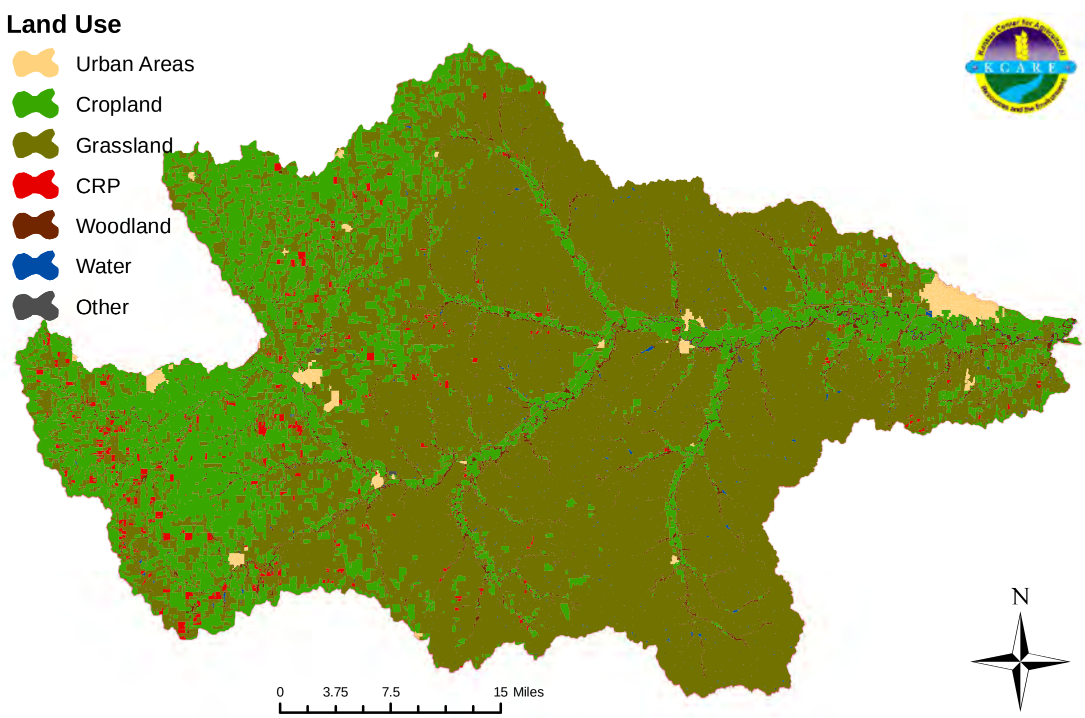


Figure 3. Land Use of the Cottonwood Watershed. [3]

Table 1. Land Use in the Watershed. [4]

Land Use	*Acres*	*Percentage*
Grassland	741,037	68.27
Cropland	282,245	26.00
Woodland	34,012	3.13
Urban Areas	11,785	1.09
CRP	11,492	1.06
Water	4,518	0.42
Other	284	0.03
Total	**1,085,373**	**100.00**

4.2 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, 2009, issued by KDHE. If the designated uses of a water body are not being met, the Water Quality Standard for that water body is not being met and therefore, it is impaired.

Table 2. Designated Water Uses for the Cottonwood Watershed. [5]

Designated Uses Table								
Stream or Lake Name	**AL**	**CR**	**DS**	**FP**	**GR**	**IW**	**IR**	**LW**
Bruno Cr	E			X				
Buck Cr, Camp Cr, Corn Cr, Gannon Cr, Little Cedar Cr Seg 11, Picket Cr, Spring Cr	E							
Marion Co L, Chase Co SFL	E	A	X	X	O	X	X	X
Palmer Cr,	E	a	X	X	X	X	X	X
Bills Cr, Beaver Cr, Cannonball Cr, Coyne Br, Dodd Cr, French Cr, Gould Cr, Mile and a Half Cr, Phenus Cr, Schaffer Cr, School Cr, Sharpes Cr, Silver Cr, Stout Run, Stibby Cr	E	b						
Buckeye Cr, Coal Cr	E	b		X				
Bull Cr, Moon Cr	E	b	O	O	X	O	O	X
Clear Cr , Cottonwood R seg 1	E	B	X	X	X	X	X	X
Clear Cr E B, Perry Cr, Stony Br	E	b	O	X	O	O	X	X
Clear Cr Seg 5, Cottonwood R S, Spring Br, Diamond Cr, Prather Cr,	E	b	X	X	X	X	X	X
Dry Cr, Kirk Cr,	E	b	O	O	X	O	O	O
Fox Cr	E	B		X				X
French Cr	E	b	X	X				
Holmes Cr, Mulvane Cr,	E	b	X	O	X	X	X	X
Antelope Cr	E	C	O	X	X	O	X	X

Designated Uses Table, cont.								
Stream or Lake Name	**AL**	**CR**	**DS**	**FP**	**GR**	**IW**	**IR**	**LW**
Coon Cr, Turkey Cr, Crocker Cr, Mercer Cr,	E	C						
Cottonwood R seg 2,3,7,8, Cottonwood R N, Doyle Cr, Unnamed Stream	E	C	X	X	X	X	X	X
Spring Cr seg 28	E	C	O	O	O	O	X	X
Little Cedar Cr seg 45	S							
Collette Cr	S	b						
Cottonwood R S Fk seg 10	S	b	X	X	X	X	X	X
Cottonwood R seg 2,4,6, Peter Pan L	S	B	X	X	X	X	X	X
Jacob Cr,	S	b		X				
Catlin Cr, Spring Cr seg 29, Bloody Cr, Middle Cr, Peyton Cr, Rock Cr	S	C		X				
Cottonwood R seg 1, Cottonwood R S Fk seg 9, Six Mile Cr	S	C	X	X	X	X	X	X
Mud Cr	S	C	X	X				

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

4.3 Special Aquatic Life Use Waters and Exceptional State Waters

Special Aquatic Life Use (SALU) 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 Cottonwood River Watershed has a special aquatic life use designation for Mud Creek, Six Mile Creek, Middle Creek, Collett Creek, Bloody Creek, Jacob Creek, Spring Creek, Catlin Creek, Little Cedar Creek and the lower portion of the Cottonwood River. **Exceptional State Waters (ESW)** are waters that are defined as “any of the surface waters or surface water segments that are of remarkable quality or of significant recreational or ecological value”. Cedar Creek and the Cottonwood River, South Fork are designated as both ESW and SALU waters.

.

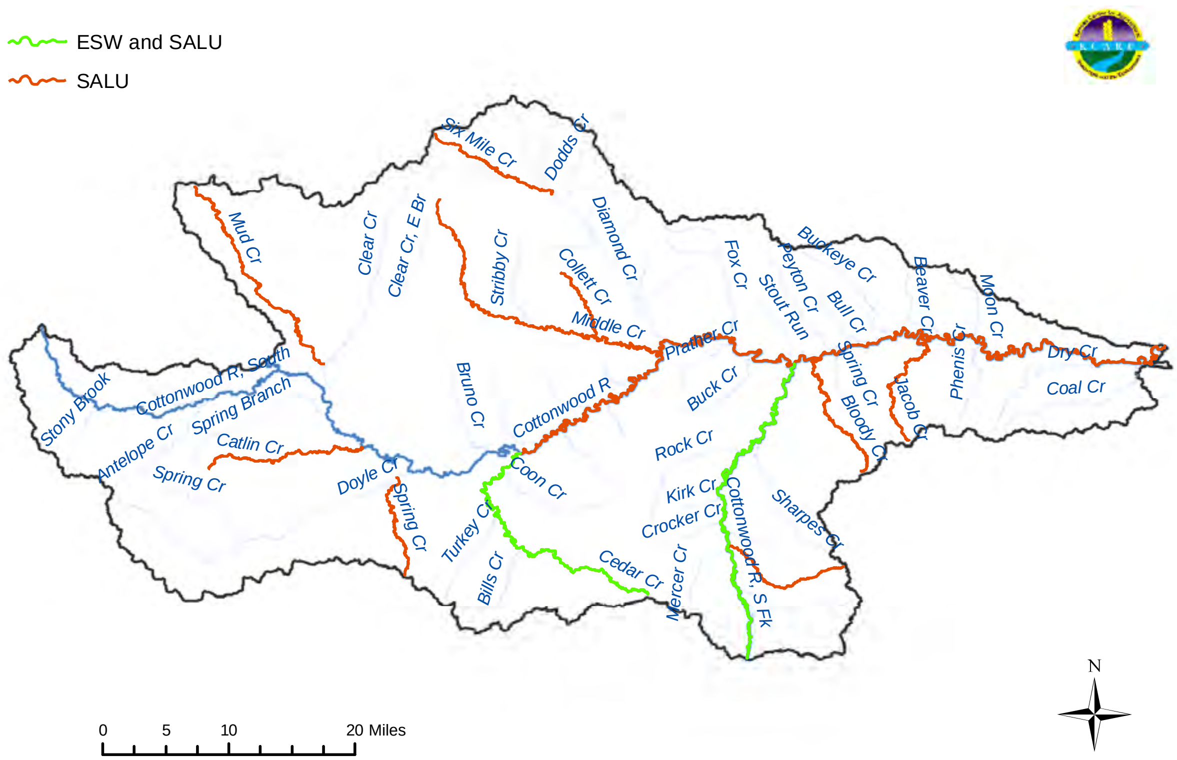


Figure 4. SALU Waters and ESW in the Watershed. [6]

The SALU waters and ESW are located in areas that are 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 *E. coli* bacteria from livestock are some of the potential pollutants.

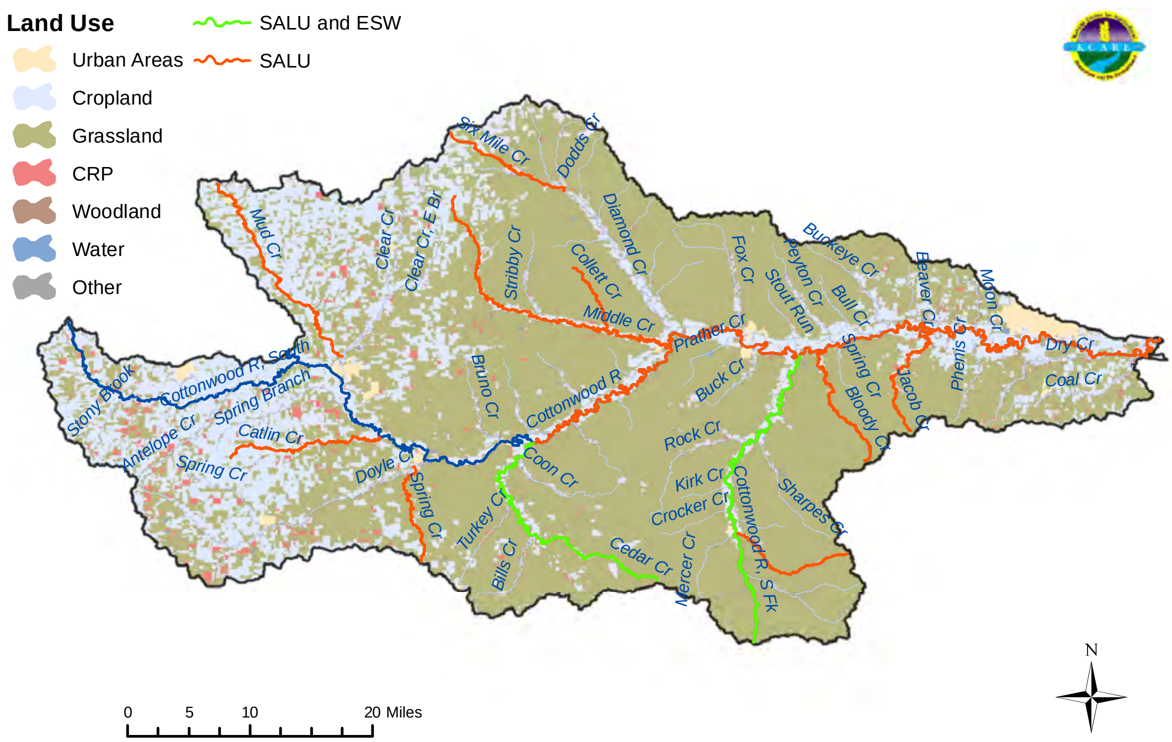


Figure 5. SALU and ESW with Land Cover.[7]

4.4 Rainfall and Runoff

Rainfall rates and duration will affect sediment runoff and nutrient runoff during high rainfall events. The Cottonwood Watershed averages 34 inches of rainfall yearly. Most high intensity rainfall events will occur in late spring and early summer.

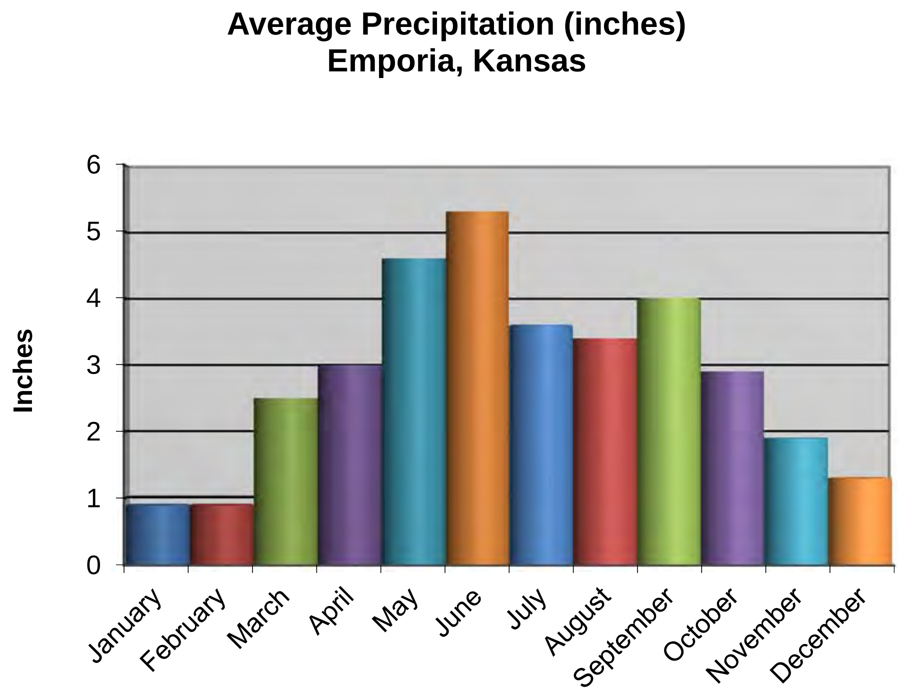


Figure 6. Average Precipitation by Month. [8]

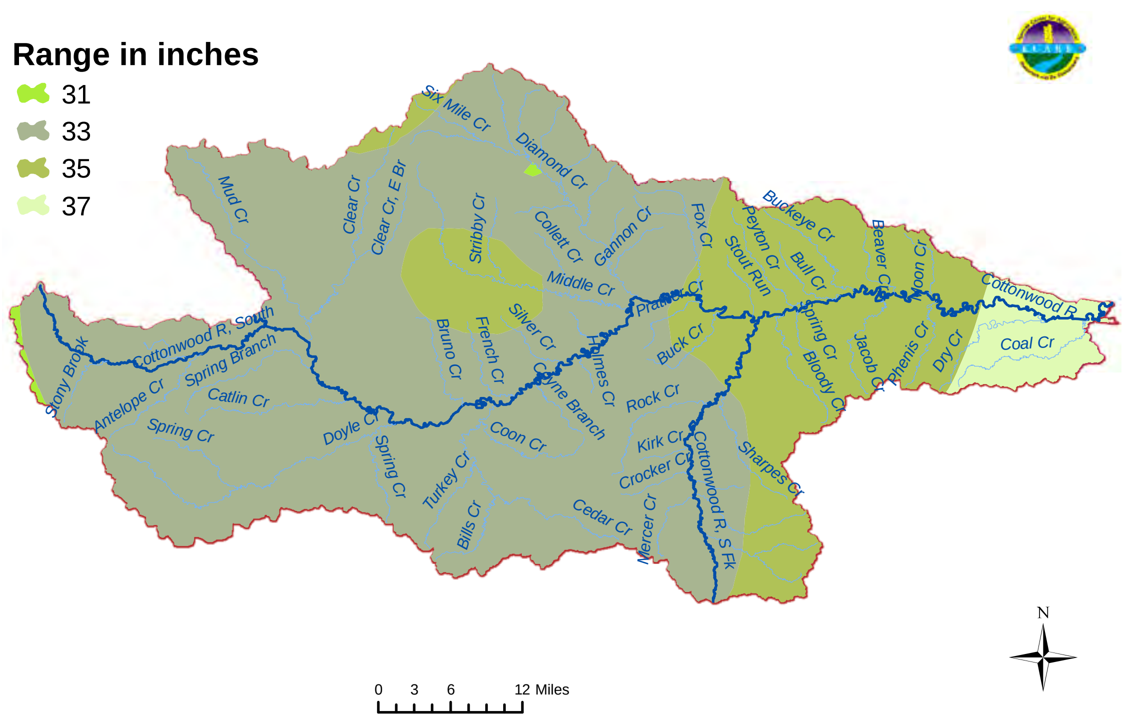


Figure 7. Average yearly Precipitation in the Watershed. [9]

4.5 Population and Wastewater Systems

The number of wastewater treatment systems is directly tied to population, particularly in rural areas that do not have access to municipal wastewater treatment facilities. Failing, improperly installed or lack of an onsite wastewater system can contribute *E.coli* bacteria or nutrients to the watershed through leakage or drainage of untreated sewage. 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. It is estimated that ten percent of wastewater systems in the watershed are failing or insufficient. [10] Therefore, the exact number of systems is directly tied to population.

Table 3. Population in the Major Counties of the Watershed. [11]

County	Population	Persons per square mile	Population Change (2000 to 2008), %
Chase	2,798	3.9	-7.7
Lyon (minus City of Emporia)	9,734	13.9	-1.0
City of Emporia	26,188		-2.3
Marion	12,100	14.2	-9.4
Morris	5,994	8.8	-1.8
Total for Watershed without Emporia	**30,626**	**Average: 10.2**	**Average: -5.0**
Total for Watershed	**Total: 56,814**	**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 10.2.

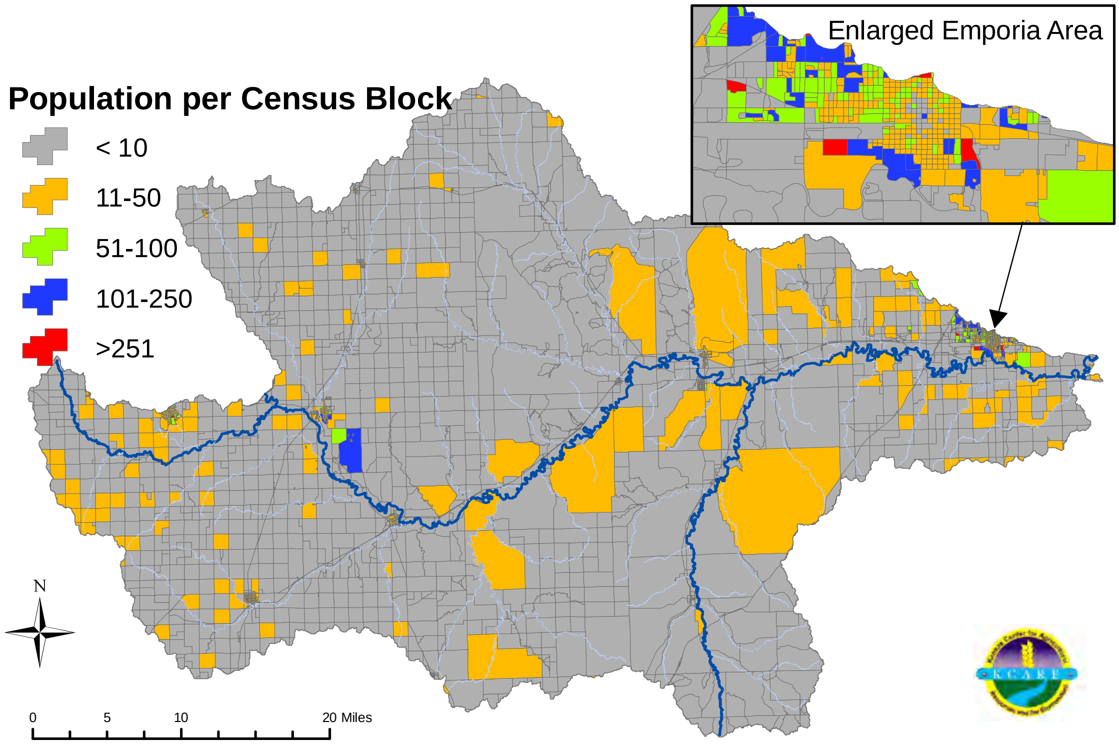


Figure 8. Census Count, 2000. [12]

4.6 Aquifers

Two aquifers underlie the watershed:

- Alluvial Aquifer - An alluvial aquifer is a part of and connected to a river system and consists of sediments deposited by rivers in the stream valleys. The Cottonwood River has an alluvial aquifer that lies along and below the river. Creeks that have alluvial aquifers are Mud, Clear, Turkey, Cedar, Middle, Diamond and the South Fork of the Cottonwood River.
- Dakota Aquifer - The Dakota aquifer extends from southwestern Kansas to the Arctic Circle. In recent years, the Dakota aquifer has been used for irrigation purposes in southwest and in north-central Kansas (Cloud, Republic and Washington counties) and continues to present time. The Dakota aquifer also provides water for municipal, industrial, and stock water supplies. The Cottonwood Watershed has a small portion of the Dakota Aquifer in its upper reaches.

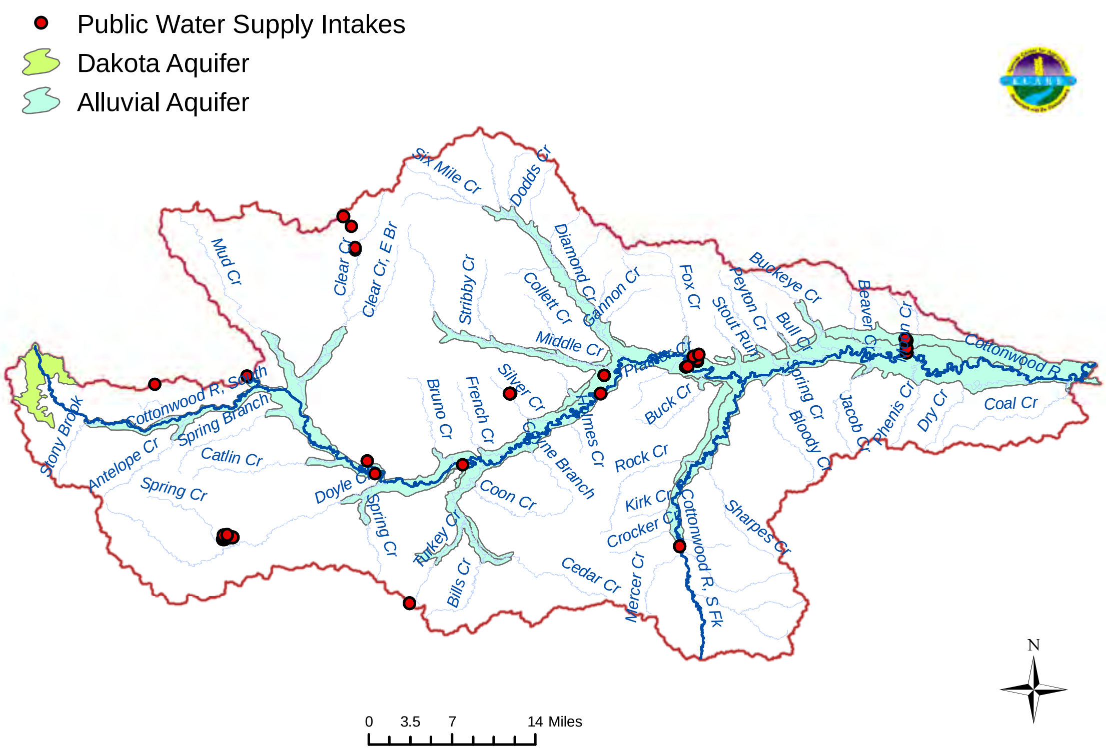


Figure 9. Aquifers in the Watershed. [13]

4.7 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. Nutrients and *E. coli* bacteria will also affect surface water supplies causing excess cost in treatment prior to public consumption. The table below lists the PWS in the Cottonwood Watershed.

Table 4. Public Water Supplies in the Cottonwood Watershed [14]

Municipality	Source	Serves (Secondary Users)	Purchase From	County	Population Served
Cedar Point	Groundwater			Chase	30
Centre USD 397	Groundwater			Marion	
Cottonwood Falls	Groundwater			Chase	966
Elmdale	Groundwater				52
Florence	Groundwater			Marion	600
Hillsboro	Groundwater	Peabody (treatment only)			2,300
Matfield Green	Groundwater			Chase	73
Peabody	Groundwater				1,203
Strong City	Groundwater			Chase	533

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. [15] Any pollutant discharge from point sources that is allowed by the state is considered to be Wasteload Allocation.

Table 5. Permitted Point Source Facilities. [16] Municipalities that have both NPDES and PWS sites are highlighted in tan.

Facility Name	Owner	Description	City	County
Associated Milk Prod. Inc	Private	Condensed and Evaporated Milk	Hillsboro	Marion
City of Hillsboro	Public	Sewerage Systems	Hillsboro	Marion
Peabody Wastewater Treatment	Public	Sewerage Systems	Peabody	Marion
Martin Marietta-hett Quarry	Private	Crushed and Broken Limestone	Marion County	Marion
Martin Marietta –Sunflower Quarry	Private	Crushed and Broken Limestone	Marion County	Marion
City of Lincolnville Wastewater Treatment Plant	Public	Sewerage System	Lincolnville	Marion
Unruh Catering Groundwater Rem	Private		Peabody	Marion
Martin Marietta Aggre-Marion	Private	Crushed and Broken Limestone	Marion	Marion
IBP Incorporated	Private	Meat Packing Plants	Emporia	Lyon
City of Strong City	Public	Sewerage Systems	Strong City	Chase
Kansas Turnpike Authority Mat	State	Inspection and Fixed Facilities	Matfield Green	Chase
Modine Manufacturing Company	Private	Motor Vehicle Parts and Accessor	Emporia	Lyon
Didde Web Press Corp.	Private	Commercial Printing, Nec	Emporia	Lyon
Cottonwood Falls Wastewater Treatment Plant	Public		Cottonwood Falls	Chase
Thunderbird Estates	Private	Operator of Res Mobile Home Sites	Emporia	Lyon

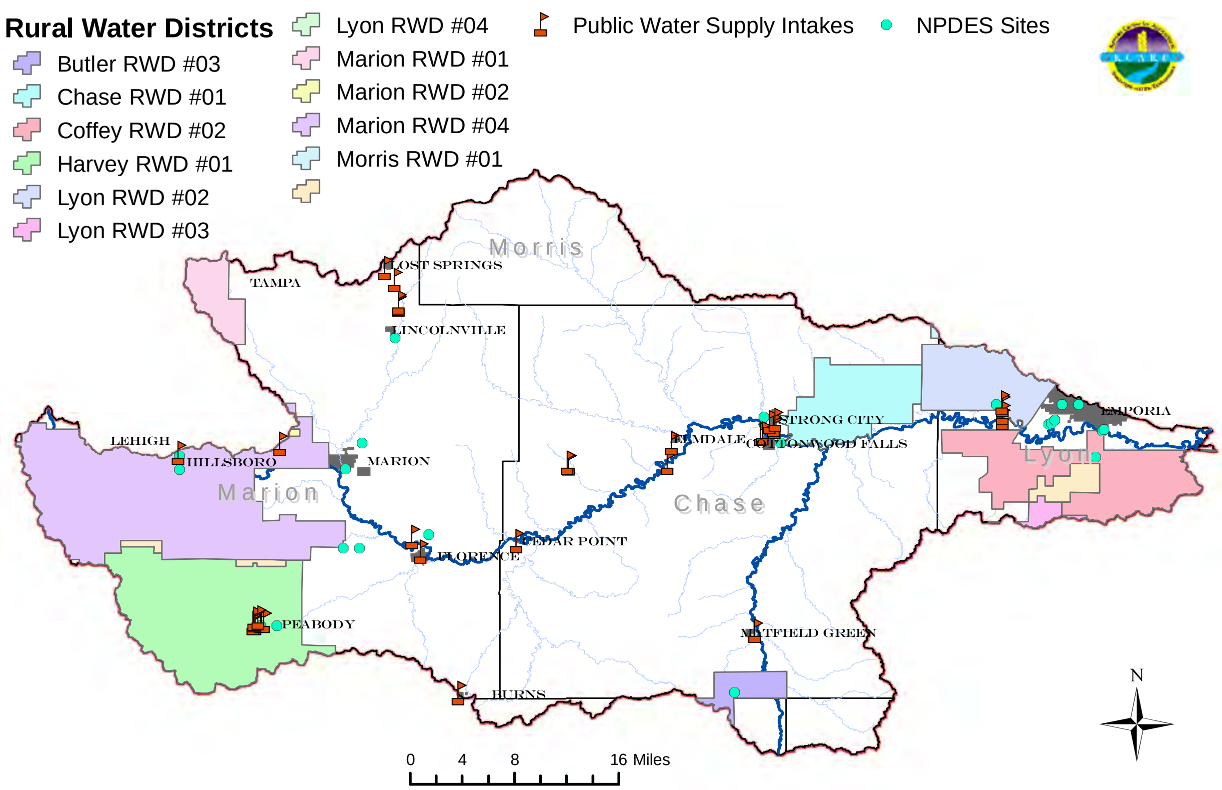


Figure 10. Rural Water Districts, Public Water Supply Diversion Points and NPDES Wastewater Treatment Plants (WTP). [17]

4.8 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. [18] 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 6. TMDLs Review Schedule for the Neosho Basin. [19]

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

Pursuant to EPA, water bodies are assigned "categories" depending on their impairment status. [20]

- Category 5 – Waters needing TMDLs
- Category 4a – Waters that have TMDLs developed for them and remain impaired
- Category 4b – NPDES permits addressed impairment or watershed planning is addressing atrazine problem
- Category 4c – Pollution (typically insufficient hydrology) is causing impairment
- Category 3 – Waters that are indeterminate and need more data or information
- Category 2 – Waters that are now compliant with certain water quality standards
- Category 1 – All designated uses are supported, no use is threatened

TMDLs in the watershed are listed in the table below.

Table 7. TMDLs in the Watershed. [21] The shaded lines indicate high, medium or low priortities. The **bold** impairments indicate ones that are included in the Targeted Areas. John Redmond Lake TMDLs are included, even though they are not geographically in the watershed, to emphasize the effect the Cottonwood Watershed has on water quality in the Lake.

Water Segment	TMDL Pollutant	End Goal of TMDL	Priority	Sampling Station
Upper Cottonwood				
High Priority				
Mud Creek	**FCB**	**< 2,000 colonies FCB / 100 ml water**	**High**	**SC691**
Medium Priority				
Marion County Lake	Dissolved Oxygen	DO > 5mg/l	Medium	LM01201

Water Segment	TMDL Pollutant	End Goal of TMDL	Priority	Sampling Station
Upper Cottonwood, cont.				
Medium Priority				
Marion County Lake	Eutrophication	Summer chlorophyll a concentrations < 12ug/L Total N concentration < 0.62 mg/L	Medium	LM01201
Cottonwood River South	**FCB**	**< 2,000 colonies FCB / 100 ml water**	**Medium**	**SC635**
Low Priority				
Cottonwood River South	**Sulfate**	**250 mg/l at outlet of the watershed**	**Low**	**SC635**
Clear Creek				**SC690**
Doyle Creek				**SC120**
Lower Cottonwood				
Water Segment	**TMDL Pollutant**	**End Goal of TMDL**	**Priority**	**Sampling Station**
Medium Priority				
Fox Creek	Biology	MBI > 4.5	Medium	SC718
Palmer Creek				SC719
South Fork Cottonwood River				SC582
Cottonwood River	FCB	< 2,000 colonies FCB / 100 ml water	Medium	SC627
Cottonwood River	FCB	< 2,000 colonies FCB / 100 ml water	Medium	SC275
Diamond Creek	Cottonwood River	< 2,000 colonies FCB / 100 ml water	Medium	SC625
Cottonwood River	Sulfate		Low	SC627 SC275
John Redmond Lake				
Water Segment	**TMDL Pollutant**	**End Goal of TMDL**	**Priority**	**Sampling Station**
Medium Priority				
John Redmond Lake	Siltation	Secchi disc depth > 0.8m Target storage capacity 65,000acre/ft for 2014	Medium	LM026001
John Redmond Lake	Eutrophication	Summer chlorophyll a concentrations < 12ug/L Total N concentration < 0.62 mg/L	Medium	LM026001

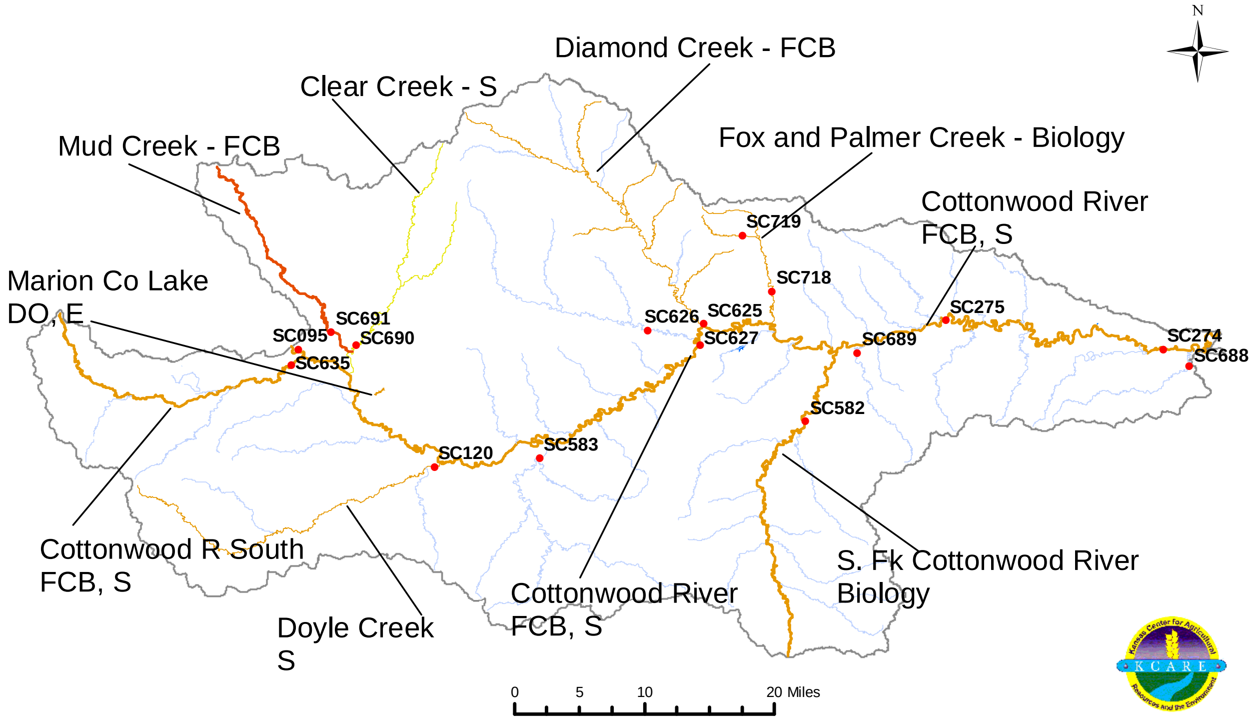


Figure 11. TMDLs in the Watershed. [22] Red color indicates high priority TMDL, orange color indicates medium priority TMDL and yellow color indicates low priority TMDL.

4.9 303d Listings in the Watershed

The Cottonwood Watershed has numerous new listings on the 2010 “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 Cottonwood 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”.

Table 8. 2010 303d List of Impaired Waters in the Cottonwood Watershed. [23] The impairments in **bold** print indicate ones that are included in the Targeted Areas.

Category	Water Segment	Impairment	Priority	Sampling Station
Low Priority				
5 – Waters needing TMDL	**Mud Creek near Marion**	**Atrazine, Sulfate**	**Low**	**SC691**
5 – Waters needing TMDL	Cedar Creek near Cedar Point	Copper, Zinc	Low	SC583

Category	Water Segment	Impairment	Priority	Sampling Station
Low Priority, cont.				
5 – Waters needing TMDL	**South Cottonwood River near Canada**	**Total Phosphorus**	**Low**	**SC635**
5 – Waters needing TMDL	Cottonwood River near Elmdale	Atrazine	Low	SC627
5 – Waters needing TMDL	**Cottonwood River near Emporia**	**Biology, Total Phosphorus**	**Low**	**SC274**
5 – Waters needing TMDL	Bloody Creek near Saffordville	Sulfate	Low	SC689
5 – Waters needing TMDL	Cottonwood River near Plymouth	Total Suspended Solids	Low	SC275
Category	**Water Segment**	**Impairment**	**Comment**	**Sampling Station**
3 – Waters that need more data	Doyle Creek	Ammonia, Dissolved Oxygen, FCB	NPDES Permit Lagoon Study Pending	NPDES51705
3 – Waters that need more data	Clear Creek near Marion	Atrazine	Recent trends indicate concern	SC690
3 – Waters that need more data	Cottonwood River	FCB	Disinfection compliance needs improvement	NPDES46728

Table 9. 2010 303d Delisted Waters. [24]

Category	Water Segment	Impairment	Comment	Sampling Station
2 – Waters now compliant	South Cottonwood River near Canada	Mercury	No longer impaired	SC635
2 – Waters now compliant	North Cottonwood River near Durham	Zinc	No longer impaired	SC636
2 – Waters now compliant	Cottonwood River near Emporia	Chlordane	Fish consumption advisory withdrawn	SC274
		E. coli bacteria	Adequate water quality	
		FCB	Went Cat 2 *E. coli* bacteria in 2008	
2 – Waters now compliant	Middle Creek near Elmdale	Lead	Cat 2 – Unstable flow analysis	SC626

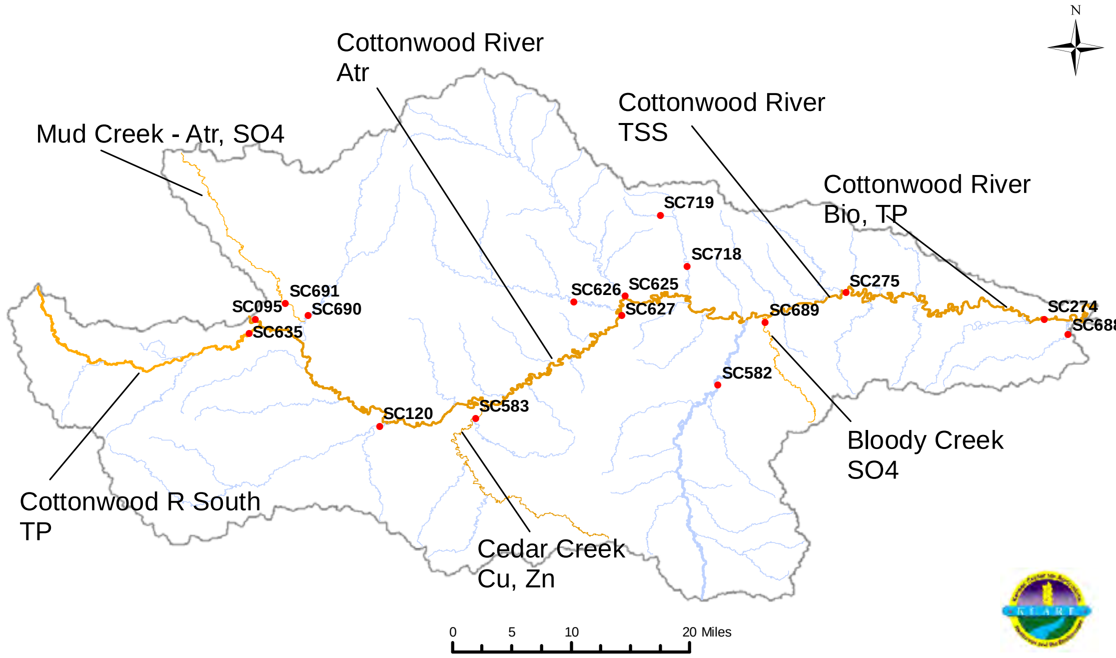


Figure 12. 303d Listings in the Watershed. [23] **O**range color indicates low priority TMDL.

4.10 Load Allocations [25]

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, Confined Animal Feeding Operations (CAFOs) or other regulated sites. Point sources are regulated and are not covered by this WRAPS project. 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.

Three sub watersheds that drain into John Redmond Lake that have been given a pollutant load responsibility: Cottonwood, Neosho Headwaters and Eagle Creek. KDHE has determined by analyzing river and creek samples the degree to which each of the sub watersheds contribute to the pollutant load in the Reservoir. Cottonwood Watershed (the Cottonwood River from Marion Lake to its confluence with the Neosho River) is attributed for 80% of the impairment allocation. Eagle Creek Watershed (Eagle Creek headwaters to its confluence with the Neosho River) is attributed for 10% of the impairment allocation.

Neosho Headwaters is attributed with a responsibility of 10% of the total load allocations.

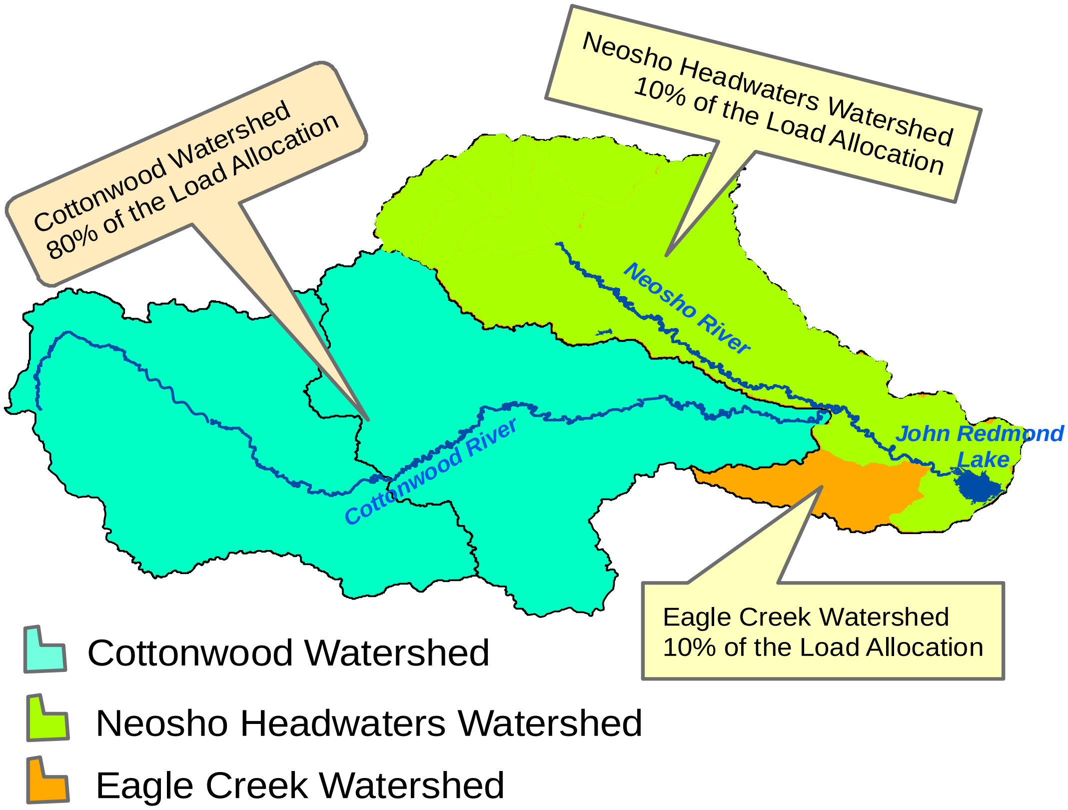


Figure 13. Load Responsibilities Assigned in Neosho Headwaters, Eagle Creek and Cottonwood Watersheds.

Load allocations for the Cottonwood Watershed as determined as 80 percent of the total pollutant loads are:

1) **Sediment nonpoint source load allocation = 472,800 tons/year**
2) **Total Phosphorus nonpoint source load allocation = 853,259 lbs/year**

4.10.1 Sediment

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 John Redmond

Reservoir, KDHE has determined that the Cottonwood Watershed is responsible for 80% of the load reduction or 238,080 tons of sediment into John Redmond Reservoir.

