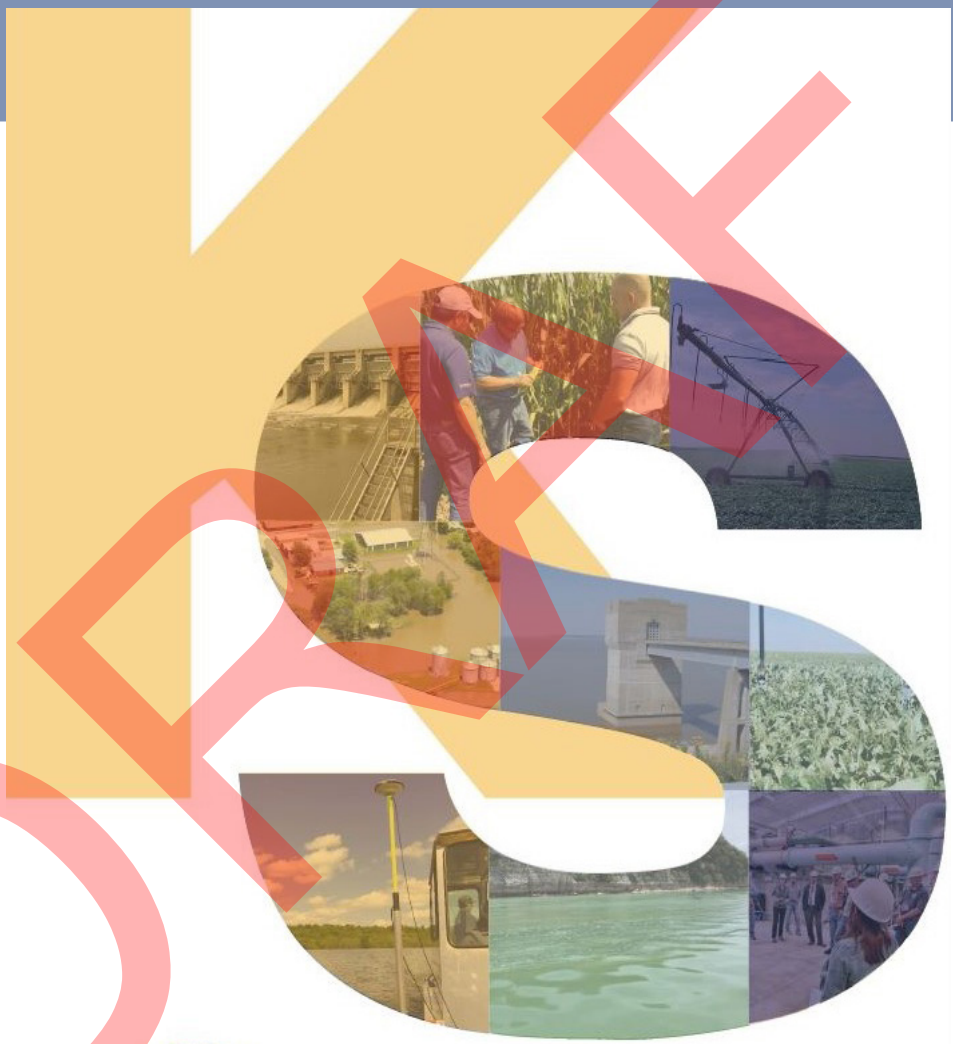
The 2021

KANSAS WATER PLAN



Kansas Water Office | KANSAS WATER PLAN

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Acknowledgements

OF THE KANSAS WATER PLAN

The *Kansas Water Plan (KWP)* is, by design, the product of numerous contributors. The levels of expertise, insight and experience necessary requires the involvement and participation of a number of state agencies, local entities, individuals and stakeholders.

Many thanks go to Governor Laura Kelly, the Kansas Water Office as well as the following:

- Kansas Department of Agriculture (with its Division of Water Resources and Division of Conservation)
- Kansas Department of Health and Environment
- Kansas Department of Wildlife and Parks
- Kansas Geological Survey
- Kansas Biological Survey
- Kansas Department of Commerce
- Kansas Corporation Commission
- Kansas State University
- University of Kansas

Recognition also goes to the members of the Kansas Water Authority, Regional Advisory Committees statewide, Groundwater Management Districts, numerous entities, stakeholders and individuals whose input proved invaluable in the development of this *KWP*.

This document would not be possible nor complete without countless source materials providing much of the information and analysis provided in this report. The work of numerous professionals is relied upon and cited throughout this report, with links to those works embedded within the text of the *KWP* to guide readers to the primary documents and additional information.

The Kansas Water Office (KWO) also provides a separate annual *State of the Resource* report that operates as a companion to the *KWP*. This complementary document provides a status check on the various water issues and programs identified in the *KWP*, on a more frequent basis.

IMPACTS OF COVID-19 PANDEMIC

It should be noted that publication of this updated KWP is a bit delayed. This delay was primarily caused by the disruptive impacts of the COVID-19 pandemic. This report reflects the admirable efforts of so many to overcome that challenge. As was true of nearly every aspect of life, the COVID-19 pandemic, beginning in the spring of 2020, interrupted and upended the anticipated schedule for development, stakeholder input and completion. Notably, this KWP is the first to include goals and action plans provided by the 14 Regional Advisory Committees. The pandemic prevented these committees from meeting in person. In order to gather in some fashion and develop this content, the RACs met virtually, collaborating through online communications, via phone calls and computer screens. The same was true for the Kansas Water Authority and all the state agencies whose input has been critical to the preparation of this document.

Executive Summary

OF 2021 KANSAS WATER PLAN

The Kansas water planning process continues to incorporate the three key state water plan characteristics mandated by the State Water Resources Planning Act: comprehensive, coordinated and continuous adaptive planning. Adaptive planning is the cornerstone upon which the planning process and the *KWP* rest. This view of water resource planning supports the ability of the decision-making process to be flexible in response to changing current and future conditions and promotes adjustments from the current situation which do not foreclose future resource use options.

Kansas faces water challenges in every corner of the state, many with potentially severe and far-reaching consequences. Comprehensive planning for water management, conservation and development of the state's water resources, especially during this era of increasing climatic changes, is more critical than ever before.

KWP objectives are organized around overarching goals that articulate the intent of the Water Resource Planning Act while recognizing current challenges. The water planning process today continues to rely on public input throughout its development. The Kansas Water Authority (KWA), Regional Advisory Committees (RACs), state agencies, partners, including the public, provide valuable advice concerning issue identification and policy development. The RACs, agencies and partners also provide guidance for the KWA, whose duty it is to reflect program priorities in its recommendations to the Governor and Legislature on how to spend State Water Plan Funds.

The *KWP* presents five guiding principles, followed by separate sections addressing each of the 14 regional planning areas in Kansas. Each regional planning section also contains goals and action plans developed by the respective RAC. This updated version of the *KWP* incorporates relevant content from *A Long-Term Vision for the Future of Water Supply in Kansas (The Vision)* document, creating a single comprehensive guide for short and long-term water planning in Kansas.

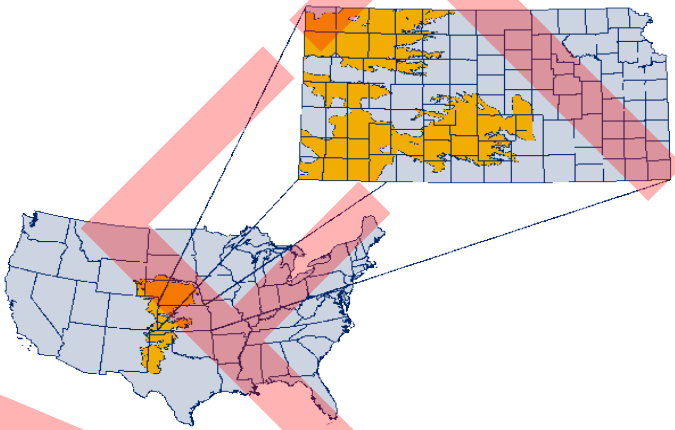
The five guiding principles provide the foundation and framework for addressing water issues in Kansas, identifying the overarching challenges and the steps needed to meet those challenges:

Guiding Principles

OF THE KANSAS WATER PLAN

(1) Conserve and Extend the High Plains Aquifer

This network of underground water sources serves as the primary water supply for much of central Kansas and most of western Kansas. The High Plains Aquifer has three components in Kansas: the Ogallala Aquifer, the Great Bend Prairie Aquifer and the Equus Beds Aquifer. Of these three, the Ogallala is suffering the most severe depletion, with some areas already effectively dry in terms of economic feasibility. It is not an overstatement to say that the future of habitability in much of western Kansas is at stake; water users of all kinds will need to adopt practices amendable to less groundwater use if these populations and economies are to remain viable.



(2) Secure, Protect and Restore Our Kansas Reservoirs

Kansas has fourteen federal reservoirs which supply water for two-thirds of the state's population. A critical issue facing these reservoirs is sedimentation, which has been reducing storage capacity at these reservoirs, some to an alarming level. Tuttle Creek Lake, for example, which serves users throughout the entire Kansas River Basin, is at 51% capacity (as of the 2020 bathymetric reservoir survey) due to sedimentation. Other challenges include Harmful Algal Blooms (HABs) with toxicity levels that threaten public health, and contractual financial obligations the state carries due to contracts with the federal government for storage and local use of the water in federal reservoirs. technologies may provide options for safely passing accumulated sediment downstream, while improved land use practices upstream help prevent excessive sedimentation from entering reservoirs.

Guiding Principles

OF THE KANSAS WATER PLAN CONTINUED

(3) Improve the State's Water Quality

The primary agency charged with assessing and managing water quality is the Kansas Department of Health and Environment (KDHE), although other agency partners have roles to play, as well. KDHE is the state entity that administers the federal Clean Water Act. Water quality issues affecting surface waters include nutrients, sedimentation, HABs and nitrate contamination. Groundwater quality is threatened by mineralization (uranium, selenium), chloride contamination and nitrates. KDHE assesses and monitors surface waters and groundwater throughout the state, maintaining and sharing essential data such as the List of Impaired Waters (Section 303(d) List). KDHE administers the Water Restoration and Protection Strategy (WRAPS) program, a framework that engages citizens and other stakeholders in a teamwork environment aimed at protecting and restoring Kansas watersheds. On another front, a number of innovative water reuse programs are demonstrating the economic and environmental benefits of re-purposing water as compared to sole reliance on single-use supplies.

(4) Reduce Our Vulnerabilities to Extreme Events

Effective water planning must account for the occurrence of extreme events, such as droughts and floods. As already evident from climate change, these events are becoming more intense and less predictable. The *KWP* acknowledges that employing state of the art science and technology is imperative to securing a safe, secure water supply for the state. Municipal conservation plans, public water supply emergency response plans, and proper reservoir management in partnership with the federal government are among the essential tools and strategies to prepare for, and respond to, extreme events. This is an area in which adaptive planning is particularly critical, in order to understand how and when extreme events are likely to occur and, ideally, how to create policies and plans that will prevent as much damage as possible.

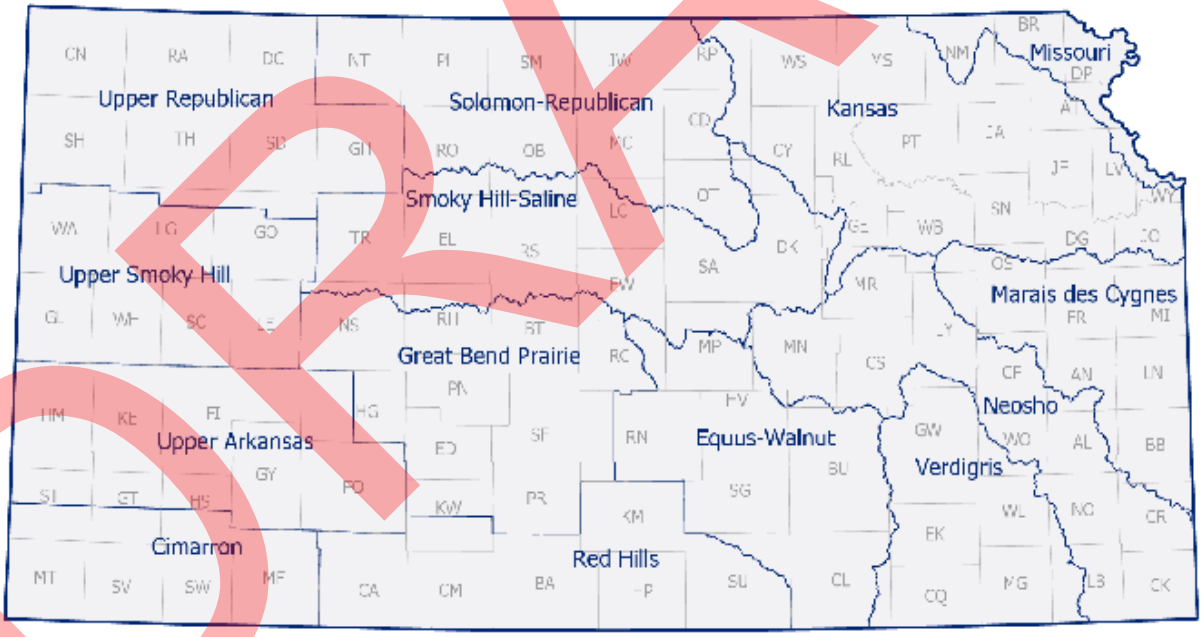
(5) Increase Awareness of Kansas Water Resources

The water planning process in Kansas relies heavily on public and stakeholder input. Perhaps the most consistent message received from these entities is the need for increased education and outreach. Success in dealing with water problems is far more likely when the public is aware, concerned and engaged. Indeed, success is unlikely without it. This was a key principle in the *Vision*, which contained recommendations that remain relevant, such as including water conservation in academic curriculum at all levels, providing outreach events and opportunities for public involvement, and implementing a social marketing campaign statewide. The *Kansas Runs on Water* marketing campaign has been launched to achieve this goal.

Regional Planning Areas

OF THE KANSAS WATER PLAN

The *KWP* also contains sections dedicated to each of the 14 Regional Planning Areas. Each Regional Planning Area section presents background geologic, topographic, and demographic information, as well as referencing issues identified in the *Guiding Principles* section that affect each region. Following this content, the *KWP* shares the related RAC's proposed goals and action plans for each respective region. These locally-developed goals and action plans largely mirror the issues and strategies identified in the *KWP's Guiding Principles*. As described above, these goals and action plans were developed by each RAC, over many months and numerous meetings, reflecting boots-on-the-ground direct involvement from members of the public and stakeholder representatives. This version of the *Kansas Water Plan* presents both professional, scientific information and local input and perspective.



> **"Locally driven solutions have the highest opportunity for long term success."**
>
> *- A Long-Term Vision for the Future of Water Supply in Kansas*

Brief History

OF KANSAS WATER PLANNING

The *KWP* is one of the primary tools used by the State of Kansas to address current water resources issues and to plan for future needs. The *KWP* guides coordination of local, state and federal actions. Statutory authority and basic guidance for formulating the *KWP* is contained in the State Water Resources Planning Act.

Early Planning Efforts

Kansas water issues have been studied, characterized and documented since creation of the Kansas Water Commission in 1917. The commission was directed by the legislature to "work out a systematic general plan for the complete development of each watershed in the state". The commission produced a 400-page report, "*Surface waters of Kansas, 1895-1919*." In 1927, the commission was dissolved and replaced with the Division of Water Resources within the State Board of Agriculture (K.S.A. 74-506, et seq.). The Legislature again directed that "general plans for the complete development of each watershed in the state" be prepared. Funding was not provided and it was not until 1947 that the first report was officially prepared.

As many as 50 companies are thought to have made windmills in Kansas between 1880 and the mid-1950s.

During these years, the emphasis was on data gathering to characterize the water resources of the state. Many technical studies were prepared as officials recognized that to assess needs and identify priorities, baseline conditions of water resources across the state needed to be established.

1950s to 1960s

Disastrous widespread flooding in 1951 followed by severe droughts in the mid-1950s focused attention on weather extremes of the state. In 1954, funding for a comprehensive water resource study was allocated from the State Emergency Fund. The resulting document "*Water in Kansas*" was presented to the Governor and Legislature on January 2, 1955. A key recommendation was "to provide the necessary organizational structure, personnel and funds to prepare and maintain a state plan of water resources development." The Kansas Water Resources Board (KWRB) was established in 1955 to fulfill this recommendation. The KWRB determined that the 12 major river basins in the state would delineate hydrologic boundaries for subsequent resource inventories, problem identification and planning needs that were compiled between 1955 and 1963.

Brief History

OF KANSAS WATER PLANNING CONTINUED

The culmination of this work was the State Water Plan Act of 1963 which mandated the preparation of a state water plan by the KWRB in cooperation with other agencies. In 1965, the KWRB submitted a draft of proposed legislation which was enacted as the *Kansas Water Plan.*

Flood of 1951, Topeka Municipal Airport

During the 1960s, the KWRB prepared reports on special water districts, groundwater, water quality control needs, irrigation, water law, and water demands for industrial, municipal and rural domestic uses. Over the next decade, KWRB became an important partner with local and state stakeholders and the federal government in many water resources development projects. These included the construction of federal dams and reservoirs by the U.S. Army Corps of Engineers (USACE) and the Bureau of Reclamation (USBR), construction of watershed dams by the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) and development of rural water districts using financial assistance from the USDA Farmer's Home Administration. Much of this activity was federally driven and some state laws were developed to complement federal programs. Water resource development was in full swing during these decades.

1970s to 1980s

Continuing into the 1970s, the KWRB expanded into studies of mineral intrusion areas as well as placing increased emphasis on conservation and management in the *KWP*. By the 1970s, rising costs and public environmental concerns altered the water resources development landscape. The era of intense water resources development was coming to an end as the need for a more management-oriented approach to water resources was recognized. Drought again gripped much of Kansas in 1976 and there was increasing concern about rapid depletion of groundwater supplies in western Kansas. Recognizing this change in priority, the Governor's Task Force on Water Resources was created in 1977. The Task Force reinforced the importance of the *KWP* in achieving interagency coordination for water resource and policy planning. A proposed reorganization to consolidate the functions of the KWRB, the Kansas Department of Agriculture -Division of Water Resources (KDA-DWR) and the water related functions of the Division of Environment of KDHE was discussed but not recommended.

Siphon Irrigation, tubes were used to take water from a canal and distribute it through channels in the field.

Brief History

OF KANSAS WATER PLANNING CONTINUED

Consolidation continued to be evaluated however and during the 1981 legislative session the KWRB was replaced by the Kansas Water Office (KWO) and the KWA effective July 1, 1981. The KWO became the new coordination agency charged with development of a state plan addressing water development, conservation and management. Comprised of 13 appointed citizen members representing various water resources interests and 11 state agency representatives, duties of the KWA include:

- Consulting with and advising the Governor, Legislature and Director of the KWO on water management issues
- Reviewing plans of any state or local agency related to the water resources of the state
- Studying laws related to water resource management issues and recommending new or amendatory legislation
- Recommending coordination of water resource management activities
- Approving amendments to the *KWP*

Clinton Lake Construction

KWO staff began immediately to reformulate the *KWP* to reflect current responsibilities and policies, and to develop new programs and modify existing ones to meet new challenges. Throughout the early 1980s numerous public meetings were held as various drafts and revisions to the *KWP* were presented. The Kansas Legislature endorsed the comprehensive, continuous coordinated planning process used to develop the *KWP* that is still used today. It was during this time that citizen advisory groups or Basin Advisory Committees (BAC) were organized in each basin to ensure continued public involvement in the water planning process. Another significant accomplishment was establishment of the State Water Plan Fund (SWPF) which is dedicated to implementation of water related programs or projects identified in the *KWP*.

1990s

With the institutional structure of the planning process, coordination and water resource focus in place, the *KWP* was regularly updated; annual guidelines were provided to agencies and the KWA provided annual recommendations for SWPF expenditures. Efforts continued to ensure that the *KWP* was relevant for water resource planning for both policy and basin priorities in Kansas. Public input continued through the BACs and was enhanced with statewide public meetings on relevant issues.

Brief History

OF KANSAS WATER PLANNING CONTINUED

2000s

With a new century came a renewed evaluation of the water planning process. In 2002, an extensive review of water resource agencies was again undertaken. An enhanced coordination process was established, including a Natural Resources Subcabinet comprised of agency executives named by the Governor. The subcabinet met weekly through 2011 to discuss and coordinate common issues. While the authority establishing the Subcabinet was not renewed, agency personnel have continued to meet regularly, recognizing the benefit of enhanced communication and agency coordination.

Beginning in 2013, the Governor requested the development of a *50-year Long-Term Vision for the Future of Water Supply in Kansas*. A team comprised of the KWO, KDA and KWA conducted more than 600 public meetings, received input from more than 15,000 stakeholders, collected data and conducted research over a period of a year. As reflected in the mission statement, the overall purpose of the document was to "Provide Kansans with the framework, policy and tools, developed in concert with stakeholders, to manage, secure and protect a reliable, long-term statewide water supply while balancing conservation with economic growth." Since its publication in 2015, *The Vision* (as it was commonly called) provided guidance statewide for long-term management of water. Its initial focus was on ensuring adequate quantity, although it also reflected water quality concerns. The KWA and RACs, among others, referenced *The Vision* during the course of their program planning and budget recommendation activities.

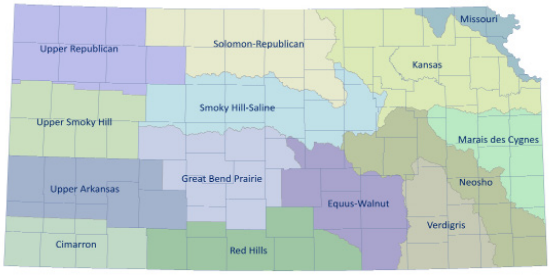
While *The Vision* served a useful purpose, its role was as an advisory document and it focused primarily on water supply, not quality. In contrast, the overarching water policy, planning and management document has remained the *KWP*, as mandated by statute. In the interest of clarity and strength of purpose and message, this 2021 version of the *KWP* has been developed to incorporate relevant aspects of *The Vision*, to create a single document to address current water needs, both quantity and quality, and to address future needs to ensure a long-term reliable safe supply of water for Kansas. The process of composing the *Guiding Principles* and the regional sections of this *KWP* involved careful review of pertinent sections of *The Vision* for inclusion into the *KWP* where appropriate.

> **"The writing is on the wall and if we don't act today, our future is bleak." At this rate, with no changes in the next 50 years, the Ogallala will be 70 percent depleted and our reservoirs will, on average, be 40 percent filled with sediment, with some already at this low level.** *- The Vision*

Brief History

OF KANSAS WATER PLANNING CONTINUED

One outcome of *The Vision* was the creation of RACs, groups of local stakeholders representing the varied local water-related interests. In December 2014, the KWA established 14 Regional Planning Areas, in conjunction with *The Vision*. The KWA approved committee membership for 14 RACs, one for each of the designated planning areas. Their charge was to identify and prioritize goals to address water needs in their respective areas and to develop regional action plans to meet those goals. These groups replaced the previous Basin Advisory Committees. The RACs meet regularly, each having the assistance of a KWO planner, to develop goals and action plans. The RACs also provide important input to the KWA for consideration in producing the KWA's annual budget recommendations to the Kansas Legislature. A key update in this version of the *KWP* is the inclusion of each RAC's goals and action plans.

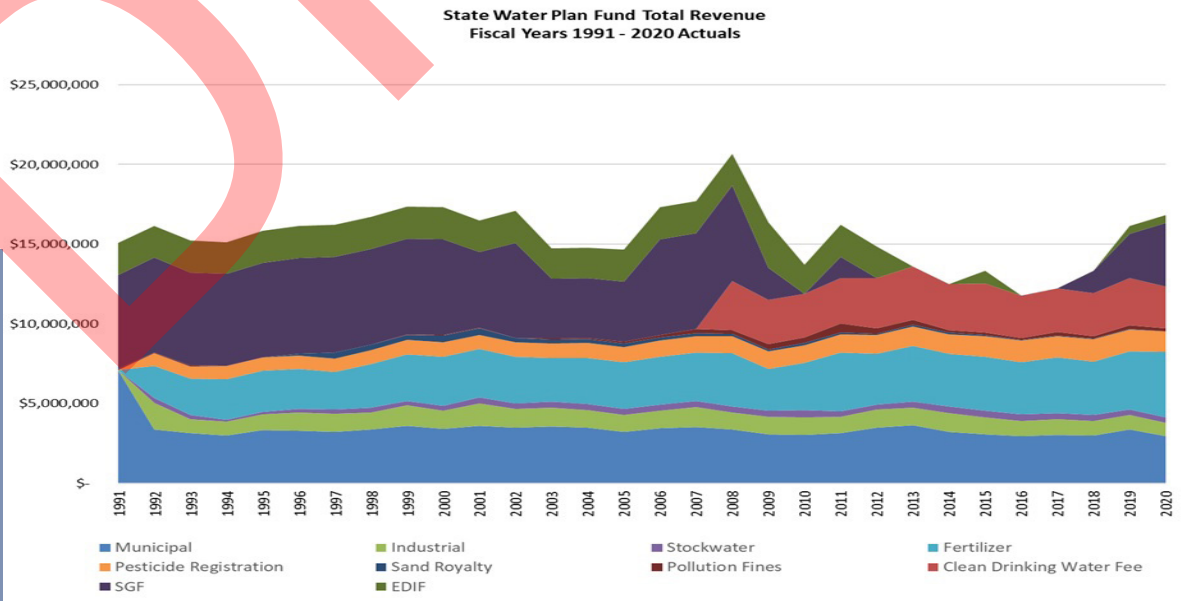


State Water Plan Fund

In 1989, the Kansas Legislature created the State Water Plan Fund (SWPF), a statutory fund specifically dedicated to implementing the *KWP*.

The SWPF, subject to appropriation acts by the Legislature, is to be used for the establishment and implementation of water-related projects or programs and related technical assistance as identified in the *KWP*. Funding from the SWPF may not be used to replace full-time equivalent positions or for recreational projects that do not meet the goals or objectives of the *KWP*.

Historically, the SWPF has generated around $17 to $20 million dollars annually. Revenue for the SWPF is generated from the following sources:



Brief History

OF KANSAS WATER PLANNING CONTINUED

The KWA, through the state water planning process, annually recommends to the Legislature and the Governor how the SWPF should be allocated, in accordance with the programs and priorities identified in the *KWP*. The KWO is charged with administering the SWPF payments. These payments from the SWPF are made by the KWO to the state agencies that implement the programs identified for funding through the budgeting process ending with the legislative appropriation actions. The agencies receiving typically receiving SWPF payments are the KDHE, the KWO and the Kansas Department of Agriculture's Division of Water Resources (KDA-DWR) and Division of Conservation (KDA-DOC). These agencies receive portions of the SWPF associated with the programs they respectively implement.

While the SWPF is a fund specifically dedicated by statute to implement the *KWP* (including $6 million to come from the SGF and $2 million to come from the EDIF), for several years the Legislature has consistently appropriated significantly less than those amounts. As of 2021, the cumulative deficit in the SWPF for the prior 13 years was approximately $80 million. The SWPF appropriation for the next fiscal year remains below the statutory mandate.


The Topeka Capital-Journal

Legislature adjourns record-long session

Dramatic arrival of senator for vote caps closing day

The KDA-DOC is the largest recipient and utilizes funds for the following programs: Water Resources Cost Share Program, Aid to Conservation Districts, Multipurpose Small Lakes Program, Nonpoint Source Program, Watershed Dam Construction, Water Quality Buffer Initiative, Conservation Reserve Enhancement Program (CREP), Water Supply Restoration Program and Riparian and Wetland Protection Program.

The KDHE uses the SWPF for Contamination Remediation, Total Maximum Daily Load (TMDL) Initiatives, WRAPS, and the Nonpoint Source Program. The Kansas Department of Wildlife and Parks (KDWP) uses funds to support stream biological monitoring among other programs. The KDA-DWR uses SWPF to address Interstate Water Issues and Subbasin Water Resources Management. The Kansas Geological Survey (KGS) utilizes funds for Assessment of the Ogallala-High Plains Aquifer.

The KWO uses funds for Assessment and Evaluation, Geographical Information System (GIS) Database Development, Reservoir Storage Operation and Maintenance, Technical Assistance to Water Users, Water Resource Education, Weather Stations, Weather Modification.

Use of the funds by the recipients may vary from year to year. However the above uses are typical of SWPF expenditures in the timeframe of this plan.

Management of

WATER IN KANSAS

State policy regarding water management is governed in large part by the Water Appropriation Act, which asserts that water in Kansas is dedicated to the use of the people of the state, with the State charged to manage that resource. As such, surface and groundwater can be appropriated for beneficial use of that water, without waste, if that use does not cause impairment of an existing, more senior water right and does not unreasonably affect the public interest. A water right does not constitute ownership of such water, only the right to use it for beneficial purposes. The date of a water right, and not the type of use, determines the priority to divert and use water at any time when supply is not sufficient to satisfy all water rights.

Water stored in federal reservoirs comes under another major management policy that is found in the State Water Plan Storage Act. KWO has authority to claim a reservation right to collect and store water in space the state owns in 13 federal reservoirs. KWO then contracts with municipal and industrial customers for a long-term water supply.

Kansas Water Resources Planning Act

The Kansas Water Resources Planning Act provides statutory authority for addressing water management in the *KWP*. This Act establishes long-range goals for the management, conservation and development of the waters of the state, including:

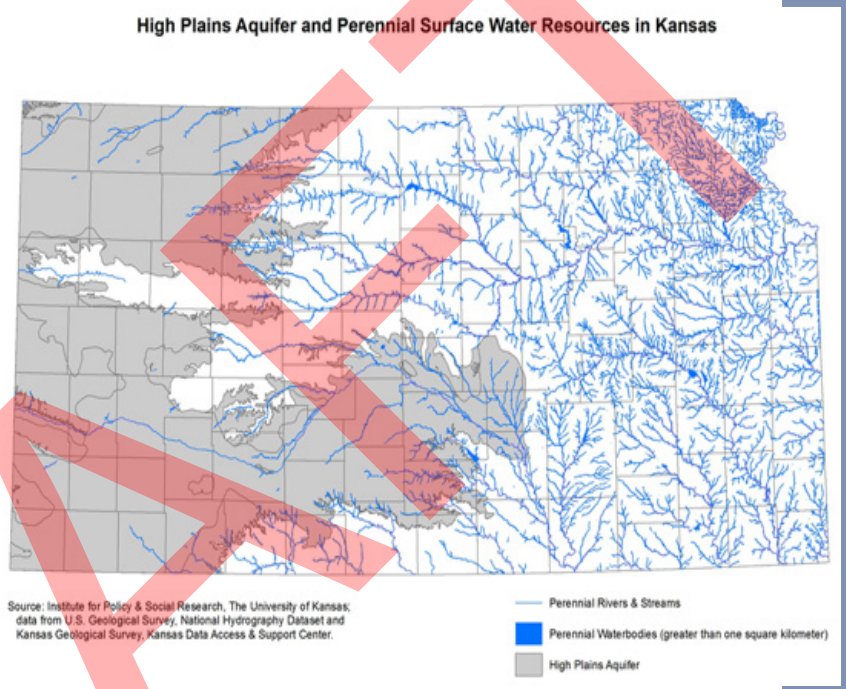
- the development, to meet the anticipated future needs of the people of the state, of sufficient supplies of water for beneficial purposes;
- the reduction of damaging floods and of losses resulting from floods;
- the protection and improvement of the quality of the water supplies of the state;
- the sound management, both public and private, of the atmospheric, surface and groundwater supplies of the state;
- the prevention of the waste of the water supplies of the state;
- the prevention of pollution of the water supplies of the state;
- the efficient, economic distribution of the water supplies of the state;
- the sound coordination of the development of the water resources of the state with the development of the other resources of the state; and
- the protection of the public interest through the conservation of the water resources of the state in a technologically and economically feasible manner.

