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

2021

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KCARE
Kansas Center for Agricultural Resources and the Environment

Kansas Department of Health and Environment

Lower Kansas RIVER WRAPS

K-STATE Research and Extension

Lower Kansas River Watershed
Project Leadership Team

Lower Kansas River WRAPS

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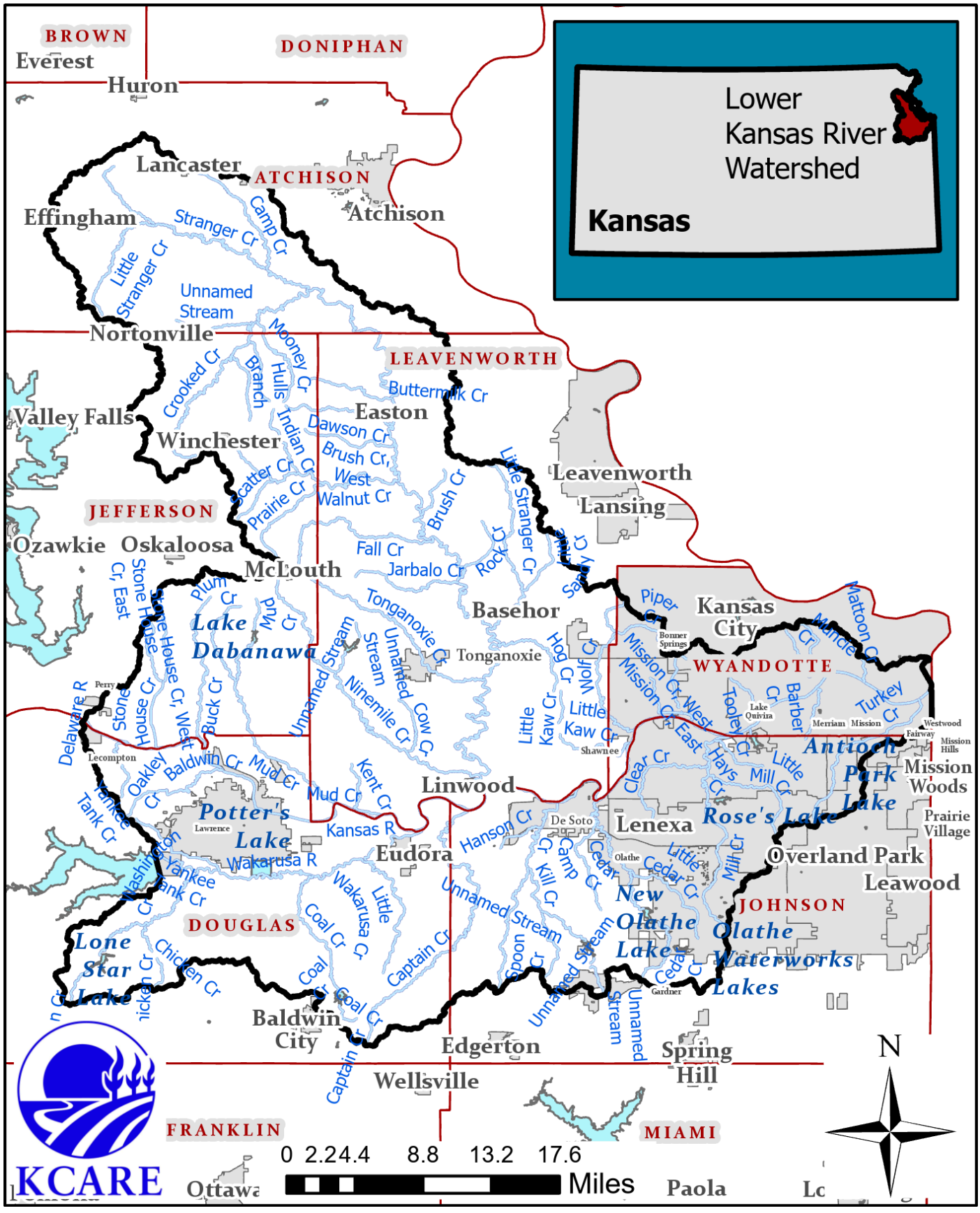
Lower
Kansas River
Watershed
Kansas
BROWN
DONIPHAN
Everest
Huron
Lancaster
ATCHISON
Atchison
Effingham
Stranger Cr
Camp Cr
Little Stranger Cr
Unnamed Stream
Nortonville
Mooney Cr
Hulls Branch
Crooked Cr
LEAVENWORTH
Buttermilk Cr
Easton
Valley Falls
Winchester
Indian Cr
Dawson Cr
Brush Cr
Scatter Cr
Prairie Cr
West Walnut Cr
Brush Cr
Little Stranger Cr
Leavenworth
Lansing
JEFFERSON
Ozawkie
Oskaloosa
McLouth
Fall Cr
Jarbalo Cr
Rock Cr
Stone House Cr East
Plum Cr
Lake Dabanawa
Mud Cr
Tonganoxie Cr
Tonganoxie
Basehor
Piper Cr
Kansas City
Mattoon Cr
Mancie Cr
Bonner Springs
WYANDOTTE
Mission Cr
Mission Cr West
Hog Cr
Wolf Cr
Little Kaw Cr
Shawnee
Lake Quivira
Tooley Cr
Barber Cr
Merriam
Mission
Westwood
Fairway
Mission Hills
Turkey Cr
Antioch Park Lake
Mission Woods
Prairie Village
Perry
Lecompton
Delaware R
Stone House Cr West
Buck Cr
Unnamed Stream
Ninemile Cr
Cow Cr
Oakley Cr
Baldwin Cr
Mud Cr
Kent Cr
Linwood
Clear Cr
Hays Cr
Mill Cr
Little Mill Cr
Yankee Tank Cr
Potter's Lake
Lawrence
Kansas R
Wakarusa R
Eudora
Hanson Cr
De Soto
Lenexa
Rose's Lake
Olathe
Cedar Cr
Little Cedar Cr
Camp Cr
Kill Cr
Overland Park
Leawood
New Olathe Lake
Olathe Waterworks Lakes
JOHNSON
Gardner
Unnamed Stream
Spoon Cr
Cedar Cr
DOUGLAS
Lone Star Lake
Chicken Cr
Coal Cr
Wakarusa R
Little Wakarusa R
Captain Cr
Baldwin City
Edgerton
Spring Hill
Wellsville
FRANKLIN
MIAMI
Ottawa
Paola
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Miles
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KCARE

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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): Measure of the amount of oxygen removed from aquatic environments by aerobic microorganisms for their metabolic requirements.

Biota: Plant and animal life of a particular region.

Chlorophyll *a*: Common pigment 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.

Municipal water system: A water system having at least 10 service connections or regularly serving an average of at least 25 individuals daily at least 60 days out of the year.

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 and 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.

RAC: Regional Advisory Committee.

RC&D: Resource Conservation and Development Region, Inc.

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 it 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 **Lower 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 requiring 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. By working as a WRAPS team, communities can take several steps toward watershed restoration and protection. 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.

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 Lower Kansas River Watershed.

Plan Update: The original Lower Kansas WRAPS program was organized in 2007 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, targeting and TMDL revisions from KDHE resulted in outdated WRAPS plan implementation goals. Therefore, the Lower Kansas River WRAPS plan was updated and revised in 2021 by Kansas State University staff and KDHE, with the guidance of the Lower Kansas River WRAPS Coordinator, KAWS, and the SLT.

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

2. Lower 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 Lower 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. Historically, "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 river basins in Kansas. The scope of this WRAPS plan will focus on the Lower Kansas River Watershed, located 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 Lower Kansas River Watershed 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.

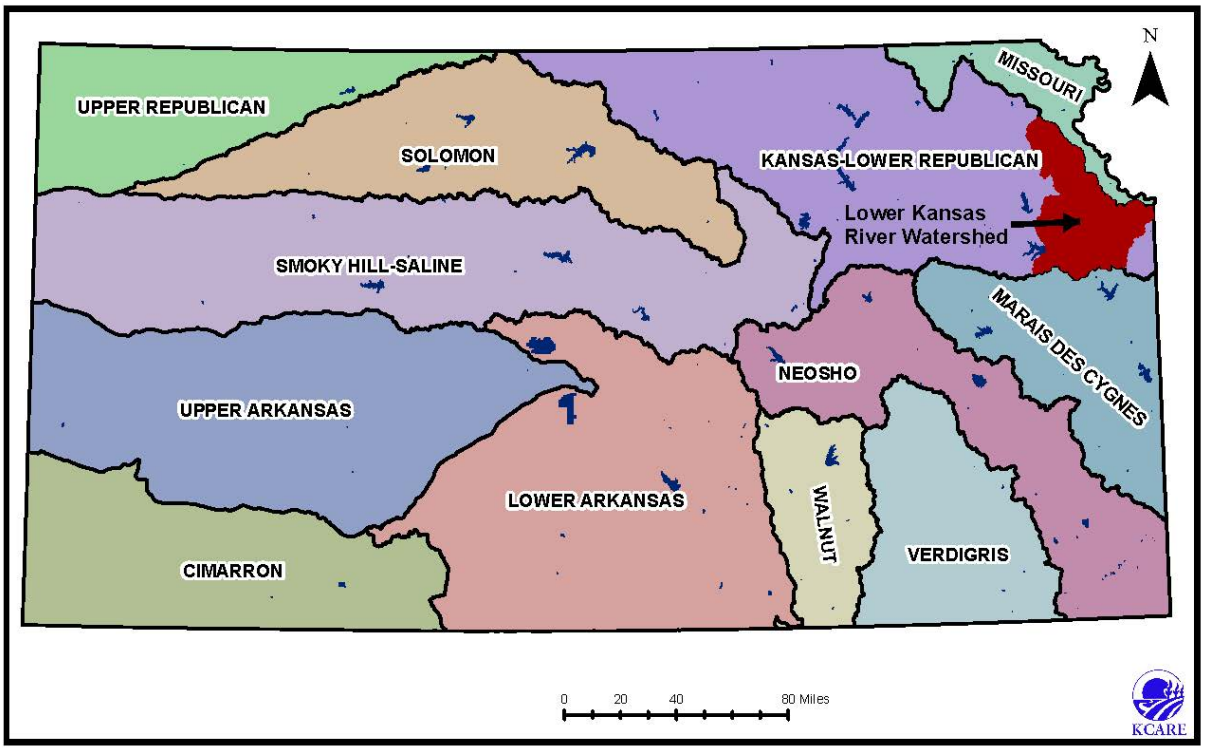


Figure 1. The 12 River Basins of Kansas and the Lower Kansas River Watershed

The Lower Kansas River Watershed is in northeastern Kansas and overlays portions of six counties, including Atchison, Douglas, Jefferson, Johnson, Leavenworth, and Wyandotte counties (**Figure 2**).

Figure 2. Lower Kansas River Watershed

D. Overview of the Lower Kansas River Watershed

The Lower Kansas River Watershed is the area of land in northeast Kansas that drains to the Kansas River and its tributaries. The Lower Kansas River Watershed covers 821,940 acres, which equates to approximately 1,284 square miles.

The headwaters of the lower portion of the Kansas River begins about halfway between the cities of Lecompton and Perry, forming the county line between Douglas and Jefferson

counties. The river flows eastward through 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 river serves to form county boundaries between Jefferson and Douglas counties, Douglas and Leavenworth counties, Leavenworth, and Johnson counties, as well as Johnson and Wyandotte counties.

E. Elevation of the Lower Kansas River Watershed

Elevation determines watershed boundaries. As shown in **Figure 3**, the upper boundary of the Lower Kansas River Watershed has an elevation of 1,154 feet, and the lowest point of the watershed has an elevation of 718 feet.

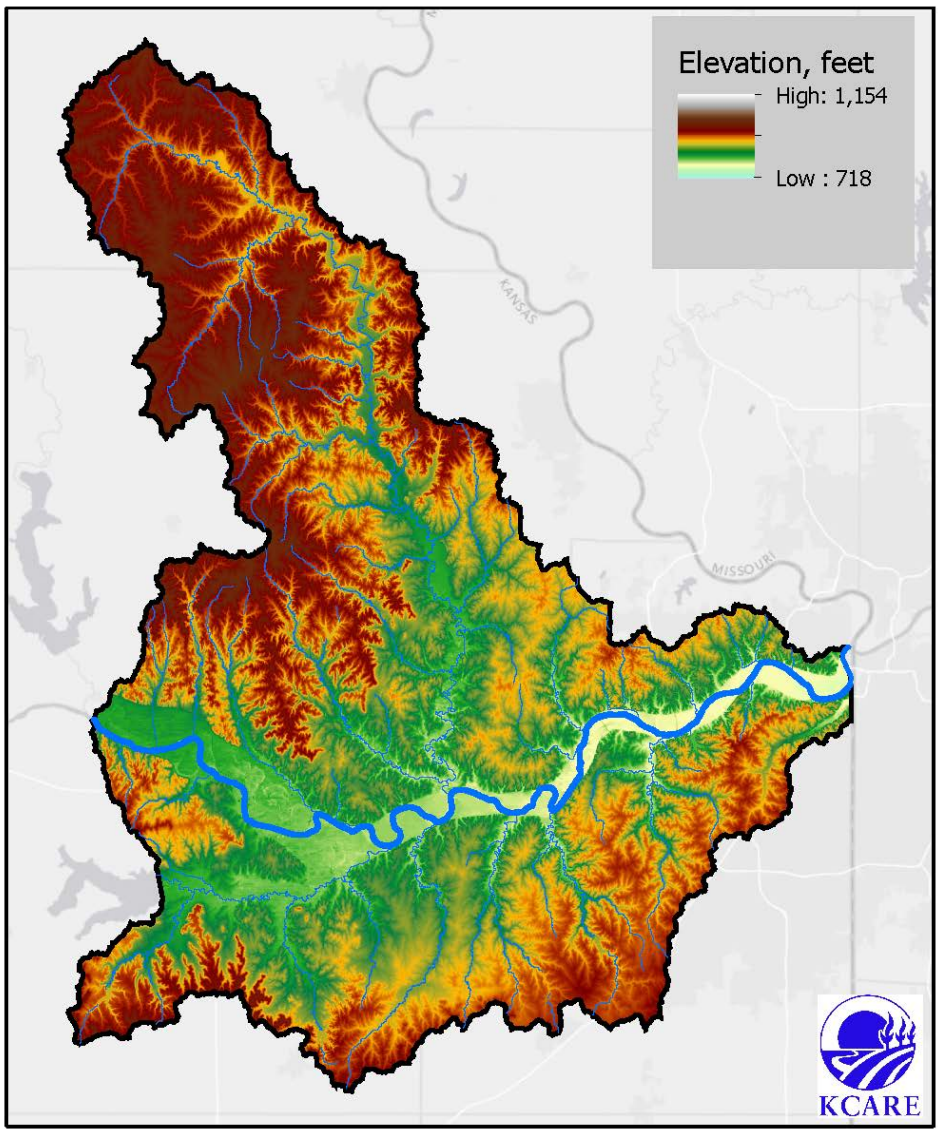


Figure 3. Elevation Relief Map of the Lower Kansas River Watershed

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 Lower 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 Lower Kansas River Watershed is part of the HUC 8, **10270104**. 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**270104: 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**0104: 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**04: 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**104**: Cataloging unit drainage of the section of the Lower Kansas River Basin in Kansas (area = 1,640 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, and HUC 10 watersheds can be divided into smaller HUC 12 watersheds. The Lower Kansas River Watershed consists of five HUC 10 delineations and can be divided further into 31 HUC 12 delineations (**Figure 4**).

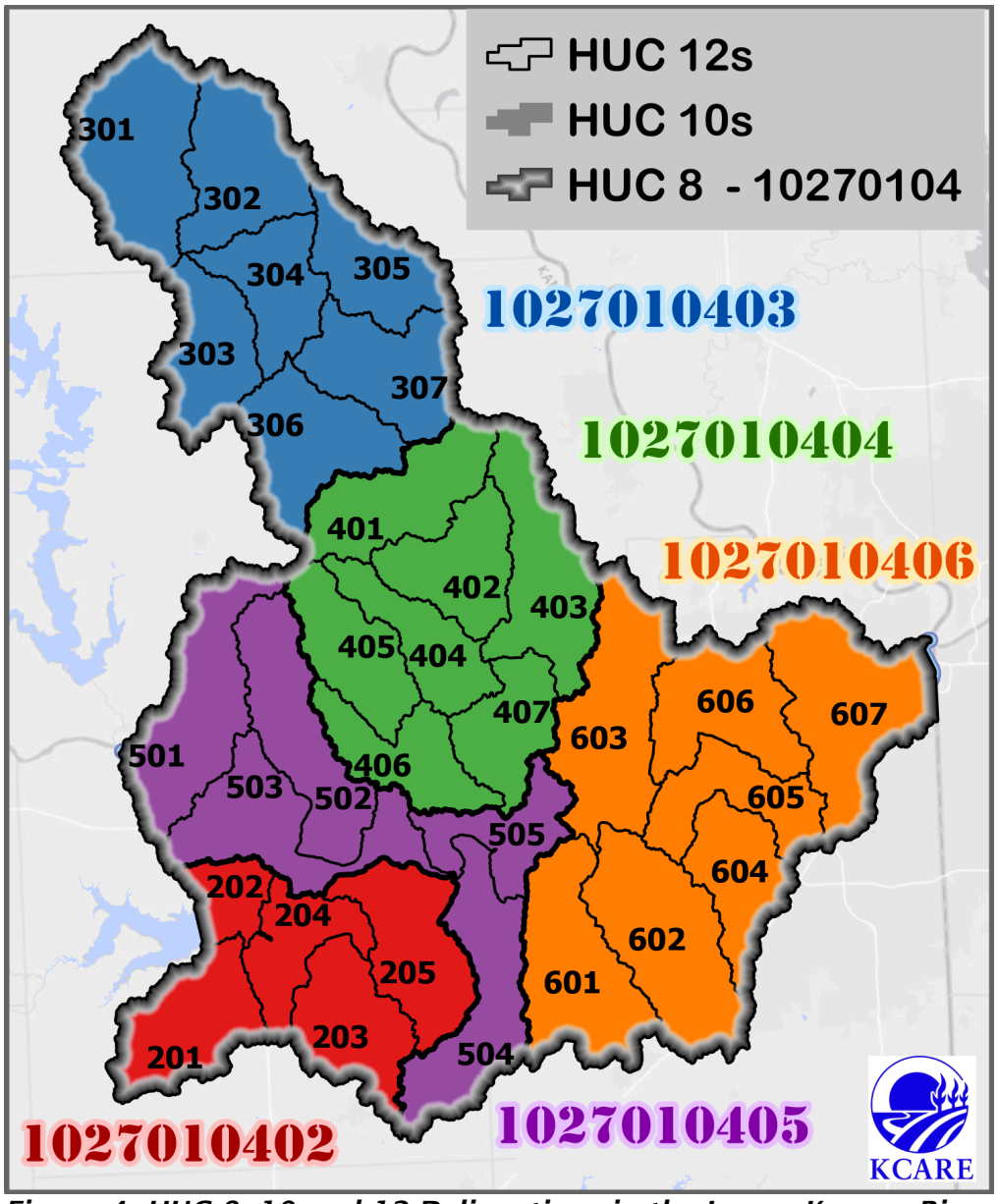


Figure 4. HUC 8, 10 and 12 Delineations in the Lower Kansas River Watershed

For simplification, this WRAPS plan will utilize HUC 10 delineations to describe targeted areas for BMP implementation and load reduction goals. These HUC 10s include: **1027010402** (home to five HUC 12s), **1027010403** (home to seven HUC 12s), **1027010404** (home to seven HUC 12s), **1027010405** (home to five HUC 12s), and **1027010406** (home to seven HUC 12s).

Please note that maps throughout this plan will refer to these HUC 10s primarily by their last three digits, as underlined above.

There are 1,284 square miles in the Lower Kansas River WRAPS project area. The project area covers the majority of the Lower Kansas HUC 8, 10270104, except for the Wakarusa River drainage area which feeds into Clinton Lake, west of the city of Lawrence, in Douglas County.

G. Lower Kansas River WRAPS History

According to the Kansas Unified Watershed Assessment prepared in 1999 by KDHE and the Natural Resources Conservation Service (NRCS), the Lower 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 Lower Kansas River Watershed was ranked 1st out of 71 watersheds in the state for restoration priority.

H. Who Are the Stakeholders?

The Lower Kansas WRAPS project, now referred to as the Lower Kansas River WRAPS, began in 2007 when the Kansas Alliance for Wetlands and Streams (KAWS) was awarded a grant from the KDHE. A coordinator for the Lower Kansas WRAPS project was hired in August of 2007 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 Lower Kansas River watershed met in October 2007 and began the process of identifying water-related issues in the basin. As a result, a diverse group of stakeholders became involved in the Lower Kansas 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 Lower Kansas WRAPS Stakeholder Leadership Team (SLT) evolved from a core group of meeting attendees. and now serves as a board to make decisions and to provide guidance to the WRAPS Coordinator. The SLT also determines priorities and provides direction for projects in the watershed. The SLT is currently comprised of seven members.

The Lower Kansas 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 Lower 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 Best Management Practice (BMP) implementation. The SLT has 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 Lower Kansas River Watershed SLT are to:

- reduce the amount of bacteria flowing into the Lower Kansas River;
- protect and restore water quality throughout the watershed; and
- educate the watershed community about water quality practices and benefits.

Accomplishing these goals will involve both an educational component as well as the implementation of BMPs in livestock areas. Efforts will focus on targeted areas in the Lower 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 Lower Kansas River Watershed.

The **main pollutants** for the Lower Kansas River Watershed are bacteria and nutrients. This plan will focus primarily on bacteria from livestock areas and therefore will affect only nutrient loading from livestock 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 Lower 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:

1. Increase water storage capacity and availability in federal reservoirs. By 2020, purchase all available storage in federal reservoirs to secure an adequate water supply for the region. By 2025, evaluate the ability to raise the conservation pool in each federal reservoir.