Table 10. Sediment Load Reductions for Cottonwood Watershed. [26]

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

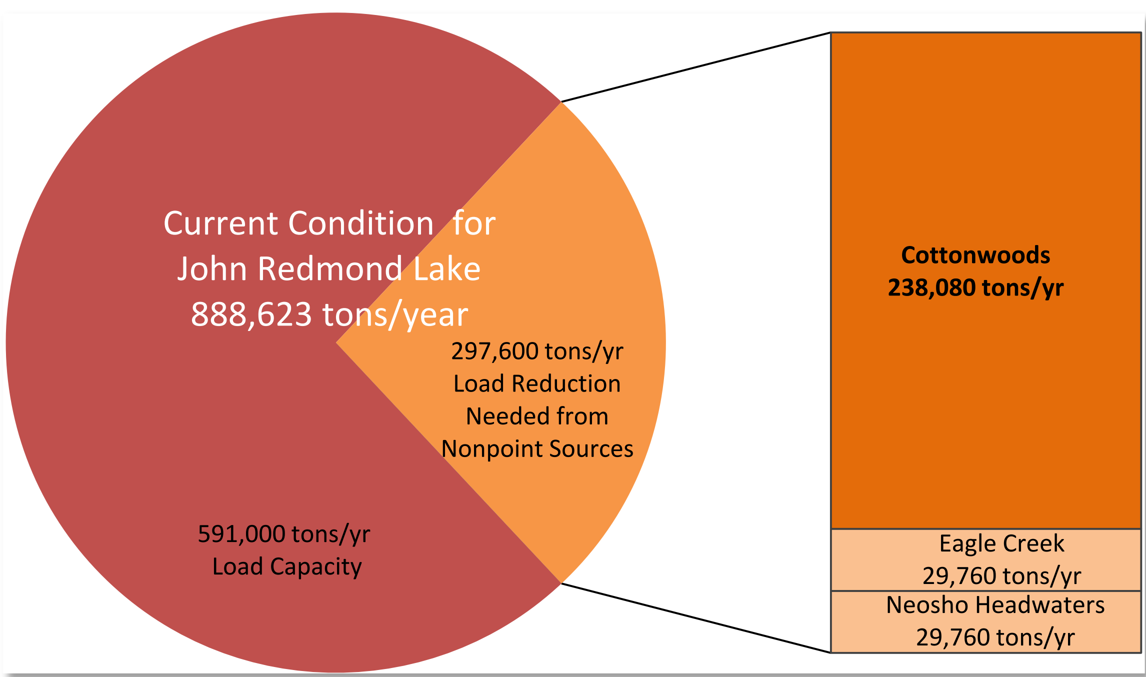


Figure 14. Sediment Load Allocations for Cottonwood, Eagle Creek and Neosho Headwaters Watersheds.

4.10.2 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 Cottonwood Watershed is responsible for 80% of the load reduction or 229,126 pounds of phosphorus.

Table 11. Phosphorus Load Reductions for the Cottonwood Watershed. [27]

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 by Watersheds (lbs/yr) to meet TMDL	
Neosho Headwaters (10% of total load reduction)	28,641
Eagle Creek (10% of total load reduction)	28,641
Required Load Reduction for Cottonwood Watershed from Nonpoint Sources (80% of Total Load for John Redmond Reservoir)	**229,126**
Total Load Reduction for John Redmond Reservoir	**286,408**

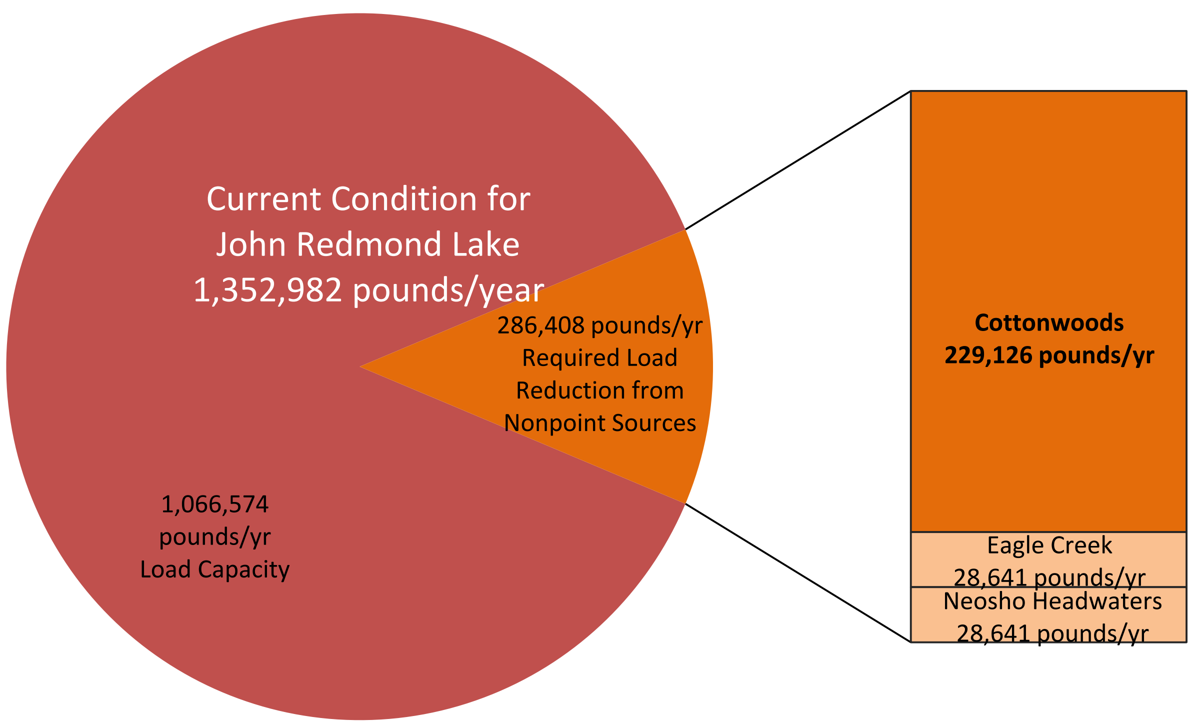


Figure 15. Phosphorus Load Reductions for Cottonwood, Eagle Creek and Neosho Headwaters Watersheds.

5.0 Critical and Targeted Areas, and Load Reduction Methodology

5.1 Critical Areas

In the Cottonwood Watershed, "Critical Areas" have been identified as areas that need to be protected or restored, such as areas that have TMDLs, emerging pollutant threats, on the 303d list or contain a public water supply. Critical areas are defined by EPA as geographic areas that are critical to implement management practices in order to achieve load reductions. [28] Two areas have been identified as Critical Areas in this WRAPS:

1. Sub watersheds that have been identified by Watershed Assessment Tools as a potential source of pollutants,
2. Sub watersheds with high priority TMDLs

5.2 Targeted Areas

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, 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 and nutrient runoff. Targeting for this watershed will be accomplished in four different areas:

1. Cropland areas will be targeted for sediment and nutrients (phosphorus),
2. Livestock areas will be targeted for nutrients (phosphorus) and *E. coli* bacteria,
3. High priority TMDL areas will be targeted for *E. coli* bacteria, and
4. Streambank areas will be targeted for sediment and nutrients (phosphorus).

There is significant overlap in these targeted areas which is to the benefit of water quality in that applying BMPs for one pollutant will also positively affect other pollutants. Detailed discussion of each Targeted Area follows in the next sections of this report.

Table 12. Overlapping Targeted Areas for Cropland, Livestock, Streambank and High Priority TMDLs.

Targeted Areas	Cropland Sediment	Livestock Nutrients	Streambank	High Priority TMDLs
Mud Creek	X	X		X
Clear Creek	X			
Cottonwood River	X		X	
South Cottonwood River	X	X		
Doyle Creek		X		X
Lightning Creek	X			
Lower End of Cottonwood River	X			

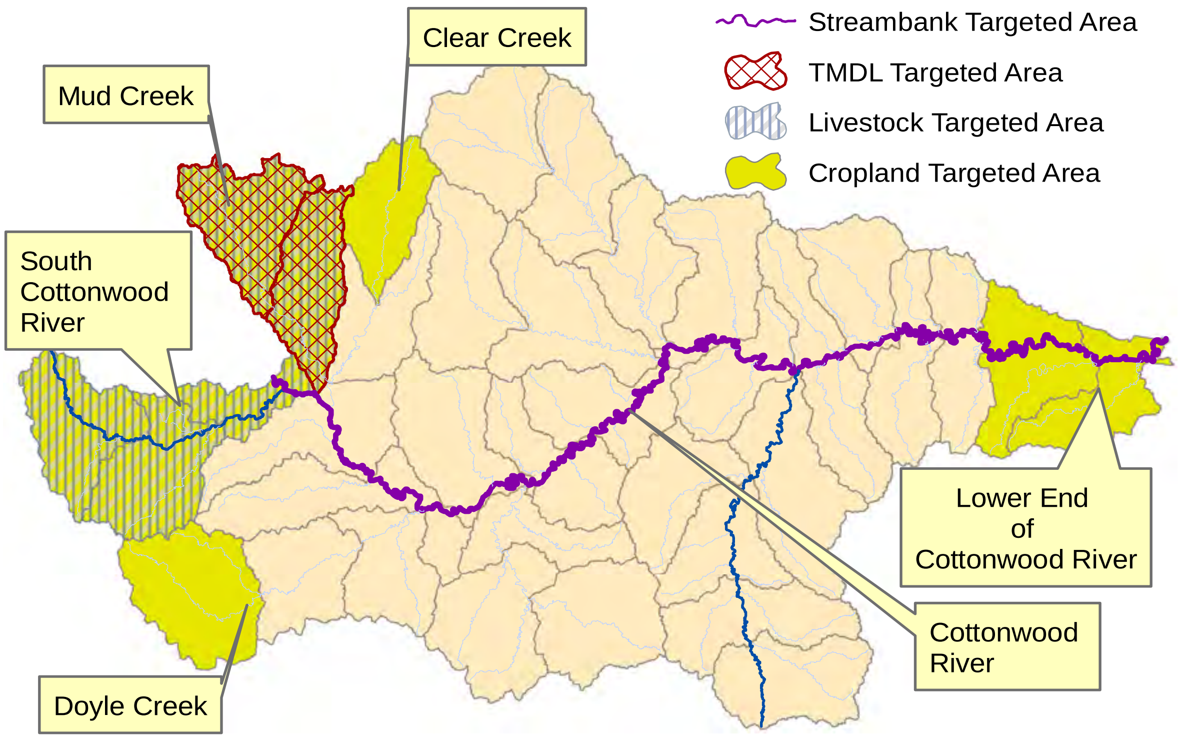


Figure 16. Targeted Areas for High Priority TMDLs, Livestock, Cropland and Streambanks.

5.2.1 Cropland Targeted Areas

The Cropland Targeted Area of this project was determined by the Soil and Water Assessment Tool (SWAT) as having the potential to runoff sediment (overland origin), and nutrients and is to be used for the determination of BMP placement.

SWAT was used as an assessment tool by Kansas State University Department of Biological and Agricultural Engineering to estimate annual average pollutant loadings such as nutrients and sediment coming from the land into the stream.

At the end of simulation runs the average annual loads are calculated for each sub watershed. Some areas have higher average annual loads than the others. Based on experience and technical knowledge, the areas or sub watershed with the top 20 to 30 percent of the highest loads among all areas within the watershed are selected as 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 Cottonwood Watershed 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. It is noted that the darker or brighter the color on the map, the higher the pollutant load potential. The watersheds in the western end of the watershed show the greatest potential for erosion, phosphorus and nitrogen runoff. The Cropland Targeted Area was determined as a composite of sediment, nitrogen and phosphorus. As stated earlier, this model accounts for land use, soil type, slope, and current conservation practices.

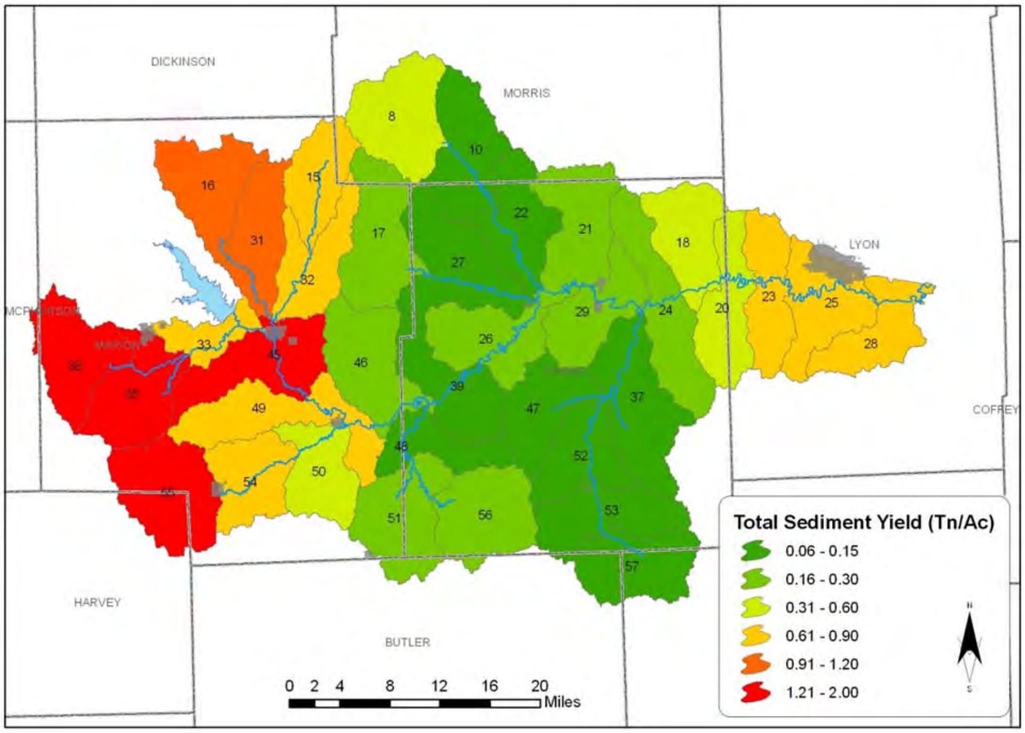


Figure 17. Total Sediment Load, tons/acre as Determined by SWAT.

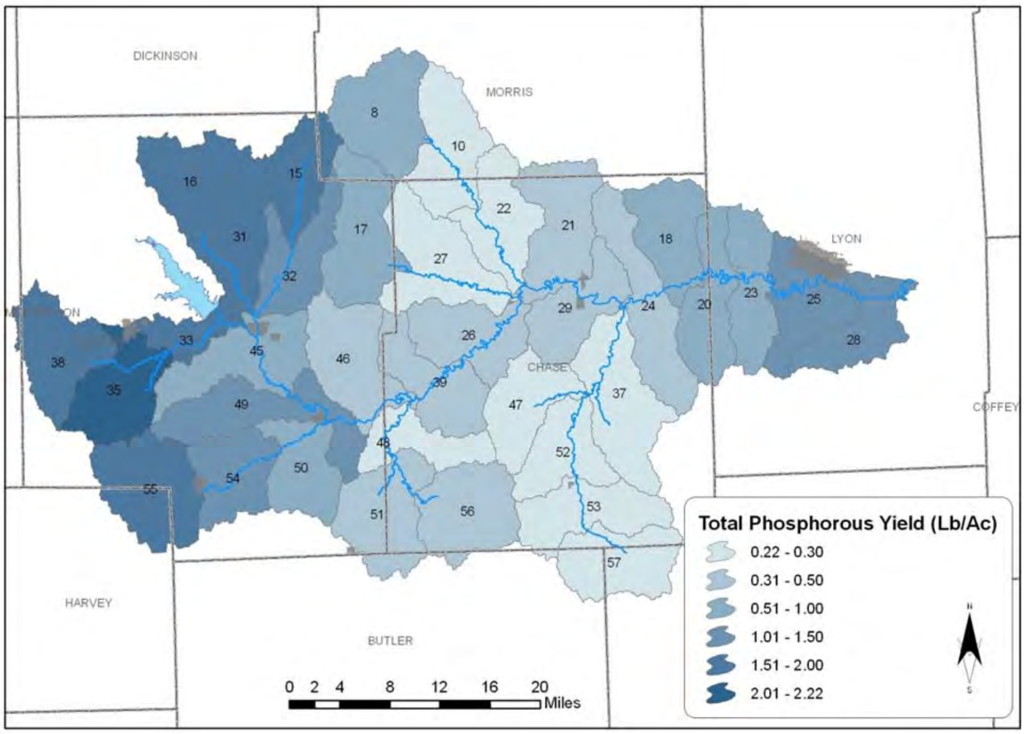


Figure 18. Total Phosphorus Load, pounds/acre as Determined by SWAT.

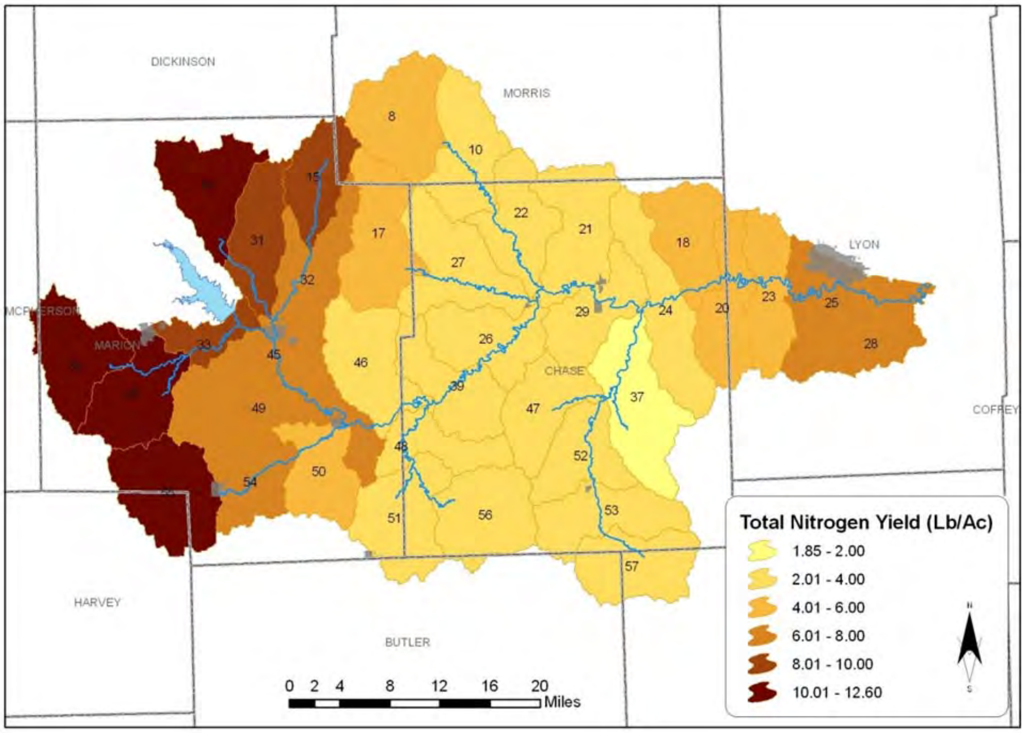


Figure 19. Total Nitrogen Load, pounds/acre as Determined by SWAT.

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. Below is a map of the areas that were groundtruthed in the watershed.

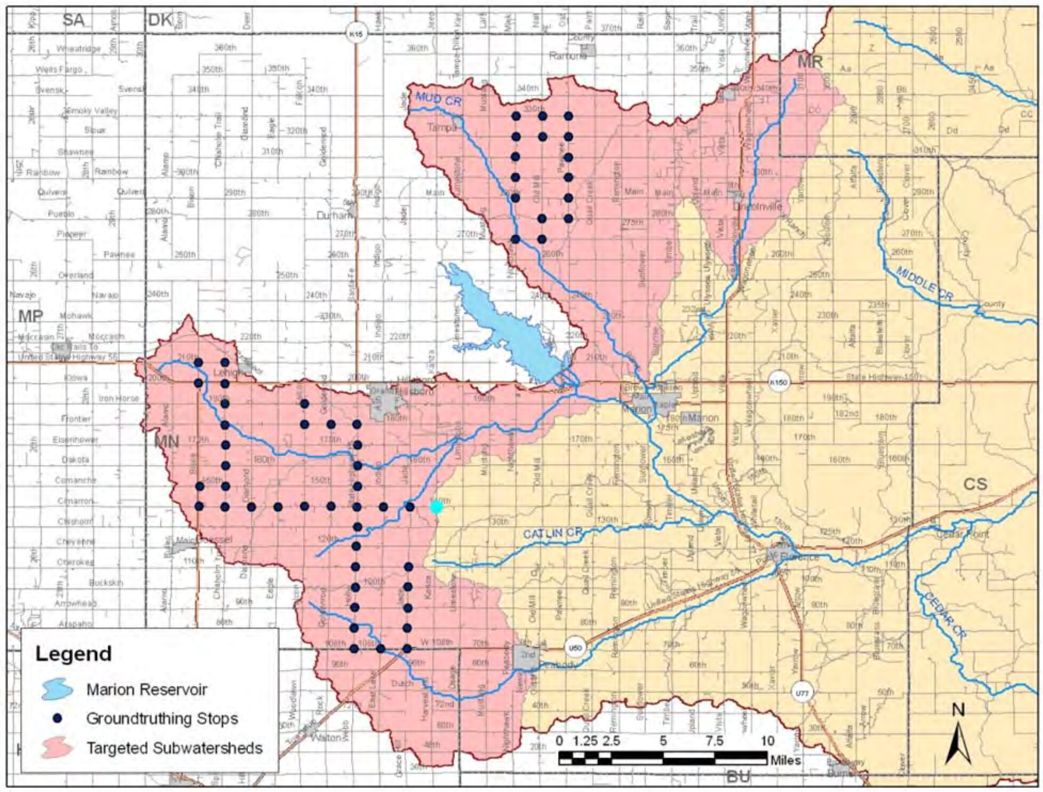


Figure 20. Groundtruthing Areas in the Watershed.

In 2009, the groundtruthing was conducted in two counties of the targeted area: Marion and Lyon. Current adoption rates are provided below for five BMPs in Marion County and four BMPs in Lyon County.

Marion County

- Conservation Crop Rotation – current adoption rate not able to determine
- Grassed waterways – current adoption rate of 38 percent
- No-till cultivation – current adoption rate of 29 percent
- Vegetative buffer strips – current adoption rate of 0 percent
- Grassed terraces – current adoption rate of 25 percent
- Permanent vegetation – current adoption rate of 9 percent

Lyon County

- Conservation Crop Rotation – current adoption rate not able to determine
- No-till cultivation – current adoption rate of 8 percent
- Vegetative buffer strips – current adoption rate of 0 percent
- Permanent vegetation – current adoption rate of 0 percent

The SWAT model was revised using the groundtruthing information. This allows the SWAT model to develop a more accurate determination of appropriate targeted areas. The SWAT model then determined number of acres needed to be implemented for each BMP to meet load reductions. Based on SLT opinion of landowner and producer acceptability, the BMPs that will be implemented for this watershed are:

- Conservation crop rotation
- Grassed waterways
- No-till
- Vegetative buffers
- Terraces
- Establish permanent vegetation

The SWAT model has delineated the targeted area into subbasins. (HUCs will be labeled with the last three digits of the HUC number.) The HUC 12s that are included in these subbasins are:

- 110702020106
- 110702020107
- 110702020108
- 110702020201
- 110702020202
- 110702020204
- 110702020301
- 110702030405
- 110702030406

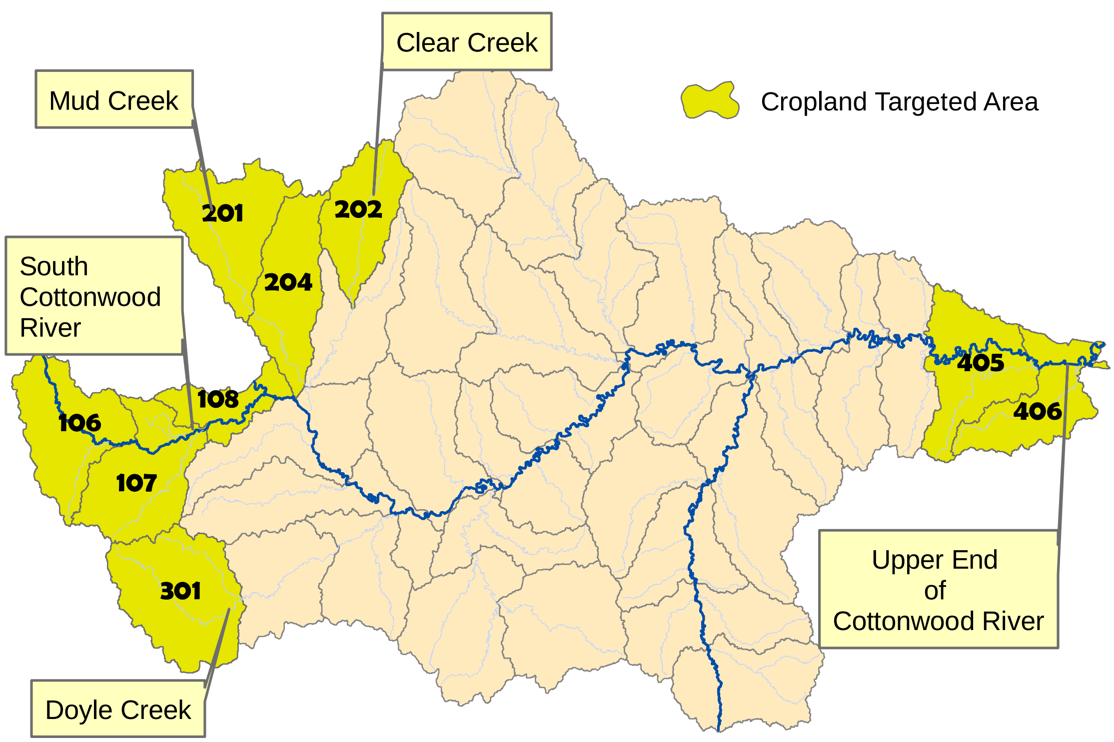


Figure 21. Cropland Targeted Area.

Table 13. Land Use by Subbasin for Cropland Targeted Area as Determined by SWAT.

Land Use Breakdown (acres)						
Sub- basin	Pasture or Hay	Percent Pasture or Hay	Cultivated	Percent Cultivated	Percent Other Land Uses	Total Acres in Subbasin
106	14,044	60.3	5,518	23.7	16.0	23,273
107	15,005	47.1	12,563	39.4	13.5	31883
108	4,403	32.2	7,091	51.9	15.9	13,665
201	13,706	44.3	14,377	46.5	9.2	30,918
202	19,115	58.3	9,972	30.4	11.3	32,767
204	11,289	66.7	3,583	21.2	12.1	16,934
301	9,492	28.4	20,688	61.9	9.7	33,423
405	14,447	46.6	7,730	25.0	28.4	30,974
406	14,154	56.7	7,457	29.9	13.4	24,942
Total	136,455	57.1	69,104	28.9	14.0	238,779

5.2.2 Livestock Targeted Area

Mud Creek has a high priority TMDL for FCB. For this reason it is in the targeted area for livestock. The livestock targeted areas were determined by examining monitoring site information for elevated nutrient concentrations along with SLT input and were approved by the SLT. A presentation of common livestock BMPs to reduce phosphorous and bacteria runoff from livestock facilities was given to the SLT. Livestock producers within these areas as well as local agency personnel familiar with these areas then discussed which BMPs were needed in the area. The top five livestock BMPs were selected by need, cost-effectiveness, and producer acceptability. Adoption rate goals were set for the next 40 years based on their overall need and what can be feasibly adopted.

Based on SLT opinion of landowner and producer acceptability, the cropland BMPs that will be implemented for this watershed are:

- Establish vegetative filter strips,
- Fence off streams,
- Move pasture feeding sites,
- Install off stream watering systems, and
- Implement rotational grazing systems.

The Livestock Targeted Area is seen in the following map and includes the HUC 12s (HUCs will be labeled with the last three digits of the HUC number.):

- 110702020106
- 110702020107
- 110702020108
- 110702020201

- 110702020204

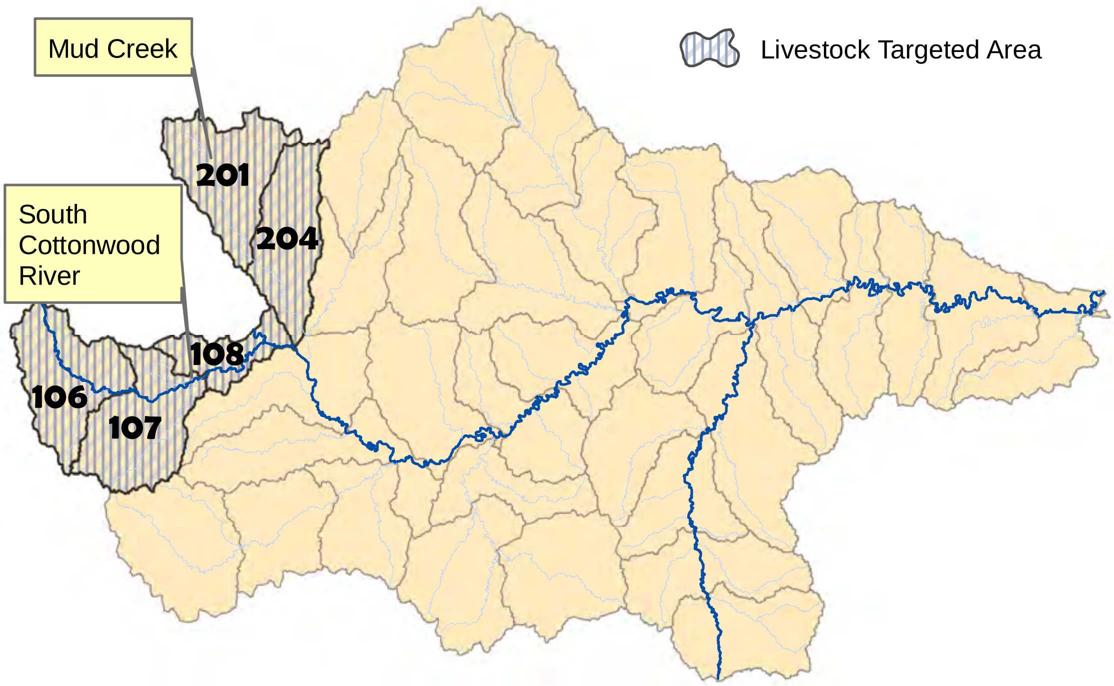


Figure 22. Livestock Targeted Area.

Table 14. Land Use by Subbasin for Livestock Targeted Area as Determined by SWAT.

Landuse Breakdown (acres)						
Subbasin	**Pasture or Hay**	**Percent Pasture or Hay**	**Cultivated**	**Percent Cultivated**	**Percent Other Land Uses**	**Total**
201	13,706	44.3	14,377	46.5	9.2	30,918
204	11,289	66.7	3,583	21.2	12.1	16,934
106	14,044	60.3	5,518	23.7	16.0	23,273
107	15,005	47.1	12,563	39.4	13.5	31883
108	4,403	32.2	7,091	51.9	15.9	13,665
Total	58,447	50.1	43,132	37.0	12.9	116,673

5.2.3 Streambank Targeted Area

A study funded by the Kansas Water Office has been completed to determine the reaches of the Cottonwood River that need riparian and streambank stabilization. This assessment along the main channel of the Cottonwood River determined the targeted area for streambank restoration. Unless a future need arises, there should be no need for another streambank assessment.

The Cottonwood River was divided into ten "reach" areas each containing numerous sites of degradable streambanks. The following map shows the location of each Reach Area. Cottonwood River segments are labeled as C1 through C10. Reach numbers N1 through N9 are targeted areas that lie along the Neosho River and have been addressed in the Neosho Headwaters WRAPS project.

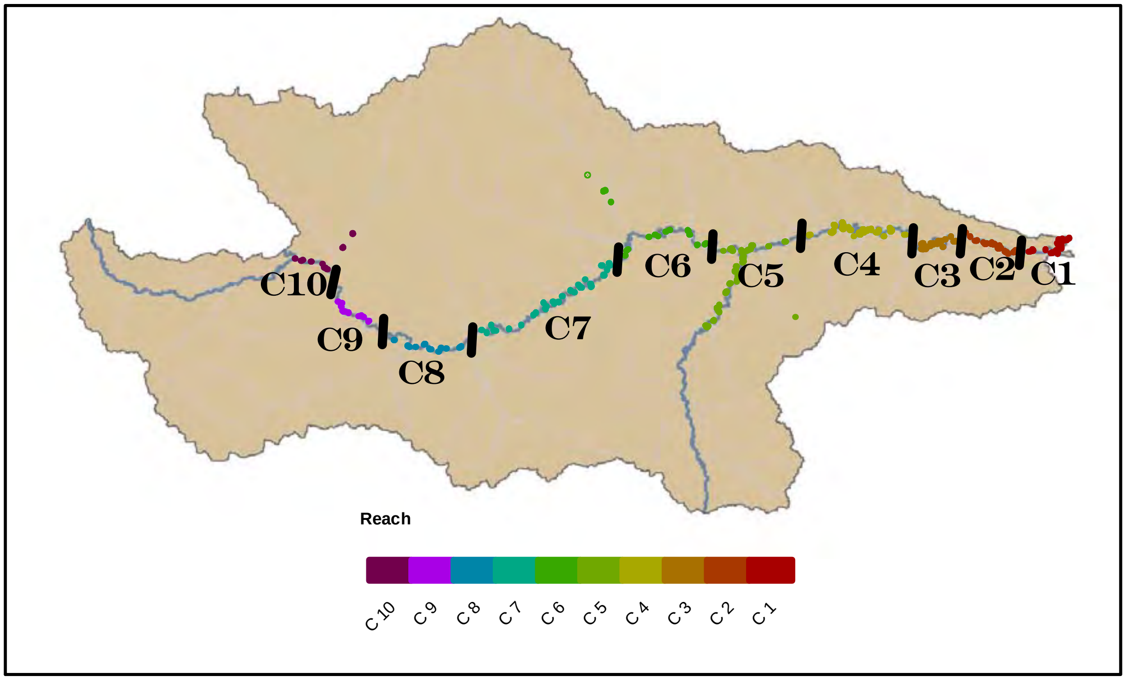


Figure 23. Targeted Areas for Streambank Stabilization along the Cottonwood River (C1 through C10).

It has been decided that the restoration projects will begin with Reach C1 and all streambank projects will be completed in this Reach Area before new projects are begun in the subsequent Reach Areas.

Table 15. Summary of Cottonwood River Streambank Hotspots.

Reach	Number of Sites	Total Erosion (tons/year)	Total Length (feet/year)	Tons Sediment /Foot/Year
C1	18	26,541	9,402	2.82
C2	16	31,977	12,311	2.60
C3	22	13,918	8,014	1.74
C4	27	26,341	13,468	1.96
C5	10	7,095	4,916	1.44
C6	12	5,064	3,302	1.53
C7	32	17,652	10,503	1.68
C8	14	10,303	5,179	1.99
C9	11	11,591	4,253	2.73
C10	7	4,948	2,335	2.12

Cottonwood River Hotspots, cont.				
Reach	Number of Sites	Total Erosion (tons/year)	Total Length (feet/year)	Tons Sediment /Foot/Year
Total	169	155,429	73,683	

5.2.4 High Priority TMDL Targeted Area

The High Priority TMDL Targeted Area is driven from a high priority TMDL in the watershed. Mud Creek has a high priority TMDL for FCB. FCB will be discussed later in this report.

The BMPs that will be implemented for the High Priority Targeted Area are contained in the Livestock Targeted Area BMPs. This is due to geographic overlap of the two targeted areas.

The high priority TMDL area is delineated into two subbasins. (HUCs will be labeled with the last three digits of the HUC number.) The HUC 12s that are included in these subbasins are:

- 110702020201
- 110702020204

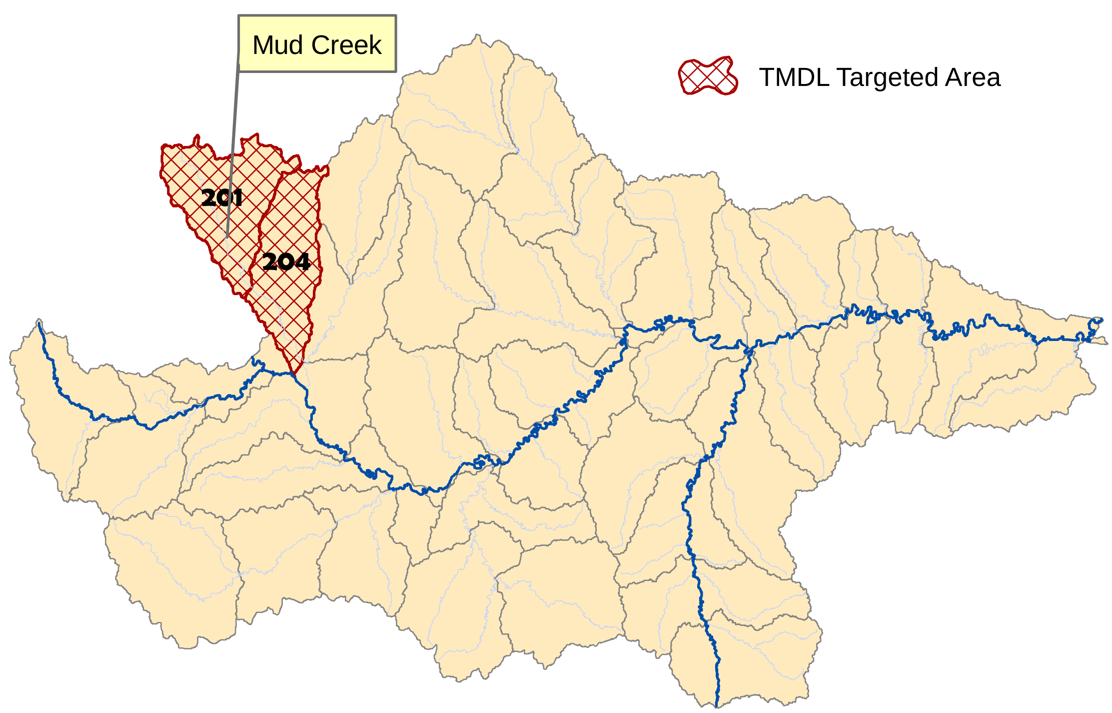


Figure 24. TMDL Targeted Area.

Table 16. Land Use for High Priority TMDL Targeted Area as Determined by SWAT.

Landuse Breakdown (acres)						
Subbasin	Pasture or Hay	Percent Pasture or Hay	Cultivated	Percent Cultivated	Percent Other Land Uses	Total
201	13,706	44.3	14,377	46.5	9.2	30,918
204	11,289	66.7	3,583	21.2	12.1	16,934
Total	24,995		17,960			47,852

5.3 Load Reduction Estimate Methodology

5.3.1 Cropland

Baseline loadings (natural runoff rates) 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. [29] Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies.

5.3.2 Livestock

Baseline nutrient loadings (natural runoff rates) per animal unit are calculated using the Livestock Waste Facilities Handbook.[30] Livestock management practice load reduction efficiencies are derived from numerous sources including K-State Research and Extension Publication MF-2737 and MF-2454.[31] Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies.

5.3.3 Streambank

A 2009 study of thirteen Neosho River restoration sites conducted by the KSU Agricultural Economists calculated the cost of stabilizing these sites at $710,011.38 or an average of $41.66 per linear foot, including all engineering and design costs. All load reductions and costs assume a properly engineered streambank restoration with the addition of a 66 foot riparian buffer.

NOTE: The SLT of the Cottonwood 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. **Nutrients and *E. coli* bacteria**
    a. **Livestock (nutrients and *E. coli* bacteria),**
    b. **Cropland (nutrients and *E. coli* bacteria), and**
    c. **High Priority TMDL (*E. coli* bacteria)**

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.

6.0 Impairments Addressed by the SLT

6.1 Sediment

There are no TMDLs for sediment in the Cottonwood Watershed. However, John Redmond Reservoir has a TMDL for **siltation (sedimentation)**. Since the Cottonwood Watershed is one of three watersheds eventually draining into John Redmond Reservoir, KDHE has used a reduction goal for the reservoir and divided responsibility for meeting the reduction goal between the three watersheds. It was determined that the Cottonwood Watershed would take responsibility for eighty percent of the reduction goal. Even though there is no sediment TMDL, there is a listing on the 303d list for TSS on the Cottonwood River near Plymouth. It is hoped that intervening BMPs that will be incorporated in the watershed will prevent the need of developing a TMDL at this location.

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.

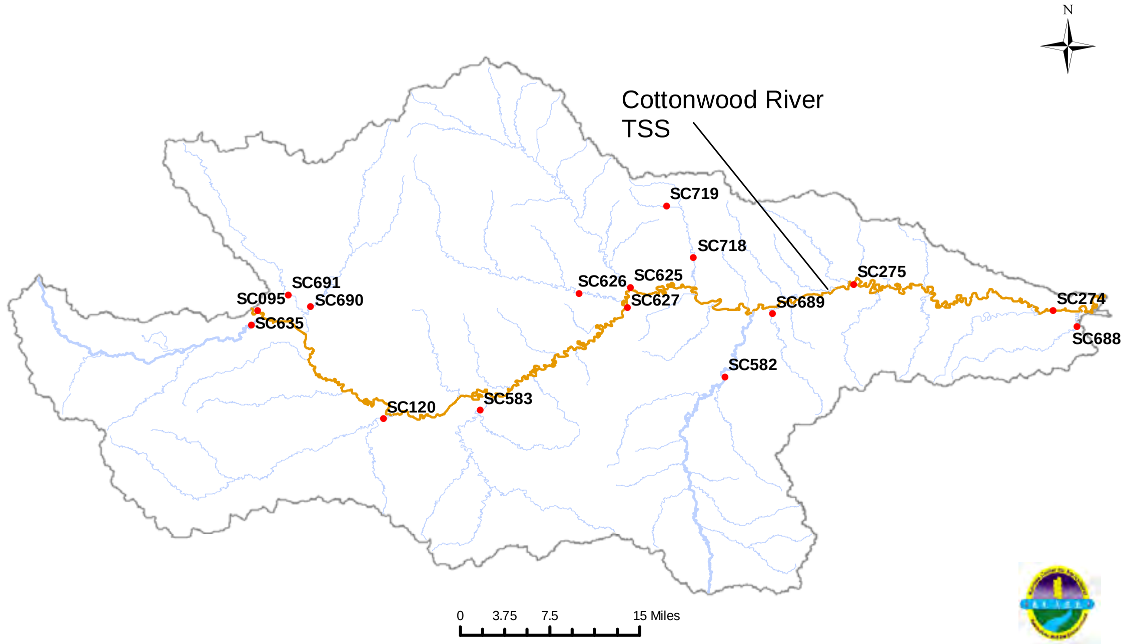


Figure 25. 303d Listing for Siltation in the Cottonwood Watershed. [20] Orange color indicates low priority at SC275.

Physical components of the terrain are important in sediment movement, such as:

- Slope of the land, propensity to generate runoff and soil type
- 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.
- Animal movement, such as livestock that regularly cross the stream or follow trails in pastures, can cause pathways that will erode.
- Silt that is present in the stream from past activities and is gradually moving downstream with each high intensity rainfall event.

Activities performed on the land affects sediment that is transported downstream to the lakes. Agricultural BMPs that will help reduce sediment deposition in waterways are (in no particular order, many other BMPs exist):

- No-till
- Minimum tillage
- Vegetative buffers and riparian areas
- Grassed waterways
- Grassed terraces
- Wetland creation
- Establishing permanent vegetative cover

- Farming on the contour
- Conservation crop rotation

Agricultural BMPs that have been selected by the SLT based on acceptability by the landowners, cost effectiveness and pollutant load reduction effectiveness are:

- Conservation Crop Rotation
- Grassed Waterways
- No-Till
- Vegetative Buffers
- Terraces
- Permanent vegetation to replace crops

This section will review several potential sources or environmental actions that have the potential of increasing sediment in the waters. They are (in no particular order of importance):

Cropland Erosion

- Land use
- T-factor or soil loss
- Hydrologic soil groups

Streambank Degradation

- Riparian quality
- Precipitation distribution

6.1.1 Cropland Erosion

Cropland BMPs have been assigned by the SLT. The targeted areas for cropland are located in the extreme western portion of the watershed and the extreme eastern portion of the watershed. Causes of erosion are discussed in more detail in the rest of this section.

6.1.1.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 (26%), woodlands (3%), and all other (3%). According to SWAT calculations, the primary land uses in the cropland targeted area of the watershed are grassland (57%), cropland (29%) and all other (14%). Table 13, page 48 provides the breakout acreages.

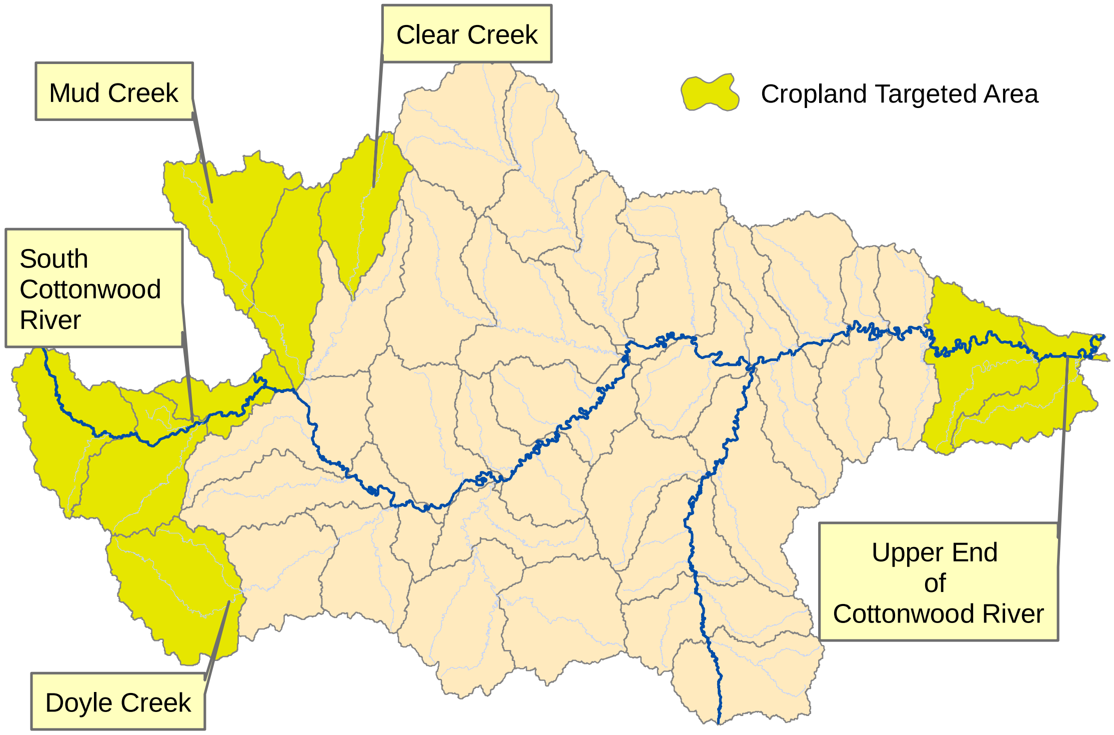


Figure 26. Targeted Area for Cropland as Determined by SWAT.

