Middle Kansas River Watershed Restoration and Protection Strategies (WRAPS) Plan

2022

This project has been funded wholly or in part by the United States Environmental Protection Agency. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation of use.

KCARE
Kansas Center for Agricultural Resources and the Environment

Kansas
Department of Health and Environment

Middle Kansas
RIVER WRAPS

K-STATE
Research and Extension

Middle Kansas River Watershed
Project Leadership Team

Middle Kansas River WRAPS
Megan Rush, WRAPS Project Coordinator

Stakeholder Leadership Team
As of February 2022, the following individuals are members of the SLT:
Dennis Schwant, Pottawatomie Conservation District, Rock Creek Watershed, and Pottawatomie County Landowner
Douglas Helmke, Kansas Rural Water Association
Chalee Braun, Shawnee County Conservation District Manager
Mary Howell, Service Provider
Mikayla Kerron, Prairie Band Potawatomi Nation
Verna Potts, Prairie Band Potawatomi Nation
Francis Kelsey, Shawnee County Supervisor and Shawnee County Landowner
Brian Boeckman, Jackson County Conservation District Manager
Molly Schmidt, Pottawatomie County Conservation District Manager
Dennis Mulroy, Nemaha County Landowner
Bill Riphahn, Shawnee County Commissioner

Kansas State University
Will Boyer, Northeast Kansas Watershed Specialist
Susan Brown, Kansas Center for Agricultural Resources and the Environment (KCARE)
Amanda Schielke, KCARE
Melissa Harvey, KCARE

Kansas Department of Health and Environment
Britini Bauer, Project Officer, Watershed Management Section
Mike Beezhold, Chief of the Watershed Management Section
Dane Boring, Planning and Standards Unit Chief

Additional Technical Assistance
County Conservation Districts in the Middle Kansas River Watershed
Kansas Department of Health and Environment
Kansas Department of Wildlife and Parks
Natural Resources Conservation Service

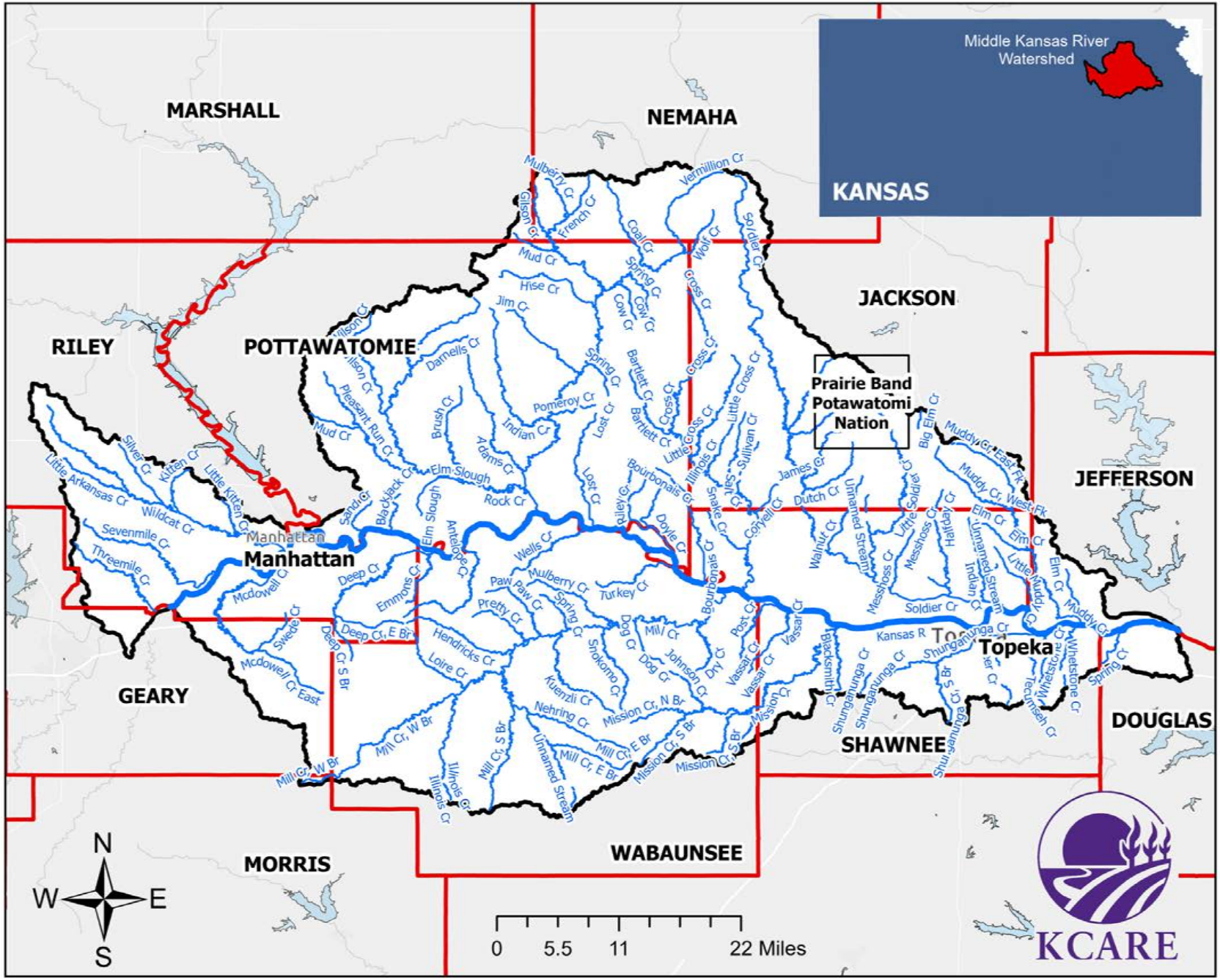

Middle Kansas River Watershed
KANSAS
MARSHALL
NEMAHA
JACKSON
RILEY
POTTAWATOMIE
Prairie Band Potawatomi Nation
JEFFERSON
Manhattan
Topeka
GEARY
SHAWNEE
DOUGLAS
WABAUNSEE
MORRIS
Kansas R
Mulberry Cr
Vermillion Cr
French Cr
Coal Cr
Wolf Cr
Mud Cr
Hise Cr
Jim Cr
Spring Cr
Cow Cr
Gross Cr
Soldier Cr
Wilson Cr
Darnells Cr
Pleasant Run Cr
Brush Cr
Pomeroy Cr
Indian Cr
Lost Cr
Bartlett Cr
Cross Cr
Little Cross Cr
Sullivan Cr
Silver Cr
Kitten Cr
Little Arkansas Cr
Wildcat Cr
Little Kitten Cr
Sevenmile Cr
Threemile Cr
Sandy Cr
Blacklack Cr
Elm Slough
Adams Cr
Rock Cr
Antelope Cr
Bourbonais Cr
Illinois Cr
Snake Cr
Doyle Cr
James Cr
Dutch Cr
Big Elm Cr
Muddy Cr, East Fk
Muddy Cr, West Fk
Unnamed Stream
Walnut Cr
Coryell Cr
Little Soldier Cr
Messhoss Cr
Halfday Cr
Elm Cr
Indian Cr
Little Muddy Cr
Muddy Cr
Soldier Cr
Wells Cr
Mulberry Cr
Paw Paw Cr
Turkey Cr
Pretty Cr
Spring Cr
Dog Cr
Mill Cr
Post Cr
Vassar Cr
Blacksmith Cr
Shunganunga Cr
Whetstone Cr
Tecumseh Cr
Sprifig Cr
Deep Cr
Emmons Cr
Deep Cr, E Br
Deep Cr, S Br
Swede Cr
Mcdowell Cr
Mcdowell Cr East
Hendricks Cr
Loire Cr
Kuenzli Cr
Snokomo Cr
Johnson Cr
Dry Cr
Nehring Cr
Mission Cr, N Br
Mission Cr, S Br
Mill Cr, W Br
Mill Cr, E Br
Unnamed Stream
Illinois Cr
N
W
E
S
0
5.5
11
22 Miles
KCARE

Table of Contents

List of Figures

List of Tables

Glossary of Terms and Acronyms

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

Biological Oxygen Demand (BOD): A measurement of the amount of oxygen utilized by the decomposition of organic material, over a specified time period (usually 5 days) in a wastewater sample; it is used as a measurement of the readily decomposable organic content of a wastewater.

Biota: Plant and animal life of a particular region.

Chlorophyll *a*: Common pigment used in photosynthesis, found in algae and other aquatic plants. Can be used for measurement of eutrophication in a water body.

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

***E. coli* bacteria (ECB):** Bacteria normally found in gastrointestinal tracts of animals. Some strains cause diarrheal diseases and are pathogenic to humans.

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

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

Hydrologic Unit Code (HUC): An identification system using numerical digits for watersheds. The smaller the watershed, the more digits a HUC will have.

KDHE: Kansas Department of Health and Environment.

KSRE: Kansas State University Research and Extension.

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

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

Nitrogen (N): Element essential for plants and animals.

Nonpoint sources (NPS): Any activity not required to have a NPDES permit that results in the release of pollutants to waters of the state. This release may result from precipitation runoff, aerial drift and deposition from the air, or the release of subsurface brine or other contaminated groundwaters to surface waters of the state.

Nutrients: Nitrogen and/or phosphorus in a water source.

Phosphorus (P): Element in water that, in excess, can lead to increased biological activity which may cause eutrophication.

Point sources (PS): Any discernible, confined, and discrete conveyance from which pollutants are or could be discharged.

Riparian zone: Areas of interchange between land and water alongside bodies of water.

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 the contrasting colors can be seen.

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

Stakeholder Leadership Team (SLT): Organization of watershed residents, landowners, farmers, ranchers, agency personnel, and any other 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 surface water-quality standards which results in failure to support their designated uses.

Total Nitrogen (TN): A chemical measurement of all nitrogen forms in a water sample.

Total Phosphorus (TP): A chemical measurement of all phosphorus forms in a water sample.

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

WRAPS: Watershed Restoration and Protection Strategy.

1. Preface and Plan Update

The purpose of this Watershed Restoration and Protection Strategy (WRAPS) report for the **Middle Kansas River Watershed** is to outline a plan of restoration and protection goals and actions for this watershed's surface waters. Watershed goals can be characterized as either "restoration" or "protection." Watershed *restoration* refers to surface waters that fail to meet water quality standards and for areas of the watershed that need improvement in habitat, land management, or other attributes. Watershed *protection* refers to surface waters currently meeting water quality standards but require protection from future degradation.

In the WRAPS process, local communities and government agencies work together toward the common goal of a healthy environment. By working as a WRAPS team, communities can take several steps toward watershed restoration and protection. Local participants, or stakeholders, provide valuable grass-roots leadership, responsibility, and resource management throughout. These community members work together to ensure that their lands' water quality is protected because they have the most at stake. Agencies bring to the table science-based information, communication, and technical and financial assistance. The team works within the watershed to build awareness and education, to engage local leadership, and to monitor and evaluate watershed conditions; they also assess, plan, and implement the WRAPS process at the local level. By working as a WRAPS team, communities can take several steps toward watershed restoration and protection.

Other crucial objectives for the WRAPS process are to maintain recreational opportunities and biodiversity while protecting the environment from flooding and the negative effects of urbanization and industrial production. Final watershed goals are to provide a sustainable water source for drinking and domestic use while preserving food, fiber, and timber production. The ultimate WRAPS goal is a **restored and protected watershed**: "local hands caring for local lands" in partnership with government agencies to improve the environment for everyone.

This report is intended to serve as an overall strategy to guide WRAPS 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 to restore and protect the water quality and watershed conditions of the Middle Kansas River Watershed.

Plan Update: The original Middle Kansas WRAPS program was organized in 2006 when the Kansas Alliance for Wetlands and Streams (KAWS) was awarded a grant from the Kansas Department of Health and Environment (KDHE). A formal plan was written, submitted, and approved in 2011. However, priority area and TMDL revisions from KDHE resulted in outdated WRAPS plan implementation goals. Therefore, the Middle Kansas River WRAPS plan was updated and revised in 2022 by Kansas State University staff and KDHE, with the guidance of the Middle Kansas River WRAPS Coordinator, KAWS, and the SLT.

***Note**: Tables throughout this plan use rounded figures.*

2. Middle Kansas River WRAPS Introduction

This section discusses the importance of a WRAPS plan and describes the key collaborators who strive to make it effective, with a special focus on the Middle Kansas River Watershed's location and stakeholders.

A. What Is a Watershed?

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

B. What Is a Watershed Restoration and Protection Strategy (WRAPS)?

WRAPS is a planning and management framework built to engage local citizen-stakeholders within a particular watershed. It is a process used to **identify** restoration and protection needs, to **establish** management goals for the watershed community, to **create** an action plan to achieve those goals, and to **implement** the action plan.

The acronym "WRAPS" originated from KDHE in response to the 1998 Clean Water Action Plan issued by the Clinton Administration. The Clean Water Action Plan directed the state environmental agency and the state conservationist of every state to complete a "unified watershed assessment." Upon completion of the assessment, states were directed to develop "watershed restoration action strategies" (WRAS).

The state of Kansas contends that restoring damage to a watershed is insufficient because it addresses only part of the need; action to protect water is a necessity, hence the new term WRAPS. "WRAPS" refers to the development of action plans that address nonpoint source pollution on a watershed basis. WRAPS projects are initiated by watershed stakeholders and receive financial support from KDHE to address Total Maximum Daily Loads (TMDLs) and related water quality concerns.

The WRAPS initiative is intended to address priority issues identified in the basin sections of the Kansas Water Plan through the development and implementation of WRAPS in priority watersheds.

C. Watershed Location

There are 12 major river basins in Kansas. The scope of this WRAPS plan will focus on the Middle Kansas River Watershed and a small portion of the Upper Kansas Watershed. For the purpose of simplification within this WRAPS plan, the Upper Kansas portion will be included as a part of the Middle Kansas River Watershed/Middle Kansas River WRAPS and will be

referred to as such unless otherwise specified. These watersheds are in the northeastern part of the state of Kansas. The Kansas River begins at the confluence of the Republican and Smoky Hill rivers, just east of Junction City. From there, the Kansas River flows 170 miles east to join the Missouri River at Kaw Point in Kansas City. The Middle Kansas River WRAPS area is in the Kansas-Lower Republican River Basin (**Figure 1**). The Kansas-Lower Republican River basin is part of the larger Missouri River Basin, which is a sub-watershed of the Mississippi River Basin, the largest watershed in North America.

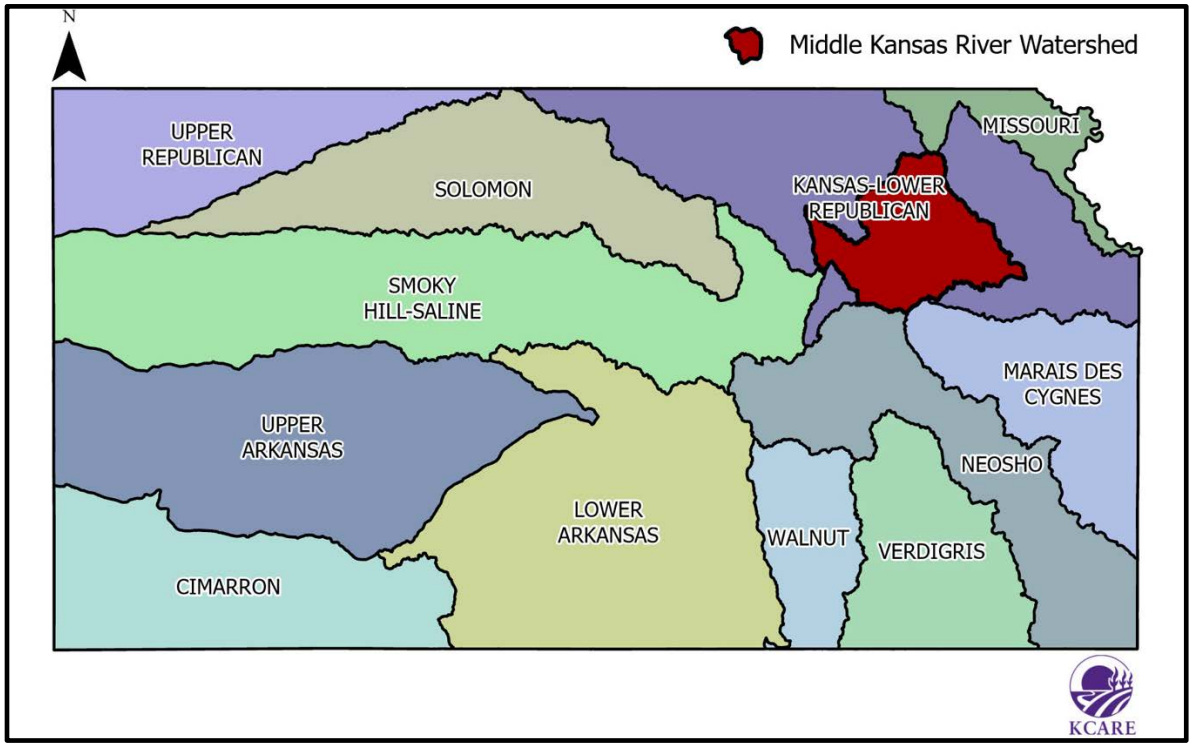


Figure 1. The 12 River Basins of Kansas and the Middle Kansas River Watershed

The Middle Kansas River Watershed is in northeastern Kansas and overlays portions of 10 counties, including Douglas, Geary, Jackson, Jefferson, Nemaha, Morris, Pottawatomie, Riley, Shawnee, and Wabaunsee counties (**Figure 2**).

As indicated in this WRAPS plan, the Prairie Band Potawatomie Nation (PBPN) is within the mid-eastern part of the Middle Kansas River Watershed and is located in Jackson County. While water segments, including Soldier Creek, run through the reservation, they are not included as part of the Middle Kansas WRAPS plan. The PBPN has their own version of a WRAPS plan that they adhere to for the purpose of protecting their waters and those downstream from the reservation. Figures in the remainder of this plan will label the area belonging to the PBPN, but stream segments will not be included.

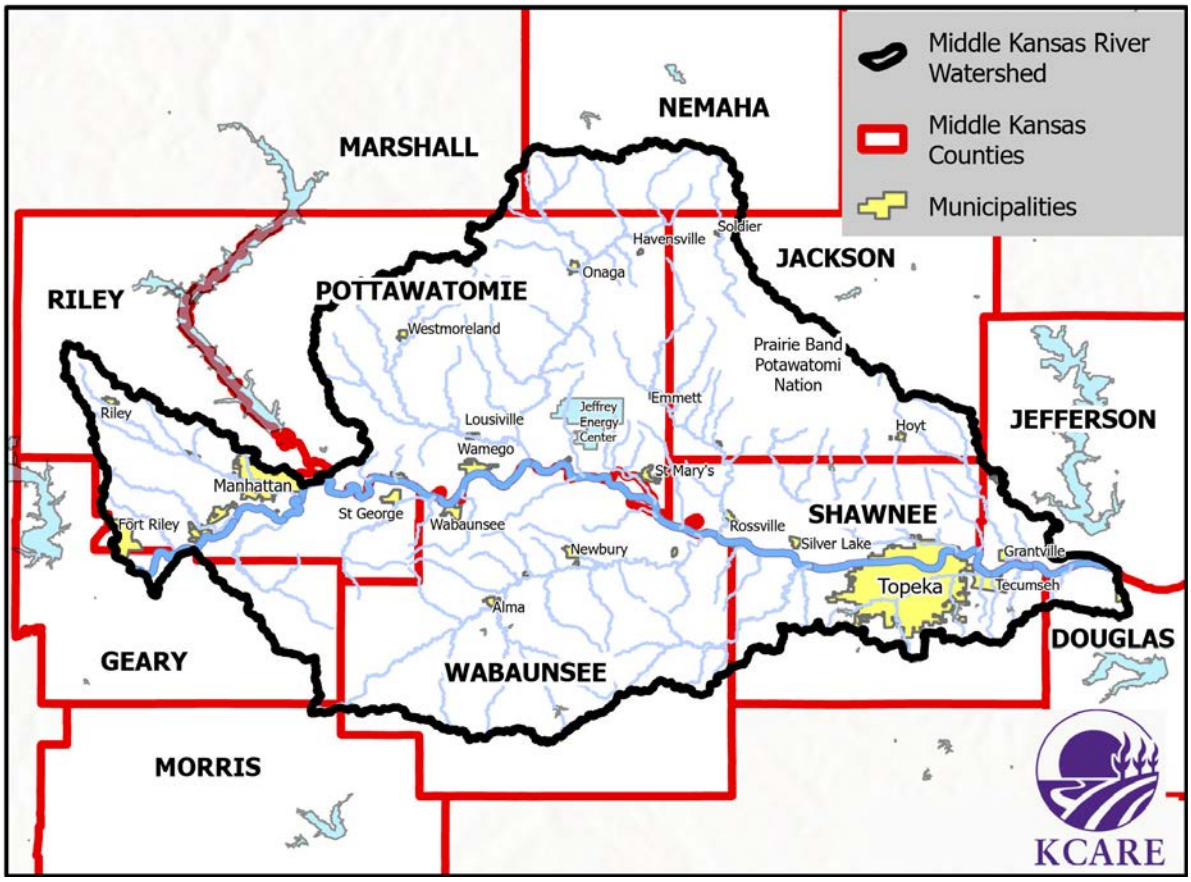


Figure 2. The Middle Kansas River Watershed

D. Overview of the Middle Kansas River Watershed

The Middle Kansas River Watershed makes up the area of land in northeast Kansas that drains into the Kansas River and its tributaries. The watershed covers 1,569,172 acres, which equates to approximately 2,452 square miles.

The headwaters of the upper portion of the Kansas River begin just northeast of Junction City in Geary County, at the confluence of the Smoky Hill and Republican Rivers. The Tuttle Creek Reservoir spillway feeds into the Big Blue River, which flows into the Kansas River just east of the City of Manhattan, in Riley County. The river continues to flow eastward through Pottawatomie, Wabaunsee, Shawnee, Jefferson, Douglas, and Leavenworth counties, and then turns northeast just east of De Soto in Johnson County and continues until it flows into the Missouri River, in Kansas City in Wyandotte County.

The Kansas River serves to form county boundaries between Wabaunsee and Pottawatomie counties, Jefferson and Douglas counties, Douglas and Leavenworth counties, Leavenworth and Johnson counties, and Johnson and Wyandotte counties.

E. Elevation of the Middle Kansas River Watershed

Elevation determines watershed boundaries. As shown in **Figure 3**, the upper boundary of the Middle Kansas River Watershed has an elevation of 1,902 feet, and the lowest point of the watershed has an elevation of 657 feet.

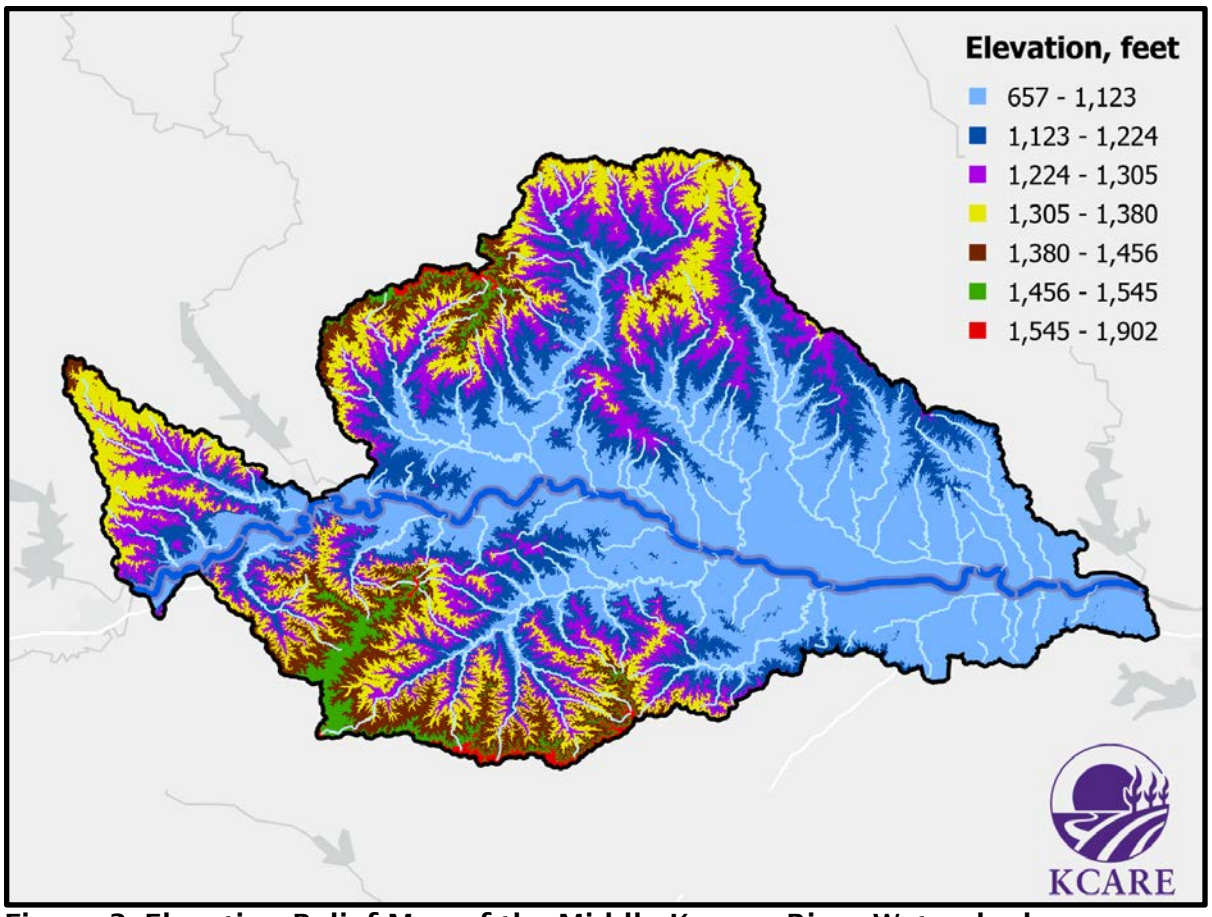


Figure 3. Elevation Relief Map of the Middle Kansas River Watershed

F. What is a Hydrologic Unit Code (HUC)?

HUC is an acronym for **H**ydrologic **U**nit **C**ode; HUCs act as an identification system for watersheds. Each watershed is assigned a unique HUC number, in addition to a common name.

As previously mentioned, the Middle Kansas River Watershed is in the Kansas-Lower Republican River Basin which is home to seven HUC 8 (meaning an 8-digit identifier code) classifications. The Middle Kansas River Watershed is part of the HUC 8, identified as 10270102, and the Upper Kansas Watershed is part of the HUC 8, identified as 10270101.

The first two numbers in the HUC code refer to the drainage region, the second two digits refer to the drainage sub-region, the third two digits refer to the accounting unit, and the fourth pair of digits is the cataloging unit. For example:

- **10**270102: Region 10, Missouri Region – The drainage within the United States of: (a) the Missouri River Basin, (b) the Saskatchewan River Basin, and (c) several small, closed basins. This includes all of Nebraska and parts of Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, North Dakota, South Dakota, and Wyoming (area = 509,547 sq. miles).
- 10**27**0102: Sub-region drainage of the Kansas River Basin, excluding the Republican and Smoky Hill River Basins. This includes Kansas, Missouri, and Nebraska (area = 15,000 sq. miles).
- 1027**01**02: Accounting unit drainage of the Kansas River Basin, excluding the Big Blue, Republican, and Smoky Hill River Basins in Kansas and Missouri (area = 5,500 sq. miles).
- 10270**1**01: Cataloging unit drainage of the section of the Upper Kanas River Basin in Kansas (area = 548 sq. miles).
- 10270**2**02: Cataloging unit drainage of the section of the Middle Kansas River Basin in Kansas (area = 2,160 sq. miles).

As watersheds become smaller, the HUC number becomes larger. HUC 8s can be split into smaller watersheds that are given HUC 10 numbers. The Middle Kansas River Watershed consists of one Upper Kansas HUC 10 delineation and nine Middle Kansas HUC 10 delineations.

These HUC 10 watersheds can be divided further, into 60 smaller HUC 12 watersheds which are listed in detail below by the last 3 digits of the HUC 12. For Best Management Practice (BMP) implementation, this WRAPS plan will target those shown in **bold**.

Upper Kansas HUC 10:

- 1027010102 is home to seven HUC 12s: 102701010201, 202, 203, 204, 205, 206, and 207

Middle Kansas HUC 10s:

- 1027010201, also referred to as the Rock Creek sub-watershed, is home to five HUC 12s: **102701020101, 102, 103, 104, and 105**
- 1027010202, also referred to as the Vermillion Creek sub-watershed, is home to nine HUC 12s: 102701020201, 202, 203, 204, **205, 206, 207, 208, and 209**
- 1027010203 is home to five HUC 12s: 102701020301, 302, 303, 304, and 305
- 1027010204 is home to four HUC 12s: 102701020401, 402, 403, and 404
- 1027010205 is home to eight HUC 12s: 102701020501, 502, 503, 504, 505, 506, 507, and 508
- 1027010206 is home to four HUC 12s: 102701020601, 602, 603, and 604
- 1027010207 is home to four HUC 12s: 102701020701, 702, 703, and 704
- 1027010208, also referred to as the Solider Creek sub-watershed, is home to eight HUC 12s: **102701020801, 802, 803**, 804, 805, 806, 807, and 808
- 1027010209 is home to six HUC 12s: 102701020901, 902, 903, 904, 905, and 906

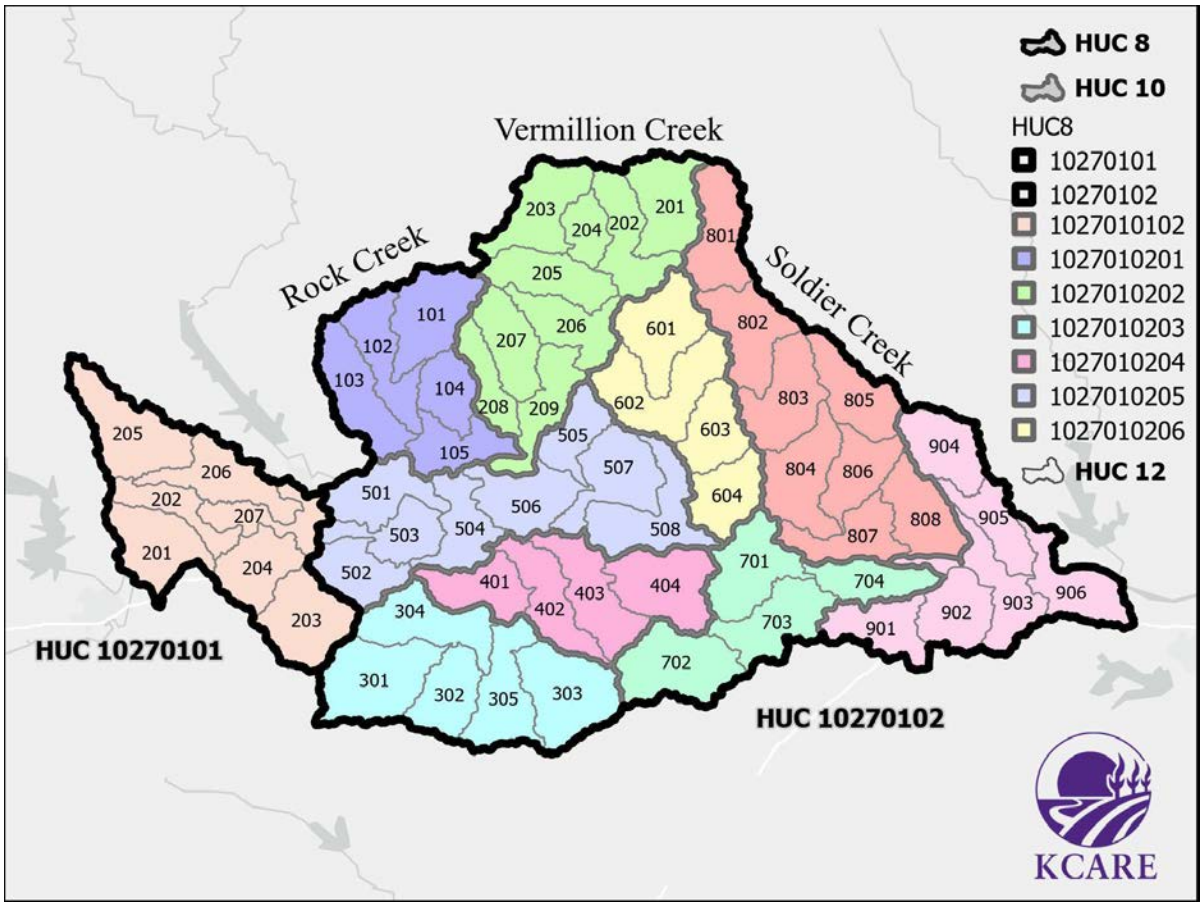


Figure 4. HUC 8, 10 and 12 Delineations in the Middle Kansas River Watershed

G. Middle Kansas River WRAPS History

According to the Kansas Unified Watershed Assessment prepared in 1999 by KDHE and the Natural Resources Conservation Service (NRCS), the Middle Kansas River Watershed is rated as a Category I watershed. This means that the watershed needs restoration and protection to sustain water quality. A Category I watershed either does not meet state water quality standards or fails to achieve aquatic system goals related to habitat and ecosystem health. Category I watersheds also are assigned a priority for restoration. The Middle Kansas River Watershed was ranked 4th out of 71 watersheds in the state for restoration priority.

H. Who Are the Stakeholders?

The Middle Kansas River WRAPS project began in 2006 when the Kansas Alliance for Wetlands and Streams (KAWS) was awarded a grant from KDHE. A coordinator for the Middle Kansas WRAPS project was hired in August of 2006 to guide the development of the WRAPS planning effort in the basin and to work with stakeholders.

Individuals with an interest in water resources in the Middle Kansas River Watershed met in September 2006 and began the process of identifying water-related issues in the basin. As a result, a diverse group of stakeholders became involved in the Middle Kansas River WRAPS

planning process. Farmers, landowners, representatives from natural resource agencies and organizations, city and county government representatives, public water suppliers, and others participated. These stakeholders discussed methods for creating a leadership team that would encompass the broad constituent base of the watershed, given its rural and urban components. The Middle Kansas River WRAPS Stakeholder Leadership Team (SLT) evolved from a core group of meeting attendees and now serves as a board that provides guidance to the WRAPS Coordinator. The SLT also determines priorities and provides direction for projects in the watershed. The SLT currently has 11 members who represent public water supplies, watershed districts, and conservation districts. They also represent entities from outreach/education, local tribes, environmental/health, fish, forestry, wildlife, and local government, as well as livestock and crop production.

The Middle Kansas River WRAPS has completed three of the four basic stages in the WRAPS process. The **development** stage included recruiting stakeholders, affirming an interest in continuing the project, and documenting stakeholder decisions. The **assessment** stage reviewed watershed conditions and identified watershed restoration and protection needs. The **planning** phase established goals and action items, developed cost estimates, and identified stakeholder implementation strategies. The Middle Kansas River WRAPS is now in the **implementation** stage, which includes securing the resources needed to execute the plan, monitoring and documenting progress, and revising the plan as needed. This includes adjustments in plan execution, as area priorities may change.

I. Goals of the Stakeholder Leadership Team (SLT)

Responsibility for restoration and protection of the watershed rests primarily in the hands of local stakeholders. In cooperation with these local stakeholders, federal and state agencies provide technical and financial assistance for education activities and BMP implementation. The SLT identified specific goals to achieve watershed improvement; it is believed that implementation of BMPs as well as financial incentives and cost-share programs will, over time, lead to decreases in surface and ground water impairments.

The **watershed goals** of the Middle Kansas River Watershed SLT are to:

- reduce the amount of bacteria from livestock sources entering the Kansas River, primarily from the Rock Creek and Vermillion Creek Watersheds;
- reduce the amount of nutrients and sediment from cropland sources entering the Kansas River, primarily from the Soldier Creek Watershed;
- protect aquatic life and restore water quality throughout the watershed; and
- educate the watershed community about water quality practices and benefits.

The SLT's secondary watershed priorities include:

- eutrophication,
- degraded streams and rivers,
- sediment/biology,
- flooding,
- livestock management,
- source water protection,

- water wells,
- grazing lands,
- biological items of concern, and
- water quantity.

Many of these secondary priorities will be positively impacted by the implementation of this plan.

Making positive strides toward these goals and priorities will involve both an educational component and the implementation of BMPs in priority areas. Efforts will focus on targeted areas in the Middle Kansas River Watershed to achieve the greatest water quality improvement at a minimal cost. Targeted areas will be discussed in **Section 6** of this plan. The SLT hopes these efforts will protect water quality throughout the Middle Kansas River Watershed.

The **main pollutants** for the Middle Kansas River Watershed are bacteria, nutrients, and sediment. This plan will focus primarily on bacteria from livestock source areas and nutrients and sediment from cropland sources.

J. Regional Advisory Committee (RAC)

In 2013, the governor of Kansas issued a call to action to develop a 50-Year Vision for incorporation into the Kansas Water Plan. Regional Advisory Committees (RACs) were developed in 2015 to work in concert with the 50-Year Vision. The Middle Kansas River Watershed is part of the **Kansas RAC**.[1] The Kansas RAC has developed five priority goals for the future of the Kansas-Lower Republican River Basin; these goals are aligned closely with the WRAPS process and are detailed below.

Kansas RAC goals:

Priority Goal #1: Increase water storage capacity and availability in federal reservoirs to secure an adequate water supply and to maintain water quality in the region.

Action Plans:

1. Increase water storage availability in federal reservoirs to supplement instream flow needs of the Kansas River.
   - Complete necessary background work to support a request to reallocate storage from water supply to water quality in Milford and Perry reservoirs. Move a sufficient amount of storage from water supply to water quality in support of Kansas River quality flow targets.
   - Determine amount of additional annual costs for calling into service the remaining water supply storage not needed to meet instream purposes and request full funding When funding is secured, call into service storage not to be included within reallocation request.

[1] Kansas Water Vision, Regional Goal Action Plans Section. https://kwo.ks.gov/docs/default-source/water-vision-water-plan/water-plan/complete-kwp-2022.pdf?sfvrsn=57338e14_2, Appendix A, page 9.

2. By 2025, evaluate the ability to raise the conservation pool in each federal reservoir.

3. The Kansas RAC recommends the KWO pursue Forecast Informed Reservoir Operation and, as articulated in the "Basin Restoration Approach: Kansas Lower Republican," the Kansas RAC advises the KWO to improve coordination with the United States Army Corps of Engineers (USACE) on reservoir releases, management plans, and future actions to address resiliency to flood and drought conditions, water quality, and quantity issues.

4. The Kansas Water Office shall gather data to determine steps to maintain consistent storage levels at specific reservoirs. As a long-term goal, KWO should incorporate existing studies and information to study the possibility of future dredging and other measures by the State of Kansas on a more consistent basis to maintain storage.

Priority Goal #2: In order to ensure water supply needs are met throughout the entire region, review regional demands for water and evaluate water supply options for areas of need.

Action Plans:

1. The KWO will compile existing information and complete additional evaluation necessary to determine areas of water supply need.

2. Explore additional storage possibilities for construction of multipurpose small lakes so that new water sources can be brought online to alleviate specific regional issues.

3. Working with Kansas Department of Agriculture-Department of Conservation (KDA-DOC), Natural Resources Conservation Service (NRCS) and local watershed districts, identify existing watershed structures that are in need of restoration and have potential to be made larger and provide supplemental water supply.

4. Working with KDA-DOC, NRCS and local watershed districts, identify watershed dam and multipurpose small lake sites that were not constructed but could be built to provide supplemental water supply.

5. KWO shall develop criteria to determine whether these sites should be expanded or built based on a broad range of issues including demonstrated need, return on investment, suitability of site for long-term use, taking into account potential for harmful algal blooms (HABs) and sedimentation, and other legal and logistical issues.

6. Seek partnership and funding opportunities for proposed projects that meet the established criteria.

7. Support the KWO and Kansas Department of Agriculture-Division of Water Resources (KDA-DWR) in their efforts to ensure all municipalities and rural water districts have

updated water conservation plans that meet the 2007 Municipal Water Conservation Plan Guidelines.

Priority Goal #3: Reduce the cumulative sediment rate of federal reservoirs and other water supply lakes in the Kansas region to ensure adequate water supply for the region for the next 40 years.

Achieve individual reduction goals set by the Kansas Water Office for each lake as set forth by the nine-element watershed plan for each within 40 years.

Action Plans:

1. Establish a complete list of major reservoirs and water supply lakes in the Kansas RAC Region. This List is referred to as Appendix A and will be attached to Priority Goal #3.