Management of

WATER IN KANSAS CONTINUED

Management of Kansas groundwater and surface water fits into six categories:

- River-reservoir management;
- Stream reaches with established Minimum Desirable Streamflow (MDS)
- Streams outside of MDS protected areas
- The Ogallala-High Plains Aquifer;
- Groundwater outside of the Ogallala-High Plains Aquifer
- Interstate water management



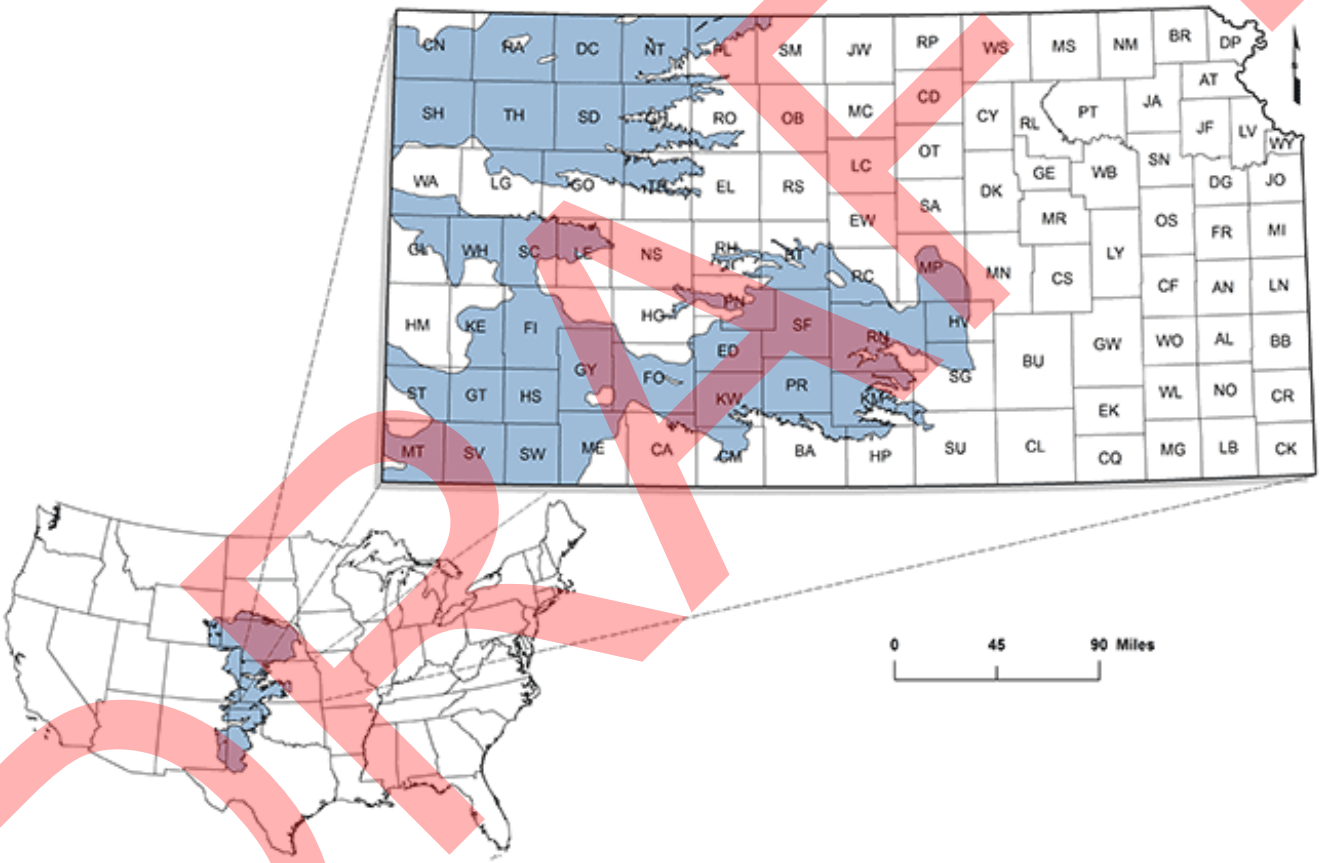
In addition to state laws and policies for water management, other significant management entities include Groundwater Management Districts (GMDs), public water suppliers, conservation districts, watershed districts and individuals who make wise water use decisions.

Overall, Kansas water resources present daunting challenges as to supply availability and safe quality. Effective short and long-term management, including significant reduction in groundwater use and practices to improve surface water contamination as well as address sedimentation are crucial to assure an adequate supply of safe water for the future. Potential for development of new water resources is very limited.

Guiding Principles

There are five guiding principles and priorities when it comes to implementing best practices to meet our state's current and future water needs.

Conserve & Extend the High Plains Aquifer



Conserve & Extend the High Plains Aquifer

Background

The High Plains Aquifer (HPA) is the largest, most economically important groundwater source in Kansas. It underlies western and south central Kansas and is composed of several hydraulically connected aquifers[1]. The Ogallala, which is the largest of these, occurs in the western third of Kansas, an area that is semi-arid with limited surface water. The eastern extension of the HPA is composed of younger sediments that make up the Great Bend Prairie and Equus Beds aquifers. Lying above the Ogallala Formation are Pleistocene and younger stream valley deposits that bear water; where these are connected to the underlying aquifer, they are considered part of the HPA.

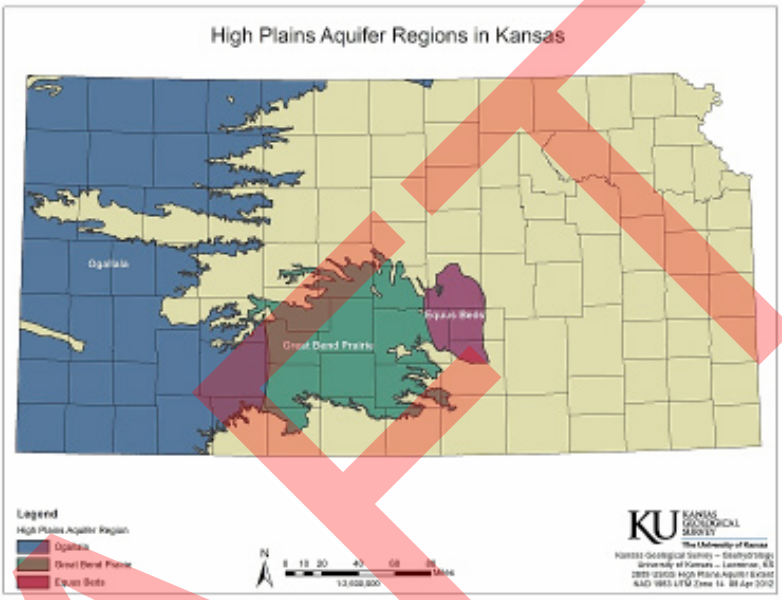


Figure 1. Map of the High Plains Aquifer in Kansas[1]

In western and south central Kansas, groundwater has historically been the most reliable source of large volumes of water for irrigation, stock watering, municipal, and industrial use. To date, there have been over 50,000 water rights approved in all of Kansas with a majority of those approved for groundwater use in the HPA (figure 2)[1].

The total average reported irrigated acres for 2010 to 2020 in the HPA is estimated to have been around 2.7 million acres[22]. Corn has been the most commonly grown crop in the HPA region in recent years. Given that corn may need up to two feet of water per acre per year, the HPA region may require up to 5.58 million acre-feet of water per year to grow corn and other crops. Although this total includes contribution from precipitation and some surface water, groundwater from the HPA has and will continue to be a very significant source of supply for crop production throughout the state.

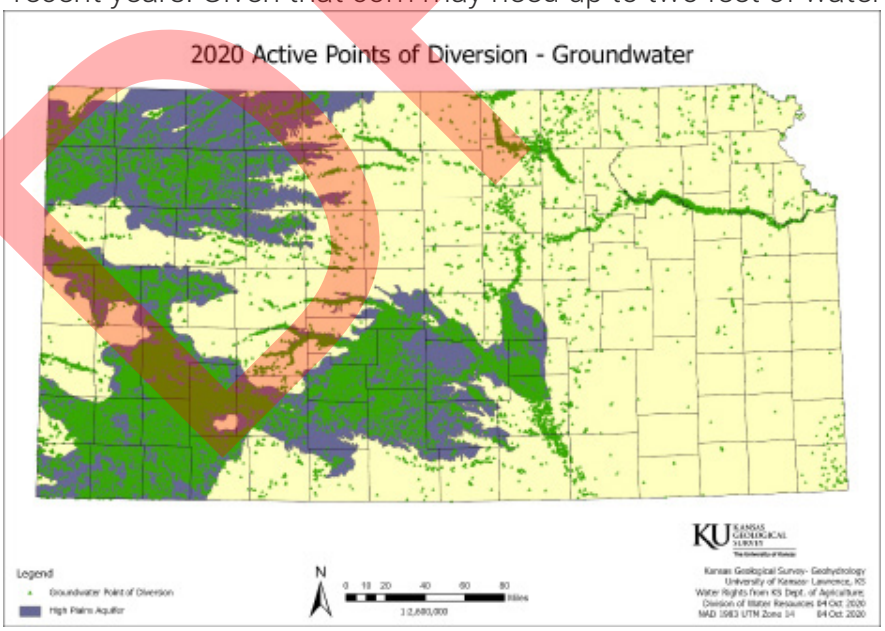


Figure 2. 2020 active groundwater points of diversion in Kansas[1]

Conserve & Extend the High Plains Aquifer

When pumping exceeds the amount of water that recharges an aquifer, groundwater declines occur (Figure 3)[1]. In the HPA, water levels are measured by the Kansas Geological Survey (KGS) and the Division of Water Resources, Kansas Department of Agriculture (KDA-DWR) each winter in approximately 1400 wells, primarily irrigation wells[25].

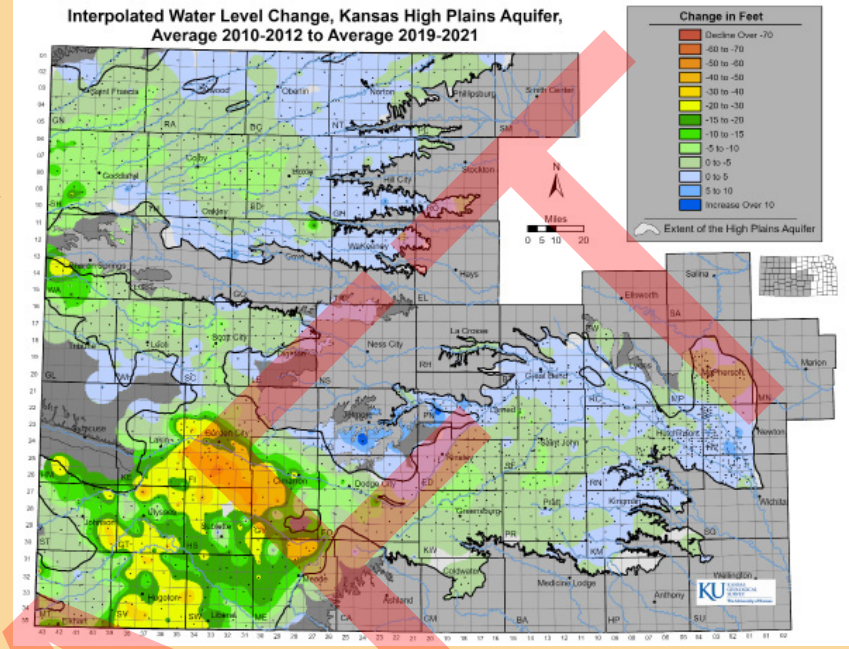


Figure 3. High Plains Aquifer region in Kansas showing the total water-level changes from 2010-2012 to 2019-2021[1]

Kansas has more than 35,000 wells with active water rights; over 27,000 of these wells overlie the HPA, with approximately 87% of them used for irrigation[25]. Groundwater levels have appreciably declined over the Ogallala region of the aquifer since the onset of substantial irrigation development (1940s to 1950s in most areas). The water levels have dropped so much in some areas of the Ogallala region that less than 40% of the original saturated thickness is left[25].

According to the KGS, the average declines in groundwater levels in the Ogallala region since predevelopment are 25 ft, 56 ft, and 103 ft for Groundwater Management Districts (GMDs) 4, 1, and 3, respectively. The average aquifer thicknesses remaining in GMDs 4, 1, and 3 are 69 ft, 31 ft, and 151 ft, respectively[25].

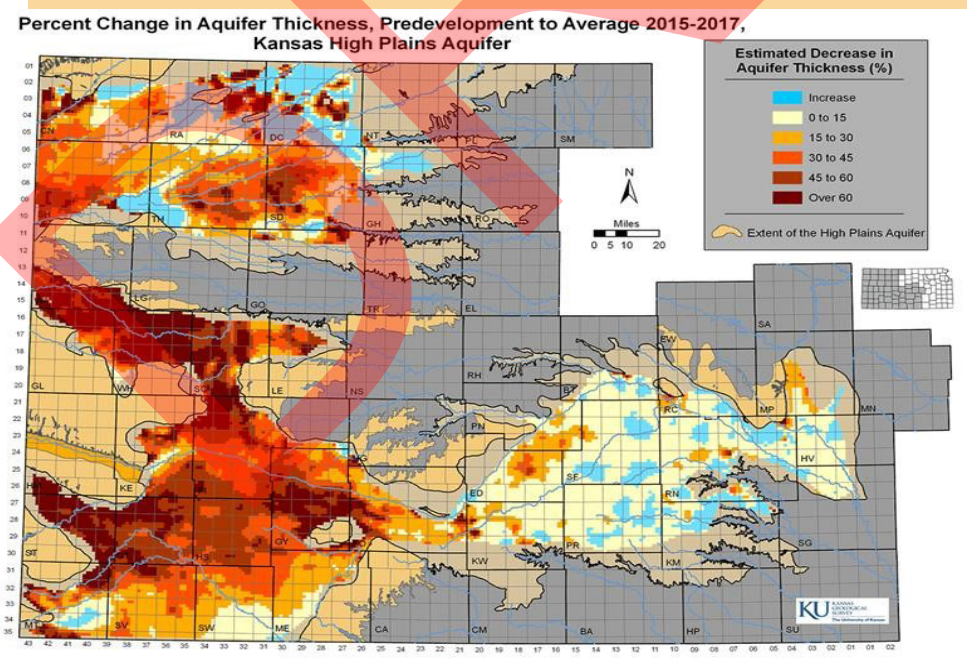


Figure 4. High Plains Aquifer region in Kansas showing the various reductions in availability of water from the time before large scale irrigation to the period 2015-2017. The darker the color, the larger the reduction in saturated thickness (water availability). [1]

During the period of 1996 to 2016, the trends in the average annual water-level decline and the cumulative water-level declines for the three GMDs in the Ogallala region have been the following:

- GMD4: steady decline rate; average -0.60 ft/yr; cumulative -12.6 ft
- GMD1: steady decline rate: average -0.50 ft/yr; cumulative -10.4 ft
- GMD3: increasing rate of decline; average -1.69 ft/yr; cumulative -35.4 ft. (Id.)

Conserve & Extend the High Plains Aquifer

The GMDs located over the Equus Beds and Great Bend Prairie segments of the High Plains Aquifer in south-central Kansas (GMD 2 and GMD 5, respectively) manage the aquifer based on safe yield policies, where the amount of water allowed for appropriation under water rights must be equal to or less than the amount of recharge, depending on the impact on water quality and minimum streamflows[26].

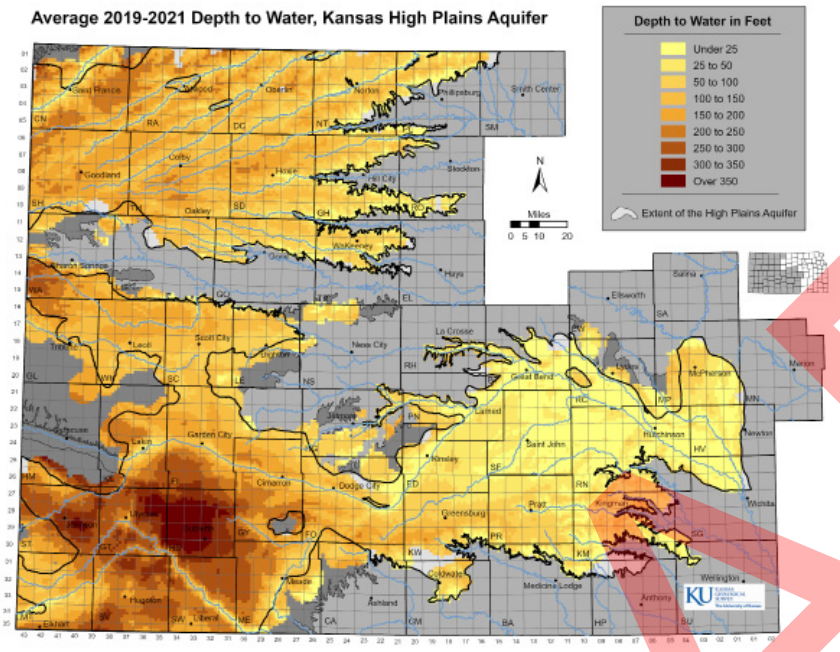


Figure 5. High Plains Aquifer region in Kanas showing the average depth to water for 2019-2021[1]

The GMDs located over the Equus Beds and Great Bend Prairie segments of the High Plains Aquifer in south-central Kansas (GMD 2 and GMD 5, respectively) manage the aquifer based on safe yield policies, where the amount of water allowed for appropriation under water rights must be equal to or less than the amount of recharge, depending on the impact on water quality and minimum streamflows.

The GMDs overlying the Ogallala portion of the HPA do not impose this kind of safe-yield limitation. To do so would require substantial decreases in the amount of water used. In studies to determine the amount of reduction in use needed to hold at the current rate of decline, much less achieve safe yield, would require 27% reduction in GMD4, 31% in GMD1 and 33% in GMD3. These reductions are averages for each district; greater reductions would be needed in the areas of more intensive water use. In addition, the KGS notes that these values are considered to be short-term, applicable to only 10 to 20 years, with more reductions required beyond then[25]. These levels of reduction in water use would affect all users dependent on the Ogallala Aquifer, calling for a shift in behaviors for towns, farms, feedlots and industries, among others. Because agricultural water use (irrigation and stockwatering) comprises most of the water use from the Ogallala Aquifer, the widespread adoption of meaningful, and feasible, water-saving practices is essential. The climatic changes underway intensify this need all the more.

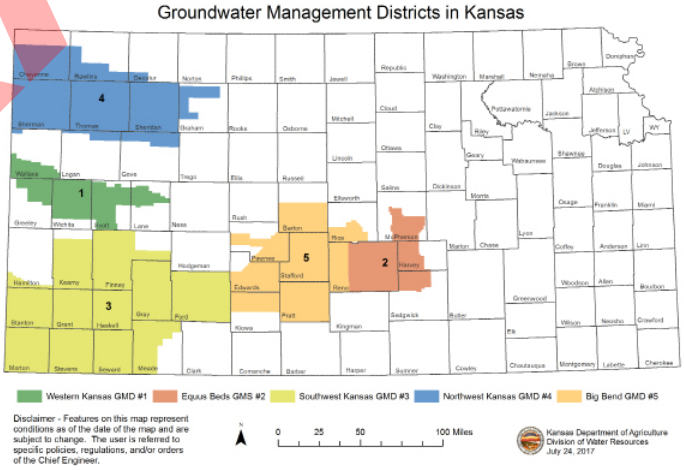


Figure 6. Groundwater Districts in Kansas[2]

The Ogallala Aquifer supports an extensive agricultural complex, including irrigated crops, a large cattle and dairy industry and biofuel plants. Each of these economic drivers requires water, as does each municipality's population and the services they provide for themselves and the surrounding regions. The continued existence of these economic activities, and the communities they support, relies on protecting and preserving the Ogallala Aquifer.

Conserve & Extend the High Plains Aquifer

Management Approach

The HPA is essential to the economy and environment, as well as to the well-being of our citizenry. A variety of local, state and federal entities are charged with the duty to help implement water conservation efforts within the region. These entities assist producers through cost-share and incentives programs, conservation and environmental programs, and education and outreach efforts. The entities responsible for providing these services include local groundwater management districts, KDA-DWR, Kansas Water Office (KWO), Kansas Department of Agriculture's Division of Conservation (KDA-DOC), Kansas Department of Health and Environment (KDHE), Kansas Geological Survey (KGS). K-State Research and Extension, United States Department of Agriculture's Natural Resources Conservation Service (USDA-NRCS), United States Department of Agriculture's Farm Services Agency (USDA_FSA) and local conservation districts.

In addition to these voluntary financial assistance programs, regulatory mechanisms exist to ensure the lawful use of water and to secure reductions in use when necessary to preserve the availability (and sometimes the quality) of a given water supply. The KDA-DWR administers the Kansas Water Appropriation Act, K.S.A. 82a-701, et seq., which, among its provisions establishes a "first in time, first in right" doctrine for priority among water rights during times of shortage, regardless of type of use. The KDA-DWR is also mandated by law to administer this rule between water right owners when an impairment complaint is lodged. The KDA-DWR has also required the installation of water flow meters on diversion works for water rights across the state, which has allowed data-driven management decisions and supported research empowering effective conservation strategies.

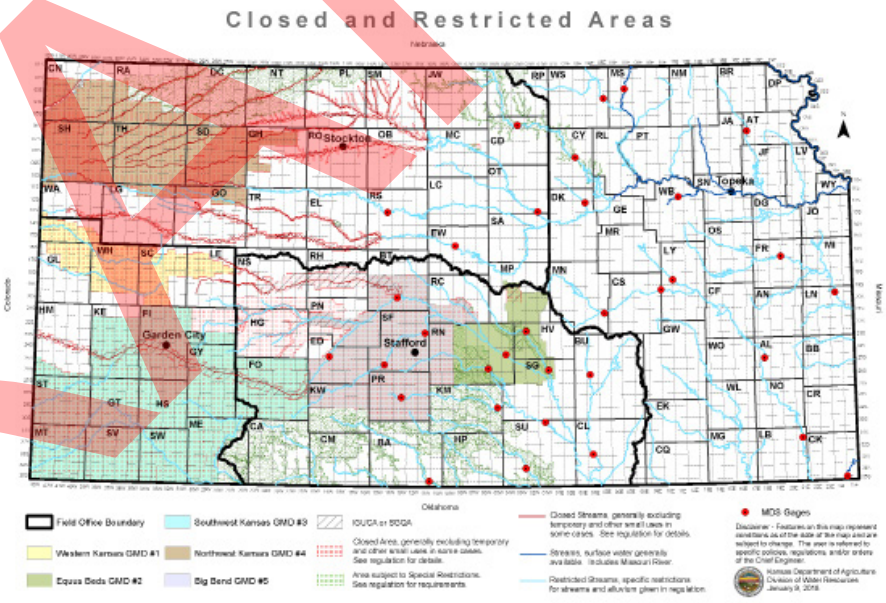


Figure 7. Closed and restricted areas in Kansas to new water appropriations and the Groundwater Management Districts[2]

Kansas water law also allows the KDA-DWR to establish Intensive Groundwater Use Control Areas (IGUCAs) in specifically-identified areas where a declining groundwater supply meets certain critical criteria. There are currently eight IGUCAs, the most recent having been established in 1992 (Walnut Creek IGUCA).

Conserve & Extend the High Plains Aquifer

Regional Conservation Efforts

Cost-Share & Incentives

- Water Transition Assistance Program (WTAP): A program offered by KDA-DOC that pays water right owners in targeted areas that are closed to new water rights appropriations, to permanently dismiss all or a portion of their active water right(s)[3].
- Conservation Reserve Enhancement Program (CREP) – Kansas Upper Arkansas River: USDA-FSA offers a program to producers in the Upper Arkansas River counties in Kansas that pays irrigators to permanently transition acreage out of irrigated production and into grasslands or other conservation practices[4].
- Irrigation Technology Initiative: KDA-DOC offers cost-share funds to assist landowners with irrigation efficiency technology. This initiative is designed to promote irrigation efficiency and water conservation by providing cost-share assistance to landowners for automated soil moisture probes[6].
- Environmental Quality Incentives Program (EQIP): USDA-NRCS program that provides financial and technical assistance to producers to implement water conservation practices[7].

Conservation & Environment

- Regional Advisory Commitee (RAC): Regional planning committees were established by the Kansas Water Authority (KWA) to focus on priority goals for the region and develop an action plan to help address water concerns and other issues within their region[8].
- Local Enhanced Management Area (LEMA): A program that allows a GMD to take action to conserve water usage in portions or all of their district. If recommended by the GMD and ordered by the Chief Engineer, the conservation measures temporarily override the appropriated water rights in the region. A LEMA has the potential to be highly effective due to local commitments and changes in farming practices[9].
- Water Conservation Areas (WCA): A program offered by KDA-DWR that allows individual farms the flexibility of their water right(s) on their land for a limited time period, as long as they officially agree to reduce water use during that period[10].
-

Education & Outreach

- K-State Research and Extension (KSRE): Offers information and guidance through their Mobile Irrigation Lab, KanSched, and Crop Water Allocator that help producers make the most efficient, economic use of their crop water. KSRE is looking into more water-tolerant crops and experimenting with multiple crop varieties in order to learn what works best in different climates and if any new crop variety can be obtained for further water conservation[11].
- Water Technology Farms (Water Tech Farms): KWO collaborates with producers and other partners to help demonstrate and educate other producers on the benefits of utilizing new irrigation technologies, practices, and services[12].
- HPA Index Well Network: A KGS program that is focused on developing an improved understanding of aquifer dynamics at scales appropriate for management. The program has a monitoring network of 25+ wells with much of the data being presented in real-time on the KGS website to allow Kansans to understand conditions in the HPA in their area. An additional goal is to directly examine water resource issues and areas of particular interest to the GMDs and KDA-DWR[13].

Conserve & Extend the High Plains Aquifer

Measuring Success

Much of the Ogallala portion of the HPA has been heavily depleted since predevelopment. Projections in some areas show no more than 20 years of water remaining if pumping continues at current rates. Other areas in west central Kansas have already reached the point of no return where many acres of once irrigated land have now been converted to dryland crops or cattle grazing. Some small areas in southwestern Kansas show more than 100 years of water remaining, but this is far from the rule in most of the HPA in western Kansas.

Although the continued life of the Ogallala Aquifer and the livelihoods of those rely on it absolutely depends on the significant reductions in pumping, too many producers still use the full authorized quantities under their water rights. And because the vast majority of Ogallala water use is irrigation, it is imperative that irrigation use be reduced. This need not mean economic disaster, however. Recent studies have shown that the same amount of yield or more can be accomplished with less water if new farming practices are introduced.

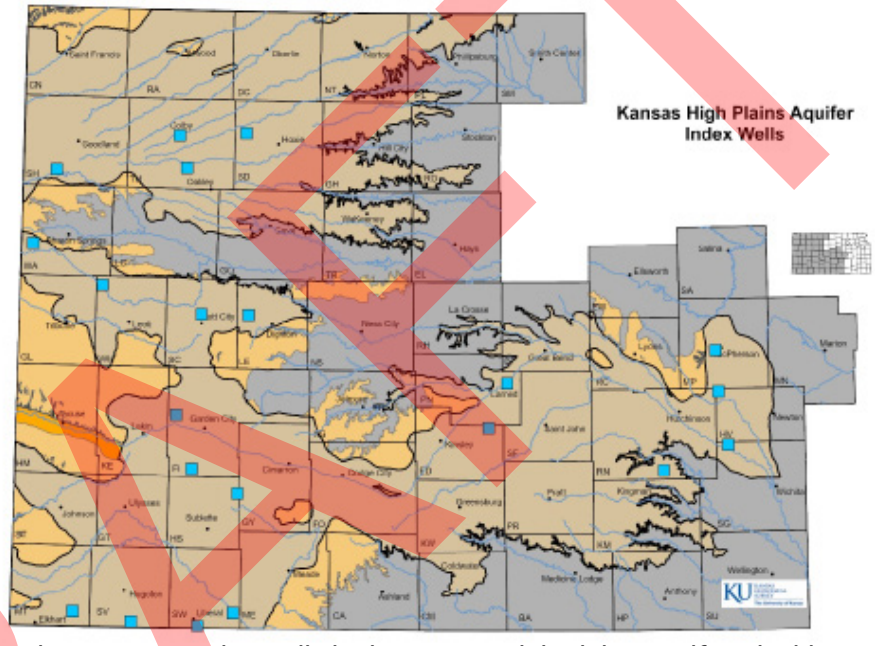


Figure 8. KGS Index Wells in the Kansas High Plains Aquifer. The blue boxes show the locations of each well[13]

The KGS currently has over 25 "Index Wells" that have been installed in the HPA region and are recording water levels every hour (Figure 8)[13]. The first three sites, located in Haskell (GMD3), Scott (GMD1), and southern Thomas (GMD4) counties were drilled in 2007[13]. Figures 9, 10, and 11 show the seasonal changes and trends in the water table for these three wells since they were installed.

As can be seen in the graphs on this page and the next, water levels can vary substantially in a single year in response to irrigation-based pumping during the growing season and climatic conditions. In recent years, the overall rate of decline has improved as much of the HPA region has seen above average precipitation rates resulting in lesser pumping demands. When favorable and timely rains do not occur, groundwater withdrawals increase and water levels typically fall.

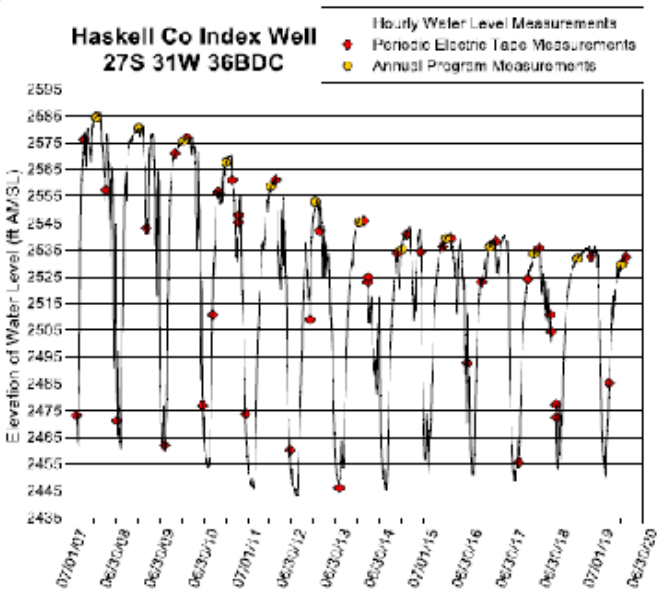


Figure 9. Haskell County index well hydrograph. The reduction in the rate of decline beginning in 2015 was due to a temporary curtailment of nearby pumping; the bottom of the aquifer is at an elevation of 2,405 ft[13]

Conserve & Extend the High Plains Aquifer

In addition to the index well program, the KGS and KDA-DWR measure roughly 1,400 wells across the HPA each winter to monitor regional changes in the groundwater supply. The data collected can be accessed through the KGS WIZARD Water Well Levels Database available on the KGS website[24].

Precipitation-based aquifer recharge is highly variable across Kansas. It can be influenced by a variety of factors including depth to water, intensity of water inflow, total precipitation and rate, temperatures, soil types, and regular land use. Research is also being conducted to explore if there is a potential recharge source from the 20,000 plus playa lakes[14] in central and western Kansas. While infiltration of water at the land surface is helpful, it may take years, decades, or even longer, for a drop of water to travel from the surface to the water table, depending on the location, depth, and material in the subsurface. The best method to keep groundwater available longer is to pump less.