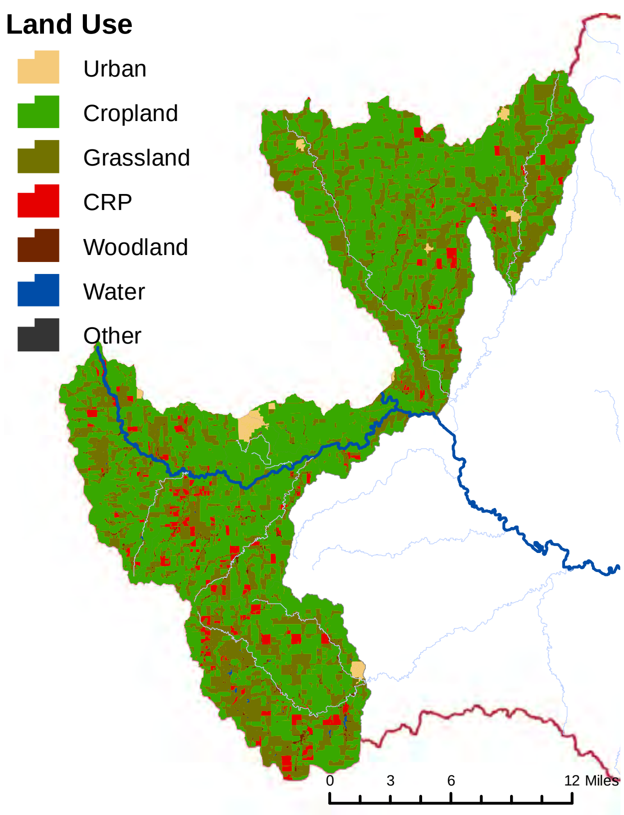


Figure 27. Land Cover in the Western Portion of the Cropland Targeted Area. [4]

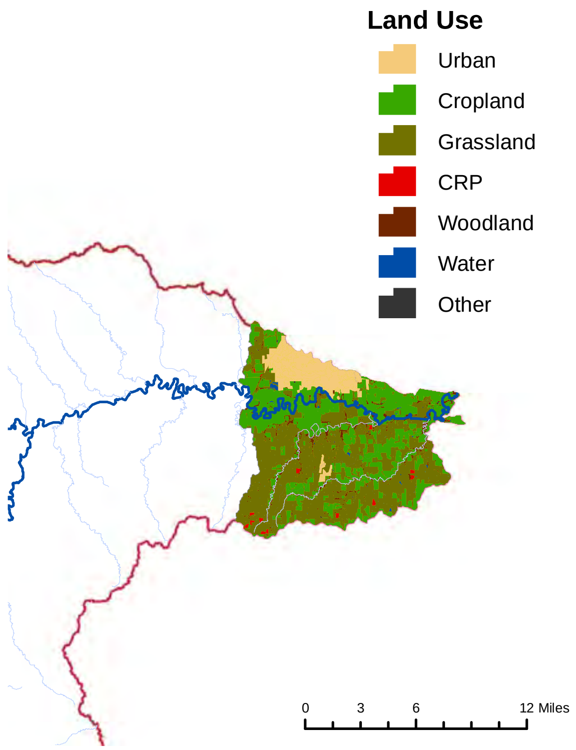


Figure 28. Land Cover of the Eastern Portion of the Cropland Targeted Area. [4]

6.1.1.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. [32]

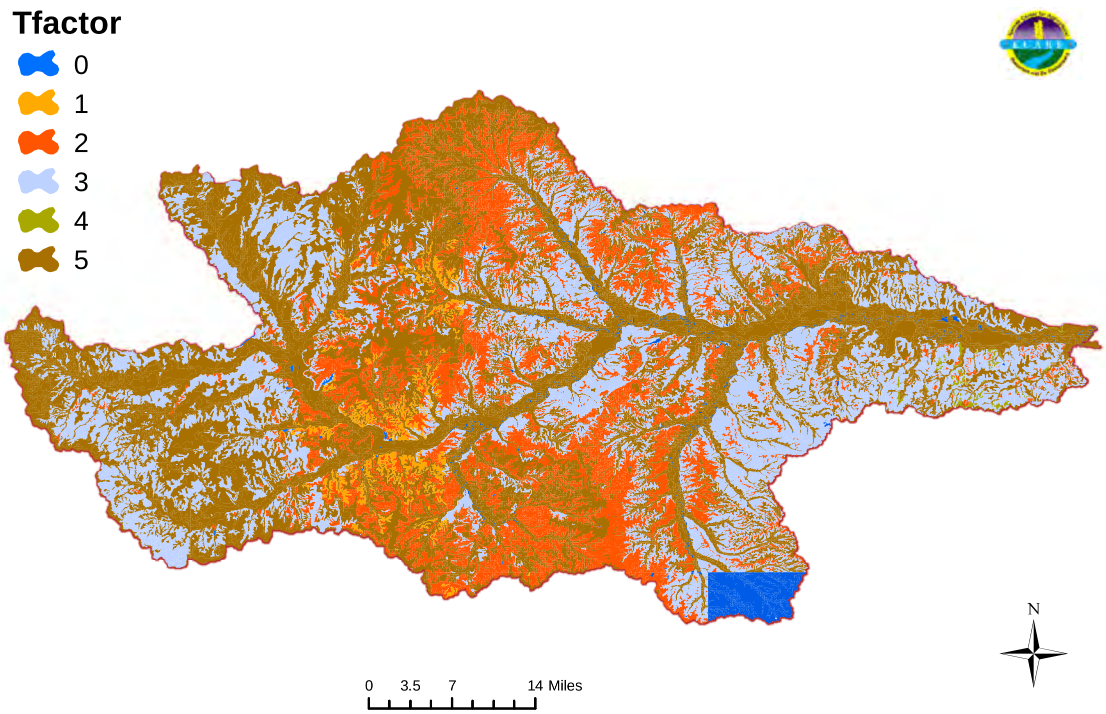


Figure 29. T Factor in the Watershed, tons/acre. [33]

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 17. T Factor in the Watershed, tons/acre. [33]

T Factor	Acres	Percent of Watershed
0	20,804	1.8
1	16,871	1.5
2	219,872	19.4
3	308,705	27.3
4	2,256	0.2
5	564,272	49.8

6.1.1.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.

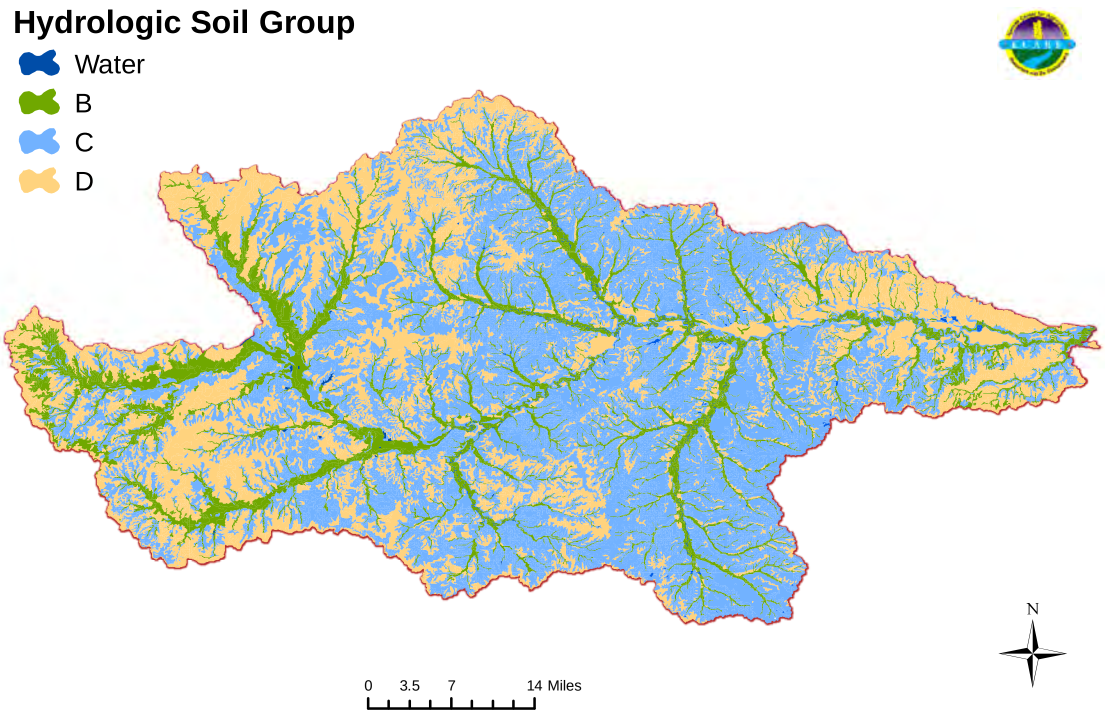


Figure 30. Hydrologic Soil Groups of the Watershed. [33]

Almost half of the watershed (51 percent) is characterized as soil group C. Thirty three 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 18. Hydrologic Soil Groups of the Watershed. [33]

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
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.	161,545	14.3
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.	586,573	51.8

HSG of the Watershed, cont.			
Hydrologic Soil Group	**Definition**	**Acres of Watershed in HSG**	**Percentage of Watershed in HSG**
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.	377,991	33.4
Other	Water, dams, pits, sewage lagoons	6,675	0.6

6.1.2 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.

6.1.2.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 targeted the Cottonwood River for streambank stabilization projects. According to the USDA/NRCS GIS mapping data, approximately fifty three percent of the 100 foot buffer area along the river is at least 51 percent forested. Forty-one percent is considered to be barren. Four percent is cropland and two percent is pasture and urban areas.

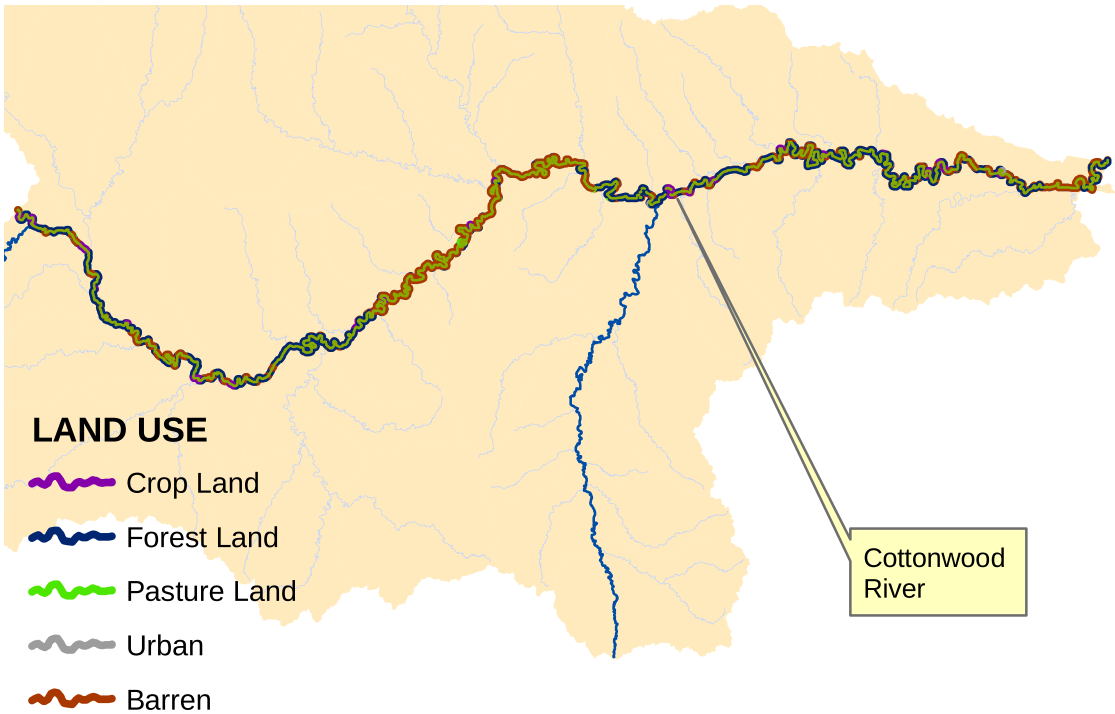


Figure 31. Land Use Within a 100 Ft. Buffer Along the Streambank Targeted Area. [34]

6.1.2.B Rainfall and Runoff

Rainfall amounts and subsequent runoff can affect sediment delivery from agricultural areas and urban areas into streams and the Cottonwood River. High water flows in the River will cause swirling and under cutting of the river banks with subsequent sloughing. Sloughing of stream and river banks is a major contributor of sediment downstream.

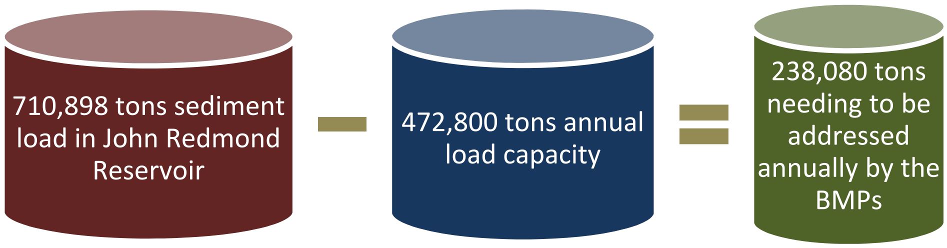
In cropland, high rainfall events can cause sheet and rill erosion. High intensity rainfall events (rainfall rates that overwhelm soil adsorptive capacity) usually occur in late spring and early summer. Extended duration of rainfall events that causes soil saturation and subsequent runoff also usually 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.

See Figures 5 and 6.

6.1.3 Sediment BMPs with Acres or Projects Needed

The current estimated sediment load from nonpoint sources entering John Redmond Reservoir is 297,600 tons per year according to the TMDL section of KDHE. **The total annual load reduction allocated to Cottonwood Watershed**

needed to meet the 89 percent sediment TMDL for John Redmond Reservoir is 238,080 tons. This is the amount of sediment that needs to be removed from the watershed and is the target of the BMP installations that will be placed in the watershed. These BMPs have been determined as feasible and approved by the SLT.



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. An added bonus is that the cropland and streambank BMPs aimed at sediment reduction will also have a positive effect on nutrient/phosphorus runoff (will be discussed in the next section). 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 19. BMPs and Acres or Projects Needed to Reduce Sediment Contribution in John Redmond Reservoir by 238,080 tons and Address the Sediment Listing on the 303d List on the Cottonwood River.

Protection Measures	Best Management Practices and Other Actions	Total Acres or Projects Needed to be Implemented Over a Forty Year Period
1.0 Prevention of sediment (TSS) contribution from **cropland**	1.1 Conservation Crop Rotations	12,111 acres
	1.2 Grassed Waterways	42,303 acres
	1.3 No-Till	57,486 acres
	1.4 Vegetative Buffers	45,364 acres
	1.5 Terraces	10,576 acres
	1.6 Establish Permanent Vegetation	12,111 acres
2. Prevention of sediment (TSS) contribution from **streambank** erosion	Streambank Restoration	Repair 73,683 feet of eroding streambank

6.1.4 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 20. Estimated Sediment Load Reductions for Implemented BMPs on Cropland Aimed at Reducing Sediment Contribution in John Redmond Reservoir by 238,080 tons and Addressing the Cottonwood River Sediment Listing on the 303d List.

Annual Soil Erosion Reduction (tons), Cropland BMPs							
Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	175	515	1,576	700	193	666	3,825
2	350	1,029	3,153	1,401	386	1,331	7,650
3	525	1,544	4,729	2,101	579	1,997	11,475
4	701	2,059	6,305	2,801	772	2,662	15,300
5	876	2,573	7,881	3,502	965	3,328	19,125
6	1,051	3,088	9,458	4,202	1,158	3,993	22,949
7	1,226	3,602	11,034	4,903	1,351	4,659	26,774
8	1,401	4,117	12,610	5,603	1,544	5,324	30,599
9	1,576	4,632	14,187	6,303	1,737	5,990	34,424
10	1,751	5,146	15,763	7,004	1,930	6,655	38,249
11	1,926	5,661	17,339	7,704	2,123	7,321	42,074
12	2,102	6,176	18,915	8,404	2,316	7,986	45,899
13	2,277	6,690	20,492	9,105	2,509	8,652	49,724
14	2,452	7,205	22,068	9,805	2,702	9,317	53,549
15	2,627	7,720	23,644	10,505	2,895	9,983	57,374
16	2,802	8,234	25,220	11,206	3,088	10,648	61,199
17	2,977	8,749	26,797	11,906	3,281	11,314	65,024
18	3,152	9,263	28,373	12,606	3,474	11,979	68,848
19	3,328	9,778	29,949	13,307	3,667	12,645	72,673
20	3,503	10,293	31,526	14,007	3,860	13,310	76,498
21	3,503	10,807	32,490	14,651	3,860	13,310	78,621
22	3,503	11,322	33,455	15,294	3,860	13,310	80,744
23	3,503	11,837	34,420	15,937	3,860	13,310	82,867
24	3,503	12,351	35,385	16,580	3,860	13,310	84,990
25	3,503	12,866	36,350	17,224	3,860	13,310	87,113
26	3,503	13,380	37,315	17,867	3,860	13,310	89,235
27	3,503	13,895	38,280	18,510	3,860	13,310	91,358
28	3,503	14,410	39,245	19,154	3,860	13,310	93,481
29	3,503	14,924	40,210	19,797	3,860	13,310	95,604
30	3,503	15,439	41,175	20,440	3,860	13,310	97,727
31	3,503	15,954	42,140	21,083	3,860	13,310	99,850
32	3,503	16,468	43,105	21,727	3,860	13,310	101,973
33	3,503	16,983	44,070	22,370	3,860	13,310	104,096
34	3,503	17,498	45,035	23,013	3,860	13,310	106,218
35	3,503	18,012	46,000	23,657	3,860	13,310	108,341

Annual Soil Erosion Reduction (tons), Cropland BMPs, cont.							
Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
36	3,503	18,527	46,965	24,300	3,860	13,310	110,464
37	3,503	19,041	47,930	24,943	3,860	13,310	112,587
38	3,503	19,556	48,894	25,586	3,860	13,310	114,710
39	3,503	20,071	49,859	26,230	3,860	13,310	116,833
40	3,503	20,585	50,824	26,873	3,860	13,310	118,956

The table below demonstrates the streambank load reductions attained by implementing streambank restoration projects.

Table 21. Estimated Sediment Load Reductions for Implemented Streambanks Restoration Projects Aimed at Reducing Sediment Contribution in John Redmond Reservoir by 238,080 tons and Addressing the Cottonwood River Sediment Listing on the 303d List.

Annual Erosion Reduction (tons), Streambank BMPs			
Year	Streambank Stabilization (feet)	Soil Load Reduction (tons)	Cumulative Erosion Reduction (tons)
1	1,842	3,887	3,887
2	1,842	3,887	7,774
3	1,842	3,887	11,660
4	1,842	3,887	15,547
5	1,842	3,887	19,434
6	1,842	3,887	23,321
7	1,842	3,887	27,207
8	1,842	3,887	31,094
9	1,842	3,887	34,981
10	1,842	3,887	38,868
11	1,842	3,887	42,755
12	1,842	3,887	46,641
13	1,842	3,887	50,528
14	1,842	3,887	54,415
15	1,842	3,887	58,302
16	1,842	3,887	62,188
17	1,842	3,887	66,075
18	1,842	3,887	69,962
19	1,842	3,887	73,849
20	1,842	3,887	77,736
21	1,842	3,887	81,622
22	1,842	3,887	85,509

Annual Erosion Reduction (tons), Streambank BMPs, cont.			
Year	Streambank Stabilization (feet)	Soil Load Reduction (tons)	Cumulative Erosion Reduction (tons)
23	1,842	3,887	89,396
24	1,842	3,887	93,283
25	1,842	3,887	97,169
26	1,842	3,887	101,056
27	1,842	3,887	104,943
28	1,842	3,887	108,830
29	1,842	3,887	112,717
30	1,842	3,887	116,603
31	1,842	3,887	120,490
32	1,842	3,887	124,377
33	1,842	3,887	128,264
34	1,842	3,887	132,150
35	1,842	3,887	136,037
36	1,842	3,887	139,924
37	1,842	3,887	143,811
38	1,842	3,887	147,698
39	1,842	3,887	151,584
40	1,842	3,887	155,471

The table below shows the combined load reduction for sediment that is attained by implementing all cropland BMPs and streambank restoration projects annually. The percent of TMDL achievement is illustrated in the right column. It will require thirty-four years to meet the sediment reduction goal in John Redmond Reservoir if all BMPs are implemented. The life of the WRAPS plan is forty years due to the objective of meeting the phosphorus reduction goal. After thirty-four years, the sediment portion of this plan will switch from being "restoration" to "protection" of the watershed.

Table 22. Combined Cropland and Streambank Load Reductions Aimed at Reducing Sediment Contribution in John Redmond Reservoir by 238,080 tons and Addressing the Cottonwood River Sediment Listing on the 303d List.

Combined Annual Erosion Reduction (tons)				
Year	Streambank Reduction (tons)	Cropland Reduction (tons)	Total Reduction (tons)	% of TMDL
1	3,887	3,825	7,712	**3%**
2	7,774	7,650	15,423	**6%**
3	11,660	11,475	23,135	**10%**
4	15,547	15,300	30,847	**13%**

Combined Annual Erosion Reduction (tons), cont.				
Year	Streambank Reduction (tons)	Cropland Reduction (tons)	Total Reduction (tons)	% of TMDL
5	19,434	19,125	38,558	**16%**
6	23,321	22,949	46,270	**19%**
7	27,207	26,774	53,982	**23%**
8	31,094	30,599	61,694	**26%**
9	34,981	34,424	69,405	**29%**
10	38,868	38,249	77,117	**32%**
11	42,755	42,074	84,829	**36%**
12	46,641	45,899	92,540	**39%**
13	50,528	49,724	100,252	**42%**
14	54,415	53,549	107,964	**45%**
15	58,302	57,374	115,675	**49%**
16	62,188	61,199	123,387	**52%**
17	66,075	65,024	131,099	**55%**
18	69,962	68,848	138,810	**58%**
19	73,849	72,673	146,522	**62%**
20	77,736	76,498	154,234	**65%**
21	81,622	78,621	160,243	**67%**
22	85,509	80,744	166,253	**70%**
23	89,396	82,867	172,263	**72%**
24	93,283	84,990	178,272	**75%**
25	97,169	87,113	184,282	**77%**
26	101,056	89,235	190,292	**80%**
27	104,943	91,358	196,301	**82%**
28	108,830	93,481	202,311	**85%**
29	112,717	95,604	208,321	**88%**
30	116,603	97,727	214,330	**90%**
31	120,490	99,850	220,340	**93%**
32	124,377	101,973	226, 350	**95%**
33	128,264	104,096	232,359	**98%**
34	132,150	106,218	238,369	**100%**
35	136,037	108,341	244,378	**103%**
36	139,924	110,464	250,388	**105%**
37	143,811	112,587	256,398	**108%**
38	147,698	114,710	262,407	**110%**
39	151,584	116,833	268,417	**113%**
40	155,471	118,956	274,427	**115%**
Sediment TMDL 238,080 Tons				

Sediment Reduction Goal is Met

Table 23. Sediment Load Reduction at the End of Forty Years by Category Aimed at Reducing Sediment Contribution in John Redmond Reservoir by 238,080 tons and Addressing the Cottonwood River Sediment Listing on the 303d List.

Best Management Practice Category	Total Load Reduction (tons)	% of Sediment TMDL
Cropland	118,956	50%
Streambank	155,471	65%
Total	**274,427**	**115%**
Sediment Goal 238,080 Tons		

Refer to Section 8, "Costs of BMP Implementation" for specific BMP costs in order to meet the TMDL.

6.2 Nutrients

6.2.1 Livestock Related Impairments

Livestock can cause certain pollutants in the water. *E. coli* bacteria are 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 bacteria loads. In addition, failing septic systems can be a source of E. coli bacteria from humans. However, for this WRAPS process, targeting will be for livestock. 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. Similarly, for this WRAPS process, targeting will be for agricultural practices.***

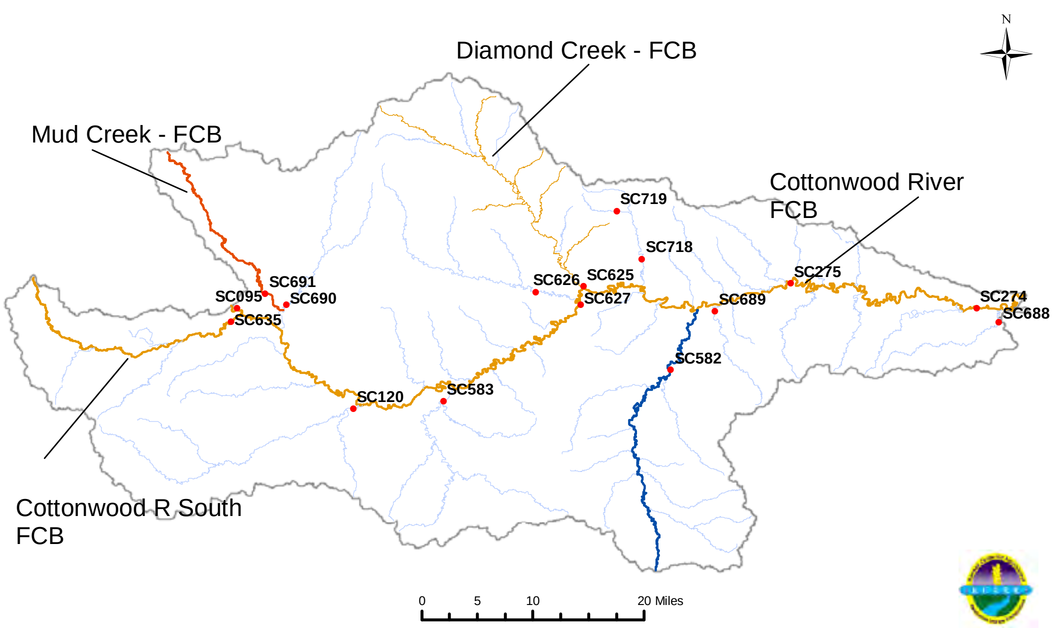


Figure 32. FCB Impairments in the Watershed.

As mentioned earlier in this report, targeting has been assigned for livestock related pollutants. It includes the Mud Creek watershed which is the only high priority FCB TMDL area in the watershed. The South Cottonwood River, the

Cottonwood River and Diamond Creek have medium priorities for FCB. The drainage areas of Mud Creek and the South Cottonwood River have been designated as targeted areas for BMP placement.

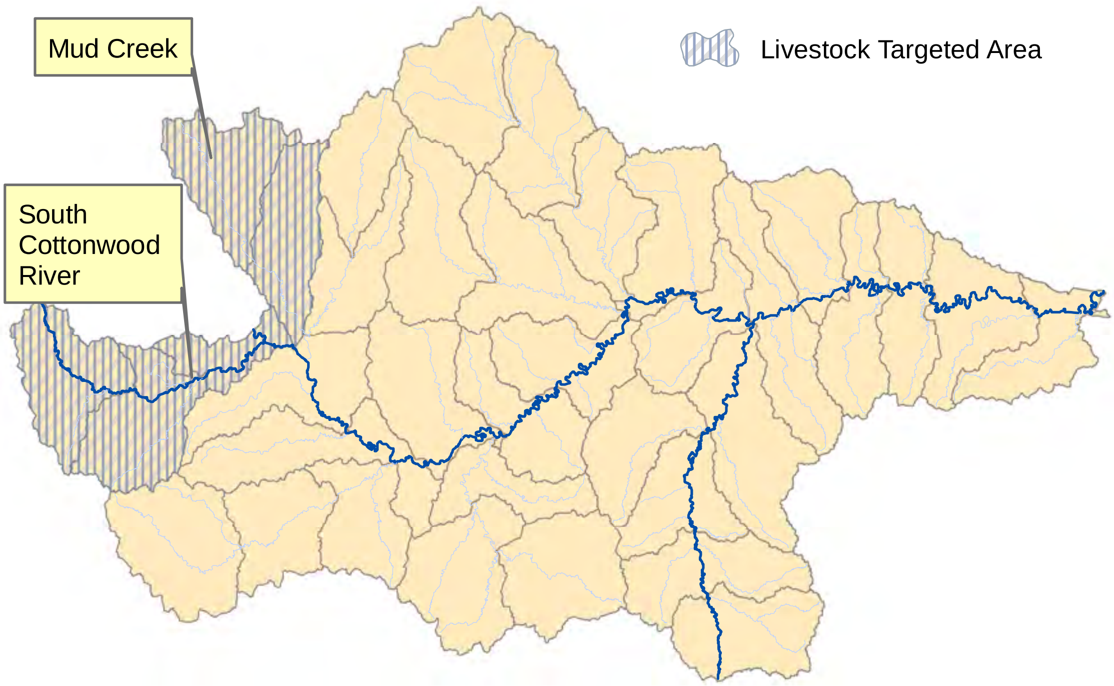


Figure 33. Targeted Areas for Livestock BMPs in the Watershed.

6.2.1.A.   Manure Runoff from Fields and Livestock Operations

Mud Creek is listed with a TMDL for **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 as an indicator of pathogen impairment and in determination of issuance of a TMDL. Currently, however, KDHE is transitioning to the use of *E. coli* bacteria as it is a more reliable indicator of human health risk. Consequently, the new methodology for assessing *E. coli* bacteria 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* bacteria 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 bacteria can originate in both rural and urban areas. It can be caused by both point and nonpoint sources.

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 *E. coli* bacteria 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 a key component in the WRAPS plan for addressing *E. coli* bacteria in Mud Creek and South Cottonwood River targeted areas.

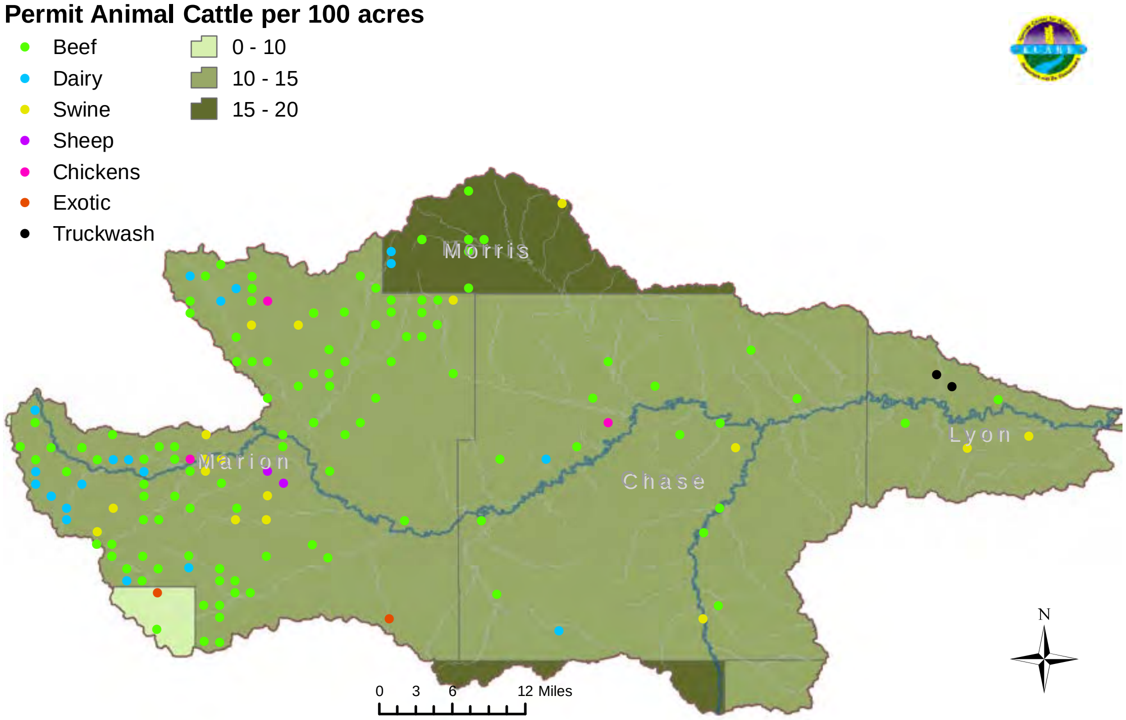


Figure 34. Confined Animal Feeding Operations and Grazing Density in the Watershed. [35]

6.2.1.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 *E. coli* bacteria in the waterways. The primary land uses in the livestock targeted area of the watershed are grassland (50%) and cropland (37%).

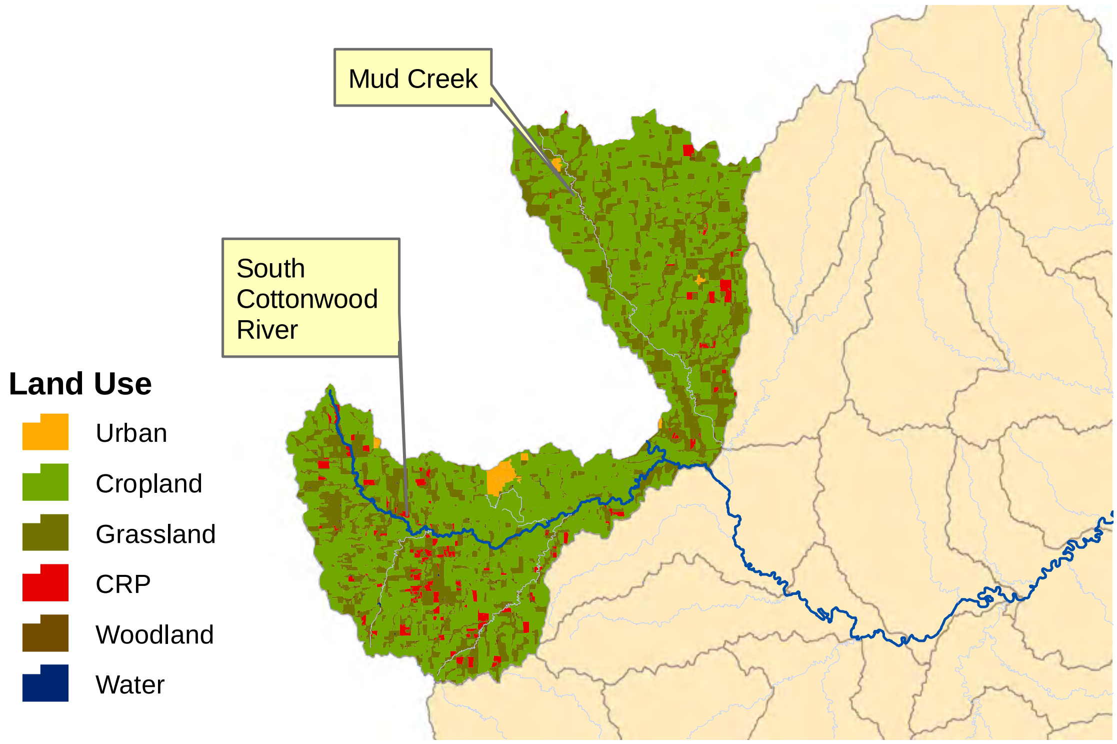


Figure 35. Land Cover of the Livestock Targeted Area of the Watershed. [36]

6.2.1.C Rainfall and Runoff

Rainfall amounts and subsequent runoff along with flooding outside the stream channel can affect *E. coli* bacteria concentrations in the streams and rivers. 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 *E. coli* bacteria or phosphorus runoff from the targeted area. Rainfall in this watershed occurs primarily in the late spring and early summer. This occurs when grass is short and runoff potential is greatest.

See Figures 5 and 6.

6.2.2 Cropland Related Nutrient Pollutants

Marion County Lake, Fox Creek, Palmer Creek and the South Fork of the Cottonwood River have TMDLs for nutrient related impairments. However, these waterbodies are not contained in the targeting areas. Listings on the 303d list that are included in one of the targeted areas are the South Cottonwood River and the Cottonwood River near Emporia. In order to be able to measure improvements in water quality, nutrients will be measured as phosphorus or Total Phosphorus (TP). Targeting for phosphorus will be the watersheds of the South Cottonwood River and the Cottonwood River near Emporia; however, reduction of manure and phosphorus in these areas will have a positive effect on water quality downstream in John Redmond Reservoir. John Redmond Reservoir has a TMDL for eutrophication.

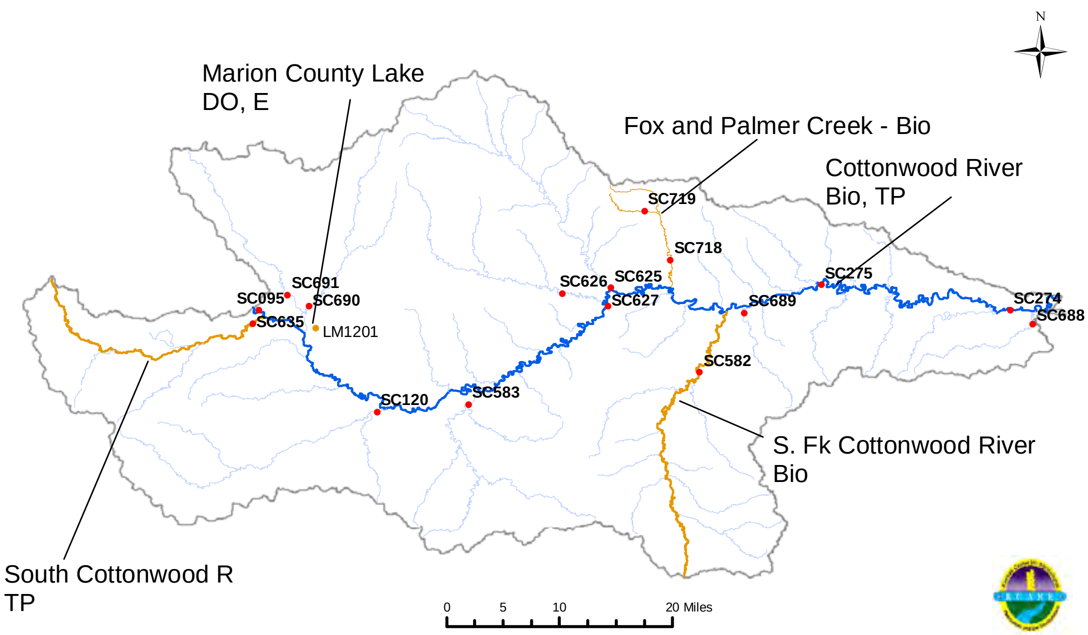


Figure 36. Nutrient Related TMDLs and 303d Listings in the Cottonwood Watershed. [37]

Eutrophication (E) 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. Marion County Lake has a TMDL for E. 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. Marion County Lake also has a TMDL for low dissolved oxygen (DO). Desirable criteria for a healthy water profile include DO 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. A TMDL for Biology (Bio) is another indicator of nutrient related impairments.

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.

6.2.2.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 Cottonwood Watershed consists of approximately twenty-six percent of the land use. Cropland in the watershed consists of mainly wheat, soybeans, corn and sorghum. CRP (Conservation Reserve Program) land is marginal farm ground that has been removed from production and planted to grass cover. The owner of the land receives a government payment as incentive for allowing the land to be removed from production. This is the best way to stop runoff of nutrients as well as sediment through erosion. CRP lands are scattered throughout the watershed and consist of one percent of the land use.

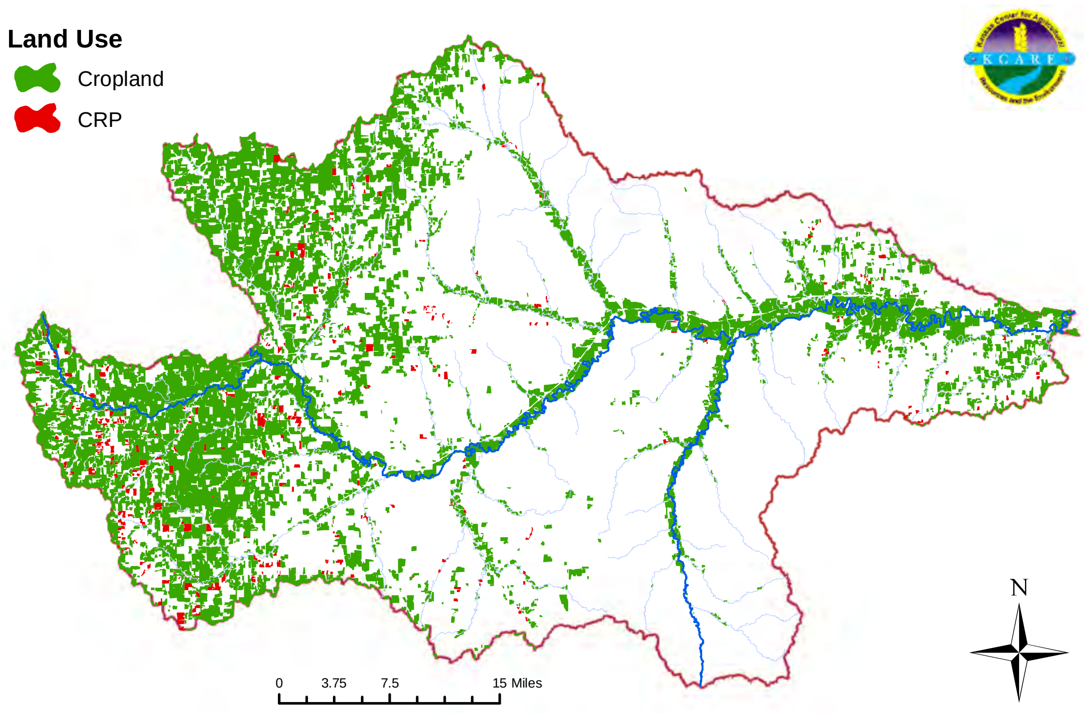


Figure 37. Cropland and CRP in the Watershed. [3]

Crops grown in the watershed will have an effect on nutrient runoff. Different crops have different nutrient requirements. The main crop grown in the watershed is wheat. Some farms apply nitrogen in the fall as anhydrous ammonia. This is usually dependent on whether the crop will be used for winter grazing of stocker calves. Nitrogen may also be applied in the spring. Wheat is a moderate user of nitrogen, as is sorghum. Corn, which is eleven percent of the crops in the watershed, is a heavy user of nitrogen fertilizer in order to support the large amount of biomass produced. Soybeans are a legume and as such, do not require nitrogen fertilizer. All farm ground should be soil tested for the proper amount of phosphorus available in the soil and phosphorus fertilizer should be applied only when needed. It should be applied at planting time and incorporated into the soil where it will attach to soil particles and prevent runoff.

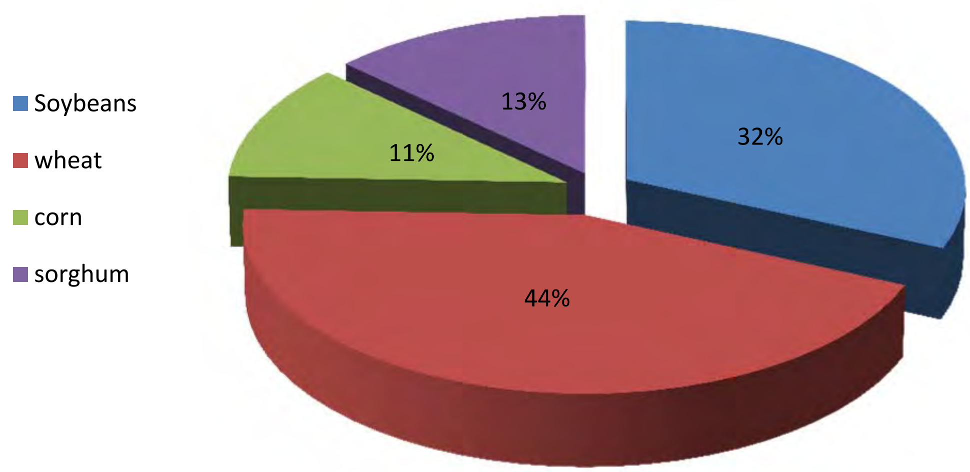


Figure 38. Farm Crops in the Watershed. [38]

6.2.2.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 6.3.1.A for additional information.

6.2.2.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 6.2.1.C for additional information.

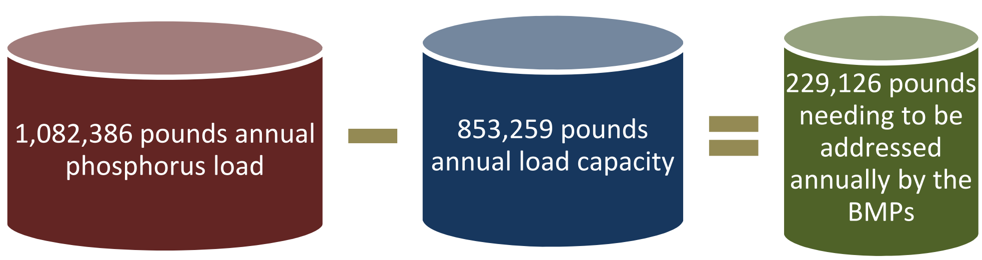
6.2.3 Streambank Related Phosphorus Pollutant

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 SLT of the Cottonwood Watershed would like to stabilize 1,842 feet of streambank per year along the Cottonwood River. 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 downstream. All livestock related BMPs that the SLT has agreed upon will be beneficial to soil loss and ultimately also help reduce phosphorus concentrations in John Redmond Reservoir.