2. The KWO shall set individual sediment reduction goals for each major reservoir and water supply lake. These goals will be included in Appendix A and updated as new information becomes available.

3. The sediment reduction goals for reservoirs and lakes will be achieved using best management practices (BMPs) implemented in the watersheds of these reservoirs and lakes in the Region. It is estimated that BMP implementation funding of a minimum of $5M annually will be required to achieve the targeted watershed goals within 40 years.

4. Reduce sediment load from out-of-state sources by working with neighboring states and supporting their efforts to implement BMPs.

5. By 2024, all state and federal lands surrounding each federal reservoir and water supply lake in the Kansas RAC Region must implement BMPs such as no-till, soil health practices, or buffers at levels to support achievement of sediment reduction at each reservoir or lake.

6. The KWO, in coordination with other state agencies, shall ensure individual WRAPS plans and Conservation Districts' goals for the Kansas RAC Region include the concept of reservoir sustainability with the goal of maintaining storage capacity in Kansas Region reservoirs.

7. Pursue innovative sediment management alternatives, such as water injection dredging technology.

8. The Kansas RAC will have representation on the NRCS Kansas Technical Committee to help ensure that reservoir sustainability and Kansas water supply issues are addressed in NRCS goal setting and programs.

9. Establish programs with local universities to leverage relevant expertise and student resources that will address the sedimentation reduction goal.

10. Obtain technical assistance and advisors (TA) at a level sufficient to meet the BMP implementation goals in the Region. It is estimated that additional TA funding of at least $350,000 annually would be necessary.

11. NRCS and local conservation districts, in coordination with other state agencies, should prioritize the completion of voluntary Comprehensive Conservation Plans for all land in the Kansas RAC Region and encourage landowners to develop such plans. These Plans will be designed to address natural resource concerns on cropland, in riparian zones, on pastureland, livestock feeding area and others on a whole land or farm unit basis rather than on an individual crop field or a single resource concern basis. Information generated from these comprehensive plans will be used to aid in identifying BMP needs and prioritization of sub-watersheds in the basin, as well as assist with funding and implementation decisions. Eligibility for BMP cost share programs should be prioritized for lands that have Comprehensive Conservation Plans.

12. The KWO shall take the lead to create a partnership list of all BMP implementation programs available to the public from federal and state agencies, natural resource organizations and other groups. This list will be created and shared via a website hosted by KWO as well as in a 1-page flyer (or multiple page booklet as needed) that will be made available to the public. This information will be updated in real time on the KWO website and quarterly on the flyer by KWO staff and distributed widely to all agencies and partners for use and distribution. This document will be a key means to inform the public about all available cost share and technical assistance available for BMP implementation.

Priority Goal #4: Improve water quality throughout the Kansas Region through the utilization of natural solutions with a goal of sustainably meeting the needs of natural and human communities in the watershed.

Action Plans:

1. KWO will provide an annual report to the RAC regarding natural solutions that have been implemented, which will include an assessment of their effectiveness to date.

2. Identify and request natural solutions be incorporated for all appropriate applications. Examples of natural solutions include:
    - Prescribed burns (reduces atmospheric carbon output by preventing larger fires later with smaller fires now, and encourages climate-adapted native vegetation);
    - Hardwood reforestation in riparian areas (reduces erosion, reduces surface runoff; lowers water temperature);
    - Reduced impact logging (leave hollow trees standing, minimize clear cutting, maintain age diversity in forest stand, preserve highest quality trees);
    - Using soil health/regenerative agriculture practices on cropland (no soil disturbance, diversity of species, living root in the soil at all times, keepings soil covered, allow livestock impact) and rangeland (short periods of intense grazing, leaving more than 50% of plant biomass ungrazed, long periods of rest);

- Wetlands and flood plains (pollution and erosion filtering, mitigation of pollutants, flood damage buffering);
- For all of the above, see Proceedings of the Natural Academy of Sciences ofthe United States of America, "Natural Climate Solutions," October 31, 2017,114 (44) 11645-11650.

3. Pursue pilot projects for identified natural solutions.

4. Request that each funded project within the Kansas Region have stated objectives to further this goal, such as maintaining and restoring stream flows and water quality for healthy aquatic and riparian communities, protecting receiving waters from pollution, protecting the quality of water supplies to meet human needs within the watershed, reducing flood risk to human communities and encouraging natural flood processes, and increasing resilience to climate change.

Priority Goal #5: Continue to reduce the duration and frequency of Harmful Algal Blooms (HABs) in the watershed.

The reduction of HABs in the Milford Lake watershed is a top priority for the Kansas Regional Planning Area.

Action Plans:

1. The Kansas RAC shall recommend to the Kansas Water Authority that a minimum of $3 million per year shall be allocated towards HAB mitigation in the Kansas Regional Planning Area with a minimum of $1.5 million to be directed to BMP implementation in the Milford Lake Watershed.

2. By 2024, all state and federal lands surrounding each federal reservoir and water supply lake in the Kansas RAC Region must implement BMPs such as no-till, soil health practices, or buffers at levels to support achievement of HAB reduction at each reservoir or lake.

3. The KWO, in coordination with other state agencies, shall ensure individual WRAPS plans and Conservation Districts' goals for the Kansas RAC Region include the concept of minimizing nutrient inflow to lakes to reduce the potential for HABs with a focus on best management practices such as no-till, soil health and nutrient management practices, or buffer.

4. Encourage stakeholders to engage in collaborative efforts that result in the reduction of nutrient loading in federal reservoirs (example, Milford RCPP).

5. The Kansas RAC recommends that the KWO include management for HABs as part of the lake level management plan to mitigate HABs in reservoirs, as well as downstream impacts.

6. Support ongoing research for identification and remediation of the causes, prevention and treatment of HABs, including potential in-lake technologies.

7. Establish programs with local universities to leverage relevant expertise and student resources that will address the HAB reduction goal.

8. NRCS and local conservation districts, in coordination with other state agencies, should prioritize the completion of voluntary Comprehensive Conservation Plans for all land in the Kansas RAC Region and encourage landowners to develop such plans. These Plans will be designed to address natural resource concerns on cropland, in riparian zones, on pastureland, livestock feeding area and others on a whole land or farm unit basis rather than on an individual crop field or a single resource concern basis. Information generated from these comprehensive plans will be used to aid in identifying BMP needs and prioritization of sub-watersheds in the basin, as well as assist with funding and implementation decisions. Eligibility for BMP cost share programs should be prioritized for lands that have Comprehensive Conservation Plans.

9. Encourage KDHE to continue providing funding to support roughfish removal.

10. Obtain technical assistance and advisors (TA) at a level sufficient to meet the HAB reduction goals in the Region.

This watershed review is an in-depth description of the Middle Kansas River Watershed. This section includes descriptions and data about the watershed's land cover and use, special water designations, annual rainfall, aquifers, population, public water supplies and permitted wastewater facilities.

A. Land Cover and Land Uses

Land use activities have a significant impact on the types and quantity of nutrient, sediment, and bacteria pollutants in the Middle Kansas River Watershed. As shown in **Figure 5**, the three major land uses in this watershed are grassland (44.9%), pasture/hay (20.1%), and cropland (15.8%). Pasture/hay and grassland land uses often can contribute livestock manure to streams and ponds that result in nutrient and bacteria runoff, in addition to sediment runoff from cattle trails and gullies in pastures. Cropland (cultivated crops) is the main source of sediment and nutrient runoff from overland flow. Nutrients leach onto sediment during runoff events and are deposited in nearby streams. Conventional tillage practices on cropland as well as a lack of maintenance of structural BMPs on agricultural land can have cumulative effects on land transformation through sheet and rill erosion.

Table 1 lists the remaining land uses in the watershed, including: deciduous forest (8.8%), developed, open space (4%), developed, low intensity (2.6%), open water (1.1%), developed medium intensity (0.9%), woody wetlands (0.8%), developed, high intensity (0.3%), herbaceous wetlands (0.3%), barren land (0.2%), mixed forest (0.2%), evergreen forest (0.1%), and shrubland (less than 1%). Properly managed forest/woodland with a good understory does not contribute a significant amount of sediment or nutrients to this watershed. In fact, forest/woodlands located along rivers and streams provide a good buffer to prevent streambank erosion.

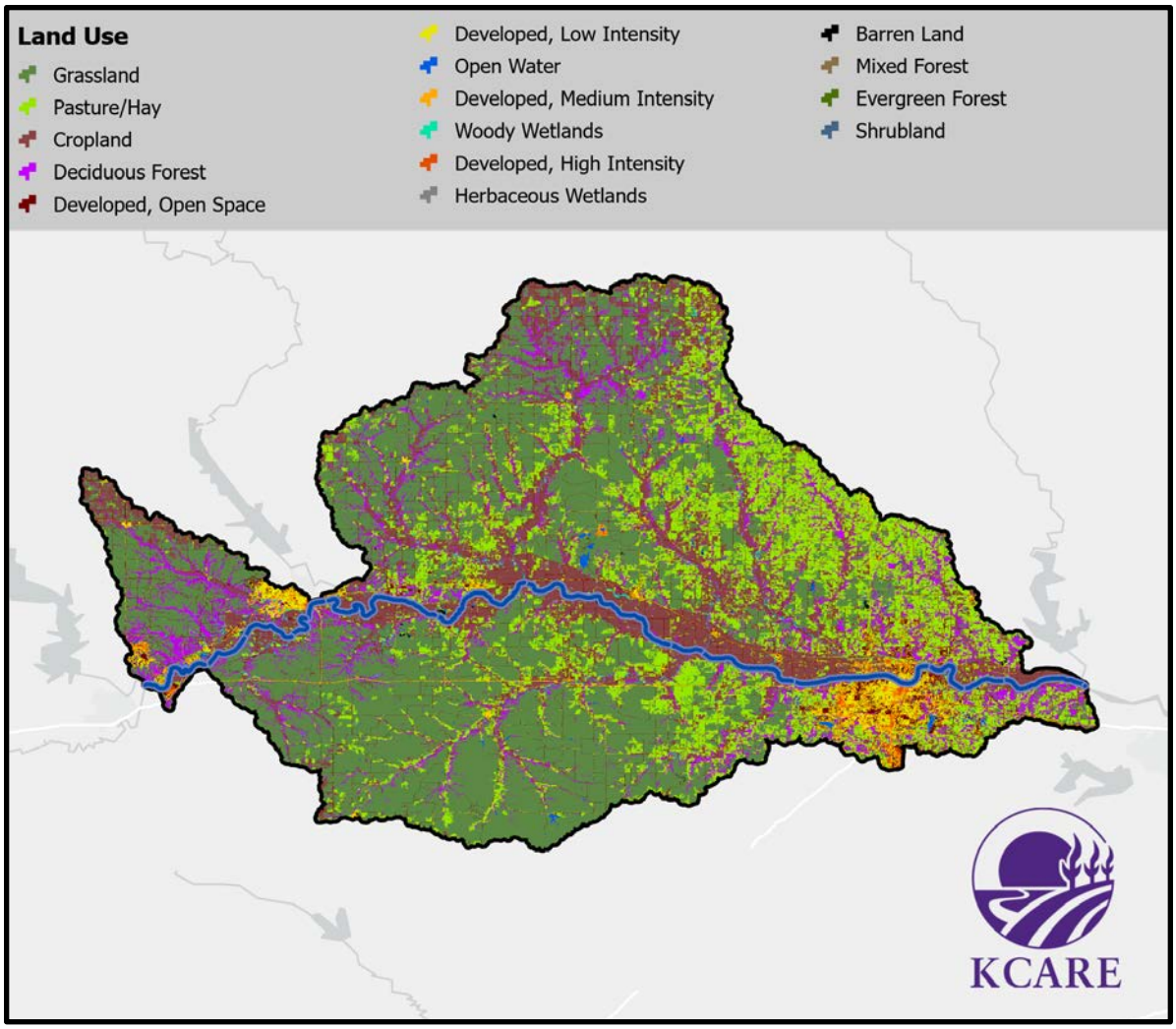


Figure 5. Land Cover and Land Use in the Middle Kansas River Watershed

Table 1. Land Use in the Middle Kansas River Watershed

Land Use in the Middle Kansas Watershed		
Land Use	**Acres**	**Percent of Watershed**
Grassland	704,001	44.9%
Pasture/Hay	315,170	20.1%
Cropland	248,528	15.8%
Deciduous Forest	137,479	8.8%
Developed, Open Space	63,296	4.0%
Developed, Low Intensity	41,119	2.6%
Open Water	17,730	1.1%
Developed, Medium Intensity	14,126	0.9%
Woody Wetlands	11,944	0.8%
Developed, High Intensity	4,911	0.3%
Herbaceous Wetlands	3,938	0.3%
Barren Land	2,973	0.2%
Mixed Forest	2,598	0.2%
Evergreen Forest	813	0.1%
Shrubland	546	Less than 0.1%
Total	**1,569,172**	**100%**

B. Designated Uses

The stream segments and lakes in the Middle Kansas River Watershed have many designated uses according to the Kansas Surface Water Register, which is prepared and maintained by KDHE's Division of Environment, Bureau of Water. Designated uses for the Middle Kansas River Watershed include aquatic life, contact recreational, domestic water supply, food procurement, groundwater recharge, industrial water supply, irrigation, and livestock water (**Table 2**). These "designated uses" are defined and assigned to specific water segments in the Kansas Surface Water Register, 2013, issued by KDHE (**Table 3**).

Waterbodies in bold will be directly affected by implementation of this 9-element watershed plan. Bold areas with asterisks indicate a violation of designated use, and a high-priority TMDL has been written.

Table 2. Designated Water Uses Abbreviation Key

Designated Uses Abbreviation Key			
AL	Aquatic Life	GR	Groundwater Recharge
CR	Contact Recreational	IW	Industrial Water Supply
DS	Domestic Water Supply	IR	Irrigation
FP	Food Procurement	LW	Livestock Water
A	Primary contact recreation stream segment is a designated public swimming area	B	Primary contact recreation stream segment is by law or written permission of the landowner open to and accessible by the public
b	Secondary contact recreation stream segment is not open to or accessible by the public under Kansas law	C	Primary contact recreation stream segment is not open to or accessible by the public under Kansas law
E	Expected aquatic life use water	S	Special aquatic life use water
O	Referenced stream segment does not support the indicated designated use	X	Referenced stream segment is assigned the indicated designated use

Table 3. Designated Water Uses in the Middle Kansas River Watershed[2]

Designated Water Uses: Middle Kansas River Watershed								
Water Segment Name:	**AL**	**CR**	**DS**	**FP**	**GR**	**IW**	**IR**	**LW**
Indian Creek (Segment 1,365), Unnamed Stream (Segment 1,367)	E	a	X	X	X	X	X	X
Kings Creek	E	a	X	O	X	X	X	X
Big Elm Creek, Unnamed Stream (Segment 1,389)	E	b	O	O	O	O	O	O
Emmons Creek, Johnson Creek	E	b	O	O	O	O	X	X
Cow Creek	E	b	O	O	X	O	O	O
Elm Creek (Segment 103), Elm Slough, Sand Creek, Wells Creek	E	b	O	O	X	O	X	X
Unnamed Stream (Segment 8)	E	b	O	X	O	O	O	O
Coryell Creek, Mud Creek (Segment 44)	E	b	O	X	O	O	O	X
Dutch Creek	E	b	O	X	O	O	X	X
Bartlett Creek, Blackjack Creek, Blacksmith Creek, Coal Creek, Dog Creek, Gilson Creek, James Creek, Mission Creek - South Branch, Pomeroy Creek, Salt Creek, Spring Creek (Segment 48), Vassar Creek	E	b	X	O	X	X	X	X
Adams Creek, Darnells Creek, Deep Creek - East Branch, Hise Creek, Illinois Creek (Segment 62), Indian Creek (Segment 20), Jim Creek, Little Cross Creek, Little Soldier Creek (Segment 7), Mud Creek (Segment 56), Muddy Creek - West Fork, Mulberry Creek (Segment 42), Post Creek, Ralls Creek, **Rock Creek (Segment 22)**, Silver Creek, Snake Creek, Spring Creek (Segment 105), Stinson Creek, Tecumseh Creek, Vermillion Creek (Segment 18), Walnut Creek, Whetstone Creek	E	b	X	X	X	X	X	X
Little Kitten Creek	E	B	O	X	X	O	O	O
Deer Creek, Lost Creek, Shunganunga Creek (segments 39 and 40), Shunganunga Creek - South Branch, **Soldier Creek (Segment 5)**	E	B	X	X	X	X	X	X
Elm Creek (Segment 98)	E	C	O	X	O	O	O	X
Threemile Creek	E	C	O	X	O	O	X	X
Rock Creek (Segment 21)*, Turkey Creek	E	C	O	X	X	O	X	X
Wilson Creek	E	C	O	X	X	X	X	X
Antelope Creek, Bourbonais Creek, Brush Creek, Clarks Creek (Segment 8 and 9), Cross Creek, Deep Creek (Segment 1,229), Doyle Creek, French Creek, Halfday Creek, Humboldt Creek, Little Muddy Creek, Little Soldier Creek (Segment 6), McDowell Creek, McDowell Creek -East Branch, Messhoss Creek, Mission Creek - North Branch, Muddy Creek, Muddy Creek - East Fork, Pleasant Run Creek, **Soldier Creek (Segments 9 and 9,009)***, Spring Creek (Segment 54), Sullivan Creek, **Vermillion Creek (Segments 15, 16, and 17)***, Wolf Creek	E	C	X	X	X	X	X	X
Little Arkansas Creek	S	b	O	X	O	O	X	X
Spring Creek (Segment 76)	S	b	O	X	X	O	O	X
Paw Paw Creek, Pretty Creek	S	b	X	O	X	X	X	X
Deep Creek (Segment 26), Deep Creek - South Branch, Kansas River (Segments 1, 3, 4, 6, 7, 10, 11, 13, 14, 24, and 25), Kitten Creek, Mission Creek (Segment 36), Wildcat Creek	S	B	X	X	X	X	X	X
Davis Creek, Kuenzli Creek, Mill Creek - South Branch, Mill Creek - West Branch (Segment 29), Mission Creek (Segment 34), Mulberry Creek (Segment 42), Ross Creek, Sevenmile Creek, Snokomo Creek, Swede Creek	S	b	X	X	X	X	X	X
Hendricks Creek	S	C	X	O	X	X	X	X
Dry Creek, Illinois Creek (Segment 30), Loire Creek, Mill Creek, Mill Creek - East Branch (Segments 31 and 33), Mill Creek - West Branch (Segment 28), Mission Creek (Segment 37), Nehring Creek, Unnamed Stream (Segment 693)	S	C	X	X	X	X	X	X

[2] Kansas Surface Water Register, 2021. Kansas Department of Health and Environment. https://www.kdhe.ks.gov/DocumentCenter/View/13293/Kansas-Surface-Water-Register-PDF?bidId=, pages 7-10 and 57.

Designated Water Uses: Middle Kansas River Watershed								
Lake Name:	**AL**	**CR**	**DS**	**FP**	**GR**	**IW**	**IR**	**LW**
Alma City Lake	E	B	X	X	X	X	X	X
Cedar Crest Lake	E	B	X	X	O	X	X	X
Central Park Lake	E	B	X	X	O	X	X	X
Dornwood Park Lake	E	B	O	X	O	O	O	O
Gage Park Lake	E	B	X	X	O	X	X	X
Jeffrey Energy Center W.A.	E	B	X	X	O	X	X	X
Lake Jivaro	E	A	X	X	O	X	X	X
Lake Shawnee	E	A	X	X	X	X	X	X
Lake Sherwood	E	A	X	X	O	X	X	X
Myer's Lake	E	B	X	X	O	X	X	X
New Alma City Lake	E	A	X	X	X	X	X	X
Odgen City Lake	E	A	X	X	X	X	X	X
Pillsbury Crossing W.A.	E	B	X	X	X	X	X	X
Pottawatomie #1	E	B	X	X	O	X	X	X
Shawnee	E	B	X	X	O	X	X	X
Topeka Public Golf Course Lake	E	B	X	X	O	X	X	X
Wabaunsee County Lake	E	A	X	X	X	X	X	X
Wamego City Lake	E	B	X	X	X	X	X	X
Warren Park Lake	E	B	X	X	O	X	X	X
Washburn Rural Environmental Lab Lake	E	B	X	X	O	X	X	X

C. Special Aquatic Life Use Waters

Special Aquatic Life Use Waters[3] (SALU) 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." All surface waters in the Konza Prairie natural areas in Geary and Riley Counties have been designated as SALU waters as well as 39 water segments in the Middle Kansas River Watershed to include (**Figure 6**):

- Deep Creek (Segment 26)
- Deep Creek - South Branch
- Dry Creek
- Hendricks Creek
- Illinois Creek (Segment 30)
- Kansas River (Segments 1, 3, 4, 6, 7, 10, 11, 13, 14, 24, and 25)
- Kuenzli Creek
- Little Arkansas Creek
- Loire Creek
- Mill Creek
- Mill Creek - East Branch (Segments 31 and 33)
- Mill Creek - South Branch

[3] Kansas Surface Water Register, 2021. Kansas Department of Health and Environment. https://www.kdhe.ks.gov/DocumentCenter/View/13293/Kansas-Surface-Water-Register-PDF?bidId=,, pages 8-10 and 55.

- Mill Creek - West Branch (Segment 28)
- Mill Creek - West Branch (Segment 29)
- Mission Creek (Segment 34)
- Mission Creek (Segment 36)
- Mission Creek (Segment 37)
- Mulberry Creek (Segment 42)
- Nehring Creek
- Paw Paw Creek
- Pretty Creek
- Ross Creek
- Sevenmile Creek
- Snokomo Creek
- Spring Creek (Segment 76)
- Swede Creek
- Unnamed Stream (Segment 693)
- Wildcat Creek

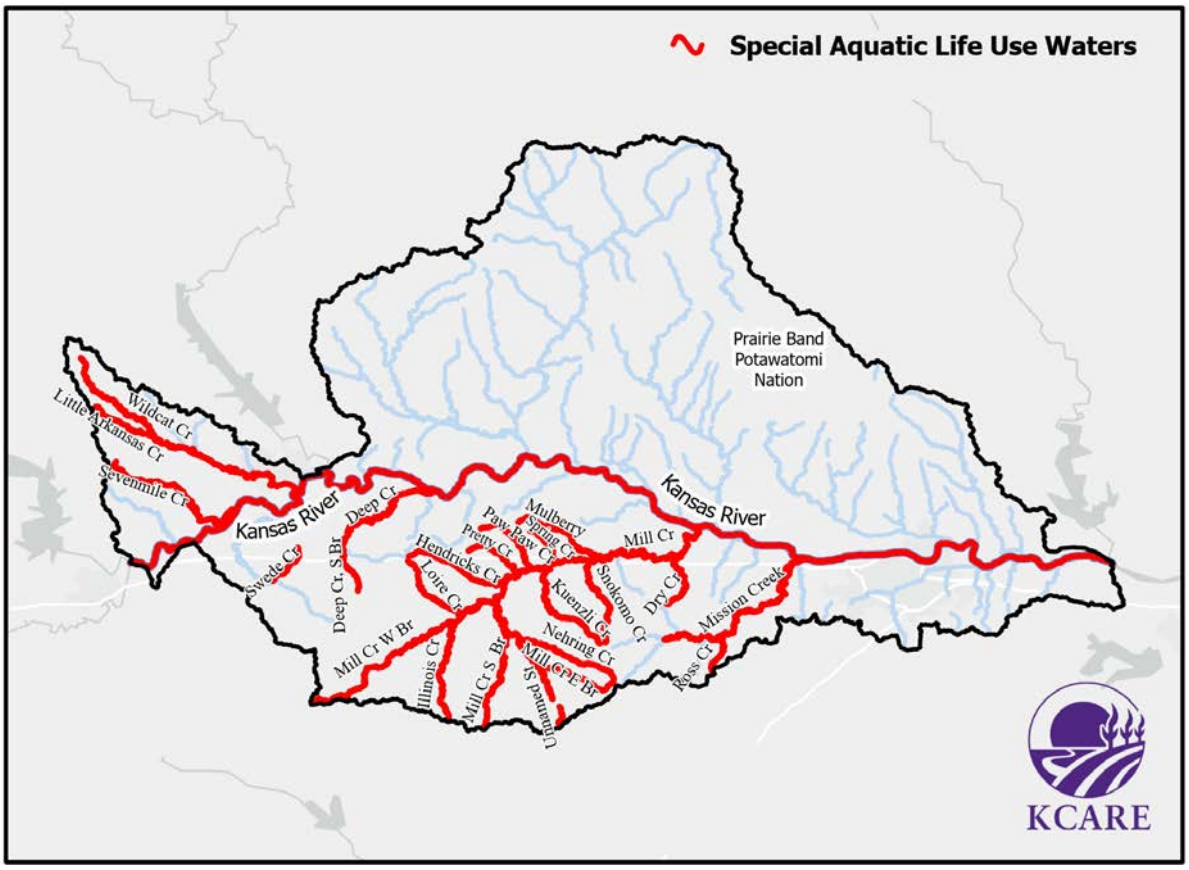


Figure 6. SALU Waters in the Middle Kansas River Watershed

D. Exceptional State Waters

Exceptional State Waters[4] (ESW) are defined as "any of the surface waters or surface water segments that are of remarkable quality or of significant recreational or ecological value." There are nine ESW-listed water segments in the Middle Kansas River Watershed to include (**Figure 7**):

- Deep Creek, Segment 26
- Deep Creek - South Branch, Segment 9,026
- Illinois Creek, Segment 30
- Mill Creek, Segment 27
- Mill Creek - East Branch, Segment 31 and 33
- Mill Creek - West Branch, Segments 28 and 29
- Unnamed Stream, Segment 693

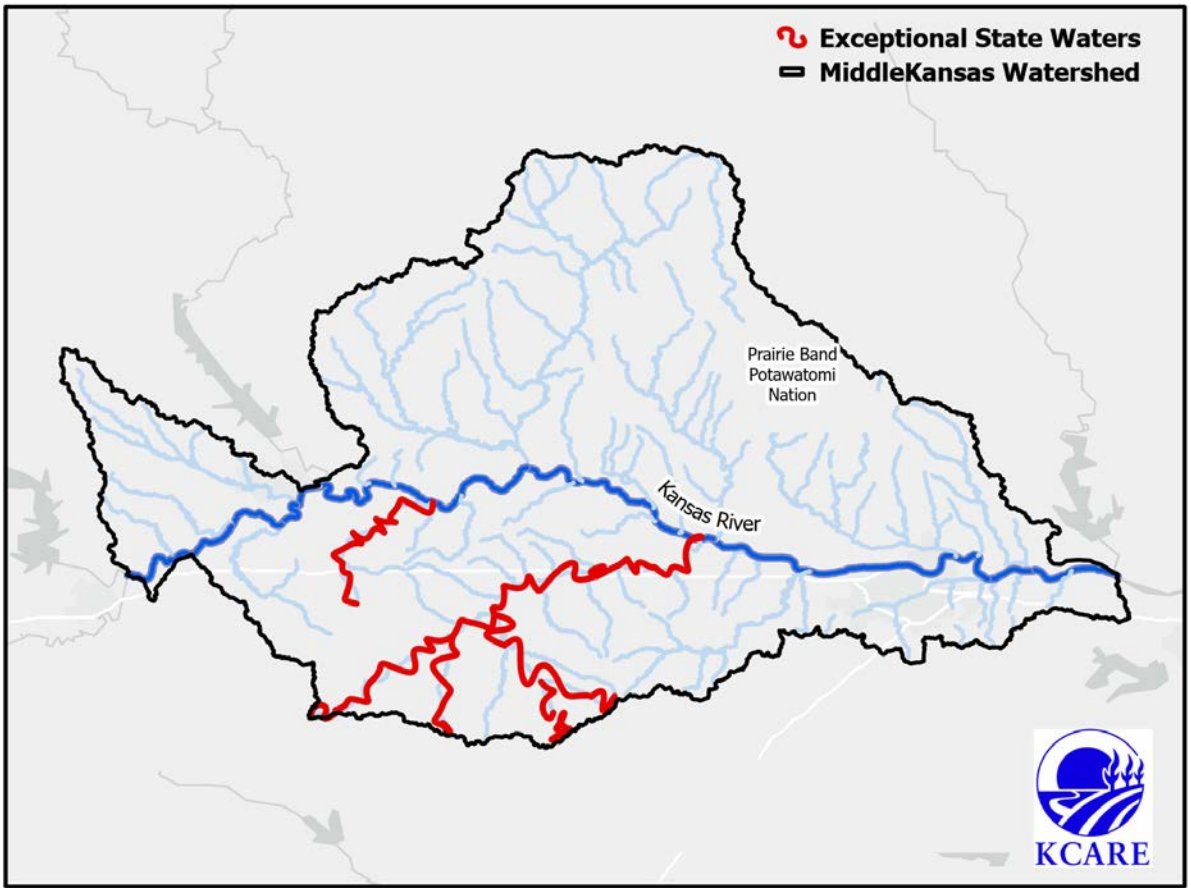


Figure 7. Exceptional State Waters in the Middle Kansas River Watershed

[4] KS Surface Water Quality Standards. K.A.R. 28-16-28d(1)(b)(2)(A) For Exceptional State Waters, K.A.R. 28-16-28b(dd). For Outstanding National Resource Waters, K.A.R. 28-16-28b(aaa). https://www.kdhe.ks.gov/DocumentCenter/View/13290/Kansas-Surface-Water-Quality-Standards-2018-PDF

E. Outstanding National Resource Waters

Outstanding National Resource Waters[4] (ONRW) are defined as "any of the surface waters or surface water segments of extraordinary recreational or ecological significance." The Middle Kansas River Watershed does not house any ONRW-listed waters.

F. Rainfall and Runoff

Rainfall amounts and duration affect sediment and nutrient runoff during high-intensity rainfall events, most of which occur in late spring and early summer. This is the time frame when cropland is either bare, or crop biomass is small; likewise, grasses are short and do not catch as much runoff. Both situations can lead to pollutants and bacteria entering the waterways. The Middle Kansas River Watershed averages 35.45 inches of rainfall annually (**Figure 8**). Precipitation data from the cities of Manhattan, Wamego and Topeka were used to calculate the watershed's average annual rainfall. As shown in **Figure 9**, the highest levels of precipitation are found in the eastern section of the watershed, and the lowest levels of precipitation are found in the far northwest corner.

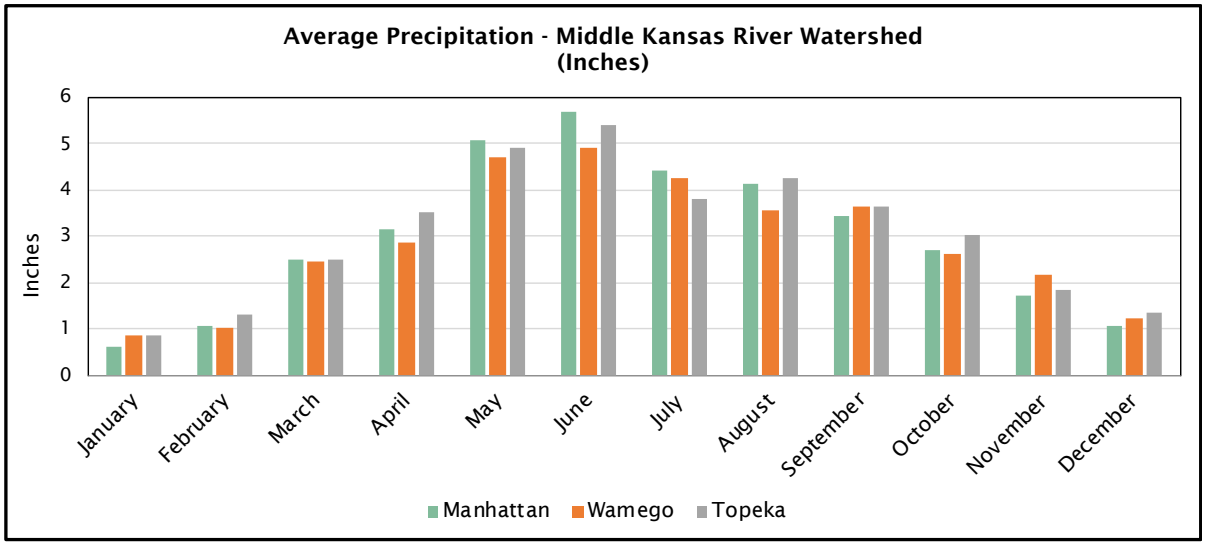


Figure 8. Middle Kansas River Watershed Monthly Average Precipitation[5]

[5] U.S. Climate Data. https://USClimatedata.com

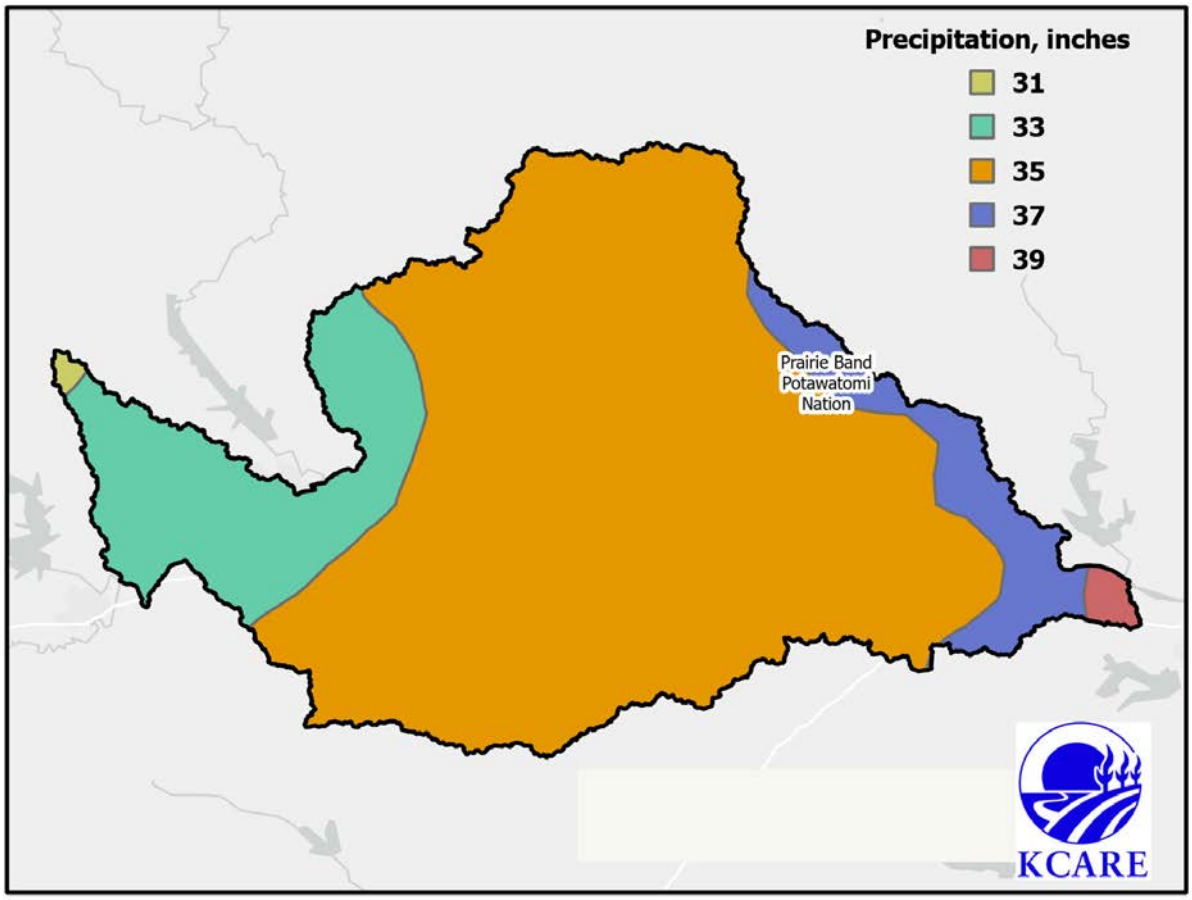


Figure 9. Annual Precipitation in the Middle Kansas River Watershed

G. Population and Wastewater Systems

The Middle Kansas River Watershed is made up of about 9% municipal/urban areas and 91% rural areas, both with above-average population densities. (**Figure 10**).

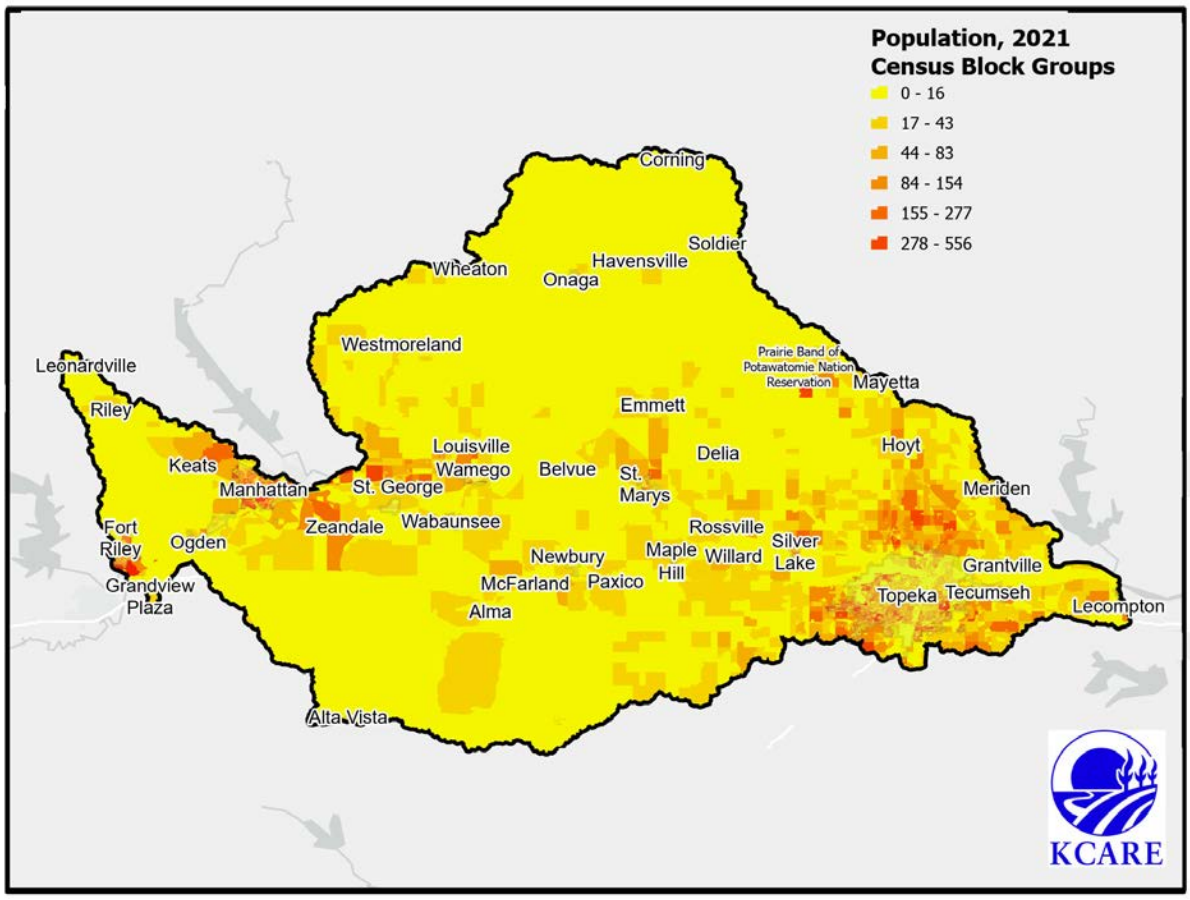


Figure 10. Middle Kansas River Watershed Population Map

Table 4. Population in the Counties of the Middle Kansas River Watershed

Estimating the Middle Kansas River Watershed Population			
County	**Square Miles***	**Population: 2020 Census**	**Persons Per Square Mile**
Douglas	475	121,304	255
Geary	404	33,309	82
Jackson	658	13,249	20
Jefferson	557	18,974	34
Morris	703	5,551	8
Nemaha	719	10,109	14
Pottawatomie	862	24,203	28
Riley	622	74,059	119
Shawnee	556	177,293	319
Wabaunsee	800	6,877	9
County Total	**6,356**	**484,928**	**76**
Municipal/Urban Totals (figured in Table 5)	**215**	**200,791**	**934**
Rural Totals	**6,141**	**284,137**	**46**
***This table represents the total square miles and population in the county, it does not take watershed boundary lines within a county into account.**			

Table 5. Rural and Urban Populations Used to Determine Wastewater Systems[6]

Middle Kansas River Watershed Municipal and Rural Population		
Township	**2020 Population**	**Square Miles**
Alma	780	0.60
Belvue	200	0.12
Corning	164	0.28
Delia	176	0.12
Emmett	186	0.20
Havensville	155	0.14
Hoyt	630	0.47
Leonardville	431	0.29
Manhattan	54,604	19.91
Maple Hill	606	0.24
Mayetta	346	0.17
McFarland	243	0.19
Ogden	1,958	1.73
Onaga	682	0.66
Paxico	215	0.14
Prairie Band Indian Reservation	1,238	122.00
Riley	952	0.69
Rossville	1,124	0.55
Silver Lake	1,406	0.59
Soldier	132	0.15
St George	998	0.65
St Marys	2,781	1.18
Topeka	125,310	61.47
Wamego	4,732	2.41
Westmoreland	742	0.49
Municipal/Urban Totals	200,791	215
Rural Totals (46 persons/square mile)	102,902	2,237
Middle Kansas River Watershed: TOTALS	**303,693**	**2,452**

Table 4 uses 2020 U.S. Census population numbers to determine the average population density of all the counties in the Middle Kansas River Watershed. Average population density for Kansas is represented as persons per square mile. It is necessary to remove the

[6] The League of Kansas Municipalities. https://www.lkm.org/.

municipal/urban populations (figured in **Table 5**) from the equation to better estimate the rural population and number of wastewater systems in the Middle Kansas River Watershed. From **Table 4**, it is calculated that rural areas in this watershed have an average of 46 persons per square mile. Given the average population density for Kansas of 32.9 persons per square mile, the Middle Kansas River Watershed has an above-average population.