   To meet this goal, the Kansas RAC developed the following **Action Steps**:

   - Increase water storage capacity and availability in federal reservoirs. By 2020, purchase all available storage in federal reservoirs to secure an adequate water supply for the region.
     - The Kansas Water Office should conduct an analysis of the impacts of the draw-downs at Milford, Tuttle Creek and Perry reservoirs due to Missouri River navigation support. The results of this study will inform the decision as to whether

[1] Kansas Water Vision, Regional Goal Action Plans Section. http://kwo.ks.gov/docs/default-source/water-vision-water-plan/vision/rpt-vision-regional-goal-action-plans-section.pdf?sfvrsn=4, page 96.

or not to accelerate the purchase of the remaining storage at the aforementioned reservoirs.
    - Working with Kansas River Water Assurance District, KDHE, the Kansas Department of Wildlife, Parks and Tourism (KDWPT) and other stakeholders, determine the amount of storage necessary within Milford and Perry reservoirs to meet instream purposes through controlled releases.
    - Complete necessary background work to support a request to reallocate storage from water supply to water quality in Milford and Perry reservoirs.
    - 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.
    - Request reallocation of remaining storage from water supply to water quality.
- By 2025, evaluate the ability to raise the conservation pool in each federal reservoir.
    - Using existing modeling, determine amount of additional yield that can be gained in each reservoir by permanently raising the conservation pool by 1, 2 and 3 feet.
    - Working with Kansas River Water Assurance District, KDHE, KDWPT, the Kansas Department of Agriculture-Department of Water Resources (KDA-DWR) and other stakeholders, begin NEPA evaluation of impacts and benefits at the reservoirs with increased pool level.
    - Work with USACE to determine updated costs of reallocation and purchase of storage.
    - Secure federal funding for reallocation study.
    - Where feasible and appropriate based on cost and impact evaluation, request USACE reallocate storage from flood control to water supply storage.
- The Kansas Water Office (KWO) 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.
- As articulated in the "*Basin Restoration Approach: Kansas Lower Republican,"* the Kansas RAC directs the KWO to improve coordination with the USACE on reservoir releases, management plans, and future actions to address water quality and quantity issues.

2. By 2050, explore additional storage possibilities such as construction of multipurpose lakes so that new water sources can be brought online.

   To meet this goal, the Kansas RAC developed the following **Action Steps**:

   - Use the existing Kansas Water Office "*Basin Restoration Approach: Kansas Lower Republican"* as a guide for planning future storage in the region.
   - Maintain an updated inventory of existing reservoir sites not built, along with pertinent data.
   - Contract with a consulting firm to determine the feasibility of building larger reservoir sites based on the "New Site Selection Criteria" from the "*Basin Restoration Approach:*

Kansas Lower Republican," with the addition of the potential sedimentation rate and upstream protection practices.

- Working with KDA-Department of Conservation (DOC), NRCS and local watershed districts, identify existing watershed structures that need restoration and have potential to be made larger and provide supplemental water supply.
- Working with KDA-DOC, NRCS and local watershed districts, identify watershed dam sites that were not constructed but could be built to provide supplemental water supply.
- KWO shall develop criteria to determine whether these sites should be expanded or built based on a broad range of issues.
- Seek partnership and funding opportunities to rehabilitate existing watershed reservoirs and/or construct new reservoirs that meet the established criteria.

3. Reduce the cumulative sediment rate of federal reservoirs and other water supply lakes by 10% in the Kansas region every 10 years through implementation of watershed best management practices.

   To meet this goal, the Kansas RAC developed the following **Action Steps**:

   - Utilize the Kansas Basin Watershed Management System (KBWM System) to reduce the overall sediment rate by 10% for the entire Kansas basin, not per reservoir, over 10 years.
     - All new funding allocated to meet RAC sedimentation reduction goals will utilize the KBWM System.
     - KBWM System utilizes and provides for the implementation of BMPs related to the reduction of sediment loading, which include a large range of measures. Approval and recommendation of BMPs for sediment reduction will be determined by the KBWM Interagency Committee (refer to KBWM System description).
     - This is accomplished by funding a minimum of $5 million annually to the System specifically for the reduction of sedimentation in the Kansas basin. At this funding rate, the goal is expected to be achieved within 30 years.
   - Within five years, all state and federal lands surrounding each reservoir in the watershed must have implemented BMPs as identified through the KBWM System.
   - Individual WRAPS plans and conservation district goals must include the concept of reservoir sustainability with the goal of maintaining storage capacity in Kansas Basin reservoirs.
   - Reservoir sustainability and reduction of sedimentation must be added as primary goals of the Kansas WRAPS Work Group.
   - The KBWM System will allow for the modification or inclusion of additional sedimentation goals as they are developed by RACs.
   - Establish programs with local universities to leverage relevant departments for expertise and student resources.
   - Existing funding allocations will continue to be distributed and managed as they have been historically with an enhanced focus on communication and coordination among funding providers. This increase in communication and coordination is an anticipated byproduct of the KBWM System.

- Additional funding for sedimentation through the KBWM System is critical to meeting the Kansas RAC Sedimentation Goals.
  - One key element of additional funding will be to secure adequate technical assistance advisors and providers for timely delivery and implementation of recommended BMPs.
  - Additional technical assistance at the state level must be developed, even with the current level of funding. NRCS currently provides technical assistance, but due to current funding and decreased staffing capacity, NRCS cannot always meet the state's implementation schedule. With additional state technical assistance providers, NRCS can dovetail and assist with projects, but projects will move forward in the event NRCS is not available. This encourages collaboration between the two groups and reduces reliance on NRCS.
- Achieving the stated goals requires the broadest participation possible. To effect a science-based solution, it is important that all relevant lands within a specific watershed be analyzed to assess their issues, determine their priority with respect to a defined problem (e.g., sedimentation of reservoirs) and identify and prioritize solutions. This may be a long-term process.
- The Kansas RAC encourages landowners in the Kansas Basin to develop and implement voluntary Comprehensive Conservation Plans for lands in the areas of resource concern.
- Education about the KBWM System and its goals and functions should be included in the Governor's Water Vision Education and Outreach Program.
  - Specific educational and outreach programs, resources and items shall be created, distributed and taught throughout the Kansas Basin focusing on the specific goals of the Kansas Basin.

4. By 2035, reduce per capita water consumption by 10% by 2035 through conservation, education, and pricing mechanisms.

   To meet this goal, the Kansas RAC developed the following **Action Steps**:

   - The Kansas RAC recognizes the need for water conservation in our region varies widely from year to year, season to season, and even throughout the region during any one time period. Regardless of the season or the current availability of water, the Kansas RAC is committed to promoting and supporting wise water use throughout the region.
   - Action Plan Section 1: Unaccounted-for Water
     - Whether or not water is in short supply, we should always use it wisely. One of the most significant issues that can and should be addressed with regard to water use is unaccounted-for water (UFW). This is water that public water suppliers have paid to pump, convey and/or treat, and which is unaccounted for due to leakage in the distribution system, failures within the water utility infrastructure, accounting system errors and/or unmetered water distribution. This UFW calculation currently includes a range of unmetered uses, which includes hydrant flushing, tower flushing for maintenance, etc.

- The Kansas Municipal Water Conservation Plan Guidelines approved by the Kansas Water Authority (KWA) in 2007 currently recommend that a utility implement a water management review when UFW exceeds 20% for a four-month period. The average UFW for all utilities in the region in 2014 was 16.6%. The guidelines for the Kansas Region should raise the bar higher by encouraging utilities to undertake the review at 15% for a four-month period, monitored monthly. The Kansas Water Office (KWO) should ensure technical assistance to conduct those management reviews when necessary, and technical assistance to address acute UFW.
    - Historically, UFW has been difficult to track, as water usage was not metered consistently. By 2017, however, this will change. The KDA-DWR required the installation of a flowmeter or other suitable water measuring device on all non-temporary, non-domestic water uses in 2014, with meter installation required for all water users by the end of 2016 and compliance required by the end of 2017. All public water suppliers currently meter their source of supply; a small number, however, remain that do not meter individual customer water usage. The RAC recommends that all public water suppliers implement customer water metering at the earliest opportunity.
    - The water metering requirement and customer metering will allow for all types of water usage to be tracked and analyzed by 2018. The most important short-term benefit of the installation of water flow meters is that it will allow for appropriate accounting of water usage. This accounting not only allows for the identification of the location and nature of leaks in the system, but the information gathered is critical also to determining the nature of water usage and where conservation measures can be wisely implemented. This information will allow communities and individual users to strategize appropriate water usage and save themselves and/or the community water and money over time.
- Over time, large users should be encouraged to sub-meter which will improve their understanding of the nature of their water consumption and allow for more effective implementation of wise water use measures.
- The KWO should educate communities about the availability of funding for utilities to conduct assessments of distribution and transmission systems and develop a proactive replacement and repair schedule to minimize water loss within the system. Utilities should, where feasible, collaborate with larger utility partners in the area for assistance with assessments. The KWO should also actively educate communities about the availability of funding for investments in infrastructure improvements to minimize water loss for all water utilities in the Kansas Region.

- Action Plan Section 2: Water Conservation Plans
    - The KWO should evaluate current conservation plan guidelines adopted by the KWA in 2007, to ensure they adequately address the Vision and Kansas Region goals and provide assistance in updating plans as necessary.
    - The KWO should work with public water suppliers in the region to ensure that all have an approved water conservation plan consistent with the updated Guidelines approved by the KWA that reflect the Vision and Kansas Region goals.

- The KWO should work with public water suppliers that have experienced drought vulnerability in the last 10 years to ensure they have robust drought response plans, with meaningful and implementable triggers and responses.
- The KWO should develop a BMP Conservation Guide for communities, highlighting available resources and success stories. This BMP Conservation Guide shall be updated bi-annually.
- The Kansas RAC recommends that communities throughout the Kansas Region adopt wise water use in public buildings and on public grounds as identified in the BMP guide.

- Action Plan Section 3: Education
  - The KWO should make use of existing educational resources from federal, state and non-governmental organizations such as the EPA's WaterSense program and WaterSense partners, and materials produced by the American Water Works Association and the Alliance for Water Efficiency.
  - The Kansas RAC supports the mission of the Kansas Water Vision Educational Task Force. Any education efforts should be carried out in collaboration with the Kansas Water Vision Education Program.
  - The Kansas RAC will submit the following recommendations to the Kansas Water Vision Educational Task Force.
    - Develop a strategic, unified messaging campaign tailored to the needs of each region that is executed across the state and through all relevant agencies through coordinated messaging methods.
    - Develop a robust and comprehensive website that will serve as a cornerstone of the education campaign.
    - Establish a shared resource center for water suppliers and major users to connect regionally and share best management practices.
- Action Plan Section 4: Incentive-based conservation practices
  - The Kansas RAC will continue to work with stakeholders to research and explore other opportunities to encourage wise use of water in the Kansas Region. The following items are examples of the type of opportunities the RAC will investigate.
  - Consider incentive-based conservation practices. Electric utilities use "throughput disincentives" authorized by the Kansas Energy Efficiency Investment Act (KEEIA) to recover revenue lost by conservation measures; something similar might be appropriate for water utilities.
  - Establish criteria that encourage Low Impact Development (LID) that focuses on lowering water use in new developments.
    - Direct the KWO to work with cities to adopt LID design criteria with the goal that city ordinances and any other requirements would encourage less water-intensive fixtures, structures and landscape in new developments.
    - Direct the KWO to award and recognize cities and developers who utilize LID that focuses on water conservation.
    - Direct the KWO to proactively promote LID concepts to land developers.
  - Work with utilities to incentivize water efficiency via lower connection rates (or other upfront cost saving incentives) for developers, property and business owners using efficient fixtures, xeriscaping, rain catchment/reuse systems, and other conservation measures.

- Offer tax credits for practices that reduce consumption without reducing production.
  - With respect to agricultural water use, provide property tax credits proportionate to water use reduction on irrigated agricultural lands.
  - Consider incentives for recycling of water within an entity or community.
  - Develop a rewards and recognition program for successful Kansas conservation activities to highlight communities, individuals, businesses and industry that implement local conservation BMPs successfully.
  - Create a private "water audit" certification program such as Leadership Energy and Environmental Design (LEED) to identify individuals achieving highly efficient water use and conservation.
  - Promote smart water use in public buildings and on public grounds such as lower volume toilets and reduced lawn watering.
  - Fund K-State Extension programming on low or no water use landscaping.

5. After 2020, reduce duration and frequency of harmful algal blooms disrupting recreation in lakes such that blooms last under a week and do not occur until after Labor Day.

   To meet this goal, the Kansas RAC developed the following **Action Step**:

- Utilize the Kansas Basin Watershed Management (KBWM) System to reduce the level of nutrients entering the reservoirs and water supply lakes.
  - All new funding allocated to meet RAC nutrient reduction goals will utilize the KBWM System.
  - KBWM System utilizes and provides for the implementation of BMPs related to the reduction of nutrient loading, which include a large range of measures. Approval and recommendation of BMPs for nutrient reduction will be determined by the KBWM Interagency Committee (refer to KBWM System description).
  - This is accomplished by a minimum allocation of $1.5 million per year to be directed to BMPs in the Milford Watershed, with a total request of $3 million per year, with the remaining $1.5 million to be distributed throughout the watershed through the KBWM System.
- Within five years, all state and federal lands surrounding each reservoir in the watershed must have implemented best management practices to address harmful algal blooms (HABs) as identified through the KBWM System.
- Individual WRAPS' Plans and local Conservation Districts' goals must include the concept of minimizing nutrient inflow to lakes with the goal of reducing the potential for HABs.
- The reduction of nutrients must be added as a primary focus of the Kansas WRAPS Work Group.
- KWO and KDHE must coordinate with USACE on management of releases during HABs and provide notice to downstream communities of the level of release.
- Ensure that KWO and KS RAC promote the inclusion of lake communities, downstream public water supply systems, and other water users into HAB meetings and discussions.

- Underscore that the preferred methodology is to use BMPs which include a large range of measures which will be vetted through the KBWM System. BMPs should be prioritized to address HABs.
- Recognize that in the near-term, dollars will need to be spent on treatment of the problem in the lakes (e.g., chemical treatment), but the goal is to shift those dollars upstream to prevention of the problem at the source – which is to prevent nutrients from flowing into the lakes.
- The RAC supports ongoing research for identification and remediation of the causes, prevention and treatment of HABs, including potential in-lake technologies.
- Establish programs with universities to leverage relevant departments for expertise and student resources.
- Achieving the stated goals requires the broadest participation possible. To effect a science-based solution, it is important that all relevant lands within a specific watershed be analyzed to assess their issues, determine their priority with respect to a defined problem (e.g., HABs) and identify and prioritize solutions. This may be a long-term process.
- The RAC encourages landowners in the Kansas Basin to develop and implement voluntary Comprehensive Conservation Plans for lands in the areas of resource concern.
- Education about the KBWM System and its goals and functions should be included in the Governor's Water Vision Education and Outreach Program.
- Specific educational and outreach programs, resources and items shall be created, distributed and taught throughout the Kansas Basin focusing on the specific goals of the Kansas Basin including the reduction of HABs.
- Establish a region wide education and communication plan with regard to HABs and include best and worst management practices.

In summary, the Kansas RAC will work in cooperation and coordination with local WRAPS groups, conservation districts, producers, and municipalities. Partnerships will implement goals by leveraging existing financial resources and finding new funding sources, implementing new conservation practices, and providing education and awareness of water quality and quantity issues in the watershed.

3. Watershed Review

This watershed review is an in-depth description of the Lower 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 Lower Kansas River Watershed. As shown in **Figure 5**, the three major land uses in this watershed are pasture/hay (36%), cropland (19%), and deciduous forest (17%). Pasture/hay and grassland (5%) land uses often can contribute livestock manure to streams and ponds, resulting 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 into sediment during runoff events and are deposited in nearby streams. Agricultural cropland under conventional tillage practices as well as a lack of maintenance of agricultural BMP structures can have cumulative effects on land transformation through sheet and rill erosion.

Table 1 lists the remaining land uses in the watershed, including: developed/open space (8%), developed, low intensity (7%), developed, medium intensity (3%), open water (1.5%), developed, high intensity (1%), woody wetlands (<1%), and other (~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.

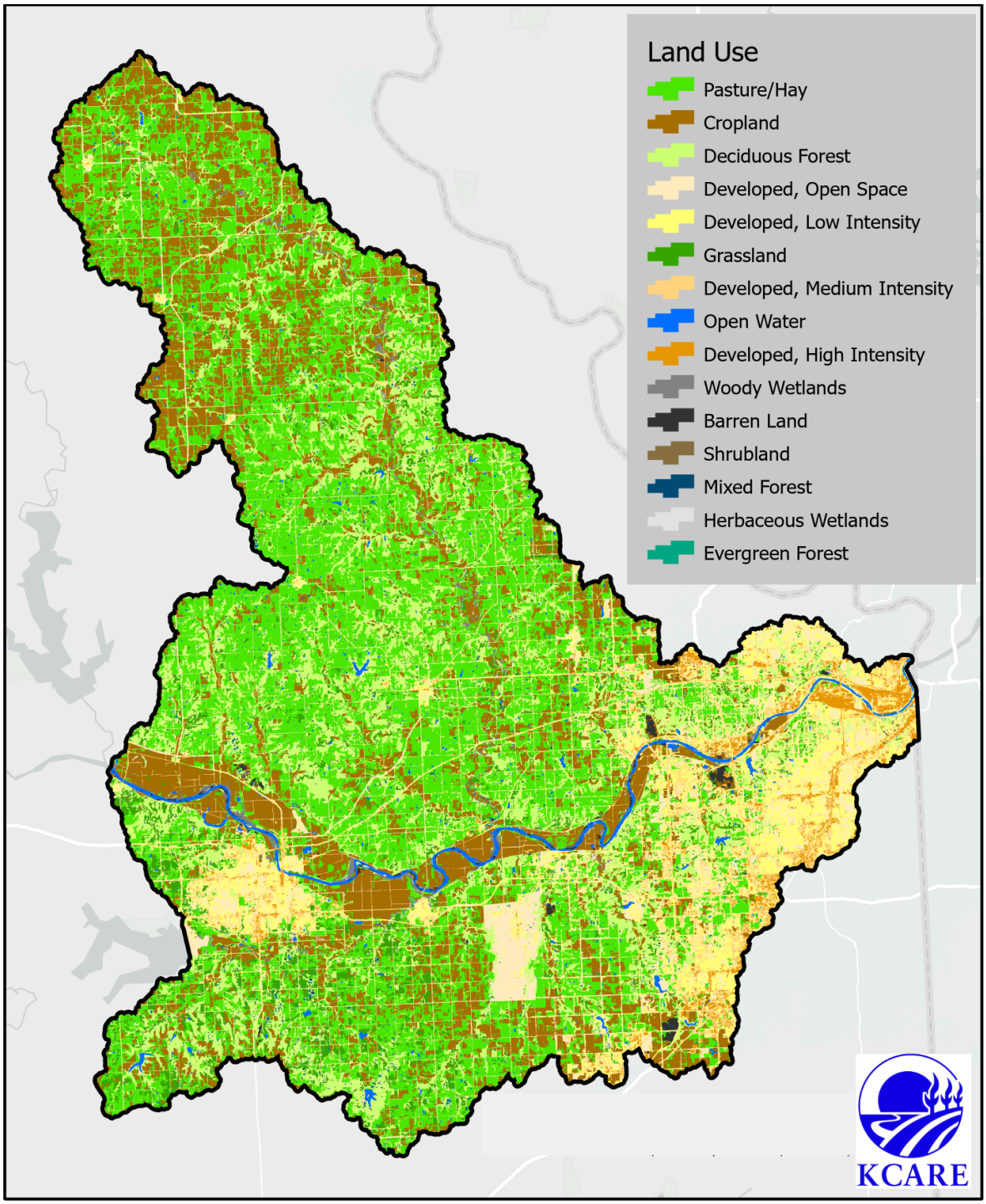


Figure 5. Land Cover and Land Use in the Lower Kansas River Watershed

Table 1. Land Use in the Lower Kansas River Watershed

Land Use in the Lower Kansas River Watershed		
Land Use	**Total Acres**	**% of Watershed**
Pasture/Hay	297,935	36.2%
Cropland	158,091	19.2%
Deciduous Forest	137,851	16.8%
Developed, Open Space	69,199	8.4%
Developed, Low Intensity	59,382	7.2%
Grassland	40,217	4.9%
Developed, Medium Intensity	23,562	2.9%
Open Water	12,383	1.5%
Developed, High Intensity	10,134	1.2%
Woody Wetlands	5,848	0.7%
Barren Land	2,616	0.3%
Shrubland	2,142	0.3%
Mixed Forest	1,793	0.2%
Herbaceous Wetlands	619	0.1%
Evergreen Forest	167	0.0%
Total	**821,940**	**100%**

B. Designated Uses

The stream segments and lakes in the Lower 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 Lower 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. Asterisks refer to a violation of designated use, and a 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 Lower Kansas River Watershed[2]

Designated Water Uses: Lower Kansas River Watershed - 10270104								
Water Segment Name:	**AL**	**CR**	**DS**	**FP**	**GR**	**IW**	**IR**	**LW**
Fall Creek, Hays Creek, Indian Creek, Little Sandy Creek, Mission Creek - East, Mission Creek - West, Unnamed Stream (Segment 11, 583 and 584)	E	b	O	O	O	O	X	X
Brush Creek, Buttermilk Creek, Chicken Creek, Cow Creek, Unnamed Stream (Segment 16)	E	b	O	O	X	O	X	X
Hulls Branch	E	b	O	X	O	O	O	O
Camp Creek (Segment 74), Jarbalo Creek, Scatter Creek	E	b	O	X	O	O	X	X
Howard Creek	E	b	O	X	X	O	O	X
Spoon Creek	E	b	O	X	X	O	X	X
Balwin Creek, Camp Creek (Segment 41), Dawson Creek, Hog Creek, Muncie Creek, Oakley Creek, Plum Creek, Rock Creek (Segment 902), Stone House Creek, Stone Hosue Creek - East, Stone House Creek - West, Wakarusa River - South Branch, Washington Creek	E	b	X	O	X	X	X	X
Barber Creek, Hanson Creek, Kent Creek, Little Stranger Creek (Segment 881), Mooney Creek, Nine Mile Creek (Segments 15 and 17), Prairie Creek, Tooley Creek, Unnamed Stream (Segment 452), Wakarusa River - Middle Branch, Walnut Creek	E	b	X	X	X	X	X	X
Stranger Creek (Segment 9)	E*	b	X	X	X	X	X	X
Clear Creek, Little Cedar Creek	E	B	O	X	X	O	X	X
Little Mill Creek	E	B	O	X	X	X	X	X
Brenner Heights Creek, Cedar Creek, Kill Creek, Mill Creek, Tonganoxie Creek, Turkey Creek, Wakarusa River (Segment 24, 25 and 30), Yankee Tank Creek	E	B	X	X	X	X	X	X
Stranger Creek (Segment 8)	E*	B*	X	X	X	X	X	X
Coal Creek	E	C	O	X	X	X	X	X
Camp Creek (Segment 66), Captain Creek, Crooked Creek (Segments 10 and 12), Little Kaw Creek, Little Stranger Creek (Segment 959), Little Turkey Creek, Little Wakarusa Creek, Mud Creek, Wakarusa River (Segment 31), Wolf Creek	E	C	X	X	X	X	X	X
Stranger Creek (Segments 5, 6 and 7)	E*	C	X	X	X	X	X	X
Buck Creek	S	b	X	X	X	X	X	X
Kansas River (Segments 1, 2, 3, 4, 18, 19, 21 and 23)	S	B	X	X	X	X	X	X

[2] Kansas Surface Water Register, 2013. Kansas Department of Health and Environment. https://www.epa.gov/sites/default/files/2014-12/documents/kswqs-register-2009.pdf, pages 8-10 and 55.