6.2.4 Phosphorus BMPs with Projects Needed

The current estimated phosphorus load from nonpoint sources entering John Redmond Reservoir is 1,352,982 pounds per year according to the TMDL section of KDHE. This load originates from The Cottonwood Watershed allotment of the total load is eighty percent or 1,082,386 pounds. This has been determined by KDHE as a result of sampling data obtained in the watershed. After subtracting the annual load capacity, t**he total annual load reduction allocated to the Cottonwood Watershed needed to meet the 80 percent of phosphorus reduction goal for John Redmond Reservoir with implemented BMPs is 229,126 pounds of phosphorus**. This is the amount of phosphorus that needs to be removed from the watershed and is the target of the BMP installations that will be placed in the watershed. These BMPs have been determined as feasible and approved by the SLT.



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, livestock and streambank targeted areas. All these BMPs will simultaneously have a positive effect on reduction of *E. coli* bacteria and sediment impairments.** 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 24. BMPs and Number of Projects to be Installed as Determined by the SLT Aimed at Meeting the 229,126 Pound Phosphorus Reduction Goal in John Redmond Reservoir.

Protection Measures	Best Management Practices and Other Actions	Total Acres or Projects Needed to be Implemented Over a Forty Year Period
1. Prevention of phosphorus (TP) contribution from **cropland**	1.1 Conservation Crop Rotations	12,111 acres
	1.2 Grassed Waterways	42,303 acres
	1.3 No-Till	57,486 acres
	1.4 Vegetative Buffers	45,364 acres
	1.5 Terraces	10,576 acres
	1.6 Establish Permanent Vegetation	12,111 acres
2. Prevention of phosphorus (TP) contribution from **livestock** erosion	2.1 Vegetative Filter Strip	80 acres
	2.2 Fence Off Streams	20, ½ mile sections
	2.3 Move Pasture Feeding Sites	120 sites
	2.4 Off Stream Watering Systems	120 systems
	2.5 Rotational Grazing	40 systems
3. Prevention of phosphorus (TP) contribution from **streambank** erosion	Streambank Restoration	Repair 73,683 feet of eroding streambank

6.2.5 Phosphorus Load Reductions

The table below lists the cropland BMPs installed with the associated phosphorus load reductions.

Table 25. Estimated Phosphorus Load Reductions for Installed BMPs for Cropland Aimed at Meeting the 229,126 Pound Phosphorus Reduction Goal in John Redmond Reservoir.

Annual Phosphorous Reduction (lbs), Cropland BMPs							
Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	267	787	1,281	1,067	295	1,014	4,712
2	534	1,574	2,562	2,135	590	2,028	9,423
3	801	2,361	3,843	3,202	885	3,042	14,135
4	1,068	3,148	5,124	4,269	1,180	4,057	18,846
5	1,334	3,935	6,405	5,336	1,476	5,071	23,558
6	1,601	4,722	7,687	6,404	1,771	6,085	28,269
7	1,868	5,509	8,968	7,471	2,066	7,099	32,981
8	2,135	6,296	10,249	8,538	2,361	8,113	37,692
9	2,402	7,083	11,530	9,605	2,656	9,127	42,404
10	2,669	7,870	12,811	10,673	2,951	10,142	47,115

Annual Phosphorous Reduction (lbs), Cropland BMPs, cont.							
Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
11	2,936	8,657	14,092	11,740	3,246	11,156	51,827
12	3,203	9,444	15,373	12,807	3,541	12,170	56,538
13	3,470	10,231	16,654	13,874	3,837	13,184	61,250
14	3,736	11,018	17,935	14,942	4,132	14,198	65,961
15	4,003	11,805	19,216	16,009	4,427	15,212	70,673
16	4,270	12,592	20,497	17,076	4,722	16,227	75,384
17	4,537	13,379	21,779	18,143	5,017	17,241	80,096
18	4,804	14,166	23,060	19,211	5,312	18,255	84,807
19	5,071	14,953	24,341	20,278	5,607	19,269	89,519
20	5,338	15,740	25,622	21,345	5,902	20,283	94,230
21	5,338	16,527	26,409	22,329	5,902	20,283	96,788
22	5,338	17,314	27,196	23,313	5,902	20,283	99,346
23	5,338	18,101	27,983	24,296	5,902	20,283	101,903
24	5,338	18,888	28,770	25,280	5,902	20,283	104,461
25	5,338	19,675	29,557	26,264	5,902	20,283	107,019
26	5,338	20,462	30,344	27,248	5,902	20,283	109,577
27	5,338	21,249	31,131	28,231	5,902	20,283	112,134
28	5,338	22,036	31,918	29,215	5,902	20,283	114,692
29	5,338	22,823	32,705	30,199	5,902	20,283	117,250
30	5,338	23,610	33,492	31,183	5,902	20,283	119,808
31	5,338	24,397	34,279	32,166	5,902	20,283	122,365
32	5,338	25,184	35,066	33,150	5,902	20,283	124,923
33	5,338	25,971	35,853	34,134	5,902	20,283	127,481
34	5,338	26,758	36,640	35,118	5,902	20,283	130,038
35	5,338	27,545	37,427	36,101	5,902	20,283	132,596
36	5,338	28,332	38,214	37,085	5,902	20,283	135,154
37	5,338	29,119	39,001	38,069	5,902	20,283	137,712
38	5,338	29,906	39,788	39,053	5,902	20,283	140,269
39	5,338	30,693	40,575	40,036	5,902	20,283	142,827
40	5,338	31,480	41,362	41,020	5,902	20,283	145,385

The table below demonstrates the phosphorus reduction attained by implementing the livestock BMPs.

Table 26. Estimated Phosphorus Load Reductions for Installed BMPs for Livestock Aimed at Meeting the 229,126 Pound Phosphorus Reduction Goal in John Redmond Reservoir.

Annual Phosphorous Load Reductions (lbs)						
Year	Vegetative Filter Strip	Fenced Off Streams	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing	Annual Load Reduction
1	1,276	90	229	229	140	1,964
2	2,552	90	459	459	280	3,839
3	3,827	180	688	688	420	5,803
4	5,103	180	917	917	560	7,677
5	6,379	270	1,147	1,147	700	9,642
6	7,655	270	1,376	1,376	840	11,516
7	8,930	360	1,605	1,605	980	13,481
8	10,206	360	1,834	1,834	1,120	15,355
9	11,482	450	2,064	2,064	1,260	17,319
10	12,758	450	2,293	2,293	1,400	19,194
11	14,033	540	2,522	2,522	1,540	21,158
12	15,309	540	2,752	2,752	1,680	23,032
13	16,585	630	2,981	2,981	1,820	24,997
14	17,861	630	3,210	3,210	1,960	26,871
15	19,136	720	3,440	3,440	2,100	28,836
16	20,412	720	3,669	3,669	2,240	30,710
17	21,688	810	3,898	3,898	2,380	32,674
18	22,964	810	4,128	4,128	2,520	34,549
19	24,239	900	4,357	4,357	2,660	36,513
20	25,515	900	4,586	4,586	2,800	38,387
21	26,791	990	4,816	4,816	2,940	40,352
22	28,067	990	5,045	5,045	3,080	42,226
23	29,342	1,080	5,274	5,274	3,220	44,191
24	30,618	1,080	5,503	5,503	3,360	46,065
25	31,894	1,170	5,733	5,733	3,500	48,029
26	33,170	1,170	5,962	5,962	3,640	49,904
27	34,445	1,260	6,191	6,191	3,780	51,868
28	35,721	1,260	6,421	6,421	3,920	53,742
29	36,997	1,350	6,650	6,650	4,060	55,707
30	38,273	1,350	6,879	6,879	4,200	57,581
31	39,548	1,440	7,109	7,109	4,340	59,546
32	40,824	1,440	7,338	7,338	4,480	61,420
33	42,100	1,530	7,567	7,567	4,620	63,384
34	43,376	1,530	7,797	7,797	4,760	65,259
35	44,651	1,620	8,026	8,026	4,900	67,223
36	45,927	1,620	8,255	8,255	5,040	69,097

Annual Phosphorous Load Reductions (lbs), cont.						
Year	Vegetative Filter Strip	Fenced Off Streams	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing	Annual Load Reduction
37	47,203	1,710	8,485	8,485	5,180	71,062
38	48,479	1,710	8,714	8,714	5,320	72,936
39	49,754	1,800	8,943	8,943	5,460	74,901
40	51,030	1,800	9,172	9,172	5,600	76,775

The table below demonstrates the streambank load reductions attained by stabilizing sites along the Cottonwood River.

Table 27. Estimated Phosphorus Load Reductions for Streambank Restoration Aimed at Meeting the 229,126 Pound Phosphorus Reduction Goal in John Redmond Reservoir.

Annual Phosphorous Load Reductions (lbs)			
Year	Streambank Stabilization (feet)	Phosphorous Reduction (lbs)	Cumulative P Load Reduction (lbs)
1	1,842	233	233
2	1,842	233	466
3	1,842	233	700
4	1,842	233	933
5	1,842	233	1,166
6	1,842	233	1,399
7	1,842	233	1,632
8	1,842	233	1,866
9	1,842	233	2,099
10	1,842	233	2,332
11	1,842	233	2,565
12	1,842	233	2,798
13	1,842	233	3,032
14	1,842	233	3,265
15	1,842	233	3,498
16	1,842	233	3,731
17	1,842	233	3,965
18	1,842	233	4,198
19	1,842	233	4,431
20	1,842	233	4,664
21	1,842	233	4,897
22	1,842	233	5,131
23	1,842	233	5,364
24	1,842	233	5,597
25	1,842	233	5,830
26	1,842	233	6,063

Annual Phosphorous Load Reductions (lbs), cont.			
Year	Streambank Stabilization (feet)	Phosphorous Reduction (lbs)	Cumulative P Load Reduction (lbs)
27	1,842	233	6,297
28	1,842	233	6,530
29	1,842	233	6,763
30	1,842	233	6,996
31	1,842	233	7,229
32	1,842	233	7,463
33	1,842	233	7,696
34	1,842	233	7,929
35	1,842	233	8,162
36	1,842	233	8,395
37	1,842	233	8,629
38	1,842	233	8,862
39	1,842	233	9,095
40	1,842	233	9,328

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

Table 28. Estimated Total Phosphorus Load Reductions for All Implemented BMPs Aimed at Meeting the 229,126 Pound Phosphorus Reduction Goal in John Redmond Reservoir.

Annual Phosphorous Load Reductions (lbs)					
Year	Streambank Reduction (lbs)	Cropland Reduction (lbs)	Livestock Reduction (lbs)	Total Reduction (lbs)	% of TMDL
1	233	4,712	1,964	6,909	3%
2	466	9,423	3,839	13,728	6%
3	700	14,135	5,803	20,637	9%
4	933	18,846	7,677	27,456	12%
5	1,166	23,558	9,642	34,365	15%
6	1,399	28,269	11,516	41,185	18%
7	1,632	32,981	13,481	48,094	21%
8	1,866	37,692	15,355	54,913	24%
9	2,099	42,404	17,319	61,822	27%
10	2,332	47,115	19,194	68,641	30%
11	2,565	51,827	21,158	75,550	33%
12	2,798	56,538	23,032	82,369	36%
13	3,032	61,250	24,997	89,278	39%

Annual Phosphorous Load Reductions (lbs), cont.					
Year	Streambank Reduction (lbs)	Cropland Reduction (lbs)	Livestock Reduction (lbs)	Total Reduction (lbs)	% of TMDL
14	3,265	65,961	26,871	96,097	42%
15	3,498	70,673	28,836	103,006	45%
16	3,731	75,384	30,710	109,826	48%
17	3,965	80,096	32,674	116,735	51%
18	4,198	84,807	34,549	123,554	54%
19	4,431	89,519	36,513	130,463	57%
20	4,664	94,230	38,387	137,282	60%
21	4,897	96,788	40,352	142,037	62%
22	5,131	99,346	42,226	146,702	64%
23	5,364	101,903	44,191	151,458	66%
24	5,597	104,461	46,065	156,123	68%
25	5,830	107,019	48,029	160,878	70%
26	6,063	109,577	49,904	165,544	72%
27	6,297	112,134	51,868	170,299	74%
28	6,530	114,692	53,742	174,964	76%
29	6,763	117,250	55,707	179,720	78%
30	6,996	119,808	57,581	184,385	80%
31	7,229	122,365	59,546	189,140	83%
32	7,463	124,923	61,420	193,806	85%
33	7,696	127,481	63,384	198,561	87%
34	7,929	130,038	65,259	203,226	89%
35	8,162	132,596	67,223	207,981	91%
36	8,395	135,154	69,097	212,647	93%
37	8,629	137,712	71,062	217,402	95%
38	8,862	140,269	72,936	222,067	97%
39	9,095	142,827	74,901	226,823	99%
40	9,328	145,385	76,775	231,488	101%
Phosphorous TMDL: 229,126 Pounds					

Phosphorus Reduction Goal is Met

Table 29. Phosphorus Load Reduction in Forty Years by Category Aimed at Meeting the 229,126 Pound Phosphorus Reduction Goal in John Redmond Reservoir.

Best Management Practice Category	Total Load Reduction (pounds)	Percent of Phosphorous TMDL
Cropland	145,385	63%
Livestock	76,775	34%
Streambank	9,328	4%
Total	**231,488**	**101%**

Refer to Section 8, "Costs of BMP Implementation" for specific BMP costs in order to meet the TMDL.

7.0 Information and Education in Support of BMPs

7.1 Information and Education Activities and Events

Table 30. Information and Education Activities and Events as Requested by the SLT in Support of Meeting the TMDLs.

Cropland BMP Implementation					
BMP	**Target Audience**	**Activity/Event Technical Assistance**	**Time Frame**	**Estimated Costs**	**Sponsor/ Responsible Agency**
Conservation Crop Rotation	Farmers in cropland targeted areas	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual	No cost	Conservation Districts NRCS
		Workshop/Field Day	Annual, Spring	Included in above	Conservation Districts K-State Extension Flint Hills RC&D
Grassed Waterways	Farmers in cropland targeted areas	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual	No cost	Conservation Districts NRCS
No-Till	Farmers in cropland targeted areas	Scholarships for producers to attend No-Till on the Plains Annual Conference	Annual, Winter	5 per year, $150 per scholarship	No-Till on the Plains
		Workshop/Field Day	Annual, Spring	Included in above	Conservation Districts K-State Extension Flint Hills RC&D
		One-on-one technical assistance for producers to implement BMPs in the targeted area	Annual	No cost	Conservation District NRCS

Cropland BMP Implementation, cont.					
BMP	**Target Audience**	**Activity/Event Technical Assistance**	**Time Frame**	**Estimated Costs**	**Sponsor/ Responsible Agency**
Vegetative Buffers	Farmers in cropland targeted areas	Workshop/field day	Annual - spring	$5,000	K-State Extension Conservation Districts Flint Hills RC&D
		One-on-one technical assistance	Annual - ongoing	No cost	Conservation Districts NRCS
		Workshop/Field Day	Annual, Spring	Included in above	Conservation Districts K-State Extension Flint Hills RC&D
		Forestry Field Day	Annual	$3,000	Kansas Forest Service
		One-on-one technical assistance for producers to implement BMPs in the targeted area	Annual	No cost	Conservation Districts NRCS
		One-on-one technical assistance for riparian tree planting	Annual, Ongoing	Included in above	Kansas Forest Service
Terraces	Farmers in cropland targeted areas	One-on-one technical assistance for producers to implement BMPs in the targeted area	Annual	No cost	Conservation Districts NRCS
		Workshop/Field Day	Annual, Spring	Included in above	Conservation Districts K-State Extension Flint Hills RC&D
Permanent Vegetation	Farmers in cropland targeted areas	Workshop/Field day	Annual, Spring	$2,000	Conservation Districts K-State Extension Flint Hills RC&D
		Forestry field day	Annual	$3,000	Kansas Forest Service

Livestock BMP Implementation					
BMP	**Target Audience**	**Activity/Event Technical Assistance**	**Time Frame**	**Estimated Costs**	**Sponsor/ Responsible Agency**
Vegetative Filter Strips	Producers in livestock targeted areas	Tour/Field Day	Annual, Summer	Included in above	Kansas Rural Center K-State Extension Conservation Districts NRCS
		One-on-one technical assistance for producers to implement BMPs in the targeted area	Annual, Ongoing	Included in above	Conservation Districts NRCS
Fenced Off Streams	Producers in livestock targeted areas	One-on-one technical assistance	Annual	$10,000	Conservation Districts NRCS K-State Extension
		Tour/Field Day	Annual, Summer	$2,500	Kansas Rural Center K-State Extension Conservation Districts NRCS

Livestock BMP Implementation, cont.					
BMP	**Target Audience**	**Activity/Event Technical Assistance**	**Time Frame**	**Estimated Costs**	**Sponsor/ Responsible Agency**
Relocate Pasture Feeding Sites	Producers in livestock targeted areas	Tour/Field Day	Annual, Summer	$5,000	Kansas Rural Center K-State Extension Conservation Districts NRCS
		Scholarships to Grazing Schools and Workshops	Annual, Winter	5 per year, $50 per scholarships	Kansas Rural Center K-State Extension Kansas Grazer's Association
		One-on-one technical assistance for producers to implement BMPs in the targeted area	Annual, Ongoing	$17,500	K-State Extension Conservation Districts NRCS
		One-on-one technical assistance to remove livestock from riparian area	Annual, Ongoing	$4,000	Kansas Forest Service
Off-Stream Watering Systems	Producers in livestock targeted areas	Tour/Field Day	Annual, Summer	Included in above	Kansas Rural Center K-State Extension Conservation Districts NRCS
		Scholarships to Grazing Schools and Workshops	Annual, Winter	Included in above	Kansas Rural Center K-State Extension Kansas Grazer's Association
		One-on-one technical assistance for producers to implement BMPs in the targeted area	Annual, Ongoing	Included in above	K-State Extension Conservation Districts NRCS

Livestock BMP Implementation, cont.					
BMP	**Target Audience**	**Activity/Event Technical Assistance**	**Time Frame**	**Estimated Costs**	**Sponsor/ Responsible Agency**
Rotational Grazing	Producers in livestock targeted areas	Tour/Field Day	Annual - summer	$2,500	Kansas Rural Center K-State Extension Conservation Districts NRCS
		One-on-one technical assistance	Annual	$10,000	Kansas Rural Center K-State Extension
Streambank BMP Implementation					
BMP	**Target Audience**	**Activity/Event Technical Assistance**	**Time Frame**	**Estimated Costs**	**Sponsor/ Responsible Agency**
Streambank Stabilization	Farmers/Landowners	Workshop/Field Day	Annual, Spring	Included in Above	Conservation Districts KSRE FH RC&D TWI KAWS
	Farmers/Landowners	Forestry Field Day	Annual	$3,000	Kansas Forest Service
	Farmers/Landowners	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual	No Cost	Conservation Districts NRCS
	Farmers/Landowners	One-on-one technical assistance for riparian tree planting	Annual, ongoing	Included above	Kansas Forest Service

General / Watershed Wide Information and Education					
BMP	**Target Audience**	**Activity/Event Technical Assistance**	**Time Frame**	**Estimated Costs**	**Sponsor/ Responsible Agency**
Educational Activities Targeting Youth	Educators, K-12 Students	Envirothon	Annual	No cost	Conservation Districts KACEE
		Day on the Farm	Annual	No cost	Conservation Districts KACEE
		Poster, essay, and speech contests	Annual	No cost	Conservation Districts KACEE
		Water Festival	Annual	$5,000	Conservation Districts K-State Extension Flint Hills RC&D KACEE
Educational Activities Targeting Adults	Watershed residents	BMP Auction	Annual	$10,000	K-State Extension Conservation Districts KACEE
		River Friendly Farms	Annual	$20,000	Kansas Rural Center
		Healthy Ecosystems – Healthy Communities	Annual, Ongoing	$17,500	Kansas PRIDE
Total Cost per Year				**$118,000**	

7.2 Evaluation of Information and Education Activities

All service providers conducting Information and Education (I&E) activities funded through the Cottonwood WRAPS will be required to include an evaluation component in their project proposals and PIPs. 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.

8.0 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

Conservation Crop Rotation: After being presented with information from K-State Research and Extension (Josh Roe) on the costs and benefits of conservation crop rotations, the SLT decided that a fair price to entice a producer to adopt a conservation crop rotation would be to pay them $5 an acre for 10 years, or a net present value of $38.84 per acre up front assuming the NRCS discount rate of 4.75%.

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.

Establish Permanent Vegetation: The cost of $150 an acre was calculated based on K-State Research and Extension estimates of the cost of planting and maintaining native grass.

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.

8.1 Costs of Implementing BMPs and Information and Education

Table 31. Estimated Costs Before Cost Share for Cropland Implemented BMPs in the Cropland Targeted Area. Individual sub watershed costs are provided in the Appendix. Expressed in 2010 dollar amounts.

Annual Cost* Before Cost-Share, Cropland BMPs							
Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$23,616	$169,211	$141,140	$80,708	$53,936	$90,830	$559,441
2	$24,324	$174,288	$145,374	$83,129	$55,554	$93,555	$576,224
3	$25,054	$179,516	$149,735	$85,623	$57,221	$96,362	$593,511
4	$25,806	$184,902	$154,227	$88,192	$58,937	$99,253	$611,317
5	$26,580	$190,449	$158,854	$90,838	$60,706	$102,230	$629,656
6	$27,377	$196,162	$163,620	$93,563	$62,527	$105,297	$648,546
7	$28,199	$202,047	$168,528	$96,370	$64,402	$108,456	$668,002
8	$29,045	$208,108	$173,584	$99,261	$66,335	$111,710	$688,042

Annual Cost* Before Cost-Share, Cropland BMPs, cont.							
Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
9	$29,916	$214,352	$178,792	$102,238	$68,325	$115,061	$708,683
10	$30,813	$220,782	$184,155	$105,306	$70,374	$118,513	$729,944
11	$31,738	$227,406	$189,680	$108,465	$72,486	$122,068	$751,842
12	$32,690	$234,228	$195,371	$111,719	$74,660	$125,730	$774,397
13	$33,671	$241,255	$201,232	$115,070	$76,900	$129,502	$797,629
14	$34,681	$248,492	$207,269	$118,522	$79,207	$133,387	$821,558
15	$35,721	$255,947	$213,487	$122,078	$81,583	$137,389	$846,205
16	$36,793	$263,626	$219,891	$125,740	$84,031	$141,511	$871,591
17	$37,897	$271,534	$226,488	$129,513	$86,552	$145,756	$897,739
18	$39,033	$279,680	$233,283	$133,398	$89,148	$150,129	$924,671
19	$40,204	$288,071	$240,281	$137,400	$91,823	$154,632	$952,411
20	$41,411	$296,713	$247,490	$141,522	$94,577	$159,271	$980,984
21	$0	$305,614	$148,395	$127,339	$0	$0	$581,348
22	$0	$314,783	$152,847	$131,159	$0	$0	$598,789
23	$0	$324,226	$157,432	$135,094	$0	$0	$616,752
24	$0	$333,953	$162,155	$139,147	$0	$0	$635,255
25	$0	$343,972	$167,020	$143,321	$0	$0	$654,313
26	$0	$354,291	$172,030	$147,621	$0	$0	$673,942
27	$0	$364,919	$177,191	$152,050	$0	$0	$694,160
28	$0	$375,867	$182,507	$156,611	$0	$0	$714,985
29	$0	$387,143	$187,982	$161,310	$0	$0	$736,435
30	$0	$398,757	$193,622	$166,149	$0	$0	$758,528
31	$0	$410,720	$199,430	$171,133	$0	$0	$781,284
32	$0	$423,042	$205,413	$176,267	$0	$0	$804,722
33	$0	$435,733	$211,576	$181,555	$0	$0	$828,864
34	$0	$448,805	$217,923	$187,002	$0	$0	$853,730
35	$0	$462,269	$224,460	$192,612	$0	$0	$879,342
36	$0	$476,137	$231,194	$198,390	$0	$0	$905,722
37	$0	$490,421	$238,130	$204,342	$0	$0	$932,893
38	$0	$505,134	$245,274	$210,472	$0	$0	$960,880
39	$0	$520,288	$252,632	$216,787	$0	$0	$989,707
40	$0	$535,896	$260,211	$223,290	$0	$0	$1,019,398

**3% Inflation*

Table 32. Estimated Costs After Cost Share for Cropland Implemented BMPs in the Cropland Targeted Area. Individual sub watershed costs are provided in the Appendix. Expressed in 2010 dollar amounts.

Annual Cost* After Cost-Share, Cropland BMPs							
Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$23,616	$84,606	$86,095	$8,071	$26,968	$45,415	$274,771
2	$24,324	$87,144	$88,678	$8,313	$27,777	$46,778	$283,014
3	$25,054	$89,758	$91,338	$8,562	$28,610	$48,181	$291,504
4	$25,806	$92,451	$94,079	$8,819	$29,469	$49,626	$300,249
5	$26,580	$95,224	$96,901	$9,084	$30,353	$51,115	$309,257
6	$27,377	$98,081	$99,808	$9,356	$31,263	$52,649	$318,535
7	$28,199	$101,024	$102,802	$9,637	$32,201	$54,228	$328,091
8	$29,045	$104,054	$105,886	$9,926	$33,167	$55,855	$337,933
9	$29,916	$107,176	$109,063	$10,224	$34,162	$57,531	$348,071
10	$30,813	$110,391	$112,335	$10,531	$35,187	$59,256	$358,513
11	$31,738	$113,703	$115,705	$10,846	$36,243	$61,034	$369,269
12	$32,690	$117,114	$119,176	$11,172	$37,330	$62,865	$380,347
13	$33,671	$120,627	$122,751	$11,507	$38,450	$64,751	$391,757
14	$34,681	$124,246	$126,434	$11,852	$39,603	$66,694	$403,510
15	$35,721	$127,974	$130,227	$12,208	$40,792	$68,694	$415,615
16	$36,793	$131,813	$134,134	$12,574	$42,015	$70,755	$428,084
17	$37,897	$135,767	$138,158	$12,951	$43,276	$72,878	$440,926
18	$39,033	$139,840	$142,302	$13,340	$44,574	$75,064	$454,154
19	$40,204	$144,035	$146,571	$13,740	$45,911	$77,316	$467,779
20	$41,411	$148,356	$150,969	$14,152	$47,289	$79,636	$481,812
21	$0	$152,807	$90,521	$12,734	$0	$0	$256,062
22	$0	$157,391	$93,236	$13,116	$0	$0	$263,744
23	$0	$162,113	$96,034	$13,509	$0	$0	$271,656
24	$0	$166,976	$98,915	$13,915	$0	$0	$279,806
25	$0	$171,986	$101,882	$14,332	$0	$0	$288,200
26	$0	$177,145	$104,938	$14,762	$0	$0	$296,846
27	$0	$182,460	$108,087	$15,205	$0	$0	$305,751
28	$0	$187,933	$111,329	$15,661	$0	$0	$314,924
29	$0	$193,571	$114,669	$16,131	$0	$0	$324,372
30	$0	$199,379	$118,109	$16,615	$0	$0	$334,103
31	$0	$205,360	$121,652	$17,113	$0	$0	$344,126
32	$0	$211,521	$125,302	$17,627	$0	$0	$354,450
33	$0	$217,866	$129,061	$18,156	$0	$0	$365,083
34	$0	$224,402	$132,933	$18,700	$0	$0	$376,036
35	$0	$231,134	$136,921	$19,261	$0	$0	$387,317

Annual Cost* After Cost-Share, Cropland BMPs, cont.							
Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
36	$0	$238,069	$141,029	$19,839	$0	$0	$398,936
37	$0	$245,211	$145,259	$20,434	$0	$0	$410,904
38	$0	$252,567	$149,617	$21,047	$0	$0	$423,231
39	$0	$260,144	$154,106	$21,679	$0	$0	$435,928
40	$0	$267,948	$158,729	$22,329	$0	$0	$449,006
*3% Inflation							

Table 33. Annual Costs Before Cost Share in the Livestock Targeted Area. Sub watershed costs are provided in the Appendix. Expressed in 2010 dollar amounts.

Livestock BMPs, Annual Cost Before Cost-Share						
Year	Vegetative Filter Strip	Fenced Off Streams	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing	Annual Cost
1	$1,428	$4,106	$6,609	$11,385	$7,000	**$30,528**
2	$1,471	$0	$6,807	$11,727	$7,210	**$27,215**
3	$1,515	$4,356	$7,011	$12,078	$7,426	**$32,387**
4	$1,560	$0	$7,222	$12,441	$7,649	**$28,872**
5	$1,607	$4,621	$7,438	$12,814	$7,879	**$34,360**
6	$1,655	$0	$7,662	$13,198	$8,115	**$30,630**
7	$1,705	$4,903	$7,891	$13,594	$8,358	**$36,452**
8	$1,756	$0	$8,128	$14,002	$8,609	**$32,496**
9	$1,809	$5,201	$8,372	$14,422	$8,867	**$38,672**
10	$1,863	$0	$8,623	$14,855	$9,133	**$34,475**
11	$1,919	$5,518	$8,882	$15,300	$9,407	**$41,027**
12	$1,977	$0	$9,148	$15,760	$9,690	**$36,574**
13	$2,036	$5,854	$9,423	$16,232	$9,980	**$43,526**
14	$2,097	$0	$9,706	$16,719	$10,280	**$38,802**
15	$2,160	$6,211	$9,997	$17,221	$10,588	**$46,176**
16	$2,225	$0	$10,297	$17,737	$10,906	**$41,165**
17	$2,292	$6,589	$10,606	$18,270	$11,233	**$48,988**
18	$2,360	$0	$10,924	$18,818	$11,570	**$43,672**
19	$2,431	$6,990	$11,251	$19,382	$11,917	**$51,972**
20	$2,504	$0	$11,589	$19,964	$12,275	**$46,331**
21	$2,579	$7,416	$11,937	$20,563	$12,643	**$55,137**
22	$2,657	$0	$12,295	$21,179	$13,022	**$49,153**
23	$2,736	$7,868	$12,664	$21,815	$13,413	**$58,495**
24	$2,818	$0	$13,043	$22,469	$13,815	**$52,146**
25	$2,903	$8,347	$13,435	$23,143	$14,230	**$62,057**

Livestock BMPs, Annual Cost Before Cost-Share, cont.						
Year	Vegetative Filter Strip	Fenced Off Streams	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing	Annual Cost
26	$2,990	$0	$13,838	$23,838	$14,656	**$55,322**
27	$3,080	$8,855	$14,253	$24,553	$15,096	**$65,836**
28	$3,172	$0	$14,680	$25,289	$15,549	**$58,691**
29	$3,267	$9,394	$15,121	$26,048	$16,015	**$69,846**
30	$3,365	$0	$15,575	$26,829	$16,496	**$62,265**
31	$3,466	$9,966	$16,042	$27,634	$16,991	**$74,099**
32	$3,570	$0	$16,523	$28,463	$17,501	**$66,057**
33	$3,677	$10,573	$17,019	$29,317	$18,026	**$78,612**
34	$3,788	$0	$17,529	$30,197	$18,566	**$70,080**
35	$3,901	$11,217	$18,055	$31,103	$19,123	**$83,400**
36	$4,018	$0	$18,597	$32,036	$19,697	**$74,348**
37	$4,139	$11,900	$19,155	$32,997	$20,288	**$88,479**
38	$4,263	$0	$19,729	$33,987	$20,897	**$78,876**
39	$4,391	$12,625	$20,321	$35,006	$21,523	**$93,867**
40	$4,523	$0	$20,931	$36,057	$22,169	**$83,679**
**3% Inflation*						

Table 34. Annual Costs After Cost Share in the Livestock Targeted Area. Sub watershed costs are provided in the Appendix. Expressed in 2010 dollar amounts.

Livestock BMPs, Annual Cost After Cost-Share						
Year	Vegetative Filter Strip	Fenced Off Streams	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing	Annual Cost
1	$714	$2,053	$3,305	$5,693	$3,500	**$15,264**
2	$735	$0	$3,404	$5,863	$3,605	**$13,607**
3	$757	$2,178	$3,506	$6,039	$3,713	**$16,194**
4	$780	$0	$3,611	$6,220	$3,825	**$14,436**
5	$804	$2,311	$3,719	$6,407	$3,939	**$17,180**
6	$828	$0	$3,831	$6,599	$4,057	**$15,315**
7	$853	$2,451	$3,946	$6,797	$4,179	**$18,226**
8	$878	$0	$4,064	$7,001	$4,305	**$16,248**
9	$904	$2,601	$4,186	$7,211	$4,434	**$19,336**
10	$932	$0	$4,312	$7,427	$4,567	**$17,237**
11	$960	$2,759	$4,441	$7,650	$4,704	**$20,514**
12	$988	$0	$4,574	$7,880	$4,845	**$18,287**
13	$1,018	$2,927	$4,711	$8,116	$4,990	**$21,763**
14	$1,049	$0	$4,853	$8,360	$5,140	**$19,401**

Livestock BMPs, Annual Cost After Cost-Share, cont.						
Year	Vegetative Filter Strip	Fenced Off Streams	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing	Annual Cost
15	$1,080	$3,105	$4,998	$8,610	$5,294	**$23,088**
16	$1,112	$0	$5,148	$8,869	$5,453	**$20,582**
17	$1,146	$3,294	$5,303	$9,135	$5,616	**$24,494**
18	$1,180	$0	$5,462	$9,409	$5,785	**$21,836**
19	$1,216	$3,495	$5,626	$9,691	$5,959	**$25,986**
20	$1,252	$0	$5,794	$9,982	$6,137	**$23,166**
21	$1,290	$3,708	$5,968	$10,281	$6,321	**$27,568**
22	$1,328	$0	$6,147	$10,590	$6,511	**$24,576**
23	$1,368	$3,934	$6,332	$10,907	$6,706	**$29,247**
24	$1,409	$0	$6,522	$11,235	$6,908	**$26,073**
25	$1,451	$4,173	$6,717	$11,572	$7,115	**$31,029**
26	$1,495	$0	$6,919	$11,919	$7,328	**$27,661**
27	$1,540	$4,427	$7,126	$12,276	$7,548	**$32,918**
28	$1,586	$0	$7,340	$12,645	$7,775	**$29,345**
29	$1,634	$4,697	$7,560	$13,024	$8,008	**$34,923**
30	$1,683	$0	$7,787	$13,415	$8,248	**$31,133**
31	$1,733	$4,983	$8,021	$13,817	$8,495	**$37,050**
32	$1,785	$0	$8,262	$14,232	$8,750	**$33,029**
33	$1,839	$5,287	$8,509	$14,659	$9,013	**$39,306**
34	$1,894	$0	$8,765	$15,098	$9,283	**$35,040**
35	$1,951	$5,609	$9,028	$15,551	$9,562	**$41,700**
36	$2,009	$0	$9,298	$16,018	$9,849	**$37,174**
37	$2,069	$5,950	$9,577	$16,498	$10,144	**$44,239**
38	$2,131	$0	$9,865	$16,993	$10,448	**$39,438**
39	$2,195	$6,313	$10,161	$17,503	$10,762	**$46,933**
40	$2,261	$0	$10,465	$18,028	$11,085	**$41,840**
**3% Inflation*						

Table 35. Annual Costs of Streambank Stabilization Projects in the Streambank Targeted Area. Expressed in 2010 dollar amounts.

Cottonwood River Annual Streambank Load Reductions and Cost						
Year	Streambank Stabilization (feet)	Soil Load Reduction (tons)	Cumulative Erosion Reduction (tons)	Phosphorous Reduction (lbs)	Cumulative P Load Reduction (lbs)	Cost*
1	1,842	3,887	3,887	233	233	$177,908
2	1,842	3,887	7,774	233	466	$183,245
3	1,842	3,887	11,660	233	700	$188,742

Cottonwood River Annual Streambank Load Reductions and Cost, cont.						
Year	Streambank Stabilization (feet)	Soil Load Reduction (tons)	Cumulative Erosion Reduction (tons)	Phosphorous Reduction (lbs)	Cumulative P Load Reduction (lbs)	Cost*
4	1,842	3,887	15,547	233	933	$194,404
5	1,842	3,887	19,434	233	1,166	$200,237
6	1,842	3,887	23,321	233	1,399	$206,244
7	1,842	3,887	27,207	233	1,632	$212,431
8	1,842	3,887	31,094	233	1,866	$218,804
9	1,842	3,887	34,981	233	2,099	$225,368
10	1,842	3,887	38,868	233	2,332	$232,129
11	1,842	3,887	42,755	233	2,565	$239,093
12	1,842	3,887	46,641	233	2,798	$246,266
13	1,842	3,887	50,528	233	3,032	$253,654
14	1,842	3,887	54,415	233	3,265	$261,263
15	1,842	3,887	58,302	233	3,498	$269,101
16	1,842	3,887	62,188	233	3,731	$277,174
17	1,842	3,887	66,075	233	3,965	$285,489
18	1,842	3,887	69,962	233	4,198	$294,054
19	1,842	3,887	73,849	233	4,431	$302,876
20	1,842	3,887	77,736	233	4,664	$311,962
21	1,842	3,887	81,622	233	4,897	$321,321
22	1,842	3,887	85,509	233	5,131	$330,961
23	1,842	3,887	89,396	233	5,364	$340,889
24	1,842	3,887	93,283	233	5,597	$351,116
25	1,842	3,887	97,169	233	5,830	$361,650
26	1,842	3,887	101,056	233	6,063	$372,499
27	1,842	3,887	104,943	233	6,297	$383,674
28	1,842	3,887	108,830	233	6,530	$395,184
29	1,842	3,887	112,717	233	6,763	$407,040
30	1,842	3,887	116,603	233	6,996	$419,251
31	1,842	3,887	120,490	233	7,229	$431,828
32	1,842	3,887	124,377	233	7,463	$444,783
33	1,842	3,887	128,264	233	7,696	$458,127
34	1,842	3,887	132,150	233	7,929	$471,871
35	1,842	3,887	136,037	233	8,162	$486,027
36	1,842	3,887	139,924	233	8,395	$500,608
37	1,842	3,887	143,811	233	8,629	$515,626
38	1,842	3,887	147,698	233	8,862	$531,095
39	1,842	3,887	151,584	233	9,095	$547,027

Cottonwood River Annual Streambank Load Reductions and Cost, cont.						
Year	**Streambank Stabilization (feet)**	**Soil Load Reduction (tons)**	**Cumulative Erosion Reduction (tons)**	**Phosphorous Reduction (lbs)**	**Cumulative P Load Reduction (lbs)**	**Cost***
40	1,842	3,887	155,471	233	9,328	$563,438
**3% Inflation*						

Table 36. Technical Assistance Needed to Implement BMPs.

BMP		**Personnel Needed to Implement BMP**	
		Technical Assistance	***Projected Annual Cost***
Cropland	1. Conservation Crop Rotation	KRC River Friendly Farms Technician	NRCS District Conservationist No Charge Conservation District Soil Technician No Charge SCC Buffer Technician No Charge KRC River Friendly Farms Technician $20,000 Kansas State Forester No Charge Watershed Coordinator and Grant Manager $45,000
	2. Grassed Waterways	SCC Buffer Technician KRC River Friendly Farms Technician	
	3. No-Till	SCC Buffer Technician WRAPS Coordinator KRC River Friendly Farms Technician	
	4. Buffers	SCC Buffer Technician KRC River Friendly Farms Technician	
	5. Terraces	SCC Buffer Technician KRC River Friendly Farms Technician	
	5. Establish Permanent Vegetation	KRC River Friendly Farms Technician	
Livestock	1. Vegetative filter strips	SCC Buffer Technician KRC River Friendly Farms Technician Watershed Specialist	
	2. Fence off streams	KRC River Friendly Farms Technician Watershed Specialist	
	3. Relocate pasture feeding sites	KRC River Friendly Farms Technician Watershed Specialist	
	4. Establish off stream watering systems	KRC River Friendly Farms Technician Watershed Specialist	
	5. Rotational grazing	KRC River Friendly Farms Technician Watershed Specialist	
Streambank	1. Stabilization	SCC Buffer Technician WRAPS Coordinator KRC River Friendly Farms Technician	
	Total		$65,000

Table 37. Total Costs After Cost Share for BMPs I&E and Technical Support if All BMPs and I&E Projects are Implemented. Expressed in 2010 dollar amounts.

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	$274,771	$15,264	$177,908	$118,000	$65,000	$650,943
2	$283,014	$13,607	$183,245	$121,540	$66,950	$668,356
3	$291,504	$16,194	$188,742	$125,186	$68,959	$690,585
4	$300,249	$14,436	$194,404	$128,942	$71,027	$709,058
5	$309,257	$17,180	$200,237	$132,810	$73,158	$732,642
6	$318,535	$15,315	$206,244	$136,794	$75,353	$752,241
7	$328,091	$18,226	$212,431	$140,898	$77,613	$777,259
8	$337,933	$16,248	$218,804	$145,125	$79,942	$798,052
9	$348,071	$19,336	$225,368	$149,479	$82,340	$824,594
10	$358,513	$17,237	$232,129	$153,963	$84,810	$846,652
11	$369,269	$20,514	$239,093	$158,582	$87,355	$874,813
12	$380,347	$18,287	$246,266	$163,340	$89,975	$898,215
13	$391,757	$21,763	$253,654	$168,240	$92,674	$928,088
14	$403,510	$19,401	$261,263	$173,287	$95,455	$952,916
15	$415,615	$23,088	$269,101	$178,486	$98,318	$984,608
16	$428,084	$20,582	$277,174	$183,840	$101,268	$1,010,948
17	$440,926	$24,494	$285,489	$189,355	$104,306	$1,044,570
18	$454,154	$21,836	$294,054	$195,036	$107,435	$1,072,515
19	$467,779	$25,986	$302,876	$200,887	$110,658	$1,108,186
20	$481,812	$23,166	$311,962	$206,914	$113,978	$1,137,832
21	$256,062	$27,568	$321,321	$213,121	$117,397	$935,469
22	$263,744	$24,576	$330,961	$219,515	$120,919	$959,715
23	$271,656	$29,247	$340,889	$226,100	$124,547	$992,439
24	$279,806	$26,073	$351,116	$232,883	$128,283	$1,018,161
25	$288,200	$31,029	$361,650	$239,870	$132,132	$1,052,881
26	$296,846	$27,661	$372,499	$247,066	$136,096	$1,080,168
27	$305,751	$32,918	$383,674	$254,478	$140,178	$1,116,999
28	$314,924	$29,345	$395,184	$262,112	$144,384	$1,145,949
29	$324,372	$34,923	$407,040	$269,975	$148,715	$1,185,025
30	$334,103	$31,133	$419,251	$278,075	$153,177	$1,215,739
31	$344,126	$37,050	$431,828	$286,417	$157,772	$1,257,193
32	$354,450	$33,029	$444,783	$295,009	$162,505	$1,289,776
33	$365,083	$39,306	$458,127	$303,860	$167,380	$1,333,756

Annual Cost of Cropland, Livestock, Streambank BMPs, I&E, and Technical Assistance adjusted for Cost Share, cont.						
	BMPs Implemented			I&E and Technical Assistance		
Year	Cropland	Livestock	Streambank	I&E	Technical Assistance	Total
34	$376,036	$35,040	$471,871	$312,976	$172,402	$1,368,325
35	$387,317	$41,700	$486,027	$322,365	$177,574	$1,414,983
36	$398,936	$37,174	$500,608	$332,036	$182,901	$1,451,655
37	$410,904	$44,239	$515,626	$341,997	$188,388	$1,501,154
38	$423,231	$39,438	$531,095	$352,257	$194,040	$1,540,061
39	$435,928	$46,933	$547,027	$362,824	$199,861	$1,592,573
40	$449,006	$41,840	$563,438	$373,709	$205,857	$1,633,850
**3% Inflation*						

8.2 Potential Funding Sources

Table 38. 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) Cooperative Conservation Partnership Initiative (CCPI) State Acres for Wildlife Enhancement (SAFE) Grassland Reserve Program (GRP) Farmable Wetlands Program (FWP)
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	

Potential Funding Sources, cont.	
Potential Funding Sources	**Potential Funding Programs**
US Fish and Wildlife	
National Wild Turkey Federation	
Quail Unlimited	
Ducks Unlimited	

Table 39. Service Providers for BMP Implementation. *

BMP		Services Needed to Implement BMP		Service Provider **
		Technical Assistance	***Information and Education***	
Cropland	1. Conservation Crop Rotation	Development of management plan	BMP workshops, tours, field days	NRCS KRC SCC No-Till on the Plains KSRE CD RC&D KDWP KFS
	2. Waterways	Design, cost share and maintenance	BMP workshops, tours, field days	
	3. No-till	Design, cost share and maintenance	BMP workshops, tours, field days	
	4. Buffers	Development of management plan	BMP workshops	
	5. Terraces	Design, cost share and maintenance	BMP workshops, field days, tours	
	6. Establish Permanent Vegetation	Development of management plan	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	
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.*

9.0 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 forty 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	X	X
2030	X	X	X
2035	X	X	X
2040	X	X	X
2045	X	X	X
2050	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 at year thirty four of the plan. 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 the full forty years of the plan. At this time, if all BMPs have been implemented, the TMDL should be met.

10.0 Measureable Milestones

10.1 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 ten years.

Below are tables outlining the expected adoption rates of BMPs in order to attain impairment reduction goals.

Table 40. Short, Medium and Long Term Goals for BMP Cropland Adoption Rates. Sub watershed adoption rates are provided in the Appendix.