Using a Middle Kansas River Watershed area of 2,452 square miles (minus the 215 urban square miles) it can be determined that there is a rural area of 2,237 square miles. With a calculated average of 46 persons per square rural mile, the estimated rural population of the Middle Kansas River Watershed is 102,902, with a total watershed population of 303,693 (**Table 5**).

The number of wastewater treatment systems is tied directly to population, particularly in rural areas without access to municipal wastewater treatment facilities. The lack of onsite wastewater systems, or systems that are either failing or improperly installed, can lead to bacteria and/or nutrients from untreated sewage leaking or draining into the watershed. Even though all the counties in the watershed have county sanitary codes, there is no way of knowing how many failing or improperly constructed systems exist in the Middle Kansas River Watershed. Using an estimated rural population of 102,902 and an estimated 2.29 persons per rural Kansas household, it can be determined that there are approximately 44,935 onsite wastewater treatment systems installed in the watershed with an expected failure rate of roughly 20%, or 8,987 systems.[7]

H. Aquifers

Portions of three aquifers underlie the Middle Kansas River Watershed: the alluvial aquifer, as well as the Glacial Drift and Flint Hills Aquifer (**Figure 11**).

- The **alluvial** aquifer is part of and connected to a river system, consisting of sediment deposited by rivers in the stream valleys. A sign of a healthy and sustainable alluvial system is adequate stream flow. The alluvial aquifer in the Middle Kansas River Watershed lies along and below the Kansas River, as well as some tributaries.
- The **Glacial Drift Aquifer** was formed by deposits of rock left by the glacier that covered northeast Kansas 700,000 years ago. These rock deposits of sand and gravel created a porous area that traps and holds water deposits. Small portions of this aquifer are in the Middle Kansas River Watershed.
- The **Flint Hills Aquifer** consists of limestone units that are water-bearing strata for many springs and public water supplies in the Flint Hills region. The Flint Hills Aquifer runs south through Kansas, spanning from Nebraska to Oklahoma. The aquifer enters Kansas through Marshall and Washington counties in the north and enters Oklahoma through Cowley County in the south.

[7] Cooperative Extension Service, University of Kentucky, College of Agriculture. http://www2.ca.uky.edu/agcomm/pubs/HENV/HENV502/HENV502.pdf

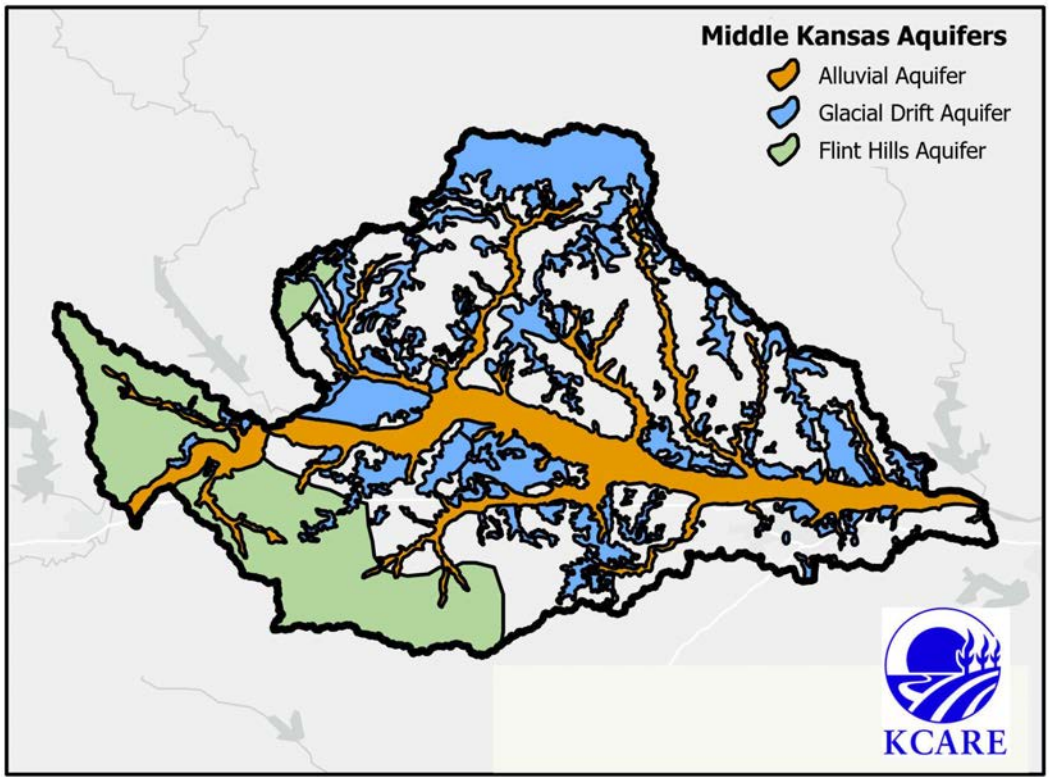


Figure 11. Aquifers in the Middle Kansas River Watershed[8]

I. Public Water Supplies

A Public Water Supply (PWS) is defined as a system for delivery to the public of piped water for human consumption that has at least 10 service connections or regularly serves at least 25 individuals daily at least 60 days out of the year. Municipal water supplies and rural water districts are considered public water supplies.

A PWS uses water from either surface water or groundwater sources, or a combination of both. Generally, groundwater sources are less prone to man-made contamination than surface water sources since soil overlying aquifers acts as a protective barrier and filter. However, some contaminants are able to leach through the soil (or where aquifers are shallow), and can have a negative impact on groundwater quality.

Sediment can affect a PWS that derives its water from a surface water supply by making it difficult to access the water at the intake or to treat the water prior to consumption. Nutrients and bacteria also will affect surface water supplies causing excess treatment costs prior to public consumption.

There are 45 public water suppliers within the Middle Kansas River Watershed, as shown in **Table 6**. Most people in the watershed receive their water from a PWS, while the rest of the watershed's population depend on private wells.

[8] US Geological Survey, Kansas Geological Survey.

Table 6. Middle Kansas River Watershed Public Water Suppliers[9]

Public Water Suppliers in the Middle Kansas Watershed		
Public Water Suppliers	**Population**	**County**
Alma, City of	780	Wabaunsee
Belvue, City of	200	Pottawatomie
Corning, City of	164	Nemaha
Delia, City of	176	Jackson
Emmett, City of	186	Pottawatomie
Frusi Aquatic Range County Complex	25	Riley
Havensville, City of	155	Pottawatomie
Hoyt, City of	630	Jackson
Hunters Island Water District	200	Riley
Jackson County Rural Water District 1	2,500	Jackson
Jefferson County Rural Water District 1	2,303	Jefferson
Jefferson County Rural Water District 15	228	Jefferson
Konza Valley Water Benefit District	345	Riley
Lake Wabaunsee Improvement District	185	Wabaunsee
Leonardville, City of	431	Riley
Manhattan, City of	54,604	Riley
Maple Hill, City of	606	Wabaunsee
Mayetta, City of	346	Jackson
McFarland, City of	243	Wabaunsee
Metro Topeka Airport Authority	500	Shawnee
Ogden, City of	1,958	Riley
Onaga, City of	682	Pottawatomie
Paxico, City of	215	Wabaunsee
Pottawatomie County Rural Water District 1	7,874	Pottawatomie
Pottawatomie County Rural Water District 2	625	Pottawatomie
Pottawatomie County Rural Water District 3	1,300	Nemaha
Pottawatomie County Rural Water District 4	1,125	Pottawatomie
Riley, City of	952	Riley
Rossville, City of	1,124	Shawnee
Shawnee County Rural Water District 2C	700	Shawnee
Shawnee County Rural Water District 4C	12,000	Shawnee
Shawnee County Rural Water District 8	6,073	Shawnee
Silver Lake, City of	1,406	Shawnee
Soldier, City of	132	Jackson
St George, City of	998	Pottawatomie
St Marys, City of	2,781	Pottawatomie
Stagg Hill Golf Club, Inc	50	Riley
Timber Creek East Water District	850	Pottawatomie
Topeka, City of	125,310	Shawnee
Wabaunsee County Rural Water District 1	400	Wabaunsee
Wabaunsee County Rural Water District 2	1,400	Wabaunsee
Walnut Grove Mobile Home Park Brensing White	256	Pottawatomie
Walnut Grove Mobile Home Park Brooks	203	Pottawatomie
Wamego, City of	4,732	Pottawatomie
Westmoreland, City of	742	Pottawatomie
Total Population Served	**238,695**	

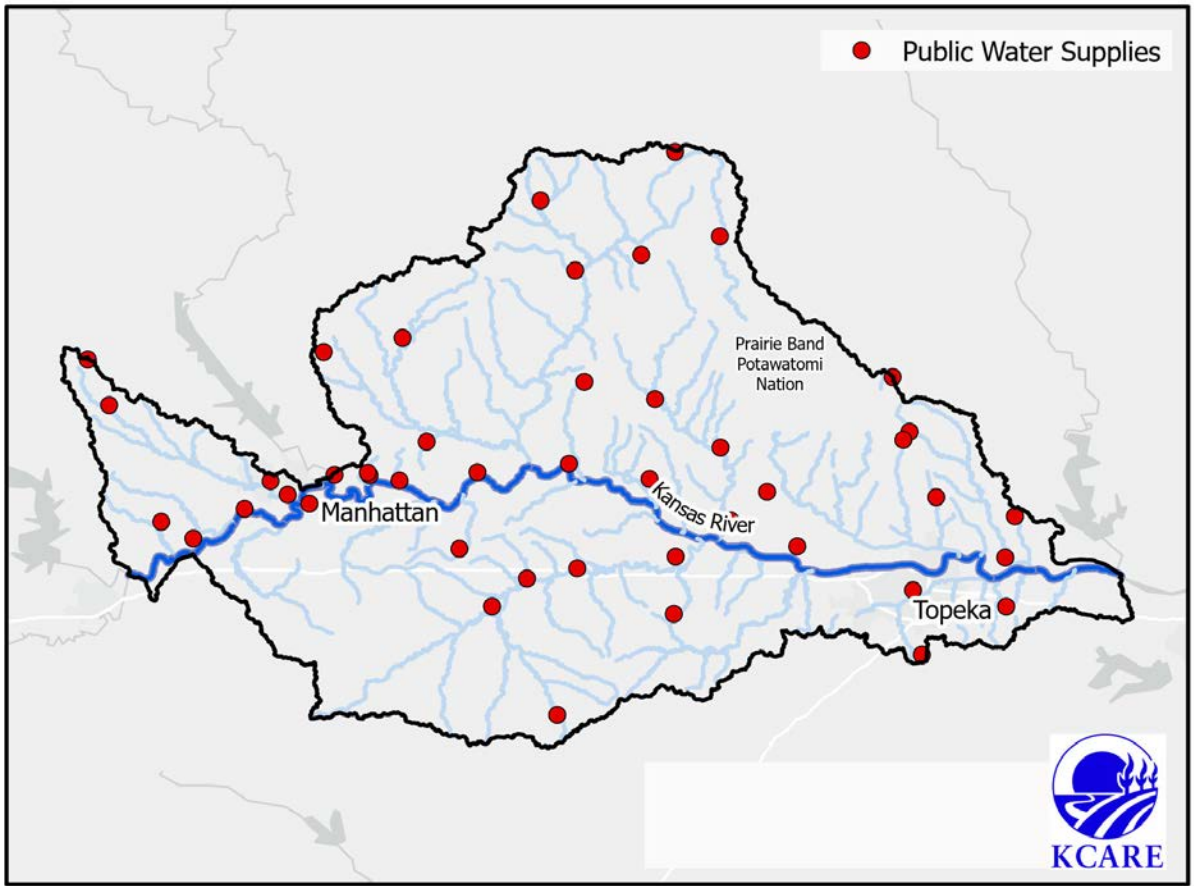


Figure 12. Public Water Supplies in the Middle Kansas River Watershed

Source water protection

The 1996 amendments to the Safe Drinking Water Act required each state to develop a Source Water Assessment Program (SWAP). Additionally, each state was required to develop a Source Water Assessment (SWA) for each PWS that treats and distributes raw source water and to make the assessment available to the public. In Kansas, there are approximately 761 PWS requiring SWAs. SWAs include the following: delineation of the source water assessment area, inventory of potential contaminant sources, and susceptibility analysis. KDHE's Watershed Management Section has implemented the Kansas SWAP plan, and all SWAs are complete[10].

The Safe Drinking Water Act did not require protection planning to be part of the SWAP process. On a voluntary basis, KDHE encourages public water supplies and their surrounding communities to use SWA as the foundation for future protection planning efforts.

The Middle Kansas River Watershed has 45 active PWS. Nearly all public water suppliers within the Middle Kansas River Watershed were required to develop a SWAP in 2003.

[9] Kansas Department of Health and Environment, March 31, 2022.
[10] Kansas Department of Health and Environment, Source Water Assessment Reports.

J. National Pollutant Discharge Elimination System (NPDES)

National Pollutant Discharge Elimination System (NPDES) permits specify the maximum amount of pollutants allowed to be discharged to surface waters. KDHE permits and regulates wastewater treatment facilities, and these facilities are considered point sources (PS) for pollutants. Municipal wastewater can contain suspended solids, biological pollutants that reduce oxygen in the water column, inorganic compounds, or bacteria. Having these PS located on streams or rivers may impact water quality in the waterways. Methods for treating municipal wastewater are similar across the country; wastewater treatment facilities remove solids and organic materials, disinfect water to kill bacteria and viruses, and discharge water to surface waterways.

Industrial point sources also can contribute toxic chemicals or heavy metals to waterways. Treatment of industrial wastewater is specific to the industry and to the pollutant discharged. Any pollutant discharge from PS allowed by the state is considered wasteload allocation. There are currently 60 permitted NPDES facilities in the Middle Kansas River Watershed (**Table 7**).

Table 7. NPDES Permitted Facilities in the Middle Kansas River Watershed[11]

NPDES Permitted Facilities in the Middle Kansas River Watershed			
Facility Name	**Facility Type**	**Description**	**County**
Alex Gnadt - Gnadt Quarry	Industrial	Mine Pit Dewatering (No Wash)	Wabaunsee
Bayer Construction - Hayden Quarry	Industrial	Mine Pit Dewatering (With Wash)	Riley
Bayer Construction - Moore Quarry	Industrial	Mine Pit Dewatering (With Wash)	Riley
BNSF Railway Company - Topeka	Industrial	Physical/Chemical Treatment	Shawnee
Capitol Concrete Products	Industrial	Waste Stabilization Pond; Overflowing	Shawnee
Concrete Supply of Topeka - Nr Hamm	Industrial	Waste Stabilization Pond; Non-Overflowing	Shawnee
Concrete Supply of Topeka- Forbes Field	Industrial	Waste Stabilization Pond; Non-Overflowing	Shawnee
Crystal Creek Clay Mine	Industrial	Mine Pit Dewatering (No Wash)	Jackson
Curtis Capoun - Arand Quarry	Industrial		Wabaunsee
Douglas Co. RWD No. 3 - Big Springs	Industrial	Waste Stabilization Pond; Overflowing	Shawnee
Eskridge Water Treatment Plant	Industrial		Wabaunsee
Evergy - Jeffrey Energy Center	Industrial	Boiler Bd/Cooling Tower Blow-Down To Drainage	Pottawatomie
Evergy- Tecumseh Energy Center	Industrial	Boiler Bd/Cooling Tower Blow-Down To Drainage	Shawnee
Farview Farms Meat Company	Industrial	Waste Stabilization Pond; Non-Overflowing w/Irrigation	Shawnee
Flint Hills Stone - Mcfarland Quarry	Industrial		Wabaunsee
Flint Hills Stone - Paxico Quarry	Industrial	Mine Pit Dewatering (No Wash)	Wabaunsee
Futamura USA, Inc.	Industrial	Activated Sludge Conventional	Shawnee
Goodyear Tire & Rubber Company	Industrial	Boiler Bd/Cooling Tower Blow-Down To Drainage	Shawnee
Hamm - Dedonder #73	Industrial	Mine Pit Dewatering (No Wash)	Pottawatomie
Hamm - Grantville #77	Industrial	Mine Pit Dewatering (No Wash)	Jefferson
Hamm - Grantville II Quarry	Industrial	Mine Pit Dewatering (With Wash)	Jefferson
Hamm - Kufahl #79	Industrial	Mine Pit Dewatering (With Wash)	Pottawatomie
Hamm - Rezac #51	Industrial	Mine Pit Dewatering (No Wash)	Jackson
Hamm - Rollin Meadows #11	Industrial	Mine Pit Dewatering (With Wash)	Shawnee
Hamm - Soldier Quarry #118	Industrial	Mine Pit Dewatering (With Wash)	Jackson

[11] NPDES Facilities Provided by KDHE on November 18, 2021.

NPDES Permitted Facilities in the Middle Kansas River Watershed, continued			
Facility Name	**Facility Type**	**Description**	**County**
Higgins Stone Company - Mission Valley	Industrial	Mine Pit Dewatering (No Wash)	Wabaunsee
Higgins Stone Company - Hurla Facility	Industrial	Mine Pit Dewatering (No Wash)	Wabaunsee
Higgins Stone - Holthaus Trust Quarry	Industrial	Mine Pit Dewatering (No Wash)	Wabaunsee
Hill's Pet Nutrition, Inc.	Industrial	Miscellaneous Cooling Water to Drainage (No Treatment)	Shawnee
Hill's Science & Technology Center	Industrial	Waste Stabilization Pond; Non-Overflowing W/Irrigation	Shawnee
Kansas Sand & Concrete - Portable Plant	Industrial	Waste Stabilization Pond; Overflowing	Shawnee
Kansas Sand & Concrete, Inc.	Industrial	Waste Stabilization Pond; Non-Overflowing	Shawnee
Kansas State University	Industrial	Miscellaneous Cooling Water to Drainage (No Treatment)	Riley
Keith Scott & Company - Heigert Site	Industrial	Mine Pit Dewatering (No Wash)	Wabaunsee
Keith Scott & Company - Wilt Site	Industrial	Mine Pit Dewatering (No Wash)	Wabaunsee
Keith Scott & Company - Mission Valley Site	Industrial	Mine Pit Dewatering (No Wash)	Wabaunsee
Keith Scott & Company - Maginley Site	Industrial	Mine Pit Dewatering (No Wash)	Wabaunsee
Lecompton Iron/Manganese Plant	Industrial	Waste Stabilization Pond; Non-Overflowing	Douglas
Meier's Ready Mix - Ogden Plant	Industrial	Waste Stabilization-Pond, Overflowing, Waste Stabilization-Pond, Overflowing	Riley
Meier's Ready Mix - Topeka 21St	Industrial	Waste Stabilization-Pond, Overflowing, Waste Stabilization-Pond, Overflowing	Shawnee
Meier's Ready Mix - Topeka Hwy 24 Plant	Industrial	Waste Stabilization-Pond, Overflowing, Waste Stabilization-Pond, Overflowing	Shawnee
Meier's Ready Mix - Urish Road Plant	Industrial	Waste Stabilization-Pond, Overflowing, Waste Stabilization-Pond, Overflowing	Shawnee
Midwest Concrete - Wamego	Industrial	Waste Stabilization Pond; Non-Overflowing	Pottawatomie
Midwest Concrete - Charlson Road	Industrial	Waste Stabilization Pond; Non-Overflowing	Riley
Midwest Concrete - Manhattan 4th Street	Industrial	Waste Stabilization Pond; Non-Overflowing	Riley
National Bio And Agro-Defense Facility	Industrial		Riley
Native Stone - Rock Sawing Operation	Industrial	Miscellaneous Cooling Water to Drainage (No Treatment)	Shawnee
Native Stone Company - Mission Valley	Industrial	Mine Pit Dewatering (No Wash)	Wabaunsee
Native Stone Company - Thomas Quarry	Industrial	Mine Pit Dewatering (No Wash)	Wabaunsee
Oldcastle Precast, Inc.	Industrial	Waste Stabilization Pond; Non-Overflowing	Shawnee
Penny's Concrete, Inc. - Manhattan	Industrial	Waste Stabilization Pond; Overflowing	Riley
Penny's Concrete-Ft. Riley Portable	Industrial	Waste Stabilization-Pond, Overflowing, Waste Stabilization-Pond, Overflowing	Riley
Pottawatomie County RWD #4 Wtp	Industrial	Reverse Osmosis (PWS)	Pottawatomie
Shawnee Co. Consolidated RWD4- Menoken	Industrial	Waste Stabilization Pond; Overflowing	Shawnee
St. Marys Groundwater Remediation	Industrial	Groundwater Remediation W/Stripper	Pottawatomie
Topeka Water Treatment Plant	Industrial	Physical/Chemical Treatment	Shawnee
Valley Concrete Operations, Inc.	Industrial	Waste Stabilization-Pond, Overflowing, Waste Stabilization-Pond, Overflowing	Pottawatomie
Wabaunsee County RWD #2	Industrial	Reverse Osmosis (PWS)	Wabaunsee
Wamego PWS Well No. 9	Industrial		Pottawatomie
Westar Energy - Jeffrey Energy Center	Industrial	Boiler Bd/Cooling Tower Blow-Down to Drainage	Pottawatomie

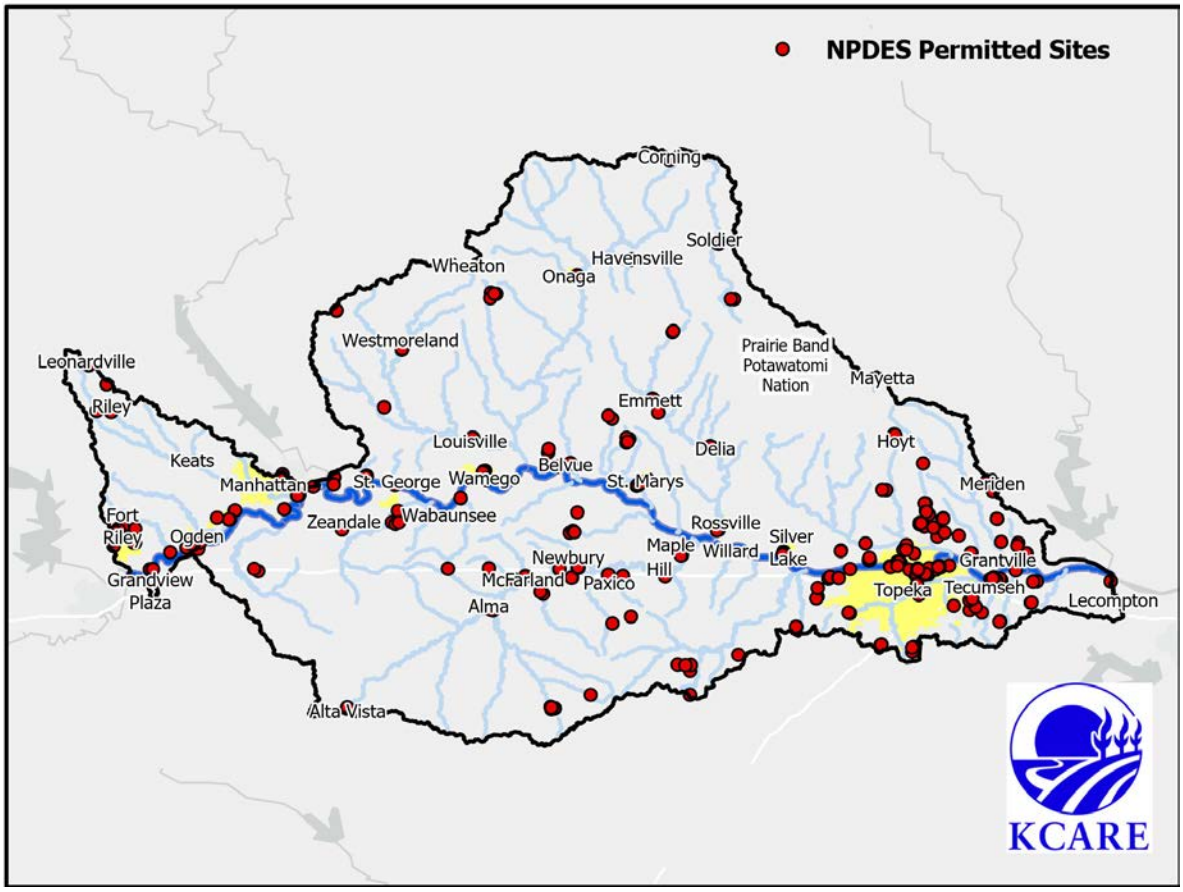


Figure 13. Middle Kansas River Watershed NPDES Sites

K. Livestock Operations in the Middle Kansas River Watershed

1. Confined livestock

Any livestock facility with an animal unit capacity of 300 or more or a facility with a daily discharge, regardless of size, must register with KDHE. Any facility, no matter what animal capacity, is required to register if KDHE investigates them due to a complaint, and the facility is found to have significant pollution potential. Facilities that register with KDHE will be site-inspected for significant pollution potential. If KDHE does not find significant pollution potential at a facility, that facility can be certified if it follows management practices recommended and approved by KDHE. These include, but are not limited to, regular cleaning of stalls, managing manure storage areas, etc.

Facilities having between 300 and 999 animal units are known as Confined Feeding Facilities (CFFs). Any CFFs identified with significant pollution potential must obtain a State of Kansas Livestock Waste Management Permit. Facilities of 1,000 animal units or more, known as Confined Animal Feeding Operations (CAFOs), must obtain an NPDES Livestock Waste Management Permit (Federal). Operations with a daily discharge, such as a dairy operation that generates an outflow from the milking barn daily, are required to

have a permit. See www.kdheks.gov/436/Livestock-Waste-Management-Secton for more information.

Table 8. Permitted Livestock Facilities in the Middle Kansas River Watershed

Permitted Livestock Facilities	
Type	**Number of Facilities in the Middle Kansas Watershed**
Beef	50
Dairy	52
Poultry	10
Swine	71
Mixed Species	23
Total	**206**

As shown in **Table 8**, there are 206 active permitted livestock facilities in the 10 counties housing the Middle Kansas River Watershed[12]. Permitted facilities are required to have a management plan for containing and utilizing manure and for lot runoff. Livestock waste facilities can be useful tools for managing livestock waste, but waste material must be land-applied from the containment facilities in a manner that does not jeopardize water resources. Within the Middle Kansas River Watershed, producers should apply livestock waste by matching the phosphorus content of the waste with soil test recommendations to avoid over-application of phosphorus in areas prone to runoff.

2. Unconfined livestock

Unconfined areas of animal concentration such as watering areas, loafing areas, or feeding areas also can have pollution potential for nutrients, sediment, and bacteria if the areas are not managed properly. Management practices for these areas can include alternative water sources, rotational grazing, proper mineral and feed placement, and proper manure application to cropland.

[12] Provided by the KDHE, October 2022.

4. Impaired Waters

Water quality in the Middle Kansas River Watershed is monitored at 25 KDHE stream segment sites, as well as 26 lake monitoring sites throughout the Watershed. (**Figures 14 and 15**)

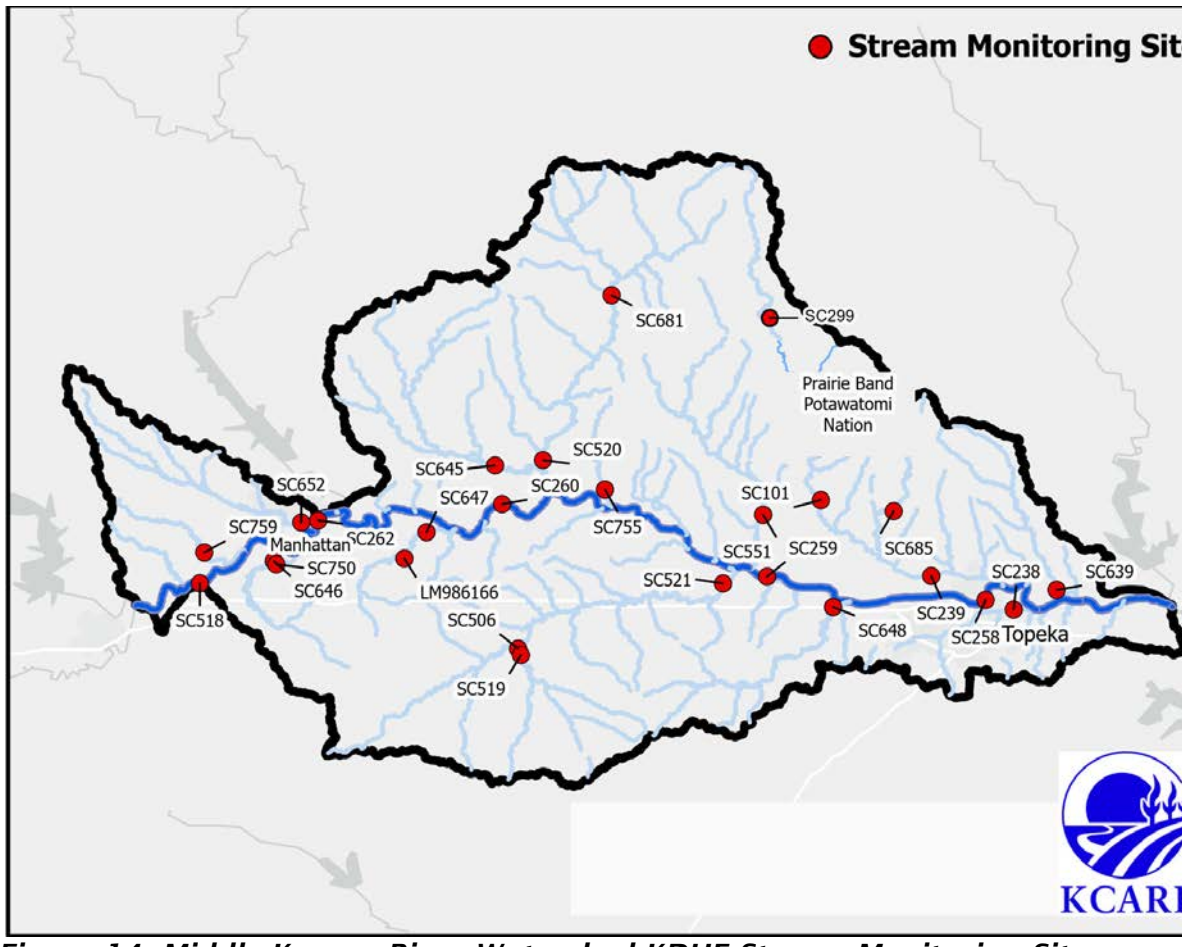


Figure 14. Middle Kansas River Watershed KDHE Stream Monitoring Sites

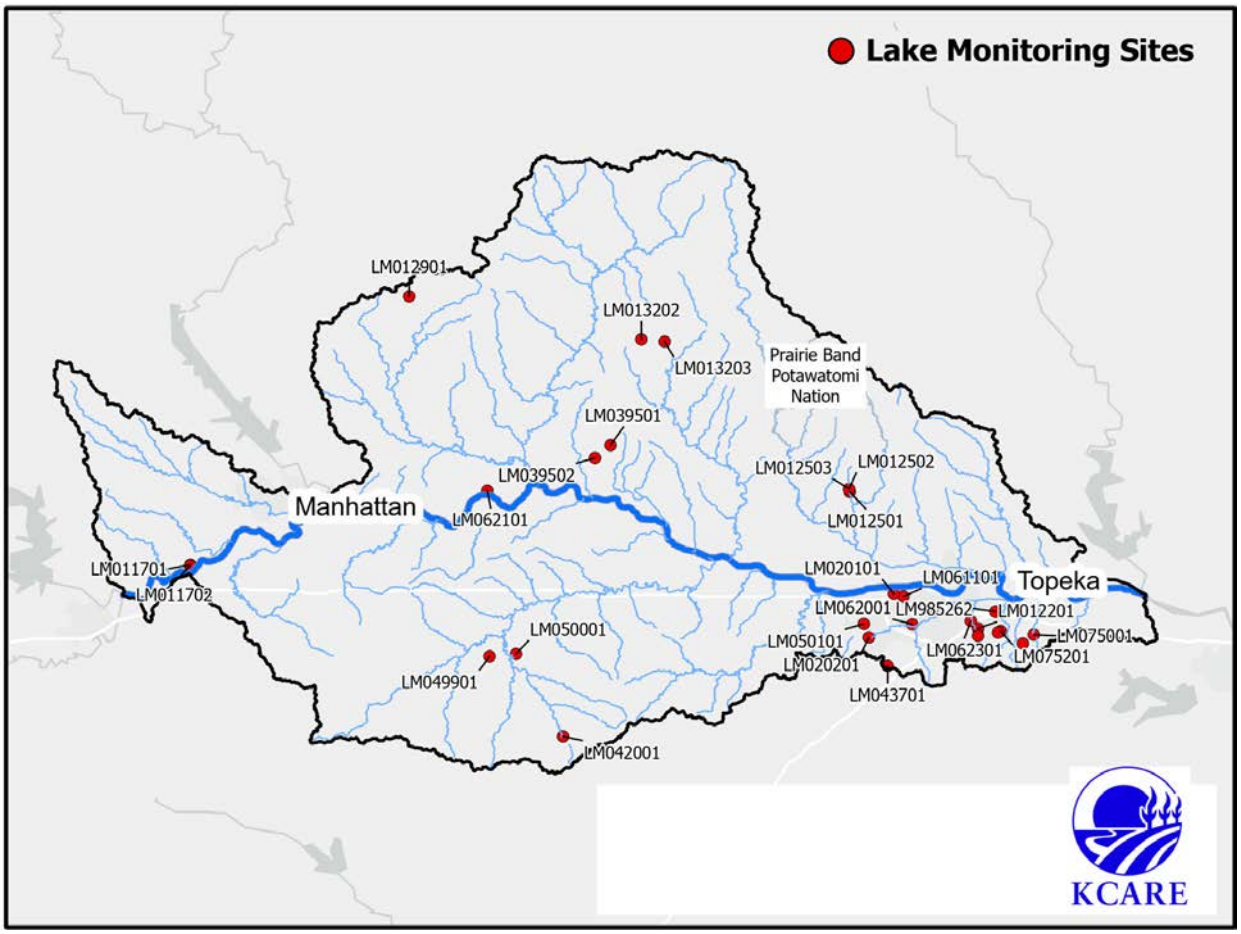


Figure 15. Middle Kansas River Watershed KDHE Lake Monitoring Sites

KDHE stream monitoring stations are either permanent or rotational sampling sites. Permanent monitoring sites are sampled continuously, while rotational sites typically are sampled every four years. All sites are sampled for nutrients (nitrogen and phosphorus), metals, ammonia, solid fractions, turbidity, alkalinity, chlorophyll, pH, dissolved oxygen, *E. coli* bacteria, and chemicals. Sample analysis determines if the water contains an unacceptable level of these pollutants.

If analysis determines that any one pollutant exceeds acceptable limits, the water segment then becomes "impaired" by that pollutant and is reported as a 303d-listed impairment. The affected water segment is listed as a Total Maximum Daily Load (TMDL) when an impairment significantly exceeds parameters and is in need of remediation.

A. 303d List of Impaired Waters in the Middle Kansas River Watershed

KDHE develops a 303d list (**Table 9**) of impaired waters biennially and submits it to EPA. To be included on this list, samples taken by the KDHE monitoring program must show that water quality standards are not met, which also means that the water's designated uses are not met. Each water segment on the list is assigned a category number to describe and report the condition of the segment. These categories include:

- Category 2: Water was previously listed as impaired but now has water quality sufficient to support its designated uses.
- Category 3: There is insufficient data and/or information to make a use support designation.
- Category 4a: A Total Maximum Daily Load (TMDL) has been developed for the waterbody/combination.
- Category 4b: NPDES permits are addressing the impairment, or a watershed plan is addressing an atrazine impairment. This is an alternative to a TMDL.
- Category 5: Data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed. These waterbodies are 303d-listed.