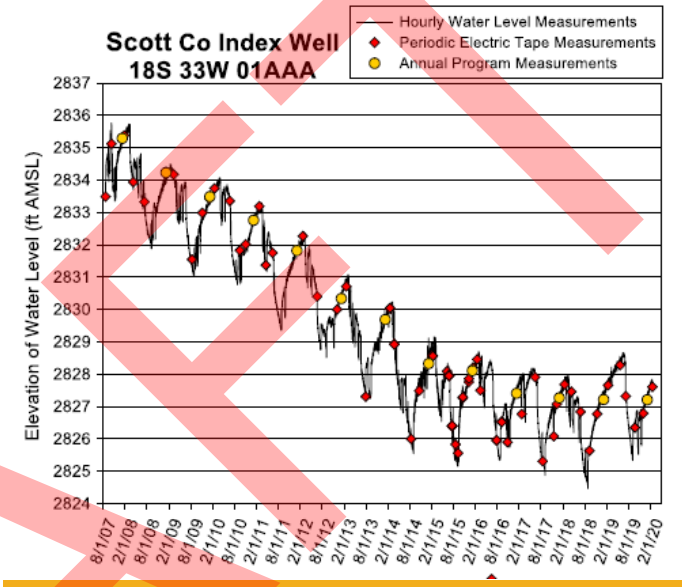


Figure 10. Scott County index well hydrograph. The increase in water level from 2018 to 2019 was due to a lengthy recovery period with virtually no pumping; the bottom of the aquifer is at an elevation of 2,744 ft[13]

Groundwater rights in Kansas allow for specific maximum annual authorized quantities can be pumped year to year. Water right holders have incentives to individually use all they are entitled to, to reap short term benefits, causing water declines to be spread across many users. However, some users are successfully managing the common aquifer with locally-developed plans that have clearly defined goals, rules and regulatory oversight. An example of this is the LEMA program[9].

Sheridan County 6 (SD-6) was the first approved LEMA in Kansas. After initially meeting a water conservation goal of 20%, they almost doubled it, reducing withdrawals by 39%. LEMA participants renewed the program for another 5-year cycle in 2018[15]. GMD4 has since developed another LEMA, which regulates nearly their entire district[15]. The success of GMD4's execution of LEMAs has motivated other GMDs to look towards implementing them within their regions as well, with GMD1 initiating a new one in Wichita County in 2021[16].

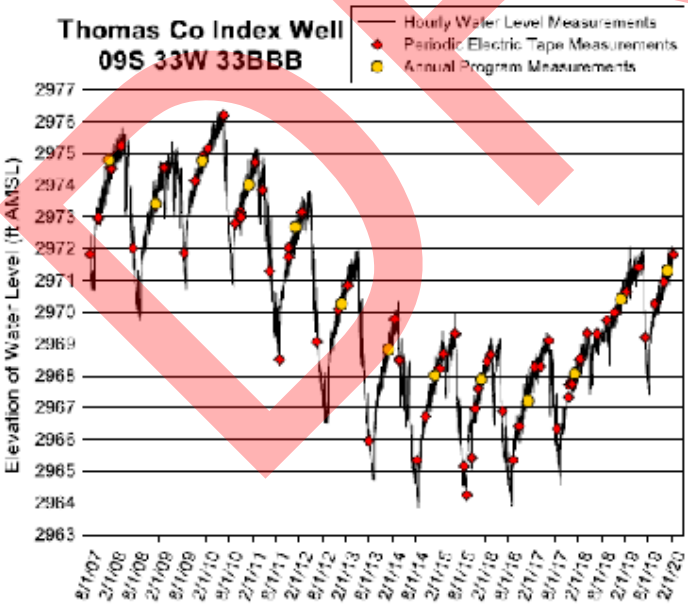


Figure 11. Thomas County index well hydrograph. The water-level increase in 2018 was due to a late-spring hailstorm that destroyed the crops in the immediate vicinity and ended the 2018 pumping season; the bottom of the aquifer is at an elevation of 2,904 ft[13]

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In April 2015, a new law established WCAs[10]. WCAs are a simple, streamlined, and flexible tool that allows any water right owner or group of owners the opportunity to develop a management plan to reduce withdrawals in an effort to extend the usable life of the aquifer in their area. As of 2021, KDA-DWR has approved 53 WCA plans in the HPA region with a total of over 86,000 irrigated acres.

Water Tech Farms continue to showcase the latest in irrigation technology, field-scale research, and water conservation efforts[12]. The farms are public-private partnerships that began in 2016 and continue to demonstrate producers can reduce water use and input costs while increasing overall profitability. This program is for the demonstration of technologies, such as:

- soil moisture probes.
- mobile drip irrigation (MDI).
- sub-surface drip irrigation (SDI).
- more efficient nozzle packages
- variable rate pivot systems, observational index wells.
- farm weather stations.
- direct crop sensing probes.
- dairy ice sweepers and water reuse systems.
- services that include aerial imagery, soil sampling and mapping.
- soil health analysis.
- water tracking.
- cover crops.
- no-till farming practices.

Northwest Kansas Technical College Water Technology Farm

With growing interest each year, more and more producers are realizing the impact that water-smart technology can have on their operations and the water-saving benefits for future generations.

Recent studies show that by using less water and introducing new farming practices, the same amount of yield or more can be produced[27]. Crop varieties are also being introduced that use less water. By encouraging producers in the region to consider adopting new tools and practices, the concept of "less water use with a greater economic return" is being realized. These new water-saving and profit-enhancing practices have generated innovative partnerships between producers, private entities and regulators. In improving soil health, these practices help the soil retain water, enhancing drought and flood resiliency and boosting water quality. Of particular importance, as climate change impacts our world, is the fact that soil health practices sequester carbon into the soil at a time when reducing carbon emissions is critical to our planet. Corporations are increasingly seeking to partner with, and financially support, producers who implement soil health practices. In so doing, the corporations benefit by reducing their carbon emissions, obtaining carbon credits, meeting consumer demand for more climate-friendly processes, and/or qualifying for sustainability investment ratings[28].

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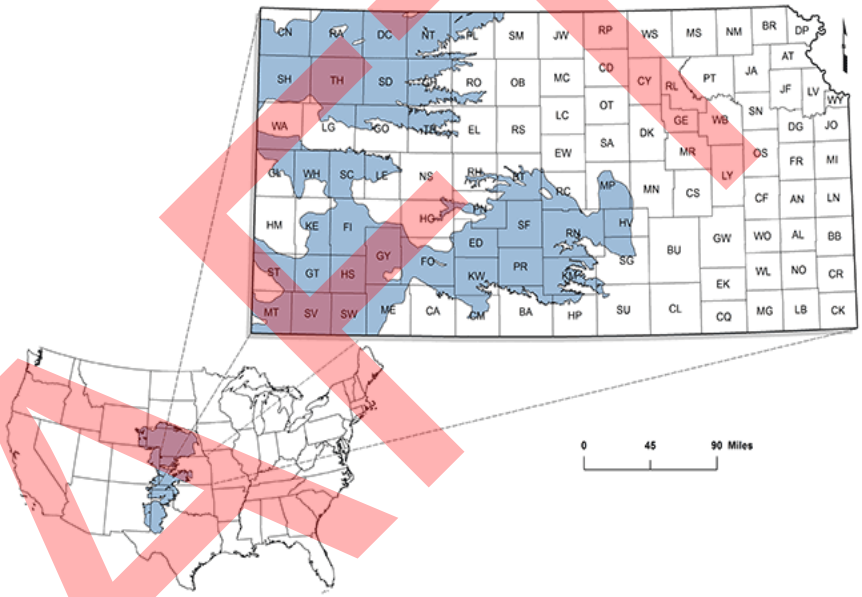
For example, General Mills has partnered with KDHE, the Ecosystem Services Market Consortium and the Cheney Lake Watershed Inc., to implement new technologies and management strategies with 24 farmers in five Kansas counties to improve soil health, reduce water use and nutrient runoff, while increasing yields. In addition, Truterra, the sustainability business and subsidiary of Land O'Lakes, has launched TruCarbon, a new carbon storage program to help farmers generate and sell carbon credits to private-sector buyers, maximizing the value and return for farmers with premium carbon credit value[30].



Further efforts that have taken place in the HPA region are with the Ogallala Water Coordinated Agriculture Project (OWCAP), a project funded by the United States Department of Agriculture National Institute of Food and Agriculture (USDA-NIFA) to provide multidisciplinary research and outreach focused on addressing issues related to groundwater declines and long-term agricultural sustainability in the High Plains region.[17]. The OWCAP team's research aims to help producers and other decision-makers in the region to sustain productive and profitable agriculture and to advance the knowledge needed to mitigate risks related to the aquifer's decline.[18]

In 2018, OWCAP and the Kansas Water Office hosted the first Ogallala Aquifer Summit which for the first time ever brought all Ogallala state together to discuss this vital resource. During the Summit attendees participated in interactive workshop sessions, panels Q&A periods, and heard from the featured Kansas Water Technology Farm [19] producers. A report summarized the ideas and input shared and identifies 'next steps' needed to continue the momentum generated at the Summit for cross-state relationship building and collaboration [19,20]

Another Summit took place in 2021 that was hosted virtually. The even was designed to build on and expand beyond the information shared and activities catalyzed by the inaugural 2018 summit. It aimed to increase networking and collaboration among the region's agricultural water management and sustaining the vitality of the High Plains region communities; and identify common vision, practices and opportunities applicable across state lines to benefit the aquifer and regions. More than 200 individuals participated in the summit including, producers, water district and city managers, technology and commodity group representatives, state and federal agency staff, university/extension staff, students and others. Keynote speakers and panelists served as springboards for thought -provoking and action-oriented discussions among participants [21] Helping to educate and change the mindset of Kansans in the HPA region is crucial for helping to conserve water.

Another outcome of the 2021 Ogallala Summit was the increased attention to the impacts of direct and indirect financial incentives for irrigators to use more groundwater than may be necessary for either profitability or productivity. Banking, insurance and property valuation influences can all encourage and reward the unnecessary use of groundwater. For example,

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higher water use can boost property values, which, in turn, provide more highly-valued collateral for more favorable bank loans.

Federal crop insurance programs may create an incentive to use water unnecessarily simply to get crop a started without the expectation of harvest, because the anticipated crop failure will result in a financially rewarding insurance payment. Such unintended consequences seem to be the result of policies that began in pro-development times, but continue to exist now that aquifer depletion is reaching crisis levels. A successful approach to reducing agricultural groundwater use, while retaining profitability, must involve updating these and other financial forces so that they encourage and reward preservation of aquifer waters.

Potential promise involves the impact on playa lakes on aquifer recharge. Playa lakes are natural shallow depressions that hold water from rainfall and runoff. According to the KGS, when playa lakes are full, they can provide recharge for underlying aquifers, as well as providing habitat for plants and animals. Western Kansas is home to more than 22,000 playas, but 80 percent of these have been plowed and planted over[29]. The KGS, in collaboration with the University of Waterloo, Kansas Biological Survey and the University of Minnesota-Mankato, are undergoing a study of the effect farming has on the ability of playas to recharge the aquifer.

Recommended Actions and Strategies - Conserve & Extend the HPA

Throughout the course of a calendar year, the KWA and RACs meet regularly to address resource concerns and future agendas. Starting in the fall of 2019, the KWO held regional meetings with local stakeholders to discuss their concerns, as well as recommendations on steps to resolve such issues. Based on applicable science, research and experience, the following actions and strategies are recommended to help conserve and extend the HPA in Kansas.

Policy or Program Recommendations

- Support soil health/carbon sequestration practices and partnerships.
- Increase incentives for water conservation programs.
- Continue support of the KGS Index Well Program.
- Provide more support to KDA-DWR for Compliance and Enforcement.
- Provide greater support for promotion, development, and management of LEMAs and WCAs.
- Ensure appropriate irrigation efficiency technology and irrigation management practices are eligible under existing or new state and federal financial assistance programs.
- Ensure crop insurance, banking and property valuation policies do not discourage water conservation and/or use of alternative, specialty and cover crops.

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Implementation Actions

- Continue to share pertinent HPA information.
- Develop a curriculum to be taught in schools explaining the past, present, and future of the HPA and related issues.
- Continue to bring the eight Ogallala states together to work on collaborative projects.
- Pursue opportunities to facilitate recycling and reuse of stockwater and other sources.
- Collaborate with crop consultants and other agricultural advisors to support farmers interested in water conservation and less water-intensive crop production.

Data, Research, and Studies

- Continue evaluation of emerging innovations on Water Tech Farms in collaboration with KSU and other partners.
- Expand research on drought tolerant and low-water crops to determine suitability for area.
- Expand research on optimum plant development stages to determine most efficient irrigation water application.
- Provide the public with reports that include studies demonstrating the benefits of pumping less water.
- Evaluate and identify most efficient system technologies for use by Kansas irrigators.
- Evaluate and identify ways to create new and strengthen existing markets for less water-intensive crops.
-

Funding and Resource Needs

- Fully fund the KWP.
- Coordinate with the Kansas Department of Commerce and the Marketing Division of the KDA to consider incentives to recruit businesses and focus economic development on businesses that value water conservation, use water-efficient technologies, and reduce the removal of water from the state.
- Encourage value-added processing within Kansas by providing financial or water right credit incentives to dairies and feedlots.

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Secure, Protect and Restore Kansas Reservoirs

Secure, Protect and Restore Kansas Reservoirs

Background

Surface water reservoirs serve to protect the public interest and facilitate multiple diverse beneficial uses within the State of Kansas. The future of Kansas reservoirs will impact water supply for all water user groups including agricultural, domestic, industrial, municipal, and recreational water user groups.

Over two-thirds of the state's population are served from municipal water diversions downstream of reservoirs. They are dependent on Kansas reservoirs (figure 1) maintaining streamflow for diversions, maintaining sufficient water quality for human uses, and providing drought resiliency. For many rural communities, the water supply supported by reservoir releases is the only source of water through periods of prolonged drought. Many rural communities and areas in the eastern half of the state receive water supply from rural water districts that are supplied from reservoirs and can distribute costs. Loss of reservoir water supply will inhibit rural revitalization efforts and be a regressive expense burden for lower income Kansans, as water suppliers incur elevated costs for water sourcing.

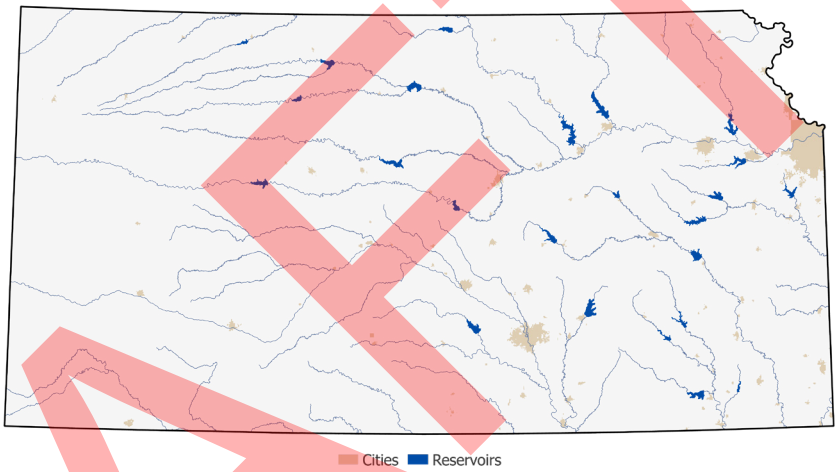

Figure 1. Reservoir and city locations within Kansas

Reservoirs support the water supply needs of a substantial amount of industry and commerce within the state, with a large amount of the state's industrial production being supplied by municipalities, rural water districts, or direct intakes of surface water. Reservoirs supply water to electrical generating facilities, aeronautical production, refinery operations, cement production, and a growing amount of irrigated agricultural acres, all of which require reliable quantity and quality of water supply to continue providing economic benefits to the state.

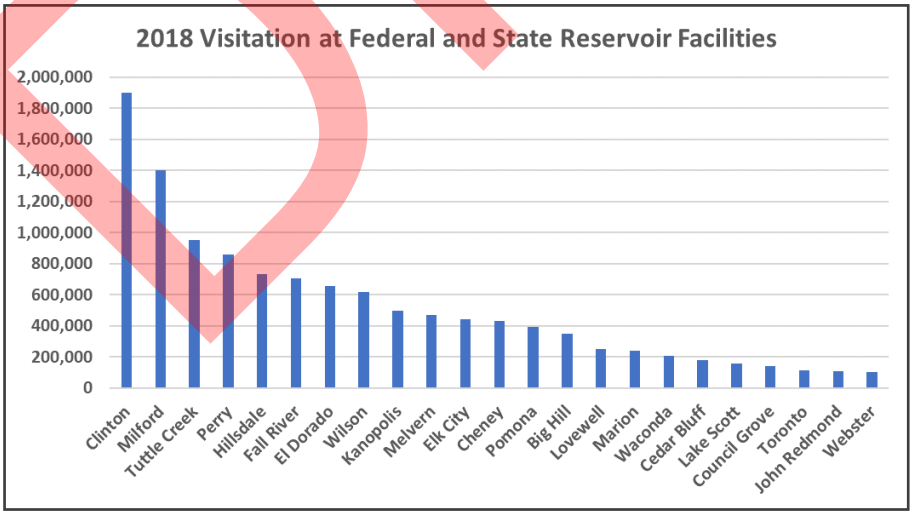

Figure 2. Number of people visiting federal and state reservoirs in Kansas in 2018, data derived from KDWP and USACE.

Recreation is a growing economic role of reservoirs, with several million visitors annually (Figure 2) participating in on-water and on-shore activities. This provides millions of dollars in economic benefits from visitor expenditures within the state. With more cities looking to develop riverfront recreational areas, maintaining reservoir water supply will allow for sufficient streamflow for recreational activities.

Secure, Protect and Restore Kansas Reservoirs

The reservoirs serve to reduce the impacts of climate variability in Kansas by reducing the impacts of flooding events that, in the recent past, would have caused widespread damage to agricultural production, in addition to loss of homes, livelihoods, and life. At times, the reservoirs serve as the sole source of water supply through prolonged drought for many Kansans by using storage to support instream uses and maintaining an adequate flow of water to user's intakes. See the *Kansas Water Plan* Guiding Principle section on Reduce our Vulnerability to Extreme Events for more information on the impacts of climate variability in Kansas.

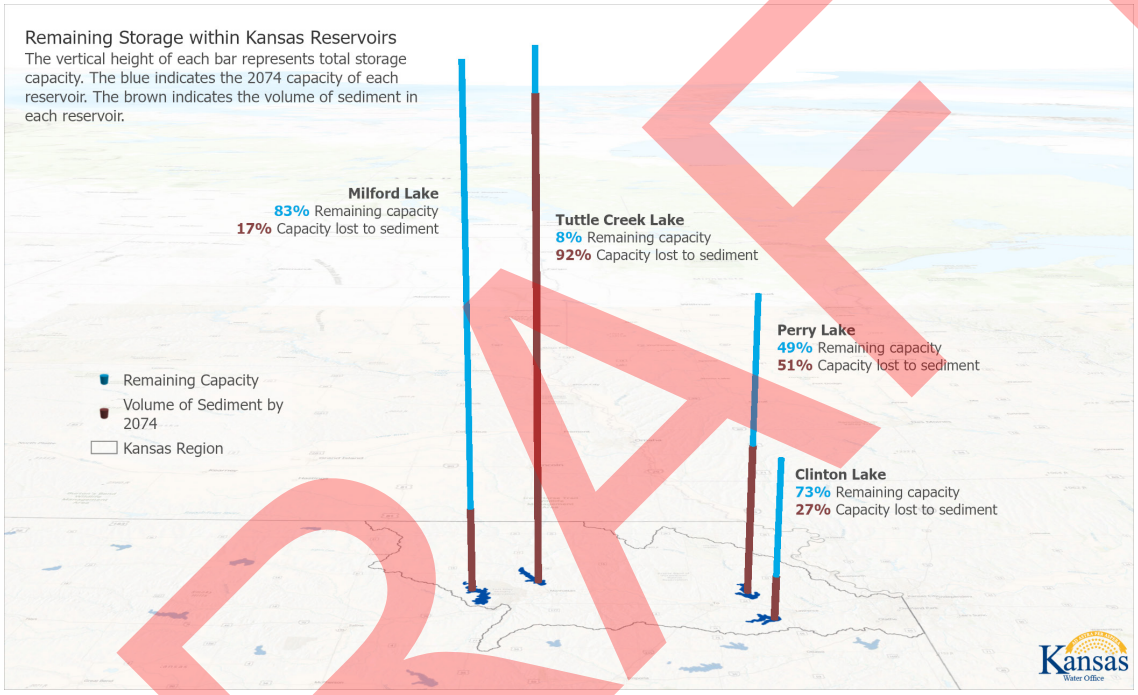

Figure 3. Projection of remaining reservoir storage within the Kansas River basin in the year 2074 if the historical sedimentation pattern continues. It is projected that 92% of Tuttle Creek Lake's initial conservation storage volume will be lost to sedimentation without implementation of sediment and basin management actions. Reductions in state owned water capacity at each reservoir on this path.

As calculated by the United States Corps of Engineers during the Kansas River Reservoirs Flood and Sediment watershed study in 2020.

There are several varied issues impacting the future of the Kansas reservoirs:

1. Storage capacity is continually being lost to sedimentation in reservoirs (figure 3). Land within the watersheds of reservoirs are losing soil which is then transported to the reservoirs through varied climatic events. Soil is trapped in the reservoirs, which reduces water supply available for future economic growth, future populations, and water supply needs through extreme climate events. Reduced reservoir water storage capacity leads to increased risk of loss for all water user groups dependent on reservoir water supply, flood protection, and water quality support.
2. A significant proportion of *Kansas Water Plan (KWP)* funding comes from fees that are paid by users that rely on reservoir water supply. The State's growing unfunded liability and inability

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to financially support its current contractual obligations for the operation of existing reservoir water supplies suppresses the ability to develop and plan for an adequate water supply for future Kansans. This impacts the State's ability to adequately fund the development, protection, and control of water resources necessary to support anticipated water uses, as stated in K.S.A. 82a-928[1].

HAB at Milford Reservoir, August 2020.

3. The increase in the number of reservoirs experiencing Harmful Algal Bloom (HAB) events[2], as well as an increase in event frequency within reservoirs as they continue to accumulate nutrients from natural and anthropogenic activity within their drainage basins, increases the cost of living for Kansans downstream, reduces economic benefits, and impacts recreational interests.This impacts rural revitalization efforts in communities supplied by reservoir water supply and increases capital expenditure needs.

Management Approach

Intentional reservoir storage management is necessary for the State to be able to continue to satisfy its statutory obligations to the people of the state. Specifically, this may lead to a lack of development or control of sufficient supplies of water to meet the future needs of the people of the state.

Reservoirs in Kansas play a key role in water security and drought resiliency planning, both by providing sufficient quantity of water to meet demands and by being a source of water to maintain water quality for drinking water, industrial, or environmental standards during times of degraded natural flow conditions. Federal Water Control manuals incorporate the need to use reservoir stored water supply to provide dilution for background naturally occurring water quality concerns, and the water quality fluctuations in response to periods of high or low streamflow events experienced in the variable Kansas climate. It is necessary to maintain adequate quantities of higher quality water in storage within Water Quality pools secured within federal reservoirs to respond to these events and maintain supply security to water users of the state.

Perry Lake. Photo Credit: U.S. Army Corps of Engineers, Kansas City District, 2019.

Reservoir operations are conducted through multiple Lake and River Regulation Manuals overseen by the United States Army Corps of Engineers (USACE), operational agreements

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with the multiple Water Assurance Districts, and the Water Access District, with flood pool operations being managed by the USACE and in coordination with out-of-state downstream river systems. Rights to water storage within the conservation or multi-purpose pools of 14 federal reservoirs have been contracted for use by the State of Kansas. Multiple cities and agricultural irrigation groups also have water storage agreements in place, such as the City of Wichita within Cheney Reservoir. This multi-purpose pool storage is operated in collaboration with the Federal Government to meet the needs of the many diverse water users and instream water quality demands.

For multiple reservoirs, there exists a financial liability that will need to be addressed by the State of Kansas, specifically where the State has agreed to the purchase of reservoir storage volume but has not needed to call the use of the storage into service. As demands rise, storage volumes are lost to reservoir sedimentation and that storage is needed to meet Kansas needs. The State will need to make the financial payments to call additional water supply into service, as outlined in the Public Water Supply Program Comprehensive Capital Development Plan[3].

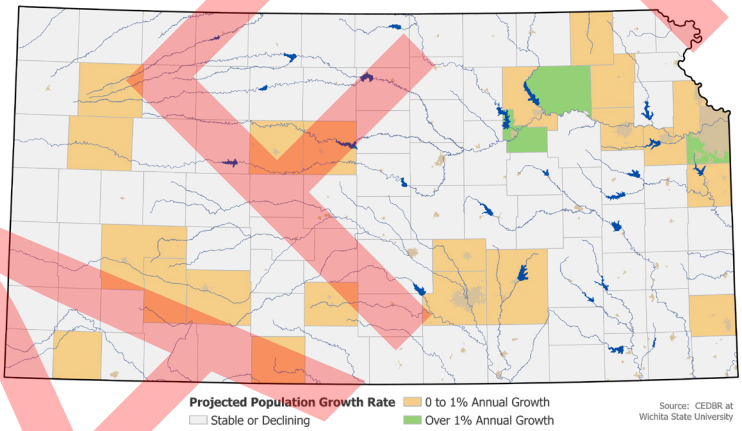

Figure 4. Projected 2070 Population Growth Rate by County, CEDBR at Wichita State University

The State must take advantage of favorable bond market conditions to reduce financial obligations to the federal government for reservoir water supply. Taking on this financial challenge in the near-term will save Kansas water users and the State millions of dollars while addressing the water supply needs for several regions of the state.

The federal reservoirs of the state were built with expected operational lifespans for their conservation storage capacity, as projected during initial design. With many of these reservoirs now over forty years old, recent and historic bathymetric surveys are showing that reservoir storage capacity is being lost in a trend similar to the initial projections for several Kansas river basins. There is a projected and observed loss of storage as sediment carried by inflowing rivers and creeks is trapped within the reservoirs, with some Kansas reservoirs trapping over 98% of the sediment carried from their upstream watersheds. This makes for future conflicts where the amount of water able to be retained in reservoir storage will be insufficient to meet the demands of multiple user groups and puts the state in the position of being unable to supply adequate amounts of water for anticipated future uses (figure 4).

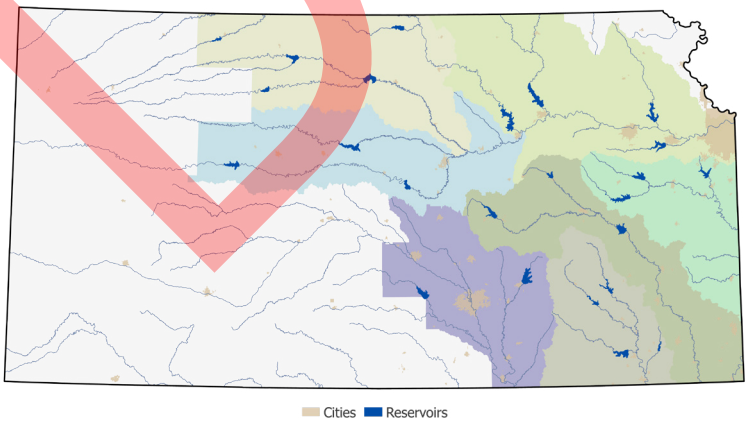

Figure 5. Regional Planning Areas with water supply reservoirs located within their boundaries

As previously stated within the *Vision for Future Water Supply in Kansas (The Vision*[4]), there have been targeted investments in the watersheds above

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multiple reservoirs used for water supply purposes, such as streambank stabilization projects, watershed dam construction, and increased support for soil health initiatives. However, the acres of agricultural lands that have had conservation practices implemented and the number of streambank stabilization sites completed, with past and current levels of funding have not remediated reservoir sedimentation issues.

As previously identified by the Blue Ribbon Water Funding Task Force for Water Resource Management[5] additional funding support is necessary to adequately reduce sedimentation rates to protect future water supply. This task force consisted of a diverse group of stakeholders, legislators, and government officials, who identified a funding need of $21 million per year to support conservation and remediation activities to secure future reservoir water supplies. Regional Advisory Committee (RAC) action plans for the Equus-Walnut (Goals 2 & 3), Kansas (Goals 1- 3), Marais des Cygnes (Goals 1 & 2), Neosho (Goals 1, 3, & 4), Smoky Hill-Saline (Goal 3), Solomon-Republican (Goals 2 & 3), and Verdigris (Goals 1) Basins support and advocate for investments to secure and develop reservoir water supplies.

Initial reservoir designs included projections of storage loss and operational plans designed to account for historical flood and drought conditions; however, preservation of storage and adaptable operations of this vital infrastructure are necessary for the future. It is of growing importance for future water supply and recreational opportunities to fund adequate levels of reservoir research. Adequate funding of reservoir research is necessary to measure the impacts of conservation initiatives that have been funded with taxpayer and water user fee support. This includes efforts such as studying the sedimentation reduction provided by streambank stabilization sites, conducting HAB pilot studies with monitoring, and measuring the impact of soil health initiatives on the nutrient and sediment loads entering the reservoirs of the state.

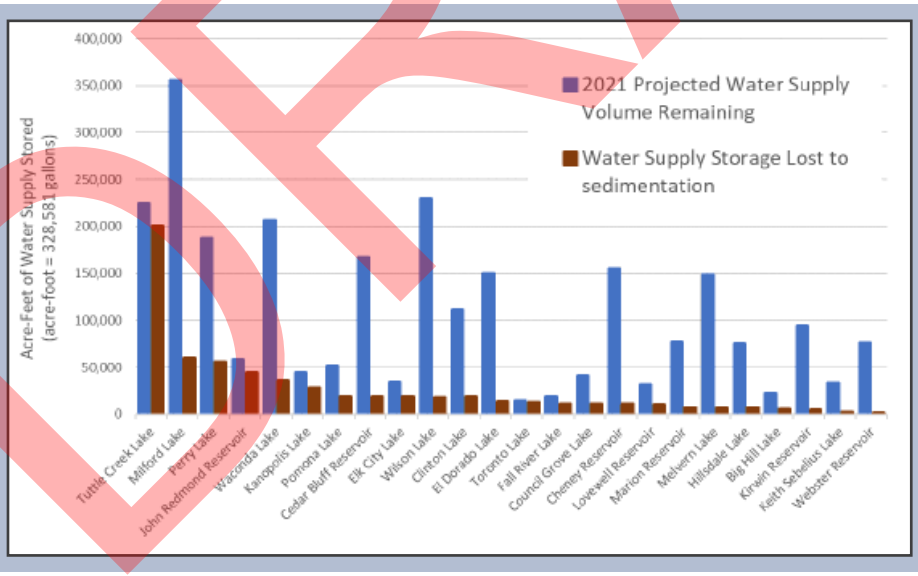

Figure 6. Amount of reservoir water supply storage remaining and lost to reservoir sedimentation.