Annual Adoption (treated acres) Rates for Cropland BMPs								
	Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Adoption
Short-Term	1	606	1,058	1,817	1,211	529	606	5,825
	2	606	1,058	1,817	1,211	529	606	5,825
	3	606	1,058	1,817	1,211	529	606	5,825
	4	606	1,058	1,817	1,211	529	606	5,825
	5	606	1,058	1,817	1,211	529	606	5,825
	Total	*3,028*	*5,288*	*9,084*	*6,053*	*2,644*	*3,028*	*29,124*
Medium-Term	6	606	1,058	1,817	1,211	529	606	5,825
	7	606	1,058	1,817	1,211	529	606	5,825
	8	606	1,058	1,817	1,211	529	606	5,825
	9	606	1,058	1,817	1,211	529	606	5,825
	10	606	1,058	1,817	1,211	529	606	5,825
	Total	*6,055*	*10,576*	*18,167*	*12,106*	*5,288*	*6,055*	*58,248*
Long-Term	11	606	1,058	1,817	1,211	529	606	5,825
	12	606	1,058	1,817	1,211	529	606	5,825
	13	606	1,058	1,817	1,211	529	606	5,825
	14	606	1,058	1,817	1,211	529	606	5,825
	15	606	1,058	1,817	1,211	529	606	5,825
	16	606	1,058	1,817	1,211	529	606	5,825
	17	606	1,058	1,817	1,211	529	606	5,825
	18	606	1,058	1,817	1,211	529	606	5,825
	19	606	1,058	1,817	1,211	529	606	5,825
	20	606	1,058	1,817	1,211	529	606	5,825
	21	0	1,058	1,058	1,058	0	0	3,173
	22	0	1,058	1,058	1,058	0	0	3,173
	23	0	1,058	1,058	1,058	0	0	3,173
	24	0	1,058	1,058	1,058	0	0	3,173
	25	0	1,058	1,058	1,058	0	0	3,173
	26	0	1,058	1,058	1,058	0	0	3,173
	27	0	1,058	1,058	1,058	0	0	3,173
	28	0	1,058	1,058	1,058	0	0	3,173
	29	0	1,058	1,058	1,058	0	0	3,173
	30	0	1,058	1,058	1,058	0	0	3,173
	31	0	1,058	1,058	1,058	0	0	3,173

Annual Adoption (treated acres) Rates for Cropland BMPs, cont.								
	Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Adoption
Long Term	32	0	1,058	1,058	1,058	0	0	3,173
	33	0	1,058	1,058	1,058	0	0	3,173
	34	0	1,058	1,058	1,058	0	0	3,173
	35	0	1,058	1,058	1,058	0	0	3,173
	36	0	1,058	1,058	1,058	0	0	3,173
	37	0	1,058	1,058	1,058	0	0	3,173
	38	0	1,058	1,058	1,058	0	0	3,173
	39	0	1,058	1,058	1,058	0	0	3,173
	40	0	1,058	1,058	1,058	0	0	3,173
	Total	***12,111***	***42,303***	***57,486***	***45,364***	***10,576***	***12,111***	***179,949***

Table 41. Short, Medium and Long Term Goals for BMP Livestock Adoption Rates.

Annual Livestock BMP Adoption Rates						
	Year	Vegetative Filter Strip	Fenced Off Streams	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing
Short-Term	1	2	1	3	3	1
	2	2		3	3	1
	3	2	1	3	3	1
	4	2		3	3	1
	5	2	1	3	3	1
	Total	*10*	*3*	*15*	*15*	*5*
Medium-Term	6	2		3	3	1
	7	2	1	3	3	1
	8	2		3	3	1
	9	2	1	3	3	1
	10	2		3	3	1
	Total	*20*	*5*	*30*	*30*	*10*
Long-Term	11	2	1	3	3	1
	12	2		3	3	1
	13	2	1	3	3	1
	14	2		3	3	1
	15	2	1	3	3	1
	16	2		3	3	1
	17	2	1	3	3	1
	18	2		3	3	1
	19	2	1	3	3	1
	20	2		3	3	1

	Annual Livestock BMP Adoption Rates, cont.					
	Year	Vegetative Filter Strip	Fenced Off Streams	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing
Long Term	21	2	1	3	3	1
	22	2		3	3	1
	23	2	1	3	3	1
	24	2		3	3	1
	25	2	1	3	3	1
	26	2		3	3	1
	27	2	1	3	3	1
	28	2		3	3	1
	29	2	1	3	3	1
	30	2		3	3	1
	31	2	1	3	3	1
	32	2		3	3	1
	33	2	1	3	3	1
	34	2		3	3	1
	35	2	1	3	3	1
	36	2		3	3	1
	37	2	1	3	3	1
	38	2		3	3	1
	39	2	1	3	3	1
	40	2		3	3	1
	Total	*80*	*20*	*120*	*120*	*40*

Table 42. Short, Medium and Long Term Goals for Information and Education Adoption Rates.

	Year	Workshops, Tours and Field Days	One on One Technical Assistance	Scholarships for Conference Attendees	Educational Events	Educational Activities	Water Festival	BMP Auction	Contacts made by Tech Assistance
Short Term	1	7	10	10	3	2	1	1	250
	2	7	10	10	3	2	1	1	250
	3	7	10	10	3	2	1	1	250
	4	7	10	10	3	2	1	1	250
	5	7	10	10	3	2	1	1	250
		35	50	50	15	10	5	5	1,250

I&E Goals, cont.									
	Year	Workshops, Tours and Field Days	One on One Technical Assistance	Scholarships for Conference Attendees	Educational Events	Educational Activities	Water Festival	BMP Auction	Contacts made by Tech Assistance
Medium Term	6	7	10	10	3	2	1	1	250
	7	7	10	10	3	2	1	1	250
	8	7	10	10	3	2	1	1	250
	9	7	10	10	3	2	1	1	250
	10	7	10	10	3	2	1	1	250
		70	100	100	30	20	10	10	2,500
Long Term	11	7	10	10	3	2	1	1	250
	12	7	10	10	3	2	1	1	250
	13	7	10	10	3	2	1	1	250
	14	7	10	10	3	2	1	1	250
	15	7	10	10	3	2	1	1	250
	16	7	10	10	3	2	1	1	250
	17	7	10	10	3	2	1	1	250
	18	7	10	10	3	2	1	1	250
	19	7	10	10	3	2	1	1	250
	20	7	10	10	3	2	1	1	250
	21	7	10	10	3	2	1	1	250
	22	7	10	10	3	2	1	1	250
	23	7	10	10	3	2	1	1	250
	24	7	10	10	3	2	1	1	250
	25	7	10	10	3	2	1	1	250
	26	7	10	10	3	2	1	1	250
	27	7	10	10	3	2	1	1	250
	28	7	10	10	3	2	1	1	250
	29	7	10	10	3	2	1	1	250
	30	7	10	10	3	2	1	1	250
	31	7	10	10	3	2	1	1	250
	32	7	10	10	3	2	1	1	250
	33	7	10	10	3	2	1	1	250
	34	7	10	10	3	2	1	1	250

I&E Goals, cont.										
	Year	Workshops, Tours and Field Days	One on One Technical Assistance	Scholarships for Conference Attendees	Educational Events	Educational Activities	Water Festival	BMP Auction	Contacts made by Tech Assistance
Long Term	35	7	10	10	3	2	1	1	250
	36	7	10	10	3	2	1	1	250
	37	7	10	10	3	2	1	1	250
	38	7	10	10	3	2	1	1	250
	39	7	10	10	3	2	1	1	250
	40	7	10	10	3	2	1	1	250
	Total	*280*	*400*	*400*	*120*	*80*	*40*	*40*	*10,000*

10.2 Benchmarks to Measure Water Quality and Social Progress

Over a forty 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, grassed waterways and terraces installed in the Cropland Targeted Area indicating that there would be a reduction in sediment into John Redmond Reservoir	NRCS

Benchmarks, cont.		
Impairment Addressed	**Criteria to Measure Water Quality Progress**	**Information Source**
Sediment, cont.	Secchi Disc depth in John Redmond Reservoir > 0.5 meters	KDHE
	Target storage in John Redmond Reservoir 65,000 acre feet in 2014	COE
	Reduction in streambank and farmland loss along the Cottonwood River	KWO
	Reduced number of gullies on upland cropland and rangeland areas	NRCS
	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 and in the vicinity of Emporia	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
	No nuisance blooms on the Cottonwood River or its shoreline	KDHE
	Total Nitrogen concentration in John Redmond Reservoir < 0.62 mg.L	KDHE
	Continued availability of use of surface water sources for public water supply	KDHE/DWR
E. coli bacteria	Number of livestock that have been relocated from close proximity to a stream indicating that there would be a reduction in *E. coli* bacteria into John Redmond Reservoir	Watershed Specialist
	No violations of bacteria criteria on primary recreation on the Cottonwood River	KDHE
	Reduced incidence of high bacteria during wet weather on Mud Creek	KDHE
Impairment Addressed	**Social Indicators to Measure Water Quality Progress**	**Information Source**
Sediment Nutrients *E. coli* 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 and along the Cottonwood River	KDWP
	Economic indicators indicating effect of John Redmond Reservoir's impact on local businesses	Coffey County Economic Development
	Improved crop yields for farms along the Cottonwood River	KSRE
	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

10.3 Phosphorus and Sediment Milestones

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 in the priority sub watersheds in the upper and lower portions of the Cottonwood River watershed, as well as along the river itself. It is estimated that it will require five years to see progress of phosphorus and sediment reduction after BMP implementation in the critical areas within those priority sub watersheds. KDHE has outlined water quality milestones for total phosphorus and total suspended solids. These goals are presented below for the upper and lower portions of the Cottonwood watershed.

10.3.1 Short Term Water Quality Milestones

10.3.1.A Phosphorus and Sediment

Table 43. Reduction Needed for TP and TSS.

	Current Condition (2000-2010) Median TP	Improved Condition (2011 – 2015) Median TP	Reduction Needed	Current Condition (2000-2010) 75% TSS	Improved Condition (2011 – 2015) 75% TSS	Reduction Needed
Sampling Site	**Total Phosphorus (median of data collected during indicated period), ppb**			**Total Suspended Solids (upper quartile of data collected during indicated period), ppm**		
UPPER COTTONWOOD						
Doyle Creek	70 ppb	66 ppb	6%	22 ppm	13 ppm	41%
South Cottonwood River	246 ppb	211 ppb	14%	33 ppm	30 ppm	9%
Mud Creek	165 ppb	128 ppb	22%	35 ppm	28 ppm	20%
Clear Creek	98 ppb	93 ppb	5%	43 ppm	37 ppm	14%
Cottonwood River at Elmdale	154 ppb	140 ppb	9%	97 ppm	72 ppm	26%
Cottonwood River at Plymouth	144 ppb	130 ppb	10%	78 ppm	70 ppm	10%
LOWER COTTONWOOD						
Cottonwood River at Emporia	487 ppb	370 ppb	24%	83 ppm	70 ppm	16%

10.3.1.B E. coli Bacteria on Mud Creek

A TMDL addressing excessive bacteria on Mud Creek was developed and approved in December, 2002. At the time, the bacteria indicator was FCB and the desired endpoint was 900 colonies per 100 ml during the primary recreation season of April through October. During the off-season between November and March, the criterion rose to 2000 colonies per 100 ml.

In 2003, the water quality standards for bacteria and recreation were changed. *E coli* bacteria became the indicator, Mud Creek was designated for Primary "C" recreation and, thus, the criterion was changed to 427 colonies per 100 ml for April through October and 3843 colonies per 100 ml during the winter. The criterion is assessed as a geometric mean of five samples taken within a 30-day period.

In 2007, Mud Creek was sampled intensively in the manner prescribed by the water quality standards. On four occasions of differing weather and flow conditions, the creek was sampled five (once six times) times within a 3-4 week period. The geometric mean of the samples was computed for each sampling occasion and the creek exceeded the primary recreation season criteria twice, violating the water quality standards. Numerous individual samples exceeded the nominal value of the criterion (427 counts), and even when discounting the weight of any individual sample, persistently high bacteria levels have been present.

KDHE now utilizes the routine (bimonthly to quarterly) sampling of bacteria to gage the likelihood of bacteria levels exceeding the criterion. The individual samples from routine monitoring were combined with the intensive collections of 2007 (April through October only). An index was computed as the natural logarithm of the sample value divided by the natural logarithm of the criterion (427). An index value of one or less indicated meeting the face value of the water quality standard for bacteria. A cumulative frequency curve was drawn for the index values. The desired endpoint is for the majority (> 90%) of the curve to lie below one.

As can be seen by the index profile for Mud Creek below, while two-thirds of the samples are below the criterion, the frequency of excursions over the criterion is too high. Therefore, the milestone for Mud Creek bacteria over the next five years will be a reduction in the index profile below the current profile line. The future profile may not yet meet the desired line, but it should begin to approach it with an increasing number of samples with E coli bacteria counts less than 427 during April through October.

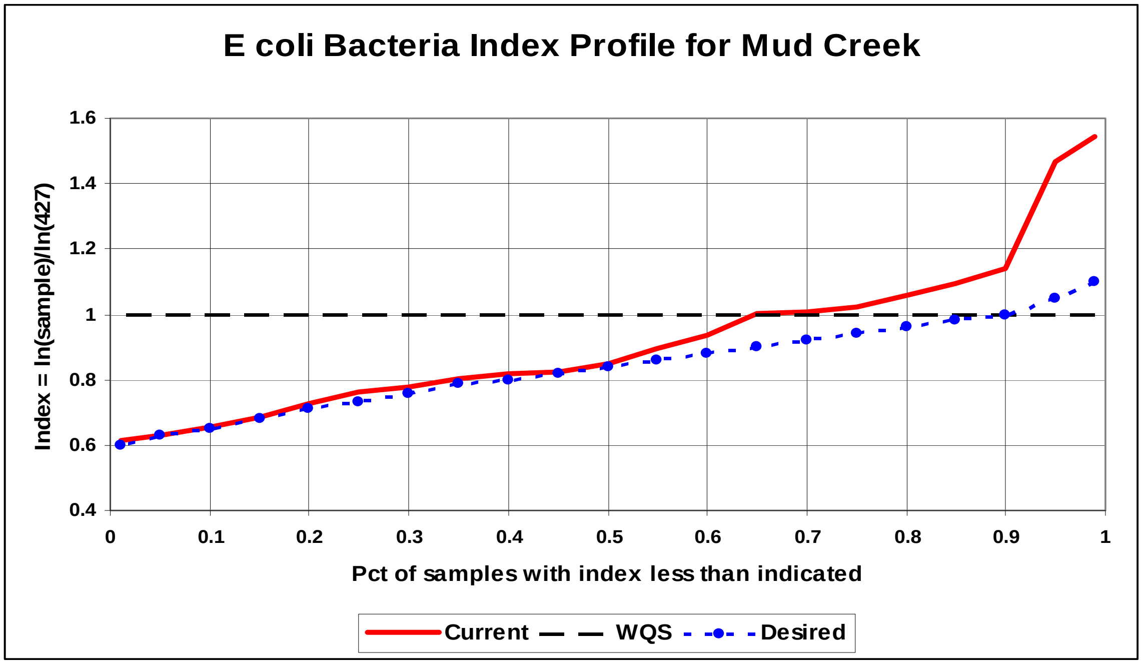


Figure 39. *E. coli* Bacteria Index for Mud Creek.

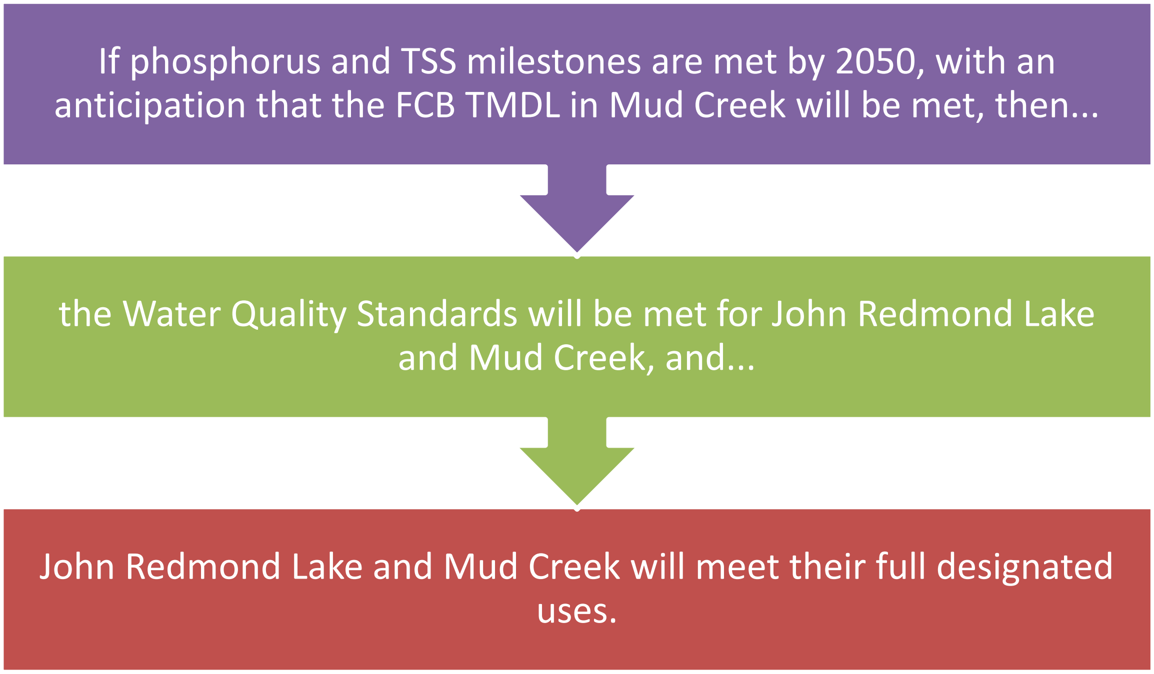
10.3.2 Mid Term Water Quality Milestones

The expectation of midterm water quality milestones is that the improved water quality from the short term milestones would continue to trend toward improvement over the midterm life of the plan.

10.3.3 Long Term Water Quality Milestones

The long-term water quality goal associated with the bacteria impairment in Mud Creek is the achievement of an ECB index below one for 90 percent of the samples based on the Primary Contact Recreation C Index, which is based on 427 cfus (colony forming units)/100 ml of water. The goal is to reduce both the magnitude and frequency of the bacteria impairment in order to meet the water quality standards for Mud Creek.

Long term water quality milestones at the end of the plan will constitute that the water quality standards for all waterways will be met, and therefore, the 30 percent reduction goals for phosphorus and sediment will be accomplished.


If phosphorus and TSS milestones are met by 2050, with an anticipation that the FCB TMDL in Mud Creek will be met, then...
the Water Quality Standards will be met for John Redmond Lake and Mud Creek, and...
John Redmond Lake and Mud Creek will meet their full designated uses.

10.3.4 BMP Implementation Milestones from 2010 to 2050

The SLT will review the number of acres, projects or contacts made in the watershed at the end of five, ten and forty years (2050). 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 forty year period.

Table 44. BMP Implementation Milestones from 2010 to 2050.

Cumulative Total													
	Cropland, acres						Livestock, number of projects					Information and Education, number	
Year	Conservation Crop Rotation	Grassed Waterways	No-Till	Buffers	Terraces	Permanent Vegetation	Vegetative Filter Strip	Fence off Stream	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing	Workshops and Field Days	Contacts made
2011	606	1,058	1,817	1,211	529	606	2	1	3	3	1	7	250
2012	606	1,058	1,817	1,211	529	606	2		3	3	1	7	250
2013	606	1,058	1,817	1,211	529	606	2	1	3	3	1	7	250
2014	606	1,058	1,817	1,211	529	606	2		3	3	1	7	250
2015	606	1,058	1,817	1,211	529	606	2	1	3	3	1	7	250
Total	**3,030**	**5,290**	**9,085**	**6,055**	**2,645**	**3,030**	***10***	***3***	***15***	***15***	***5***	***35***	***1,250***
2016	606	1,058	1,817	1,211	529	606	2		3	3	1	7	250
2017	606	1,058	1,817	1,211	529	606	2	1	3	3	1	7	250
2018	606	1,058	1,817	1,211	529	606	2		3	3	1	7	250
2019	606	1,058	1,817	1,211	529	606	2	1	3	3	1	7	250
2020	606	1,058	1,817	1,211	529	606	2		3	3	1	7	250
Total	**6,060**	**10,580**	**18,170**	**12,110**	**5,290**	**6,060**	***20***	***5***	***30***	***30***	***10***	***70***	***2,500***

Cumulative Total, cont.												
	Cropland, acres						Livestock, number of projects					Information and Education, number	
Year	Conservation Crop Rotation	Grassed Waterways	No-Till	Buffers	Terraces	Permanent Vegetation	Vegetative Filter Strip	Fence off Stream	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing	Workshops and Field Days	Contacts made
2021	606	1,058	1,817	1,211	529	606	2	1	3	3	1	7	250
2022	606	1,058	1,817	1,211	529	606	2		3	3	1	7	250
2023	606	1,058	1,817	1,211	529	606	2	1	3	3	1	7	250
2024	606	1,058	1,817	1,211	529	606	2		3	3	1	7	250
2025	606	1,058	1,817	1,211	529	606	2	1	3	3	1	7	250
2026	606	1,058	1,817	1,211	529	606	2		3	3	1	7	250
2027	606	1,058	1,817	1,211	529	606	2	1	3	3	1	7	250
2028	606	1,058	1,817	1,211	529	606	2		3	3	1	7	250
2029	606	1,058	1,817	1,211	529	606	2	1	3	3	1	7	250
2030	606	1,058	1,817	1,211	529	606	2		3	3	1	7	250
2031	0	1,058	1,058	1,058	0	0	2	1	3	3	1	7	250
2032	0	1,058	1,058	1,058	0	0	2		3	3	1	7	250
2033	0	1,058	1,058	1,058	0	0	2	1	3	3	1	7	250
2034	0	1,058	1,058	1,058	0	0	2		3	3	1	7	250
2035	0	1,058	1,058	1,058	0	0	2	1	3	3	1	7	250
2036	0	1,058	1,058	1,058	0	0	2		3	3	1	7	250
2037	0	1,058	1,058	1,058	0	0	2	1	3	3	1	7	250
2038	0	1,058	1,058	1,058	0	0	2		3	3	1	7	250
2039	0	1,058	1,058	1,058	0	0	2	1	3	3	1	7	250
2040	0	1,058	1,058	1,058	0	0	2		3	3	1	7	250

Cumulative Total, cont.													
	Cropland, acres						Livestock, number of projects					Information and Education, number	
Year	Conservation Crop Rotation	Grassed Waterways	No-Till	Buffers	Terraces	Permanent Vegetation	Vegetative Filter Strip	Fence off Stream	Relocate Pasture Feeding Site	Off Stream Watering System	Rotational Grazing	Workshops and Field Days	Contacts made
2041	0	1,058	1,058	1,058	0	0	2	1	3	3	1	7	250
2042	0	1,058	1,058	1,058	0	0	2		3	3	1	7	250
2043	0	1,058	1,058	1,058	0	0	2	1	3	3	1	7	250
2044	0	1,058	1,058	1,058	0	0	2		3	3	1	7	250
2045	0	1,058	1,058	1,058	0	0	2	1	3	3	1	7	250
2046	0	1,058	1,058	1,058	0	0	2		3	3	1	7	250
2047	0	1,058	1,058	1,058	0	0	2	1	3	3	1	7	250
2048	0	1,058	1,058	1,058	0	0	2		3	3	1	7	250
2049	0	1,058	1,058	1,058	0	0	2	1	3	3	1	7	250
2050	0	1,058	1,058	1,058	0	0	2		3	3	1	7	250
Total	**12,120**	**42,320**	**57,500**	**45,380**	**10,580**	**12,120**	***80***	***20***	***120***	***120***	***40***	***280***	***10,000***

11.0 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 no-till.

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. This data will be of interest to the SLT when analyzing the effectiveness of BMP placement.

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 Cottonwood River drainage and in John Redmond Reservoir.

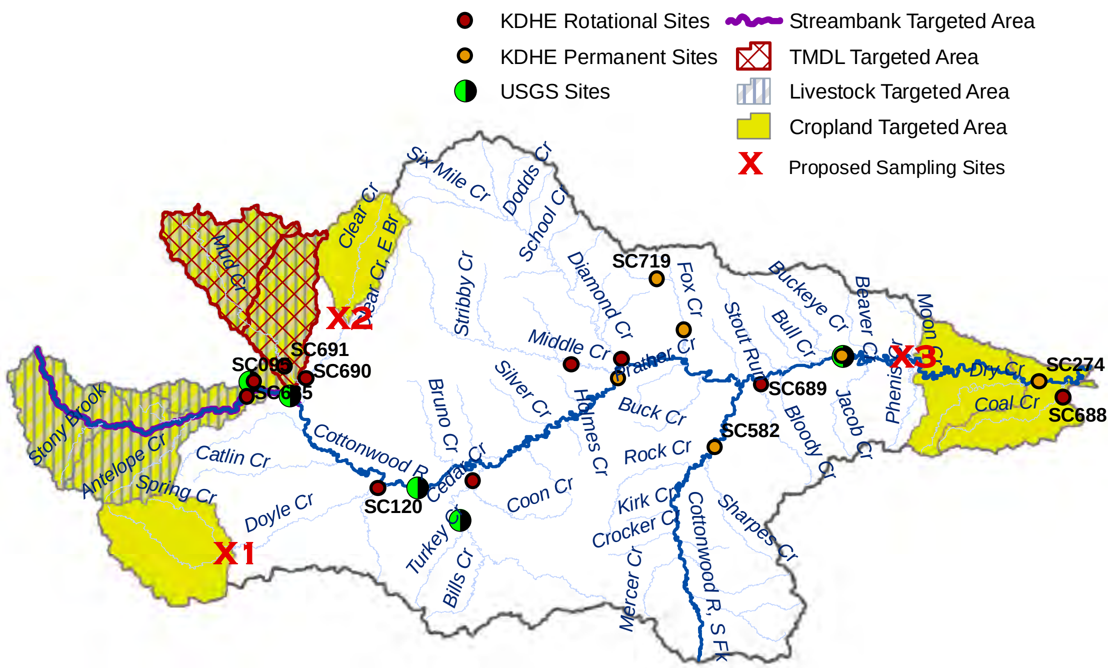


Figure 40. Monitoring Sites in the Watershed with Proposed Sites. [39]

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. KDHE will be requested to provide additional monitoring sites needing to be installed. The cost and implementation of these sites will be dependent on funding.

Table 45. Monitoring Sites and Tests Needed to Direct the SLT in Water Quality Evaluations.

Cropland Targeted Area				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
KDHE	691	Sediment, Phosphorus	Mud Creek	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	095	Sediment, Phosphorus	Cottonwood River	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	635	Sediment, Phosphorus	South Cottonwood River	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	274	Sediment, Phosphorus	Cottonwood River	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen

Cropland Targeted Area, cont.				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
KDHE	688	Sediment, Phosphorus	Coal Creek	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site **X1** (refer to map above)	Sediment, Phosphorus	Doyle Creek	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site **X2** (refer to map above)	Sediment, Phosphorus	Clear Creek	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	Proposed Site **X3** (refer to map above)	Sediment, Phosphorus	Cottonwood River	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
Livestock Targeted Area				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
KDHE	691	Phosphorus	Mud Creek	pH, DO, Phosphorus, Nitrogen
KDHE	095	Phosphorus	Cottonwood River	pH, DO, Phosphorus, Nitrogen
KDHE	635	Phosphorus	South Cottonwood River	pH, DO, Phosphorus, Nitrogen
Streambank Targeted Area				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
KDHE	627	Sediment, Phosphorus	Cottonwood River	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	275	Sediment, Phosphorus	Cottonwood River	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	274	Sediment, Phosphorus	Cottonwood River	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen
KDHE	095	Sediment, Phosphorus	Cottonwood River below Marion Lake Dam	Turbidity, TSS, pH, DO, Phosphorus, Nitrogen

High Priority TMDL Targeted Area				
Agency	**Site Number or Name**	**Pollutant Target**	**River, Stream or Lake**	**Sampling Tests Needed**
KDHE	691	*E. coli* bacteria	Mud Creek	*E. coli* bacteria

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 sites691, 095 and 635 for sediment and nutrient determination for the upper section of the targeted area. The lower section of the targeted area can utilize KDHE sampling sites 274 and 688. Portions of the upper section of the cropland targeted area could benefit with additional monitoring on streams directly exiting the targeted area:
  - Site X1 - Doyle Creek as it exits the targeted area.
  - Site X2 – Clear Creek as it exits the targeted area.
  - Site X3 – Cottonwood River as it enters the targeted area.
- The *Livestock Targeted Area* can utilize the same existing sampling sites as the cropland monitoring sites. These are site numbers 691, 095 and 635. These sampling sites should be sufficient since it drains the entire targeted area.
- The *Streambank Targeted Area* can utilize sampling site numbers 627, 275, 274, and 095.
- The High Priority Targeted Area will utilize KDHE site number 691 on Mud Creek to test for *E. coli* bacteria.

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 from John Redmond Reservoir 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 Cottonwood 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.

12.0 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.
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.
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, COE 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.

13.0 Appendix

13.1 Service Providers

Table 46. Potential Service Provider Listing.

Organization	Programs	Purpose	Technical or Financial Assistance	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	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	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	www.kaws.org

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Website address
Kansas Association for Conservation and Environmental Education	Project Learning Tree WILD & WILD Aquatic WET Leopold Education Project	Promotes and provides effective, non-biased and science-based environmental education to all Kansas.	Technical	www.kacee.org
Kansas Dept. of Agriculture	Watershed structures permitting.	Available for watershed districts and multipurpose small lakes development.	Technical and Financial	www.accesskansas.org/kda
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	www.kdheks.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	www.kdwp.state.ks.us/

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	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	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	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	www.krwa.net

Kansas State Research and Extension	Water Quality Programs, Waste Management Programs	Provide programs, expertise and educational materials that relate to minimizing the impact of rural and urban activities on water quality.	Technical	www.ksre.ksu.edu
	Kansas Center for Agricultural Resources and Environment (KCARE)	Educational program to develop leadership for improved water quality.		
	Kansas Environmental Leadership Program (KELP)	Provide guidance to local governments on water protection programs.		
	Kansas Local Government Water Quality Planning and Management	Reduce non-point source pollution emanating from Kansas grasslands.		
	Rangeland and Natural Area Services (RNAS)	Service-learning projects available to college and university faculty and community watersheds in Kansas.		
	WaterLINK	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.		
	Kansas Pride: Healthy Ecosystems/Healthy Communities	Education combined with volunteer soil and water testing for enhanced natural resource stewardship.		
	Citizen Science			

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Website address
Kansas Water Office	Public Information and Education	Provide information and education to the public on Kansas Water Resources	Technical and Financial	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	www.notill.org

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	Website address
Division of Conservation and Conservation Districts	Water Resources Cost Share	Provide cost share assistance to landowners for establishment of water conservation practices.	Technical and Financial	www.ksda.gov/doc/ www.kacdnet.org
	Nonpoint Source Pollution Control Fund	Provides financial assistance for nonpoint pollution control projects which help restore water quality.		
	Riparian and Wetland Protection Program	Funds to assist with wetland and riparian development and enhancement.		
	Stream Rehabilitation Program	Assist with streams that have been adversely altered by channel modifications.		
	Kansas Water Quality Buffer Initiative	Compliments Conservation Reserve Program by offering additional financial incentives for grass filters and riparian forest buffers.		
	Watershed district and multipurpose lakes	Programs are available for watershed district and multipurpose small lakes.		

Organization	Programs and Technical Assistance	Purpose	Technical or Financial Assistance	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	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	www.fws.gov
US Geological Survey	National Streamflow Information Program Water Cooperative Program	Provide streamflow data Provide cooperative studies and water-quality information	Technical	ks.water.usgs.gov Nrtwq.usgs.gov

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

13.2 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.

13.3 Sub Watershed Tables

13.3.1 Load Reduction Rates by Sub Watershed

Table 47. Sediment Reduction Rates by Sub Watershed.

Sub Watershed #15 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	12	37	104	46	14	44	257
2	23	74	208	93	28	88	514
3	35	111	312	139	42	132	770
4	46	148	416	185	56	176	1,027
5	58	185	520	231	69	220	1,284
6	69	222	625	278	83	264	1,541
7	81	259	729	324	97	308	1,797
8	93	296	833	370	111	352	2,054
9	104	333	937	416	125	396	2,311
10	116	370	1,041	463	139	440	2,568
11	127	407	1,145	509	153	483	2,824
12	139	444	1,249	555	167	527	3,081
13	150	481	1,353	601	180	571	3,338
14	162	518	1,457	648	194	615	3,595
15	173	555	1,561	694	208	659	3,852
16	185	592	1,666	740	222	703	4,108
17	197	629	1,770	786	236	747	4,365
18	208	666	1,874	833	250	791	4,622
19	220	703	1,978	879	264	835	4,879
20	231	740	2,082	925	278	879	5,135
21	231	777	2,151	972	278	879	5,288
22	231	814	2,221	1,018	278	879	5,441
23	231	851	2,290	1,064	278	879	5,593
24	231	888	2,359	1,110	278	879	5,746
25	231	925	2,429	1,157	278	879	5,899
26	231	962	2,498	1,203	278	879	6,051
27	231	999	2,568	1,249	278	879	6,204
28	231	1,036	2,637	1,295	278	879	6,357
29	231	1,073	2,706	1,342	278	879	6,509
30	231	1,110	2,776	1,388	278	879	6,662
31	231	1,147	2,845	1,434	278	879	6,815
32	231	1,184	2,915	1,480	278	879	6,967

33	231	1,221	2,984	1,527	278	879	7,120
34	231	1,258	3,053	1,573	278	879	7,273
35	231	1,295	3,123	1,619	278	879	7,425
36	231	1,332	3,192	1,666	278	879	7,578
37	231	1,369	3,262	1,712	278	879	7,731
38	231	1,406	3,331	1,758	278	879	7,883
39	231	1,443	3,400	1,804	278	879	8,036
40	231	1,480	3,470	1,851	278	879	8,189

Sub Watershed #16 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	26	84	237	105	32	100	584
2	53	168	474	211	63	200	1,169
3	79	253	711	316	95	300	1,753
4	105	337	948	421	126	400	2,338
5	132	421	1,185	527	158	500	2,922
6	158	505	1,422	632	190	600	3,507
7	184	590	1,659	737	221	700	4,091
8	211	674	1,895	842	253	800	4,675
9	237	758	2,132	948	284	900	5,260
10	263	842	2,369	1,053	316	1,000	5,844
11	290	927	2,606	1,158	347	1,100	6,429
12	316	1,011	2,843	1,264	379	1,200	7,013
13	342	1,095	3,080	1,369	411	1,300	7,598
14	369	1,179	3,317	1,474	442	1,401	8,182
15	395	1,264	3,554	1,580	474	1,501	8,766
16	421	1,348	3,791	1,685	505	1,601	9,351
17	448	1,432	4,028	1,790	537	1,701	9,935
18	474	1,516	4,265	1,895	569	1,801	10,520
19	500	1,601	4,502	2,001	600	1,901	11,104
20	527	1,685	4,739	2,106	632	2,001	11,689
21	527	1,769	4,897	2,211	632	2,001	12,036
22	527	1,853	5,055	2,317	632	2,001	12,384
23	527	1,938	5,212	2,422	632	2,001	12,731
24	527	2,022	5,370	2,527	632	2,001	13,079
25	527	2,106	5,528	2,633	632	2,001	13,426
26	527	2,190	5,686	2,738	632	2,001	13,774
27	527	2,275	5,844	2,843	632	2,001	14,121
28	527	2,359	6,002	2,948	632	2,001	14,469
29	527	2,443	6,160	3,054	632	2,001	14,816
30	527	2,527	6,318	3,159	632	2,001	15,164

31	527	2,612	6,476	3,264	632	2,001	15,511
32	527	2,696	6,634	3,370	632	2,001	15,859
33	527	2,780	6,792	3,475	632	2,001	16,206
34	527	2,864	6,950	3,580	632	2,001	16,554
35	527	2,948	7,108	3,686	632	2,001	16,901
36	527	3,033	7,266	3,791	632	2,001	17,249
37	527	3,117	7,424	3,896	632	2,001	17,596
38	527	3,201	7,582	4,002	632	2,001	17,944
39	527	3,285	7,740	4,107	632	2,001	18,291
40	527	3,370	7,898	4,212	632	2,001	18,639

Sub Watershed #25 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	7	0	65	29	0	28	129
2	15	0	131	58	0	55	259
3	22	0	196	87	0	83	388
4	29	0	262	116	0	110	517
5	36	0	327	145	0	138	647
6	44	0	392	174	0	166	776
7	51	0	458	203	0	193	905
8	58	0	523	233	0	221	1,035
9	65	0	588	262	0	248	1,164
10	73	0	654	291	0	276	1,293
11	80	0	719	320	0	304	1,422
12	87	0	785	349	0	331	1,552
13	94	0	850	378	0	359	1,681
14	102	0	915	407	0	386	1,810
15	109	0	981	436	0	414	1,940
16	116	0	1,046	465	0	442	2,069
17	123	0	1,112	494	0	469	2,198
18	131	0	1,177	523	0	497	2,328
19	138	0	1,242	552	0	524	2,457
20	145	0	1,308	581	0	552	2,586
21	145	0	1,308	581	0	552	2,586
22	145	0	1,308	581	0	552	2,586
23	145	0	1,308	581	0	552	2,586
24	145	0	1,308	581	0	552	2,586
25	145	0	1,308	581	0	552	2,586
26	145	0	1,308	581	0	552	2,586
27	145	0	1,308	581	0	552	2,586
28	145	0	1,308	581	0	552	2,586

29	145	0	1,308	581	0	552	2,586
30	145	0	1,308	581	0	552	2,586
31	145	0	1,308	581	0	552	2,586
32	145	0	1,308	581	0	552	2,586
33	145	0	1,308	581	0	552	2,586
34	145	0	1,308	581	0	552	2,586
35	145	0	1,308	581	0	552	2,586
36	145	0	1,308	581	0	552	2,586
37	145	0	1,308	581	0	552	2,586
38	145	0	1,308	581	0	552	2,586
39	145	0	1,308	581	0	552	2,586
40	145	0	1,308	581	0	552	2,586

Sub Watershed #28 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	7	0	63	28	0	27	125
2	14	0	127	56	0	54	251
3	21	0	190	84	0	80	376
4	28	0	254	112	0	107	501
5	35	0	317	140	0	134	627
6	42	0	381	168	0	161	752
7	49	0	444	196	0	188	877
8	56	0	508	224	0	214	1,003
9	63	0	571	252	0	241	1,128
10	71	0	635	280	0	268	1,253
11	78	0	698	308	0	295	1,379
12	85	0	762	336	0	321	1,504
13	92	0	825	364	0	348	1,629
14	99	0	889	392	0	375	1,754
15	106	0	952	420	0	402	1,880
16	113	0	1,016	448	0	429	2,005
17	120	0	1,079	476	0	455	2,130
18	127	0	1,143	504	0	482	2,256
19	134	0	1,206	532	0	509	2,381
20	141	0	1,270	560	0	536	2,506
21	141	0	1,270	560	0	536	2,506
22	141	0	1,270	560	0	536	2,506
23	141	0	1,270	560	0	536	2,506
24	141	0	1,270	560	0	536	2,506
25	141	0	1,270	560	0	536	2,506
26	141	0	1,270	560	0	536	2,506

27	141	0	1,270	560	0	536	2,506
28	141	0	1,270	560	0	536	2,506
29	141	0	1,270	560	0	536	2,506
30	141	0	1,270	560	0	536	2,506
31	141	0	1,270	560	0	536	2,506
32	141	0	1,270	560	0	536	2,506
33	141	0	1,270	560	0	536	2,506
34	141	0	1,270	560	0	536	2,506
35	141	0	1,270	560	0	536	2,506
36	141	0	1,270	560	0	536	2,506
37	141	0	1,270	560	0	536	2,506
38	141	0	1,270	560	0	536	2,506
39	141	0	1,270	560	0	536	2,506
40	141	0	1,270	560	0	536	2,506

Sub Watershed #31 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	18	58	164	73	22	69	405
2	36	117	328	146	44	139	809
3	55	175	492	219	66	208	1,214
4	73	233	656	292	87	277	1,618
5	91	292	820	364	109	346	2,023
6	109	350	984	437	131	416	2,427
7	128	408	1,148	510	153	485	2,832
8	146	467	1,312	583	175	554	3,237
9	164	525	1,476	656	197	623	3,641
10	182	583	1,640	729	219	693	4,046
11	200	641	1,804	802	241	762	4,450
12	219	700	1,968	875	262	831	4,855
13	237	758	2,132	948	284	900	5,259
14	255	816	2,296	1,021	306	970	5,664
15	273	875	2,460	1,093	328	1,039	6,069
16	292	933	2,624	1,166	350	1,108	6,473
17	310	991	2,788	1,239	372	1,177	6,878
18	328	1,050	2,952	1,312	394	1,247	7,282
19	346	1,108	3,116	1,385	416	1,316	7,687
20	364	1,166	3,280	1,458	437	1,385	8,091
21	364	1,225	3,390	1,531	437	1,385	8,332
22	364	1,283	3,499	1,604	437	1,385	8,572
23	364	1,341	3,608	1,677	437	1,385	8,813
24	364	1,400	3,718	1,749	437	1,385	9,054

25	364	1,458	3,827	1,822	437	1,385	9,294
26	364	1,516	3,936	1,895	437	1,385	9,535
27	364	1,575	4,046	1,968	437	1,385	9,775
28	364	1,633	4,155	2,041	437	1,385	10,016
29	364	1,691	4,264	2,114	437	1,385	10,256
30	364	1,749	4,374	2,187	437	1,385	10,497
31	364	1,808	4,483	2,260	437	1,385	10,737
32	364	1,866	4,592	2,333	437	1,385	10,978
33	364	1,924	4,702	2,406	437	1,385	11,219
34	364	1,983	4,811	2,478	437	1,385	11,459
35	364	2,041	4,920	2,551	437	1,385	11,700
36	364	2,099	5,030	2,624	437	1,385	11,940
37	364	2,158	5,139	2,697	437	1,385	12,181
38	364	2,216	5,248	2,770	437	1,385	12,421
39	364	2,274	5,358	2,843	437	1,385	12,662
40	364	2,333	5,467	2,916	437	1,385	12,902

Sub Watershed #33 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	10	31	88	39	12	37	218
2	20	63	177	79	24	75	436
3	29	94	265	118	35	112	654
4	39	126	353	157	47	149	872
5	49	157	442	196	59	186	1,090
6	59	188	530	236	71	224	1,307
7	69	220	618	275	82	261	1,525
8	79	251	707	314	94	298	1,743
9	88	283	795	353	106	336	1,961
10	98	314	883	393	118	373	2,179
11	108	346	972	432	130	410	2,397
12	118	377	1,060	471	141	448	2,615
13	128	408	1,148	510	153	485	2,833
14	137	440	1,237	550	165	522	3,051
15	147	471	1,325	589	177	559	3,269
16	157	503	1,413	628	188	597	3,487
17	167	534	1,502	667	200	634	3,704
18	177	565	1,590	707	212	671	3,922
19	186	597	1,678	746	224	709	4,140
20	196	628	1,767	785	236	746	4,358
21	196	660	1,826	825	236	746	4,488
22	196	691	1,885	864	236	746	4,617

23	196	722	1,943	903	236	746	4,747
24	196	754	2,002	942	236	746	4,876
25	196	785	2,061	982	236	746	5,006
26	196	817	2,120	1,021	236	746	5,136
27	196	848	2,179	1,060	236	746	5,265
28	196	879	2,238	1,099	236	746	5,395
29	196	911	2,297	1,139	236	746	5,524
30	196	942	2,356	1,178	236	746	5,654
31	196	974	2,415	1,217	236	746	5,783
32	196	1,005	2,474	1,256	236	746	5,913
33	196	1,037	2,532	1,296	236	746	6,042
34	196	1,068	2,591	1,335	236	746	6,172
35	196	1,099	2,650	1,374	236	746	6,302
36	196	1,131	2,709	1,413	236	746	6,431
37	196	1,162	2,768	1,453	236	746	6,561
38	196	1,194	2,827	1,492	236	746	6,690
39	196	1,225	2,886	1,531	236	746	6,820
40	196	1,256	2,945	1,571	236	746	6,949

Sub Watershed #35 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	35	112	316	140	42	133	779
2	70	224	631	281	84	267	1,557
3	105	337	947	421	126	400	2,336
4	140	449	1,262	561	168	533	3,114
5	175	561	1,578	701	210	666	3,893
6	210	673	1,894	842	252	800	4,671
7	245	786	2,209	982	295	933	5,450
8	281	898	2,525	1,122	337	1,066	6,228
9	316	1,010	2,841	1,262	379	1,199	7,007
10	351	1,122	3,156	1,403	421	1,333	7,785
11	386	1,234	3,472	1,543	463	1,466	8,564
12	421	1,347	3,787	1,683	505	1,599	9,342
13	456	1,459	4,103	1,824	547	1,732	10,121
14	491	1,571	4,419	1,964	589	1,866	10,899
15	526	1,683	4,734	2,104	631	1,999	11,678
16	561	1,795	5,050	2,244	673	2,132	12,456
17	596	1,908	5,365	2,385	715	2,265	13,235
18	631	2,020	5,681	2,525	757	2,399	14,013
19	666	2,132	5,997	2,665	800	2,532	14,792
20	701	2,244	6,312	2,805	842	2,665	15,570

21	701	2,357	6,523	2,946	842	2,665	16,033
22	701	2,469	6,733	3,086	842	2,665	16,496
23	701	2,581	6,943	3,226	842	2,665	16,959
24	701	2,693	7,154	3,367	842	2,665	17,422
25	701	2,805	7,364	3,507	842	2,665	17,885
26	701	2,918	7,575	3,647	842	2,665	18,348
27	701	3,030	7,785	3,787	842	2,665	18,810
28	701	3,142	7,996	3,928	842	2,665	19,273
29	701	3,254	8,206	4,068	842	2,665	19,736
30	701	3,367	8,416	4,208	842	2,665	20,199
31	701	3,479	8,627	4,348	842	2,665	20,662
32	701	3,591	8,837	4,489	842	2,665	21,125
33	701	3,703	9,048	4,629	842	2,665	21,588
34	701	3,815	9,258	4,769	842	2,665	22,051
35	701	3,928	9,468	4,910	842	2,665	22,514
36	701	4,040	9,679	5,050	842	2,665	22,977
37	701	4,152	9,889	5,190	842	2,665	23,439
38	701	4,264	10,100	5,330	842	2,665	23,902
39	701	4,376	10,310	5,471	842	2,665	24,365
40	701	4,489	10,520	5,611	842	2,665	24,828

Sub Watershed #38 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	30	96	271	120	36	114	668
2	60	193	542	241	72	229	1,336
3	90	289	813	361	108	343	2,004
4	120	385	1,083	481	144	457	2,672
5	150	481	1,354	602	181	572	3,340
6	181	578	1,625	722	217	686	4,008
7	211	674	1,896	843	253	800	4,676
8	241	770	2,167	963	289	915	5,345
9	271	867	2,438	1,083	325	1,029	6,013
10	301	963	2,708	1,204	361	1,144	6,681
11	331	1,059	2,979	1,324	397	1,258	7,349
12	361	1,156	3,250	1,444	433	1,372	8,017
13	391	1,252	3,521	1,565	469	1,487	8,685
14	421	1,348	3,792	1,685	506	1,601	9,353
15	451	1,444	4,063	1,806	542	1,715	10,021
16	481	1,541	4,333	1,926	578	1,830	10,689
17	512	1,637	4,604	2,046	614	1,944	11,357
18	542	1,733	4,875	2,167	650	2,058	12,025

19	572	1,830	5,146	2,287	686	2,173	12,693
20	602	1,926	5,417	2,407	722	2,287	13,361
21	602	2,022	5,597	2,528	722	2,287	13,759
22	602	2,119	5,778	2,648	722	2,287	14,156
23	602	2,215	5,958	2,769	722	2,287	14,553
24	602	2,311	6,139	2,889	722	2,287	14,950
25	602	2,407	6,320	3,009	722	2,287	15,347
26	602	2,504	6,500	3,130	722	2,287	15,745
27	602	2,600	6,681	3,250	722	2,287	16,142
28	602	2,696	6,861	3,370	722	2,287	16,539
29	602	2,793	7,042	3,491	722	2,287	16,936
30	602	2,889	7,222	3,611	722	2,287	17,334
31	602	2,985	7,403	3,732	722	2,287	17,731
32	602	3,082	7,583	3,852	722	2,287	18,128
33	602	3,178	7,764	3,972	722	2,287	18,525
34	602	3,274	7,945	4,093	722	2,287	18,922
35	602	3,370	8,125	4,213	722	2,287	19,320
36	602	3,467	8,306	4,333	722	2,287	19,717
37	602	3,563	8,486	4,454	722	2,287	20,114
38	602	3,659	8,667	4,574	722	2,287	20,511
39	602	3,756	8,847	4,695	722	2,287	20,909
40	602	3,852	9,028	4,815	722	2,287	21,306

Sub Watershed #55 Annual Soil Erosion Reduction (tons), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	30	95	268	119	36	113	660
2	59	190	535	238	71	226	1,320
3	89	285	803	357	107	339	1,980
4	119	381	1,070	476	143	452	2,640
5	149	476	1,338	595	178	565	3,300
6	178	571	1,605	714	214	678	3,960
7	208	666	1,873	832	250	791	4,620
8	238	761	2,141	951	285	904	5,280
9	268	856	2,408	1,070	321	1,017	5,940
10	297	951	2,676	1,189	357	1,130	6,600
11	327	1,047	2,943	1,308	392	1,243	7,260
12	357	1,142	3,211	1,427	428	1,356	7,920
13	387	1,237	3,479	1,546	464	1,469	8,580
14	416	1,332	3,746	1,665	499	1,582	9,240
15	446	1,427	4,014	1,784	535	1,695	9,900
16	476	1,522	4,281	1,903	571	1,808	10,560

17	505	1,617	4,549	2,022	607	1,921	11,220
18	535	1,713	4,816	2,141	642	2,034	11,881
19	565	1,808	5,084	2,260	678	2,147	12,541
20	595	1,903	5,352	2,378	714	2,260	13,201
21	595	1,998	5,530	2,497	714	2,260	13,593
22	595	2,093	5,708	2,616	714	2,260	13,985
23	595	2,188	5,887	2,735	714	2,260	14,378
24	595	2,283	6,065	2,854	714	2,260	14,770
25	595	2,378	6,244	2,973	714	2,260	15,163
26	595	2,474	6,422	3,092	714	2,260	15,555
27	595	2,569	6,600	3,211	714	2,260	15,948
28	595	2,664	6,779	3,330	714	2,260	16,340
29	595	2,759	6,957	3,449	714	2,260	16,733
30	595	2,854	7,135	3,568	714	2,260	17,125
31	595	2,949	7,314	3,687	714	2,260	17,518
32	595	3,044	7,492	3,806	714	2,260	17,910
33	595	3,140	7,671	3,924	714	2,260	18,302
34	595	3,235	7,849	4,043	714	2,260	18,695
35	595	3,330	8,027	4,162	714	2,260	19,087
36	595	3,425	8,206	4,281	714	2,260	19,480
37	595	3,520	8,384	4,400	714	2,260	19,872
38	595	3,615	8,563	4,519	714	2,260	20,265
39	595	3,710	8,741	4,638	714	2,260	20,657
40	595	3,806	8,919	4,757	714	2,260	21,050

Table 48. Phosphorus Reduction Rates by Sub Watershed.