KDHE has identified 30 *303d-listed* waters in the Middle Kansas River Watershed **(Table 9, Figures 16 and 17)**. *All category 4a (TMDL) listings are described in the following "TMDL" section.*

Table 9. 303d-Listed Waters in the Middle Kansas River Watershed[13]

303d List of Impaired Waters, HUC 10270101				
Water Segment	**Category**	**Impairment**	**Priority**	**Sampling Station**
Kansas River	5	TSS	2025	SC518
Seven Mile Creek	3	Biology	-	SC759
303d List of Impaired Waters, HUC 10270102				
Water Segment	**Category**	**Impairment**	**Priority**	**Sampling Station**
Deep Creek	3	Biology	-	SC647
Dornwood Park Lake	3	Eutrophication	-	LM062301
Halfday Creek	5	Biology	2025	SB376
Illinois Creek	3	Biology	-	SC726
Kansas River at Wamego	5	Biology	2025	SC260
		TSS		
Kansas River at Willard	5	Biology	2025	SC259
		TSS		
Lost Creek near Belvue	5	Chloride	2025	SC755
		Selenium		
	3	Arsenic		
Mission Creek near Valencia	5	Biology	2025	SC648
		E. coli		
Muddy Creek near Grantville	5	*E. coli*	2025	SC639
Myer's Lake	3	pH	-	LM075201
Pillsbury Crossing	3	Mercury	-	LM030201
Pottawatomie County State Fishing Lake #1	5	Dissolved Oxygen	2024	LM012901
		Eutrophication		
Shunganunga Creek	3	Diazinon	-	SC238
Soldier Creek near Delia	5	Atrazine	2025	SC101
Soldier Creek near Topeka	5	Atrazine	2025	SC239
		E. coli		
Topeka Public Golf Course Lake	5	Eutrophication	2025	LM050101
Vermillion Creek near Louisville	5	Atrazine	2025	SC520
		Biology		
Wabaunsee County Lake	5	Eutrophication	2025	LM042001
Wamego City Lake	3	Mercury	-	LM062101
West Branch Mill Creek near Alma	3	Biology	-	SC506

[13] Kansas Department of Health and Environment, 2022.
https://www.kdhe.ks.gov/1219/303d-Methodology-List-of-Impaired-Waters
https://www.kdhe.ks.gov/DocumentCenter/View/22777/2022-303d-List-PDF?bidId=

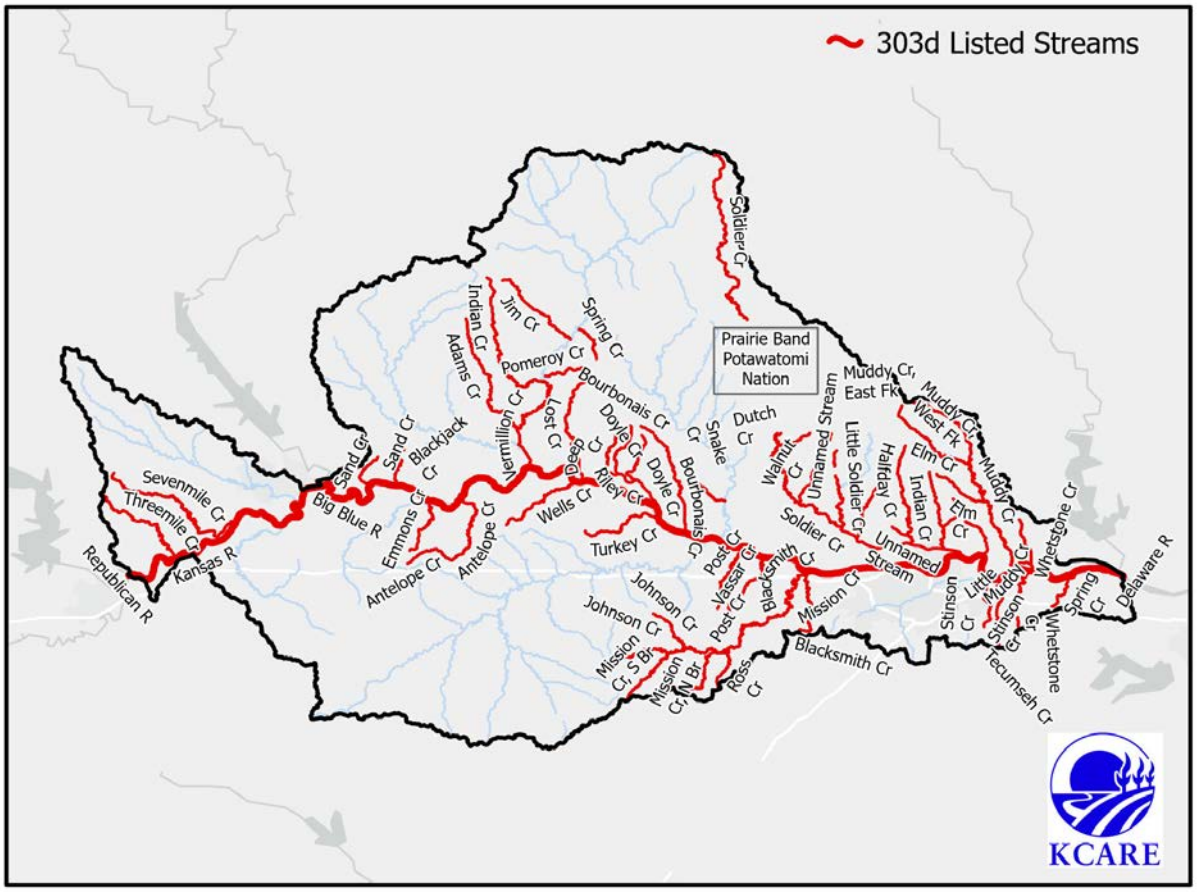


Figure 16. 303d-Listed Stream Waters in the Middle Kansas River Watershed

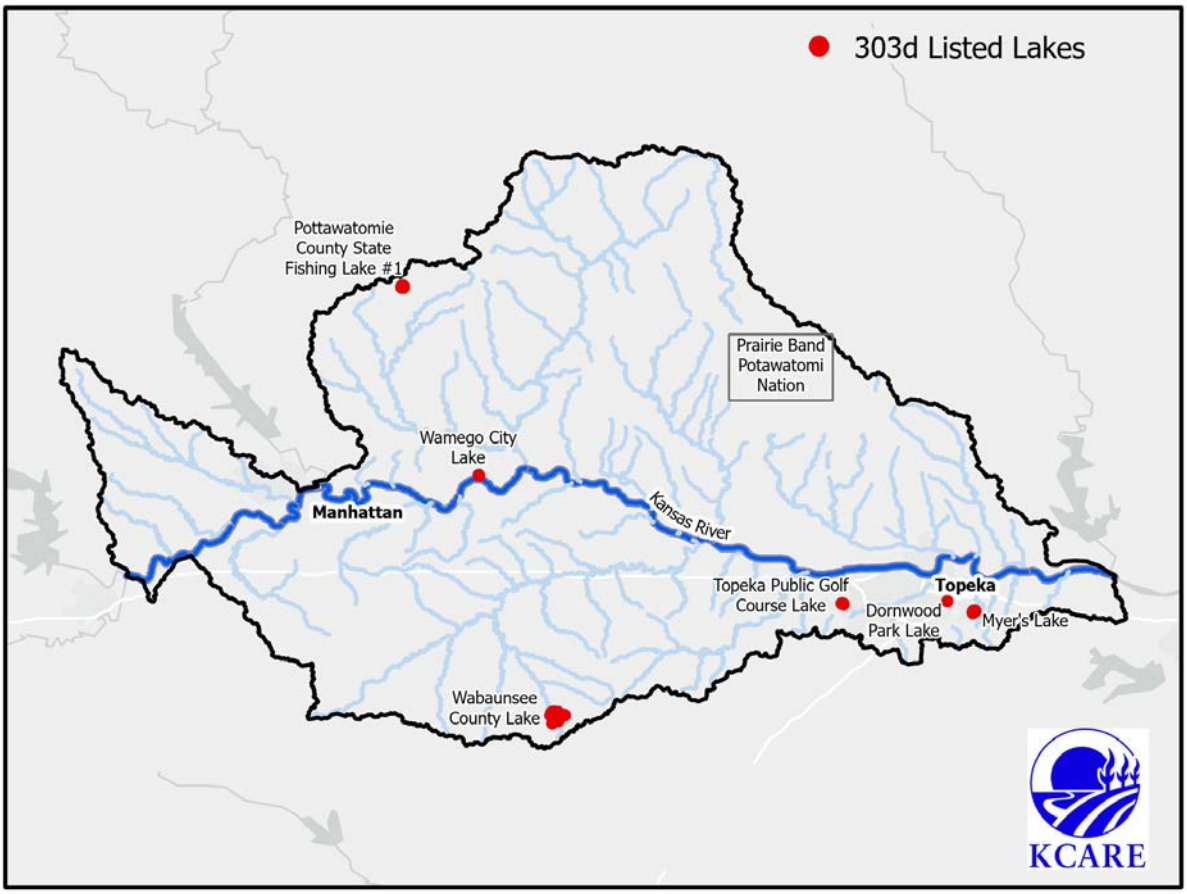


Figure 17. 303d-Listed Lakes in the Middle Kansas River Watershed

B. Total Maximum Daily Loads (TMDL)

1. What is a TMDL?

A 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 its designated uses. TMDLs in Kansas may be established on a watershed basis and may use a pollutant-by-pollutant approach, a biomonitoring approach, or both as appropriate. TMDL establishment means that a draft TMDL has been completed, there has been public notice and comment on the TMDL, public comments have been considered, necessary revisions to the TMDL have been made, and the TMDL has been submitted to EPA for approval. In a TMDL, the desired outcome of the process is indicated, using the current situation as the baseline. Deviations from the water quality standards are documented, and the TMDL states its objective to meet the appropriate water quality standard by quantifying the degree of pollution reduction expected over time.

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 12 Kansas basins every five years on a rotational schedule. The Middle Kansas River Watershed is part of the Kansas-Lower Republican River Basin and was reviewed in 2020; it is scheduled for review again in 2025.

2. Middle Kansas River Watershed TMDLs

To be issued a TMDL, water samples taken during the KDHE monitoring program indicate that water quality standards have not been met. This in turn means that designated uses have not been met.

The Middle Kansas River Watershed has 28 TMDLs (**Table 10, Figures 18 and 19)**). However, this plan will only target six of these TMDLs in HUC 10 #10270102:

- Soldier Creek (monitoring site SC299): Biology
- Soldier Creek near Circleville (monitoring site SC299): Biology
- Soldier Creek near Delia (monitoring site SC101): Biology
- Rock Creek near Louisville (monitoring site SC645): *E. coli*
- Vermillion Creek near Louisville (monitoring site SC520): *E. coli*
- Vermillion Creek near Onaga (monitoring site SC681): *E. coli*

For this Middle Kansas River Watershed plan, focus and priority will be given to the highlighted TMDLs as listed below. However, the remaining TMDLs will be impacted positively by BMP implementation targeted to reduce livestock bacteria and nutrients (primarily phosphorus) from entering the water.

Table 10. TMDLs in the Middle Kansas River Watershed[14]

TMDLs in the Middle Kansas River Watershed: HUC 10270101					
Water Segment	**Category**	**Impairment**	**Priority**	**Goal of TMDL**	**Sampling Station**
Kansas River near Ogden	4a	*E. coli*	Medium	-	SC518
		Sulfate	Low	-	
		Total Phosphorus	High	-	
		Chloride		-	
Wildcat Creek	4a	*E. coli*	High	-	SC652
		Dissolved Oxygen		-	
Ogden City Lake	4a	Eutrophication	Low	-	LM011701

[14] Kansas Department of Health and Environment, 2022.
https://www.kdhe.ks.gov/DocumentCenter/View/22777/2022-303d-List-PDF?bidId=

TMDLs in the Middle Kansas River Watershed: HUC 10270102, continued					
Water Segment	**Category**	**Impairment**	**Priority**	**Goal of TMDL**	**Sampling Station**
Central Park Lake	4a	Eutrophication	Low	-	LM060901
Cross Creek	4a	Eutrophication	High	-	SC551
Gage Park Lake	4a	Eutrophication	Low	-	LM061101
Kansas River near Topeka	4a	Fecal coliform	Medium	-	SC258
Kansas River near Wamego	4a	Fecal coliform	Medium	-	SC260
		Total Phosphorus	High	-	
Kansas River at Willard	4a	*E. coli*	High	-	SC259
		Total Phosphorus		-	
Lake Shawnee	4a	Eutrophication	High	-	LM012201
Myer's Lake	4a	Eutrophication	Low	-	LM075201
Rock Creek near Louisville	4a	*E. coli*	High	1) Geometric means of 5 samples taken within a 30-day period to be below 427 counts during April to October. 2) Two separate years with 4 intensive samplings each for geometric mean.	SC645
Shunganunga Creek	4a	E. coli	High	-	SC238
		Total Phosphorus		-	
Soldier Creek	4a	Biology	High	1) Average EPT count of 48% or greater. MBI values should approach 4.5. 2) Average TSS levels below 100mg/l for flows less than 1,000cfs.	SC299
Soldier Creek near Circleville	4a	Biology	High		SC299
Soldier Creek near Delia	4a	Biology	High		SC101
Vermillion Creek near Louisville	4a	*E. coli*	High	1) Geometric means of 5 samples taken within a 30-day period to be below 427 counts during April to October. 2) Two separate years with 4 intensive samplings each for geometric mean.	SC520
Vermillion Creek near Onaga	4a	*E. coli*	High	1) Geometric means of 5 samples taken within a 30-day period to be below 427 counts during April to October. 2) Two separate years with 4 intensive samplings each for geometric mean.	SC681
Wamego City Lake	4a	Eutrophication	Low	-	LM062101
Warren Park Lake	4a	Aquatic Plants	Low	-	LM062001
		Eutrophication		-	

Please note that the *E. coli* TMDLs were originally written as fecal coliform impairments. This was changed in 2003; however, some TMDLs found online have not been updated.

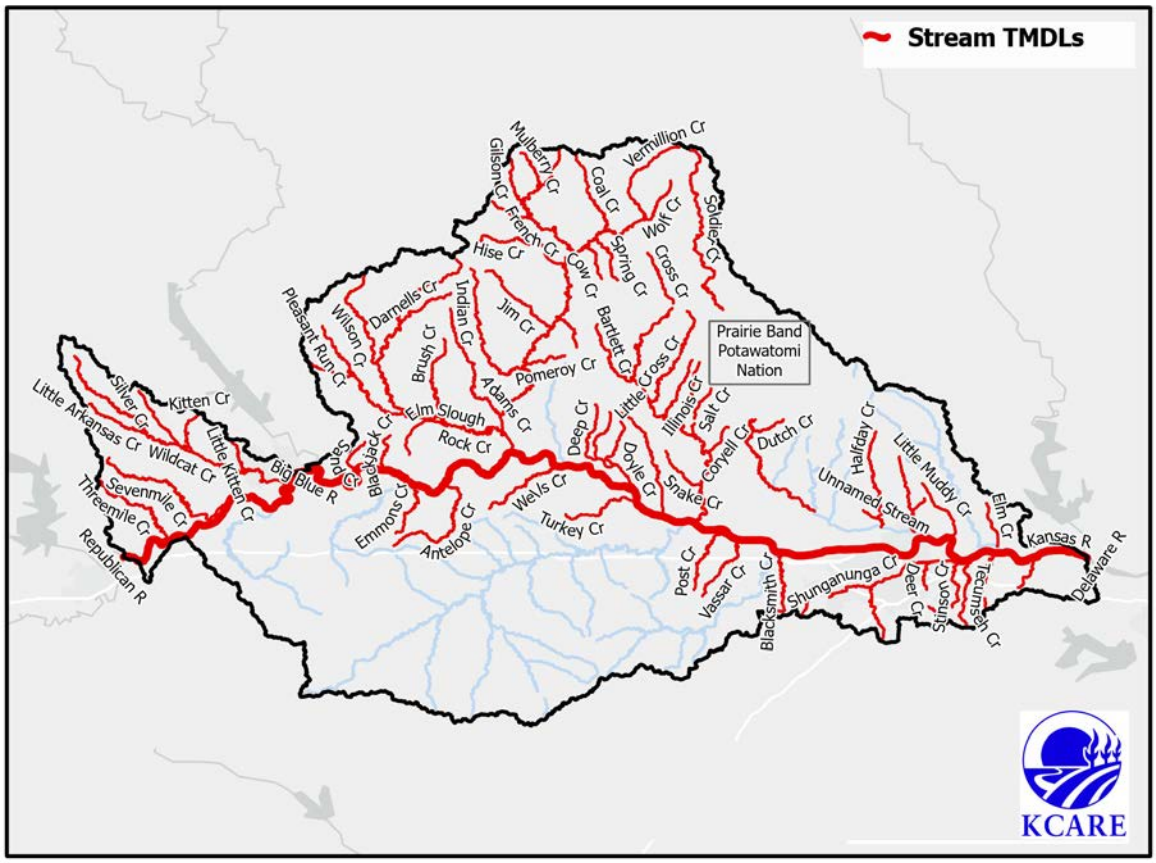


Figure 18. Streams with a TMDL in the Middle Kansas River Watershed

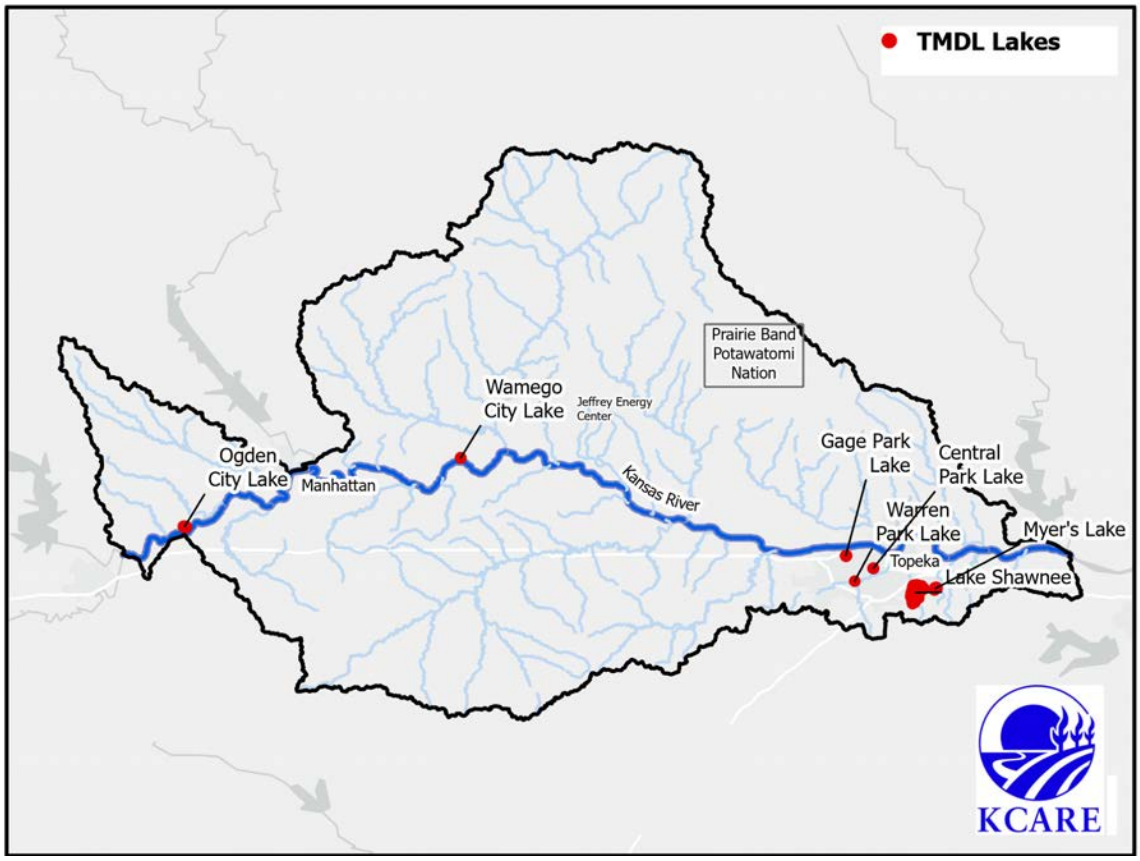


Figure 19. Lake Waters with a TMDL in the Middle Kansas River Watershed

Note: Some of the implemented strategies for addressing the current priority TMDLs as determined by the SLT and outlined in this plan will have additional benefits by proactively addressing the 303d-listed impairments. The goal is to eliminate the need to develop a TMDL for the current 303d-listed impairment.

5. Watershed Impairments to be Addressed

The Middle Kansas River Watershed SLT acknowledges all TMDL and 303d-listed water segments in the watershed. The SLT will focus this WRAPS plan on six segments of impaired waters with TMDLs (**Figure 20**):

1. Biology in Soldier Creek
2. Biology in Soldier Creek near Circleville
3. Biology in Soldier Creek near Delia
4. *E. coli* in Rock Creek near Louisville
5. *E. coli* in Vermillion Creek near Louisville
6. *E. coli* in Vermillion Creek near Onaga

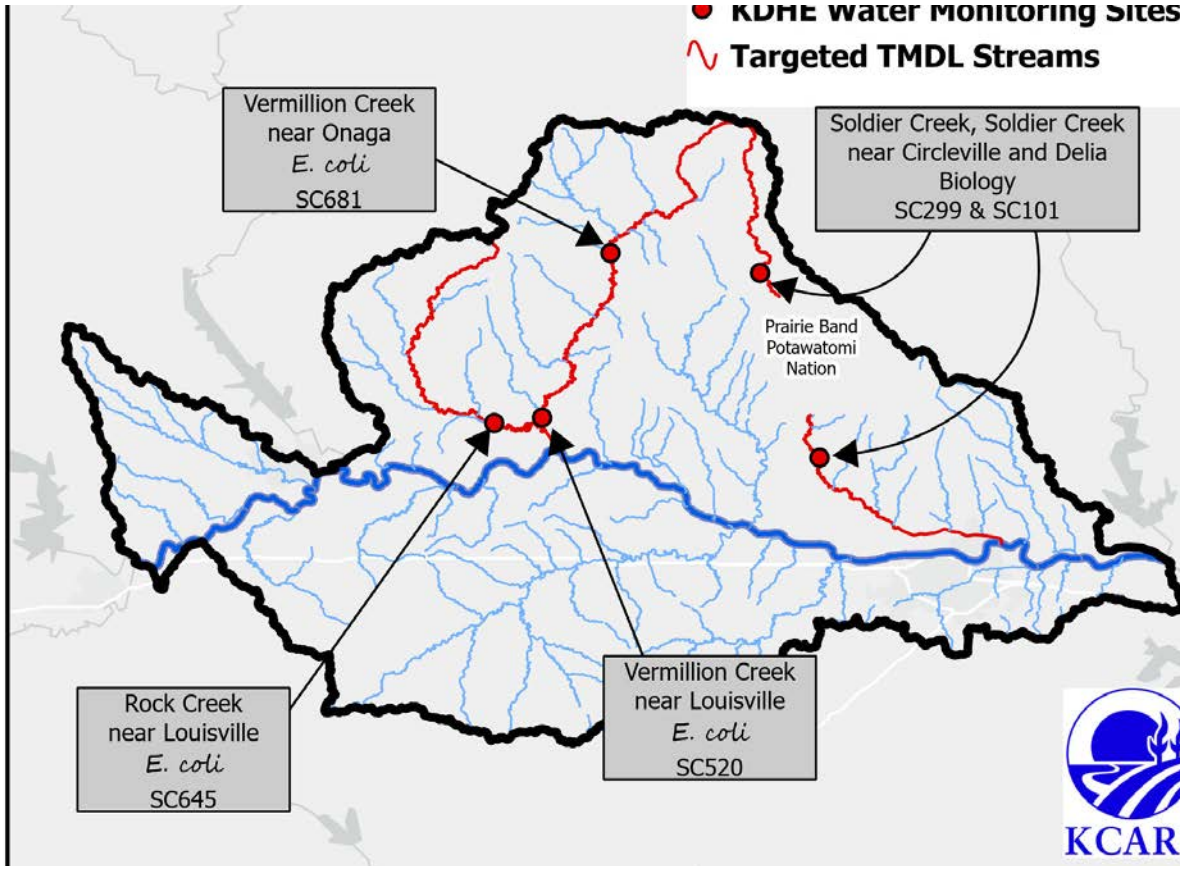


Figure 20. TMDL-Impaired Waters to be Addressed by this WRAPS Plan

All goals and BMPs will be aimed at protecting the Middle Kansas River Watershed from further degradation (**Table 11**)

Table 11. Middle Kansas River Watershed TMDL Impairment Loads and Goals

Load Allocations for the Middle Kansas River Watershed			
Impairment/TMDL	**Current Load**	**Allowed Load**	**Required Reduction**
Biology: **Solider Creek, Soldier Creek near Circleville, and Soldier Creek near Delia**	27,900 tons of sediment per year	9,500 tons of sediment per year	18,400 tons of sediment per year
E. coli: **Rock Creek near Louisville, Vermillion Creek near Louisville, and Vermillion Creek near Onaga**	*Load Reduction will be assumed by reductions made in nutrient loading due to proper BMP implementation in livestock areas along riparian corridors.*		

This WRAPS plan only addresses the Biology and *E. coli* TMDLs. It should be noted that nearly all 303d and TMDL impairment listings throughout the watershed will be affected positively by this WRAPS plan's targeted BMP implementation, specifically those involving nutrients (biology, dissolved oxygen [DO], *E. coli*, eutrophication, total phosphorus, etc.).

A. Biology

The Middle Kansas River Watershed has been listed for having a high-priority TMDL for the impairment of **Biology** as well as nine additional water segments that are 303d listed with this impairment. **This plan will focus implementation and load reduction goals on the high priority TMDL which includes Solider Creek, Soldier Creek near Circleville, and Soldier Creek near Delia.** Although the areas listed below will not be targeted specifically with BMP implementation, they will be impacted positively by BMP implementation throughout the watershed.

- Seven Mile Creek - 303d listed
- Deep Creek - 303d listed
- Halfday Creek - 303d listed
- Illinois Creek - 303d listed
- Kansas River at Wamego - 303d listed
- Kansas River at Willard - 303d listed
- Mission Creek near Valencia - 303d listed
- Vermillion Creek near Louisville - 303d listed
- West Branch Mill Creek near Alma - 303d listed

1. Sources of the impairment

KDHE has determined that the high-priority Biology TMDL in Solider Creek is due to excessive sediment, or high total suspended solids (TSS). There is a direct relation between levels of nutrient loading and biological integrity. Nutrients can attach to suspended soil

particles in the water column and make their way into stream segments during runoff events. Physical components of the terrain, such as slope, propensity to generate runoff and soil type are important to sediment movement. Sediment transfer also can originate from alteration of stream channels, streambank erosion and sloughing of the sides of rivers and streambanks. A lack of riparian cover can cause washing on the banks of streams or rivers and enhance erosion.

Nutrient loading, specifically phosphorus and nitrogen, can originate in both rural and urban areas and can be caused by both point and nonpoint sources. This plan focuses primarily on agricultural nonpoint source contributions, even though other possible sources will be included as part of the discussion. Decreased sediment and nutrient loads should result in improved aquatic communities and biological metrics indicative of improved water quality. Waters with adequate biology levels tend to sustain a Macroinvertebrate Biotic Index score below 4.5 while maintaining healthy total phosphorus and total nitrogen levels.

There are many sediment and nutrient pollutant sources that may contribute to the Biology impairment including: land use, soil erosion by wind and/or water, riparian quality, wastewater treatment facilities, population, confined animal feeding operations, grazing density, rainfall, and runoff. These are detailed below.

Land use

Land use activities have a significant impact on sediment and nutrient transfer in the watershed. Sediment can originate from streambank erosion and streambank sloughing caused by a lack of riparian cover. Sheet and rill erosion from cropping and pasture systems also contribute sediment into the ecosystem. Construction projects can leave disturbed areas of soil and unvegetated roadside ditches that can erode during a rainfall event. In addition, agricultural cropland using conventional tillage practices and lacking maintenance from agricultural BMP structures can have cumulative effects on land transformation through sheet and rill erosion. Fertilizer or manure applied to frozen ground or cropland prior to a rainfall event can be transported easily downstream. Livestock allowed stream access to drink or loaf will contribute manure/phosphorus directly into the stream. Overgrazed pastures do not provide adequate biomass to trap manure runoff.

Agricultural BMPs designed to help reduce sediment and nutrient runoff include: implementing cover crops, no-till, minimum tillage, vegetative buffers and riparian areas; creating grassed waterways and grassed terraces; establishing permanent vegetative cover and grazing management plans; providing off-stream watering sites by fencing streams and ponds; relocating pasture feeding sites and feeding pens away from streams; implementing rotational grazing; and placing vegetative filter strips along waterways.

Soil erosion by wind and/or water

NRCS has established a “T-factor” in evaluating soil erosion, where T represents the soil loss tolerance factor. It is defined as the maximum amount of erosion at which soil quality as a medium for plant growth can be maintained. It is assigned to soils without respect to land use or cover and ranges from one ton per acre for shallow soils, to five tons per acre

for deep soils that are not as affected by loss of productivity by erosion. T-factors represent the goal for maximum annual soil loss in sustaining the productivity of land use.[15]

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 vegetated riparian areas, can be used to impede erosion and streambank sloughing. Livestock restriction along the stream will prevent livestock from entering streams and degrading the streambanks. Cropland requires permanent vegetation adjacent to streams to impede the sediment flow from fields.

Wastewater treatment facilities

KDHE permits and regulates wastewater treatment facilities. National Pollutant Discharge Elimination System (NPDES) permits specify the maximum amount of pollutants allowed to be discharged to surface waters. There are 60 NPDES facilities in the Middle Kansas River Watershed at the time of this document's publication.

Population

Watershed population can affect nutrient (phosphorus) runoff. There are an estimated 44,935 domestic onsite wastewater systems in the Middle Kansas River Watershed, located mainly in rural areas. Although the functional condition of these systems is generally unknown, it is projected that nearly 20% (~ 8,987) may be failing; onsite wastewater could be an area of possible pollution contribution for evaluation.

Confined animal feeding operations (CAFOs)

In Kansas, animal feeding operations (AFOs) with more than 300 animal units (AUs) and fewer than 1,000 AUs must register with KDHE. An AU is an equal standard for all animals based on size and manure production. For example, one AU equals one animal weighing 1,000 pounds. Confined animal feeding operations (CAFOs) are those with more than 999 AUs, and they must be federally permitted. There are 206 certified or permitted AFOs and CAFOs within this watershed. However, this WRAPS plan will only address *E. coli* TMDLs in the Rock and Vermillion Creek sub-watersheds, where there are 28 CAFOS present (**Table 12**). There are also numerous small livestock farms (below 300 AUs) that contribute to the nutrient loads. In addition to livestock-contributed waste, improperly disposed of pet waste also can be a contributor to the phosphorus loads, although at a much smaller quantity.

[15] NRCS T factor. https://www.nrcs.usda.gov/nri and https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soils/soil-health/manage-for-soil-carbon

Table 12. Permitted Facilities in the Middle Kansas River Watershed

Permitted Livestock Facilities			
Type	Number of Facilities in the Middle Kansas Watershed	Number of Facilities in the Rock Creek Sub-watershed	Number of Facilities in the Vermillion Creek Sub-watershed
Beef	50	2	5
Dairy	52	0	1
Poultry	10	0	0
Swine	71	9	5
Mixed Species	23	4	2
Total	**206**	**15**	**13**

Grazing density

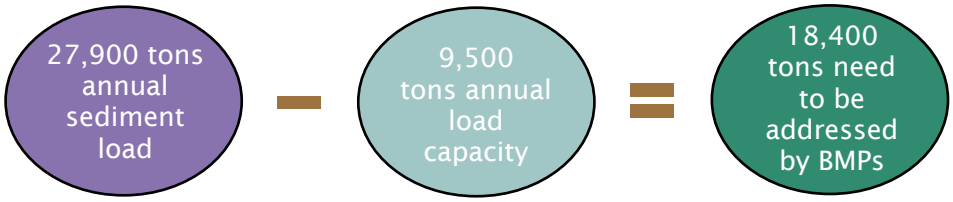
Approximately 64% of the Middle Kansas River Watershed is grassland/pasture/hay land. Grassland in this area of Kansas is a highly productive forage source for beef cattle. Grazing density affects grass cover and potential manure runoff: an overgrazed pasture will not have the needed forage biomass to trap and hold manure in a high rainfall event. Also, allowing cattle to drink or loaf in streams increases the occurrence of nutrients, namely phosphorus, and *E. coli* bacteria in the waterway. Grazing density ranges from 8.0 to 16.1, with an average of 11.9 cattle per 100 acres across the watershed.[16] This is considered low density when compared with statewide density numbers.

Rainfall and runoff

Rainfall amounts and subsequent runoff affect sediment, nutrient, and bacteria runoff from agricultural and urban areas into stream segments. The amount and timing of rainfall events affect manure runoff from livestock allowed access to streams, or manure applied before a rainfall or on frozen ground. Therefore, it is important to maintain adequate grass density to slow the runoff of manure over pastures.

2. Pollutant loads

The current estimated sediment load in the Middle Kansas River Watershed is 27,900 tons per year, according to the TMDL section of KDHE. The total sediment load reduction needed to meet help meet the Biology TMDL is 18,400 tons of sediment, a reduction of roughly 66%. **If all BMPs have been implemented by the end of this 20-year WRAPS plan, a reduction of 18,410 tons per year of sediment will have been saved.**



In addition to sediment load reductions, the BMP implementation structure of this plan will subsequently have a positive effect on phosphorus and nitrogen loading. If all BMPs are

[16] https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Kansas/index.php

implemented as planned, **72,591 pounds of P** and **176,560 pounds of N** will be prevented from entering Middle Kansas water segments at the end of this 20-year plan. The P and N nutrient load reductions will improve water quality impairments such as biology, dissolved oxygen, eutrophication, etc. throughout the watershed. Although this is not the goal of this WRAPS plan, it is certainly a positive effect.

3. Which BMPs will be implemented to meet the TMDL?

The Middle Kansas River WRAPS plan will focus simultaneously on both the Biology and *E. coli* TMDLs.

The SLT identified specific cropland and streambank BMPs that are acceptable to watershed residents and will result in significant sediment and, subsequently, nutrient and pollutant load reductions. The cropland BMPs designed to reduce sediment loading include: companion cropping, cover crops, grassed waterways, no-till, permanent vegetation, planting green, sediment basins, terraces, vegetative buffers, and wetlands. The streambank BMPs designed to reduce sediment loading include: soil-bioengineering, weirs, vanes, and longitudinal peak stone toes, which will all be considered "streambank stabilization/restoration" for the purpose of this plan. Specific projects needing annual implementation have been determined through modeling and economic analysis and have been approved by the SLT (**Table 13**).

Table 13. BMPs to Prevent and/or Reduce Sediment Loss

BMPs to Reduce Sediment Loading in Soldier Creek Sub-watershed		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of sediment contribution from **cropland**	Companion Cropping	37 acres
	Cover Crops	200 acres
	Grassed Waterways	95 acres
	No-Till	365 acres
	Permanent Vegetation	7 acres
	Planting Green	37 acres
	Sediment Basins	7 acres
	Terraces	51 acres
	Vegetative Buffers	146 acres
	Wetlands	7 acres
Prevention of sediment contribution from **streambanks**	Streambank Stabilization/Restoration Projects	500 feet

The implementation of cropland and streambank BMPs in the watershed will have a positive impact on the watershed including several impairments (biology, dissolved oxygen, eutrophication, total phosphorus, and total suspended solids).

B. *E. coli*

The Middle Kansas River Watershed has six stream segments with a high-priority TMDL for ***E. coli*** and three segments with a medium-priority TMDL, as well as three additional segments that are 303d listed. **Rock Creek, near Louisville, Vermillion Creek near Louisville, and Vermillion Creek near Onaga are the only three high-priority *E. coli* TMDL segments that will be targeted specifically with BMP implementation and load reduction goals.** However, nearly all impaired waters listed below will be impacted positively by BMP implementation throughout the watershed.

- Kansas River at Willard - TMDL listed (high priority)
- Kansas River near Ogden - TMDL listed (medium priority)
- Kansas River near Topeka (Fecal coliform) - TMDL listed (medium priority)
- Kansas River near Wamego (Fecal coliform) - TMDL listed (medium priority)
- Mission Creek near Valencia - 303d listed
- Muddy Creek near Grantville - 303d listed
- Shunganunga Creek - TMDL listed (high priority)
- Soldier Creek near Topeka - 303d listed
- Wildcat Creek - TMDL listed (high priority)

E. coli are present in human and animal waste and 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. *E. coli* presence indicates that disease-causing organisms, or pathogens, also may be present. Presence of *E. coli* in waterways can originate from failing septic systems, runoff from livestock production areas, proximity of animals to water sources, and manure application to land if it is applied before a rainfall event or on frozen ground. TMDLs for *E. coli* have a primary contact recreation (such as swimming) upper limit of 427cfu/100mL of water in April through October, and 3,843/100 mL in November through March. TMDLs for *E. coli* for secondary contact recreation Class B (such as boating and fishing) have an upper limit of 3,843 cfu/100 mL of water.[17]

Bacteria TMDLs first were developed using fecal coliform bacteria (FCB) data in 1999; since then, the bacteria indicator has changed to *E. coli*. The method to assess bacteria has changed to looking at geometric means of at least five samples taken within a given 30-day period. Bacteria loads are nonsensical, resulting in huge numbers, given that high bacteria levels coincide with high runoff flows. The capability to abate bacteria pollution comes down to the ability to detain bacteria-laden water long enough to kill the bacteria. Because of the unique situation that defines bacteria impairment, an alternative manner to assess load reductions was necessary.

The critical measure of improving the sanitary conditions in any of the watershed's streams is not only to reduce the magnitude of bacteria samples collected, but also to reduce the frequency and duration of high bacteria levels. To measure these reductions, the bacteria count values of individual samples are transformed using logarithms and normalized by dividing by the

[17] Kansas Surface Water Quality Standards - https://www.kdhe.ks.gov/DocumentCenter/View/13319/Kansas-Surface-Water-Quality-Standards---Tables-of-Numeric-Criteria-March-2-2017-PDF, page 19.

logarithm of the applicable bacteria criterion. For most streams, the primary contact recreation criterion is either 262 or 427 counts, depending upon the accessibility of the stream. Note there is still allowance for occasional spikes of high bacteria, provided they do not occur frequently.

There are many bacteria pollutant sources that may contribute to the *E. coli* impairment including: land use, wastewater treatment facilities, population, confined animal feeding operations, grazing density, rainfall and runoff. These are detailed below.

1. Impairment sources

Bacteria can originate in both rural and urban areas. *E. coli* can be caused by both point and nonpoint sources. Livestock or wildlife access to streams, improper manure disposal, failing onsite wastewater systems, and manure runoff from livestock operations can contribute to *E. coli* in streams.

Land use

Livestock production areas are a source of bacteria in streams within the Middle Kansas River Watershed, as manure generated by any mammal can contain *E. coli*. Livestock housed in proximity to a stream or allowed to loaf in a water source can shed *E. coli*. Wild animals also contribute *E. coli* in streams and lakes but limiting the wild animal population from water sources is not as easy as limiting livestock.

Wastewater treatment facilities

KDHE permits and regulates wastewater treatment facilities. National Pollutant Discharge Elimination System (NPDES) permits specify the maximum amount of pollutants allowed to be discharged to surface waters. There are 60 NPDES facilities in the Middle Kansas River Watershed at the time of this document's publication.

Population

Watershed population can affect nutrient (phosphorus) runoff. There are an estimated 44,935 domestic onsite wastewater systems in the Middle Kansas River Watershed, located mainly in rural areas. Although the functional condition of these systems is generally unknown, it is projected that nearly 20% (~ 8,987) may be failing; onsite wastewater could be an area of possible pollution contribution for evaluation.

Confined animal feeding operations (CAFOs)

In Kansas, animal feeding operations (AFOs) with 300 or more animal units (AUs) and fewer than 1,000 AUs must register with KDHE. An AU is an equal standard for all animals based on size and manure production. For example, one AU equals one animal weighing 1,000 pounds. Confined animal feeding operations (CAFOs) are those with more than 999 AUs, and they must be federally permitted. There are 206 certified or permitted AFOs and CAFOs within this watershed. However, this WRAPS plan will only address *E. coli* TMDLs in the Rock and Vermillion Creek sub-watersheds, where there are 28 CAFOS present (**Table 12**). There are also numerous small livestock farms (below 300 AUs) that contribute to the nutrient loads. In addition to livestock-contributed waste, improperly

disposed of pet waste also can be a contributor to the phosphorus loads, although at a much smaller quantity.

Grazing density

Approximately 64% of the Middle Kansas River Watershed is grassland/pasture/hay land. Grassland in this area of Kansas is a highly productive forage source for beef cattle. Grazing density affects grass cover and potential manure runoff: an overgrazed pasture will not have the needed forage biomass to trap and hold manure in a high rainfall event. Also, allowing cattle to drink or loaf in streams increases the occurrence of nutrients, namely phosphorus, and *E. coli* bacteria in the waterway. Grazing density ranges from 8.0 to 16.1, with an average of 11.9 cattle per 100 acres across the watershed.[18] This is considered low density when compared with statewide density numbers.

Rainfall and runoff

Rainfall amounts and subsequent runoff affect nutrient and bacteria runoff from agricultural and urban areas into stream segments. The amount and timing of rainfall events affect manure runoff from livestock allowed access to streams, or manure applied before a rainfall or on frozen ground. Therefore, it is important to maintain adequate grass density to slow the runoff of manure over pastures.

2. Pollutant loads

The current pollutant load for *E. coli* cannot be estimated. *E. coli* concentrations are difficult to model, and the scope of this WRAPS project does not include modeling. The lifespan of *E. coli* is affected by variations in initial bacteria loading, ambient temperature, amount of sunlight or UV rays, and a decrease in survivability over time.

There are no quantitative numbers for current load, load allocation and required load reductions for *E. coli*. Since there is not a traditional load allocation made for *E. coli* bacteria, the margin of safety will be framed around the desired endpoints of applicable water quality standards:

- This requires geometric means of five samples taken within a 30-day period to be below the applicable criterion of 427 counts during April to October.
- To increase confidence in compliance, two separate years with four intensive samplings each for geometric mean calculations will be used to assess compliance.

Since there is no bacteria load reduction calculation at this time, the SLT, with guidance from KDHE, will assume *E. coli* bacteria load reductions are sufficiently made through the livestock BMP implementation schedule provided in this WRAPS plan.

In addition to assumed reductions in *E. coli* bacteria contributions from livestock BMP implementation, this WRAPS plan will subsequently have a positive effect on phosphorus and nitrogen loading as well. If all livestock BMPs are implemented as planned, **23,641 pounds of P** and **44,527 pounds of N** will be prevented from entering Middle Kansas water

[18] https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/County_Profiles/Kansas/index.php

segments at the end of this 20-year plan. The P and N nutrient load reductions will improve water quality impairments such as biology, dissolved oxygen, eutrophication, etc. throughout the watershed. Although this is not the goal of this WRAPS plan, it is certainly a positive effect.

3. Which BMPs will be implemented to meet the TMDL?

The SLT identified specific BMPs acceptable to watershed residents, related to livestock management practices and the prevention of *E. coli* from entering the waterways. The livestock BMPs designed to reduce bacteria loading include: alternative watering systems, grazing management plans, relocating feedlots, relocating pasture feeding sites, and vegetative filter strips. Specific projects needing annual implementation have been determined through modeling and economic analysis and have been approved by the SLT (**Tables 14**).