Designated Water Uses: Lower Kansas River Watershed - 10270104, continued								
Lake Name:	AL	CR	DS	FP	GR	IW	IR	LW
Antioch Park Lake	E	A	X	X	O	X	X	X
Baker Wetlands	E	B	X	X	X	X	X	X
Cedar Lake	E	B	X	X	O	X	X	X
Douglas County State Fishing Lake	E	B	X	X	O	X	X	X
Frisco Lake	E	B	X	X	O	X	X	X
Gardner City Lake	E	A	X	X	O	X	X	X
Lake Dabanawa	E	A	X	X	O	X	X	X
Lake Quivera	E	A	X	X	X	X	X	X
Lakeview Estates Lake	E	B	X	X	O	X	X	X
Leavenworth County State Fishing Lake	E	B	X	X	O	X	X	X
Lenexa City Lake	E	B	X	X	O	X	X	X
Lone Star Lake	E	A	X	X	O	X	X	X
Mahaffie Farmstead Lake	E	B	X	X	O	X	X	X
Mary's Lake	E	B	X	X	X	X	X	X
New Olathe Lake	E	A	X	X	O	X	X	X
North Park Lake	E	B	X	X	X	X	X	X
Olathe Waterworks Lake	E	B	X	X	O	X	X	X
Pierson Park Lake	E	B	X	X	X	X	X	X
Potter's Lake	E	B	X	X	O	X	X	X
Rose's Lake	E	B	X	X	O	X	X	X
Shawnee Mission Lake	E	A	X	X	O	X	X	X
Sunflower Park Lake	E	B	X	X	O	X	X	X

C. Special Aquatic Life Use Waters[3]

Special Aquatic Life Use (SALU) waters are defined as "surface waters that contain combinations of habitat types and indigenous biota not found commonly in the state, or surface waters that contain representative populations of threatened or endangered species." The Lower Kansas River Watershed has two waterbodies considered SALU waters (**Figure 6**):

- Buck Creek
- Kansas River

[3] [3] Kansas Surface Water Register, 2013. Kansas Department of Health and Environment. https://www.epa.gov/sites/default/files/2014-12/documents/kswqs-register-2009.pdf, pages 8-10 and 55.

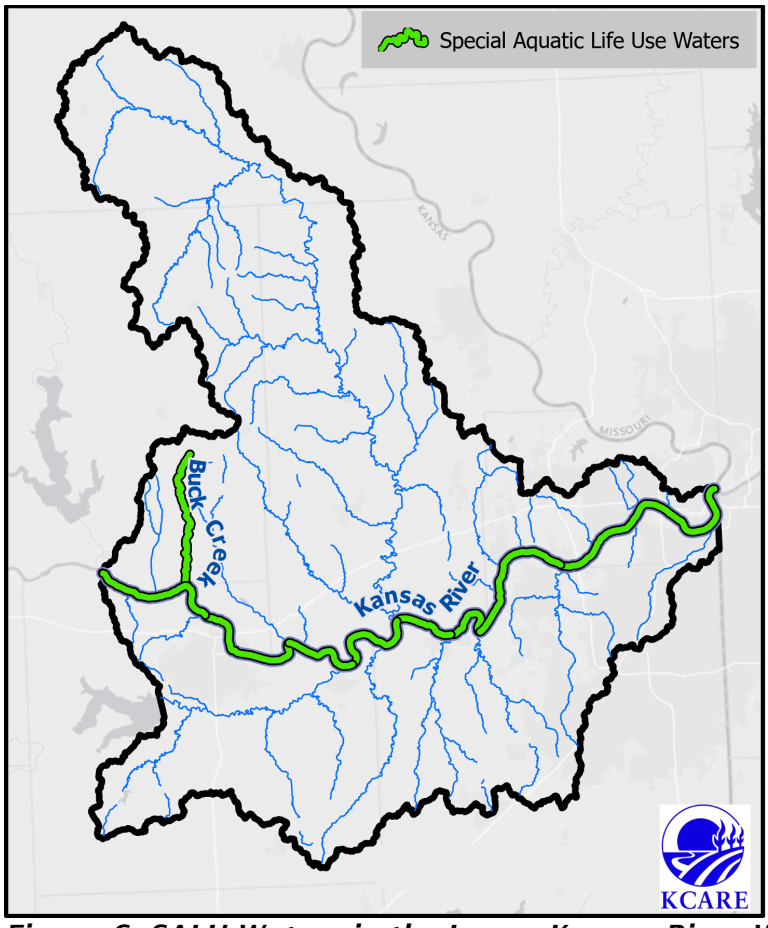


Figure 6. SALU Waters in the Lower Kansas River Watershed

D. Exceptional State Waters[4]

Exceptional State Waters (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 no ESW-listed waters in the Lower Kansas River Watershed.

E. Outstanding National Resource Waters[4]

Outstanding National Resource Waters (ONRW) are defined as "any of the surface waters or surface water segments of extraordinary recreational or ecological significance." The Lower Kansas River Watershed does not contain 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

[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

cropland is either bare, or crop biomass is small; likewise, grasses are short and do not catch runoff. Both situations can lead to pollutants and bacteria entering the waterways. The Lower Kansas River Watershed averages 38.8 inches of rainfall annually (**Figure 7**). Precipitation data from the cities of Atchison (just northwest of the watershed), Bonner Springs, Lawrence, and Olathe were used to calculate the watershed's average annual rainfall. As shown in **Figure 8**, the highest levels of precipitation are found in the central to southern section of the watershed, with the least levels of precipitation are found in the far northwest corner.

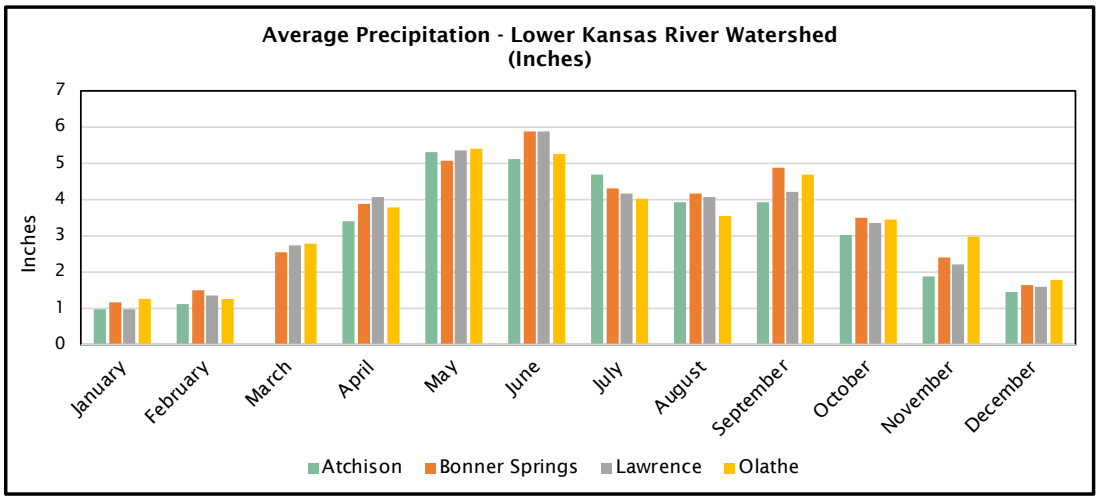


Figure 7. Lower Kansas River Watershed Monthly Average Precipitation[5]

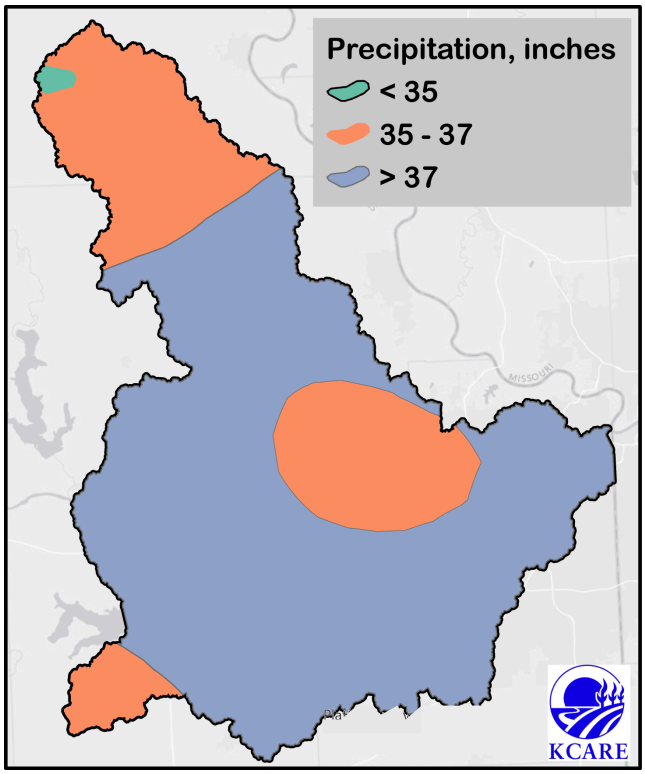


Figure 8. Annual Precipitation in the Lower Kansas River Watershed

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

G. Population and Wastewater Systems

The Lower Kansas River Watershed is made up of about 50% urban area, with an above-average population density, and 50% rural area with a slightly above-average population density (**Figure 9**).

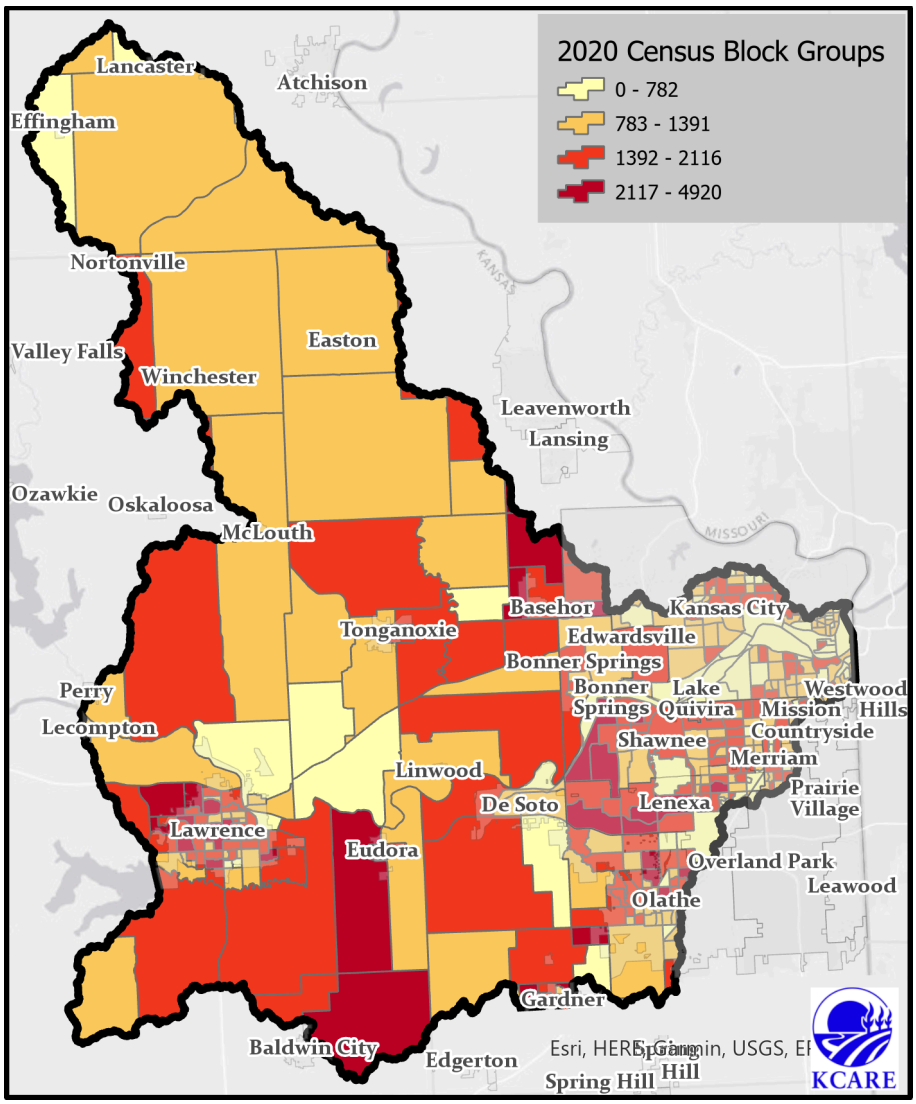


Figure 9. Lower Kansas River Watershed Population Map

Table 4 uses county population averages to determine how many persons reside in the area per square mile. Using a Lower Kansas River Watershed area of 1,284 square miles and the average of 395 persons per square mile, as determined in **Table 4**, the estimated total population for the Lower Kansas River Watershed is 507,180 (**Table 5**). From there, it can be determined that the average for the Lower Kansas River Watershed is 1,617 persons per square mile in municipal/urban areas (284 square miles) and 48 persons per square mile in rural areas (1,000 square miles) (**Table 5**). Since the average population density for Kansas, represented as persons per square mile, is 32.9, the Lower Kansas River Watershed has an above-average population.

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

Estimating the Lower Kansas River Watershed Population			
County	**Square Miles***	**Population: 2020 Census**	**Persons Per Square Mile**
Atchison	434	16,348	38
Douglas	475	118,785	250
Jefferson	557	18,368	33
Johnson	480	609,863	1,271
Leavenworth	469	81,881	175
Wyandotte	156	169,245	1,085
TOTAL	**2,571**	**1,014,490**	**395**

This is the total square miles 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]

Lower Kansas River Watershed Municipal and Rural Population			
Township	**2020 Population**	**Square Miles**	**Persons Per Square Mile**
Basehor	6,194	7.00	885
Bonner Springs	7,804	16.00	488
De Soto	6,443	11.00	586
Easton	260	0.16	1,625
Edwardsville	4,494	9.00	499
Effingham	521	0.62	840
Eudora	6,384	3.00	2,128
Gardner	21,871	10.00	2,187
Kansas City, KS (population: 152,522 ~ 50% in the watershed)	76,261	64.00	1,192
Lancaster	288	0.20	1,440
Lawrence	97,286	35.00	2,780
Lecompton	655	2.00	328
Lenexa (population: 55,294 ~ 95% in the watershed)	52,529	32.00	1,642
Linwood	391	0.60	652
Mclouth	844	0.58	1,455
Merriam	11,178	4.00	2,795
Nortonville	609	0.44	1,384
Olathe (population: 139,605 ~ 60% in the watershed)	83,763	37.00	2,264
Overland Park (population: 192,536 ~ 5% in the watershed)	9,627	4.00	2,407
Shawnee	65,845	43.00	1,531
Tonganoxie	5,524	4.00	1,381
Winchester	528	0.36	1,467
Municipal/Urban Totals	459,299	284	1,617
Rural Totals	47,881	1,000	48
Lower Kansas River Watershed: TOTALS	**507,180**	**1,284**	**395**

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

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 other 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 Lower Kansas River Watershed. Using a rural population of roughly 47,881 and an estimated 2.29 persons per rural Kansas household, it can be determined that there are approximately 20,908 onsite wastewater treatment systems installed in the watershed with an expected failure rate of roughly 20%, or 4,182 systems.[7]

H. Aquifers

Portions of two aquifers underlie the Lower Kansas River Watershed: the alluvial aquifer and the Glacial Drift Aquifer (**Figure 10**).

- 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 Lower Kansas River Watershed lies along and below Stranger Creek and the Kansas River, as well as some tributaries to each. Many additional water segments in the watershed are connected by the alluvial aquifer, including: Crooked Creek, Buttermilk Creek, Dawson Creek, Scatter Creek, Fall Creek, Tonganoxie Creek, Mud Creek, Nine Mile Creek, Wakarusa River, Chicken Creek, Washington Creek and Coal Creek.
- 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.

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

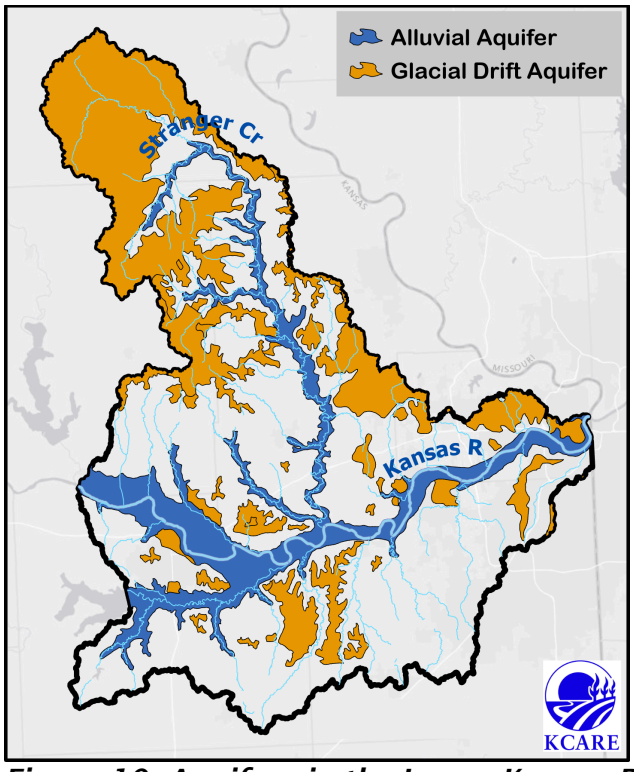


Figure 10. Aquifers in the Lower Kansas River Watershed[8]

I. Public Water Supplies

A Public Water Supply (PWS) is defined as any system that supplies piped water to the public for human consumption, given that the system has at least 10 service connections, or regularly serves an average of 25 or more individuals for 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, contaminants able to leach through the soil (or where aquifers are shallow) 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 37 public water suppliers within the Lower Kansas River Watershed, as shown in **Table 6**. The majority of 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. Lower Kansas River Watershed Public Water Suppliers[9]

Public Water Suppliers in the Lower Kansas River Watershed		
Public Water Suppliers	**Population**	**County**
Atchison County Rural Water District 5C	3,645	Atchison
Bonner Springs, City of	7,804	Wyandotte
Building Blocks Day Care Center LLC	125	Johnson
Clearview City, City of	450	Johnson
Desoto, City of	6,443	Johnson
Douglas County Rural Water District 1	1,400	Douglas
Douglas County Rural Water District 2	1,163	Douglas
Douglas County Rural Water District 4	3,000	Douglas
Douglas County Rural Water District 6	360	Douglas
Easton, City of	260	Leavenworth
Effingham, City of	521	Atchison
Eudora, City of	6,384	Douglas
Gardner, City of	21,871	Johnson
Jefferson County Rural Water District 12	3,635	Jefferson
Jefferson County Rural Water District 13	2,115	Jefferson
Jefferson County Rural Water District 2	642	Jefferson
Lancaster, City of	288	Atchison
Lawrence, City of	97,286	Douglas
Lawrence, Kansas Turnpike Authority	25	Douglas
Leavenworth County Rural Water District 10	499	Leavenworth
Leavenworth County Rural Water District 6	240	Leavenworth
Leavenworth County Rural Water District 7	3,000	Leavenworth
Leavenworth County Rural Water District 8	2,500	Leavenworth
Leavenworth County Rural Water District 9	2,000	Leavenworth
Lecompton, City of	655	Douglas
Linwood, City of	391	Leavenworth
McLouth, City of	844	Jefferson
New Century Air Center	500	Johnson
Northeast District Office	1	Douglas
Nortonville, City of	609	Jefferson
Olathe, City of	139,605	Johnson
Paradise Park Mobile Home Court	110	Leavenworth
Suburban Water Company	4,700	Leavenworth
Tonganoxie, City of	5,524	Leavenworth
University of Kansas	35,000	Douglas
Water District 1 of Johnson County	455,000	Johnson
Winchester, City of	528	Jefferson
Total Population Served	**809,123**	

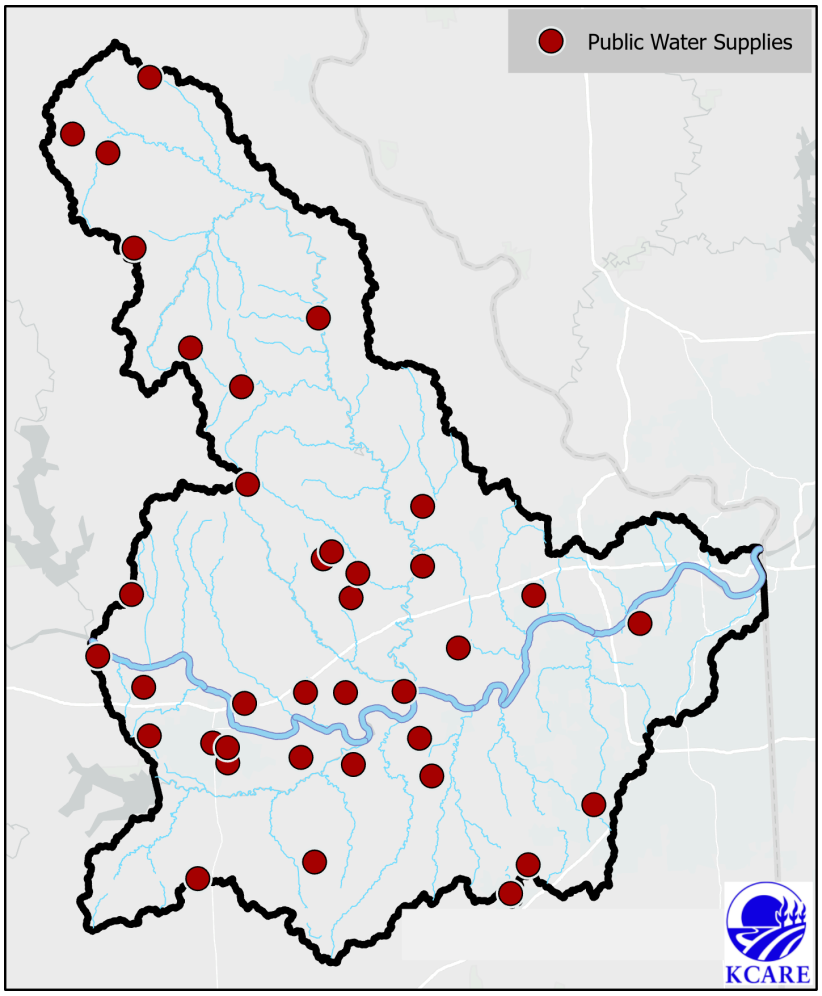


Figure 11. Public Water Supplies in the Lower Kansas River Watershed

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.