Reservoir data and research support is needed to:

- Identify and implement innovative strategies to reduce flooding and damage reduction.
- Utilize new technologies to more efficiently conduct remote sensing and information transfer to impacted stakeholders.
- Identify alternative sediment, nutrient, and basin management strategies to reduce impacts to

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reservoirs, while avoiding downstream impacts.
- Better quantify the sedimentation issue (figure 6) through updated reservoir bathymetric surveys and surface water monitoring where feasible.
- Identify if the reservoirs are losing storage capacity as initially projected or impacts from behavioral changes within the watersheds.
- Identify impacts of large-scale climatic events, such as the extensive flood events of 2019.

Water users along the Kansas River will financially, environmentally, and recreationally benefit from having additional storage designated as Water Quality within Milford Lake and Perry Lake multi-purpose storage pools. The Water Quality pools are dedicated to supporting the low flow quantity and quality requirements of all water user groups dependent on reservoir supported streamflow and instream uses.

Reservoirs of the state, including federal reservoirs, multi-purpose small lakes, municipal reservoirs, and watershed dams all play a role in reducing the impacts of extreme flood events on the state and its citizens. Following the prolonged and, in some regions of the state, record flooding of 2019, several improvements the State should make to prepare before the next destructive flood event were identified. See the *Reducing Our Vulnerability to Extreme Events* section for more information on flood impacts to Kansans.

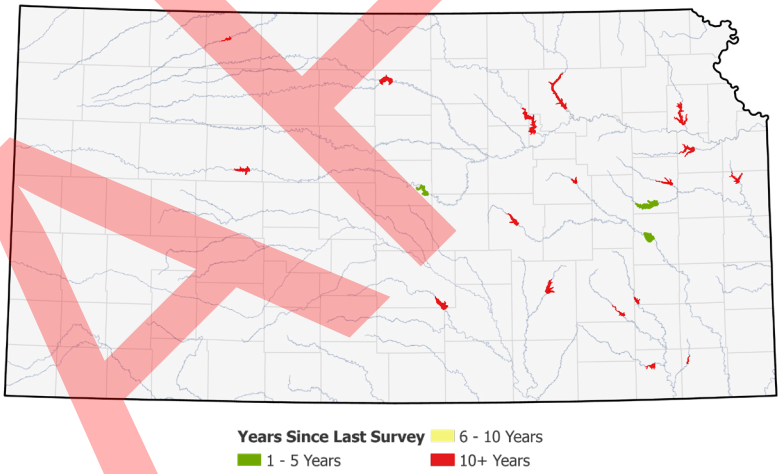

Figure 7. Years since last reservoir volumetric survey has been completed.

With flood operations being conducted in accordance with river and reservoir operations manuals by the USACE, there is an opportunity for the State to invest in the review and development of recommendations to be incorporated into operational manuals. The ongoing Lower Missouri River study with the USACE and states of Iowa, Kansas, Missouri, and Nebraska is studying the current impacts of flood operations and if there are alternatives that could reduce flooding impacts to the states along the Missouri River. For Kansas specifically, as seen in 2019, operational limits on the amount of allowable Missouri River flow during various flood stages required record breaking amounts of water to be stored in Kansas reservoirs. This increased the risk to Kansans by having almost no available flood control storage for additional precipitation events, and severely impacted recreational user groups. Modifications to the Missouri River control manual could allow the USACE to make earlier releases of water stored in flood control pools of Kansas reservoirs, reducing potential impacts to the state.

Additonally, the ongoing Kansas River Reservoirs Flood and Sediment Study[6] is a collaborative initiative between the USACE and State to review current reservoir conditions, needs, and operations, while also planning for the future water supply needs, challenges, and limitations within the Smoky Hill-Saline, Solomon-Republican, and Kansas Regional Planning Areas. Additionally, the study incorporates how future climatic variability may impact water supply and recreational reservoir uses, including analysis of what happens if no actions are taken to sustain the usable lifetimes of the federal reservoirs.

Secure, Protect and Restore Kansas Reservoirs

Measuring Success

To identify and measure the impact of investments in supporting reservoir goals, there needs to be increased observation and measurement of the condition of the reservoirs. Observing changes to sedimentation and stream channel geomorphology through additional and more frequent data collection will help agricultural, industrial, municipal, and recreational water user groups better plan for their future demands and capital investments.

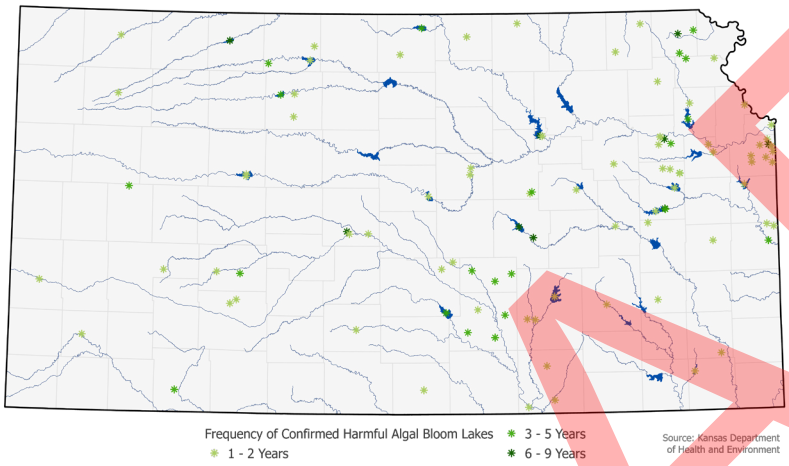

Figure 8. Reservoirs with Harmful Algal Blooms confirmed by Kansas Department of Health and Environment testing 2010 – 2020, KDHE.

Additional reservoir monitoring and research will help to better predict, monitor, and respond to harmful algal bloom events (figure 8) that impact recreational and water supply user groups and to further develop algal bloom response and mitigation techniques.

It is necessary to incorporate both quantitative and qualitative metrics into future water resource plan development to monitor whether public funds and user fees are being utilized productively and efficiently to support the future of reservoirs within the state. With the requirements of Performance Based Budgeting at the state level, there has been increased incorporation of regionally-supported budget initiatives into State Water Plan Fund (SWPF) proposals and development of performance metrics for expenditures.

The Kansas Water Authority (KWA) approved the *KWP* Budget Guidelines in January 2020, stating how funds should be used to:

- meet statutory obligations.
- tie projects to *The Vision* or *KWP*.
- support appropriate metrics and benchmarks.
- allocate water user groups' fees to reasonably support that group's future water supply, as seen with sedimentation reduction projects being funded above reservoirs that provide water supply for downstream water user groups and fee payers.
- allow the flexibility to fund expenditures that can be justified to be in response to an emerging threat to water resources or public health.

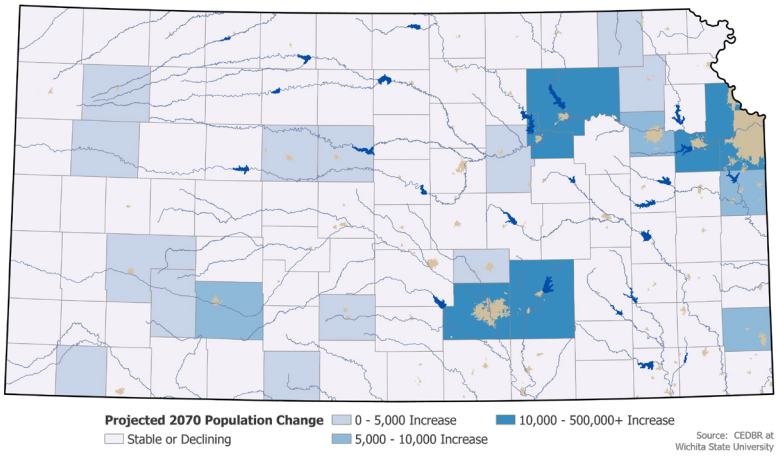

Figure 9. Projected 2070 Population Change by County.

Secure, Protect and Restore Kansas Reservoirs

Recommended Actions

Though the reservoirs in the state were designed with projected losses to their water supply capabilities, the needs of a growing Kansas population (figure 9) and agricultural use downstream of reservoirs do not have finite lifetimes or projected demand reductions. Multiple regions of the state need to have reservoir water supply secured, protected, or restored to meet the water needs of the future.

Recommended Actions and Strategies - Secure, Protect and Restore Kansas Reservoirs

Policy or Program Recommendations

- Continue support, development and sustained technical capacity to ensure groundwater and surface water models are current, defendable and ready for use at all times.
- Continue support for RAC Goals addressing reservoir issues (EW, KS, MdC, NEO, SHS, SR & VE).
- Continue to support Kansas Department of Health and Environment (KDHE) in Water Quality management.
- Continue to support KDHE nutrient reduction work group.
- Continue to support reservoir research priorities as developed by the Kansas Water Research Coordination Group.
- Identify and overcome hurdles with federal permitting for practices and structures that decrease sedimentation to federal reservoirs.
- Assess the most suitable locations for the formation of additional Water Assurance Districts where appropriate, to expand and improve coordination of the use of available supplies from Kansas reservoirs.
- Actively pursue the goal of reservoir restoration and sustainability with intentional intervention.
- Evaluate potential additional water supply through inter-connectivity of reservoir storage, reallocation and/or operational efficiency.
- Develop multi-state relationships to address interstate river reservoir system management, ensuring that Kansas is represented in any policy or operational changes.

Implementation Actions

- Collaborate with USACE to increase Water Quality pool allocations where needed, which will ensure sufficient flows to support instream uses and maintain water quality for users.
- Support watershed conservation practices with soil health initiatives, streambank stabilization, and riparian corridor restoration.
- In regions where it is infeasible to restore water supply storage in current reservoirs, explore additional storage possibilities with the construction of multipurpose small lakes to alleviate regional water supply issues.
- Pursue innovative in-lake sediment management measures to restore and sustain reservoir storage.
- Develop a stream-aquifer model of the Kansas River alluvial aquifer from Junction City to the junction with the Missouri River to examine the effect of scenarios of future development and management on groundwater and river water levels.

Secure, Protect and Restore Kansas Reservoirs

Data, Research, and Studies

- Work to increase efficiency of reservoir operations through low-flow release modifications and operating reservoirs as a system. As data resources and climate conditions allow, incorporate Forecast Informed Reservoir Operations to increase water supply resiliency and efficiency.
- Develop future climatic scenario reservoir water supply planning capabilities.
- Support HAB data collection and remediation projects.
- Study benefits of watershed conservation practice implementation on sedimentation and nutrient loading rates, utilize budgetary guidelines and performance metrics to direct future funding sources to those that are shown to improve reservoir conditions.
- Engage in active sediment management studies with federal partners as cost share and funding opportunities arise.
- Increase the frequency of reservoir bathymetry to monitor progress on sedimentation trends, show reservoir storage loss, and conduct future water supply planning projections.

Funding and Resource Needs

- Utilize low borrowing rates to secure reservoir storage. Complete principal and interest payments to the federal government to fulfill contractual obligations and maintain a solvent Water Marketing Program.
- Fund and implement strategies supported by RACs to reduce sedimentation and nutrient loading rates within water supply reservoirs. In reservoirs where conservation alone will not satisfy future water supply demands, work towards implementation of active sediment management strategies.
- The Blue Ribbon Water Funding Task Force for Water Resource Management identified some funding levels for conservation practices that have not been supported thus far. Additionally, RACs are having discussions on new methods to fund reservoir conservation initiatives, with some privately funded initiatives being implemented.

Secure, Protect and Restore Kansas Reservoirs

Resources

1. Kansas State Legislature. http://www.kslegislature.org/li/b2021_22/statute/082a_000_0000_chapter/082a_009_0000_article/082a_009_0028_section/082a_009_0028_k/
2. Kansas Department of Health and Environment. https://www.kdheks.gov/algae-illness/what_is_a_hab.htm
3. Kansas Water Office. https://kwo.ks.gov/docs/default-source/kwa-meeting-materials/kwa-member-handbook/5-rpt_2017_pws_ccdp_final_051817.pdf?sfvrsn=4
4. Kansas Water Office. https://www.kwo.ks.gov/water-vision-water-plan/water-vision
5. Kansas Water Office. https://kwo.ks.gov/docs/default-source/water-vision-water-plan/vision/blue_ribbon_ftf_final_report.pdf?sfvrsn=4
6. Kansas Water Office. https://kwo.ks.gov/projects/kansas-watershed-study

Improve the State's Water Quality

Improve the State's Water Quality

Background

Kansas has developed a robust monitoring and assessment program to track trends and conditions in water to achieve the objectives of the *Kansas Water Plan (KWP)* and to maintain state primacy for administration of federal water quality programs.

The Kansas Department of Health and Environment (KDHE) has primary responsibility for surface water chemical and biological monitoring and assessment. In addition to KDHE statewide monitoring and assessment programs, many other entities, including federal, state, and local agencies and consultants, have conducted focused assessments and reports on specific geographic areas or water quality concerns. Information provided in this section is mostly limited to state agency programs.

Cheyenne Bottoms. Photo Credit: The Nature Conservancy.

Water quality monitoring and assessment operations in Kansas are used to determine impaired water status. KDHE maintains several ongoing programs that collectively fulfill the environmental surveillance and reporting requirements of the Clean Water Act (CWA) and provide the technical data needed to identify and respond to existing and emerging water pollution problems.

Programs administered by the KDHE Watershed Planning, Monitoring, and Assessment Section (WPMAS) are designed to meet the environmental surveillance and reporting requirements of the CWA and other applicable federal and state laws[3]. Information obtained through these efforts is applied in the development of the State's biennial Integrated Water Quality Assessment and 303(d) list of water quality-limited surface waters. Water quality data are also applied in the formulation of total maximum daily load[4] (TMDLs) for 303(d)-listed water bodies, used to inform water quality standards development, and guide implementation of pollutant and pollution reduction activities.

The Integrated Water Quality Assessment[1] is a compilation of water quality issues across the state. The WPMAS monitors water quality conditions in streams and publicly owned lakes and wetlands throughout Kansas. The KDHE list of impaired waters[2] identified:

- 86% of state's assessed stream miles are impaired for one of these uses - aquatic life, contact recreation, or food procurement.
- Over 96% of the state's assessed lakes are impaired for one of these uses - aquatic life, contact recreation, or food procurement.
- Less than 5% of the state's assessed wetlands support aquatic life and recreational uses.

The WPMAS works with other KDHE programs, such as the Spill Response and Storage Tank Program, to identify potential risks to natural resources resulting from the unauthorized release

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of pollutants[5] to the waters of the state. The 2019-2028 Kansas Water Quality Monitoring and Assessment Strategy[6] is a tool to use when reviewing regulatory expectation, budgetary realities and technological, and methodological advances in environmental surveillance.

General Water Quality Issues

SURFACE WATER

The Kansas 2020 303(d) list identified 486 station/pollutant combinations of water quality impairment on lakes, wetlands, and stream systems (watersheds), encompassing 2,278 stream segment/pollutant combinations, and needing the development of TMDL plans to address the offending pollutants. The 2020 list also identified 514 station/pollutant combinations of waters that were cited as impaired in prior lists but now meet water quality standards, with 44 of these being new in 2020. Waters listed on the 303(d) list are individually targeted for TMDL development, according to a priority ranking established by KDHE and approved by Environmental Protection Agency (EPA).

To address some of these water quality concerns, multiple agencies and non-governmental organizations (NGO's) collaborate to provide viable management tools. Several of these agencies and organizations continue to promote Best Management Practice (BMP) implementation, which has proven to reduce the movement of sediment, phosphorus, and nitrogen into Kansas waters.

A significant amount of research has been conducted concerning the effects of wetlands on water quality. The research indicates there are positive effects a healthy, functioning wetland has on water quality. The Kansas Water Office (KWO) serves as the wetland[8] coordinating agency for the State, engaging with numerous partners across Kansas on wetland-related activities.

Aquatic Nuisance Species (ANS) are a source of significant ecological and socio-economic problems throughout North America. As of 2020, there were more than 30 water bodies and streams in Kansas infested with zebra mussels (figure 1). In 1999, non-indigenous species

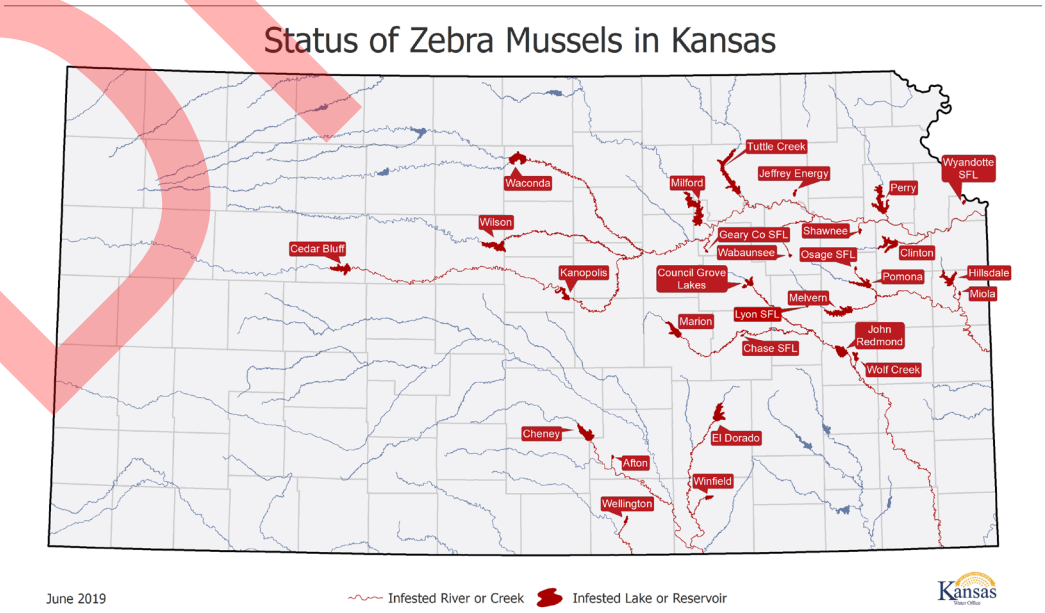

Figure 1. Zebra Mussel Infested Waters[10].

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(aquatic and terrestrial) in the United States were estimated to cause major environmental damages and losses adding up to more than $138 billion per year[9]. The Kansas Department of Wildlife and Parks (KDWP) continues to work diligently to limit the spread of ANS species though public awareness campaigns shared through multiple media outlets, such as their webpage[10]. There are multiple regional and national entities[11] working in collaboration to address ANS issues.

Zebra Mussels. Photo Credit: NOAA.

The KDHE Harmful Algae Bloom (HAB) Response Program was established in 2010, with this program identifying over 100 water bodies affected by HABs in the past 10 years. A HAB refers to a dense growth of algae that has the potential for creating toxins that have acute and chronic effects on liver, kidney, lungs, and nervous system, and there are no known antidotes to the toxins. There is an upward trend on the number of water bodies affected by HABs in Kansas; Figure 2 illustrates the affected waters in 2020. KDHE's complaint-based program addresses blooms on public waters[12], with no agency sampling or laboratory analysis being conducted on private waters[13]. Managers of private waters are encouraged to perform a jar test and use private labs if they believe they are experiencing a bloom. Under the KDHE program, there are three levels of Advisories: Watch, Warning, and Hazard. With this emerging issue occurring across the country, the EPA[14] has compiled information and research on HABs. KDHE has considered a number of HAB mitigation strategies at Milford Lake, including reservoir drawdown to reduce cyanobacteria habitat, vegetation to remove nutrients, peroxide based algaecide, ultrasound, and rough fish removal.

HAB outbreak, Marion Reservoir 2021, Photo Credit: Tulsa USACE

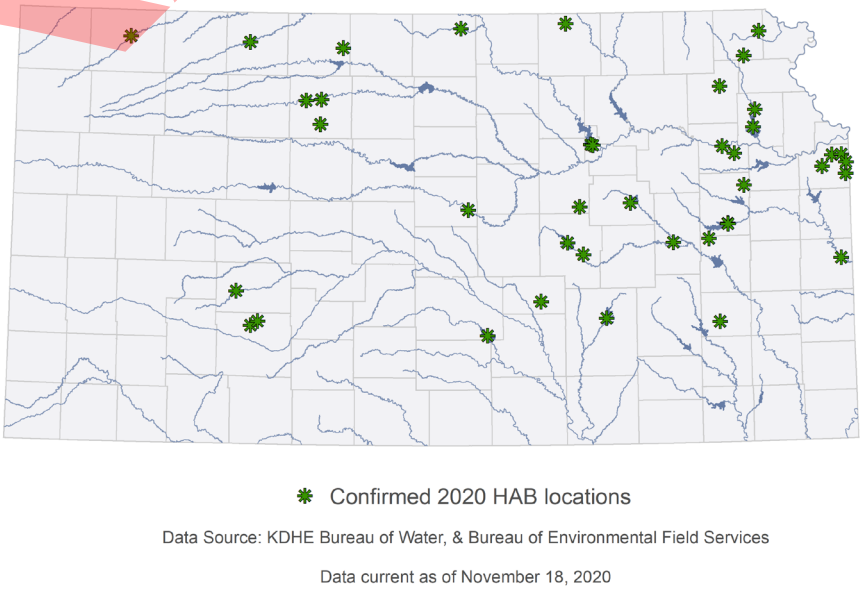

Figure 2. 2020 HAB Lakes[12].

Improve the State's Water Quality

The Kansas Water Plan Guiding Principle: *Securing, Protecting, and Restoring our Kansas Reservoirs* mentions the use of stored water supply to provide dilution of naturally occurring water quality concerns. As seen in 2018 and 2020 within the Kansas and Smoky Hill Rivers, the use of water stored within reservoirs was necessary to dilute chlorides and sulfates that are naturally occurring in the upper portions of the watersheds. In 2018, Tuttle Creek and Milford Reservoir releases were required to dilute high chlorides that were released from Wilson Reservoir. In 2020, during periods of prolonged low flows in the Smoky Hill and Kansas Rivers, releases were also needed from Tuttle Creek and Milford Reservoirs to dilute high chloride waters that were being discharged from the Smoky Hill River alluvium after the flooding seen in 2019.

The Tuttle Creek Reservoir Water Control Manual states that water stored within a water quality pool of Tuttle Creek Reservoir will be used to maintain downstream chlorides below 250 mg/L to improve water quality and protect water supply uses. The U.S. Geological Survey (USGS) has multiple gages that monitor dissolved chlorides[15] at several locations around the state. With the projected loss[16] of storage at Tuttle Creek Reservoir, there will be reduced quantities of water available to be held in storage for dilution and the support of improved water quality through periods of drought and low flows on the Kansas River.

GROUNDWATER

Currently there are several groundwater projects being conducted across the state to assess water quality concerns. The KWO is currently funding one such study in the Missouri Region Planning Area to evaluate groundwater quality[17] with the Kansas Geological Survey (KGS) conducting the work. Nitrate is the most common inorganic contaminant in Kansas groundwater. Previous studies have found that about 30% of domestic wells in Kansas have nitrate levels greater than the Maximum Contaminant Level (MCL) for public drinking water[31]. Figure 3 illustrates how the nitrates get into the water supply and figure 4 shows areas in the state that have nitrate problems.

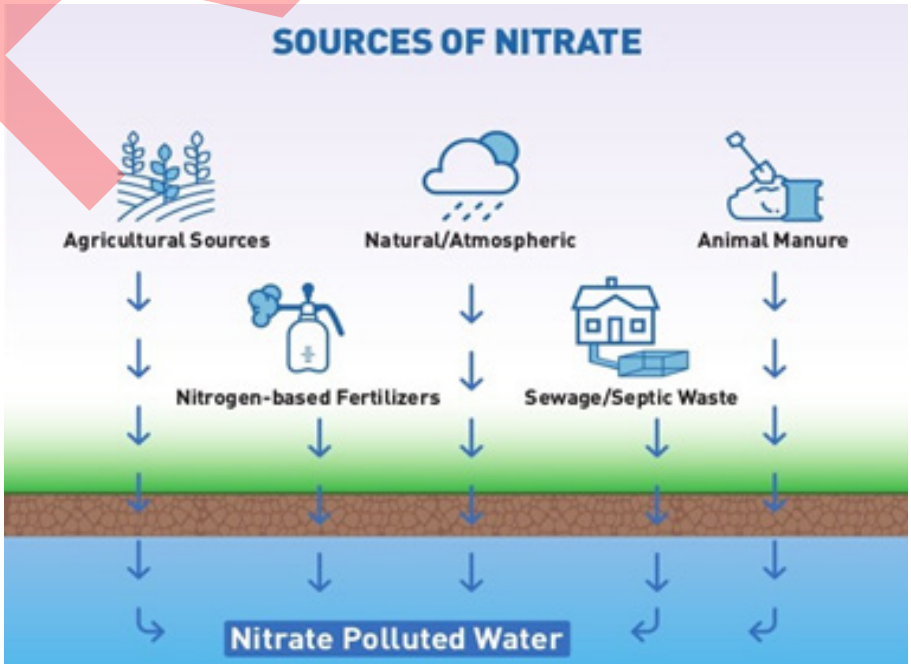

Figure 3. How nitrate moves into groundwater, Beta Analytic Inc.

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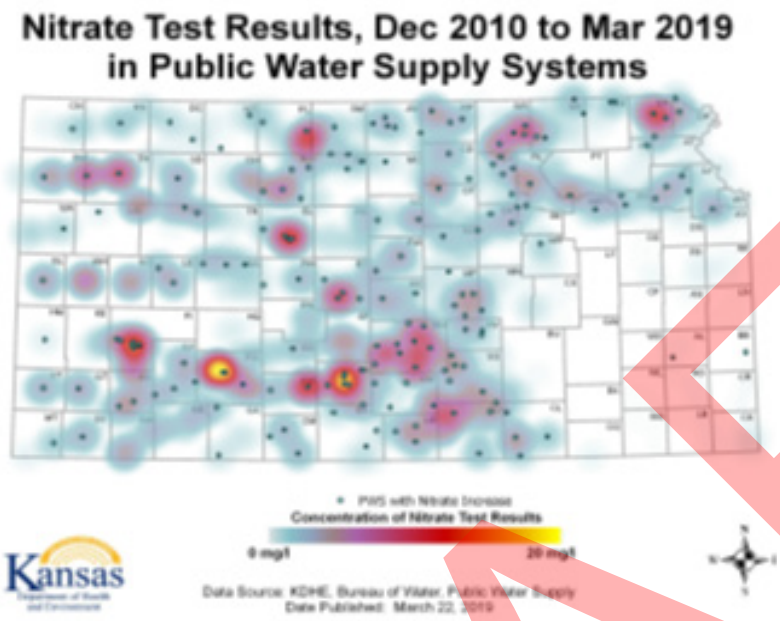


Figure 4. Nitrate Test Results in Public Water Supply Systems[1].

One groundwater quality issue of concern is the Equus Beds chloride plume[18]. This problem stems from past oilfield production, with produced water having been deposited in evaporation pits which allowed infiltration of produced water into the underlying aquifer. The groundwater plume has high chloride concentrations of up to 1,600 milligrams per liter, rendering it unusable for most purposes. Initial steps have been taken to document the movement of the plume and identify possible solutions to address the problem. The KWO and KDHE have collaborated on this study using State Water Plan Fund (SWPF) resources to evaluate the extent of the chloride plume with an estimated remediation cost of $50,000,000[19].

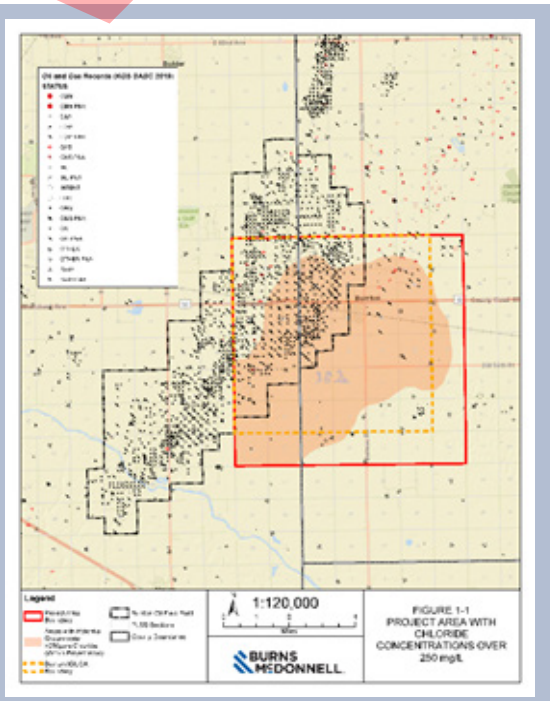
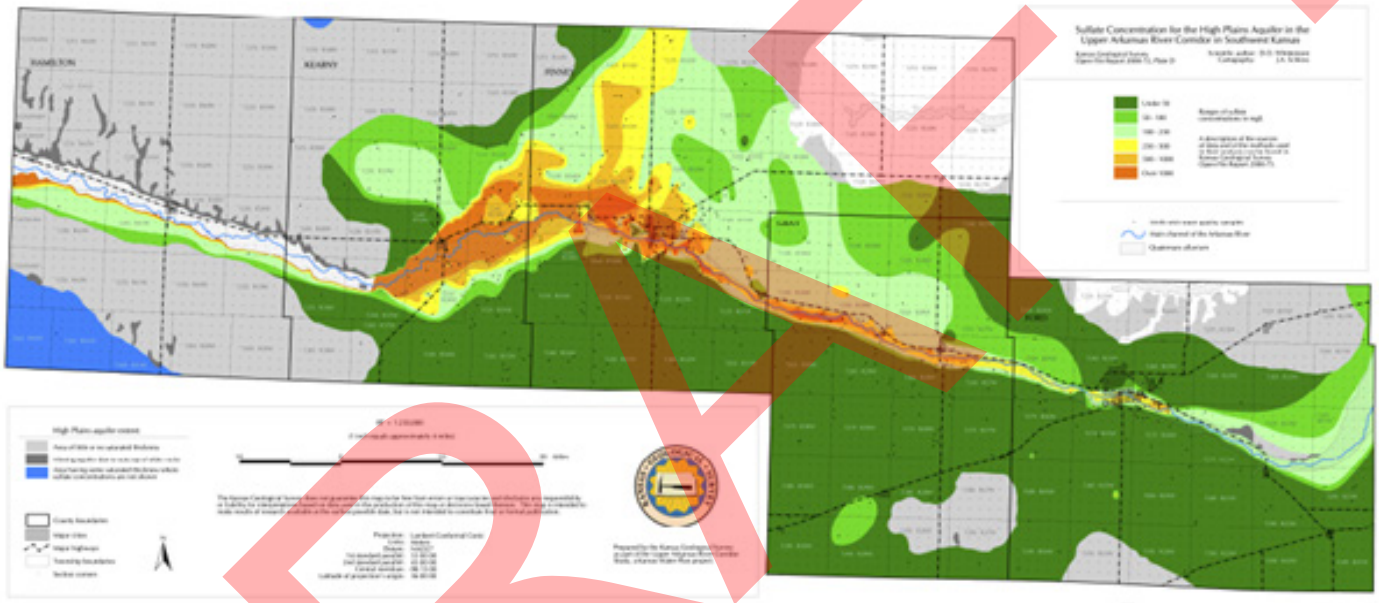


Figure 5. Project Area with Chloride Concentrations over 250 mg/L, Burns & McDonnell

Improve the State's Water Quality

The KDHE is leading a group of agencies in continuing a 2009 groundwater study[20] looking at naturally-occurring minerals in private water wells in southwest Kansas. A total of 13 parameters, from arsenic to uranium, are being analyzed for presence and levels. Additionally, beginning in 2019, KWO, KDHE, Kansas Department of Agriculture (KDA), and KGS partnered on a groundwater study focused on analyzing the impacts of naturally occurring minerals on water used for human consumption from private water wells within the Upper Arkansas Regional Planning Area[21]. The project invited homeowners within the study area (portions of Hamilton, Kearny, Finney, Gray, and Ford counties) to provide voluntary water samples.