Table 14. BMPs to Prevent* E. coli *Bacteria Loading

Livestock BMPs to Reduce *E. coli* in Rock and Vermillion Creek Sub-watersheds		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of *E. coli* bacteria and nutrient contribution from livestock	Alternative Watering System	1 project every 2 years of the plan, beginning in year 2. 10 projects during the life of the plan.
	Grazing Management Plan	1 project every 2 years of the plan, beginning in year 1. 10 projects during the life of the plan.
	Relocate Fedlot	1 project every 2 years of the plan, beginning in year 2. 10 projects during the life of the plan.
	Relocate Pasture Feeding Sites	1 project every 2 years of the plan, beginning in year 1. 10 projects during the life of the plan.
	Vegetative Filter Strips	1 project every 2 years of the plan, beginning in year 1. 10 projects during the life of the plan.

The implementation of these livestock BMPs in the watershed will address bacteria and nutrient loading and will subsequently improve all biology, DO, E. coli*, eutrophication, total phosphorus, etc. impairments in the watershed.*

C. Other Impairment Concerns in the Middle Kansas River Watershed

1. Arsenic

The Lost Creek near Belvue has been 303d listed for arsenic. According to the CDC, "Arsenic can enter the water supply from natural deposits in the earth or from industrial and agricultural pollution. It is widely believed that naturally occurring arsenic dissolves out of certain rock formations when groundwater levels drop significantly. Some industries in the United States release thousands of pounds of arsenic into the environment every year. Once released, arsenic remains in the environment for a long time. Arsenic is removed from the air by rain, snow, and gradual settling. Once on the ground or in surface water, arsenic can slowly enter groundwater. High arsenic levels in private wells may come from certain arsenic-containing fertilizers used in the past or industrial waste. It may also indicate improper well construction or overuse of chemical fertilizers or herbicides in the past."

The arsenic impairment will not be impacted by the Middle Kansas River WRAPS plan.

2. Atrazine

Atrazine is a relatively inexpensive herbicide widely used in corn, sorghum, and soybean production. Atrazine enters streams and lakes by way of sediment runoff. It has a slow chemical breakdown, so once atrazine enters the water, it can linger for a long time. Atrazine is one of the most commonly detected herbicides in groundwater and has been connected to health issues in animals and humans, including reproductive system problems in humans. This chemical is lab-created, requires a license for usage, and is considered a health threat in contaminated waters.

The Middle Kansas River Watershed has three creeks with 303d-listed atrazine impairments:

- Soldier Creek near Delia,
- Solider Creek near Topeka, and
- Vermillion Creek near Louisville.

Atrazine is not a targeted impairment addressed directly by this WRAPS plan. However, efforts to reduce the amount of sediment entering streams will have a positive effect on atrazine loading.

3. Aquatic life/plants

The Middle Kansas River Watershed has one low-priority TMDL for aquatic plants in Warren Park Lake. These are combined for the purpose of this report as they are both relating to submerged life and aquatic health.

Aquatic plants provide sufficient oxygen, food, and shelter to aquatic life. An excessive amount of nutrients from livestock and cropland areas can cause the plants to over-grow

and supply too much oxygen to aquatic life, known as eutrophication. This results in an imbalance of dissolved oxygen available to aquatic life and can often create a deadly environment. Overgrowth of aquatic plants is also considered to be a recreation impairment.

In contrast, insufficient light due to turbidity, often caused by total suspended solids (TSS), can cause aquatic plants to die, which subsequently can negatively impact aquatic life by not creating the oxygen and nutrients required to sustain life. Plants provide habitat from predators as well, so the death of aquatic plants certainly can cause the death of smaller aquatic life forms.

Aquatic life and aquatic plants will benefit from BMP implementation in the targeted areas but is not a goal of this WRAPS plan.

4. Chloride

Chlorides constitute approximately 0.05% of the earth's crust. Chloride concentrations between 1 and 100 ppm (parts per million) are normal in freshwater. Chloride ions come into solution in water from underground aquifers and other geological formations that contain groundwater. EPA recommends levels no higher than 250 mg/L in drinking water to avoid salty tastes and undesirable odors.

High chloride levels may indicate a possible pollution of well water from sewage sources. Chloride can increase the electrical conductivity of water, and thus increases its corrosivity. In metal pipes, chloride reacts with metal ions to form soluble salts which increases levels of metals in drinking water.

There are two water bodies with chloride impairments in the watershed:

- Kansas River near Ogden - TMDL listed (high priority), and
- Lost Creek near Belvue - 303d listed.

The Middle Kansas River WRAPS plan will not address or impact chloride.

5. Diazinon

The Shunganunga Creek in the Middle Kansas River Watershed has been 303d listed for diazinon. Diazinon is an insecticide that belongs to a group of chemicals known as organophosphates. Diazinon is used in agriculture to control insects on field crops. Diazinon has been used in the United States since 1956 and was banned from residential use in 2004.

Diazinon works by affecting the chemicals that make insects' nervous systems function properly. This results in a loss of control over the nervous system that eventually leads to the death of the insect.

Since diazinon is only used in agricultural settings, the main way in which the public could be exposed is through eating food treated with diazinon. Diazinon may also be present in surface or well water as a result of run-off and movement through the soil from areas where diazinon is used in farming. Diazinon exposure in a human, whether from ingestion, skin contact, or inhalation can result in nervous system health effects, and even death, just like it does in insects.

This WRAPs plan will not address the diazinon 303d listing.

6. Dissolved oxygen

Excess nutrients often come off crop fields due to sediment leaching during runoff events. Excess nutrients also can originate from failing septic systems, livestock manure, and fertilizer runoff in rural and urban areas. Excess nutrient loading from the watershed creates accelerated rates of eutrophication, followed by decreasing amounts of dissolved oxygen (DO) in the water. This results in an unfavorable habitat for aquatic life. Desirable criteria for healthy water dictate DO rates more than 5 mg/L in 80% of the water column and biological oxygen demand (BOD) fewer than 3 mg/L.

There are two water bodies with dissolved oxygen impairments in the Middle Kansas River Watershed:

- Pottawatomie County State Fishing Lake #1 - 303d listed, and
- Wildcat Creek - TMDL listed (high priority).

While this plan does not target the DO TMDL impairment specifically, the implementation of nutrient and bacteria livestock BMPs will reduce the amount of phosphorus found in runoff in the targeted areas and down-stream.

7. Eutrophication

Eutrophication occurs when a water body receives excess nutrients. Excess nutrients, primarily phosphorus and nitrogen, create conditions favorable for algal blooms and plant growth. Algal blooms and aquatic plant growth may increase oxygen levels temporarily, but the bloom will die off after nutrients become scarce. During this die-off, there are reduced dissolved oxygen (DO) levels in the water because algal decomposition utilizes the oxygen. This results in an unfavorable habitat for aquatic life.

The impairments in this watershed mainly stem from non-point pollution sources (NPS). This means that there is not one specific outlet where contaminants enter the water course but rather multiple sites that contribute to the overall pollutant loads. Excess nutrients can originate from manure and fertilizer runoff in rural and urban areas. In the Middle Kansas River Watershed, urbanization, agricultural land use, and small livestock operations all contribute excess nutrients to the watershed.

The Middle Kansas River Watershed has eight TMDLs and four 303d-listed water bodies for eutrophication.

- Central Park Lake - TMDL listed (low priority)
- Cross Creek - TMDL listed (high priority)
- Dornwood Park Lake - 303d listed
- Gage Park Lake - TMDL listed (low priority)
- Lake Shawnee - TMDL listed (high priority)
- Myer's Lake - TMDL listed (low priority)
- Ogden City Lake - TMDL listed (low priority)
- Pottawatomie County State Fishing Lake #1 - 303d listed
- Topeka Public Gold Course Lake - 303d listed
- Wabaunsee County Lake - 303d listed
- Wamego City Lake - TMDL listed (low priority)
- Warren Park Lake - TMDL listed (low priority)

These areas will not be targeted specifically with BMP implementation and load reduction goals, they will be impacted positively by cropland and livestock BMP implementation in the targeted areas.

8. Mercury

Mercury is a naturally occurring metal that combines with other elements to form inorganic mercury compounds. Mercury also combines with carbon to make organic mercury compounds. The major source of mercury is from natural degassing of the earth's crust. Other sources can include the combustion of fossil fuels and industrial releases. The EPA has found that mercury in water has the potential to cause kidney damage from short-term exposures at levels above the maximum contaminant level (MCL).

The Middle Kansas River Watershed has two water segments with 303d listings for mercury:

- Pillsbury Crossing, southeast of Manhattan, and
- Wamego City Lake.

This plan will not address or impact mercury levels in the watershed.

9. pH

Myer's Lake in the Middle Kansas River Watershed has been 303d listed for pH. Water quality standards for the State of Kansas indicate that artificial sources of pollution shall not cause the pH of any surface water outside of a zone of initial dilution to be below 6.5 and above 8.5 (KAR 28-16-28e(c)(2)(C)). These standards are established as "fully supporting aquatic life," as most aquatic life is adapted to a specific range of pH levels. Extreme pH can have a negative impact on fish, aquatic insects, and other aquatic life. High pH may also increase the toxicity of other substances.

This plan will not address or impact pH in these areas.

10. Sulfate

The Kansas River near Ogden has a low-priority TMDL listing for sulfate. Sulfur is an essential plant nutrient. Aquatic organisms use sulfur, and reduced concentrations of it have a detrimental effect on algal growth. The most common form of sulfur in well-oxygenated waters is sulfate. When sulfate is less than 0.5 mg/L, algal growth will not occur. On the other hand, sulfate salts can be major contaminants in natural waters.

Sulfate in Kansas waters can occur naturally or as the result of municipal or industrial discharges. Naturally occurring sulfates can result from the breakdown of leaves that fall into a stream, or from water passing through rock or soil containing gypsum and other common minerals. The suggested drinking water limit for sulfate is 250 mg/L. High sulfate concentrations in drinking water have three effects: the formation of hard scales in boilers and heat exchangers, a bitter taste, and laxative effects for those unused to it. Sulfates are not considered toxic to plants or animals at normal concentrations; however, high concentrations of sulfates can be toxic to cattle.

The Middle Kansas River Watershed WRAPS plan will not address the sulfate impairment.

11. Selenium

The Middle Kansas River Watershed has one 303d listing for selenium in the Lost Creek near Belvue. The general levels of selenium in groundwater and surface water range from 0.06 to about 400 µg/L; in some areas, levels in groundwater may approach 6000 µg/L. Selenium is an essential component of various enzymes and proteins, called selenoproteins, that help to make DNA and protect against cell damage and infections; these proteins are also involved in reproduction and the metabolism of thyroid hormones. However, selenium is toxic at higher concentrations. The EPA has set the Maximum Contaminant Level (MCL) and the Maximum Contaminant Level Goal (MCLG) in drinking water for selenium at 0.05 mg/L.

This plan will not address or impact the selenium listing in this watershed.

12. Total Phosphorus

Phosphorus loading can originate in both rural and urban areas and can be caused by both point and nonpoint sources. Land use activities can affect phosphorus runoff into streams. Some examples of this include fertilizer or manure applied to frozen ground or cropland prior to a rainfall event can be transported easily downstream; or livestock allowed access to streams to drink or loaf will contribute manure directly into the stream.

Four water segments in the Middle Kansas River Watershed have high-priority TMDLs for total phosphorus impairments:

- Kansas River near Ogden,
- Kansas River near Wamego,
- Kansas River at Willard, and

- Shunganunga Creek.

This plan will not directly address total phosphorus impairments in these four water segments. BMP implementation addressing the biology and *E. coli* TMDLs in the Watershed will result in nutrient (including phosphorus) load reductions throughout targeted portions of the watershed. Therefore, the implementation of this WRAPS plan will result in total phosphorus load reductions in Rock, Soldier, and Vermillion Creeks and downstream to include the Kansas River.

13. Total Suspended Solids

Total suspended solids (TSS) are particles such as soil, algae, and finely divided plant material suspended in water. These pollutants may attach to sediment particles on the land and be carried into water segments with storm water runoff. Once in the water, the pollutants may be released from the sediment or travel farther downstream. These particles can come from cropland, streambanks, construction sites, or industrial and municipal wastewater. High TSS levels can block light from reaching submerged vegetation, which slows photosynthesis. High levels also can cause an increase in surface water temperature, as the suspended particles absorb heat from sunlight, harming aquatic life. There are several additional ways that high TSS levels can damage aquatic life including: clogging gills, reducing growth rates, and smothering the eggs of fish, aquatic insects, and larvae. High TSS levels also can cause problems for industrial use, as solids may clog or scour pipes and machinery.

The Middle Kansas River Watershed has three 303d listings for the TSS impairment:

- Kansas River,
- Kansas River at Wamego, and
- Kansas River at Willard.

TSS will not be a targeted priority for this WRAPS plan, however it may be positively impacted by the cropland and streambank BMP projects.

6. Targeted Areas

Implementing BMPs is necessary to improve a watershed's water quality. All crop fields, pastures, and feed lots are susceptible to runoff waters to some degree; these can contribute sediment and nutrients to nearby water segments. However, some crop fields, pastures, and feed lots are more susceptible than others, including areas with proximity to streams, soils prone to erosion and nutrient leaching, high water flow areas along streams, etc. Areas such as these are considered *high priority* and are targeted for BMP implementation. It has been determined that focusing BMP implementation in high-priority areas offers a greater improvement in water quality since these areas are generally major contributors to non-point source pollution and, ultimately, 303d and TMDL listings.

A. Studies Conducted to Determine Targeted Areas

1. Spreadsheet Tool for Estimating Pollutant Loads (STEPL)

STEPL is a simple watershed model that provides both agricultural and urban annual average sediment and nutrient simulations as well as an evaluation of how various BMPs are implemented. The STEPL model calculates nutrient loading based on the runoff volume and pollutant concentrations in the runoff water, as it is influenced by factors such as the land use distribution and management practices.

In 2006, the Middle Kansas River Watershed SLT met and examined the STEPL maps, which illustrated expected pollutant loads at the HUC 12 level. Maps showing sediment, nitrogen, phosphorus, and biological oxygen demand (BOD) loads were used to determine targeted areas at that time. Those targeted areas have since changed to focus on bacteria and biology.

2. Aerial assessment

KDHE has analyzed aerial images and determined areas of interest for BMP targeting to include livestock areas near stream segments (**Figure 21**). Specific targeted areas are discussed later in this section of the WRAPS plan.

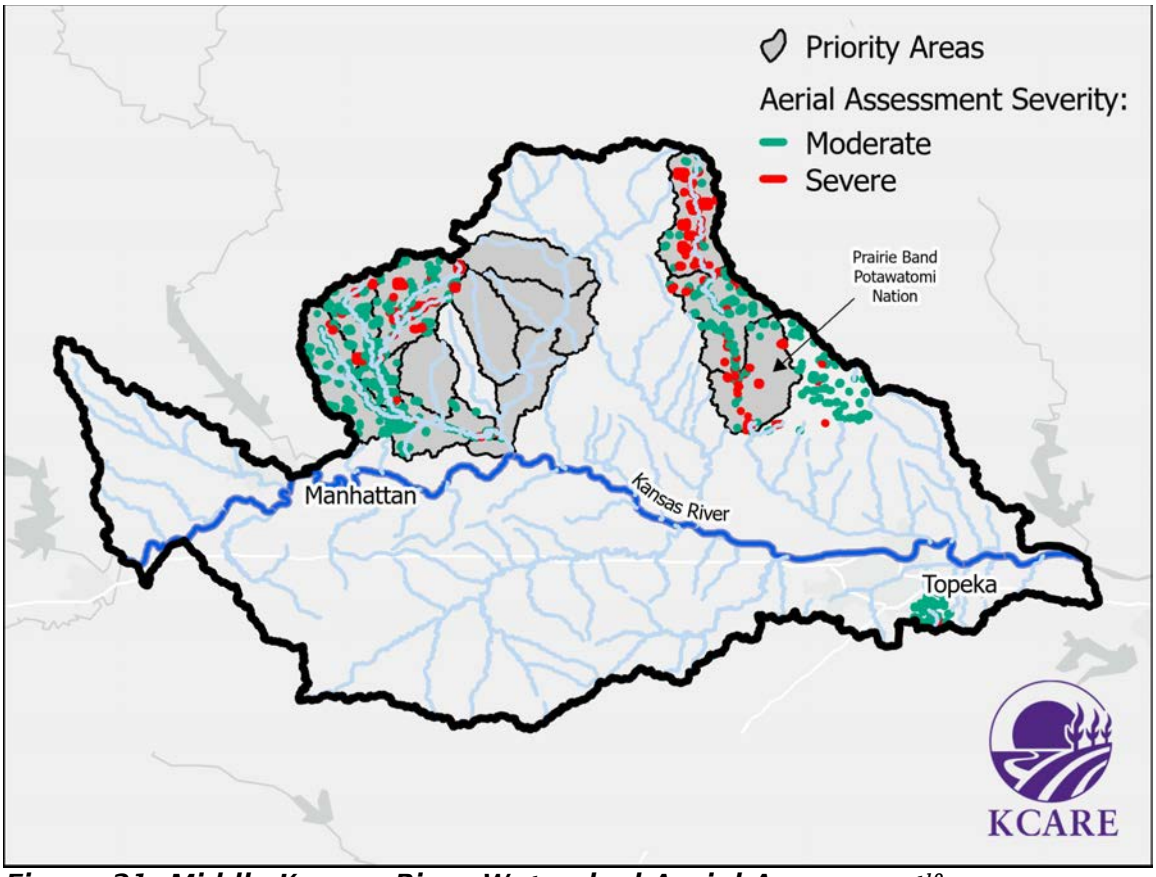


Figure 21. Middle Kansas River Watershed Aerial Assessment[19]

3. Ground-truthing

After using STEPL to locate initial targeted areas in the Middle Kansas River Watershed, the area was ground-truthed. Ground-truthing is a method that involves "windshield surveys" conducted by local agency personnel and SLT members familiar with the area and its land use history. Ground-truthing determines the current BMP adoption rate, provides photos of the targeted areas, and may generate additional water quality concerns not captured by watershed modeling. In 2012, ground-truthing began taking place in the Rock Creek sub-watershed, and in 2015 it took place in the Vermillion sub-watershed.

4. Water monitoring

Water quality monitoring activities have taken place in the Rock, Soldier, and Vermillion Creek sub-watersheds. Water sampling was used to help determine which HUC 12 sub-watersheds would be targeted for BMP implementation.

[19] Aerial Assessment figure provided by the Kansas Department of Health and Environment in September 2021.

5. **Priority revisions in 2022**

   In 2021, KDHE determined that BMP efforts should be focused on stream proximity, because stream segments are the route by which pollutants travel into larger water systems and, ultimately, lakes. By narrowing the focus to riparian corridors, the Middle Kansas River Watershed SLT can focus on *E. coli* in livestock areas in the northwestern portions of the watershed. KDHE believes that focusing livestock BMP practices in **riparian corridors, which is one-half mile on both sides of water segments**, significantly reduces bacteria and nutrient loading.

B. Targeted Areas

It is more economical for watersheds to use specific BMP placement, rather than randomly applying BMPs throughout the watershed. Every watershed has specific locations that contribute a greater pollutant load due to soil type, proximity to streams, and land-use practices. By using BMPs in these specific areas, pollutants can be reduced at a more efficient rate.

As previously mentioned, the STEPL model, KDHE aerial assessments, ground-truthing, water monitoring, and stream proximity were all used to determine the targeted areas for this Middle Kansas River WRAPS plan. Targeting assessment data were presented to, considered, and approved by the SLT and KDHE.

The SLT decided to target the following areas in the Middle Kansas River Watershed for BMP implementation:

1. **Cropland and streambank**

   These areas will be targeted for **sediment/TSS** reductions, which will subsequently reduce nutrient (phosphorus and nitrogen) contributions, both of which will have a positive impact on the **Biology TMDLs** in the Soldier Creek sub-watershed. BMP implementation will take place throughout three HUC 12s (**Figure 22**).

   <u>Solider Creek sub-watershed</u>
   - HUC 102701020801
   - HUC 102701020802
   - HUC 102701020803

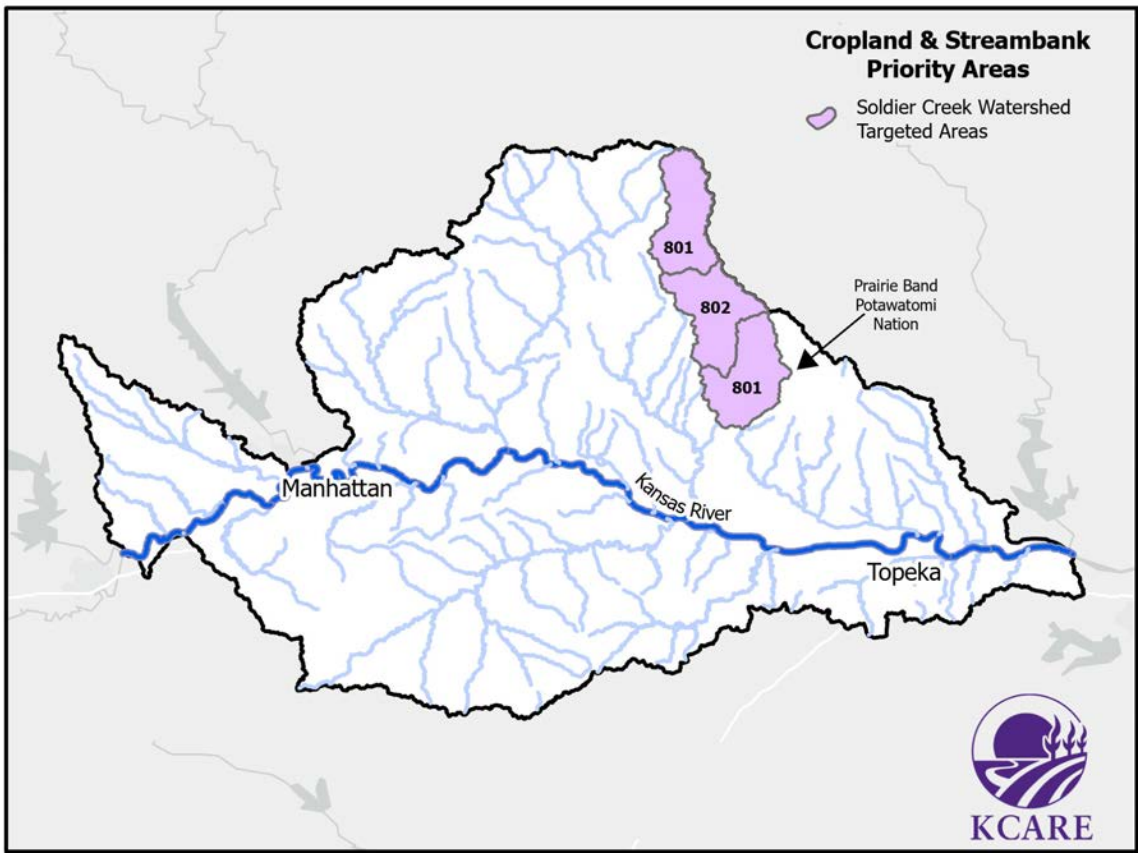


Figure 22. Cropland and Streambank Targeted Areas in the Middle Kansas River Watershed

2. Livestock

These areas will be targeted to reduce ***E. coli*** **bacteria** contributions in TMDL areas. This will subsequently reduce phosphorus and nitrogen loading as well. BMP implementation will take place in the riparian corridors of two sub-watersheds and nine HUC 12s (**Figure 23**).

Rock Creek sub-watershed

- HUC 102701020101
- HUC 102701020102
- HUC 102701020103
- HUC 102701020104
- HUC 102701020105

Vermillion Creek sub-watershed

- HUC 102701020205
- HUC 102701020206
- HUC 102701020207
- HUC 102701020209

Focusing on livestock BMP implementation in these targeted areas will have positive impacts on water segments downstream.

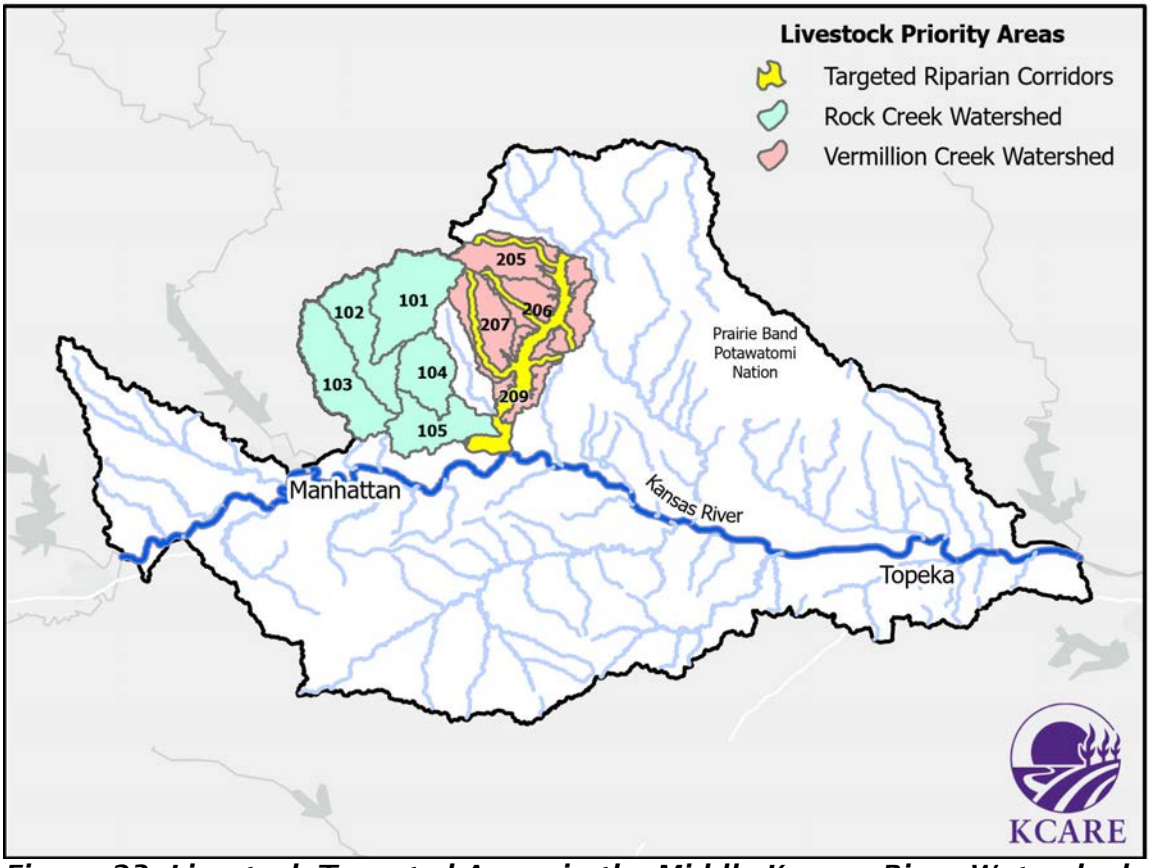


Figure 23. Livestock Targeted Areas in the Middle Kansas River Watershed

C. Load Reduction Estimate Methodology

Load reductions will be estimated for each pollutant addressed in each area to measure success in meeting TMDL goals.

1. Cropland

Baseline loadings are calculated using the AnnAGNPS model delineated to the HUC 12 watershed scale. BMP load reduction efficiencies are derived from Kansas State University Research and Extension Publication MF-2572.[20] Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies.

2. Streambank

The Kansas Alliance for Wetlands and Stream (KAWS) conducted an assessment in 2010 and identified a total of 52 eroding streambank sites for potential stabilization/restoration along the riparian corridors of Soldier Creek. Eroding sites identified by the assessment represent a total of 30,920 linear feet of eroding streambank. Additional assessments to

[20] https://www.bookstore.ksre.ksu.edu/pubs/MF2572.pdf

finely-tune streambank targeting and to derive more accurate streambank erosion estimates may be needed.

3. Livestock

Baseline nutrient loadings per animal unit are calculated using the Livestock Waste Facilities Handbook[21] and these three publications: *Decreasing Nitrogen and Phosphorus Excretion by Dairy Cattle*[22], *Fertilizing Cropland with Beef Manure*[23], and *Estimating Manure Nutrient Excretion*[24]. Livestock management practice load reduction efficiencies are derived from numerous sources, including Kansas State University Research and Extension Publication MF-2737[25] and MF-2454[26].

Load reduction estimates are the product of baseline loading and the applicable BMP load reduction efficiencies. According to the 2019 Ag Census, stocking rates in the Middle Kansas River Watershed range from 16 to 29.6, with an average of 18.3 cattle per 100 acres. For the purpose this plan, it is assumed that there is a stocking rate of 1 animal unit per 5.46 acres and that each livestock project will positively affect an average of 160 acres. In other words, load-reductions are calculated using 29 animal units per project.

[21] https://www-mwps.sws.iastate.edu/catalog/manure-management/livestock-waste-facilities-handbook
[22] Sudduth, T.Q. and M.J. Loveless. *Decreasing Nitrogen and Phosphorus Excretion by Dairy Cattle*. https://www.clemson.edu/extension/camm/manuals/dairy/dch3b_04.pdf
[23] Schmitt, Michael and George Rehm. *Fertilizing Cropland with Beef Manure*. 2002. University of Minnesota Extension Bulletin.
[24] Koelsch, Rick. *Estimating Manure Nutrient Excretion.* 2007. University of Nebraska Extension Bulletin.
[25] MF-2737 Available at: https://www.bookstore.ksre.ksu.edu/pubs/MF2737.pdf
[26] MF-2454 Available at: https://www.bookstore.ksre.ksu.edu/pubs/MF2454.pdf

7. Implementation

As mentioned in the previous section, BMP implementation in the Middle Kansas River Watershed will take place in three sub-watersheds to include Rock Creek, Soldier Creek, and Vermillion Creek. Cropland, streambank, and livestock areas will be targeted to effectively improve the following TMDL impairments:

- **Biology:** cropland and streambank areas throughout the Soldier Creek sub-watershed
- ***E. coli*:** livestock areas throughout the Rock Creek sub-watershed and within the riparian corridors (one-half mile on either side of a stream segment) of the Vermillion Creek sub-watershed

Cropland BMPs will reduce sediment/TSS and nutrient (phosphorus and nitrogen) loading, thereby improving the three Biology TMDLs in three Soldier Creek water segments. In addition, these reductions subsequently will work to improve the Middle Kansas River Watershed's non-targeted impairments: aquatic life/plants, biology, DO, eutrophication, total phosphorus, and TSS.

Streambank BMPs, or stabilization projects, will reduce sediment/TSS (and nutrient) loading, thereby improving the three Biology TMDLs in three Soldier Creek water segments. In addition, these reductions subsequently will work to improve the watershed's non-targeted impairments: aquatic life/plants, biology, DO, eutrophication, total phosphorus, and TSS. *E. coli* impairments also will be improved if streambank stabilization projects take place in livestock production areas.

Cropland and streambank BMP implementation in the Soldier Creek sub-watershed should result in a load reduction of 18,400 tons of sediment annually over the course of this 20-year plan.

Livestock BMPs will reduce nutrient loading, particularly phosphorus, and bacteria loading by moving cattle away from water segments. This will directly address the three *E. coli* TMDLs found in Rock Creek near Louisville, and the Vermillion Creek water segments (2). These reductions will also improve the Middle Kansas River Watershed's non-targeted impairments: aquatic life/plants, biology, DO, *E. coli*, eutrophication, and total phosphorus.

This WRAPS plan only addresses the Biology and *E. coli* TMDLs in the before-mentioned three sub-watersheds, all of which will share the same phosphorus load reduction goal of 116,000 pounds annually.

A. Addressing the Biology TMDL in the Middle Kansas River Watershed

The Middle Kansas has a high-priority TMDL for Biology in the Soldier Creek sub-watershed. This WRAPS plan will address these Biology TMDLs by reducing the amount of sediment loss in targeted areas.

The Middle Kansas River Watershed has two targeted areas for sediment/TSS load reductions: **cropland** and **streambank** areas. It is expected that adoption and implementation of sediment

BMPs will result in total sediment load reductions of **21,997 tons of sediment** at the conclusion of this 20-year WRAPS plan.

There are 14,617 cropland acres in the areas targeted for sediment load reduction in the Middle Kansas River Watershed (**Table 15**). Land use in the sediment-targeted area does make an impact as cropland is known to be highly susceptible to runoff and erosion during rainfall events. Cropland BMP implementation will take place throughout the targeted portions of the watershed. Streambank BMP implementation, also referred to as stabilization or restoration, will take place primarily along Soldier Creek or along high-priority tributaries.

Table 15. Land Use in the Sediment Targeted Areas

Land Use in the Soldier Creek Targeted Area		
Land Use	**Acres**	**Percent of Watershed**
Pasture/Hay	38,717	43.3%
Grassland	24,144	27.0%
Cropland	14,617	16.4%
Deciduous Forest	7,263	8.1%
Developed, Open Space	2,651	3.0%
Woody Wetlands	861	1.0%
Developed, Low Intensity	487	0.5%
Open Water	342	0.4%
Evergreen Foreest	133	0.1%
Herbaceous Wetlands	54	0.1%
Shrubland	36	Less than 0.1
Barren Land	13	Less than 0.1
Developed, Medium Intensity	6	Less than 0.1
Total	89,324	100%

Any BMPs implemented in the targeted areas simultaneously will reduce both sediment and nutrient loading.

1. Cropland targeted for sediment reductions in the Middle Kansas River Watershed

a. Targeted cropland areas for sediment reductions: Soldier Creek sub-watershed

Cropland BMPs will be implemented to reduce sediment loading in the Soldier Creek sub-watershed to protect local streams, including the three that currently have a Biology TMDL. *Any cropland BMPs implemented in the targeted areas will reduce sediment loss, thereby simultaneously reducing nutrient loading.*

As shown in **Figure 24**, cropland BMPs will be implemented throughout the following three HUC 12s:

- 102701020801
- 102701020802
- 102701020803

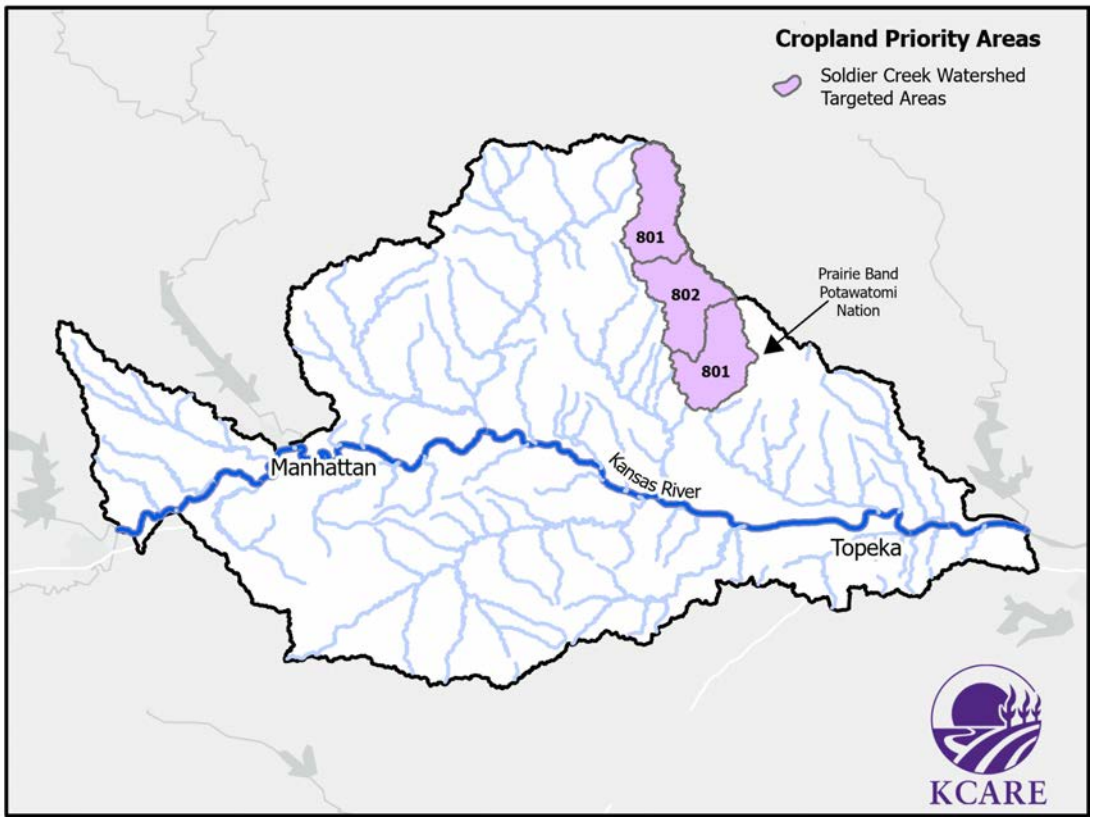


Figure 24. Cropland Targeted Area in the Middle Kansas River Watershed

b. Cropland BMPs for sediment reductions

The following BMPs will be implemented to reduce sediment (and nutrient) loading from crop fields in the Soldier Creek sub-watershed's targeted areas:

- Companion cropping
- Cover crops
- Grassed waterways
- No-till
- Permanent vegetation
- Planting green
- Sediment basins
- Terraces
- Vegetative buffers
- Wetlands

Table 16. Cropland BMPs Needed to Reduce Sediment Loading

BMPs to Reduce Sediment Loading in Soldier Creek Sub-watershed		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of sediment contribution from **cropland**	Companion Cropping	37 acres
	Cover Crops	200 acres
	Grassed Waterways	95 acres
	No-Till	365 acres
	Permanent Vegetation	7 acres
	Planting Green	37 acres
	Sediment Basins	7 acres
	Terraces	51 acres
	Vegetative Buffers	146 acres
	Wetlands	7 acres

Table 17. Adoption Rates for Cropland BMPs to Address Sediment

Soldier Creek Annual Adoption (treated acres), Cropland BMPs											
Year	**Companion Cropping**	**Cover Crops**	**Grassed Waterways**	**No-Till**	**Permanent Vegetation**	**Planting Green**	**Sediment Basins**	**Terraces**	**Vegetative Buffers**	**Wetlands**	**Total Adoption**
1	37	200	95	365	7	37	7	51	146	7	952
2	37	200	95	365	7	37	7	51	146	7	952
3	37	200	95	365	7	37	7	51	146	7	952
4	37	200	95	365	7	37	7	51	146	7	952
5	37	200	95	365	7	37	7	51	146	7	952
6	37	200	95	365	7	37	7	51	146	7	952
7	37	200	95	365	7	37	7	51	146	7	952
8	37	200	95	365	7	37	7	51	146	7	952
9	37	200	95	365	7	37	7	51	146	7	952
10	37	200	95	365	7	37	7	51	146	7	952
11	37	200	95	365	7	37	7	51	146	7	952
12	37	200	95	365	7	37	7	51	146	7	952
13	37	200	95	365	7	37	7	51	146	7	952
14	37	200	95	365	7	37	7	51	146	7	952
15	37	200	95	365	7	37	7	51	146	7	952
16	37	200	95	365	7	37	7	51	146	7	952
17	37	200	95	365	7	37	7	51	146	7	952
18	37	200	95	365	7	37	7	51	146	7	952
19	37	200	95	365	7	37	7	51	146	7	952
20	37	200	95	365	7	37	7	51	146	7	952
Total	**730**	**3,999**	**1,898**	**7,301**	**146**	**730**	**146**	**1,022**	**2,920**	**146**	**19,039**

Cropland acres may have multiple practices implemented on them, therefore, total adoption acres may appear to exceed cropland acres avaialble in the watershed.

c. *Sediment/TSS load reductions from cropland BMP implementation*

The implementation of cropland BMPs on 952 acres per year in the Middle Kansas River Watershed's targeted areas will result in a sediment load reduction of 3,410 tons at the end of this 20-year WRAPS plan (**Table 18**).

Table 18. Cumulative Sediment Load Reductions from Cropland BMP Implementation

Soldier Creek Annual Soil Erosion Reduction (tons), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Load Reduction
1	6	35	16	63	3	6	1	7	32	1	170
2	13	69	33	127	6	13	2	13	63	2	341
3	19	104	49	190	9	19	3	20	95	3	511
4	25	139	66	253	12	25	4	27	127	4	682
5	32	174	82	317	15	32	5	33	158	5	852
6	38	208	99	380	18	38	6	40	190	6	1,023
7	44	243	115	444	21	44	7	47	222	7	1,193
8	51	278	132	507	24	51	8	53	253	8	1,364
9	57	312	148	570	27	57	9	60	285	9	1,534
10	63	347	165	634	30	63	10	67	317	10	1,705
11	70	382	181	697	33	70	10	73	349	10	1,875
12	76	417	198	760	36	76	11	80	380	11	2,046
13	82	451	214	824	39	82	12	87	412	12	2,216
14	89	486	231	887	42	89	13	93	444	13	2,387
15	95	521	247	951	45	95	14	100	475	14	2,557
16	101	555	264	1,014	48	101	15	106	507	15	2,728
17	108	590	280	1,077	51	108	16	113	539	16	2,898
18	114	625	297	1,141	54	114	17	120	570	17	3,069
19	120	660	313	1,204	57	120	18	126	602	18	3,239
20	127	694	330	1,267	60	127	19	133	634	19	3,410

2. Streambanks targeted for sediment load reduction in the Middle Kansas River Watershed

a. Targeted streambank areas for sediment reductions: Solider Creek sub-watershed

Streambank restoration will be used to reduce channel-bank erosion and streambank sloughing during heavy rainfall and high-flow events. This will reduce the amount of sediment entering water segments in the Soldier Creek sub-watershed. Streambank restoration/stabilization implementation will also reduce nutrient loading as nutrients can attach to soil particles that enter water segments causing biology, dissolved oxygen, eutrophication, and total phosphorus water impairments.