[9] Kansas Department of Health and Environment, November 8, 2021.
[10] Kansas Department of Health and Environment, Source Water Assessment Reports.

The Lower Kansas River Watershed has 37 active PWS sites. Nearly all public water suppliers within the Lower Kansas River Watershed were required to develop a SWAP in 2003.

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 19 permitted NPDES facilities in the Lower Kansas River Watershed (**Table 7**).

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

NPDES Permitted Facilities in the Lower Kansas River Watershed			
Facility Name	**Facility Type**	**Description**	**County**
University Of Kansas Sunflower Waste	Industrial	Groundwater Remediation	Douglas
BNSF Railway Company - Argentine (KC)	Industrial	Railway	Wyandotte
Hallmark Cards Inc.	Industrial	Cooling / Heating Wastewater Discharge	Douglas
Fuchs Lubricants Comapany	Industrial	Cooling / Heating Wastewater Discharge	Wyandotte
Desoto (Saap) Water Treatment Plt	Industrial	Public Water Supply System	Johnson
Ecovyst Catalyst Technologies LLC	Industrial	Cooling / Heating Wastewater Discharge	Wyandotte
Bonner Springs Water Treatment Plant	Industrial	Potable Water Production	Wyandotte
Hamm Material Recovery Facility	Industrial	Car Wash	Douglas
Than - Harcros Groundwater Remediation	Industrial	Groundwater Remediation	Wyandotte
Kansas River Hydropower North Plant	Industrial	Power Generation	Douglas
Public Wholesale Watershed District #25	Industrial	Public Water Supply System	Douglas
Leavenworth County Rural Water District #9	Industrial	Potable Water Production	Leavenworth
Suburban Water Treatment Plant	Industrial	Public Water Supply System	Leavenworth
National Cold Storage of KC Inc.	Industrial	Cold Storage	Leavenworth
Cargill, Inc. (Atchison Grain Elevator)	Industrial	Groundwater Remediation	Atchison
Lawrence - Farmland Industries	Industrial	Inorganic Chemicals (Fertilizers, Etc)	Douglas
Exxon Mobil Corporation - Olathe	Industrial	Petroleum Products	Johnson
Lawrence - Clinton Reservoir Public Water Supply	Industrial	Potable Water Production	Douglas
BPU - (KC) Kaw Power Station	Industrial	Power Generation	Wyandotte

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

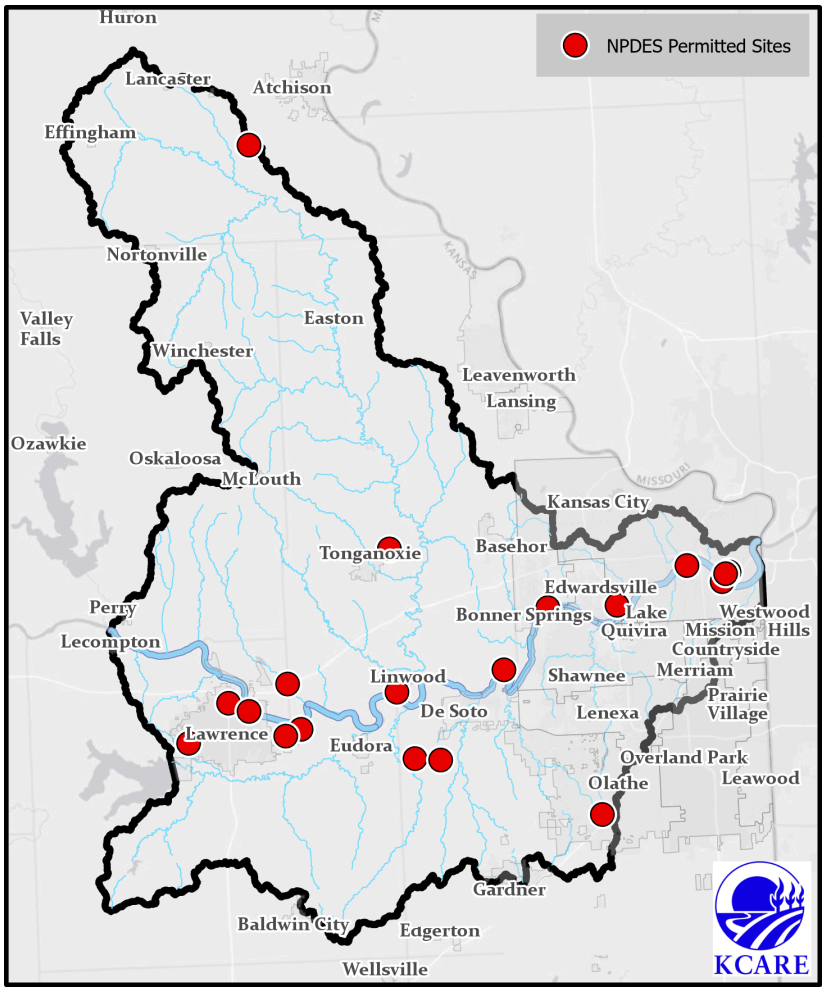


Figure 12. Lower Kansas River Watershed NPDES Sites

K. Livestock Operations in the Lower 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/feedlots** for more information.

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

Permitted Livestock Facilities	
County	**Number of Facilities**
Atchison	2
Douglas	11
Jefferson	3
Johnson	4
Leavenworth	11
Wyandotte	0
Total	**31**

As shown in **Table 8**, there are 31 active permitted livestock facilities in the six counties housing the Lower Kansas River Watershed. 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 Lower 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.

4. Impaired Waters

Water quality in the Lower Kansas River Watershed is monitored at 32 sites (**Figures 13 and 14**). These sites include eight permanent and 10 rotational KDHE sampling sites, as well as two inactive monitoring sites. Twelve additional active monitoring sites can be found in lakes throughout the southern portion of the Lower Kansas River Watershed.

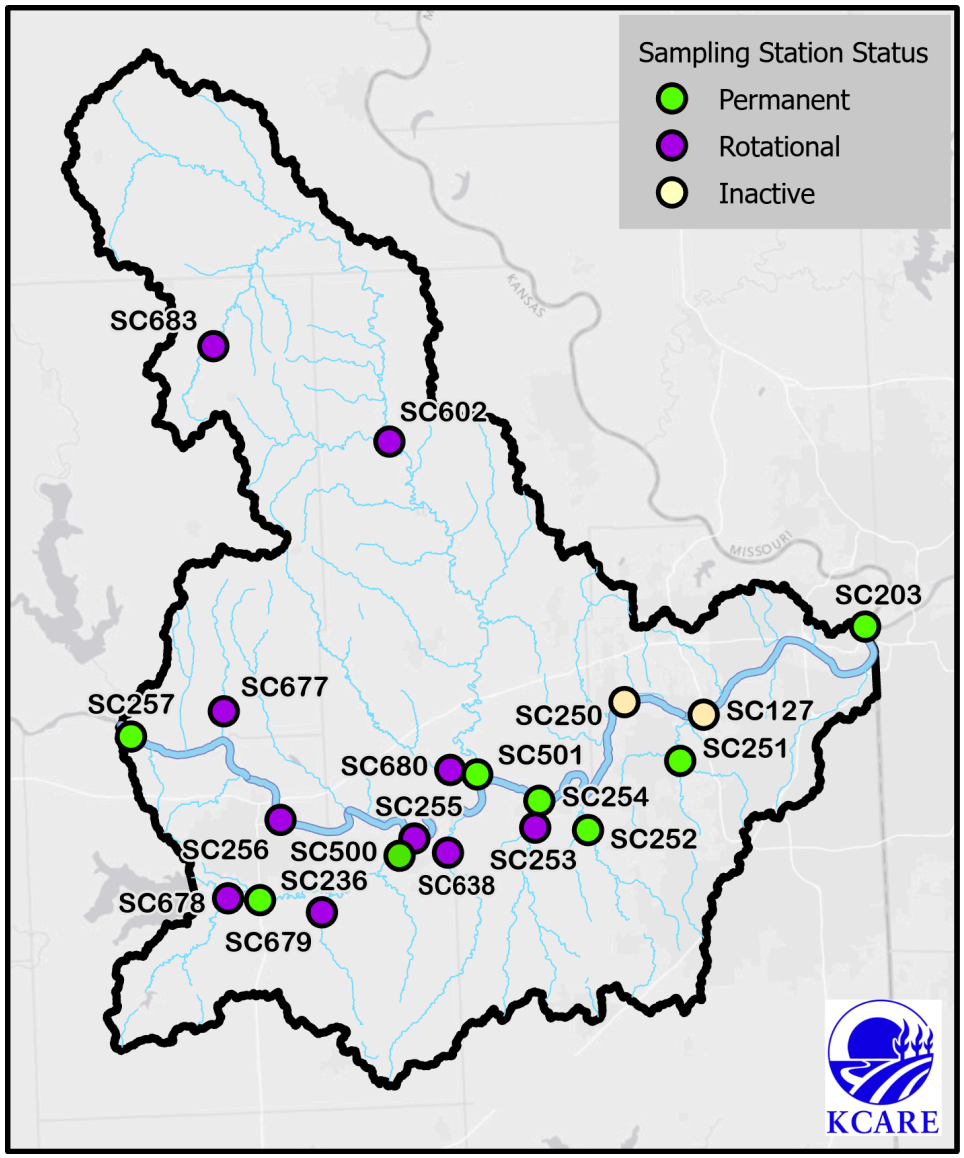


Figure 13. Lower Kansas River Watershed Stream Monitoring Sites

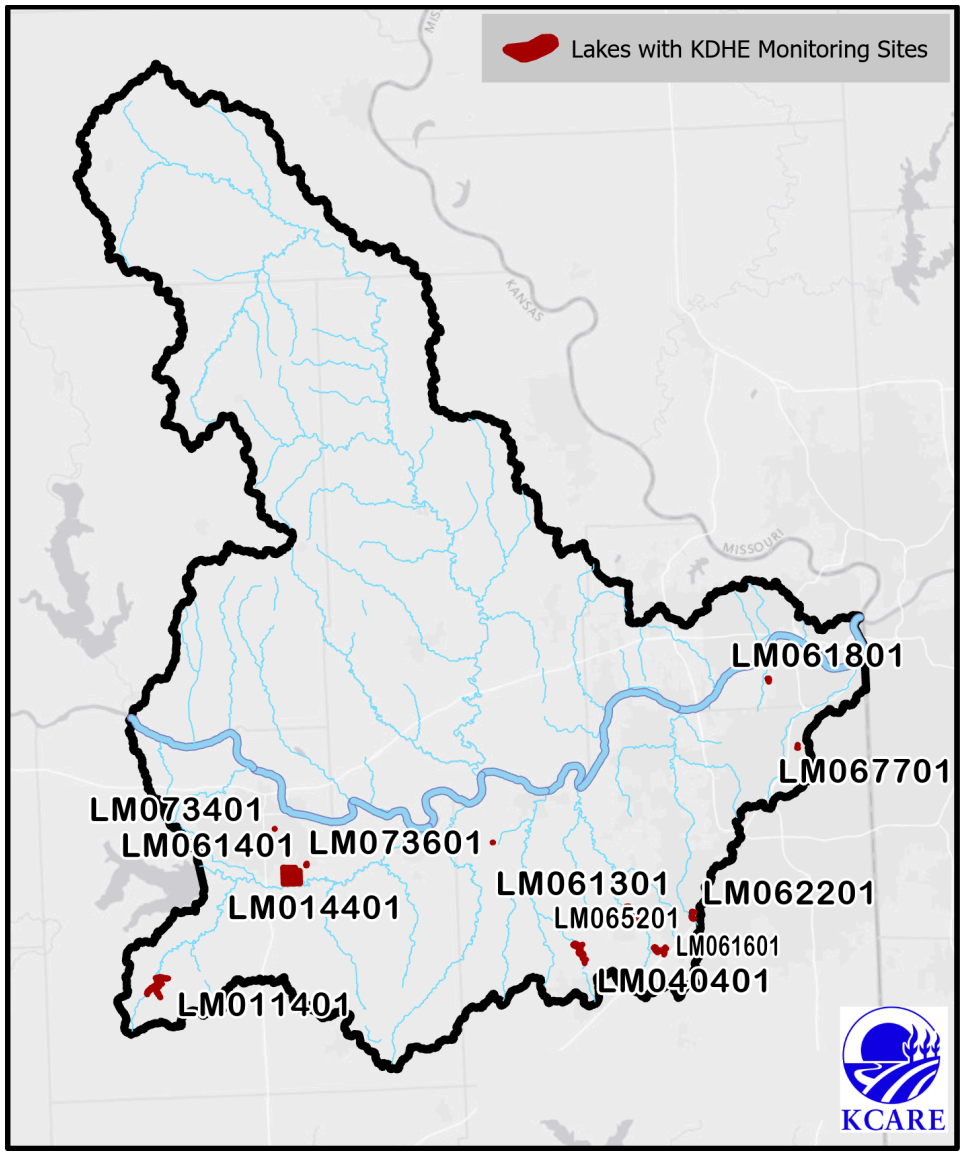


Figure 14. Lower Kansas River Watershed Lake Monitoring Sites

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) if it is in dire need of pollutant reduction and is considered "high priority."

A. 303d List of Impaired Waters in the Lower 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 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 32 *303d-listed* waters in the Lower Kansas River Watershed **(Table 9)**. *All category 4a (TMDL) listings are described in the following "TMDL" section.*

Table 9. 303d-Listed Waters in the Lower Kansas River Watershed[12]

303d List of Impaired Waters				
Water Segment	**Category**	**Impairment**	**Priority**	**Sampling Station**
Antioch Park Lake	5	DDT	2023	LM067701
		Dieldrin		
		Eutrophication		
		Heptachlor Epoxide		
Baker Wetlands	5	Eutrophication	2022	LM014401
	5	Lead	2023	
	5	pH	2022	
Captain Creek near Eudora	5	Atrazine	2023	SC638
	3	*E. coli*		
Crooked Creek near Winchester	5	Atrazine	2023	SC683
	3	*E. coli*		SC683
Douglas County State Fishing Lake	5	Eutrophication	2022	LM011301
Kansas River at Desoto	5	Total Suspended Solids	2023	SC254
Kansas River at Eudora	5	Polychlorinated biphenyls (PCB)	2023	SC255
		Total Suspended Solids		
Kansas River at Kansas City, KS	5	Total Suspended Solids	2023	SC203
Kansas River at Lecompton	5	Total Suspended Solids	2023	SC257
Kill Creek at Desoto	5	Atrazine	2023	SC253
Lake Quivera	5	Eutrophication	2023	LM022701
Leavenworth County State Fishing Lake	5	Eutrophication	2022	LM012301
Lenexa Lake	5	Eutrophication	2022	LM022601
Mahaffie Farmstead Lake	5	Eutrophication	2023	LM020401
Mill Creek near Shawnee	3	Diazinon		SC251
Rose's Lake	5	Eutrophication	2022	LM062501
Stranger Creek near Easton	5	Atrazine	2023	SC602
		Biology		
		Total Suspended Solids		
Stranger Creek near Linwood	5	Atrazine	2023	SC501
		Biology		
Turkey Creek	5	Ammonia	2023	NPDES55492
Wakarusa River near Eudora	5	Biology	2023	SC500
		Total Suspended Solids		

[12] Kansas Department of Health and Environment, 2021.
https://www.kdhe.ks.gov/1219/303d-Methodology-List-of-Impaired-Waters

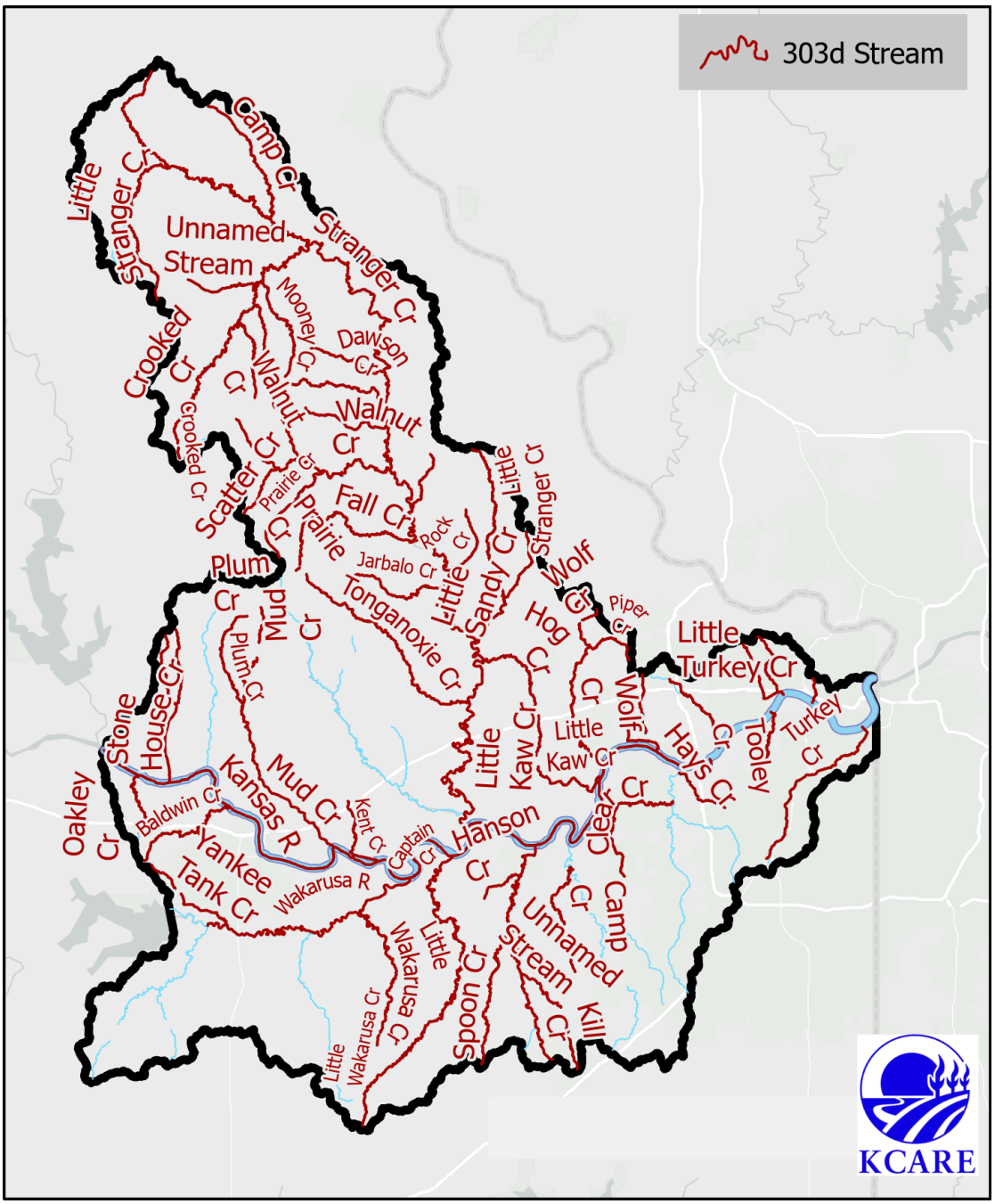


Figure 15. 303d-Listed Stream Waters in the Lower Kansas River Watershed

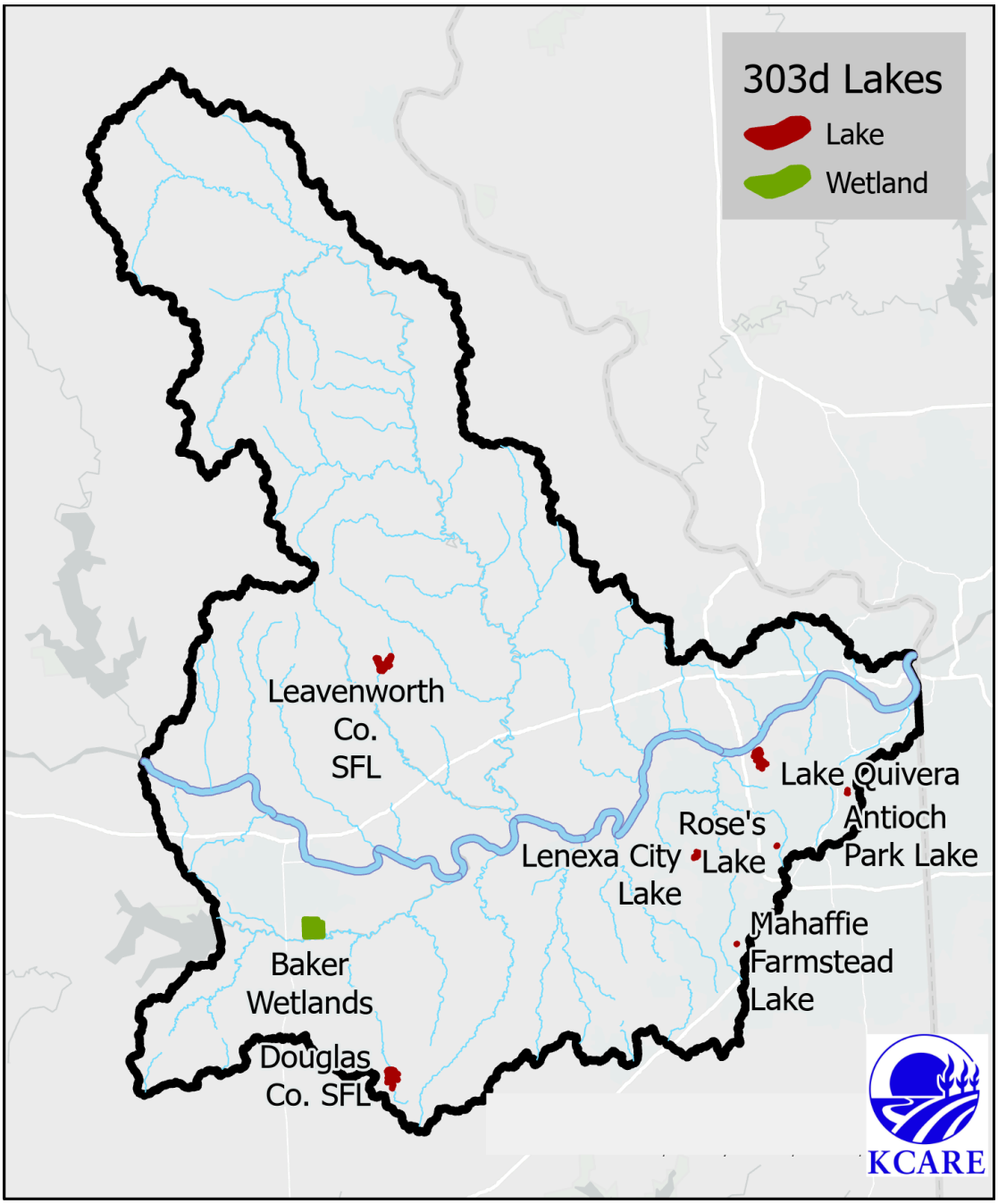


Figure 16. 303d-Listed Lakes in the Lower Kansas River Watershed

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 and 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 Lower 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. Lower 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 Lower Kansas River Watershed has 54 TMDLs (**Table 10**). However, this plan will only target four of these TMDLs, found in three creeks in the watershed:

- Crooked Creek (monitoring site SC683): Total Phosphorus (TP)
- Nine Mile Creek (monitoring site SC680): *E. coli*
- Stranger Creek (monitoring sites SC501 and SC602): *E. coli* and TP

For this Lower Kansas River Watershed plan, focus and priority will be given to the highlighted TMDLs as listed below. 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 Lower Kansas River Watershed[13]

TMDLs in the Lower Kansas River Watershed					
Water Segment	**Category**	**Impairment**	**Priority**	**Goal of TMDL**	**Sampling Station**
Antioch Park Lake	4a	Chlordane	Low	-	LM067701
Baker Wetlands	4a	Dissolved Oxygen	High	-	LM014401
Buck Creek near Williamstown	4a	*E. coli*	Medium	-	SC677
Cedar Creek near Cedar Junction	4a	*E. coli*	High	-	SC252
		Nitrate		-	
		Total Phosphorus		-	
Cedar Lake	4a	Eutrophication	High	-	LM061601
				-	LM030001
Coal Creek near Sibleyville	4a	*E. coli*	Medium	-	SC679
Crooked Creek near Winchester	4a	Biology	Low		SC683
	4a	Total Phosphorus	High	ALUS Index score ≥ 14, sestonic clorophylll *a* ≤ 10 µg/L, DO concentrations > 5.0 mg/L, DO saturation < 110%, and pH within range of 6.5-8.5	SC683
Frisco Lake	4a	Eutrophication	Low	-	LM065201
Gardner City Lake	4a	Dissolved Oxygen	High	-	LM040401
		Eutrophication		-	
Kansas River at Desoto	4a	Biology	Medium	-	SC254
		Biology/Sediment		-	
		E. coli	High	-	
		Total Phosphorus		-	
Kansas River at Eudora	4a	Biology	Medium	-	SC255
		E. coli	High	-	
		Total Phosphorus	High	-	
Kansas River at Kansas City, KS	4a	Biology	Medium	-	SC203
		Biology/Sediment		-	
		E. coli	High	-	
		Total Phosphorus		-	
Kansas River at Lecompton	4a	Biology	Medium	-	SC257
		E. coli	High	-	
		Total Phosphorus		-	
Kill Creek at Desoto	4a	*E. coli*	High	-	SC253
		Total Phosphorus		-	
Lakeview Estates Lake	4a	Eutrophication	Low	-	LM075301
Lone Star Lake	4a	Eutrophication	Low	-	LM011401
Mary's Lake	4a	Dissolved Oxygen	Medium	-	LM061401
		Eutrophication		-	
		pH		-	

[13] Kansas Department of Health and Environment, 2018. https://www.kdhe.ks.gov/1219/303d-Methodology-List-of-Impaired-Waters

TMDLs in the Lower Kansas River Watershed, continued					
Water Segment	**Category**	**Impairment**	**Priority**	**Goal of TMDL**	**Sampling Station**
Mill Creek near Shawnee	4a	Biology	High	-	SC251
		Biology/Sediment	Medium	-	
		Chloride	Low	-	
		E. coli	High	-	
		Total Phosphorus		-	
New Olathe Lake	4a	Eutrophication	High	-	LM061301
Nine Mile Creek	4a	*E. coli*	High	1) Less than 10 % of Spring samples exceed primary criterion at flows under 785 cfs with no samples exceeding the criterion at flows under 125 cfs. 2) Less than 10% of Summer/Fall samples exceed the primary criterion at flows under 785 cfs with no samples exceeding the criterion at flows under 18 cfs. 3) Less than 10% of Winter samples exceed secondary criterion at flows under 785 cfs.	SC680
Olathe Waterworks Lakes	4a	Eutrophication	Low	-	LM062201
Pierson Park Lake	4a	Eutrophication	Low	-	LM061801
Potter's Lake	4a	Eutrophication	Low	-	LM073401
Stranger Creek	4a	*E. coli*	High	1) Less than 10 % of Spring samples exceed primary criterion at flows under 785 cfs with no samples exceeding the criterion at flows under 125 cfs. 2) Less than 10% of Summer/Fall samples exceed the primary criterion at flows under 785 cfs with no samples exceeding the criterion at flows under 18 cfs. 3) Less than 10% of Winter samples exceed secondary criterion at flows under 785 cfs.	SC501 SC602
		Total Phosphorus		ALUS Index score $\geq$ 14, sestonic clorophyllI *a* $\leq$ 10 µg/L, DO concentrations > 5.0 mg/L, DO saturation < 110%, and pH within range of 6.5-8.5	
Sunflower Park Lake	4a	Dissolved Oxygen	Medium	-	LM073601
		Eutrophication		-	
Wakarusa near Eudora	4a	*E. coli*	High	-	SC500
		Total Phosphorus		-	
Wakarusa near Topeka	4a	Biology	High	-	SC109
		Biology/Sediment		-	
		E. coli		-	
Washington Creek	4a	Dissolved Oxygen	High	-	SC678

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 yet.

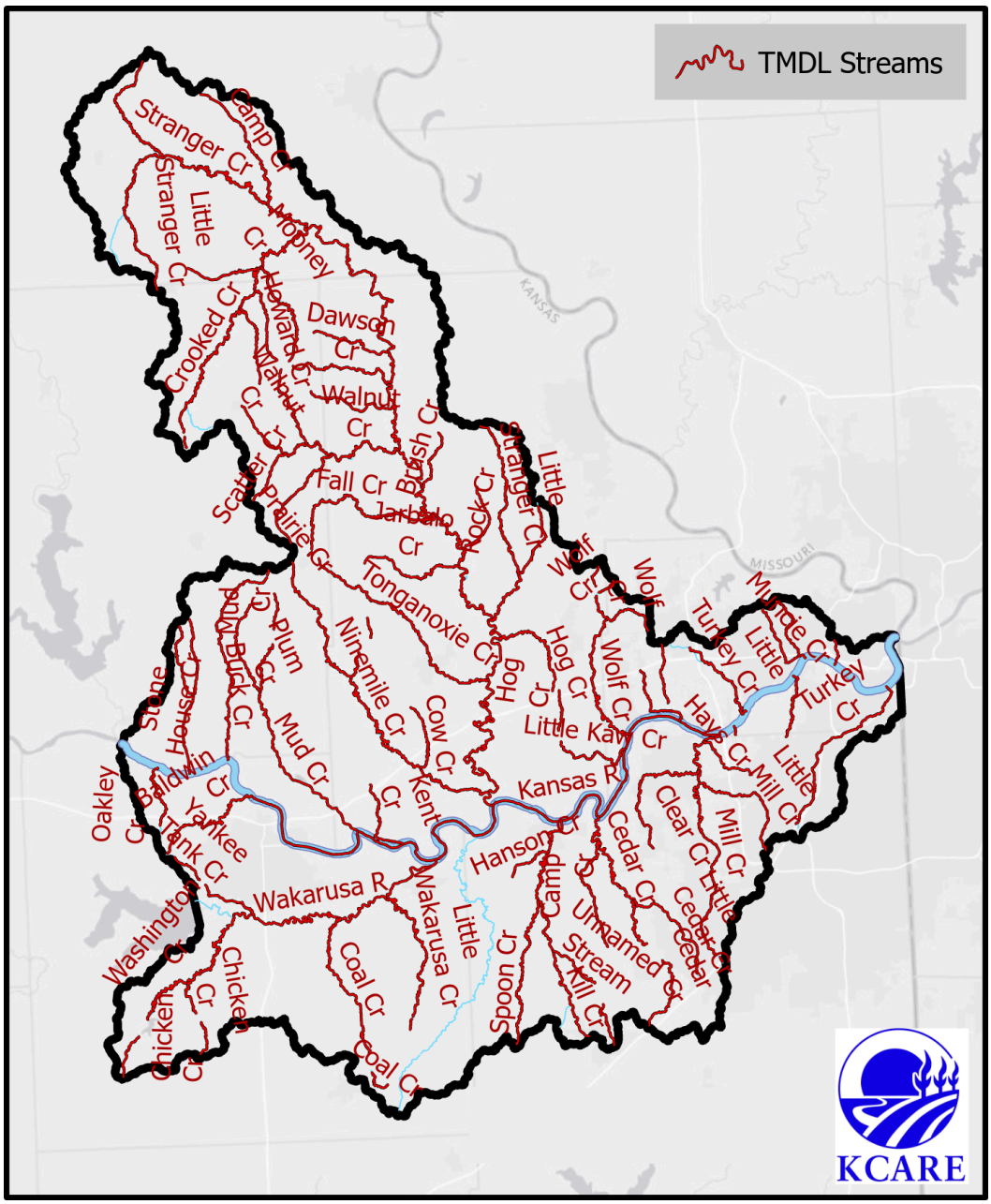


Figure 17. Streams with a TMDL in the Lower Kansas River Watershed

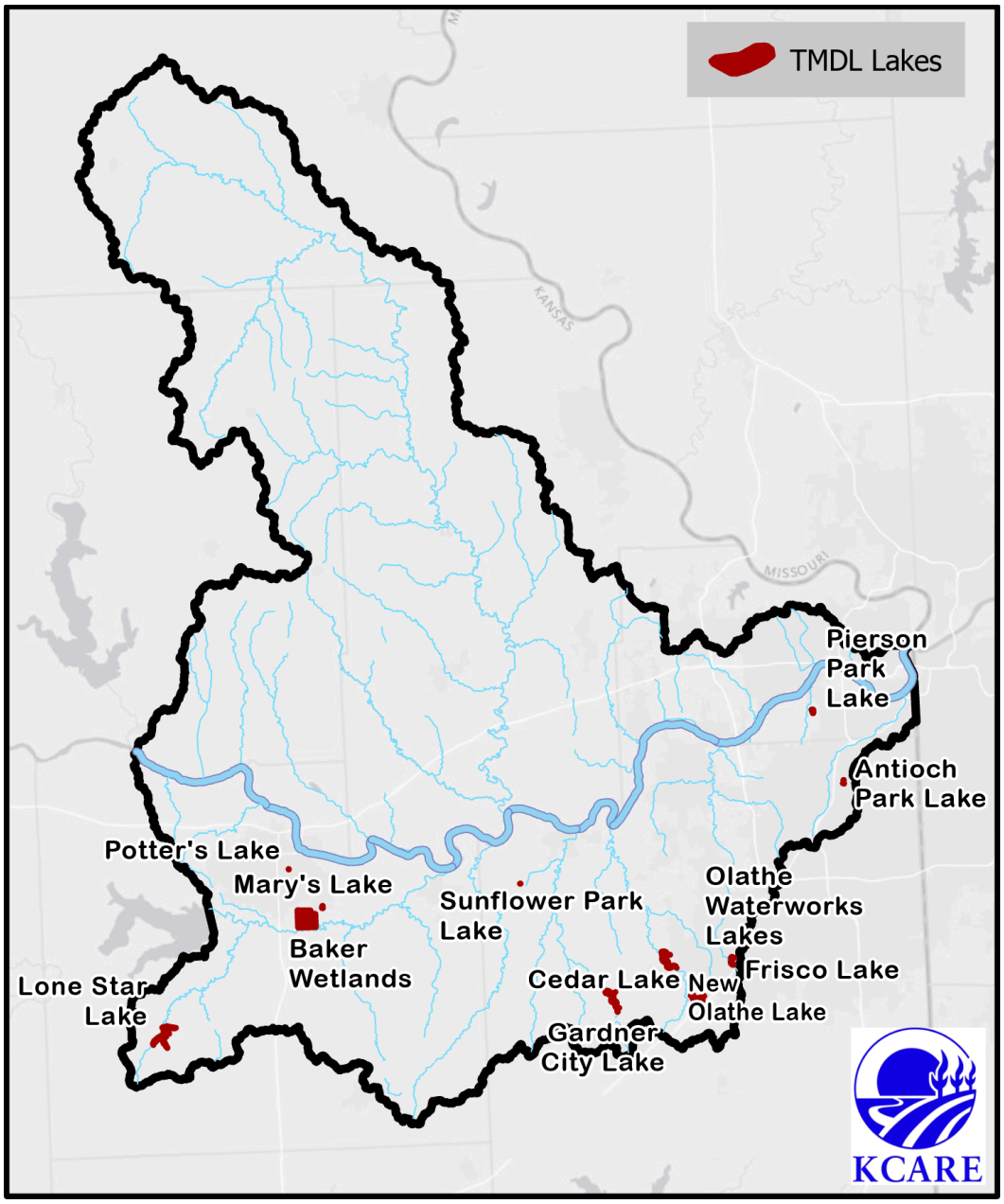


Figure 18. Lake Waters with a TMDL in the Lower Kansas River Watershed

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 ultimate goal will be to eliminate the need to develop a TMDL for the current 303d-listed impairment.

5. Watershed Impairments to be Addressed

The Lower Kansas River Watershed SLT acknowledges all TMDL and 303d-listed water segments in the watershed. The SLT will focus this WRAPS plan on four TMDL-listed impairments (**Figure 19**):

1. *E. coli* in Nine Mile Creek
2. *E. coli* in Stranger Creek
3. Total Phosphorus in Crooked Creek
4. Total Phosphorus in Stranger Creek

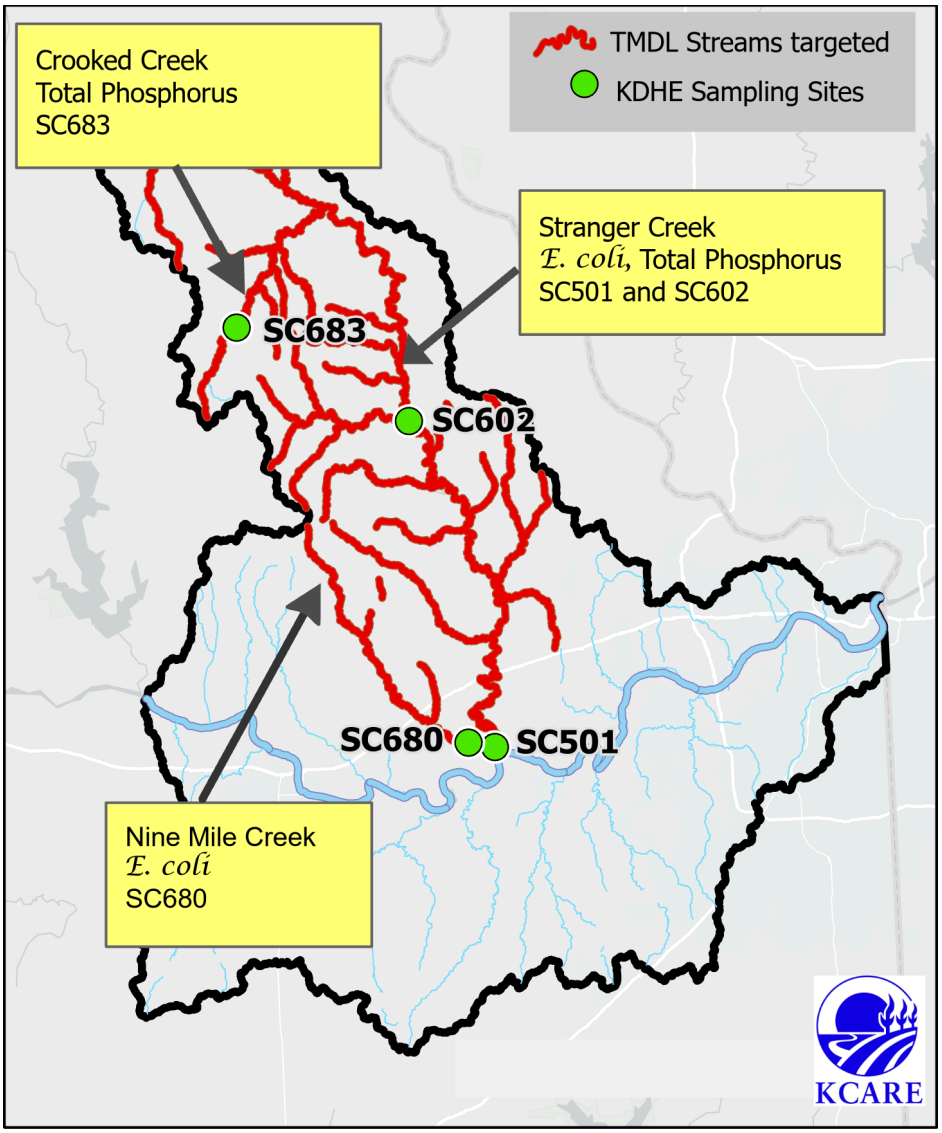


Figure 19. TMDL Impaired Waters to be Addressed by this WRAPS Plan

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

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

Load Allocations for the Lower Kansas River Watershed			
Impairment/TMDL	**Current Load**	**Allowed Load**	**Required Reduction**
E. coli: **Nine Mile Creek and Stranger Creek**	Less than 10% exceedances of the nominal *E. coli* Bacteria (ECB) criterion at flows under 785 cfs. *Load Reduction will be assumed by reductions made in Total Phosphorus as indicated below.*		
Total Phosphorus: Crooked Creek and Stranger Creek	17,483 pounds per year	12,231 pounds per year	5,252 pounds per year

This WRAPS plan only addresses the *E. coli* and Total Phosphorus TMDLs, both of which will share the same load reduction goal, a reduction of 5,252 pounds per year in phosphorus. 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. *E. coli*

The Lower Kansas River Watershed has 11 stream segments with a high priority TMDL for ***E. coli*** and two segments with a medium priority TMDL, as well as two additional segments that are 303d listed. **Nine Mile Creek and Stranger Creek are the only two high priority *E. coli* TMDLs that will be targeted specifically with BMP implementation and load reduction goals.** However, nearly all impaired waters listed below will be positively impacted by BMP implementation throughout the watershed.

- Buck Creek near Williamstown - TMDL listed (medium priority)
- Captain Creek near Eudora - 303d listed
- Cedar Creek near Cedar Junction - TMDL listed (high priority)
- Coal Creek near Sibleyville - TMDL listed (medium priority)
- Crooked Creek near Winchester - 303d listed
- Kansas River at Desoto - TMDL listed (high priority)
- Kansas River at Eudora - TMDL listed (high priority)
- Kansas River at Kansas City, KS - TMDL listed (high priority)
- Kansas River at Lecompton - TMDL listed (high priority)
- Kill Creek at Desoto - TMDL listed (high priority)
- Mill Creek near Shawnee - TMDL listed (high priority)
- Wakarusa near Eudora - TMDL listed (high priority)
- Wakarusa near Topeka - 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* are not harmful to humans, but its 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, close 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 an upper limit of 200cfu/100ml of water for primary contact recreation (such as swimming), and an upper limit of 2,000cfu/ml of water for secondary, non-contact recreation (such as boating and fishing).

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 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.

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 Lower 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 19 NPDES facilities in the Lower Kansas River Watershed at the time of this document's publication.

Population

Watershed population can affect nutrient (phosphorus) runoff. There are an estimated 20,908 domestic onsite wastewater systems in the Lower Kansas River Watershed, located mainly in rural areas. Although the functional condition of these systems is generally

unknown, it is projected that nearly 20% (~ 4,182) 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 31 certified or permitted AFOs and CAFOs within this watershed. There also are 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 41% of the Lower Kansas River Watershed is 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 23.2 to 27.8, with an average of 26.3 cattle per 100 acres across the watershed.[14] This is considered to be medium 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:

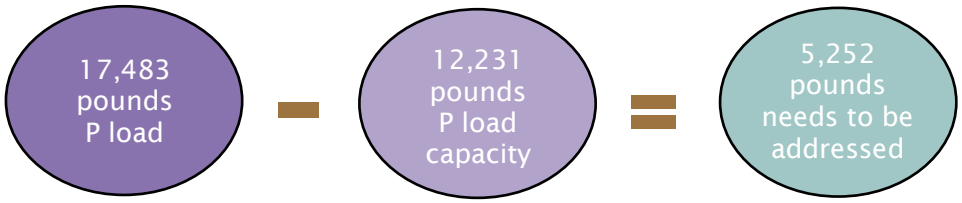
- Less than 10% of spring samples exceed primary criterion at flows under 785 cfs with no samples exceeding the criterion at flows under 125 cfs.

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

- Less than 10% of summer/fall samples exceed the primary criterion at flows under 785 cfs with no samples exceeding the criterion at flows under 18 cfs.
- Less than 10% of winter samples exceed secondary criterion at flows under 785 cfs.

Since there is no bacteria load reduction calculation at this time, the SLT decided to use phosphorus load reduction as an indicator of plan success. The assumption is that total phosphorus reductions resulting from livestock BMP implementation in the targeted areas also will reduce *E. coli*.

It has been determined that a 30% reduction in P is necessary to meet the Lower Kansas River Watershed's *E. coli* and TP TMDLs, which equates to a reduction of 5,252 pounds per year. **If all BMPs have been implemented, 10,060 pounds of P will have been reduced from the watershed at the end of this five-year plan.** This exceeds the load reduction required to meet the TMDL by roughly 92%.



Nitrogen (N) is not a nutrient targeted for reduction by this plan; however, it will be positively impacted by BMP implementation. If all BMPs have been implemented, 18,948 pounds of N will have been reduced from the watershed at the end of this five-year plan. The P and N nutrient 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 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. They are: alternative watering systems, grazing management plans, relocating feeding areas, vegetative filter strips and wetland development. The number of required annual projects was determined and approved by the SLT.

Table 12. BMPs to Prevent and/or Reduce Bacteria Loading

BMPs to Reduce *E. coli*		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of *E. coli* contribution from livestock	Alternative Watering System	1 project in years 1, 3, and 5. 3 total projects during life of plan.
	Grazing Management Plan	1 project in years 2 and 4. 2 total during life of plan.
	Relocate Pasture Feeding Areas	1 project in years 1, 3, and 5. 3 total projects during life of plan.
	Vegetative Filter Strips	1 project in years 2 and 4. 2 total during life of plan.
	Wetland Development	1 project in years 1, 3, and 5. 3 total projects during life of plan.