Sub Watershed #15 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	19	62	93	77	23	73	347
2	39	123	185	154	46	147	694
3	58	185	278	231	69	220	1,041
4	77	247	370	308	93	293	1,388
5	96	308	463	386	116	366	1,735
6	116	370	555	463	139	440	2,082
7	135	432	648	540	162	513	2,429
8	154	493	740	617	185	586	2,776
9	173	555	833	694	208	659	3,123
10	193	617	925	771	231	733	3,470
11	212	679	1,018	848	254	806	3,817
12	231	740	1,110	925	278	879	4,164
13	251	802	1,203	1,002	301	952	4,511

14	270	864	1,295	1,080	324	1,026	4,858
15	289	925	1,388	1,157	347	1,099	5,205
16	308	987	1,480	1,234	370	1,172	5,552
17	328	1,049	1,573	1,311	393	1,245	5,899
18	347	1,110	1,666	1,388	416	1,319	6,246
19	366	1,172	1,758	1,465	440	1,392	6,593
20	386	1,234	1,851	1,542	463	1,465	6,940
21	386	1,295	1,912	1,619	463	1,465	7,140
22	386	1,357	1,974	1,696	463	1,465	7,341
23	386	1,419	2,036	1,773	463	1,465	7,541
24	386	1,480	2,097	1,851	463	1,465	7,742
25	386	1,542	2,159	1,928	463	1,465	7,942
26	386	1,604	2,221	2,005	463	1,465	8,143
27	386	1,666	2,282	2,082	463	1,465	8,343
28	386	1,727	2,344	2,159	463	1,465	8,544
29	386	1,789	2,406	2,236	463	1,465	8,744
30	386	1,851	2,467	2,313	463	1,465	8,944
31	386	1,912	2,529	2,390	463	1,465	9,145
32	386	1,974	2,591	2,467	463	1,465	9,345
33	386	2,036	2,652	2,545	463	1,465	9,546
34	386	2,097	2,714	2,622	463	1,465	9,746
35	386	2,159	2,776	2,699	463	1,465	9,947
36	386	2,221	2,838	2,776	463	1,465	10,147
37	386	2,282	2,899	2,853	463	1,465	10,348
38	386	2,344	2,961	2,930	463	1,465	10,548
39	386	2,406	3,023	3,007	463	1,465	10,749
40	386	2,467	3,084	3,084	463	1,465	10,949

Sub Watershed #16 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	48	153	230	191	57	182	862
2	96	306	460	383	115	364	1,723
3	144	460	689	574	172	546	2,585
4	191	613	919	766	230	728	3,446
5	239	766	1,149	957	287	909	4,308
6	287	919	1,379	1,149	345	1,091	5,169
7	335	1,072	1,608	1,340	402	1,273	6,031
8	383	1,225	1,838	1,532	460	1,455	6,893
9	431	1,379	2,068	1,723	517	1,637	7,754
10	479	1,532	2,298	1,915	574	1,819	8,616
11	527	1,685	2,527	2,106	632	2,001	9,477

12	574	1,838	2,757	2,298	689	2,183	10,339
13	622	1,991	2,987	2,489	747	2,365	11,200
14	670	2,144	3,217	2,680	804	2,546	12,062
15	718	2,298	3,446	2,872	862	2,728	12,924
16	766	2,451	3,676	3,063	919	2,910	13,785
17	814	2,604	3,906	3,255	976	3,092	14,647
18	862	2,757	4,136	3,446	1,034	3,274	15,508
19	909	2,910	4,365	3,638	1,091	3,456	16,370
20	957	3,063	4,595	3,829	1,149	3,638	17,231
21	957	3,217	4,748	4,021	1,149	3,638	17,729
22	957	3,370	4,901	4,212	1,149	3,638	18,227
23	957	3,523	5,055	4,404	1,149	3,638	18,725
24	957	3,676	5,208	4,595	1,149	3,638	19,223
25	957	3,829	5,361	4,787	1,149	3,638	19,720
26	957	3,982	5,514	4,978	1,149	3,638	20,218
27	957	4,136	5,667	5,169	1,149	3,638	20,716
28	957	4,289	5,820	5,361	1,149	3,638	21,214
29	957	4,442	5,974	5,552	1,149	3,638	21,712
30	957	4,595	6,127	5,744	1,149	3,638	22,209
31	957	4,748	6,280	5,935	1,149	3,638	22,707
32	957	4,901	6,433	6,127	1,149	3,638	23,205
33	957	5,055	6,586	6,318	1,149	3,638	23,703
34	957	5,208	6,739	6,510	1,149	3,638	24,201
35	957	5,361	6,893	6,701	1,149	3,638	24,698
36	957	5,514	7,046	6,893	1,149	3,638	25,196
37	957	5,667	7,199	7,084	1,149	3,638	25,694
38	957	5,820	7,352	7,275	1,149	3,638	26,192
39	957	5,974	7,505	7,467	1,149	3,638	26,690
40	957	6,127	7,658	7,658	1,149	3,638	27,187

Sub Watershed #25 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	10	0	50	42	0	39	141
2	21	0	100	83	0	79	282
3	31	0	149	125	0	118	423
4	42	0	199	166	0	158	565
5	52	0	249	208	0	197	706
6	62	0	299	249	0	237	847
7	73	0	349	291	0	276	988
8	83	0	399	332	0	315	1,129
9	93	0	448	374	0	355	1,270

10	104	0	498	415	0	394	1,411
11	114	0	548	457	0	434	1,553
12	125	0	598	498	0	473	1,694
13	135	0	648	540	0	513	1,835
14	145	0	697	581	0	552	1,976
15	156	0	747	623	0	591	2,117
16	166	0	797	664	0	631	2,258
17	176	0	847	706	0	670	2,399
18	187	0	897	747	0	710	2,541
19	197	0	947	789	0	749	2,682
20	208	0	996	831	0	789	2,823
21	208	0	996	831	0	789	2,823
22	208	0	996	831	0	789	2,823
23	208	0	996	831	0	789	2,823
24	208	0	996	831	0	789	2,823
25	208	0	996	831	0	789	2,823
26	208	0	996	831	0	789	2,823
27	208	0	996	831	0	789	2,823
28	208	0	996	831	0	789	2,823
29	208	0	996	831	0	789	2,823
30	208	0	996	831	0	789	2,823
31	208	0	996	831	0	789	2,823
32	208	0	996	831	0	789	2,823
33	208	0	996	831	0	789	2,823
34	208	0	996	831	0	789	2,823
35	208	0	996	831	0	789	2,823
36	208	0	996	831	0	789	2,823
37	208	0	996	831	0	789	2,823
38	208	0	996	831	0	789	2,823
39	208	0	996	831	0	789	2,823
40	208	0	996	831	0	789	2,823

Sub Watershed #28 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	11	0	51	42	0	40	144
2	21	0	102	84	0	80	287
3	32	0	152	126	0	121	431
4	42	0	203	168	0	161	574
5	53	0	254	210	0	201	718
6	63	0	305	252	0	241	861
7	74	0	355	294	0	281	1,005

8	85	0	406	336	0	321	1,148
9	95	0	457	378	0	362	1,292
10	106	0	508	420	0	402	1,435
11	116	0	559	462	0	442	1,579
12	127	0	609	504	0	482	1,723
13	137	0	660	546	0	522	1,866
14	148	0	711	588	0	563	2,010
15	159	0	762	630	0	603	2,153
16	169	0	813	672	0	643	2,297
17	180	0	863	714	0	683	2,440
18	190	0	914	756	0	723	2,584
19	201	0	965	798	0	764	2,727
20	212	0	1,016	840	0	804	2,871
21	212	0	1,016	840	0	804	2,871
22	212	0	1,016	840	0	804	2,871
23	212	0	1,016	840	0	804	2,871
24	212	0	1,016	840	0	804	2,871
25	212	0	1,016	840	0	804	2,871
26	212	0	1,016	840	0	804	2,871
27	212	0	1,016	840	0	804	2,871
28	212	0	1,016	840	0	804	2,871
29	212	0	1,016	840	0	804	2,871
30	212	0	1,016	840	0	804	2,871
31	212	0	1,016	840	0	804	2,871
32	212	0	1,016	840	0	804	2,871
33	212	0	1,016	840	0	804	2,871
34	212	0	1,016	840	0	804	2,871
35	212	0	1,016	840	0	804	2,871
36	212	0	1,016	840	0	804	2,871
37	212	0	1,016	840	0	804	2,871
38	212	0	1,016	840	0	804	2,871
39	212	0	1,016	840	0	804	2,871
40	212	0	1,016	840	0	804	2,871

Sub Watershed #31 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	31	99	149	124	37	118	558
2	62	198	297	248	74	235	1,115
3	93	297	446	372	112	353	1,673
4	124	397	595	496	149	471	2,231
5	155	496	744	620	186	589	2,788

6	186	595	892	744	223	706	3,346
7	217	694	1,041	867	260	824	3,904
8	248	793	1,190	991	297	942	4,461
9	279	892	1,338	1,115	335	1,060	5,019
10	310	991	1,487	1,239	372	1,177	5,576
11	341	1,091	1,636	1,363	409	1,295	6,134
12	372	1,190	1,784	1,487	446	1,413	6,692
13	403	1,289	1,933	1,611	483	1,530	7,249
14	434	1,388	2,082	1,735	520	1,648	7,807
15	465	1,487	2,231	1,859	558	1,766	8,365
16	496	1,586	2,379	1,983	595	1,884	8,922
17	527	1,685	2,528	2,107	632	2,001	9,480
18	558	1,784	2,677	2,231	669	2,119	10,038
19	589	1,884	2,825	2,355	706	2,237	10,595
20	620	1,983	2,974	2,478	744	2,355	11,153
21	620	2,082	3,073	2,602	744	2,355	11,475
22	620	2,181	3,172	2,726	744	2,355	11,797
23	620	2,280	3,272	2,850	744	2,355	12,120
24	620	2,379	3,371	2,974	744	2,355	12,442
25	620	2,478	3,470	3,098	744	2,355	12,764
26	620	2,578	3,569	3,222	744	2,355	13,086
27	620	2,677	3,668	3,346	744	2,355	13,408
28	620	2,776	3,767	3,470	744	2,355	13,731
29	620	2,875	3,866	3,594	744	2,355	14,053
30	620	2,974	3,965	3,718	744	2,355	14,375
31	620	3,073	4,065	3,842	744	2,355	14,697
32	620	3,172	4,164	3,965	744	2,355	15,019
33	620	3,272	4,263	4,089	744	2,355	15,341
34	620	3,371	4,362	4,213	744	2,355	15,664
35	620	3,470	4,461	4,337	744	2,355	15,986
36	620	3,569	4,560	4,461	744	2,355	16,308
37	620	3,668	4,659	4,585	744	2,355	16,630
38	620	3,767	4,759	4,709	744	2,355	16,952
39	620	3,866	4,858	4,833	744	2,355	17,275
40	620	3,965	4,957	4,957	744	2,355	17,597

Sub Watershed #33 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	17	56	84	70	21	66	314
2	35	112	168	140	42	133	628
3	52	168	251	209	63	199	942

4	70	223	335	279	84	265	1,256
5	87	279	419	349	105	332	1,571
6	105	335	503	419	126	398	1,885
7	122	391	586	489	147	464	2,199
8	140	447	670	558	168	530	2,513
9	157	503	754	628	188	597	2,827
10	175	558	838	698	209	663	3,141
11	192	614	921	768	230	729	3,455
12	209	670	1,005	838	251	796	3,769
13	227	726	1,089	907	272	862	4,083
14	244	782	1,173	977	293	928	4,397
15	262	838	1,256	1,047	314	995	4,712
16	279	893	1,340	1,117	335	1,061	5,026
17	297	949	1,424	1,187	356	1,127	5,340
18	314	1,005	1,508	1,256	377	1,194	5,654
19	332	1,061	1,591	1,326	398	1,260	5,968
20	349	1,117	1,675	1,396	419	1,326	6,282
21	349	1,173	1,731	1,466	419	1,326	6,463
22	349	1,228	1,787	1,536	419	1,326	6,645
23	349	1,284	1,843	1,605	419	1,326	6,826
24	349	1,340	1,899	1,675	419	1,326	7,008
25	349	1,396	1,954	1,745	419	1,326	7,189
26	349	1,452	2,010	1,815	419	1,326	7,371
27	349	1,508	2,066	1,885	419	1,326	7,552
28	349	1,564	2,122	1,954	419	1,326	7,734
29	349	1,619	2,178	2,024	419	1,326	7,915
30	349	1,675	2,234	2,094	419	1,326	8,097
31	349	1,731	2,289	2,164	419	1,326	8,278
32	349	1,787	2,345	2,234	419	1,326	8,460
33	349	1,843	2,401	2,303	419	1,326	8,641
34	349	1,899	2,457	2,373	419	1,326	8,823
35	349	1,954	2,513	2,443	419	1,326	9,004
36	349	2,010	2,569	2,513	419	1,326	9,186
37	349	2,066	2,624	2,583	419	1,326	9,367
38	349	2,122	2,680	2,652	419	1,326	9,549
39	349	2,178	2,736	2,722	419	1,326	9,730
40	349	2,234	2,792	2,792	419	1,326	9,912

Sub Watershed #35 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	48	154	231	193	58	183	868

2	96	309	463	386	116	366	1,736
3	145	463	694	579	174	550	2,604
4	193	617	926	771	231	733	3,472
5	241	771	1,157	964	289	916	4,340
6	289	926	1,389	1,157	347	1,099	5,208
7	338	1,080	1,620	1,350	405	1,283	6,076
8	386	1,234	1,852	1,543	463	1,466	6,943
9	434	1,389	2,083	1,736	521	1,649	7,811
10	482	1,543	2,314	1,929	579	1,832	8,679
11	530	1,697	2,546	2,122	636	2,016	9,547
12	579	1,852	2,777	2,314	694	2,199	10,415
13	627	2,006	3,009	2,507	752	2,382	11,283
14	675	2,160	3,240	2,700	810	2,565	12,151
15	723	2,314	3,472	2,893	868	2,748	13,019
16	771	2,469	3,703	3,086	926	2,932	13,887
17	820	2,623	3,935	3,279	984	3,115	14,755
18	868	2,777	4,166	3,472	1,042	3,298	15,623
19	916	2,932	4,398	3,665	1,099	3,481	16,491
20	964	3,086	4,629	3,857	1,157	3,665	17,359
21	964	3,240	4,783	4,050	1,157	3,665	17,860
22	964	3,395	4,938	4,243	1,157	3,665	18,362
23	964	3,549	5,092	4,436	1,157	3,665	18,863
24	964	3,703	5,246	4,629	1,157	3,665	19,365
25	964	3,857	5,400	4,822	1,157	3,665	19,866
26	964	4,012	5,555	5,015	1,157	3,665	20,367
27	964	4,166	5,709	5,208	1,157	3,665	20,869
28	964	4,320	5,863	5,400	1,157	3,665	21,370
29	964	4,475	6,018	5,593	1,157	3,665	21,872
30	964	4,629	6,172	5,786	1,157	3,665	22,373
31	964	4,783	6,326	5,979	1,157	3,665	22,875
32	964	4,938	6,481	6,172	1,157	3,665	23,376
33	964	5,092	6,635	6,365	1,157	3,665	23,878
34	964	5,246	6,789	6,558	1,157	3,665	24,379
35	964	5,400	6,943	6,751	1,157	3,665	24,881
36	964	5,555	7,098	6,943	1,157	3,665	25,382
37	964	5,709	7,252	7,136	1,157	3,665	25,884
38	964	5,863	7,406	7,329	1,157	3,665	26,385
39	964	6,018	7,561	7,522	1,157	3,665	26,887
40	964	6,172	7,715	7,715	1,157	3,665	27,388

Sub Watershed #38 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	39	124	186	155	46	147	696
2	77	248	371	310	93	294	1,393
3	116	371	557	464	139	441	2,089
4	155	495	743	619	186	588	2,786
5	193	619	929	774	232	735	3,482
6	232	743	1,114	929	279	882	4,179
7	271	867	1,300	1,083	325	1,029	4,875
8	310	990	1,486	1,238	371	1,176	5,572
9	348	1,114	1,671	1,393	418	1,323	6,268
10	387	1,238	1,857	1,548	464	1,470	6,964
11	426	1,362	2,043	1,702	511	1,617	7,661
12	464	1,486	2,229	1,857	557	1,764	8,357
13	503	1,610	2,414	2,012	604	1,911	9,054
14	542	1,733	2,600	2,167	650	2,058	9,750
15	580	1,857	2,786	2,321	696	2,205	10,447
16	619	1,981	2,971	2,476	743	2,352	11,143
17	658	2,105	3,157	2,631	789	2,499	11,839
18	696	2,229	3,343	2,786	836	2,646	12,536
19	735	2,352	3,529	2,941	882	2,793	13,232
20	774	2,476	3,714	3,095	929	2,941	13,929
21	774	2,600	3,838	3,250	929	2,941	14,331
22	774	2,724	3,962	3,405	929	2,941	14,734
23	774	2,848	4,086	3,560	929	2,941	15,136
24	774	2,971	4,210	3,714	929	2,941	15,538
25	774	3,095	4,333	3,869	929	2,941	15,941
26	774	3,219	4,457	4,024	929	2,941	16,343
27	774	3,343	4,581	4,179	929	2,941	16,745
28	774	3,467	4,705	4,333	929	2,941	17,148
29	774	3,591	4,829	4,488	929	2,941	17,550
30	774	3,714	4,952	4,643	929	2,941	17,953
31	774	3,838	5,076	4,798	929	2,941	18,355
32	774	3,962	5,200	4,952	929	2,941	18,757
33	774	4,086	5,324	5,107	929	2,941	19,160
34	774	4,210	5,448	5,262	929	2,941	19,562
35	774	4,333	5,572	5,417	929	2,941	19,965
36	774	4,457	5,695	5,572	929	2,941	20,367
37	774	4,581	5,819	5,726	929	2,941	20,769
38	774	4,705	5,943	5,881	929	2,941	21,172
39	774	4,829	6,067	6,036	929	2,941	21,574
40	774	4,952	6,191	6,191	929	2,941	21,976

Sub Watershed #55 Annual Phosphorous Reduction (lbs), Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Load Reduction
1	43	139	209	174	52	165	782
2	87	278	417	348	104	330	1,564
3	130	417	626	521	156	495	2,346
4	174	556	834	695	209	660	3,129
5	217	695	1,043	869	261	826	3,911
6	261	834	1,251	1,043	313	991	4,693
7	304	973	1,460	1,217	365	1,156	5,475
8	348	1,112	1,669	1,390	417	1,321	6,257
9	391	1,251	1,877	1,564	469	1,486	7,039
10	435	1,390	2,086	1,738	521	1,651	7,822
11	478	1,530	2,294	1,912	574	1,816	8,604
12	521	1,669	2,503	2,086	626	1,981	9,386
13	565	1,808	2,711	2,260	678	2,147	10,168
14	608	1,947	2,920	2,433	730	2,312	10,950
15	652	2,086	3,129	2,607	782	2,477	11,732
16	695	2,225	3,337	2,781	834	2,642	12,514
17	739	2,364	3,546	2,955	886	2,807	13,297
18	782	2,503	3,754	3,129	939	2,972	14,079
19	826	2,642	3,963	3,302	991	3,137	14,861
20	869	2,781	4,171	3,476	1,043	3,302	15,643
21	869	2,920	4,311	3,650	1,043	3,302	16,095
22	869	3,059	4,450	3,824	1,043	3,302	16,547
23	869	3,198	4,589	3,998	1,043	3,302	16,999
24	869	3,337	4,728	4,171	1,043	3,302	17,451
25	869	3,476	4,867	4,345	1,043	3,302	17,903
26	869	3,615	5,006	4,519	1,043	3,302	18,355
27	869	3,754	5,145	4,693	1,043	3,302	18,806
28	869	3,893	5,284	4,867	1,043	3,302	19,258
29	869	4,032	5,423	5,041	1,043	3,302	19,710
30	869	4,171	5,562	5,214	1,043	3,302	20,162
31	869	4,311	5,701	5,388	1,043	3,302	20,614
32	869	4,450	5,840	5,562	1,043	3,302	21,066
33	869	4,589	5,979	5,736	1,043	3,302	21,518
34	869	4,728	6,118	5,910	1,043	3,302	21,970
35	869	4,867	6,257	6,083	1,043	3,302	22,422
36	869	5,006	6,396	6,257	1,043	3,302	22,874
37	869	5,145	6,535	6,431	1,043	3,302	23,326
38	869	5,284	6,674	6,605	1,043	3,302	23,777

39	869	5,423	6,813	6,779	1,043	3,302	24,229
40	869	5,562	6,952	6,952	1,043	3,302	24,681

13.3.2 Adoption Rates by Sub Watershed

Table 49. Short, Medium and Long Term Goals by Sub Watershed.

Sub Watershed #15 Annual Adoption (treated acres), Cropland BMPs

	Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Adoption
Short-Term	1	51	103	154	103	51	51	514
	2	51	103	154	103	51	51	514
	3	51	103	154	103	51	51	514
	4	51	103	154	103	51	51	514
	5	51	103	154	103	51	51	514
	Total	*257*	*514*	*771*	*514*	*257*	*257*	*2,570*
Medium-Term	6	51	103	154	103	51	51	514
	7	51	103	154	103	51	51	514
	8	51	103	154	103	51	51	514
	9	51	103	154	103	51	51	514
	10	51	103	154	103	51	51	514
	Total	*514*	*1,028*	*1,542*	*1,028*	*514*	*514*	*5,141*
Long-Term	11	51	103	154	103	51	51	514
	12	51	103	154	103	51	51	514
	13	51	103	154	103	51	51	514
	14	51	103	154	103	51	51	514
	15	51	103	154	103	51	51	514
	16	51	103	154	103	51	51	514
	17	51	103	154	103	51	51	514
	18	51	103	154	103	51	51	514
	19	51	103	154	103	51	51	514
	20	51	103	154	103	51	51	514
	21	0	103	103	103	0	0	308
	22	0	103	103	103	0	0	308
	23	0	103	103	103	0	0	308
	24	0	103	103	103	0	0	308
	25	0	103	103	103	0	0	308
	26	0	103	103	103	0	0	308
	27	0	103	103	103	0	0	308
	28	0	103	103	103	0	0	308
	29	0	103	103	103	0	0	308
	30	0	103	103	103	0	0	308

	Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Adoption
	31	0	103	103	103	0	0	308
	32	0	103	103	103	0	0	308
	33	0	103	103	103	0	0	308
	34	0	103	103	103	0	0	308
	35	0	103	103	103	0	0	308
	36	0	103	103	103	0	0	308
	37	0	103	103	103	0	0	308
	38	0	103	103	103	0	0	308
	39	0	103	103	103	0	0	308
	40	0	103	103	103	0	0	308
	Total	*1,028*	*4,112*	*5,141*	*4,112*	*1,028*	*1,028*	*16,450*

Sub Watershed #16 Annual Adoption (treated acres), Cropland BMPs

	Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Adoption
Short-Term	1	96	191	287	191	96	96	957
	2	96	191	287	191	96	96	957
	3	96	191	287	191	96	96	957
	4	96	191	287	191	96	96	957
	5	96	191	287	191	96	96	957
	Total	*479*	*957*	*1,436*	*957*	*479*	*479*	*4,787*
Medium-Term	6	96	191	287	191	96	96	957
	7	96	191	287	191	96	96	957
	8	96	191	287	191	96	96	957
	9	96	191	287	191	96	96	957
	10	96	191	287	191	96	96	957
	Total	*957*	*1,915*	*2,872*	*1,915*	*957*	*957*	*9,573*
Long-Term	11	96	191	287	191	96	96	957
	12	96	191	287	191	96	96	957
	13	96	191	287	191	96	96	957
	14	96	191	287	191	96	96	957
	15	96	191	287	191	96	96	957
	16	96	191	287	191	96	96	957
	17	96	191	287	191	96	96	957
	18	96	191	287	191	96	96	957
	19	96	191	287	191	96	96	957
	20	96	191	287	191	96	96	957
	21	0	191	191	191	0	0	574
	22	0	191	191	191	0	0	574
	23	0	191	191	191	0	0	574
	24	0	191	191	191	0	0	574

	25	0	191	191	191	0	0	574
	26	0	191	191	191	0	0	574
	27	0	191	191	191	0	0	574
	28	0	191	191	191	0	0	574
	29	0	191	191	191	0	0	574
	30	0	191	191	191	0	0	574
	31	0	191	191	191	0	0	574
	32	0	191	191	191	0	0	574
	33	0	191	191	191	0	0	574
	34	0	191	191	191	0	0	574
	35	0	191	191	191	0	0	574
	36	0	191	191	191	0	0	574
	37	0	191	191	191	0	0	574
	38	0	191	191	191	0	0	574
	39	0	191	191	191	0	0	574
	40	0	191	191	191	0	0	574
	Total	*1,915*	*7,658*	*9,573*	*7,658*	*1,915*	*1,915*	*30,634*

Sub Watershed #25 Annual Adoption (treated acres), Cropland BMPs

	Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Adoptio n
Short-Term	1	42	0	125	83	0	42	291
	2	42	0	125	83	0	42	291
	3	42	0	125	83	0	42	291
	4	42	0	125	83	0	42	291
	5	42	0	125	83	0	42	291
	Total	*208*	*0*	*623*	*415*	*0*	*208*	*1,453*
Medium-Term	6	42	0	125	83	0	42	291
	7	42	0	125	83	0	42	291
	8	42	0	125	83	0	42	291
	9	42	0	125	83	0	42	291
	10	42	0	125	83	0	42	291
	Total	*415*	*0*	*1,246*	*831*	*0*	*415*	*2,906*
Long-Term	11	42	0	125	83	0	42	291
	12	42	0	125	83	0	42	291
	13	42	0	125	83	0	42	291
	14	42	0	125	83	0	42	291
	15	42	0	125	83	0	42	291
	16	42	0	125	83	0	42	291
	17	42	0	125	83	0	42	291
	18	42	0	125	83	0	42	291

	19	42	0	125	83	0	42	291
	20	42	0	125	83	0	42	291
	21	0	0	0	0	0	0	0
	22	0	0	0	0	0	0	0
	23	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0
	26	0	0	0	0	0	0	0
	27	0	0	0	0	0	0	0
	28	0	0	0	0	0	0	0
	29	0	0	0	0	0	0	0
	30	0	0	0	0	0	0	0
	31	0	0	0	0	0	0	0
	32	0	0	0	0	0	0	0
	33	0	0	0	0	0	0	0
	34	0	0	0	0	0	0	0
	35	0	0	0	0	0	0	0
	36	0	0	0	0	0	0	0
	37	0	0	0	0	0	0	0
	38	0	0	0	0	0	0	0
	39	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0
	Total	*830*	*0*	*2,491*	*1,661*	*0*	*830*	*5,812*

Sub Watershed #28 Annual Adoption (treated acres), Cropland BMPs

	Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Adoptio n
Short-Term	1	35	0	106	70	0	35	246
	2	35	0	106	70	0	35	246
	3	35	0	106	70	0	35	246
	4	35	0	106	70	0	35	246
	5	35	0	106	70	0	35	246
	Total	*176*	*0*	*529*	*350*	*0*	*176*	*1,232*
Medium-Term	6	35	0	106	70	0	35	246
	7	35	0	106	70	0	35	246
	8	35	0	106	70	0	35	246
	9	35	0	106	70	0	35	246
	10	35	0	106	70	0	35	246
	Total	*353*	*0*	*1,058*	*700*	*0*	*353*	*2,463*
Long-Term	11	35	0	106	70	0	35	246
	12	35	0	106	70	0	35	246
	13	35	0	106	70	0	35	246

	14	35	0	106	70	0	35	246
	15	35	0	106	70	0	35	246
	16	35	0	106	70	0	35	246
	17	35	0	106	70	0	35	246
	18	35	0	106	70	0	35	246
	19	35	0	106	70	0	35	246
	20	35	0	106	70	0	35	246
	21	0	0	0	0	0	0	0
	22	0	0	0	0	0	0	0
	23	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0
	26	0	0	0	0	0	0	0
	27	0	0	0	0	0	0	0
	28	0	0	0	0	0	0	0
	29	0	0	0	0	0	0	0
	30	0	0	0	0	0	0	0
	31	0	0	0	0	0	0	0
	32	0	0	0	0	0	0	0
	33	0	0	0	0	0	0	0
	34	0	0	0	0	0	0	0
	35	0	0	0	0	0	0	0
	36	0	0	0	0	0	0	0
	37	0	0	0	0	0	0	0
	38	0	0	0	0	0	0	0
	39	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0
	Total	*705*	*0*	*2,116*	*1,400*	*0*	*705*	*4,926*

Sub Watershed #31 Annual Adoption (treated acres), Cropland BMPs

	Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Adoptio n
Short-Term	1	73	146	219	146	73	73	729
	2	73	146	219	146	73	73	729
	3	73	146	219	146	73	73	729
	4	73	146	219	146	73	73	729
	5	73	146	219	146	73	73	729
	Total	*364*	*729*	*1,093*	*729*	*364*	*364*	*3,645*
Medium-Term	6	73	146	219	146	73	73	729
	7	73	146	219	146	73	73	729
	8	73	146	219	146	73	73	729

	9	73	146	219	146	73	73	729
	10	73	146	219	146	73	73	729
	Total	*729*	*1,458*	*2,187*	*1,458*	*729*	*729*	*7,290*
Long-Term	11	73	146	219	146	73	73	729
	12	73	146	219	146	73	73	729
	13	73	146	219	146	73	73	729
	14	73	146	219	146	73	73	729
	15	73	146	219	146	73	73	729
	16	73	146	219	146	73	73	729
	17	73	146	219	146	73	73	729
	18	73	146	219	146	73	73	729
	19	73	146	219	146	73	73	729
	20	73	146	219	146	73	73	729
	21	0	146	146	146	0	0	437
	22	0	146	146	146	0	0	437
	23	0	146	146	146	0	0	437
	24	0	146	146	146	0	0	437
	25	0	146	146	146	0	0	437
	26	0	146	146	146	0	0	437
	27	0	146	146	146	0	0	437
	28	0	146	146	146	0	0	437
	29	0	146	146	146	0	0	437
	30	0	146	146	146	0	0	437
	31	0	146	146	146	0	0	437
	32	0	146	146	146	0	0	437
	33	0	146	146	146	0	0	437
	34	0	146	146	146	0	0	437
	35	0	146	146	146	0	0	437
	36	0	146	146	146	0	0	437
	37	0	146	146	146	0	0	437
	38	0	146	146	146	0	0	437
	39	0	146	146	146	0	0	437
	40	0	146	146	146	0	0	437
	Total	*1,458*	*5,832*	*7,290*	*5,832*	*1,458*	*1,458*	*23,326*

Sub Watershed #33 Annual Adoption (treated acres), Cropland BMPs

	Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Adoptio n
Short-Term	1	44	87	131	87	44	44	436
	2	44	87	131	87	44	44	436
	3	44	87	131	87	44	44	436
	4	44	87	131	87	44	44	436

	5	44	87	131	87	44	44	436
	Total	*218*	*436*	*654*	*436*	*218*	*218*	*2,181*
Medium-Term	6	44	87	131	87	44	44	436
	7	44	87	131	87	44	44	436
	8	44	87	131	87	44	44	436
	9	44	87	131	87	44	44	436
	10	44	87	131	87	44	44	436
	Total	*436*	*873*	*1,309*	*873*	*436*	*436*	*4,363*
Long-Term	11	44	87	131	87	44	44	436
	12	44	87	131	87	44	44	436
	13	44	87	131	87	44	44	436
	14	44	87	131	87	44	44	436
	15	44	87	131	87	44	44	436
	16	44	87	131	87	44	44	436
	17	44	87	131	87	44	44	436
	18	44	87	131	87	44	44	436
	19	44	87	131	87	44	44	436
	20	44	87	131	87	44	44	436
	21	0	87	87	87	0	0	262
	22	0	87	87	87	0	0	262
	23	0	87	87	87	0	0	262
	24	0	87	87	87	0	0	262
	25	0	87	87	87	0	0	262
	26	0	87	87	87	0	0	262
	27	0	87	87	87	0	0	262
	28	0	87	87	87	0	0	262
	29	0	87	87	87	0	0	262
	30	0	87	87	87	0	0	262
	31	0	87	87	87	0	0	262
	32	0	87	87	87	0	0	262
	33	0	87	87	87	0	0	262
	34	0	87	87	87	0	0	262
	35	0	87	87	87	0	0	262
	36	0	87	87	87	0	0	262
	37	0	87	87	87	0	0	262
	38	0	87	87	87	0	0	262
	39	0	87	87	87	0	0	262
	40	0	87	87	87	0	0	262
	Total	*873*	*3,490*	*4,363*	*3,490*	*873*	*873*	*13,960*

Sub Watershed #35 Annual Adoption (treated acres), Cropland BMPs

	Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Adoption
Short-Term	1	88	175	263	175	88	88	877
	2	88	175	263	175	88	88	877
	3	88	175	263	175	88	88	877
	4	88	175	263	175	88	88	877
	5	88	175	263	175	88	88	877
	Total	*438*	*877*	*1,315*	*877*	*438*	*438*	*4,384*
Medium-Term	6	88	175	263	175	88	88	877
	7	88	175	263	175	88	88	877
	8	88	175	263	175	88	88	877
	9	88	175	263	175	88	88	877
	10	88	175	263	175	88	88	877
	Total	*877*	*1,753*	*2,630*	*1,753*	*877*	*877*	*8,767*
Long-Term	11	88	175	263	175	88	88	877
	12	88	175	263	175	88	88	877
	13	88	175	263	175	88	88	877
	14	88	175	263	175	88	88	877
	15	88	175	263	175	88	88	877
	16	88	175	263	175	88	88	877
	17	88	175	263	175	88	88	877
	18	88	175	263	175	88	88	877
	19	88	175	263	175	88	88	877
	20	88	175	263	175	88	88	877
	21	0	175	175	175	0	0	526
	22	0	175	175	175	0	0	526
	23	0	175	175	175	0	0	526
	24	0	175	175	175	0	0	526
	25	0	175	175	175	0	0	526
	26	0	175	175	175	0	0	526
	27	0	175	175	175	0	0	526
	28	0	175	175	175	0	0	526
	29	0	175	175	175	0	0	526
	30	0	175	175	175	0	0	526
	31	0	175	175	175	0	0	526
	32	0	175	175	175	0	0	526
	33	0	175	175	175	0	0	526
	34	0	175	175	175	0	0	526
	35	0	175	175	175	0	0	526
	36	0	175	175	175	0	0	526
	37	0	175	175	175	0	0	526

	38	0	175	175	175	0	0	526
	39	0	175	175	175	0	0	526
	40	0	175	175	175	0	0	526
	Total	*1,753*	*7,014*	*8,767*	*7,014*	*1,753*	*1,753*	*28,054*

Sub Watershed #38 Annual Adoption (treated acres), Cropland BMPs

	Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Adoptio n
Short-Term	1	86	172	258	172	86	86	860
	2	86	172	258	172	86	86	860
	3	86	172	258	172	86	86	860
	4	86	172	258	172	86	86	860
	5	86	172	258	172	86	86	860
	Total	*430*	*860*	*1,290*	*860*	*430*	*430*	*4,299*
Medium-Term	6	86	172	258	172	86	86	860
	7	86	172	258	172	86	86	860
	8	86	172	258	172	86	86	860
	9	86	172	258	172	86	86	860
	10	86	172	258	172	86	86	860
	Total	*860*	*1,720*	*2,579*	*1,720*	*860*	*860*	*8,598*
Long-Term	11	86	172	258	172	86	86	860
	12	86	172	258	172	86	86	860
	13	86	172	258	172	86	86	860
	14	86	172	258	172	86	86	860
	15	86	172	258	172	86	86	860
	16	86	172	258	172	86	86	860
	17	86	172	258	172	86	86	860
	18	86	172	258	172	86	86	860
	19	86	172	258	172	86	86	860
	20	86	172	258	172	86	86	860
	21	0	172	172	172	0	0	516
	22	0	172	172	172	0	0	516
	23	0	172	172	172	0	0	516
	24	0	172	172	172	0	0	516
	25	0	172	172	172	0	0	516
	26	0	172	172	172	0	0	516
	27	0	172	172	172	0	0	516
	28	0	172	172	172	0	0	516
	29	0	172	172	172	0	0	516
	30	0	172	172	172	0	0	516
	31	0	172	172	172	0	0	516

	32	0	172	172	172	0	0	516
	33	0	172	172	172	0	0	516
	34	0	172	172	172	0	0	516
	35	0	172	172	172	0	0	516
	36	0	172	172	172	0	0	516
	37	0	172	172	172	0	0	516
	38	0	172	172	172	0	0	516
	39	0	172	172	172	0	0	516
	40	0	172	172	172	0	0	516
	Total	*1,720*	*6,878*	*8,598*	*6,878*	*1,720*	*1,720*	*27,514*

Sub Watershed #55 Annual Adoption (treated acres), Cropland BMPs

	Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Adoptio n
Short-Term	1	91	183	274	183	91	91	915
	2	91	183	274	183	91	91	915
	3	91	183	274	183	91	91	915
	4	91	183	274	183	91	91	915
	5	91	183	274	183	91	91	915
	Total	*457*	*915*	*1,372*	*915*	*457*	*457*	*4,574*
Medium-Term	6	91	183	274	183	91	91	915
	7	91	183	274	183	91	91	915
	8	91	183	274	183	91	91	915
	9	91	183	274	183	91	91	915
	10	91	183	274	183	91	91	915
	Total	*915*	*1,830*	*2,744*	*1,830*	*915*	*915*	*9,148*
Long-Term	11	91	183	274	183	91	91	915
	12	91	183	274	183	91	91	915
	13	91	183	274	183	91	91	915
	14	91	183	274	183	91	91	915
	15	91	183	274	183	91	91	915
	16	91	183	274	183	91	91	915
	17	91	183	274	183	91	91	915
	18	91	183	274	183	91	91	915
	19	91	183	274	183	91	91	915
	20	91	183	274	183	91	91	915
	21	0	183	183	183	0	0	549
	22	0	183	183	183	0	0	549
	23	0	183	183	183	0	0	549
	24	0	183	183	183	0	0	549
	25	0	183	183	183	0	0	549

	26	0	183	183	183	0	0	549
	27	0	183	183	183	0	0	549
	28	0	183	183	183	0	0	549
	29	0	183	183	183	0	0	549
	30	0	183	183	183	0	0	549
	31	0	183	183	183	0	0	549
	32	0	183	183	183	0	0	549
	33	0	183	183	183	0	0	549
	34	0	183	183	183	0	0	549
	35	0	183	183	183	0	0	549
	36	0	183	183	183	0	0	549
	37	0	183	183	183	0	0	549
	38	0	183	183	183	0	0	549
	39	0	183	183	183	0	0	549
	40	0	183	183	183	0	0	549
	Total	*1,830*	*7,318*	*9,148*	*7,318*	*1,830*	*1,830*	*29,274*

13.3.3 Costs by Sub Watershed

Table 50. Costs Before Cost Share by Sub Watershed.