As shown in **Figure 25**, streambank stabilization/restoration projects will be implemented along priority areas along the upper portion of Soldier Creek which is the water segment found in the following HUC 12s:

- 102701020801
- 102701020802
- 102701020803

There will be no stabilization/restoration projects installed outside of the priority HUC 12 areas; however, the portion of Soldier Creek below the targeted HUC 12s will be positively impacted by the installation of the projects upstream.

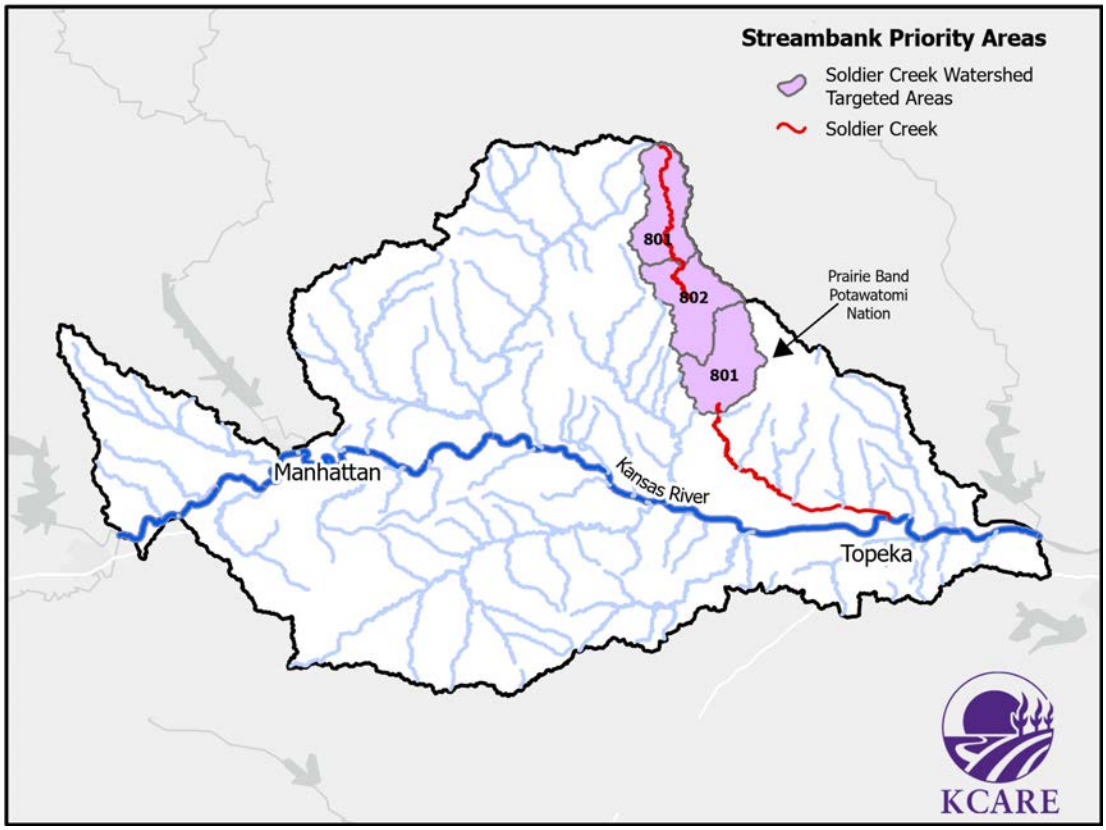


Figure 25. Streambank Stabilization Areas in the Middle Kansas River Watershed

b. ***Streambank stabilization for sediment reductions***

The project will stabilize 500 linear feet (lf) of streambank annually in the targeted areas for the duration of this 20-year WRAPS plan, for a total of 10,000 linear feet of streambank protected from soil erosion and soil loss **(Table 19**).

Table 19. Adoption Rate for Streambank Stabilization to Address Sediment

Annual Adoption (lf), Streambank Stabilization/Restoration		
Year	Streambank Stabilization (linear feet)	Cumulative Streambank Stabilization
1	500	500
2	500	1,000
3	500	1,500
4	500	2,000
5	500	2,500
6	500	3,000
7	500	3,500
8	500	4,000
9	500	4,500
10	500	5,000
11	500	5,500
12	500	6,000
13	500	6,500
14	500	7,000
15	500	7,500
16	500	8,000
17	500	8,500
18	500	9,000
19	500	9,500
20	500	10,000

c. ***Sediment load reductions from streambank stabilization project implementation***

The implementation of 500 linear feet of streambank stabilization each project year along Soldier Creek will result in a sediment load reduction of 15,000 tons at the end of this 20-year WRAPS plan **(Table 20).**

Table 20. Sediment Load Reduction from Streambank Stabilization

Annual Sediment Reductions (tons), Streambank Stabilization/Restoration			
Year	Streambank Stabilization (linear feet)	Soil Load Reduction (tons)	Cumulative Erosion Reduction (tons)
1	500	750	750
2	500	750	1,500
3	500	750	2,250
4	500	750	3,000
5	500	750	3,750
6	500	750	4,500
7	500	750	5,250
8	500	750	6,000
9	500	750	6,750
10	500	750	7,500
11	500	750	8,250
12	500	750	9,000
13	500	750	9,750
14	500	750	10,500
15	500	750	11,250
16	500	750	12,000
17	500	750	12,750
18	500	750	13,500
19	500	750	14,250
20	500	750	15,000

3. Meeting the sediment/TSS goals in the Middle Kansas River Watershed

Adoption and implementation of sediment BMPs in cropland and streambank areas will result in a total sediment load reduction of 18,410 tons at the conclusion of this 20-year WRAPS plan (**Table 21**). The sediment load reduction goal in this plan was 18,400 tons, therefore the implementation of all sediment BMPs during the 20-year span will meet the sediment reduction goal in year 20 (**Table 22**).

Table 21. Meeting the Middle Kansas River Watershed Sediment Goal

Meeting the Sediment Goal		
BMP Category	Total Load Reduction (tons)	% of Sediment Goal
Cropland	3,410	18.5%
Streambank	15,000	81.5%
Total	**18,410**	**100.1%**
Sediment Reduction Goal: 18,400 tons		

Table 22. Meeting the Sediment/TSS Goal: Cumulative Sediment Reductions by Area

Meeting the Sediment Goal				
Year	Cropland Reduction (tons)	Streambank Reduction (tons)	Total Reduction (tons)	% of TMDL
1	170	750	920	5%
2	341	1,500	1,841	10%
3	511	2,250	2,761	15%
4	682	3,000	3,682	20%
5	852	3,750	4,602	25%
6	1,023	4,500	5,523	30%
7	1,193	5,250	6,443	35%
8	1,364	6,000	7,364	40%
9	1,534	6,750	8,284	45%
10	1,705	7,500	9,205	50%
11	1,875	8,250	10,125	55%
12	2,046	9,000	11,046	60%
13	2,216	9,750	11,966	65%
14	2,387	10,500	12,887	70%
15	2,557	11,250	13,807	75%
16	2,728	12,000	14,728	80%
17	2,898	12,750	15,648	85%
18	3,069	13,500	16,569	90%
19	3,239	14,250	17,489	95%
20	3,410	15,000	18,410	100%

BMPs implemented in cropland and streambank areas will reduce both sediment and nutrients, thereby positively affecting the atrazine, biology, dissolved oxygen, E. coli*, eutrophication, total phosphorus and TSS impairments in the Middle Kansas River Watershed.*

B. *E. coli* Bacteria Reductions in the Middle Kansas River Watershed

The Middle Kansas has a high-priority TMDL for *E. coli* in Rock Creek near Louisville, Vermillion Creek near Louisville, and Vermillion Creek near Onaga. The Middle Kansas River Watershed has one targeted area for *E. coli* bacteria reductions: **livestock areas**.

There are 43,028 acres of grassland and pasture/hay land (**Table 23**) in the Rock and Vermillion Creek sub-watersheds, making up 28% of these priority areas. Land use, along with water monitoring data suggest that livestock are somewhat prominent in these areas and that livestock BMPs would reduce the bacteria loading taking place. Therefore, livestock BMP will be implemented throughout the Rock Creek sub-watershed to address the *E. coli* TMDL in Rock Creek. This WRAPS plan will also address the Vermilion Creek *E. coli* TMDL by

targeting livestock areas within riparian corridors (one-half mile on each side of water segment) where outputs are most likely entering stream segments.

Table 23. Land Use in the Livestock Targeted Areas

Land Use in the Rock and Vermillion Creek Targeted Areas		
Land Use	**Acres**	**Percent of Watershed**
Cropland	88,628	57.2%
Grassland	23,566	15.2%
Pasture/Hay	19,462	12.6%
Deciduous Forest	13,785	8.9%
Developed, Open Space	5,132	3.3%
Woody Wetlands	1,454	0.9%
Herbaceous Wetlands	1,048	0.7%
Developed, Low Intensity	885	0.6%
Open Water	593	0.4%
Developed, Medium Intensity	220	0.1%
Mixed Forest	81	Less than 0.1
Shrubland	62	Less than 0.1
Barren Land	28	Less than 0.1
Developed, High Intensity	23	Less than 0.1
Evergreen Forest	7	Less than 0.1
Total	**154,974**	**100%**

It is presumed that adoption and implementation of livestock BMPs throughout the Rock Creek sub-watershed, as well as livestock BMP implementation in the riparian corridor areas of the Vermillion Creek sub-watershed, will result in a decrease in *E. coli* in the targeted stream waters. Unfortunately, there are no quantitative figures for *E. coli* reductions without intensive water monitoring. Nutrient reductions, namely phosphorus, will certainly be made with BMP implementation and will serve as an indicator that *E. coli* reductions are also being made.

1. Targeted livestock areas for *E. coli* reductions

Livestock area BMPs will be implemented to reduce *E. coli* bacteria loading and will simultaneously serve to reduce nutrients in the Middle Kanas River Watershed.

As shown in **Figure 26**, livestock BMP implementation will take place in the riparian corridors of two sub-watersheds and nine HUC 12s to include:

Rock Creek sub-watershed

- HUC 102701020101
- HUC 102701020102
- HUC 102701020103
- HUC 102701020104
- HUC 102701020105

Vermillion Creek sub-watershed

- HUC 102701020205
- HUC 102701020206
- HUC 102701020207
- HUC 102701020209

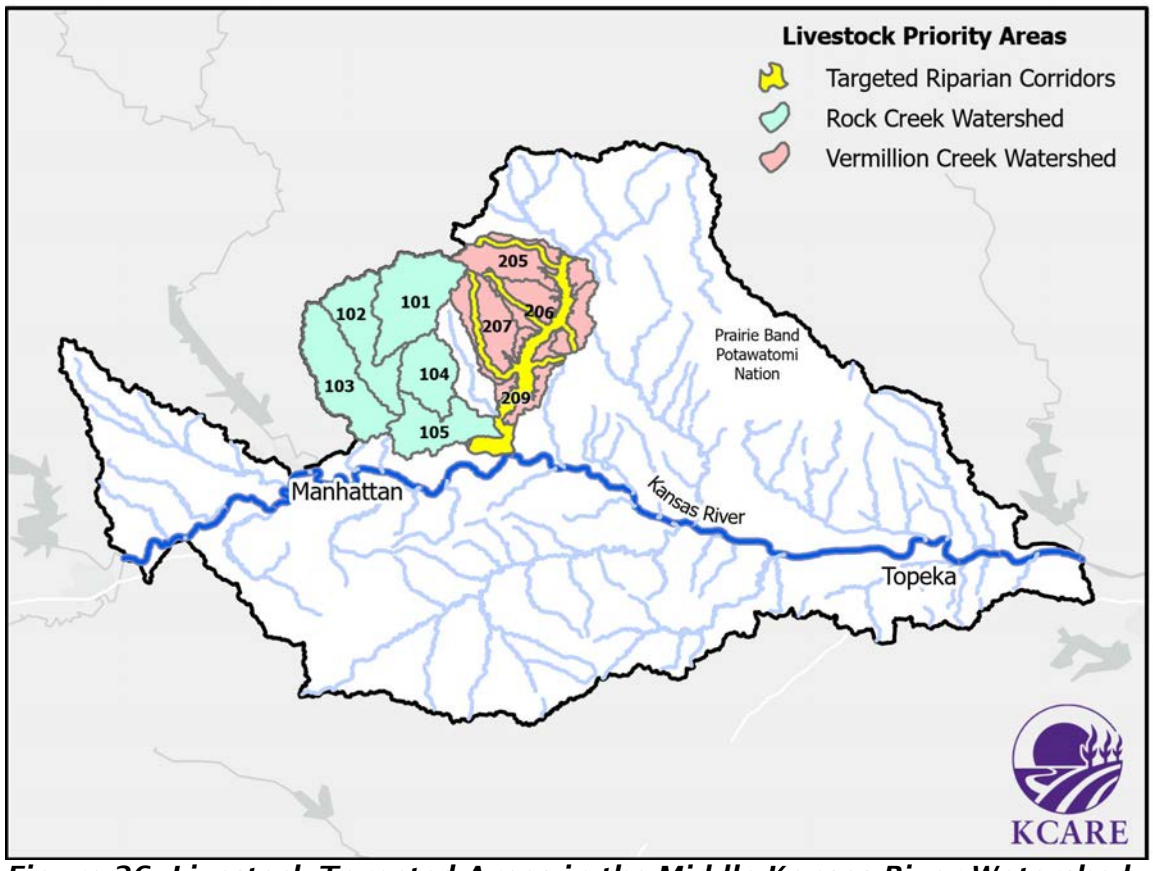


Figure 26. Livestock-Targeted Areas in the Middle Kansas River Watershed

2. Livestock area BMPs for *E. coli* reductions in the Middle Kansas River Watershed

The following BMPs will be implemented to reduce *E. coli* bacteria through nutrient loading from livestock targeted areas:

- alternative watering system,
- grazing management plan,
- relocate feedlot,
- relocate pasture feeding sites, and
- vegetative filter strips.

Table 24. **E. coli** ***BMP Adoption Rates in Livestock Areas***

Livestock BMPs to Reduce *E. coli* in Rock and Vermillion Creek Sub-watersheds		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of *E. coli* bacteria and nutrient contribution from livestock	Alternative Watering System	1 project every 2 years of the plan, beginning in year 2. 10 projects during the life of the plan.
	Grazing Management Plan	1 project every 2 years of the plan, beginning in year 1. 10 projects during the life of the plan.
	Relocate Fedlot	1 project every 2 years of the plan, beginning in year 2. 10 projects during the life of the plan.
	Relocate Pasture Feeding Sites	1 project every 2 years of the plan, beginning in year 1. 10 projects during the life of the plan.
	Vegetative Filter Strips	1 project every 2 years of the plan, beginning in year 1. 10 projects during the life of the plan.

***Table 25. Adoption Rates for Livestock BMPs to address* E. coli**

Annual Livestock BMP Adoption						
Year	Alternate Watering System	Grazing Management Plan	Relocate Feedlot	Relocate Pasture Feeing Sites	Vegetative Filter Strips	Projects Per Year
1	0	1	0	1	1	3
2	1	0	1	0	0	2
3	0	1	0	1	1	3
4	1	0	1	0	0	2
5	0	1	0	1	1	3
6	1	0	1	0	0	2
7	0	1	0	1	1	3
8	1	0	1	0	0	2
9	0	1	0	1	1	3
10	1	0	1	0	0	2
11	0	1	0	1	1	3
12	1	0	1	0	0	2
13	0	1	0	1	1	3
14	1	0	1	0	0	2
15	0	1	0	1	1	3
16	1	0	1	0	0	2
17	0	1	0	1	1	3
18	1	0	1	0	0	2
19	0	1	0	1	1	3
20	1	0	1	0	0	2
Total	**10**	**10**	**10**	**10**	**10**	**50**

3. *E. coli* load reductions from livestock BMP implementation

It is not possible to estimate the current pollutant load for *E. coli* bacteria in the watershed due to several factors. First, environmental factors affect the viability of *E. coli* since it is a living organism. Next, the viability of *E. coli* is affected by variations in initial bacteria loading, ambient temperature, amount of sunlight or UV rays, and a decrease in survivability over time. In addition, *E. coli* concentrations are difficult to model, and the scope of this WRAPS project does not include modeling for *E. coli*. Therefore, it is assumed that the specific livestock BMPs that the SLT has laid out for implementation in priority riparian areas will result in reduced *E. coli* contamination. The implementation of 2-3 livestock BMP projects per year will no doubt result in less *E. coli* bacteria in the Middle Kansas River Watershed's streams and rivers.

BMPs implemented in priority livestock areas will reduce bacteria as well as nutrients (phosphorus and nitrogen), thereby positively affecting the biology, dissolved oxygen, eutrophication, and total phosphorus impairments in the Middle Kansas River Watershed.

C. Nutrient Load Reductions in the Middle Kansas River Watershed

The Middle Kansas River Watershed WRAPS plan will focus on addressing the Biology and *E. coli* high-priority TMDLS; however, implementing sediment and livestock BMPs in priority cropland, streambank, and livestock areas, nutrient loading will subsequently be reduced.

1. Phosphorus load reductions

a. Phosphorus load reductions from cropland BMP implementation

The cropland sediment BMP implementation that takes place in the Soldier Creek sub-watershed will also result in a reduction in phosphorus loading. BMP implementation as structured in this plan will result in a phosphorus load reduction of 1,164 pounds per year and a total load reduction of 23,288 pounds over the course of this 20-year WRAPS plan (**Table 26**).

Table 26. Phosphorus Load Reductions from Cropland BMPs

Soldier Creek Annual Phosphorous Reduction (pounds), Cropland BMPs											
Year	Permanent Vegetation	Grassed Waterways	No-Till	Cover Crops	Vegetative Buffers	Terraces	Sediment Basins	Planting Green	Companion Cropping	Wetlands	Total Load Reduction
1	18	97	465	255	186	39	6	47	47	6	1,164
2	35	194	931	510	372	78	11	93	93	11	2,329
3	53	290	1,396	765	559	117	17	140	140	17	3,493
4	71	387	1,862	1,020	745	156	22	186	186	22	4,658
5	88	484	2,327	1,275	931	195	28	233	233	28	5,822
6	106	581	2,793	1,530	1,117	235	34	279	279	34	6,986
7	124	678	3,258	1,785	1,303	274	39	326	326	39	8,151
8	141	774	3,724	2,039	1,489	313	45	372	372	45	9,315
9	159	871	4,189	2,294	1,676	352	50	419	419	50	10,480
10	177	968	4,654	2,549	1,862	391	56	465	465	56	11,644
11	195	1,065	5,120	2,804	2,048	430	61	512	512	61	12,808
12	212	1,162	5,585	3,059	2,234	469	67	559	559	67	13,973
13	230	1,259	6,051	3,314	2,420	508	73	605	605	73	15,137
14	248	1,355	6,516	3,569	2,606	547	78	652	652	78	16,302
15	265	1,452	6,982	3,824	2,793	586	84	698	698	84	17,466
16	283	1,549	7,447	4,079	2,979	626	89	745	745	89	18,630
17	301	1,646	7,912	4,334	3,165	665	95	791	791	95	19,795
18	318	1,743	8,378	4,589	3,351	704	101	838	838	101	20,959
19	336	1,839	8,843	4,844	3,537	743	106	884	884	106	22,124
20	354	1,936	9,309	5,099	3,724	782	112	931	931	112	23,288

b. Phosphorus load reductions from streambank stabilization/restoration projects

The streambank stabilization/restoration that takes place in the Soldier Creek sub-watershed will result in sediment and phosphorus load reductions. If 500 linear feet are stabilized/restored each year as planned, 45 pounds of phosphorus will be reduced each year for a total of 900 pounds over the course of this 20-year WRAPS plan **(Table 27).**

Table 27. Phosphorus Load Reductions from Streambank Stabilization

Annual Phosphorus Reductions, Streambank BMPs			
Year	Streambank Stabilization (linear feet)	Phosphorous Reduction (lbs)	Cumulative P Load Reduction (lbs)
1	500	45	45
2	500	45	90
3	500	45	135
4	500	45	180
5	500	45	225
6	500	45	270
7	500	45	315
8	500	45	360
9	500	45	405
10	500	45	450
11	500	45	495
12	500	45	540
13	500	45	585
14	500	45	630
15	500	45	675
16	500	45	720
17	500	45	765
18	500	45	810
19	500	45	855
20	500	45	900

c. Phosphorus load reductions from livestock BMP implementation

The livestock BMP implementation that takes place in the Rock and Vermillion Creek sub-watersheds will undoubtedly result in a reduction in phosphorus loading. BMP implementation as structured in this plan will result in a phosphorus load reduction of 23,641 pounds at the conclusion of this 20-year WRAPS plan **(Table 28)**.

Load reductions from livestock sources are calculated using animal units per "project" as described in Section 6.C.3.

Table 28. Phosphorus Load Reductions from Livestock BMPs

Phosphorus Load Reduction (lbs), Livestock BMPs							
Year	Alternative Watering System	Grazing Management Plan	Relocate Feedlot	Relocate Pasture Feeding Sites	Vegetative Filter Strips	Annual Total	Cumulative Load Reduction
1	0	102	0	19	888	1,009	1,009
2	23	0	1,332	0	0	1,355	2,364
3	0	102	0	19	888	1,009	3,373
4	23	0	1,332	0	0	1,355	4,728
5	0	102	0	19	888	1,009	5,737
6	23	0	1,332	0	0	1,355	7,092
7	0	102	0	19	888	1,009	8,101
8	23	0	1,332	0	0	1,355	9,456
9	0	102	0	19	888	1,009	10,465
10	23	0	1,332	0	0	1,355	11,820
11	0	102	0	19	888	1,009	12,829
12	23	0	1,332	0	0	1,355	14,184
13	0	102	0	19	888	1,009	15,193
14	23	0	1,332	0	0	1,355	16,549
15	0	102	0	19	888	1,009	17,558
16	23	0	1,332	0	0	1,355	18,913
17	0	102	0	19	888	1,009	19,922
18	23	0	1,332	0	0	1,355	21,277
19	0	102	0	19	888	1,009	22,286
20	23	0	1,332	0	0	1,355	23,641

d. Cumulative phosphorus load reductions

Over the course of this 20-year WRAPS plan, a total phosphorus load reduction of 47,829 pounds will be accomplished by following the cropland, streambank, and livestock BMP implementation schedules outlined in this plan (**Figure 29**).

Table 29. Total Phosphorus Load Reductions in the Middle Kansas River Watershed

Total Phosphorus Load Reductions				
Year	Cropland Reduction (lbs)	Streambank Reduction (lbs)	Livestock Reduction (lbs)	Total Reduction (lbs)
1	1,164	45	1,009	2,218
2	2,329	90	2,364	4,783
3	3,493	135	3,373	7,001
4	4,658	180	4,728	9,566
5	5,822	225	5,737	11,784
6	6,986	270	7,092	14,349
7	8,151	315	8,101	16,567
8	9,315	360	9,456	19,132
9	10,480	405	10,465	21,350
10	11,644	450	11,820	23,914
11	12,808	495	12,829	26,133
12	13,973	540	14,184	28,697
13	15,137	585	15,193	30,916
14	16,302	630	16,549	33,480
15	17,466	675	17,558	35,699
16	18,630	720	18,913	38,263
17	19,795	765	19,922	40,481
18	20,959	810	21,277	43,046
19	22,124	855	22,286	45,264
20	23,288	900	23,641	47,829

2. Nitrogen load reductions

a. Nitrogen load reductions from cropland BMP implementation

The sediment BMP implementation that takes place on cropland areas in the Soldier Creek sub-watershed will subsequently result in a reduction in nitrogen loading. BMP implementation as structured in this plan will result in a nitrogen load reduction of 3,273 pounds per year and a total load reduction of 65,458 pounds over the course of this 20-year WRAPS plan (**Table 30**).

Table 30. Nitrogen Load Reductions from Cropland BMPs

Soldier Creek Annual Nitrogen Reduction (pounds), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Load Reduction
1	102	559	424	1,020	78	102	0	171	816	0	3,273
2	204	1,118	849	2,041	155	204	0	343	1,633	0	6,546
3	306	1,677	1,273	3,061	233	306	0	514	2,449	0	9,819
4	408	2,235	1,698	4,081	310	408	0	686	3,265	0	13,092
5	510	2,794	2,122	5,102	388	510	0	857	4,081	0	16,364
6	612	3,353	2,547	6,122	465	612	0	1,028	4,898	0	19,637
7	714	3,912	2,971	7,142	543	714	0	1,200	5,714	0	22,910
8	816	4,471	3,396	8,163	620	816	0	1,371	6,530	0	26,183
9	918	5,030	3,820	9,183	698	918	0	1,543	7,346	0	29,456
10	1,020	5,589	4,245	10,203	775	1,020	0	1,714	8,163	0	32,729
11	1,122	6,147	4,669	11,223	853	1,122	0	1,886	8,979	0	36,002
12	1,224	6,706	5,093	12,244	931	1,224	0	2,057	9,795	0	39,275
13	1,326	7,265	5,518	13,264	1,008	1,326	0	2,228	10,611	0	42,548
14	1,428	7,824	5,942	14,284	1,086	1,428	0	2,400	11,428	0	45,821
15	1,530	8,383	6,367	15,305	1,163	1,530	0	2,571	12,244	0	49,093
16	1,633	8,942	6,791	16,325	1,241	1,633	0	2,743	13,060	0	52,366
17	1,735	9,501	7,216	17,345	1,318	1,735	0	2,914	13,876	0	55,639
18	1,837	10,059	7,640	18,366	1,396	1,837	0	3,085	14,693	0	58,912
19	1,939	10,618	8,065	19,386	1,473	1,939	0	3,257	15,509	0	62,185
20	2,041	11,177	8,489	20,406	1,551	2,041	0	3,428	16,325	0	65,458

b. Nitrogen load reductions from livestock BMP implementation

The livestock BMP implementation in the Rock and Vermillion Creek sub-watersheds will undoubtedly result in a reduction in nitrogen loading. BMP implementation as structured in this plan will result in a nitrogen load reduction of 44,527 pounds at the conclusion of this 20-year WRAPS plan (**Table 31**).

Load reductions from livestock sources are calculated using animal units per "project" as described in Section 6.C.3.

Table 31. Nitrogen Load Reductions from Livestock BMPs

Nitrogen Load Reduction (lbs), Livestock BMPs							
Year	Alternative Watering System	Grazing Management Plan	Relocate Feedlot	Relocate Pasture Feeding Sites	Vegetative Filter Strips	Annual Total	Cumulative Load Reduction
1	0	192	0	35	1,673	1,901	1,901
2	43	0	2,510	0	0	2,552	4,453
3	0	192	0	35	1,673	1,901	6,353
4	43	0	2,510	0	0	2,552	8,905
5	0	192	0	35	1,673	1,901	10,806
6	43	0	2,510	0	0	2,552	13,358
7	0	192	0	35	1,673	1,901	15,259
8	43	0	2,510	0	0	2,552	17,811
9	0	192	0	35	1,673	1,901	19,711
10	43	0	2,510	0	0	2,552	22,264
11	0	192	0	35	1,673	1,901	24,164
12	43	0	2,510	0	0	2,552	26,716
13	0	192	0	35	1,673	1,901	28,617
14	43	0	2,510	0	0	2,552	31,169
15	0	192	0	35	1,673	1,901	33,070
16	43	0	2,510	0	0	2,552	35,622
17	0	192	0	35	1,673	1,901	37,522
18	43	0	2,510	0	0	2,552	40,075
19	0	192	0	35	1,673	1,901	41,975
20	43	0	2,510	0	0	2,552	44,527

c. Cumulative nitrogen load reductions

Over the course of this 20-year WRAPS plan, a total nitrogen load reduction of 109,985 pounds will inadvertently be accomplished by following the cropland and livestock BMP implementation schedules outlined in this plan (**Table 32**).

Table 32. Total Nitrogen Load Reductions in the Middle Kansas River Watershed

Total Nitrogen Load Reduction			
Year	Cropland Reduction (lbs)	Livestock Reduction (lbs)	Total Reduction (lbs)
1	3,273	1,901	5,173
2	6,546	4,453	10,999
3	9,819	6,353	16,172
4	13,092	8,905	21,997
5	16,364	10,806	27,170
6	19,637	13,358	32,996
7	22,910	15,259	38,169
8	26,183	17,811	43,994
9	29,456	19,711	49,168
10	32,729	22,264	54,993
11	36,002	24,164	60,166
12	39,275	26,716	65,991
13	42,548	28,617	71,165
14	45,821	31,169	76,990
15	49,093	33,070	82,163
16	52,366	35,622	87,988
17	55,639	37,522	93,162
18	58,912	40,075	98,987
19	62,185	41,975	104,160
20	65,458	44,527	109,985

8. Information and Education

The SLT determined which Information and Education (I&E) activities are needed in the Middle Kansas River Watershed. These important activities provide watershed residents with an improved awareness of local watershed issues, leading to increased adoption rates of BMPs. All I&E activities and events are evaluated based on productivity, attendance, and achievement of objectives.

A. I&E Activities and Events in the Middle Kansas River Watershed

Listed below are the I&E activities and events along with their costs and possible sponsoring agencies. If all listed I&E events and activities take place, the total cost would be **$47,300** per year. *It is understood that funding from non-WRAPS sources will be required if all these activities are to take place.*

Table 33. I&E: Cropland BMP Education

Cropland BMP Implementation					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Companion Cropping	Landowners/ Producers	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual	No Cost	Conservation Districts, Middle Kansas WRAPS, KAWS
Cover Crops	Landowners/ Producers	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual	No Cost	Conservation Districts, NRCS
		Cropland BMPs Workshop/Field Day	Annual, Spring	$2,000	Conservation Districts, Middle Kansas WRAPS, KAWS
Grassed Waterways	Landowners/ Producers	Cropland BMPs Workshop/Field Day	Annual, Spring	Included Above	Conservation Districts, Middle Kansas WRAPS, KAWS
		One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual	No Cost	Conservation Districts, NRCS
No-till	Landowners/ Producers	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual	No Cost	Conservation Districts, NRCS
		Scholarships for producers to attend No-till on the Plains Annual Conference	Annual, Winter	$750	No-till on the Plains, Middle Kasnas WRAPS
		Cropland BMPs Workshop/Field Day	Annual, Spring	Included Above	Conservation Districts, Middle Kansas WRAPS, KAWS
Permanent Vegetation	Landowners/ Producers	Cropland BMPs Workshop/Field Day	Annual, Spring	Included Above	Conservation Districts, Middle Kansas WRAPS, KAWS
		Forestry Field Day	Annual	$3,000	Kansas Forest Service
Planting Green	Landowners/ Producers	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual, Summer	No Cost	Conservation Districts, Middle Kansas WRAPS, KAWS
Sediment Basin	Landowners/ Producers	Sediemnt Basin and Wetland Field Day/tour	Every other year	$2,000	Conservation Districts, KAWS, NRCS
		One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual	No Cost	Conservation Districts, NRCS
Terraces	Landowners/ Producers	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual	No Cost	Conservation Districts, NRCS
		Cropland BMPs Workshop/Field Day	Annual, Spring	Included Above	Conservation Districts, Middle Kansas WRAPS, KAWS
Vegetative Buffers	Landowners/ Producers	Forestry Field Day	Annual	Included in Foresty Field Day mentioned above	Kansas Forest Service
		Cropland BMPs Workshop/Field Day	Annual, Spring	Included Above	Conservation Districts, Middle Kansas WRAPS, KAWS
		One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual	No Cost	Conservation Districts, KDWP, NRCS
		One-on-one technical assistance for riparian tree planting	Annual, on-going	Included Above	Kansas Forest Service
Wetlands	Landowners/ Producers	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual	No Cost	Conservation Districts, NRCS
		Sediment Basin and Wetland Field Day/Tour	Every other year	Included with Sediment Basin and Wetland Field Day/Tour	Conservation Districts, KAWS, NRCS

Table 34. I&E: Streambank Stabilization/Restoration Education

Streambank BMP Implementation					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Streambank Stabilization/ Restoration which may include: *Soil-bioengineering, Weirs, Vanes, and/or Longitudinal peak stone toe BMPs.*	Landowners/ Producers	Streambank Stabilization tour in targeted areas	Every other year	Included with Sediment Basin and Wetland Field Day/Tour	Conservation Districts, KAWS, NRCS, DOC
		One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual	No Cost	Conservation Districts, NRCS, DOC

Table 35. I&E: Livestock BMP Education

Livestock BMP Implementation					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Alternative Watering System	Livestock Producers/ Landowners	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual - Ongoing	$4,000	Division of Conservation (DOC), Conservation Districts, K-State Research and Extension (KSRE), Kansas Rural Center, Kansas Alliance for Wetlands and Streams (KAWS), NRCS, and WRAPS
		Tour/Field Day	Annual - Summer	$10,000	
Grazing Management Plan	Livestock Producers/ Landowners	Scholarships to Grazing Schools and workshops	Annual - Summer and Winter	$500	
Relocate Feeding Areas - Feedlots and Pasture Feeding Sites	Livestock Producers/ Landowners	One-on-one technical assistance for producers to implement BMPs in the targeted area.	Annual - Ongoing	Included Above	
		Tour/Field Day	Annual - Summer	Included Above	
Vegetative Filter Strips	Livestock Producers/ Landowners	Scholarships to Grazing Schools and workshops	Annual - Winter	Included Above	

Table 36. I&E: Middle Kansas River Watershed Resident Education

General / Watershed-Wide Information and Education					
BMP	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Education Activities Targeting Youth	K-12 Students and Educators	Water festivals/ Water Rally	Annual Spring or Summer	$1,000	Conservation Districts
		Poster, essay, speech contests	Annual - Spring	$200	Conservation Districts
		Day on the Farm	Annual - Spring	$500	Conservation Districts, Kansas Farm Bureau, KSRE
		Range Youth Camp	Annual	$1,100	Conservation Dristricts, NRCS
		Topeka Water Festival	Annual	$3,000	Shawnee County Conservation District and KACEE
		Envirothon	Annual - Winter	$500	Conservation Districts, NRCS
Education Activities Targeting Adults	Watershed Residents	Maintain a Middle Kansas River WRAPS Website	Annual - Ongoing	$1,000	WRAPS and KAWS
		Watershed Announcements/ Advertisement (television, radio, newspaper, etc.)	Annual - Ongoing	$1,000	WRAPS
		Media campaign to promote forestry practices	Annual - Ongoing	$500	Kansas Forest Service
		Educational presentations to conservation districts and community groups	Annual - Ongoing	$100	WRAPS
		Watershed tour highlighting practices	Annual - Fall	$1,000	Watershed Specialists, K-State Research and Extension, Kansas Rural Center, Conservation Districts, NRCS, KAWS, and WRAPS
		Referral Program provides information and referral to technical assistance individuals	Annual - Ongoing	$100	NRCS, Conservation Districts, KCARE and WRAPS
		BMP Auction (in targeted watersheds only)	Annual	$9,000	KSRE and Conservation Districts in the targeted areas
		Middle Kansas River Watershed and BMP brochures	Annual	$500	WRAPS

Table 37. **I&E: Middle Kansas River Watershed Education on Water Issues**

Watershed Issues Information and Education					
Issue (in order of priority to the SLT)	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs (annually)**	**Sponsor/Responsible Agency**
Bacteria	Watershed Landowners and Residents	Water Testing	Semi-Annually Four (4) locations	$2,000	Conservation District, KAWS, KDHE, and Mid America Regional Council (MARC)
Nutrient Management	Watershed Landowners and Residents	Onsite Visits - educate producers on various BMPs and assess their operation for possible BMP implementation.	Bi-Monthly	$300	Conservation Districts
Eutrophication	Watershed Landowners and Residents	Promote urban water quality BMPs	Annually	$500	Conservation Districts
Degraded Streams and Rivers	Watershed Landowners and Residents	Onsite Visits - educate producers on various BMPs and assess their operation for possible BMP implementation.	As needed	$500	Conservation District, KAWS, KDHE, MARC
Sediment/ Biology	Watershed Landowners and Residents	Sampling	Annually	$500	Conservation District, KAWS, KDHE, Kansas Forest Service
Flooding	City/County, Watershed Landowners and Residents	Onsite Visits - educate producers on various BMPs and assess their operation for possible BMP implementation.	Semi-Annually	$250	City, County Officials, Conservation Districts
Livestock Management and Grazing Lands	Watershed Landowners and Residents	Onsite Visits - educate producers on various BMPs and assess their operation for possible BMP implementation.	As needed	$500	Conservation Districts, Kansas Watershed Specialists
Source Water Protection	Public Water Systems in the Watershed	Kansas Rural Water Association will publicize the availability of technical assistance in the development and updating of source water plans.	Annually	No Cost	Kansas Rural Water Association
Water Quantity	Watershed Landowners and Residents	Promote drought BMPs for crop and livestock producers	As needed	$500	KAWS, Conservation Districts
Biological Items of Concern	Watershed Landowners and Residents	Promote BMPs that protect endangered species.	Annually	$250	Kansas Department of Wildlife and Parks (KDWP), U.S. Fish and Wildlife
Water Wells	Watershed Landowners and Residents	Onsite Visits - educate producers on various BMPs and assess their operation for possible BMP implementation.	As needed	$250	Conservation Districts
Total Cost (per year) for All Information and Education Activities				**$47,300**	

B. Evaluation of Information and Education Activities

All service providers conducting I&E activities funded through the Middle Kansas River WRAPS will be required to include an evaluation component in their project implementation proposals. Evaluation methods will vary based on the activity. All service providers will be required to submit a brief written evaluation of their I&E activity summarizing the activity's success in achieving the learning objectives, and how the activity contributed to achieving long-term WRAPS goals and/or objectives for pollutant load reductions.

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 or activity, development of a basic logic model identifying long-, medium-, and short-term behavior changes or other expected outcomes 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, usefulness of information, etc.;
- pre- and post-surveys to determine the amount of knowledge gained, anticipated behavior changes, need for further learning, etc.; and
- follow-up interviews (e.g., one-on-one contacts, phone calls, or e-mails) with selected participants to gather more in-depth input regarding the effectiveness of the I&E activity.

9. Cost of Implementing BMPs and Funding Sources

The SLT reviewed all the recommended BMPs listed in this WRAPS plan to address the Biology and *E. coli* TMDLs and determined which BMPs will receive implementation funding in cropland, streambank, and livestock areas. An added benefit is that most of the targeted BMPs will have positive impacts on other impairments in the Middle Kansas River Watershed, including the dissolved oxygen, eutrophication, and total phosphorus TMDLs. Below are the expenses before and after cost-share for implementing the scheduled BMPs (**Tables 38-43**). Costs can be shared with any potential funding sources (**Table 45**). Cost derivations are in the appendix.