The implementation of livestock BMPs in the watershed and the movement of feeding sites and the addition of alternate watering systems away from streams will have a positive impact on the E. coli *TMDL.*

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

B. Total Phosphorus

The Lower Kansas River Watershed has been listed for having 10 high-priority TMDLs for the impairment of **total phosphorus (TP)**. **This plan will only focus on two of these, the Crooked Creek and Stranger Creek[15] TP TMDL impairments.** Although the areas listed below will not be targeted specifically with BMP implementation and load reduction expectations, they will be impacted positively by BMP implementation throughout the watershed. These areas include:

- Cedar Creek near Cedar Junction: TMDL listed (high priority)
- Kansas River at Desoto: TMDL listed (high priority)
- Kansas River at Eudora: TMDL listed (high priority)
- Kansas River at Kansas City, KS: TMDL listed (high priority)
- Kansas River at Lecompton: TMDL listed (high priority)
- Kill Creek at Desoto: TMDL listed (high priority)
- Mill Creek near Shawnee: TMDL listed (high priority)
- Wakarusa near Eudora: TMDL listed (high priority)

The Lower Kansas River's TP and *E. coli* TMDLs will be addressed simultaneously and are combined as one phosphorus load reduction goal in this plan. The livestock BMPs implemented to reduce phosphorus and bacteria loading will no doubt have positive impacts on the Kansas River and on the watershed as a whole.

[15] KDHE, TP TMDL for the Delaware River, https://www.kdheks.gov/tmdl/2019/Delaware_TP.pdf

1. Sources of the impairment

Phosphorus loading 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.

Land use

Land use activities can affect phosphorus runoff into streams. For example, 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 directly into the stream. Overgrazed pastures do not provide adequate biomass to trap manure runoff.

Agricultural BMPs designed to help reduce phosphorus 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.

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 19 NPDES facilities in the Lower Kansas River Watershed at the time of this document's publication.

Population

Watershed population can affect nutrient (phosphorus) runoff. There are an estimated 20,908 domestic onsite wastewater systems in the Lower Kansas River Watershed, located mainly in rural areas. Although the functional condition of these systems is generally unknown, it is projected that nearly 20% (~ 4,182) 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 31 certified or permitted AFOs and CAFOs in this watershed. 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 can also be a contributor to the phosphorus loads, although at a much smaller quantity.

Grazing density

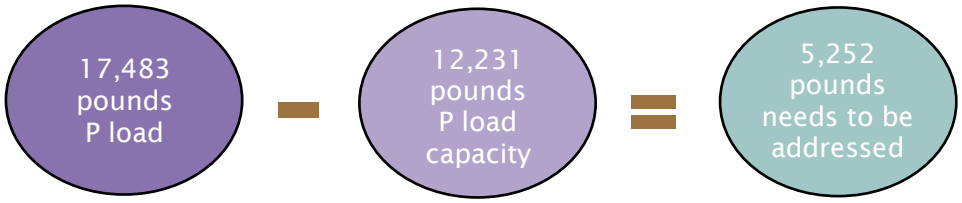
Approximately 41% of the Lower Kansas River Watershed is pasture/hay land. Grassland in this area of Kansas is a highly productive forage source for beef cattle. Grazing density affects grass cover and potential manure runoff: an overgrazed pasture will not have the needed forage biomass to trap and 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 23.2 to 27.8, with an average of 26.3 cattle per 100 acres across the watershed.[16] This is considered medium 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 affects manure runoff from livestock allowed access to streams or from manure applied before a rainfall or on frozen ground. Therefore, it is important to maintain adequate grass density to slow the runoff of manure from pastures.

2. Pollutant loads

It has been determined that a 30% reduction in P is necessary to meet the Lower Kansas River Watershed's *E. coli* and TP TMDLs, which equates to a reduction of 5,252 pounds per year. **If all BMPs have been implemented, 10,060 pounds of P will have been reduced from the watershed at the end of this five-year plan.** This exceeds the load reduction required to meet the TMDL by roughly 92%.



In addition to the load reduction shown above, the Lower Kansas River's TP TMDL in Stranger and Nine Mile Creeks has established numeric milestones to achieve the desired endpoints. This includes :

- ALUS Index score > 14,
- Sestonic chlorophyll *a* < 10 µg/L,
- DO > 5 mg/L with saturation < 110%, and
- pH range 6.5 - 8.5.

Achievement of the biological endpoints indicates that phosphorus loads are within the loading capacity of the stream, that water quality standards are attained, and that full support of the designated uses of the stream have been restored.

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

While nitrogen (N) is not a nutrient targeted for reduction by this plan, it will be impacted positively by BMP implementation. If all BMPs have been implemented, 18,948 pounds of N will have been reduced from the watershed at the end of this five-year plan. As mentioned in the *E. coli* section, the P and N nutrient reductions will improve water quality impairments such as biology, dissolved oxygen, eutrophication, etc.. Although this is not the goal of this WRAPS plan, it is a positive result.

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

The Lower Kansas River WRAPS plan will focus simultaneously on both the *E. coli* and TP TMDLs. The SLT identified specific livestock BMPs which will result in significant bacteria and nutrient pollutant reductions and are acceptable to watershed residents. These livestock BMPs include: alternative watering systems, grazing management plans, relocating feeding areas, vegetative filters strips and wetland development. 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 Phosphorus Loading

BMPs to Reduce Nutrient Loading		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of nutrient (phosphorus) contribution from livestock	Alternative Watering System	1 project in years 1, 3, and 5. 3 total projects during life of plan.
	Grazing Management Plan	1 project in years 2 and 4. 2 total during life of plan.
	Relocate Pasture Feeding Areas	1 project in years 1, 3, and 5. 3 total projects during life of plan.
	Vegetative Filter Strips	1 project in years 2 and 4. 2 total during life of plan.
	Wetland Development	1 project in years 1, 3, and 5. 3 total projects during life of plan.

The implementation of livestock BMPs in the watershed, the movement of feeding sites, and the establishment of alternate watering systems away from the stream will have a positive impact on the E. coli *TMDL. The implementation of livestock BMPs to address nutrient loading subsequently will improve all biology, DO, eutrophication, etc. impairments in the watershed.*

C. Other Impairment Concerns in the Lower Kansas River Watershed

1. Ammonia

Turkey Creek, in the Lower Kansas River Watershed, has been 303d listed for ammonia. Ammonia in water is non-toxic to humans, but it is toxic to aquatic life. Unlike other forms of nitrogen which can indirectly harm aquatic ecosystems by increasing nutrient levels and promoting algae growth (eutrophication), ammonia has direct toxic effects on aquatic ecosystems.

The ammonia impairment will not be impacted by the Lower 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 Lower Kansas River Watershed has five creeks with 303d-listed atrazine impairments:

- Captain Creek near Eudora,
- Crooked Creek near Winchester,
- Kill Creek near Desoto,
- Stranger Creek near Easton, and
- Stranger Creek near Linwood.

Atrazine is not a targeted impairment addressed directly by this WRAPS plan, as the plan focuses on high-priority *E. coli* and TP TMDLs.

3. Biology

There is a direct relation between levels of nutrient loading and biological integrity. Decreased 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.

Ten water segments in the Lower Kansas River Watershed have biology TMDLs or are 303d listed:

- Crooked Creek near Winchester: TMDL listed (high priority),
- Kansas River at Desoto: TMDL listed (medium priority),
- Kansas River near Eudora: TMDL listed (medium priority),
- Kansas River near Kansas City, KS: TMDL listed (medium priority),
- Kansas River near Lecompton: TMDL listed (medium priority),
- Mill Creek near Shawnee: TMDL listed (high priority),
- Stranger Creek near Easton: 303d listed
- Stranger Creek near Lindon: 303d listed
- Wakarusa near Eudora: 303 listed, and
- Wakarusa near Topeka: TMDL listed (high priority).

Biology TMDLs are not a priority focus in this plan; however, implementing BMPs to address bacteria and total phosphorus should positively impact the biology in targeted areas.

4. Biology/Sediment

High levels of suspended solids, or sediment, added to surface waters by artificial sources can interfere with the behavior, reproduction, physical habitat or other factors related to the survival and propagation of aquatic or semi-aquatic or terrestrial wildlife.

The Lower Kansas River Watershed has four biology/sediment TMDLS:

- Kansas River at Desoto (medium priority),
- Kansas River near Kansas City, KS (medium priority),
- Mill Creek near Shawnee (medium priority), and
- Wakarusa near Topeka (high priority).

Biology/sediment TMDLs are not a priority focus in this plan; however, implementing BMPs to address bacteria and total phosphorus should have positive impacts on the biology in targeted areas.

5. Chemicals

There are five pesticide/insecticide chemicals that have been 303d or TMDL listed in the Lower Kansas River Watershed:

- Antioch Park Lake: 303d listed for DDT, Dieldrin, and Heptachlor Epoxide,
- Antioch Park Lake: TMDL listed for Chlordane (low priority), and
- Mill Creek near Shawnee: 303d listed for Diazinon.

The Kansas River near Eudora is 303d listed for another substance, Polychlorinated biphenyls (PCBs). PCBs are manufactured organic chemicals no longer produced in the United States but are still in the environment and can cause health problems. PCBs do not easily break down and may remain in the air, water, and soil for long periods of time.

These chemicals will not be affected by this WRAPS plan.

6. 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 to avoid salty tastes and undesirable odors.

High chloride 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.

The Lower Kansas River Watershed has one water body with a low-priority TMDL listing for chloride: Mill Creek near Shawnee. This plan will not address or impact chloride in Mill Creek.

7. 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 five DO TMDLs in the Lower Kansas River Watershed:

- Baker Wetlands (high priority),
- Gardner City Lake (high priority),
- Mary's Lake (medium priority),
- Sunflower Park Lake (medium priority), and
- Washington Creek (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. This will have positive effects on DO rates in the Lower Kansas River Watershed.

8. Eutrophication

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. Desirable criteria for healthy water dictate DO rates more than 5 mg/L and biological oxygen demand (BOD) lower than 3 mg/L.

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 Lower Kansas River Watershed, urbanization, agricultural land use, and small livestock operations all contribute excess nutrients to the watershed.

The Lower Kansas River Watershed has 11 TMDLs and eight 303d-listed water bodies for eutrophication. These areas include:

- Antioch Park Lake: 303d listed,
- Baker Wetlands: 303d listed,
- Cedar Lake: TMDL listed (high priority),
- Douglas County State Fishing Lake: 303d listed,
- Frisco Lake: TMDL listed (low priority),
- Gardner City Lake: TMDL listed (high priority),
- Lakeview Estates Lake: TMDL listed (low priority),
- Lake Quivera: 303d listed,
- Leavenworth County State Fishing Lake: 303d listed,
- Lenexa Lake: 303d listed,
- Lone Star Lake: TMDL listed (low priority),
- Mahaffie Farmstead Lake: 303d listed,
- Mary's Lake: TMDL listed (medium priority),
- New Olathe Lake: TMDL listed (high priority),
- Olathe Waterworks Lake: TMDL listed (low priority)
- Pierson Park Lake: TMDL listed (low priority),
- Potter's Lake: TMDL listed (low priority),
- Rose's Lake :303d listed, and
- Sunflower Lake: TMDL listed (medium priority).

Although these areas will not be targeted specifically with BMP implementation and load reduction goals, they will be impacted positively by livestock BMP implementation throughout the watershed.

9. Lead

Lead does not occur naturally in Kansas water sources. Lead can enter drinking water when a chemical reaction occurs in plumbing materials containing lead. The dissolving of metal from pipes and fixtures is known as corrosion. This reaction is more severe when water has high acidity or low mineral content. How much lead enters the water is related to the acidity or alkalinity of the water, the types and amounts of minerals in the water, the amount of lead that the water comes into contact with, the water temperature, the amount of wear in the pipes, the time water stays in pipes, and the presence of protective scales or coatings in the pipes.

The Lower Kansas River Watershed has one water body 303d-listed for having a lead impairment: Baker Wetlands. This plan will not address lead in the watershed.

10. Nitrate

There are many ways that nutrients or nitrogen compounds can end up in drinking water. These sources include everything from natural deposits in soil, to atmospheric nitrogen, to human activities. Sewage treatment, septic systems at homes, fertilizers on lawns,

fertilizers on farms, and livestock management can also be sources of nutrients in waterways.

High nitrate levels in waters can cause health issues. You cannot taste, smell, or see nitrates in water. Consuming too much nitrate can be harmful, especially for babies; over-consumption can affect how blood carries oxygen and can cause methemoglobinemia, also known as blue baby syndrome.

The Lower Kansas River Watershed has one water segment with a high-priority TMDL listing for nitrate: Cedar Creek near Cedar Junction. This plan will not address or impact nitrates in Cedar Creek.

11. 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.

The Lower Kansas River Watershed has two impaired water bodies with a 303d or TMDL listing for pH:

- Baker Wetlands: 303d listed, and
- Mary's Lake: TMDL listed (medium priority).

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

12. 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 Lower Kansas River Watershed has six 303d listings for the TSS impairment:

- Kansas River at Desoto,
- Kansas River at Eudora,
- Kansas River at Kansas City, KS,
- Kansas River at Lecompton,
- Stranger Creek near Easton, and the
- Wakarusa River near Eudora.

TSS will not be a targeted priority for this WRAPS plan.

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.

From 2008 – 2009, the Lower 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 phosphorus only and in select riparian corridors in the northern and central portion of the watershed.

2. Aerial assessment

KDHE has analyzed aerial images and determined areas of interest for BMP targeting to include livestock areas near stream segments (**Figure 20**). Specific targeted areas are discussed later in this section of the WRAPS plan.

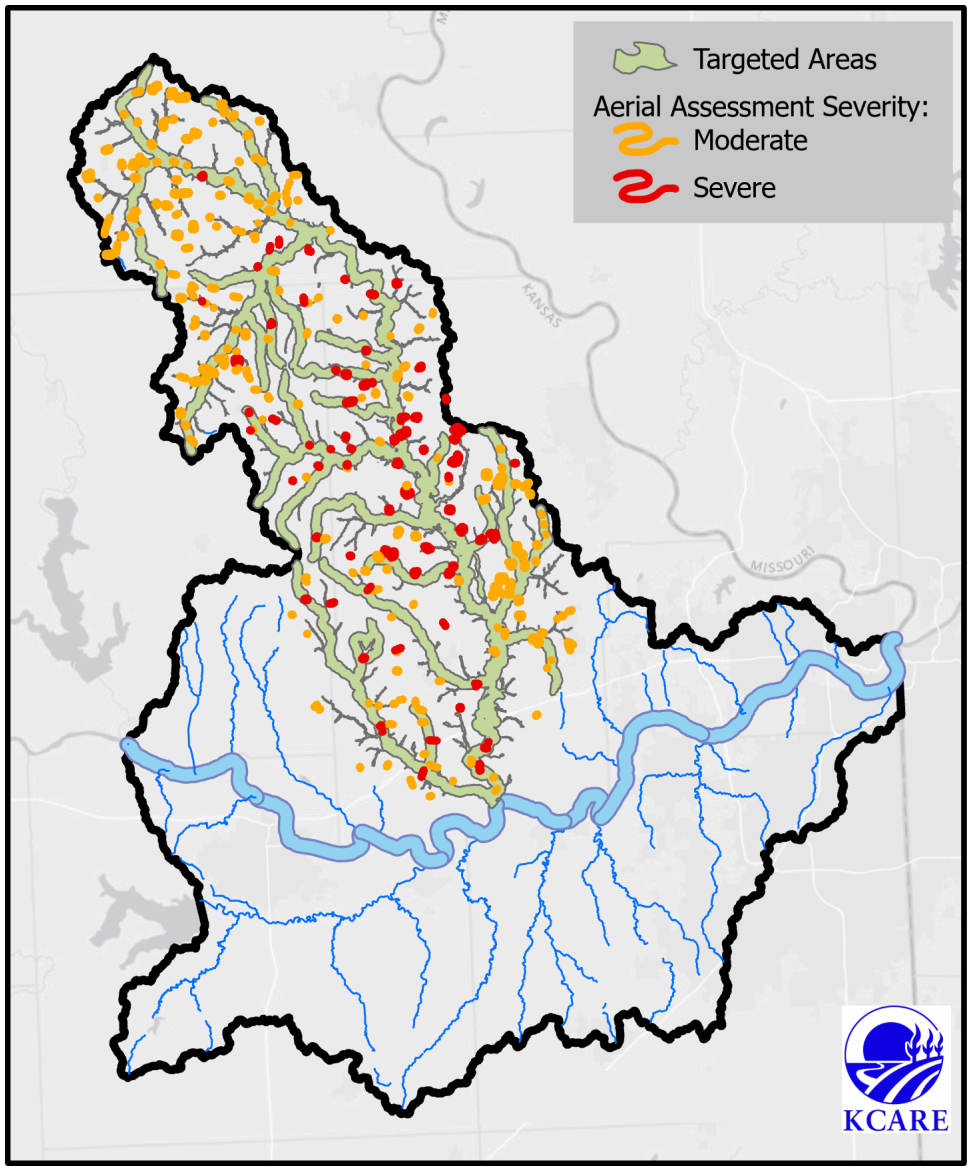


Figure 20. Lower Kansas River Watershed Aerial Assessment[17]

3. Priority revisions in 2021

In 2021, KDHE determined that BMP efforts should be focused on stream proximity, considering that stream segments are the route by which pollutants travel into larger water systems and, ultimately, lakes. By narrowing the focus to riparian corridors, defined as areas one-half mile on either side of the stream or river segment, the Lower Kansas River Watershed SLT can focus on the northern and central portions of the watershed, including Nine Mile Creek and Stranger Creeks which were of special interest to the stakeholders. 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.

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

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 utilizing BMPs in these specific areas, pollutants can be reduced at a more efficient rate.

As previously mentioned, the STEPL model, KDHE aerial assessment, and stream proximity were used to determine the targeted areas for this Lower Kansas River WRAPS plan. Targeting assessment data were presented to, considered, and approved by the SLT and KDHE.

The SLT decided to target livestock areas in the Lower Kansas River Watershed for BMP implementation. Livestock areas will be targeted for nutrients, namely **phosphorus**, which will subsequently have positive effects on ***E coli* bacteria**. BMP implementation will take place in the riparian corridors of 14 HUC 12s (**Figure 21**).

- HUC 10270104301
- HUC 10270104302
- HUC 10270104303
- HUC 10270104304
- HUC 10270104305
- HUC 10270104306
- HUC 10270104307
- HUC 10270104401
- HUC 10270104402
- HUC 10270104403
- HUC 10270104404
- HUC 10270104405
- HUC 10270104406
- HUC 10270104407

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

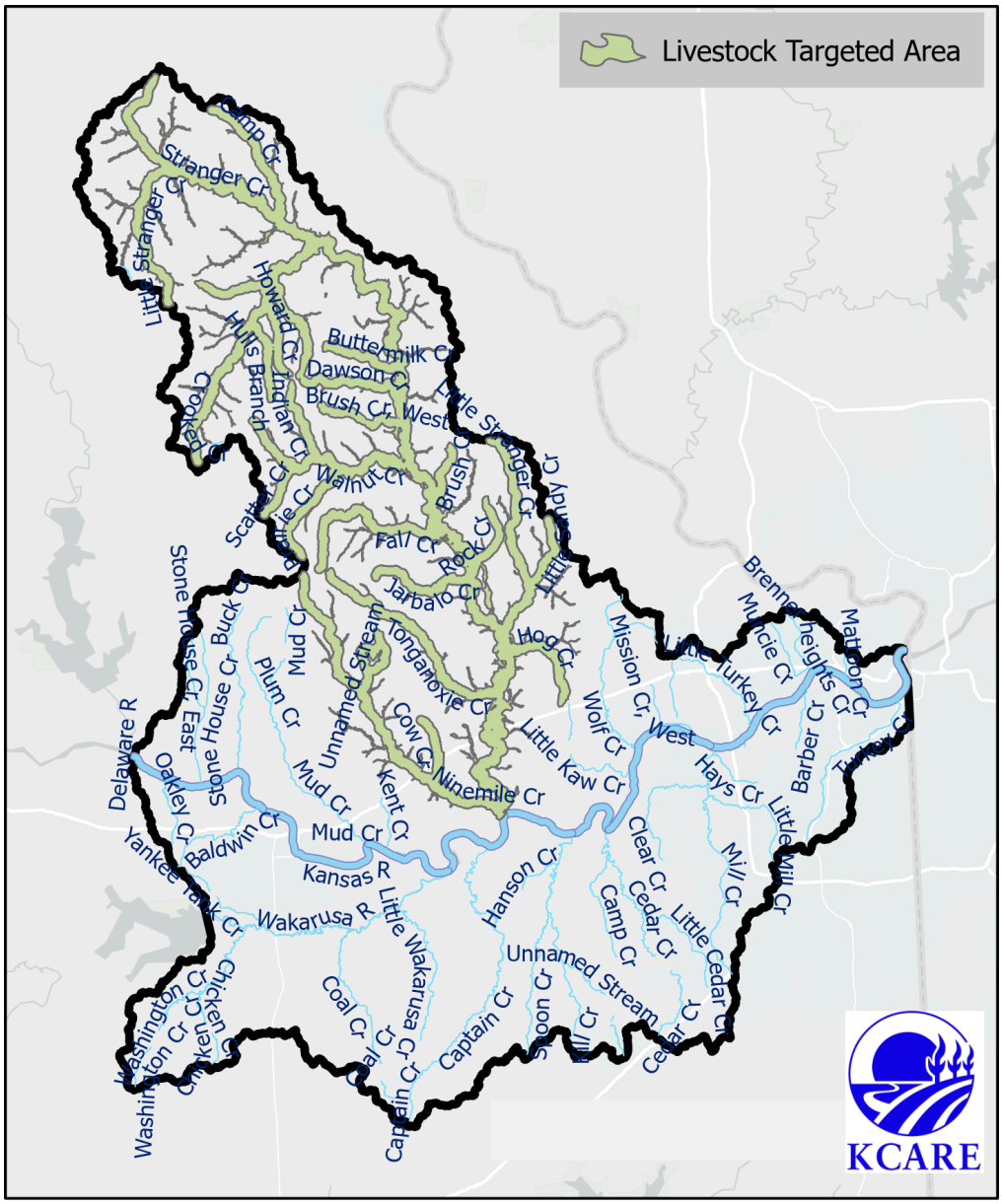


Figure 21. Livestock Targeted Areas in the Lower Kansas River Watershed

C. Load Reduction Estimate Methodology

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

Livestock

Baseline nutrient loadings per animal unit are calculated using the Livestock Waste Facilities Handbook[18] and these three publications: *Decreasing Nitrogen and Phosphorus Excretion by*

[18] https://www-mwps.sws.iastate.edu/catalog/manure-management/livestock-waste-facilities-handbook

Dairy Cattle[19], *Fertilizing Cropland with Beef Manure*[20], and *Estimating Manure Nutrient Excretion*[21]. Livestock management practice load reduction efficiencies are derived from numerous sources, including Kansas State University Research and Extension Publication MF-2737[22] and MF-2454[23]. 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 Lower Kansas River Watershed range from 23.2 to 27.8, with an average of 26.3 cattle per 100 acres.

[19] 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

[20] Schmitt, Michael and George Rehm. *Fertilizing Cropland with Beef Manure*. 2002. University of Minnesota Extension Bulletin.