Figure 6. Sulfate Concentration for the High Plains Aquifer[31].



KDHE is collaborating with Fort Hays State University (FHSU) on a 2-year study in the northwestern[22] part of the state on a similar project. Private well owners within the study area will be given the opportunity to have their wells tested for common minerals and contaminants, allowing KDHE to understand the extent of contamination issues in the region. The study area includes portions of Norton, Phillips, Decatur, and Rawlins counties, aiming to analyze water samples for minerals including arsenic, selenium, nitrate, chloride, iron, manganese, sulfate, and uranium.

Surface Water Monitoring Programs

KDHE's Stream Chemistry Monitoring Program's sampling network is comprised of 327 monitoring sites spanning all the major river basins in Kansas. With 160 permanent sites, 40 sites are sampled per quarter, whereas the remaining 167 sites are monitored using a four-year rotational approach. Sampling stations are chosen to represent water quality conditions in more than 97% of the state's contributing drainage area.

KDHE has maintained a Stream Biological Monitoring Program since 1972. This program examines the structural attributes of aquatic macroinvertebrate assemblages and utilizes this information to provide a more refined picture of the ecological status of streams in Kansas. Unlike water chemistry measurements alone, which reflect conditions occurring at the moment

Improve the State's Water Quality

of sample collection, biological monitoring provides an integrated measure of environmental conditions over time frames ranging from weeks to years, depending on the biological assemblage of interest. About 45 long-term core network stations located in watersheds of major rivers and streams are sampled every year when conditions allow. Additional sites are visited each year, as dictated by TMDL development needs, special studies, and pollutant investigations. Since inception, the program has collected macroinvertebrate samples and conducted freshwater mussel surveys at 225 sites throughout the state and the current database contains more than 90,000 high resolution (predominantly genus/species level) records from over 2,200 separate samples.

The lake and wetland monitoring program within KDHE surveys water quality conditions in publicly owned and publicly accessible lakes and wetlands throughout Kansas. Individual water bodies are sampled on a 3 to 6-year rotational schedule and water quality information is maintained on 175 lakes and wetlands in the state. These include all 24 federal reservoirs, most state fishing lakes, and various other county or locally owned and several privately owned but publicly accessible lakes.

Kansas River. Photo Credit: Greenability Magazine.

The KDHE stream probabilistic monitoring program differs from the stream chemistry monitoring program in that monitoring sites are a randomly selected subset of Kansas streams. Results generated through the probabilistic monitoring program can be extrapolated with known statistical confidence to the state's entire population of streams, including hundreds of smaller water bodies largely outside the historical and current purview of the targeted monitoring programs.

The KDWP manages a Stream Survey and Monitoring Program[23] with multiple crews collecting valuable data. Although this program has no regulatory or enforcement authority, its goal is to assess biological communities present within Kansas streams. Sampling generally occurs from late spring to summer and each year focuses on a river basin of interest.

FISH TISSUE CONTAMINANT AND FISH CONSUMPTION ADVISORY PROGRAMS

Working with other state and federal agencies, KDHE also collects and analyzes fish tissue samples from streams and lakes throughout Kansas. On an annual basis, fish tissue from 200 to 300 individual fish captured from about 40 monitoring sites are analyzed for mercury. Organic contaminant concentrations, e.g., pesticides and polychlorinated biphenyls (PCBs), are evaluated at 5 to 10 monitoring sites per year. Sample site selection for both mercury and organic contaminants is based on a combination of targeted long-term screening sites as

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well as collection according to the screening sampling design in support of the KDHE Stream Probabilistic Monitoring Program. Based on this data, KDHE, in partnership with KDWP, issues annual fish tissue consumption advisories which identify fish or other aquatic life that should be eaten in limited quantities or avoided altogether. Advisories are formulated using EPA risk assessment methods which account for contaminant level and length of exposure. 2020 fish consumption advisories are located here[24] . In some waters of the state, it is recommended that no fish is consumed. This information is also listed in annual fishing regulations published by KDWP.

Channel catfish. Photo Credit: Julia Hampton, Great Rivers Field Station.

WATERSHED RESTORATION AND PROTECTION STRATEGIES

Interested stakeholders form local leadership teams that assess watersheds and develop Watershed Restoration and Protection Strategy[25] (WRAPS) plans to restore and protect surface water resources in these areas. WRAPS efforts can address a variety of water resource concerns statewide. The concerns can include water quality, water supply protection, flooding, and wetland and riparian habitat protection or restoration. Solutions to identified concerns are developed locally by stakeholders within the watershed. WRAPS groups draw upon available water quality information and may supplement existing data with targeted assessments to guide planning and implementation activities. In some cases, Soil and Water Assessment Tool (SWAT) modeling is applied to their watersheds.

Currently there are 36 Kansas WRAPS plans that include costs associated with Best Management Practices (BMP) implementation, technical assistance, additional project coordination, and education. If plan expenses are totaled for all WRAPS Projects and extended through the length (years) of each watershed plan, the total amount needed to address the water quality impairments identified in WRAPS plans is approximately $624,800,000[26].

WATER QUALITY BASED EFFLUENT LIMITATIONS

Prior to the issuance of any permit that authorizes a facility to discharge effluent to the waters of the state, KDHE must certify, in writing, that the planned release of effluent will not result in violations of Kansas Surface Water Quality Standards (KSWQS), other applicable state laws, or any federally[27] promulgated water quality standards. A review of the discharge's potential impact on the quality of the receiving surface water is conducted by KDHE. Currently, about 1,500 municipal, industrial, commercial, and federal facilities in Kansas are authorized by KDHE to release treated effluent to the waters of the state.

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NONPOINT SOURCE POLLUTION MANAGEMENT PLAN

The Kansas Nonpoint Source (NPS) Pollution Management Plan[28] is intended to outline a strategic plan for NPS management in Kansas that addresses the nine key program elements required by EPA and provide a framework for coordination and collaboration among agencies and organizations involved in NPS-related management activities. The plan's management objectives include projects implemented and documented improvements in water quality attributable to NPS pollution control efforts.

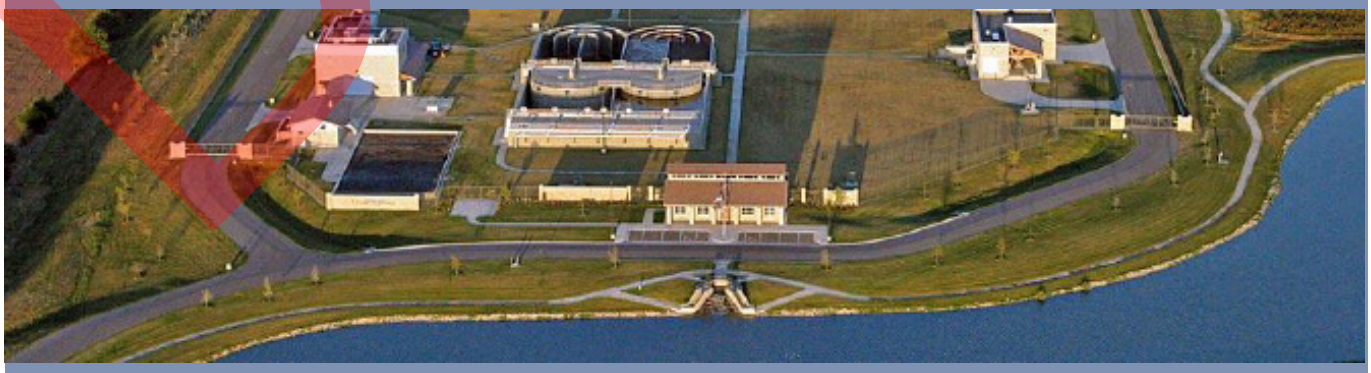
Groundwater Monitoring Program

Kansas no longer maintains a statewide groundwater quality monitoring program and funding for the renewal of such an effort appears unlikely in the near future. However, an earlier monitoring program (suspended in 2002 due to budgetary constraints) evaluated groundwater quality at more than 200 sites in Kansas. Individual wells in the monitoring network were sampled on a two-year rotational basis, with approximately half of these wells being sampled in any given year. The program's surviving electronic database contains roughly 150,000 records spanning 120 different physical, chemical, and radiological parameters and 327 groundwater quality monitoring locations.

Water Reuse

There are reuse projects taking place statewide, some with large amounts of water being reused. For example, Spirit AeroSystems in Wichita is treating 2-3 million gallons of water a day for reuse, as well as using treated effluent water from the City of Wichita. Most of the reuse water across the state is applied to ball fields, golf courses, or agriculture fields. The technology is available to treat water from toilet to tap; however, there is still a negative public perception and a significant financial investment, which limits further utilization. A Water Reuse presentation[29] was given at the 2017 Governor's Water Conference outlining issues with water reuse. Water reuse is one of the areas that multiple cities and industries are utilizing as it provides environmental and economic benefits.

Photo Credit: City of Wichita.



Improve the State's Water Quality

Additional Reports

A variety of additional reports, special publications, and peer-reviewed journal articles are generated by KDHE[30] to disseminate water quality information to the broader scientific community, elected officials, regulated entities, and the general public.

Measuring Success

Multiple items can be used to measure the success of *Improving the State's Water Quality*:

- Reduction of impaired waters on 303(d) list in accordance with WRAPS 9-element plans.
- Limitation of ANS to current infested waters.
- Reduction in the number of HAB events and duration.
- Limitation of reservoir storage loss through initiatives and implementation.
- Enhancement of groundwater quality through remediation steps.
- Expansion of water reuse technology.

Recommended Actions and Strategies - Water Quality

Policy or Program Recommendations

- Regional Advisory Committee (RAC) Goals addressing water quality/reuse (CM, EW, GBP, KS, MO, NEO, SHS, SR, UR, USH, VE).
- Continue to support KDHE in Water Quality management.
- Legislative support for increased soil health practices.
- KDHE nutrient reduction work group.
- Current Research Appropriations (Bathymetric Surveys, Kansas River Alluvium, Streambank Stabilization, and Real-Time Flood Mapping).

Implementation Actions

- Follow RAC Action Items.
- Continue to work closely with USGS, KGS, and KDHE on appropriate actions.
- Encourage more adoption of soil health implementation.
- Encourage and promote municipalities & Public Water Supply water reuse efforts.
- Promote more water quality off-site mitigation and carbon sequestration partnerships.
- Encourage communities to play a bigger role in water quality initiative with support from local Conservation Districts (CD).

Data, Research, and Studies

- Facilitate/support data collection of groundwater and surface water quality
- Support the Groundwater Management District (GMD) 5 study with Kansas State University (KSU) concerning nitrate levels in private wells with assistance from KDA-Division of Conservation CD and KDHE.
- Add KDHE mineralization studies in southwest and northwest Kansas.

Funding and Resource Needs

- Partnerships with private companies or other entities to aid in BMP implementation.
- Use of State Water Plan funds or other funding opportunities to secure data/information.

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Resources

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Reduce Vulnerability to Extreme Events

Reduce Vulnerability to Extreme Events

Background

Extreme weather events impact Kansas regularly. Severe flooding episodes of note have occurred in Kansas in 1935, 1951, 1965, 1973, 1976, 1981, 1983, 2007, 2011 and again in 2019. Kansas has also repeatedly experienced droughts, most notable the "Dirty Thirties" and the 1950s drought. While these events have typically been used as standards for severe droughts in Kansas in the past hundred years, paleoclimate proxy evidence indicates droughts in Kansas of even greater severity and duration over the past thousand years[1]. The state's diverse climate and propensity for both extremely wet and dry conditions creates unique challenges. In some years, both flooding and drought can occur simultaneously, as they did in 2011 when above-average snowpack melt and precipitation impacted the Missouri River system and caused northeast Kansas to flood while much of the state was in a moderate to exceptional drought[2].

A huge dust storm moves across the High Plains during the Dust Bowl of the 1930s. Photo Credit: USDAgov / Flickr.

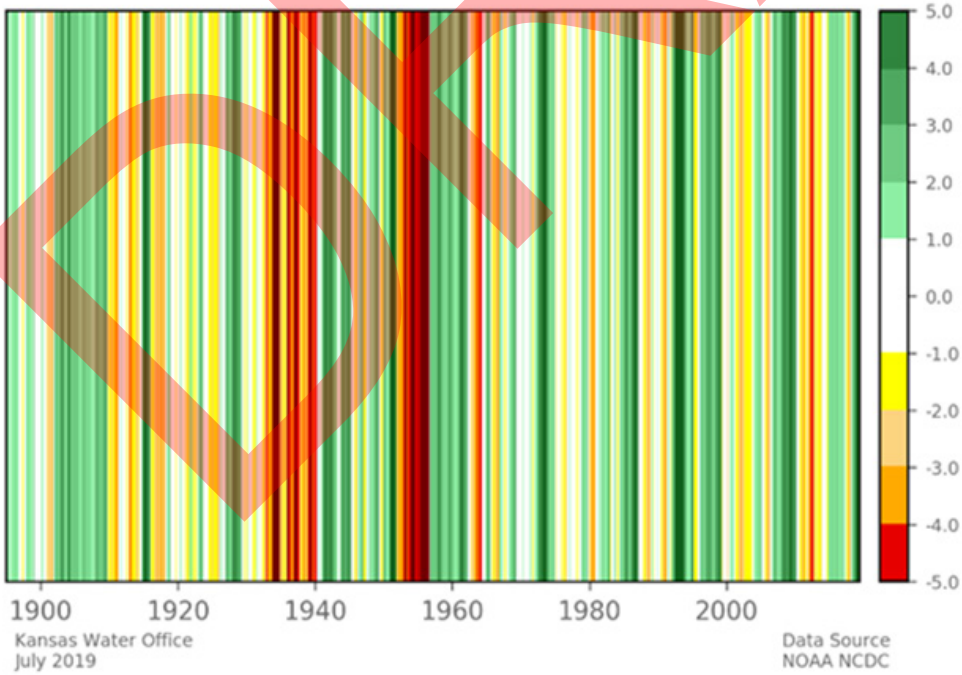


Figure 1. Historical Kansas Palmer Drought Severity Index (PDSI) values.

PDSI utilizes precipitation, temperature, and available water content data to estimate relative dryness. Classifications typically range from extremely wet (PDSI > 4.0) to extreme drought (PDSI < -4.0).

Historical PDSI data illustrates the year-to-year variability of water resources in Kansas, as well as the severity of extreme events like the 1930s and 1950s droughts.

Reduce Vulnerability to Extreme Events

Climatologists have indicated that Kansas is facing a warming trend in our future accompanied by a potential increase in the frequency, duration, and intensity of extreme events. Recent decades support this trend, with temperature increases particularly notable in the spring[3], which affects the planting of crops. The Fourth National Climate Assessment, 2018, projects that average annual temperatures will increase in the Southern Great Plains by 4.4 to 8.4 degrees Fahrenheit by the late 21st century, compared to average conditions for 1976-2005[4]. Even small increases in average temperatures result in increased evaporation and evapotranspiration, as well as raise the risk of heat waves, wildfires, and droughts. Additionally, higher surface water evaporation and more turbulent atmospheric conditions can lead to severe weather.

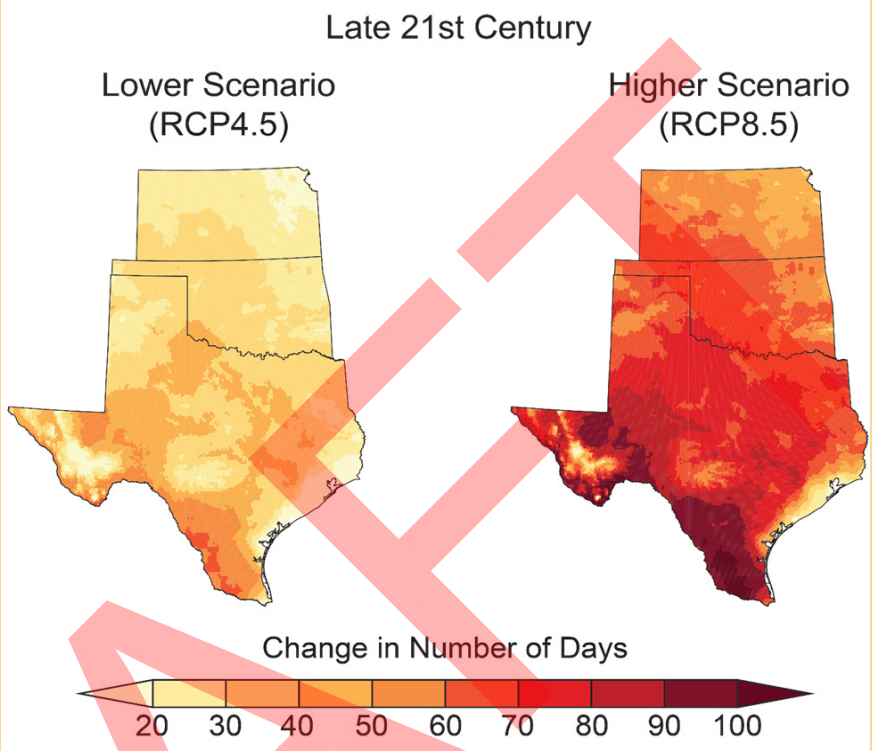


Figure 2. Projected increase in number of days above 100°F throughout the Southern Great Plains. The Representative Concentration Pathways (RCP) are greenhouse gas concentration trajectories used by the Intergovernmental Panel on Climate Change (IPCC) and are labeled based on projected radiative forcing values (RCP4.5 - lower scenario, RCP8.5 - higher scenario), a measure of the greenhouse effect, in 2100[4] (from Kloesel et al., 2018).

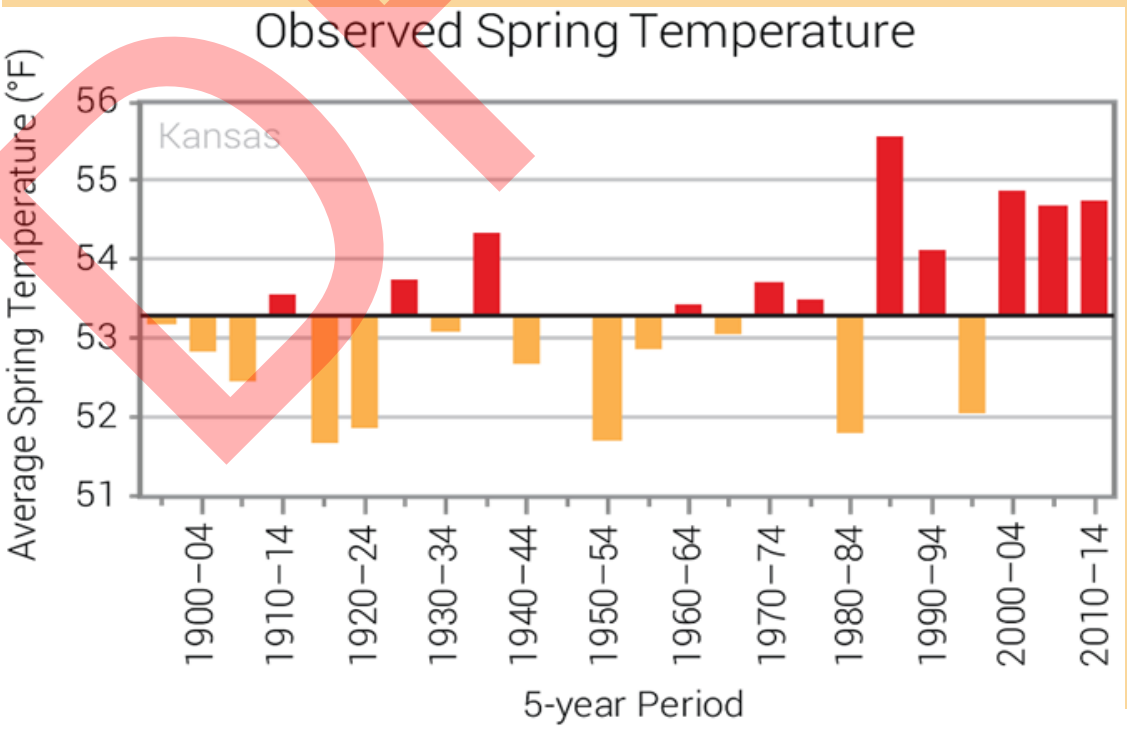


Figure 3. Warming trends in Kansas have been particularly noticeable in the spring in recent decades[3] (from Frankson et al., 2017).

Reduce Vulnerability to Extreme Events

PRECIPITATION VARIABILITY

Future predictions for average annual precipitation are somewhat uncertain, with projections indicating a slight increase in winter precipitation and decrease in summer precipitation. However, the anticipated increase in the frequency and intensity of extreme precipitation events could result in decreased soil moisture, as soil would have less time to absorb the precipitation and longer periods between precipitation events to dry out. Such conditions would have a direct, negative impact on agriculture and put a greater strain on water supply/resource management infrastructure.

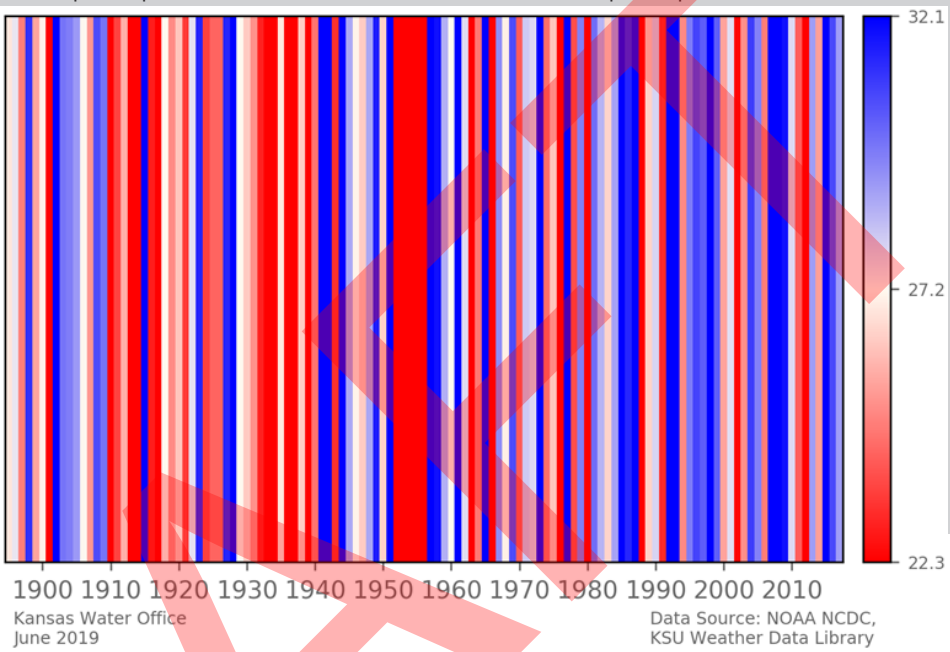


Figure 4. Statewide annual precipitation, inches (1895-2017). Blue stripes indicate years with above average precipitation (>27.2") and red stripes indicate years with below average precipitation (<27.2"). The variation in color patterns demonstrates the diverse range of water resource conditions, both in duration and frequency of wet and dry conditions, that Kansas experiences.

Figure 4 illustrates the inherent variability and climatic challenges in our state. What has historically allowed the State of Kansas to grow and prosper is the monitoring and utilization of water resources to combat extreme events. The State supports extensive monitoring, such as the Kansas Mesonet[5] and the streamgaging partnership with the United States Geological Survey (USGS)[6], to evaluate historical events and assess when current conditions are approaching a critical point. The Kansas Mesonet, housed at Kansas

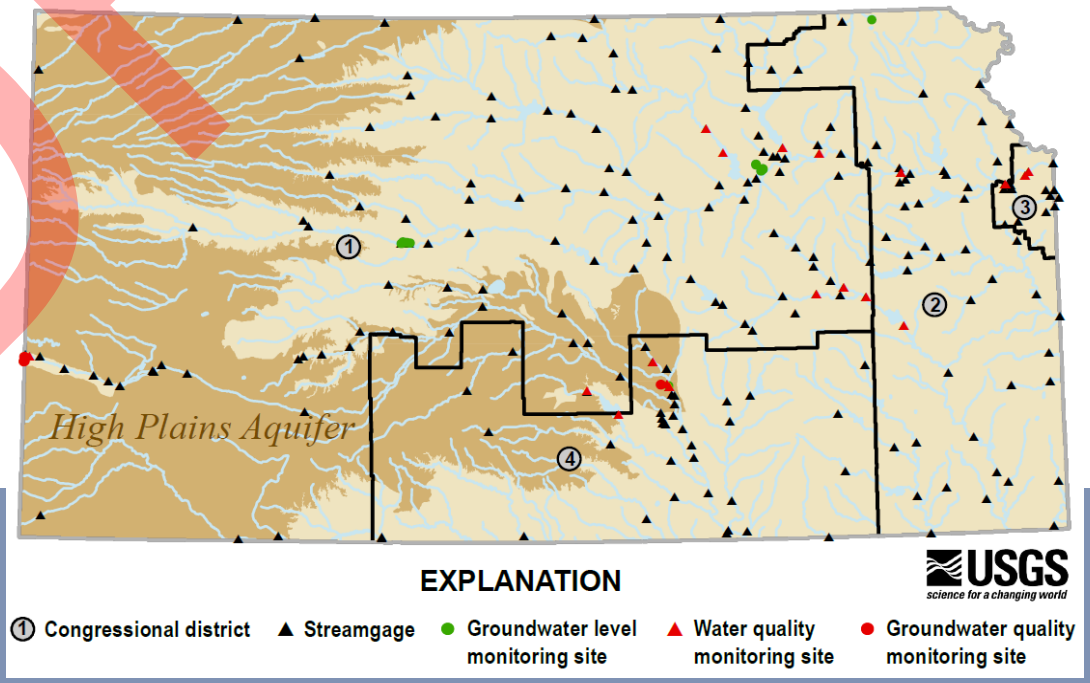


Figure 5. USGS monitoring network in Kansas[6] (from Painter et al., 2017).

Reduce Vulnerability to Extreme Events

State University, supports multiple state agencies and water resource managers through their network of weather stations, weather summaries, and climate analyses. In addition to housing the Kansas Weather Data Library, the Mesonet provides education and outreach to agriculture producers and K-12 stem initiatives, research support for our state's universities, and many other decision support tools to Kansans. To access the Weather Data Library or to learn more about the services provided by the Kansas Mesonet, visit their website.

The USGS streamgaging network (figure 5) provides near real-time, continuous flow monitoring throughout Kansas. Monitoring data are used to generate flow statistics and duration curves and are posted on the USGS website through the National Water Information System. This information helps provide context as to how extreme events have impacted Kansas in the past and project how they may continue to do so in the future.

FLOODING IN KANSAS

Flooding usually occurs quickly when precipitation exceeds infiltration and then exceeds channel capacity. Preparations to warn of flooding, protect infrastructure, and prevent sediment and nutrients from entering water bodies can decrease adverse effects and duration of impacts. Intense precipitation events also increase the presence of sediment, nutrients, and various pollutant loads in streams, which can ultimately end up in reservoirs that store flood waters. Once sediment enters a reservoir during a flood event, it is deposited on the lake bed, decreasing the available storage space needed to withstand future floods and droughts. Much of the state's lost storage in reservoirs can be attributed to inflows of sediment during flood events. Local and regional water utility infrastructure can also be at risk, threatening the delivery of safe drinking water to users.

In 2019, saturated conditions in the Great Plains early in the year were amplified by the wettest spring on record and additional summer rains. Thanks to the State's system of federal reservoirs, levees and watershed dams, Kansas was able to concentrate the majority of flood damage to our reservoirs and riparian corridors. This localized damage, however, came at a cost to Kansas. Significant water storage space was lost in our reservoirs due to the substantial sediment and debris inflows. Low-lying riparian areas, often accompanied by productive farm ground, public infrastructure, and other assets, endured the erosive forces of flood waters and long periods of inundation.

Flooding in Elmdale, KS - May 8, 2019.
Photo Credit: Chase County Emergency Management Director Scott Wiltse.

Reduce Vulnerability to Extreme Events

During the 2019 flood disaster, the Kansas Department of Agriculture-Division of Water Resources (KDA-DWR) reported only 10.0% of homes within Kansas' mapped floodplains were carrying flood insurance through the National Flood Insurance Program (NFIP). They also reported that the 287 NFIP claims made in Kansas during that time totaled $3.78 million.

Floodplain maps provide guidance for local land use planning. However, other considerations often take precedence when development occurs in floodplains. Mapping these flood prone areas is an ongoing effort that requires in-depth analysis of floodplain characteristics, fluvial morphology, and planning for increased flood magnitudes. Ultimately, the effectiveness of real-time hydrology information is reliant on our ability to share the information with multiple user groups.

Additionally, the State oversees the permitting, construction, and inspection of our smaller watershed reservoirs. As these structures age, they become less functional and a potential breach danger to downstream residents if not properly maintained.

Water utilities tend to be vulnerable to flood events due to their proximity to surface water resources. Water treatment intakes may be compromised by a blockage or loss of power. Wastewater systems can be overwhelmed by stormwater entering municipal sewer systems and may also be over-topped by adjacent floodwater.

The development of vulnerability assessments and emergency plans is key to minimizing these disruptions of safe water to Kansans. Managing a flood event requires well-developed procedures for communication between forecasting agencies, emergency responders, government officials, utility providers, and the general public. Real-time information on weather, stream flow, reservoir storage, levee integrity and other items are used to inform the State's emergency operations. The Kansas Division of Emergency Management (KDEM) provides guidance for hazard response in the 2017 Kansas Response Plan and information on mitigation in the 2018 State Hazard Mitigation Plan.

Businesses halted during the Summer 1952 flood that hit Manhattan, KS. Store fronts were destroyed and merchandise floated down Poyntz Avenue. Photo Credit: Kansas State University, 1952 Royal Purple.

Reduce Vulnerability to Extreme Events

DROUGHT IN KANSAS

Each year, drought costs the United States an average of $8-9 billion, as estimated by the USGS[11]. Kansas is one of the many states with a history of significant impacts from drought. In recent years, drought-related losses in Kansas have been particularly significant in agriculture. In 2017, Kansas ranked 2nd in the country for total crop acres. The total value of agricultural products sold in 2017 was $18.8 billion according to the USDA's National Agricultural Statistics Service[12].