A. Cropland BMP Implementation Costs

Table 38. Implementation Costs: Cropland BMPs Before Cost-Share

Year		Grassed Waterways	No-Till		Vegetative Buffers	Terraces	Sediment Basins			Wetlands	Tota
1	$409	$13,762	$14,602	$7,998	$2,336	$6,491	$2,285	$1,460	$1,460	$584	$51
2	$421	$14,175	$15,040	$8,238	$2,406	$6,685	$2,354	$1,504	$1,504	$602	$52
3	$434	$14,601	$15,491	$8,485	$2,479	$6,886	$2,424	$1,549	$1,549	$620	$54
4	$447	$15,039	$15,956	$8,740	$2,553	$7,092	$2,497	$1,596	$1,596	$638	$56
5	$460	$15,490	$16,435	$9,002	$2,630	$7,305	$2,572	$1,643	$1,643	$657	$57
6	$474	$15,954	$16,928	$9,272	$2,708	$7,524	$2,649	$1,693	$1,693	$677	$59
7	$488	$16,433	$17,436	$9,550	$2,790	$7,750	$2,729	$1,744	$1,744	$697	$61
8	$503	$16,926	$17,959	$9,837	$2,873	$7,983	$2,811	$1,796	$1,796	$718	$63
9	$518	$17,434	$18,497	$10,132	$2,960	$8,222	$2,895	$1,850	$1,850	$740	$65
10	$533	$17,957	$19,052	$10,436	$3,048	$8,469	$2,982	$1,905	$1,905	$762	$67
11	$549	$18,495	$19,624	$10,749	$3,140	$8,723	$3,071	$1,962	$1,962	$785	$69
12	$566	$19,050	$20,213	$11,071	$3,234	$8,984	$3,163	$2,021	$2,021	$809	$71
13	$583	$19,622	$20,819	$11,403	$3,331	$9,254	$3,258	$2,082	$2,082	$833	$73
14	$600	$20,211	$21,444	$11,745	$3,431	$9,532	$3,356	$2,144	$2,144	$858	$75
15	$618	$20,817	$22,087	$12,098	$3,534	$9,818	$3,457	$2,209	$2,209	$883	$77
16	$637	$21,441	$22,749	$12,461	$3,640	$10,112	$3,560	$2,275	$2,275	$910	$80
17	$656	$22,085	$23,432	$12,834	$3,749	$10,415	$3,667	$2,343	$2,343	$937	$82
18	$676	$22,747	$24,135	$13,219	$3,862	$10,728	$3,777	$2,413	$2,413	$965	$84
19	$696	$23,430	$24,859	$13,616	$3,977	$11,050	$3,890	$2,486	$2,486	$994	$87
20	$717	$24,132	$25,605	$14,025	$4,097	$11,381	$4,007	$2,560	$2,560	$1,024	$90
Total	**$10,986**	**$369,800**	**$392,361**	**$214,909**	**$62,778**	**$174,405**	**$61,405**	**$39,236**	**$39,236**	**$15,694**	**$1,38**

*3% Inflation

Table 39. Implementation Costs: Cropland BMPs After Cost-Share

Soldier Creek Annual Cost* After Cost-Share, Cropland BMPs											
Year	Permanent Vegetation	Grassed Waterways	No-Till	Cover Crops	Vegetative Buffers	Terraces	Sediment Basins	Planting Green	Companion Cropping	Wetlands	Total Cost
1	$123	$4,129	$4,381	$2,399	$701	$1,947	$686	$438	$438	$175	$15,416
2	$126	$4,253	$4,512	$2,471	$722	$2,006	$706	$451	$451	$180	$15,879
3	$130	$4,380	$4,647	$2,546	$744	$2,066	$727	$465	$465	$186	$16,355
4	$134	$4,512	$4,787	$2,622	$766	$2,128	$749	$479	$479	$191	$16,846
5	$138	$4,647	$4,930	$2,701	$789	$2,192	$772	$493	$493	$197	$17,351
6	$142	$4,786	$5,078	$2,782	$813	$2,257	$795	$508	$508	$203	$17,872
7	$146	$4,930	$5,231	$2,865	$837	$2,325	$819	$523	$523	$209	$18,408
8	$151	$5,078	$5,388	$2,951	$862	$2,395	$843	$539	$539	$216	$18,960
9	$155	$5,230	$5,549	$3,039	$888	$2,467	$868	$555	$555	$222	$19,529
10	$160	$5,387	$5,716	$3,131	$915	$2,541	$895	$572	$572	$229	$20,115
11	$165	$5,549	$5,887	$3,225	$942	$2,617	$921	$589	$589	$235	$20,718
12	$170	$5,715	$6,064	$3,321	$970	$2,695	$949	$606	$606	$243	$21,340
13	$175	$5,887	$6,246	$3,421	$999	$2,776	$977	$625	$625	$250	$21,980
14	$180	$6,063	$6,433	$3,524	$1,029	$2,859	$1,007	$643	$643	$257	$22,639
15	$186	$6,245	$6,626	$3,629	$1,060	$2,945	$1,037	$663	$663	$265	$23,319
16	$191	$6,432	$6,825	$3,738	$1,092	$3,034	$1,068	$682	$682	$273	$24,018
17	$197	$6,625	$7,030	$3,850	$1,125	$3,125	$1,100	$703	$703	$281	$24,739
18	$203	$6,824	$7,240	$3,966	$1,158	$3,218	$1,133	$724	$724	$290	$25,481
19	$209	$7,029	$7,458	$4,085	$1,193	$3,315	$1,167	$746	$746	$298	$26,245
20	$215	$7,240	$7,681	$4,207	$1,229	$3,414	$1,202	$768	$768	$307	$27,033
Total	**$3,296**	**$110,940**	**$117,708**	**$64,473**	**$18,833**	**$52,321**	**$18,421**	**$11,771**	**$11,771**	**$4,708**	**$414,243**
*3% Inflation											

B. Streambank Stabilization/Restoration Implementation Costs

Table 40. Implementation Costs: Streambank BMPs

Soldier Creek Annual Cost*, Streambank BMPs		
Year	**Streambank Stabilization (lf)**	**Cost***
1	500	$48,290
2	500	$49,739
3	500	$51,231
4	500	$52,768
5	500	$54,351
6	500	$55,981
7	500	$57,661
8	500	$59,391
9	500	$61,172
10	500	$63,007
11	500	$64,898
12	500	$66,845
13	500	$68,850
14	500	$70,915
15	500	$73,043
16	500	$75,234
17	500	$77,491
18	500	$79,816
19	500	$82,210
20	500	$84,677
Total		**$1,297,570**
**3% Inflation*		

C. Livestock BMP Implementation Costs

Table 41. Implementation Costs: Livestock BMPs Before Cost-Share

Rock Creek and Vermillioin Creek Implementation Cost* Before Cost-Share, Livestock BMPs						
Year	Alternative Watering System	Grazing Management Plan	Relocate Feedlot	Relocate Pasture Feeding Sites	Vegetative Filter Strips	Cumulative Annual Cost with Inflation
1	$0	$1,040	$0	$2,203	$800	$4,043
2	$5,000	$0	$10,000	$0	$0	$15,450
3	$0	$1,040	$0	$2,203	$800	$4,289
4	$5,000	$0	$10,000	$0	$0	$16,391
5	$0	$1,040	$0	$2,203	$800	$4,550
6	$5,000	$0	$10,000	$0	$0	$17,389
7	$0	$1,040	$0	$2,203	$800	$4,828
8	$5,000	$0	$10,000	$0	$0	$18,448
9	$0	$1,040	$0	$2,203	$800	$5,122
10	$5,000	$0	$10,000	$0	$0	$19,572
11	$0	$1,040	$0	$2,203	$800	$5,433
12	$5,000	$0	$10,000	$0	$0	$20,764
13	$0	$1,040	$0	$2,203	$800	$5,764
14	$5,000	$0	$10,000	$0	$0	$22,028
15	$0	$1,040	$0	$2,203	$800	$6,115
16	$5,000	$0	$10,000	$0	$0	$23,370
17	$0	$1,040	$0	$2,203	$800	$6,488
18	$5,000	$0	$10,000	$0	$0	$24,793
19	$0	$1,040	$0	$2,203	$800	$6,883
20	$5,000	$0	$10,000	$0	$0	$26,303
Total						**$258,022**
3% Inflation						

Table 42. Implementation Costs: Livestock BMPs After Cost-Share

Rock Creek and Vermillioin Creek Implementation Cost* After Cost-Share, Livestock BMPs						
Year	Alternative Watering System	Grazing Management Plan	Relocate Feedlot	Relocate Pasture Feeding Sites	Vegetative Filter Strips	Cumulative Annual Cost with Inflation
1	$0	$312	$0	$661	$240	$1,213
2	$1,500	$0	$3,000	$0	$0	$4,635
3	$0	$312	$0	$661	$240	$1,287
4	$1,500	$0	$3,000	$0	$0	$4,917
5	$0	$312	$0	$661	$240	$1,365
6	$1,500	$0	$3,000	$0	$0	$5,217
7	$0	$312	$0	$661	$240	$1,448
8	$1,500	$0	$3,000	$0	$0	$5,534
9	$0	$312	$0	$661	$240	$1,536
10	$1,500	$0	$3,000	$0	$0	$5,871
11	$0	$312	$0	$661	$240	$1,630
12	$1,500	$0	$3,000	$0	$0	$6,229
13	$0	$312	$0	$661	$240	$1,729
14	$1,500	$0	$3,000	$0	$0	$6,608
15	$0	$312	$0	$661	$240	$1,835
16	$1,500	$0	$3,000	$0	$0	$7,011
17	$0	$312	$0	$661	$240	$1,946
18	$1,500	$0	$3,000	$0	$0	$7,438
19	$0	$312	$0	$661	$240	$2,065
20	$1,500	$0	$3,000	$0	$0	$7,891
Total						**$77,407**
3% Inflation						

D. Total Costs for BMP Implementation and Education Activities

Table 43. Cost to Implement the Middle Kansas River WRAPS Plan

Total Annual WRAPS Cost after Cost-Share by BMP Category					
Year	Cropland	Streambank	Livestock	I&E	Total Annual Cost with Inflation*
1	$15,416	$48,290	$1,213	$47,300	$112,219
2	$15,879	$49,739	$4,635	$48,719	$118,972
3	$16,355	$51,231	$1,287	$50,181	$119,053
4	$16,846	$52,768	$4,917	$51,686	$126,217
5	$17,351	$54,351	$1,365	$53,237	$126,304
6	$17,872	$55,981	$5,217	$54,834	$133,904
7	$18,408	$57,661	$1,448	$56,479	$133,996
8	$18,960	$59,391	$5,534	$58,173	$142,058
9	$19,529	$61,172	$1,536	$59,918	$142,156
10	$20,115	$63,007	$5,871	$61,716	$150,710
11	$20,718	$64,898	$1,630	$63,567	$150,813
12	$21,340	$66,845	$6,229	$65,474	$159,888
13	$21,980	$68,850	$1,729	$67,438	$159,998
14	$22,639	$70,915	$6,608	$69,462	$169,625
15	$23,319	$73,043	$1,835	$71,545	$169,742
16	$24,018	$75,234	$7,011	$73,692	$179,955
17	$24,739	$77,491	$1,946	$75,903	$180,079
18	$25,481	$79,816	$7,438	$78,180	$190,914
19	$26,245	$82,210	$2,065	$80,525	$191,046
20	$27,033	$84,677	$7,891	$82,941	$202,541
Total					**$3,060,189**
3% Inflation					

10. Technical Assistance and Funding Sources

Technical assistance and various funding sources may be required to implement the BMPs and the watershed education programs listed in this WRAPS plan. Possible technical assistance providers and funding sources are presented in **Tables 44** and **45.**

Table 44. Potential Technical Assistance Providers for Plan Implementation

Croplan	Companion Cropping	Middle Kansas River WRAPS Coordina Division of Conservation: Geary, Jackson, Morris, Nemaha, Pottawaton Riley, Shawnee and Wabaunsee Cour Conservation Districts, Farm Servic Agency, Kansas Department of Wildl and Parks, Kansas Forest Service, Kansas Rural Water Association, KAV KSRE Watershed Specialists, NRCS, a the Glacial Hills Resource Conservati and Development (RC&D)
	Cover Crops	
	Grassed Waterways	
	No-till	
	Permanent Vegetation	
	Planting Green	
	Sediment Basin	
	Terraces	
	Vegetative Buffers	
	Wetlands	
Streamba	Stabilization/Restoration to possibly include:	
Livestoc	Alternative Watering System	
	Relocate Feeding Areas - outside priority areas/cover crops	

Table 45. Potential Funding Sources for Plan Implementation

Potential BMP Funding Sources	
Potential Funding Sources	**Potential Funding Programs**
Division of Conservation (DOC)	State Water Resources Cost Share Program (SWRCSP)
	Streambank Restoration funds
	Riparian and Wetland Protection Program (RWPP)
	Landowner incentive funds for streambank restoration projects
	Conservation Districts Non-point Source Pollution Funds (NPS)
Environmental Protection Agency (EPA) and the Kansas Department of Health and Environment (KDHE)	Section 319 Clean Water Act funds
	State Revolving Fund (SRF)
	WRAPS Grants
Kansas Department of Wildlife and Parks (KDWP)	Partnering for Wildlife
	Wildlife Habitat Incentive Program (WHIP) Habitat First Program
Kansas Forest Service	Rural Forestry Program
	Forestland Enhancement Program (FLEP)
Kansas Rural Water Association	Kansas Public Water Supply Loan Fund
Kansas State University, Research & Extension	Varies
Pheasants Forever, Quail Forever and other private entities	Varies
United States Department of Agriculture (USDA): Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA)	Environmental Quality Incentives Program (EQIP)
	Conservation Reserve Program (CRP)
	Continuous Conservation Reserve Program (CCRP)
	Wetland Reserve Program (WRP)
	Wildlife Habitat Incentive Program (WHIP)
	Forestland Enhancement Program (FLEP)
	State Acres for Wildlife Enhancement (SAFE)
	Grassland Reserve Program (GRP)
	Farmable Wetlands Program (FWP)

11. Measurable Milestones

The interim timeframe for all BMP implementation is 20 years from the date of publication of this report. Targeting and BMP implementation may shift over time to achieve TMDLs.

The estimated timeframe for reaching the sediment load reduction goal to address the **Biology TMDL** in the Middle Kansas River Watershed will be in year 17 of this WRAPS plan. The ***E. coli* TMDL** will be assumed to have significantly improved by year 20 of this plan. Reductions in nutrients from implemented livestock BMPs serve as evidence that positive impacts have been made toward *E. coli* bacteria loading. After these load reduction goals are achieved, the process will become one of protection rather than restoration.

Although phosphorus and nitrogen load reductions are not a priority in this plan, both will be reduced through the BMP implementation efforts designed to reduce both sediment and bacteria loading. Reductions in phosphorus and nitrogen will improve water quality throughout the watershed by positively impacting the biology, dissolved oxygen, eutrophication, and total phosphorus impairments found throughout the Middle Kansas River Watershed.

A. Measurable Milestones for BMP Implementation

Milestones will be determined at the end of the 20-year plan by number of acres treated, projects installed, contacts made to watershed residents and water quality parameters(**Tables 46-48**). The SLT will examine these criteria to determine if adequate progress has been made on BMP implementations to date. If they determine that adequate progress has not been made, they will readjust the implementation projects to achieve the TMDL, given another 5- to 10-year timeframe.

Table 46. Cropland BMP Implementation Milestones

Soldier Creek Annual Adoption (treated acres), Cropland BMPs												
	Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Adoption
Short-Term	1	37	200	95	365	7	37	7	51	146	7	952
	2	37	200	95	365	7	37	7	51	146	7	952
	3	37	200	95	365	7	37	7	51	146	7	952
	4	37	200	95	365	7	37	7	51	146	7	952
	5	37	200	95	365	7	37	7	51	146	7	952
Total		*183*	*1,000*	*475*	*1,825*	*37*	*183*	*37*	*256*	*730*	*37*	*4,760*
Medium-Term	6	37	200	95	365	7	37	7	51	146	7	952
	7	37	200	95	365	7	37	7	51	146	7	952
	8	37	200	95	365	7	37	7	51	146	7	952
	9	37	200	95	365	7	37	7	51	146	7	952
	10	37	200	95	365	7	37	7	51	146	7	952
Total		*365*	*2,000*	*949*	*3,651*	*73*	*365*	*73*	*511*	*1,460*	*73*	*9,520*
Long-Term	11	37	200	95	365	7	37	7	51	146	7	952
	12	37	200	95	365	7	37	7	51	146	7	952
	13	37	200	95	365	7	37	7	51	146	7	952
	14	37	200	95	365	7	37	7	51	146	7	952
	15	37	200	95	365	7	37	7	51	146	7	952
	16	37	200	95	365	7	37	7	51	146	7	952
	17	37	200	95	365	7	37	7	51	146	7	952
	18	37	200	95	365	7	37	7	51	146	7	952
	19	37	200	95	365	7	37	7	51	146	7	952
	20	37	200	95	365	7	37	7	51	146	7	952
Total		*730*	*3,999*	*1,898*	*7,301*	*146*	*730*	*146*	*1,022*	*2,920*	*146*	*19,039*

Table 47. Streambank Stabilization/Restoration Implementation Milestones

Soldier Creek Implementation Milestones (treated linear feet), Streambank BMPs		
	Year	Streambank Stabilization (lf) Total Adoption
Short-Term	1	500
	2	500
	3	500
	4	500
	5	500
Total		*2,500*
Medium-Term	6	500
	7	500
	8	500
	9	500
	10	500
Total		*5,000*
Long-Term	11	500
	12	500
	13	500
	14	500
	15	500
	16	500
	17	500
	18	500
	19	500
	20	500
Total		*10,000*

Table 48. Livestock BMP Implementation Milestones

Rock Creek and Vermillion Creek Implementation Milestones (projects), Livestock BMPs							
	Year	Alternative Watering System	Grazing Management Plan	Relocate Feedlot	Relocate Pasture Feeding Sites	Vegetative Filter Strips	Total Adoption Projects Per Year
Short-Term	1	0	1	0	1	1	3
	2	1	0	1	0	0	2
	3	0	1	0	1	1	3
	4	1	0	1	0	0	2
	5	0	1	0	1	1	3
Total		*2*	*3*	*2*	*3*	*3*	*13*
Medium-Term	6	1	0	1	0	0	2
	7	0	1	0	1	1	3
	8	1	0	1	0	0	2
	9	0	1	0	1	1	3
	10	1	0	1	0	0	2
Total		*5*	*5*	*5*	*5*	*5*	*25*
Long-Term	11	0	1	0	1	1	3
	12	1	0	1	0	0	2
	13	0	1	0	1	1	3
	14	1	0	1	0	0	2
	15	0	1	0	1	1	3
	16	1	0	1	0	0	2
	17	0	1	0	1	1	3
	18	1	0	1	0	0	2
	19	0	1	0	1	1	3
	20	1	0	1	0	0	2
Total		*10*	*10*	*10*	*10*	*10*	*50*

B. Benchmarks to Measure Water Quality and Social Progress

The goal of this WRAPS plan is that in the next 20-year time frame, the Middle Kansas River Watershed will see improved water quality throughout the watershed, specifically reduced sediment (TSS), and *E. coli* bacteria.

After reviewing the criteria listed in **Table 49**, the SLT will assess and revise the overall strategy for the watershed in five years. New goals will be set and new BMPs will be implemented to achieve improved water quality. KDHE TMDL staff, Water Plan staff and the SLT will coordinate every five years to discuss benchmarks and TMDL updates. Using data obtained by KDHE, the following indicator and parameter criteria shall be used to assess progress toward successful implementation to abate pollutant loads.

Table 49. Middle Kansas River Watershed Benchmarks to Measure Progress

Benchmarks to Measure Water Quality Progress		
Impairment Addressed	**Criteria to Measure Water Quality Progress**	**Information Source**
Biology	Maintain median TSS below 50 ppm. Average EPT count of 48% or greater. 50% of MBI values through the monitoring period are less than 4.5, and that no sample has an MBI value greater than 5.	KDHE
E.. Coli	The ultimate endpoint of this TMDL will be to achieve the Kansas Water Quality Standards and support primary recreation on Rock and Vermillion Creeks. This requires geometric means of 5 samples taken within a 30-day period to be below the applicable criterion of 427 counts during April to October.	KDHE
Impairment Addressed	**Social Indicators to Measure Water Quality Progress**	**Information Source**
Biology and *E. coli*	Taste and odor issues in public water supply drawn from Middle Kansas River Watershed water segments.	KDHE, KSRE, NRCS, DOC
	Survey of water quality issues to determine whether information and education programs are having an effect on public perception.	
	Number of attendees at field days and tours.	
	Number of BMP acres and projects implemented in the targeted areas.	

C. Water Quality Milestones Used to Determine Improvements

The goal of the Middle Kansas River WRAPS plan is to restore water quality for uses that support aquatic life, primary-contact recreation, and public water supply for the watershed. This restoration plan specifically addresses the high-priority Biology ad *E. coli* TMDLs. To reach load reduction goals, a BMP implementation schedule spanning 20 years has been developed. Water quality milestones are established to measure water quality improvements within the watershed due to plan implementation.

The BMPs included in this plan will be implemented in targeted areas as laid out in **Sections 5 and 6** of this WRAPS plan. With these targeted areas in place, BMP implementation will result in positive impacts on water quality and impairment listings throughout the watershed.

D. Water Quality Milestones for the Middle Kansas River Watershed

The Middle Kansas River Watershed has Biology and *E. coli* TMDLs addressed by this WRAPS plan. Milestones for each TMDL are determined by set parameters designed to meet long-term goals to indicate the success of this WRAPS plan.

1. **Water quality milestones for Biology**

   There is a high-priority Biology impairment in the Middle Kansas River Watershed, located in Soldier Creek, Soldier Creek near Circleville, and Soldier Creek near Delia. Cropland and streambank BMPs implemented will reduce sediment/total suspended solids (TSS) and subsequently nutrients, specifically phosphorus, and this will improve water quality in those water segments as well as those into which they flow.

   According to KDHE on August 23, 2022, the WRAPS plan has met the water quality long-term goal of median TSS < 50 ppm. However, the biology TMDL indicates that there are still issues attributed to high sediment, therefore, a TSS water quality goal would be to maintain median TSS below 50 ppm.

   In addition to maintaining a median TSS < 50 ppm, concurrent biological sampling in Solider Creek should show improvements in the macroinvertebrates index scores over the same period. The Macroinvertebrate Biotic Index (MBI) is a biological monitoring metric that can be used to assess compliance with water quality standards. The MBI values can be used to determine the extent to which the monitored water body can support aquatic life as follows:

   MBI $\leq$ 4.5 fully supports aquatic life
   MBI 4.5 to < 5.4 partially supports aquatic life
   MBI $\geq$ 5.4 does not support aquatic life

   Based on the biological data collected and sampled from 1985 to 2020, the MBI values average 4.97. Of the samples taken during the referenced period of record, 29% had MBI values below 4.5. Of the more recent samples taken from 2017 to 2020, 100% had MBI values greater than 5. The end goal for Soldier Creek is for the average MBI to be less than 4.5. An indication of water quality progress would be that at least 50% of MBI values through the monitoring period are less than 4.5, and that no sample has an MBI value greater than 5.

2. **Water quality milestones for *E. coli***

   The Middle Kansas River has three high-priority *E. coli* TMDLs in Rock Creek near Louisville, Vermillion Creek near Louisville, and Vermillion Creek near Onaga. Livestock BMP implementation will result in nutrient load reductions and will aid in reducing *E. coli* bacteria in these water segments as well as the rivers into which they feed.

   The *E. coli* values are expressed as a percentile meeting water quality standards (WQS). This is based on an index of the natural log of samples, divided by the natural log of 427, which represents the water quality standard (WQS). According to KDHE, while the "end goal" of achieving 90% of samples within the WQS isn't enough to initiate a delisting, it would be sufficient to justify doing the intensive sampling that is required to obtain a delisting. The desired WQS can be found in **Table 50**.

Table 50. Middle Kansas River Water Quality Milestones: E. coli[27]

Sampling Site	Past Condition (2001-2011)	Current Condition (2012-2021)	Near Term Goal	End Goal
Rock Creek	74	86	88	90
Vermillion Creek	80	80	85	90
Values are % of *E. coli* samples attaining Water Quality Standard criteria at time of sampling.				

[27] Provided by KDHE on September 7, 2022.

12. Monitoring Water Quality

KDHE continues to monitor water quality in the Middle Kansas River Watershed by maintaining the monitoring stations located within the watershed. **Figures 27** and **28** illustrate the locations of the monitoring sites within the Middle Kansas River Watershed as well as the BMP-targeted areas identified and discussed in previous sections of this plan.

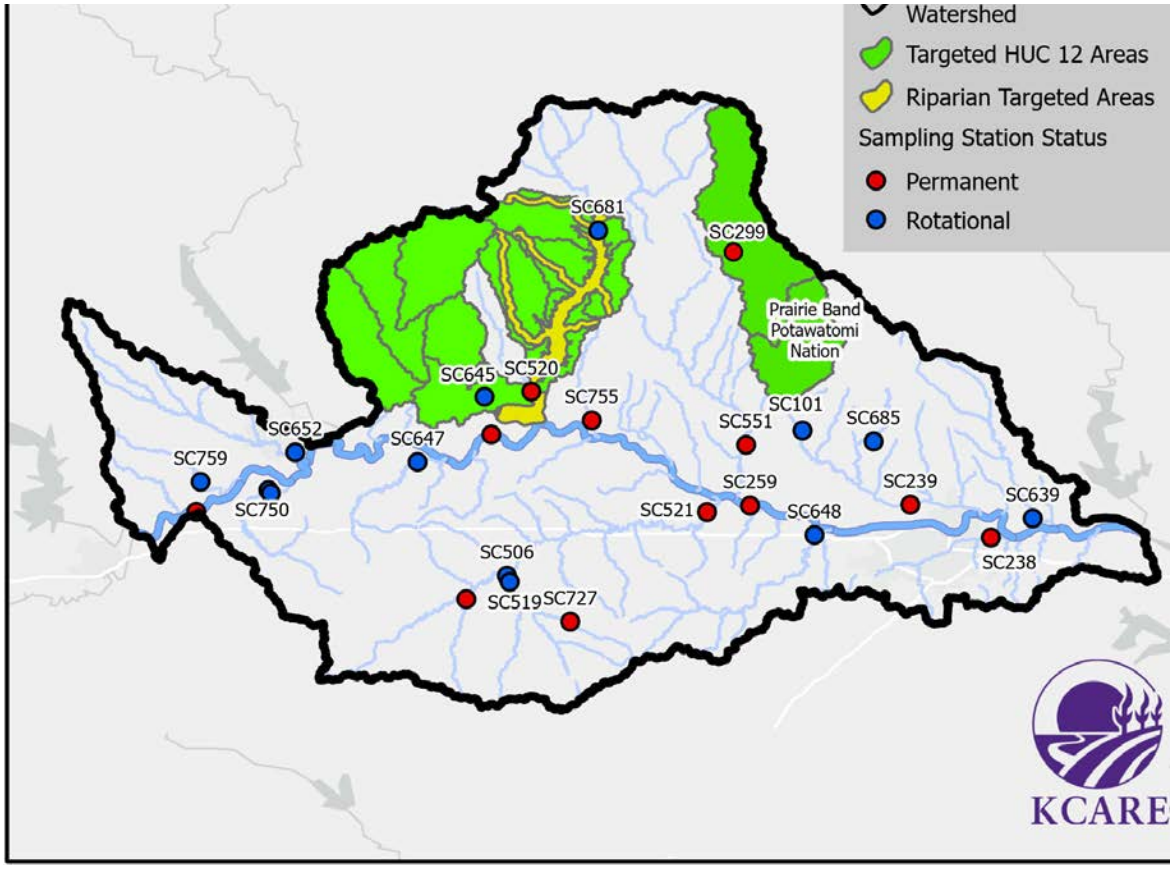


Figure 27. Stream Monitoring Sites and Targeted Areas

KDHE continues to monitor water quality in the Middle Kansas River Watershed by maintaining 25 stream chemistry stations and 26 lake monitoring stations. Twelve of these monitoring sites are permanent and include:

- SC238
- SC239
- SC259
- SC260
- SC299 – Soldier Creek and Soldier Creek near Circleville
- SC518
- SC520 – Vermillion Creek near Louisville

- SC521
- SC551
- SC726
- SC727
- SC755

Thirteen of the KDHE stream chemistry stations in the watershed will continue to be sampled on a rotational basis every four years. These stations are sampled on a quarterly basis during the sampling year; the next scheduled sampling year for the rotational stations is in 2025. These sites include:

- SC101 – Soldier Creek near Delia
- SC506
- SC519
- SC639
- SC645 – Rock Creek near Louisville
- SC646
- SC647
- SC648
- SC652
- SC681 – Vermillion Creek near Onaga
- SC685
- SC750
- SC759

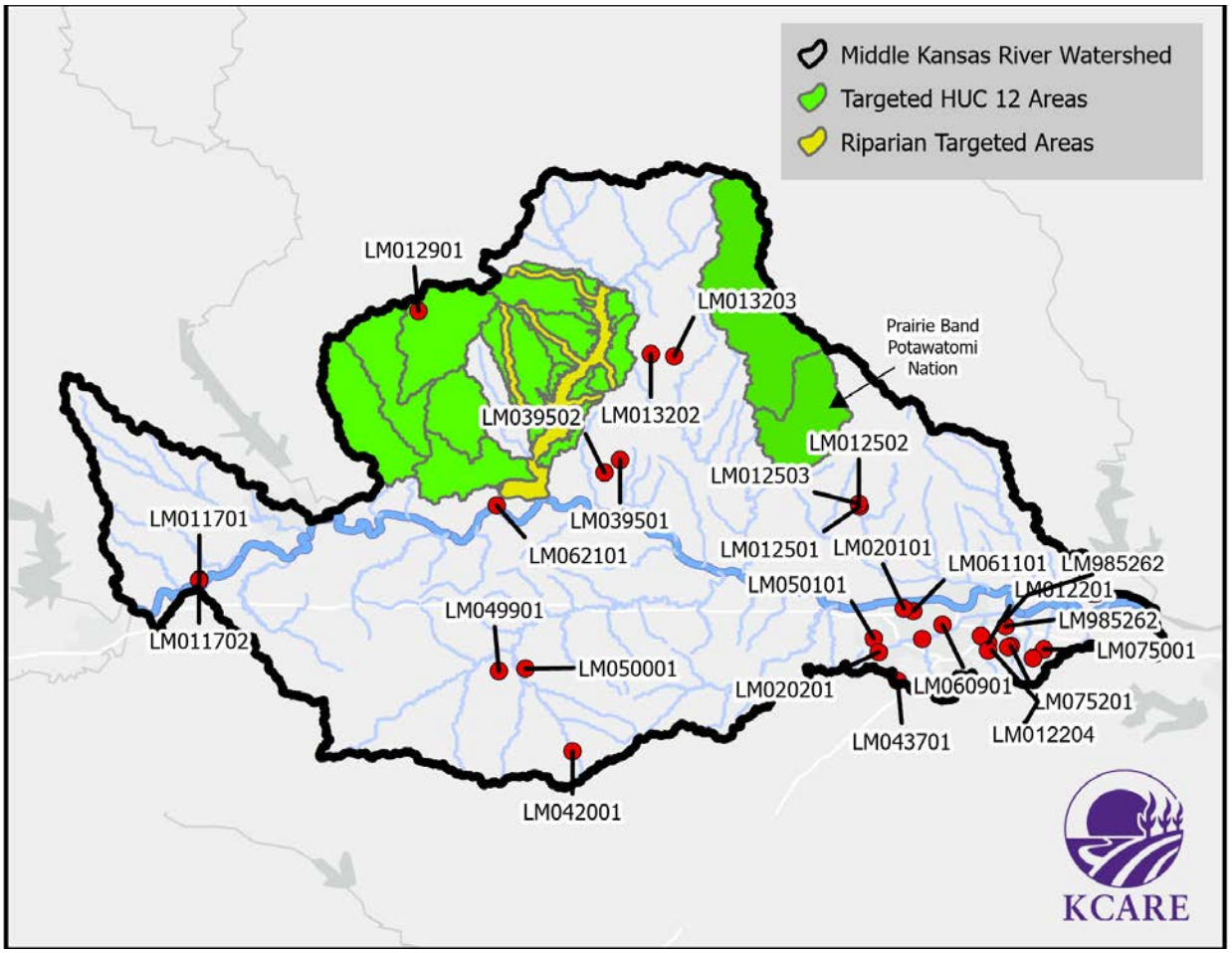


Figure 28. Lake Monitoring Sites and Targeted Areas

The 26 KDHE lake monitoring stations will be sampled every three years with the next sampling year scheduled for 2025. These sites are found at the following locations:

- LM011701
- LM011702
- LM012201
- LM012204
- LM012501
- LM012502
- LM012503
- LM012901
- LM013202
- LM013203
- LM020101
- LM020201
- LM039501
- LM039502
- LM042001
- LM043701
- LM049901
- LM050001
- LM050101
- LM060901
- LM061101
- LM062001
- LM062101
- LM075001
- LM075201
- LM985262

Typically, monitoring takes place May through September. Monitoring sites are sampled for nutrients, bacteria, chemicals, turbidity, alkalinity, DO, pH, ammonia, and metals, with the

addition of chlorophyll *a* measurements. The pollutant indicators tested for each site may vary depending on the season at collection time and other factors. Sampling data include temperature, conductivity, and Secchi disc depth. The SLT will request that KDHE reviews analyzed data from all monitoring sources on an annual basis, with data collected in the targeted HUC 12s of special interest. Monitoring data will be used to direct the SLT in their evaluation of water quality progress.

Monitoring data in the Middle Kansas River Watershed will be used to determine water quality progress, to track water quality milestones, and to determine the effectiveness of the BMP implementation outlined in this plan. The review schedule for the monitoring data will be tied to the water quality milestones developed in the Middle Kansas River Watershed, as well as the sampling frequency of the sampling data.

The BMP implementation schedule and water quality milestones for the Middle Kansas River Watershed extend through a 20-year period from 2023-2043. During that period, KDHE will continue to analyze and to evaluate the collected monitoring data.

After the first five years of monitoring and BMP implementation, KDHE will evaluate the available water quality data to determine whether the water quality milestones have been achieved. KDHE and the SLT can address any necessary modifications or revisions to the plan based on data analysis. At the end of this plan in 2043, a determination will be made as to whether the water quality standards have been attained or if the plan needs to be extended.

In addition to the planned review of the monitoring data and water quality milestones, KDHE and the SLT may revisit this plan in shorter increments. This allows KDHE and the SLT to evaluate newly available information, to incorporate revisions to applicable TMDLs, or to address potential water quality indicators that might trigger an immediate review.

13. Review of the WRAPS Plan

In the year 2027, this WRAPS plan will be reviewed and revised according to results from monitoring data. At this time, the SLT will review the criteria listed below, in addition to any other concerns that may occur at this plan's future review.

The SLT will request the following reports on the milestone achievements for Biology and *E. coli* load reductions and water quality improvements.

- KDHE will report on current and desired endpoints for water quality in the Middle Kansas River Watershed regarding the **Biology TMDL**. Improvements regarding the Biology TMDL will be measured by sediment/TSS load reductions. The sediment goal was a reduction of 18,400 tons, which is a 66% load reduction. If the plan is implemented as structured, the sediment goal should be met in year 20 of this WRAPS plan. Other conditions expected in relation to the Biology TMDL include:
    1. Maintain TSS median < 50 ppm,
    2. Average EPT count of 48% or greater,
    3. 50% of MBI values through the monitoring period are less than 4.5, and
    4. No sample has an MBI value greater than 5.

- KDHE will report on current and desired endpoints for water quality in the Middle Kanas River Watershed regarding the ***E. coli* TMDL.** The goal is to achieve Kansas Water Quality Standards and to support primary recreation on Rock and Vermillion Creeks by the end of this 20-year plan. Other conditions expected in relation to the *E. coli* TMDL include:
    1. Geometric means of five samples taken within a 30-day period to be below 427 counts during April to October.
    2. Two separate years with four intensive samplings each for geometric mean.

- KDHE will report on other TMDLs, including possible nutrient and sediment criteria, revised load allocations pertaining to the Biology and *E. coli* TMDLs, and new wasteload allocations defined for point sources.

- KDHE will report on trends in water quality in the Kansas River and throughout the Middle Kansas River Watershed.

In turn, the SLT will provide various reports when necessary. These include:

- Progress toward achieving the benchmarks listed in this report;
- Progress toward achieving the BMP adoption rates in this report; and
- Discussion of necessary adjustments and revisions needed for the targets in this plan.

14. Appendix

A. Potential Service Providers

Table 51. Service Provider List

Organization	Programs	Purpose	Technical or Financial Assistar	Website Addı
Kansas Depa of Health Environment	* Watershed Restoration and Protectic Strategy (WRAPS) * State Revolving Fund * Nonpoint Source Pollution Progran * Watershed Management Programs * National Pollutant Discharge Elimination System (NPDES) Program * Livestock operation certification an permitting * Local Environmental Protection Progr (LEPP)	Funding for programs to reduce nonpoint source pollution. Funding for local watershed projects and coordination (WRAPS). Low cost and "forgivable" loans for BMPs and green infrastructure projects. Compliance monitoring.	Technical and Financial	www.kdheks.g
Kansas Fo Service (K	*Forest Stewardship Program * Rural Forestry Program * Riparian Forestry Programs	Assist private landowners with the management of woodlands and windbreaks through education, planning and on-site assistance from professional foresters.	Technical and Financial	www.kansasfores
Kansas Depa of Wildlife & (KDWP)	* Wildlife Habitat Improvement Progra * Walk-in Hunting Program * North American Waterfowl Conservati Act * Work with non-profits such as Ducl Unlimited, Pheasants Forever and oth state and federal agencies to promote wildlife habitat	enforcement, and state parks in Kansas. Also works with nongame, threatened and endangered species programs. Educational programs and landowner assistance to promote enhanced wildlife habitat. Manage lands associated with state parks, wetlands and other conservation areas.	Technical and Financial	ksoutdoors.c
Kansas Rural (KRC)	* Clean Water Farms Project * Grazing Management	KRC is a non-profit, non-governmental organization organized in 1979 to promote long-term health of the land and its people through research, education, and advocacy; KRC promotes family	Technical and Financial	www.kansasrural .org
Kansas St Research Extension (I	* Watershed Specialist Program * County Extension Offices * Kansas Public Healthy Ecosystems * Healthy Communities Program * Citizen Science Kansas Center for Ag Resources and	Provide education, information and technical assistance to build awareness of water quality issues, identify sources of water quality, impairment and demonstrate, promote and implement BMPs for water quality improvement and	Technical	www.ksre.ksu.
Kansas Asso for Conservat and Environme Educatic (KACEE	* Facilitation and Educational Worksho related to Environmental Education.	KACEE is a non-profit, non-governmental organization that promotes and provides non-biased and science-based environmental education.	Technical	www.kacee.o

Service Provider List, Continued

Organization	Programs	Purpose	Technical or Financial Assistance	Website Address
Natural Resources Conservation Service (NRCS)	* Environmental Quality Incentive Program (EQIP) * Conservation Planning and Compliance Program * Multiple USDA Conservation Programs administered directly by NRCS or in partnership with the Farm Service Agency such as CRP, WRP and others.	NRCS is a Federal agency that works in partnership with the landowners to benefit the soil, water, air, plants, and animals for productive lands and healthy ecosystems through conservation planning and assistance. NRCS maintains field offices at USDA Service Centers in nearly every county in Kansas.	Technical and Financial	www.nrcs.usda.gov
Northeast Kansas Environmental Services (NEKES)	* Wastewater Management Program * Local Environmental Protection Program * Enforcement of state laws and sanitary codes especially as related to on-site wastewater, private wells and waste disposal issues.	NEKES is an environmental coalition of five county governments in Northeast Kansas that provides enforcement of local, state and federal laws, regulations and codes that address environmental issues in the affiliated counties. The counties are Atchison, Brown, Doniphan, Jackson and Nemaha. NEKES reports to the five County Commissions and is administrated by the Directors of the five County Health Departments.	Technical	www.nekes.org
County Conservation Districts (CCD)	* State Water Resources Cost Share Program * Nonpoint Source Pollution Programs * Works with local NRCS field office staff, FSA and other conservation agencies.	CDs are the primary local unit of government responsible for the conservation of soil, water, and related natural resources within a county's boundary; they are political subdivisions of state government utilizing funding from county and state allocations co-located with the local NRCS field office.	Technical and Financial * Douglas CCD: (785) 843-4260 * Geary CCD (785) 238-4251 * Jackson CCD (785) 364-3329 * Jefferson CCD: (785) 863-2201 * Morris CCD: (620) 767-5111 * Nemaha CCD: (785) 336-2186 *Pottawatomie CCD: (785) 457-3398 * Riley CCD: (785) 537-8764 * Shawnee CCD: (785) 338-9946 * Wabaunsee CCD: (785) 765-3836	https://agriculture.ks.gov/divisions-programs/division-of-conservation/doc-home
Division of Conservation (DOC)	* Aid to CDs * Water Resources Cost Share Program * Non-Point Source Pollution Control Program * Riparian and Wetland Protection Program * Kansas Water Quality Buffer Initiative * Watershed Dam Program * Multipurpose Small Lakes Program * Other Water Supply/Rights Programs	The DOC works with 105 local conservation districts, 88 organized watershed districts, other special purpose districts, and state and federal agencies to administer programs to improve water quality, reduce soil erosion, conserve water, reduce flooding and provide local water supply. The SCC has responsibility to administer the Conservation Districts Law, the Watershed District Act and other statutes.	Technical and Financial	https://agriculture.ks.gov/divisions-programs/division-of-conservation/doc-home
Kansas Water Office (KWO)	*Water planning, policy, coordination and marketing for the state	KWO coordinates the Kansas water planning process in cooperation with the Kansas Water Authority (KWA). KWA's 24 members include representatives from diverse water use interest groups and leaders of the state's natural resource agencies. Advice on policy development comes from Basin Advisory Committees (BACs) in each of the state's 12 river basins and other local stakeholders. KWA in turn advises the Governor and Legislature on water issues to be considered for policy enactment.	Technical	www.kwo.org
Kansas Rural Water Association (KRWA)	*Assist public water supplies with Source Water Protection Planning *Educate system operators	Provide leadership, education, and technical assistance to public water and wastewater utilities.	Technical	www.krwa.net
No-till on the Plains	*Field days, workshops, technical consulting	A non-profit educational organization providing information to farmers on adopting no-till and other sustainable production methods	Technical	www.notill.org
U.S. Geological Survey (USGS)	* WaterWatch (streamflow conditions) * National Streamflow Information Program * Flood Inundation and mapping * Groundwater Resources Program * National Water Quality Assessment Program	Scientific organization that provides stream flow data and conducts research related to water resources	Technical	www.usgs.gov
U.S. Army Corps of Engineers (USACE)	* Water Quality Program * Reservoir Management	Manages federal reservoirs in Kansas and operates a water quality program	Technical	www.usace.army.mil

B. BMP Definitions

1. Cropland BMPs

a. Companion cropping

- Companion cropping is the establishment of two or more plant species in proximity for some cultural benefit (such as pest control or higher yield). The concept embraces several strategies that increase the biodiversity of agroecosystems.
- Companion cropping can also improve soil health.
- Similar to cover crops and therefore likely to have a 40% erosion, 25% nitrogen, and 50% phosphorus reduction efficiency.

b. Cover crops

- A cover crop is a crop of a specific plant grown primarily for the benefit of the soil rather than the crop yield.
- Cover crops commonly are used to suppress weeds, manage soil erosion, help build and improve soil fertility and quality, and control diseases and pests.
- Cover crops are typically grasses or legumes but may be comprised of other green plants.
- Cover crops can reduce erosion from wind and water, sequester carbon in plant biomass and soils to increase soil organic matter content, capture and recycle excess nutrients in the soil profile, promote biological nitrogen fixation, increase biodiversity, promote weed suppression, provide supplemental forage, promote soil moisture management, and reduce particulate emissions into the atmosphere.
- Cover crops have a 40% erosion, 25% nitrogen, and 50% phosphorus reduction efficiency.

c. Grassed waterways

- Grassed waterways are defined as a grassed strip used as an outlet to prevent silt and gully formation.
- They can also be used as outlets for water from terraces.
- On average for Kansas fields, a one-acre waterway will treat 10 acres of cropland.
- Grassed waterways have a 10-year lifespan, with 40% erosion, 40% nitrogen, and a 40% phosphorus reduction efficiency.

d. No-till

- No-till is a management system in which other methods are used for weed control and seedbed preparation.
- In a 100% no-till system, the soil surface is never disturbed, except for planting or drilling operations; this maintains nutrient levels and aids in preventing nutrients from leaving the field due to runoff events.
- This system has a 40% erosion, 25% nitrogen, and 50% phosphorous reduction efficiency.

e. Permanent vegetation

- Establishing permanent vegetation on sites that have or are expected to have high erosion rates, and on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation using normal practices.
- Establishing permanent vegetation can stabilize areas with existing or expected high rates of soil erosion by water and wind.
- Has a reduction efficiency of 95% for erosion, 95% for nitrogen, and 95% for phosphorus.

f. Planting green

- Planting green is where cash crops are planted into living cover crops instead of the more common practice of planting into desiccated cover crops killed with an herbicide a week or more beforehand.
- Planting green allows for a living root year round so it is similar to establishing permanent vegetation.
- Has a reduction efficiency of 40% for erosion, 25% for nitrogen, and 50% for phosphorus.

g. Sediment basins

- Sediment basins act as a water impoundment, made by constructing an earthen dam that traps sediment and nutrients from leaving the edge of a field.
- They may include grade stabilization structures that control runoff and prevent gully erosion.
- They also provide a source of water.
- 30% erosion, and 30% phosphorus reduction efficiency.

h. Terraces

- Terraces are earth embankments and/or channels constructed across the slope to intercept runoff water and trap soil.
- They are one of the oldest/most common BMPs.
- Terraces have a 10-year lifespan, with 30% erosion, 30% nitrogen, and a 30% phosphorus reduction efficiency.

i. Vegetative buffers

- Vegetative buffers are areas of a 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, a one-acre buffer treats 15 acres of cropland, and they have a 50% erosion, 50% nitrogen, and a 50% phosphorus reduction efficiency.

j. Wetlands

- Creating a wetland where water covers the soil or is present at the surface of the soil all year or for varying periods of the year, including the growing season.
- One acre of wetland will treat 15 acres of cropland, on average.
- 30% erosion and P reduction efficiency.