Sub Watershed #15 Annual Cost* Before Cost-Share, Cropland BMPs							
Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$2,005	$16,450	$11,981	$6,854	$5,243	$7,711	$50,243
2	$2,065	$16,943	$12,340	$7,060	$5,401	$7,942	$51,751
3	$2,127	$17,451	$12,711	$7,271	$5,563	$8,180	$53,303
4	$2,191	$17,975	$13,092	$7,490	$5,730	$8,426	$54,902
5	$2,256	$18,514	$13,485	$7,714	$5,901	$8,679	$56,549
6	$2,324	$19,070	$13,889	$7,946	$6,078	$8,939	$58,246
7	$2,394	$19,642	$14,306	$8,184	$6,261	$9,207	$59,993
8	$2,466	$20,231	$14,735	$8,430	$6,449	$9,483	$61,793
9	$2,540	$20,838	$15,177	$8,682	$6,642	$9,768	$63,647
10	$2,616	$21,463	$15,632	$8,943	$6,841	$10,061	$65,556
11	$2,694	$22,107	$16,101	$9,211	$7,047	$10,363	$67,523
12	$2,775	$22,770	$16,584	$9,488	$7,258	$10,673	$69,549
13	$2,858	$23,453	$17,082	$9,772	$7,476	$10,994	$71,635
14	$2,944	$24,157	$17,594	$10,065	$7,700	$11,323	$73,784
15	$3,032	$24,881	$18,122	$10,367	$7,931	$11,663	$75,998
16	$3,123	$25,628	$18,666	$10,678	$8,169	$12,013	$78,278
17	$3,217	$26,397	$19,226	$10,999	$8,414	$12,373	$80,626
18	$3,314	$27,189	$19,803	$11,329	$8,666	$12,745	$83,045
19	$3,413	$28,004	$20,397	$11,668	$8,926	$13,127	$85,536

20	$3,515	$28,844	$21,009	$12,019	$9,194	$13,521	$88,102
21	$0	$29,710	$14,426	$12,379	$0	$0	$56,515
22	$0	$30,601	$14,859	$12,750	$0	$0	$58,210
23	$0	$31,519	$15,305	$13,133	$0	$0	$59,957
24	$0	$32,465	$15,764	$13,527	$0	$0	$61,755
25	$0	$33,439	$16,237	$13,933	$0	$0	$63,608
26	$0	$34,442	$16,724	$14,351	$0	$0	$65,516
27	$0	$35,475	$17,225	$14,781	$0	$0	$67,482
28	$0	$36,539	$17,742	$15,225	$0	$0	$69,506
29	$0	$37,635	$18,274	$15,681	$0	$0	$71,591
30	$0	$38,765	$18,823	$16,152	$0	$0	$73,739
31	$0	$39,927	$19,387	$16,636	$0	$0	$75,951
32	$0	$41,125	$19,969	$17,136	$0	$0	$78,230
33	$0	$42,359	$20,568	$17,650	$0	$0	$80,577
34	$0	$43,630	$21,185	$18,179	$0	$0	$82,994
35	$0	$44,939	$21,821	$18,724	$0	$0	$85,484
36	$0	$46,287	$22,475	$19,286	$0	$0	$88,048
37	$0	$47,676	$23,149	$19,865	$0	$0	$90,690
38	$0	$49,106	$23,844	$20,461	$0	$0	$93,410
39	$0	$50,579	$24,559	$21,075	$0	$0	$96,213
40	$0	$52,096	$25,296	$21,707	$0	$0	$99,099

**3% Inflation*

Sub Watershed #16 Annual Cost* Before Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$3,733	$30,634	$22,312	$12,764	$9,764	$14,360	$93,567
2	$3,845	$31,553	$22,981	$13,147	$10,057	$14,790	$96,374
3	$3,961	$32,499	$23,671	$13,541	$10,359	$15,234	$99,265
4	$4,080	$33,474	$24,381	$13,948	$10,670	$15,691	$102,243
5	$4,202	$34,478	$25,112	$14,366	$10,990	$16,162	$105,310
6	$4,328	$35,513	$25,865	$14,797	$11,320	$16,647	$108,470
7	$4,458	$36,578	$26,641	$15,241	$11,659	$17,146	$111,724
8	$4,592	$37,675	$27,441	$15,698	$12,009	$17,660	$115,075
9	$4,729	$38,806	$28,264	$16,169	$12,369	$18,190	$118,528
10	$4,871	$39,970	$29,112	$16,654	$12,740	$18,736	$122,083
11	$5,017	$41,169	$29,985	$17,154	$13,123	$19,298	$125,746
12	$5,168	$42,404	$30,885	$17,668	$13,516	$19,877	$129,518
13	$5,323	$43,676	$31,811	$18,198	$13,922	$20,473	$133,404
14	$5,483	$44,986	$32,766	$18,744	$14,339	$21,087	$137,406
15	$5,647	$46,336	$33,749	$19,307	$14,770	$21,720	$141,528
16	$5,817	$47,726	$34,761	$19,886	$15,213	$22,372	$145,774

17	$5,991	$49,158	$35,804	$20,482	$15,669	$23,043	$150,147
18	$6,171	$50,633	$36,878	$21,097	$16,139	$23,734	$154,652
19	$6,356	$52,152	$37,984	$21,730	$16,623	$24,446	$159,291
20	$6,547	$53,716	$39,124	$22,382	$17,122	$25,179	$164,070
21	$0	$55,328	$26,865	$23,053	$0	$0	$105,246
22	$0	$56,988	$27,671	$23,745	$0	$0	$108,403
23	$0	$58,697	$28,501	$24,457	$0	$0	$111,655
24	$0	$60,458	$29,356	$25,191	$0	$0	$115,005
25	$0	$62,272	$30,237	$25,947	$0	$0	$118,455
26	$0	$64,140	$31,144	$26,725	$0	$0	$122,009
27	$0	$66,064	$32,078	$27,527	$0	$0	$125,669
28	$0	$68,046	$33,041	$28,353	$0	$0	$129,439
29	$0	$70,087	$34,032	$29,203	$0	$0	$133,322
30	$0	$72,190	$35,053	$30,079	$0	$0	$137,322
31	$0	$74,356	$36,104	$30,982	$0	$0	$141,442
32	$0	$76,586	$37,188	$31,911	$0	$0	$145,685
33	$0	$78,884	$38,303	$32,868	$0	$0	$150,056
34	$0	$81,251	$39,452	$33,854	$0	$0	$154,557
35	$0	$83,688	$40,636	$34,870	$0	$0	$159,194
36	$0	$86,199	$41,855	$35,916	$0	$0	$163,970
37	$0	$88,785	$43,111	$36,994	$0	$0	$168,889
38	$0	$91,448	$44,404	$38,103	$0	$0	$173,956
39	$0	$94,192	$45,736	$39,247	$0	$0	$179,174
40	$0	$97,017	$47,108	$40,424	$0	$0	$184,549

**3% Inflation*

Sub Watershed #25 Annual Cost* Before Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$1,619	$0	$9,676	$5,537	$0	$6,225	$23,056
2	$1,667	$0	$9,967	$5,703	$0	$6,412	$23,748
3	$1,717	$0	$10,266	$5,874	$0	$6,604	$24,461
4	$1,769	$0	$10,574	$6,050	$0	$6,802	$25,194
5	$1,822	$0	$10,891	$6,232	$0	$7,006	$25,950
6	$1,876	$0	$11,217	$6,419	$0	$7,216	$26,729
7	$1,933	$0	$11,554	$6,611	$0	$7,433	$27,531
8	$1,991	$0	$11,901	$6,809	$0	$7,656	$28,357
9	$2,050	$0	$12,258	$7,014	$0	$7,886	$29,207
10	$2,112	$0	$12,625	$7,224	$0	$8,122	$30,083
11	$2,175	$0	$13,004	$7,441	$0	$8,366	$30,986
12	$2,240	$0	$13,394	$7,664	$0	$8,617	$31,916
13	$2,308	$0	$13,796	$7,894	$0	$8,875	$32,873

14	$2,377	$0	$14,210	$8,131	$0	$9,142	$33,859
15	$2,448	$0	$14,636	$8,375	$0	$9,416	$34,875
16	$2,522	$0	$15,075	$8,626	$0	$9,698	$35,921
17	$2,597	$0	$15,528	$8,885	$0	$9,989	$36,999
18	$2,675	$0	$15,993	$9,151	$0	$10,289	$38,109
19	$2,755	$0	$16,473	$9,426	$0	$10,598	$39,252
20	$2,838	$0	$16,967	$9,709	$0	$10,916	$40,430
21	$0	$0	$0	$0	$0	$0	$0
22	$0	$0	$0	$0	$0	$0	$0
23	$0	$0	$0	$0	$0	$0	$0
24	$0	$0	$0	$0	$0	$0	$0
25	$0	$0	$0	$0	$0	$0	$0
26	$0	$0	$0	$0	$0	$0	$0
27	$0	$0	$0	$0	$0	$0	$0
28	$0	$0	$0	$0	$0	$0	$0
29	$0	$0	$0	$0	$0	$0	$0
30	$0	$0	$0	$0	$0	$0	$0
31	$0	$0	$0	$0	$0	$0	$0
32	$0	$0	$0	$0	$0	$0	$0
33	$0	$0	$0	$0	$0	$0	$0
34	$0	$0	$0	$0	$0	$0	$0
35	$0	$0	$0	$0	$0	$0	$0
36	$0	$0	$0	$0	$0	$0	$0
37	$0	$0	$0	$0	$0	$0	$0
38	$0	$0	$0	$0	$0	$0	$0
39	$0	$0	$0	$0	$0	$0	$0
40	$0	$0	$0	$0	$0	$0	$0

**3% Inflation*

Sub Watershed #28 Annual Cost* Before Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$1,375	$0	$8,220	$4,667	$0	$5,288	$19,549
2	$1,416	$0	$8,466	$4,807	$0	$5,446	$20,135
3	$1,458	$0	$8,720	$4,951	$0	$5,610	$20,739
4	$1,502	$0	$8,982	$5,099	$0	$5,778	$21,361
5	$1,547	$0	$9,251	$5,252	$0	$5,951	$22,002
6	$1,594	$0	$9,529	$5,410	$0	$6,130	$22,662
7	$1,642	$0	$9,815	$5,572	$0	$6,314	$23,342
8	$1,691	$0	$10,109	$5,739	$0	$6,503	$24,042
9	$1,741	$0	$10,412	$5,912	$0	$6,698	$24,763
10	$1,794	$0	$10,725	$6,089	$0	$6,899	$25,506

11	$1,848	$0	$11,046	$6,272	$0	$7,106	$26,272
12	$1,903	$0	$11,378	$6,460	$0	$7,319	$27,060
13	$1,960	$0	$11,719	$6,654	$0	$7,539	$27,872
14	$2,019	$0	$12,071	$6,853	$0	$7,765	$28,708
15	$2,079	$0	$12,433	$7,059	$0	$7,998	$29,569
16	$2,142	$0	$12,806	$7,271	$0	$8,238	$30,456
17	$2,206	$0	$13,190	$7,489	$0	$8,485	$31,370
18	$2,272	$0	$13,586	$7,713	$0	$8,739	$32,311
19	$2,340	$0	$13,993	$7,945	$0	$9,002	$33,280
20	$2,411	$0	$14,413	$8,183	$0	$9,272	$34,278
21	$0	$0	$0	$0	$0	$0	$0
22	$0	$0	$0	$0	$0	$0	$0
23	$0	$0	$0	$0	$0	$0	$0
24	$0	$0	$0	$0	$0	$0	$0
25	$0	$0	$0	$0	$0	$0	$0
26	$0	$0	$0	$0	$0	$0	$0
27	$0	$0	$0	$0	$0	$0	$0
28	$0	$0	$0	$0	$0	$0	$0
29	$0	$0	$0	$0	$0	$0	$0
30	$0	$0	$0	$0	$0	$0	$0
31	$0	$0	$0	$0	$0	$0	$0
32	$0	$0	$0	$0	$0	$0	$0
33	$0	$0	$0	$0	$0	$0	$0
34	$0	$0	$0	$0	$0	$0	$0
35	$0	$0	$0	$0	$0	$0	$0
36	$0	$0	$0	$0	$0	$0	$0
37	$0	$0	$0	$0	$0	$0	$0
38	$0	$0	$0	$0	$0	$0	$0
39	$0	$0	$0	$0	$0	$0	$0
40	$0	$0	$0	$0	$0	$0	$0

**3% Inflation*

Sub Watershed #31 Annual Cost* Before Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$2,843	$23,326	$16,990	$9,719	$7,435	$10,934	$71,248
2	$2,928	$24,026	$17,499	$10,011	$7,658	$11,262	$73,385
3	$3,016	$24,747	$18,024	$10,311	$7,888	$11,600	$75,587
4	$3,107	$25,489	$18,565	$10,621	$8,125	$11,948	$77,854
5	$3,200	$26,254	$19,122	$10,939	$8,368	$12,307	$80,190
6	$3,296	$27,042	$19,696	$11,267	$8,620	$12,676	$82,596
7	$3,395	$27,853	$20,287	$11,605	$8,878	$13,056	$85,074

8	$3,496	$28,689	$20,895	$11,954	$9,144	$13,448	$87,626
9	$3,601	$29,549	$21,522	$12,312	$9,419	$13,851	$90,255
10	$3,709	$30,436	$22,168	$12,682	$9,701	$14,267	$92,962
11	$3,821	$31,349	$22,833	$13,062	$9,992	$14,695	$95,751
12	$3,935	$32,289	$23,518	$13,454	$10,292	$15,136	$98,624
13	$4,053	$33,258	$24,223	$13,857	$10,601	$15,590	$101,582
14	$4,175	$34,256	$24,950	$14,273	$10,919	$16,057	$104,630
15	$4,300	$35,283	$25,698	$14,701	$11,247	$16,539	$107,769
16	$4,429	$36,342	$26,469	$15,142	$11,584	$17,035	$111,002
17	$4,562	$37,432	$27,263	$15,597	$11,931	$17,546	$114,332
18	$4,699	$38,555	$28,081	$16,065	$12,289	$18,073	$117,762
19	$4,840	$39,712	$28,924	$16,547	$12,658	$18,615	$121,295
20	$4,985	$40,903	$29,791	$17,043	$13,038	$19,173	$124,933
21	$0	$42,130	$20,457	$17,554	$0	$0	$80,141
22	$0	$43,394	$21,070	$18,081	$0	$0	$82,545
23	$0	$44,696	$21,703	$18,623	$0	$0	$85,022
24	$0	$46,037	$22,354	$19,182	$0	$0	$87,572
25	$0	$47,418	$23,024	$19,757	$0	$0	$90,199
26	$0	$48,840	$23,715	$20,350	$0	$0	$92,905
27	$0	$50,306	$24,426	$20,961	$0	$0	$95,693
28	$0	$51,815	$25,159	$21,589	$0	$0	$98,563
29	$0	$53,369	$25,914	$22,237	$0	$0	$101,520
30	$0	$54,970	$26,691	$22,904	$0	$0	$104,566
31	$0	$56,619	$27,492	$23,591	$0	$0	$107,703
32	$0	$58,318	$28,317	$24,299	$0	$0	$110,934
33	$0	$60,067	$29,166	$25,028	$0	$0	$114,262
34	$0	$61,869	$30,041	$25,779	$0	$0	$117,690
35	$0	$63,726	$30,943	$26,552	$0	$0	$121,221
36	$0	$65,637	$31,871	$27,349	$0	$0	$124,857
37	$0	$67,606	$32,827	$28,169	$0	$0	$128,603
38	$0	$69,635	$33,812	$29,014	$0	$0	$132,461
39	$0	$71,724	$34,826	$29,885	$0	$0	$136,435
40	$0	$73,875	$35,871	$30,781	$0	$0	$140,528

**3% Inflation*

Sub Watershed #33 Annual Cost* Before Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$1,701	$13,960	$10,168	$5,817	$4,450	$6,544	$42,639
2	$1,752	$14,379	$10,473	$5,991	$4,583	$6,740	$43,918
3	$1,805	$14,810	$10,787	$6,171	$4,721	$6,942	$45,236
4	$1,859	$15,254	$11,110	$6,356	$4,862	$7,151	$46,593

5	$1,915	$15,712	$11,444	$6,547	$5,008	$7,365	$47,991
6	$1,972	$16,183	$11,787	$6,743	$5,158	$7,586	$49,431
7	$2,032	$16,669	$12,141	$6,945	$5,313	$7,814	$50,913
8	$2,092	$17,169	$12,505	$7,154	$5,473	$8,048	$52,441
9	$2,155	$17,684	$12,880	$7,368	$5,637	$8,289	$54,014
10	$2,220	$18,215	$13,267	$7,589	$5,806	$8,538	$55,635
11	$2,287	$18,761	$13,665	$7,817	$5,980	$8,794	$57,304
12	$2,355	$19,324	$14,074	$8,052	$6,159	$9,058	$59,023
13	$2,426	$19,904	$14,497	$8,293	$6,344	$9,330	$60,793
14	$2,499	$20,501	$14,932	$8,542	$6,535	$9,610	$62,617
15	$2,573	$21,116	$15,380	$8,798	$6,731	$9,898	$64,496
16	$2,651	$21,749	$15,841	$9,062	$6,933	$10,195	$66,431
17	$2,730	$22,402	$16,316	$9,334	$7,141	$10,501	$68,423
18	$2,812	$23,074	$16,806	$9,614	$7,355	$10,816	$70,476
19	$2,896	$23,766	$17,310	$9,902	$7,575	$11,140	$72,590
20	$2,983	$24,479	$17,829	$10,200	$7,803	$11,475	$74,768
21	$0	$25,213	$12,243	$10,506	$0	$0	$47,961
22	$0	$25,970	$12,610	$10,821	$0	$0	$49,400
23	$0	$26,749	$12,988	$11,145	$0	$0	$50,882
24	$0	$27,551	$13,378	$11,480	$0	$0	$52,409
25	$0	$28,378	$13,779	$11,824	$0	$0	$53,981
26	$0	$29,229	$14,193	$12,179	$0	$0	$55,601
27	$0	$30,106	$14,618	$12,544	$0	$0	$57,269
28	$0	$31,009	$15,057	$12,920	$0	$0	$58,987
29	$0	$31,939	$15,509	$13,308	$0	$0	$60,756
30	$0	$32,898	$15,974	$13,707	$0	$0	$62,579
31	$0	$33,885	$16,453	$14,119	$0	$0	$64,456
32	$0	$34,901	$16,947	$14,542	$0	$0	$66,390
33	$0	$35,948	$17,455	$14,978	$0	$0	$68,382
34	$0	$37,027	$17,979	$15,428	$0	$0	$70,433
35	$0	$38,137	$18,518	$15,891	$0	$0	$72,546
36	$0	$39,282	$19,074	$16,367	$0	$0	$74,722
37	$0	$40,460	$19,646	$16,858	$0	$0	$76,964
38	$0	$41,674	$20,235	$17,364	$0	$0	$79,273
39	$0	$42,924	$20,842	$17,885	$0	$0	$81,651
40	$0	$44,212	$21,468	$18,422	$0	$0	$84,101

**3% Inflation*

Sub Watershed #35 Annual Cost* Before Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$3,419	$28,054	$20,433	$11,689	$8,942	$13,151	$85,689

2	$3,522	$28,896	$21,046	$12,040	$9,211	$13,545	$88,260
3	$3,627	$29,763	$21,678	$12,401	$9,487	$13,951	$90,907
4	$3,736	$30,656	$22,328	$12,773	$9,772	$14,370	$93,635
5	$3,848	$31,575	$22,998	$13,156	$10,065	$14,801	$96,444
6	$3,964	$32,523	$23,688	$13,551	$10,367	$15,245	$99,337
7	$4,083	$33,498	$24,398	$13,958	$10,678	$15,702	$102,317
8	$4,205	$34,503	$25,130	$14,376	$10,998	$16,173	$105,387
9	$4,331	$35,538	$25,884	$14,808	$11,328	$16,659	$108,548
10	$4,461	$36,605	$26,661	$15,252	$11,668	$17,158	$111,805
11	$4,595	$37,703	$27,461	$15,709	$12,018	$17,673	$115,159
12	$4,733	$38,834	$28,284	$16,181	$12,378	$18,203	$118,614
13	$4,875	$39,999	$29,133	$16,666	$12,750	$18,749	$122,172
14	$5,021	$41,199	$30,007	$17,166	$13,132	$19,312	$125,837
15	$5,172	$42,435	$30,907	$17,681	$13,526	$19,891	$129,612
16	$5,327	$43,708	$31,834	$18,212	$13,932	$20,488	$133,501
17	$5,487	$45,019	$32,789	$18,758	$14,350	$21,103	$137,506
18	$5,651	$46,370	$33,773	$19,321	$14,780	$21,736	$141,631
19	$5,821	$47,761	$34,786	$19,900	$15,224	$22,388	$145,880
20	$5,995	$49,194	$35,830	$20,497	$15,680	$23,059	$150,256
21	$0	$50,669	$24,603	$21,112	$0	$0	$96,385
22	$0	$52,189	$25,341	$21,746	$0	$0	$99,276
23	$0	$53,755	$26,101	$22,398	$0	$0	$102,255
24	$0	$55,368	$26,885	$23,070	$0	$0	$105,322
25	$0	$57,029	$27,691	$23,762	$0	$0	$108,482
26	$0	$58,740	$28,522	$24,475	$0	$0	$111,736
27	$0	$60,502	$29,377	$25,209	$0	$0	$115,088
28	$0	$62,317	$30,259	$25,965	$0	$0	$118,541
29	$0	$64,186	$31,167	$26,744	$0	$0	$122,097
30	$0	$66,112	$32,102	$27,547	$0	$0	$125,760
31	$0	$68,095	$33,065	$28,373	$0	$0	$129,533
32	$0	$70,138	$34,057	$29,224	$0	$0	$133,419
33	$0	$72,242	$35,078	$30,101	$0	$0	$137,422
34	$0	$74,410	$36,131	$31,004	$0	$0	$141,544
35	$0	$76,642	$37,214	$31,934	$0	$0	$145,791
36	$0	$78,941	$38,331	$32,892	$0	$0	$150,164
37	$0	$81,309	$39,481	$33,879	$0	$0	$154,669
38	$0	$83,749	$40,665	$34,895	$0	$0	$159,309
39	$0	$86,261	$41,885	$35,942	$0	$0	$164,089
40	$0	$88,849	$43,142	$37,020	$0	$0	$169,011

3% Inflation

Sub Watershed #38 Annual Cost* Before Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$3,353	$27,514	$20,039	$11,464	$8,770	$12,897	$84,037
2	$3,454	$28,339	$20,641	$11,808	$9,033	$13,284	$86,558
3	$3,557	$29,189	$21,260	$12,162	$9,304	$13,682	$89,155
4	$3,664	$30,065	$21,898	$12,527	$9,583	$14,093	$91,830
5	$3,774	$30,967	$22,554	$12,903	$9,871	$14,516	$94,585
6	$3,887	$31,896	$23,231	$13,290	$10,167	$14,951	$97,422
7	$4,004	$32,853	$23,928	$13,689	$10,472	$15,400	$100,345
8	$4,124	$33,838	$24,646	$14,099	$10,786	$15,862	$103,355
9	$4,248	$34,853	$25,385	$14,522	$11,110	$16,338	$106,456
10	$4,375	$35,899	$26,147	$14,958	$11,443	$16,828	$109,649
11	$4,506	$36,976	$26,931	$15,407	$11,786	$17,332	$112,939
12	$4,642	$38,085	$27,739	$15,869	$12,140	$17,852	$116,327
13	$4,781	$39,228	$28,571	$16,345	$12,504	$18,388	$119,817
14	$4,924	$40,405	$29,428	$16,835	$12,879	$18,940	$123,411
15	$5,072	$41,617	$30,311	$17,340	$13,265	$19,508	$127,114
16	$5,224	$42,865	$31,221	$17,861	$13,663	$20,093	$130,927
17	$5,381	$44,151	$32,157	$18,396	$14,073	$20,696	$134,855
18	$5,542	$45,476	$33,122	$18,948	$14,495	$21,317	$138,901
19	$5,709	$46,840	$34,116	$19,517	$14,930	$21,956	$143,068
20	$5,880	$48,245	$35,139	$20,102	$15,378	$22,615	$147,360
21	$0	$49,693	$24,129	$20,705	$0	$0	$94,527
22	$0	$51,183	$24,853	$21,326	$0	$0	$97,363
23	$0	$52,719	$25,598	$21,966	$0	$0	$100,283
24	$0	$54,300	$26,366	$22,625	$0	$0	$103,292
25	$0	$55,929	$27,157	$23,304	$0	$0	$106,391
26	$0	$57,607	$27,972	$24,003	$0	$0	$109,582
27	$0	$59,336	$28,811	$24,723	$0	$0	$112,870
28	$0	$61,116	$29,675	$25,465	$0	$0	$116,256
29	$0	$62,949	$30,566	$26,229	$0	$0	$119,744
30	$0	$64,838	$31,483	$27,016	$0	$0	$123,336
31	$0	$66,783	$32,427	$27,826	$0	$0	$127,036
32	$0	$68,786	$33,400	$28,661	$0	$0	$130,847
33	$0	$70,850	$34,402	$29,521	$0	$0	$134,773
34	$0	$72,975	$35,434	$30,406	$0	$0	$138,816
35	$0	$75,165	$36,497	$31,319	$0	$0	$142,980
36	$0	$77,419	$37,592	$32,258	$0	$0	$147,270
37	$0	$79,742	$38,720	$33,226	$0	$0	$151,688
38	$0	$82,134	$39,881	$34,223	$0	$0	$156,238
39	$0	$84,598	$41,078	$35,249	$0	$0	$160,925
40	$0	$87,136	$42,310	$36,307	$0	$0	$165,753

*3% Inflation

Sub Watershed #55 Annual Cost* Before Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$3,568	$29,274	$21,321	$12,197	$9,331	$13,722	$89,413
2	$3,675	$30,152	$21,961	$12,563	$9,611	$14,134	$92,095
3	$3,785	$31,056	$22,620	$12,940	$9,899	$14,558	$94,858
4	$3,899	$31,988	$23,298	$13,328	$10,196	$14,994	$97,704
5	$4,016	$32,948	$23,997	$13,728	$10,502	$15,444	$100,635
6	$4,136	$33,936	$24,717	$14,140	$10,817	$15,908	$103,654
7	$4,260	$34,954	$25,459	$14,564	$11,142	$16,385	$106,764
8	$4,388	$36,003	$26,222	$15,001	$11,476	$16,876	$109,967
9	$4,519	$37,083	$27,009	$15,451	$11,820	$17,383	$113,266
10	$4,655	$38,195	$27,819	$15,915	$12,175	$17,904	$116,663
11	$4,795	$39,341	$28,654	$16,392	$12,540	$18,441	$120,163
12	$4,939	$40,522	$29,514	$16,884	$12,916	$18,994	$123,768
13	$5,087	$41,737	$30,399	$17,390	$13,304	$19,564	$127,481
14	$5,239	$42,989	$31,311	$17,912	$13,703	$20,151	$131,306
15	$5,396	$44,279	$32,250	$18,450	$14,114	$20,756	$135,245
16	$5,558	$45,607	$33,218	$19,003	$14,537	$21,378	$139,302
17	$5,725	$46,976	$34,214	$19,573	$14,973	$22,020	$143,481
18	$5,897	$48,385	$35,241	$20,160	$15,423	$22,680	$147,786
19	$6,074	$49,836	$36,298	$20,765	$15,885	$23,361	$152,219
20	$6,256	$51,331	$37,387	$21,388	$16,362	$24,062	$156,786
21	$0	$52,871	$25,672	$22,030	$0	$0	$100,573
22	$0	$54,458	$26,443	$22,691	$0	$0	$103,591
23	$0	$56,091	$27,236	$23,371	$0	$0	$106,698
24	$0	$57,774	$28,053	$24,072	$0	$0	$109,899
25	$0	$59,507	$28,894	$24,795	$0	$0	$113,196
26	$0	$61,292	$29,761	$25,539	$0	$0	$116,592
27	$0	$63,131	$30,654	$26,305	$0	$0	$120,090
28	$0	$65,025	$31,574	$27,094	$0	$0	$123,693
29	$0	$66,976	$32,521	$27,907	$0	$0	$127,403
30	$0	$68,985	$33,497	$28,744	$0	$0	$131,226
31	$0	$71,055	$34,502	$29,606	$0	$0	$135,162
32	$0	$73,186	$35,537	$30,494	$0	$0	$139,217
33	$0	$75,382	$36,603	$31,409	$0	$0	$143,394
34	$0	$77,643	$37,701	$32,351	$0	$0	$147,696
35	$0	$79,973	$38,832	$33,322	$0	$0	$152,126
36	$0	$82,372	$39,997	$34,322	$0	$0	$156,690
37	$0	$84,843	$41,197	$35,351	$0	$0	$161,391

38	$0	$87,388	$42,432	$36,412	$0	$0	$166,233
39	$0	$90,010	$43,705	$37,504	$0	$0	$171,220
40	$0	$92,710	$45,017	$38,629	$0	$0	$176,356

**3% Inflation*

Table 51. Costs by BMP After Cost Share.

Sub Watershed #15 Annual Cost* After Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$2,005	$8,225	$7,308	$685	$2,622	$3,855	$24,700
2	$2,065	$8,472	$7,528	$706	$2,700	$3,971	$25,441
3	$2,127	$8,726	$7,753	$727	$2,781	$4,090	$26,205
4	$2,191	$8,987	$7,986	$749	$2,865	$4,213	$26,991
5	$2,256	$9,257	$8,226	$771	$2,951	$4,339	$27,801
6	$2,324	$9,535	$8,472	$795	$3,039	$4,469	$28,635
7	$2,394	$9,821	$8,727	$818	$3,130	$4,604	$29,494
8	$2,466	$10,115	$8,988	$843	$3,224	$4,742	$30,378
9	$2,540	$10,419	$9,258	$868	$3,321	$4,884	$31,290
10	$2,616	$10,731	$9,536	$894	$3,421	$5,030	$32,228
11	$2,694	$11,053	$9,822	$921	$3,523	$5,181	$33,195
12	$2,775	$11,385	$10,117	$949	$3,629	$5,337	$34,191
13	$2,858	$11,727	$10,420	$977	$3,738	$5,497	$35,217
14	$2,944	$12,078	$10,733	$1,007	$3,850	$5,662	$36,273
15	$3,032	$12,441	$11,055	$1,037	$3,965	$5,832	$37,362
16	$3,123	$12,814	$11,386	$1,068	$4,084	$6,007	$38,482
17	$3,217	$13,198	$11,728	$1,100	$4,207	$6,187	$39,637
18	$3,314	$13,594	$12,080	$1,133	$4,333	$6,372	$40,826
19	$3,413	$14,002	$12,442	$1,167	$4,463	$6,564	$42,051
20	$3,515	$14,422	$12,815	$1,202	$4,597	$6,760	$43,312
21	$0	$14,855	$8,800	$1,238	$0	$0	$24,893
22	$0	$15,301	$9,064	$1,275	$0	$0	$25,639
23	$0	$15,760	$9,336	$1,313	$0	$0	$26,409
24	$0	$16,232	$9,616	$1,353	$0	$0	$27,201
25	$0	$16,719	$9,904	$1,393	$0	$0	$28,017
26	$0	$17,221	$10,201	$1,435	$0	$0	$28,857
27	$0	$17,738	$10,507	$1,478	$0	$0	$29,723
28	$0	$18,270	$10,823	$1,522	$0	$0	$30,615
29	$0	$18,818	$11,147	$1,568	$0	$0	$31,533
30	$0	$19,382	$11,482	$1,615	$0	$0	$32,479
31	$0	$19,964	$11,826	$1,664	$0	$0	$33,454
32	$0	$20,563	$12,181	$1,714	$0	$0	$34,457

33	$0	$21,180	$12,546	$1,765	$0	$0	$35,491
34	$0	$21,815	$12,923	$1,818	$0	$0	$36,556
35	$0	$22,469	$13,311	$1,872	$0	$0	$37,652
36	$0	$23,143	$13,710	$1,929	$0	$0	$38,782
37	$0	$23,838	$14,121	$1,986	$0	$0	$39,945
38	$0	$24,553	$14,545	$2,046	$0	$0	$41,144
39	$0	$25,289	$14,981	$2,107	$0	$0	$42,378
40	$0	$26,048	$15,431	$2,171	$0	$0	$43,649

**3% Inflation*

Sub Watershed #16 Annual Cost* After Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$3,733	$15,317	$13,610	$1,276	$4,882	$7,180	$45,999
2	$3,845	$15,776	$14,018	$1,315	$5,029	$7,395	$47,379
3	$3,961	$16,250	$14,439	$1,354	$5,180	$7,617	$48,800
4	$4,080	$16,737	$14,872	$1,395	$5,335	$7,846	$50,264
5	$4,202	$17,239	$15,318	$1,437	$5,495	$8,081	$51,772
6	$4,328	$17,756	$15,778	$1,480	$5,660	$8,323	$53,325
7	$4,458	$18,289	$16,251	$1,524	$5,830	$8,573	$54,925
8	$4,592	$18,838	$16,739	$1,570	$6,005	$8,830	$56,573
9	$4,729	$19,403	$17,241	$1,617	$6,185	$9,095	$58,270
10	$4,871	$19,985	$17,758	$1,665	$6,370	$9,368	$60,018
11	$5,017	$20,584	$18,291	$1,715	$6,561	$9,649	$61,819
12	$5,168	$21,202	$18,840	$1,767	$6,758	$9,938	$63,673
13	$5,323	$21,838	$19,405	$1,820	$6,961	$10,237	$65,583
14	$5,483	$22,493	$19,987	$1,874	$7,170	$10,544	$67,551
15	$5,647	$23,168	$20,587	$1,931	$7,385	$10,860	$69,577
16	$5,817	$23,863	$21,204	$1,989	$7,606	$11,186	$71,665
17	$5,991	$24,579	$21,840	$2,048	$7,835	$11,521	$73,815
18	$6,171	$25,316	$22,496	$2,110	$8,070	$11,867	$76,029
19	$6,356	$26,076	$23,170	$2,173	$8,312	$12,223	$78,310
20	$6,547	$26,858	$23,866	$2,238	$8,561	$12,590	$80,659
21	$0	$27,664	$16,388	$2,305	$0	$0	$46,357
22	$0	$28,494	$16,879	$2,374	$0	$0	$47,748
23	$0	$29,349	$17,386	$2,446	$0	$0	$49,180
24	$0	$30,229	$17,907	$2,519	$0	$0	$50,655
25	$0	$31,136	$18,444	$2,595	$0	$0	$52,175
26	$0	$32,070	$18,998	$2,672	$0	$0	$53,740
27	$0	$33,032	$19,568	$2,753	$0	$0	$55,352
28	$0	$34,023	$20,155	$2,835	$0	$0	$57,013
29	$0	$35,044	$20,759	$2,920	$0	$0	$58,723

30	$0	$36,095	$21,382	$3,008	$0	$0	$60,485
31	$0	$37,178	$22,024	$3,098	$0	$0	$62,300
32	$0	$38,293	$22,684	$3,191	$0	$0	$64,169
33	$0	$39,442	$23,365	$3,287	$0	$0	$66,094
34	$0	$40,625	$24,066	$3,385	$0	$0	$68,077
35	$0	$41,844	$24,788	$3,487	$0	$0	$70,119
36	$0	$43,099	$25,531	$3,592	$0	$0	$72,222
37	$0	$44,392	$26,297	$3,699	$0	$0	$74,389
38	$0	$45,724	$27,086	$3,810	$0	$0	$76,621
39	$0	$47,096	$27,899	$3,925	$0	$0	$78,919
40	$0	$48,509	$28,736	$4,042	$0	$0	$81,287

3% Inflation

Sub Watershed #25 Annual Cost* After Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$1,619	$0	$5,903	$554	$0	$3,113	$11,187
2	$1,667	$0	$6,080	$570	$0	$3,206	$11,523
3	$1,717	$0	$6,262	$587	$0	$3,302	$11,869
4	$1,769	$0	$6,450	$605	$0	$3,401	$12,225
5	$1,822	$0	$6,643	$623	$0	$3,503	$12,591
6	$1,876	$0	$6,843	$642	$0	$3,608	$12,969
7	$1,933	$0	$7,048	$661	$0	$3,716	$13,358
8	$1,991	$0	$7,259	$681	$0	$3,828	$13,759
9	$2,050	$0	$7,477	$701	$0	$3,943	$14,172
10	$2,112	$0	$7,701	$722	$0	$4,061	$14,597
11	$2,175	$0	$7,933	$744	$0	$4,183	$15,035
12	$2,240	$0	$8,170	$766	$0	$4,308	$15,486
13	$2,308	$0	$8,416	$789	$0	$4,438	$15,950
14	$2,377	$0	$8,668	$813	$0	$4,571	$16,429
15	$2,448	$0	$8,928	$837	$0	$4,708	$16,922
16	$2,522	$0	$9,196	$863	$0	$4,849	$17,429
17	$2,597	$0	$9,472	$888	$0	$4,995	$17,952
18	$2,675	$0	$9,756	$915	$0	$5,144	$18,491
19	$2,755	$0	$10,049	$943	$0	$5,299	$19,045
20	$2,838	$0	$10,350	$971	$0	$5,458	$19,617
21	$0	$0	$0	$0	$0	$0	$0
22	$0	$0	$0	$0	$0	$0	$0
23	$0	$0	$0	$0	$0	$0	$0
24	$0	$0	$0	$0	$0	$0	$0
25	$0	$0	$0	$0	$0	$0	$0
26	$0	$0	$0	$0	$0	$0	$0

27	$0	$0	$0	$0	$0	$0	$0
28	$0	$0	$0	$0	$0	$0	$0
29	$0	$0	$0	$0	$0	$0	$0
30	$0	$0	$0	$0	$0	$0	$0
31	$0	$0	$0	$0	$0	$0	$0
32	$0	$0	$0	$0	$0	$0	$0
33	$0	$0	$0	$0	$0	$0	$0
34	$0	$0	$0	$0	$0	$0	$0
35	$0	$0	$0	$0	$0	$0	$0
36	$0	$0	$0	$0	$0	$0	$0
37	$0	$0	$0	$0	$0	$0	$0
38	$0	$0	$0	$0	$0	$0	$0
39	$0	$0	$0	$0	$0	$0	$0
40	$0	$0	$0	$0	$0	$0	$0

**3% Inflation*

Sub Watershed #28 Annual Cost* After Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$1,375	$0	$5,014	$467	$0	$2,644	$9,499
2	$1,416	$0	$5,164	$481	$0	$2,723	$9,784
3	$1,458	$0	$5,319	$495	$0	$2,805	$10,078
4	$1,502	$0	$5,479	$510	$0	$2,889	$10,380
5	$1,547	$0	$5,643	$525	$0	$2,976	$10,691
6	$1,594	$0	$5,813	$541	$0	$3,065	$11,012
7	$1,642	$0	$5,987	$557	$0	$3,157	$11,342
8	$1,691	$0	$6,167	$574	$0	$3,251	$11,683
9	$1,741	$0	$6,352	$591	$0	$3,349	$12,033
10	$1,794	$0	$6,542	$609	$0	$3,449	$12,394
11	$1,848	$0	$6,738	$627	$0	$3,553	$12,766
12	$1,903	$0	$6,940	$646	$0	$3,660	$13,149
13	$1,960	$0	$7,149	$665	$0	$3,769	$13,543
14	$2,019	$0	$7,363	$685	$0	$3,882	$13,950
15	$2,079	$0	$7,584	$706	$0	$3,999	$14,368
16	$2,142	$0	$7,812	$727	$0	$4,119	$14,799
17	$2,206	$0	$8,046	$749	$0	$4,242	$15,243
18	$2,272	$0	$8,287	$771	$0	$4,370	$15,701
19	$2,340	$0	$8,536	$794	$0	$4,501	$16,172
20	$2,411	$0	$8,792	$818	$0	$4,636	$16,657
21	$0	$0	$0	$0	$0	$0	$0
22	$0	$0	$0	$0	$0	$0	$0
23	$0	$0	$0	$0	$0	$0	$0

24	$0	$0	$0	$0	$0	$0	$0
25	$0	$0	$0	$0	$0	$0	$0
26	$0	$0	$0	$0	$0	$0	$0
27	$0	$0	$0	$0	$0	$0	$0
28	$0	$0	$0	$0	$0	$0	$0
29	$0	$0	$0	$0	$0	$0	$0
30	$0	$0	$0	$0	$0	$0	$0
31	$0	$0	$0	$0	$0	$0	$0
32	$0	$0	$0	$0	$0	$0	$0
33	$0	$0	$0	$0	$0	$0	$0
34	$0	$0	$0	$0	$0	$0	$0
35	$0	$0	$0	$0	$0	$0	$0
36	$0	$0	$0	$0	$0	$0	$0
37	$0	$0	$0	$0	$0	$0	$0
38	$0	$0	$0	$0	$0	$0	$0
39	$0	$0	$0	$0	$0	$0	$0
40	$0	$0	$0	$0	$0	$0	$0

**3% Inflation*

Sub Watershed #31 Annual Cost* After Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$2,843	$11,663	$10,364	$972	$3,718	$5,467	$35,026
2	$2,928	$12,013	$10,675	$1,001	$3,829	$5,631	$36,077
3	$3,016	$12,373	$10,995	$1,031	$3,944	$5,800	$37,160
4	$3,107	$12,745	$11,325	$1,062	$4,062	$5,974	$38,274
5	$3,200	$13,127	$11,664	$1,094	$4,184	$6,153	$39,423
6	$3,296	$13,521	$12,014	$1,127	$4,310	$6,338	$40,605
7	$3,395	$13,926	$12,375	$1,161	$4,439	$6,528	$41,823
8	$3,496	$14,344	$12,746	$1,195	$4,572	$6,724	$43,078
9	$3,601	$14,775	$13,128	$1,231	$4,709	$6,926	$44,371
10	$3,709	$15,218	$13,522	$1,268	$4,851	$7,133	$45,702
11	$3,821	$15,674	$13,928	$1,306	$4,996	$7,347	$47,073
12	$3,935	$16,145	$14,346	$1,345	$5,146	$7,568	$48,485
13	$4,053	$16,629	$14,776	$1,386	$5,300	$7,795	$49,939
14	$4,175	$17,128	$15,219	$1,427	$5,459	$8,029	$51,438
15	$4,300	$17,642	$15,676	$1,470	$5,623	$8,270	$52,981
16	$4,429	$18,171	$16,146	$1,514	$5,792	$8,518	$54,570
17	$4,562	$18,716	$16,631	$1,560	$5,966	$8,773	$56,207
18	$4,699	$19,277	$17,130	$1,606	$6,145	$9,036	$57,893
19	$4,840	$19,856	$17,643	$1,655	$6,329	$9,307	$59,630
20	$4,985	$20,451	$18,173	$1,704	$6,519	$9,587	$61,419

21	$0	$21,065	$12,479	$1,755	$0	$0	$35,299
22	$0	$21,697	$12,853	$1,808	$0	$0	$36,358
23	$0	$22,348	$13,239	$1,862	$0	$0	$37,449
24	$0	$23,018	$13,636	$1,918	$0	$0	$38,572
25	$0	$23,709	$14,045	$1,976	$0	$0	$39,729
26	$0	$24,420	$14,466	$2,035	$0	$0	$40,921
27	$0	$25,153	$14,900	$2,096	$0	$0	$42,149
28	$0	$25,907	$15,347	$2,159	$0	$0	$43,413
29	$0	$26,685	$15,808	$2,224	$0	$0	$44,716
30	$0	$27,485	$16,282	$2,290	$0	$0	$46,057
31	$0	$28,310	$16,770	$2,359	$0	$0	$47,439
32	$0	$29,159	$17,273	$2,430	$0	$0	$48,862
33	$0	$30,034	$17,792	$2,503	$0	$0	$50,328
34	$0	$30,935	$18,325	$2,578	$0	$0	$51,838
35	$0	$31,863	$18,875	$2,655	$0	$0	$53,393
36	$0	$32,819	$19,441	$2,735	$0	$0	$54,995
37	$0	$33,803	$20,025	$2,817	$0	$0	$56,645
38	$0	$34,817	$20,625	$2,901	$0	$0	$58,344
39	$0	$35,862	$21,244	$2,988	$0	$0	$60,094
40	$0	$36,938	$21,881	$3,078	$0	$0	$61,897

**3% Inflation*

Sub Watershed #33 Annual Cost* After Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$1,701	$6,980	$6,202	$582	$2,225	$3,272	$20,962
2	$1,752	$7,189	$6,388	$599	$2,292	$3,370	$21,591
3	$1,805	$7,405	$6,580	$617	$2,360	$3,471	$22,239
4	$1,859	$7,627	$6,777	$636	$2,431	$3,575	$22,906
5	$1,915	$7,856	$6,981	$655	$2,504	$3,683	$23,593
6	$1,972	$8,092	$7,190	$674	$2,579	$3,793	$24,301
7	$2,032	$8,334	$7,406	$695	$2,657	$3,907	$25,030
8	$2,092	$8,585	$7,628	$715	$2,736	$4,024	$25,781
9	$2,155	$8,842	$7,857	$737	$2,818	$4,145	$26,554
10	$2,220	$9,107	$8,093	$759	$2,903	$4,269	$27,351
11	$2,287	$9,381	$8,335	$782	$2,990	$4,397	$28,171
12	$2,355	$9,662	$8,585	$805	$3,080	$4,529	$29,016
13	$2,426	$9,952	$8,843	$829	$3,172	$4,665	$29,887
14	$2,499	$10,250	$9,108	$854	$3,267	$4,805	$30,784
15	$2,573	$10,558	$9,382	$880	$3,365	$4,949	$31,707
16	$2,651	$10,875	$9,663	$906	$3,466	$5,097	$32,658
17	$2,730	$11,201	$9,953	$933	$3,570	$5,250	$33,638