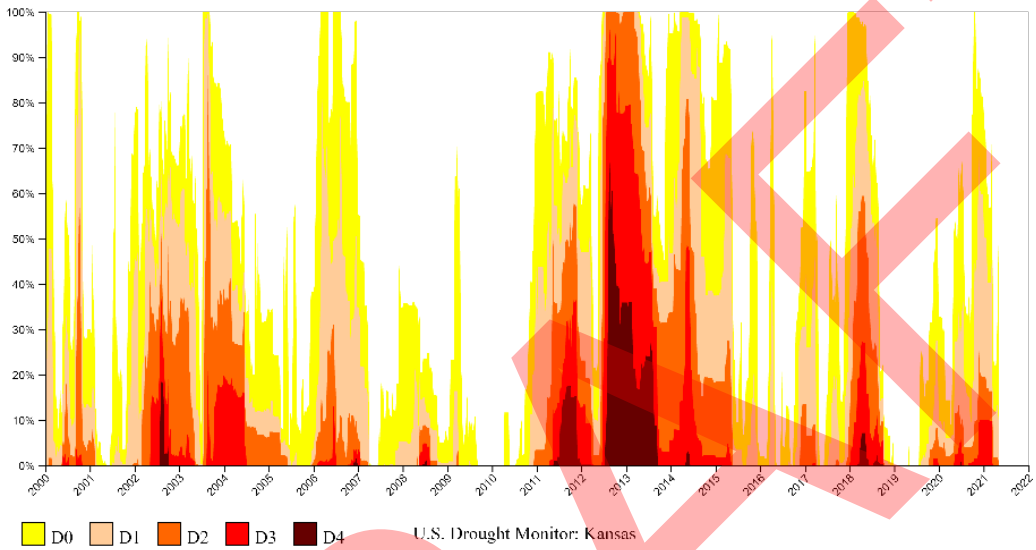
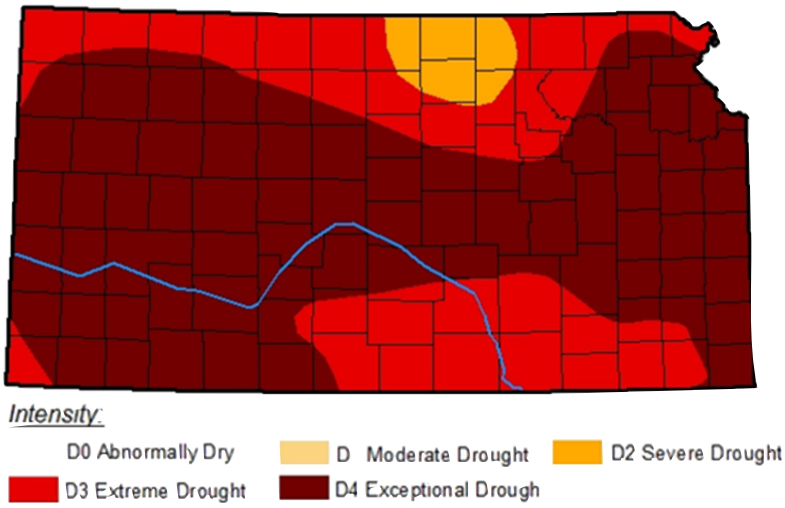


Figure 6. Drought in Kansas from 2000-Present (U.S. Drought Monitor: Kansas).

In 2011, however, the Kansas Department of Agriculture (KDA) estimated that drought caused roughly $1.8 billion in crop losses in Kansas including the price farmers would have received for lost production and nearly $366 million in drought-related herd liquidation to overfilled cattle livestock auction houses. Even more destructive, the 2012 drought caused more than $3 billion in drought-related crop losses in Kansas. Additionally, more than $1.3 billion in crop insurance indemnity payments for failed commodities were paid to Kansans in 2012 according to the U.S. Department of Agriculture's Risk Management Agency[13]. More recently, though less severe, the 2018 drought resulted in a drought declaration for the majority of the state with losses throughout the Great Plains and Southwest regions of the country estimated by the NOAA National Centers for Environmental Information (NCEI) at approximately $3.1 billion[14].

Figure 7. Kansas drought conditions in late August 2012[15] (Adapted from Brewer, 2012).



Reduce Vulnerability to Extreme Events

Adapting to changing conditions and minimizing harm from severe droughts is vital for Kansas water resource management and agriculture. The use of cover crops can help reduce vulnerability to drought by increasing soil pore space, which increases infiltration, reduces evaporation, keeps soils cooler, and positively impacts yields during drought. Additionally, no-till or strip-till farming practices, along with drought tolerant crops and decision-support tools such as irrigation scheduling and crop water allocation planning can help manage risk. A number of federal and state lakes provide an alternate water supply for livestock during droughts. Whatever measures are taken, maximizing conservation practices and efficient water use during a drought is critical.

Clearly, even a single year of extreme drought can result in severe agricultural impacts. Drought impacts, however, are not limited to agriculture. Intense flash droughts can rapidly impact water supplies. With approximately two-thirds of the Kansas population relying on surface water for municipal and industrial needs, depletion of these resources creates a significant strain on communities and businesses. Water system operators must monitor, plan, and coordinate to minimize drought impacts.

Governor's drought tour, 2012.

A field of corn withers under triple-degree heat north of Wichita, during the most recent drought. Photo Credit: Mike Hutmacher, July 2012.

Maximizing conservation practices and efficient water use during a drought is critical.

Reduce Vulnerability to Extreme Events

DROUGHT PLANNING

For communities using a common source of supply, drought plans should be consistent in use restrictions to minimize societal issues of fairness and equity. Alternate supplies also need to be developed for Public Water Supply (PWS) systems vulnerable to drought. Where possible, regionalization through the interconnection of water supply systems should be considered to help address drought vulnerability. In addition, efforts to identify and repair existing aging public water supply infrastructure should be continued and expanded.

Ultimately, drought mitigation planning is needed by all sectors that use water. Additional storage of water in reservoirs or aquifers would give Kansans greater ability to manage potential changes in precipitation timing, duration, and frequency, such as extended dry spells. This can be accomplished through conservation practices to extend and conserve groundwater resources, building or purchasing additional storage, or the recovery of existing surface water storage lost to sedimentation. All potential options for drought mitigation should be pursued to protect Kansans and the future economic health of the state.

Water tower in Kansas. Photo Credit: City of Hays.

MUNICIPAL WATER CONSERVATION PLANS[16]

Having a state-approved water conservation plan is a public water system's first line of defense against drought. Technical assistance for developing a plan is available through the Kansas Water Office (KWO) upon request. While there is no statutory requirement, a public-water supplier may be required to develop a water conservation plan as a condition of a water right, involvement in a program or as a condition of a grant or other funding. Many suppliers recognize the value of water conservation for their community and voluntarily develop water conservation plans. The Kansas Rural Water Association provides technical assistance for developing municipal water conservation plans through the State Water Plan Fund (SWPF).

PUBLIC WATER SUPPLY EMERGENCY RESPONSE PLANS (ERPS)[17]

Kansas Department of Health and Environment (KDHE) requires the development of ERPS plans to address threats to a public water supply and steps to restore the safe delivery of water following a natural or man-made disaster. Drought plans are currently not a requirement, but are a suggested action plan of the ERPS.

Reduce Vulnerability to Extreme Events

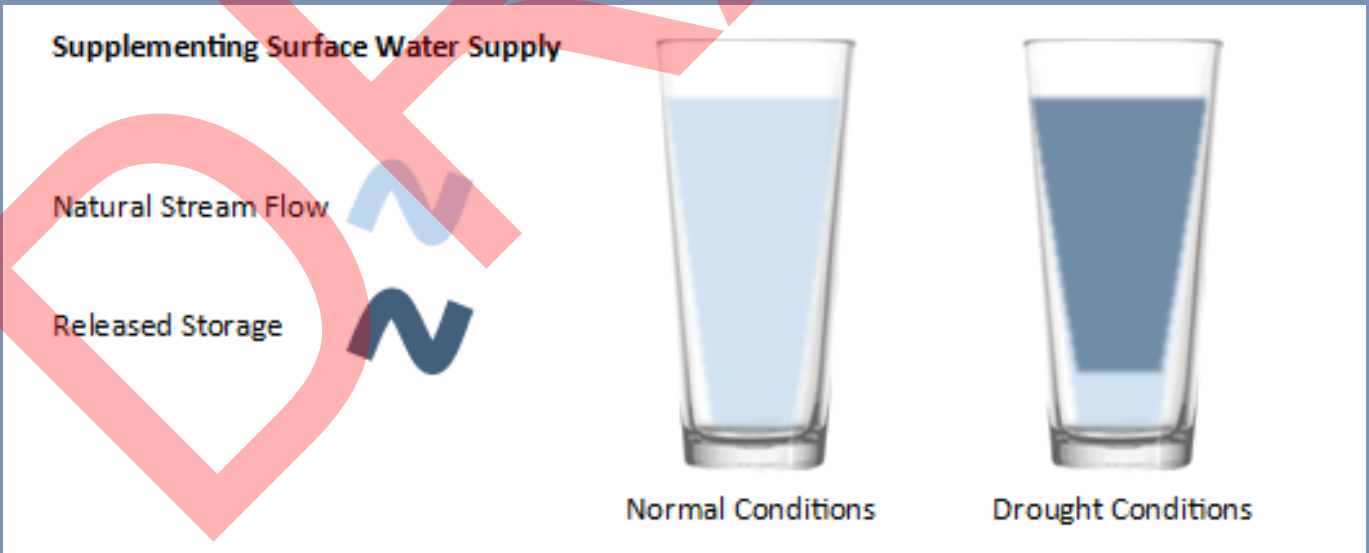
Management Approach

Kansas relies heavily on access to surface and groundwater water resources for everyday use. When managing through extreme events, these storage resources play a critical public safety role in fighting drought or holding back flood water.

RESERVOIR MANAGEMENT THROUGH FEDERAL PARTNERSHIP

The United States Army Corps of Engineers (USACE) and the United States Bureau of Reclamation (USBR) operate the State's federal reservoirs primarily for flood control. During a flood event, reservoir operations by these federal agencies are designed to minimize flood damage to entire basins across multiple states.

All 24 federal reservoirs also provide critical water supply during times of drought. The majority of water supply in USBR reservoirs is used to meet irrigation demands, generally in western and central Kansas. USACE reservoirs are predominantly in eastern Kansas and are primarily used to satisfy municipal and industrial needs. These are operated cooperatively between the USACE and the KWO. During drought, the majority of flow in a river is actively managed with prescribed releases from USACE reservoirs, often providing the majority of water needed.



Reduce Vulnerability to Extreme Events

MANAGING DROUGHT

In addition to the management of reservoir storage, the KWO is responsible for monitoring drought, publishing drought reports, and notifying the Governor when drought conditions exist within the state. The KWO monitors conditions through numerous federal and state climate, weather, agricultural, and agency tools to compile and track pertinent conditions in Kansas. Coordination of drought response activities in Kansas is accomplished through the Governor's Drought Response Team, which is charged with monitoring conditions, coordinating resources, and supplying the Governor's Office with updates or recommendations to deploy additional resources as needed. The use of Kansas water resources in times of shortage is guided by the Kansas Water Appropriation Act and the State Water Plan Storage Act. The Director of the KWO serves as the committee chair and advises the Governor when to assemble this team, which represents 11 state and federal agencies.

ASSESSMENT, PREVENTION AND RECOVERY

The State of Kansas has developed programs within multiple agencies tasked with floodplain management and mapping, non-federal dam safety, flood control lake development, disaster response planning, hazard mitigation, and more. Additionally, the State engages with many federal agencies that supply information on weather forecasts, river conditions, damage estimates, and disaster relief for qualified applicants.

Dry soil. Photo Credit: K-State Research and Extension.

Reduce Vulnerability to Extreme Events

Measuring Success

In Kansas, our best measure for extreme event resiliency is economic impact. A high economic impact from flooding or drought suggests vulnerability or inability to withstand such an event. From 1980 to 2021, 6 flooding and 17 drought billion-dollar (CPI-adjusted) disaster events affected Kansas[14] (figure 7). Weather and climate disaster statistics are collected and distributed by NOAA's National Center for Environmental Information. Assessment data are provided by a number of sources including insurance companies and state and federal agencies.

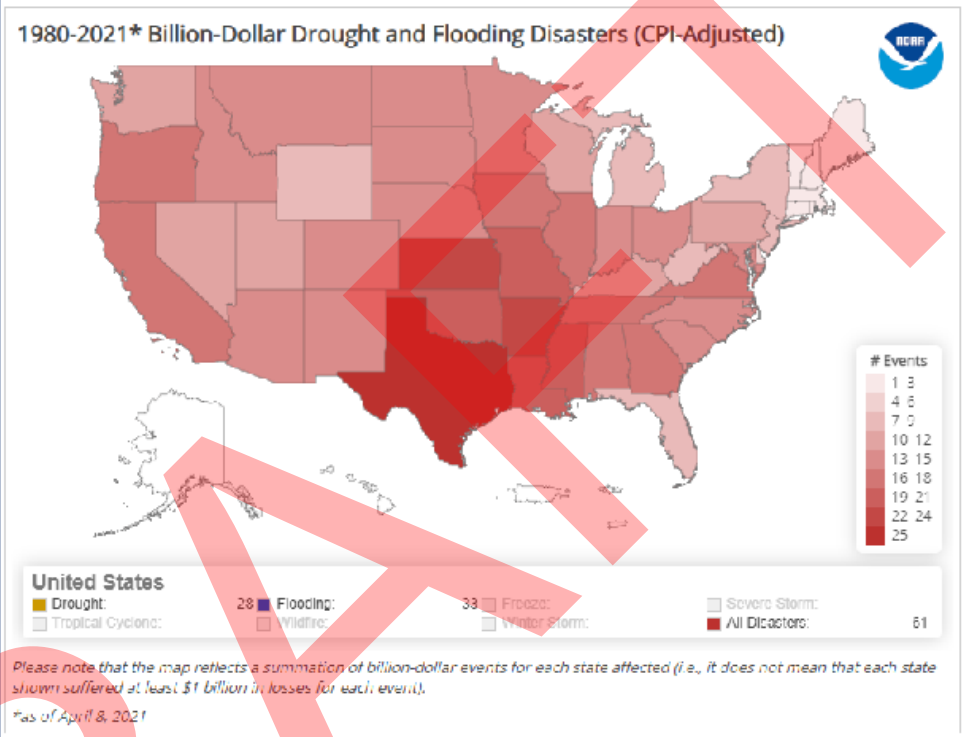


Figure 7: 1980-2021 billion-dollar drought and flooding disasters.[14]

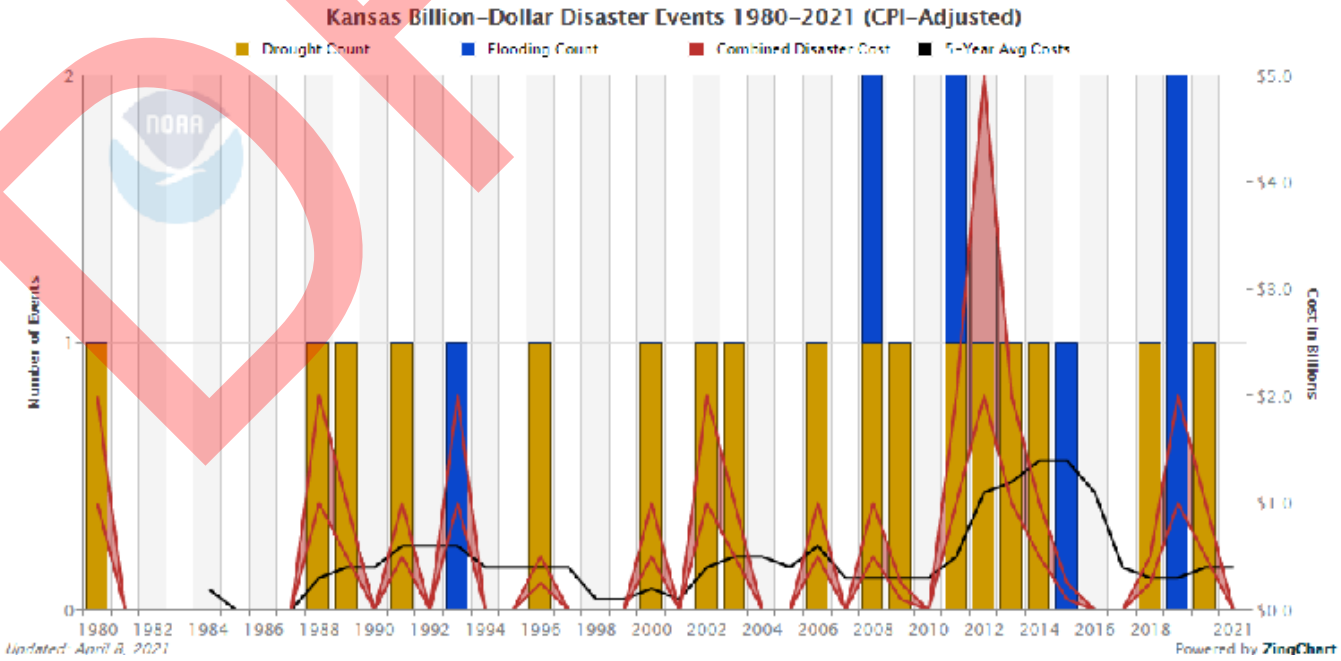


Figure 8: 1980-2021 billion-dollar disasters.[14]

Reduce Vulnerability to Extreme Events

Recommended Actions

In response to the increasing frequency of natural disasters across the country, federal assistance programs are shifting focus to projects that reduce or eliminate the risk of repetitive damage. The National Institute of Building Sciences has found that the economic benefits of hazard mitigation significantly outweigh the costs of damages by as much as 6:1 when using traditional cost-benefit analysis. Typically, federal programs require a portion of state or local cost share. This effort to spend federal dollars more efficiently has created a competitive environment among states to put forth well-informed and partially funded mitigation projects. These projects require stakeholder engagement, planning, engineering, and capital. It is critical that the State of Kansas engage in this process in order to join our neighboring states in minimizing extreme event impacts in the future.

Recommended Actions and Strategies - Flood

Policy or Program Recommendations

- Improve collaboration between state, federal, and public stakeholders and encourage pooling of resources to enhance flood planning and response.
- Pursue better coordination of data sharing and public information.
- Ensure that Kansas is represented in interstate discussions of flood-related issues.

Implementation Actions

- Assemble a group of subject experts to identify the areas of greatest need and opportunity, improve flood planning and response, and determine the best path forward.
- Compile critical flood information currently spread across several agencies into a single, publicly-accessible location with a user-friendly interface.
- Continue the development of real-time flood inundation mapping and other water-related disaster support tools and resources in Kansas.
- Work with state and federal agencies and emergency managers to develop a methodology for assessing damages to stakeholders from floods in a timely manner.
- Develop flexible reservoir management strategies that provide the ability for precautionary drawdowns if there are indications of coming flood conditions.
- Promote the use of dry dams and flood easements to temporarily hold flood water behind roadways or other opportunistic land features.
- Support monitoring to evaluate the impact of flood conditions on water quality, such as debris and nutrient runoff, and incorporate identified concerns into flood management strategies.

Data, Research, and Studies

- Work with state and federal partners to identify existing data gaps, including needs for additional stream gages within the monitoring network to improve river forecasting.
- Continue the development of advanced flow modeling for future flood planning, and identify basins lacking the data necessary to support more sophisticated modeling methods.
- Evaluate past climate and stream gage data, current climate trends, and projections for extreme event frequency, size, and duration in Kansas to update flood planning based on such statistics as appropriate.
- Support efforts to improve forecasting to predict extreme conditions and pursue flexible reservoir management strategies that maximize the benefit of such information.

Reduce Vulnerability to Extreme Events

Funding and Resource Needs

- Shift focus from reactionary to preventative, emphasizing mitigation efforts that reduce or eliminate the risk of repetitive flood damage, and be more competitive for funding from federal assistance programs.
- Determine existing infrastructure needs to repair damage from past floods and prevent additional losses from occurring in the future.
- Prioritize sustainable development and avoid rebuilding in the floodplain to reduce repetitive damages.
- Work with federal partners to maximize matching funds and pursue cost-effective measures that address data and infrastructure needs.

Recommended Actions and Strategies - Drought

Policy or Program Recommendations

- Prioritize the conservation and maintenance of existing water storage, both surface water and groundwater, to ensure sufficient supply under future drought conditions.
- Ensure sufficient staff and in-state expertise to optimize drought planning strategies
- Develop and promote new drought mitigation tactics for water managers to utilize through an updated water conservation planning document.
- Ensure that Kansas is represented in interstate discussions of drought-related issues.
- Encourage communities to maintain and manage local public water supply systems.

Implementation Actions

- Develop sediment management plans for water supply reservoirs, emphasizing sustainability and the restoration and protection of reservoir storage where feasible.
- Develop flexible reservoir management strategies that provide the ability to eliminate drawdowns and increase water storage if there are indications of coming drought conditions.
- Utilize Best Management Practices (BMPs) and conservation practices, such as cover crops, no-till or strip-till, drought-tolerant crops, irrigation scheduling and crop water allocation planning to prepare for and reduce negative impacts from drought.
- Make drought plans a mandatory component of emergency plans.
- Conduct drought simulation exercises to educate the public and identify gaps in conservation efforts and incorporate drought simulation efforts into state hazard planning and seek funding and support for efforts from federal partners.
- Develop informational resource for eastern Kansas, similar to the Estimated Usable Lifetime of the Ogallala Aquifer, that shows municipalities and other public water suppliers at greatest risk today, in the immediate future or in the long-term of having insufficient water supplies to serve area's needs through drought.
- Update water conservation plan guidelines and ensure all communities and rural water districts have current water conservation and drought management plans.
- Consider development of rural water districts in areas where domestic groundwater supplies have been depleted or are unusable.
- Educate landowners on the importance of groundwater conservation, the need for sustainable practices, and encourage participation in existing programs.

Reduce Vulnerability to Extreme Events

- Implement urban stormwater runoff capture and reuse in areas where such storage and reuse may serve as an additional source of supply without impairing water quality.
- Evaluate state-owned facilities for water conservation effectiveness and develop standards for new state construction or renovation with consideration for existing standards such as LEED.
- Support monitoring to evaluate the impact of drought conditions on water quality, such as harmful Algal Bloom (HAB) occurrence, and incorporate identified concerns into drought management strategies.

Data, Research, and Studies

- Investigate and pursue innovative sediment management technologies, such as Water Injection Dredging (WID) and hydrosuction, to preserve reservoir storage and pass sediment downstream.
- Improve forecasting to predict extreme conditions and pursue flexible reservoir management strategies that maximize the benefit of such information.
- Investigate the potential for water supply reallocations in Perry and Milford Reservoirs to ensure sufficient storage for water quality releases.
- Evaluate past climate and stream gage data, current climate trends and, projections for extreme event frequency, size, and duration in Kansas to update drought planning based on such statistics as appropriate.
- Develop advanced models that incorporate climate variability modeling into the water supply model to optimize drought planning strategies.
- Investigate the potential for technologies like aquifer storage and recovery (ASR), artificial recharge, and dry dams to reduce runoff and evaporation losses.

Funding and Resource Needs

- Work with the legislature and federal partners to identify consistent funding to maximize matching opportunities related to reservoir management and agriculture.
- Prioritize funding for the development of sediment management plans and pilot projects.
- Expand in-state expertise related to drought forecasting, modeling, and planning and secure sufficient funding to address any staffing needs that are identified.
- Pursue funding necessary to assist and incentivize landowner participation in groundwater conservation programs.

Actions should consider both short and long-term economic and environmental impacts to communities, agriculture producers, the energy sector, transportation infrastructure, and recreation facilities. Ultimately, reducing vulnerability to extreme events in Kansas is best accomplished by acknowledging the risks and mitigating likely impacts from flooding or drought. This requires plans and actions that will assure the safety of our citizens and provide a clean, sufficient water supply to Kansans.

Reduce Vulnerability to Extreme Events

Resources

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Increase Awareness of Kansas Water Resources

Increase Awareness of Kansas Water Resources

Background

As the *Long-Term Vision for the Future of Water Supply in Kansas* (*The Vision*) was being developed and more than 600 public input meetings were held across Kansas, one message heard repeatedly was the need for increased education and outreach for Kansans of all ages on water resource issues within the state. While there are many existing water-related educational programs available for both youth and adults, it was noted through these public input meetings that a central message and coordinated educational resources were lacking in helping to better connect users to their Kansas water resources.

Many of the action items previously developed in association with *The Vision*, as well as some goals developed by Regional Advisory Committees (RACs), highlight the need for additional development of a state-wide water message and a "one-stop-shop"[1] for information and learning resources. To meet this goal, an inter-agency and inter-organizational coordinating team was previously developed in 2015. This team met throughout 2016 and hosted a series of outreach meetings to solicit input into the development of statewide education and public outreach materials as well as to develop tangible action plans aimed at strengthening Kansans' knowledge and awareness of water and water-related issues. From those meetings, a *Vision Education Public Outreach Supplement Section* was created and now serves as the foundation for the Kansas Water Plan Guiding Principle: *Increasing Awareness of Kansas Water Resources*.

KACEE Field Day.

Included within this document are overarching principles which directed the development of the *Vision Education Public Outreach Supplement Section* to *The Vision*. These overarching principles will continue to serve as precepts for this guiding principle. No actions are intended to displace current water education programs. Instead, these initiatives are designed to promote such programs and to encourage the development of complementary programs.

Long-standing water education programs include: youth conservation poster and essay contests hosted through the County Conservation Districts, local community water festivals, Kansas Association of Conservation and Environmental Education (KACEE) Project WET, as well as the Awesome Aqua magazine and natural resource educator's guides developed through Kansas Foundation for Agriculture in the Classroom[2]. KACEE, Kansas Department of Wildlife and Parks (KDWP), Conservation Districts and others provide an avenue for delivery of critical information.

The initiatives and concepts described are strategic in nature and, as such, do not describe the details of the implementation of the initiatives. The initiative implementation plans will be developed following the approval of the initiatives. Any local, regional or state agency, educational institution, non-government organization, private company or individual stakeholders interested in water education programs are invited and encouraged to provide input and feedback regarding the

Increase Awareness of Kansas Water Resources

implementation plans and to participate in these initiatives. These initiatives will be unified through a social marketing campaign and the *Kansas Runs on Water website*[3]. All strategies and action items for this principle support *Kansas Water Plan (KWP)* implementation and associated priorities.

Measuring Success

This collaborative effort represents an opportunity to build upon and maximize the many successful education organizations and activities currently in place in Kansas. While we have many successes related to water resource education in Kansas to celebrate, gaps still exist and opportunities to strengthen Kansans' knowledge and awareness of water and water-related issues remain. Filling the gaps and success in the end will require everyone on all levels working together with a common goal of conserving and protecting our water resources for future generations.

Measuring success may be recognized in numerous ways with varying metrics. Success may be simultaneously measured based on improving attitudes towards water conservation, motivation, cooperative behaviors, and confidence in knowledge of where water comes from, in addition to physically measurable results based on monitoring. Establishment of region-specific, targeted improvements for household, agricultural, and industrial/municipal water conservation will need to be made. These measures will be shared through community outreach, workshops, and educational events[4]. The value of water education is held deeply by Kansans and is documented in the Goals and Action Plans[5] for the RACs across the state (figure 1).

Field Day.

Region	Education & Outreach-Related Goals				
	Goal 1	Goal 2	Goal 3	Goal 4	Goal 5
Cimarron		X	X	X	
Equus-Walnut	X	X	X		X
Great Bend Prairie	X		X	X	X
Kansas			X		X
Marais des Cygnes	X	X	X		
Missouri			X	X	
Neosho	X				
Red Hills	X				
Smoky Hill-Saline		X	X	X	
Solomon-Republican					
Upper Arkansas	X				
Upper Republican		X		X	X
Upper Smoky Hill	X	X	X		

Figure 1: RAC Education and Outreach Related Goals

Increase Awareness of Kansas Water Resources

Recommended Actions

Recommended Actions and Strategies - Education

Policy or Program Recommendations

- Appoint an advisory group to establish Kansans' baseline knowledge of water issues[6].
- Create a long-term commitment to water conservation[7].
- Enhance educational programming for local, state, and federal policy makers and officials.
- Encourage the development of higher education water and agricultural industry-related educational programs and research.
- Utilize agricultural education, 4-H, and FFA to incentivize young people.
- Create incentives to recruit businesses and focus economic development on businesses that demonstrate water conservation, efficiency, and/or reuse.

Implementation Actions

- Enhance and maintain the statewide marketing campaign and water resource information sharing through the *Kansas Runs on Water* campaign and website.
- Develop and implement Kansas water-related educational resources/curriculum.
- Create opportunities for collaboration between those involved in youth water education.
- Hold a statewide Summit on Water Education for educators and educational organizations.
- Develop a grant program for water education organizations and RACs.
- Develop a grant-sponsored internship/mentorship program in water-related careers.
- Launch, promote, and award financial resources for statewide water education program.
- Provide recognition and awards to youth for water-related projects.
- Establish and hire Community Outreach Specialist position(s).
- Develop an education/training strategy to establish and share targeted improvements for household, agricultural, and industrial/municipal water quality and quantity-related conservation, as well as reuse and lower quality water.
- Develop workshops, programs, educational materials and professional development opportunities for both educators and multiple water-related career paths.
- Hold a "Kansas Water Day" statewide experience with activities that highlight the value and importance of a reliable, long-term water supply.
- Develop a rewards/recognition program for demonstrated water conservation.

Data, Research, and Studies

- Establish baseline knowledge of Kansans' comprehension of water issues and assess periodically.
- Share regional and statewide information on current groundwater, surface water, water quality, and water storage conditions.
- Continue evaluation and information sharing on the economic impacts of reduced water use, conservation practice implementation, land management, and/or reuse for multiple user groups.
- Evaluate higher education institutions' current academic offerings and identify water-related courses and curricula.
- Complete and evaluate U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA) funded grant projects.

Increase Awareness of Kansas Water Resources

- Improve adoptability of alternate crops and other less water intensive crops through research and education.
- Coordinate with university researchers and agency partners on collaborative *KWP* research needs supporting implementation efforts.
- Coordinate with local water management districts to develop on-line water availability tool that could be used by individuals, organizations, local entities and consultants to evaluate potential water development or management projects.
- Conduct economic analyses to estimate impacts to individual, regional, and statewide economies associated with a variety water resource management decisions.
- Create decision-making tools for stakeholders highlighting economic benefits of adoption.
- Provide needed research and education that leads to increased adoption of cover crops to reduce field soil loss while improving overall soil health.

Funding and Resource Needs

- Financial resources needed to fully implement the recommended strategies and actions for *Increasing Awareness of Kansas Water Resources* could be in excess of $1,000,000 per year, depending on the extent to which a full education and outreach campaign is implemented.
- Leverage funding through collaboration amongst participating agencies.
- Establish collaborative research proposals that implement Kansas Water Plan towards which funding could be directed as grant and other funding opportunities arise.

Increase Awareness of Kansas Water Resources

Resources

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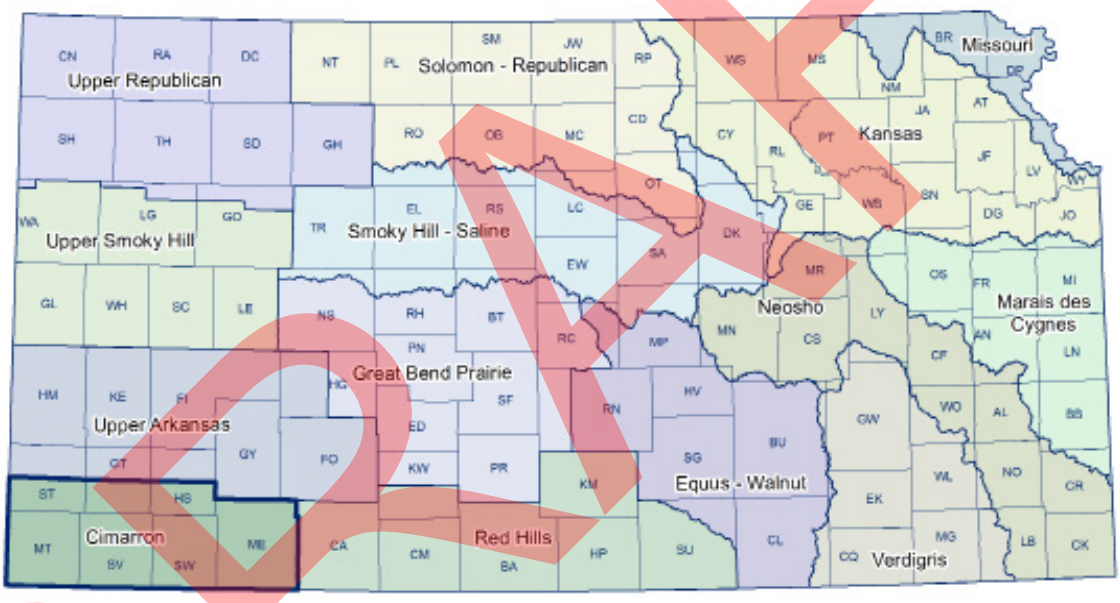
Cimarron Region



Cimarron Region

Regional Description

The Cimarron Regional Planning Area is located in the southwest corner of Kansas covering 3,995 square miles, including all of Meade, Morton, Seward, and Stevens counties and the southern portions of Grant, Haskell, and Stanton counties (Figure 1).