[21] Koelsch, Rick. *Estimating Manure Nutrient Excretion.* 2007. University of Nebraska Extension Bulletin.

[22] MF-2737 Available at: https://www.bookstore.ksre.ksu.edu/pubs/MF2737.pdf

[23] 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 Lower Kansas River Watershed will take place in 14 HUC 12's in the northern and central portion of the watershed. Livestock BMPs will reduce both phosphorus and nitrogen nutrient loading, thereby addressing the **total phosphorus** TMDL. Reductions in TP will subsequently have a positive impact on the ***E. coli*** TMDL as well. These reductions also will improve the non-targeted biology, *E. coli*, eutrophication, DO and total phosphorus impairment listings throughout the entire Lower Kansas River Watershed.

This WRAPS plan only addresses the *E. coli* and total phosphorus TMDLs, both of which will share the same load reduction goal, a reduction of 5,252 pounds per year in phosphorus.

A. *E. coli* Load Reductions in the Lower Kansas River Watershed

The Lower Kansas River Watershed has high TMDL rankings for *E. coli* in Nine Mile Creek and Stranger Creek. The watershed will only target **livestock areas** for *E. coli* load reductions. *E. coli* load reductions will be realized through quantified reductions in total phosphorus as it can be assumed that nutrient reductions made through BMP implementation will also result in less *E. coli* bacteria entering the water segments as well. Therefore, all tables from this point will only reflect BMPs and associated reductions for total phosphorus.

B. Nutrient Load Reductions in the Lower Kansas River Watershed

The Lower Kansas River Watershed has high TMDL rankings for total phosphorus in Crooked Creek and Stranger Creek. The watershed will only target **livestock areas** for nutrient load reductions. Adoption and implementation of nutrient BMPs will result in total nutrient load reductions of **10,060 pounds of phosphorus**. These load reductions will meet and exceed the required reductions to meet the TP TMDLs in Crooked and Stranger Creeks by 92%. While nitrogen is not a priority impairment in this plan, livestock BMPs that reduce phosphorus loading will simultaneously reduce nitrogen loading as well.

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

There are 73,508 pasture/hay/grassland acres in the targeted areas for phosphorus load reductions in the Lower Kansas River Watershed (**Table 14**). Land use in the nutrient-targeted area does make a difference in the amount of phosphorus entering the water. The 49% of pasture/hay/grassland in the targeted HUC 12s is the reason livestock areas have been prioritized as targeted areas in the Lower Kansas River Watershed. Variation in load reductions is due to the differences in stocking rates and grazing duration in native grass pastures, cool-season grass pastures, and cropland.

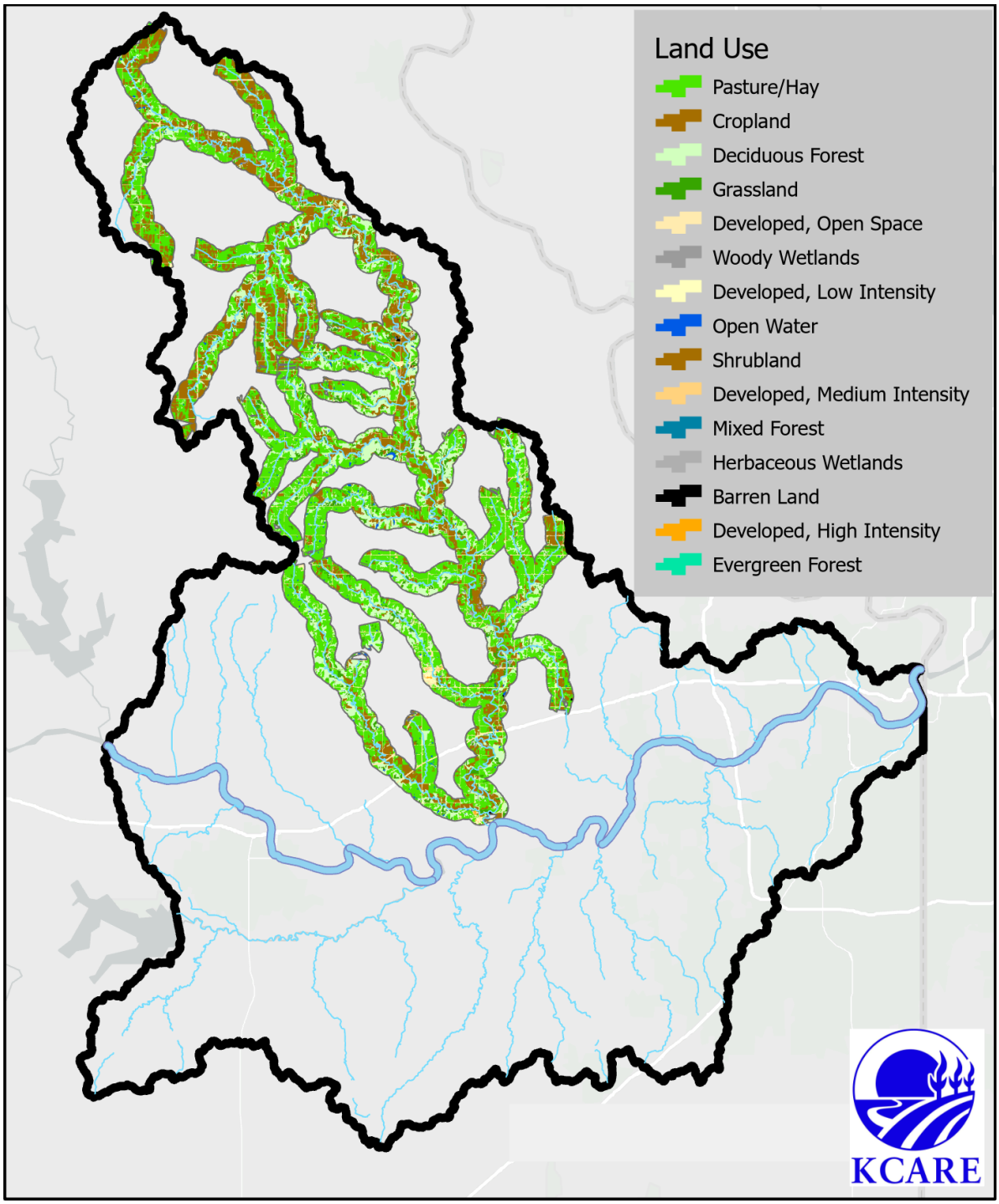


Figure 22. Land Use in the Nutrient Targeted Areas

Table 14. Land Use in the Nutrient Targeted Areas

Land Use in the Targeted Area		
Land Use	**Total Acres**	**% of Targeted Area**
Pasture/Hay	67,169	44.8%
Cropland	33,562	22.4%
Deciduous Forest	31,822	21.2%
Grassland	6,339	4.2%
Developed, Open Space	5,887	3.9%
Woody Wetlands	2,019	1.3%
Developed, Low Intensity	1,334	0.9%
Open Water	1,034	0.7%
Shrubland	326	0.2%
Developed, Medium Intensity	212	0.1%
Mixed Forest	166	0.1%
Herbaceous Wetlands	99	0.1%
Barren Land	48	0.0%
Developed, High Intensity	36	0.0%
Evergreen Forest	3	0.0%
Total	**150,057**	**100%**

1. Targeted livestock areas for nutrient reduction

Livestock area BMPs will be implemented to reduce nutrient (specifically phosphorus) loading in the Lower Kansas River Watershed to protect local streams, including Crooked and Stranger Creek. BMPs to reduce phosphorus will also prove to reduce *E. coli* bacteria and will protect Nine Mile and Stranger Creek from further degradation.

As shown in **Figure 21**, livestock area BMPs will be implemented along the riparian corridors in about half the watershed to include 14 of the 31 HUC 12s in the Lower Kansas River Watershed. These targeted HUC 12s include:

- HUC 10270104301
- HUC 10270104302
- HUC 10270104303
- HUC 10270104304
- HUC 10270104305
- HUC 10270104306
- HUC 10270104307
- HUC 10270104401
- HUC 10270104402
- HUC 10270104403
- HUC 10270104404
- HUC 10270104405
- HUC 10270104406
- HUC 10270104407

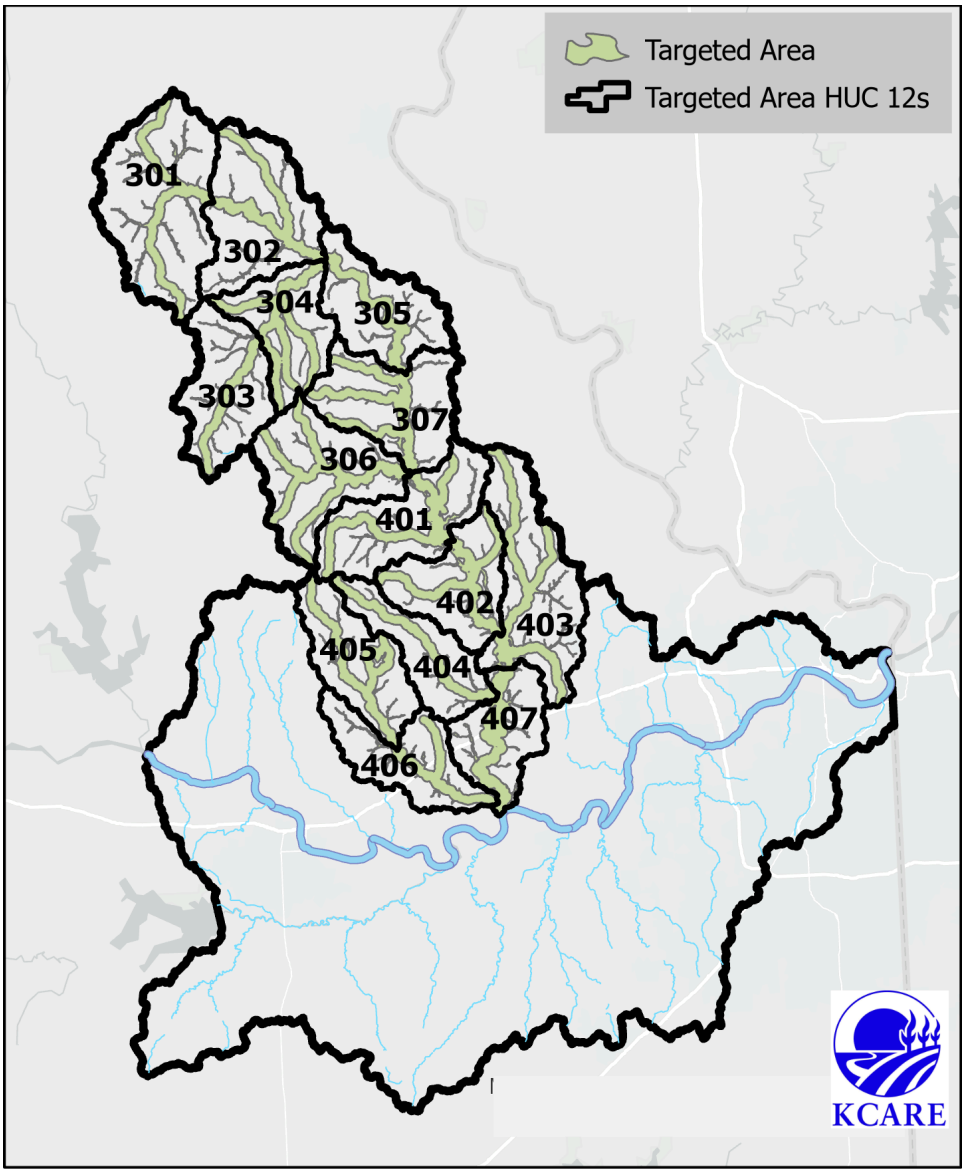


Figure 23. Livestock Targeted Areas in the Lower Kansas River Watershed

2. Livestock area BMPs for nutrient reductions

The following BMPs will be implemented to reduce nutrient loading from livestock in the targeted areas:

- Alternative watering system: An alternative watering system helps prevent livestock from entering ponds and creeks, thereby removing animal waste from being directly deposited into those waterways. It has been proven that cattle will choose fresh water in an alternative watering system over creek water, and this greatly reduces nutrients and bacteria from getting into the watershed's stream flow.

- Grazing management plan: A grazing management plan is a site-specific conservation plan developed for a landowner which addresses one or more resource concerns on land

where grazing-related activities or practices will be applied. A grazing management plan is used as a tool allowing producers to organize their land, to improve forage production, to determine livestock sustainability, to allocate budget resources, and to determine the effort and time necessary for long-term livestock production goals. In the Lower Kansas River Watershed, hot-wire fencing is a large part of this BMP, which keeps cattle in certain areas/paddocks during certain times of the year. This type of fencing is used to keep livestock away from riparian corridor areas, which prevents livestock waste from entering the stream.

- Relocate feeding areas - outside priority areas/cover crops: This BMP requires livestock to be relocated/moved from priority/targeted areas to non-priority/non-targeted areas, out of and away from riparian corridors. Cover crops are planted or will be established for grazing purposes. Moving livestock out of riparian corridor areas will prevent nutrients and bacteria from entering water segments. *For simplification purposes, this plan will use "relocate feeding areas" in most tables to refer to this BMP*.

- Vegetative filter strips: Vegetative filter strips are land areas of either planted or indigenous vegetation, situated between a potential pollutant-source area and a surface-water body that receives runoff. Riparian corridors benefit greatly from vegetative filter strips as they naturally filter out pollutants.

- Wetland development: Wetland development includes the establishment of new wetlands or the restoration of historical wetlands. Wetlands can work as a natural filter while providing habitat for local wildlife and organisms. In a wetland, plants, and beneficial bacteria work in harmony with microorganisms to remove nutrients and fine sediments, preventing them from moving on to stream segments within the watershed.

Table 15. Nutrient BMP Adoption Rates in Livestock Areas

BMPs to Reduce *E. coli* and Phosphorus Loading		
Protection Measures	**Best Management Practices**	**Annual Adoption Rate Goal**
Prevention of *E. coli* bacteria and nutrient (phosphorus) contribution from livestock	Alternative Watering System	1 project in years 1, 3, and 5. 3 total projects during life of plan.
	Grazing Management Plan	1 project in years 2 and 4. 2 total during life of plan.
	Relocate Pasture Feeding Areas	1 project in years 1, 3, and 5. 3 total projects during life of plan.
	Vegetative Filter Strips	1 project in years 2 and 4. 2 total during life of plan.
	Wetland Development	1 project in years 1, 3, and 5. 3 total projects during life of plan.

Table 16. Adoption Rates for Livestock BMPs to Address Nutrients

Annual Livestock BMP Adoption						
Year	Alternate Watering System	Grazing Management Plan	Relocate Pasture Feeding Areas	Vegetative Filter Strips	Wetland Development	Projects Per Year
1	1	0	1	0	1	3
2	0	1	0	1	0	2
3	1	0	1	0	1	3
4	0	1	0	1	0	2
5	1	0	1	0	1	3
Total	**3**	**2**	**3**	**2**	**3**	**13**

3. Phosphorus load reductions from livestock BMP implementation

The implementation of 2–3 livestock BMP projects per year in the targeted areas will result in a phosphorus load reduction of 10,060 pounds at the end of this five-year WRAPS plan (**Table 17**).

Table 17. Phosphorus Reductions from Livestock BMP Implementation

Estimated Phosphorus Load Reduction (lbs.)								
Year	Alternate Watering System	Grazing Management Plan	Relocate Pasture Feeding Areas	Vegetative Filter Strips	Wetland Development	Annual Load Reduction	Cumulative Load Reduction	% of Required Reduction
1	22	0	425	0	18	465	465	9%
2	22	101	425	878	18	1,444	1,909	36%
3	45	101	849	878	36	1,909	3,818	73%
4	45	202	849	1,757	36	2,889	6,707	128%
5	67	202	1,274	1,757	54	3,353	10,060	192%
Phosphorus Load Reduction Required: 5,252 pounds								

4. Nitrogen load reductions from livestock BMP implementation

As mentioned, nitrogen is not a priority impairment in this plan, however it will be impacted positively as livestock acres are treated for nutrients through BMP implementation. This is a bonus to this plan and will further improve nutrient impaired waters throughout the watershed. The implementation of the 2–3 livestock BMP projects per year in the targeted areas will result in a nitrogen load reduction of 18,948 pounds at the end of this five-year WRAPS plan (**Table 18**).

Table 18. Nitrogen Reductions from Livestock BMP Implementation

Estimated Nitrogen Load Reduction (lbs.)							
Year	Alternate Watering System	Grazing Management Plan	Relocate Pasture Feeding Areas	Vegetative Filter Strips	Wetland Development	Annual Load Reduction	Cumulative Load Reduction
1	42	0	800	0	34	876	876
2	42	190	800	1,655	34	2,720	3,596
3	84	190	1,599	1,655	68	3,596	7,192
4	84	381	1,599	3,309	68	5,441	12,632
5	126	381	2,399	3,309	102	6,316	18,948

5. Meeting the *E. coli* and total phosphorus TMDLs

Adoption and implementation of nutrient BMPs in livestock areas will result in a total phosphorus load reduction of 10,060 pounds at the conclusion of this 5-year WRAPS plan. The load reduction goal to meet the total phosphorus TMDL is 5,252 pounds of phosphorus, therefore the implementation of all livestock BMPs during the 5-year span will exceed the TP reduction goal by roughly 92%.

The load reductions achieved by this plan will exceed the required phosphorus reductions to meet both the *E. coli* TMDL in Nine Mile and Stranger Creeks as well as the total phosphorus TMDLs in Crooked and Stranger Creeks.

8. Information and Education

The SLT determined which Information and Education (I&E) activities are needed in the Lower 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 Lower 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 **$37,050**. *It is understood that funding from non-WRAPS sources will be required if all these activities are to take place.*

Table 19. 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	$15,000	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	$5,000	
Grazing Management Plan	Livestock Producers/ Landowners	Scholarships to Grazing Schools and Workshops	Annual - Winter	5 per year, $50 per scholarship ($250 total)	Division of Conservation (DOC), Conservation Districts, K-State Research and Extension (KSRE), Kansas Rural Center, KAWS, NRCS, and WRAPS
Relocate Feeding Areas - outside priroity areas/cover crops	Livestock Producers/ Landowners	One-on-one technical assistance for producers to implement BMPs in the targeted area	Annual - Ongoing	Included Above	Division of Conservation (DOC), Conservation Districts, K-State Research and Extension (KSRE), Kansas Rural Center, KAWS, NRCS, and WRAPS
		Tour/Field Day	Annual - Summer	Included Above	
Vegetative Filter Strips	Livestock Producers/ Landowners	Scholarships to Grazing Schools and Workshops	Annual - Winter	Included Above	Division of Conservation (DOC), Conservation Districts, K-State Research and Extension (KSRE), Kansas Rural Center, KAWS, NRCS, and WRAPS
Wetland Development	Livestock Producers/ Landowners	Tour/Field Day	Annual - Summer	Included Above	Division of Conservation (DOC), Conservation Districts, K-State Research and Extension (KSRE), Kansas Rural Center, KAWS, NRCS, Ducks Unlimited, and WRAPS
		Scholarships to Grazing Schools and Workshop	Annual - Winter	Included Above	
		One-on-one technical assistance for producers to implement BMPs in the targeted area	Annual - Ongoing	Included Above	
		One-on-one technical assistance to remove livestock from riparian area	Annual, Ongoing	$4,000	

Table 20. I&E: Lower 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	$500 per event	Conservation Districts
		Events/campaigns created by student environmental groups at high schools in the watershed	Annual - Spring, Summer or Fall	$250 per event	Local school districts, KSRE, Local environmental volunteer organizations
		Poster, essay, speech contests	Annual - Spring	$200	Conservation Districts
		Day at the Farm	Annual - Spring	$500 per event	Conservation Districts, Kansas Farm Bureau, KSRE
		Thank You Farmer	Annual - Winter	$200	Conservation Districts
Education Activities Targeting Adults	Watershed Residents	Maintain a Lower 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	Jefferson County Health Department, Conservation Districts
		Abandoned well plugging demonstration	Annual - Summer	$1,000	Conservation Districts
		Lower Kansas River Watershed and BMP brochures	Annual	$500	WRAPS
		Rain barrel/rain garden workshop	Biannual - Spring and late Summer	$1,000	Conservation Districts, K-State Research and Extension in Leavenworth County, and WRAPS

Table 21. **I&E: Lower Kansas River Watershed Education on Water Issues**

Watershed Issues Information and Education					
Issue	**Target Audience**	**Information/Education Activity/Event**	**Time Frame**	**Estimated Costs**	**Sponsor/Responsible Agency**
Bacteria	Watershed Landowners	Water Testing	Semi-Annually Four (4) locations	$2,000	Conservation District, KAWS, KDHE, and Mid America Regional Council (MARC)
Flooding	City/County/ Watershed Landowners	Area Visits	Semi-Annually	$200	City, County Officials, Conservation Districts
Identify/ Protect Green Space	City/County/ Government Officials	Scheduled Meetings	Annually	$100	County Planning and Zoning, Conservation Districts
Nutrients	Watershed Landowners	Onsite Visits	Bi-Monthly	$300 per year	Conservation Districts
Pesticides	Watershed Landowners	Onsite Visits	Quarterly	$1,000 per year	Conservation Districts, Kansas Rural Center
Sediment/ Biology	Watershed Landowners	Sampling	Annually	$500	Conservation District, KAWS, KDHE, MARC
Source Water	County/ Landowners	Scheduled Meetings	Semi-Annually	$100	County Planning and Zoning, Conservation Districts
Water Conservation	Watershed Landowners	Onsite Visits	Quarterly	$500	KAWS, Conservation Districts
Water Wells	Watershed Landowners	Onsite Visits	As Needed	$250	Conservation Districts
Total Cost (per year) for all Information and Education Activities				**$37,050**	

B. Evaluation of Information and Education Activities

All service providers conducting I&E activities funded through the Lower 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 *E. coli* and total phosphorus TMDLs and determined which BMPs will receive implementation funding in livestock areas. An added benefit is that most of the targeted BMPs will have positive impacts on other impairments in the Lower Kansas River Watershed, including the biology, dissolved oxygen and eutrophication TMDLs. Below are expenses before and after cost-share for implementing livestock BMPs. Costs can be shared with any potential funding sources (**Table 26**). Cost derivations are in the appendix.