18	$2,812	$11,537	$10,251	$961	$3,677	$5,408	$34,647
19	$2,896	$11,883	$10,559	$990	$3,788	$5,570	$35,687
20	$2,983	$12,239	$10,876	$1,020	$3,901	$5,737	$36,757
21	$0	$12,607	$7,468	$1,051	$0	$0	$21,125
22	$0	$12,985	$7,692	$1,082	$0	$0	$21,759
23	$0	$13,374	$7,923	$1,115	$0	$0	$22,412
24	$0	$13,776	$8,160	$1,148	$0	$0	$23,084
25	$0	$14,189	$8,405	$1,182	$0	$0	$23,777
26	$0	$14,615	$8,657	$1,218	$0	$0	$24,490
27	$0	$15,053	$8,917	$1,254	$0	$0	$25,225
28	$0	$15,505	$9,185	$1,292	$0	$0	$25,981
29	$0	$15,970	$9,460	$1,331	$0	$0	$26,761
30	$0	$16,449	$9,744	$1,371	$0	$0	$27,564
31	$0	$16,942	$10,036	$1,412	$0	$0	$28,391
32	$0	$17,451	$10,337	$1,454	$0	$0	$29,242
33	$0	$17,974	$10,648	$1,498	$0	$0	$30,120
34	$0	$18,513	$10,967	$1,543	$0	$0	$31,023
35	$0	$19,069	$11,296	$1,589	$0	$0	$31,954
36	$0	$19,641	$11,635	$1,637	$0	$0	$32,912
37	$0	$20,230	$11,984	$1,686	$0	$0	$33,900
38	$0	$20,837	$12,343	$1,736	$0	$0	$34,917
39	$0	$21,462	$12,714	$1,788	$0	$0	$35,964
40	$0	$22,106	$13,095	$1,842	$0	$0	$37,043

**3% Inflation*

Sub Watershed #35 Annual Cost* After Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$3,419	$14,027	$12,464	$1,169	$4,471	$6,575	$42,126
2	$3,522	$14,448	$12,838	$1,204	$4,605	$6,773	$43,390
3	$3,627	$14,881	$13,223	$1,240	$4,743	$6,976	$44,691
4	$3,736	$15,328	$13,620	$1,277	$4,886	$7,185	$46,032
5	$3,848	$15,788	$14,029	$1,316	$5,032	$7,401	$47,413
6	$3,964	$16,261	$14,450	$1,355	$5,183	$7,623	$48,836
7	$4,083	$16,749	$14,883	$1,396	$5,339	$7,851	$50,301
8	$4,205	$17,252	$15,329	$1,438	$5,499	$8,087	$51,810
9	$4,331	$17,769	$15,789	$1,481	$5,664	$8,329	$53,364
10	$4,461	$18,302	$16,263	$1,525	$5,834	$8,579	$54,965
11	$4,595	$18,851	$16,751	$1,571	$6,009	$8,837	$56,614
12	$4,733	$19,417	$17,253	$1,618	$6,189	$9,102	$58,312
13	$4,875	$19,999	$17,771	$1,667	$6,375	$9,375	$60,062
14	$5,021	$20,599	$18,304	$1,717	$6,566	$9,656	$61,863

15	$5,172	$21,217	$18,853	$1,768	$6,763	$9,946	$63,719
16	$5,327	$21,854	$19,419	$1,821	$6,966	$10,244	$65,631
17	$5,487	$22,510	$20,002	$1,876	$7,175	$10,551	$67,600
18	$5,651	$23,185	$20,602	$1,932	$7,390	$10,868	$69,628
19	$5,821	$23,880	$21,220	$1,990	$7,612	$11,194	$71,717
20	$5,995	$24,597	$21,856	$2,050	$7,840	$11,530	$73,868
21	$0	$25,335	$15,008	$2,111	$0	$0	$42,454
22	$0	$26,095	$15,458	$2,175	$0	$0	$43,727
23	$0	$26,878	$15,922	$2,240	$0	$0	$45,039
24	$0	$27,684	$16,400	$2,307	$0	$0	$46,390
25	$0	$28,514	$16,892	$2,376	$0	$0	$47,782
26	$0	$29,370	$17,398	$2,447	$0	$0	$49,216
27	$0	$30,251	$17,920	$2,521	$0	$0	$50,692
28	$0	$31,158	$18,458	$2,597	$0	$0	$52,213
29	$0	$32,093	$19,012	$2,674	$0	$0	$53,779
30	$0	$33,056	$19,582	$2,755	$0	$0	$55,393
31	$0	$34,048	$20,169	$2,837	$0	$0	$57,054
32	$0	$35,069	$20,774	$2,922	$0	$0	$58,766
33	$0	$36,121	$21,398	$3,010	$0	$0	$60,529
34	$0	$37,205	$22,040	$3,100	$0	$0	$62,345
35	$0	$38,321	$22,701	$3,193	$0	$0	$64,215
36	$0	$39,471	$23,382	$3,289	$0	$0	$66,142
37	$0	$40,655	$24,083	$3,388	$0	$0	$68,126
38	$0	$41,874	$24,806	$3,490	$0	$0	$70,170
39	$0	$43,131	$25,550	$3,594	$0	$0	$72,275
40	$0	$44,425	$26,316	$3,702	$0	$0	$74,443

**3% Inflation*

Sub Watershed #38 Annual Cost* After Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$3,353	$13,757	$12,224	$1,146	$4,385	$6,449	$41,314
2	$3,454	$14,170	$12,591	$1,181	$4,517	$6,642	$42,553
3	$3,557	$14,595	$12,968	$1,216	$4,652	$6,841	$43,830
4	$3,664	$15,032	$13,358	$1,253	$4,792	$7,046	$45,145
5	$3,774	$15,483	$13,758	$1,290	$4,935	$7,258	$46,499
6	$3,887	$15,948	$14,171	$1,329	$5,083	$7,476	$47,894
7	$4,004	$16,426	$14,596	$1,369	$5,236	$7,700	$49,331
8	$4,124	$16,919	$15,034	$1,410	$5,393	$7,931	$50,811
9	$4,248	$17,427	$15,485	$1,452	$5,555	$8,169	$52,335
10	$4,375	$17,950	$15,950	$1,496	$5,721	$8,414	$53,905
11	$4,506	$18,488	$16,428	$1,541	$5,893	$8,666	$55,522

12	$4,642	$19,043	$16,921	$1,587	$6,070	$8,926	$57,188
13	$4,781	$19,614	$17,429	$1,634	$6,252	$9,194	$58,904
14	$4,924	$20,202	$17,951	$1,684	$6,439	$9,470	$60,671
15	$5,072	$20,808	$18,490	$1,734	$6,633	$9,754	$62,491
16	$5,224	$21,433	$19,045	$1,786	$6,832	$10,047	$64,366
17	$5,381	$22,076	$19,616	$1,840	$7,037	$10,348	$66,297
18	$5,542	$22,738	$20,204	$1,895	$7,248	$10,658	$68,286
19	$5,709	$23,420	$20,811	$1,952	$7,465	$10,978	$70,334
20	$5,880	$24,123	$21,435	$2,010	$7,689	$11,307	$72,444
21	$0	$24,846	$14,719	$2,071	$0	$0	$41,635
22	$0	$25,592	$15,160	$2,133	$0	$0	$42,885
23	$0	$26,359	$15,615	$2,197	$0	$0	$44,171
24	$0	$27,150	$16,083	$2,263	$0	$0	$45,496
25	$0	$27,965	$16,566	$2,330	$0	$0	$46,861
26	$0	$28,804	$17,063	$2,400	$0	$0	$48,267
27	$0	$29,668	$17,575	$2,472	$0	$0	$49,715
28	$0	$30,558	$18,102	$2,546	$0	$0	$51,206
29	$0	$31,475	$18,645	$2,623	$0	$0	$52,743
30	$0	$32,419	$19,204	$2,702	$0	$0	$54,325
31	$0	$33,391	$19,781	$2,783	$0	$0	$55,955
32	$0	$34,393	$20,374	$2,866	$0	$0	$57,633
33	$0	$35,425	$20,985	$2,952	$0	$0	$59,362
34	$0	$36,488	$21,615	$3,041	$0	$0	$61,143
35	$0	$37,582	$22,263	$3,132	$0	$0	$62,977
36	$0	$38,710	$22,931	$3,226	$0	$0	$64,867
37	$0	$39,871	$23,619	$3,323	$0	$0	$66,813
38	$0	$41,067	$24,328	$3,422	$0	$0	$68,817
39	$0	$42,299	$25,057	$3,525	$0	$0	$70,882
40	$0	$43,568	$25,809	$3,631	$0	$0	$73,008

**3% Inflation*

Sub Watershed #55 Annual Cost* After Cost-Share, Cropland BMPs

Year	Conservation Crop Rotations	Grassed Waterways	No-Till	Vegetative Buffers	Terraces	Permanent Vegetation	Total Cost
1	$3,568	$14,637	$13,006	$1,220	$4,665	$6,861	$43,957
2	$3,675	$15,076	$13,396	$1,256	$4,805	$7,067	$45,275
3	$3,785	$15,528	$13,798	$1,294	$4,950	$7,279	$46,634
4	$3,899	$15,994	$14,212	$1,333	$5,098	$7,497	$48,033
5	$4,016	$16,474	$14,638	$1,373	$5,251	$7,722	$49,474
6	$4,136	$16,968	$15,077	$1,414	$5,409	$7,954	$50,958
7	$4,260	$17,477	$15,530	$1,456	$5,571	$8,192	$52,487
8	$4,388	$18,001	$15,996	$1,500	$5,738	$8,438	$54,061

9	$4,519	$18,541	$16,476	$1,545	$5,910	$8,691	$55,683
10	$4,655	$19,098	$16,970	$1,591	$6,087	$8,952	$57,354
11	$4,795	$19,671	$17,479	$1,639	$6,270	$9,221	$59,074
12	$4,939	$20,261	$18,003	$1,688	$6,458	$9,497	$60,846
13	$5,087	$20,869	$18,543	$1,739	$6,652	$9,782	$62,672
14	$5,239	$21,495	$19,100	$1,791	$6,851	$10,076	$64,552
15	$5,396	$22,139	$19,673	$1,845	$7,057	$10,378	$66,488
16	$5,558	$22,804	$20,263	$1,900	$7,269	$10,689	$68,483
17	$5,725	$23,488	$20,871	$1,957	$7,487	$11,010	$70,538
18	$5,897	$24,192	$21,497	$2,016	$7,711	$11,340	$72,654
19	$6,074	$24,918	$22,142	$2,077	$7,943	$11,680	$74,833
20	$6,256	$25,666	$22,806	$2,139	$8,181	$12,031	$77,078
21	$0	$26,436	$15,660	$2,203	$0	$0	$44,299
22	$0	$27,229	$16,130	$2,269	$0	$0	$45,628
23	$0	$28,046	$16,614	$2,337	$0	$0	$46,997
24	$0	$28,887	$17,112	$2,407	$0	$0	$48,406
25	$0	$29,754	$17,626	$2,479	$0	$0	$49,859
26	$0	$30,646	$18,154	$2,554	$0	$0	$51,354
27	$0	$31,566	$18,699	$2,630	$0	$0	$52,895
28	$0	$32,513	$19,260	$2,709	$0	$0	$54,482
29	$0	$33,488	$19,838	$2,791	$0	$0	$56,116
30	$0	$34,493	$20,433	$2,874	$0	$0	$57,800
31	$0	$35,527	$21,046	$2,961	$0	$0	$59,534
32	$0	$36,593	$21,677	$3,049	$0	$0	$61,320
33	$0	$37,691	$22,328	$3,141	$0	$0	$63,159
34	$0	$38,822	$22,997	$3,235	$0	$0	$65,054
35	$0	$39,986	$23,687	$3,332	$0	$0	$67,006
36	$0	$41,186	$24,398	$3,432	$0	$0	$69,016
37	$0	$42,422	$25,130	$3,535	$0	$0	$71,087
38	$0	$43,694	$25,884	$3,641	$0	$0	$73,219
39	$0	$45,005	$26,660	$3,750	$0	$0	$75,416
40	$0	$46,355	$27,460	$3,863	$0	$0	$77,678

**3% Inflation*

13.4 Kansas Water Office Cottonwood Watershed Structure Model

Watershed Detention Structure Reductions to Sediment Yield and Flood Frequency for the Cottonwood River near Plymouth, Kansas

Executive Summary

The Kansas Water Office has developed a model to analyze the impact of enhanced detention storage in the Cottonwood River basin. The model evaluates the changes to the mean annual sediment yield and flood frequency for the flows recorded on the Cottonwood River near Plymouth from 1990 through 2009 by temporarily storing a portion of the historic flows in an artificial detention pool. The overall size of the artificial detention pool in the model is user specified. The user specified volume is conceptualized within the model by adding or removing watershed structures within the Cottonwood basin. Each watershed structure has the same physical properties established by reviewing and averaging the properties of all the planned structures in the basin. KWO modeled total detention volumes ranging from 10,000 to 200,000 acre-feet for this report.

In order gain appreciable reductions to sediment yields and flood frequencies on the Cottonwood River the evacuation time of the 'typical' watershed structure detention pool had to be increased significantly over the standard design evacuation rate for those 'typical' watershed structures.

Model results indicate sediment yield reductions limit out for very large detention volumes in the basin near 24% below the mean annual sediment yield for the last 20 years. Reductions to mean annual sediment yields are generally linear as total detention volumes increase. Flood frequency reductions of about 88% can be achieved with very large detention volume values. The reductions to the flood frequency are not linear but S-shaped. Initial flood frequency reductions are relatively large for the smaller detention volumes, the reduction rate declines for the medium sized detention volumes and then increases again for the largest detention volumes simulated.

Sediment yield and flood frequency reductions for the total detention volume of currently planned watershed structures in watershed districts located above the Cottonwood River near Plymouth were also calculated. The 31,155 acre-feet of detention storage of those planned structures would reduce the mean annual sediment yield at Plymouth by 4.3% and the flood flows were reduced by 20% during the modeled period (1990 – 2009).

Introduction

The KWO has developed an artificial detention pool model in response two issues on the Cottonwood River;

1. the impact of enhancing detention pool volumes on the flood frequency on the Cottonwood River
2. improving the estimated impact on mean annual sediment yield from additional watershed structures in the Cottonwood River drainage area,

The first issue is associated with a request made by the Cottonwood watershed reduction and protection strategies (WRAPS) stakeholder leadership team about flood frequency reduction and the second issue is a KWO initiative to improve upon previous sediment yield reduction estimates. Both issues are strictly related to watershed structure detention volume impacts on the Cottonwood River.

The computer model routes 1990 – 2009 runoff flows from within the Cottonwood River basin below Marion Reservoir through a user-specified artificial detention pool to analyze the impact on flow rates and sediment yields on the Cottonwood River near Plymouth, Kansas. The numbers of days equaling or exceeding historic flood flows are compared to the modeled flows to determine the reduction to flood flow frequency. The modeled flows are also utilized to create mean annual flow exceedence curves to compare to the historic mean annual flow exceedence curves. The change to those exceedence curves is used to calculate the changes to mean annual sediment yields on the Cottonwood River associated with enhanced flow detention.

Methodology

Figure 1 locates existing and planned watershed structures within watershed districts, USGS flow gaging stations and the sub watersheds of those stations and the estimated mean sediment yield for streams on the Kansas Surface Water Register in the Cottonwood basin. Figure 2 shows 1990 – 2009 flow volumes for the four sub watersheds (depicted by the matching colors in Figure 1).

Gaged average daily flows (1990 – 2009) on the Cottonwood River below Marion Reservoir (07179795) were subtracted from the average daily gaged flows recorded at the Cottonwood River near Plymouth (07182250) on a two day lag. The two day lag was selected based upon the reported travel time in the Marion Reservoir Water Control Manual (1996, page A-19) between Marion Reservoir and the gage near Plymouth. This adjusted flow at Plymouth represents the flow contributed from the drainage area above Plymouth and below Marion Reservoir where the enhancements to detention storage would be located.

If the artificial detention pool was available to temporarily store all adjusted flows at Plymouth, then the model would function by routing all adjusted flows through the artificial detention pool in the model. In reality, this would not be the case unless the detention pool was created on the Cottonwood River near Plymouth gage site. The KWO model assumes the artificial detention pool is comprised of a set of 'typical' watershed structures impounding much smaller drainages. The 'typical' structures were defined by calculating the average detention volume of the 60 planned (but not built) structures located in the watershed districts above the Plymouth gage site (Figure 1). The average detention volume was just under 520 acre-feet for the planned structures. The average drainage area was just over 2.8 square miles. Changes to the artificial detention pool volume within the model add or remove 'typical' watershed structures proportional to the size of the total artificial volume change.

The fraction of the total area controlled by the 'typical' watershed structures determines the fraction of the adjusted Plymouth flows available for potential detention pool storage. Since most of the 60 planned watershed structures above Plymouth are located on intermittent streams, the flows generated from

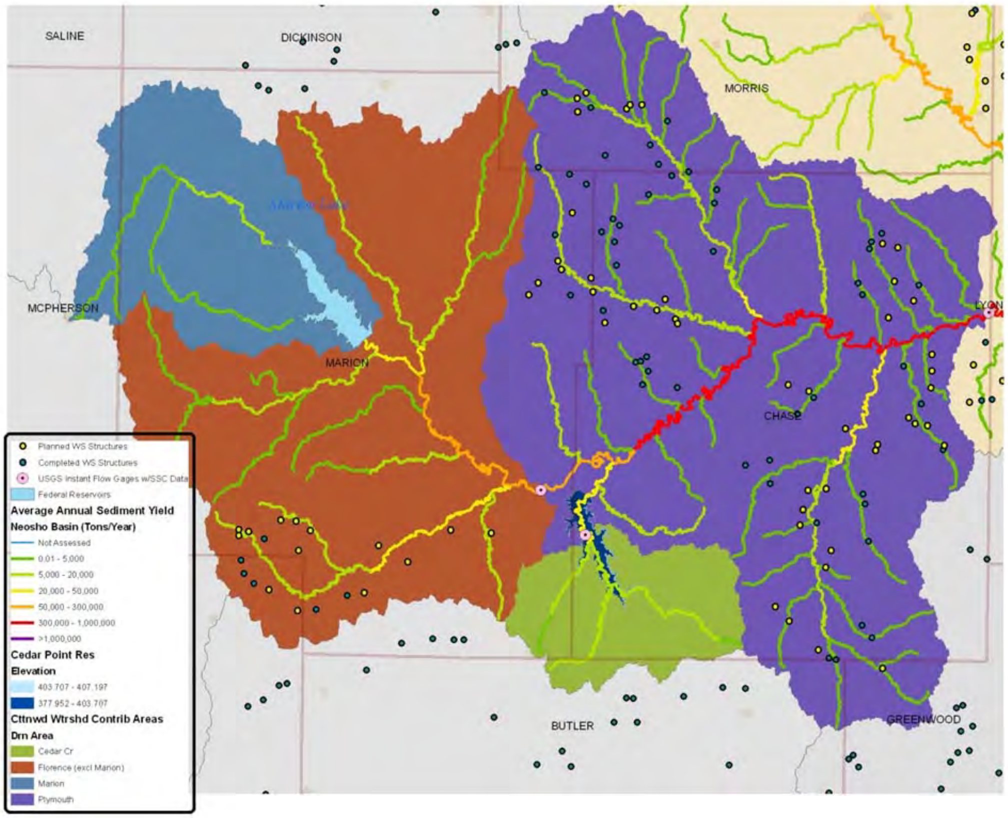


Figure 1: Flow gages, completed and planned watershed structures and estimated sediment yield for the Cottonwood basin.

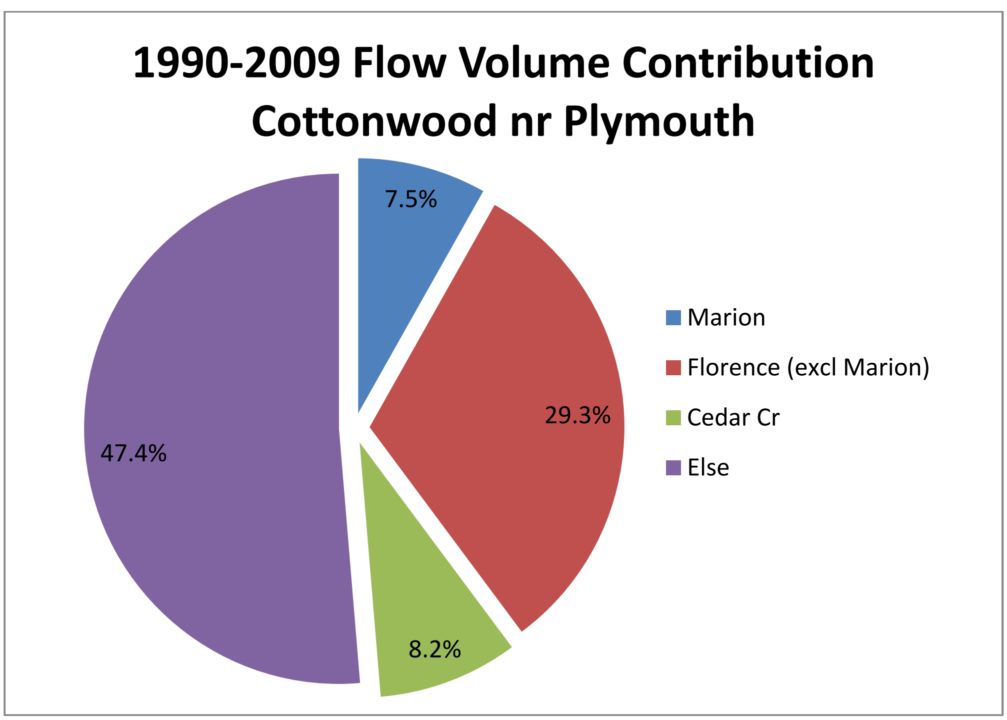


Figure 2: Volumetric flow comparison of sub watersheds within the Cottonwood R. subbasin (1990-2009)

perennial streams (conceptualized as baseflows for this model) in the watershed would not be available for detention pool storage. The model assumes that flows less than the adjusted median flow at Plymouth (~ 230 cfs) are baseflows and flows greater than that median flow are created during wetter periods. The runoff events creating wetter periods cause flow within the intermittent streams upon which the 'typical' watershed structures would be located and are available for detention pool storage with the model. As an example, if the controlled drainage area of additional watershed structures was 10% of the total drainage area at Plymouth (1,507.5 square miles, excluding the Marion Reservoir drainage area), then 10% of the flows that exceed the maximum baseflow (230 cfs) are available to store in the artificial detention pool within the model.

The KWO model runs on a daily time step. Once the runoff proportioned to the drainage area controlled by the modeled watershed structures is skimmed into the artificial detention pool, it becomes available for release. If the entire detention pool volume becomes filled, all flows are bypassed through the artificial detention pool until storage space is eventually created by releases. The last calculation at the end of each time step adds the Marion releases (from two days earlier) to the artificial detention pool modified flows at Plymouth.

Detention pool releases are governed by the 'typical' watershed structures concept used in the model. Standard design for watershed structures is to completely evacuate the detention pool within 5 days of fill. A pipe size of 24 inches meets this standard design criterion; however no improvements to sediment yield or flood frequency were notes with this design. Therefore, two smaller pipe size options were reviewed in the model; a 12 inch pipe and an 18 inch pipe. Both options were used to drain the detention pool in each of the 'typical' structures. The 18 inches pipe option took 13 days to completely drain the detention pool of the 'typical' structure, while the 12 inch pipe took 30 days.

As previously noted, the 'typical' structure had a detention volume of almost 520 acre-feet. The average depth of the 60 planned watershed structures when full is 12 feet. A table (Table 1, below) was created for various intervals in the hypothetical 12 foot detention pool and the releases associated with those intervals were determined by comparing several discharge calculation methods. When comparing discharge calculation methods, the lower discharge values were selected to create the discharge rating curves. At heights less than 2 feet above the riser, discharges were calculated using either the standard weir formula or standard orifice formula. The standard weir formula is:

$$Q = C_w L(2gh)^{3/2}$$

where,
Q = weir flow discharge (cfs)
Cw = dimensionless weir discharge coefficient
L = effective weir length (ft)
g = acceleration due to gravity (32.2 ft/s^2)
h = water depth above crest

The standard orifice formula is:

$$Q=cA(2gh)^{0.5}$$

where,
Q= the orifice flow discharge (cfs)
c = 0.6 (a dimensionless discharge coefficient)
A = cross-sectional area of 12 or 18 inch pipe
g = gravity (32.2 ft/sec^2)
h = head on the orifice

At heights greater than 2 feet above the riser, discharges were calculated using either the standard orifice formula or pipe-full computations. The artificial pool is sized to the user specified volume and the *number* of 'typical' structures is scaled to that volume. Releases are governed based upon the release rating curve in Table 1 and the head in the detention pool storage. Releases made in the model are scaled from the number of 'typical' structures associated with the artificial detention volume.

	Standpipe Diameter (ft)	
	1.5	1
Head (ft)	Discharge (cfs)	
12	29.5	12.0
11	28.2	11.7
10	26.9	11.5
9	25.5	11.3
8	24.1	10.7
7	22.5	10.0
6	20.8	9.3
5	19.0	8.5
4	17.0	7.6
3	14.7	6.6
2	12.0	5.3
1.5	8.8	4.6
1.35	8.4	4.4
1.2	7.9	4.1
1.05	7.4	3.9
0.9	6.9	3.6
0.75	6.2	3.3
0.6	5.4	2.9
0.45	4.4	2.5
0.3	2.8	1.8
0.15	1.1	0.7
0	0.0	0.0

Table 1: Discharge Rating Curves for Modeled Typical Watershed Structure

The model summarizes and compares the number of days that flood flows are equaled or exceeded at Plymouth to the historic (1990-2009) observed number of flood days. Flood flows at Plymouth are flows equaling or exceeding 13,300 cfs (http://waterdata.usgs.gov/nwisweb/local/nwis_host/dkslwr/local/site_text/ratings/07182250.1.rdb accessed on May 20, 2010).
The method of developing mean annual sediment yield estimates for the Neosho basin was described in a previous KWO report (KWO, 2009a) and included a sediment yield estimate for the Plymouth on the Cottonwood River. Those yields were created based upon the method described in Sedimentation Engineering (Vanoni, 2006) for estimating long-term sediment yields by flow duration-sediment rating curves.

Previous studies and analysis of the stream system sediment loading pattern in the Cottonwood basin indicated that most of the sediment load is generated from the stream banks of the Cottonwood River rather than from primary tributaries or the land surface in the basin (TWI 2007; KWO 2009a and Sheshukov 2010). Therefore, the KWO detention model assumes no change to the current sediment rating curve at Plymouth. The change to the sediment yield at Plymouth occurs because storage in the artificial detention pool changes the flow exceedence curve at Plymouth. Since most of the mean annual sediment yield is generated during high flow events, the storage of a portion of those high flows in detention pools reduces the magnitude of those large runoff events and changes the mean annual flow exceedence curve at Plymouth. It is this change to mean annual flow exceedence that reduces the sediment yield at Plymouth.

Any reductions to the sediment yield on primary tributaries to the Cottonwood River due to enhanced detention structure storage are not included in this KWO flow detention model. Even though the primary source of sediment at Plymouth is from the stream banks of the Cottonwood River, it should be noted that sediment yield reductions can also be expected on the primary tributaries as a result of enhanced detention. The method of calculating the expected tributary sediment yield reductions was described in a previous KWO report (KWO, 2009b). That method related mean annual sediment yield on primary tributaries to the Cottonwood and Neosho Rivers to the uncontrolled drainage area in them. The regression relation indicated that as the uncontrolled drainage area of a watershed decreased, so did the mean annual sediment yield. Therefore, as structures are added within a tributary watershed to the Cottonwood River, the mean annual sediment yield should decline in that watershed. Unlike the main stem sediment yield that is primarily affected by changes to the flow exceedence gained from enhanced detention flow storage, the tributary yield reduction should be affected by both an anticipated change to the sediment rating curve and the change to flow exceedences on the primary tributary.

The KWO flow detention model includes estimates for the construction cost of watershed structures based upon reported construction costs of structures completed within the last 20 years and the drainage area of those impoundments (KWO, 2009b). Using the drainage area of the 'typical' watershed structure developed for the KWO detention model (2.8 square miles) the estimated construction cost of the 'typical' watershed structure was estimated at $168,000. As the size of the artificial detention pool is increased or decreased, the model adds or removes the number of watershed structures and adjusts the total estimated construction cost for the number of 'typical' structures needed to create the overall size of the specified artificial detention pool.

Total mitigation costs are also included in the KWO detention model using the same 'typical' structure estimation method. Ten completed watershed structures in the Neosho basin, having physical properties most similar to the 'typical' watershed structure used in the model, were reviewed for length of stream inundated by the principal pool, dam width covering the primary stream impounded and the type of stream covered by the dam and inundated by impoundment at the principal pool. The estimated mitigation cost for the 'typical' structure used in the KWO detention model for the Cottonwood basin is $433,000. Like the construction cost estimate, as the size of the artificial detention pool is increased or decreased, the model adds or removes the number of watershed structures and adjusts the total estimated mitigation cost for the number of 'typical' structures needed to create the overall size of the specified artificial detention pool.

Results

Although two different pipe sizes were initially reviewed to create detention discharge rating curves, the 12 inch pipe option was significantly better than the 18 inch option in sediment yield and flood flow frequency reductions in this model. For the 18 inch pipe scenario the detention pool never completely filled during the simulation period (a condition that would force any excess detention flows over the emergency spillway). For the 12 inch pipe scenario, there were only 5 days during the simulation in which the artificial detention pool was complete filled (2 days in 1993 and 3 days in 1998). Since the discharge rating curve for the 12 inch pipe detained stored flows longer by releasing stored water more slowly than the 18 inch pipe option, high flows were generally lower at the Plymouth gage site. The results presented in the text of this report relate only the 12 inch pipe scenario; however, the 18 inch pipe scenario has been included in the graphs and tables of this report for comparison purposes.

The difficulty with longer detention times for watershed structures is that the detention pool inundation duration becomes sufficiently long to drown terrestrial plants in the inundation zone. The standard design evacuation rate of less than 5 days for watershed structures enhances the survivability of terrestrial plants in the inundation zone.

Eleven different artificial detention pool sizes were created to generate the results of this report (Table 2). The total artificial pool size varied from 10,000 to 200,000 acre-feet of storage. The 10,000 acre-foot detention pool controls about 3.6% of the contributing area to the Plymouth gage site on the Cottonwood River (excluding Marion Reservoir's drainage area). The 200,000 acre-foot pool controls about 71.7% of the contributing area at Plymouth which would cover much of the drainage contribution of the intermittent streams in the modeled area. Mean annual sediment yield reductions ranged from less than 1.5% of the current estimated mean annual sediment yield for the 10,000 acre-foot artificial detention pool, to nearly a 25% reduction for the 200,000 acre-foot pool. Flood exceedence frequencies at Plymouth were reduced from historic frequencies by 12% for the 10,000 acre-foot artificial detention pool and 88% for the 200,000 acre-foot pool. Total cost estimates (construction plus mitigation) ranged from about $11.5 million for the 10,000 acre-foot pool to $231.5 million for the 200,000 acre-foot detention pool scenario.

	12" Pipe for Typical WS Structures				18" Pipe for Typical WS Structures				
WS Detention Pool Vol (af)	WS Mod Mean Annual Sed Yld (Plymouth) T/Yr	Main Stem % Reduction	Plymouth (Main Stem) Sed Redn (T/Yr)	# Days Flood Flows	WS Mod Mean Annual Sed Yld (Plymouth) T/Yr	Main Stem % Reduction	Plymouth (Main Stem) Sed Redn (T/Yr)	# Days Flood Flows	Constr + Mitigatn Cost ($)
0	719,224	0.00	0	59	719,224	0.00	0	59	
10000	708,883	1.44	10,341	52	715,509	0.52	3,715	54	11,574,498
20000	698,970	2.82	20,254	48	711,824	1.03	7,400	52	23,148,995
30000	689,144	4.18	30,080	47	707,935	1.57	11,289	49	34,723,493
31155	688,007	4.34	31,217	47	707,495	1.63	11,729	49	36,060,347
40000	679,196	5.57	40,028	45	704,103	2.10	15,121	48	46,297,990
50000	669,485	6.92	49,739	43	700,405	2.62	18,819	48	57,872,488
56450	663,469	7.75	55,755	41	698,163	2.93	21,061	46	65,338,039
75000	646,554	10.10	72,670	33	691,794	3.81	27,430	44	86,808,732
87605	635,120	11.69	84,104	31	687,015	4.48	32,209	43	101,398,386
125000	603,185	16.13	116,039	18	673,900	6.30	45,324	34	144,681,220
200000	549,290	23.63	169,934	7	650,390	9.57	68,834	23	231,489,952

Table 2: KWO detention model results

Sediment yield reductions for the eleven different artificial detention pool sized model followed a roughly linear pattern. The slope of the trend in detention volume by mean annual sediment yield declines slightly for the largest artificial detention pool volume scenarios (Figure 3).

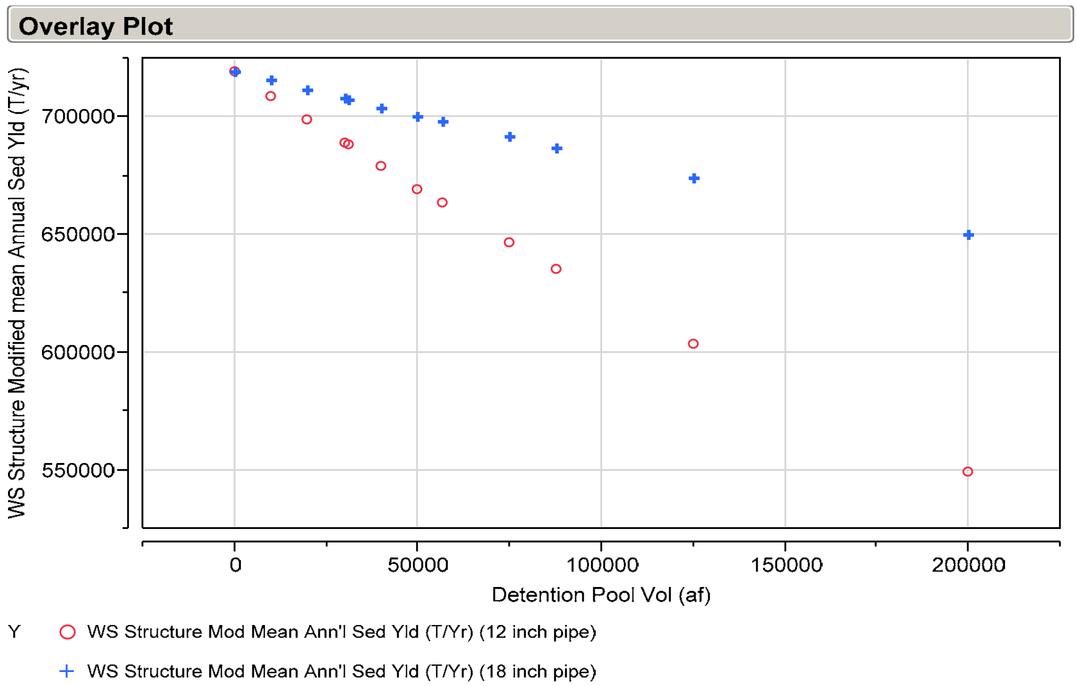


Figure 3: Reduction to mean annual sediment yield for various sized artificial detention pool

Flood frequency reductions by detention pool volumes followed an S-shaped curve. The relative reduction to the number of days that equaled or exceeded flood flows at Plymouth is greatest for small detention volumes. The slope of the trend flattens out across the medium sized artificial detention volumes, and then increases again for the largest detention volumes (Figure 4).

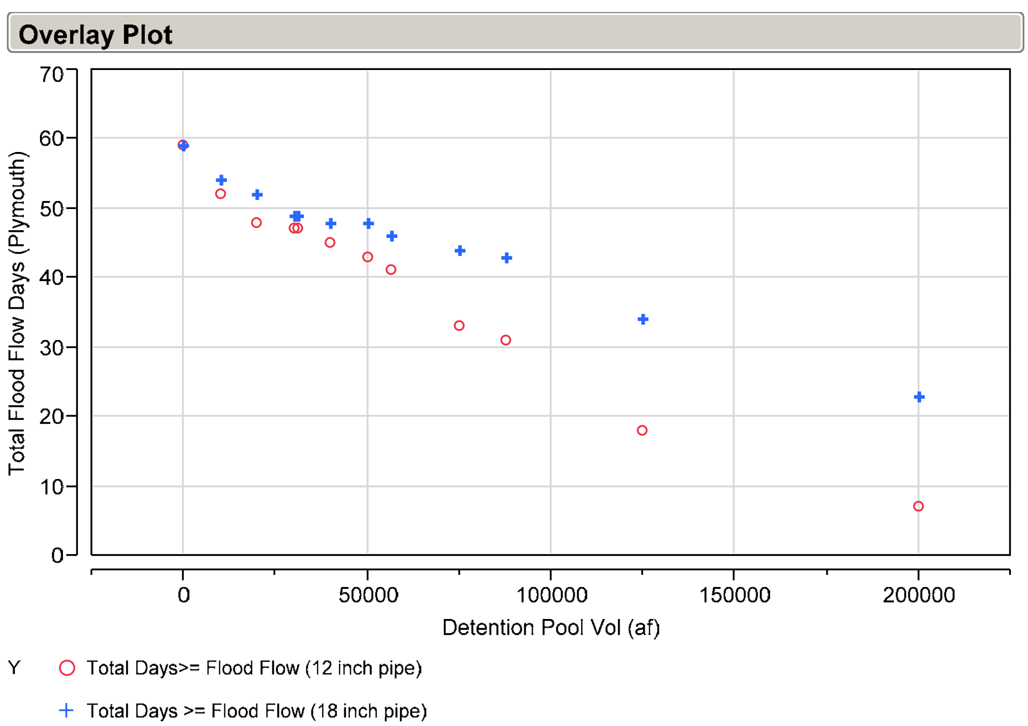


Figure 4: Change in the number of flood days for various sized detention pools

References Cited

Kansas Water Office, 2009a, Mean Annual Sediment Yield Estimation for the Neosho Basin, available online: http://www.kwo.org/Reports%20%26%20Publications/EstimatingMeanAnnualSedimentYield_092209_cbg.pdf, accessed June 7, 2010.

Kansas Water Office, 2009b, Reservoir Road Map Vol III, p. 88-90. Available online: http://www.kwo.org/ReservoirRoadmap/Rpt_Reservoir_Roadmap_Volume_III.pdf accessed June 7, 2010.

Sheshukov, A. Y, et al, Kansas State University, 2010, (Draft Report) Modeling of John Redmond Watershed with Soil and Water Assessment Tool (SWAT) (reference will be updated and hyperlinked when final report is received in June 2010).

The Watershed Institute 2007, Enchanced Riparian Area/Stream Channel Assessment for John Redmond Feasibility Study; available online: http://www.kwo.org/Reports%20%26%20Publications/RiparianReport/Rpt_EnhancedRiparianAreaStreamChannelAssessment_Intro.pdf, accessed June 7, 2010.

Vanoni, V.I., editor, 2006, Sedimentation Engineering, American Society of Civil Engineers, p.277-2

14.0 Bibliography

[1] Map prepared by the Kansas Water Office.

[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] Calculated from Kansas Applied Remote Sensing Program, 2005. Kansas Land Cover Patterns, Kansas Geospatial Community Commons

[5] Kansas Surface Water Register, 2009. Kansas Department of Health and Environment. http://www.kdheks.gov/befs/download/Current_Kansas_Surface_Register.pdf

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

[7] 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

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

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

[10] 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%.

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

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

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

[14] Kansas Water Office. 2009.

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

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

[17] Kansas Geospatial Community Commons. Kansas Department of Health and Environment. Rural Water Districts, 2006, Public Water Supply, 1994. These sites include those that are currently in use and those that have been functional in the past. NPDES Treatment Facilities, 1994. http://www.kansasgis.org/catalog/catalog.cfm

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

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

[20] Kansas Department of Health and Environment. 2010 303d list. http://www.kdheks.gov/tmdl/

[21] Kansas Department of Health and Environment, 2010.

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

[23] Kansas Department of Health and Environment, 2010. http://www.kdheks.gov/tmdl/download/2010_303d_List.pdf

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

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

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

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

[28] EPA website. http://water.epa.gov/type/watersheds/datait/watershedcentral/goal4.cfm

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

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

[31] 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

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

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

[34] Kansas Geospatial Community Commons. USDA/NRCS data base. http://www.kansasgis.org/catalog/catalog.cfm

[35] 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

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

[37] Kansas Geospatial Commons. Kansas Department of Health and Environment, 2010.

[38] Total farm crops in the counties of the watershed by percentage. 2007 Census of Agriculture, USDA NASS. www.agcensus.usda.gov

[39] 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

Cottonwood Watershed Restoration and Protection Strategy (WRAPS)

PROPOSED AMENDMENT TO APPROVED NINE ELEMENT PLAN

Overview

This amendment to the existing (approved) nine element watershed plan adds the Marion County Lake subwatershed (11070202020050) as a targeted area for livestock best management practices (see Figure 1 below).

Figure 1: Boundaries of Proposed Marion County Lake Targeted Area

Justification

The Stakeholder Leadership Team has identified the need to add the Marion County Lake targeted area for the following reasons:

1. Marion County Lake currently has two medium priority TMDLs for eutrophication and dissolved oxygen. The lake is classified as fully eutrophic.

2. Analysis of water quality monitoring data from LM012101 (see table below) indicates that water quality conditions have continued to decline in the lake since the TMDLs were first established in 2001. This data shows that nutrients (both total phosphorus and total nitrogen) are the primary water quality concern.

3. Marion County Lake serves as a significant recreational resource in the Upper Cottonwood watershed. Its designated uses include both primary and secondary contact recreation, as well as aquatic life support and food procurement. The lake has experienced algal blooms during the summer for the past few years, impacting recreational uses and generating significant concern among recreational users and local government officials.

4. Much of the emphasis in the existing watershed plan focuses on reducing pollution loads entering John Redmond Reservoir, which is located downstream, but outside of, the boundaries of the Upper and Lower Cottonwood watersheds. Adding the Marion County Lake as a targeted area demonstrates the need for WRAPS to address varied waterbodies of concern to local stakeholders, not just those that are ranked most highly based on the state's priorities.

Table 1: Summary of Water Quality Monitoring Data for Marion County Lake (LM012101)

Year	TKN (mg/l) @ 0.5m	TKN (mg/L) >=8.0m	TP(mg/L) @ 0.5m	TP (mg/L) >=8.0m	TN:TP	Chla (ug/l)	Secchi (m)
1988			0.130	1.055		9.960	
1993	0.100	0.100	0.050	0.165	2.500	9.750	1.000
1997	0.504	2.115	0.050	0.895	11.570	17.200	1.200
2001	0.455	2.470	0.057	0.796	9.040	18.700	1.160
2005	0.852	4.107	0.043	1.353	23.630	37.050	1.380
2009	1.235	3.081	0.099	0.684	14.070	56.700	1.350
Current Condition from TMDL (1988-2001)	0.353	1.562	0.072	0.728	7.703	13.903	1.120
Current Condition (2005 & 2009)	1.043	3.594	0.071	1.018	18.850	46.875	1.365

Pollution Load Reductions

The Marion County Lake targeted area is comprised of 60% grassland and 35% cropland, indicating the need to focus pollution load reduction efforts on livestock BMPs. This amendment proposes to utilize the livestock BMPs currently included in the watershed plan:

- Relocation of feeding pens
- Relocation of pasture feeding sites
- Off-stream watering systems
- Fencing out of streams and riparian areas.

Based on the existing eutrophication TMDL, the current annual load for phosphorus is estimated at 1,330 pounds. The load capacity is set at 819 pounds. Factoring in a margin of safety of 82 pounds, the required phosphorus load reduction is 593 pounds per year. Figure 2 below illustrates these phosphorus load calculations.

Figure 2: Required Phosphorus Load Reductions for Proposed Target Area

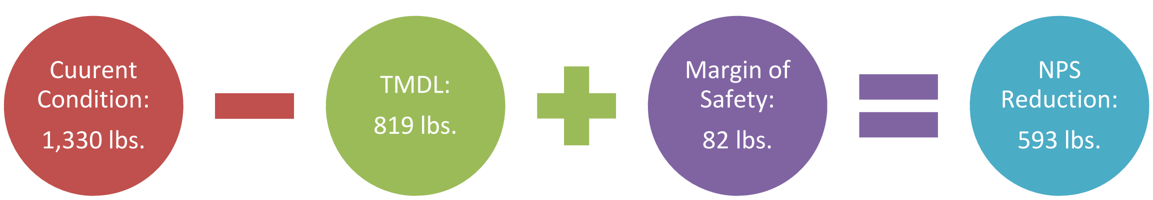


Table 2 below identifies proposed adoption rates for livestock BMPs in this targeted area, cost-estimates, and estimates for pollution load reductions expected to be achieved through BMP implementation. Over a ten-year implementation timeframe, the implementation of five livestock BMPs is expected to result in a phosphorus load reduction of 957 pounds peryear, achieving 161% of the required reduction. Nitrogen loading is expected to be reduced by 1,803 pounds per year.

Table 2: Supporting Information for Proposed Amendment

Proposed Livestock BMP Adoption						
Relocate Feeding Pens	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams or Riparian	Total		
1	1	2	1	5		
Estimated Cost Before Cost-Share						
Vegetative Filter Strip	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams or Riparian	Total		
$12,000	$2,203	$7,590	$4,106	$25,899		
Estimated Cost After Cost-Share						
Vegetative Filter Strip	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams or Riparian	Total		
$6,000	$1,102	$3,795	$2,053	$12,950		
Phosphorous Load Reduction (pounds/year)						
Vegetative Filter Strip	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams or Riparian	Total	Required Reduction to Meet TMDL	% of TMDL Met Within 10 Years
638	76	153	90	957	593	161%
Nitrogen Load Reduction (pounds/year)						
Vegetative Filter Strip	Relocate Pasture Feeding Site	Off-Stream Watering System	Fence out Streams or Riparian	Total		
1,201	144	288	170	1,803		