The Cimarron Region is bordered by Oklahoma on the south and Colorado on the west.

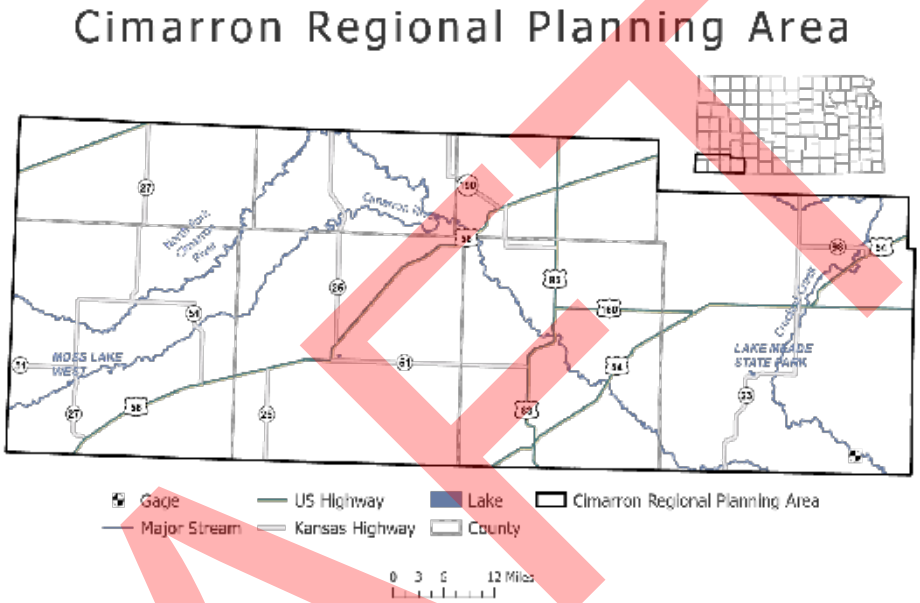


Figure 1. Cimarron Regional Planning Area

CLIMATE & LAND USE

The climate of the region is characterized by moderate to low precipitation, relatively high wind velocities, a wide range of temperatures, and abrupt weather changes. Average annual precipitation varies from 16 inches in the west to 22 inches in the east (Figure 2). The high winds and low humidity of the region contribute to a high evaporation rate.

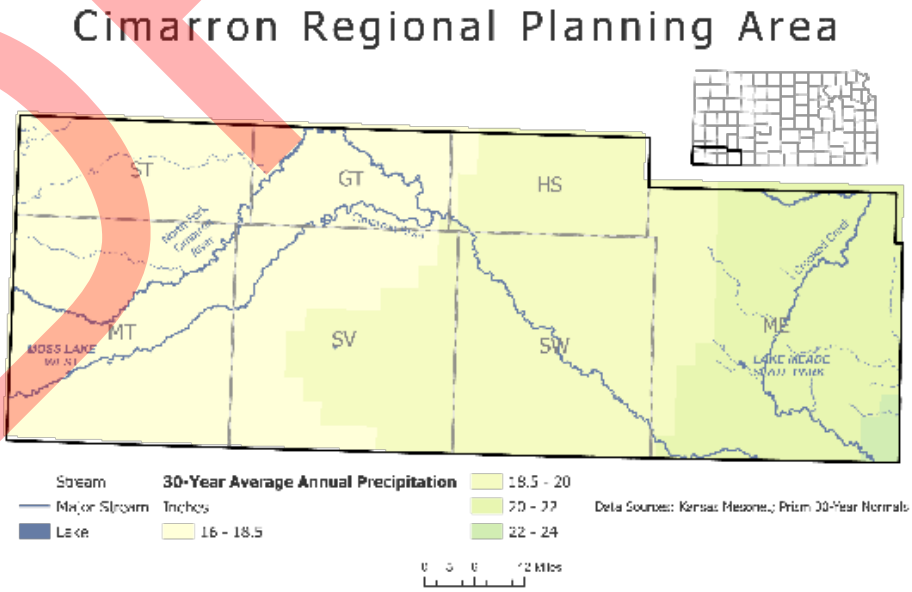


Figure 2. 30-year average annual precipitation in the Cimarron Region

Cimarron Region

The Cimarron Region is located within the High Plains physiographic region, which is comprised of rolling sand plains, rangeland, and cropland. The longest stretch of publicly-owned riparian habitat in Kansas is located within the Cimarron National Grasslands. Rock cliffs, cottonwood groves, grassy fields, yucca, and sage brush are scattered throughout the land. Seasonal variety is provided by native grasses and riparian vegetation along the Cimarron River. Land use activities can have a significant impact on the region. The three major land uses in this region are cultivated crops (57%), herbaceous (26%) and shrub/scrub (11%) as derived from the National Land Cover Database (NLCD) 2016 dataset. Figure 3 lists the remaining land uses in the region, including: developed/urban open space.

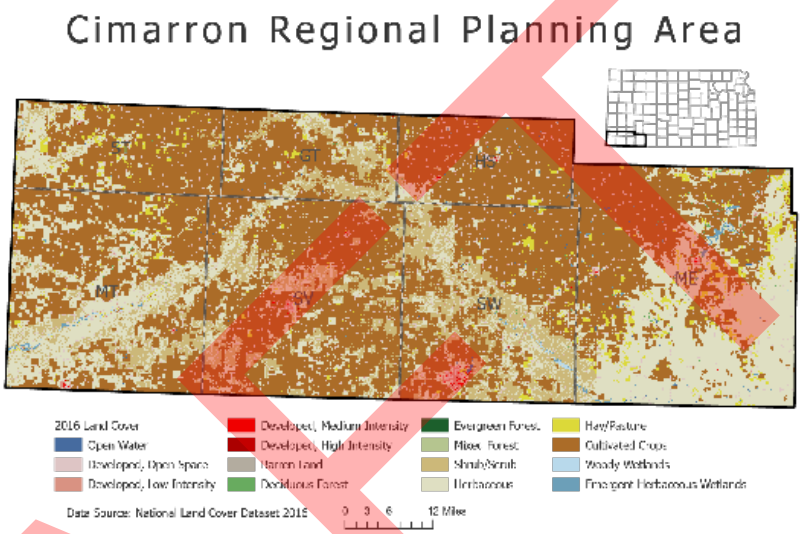


Figure 3. 2016 Cimarron regional land cover

Playa lake wetlands occur in the region, providing habitat for migrating birds and the aquatic organisms that support them. Mixed grass and sand sage prairie ecosystems dominate the region. Key wildlife species include the bobwhite quail, lesser prairie chicken, pheasant, turkey, deer, and pronghorn antelope.

POPULATION & ECONOMY

Based upon 2019 information derived from state-released information to the U.S. Census Bureau, there were an estimated 40,093 residents in the region. For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over or under represented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census (Figure 4).

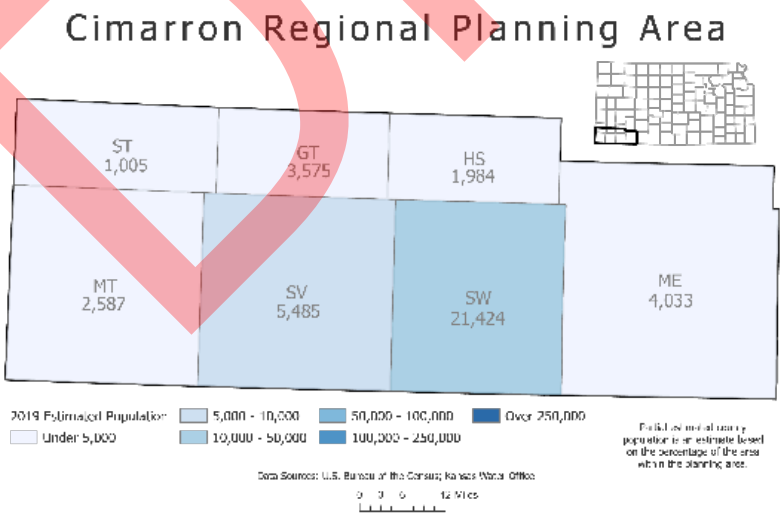


Figure 4. 2019 estimated population by county

It is anticipated that Stevens County will see limited population growth through the year 2070 while the other counties within the region are likely to remain stable or decline. With crops such as corn, cotton, hay, wheat, grain sorghum, and soybeans being grown, agriculture is the basis of the economy of the region. Livestock production of cattle and hogs is an important part of the area's agriculture; this includes both feedlots and ranching. Beef processing and a growing dairy industry are also major contributors to the economy, as is energy production including oil, gas, and biofuel production.

Cimarron Region

Primary Water Resources in the Region

SURFACE WATER

The majority of the region is drained by the Cimarron River and tributaries, the North Fork of the Cimarron and Crooked Creek (Figure 5). The Cimarron River flows into the Arkansas River near Tulsa, Oklahoma. Streamflow of these sources has not been sustained within the Cimarron Regional Planning Area. They have characteristics of ephemeral streams with localized flow for brief periods in response to rainfall and climatic events.

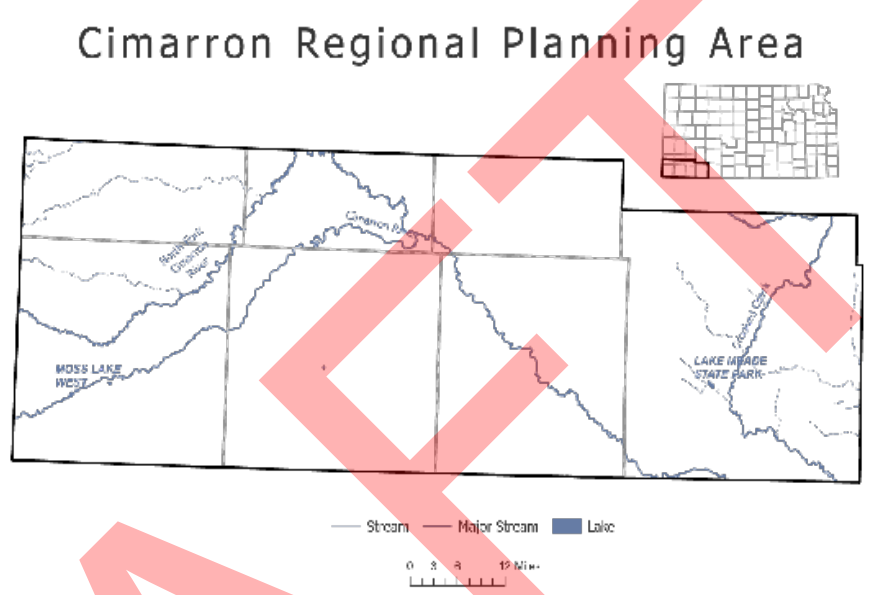


Figure 5. Major water resources in the Cimarron Region

Playas lakes are present throughout much of the region. These shallow and ephemeral ponds that are seen after rainfall events can act as areas of enhanced groundwater recharge and provide habitat for many species of plants and wildlife.

GROUNDWATER

The principle aquifers (Figure 6) in the area include the Ogallala portion of the High Plains Aquifer (Ogallala Aquifer) and alluvial aquifer, as discussed in the *Kansas Water Plan (KWP) Conserve & Extend the High Plains Aquifer* section.

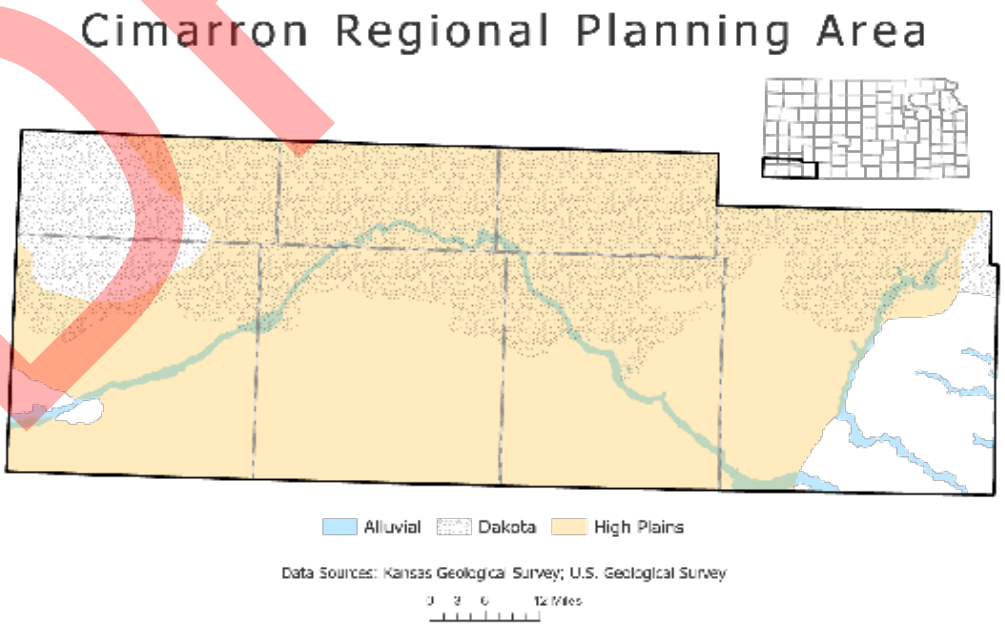


Figure 6. Principle aquifer boundaries in the Cimarron Region

Cimarron Region

The High Plains Aquifer consists of several hydraulically connected aquifers, the largest of which is the Ogallala (Figure 7).

The Ogallala Aquifer is distinctive from other aquifers in Kansas in that it generally has low annual recharge. The Dakota Aquifer is present in the region and is used where the mineral content is acceptable.

As noted in the *Improve the State's Water Quality* section, the Kansas Department of Health and Environment (KDHE) conducted a mineralization study looking at private wells in a portion of this region. The Dakota is hydraulically connected to the Ogallala Aquifer in some areas.

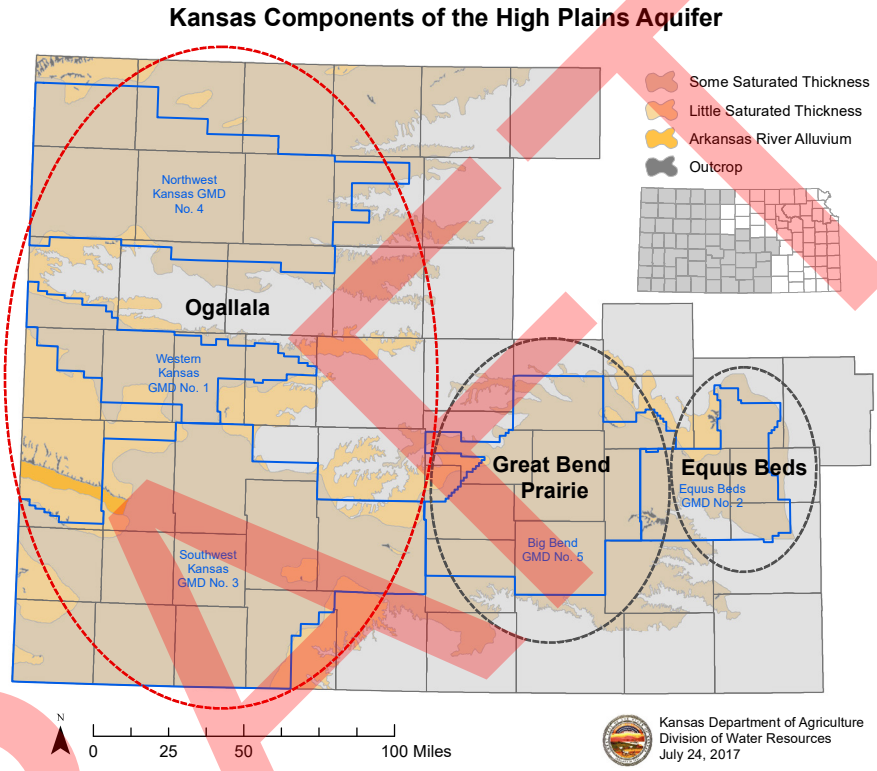


Figure 7. Kansas Components of the High Plains Aquifer, KDA

Primary Water Use by Source

GROUNDWATER

The primary use of groundwater sources within the region is irrigation, accounting for 96% of the reported groundwater usage within the region. The remaining reported usage comes from municipalities, stockwater, and industry (Figure 8).

The groundwater comes predominantly from the Ogallala Aquifer and alluvial deposits along major streams.

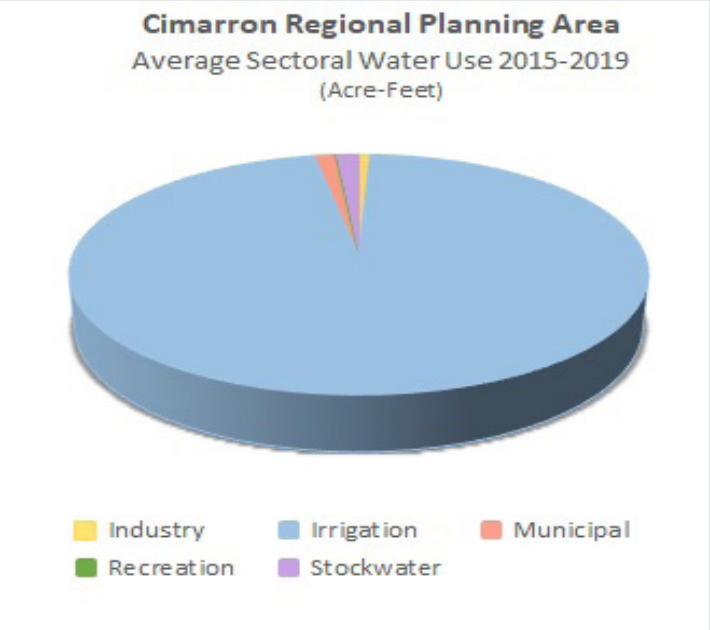


Figure 8. Average sectoral water usage

Cimarron Region

Regional Issues & Priorities

OGALLALA AQUIFER LEVEL DECLINES

Since the 1970s, the Ogallala Aquifer, as detailed in the *Conserve & Extend the High Plains Aquifer* section, has been developed so extensively that the amount of water withdrawn annually is significantly more than the recharge, resulting in groundwater declines. Some areas are already experiencing shortages in meeting demand.

As groundwater level declines (Figure 9), the aquifer loses hydraulic connection with the overlying alluvial aquifers and rivers and no longer contributes much, if any, base streamflow. This loss of hydraulic connection between surface and groundwater within the region has caused streams to dry up between rain events. Kansas Geological Survey (KGS), in an effort to help develop a better understanding of the aquifer dynamics at a scale that would be appropriate for management, created the Index Well Program: a network of well-monitoring systems that aids in tracking water level changes while providing real-time data.

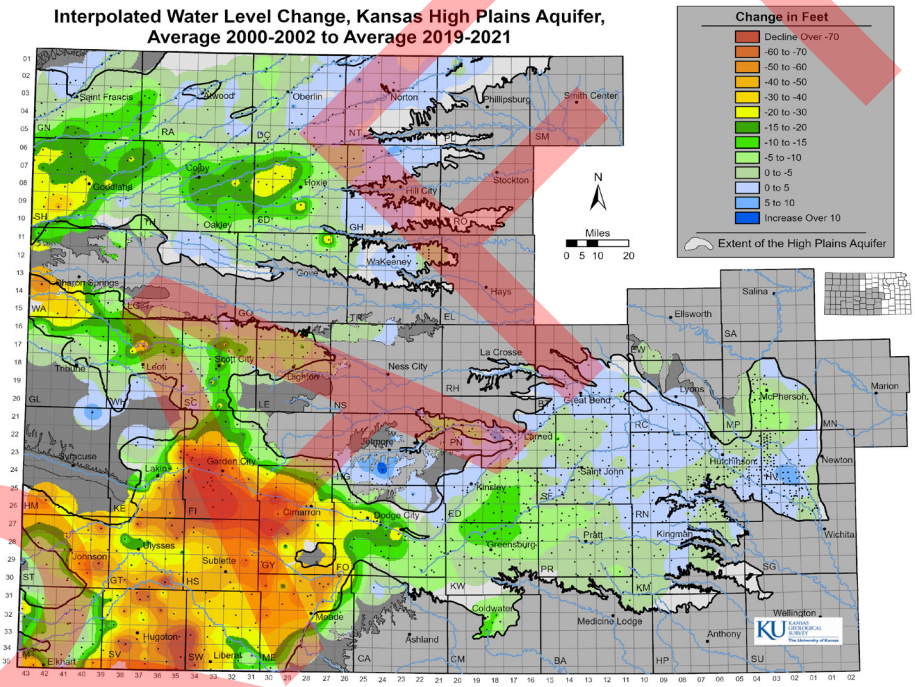


Figure 9. Water Level Change, Kansas High Plains Aquifer, KGS

The Ogallala Aquifer is characterized by low recharge and high declines. The expected "usable life" of the aquifer, when the aquifer is no longer able to support the current high rates of pumping, varies widely due to differences in the amount of saturated thickness, hydraulic conductivity, withdrawals, and other variables.

Water appropriations and use are overseen by the Kansas Department of Agriculture-Division of Water Resources (KDA-DWR). All of the streams and alluvial corridors in the region are either closed or restricted to new appropriations. Minimum desirable streamflow has not been established at any sites in the region, though many streams now flow only during rainfall events. Generally, the Ogallala Aquifer has no new appropriations available. In limited cases, a new water appropriation for groundwater, limited to quantities under 15 acre-feet, can be obtained within Southwest Kansas Groundwater Management District No. 3 (GMD3).

GMD3 is a water management entity in the region, overlying the Ogallala Aquifer in Grant, Haskell, Meade, Morton, Seward, Stanton, and Stevens counties. GMD3, incorporated in 1976, is charged with developing local water policy to conserve the aquifer that is compatible with state laws while promoting voluntary, incentive-based water conservation efforts with available tools and resources.

Cimarron Region

WATER QUALITY

Natural sources of chloride and sulfates have been found to impact the Cimarron River and Crooked Creek (Figure 10). Chloride concentrations may also be elevated in the Ogallala Aquifer and streams of the area from the upwelling of groundwater from the Permian formations below. This is especially true in the southern portions of eastern Seward and western Meade counties. Evaporite minerals in the Permian formations (halite, anhydrite and gypsum) are dissolved and moved upward as hydraulic head is reduced by aquifer pumping above, contributing to higher concentrations of chlorides in the area.

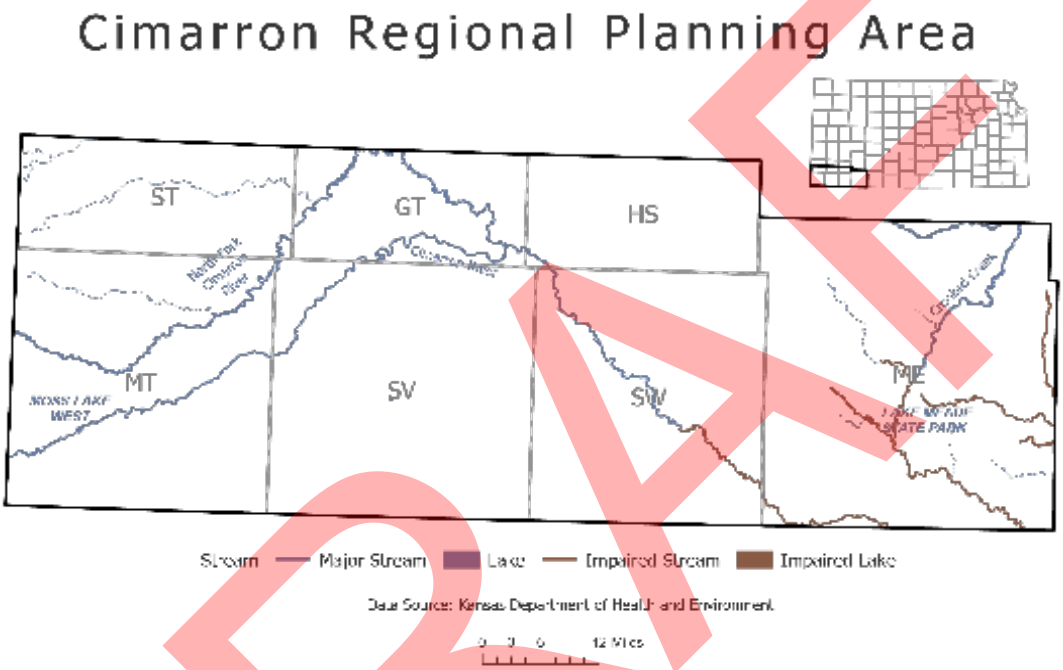


Figure 10. Impaired water resources in the Cimarron Region

The saline groundwater discharges into the Cimarron River in southeast Seward County and southwest Meade County. River salinity has increased as fresh groundwater discharge is reduced with the decline of groundwater levels. Crooked Creek and some of its tributaries also have impaired use due to chloride concentrations as a result of this same process.

All the counties within the region have adopted sanitary codes that can help to manage bacteria and nutrient inputs into surface and groundwater. All conservation districts in the region have adopted nonpoint source pollution management plans.

The Clean Water Act requires states to conduct Total Maximum Daily Load (TMDL) studies and develop TMDLs for water bodies identified on the State's List of Impaired Waters (Section 303(d) List). TMDLs are quantitative objectives and strategies needed to achieve the state's surface water quality standards. TMDLs have been developed in the region to address dissolved oxygen, pH, aquatic plants, and eutrophic conditions as the highest priority impairments.

Meade State Park. Photo Credit: KDWP

Cimarron Advisory Committee

Regional Goals & Action Plans

ACTION STEPS: (APPLY TO BOTH #1 & #2 GOALS

Priority Goal #1: Reduce the rate of decline of the Ogallala Aquifer in the region through voluntary, incentive-based conservation as assessed every five years.

- Define and quantify the regional aquifer decline, establishing a baseline for comparison.
- Promote steps/programs to ensure water quality. (Mention this mainly for the chloride area in the east part of region and also from past concerns of injection wells leaks and oil/gas drilling in the west).
- Monitor/promote/protect water coming into or protect water leaving the area (kind of goes in with the talks in past of meeting with water users from neighboring states and also the RACs past support for the monitoring well in Morton County that was denied).
- Work with partners, including KDA and NRCS, to develop baseline of water saving technologies in use and voluntary incentive-based conservation occurring and a method to track participation. Consider using the annual water use reporting system, producer surveys and other means to identify water-saving efforts if needed.
- Secure funding, including statutory State General Fund transfer to State Water Plan Fund, to support water conservation programs and evaluation of technologies, crop varieties and water management to save water.
- Provide water users with information on available tools and programs, including but not limited to; LEMAS, WCAs, Multi-Year Flex Accounts, Water Banks, Irrigation Scheduling,RCPP-Soil Probe program through GMDs, KWO Water Technology Farms, K-State Extension tools, K-State Research and additional tools and programs as made available.

Measuring success:

Goal 1: Initiate a LEMA within the region and increase the number of acres in WCAs.

Cimarron Advisory Committee

Regional Goals & Action Plans

Priority Goal #2:
Extend the usable lifetime of the Ogallala Aquifer in the region through technology adoption (irrigation, industrial, municipal, etc.), new crop varieties and conservation for all uses and for many generations.

ACTION STEPS:

- Change producer perception from a "use it or lose it" mentality.
- Use demonstration projects to educate producers to economically reduce water used. (KWO Water Technology Farms, LEMAS, WCAs, K-State Research and Extension farm projects and other water management and water efficiency projects can provide valuable examples and information to producers to encourage their participation in water saving efforts.).
- GMD3 and KDA-DWR work with producers to establish LEMAs and WCAs.
- Build a network of agencies, organizations, researchers, industry and producers to disseminate credible, accurate information on water use, conservation and technology, programs and tools to reduce water use.

    a. Utilize K-State and others to develop technologies and crop varieties to enhance water savings methodologies and deliver information.

    b. Work with producer and farm groups to reach other producers.

    c. Include municipal and industrial users in outreach.

    d. Include related industries such as banking, insurance and property valuation entities in outreach.

Cimarron Advisory Committee

Regional Goals & Action Plans

Priority Goal #2 Continued.

ACTION STEPS:

- Evaluate the effectiveness of technologies and crop varieties to develop voluntary incentives and tools to economically reduce water usage.

  a. Support KWO Water Technology Farms in the region for evaluation of technologies and management methods to reduce the current level of water use with a goal of at least one WTF in a water stressed area and one in a non-stressed area.

  b. Develop mobile drip irrigation (MDI) statistics so funds could become available for technology upgrades through state and federal programs.

  c. Work with federal partners to make additional water-saving technologies eligible for federal assistance programs.

  d. Disseminate to all users scientific and economic information on technology efficiencies and crop varieties as well as other relevant information from pilot studies, research and water tech farms.

- Use positive press releases to spread the word as WCAs are developed.
- Public water suppliers and industrial users should consider alternative uses of non-potable water and existing water supplies before developing any new water supplies.
- Public water suppliers should consider water rate structures to promote water conservation.

Measuring success:

Goal 2: Annually track the number of acres planted of water saving crop varieties and show an increasing trend.

Cimarron Advisory Committee

Regional Goals & Action Plans

Priority Goal #3: Encourage all water users to conserve and make the best beneficial use of water.

ACTION STEPS:

- Increase adoption of water conservation through education by those who are currently using the technology and adaption of a Master Water Manager program.
- Identify existing conservation success stories and share with area producers, industry or municipalities as applicable.
- Initiate demonstration projects with willing producers in the region (technologies, crop varieties and management techniques) to reduce water use.
- Develop format/program to allow water users to document current water savings, if not in an approved program.
- Work with municipalities to educate customers on beneficial water use.

Work with municipalities to develop meaningful water concentration strategies for their operations and customers, with demonstratable water saving results.

Measuring success:

Goal 3: Collaborate with agency partners to get an incentive-based certified master water irrigator program in the region that highlights water saving technologies.