A. Livestock BMP Implementation Costs

Table 22. Implementation Costs: Livestock BMPs Before Cost-Share

Lower Kansas River, Implementation Cost Before Cost-Share (3% Inflation)						
Year	Alternate Watering System	Grazing Management Plan	Relocate Pasture Feeding Area	Vegetative Filter Strips	Wetland Development	Total Cost
1	$5,000	$0	$10,000	$0	$5,000	$20,000
2	$0	$1,030	$0	$824	$0	$1,854
3	$5,305	$0	$10,609	$0	$5,305	$21,219
4	$0	$1,093	$0	$874	$0	$1,967
5	$5,628	$0	$11,255	$0	$5,628	$22,511
Total	**$15,933**	**$2,123**	**$31,864**	**$1,698**	**$15,933**	**$67,551**

Table 23. Implementation Costs: Livestock BMPs After Cost-Share

Lower Kansas River, Implementation Cost After Cost-Share (3% Inflation)						
Year	Alternate Watering System	Grazing Management Plan	Relocate Pasture Feeding Area	Vegetative Filter Strips	Wetland Development	Total Cost
1	$1,500	$0	$3,000	$0	$1,500	$6,000
2	$0	$309	$0	$247	$0	$556
3	$1,592	$0	$3,183	$0	$1,592	$6,367
4	$0	$328	$0	$262	$0	$590
5	$1,688	$0	$3,377	$0	$1,688	$6,753
Total	**$4,780**	**$637**	**$9,560**	**$509**	**$4,780**	**$20,266**

B. Total Costs for BMP Implementation and Education Activities

Table 24. Cost to Implement the Lower Kansas River WRAPS Plan

Total Cost to Implement WRAPS Plan, After Cost-Share (3% Inflation)			
Year	**Livestock**	**I&E**	**Total Cost**
1	$6,000	$37,050	$43,050
2	$556	$38,162	$38,718
3	$6,366	$39,306	$45,672
4	$590	$40,486	$41,076
5	$6,753	$41,700	$48,453
Totals	**$20,265**	**$196,703**	**$216,969**

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 25** and **26.**

Table 25. Potential Technical Assistance Providers for Plan Implementation

Technical Assistance to Aid in BMP Implementation		
BMPs To Be Implemented		**Technical Assistance**
Livestock	Alternative Watering System	Lower Kansas River WRAPS Coordinator, Atchison, Douglas, Jefferson, Johnson, Leavenworth, and Wyandotte County Conservation Districts, Farm Service Agency, Kansas Department of Wildlife, Parks and Tourism, Kansas Forest Service, KAWS, KSRE Watershed Specialists, NRCS, and the Glacial Hills Resource Conservation and Development (RC&D)
	Grazing Management Plan	
	Relocate Feeding Areas - outside priority areas/cover crops	
	Vegetative Filter Strips	
	Wetland Development	

Table 26. Potential Funding Sources for Plan Implementation

Potential BMP Funding Sources	
Potential Funding Sources	**Potential Funding Programs**
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)
Environmental Protection Agency (EPA) and the Kansas Department of Health and Environment (KDHE)	Section 319 Clean Water Act funds
	State Revolving Fund (SRF)
	American Recovery and Reinvestment Act (ARRA)
	WRAPS Grants
Kansas Department of Wildlife and Parks (KDWP)	Partnering for Wildlife
	Wildlife Habitat Incentive Program (WHIP)
Division of Conservation (DOC)	State Water Resources Cost Share Program (SWRCSP)
	Streambank Restoration funds
	Riparian and Wetland Protection Program (RWPP)

Potential BMP Funding Sources Continued	
Potential Funding Sources	**Potential Funding Programs**
DOC, Continued	Landowner incentive funds for streambank restoration projects
	Conservation Districts Non-point Source Pollution Funds (NPS)
Kansas Forest Service	Rural Forestry Program
	Forestland Enhancement Program (FLEP)
Kansas State University, Research & Extension	Varies
Habitat First	Varies
Pheasants Forever, Quail Forever and other private entities	Varies

11. Measurable Milestones

The interim timeframe for all BMP implementation is five 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 phosphorus load reduction goals to address the ***E. coli*** and **TP TMDLs** in the Lower Kansas River Watershed will be in year four of this WRAPS plan. After the phosphorus goals are achieved, the process will become one of protection rather than restoration.

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

A. Measurable Milestones for BMP Implementation

Milestones will be determined at the end of the five-year plan by number of acres treated, projects installed, contacts made to watershed residents and water quality parameters. 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 five- to 10-year timeframe.

Table 27. Livestock BMP Implementation Milestones

Livestock BMP Implementation Milestones (projects)							
	Year	Alternate Watering System	Grazing Management Plan	Relocate Pasture Feeding Areas	Vegetative Filter Strips	Wetland Development	Total Adoption / Projects Per Year
Short-Term	1	1	0	1	0	1	3
	2	0	1	0	1	0	2
	3	1	0	1	0	1	3
	4	0	1	0	1	0	2
	5	1	0	1	0	1	3
Total		**3**	**2**	**3**	**2**	**3**	**13**

B. Benchmarks to Measure Water Quality and Social Progress

The goal of this WRAPS plan is that in the next five-year time frame, the Lower Kansas River Watershed will see improved water quality throughout the watershed, specifically reduced *E. coli* bacteria in Nine Mile and Strangers Creeks and reduced total phosphorus in Crooked and Stranger Creeks.

After reviewing the criteria listed in **Table 28**, the SLT will assess and revise the overall strategy plan 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 update plans. 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 28. Lower Kansas River Watershed Benchmarks to Measure Progress

Benchmarks to Measure Water Quality Progress		
Impairment Addressed	**Criteria to Measure Water Quality Progress**	**Information Source**
E. coli	Less than 10% exceedances of the nominal *E. coli* Bacteria (ECB) criterion at flows under 785 cfs.	KDHE
Total Phosphorus	**Lower Kansas River Watershed:** ALUS Index > 14 Sestonic Chlorophyll ≤ 10 µg/L Dissolved oxygen concentrations > 5.0 mg/L, with saturation < 110% pH values within the range of 6.5 to 8.5.	KDHE
Impairment Addressed	**Social Indicators to Measure Water Quality Progress**	**Information Source**
***E. coli*/ Nutrients**	Taste and odor issues in public water supply drawn from Lower Kansas River Watershed water segments.	KDHE
	Survey of water quality issues to determine whether information and education programs are having an effect on public perception.	KSRE
	Number of attendees at field days and tours.	KSRE
	Number of BMP acres and projects impelemented in the targeted acres.	NRCS

C. Water Quality Milestones Used to Determine Improvements

The goal of the Lower 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 *E. coli* and total phosphorus TMDLs. To reach load reduction goals, a BMP implementation schedule spanning five 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 along the riparian corridors of livestock areas in targeted portions of the Lower Kansas River Watershed. 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 Lower Kansas River Watershed

The Lower Kansas River Watershed has *E. coli* and total phosphorus (TP) TMDLs addressed by this WRAPS plan. Milestones[24] for each TMDL are determined by set parameters designed to exhibit long-term goals to indicate the success of this WRAPS plan.

[24] Milestones provided by KDHE on January 14, 2022.

1. Water quality milestones for *E. coli*

The Lower Kansas River has high-priority *E. coli* TMDLs in Stranger and Nine Mile Creeks. Livestock areas targeted for nutrient reductions will aid in reducing *E. coli* bacteria in these water segments as well as the rivers that they feed into.

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). The desired WQS can be found in **Table 29**.

Table 29. Lower Kansas River Water Quality Milestones: **E. coli**

Water Quality Milestones: *E. coli*				
Sampling Site	Past Condition	Current Condition	5-year Goal	10-year Long-Term Goal
	2000-2010 Water Quality Standard (WQS)	2011 - 2021 WQS	2026 WQS	Delsiting Level 2031 WQS
Nine Mile at Tonganoxie	50	Not enough data	75	90
Stranger at Linwood	75	80	85	90
Stranger at Easton	65	Not enough data	75	90

2. Water quality milestones for TP

There are two high-priority TP impairments in the Lower Kansas River Watershed, located in Crooked and Stranger Creeks. Livestock BMPs implemented will reduce nutrients, specifically phosphorus, and will improve water quality in those water segments as well as those they flow into.

The desired endpoint for TP is a narrative criterion, however it is expected that the aquatic life support will not be met until TP has no exceedances of 190 ppb, based on levels of support in the ecoregion as determined by the ALUS index. **Table 30** shows the milestones for TP.

Table 30. Lower Kansas River Water Quality Milestones: Total Phosphorus

Water Quality Milestones: Total Phosphorus				
Sampling Site	Past Condition 2000-2010	10-Year Goal 2011-2021	Long-Term Goal 2022-2027	
	Average TP	Current Condition Average TP	Improved Condition Average TP	Total Reduction Needed
	Total Phosphorus (TP) (average of data collected during indicated period), ppb			
Nine Mile at Tonganoxie	167	121	100	18%
Stranger at Easton	271	314	252	20%

12. Monitoring Water Quality

KDHE continues to monitor water quality in the Lower Kansas River Watershed by maintaining the monitoring stations located within the watershed. **Figures 24** and **25** illustrate the locations of the monitoring sites within the Lower Kansas River Watershed as well as the BMP-targeted areas identified and discussed in previous sections of this plan.

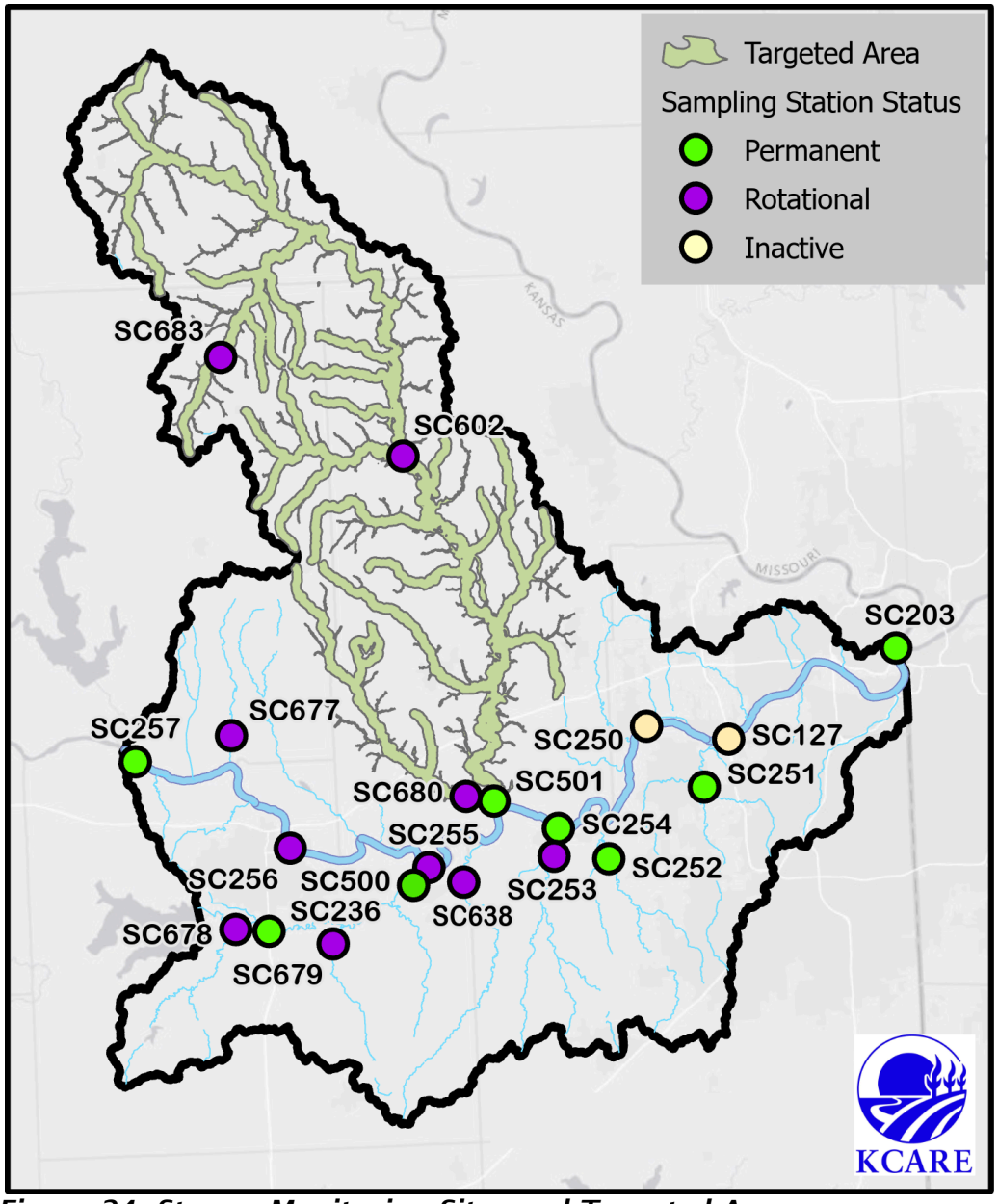


Figure 24. Stream Monitoring Sites and Targeted Areas

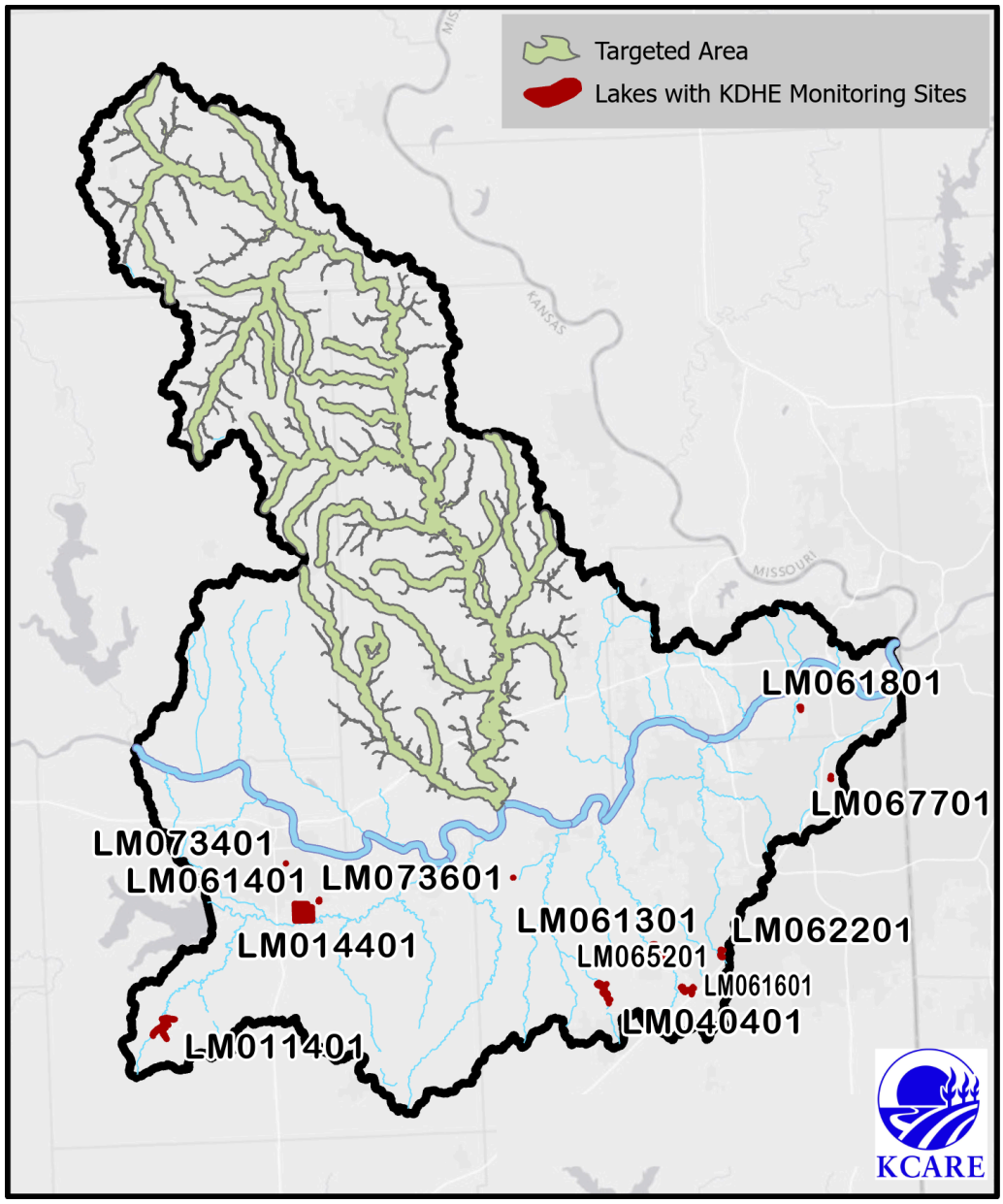


Figure 25. Lake Monitoring Sites and Targeted Areas

KDHE continues to monitor water quality in the Lower Kansas River Watershed by maintaining 18 stream chemistry stations and 12 lake monitoring stations. Eight of these monitoring sites are permanent and include:

- SC203
- SC251
- SC252
- SC254
- SC257
- SC500
- SC501 – Stranger Creek
- SC679

Ten 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:

- SC253
- SC255
- SC256
- SC602 – Stranger Creek
- SC638
- SC677
- SC678
- SC679
- SC680 – Nine Mile Creek
- SC683 – Crooked Creek

The KDHE lake monitoring stations will be sampled every three years with the next sampling year scheduled for 2022. These sites are found at the following locations:

- LM011401
- LM014401
- LM040401
- LM061301
- LM061401
- LM061601
- LM061801
- LM062201
- LM065201
- LM067701
- LM073401
- LM073601

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 Lower 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 Lower Kansas River Watershed, as well as the frequency of the sampling data.

The BMP implementation schedule and water quality milestones for the Lower Kansas River Watershed extend through a five-year period from 2022-2027. 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 2027, a determination will be made as to whether the water quality standards have been attained and 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 *E. coli* and phosphorus load reductions.

- KDHE reports on current and desired endpoints for water quality in the Lower Kanas River Watershed regarding the ***E. coli* TMDL**: less than 10% exceedances of the nominal *E. coli* bacteria (ECB) criterion at flows under 785 cfs. Other conditions expected in relation to the *E. coli* TMDL:
    1) Less than 10 % of Spring samples exceed primary criterion at flows under 785 cfs with
    2) no samples exceeding the criterion at flows under 125 cfs,
    3) Less than 10% of Summer/Fall samples exceed the primary criterion at flows under 785 cfs with no samples exceeding the criterion at flows under 18 cfs, and
    4) Less than 10% of Winter samples exceed secondary criterion at flows under 785 cfs.
- KDHE reports on current and desired endpoints for water quality in the Lower Kansas River Watershed regarding the **total phosphorus (TP) TMDL**. The TP TMDL and the *E. coli* TMDL were rolled into one phosphorus load reduction goal: phosphorus must be reduced by 5,252 pounds per year, roughly a 30% reduction. Other conditions expected in relation to the TP TMDL:
    1) ALUS Index score > 14,
    2) Sestonic chlorophyll a < 10 µg/L,
    3) DO concentrations > 5.0 mg/L,
    4) DO saturation < 110%, and
    5) pH within range of 6.5-8.5.
- KDHE reports on TMDLs, including possible nutrient and sediment criteria, revised load allocations, and new wasteload allocations defined for point sources.
- KDHE reports on trends in water quality in the Kansas River and throughout the 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 31. Service Provider List

Organization	Programs	Purpose	Technical or Financial Assistance	Website Address
U.S. Environmental Protection Agency (EPA)	* Clean Water Act (CWA) Section 319 Funds * State Revolving Fund (SRF) Program * American Recovery and Reinvestment Act (ARRA) Funds	CWA provides grant funds for water protection activities. SRF and ARRA provide loans for water pollution control activities and green infrastructure.	Financial	www.epa.gov
Kansas Department of Health & Environment (KDHE)	* Watershed Restoration and Protection Strategy (WRAPS) * State Revolving Fund * Nonpoint Source Pollution Program * Watershed Management Programs * National Pollutant Discharge Elimination System (NPDES) Program * Livestock operation certification and permitting * Local Environmental Protection Program (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.gov
Kansas Alliance for Wetlands and Streams (KAWS)	*Streambank Stabilization *Wetland Restoration *Cost share programs *Riparian and streambank assessment	KAWS is a non-profit, non-governmental organization organized in 1996 to promote the protection, enhancement and restoration of wetlands and streams in Kansas.	Technical and Financial	www.kaws.org
Kansas Forest Service (KFS)	*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.kansasforests.org
Kansas Department of Wildlife & Parks (KDWP)	* Land and Water Conservation Funding * Conservation Easements * Wildlife Habitat Improvement Program * Walk-in Hunting Program * North American Waterfowl Conservation Act * Work with non-profits such as Ducks Unlimited, Pheasants Forever and other state and federal agencies to promote wildlife habitat	Supervises the fisheries, wildlife, law 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.com
Kansas Department of Agriculture (KDA)	* Watershed Structures * Water Appropriation * Permitting	Deal with water resource management for the benefit of all Kansans, permitting, minimum desirable stream flow, dam safety and regulation.	Technical and Financial	www.ksda.gov
Kansas Rural Center (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 farming and stewardship of soil and water.	Technical and Financial	www.kansasruralcenter.org
Kansas State Research & Extension (KSRE)	* Watershed Specialist Program * County Extension Offices * Kansas Public Healthy Ecosystems * Healthy Communities Program * Citizen Science Kansas Center for Ag Resources and Environment (KCARE)	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 protection.	Technical	www.ksre.ksu.edu
Kansas Association for Conservation and Environmental Education (KACEE)	* Facilitation and Educational Workshops 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.org

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 * Atchison CCD: (913) 833-574 * Douglas CCD: (785) 843-4260 * Jefferson/Leavenworth CCD: (785) 863-2221 * Johnson CCD: (913) 715-7022 * Wyandotte CCD: (913) 334-6329	https://kacdnet.org/districts/
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 (collects monitoring for Perry Lake) * Reservoir Management	Manages federal reservoirs in Kansas and operates a water quality program	Technical	www.usace.army.mil

B. Livestock BMP Definitions

1. **Alternate watering system**
   - These are watering systems designed so that livestock do not enter a stream or body of water.
   - 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 for limited stream access.

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

3. **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 out of targeted areas and into other non-targeted areas altogether.
   - 100% phosphorus reduction efficiency.

4. **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.

5. **Wetland development**
   - 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.
   - 30% erosion and P reduction efficiency.
   - 70% cost-share available.
   - One acre of wetland will treat 15 acres of cropland, on average.

C. Livestock Budget Derivations[25]

Summarized derivation of livestock BMP cost estimates

- Alternate watering system: $1,500 per unit with 70% cost-share.
- Grazing management plan: $309 per plan with 70% cost-share.
- Relocate pasture feeding areas: $3,000 with 70% cost-share. Cost includes fencing, new watering system, concrete, and labor.
- Vegetative filter strips: $247 with 70% cost-share. Cost includes building ¼ mile of fence, a permeable surface, and labor.
- Wetland development: $1,500 with 70% cost share.

[25] All cost derivations were calculated using rates effective in May 2021 in combination with figures provided by the WRAPS coordinator.