2. Streambank BMPs

- Some streambank BMPs that may be used are soil-bioengineering, weirs, vanes, and longitudinal peak stone toes.
- Reduction efficiencies for sediment and phosphorus greatly depend on soil type, the amount of soil saved based on the size (length and height of streambank) of the project, and erodibility.

3. Livestock BMPs

a. Alternate watering system

- These are watering systems designed so that livestock do not enter a stream or body of water to drink.
- Studies show cattle will drink from tank over a stream or pond 80% of the time.
- These systems have a 10- to 25-year lifespan.
- 85% phosphorus reduction efficiency and greater efficiencies with limited stream access.

b. Grazing management plan

- Grazing management plans are designed to avoid over-grazing of pastures and improved grazing distribution.
- 25% phosphorus reduction efficiency.

c. Relocate feedlots

- Moving feedlot locations or pens away from a stream, waterway, or body of water to increase waste removal and filtration of manure.
- 100% phosphorus reduction efficiency.

d. Relocate pasture feeding sites

- Moving feeding sites in a pasture away from a stream, waterway, or body of water to increase the filtration and waste removal (e.g., move bale feeders away from the stream).
- Relocation can be outside of the targeted area and can incorporate cover crops. In the case of this plan, livestock will be removed away from streams and priority water segments.
- 70% phosphorus reduction efficiency.

e. Vegetative filter strips

- A vegetated area that receives runoff during rainfall from an animal feeding operation.

- This practice often requires a land area equal to or more than the drainage area (i.e., as large as the feedlot).
- Vegetative filter strips have a 10-year lifespan and require periodic mowing or haying.
- 50% phosphorus reduction efficiency.

C. BMP Budget Derivations[28]

Summarized derivation of cropland BMP cost estimates

- Companion cropping: $40 per treated acre with 70% cost share.
- Cover crops: $40 per treated acre with 70% cost share.
- Grassed waterways: $145 per treated acre with 70% cost share.
- No-till: $40 per treated acre with 70% cost share.
- Permanent vegetation: $56 per treated acre with 70% cost share.
- Planting green: $40 per treated acre with 70% cost share.
- Sediment basins: $313 per treated acre with 70% cost share.
- Terraces: $127 per treated acre with 70% cost share.
- Vegetative buffers: $16 per treated acre with 70% cost share.
- Wetlands: $80 per treated acre with 70% cost share.

Summarized derivation of streambank BMP cost estimates

A 2009 study conducted by Kansas State University agricultural economists calculated that streambank stabilization costs an average of $96.58 per linear foot, including all engineering and design costs. Sites are extremely variable.

[28] All cost derivations were calculated using rates effective in September 2022 in combination with figures provided by the WRAPS coordinator.

Summarized derivation of livestock BMP cost estimates

- Alternate watering system: $5,000 per unit with 70% cost-share.
- Grazing management plan: $1,040 per plan with 70% cost-share.
- Relocate feedlots: $10,000 with 70% cost share. Cost includes fencing, new watering system, concrete, and labor.
- Relocate pasture feeding areas: $2,203 with 70% cost-share. Cost includes fencing, new watering system, concrete, and labor.
- Vegetative filter strips: $800 with 70% cost-share. Cost includes building ¼ mile of fence, a permeable surface, and labor.

D. 20-year Project Tables by Sub-watershed

Cropland areas will be targeted for sediment load reductions to address the high-priority Biology TMDL in the Middle Kansas River Watershed, specifically the Soldier Creek sub-watershed. While nutrients are not a targeted impairment of this plan, they will be positively impacted by sediment BMP implementation in cropland areas. Cropland BMPs will take place in the following three HUC 12s:

- 102701020801
- 102701020802
- 102701020803

Below are the sub-watershed adoption/implementation, load reduction, and costs tables for each HUC 12.

1. Cropland BMP implementation in the Middle Kansas River Watershed

Sub-watershed #801 Annual Adoption (treated acres), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Adoption
1	19	67	51	195	4	19	4	27	78	4	468
2	19	67	51	195	4	19	4	27	78	4	468
3	19	67	51	195	4	19	4	27	78	4	468
4	19	67	51	195	4	19	4	27	78	4	468
5	19	67	51	195	4	19	4	27	78	4	468
6	19	67	51	195	4	19	4	27	78	4	468
7	19	67	51	195	4	19	4	27	78	4	468
8	19	67	51	195	4	19	4	27	78	4	468
9	19	67	51	195	4	19	4	27	78	4	468
10	19	67	51	195	4	19	4	27	78	4	468
11	19	67	51	195	4	19	4	27	78	4	468
12	19	67	51	195	4	19	4	27	78	4	468
13	19	67	51	195	4	19	4	27	78	4	468
14	19	67	51	195	4	19	4	27	78	4	468
15	19	67	51	195	4	19	4	27	78	4	468
16	19	67	51	195	4	19	4	27	78	4	468
17	19	67	51	195	4	19	4	27	78	4	468
18	19	67	51	195	4	19	4	27	78	4	468
19	19	67	51	195	4	19	4	27	78	4	468
20	19	67	51	195	4	19	4	27	78	4	468
Total	389	1,333	1,012	3,892	78	389	78	545	1,557	78	9,351

Sub-watershed #802 Annual Adoption (treated acres), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Adoption
1	8	67	20	76	2	8	2	11	31	2	224
2	8	67	20	76	2	8	2	11	31	2	224
3	8	67	20	76	2	8	2	11	31	2	224
4	8	67	20	76	2	8	2	11	31	2	224
5	8	67	20	76	2	8	2	11	31	2	224
6	8	67	20	76	2	8	2	11	31	2	224
7	8	67	20	76	2	8	2	11	31	2	224
8	8	67	20	76	2	8	2	11	31	2	224
9	8	67	20	76	2	8	2	11	31	2	224
10	8	67	20	76	2	8	2	11	31	2	224
11	8	67	20	76	2	8	2	11	31	2	224
12	8	67	20	76	2	8	2	11	31	2	224
13	8	67	20	76	2	8	2	11	31	2	224
14	8	67	20	76	2	8	2	11	31	2	224
15	8	67	20	76	2	8	2	11	31	2	224
16	8	67	20	76	2	8	2	11	31	2	224
17	8	67	20	76	2	8	2	11	31	2	224
18	8	67	20	76	2	8	2	11	31	2	224
19	8	67	20	76	2	8	2	11	31	2	224
20	8	67	20	76	2	8	2	11	31	2	224
Total	153	1,333	397	1,526	31	153	31	214	610	31	4,476

Sub-watershed #803 Annual Adoption (treated acres), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Adoption
1	9	67	24	94	2	9	2	13	38	2	261
2	9	67	24	94	2	9	2	13	38	2	261
3	9	67	24	94	2	9	2	13	38	2	261
4	9	67	24	94	2	9	2	13	38	2	261
5	9	67	24	94	2	9	2	13	38	2	261
6	9	67	24	94	2	9	2	13	38	2	261
7	9	67	24	94	2	9	2	13	38	2	261
8	9	67	24	94	2	9	2	13	38	2	261
9	9	67	24	94	2	9	2	13	38	2	261
10	9	67	24	94	2	9	2	13	38	2	261
11	9	67	24	94	2	9	2	13	38	2	261
12	9	67	24	94	2	9	2	13	38	2	261
13	9	67	24	94	2	9	2	13	38	2	261
14	9	67	24	94	2	9	2	13	38	2	261
15	9	67	24	94	2	9	2	13	38	2	261
16	9	67	24	94	2	9	2	13	38	2	261
17	9	67	24	94	2	9	2	13	38	2	261
18	9	67	24	94	2	9	2	13	38	2	261
19	9	67	24	94	2	9	2	13	38	2	261
20	9	67	24	94	2	9	2	13	38	2	261
Total	**188**	**1,333**	**490**	**1,884**	**38**	**188**	**38**	**264**	**753**	**38**	**5,213**

2. Cropland BMP implementation: Cumulative soil erosion load reductions

Sub-watershed #801 Annual Soil Erosion Reduction (tons), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Load Reduction
1	3	12	9	34	2	3	1	4	17	1	84
2	7	23	18	68	3	7	1	7	34	1	168
3	10	35	26	101	5	10	2	11	51	2	252
4	14	46	35	135	6	14	2	14	68	2	336
5	17	58	44	169	8	17	3	18	84	3	420
6	20	69	53	203	10	20	3	21	101	3	504
7	24	81	61	236	11	24	4	25	118	4	588
8	27	93	70	270	13	27	4	28	135	4	672
9	30	104	79	304	14	30	5	32	152	5	756
10	34	116	88	338	16	34	5	35	169	5	839
11	37	127	97	372	18	37	6	39	186	6	923
12	41	139	105	405	19	41	6	43	203	6	1,007
13	44	150	114	439	21	44	7	46	220	7	1,091
14	47	162	123	473	22	47	7	50	236	7	1,175
15	51	174	132	507	24	51	8	53	253	8	1,259
16	54	185	141	541	26	54	8	57	270	8	1,343
17	57	197	149	574	27	57	9	60	287	9	1,427
18	61	208	158	608	29	61	9	64	304	9	1,511
19	64	220	167	642	30	64	10	67	321	10	1,595
20	68	231	176	676	32	68	10	71	338	10	1,679

Sub-watershed #802 Annual Soil Erosion Reduction (tons), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Load Reduction
1	1	12	3	13	1	1	0	1	7	0	40
2	3	23	7	26	1	3	0	3	13	0	80
3	4	35	10	40	2	4	1	4	20	1	120
4	5	46	14	53	3	5	1	6	26	1	160
5	7	58	17	66	3	7	1	7	33	1	200
6	8	69	21	79	4	8	1	8	40	1	240
7	9	81	24	93	4	9	1	10	46	1	280
8	11	93	28	106	5	11	2	11	53	2	320
9	12	104	31	119	6	12	2	13	60	2	359
10	13	116	34	132	6	13	2	14	66	2	399
11	15	127	38	146	7	15	2	15	73	2	439
12	16	139	41	159	8	16	2	17	79	2	479
13	17	150	45	172	8	17	3	18	86	3	519
14	19	162	48	185	9	19	3	19	93	3	559
15	20	174	52	199	9	20	3	21	99	3	599
16	21	185	55	212	10	21	3	22	106	3	639
17	23	197	59	225	11	23	3	24	113	3	679
18	24	208	62	238	11	24	4	25	119	4	719
19	25	220	65	252	12	25	4	26	126	4	759
20	26	231	69	265	13	26	4	28	132	4	799

Sub-watershed #803 Annual Soil Erosion Reduction (tons), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Load Reduction
1	2	12	4	16	1	2	0	2	8	0	47
2	3	23	9	33	2	3	0	3	16	0	93
3	5	35	13	49	2	5	1	5	25	1	140
4	7	46	17	65	3	7	1	7	33	1	186
5	8	58	21	82	4	8	1	9	41	1	233
6	10	69	26	98	5	10	1	10	49	1	280
7	11	81	30	114	5	11	2	12	57	2	326
8	13	93	34	131	6	13	2	14	65	2	373
9	15	104	38	147	7	15	2	15	74	2	419
10	16	116	43	163	8	16	2	17	82	2	466
11	18	127	47	180	9	18	3	19	90	3	513
12	20	139	51	196	9	20	3	21	98	3	559
13	21	150	55	213	10	21	3	22	106	3	606
14	23	162	60	229	11	23	3	24	114	3	652
15	25	174	64	245	12	25	4	26	123	4	699
16	26	185	68	262	12	26	4	27	131	4	746
17	28	197	72	278	13	28	4	29	139	4	792
18	29	208	77	294	14	29	4	31	147	4	839
19	31	220	81	311	15	31	5	33	155	5	885
20	33	231	85	327	16	33	5	34	163	5	932

3. Cropland BMP implementation: Cumulative phosphorus load reductions

Sub-watershed #801 Annual Phosphorous Reduction (pounds), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Load Reduction
1	25	85	52	248	9	25	3	21	99	3	570
2	50	170	103	496	19	50	6	42	198	6	1,140
3	74	255	155	744	28	74	9	63	298	9	1,709
4	99	340	206	992	38	99	12	83	397	12	2,279
5	124	425	258	1,241	47	124	15	104	496	15	2,849
6	149	510	310	1,489	57	149	18	125	595	18	3,419
7	174	595	361	1,737	66	174	21	146	695	21	3,989
8	198	680	413	1,985	75	198	24	167	794	24	4,558
9	223	765	464	2,233	85	223	27	188	893	27	5,128
10	248	850	516	2,481	94	248	30	208	992	30	5,698
11	273	935	568	2,729	104	273	33	229	1,092	33	6,268
12	298	1,020	619	2,977	113	298	36	250	1,191	36	6,838
13	323	1,105	671	3,225	123	323	39	271	1,290	39	7,407
14	347	1,190	723	3,474	132	347	42	292	1,389	42	7,977
15	372	1,275	774	3,722	141	372	45	313	1,489	45	8,547
16	397	1,360	826	3,970	151	397	48	333	1,588	48	9,117
17	422	1,445	877	4,218	160	422	51	354	1,687	51	9,687
18	447	1,530	929	4,466	170	447	54	375	1,786	54	10,256
19	471	1,615	981	4,714	179	471	57	396	1,886	57	10,826
20	496	1,700	1,032	4,962	189	496	60	417	1,985	60	11,396

Sub-watershed #802 Annual Phosphorous Reduction (pounds), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Load Reduction
1	10	85	20	97	4	10	1	8	39	1	275
2	19	170	40	195	7	19	2	16	78	2	550
3	29	255	61	292	11	29	4	25	117	4	825
4	39	340	81	389	15	39	5	33	156	5	1,100
5	49	425	101	486	18	49	6	41	195	6	1,375
6	58	510	121	584	22	58	7	49	233	7	1,650
7	68	595	142	681	26	68	8	57	272	8	1,925
8	78	680	162	778	30	78	9	65	311	9	2,200
9	88	765	182	875	33	88	11	74	350	11	2,475
10	97	850	202	973	37	97	12	82	389	12	2,750
11	107	935	223	1,070	41	107	13	90	428	13	3,025
12	117	1,020	243	1,167	44	117	14	98	467	14	3,300
13	126	1,105	263	1,264	48	126	15	106	506	15	3,575
14	136	1,190	283	1,362	52	136	16	114	545	16	3,850
15	146	1,275	303	1,459	55	146	18	123	584	18	4,125
16	156	1,360	324	1,556	59	156	19	131	622	19	4,400
17	165	1,445	344	1,653	63	165	20	139	661	20	4,675
18	175	1,530	364	1,751	67	175	21	147	700	21	4,950
19	185	1,615	384	1,848	70	185	22	155	739	22	5,225
20	195	1,700	405	1,945	74	195	23	163	778	23	5,500

Sub-watershed #803 Annual Phosphorous Reduction (pounds), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Load Reduction
1	12	85	25	120	5	12	1	10	48	1	320
2	24	170	50	240	9	24	3	20	96	3	639
3	36	255	75	360	14	36	4	30	144	4	959
4	48	340	100	480	18	48	6	40	192	6	1,278
5	60	425	125	600	23	60	7	50	240	7	1,598
6	72	510	150	720	27	72	9	61	288	9	1,918
7	84	595	175	841	32	84	10	71	336	10	2,237
8	96	680	200	961	37	96	12	81	384	12	2,557
9	108	765	225	1,081	41	108	13	91	432	13	2,876
10	120	850	250	1,201	46	120	14	101	480	14	3,196
11	132	935	275	1,321	50	132	16	111	528	16	3,516
12	144	1,020	300	1,441	55	144	17	121	576	17	3,835
13	156	1,105	325	1,561	59	156	19	131	624	19	4,155
14	168	1,190	350	1,681	64	168	20	141	672	20	4,474
15	180	1,275	375	1,801	68	180	22	151	720	22	4,794
16	192	1,360	400	1,921	73	192	23	161	768	23	5,114
17	204	1,445	425	2,041	78	204	24	171	816	24	5,433
18	216	1,530	450	2,161	82	216	26	182	865	26	5,753
19	228	1,615	475	2,281	87	228	27	192	913	27	6,072
20	240	1,700	500	2,401	91	240	29	202	961	29	6,392

4. Cropland BMP implementation: Cumulative nitrogen load reductions

Sub-watershed #801 Annual Nitrogen Reduction (pounds), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Load Reduction
1	54	186	226	544	41	54	0	91	435	0	1,633
2	109	373	453	1,088	83	109	0	183	870	0	3,266
3	163	559	679	1,632	124	163	0	274	1,305	0	4,899
4	218	745	905	2,176	165	218	0	366	1,741	0	6,532
5	272	931	1,131	2,720	207	272	0	457	2,176	0	8,165
6	326	1,118	1,358	3,263	248	326	0	548	2,611	0	9,798
7	381	1,304	1,584	3,807	289	381	0	640	3,046	0	11,432
8	435	1,490	1,810	4,351	331	435	0	731	3,481	0	13,065
9	490	1,677	2,036	4,895	372	490	0	822	3,916	0	14,698
10	544	1,863	2,263	5,439	413	544	0	914	4,351	0	16,331
11	598	2,049	2,489	5,983	455	598	0	1,005	4,786	0	17,964
12	653	2,235	2,715	6,527	496	653	0	1,097	5,222	0	19,597
13	707	2,422	2,941	7,071	537	707	0	1,188	5,657	0	21,230
14	761	2,608	3,168	7,615	579	761	0	1,279	6,092	0	22,863
15	816	2,794	3,394	8,159	620	816	0	1,371	6,527	0	24,496
16	870	2,981	3,620	8,703	661	870	0	1,462	6,962	0	26,129
17	925	3,167	3,847	9,246	703	925	0	1,553	7,397	0	27,762
18	979	3,353	4,073	9,790	744	979	0	1,645	7,832	0	29,395
19	1,033	3,539	4,299	10,334	785	1,033	0	1,736	8,267	0	31,029
20	1,088	3,726	4,525	10,878	827	1,088	0	1,828	8,703	0	32,662

Sub-watershed #802 Annual Nitrogen Reduction (pounds), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Load Reduction
1	21	186	89	213	16	21	0	36	171	0	753
2	43	373	177	426	32	43	0	72	341	0	1,507
3	64	559	266	640	49	64	0	107	512	0	2,260
4	85	745	355	853	65	85	0	143	682	0	3,013
5	107	931	443	1,066	81	107	0	179	853	0	3,767
6	128	1,118	532	1,279	97	128	0	215	1,023	0	4,520
7	149	1,304	621	1,492	113	149	0	251	1,194	0	5,274
8	171	1,490	709	1,706	130	171	0	287	1,364	0	6,027
9	192	1,677	798	1,919	146	192	0	322	1,535	0	6,780
10	213	1,863	887	2,132	162	213	0	358	1,706	0	7,534
11	235	2,049	976	2,345	178	235	0	394	1,876	0	8,287
12	256	2,235	1,064	2,558	194	256	0	430	2,047	0	9,040
13	277	2,422	1,153	2,771	211	277	0	466	2,217	0	9,794
14	298	2,608	1,242	2,985	227	298	0	501	2,388	0	10,547
15	320	2,794	1,330	3,198	243	320	0	537	2,558	0	11,301
16	341	2,981	1,419	3,411	259	341	0	573	2,729	0	12,054
17	362	3,167	1,508	3,624	275	362	0	609	2,899	0	12,807
18	384	3,353	1,596	3,837	292	384	0	645	3,070	0	13,561
19	405	3,539	1,685	4,051	308	405	0	680	3,240	0	14,314
20	426	3,726	1,774	4,264	324	426	0	716	3,411	0	15,067

Sub-watershed #803 Annual Nitrogen Reduction (pounds), Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Load Reduction
1	26	186	109	263	20	26	0	44	211	0	886
2	53	373	219	526	40	53	0	88	421	0	1,773
3	79	559	328	790	60	79	0	133	632	0	2,659
4	105	745	438	1,053	80	105	0	177	842	0	3,546
5	132	931	547	1,316	100	132	0	221	1,053	0	4,432
6	158	1,118	657	1,579	120	158	0	265	1,263	0	5,319
7	184	1,304	766	1,843	140	184	0	310	1,474	0	6,205
8	211	1,490	876	2,106	160	211	0	354	1,685	0	7,092
9	237	1,677	985	2,369	180	237	0	398	1,895	0	7,978
10	263	1,863	1,095	2,632	200	263	0	442	2,106	0	8,864
11	290	2,049	1,204	2,895	220	290	0	486	2,316	0	9,751
12	316	2,235	1,314	3,159	240	316	0	531	2,527	0	10,637
13	342	2,422	1,423	3,422	260	342	0	575	2,737	0	11,524
14	369	2,608	1,533	3,685	280	369	0	619	2,948	0	12,410
15	395	2,794	1,642	3,948	300	395	0	663	3,159	0	13,297
16	421	2,981	1,752	4,212	320	421	0	708	3,369	0	14,183
17	447	3,167	1,861	4,475	340	447	0	752	3,580	0	15,070
18	474	3,353	1,971	4,738	360	474	0	796	3,790	0	15,956
19	500	3,539	2,080	5,001	380	500	0	840	4,001	0	16,843
20	526	3,726	2,190	5,264	400	526	0	884	4,212	0	17,729

5. Cropland BMP implementation: Costs before cost-share

Sub-watershed #801 Annual Cost* Before Cost-Share, Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Cost
1	$778	$2,666	$7,336	$7,784	$218	$778	$1,218	$3,460	$1,245	$311	$25,796
2	$802	$2,746	$7,557	$8,018	$224	$802	$1,255	$3,564	$1,283	$321	$26,570
3	$826	$2,828	$7,783	$8,258	$231	$826	$1,292	$3,671	$1,321	$330	$27,367
4	$851	$2,913	$8,017	$8,506	$238	$851	$1,331	$3,781	$1,361	$340	$28,188
5	$876	$3,001	$8,257	$8,761	$245	$876	$1,371	$3,894	$1,402	$350	$29,034
6	$902	$3,091	$8,505	$9,024	$253	$902	$1,412	$4,011	$1,444	$361	$29,905
7	$929	$3,183	$8,760	$9,295	$260	$929	$1,455	$4,131	$1,487	$372	$30,802
8	$957	$3,279	$9,023	$9,573	$268	$957	$1,498	$4,255	$1,532	$383	$31,726
9	$986	$3,377	$9,294	$9,861	$276	$986	$1,543	$4,383	$1,578	$394	$32,678
10	$1,016	$3,479	$9,572	$10,156	$284	$1,016	$1,589	$4,514	$1,625	$406	$33,658
11	$1,046	$3,583	$9,860	$10,461	$293	$1,046	$1,637	$4,650	$1,674	$418	$34,668
12	$1,077	$3,690	$10,155	$10,775	$302	$1,077	$1,686	$4,789	$1,724	$431	$35,708
13	$1,110	$3,801	$10,460	$11,098	$311	$1,110	$1,737	$4,933	$1,776	$444	$36,779
14	$1,143	$3,915	$10,774	$11,431	$320	$1,143	$1,789	$5,081	$1,829	$457	$37,883
15	$1,177	$4,033	$11,097	$11,774	$330	$1,177	$1,843	$5,234	$1,884	$471	$39,019
16	$1,213	$4,154	$11,430	$12,127	$340	$1,213	$1,898	$5,391	$1,940	$485	$40,190
17	$1,249	$4,278	$11,773	$12,491	$350	$1,249	$1,955	$5,552	$1,999	$500	$41,395
18	$1,287	$4,406	$12,126	$12,866	$360	$1,287	$2,013	$5,719	$2,059	$515	$42,637
19	$1,325	$4,539	$12,490	$13,252	$371	$1,325	$2,074	$5,890	$2,120	$530	$43,916
20	$1,365	$4,675	$12,864	$13,649	$382	$1,365	$2,136	$6,067	$2,184	$546	$45,234
Total	**$20,916**	**$71,636**	**$197,132**	**$209,159**	**$5,856**	**$20,916**	**$32,733**	**$92,971**	**$33,465**	**$8,366**	**$693,152**
**3% Inflation*											

Sub-watershed #802 Annual Cost* Before Cost-Share, Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Cost
1	$305	$2,666	$2,876	$3,051	$85	$305	$477	$1,356	$488	$122	$11,732
2	$314	$2,746	$2,962	$3,143	$88	$314	$492	$1,397	$503	$126	$12,084
3	$324	$2,828	$3,051	$3,237	$91	$324	$507	$1,439	$518	$129	$12,447
4	$333	$2,913	$3,142	$3,334	$93	$333	$522	$1,482	$533	$133	$12,820
5	$343	$3,001	$3,236	$3,434	$96	$343	$537	$1,526	$549	$137	$13,205
6	$354	$3,091	$3,334	$3,537	$99	$354	$554	$1,572	$566	$141	$13,601
7	$364	$3,183	$3,434	$3,643	$102	$364	$570	$1,619	$583	$146	$14,009
8	$375	$3,279	$3,537	$3,752	$105	$375	$587	$1,668	$600	$150	$14,429
9	$386	$3,377	$3,643	$3,865	$108	$386	$605	$1,718	$618	$155	$14,862
10	$398	$3,479	$3,752	$3,981	$111	$398	$623	$1,769	$637	$159	$15,308
11	$410	$3,583	$3,865	$4,100	$115	$410	$642	$1,823	$656	$164	$15,767
12	$422	$3,690	$3,980	$4,223	$118	$422	$661	$1,877	$676	$169	$16,240
13	$435	$3,801	$4,100	$4,350	$122	$435	$681	$1,934	$696	$174	$16,727
14	$448	$3,915	$4,223	$4,480	$125	$448	$701	$1,992	$717	$179	$17,229
15	$461	$4,033	$4,350	$4,615	$129	$461	$722	$2,051	$738	$185	$17,746
16	$475	$4,154	$4,480	$4,753	$133	$475	$744	$2,113	$761	$190	$18,278
17	$490	$4,278	$4,614	$4,896	$137	$490	$766	$2,176	$783	$196	$18,826
18	$504	$4,406	$4,753	$5,043	$141	$504	$789	$2,242	$807	$202	$19,391
19	$519	$4,539	$4,895	$5,194	$145	$519	$813	$2,309	$831	$208	$19,973
20	$535	$4,675	$5,042	$5,350	$150	$535	$837	$2,378	$856	$214	$20,572
Total	**$8,198**	**$71,636**	**$77,268**	**$81,982**	**$2,295**	**$8,198**	**$12,830**	**$36,441**	**$13,117**	**$3,279**	**$315,244**
**3% Inflation*											

Sub-watershed #803 Annual Cost* Before Cost-Share, Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Cost
1	$377	$2,666	$3,550	$3,767	$105	$377	$590	$1,674	$603	$151	$13,860
2	$388	$2,746	$3,657	$3,880	$109	$388	$607	$1,725	$621	$155	$14,275
3	$400	$2,828	$3,767	$3,996	$112	$400	$625	$1,776	$639	$160	$14,704
4	$412	$2,913	$3,880	$4,116	$115	$412	$644	$1,830	$659	$165	$15,145
5	$424	$3,001	$3,996	$4,240	$119	$424	$664	$1,885	$678	$170	$15,599
6	$437	$3,091	$4,116	$4,367	$122	$437	$683	$1,941	$699	$175	$16,067
7	$450	$3,183	$4,239	$4,498	$126	$450	$704	$1,999	$720	$180	$16,549
8	$463	$3,279	$4,367	$4,633	$130	$463	$725	$2,059	$741	$185	$17,046
9	$477	$3,377	$4,498	$4,772	$134	$477	$747	$2,121	$764	$191	$17,557
10	$492	$3,479	$4,632	$4,915	$138	$492	$769	$2,185	$786	$197	$18,084
11	$506	$3,583	$4,771	$5,063	$142	$506	$792	$2,250	$810	$203	$18,626
12	$521	$3,690	$4,915	$5,214	$146	$521	$816	$2,318	$834	$209	$19,185
13	$537	$3,801	$5,062	$5,371	$150	$537	$841	$2,387	$859	$215	$19,761
14	$553	$3,915	$5,214	$5,532	$155	$553	$866	$2,459	$885	$221	$20,353
15	$570	$4,033	$5,370	$5,698	$160	$570	$892	$2,533	$912	$228	$20,964
16	$587	$4,154	$5,531	$5,869	$164	$587	$918	$2,609	$939	$235	$21,593
17	$604	$4,278	$5,697	$6,045	$169	$604	$946	$2,687	$967	$242	$22,241
18	$623	$4,406	$5,868	$6,226	$174	$623	$974	$2,768	$996	$249	$22,908
19	$641	$4,539	$6,044	$6,413	$180	$641	$1,004	$2,851	$1,026	$257	$23,595
20	$661	$4,675	$6,226	$6,605	$185	$661	$1,034	$2,936	$1,057	$264	$24,303
Total	**$10,122**	**$71,636**	**$95,401**	**$101,221**	**$2,834**	**$10,122**	**$15,841**	**$44,993**	**$16,195**	**$4,049**	**$372,414**
*3% Inflation											

6. Cropland BMP implementation: Costs after cost-share

Sub-watershed #801 Annual Cost* After Cost-Share, Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Cost
1	$234	$800	$2,201	$2,335	$65	$234	$365	$1,038	$374	$93	$7,739
2	$241	$824	$2,267	$2,405	$67	$241	$376	$1,069	$385	$96	$7,971
3	$248	$849	$2,335	$2,477	$69	$248	$388	$1,101	$396	$99	$8,210
4	$255	$874	$2,405	$2,552	$71	$255	$399	$1,134	$408	$102	$8,456
5	$263	$900	$2,477	$2,628	$74	$263	$411	$1,168	$421	$105	$8,710
6	$271	$927	$2,551	$2,707	$76	$271	$424	$1,203	$433	$108	$8,971
7	$279	$955	$2,628	$2,788	$78	$279	$436	$1,239	$446	$112	$9,241
8	$287	$984	$2,707	$2,872	$80	$287	$449	$1,277	$460	$115	$9,518
9	$296	$1,013	$2,788	$2,958	$83	$296	$463	$1,315	$473	$118	$9,803
10	$305	$1,044	$2,872	$3,047	$85	$305	$477	$1,354	$488	$122	$10,097
11	$314	$1,075	$2,958	$3,138	$88	$314	$491	$1,395	$502	$126	$10,400
12	$323	$1,107	$3,047	$3,232	$91	$323	$506	$1,437	$517	$129	$10,712
13	$333	$1,140	$3,138	$3,329	$93	$333	$521	$1,480	$533	$133	$11,034
14	$343	$1,175	$3,232	$3,429	$96	$343	$537	$1,524	$549	$137	$11,365
15	$353	$1,210	$3,329	$3,532	$99	$353	$553	$1,570	$565	$141	$11,706
16	$364	$1,246	$3,429	$3,638	$102	$364	$569	$1,617	$582	$146	$12,057
17	$375	$1,283	$3,532	$3,747	$105	$375	$586	$1,666	$600	$150	$12,419
18	$386	$1,322	$3,638	$3,860	$108	$386	$604	$1,716	$618	$154	$12,791
19	$398	$1,362	$3,747	$3,976	$111	$398	$622	$1,767	$636	$159	$13,175
20	$409	$1,402	$3,859	$4,095	$115	$409	$641	$1,820	$655	$164	$13,570
Total	**$6,275**	**$21,491**	**$59,140**	**$62,748**	**$1,757**	**$6,275**	**$9,820**	**$27,891**	**$10,040**	**$2,510**	**$207,946**
3% Inflation											

Sub-watershed #802 Annual Cost* After Cost-Share, Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Cost
1	$92	$800	$863	$915	$26	$92	$143	$407	$146	$37	$3,520
2	$94	$824	$889	$943	$26	$94	$148	$419	$151	$38	$3,625
3	$97	$849	$915	$971	$27	$97	$152	$432	$155	$39	$3,734
4	$100	$874	$943	$1,000	$28	$100	$157	$445	$160	$40	$3,846
5	$103	$900	$971	$1,030	$29	$103	$161	$458	$165	$41	$3,961
6	$106	$927	$1,000	$1,061	$30	$106	$166	$472	$170	$42	$4,080
7	$109	$955	$1,030	$1,093	$31	$109	$171	$486	$175	$44	$4,203
8	$113	$984	$1,061	$1,126	$32	$113	$176	$500	$180	$45	$4,329
9	$116	$1,013	$1,093	$1,159	$32	$116	$181	$515	$186	$46	$4,459
10	$119	$1,044	$1,126	$1,194	$33	$119	$187	$531	$191	$48	$4,592
11	$123	$1,075	$1,159	$1,230	$34	$123	$193	$547	$197	$49	$4,730
12	$127	$1,107	$1,194	$1,267	$35	$127	$198	$563	$203	$51	$4,872
13	$130	$1,140	$1,230	$1,305	$37	$130	$204	$580	$209	$52	$5,018
14	$134	$1,175	$1,267	$1,344	$38	$134	$210	$597	$215	$54	$5,169
15	$138	$1,210	$1,305	$1,384	$39	$138	$217	$615	$222	$55	$5,324
16	$143	$1,246	$1,344	$1,426	$40	$143	$223	$634	$228	$57	$5,483
17	$147	$1,283	$1,384	$1,469	$41	$147	$230	$653	$235	$59	$5,648
18	$151	$1,322	$1,426	$1,513	$42	$151	$237	$672	$242	$61	$5,817
19	$156	$1,362	$1,469	$1,558	$44	$156	$244	$693	$249	$62	$5,992
20	$160	$1,402	$1,513	$1,605	$45	$160	$251	$713	$257	$64	$6,172
Total	**$2,459**	**$21,491**	**$23,180**	**$24,594**	**$689**	**$2,459**	**$3,849**	**$10,932**	**$3,935**	**$984**	**$94,573**
**3% Inflation*											

Sub-watershed #803 Annual Cost* After Cost-Share, Cropland BMPs											
Year	Companion Cropping	Cover Crops	Grassed Waterways	No-Till	Permanent Vegetation	Planting Green	Sediment Basins	Terraces	Vegetative Buffers	Wetlands	Total Cost
1	$113	$800	$1,065	$1,130	$32	$113	$177	$502	$181	$45	$4,158
2	$116	$824	$1,097	$1,164	$33	$116	$182	$517	$186	$47	$4,283
3	$120	$849	$1,130	$1,199	$34	$120	$188	$533	$192	$48	$4,411
4	$123	$874	$1,164	$1,235	$35	$123	$193	$549	$198	$49	$4,543
5	$127	$900	$1,199	$1,272	$36	$127	$199	$565	$204	$51	$4,680
6	$131	$927	$1,235	$1,310	$37	$131	$205	$582	$210	$52	$4,820
7	$135	$955	$1,272	$1,349	$38	$135	$211	$600	$216	$54	$4,965
8	$139	$984	$1,310	$1,390	$39	$139	$218	$618	$222	$56	$5,114
9	$143	$1,013	$1,349	$1,432	$40	$143	$224	$636	$229	$57	$5,267
10	$147	$1,044	$1,390	$1,475	$41	$147	$231	$655	$236	$59	$5,425
11	$152	$1,075	$1,431	$1,519	$43	$152	$238	$675	$243	$61	$5,588
12	$156	$1,107	$1,474	$1,564	$44	$156	$245	$695	$250	$63	$5,755
13	$161	$1,140	$1,519	$1,611	$45	$161	$252	$716	$258	$64	$5,928
14	$166	$1,175	$1,564	$1,660	$46	$166	$260	$738	$266	$66	$6,106
15	$171	$1,210	$1,611	$1,709	$48	$171	$268	$760	$274	$68	$6,289
16	$176	$1,246	$1,659	$1,761	$49	$176	$276	$783	$282	$70	$6,478
17	$181	$1,283	$1,709	$1,813	$51	$181	$284	$806	$290	$73	$6,672
18	$187	$1,322	$1,760	$1,868	$52	$187	$292	$830	$299	$75	$6,872
19	$192	$1,362	$1,813	$1,924	$54	$192	$301	$855	$308	$77	$7,079
20	$198	$1,402	$1,868	$1,982	$55	$198	$310	$881	$317	$79	$7,291
Total	**$3,037**	**$21,491**	**$28,620**	**$30,366**	**$850**	**$3,037**	**$4,752**	**$13,498**	**$4,859**	**$1,215**	**$111,724**
**3% Inflation*											