Cimarron Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

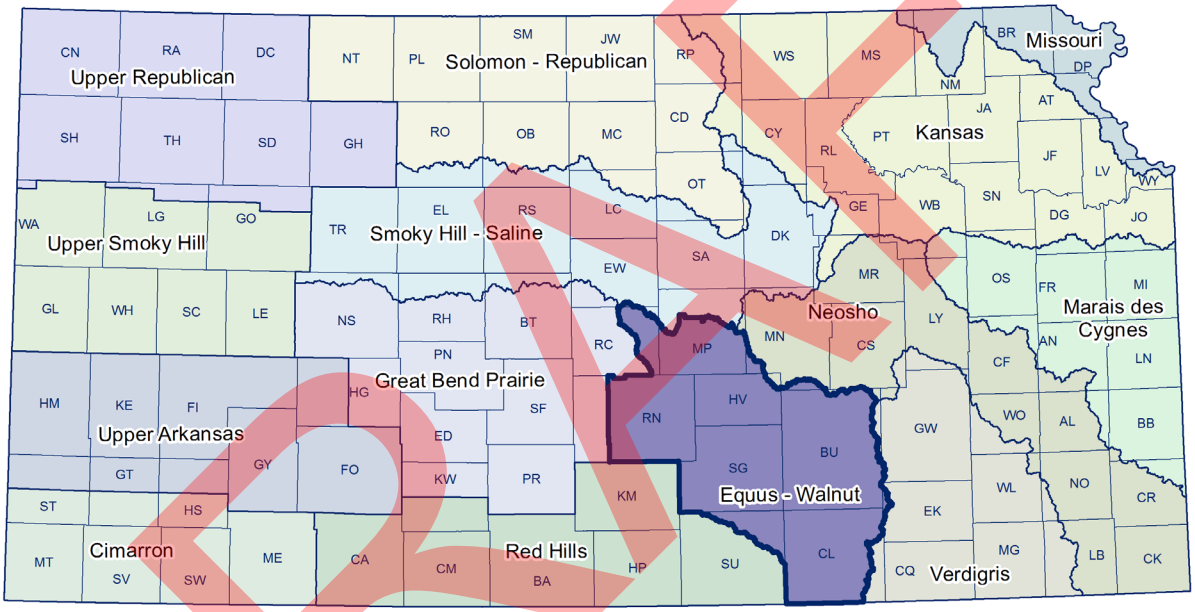
- Educate water users on new water-saving technologies through local papers, extension, meetings of producer groups, irrigation organizations, conservation districts, GMD3 involvement and other means.
- Develop and disseminate results from the use of water-saving tools by those who have adopted technology and management tools to economically reduce water usage.
- Use local demonstrations of KWO Water Technology Farms/ demo farms in region to share techniques.
- Provide WCA information, including dissemination with water use reports.
- Develop widespread awareness of EQIP, CRP, RCPP, CIG and other program availability and increase participation.
- Encourage improvement of municipal conservation plans, municipal rate structures and other means to encourage water use reductions.

Priority Goal #4:
As measured through increase in adoption by 50% as assessed each five years, promote the adoption of irrigation efficient technology and invest in university research to evaluate the effectiveness of such technology and crop varieties to develop voluntary incentives and tools to economically reduce water usage. Recommended strategy to achieve Goal - Increase adoption through education by those who are currently using the technology.

Measuring success:

Goal 4: Document education events/programs to students, producers, and communities and show an increasing trend in participation.

Equus-Walnut Region



Equus-Walnut Region

Regional Description

The Equus-Walnut Regional Planning Area is located in southcentral Kansas. The regional area is bordered by Oklahoma on the south, Great Bend Prairie and Red Hills on the west, Smoky Hill-Saline on the north, Neosho on the northeast, and Verdigris on the east.

The Equus-Walnut Regional Planning Area covers approximately 5,811 square miles and includes all of Harvey and Sedgwick counties, portions of Rice, Reno, McPherson, Sumner, Butler, and Cowley counties, along with very small portions of Chase, Elk, Ellsworth, Greenwood, and Marion counties (Figure 1).

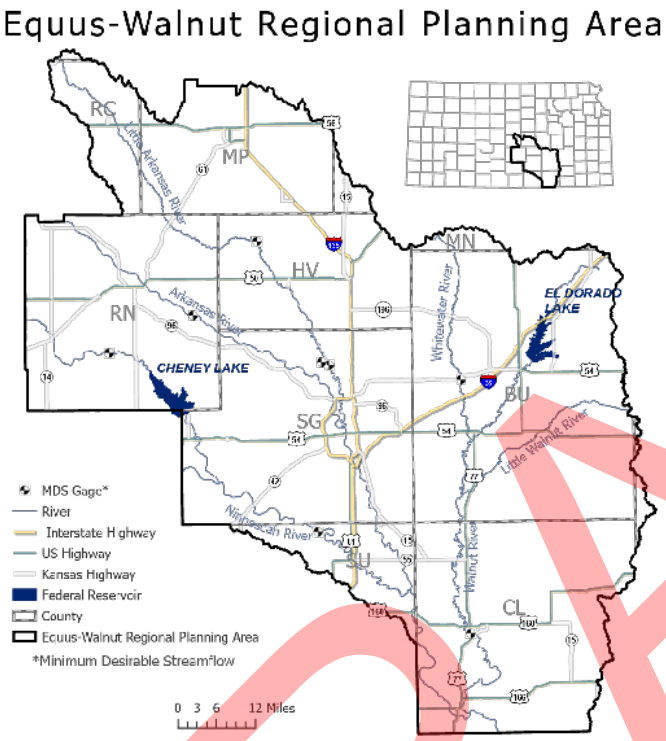


Figure 1. Equus-Walnut Regional Planning Area

CLIMATE & LAND USE

As is common across all of Kansas, the climate of the Equus-Walnut Region is characterized by extremes with highly variable precipitation and temperature. Average annual precipitation amount varies from around 26 inches in the northwest to about 41.5 inches in the southeast (Figure 2). Normal annual mean temperatures for the region range from around 55 to 59 degrees Fahrenheit.

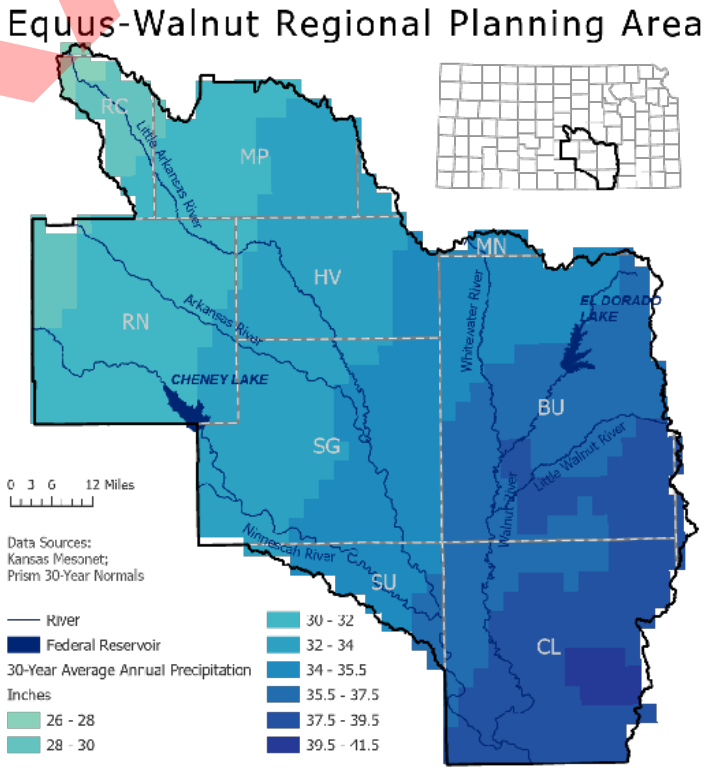


Figure 2. 30-year average annual precipitation

Equus-Walnut Region

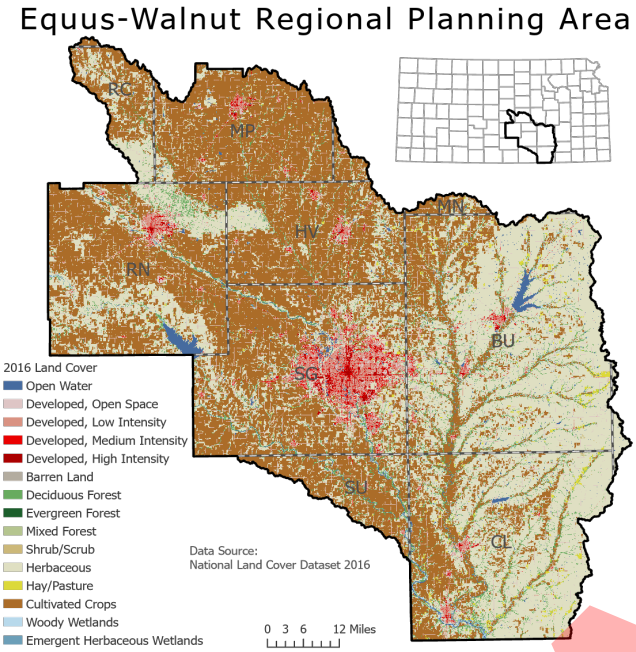


Figure 3. Equus-Walnut regional land cover

Land use activities can have a significant impact on the region. The three major land uses in this region are cultivated crops (45%), herbaceous (39%), and developed/urban open space (8%) as derived from the National Land Cover Database (NLCD) 2016 dataset. Figure 3 lists the remaining land uses in the region, including: deciduous forest, pasture/hay, and water.

Topography within the region is flat in the west to gently rolling with narrow, shallow valleys and low relief in the east.

POPULATION & ECONOMY

Based upon 2019 information derived from state-released information to the U.S. Census Bureau, there were an estimated 702,746 residents in the region (Figure 4). Approximately 512,042 residents, or 73% of the total population within the region, reside within the Wichita/Sedgwick County area. For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over or under represented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census.

Agriculture and manufacturing, particularly the aircraft manufacturing industry, serve as the basis of the economy within the region. Crops grown include wheat, corn, grain sorghum, and alfalfa, with a sizable portion of this acreage being irrigated. Livestock production is an important part of the area's agriculture; beef cattle is the predominant livestock raised in the region.

The oil and gas industry is also a prominent part of the regional economy with numerous production and injection wells present, as well as refinery facilities in El Dorado.

Wichita serves as the regional hub for economic activity, but the cities of Hutchinson, McPherson, Newton, El Dorado, Winfield, and Arkansas City are also home to various industrial and commercial enterprises.

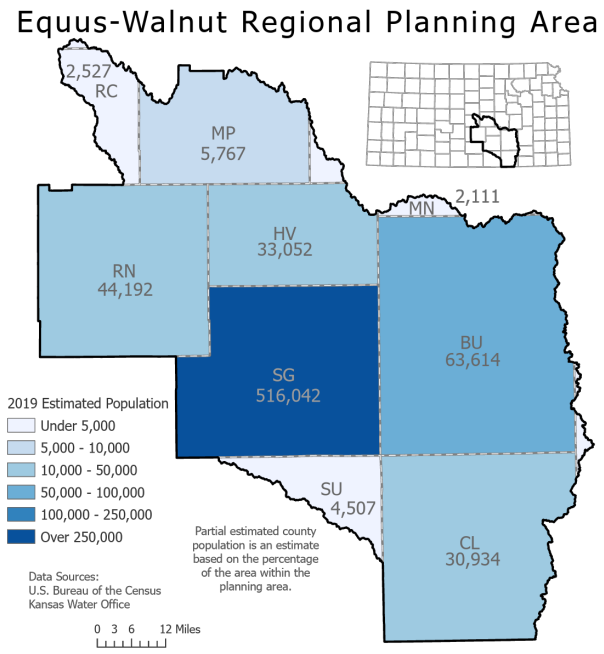


Figure 4. 2019 estimated population by county

Equus-Walnut Region

Primary Water Resources in the Region

SURFACE WATER

The principal tributaries within the Equus-Walnut Region include the Arkansas, Little Arkansas, North Fork Ninnescah, Ninnescah, Whitewater, and Walnut Rivers. Two federal reservoirs are also located within the region: Cheney Reservoir on the North Fork Ninnescah River and El Dorado Lake on the Walnut River (Figure 5).

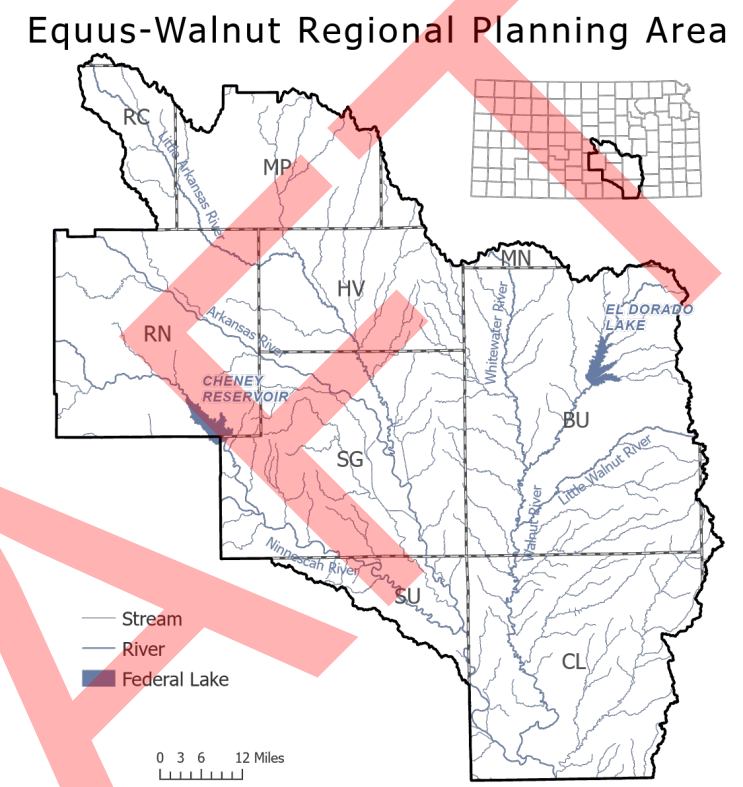


Figure 5. Surface water within the Equus-Walnut Region

Keeper of the Plains, Wichita, KS. Photo Credit: Visit Wichita

Equus-Walnut Region

GROUNDWATER

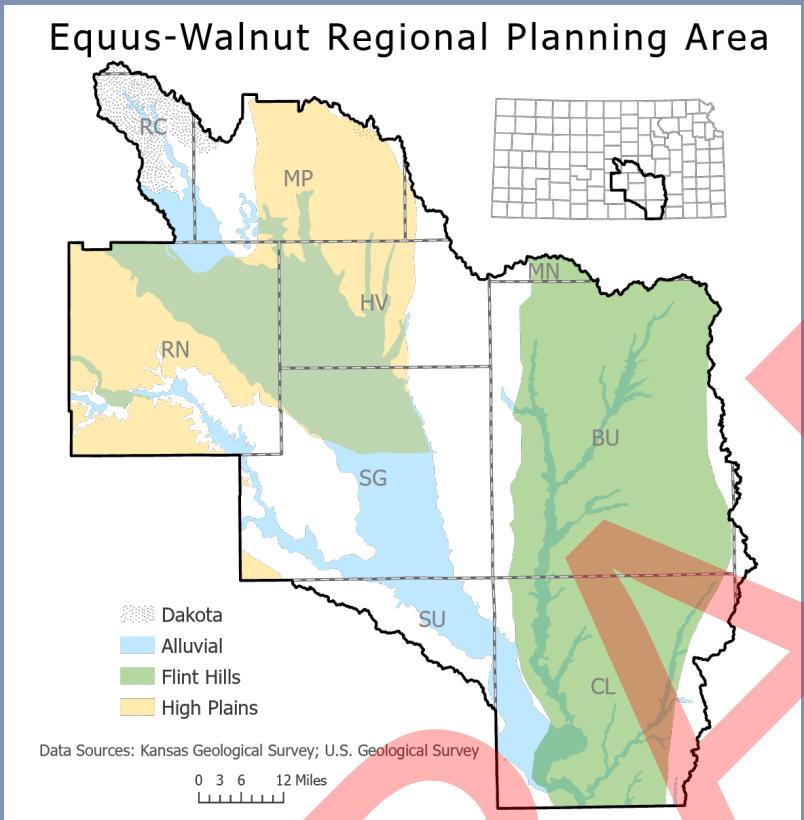


Figure 6. Principle aquifer boundaries in the Equus-Walnut Region

The principal aquifer within the region is the highly rechargeable Equus Beds Aquifer, the farthest east portion of the High Plains Aquifer in Kansas (Figure 6). Other aquifers present within the region include the Flint Hills and Dakota, along with alluvial aquifers along and near major tributaries within the region.

The Equus Beds Aquifer provides drinking water to about a half million people and is a primary water supply for the City of Wichita, along with Cheney Reservoir. Groundwater pumping for municipal and irrigation uses, as well as during periodic drought conditions, has led to water-level declines and concerns about future water supply. For this reason, the City of Wichita developed an Aquifer Storage and Recovery Project (ASR), to artificially recharge the aquifer from water diverted and treated from the Little Arkansas River to help meet Wichita's needs. Depth to bedrock from land surface varies in the area from approximately 100 to over 250 feet below land surface. Nitrate concentrations are highest in the shallow part of the aquifer and exceedances occur in the southeastern part of the aquifer. Chloride plumes threatening multiple areas of the aquifer move eastward, towards multiple groundwater users, at 0.8' per day

.

The Flint Hills Aquifer consists of limestone units that are water-bearing strata for many springs and limited public water supplies in the Flint Hills. Most wells in the aquifer are utilized irrigation purposes.

The Dakota Aquifer, found in the northwest corner of the region, serves a much smaller portion of the population and ranges in depth from approximately 100 to 220 feet below land surface.

Equus-Walnut Region

Primary Water Use by Source

GROUNDWATER

Groundwater is the primary source of water, with sources that include the Equus Beds Aquifer, a primary water supply source for the City of Wichita, and alluvial deposits along major streams. Irrigation and municipal usage account for 52% and 40%, respectively, of the reported water use within the region. Other reported water use within the region includes industry (7%), recreation (1%) and stock (less than 1%) (Figure 7).

SURFACE WATER

There are 106 public water suppliers in the region, including 35 rural water districts and 2 public wholesale water supply districts. Groundwater and/or surface water sources are both prevalently used by public water suppliers within the region. There are 52 municipalities in the region with approved water conservation plans.

Cheney Reservoir and El Dorado Lake serve as major water supply sources within the Equus Walnut Regional Planning Area. The City of Wichita draws approximately 60% of its daily water supply from Cheney Reservoir, but this number can fluctuate on an annual basis depending on available water supply within Cheney Reservoir in relation to the Equus Beds Aquifer.

El Dorado Lake is a primary water supply source for the City of El Dorado with enough capacity to allow El Dorado to draw approximately 23 million gallons per day during a 50-year drought.

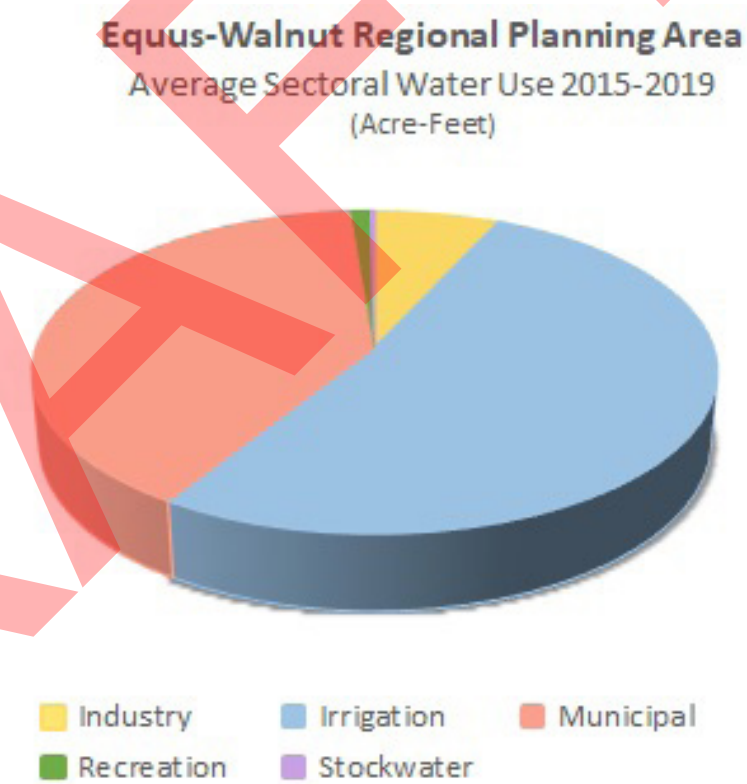


Figure 7. Average sectoral water usage

Regional Issues & Priorities

WATER SUPPLY AVAILABILITY

Groundwater Sustainability

Sustainable use of groundwater within the Equus-Walnut Region is an identified priority of the Regional Advisory Committee. Analysis of groundwater levels indicate groundwater levels over the last 20 years are generally steady (+/- 5' change) within most areas within the GMD2 portion of the region, with areas of greater increase in Harvey County in the general area of the City of Wichita's well field as well as areas of greater decrease in portions of south central McPherson County. In January 2017, the Kansas Geological Survey completed the Equus Beds Groundwater Management District No. 2 Sustainability Assessment, using their Qstable

Equus-Walnut Region

methodology to determine the average annual water use that would produce stable areally averaged water levels at the GMD, county, township, and other defined area intervals. At the GMD level, this analysis revealed that average annual reported water use appears to have been very close to the sustainable level for the 1996-2014 and 2005-2014 assessment periods. Information from this assessment can be utilized by GMD2 to review and update safe yield for areas within and adjacent to the GMD.

Technology & Crop Varieties

Stakeholder input provided through the water planning process in Kansas has previously shown broad support for promotion of irrigation efficiency technologies, adoption of less water intensive crop varieties, promotion of technologies for the treatment of alternative/lower quality sources of water and implementation of research-based technology aimed at better understanding our state's water supply as areas where efforts could be focused to positively impact Kansas water resources. This is particularly true within the Equus-Walnut Regional Planning Area, where both surface and groundwater quantity as well as quality concerns exist which could benefit from any of these previously noted approaches. With both irrigated and dryland crops viable across many portions of the Equus-Walnut Region, continued research and adoption of advances in new technologies and crop varieties provide the opportunity for water conservation without decreases in crop yields.

Wichita Aquifer Storage & Recovery (ASR)

The City of Wichita currently operates an ASR project which allows for the diversion of water from the Little Arkansas River during high flow periods, treatment of the diverted water to drinking water standards, then injection of the treated water into the Equus Beds Aquifer for later recovery and use. Through this process, the city accumulates recharge credits with Kansas Department of Agriculture Division of Water Resources (KDA-DWR) allowing Wichita to subsequently withdraw this additional water from the Equus Beds Aquifer beyond their native water rights. With the recent recovery of the Equus Beds Aquifer in the Wichita wellfield area to near pre-development conditions, recharge activities are being hampered by limited space within the aquifer, leading to the development of a proposal by Wichita for a new way to develop recharge credits.

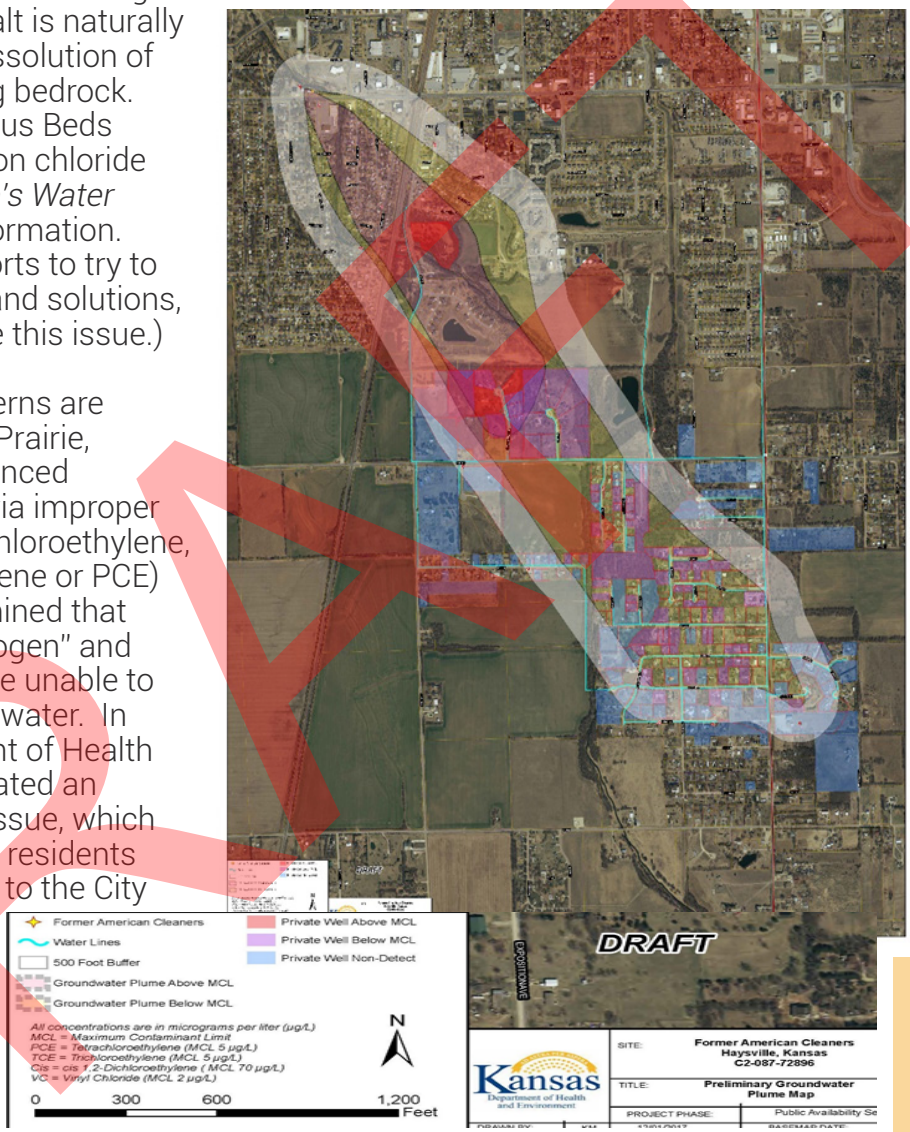
Wichita ASR. Photo Credit: Burns & McDonnell

In March 2018, Wichita submitted to KDA-DWR a proposal for modifications to the conditions associated with Wichita's existing Phase II ASR permits. The request included lower minimum index levels used to determine when Wichita can withdraw accumulated recharge credits, as well as authorization of new credits. Credits would be accumulated during times of limited aquifer recharge capacity, where Wichita would receive recharge credits for treating surface water diverted at its ASR Project on the Little Arkansas River and sent directly to Wichita, offset by reduced Equus Bed Aquifer use. Public meetings and the formal phase of public hearings took place from 2018 through 2021, with a written recommendation to the Chief Engineer anticipated later in 2021.

Equus-Walnut Region

Groundwater Quality

Groundwater contamination is a growing concern in the Equus-Walnut Region. Several sources of salt have been identified as contributing to groundwater contamination, including waste from past practices in salt mining or oil production. Some of the salt is naturally occurring, arising from the dissolution of salt deposits in the underlying bedrock. This plume of salts in the Equus Beds Aquifer is known as the Burrton chloride plume. See *Improve the State's Water Quality* section for further information. (Add closing sentence on efforts to try to identify remediation options and solutions, as well as funding, to mitigate this issue.)



Additional groundwater concerns are found in Haysville and Pretty Prairie, Kansas. Haysville has experienced groundwater contamination via improper dry-cleaning chemical (tetrachloroethylene, also known as perchloroethylene or PCE) disposal. The EPA has determined that PCE is a "likely human carcinogen" and the affected region is therefore unable to use the contaminated groundwater. In July 2017, Kansas Department of Health and Environment (KDHE) initiated an emergency response to this issue, which included access for impacted residents to clean water via connection to the City of Haysville water supply. KDHE plans to proceed with remediation of the contamination plume.

Pretty Prairie, Kansas has been affected by contaminated water since the 1990s. The contamination is thought to have been caused by nitrate fertilizers used on wheat, soybean, and sorghum crops in the area. Concentrations are higher near the surface, putting household wells and rural water systems at risk. In order to address the elevated nitrate levels, the City of Pretty Prairie's existing water treatment system had to be replaced by a 2.4 million-dollar reverse osmosis water treatment system. In June 2019, the treatment plant began operating.

Equus-Walnut Region

KWO Water Technology Farms

KWO Water Technology Farms (Water Tech Farms) are pilot public-private partnerships with producers where irrigation technology is demonstrated, related research is conducted on the field scale, and water conservation is supported. There are currently three Water Tech Farms in the region. R&E Goering Farm, located in McPherson County, has been a Water Tech Farm since 2019. Jacob Farms, located in Sedgwick County, has been a Water Tech Farm since 2018. Weber Farms, located in Harvey County, has been a Water Tech Farm since 2018. All three of the Water Tech Farms have been crucial to the region in providing valuable information on expanding the conversation and education of producers and decision makers on water conservation in the area.

R & E Goering Farm

Technology & Crop Varieties

Stakeholder input provided through the water planning process in Kansas has previously shown broad support for promotion of irrigation efficiency technologies, adoption of less water intensive crop varieties, promotion of technologies for the treatment of alternative/lower quality sources of water and implementation of research-based technology aimed at better understanding our state's water supply as areas where efforts could be focused to positively impact Kansas water resources. This is particularly true within the Equus-Walnut Regional Planning Area, where both surface and groundwater quantity as well as quality concerns exist which could benefit from any of these previously noted approaches. With both irrigated and dryland crops viable across many portions of the Equus-Walnut Region, continued research and adoption of advances in new technologies and crop varieties provide the opportunity for water conservation without decreases in crop yields.

Equus-Walnut Region

SURFACE WATER RESOURCES

Surface Water Quality Conditions in the Region

Many streams within the region are experiencing water quality impairments, as indicated by the 2020 303(d) list. Impaired waters experiencing TMDLs for eutrophication, siltation, and biology are the most prevalent in the region. Siltation and eutrophication are the primary water quality problems affecting the lakes in this region. As sediment accumulates in a reservoir's multipurpose pool, the capacity for water supply storage is reduced.

Water quality and related water resource issues are addressed through a combination of Watershed Restoration and Protection Strategy (WRAPS) efforts utilizing voluntary, incentive-based approaches, as well as regulatory programs. Watersheds with WRAPS projects currently underway in the region encompass high priority areas for Total Maximum Daily Load (TMDL) implementation, areas with a high improvement potential index for nutrient reduction, source water assessment areas, and priority areas for wetland and riparian protection. The restoration and protection of watersheds, particularly those watersheds above public water supply reservoirs, is a priority in the Equus-Walnut region. Sediment reducing cropland BMPs, such as continuous no-till with use of cover crops and buffers, and phosphorus reducing livestock BMPs like nutrient management plans for producers are key WRAPS projects being implemented. Excess available nutrients can lead to Harmful Algae Blooms (HABs) which can be exacerbated by certain Aquatic Nuisance Species (ANS).

Harmful Algal Bloom

An important consideration for watershed restoration and protection in this region is urbanization. Local land use planning and zoning efforts provide cities and counties effective tools to minimize the potential impacts of development on water resources.

In 2020, General Mills launched a regenerative agriculture pilot in conjunction with the KDHE WRAPS project with producers in the Cheney Reservoir watershed which provides water to more than 400,000 Wichita residents. The 3-year pilot is comprised of 24 wheat growers in and around the 650,000-acre watershed where more than 99% of the land is used for agricultural purposes. The goal of the pilot program is to encourage farming practices that improve both soil health and water quality in the Cheney Reservoir region such that a more resilient and clean water supply for Wichita residents is accomplished through regenerative agriculture best management practices.

Regenerative agriculture is a holistic method of farming, implementing practices designed to protect and intentionally enhance natural resources and farming communities. These practices focus on pulling carbon from the air and storing it in the soil, in addition to helping

General Mills Field Day. Photo Credit: KDHE

Equus-Walnut Region

the land be more resilient to extreme weather events. Additionally, regenerative agriculture practices help increase water infiltration and reduce soil erosion. The benefits from regenerative agriculture can translate to farmers' pocketbooks by ensuring that more nutrients stay in the field to be absorbed by plants rather than washed or blown away through soil erosion. Participating producers will have access to continuing education via the Soil Health Academy, farmer-focused field days and a private Facebook group to encourage ongoing exchange of ideas and best practices.

Continuous education through workshops and partnerships such as the General Mills pilot and the Soil Health Academy are important to encouraging behaviors and activities of individuals to incorporate water-quality-improving measures in their daily lives.

COMPREHENSIVE WATER SUPPLY PLANNING

Groundwater Contamination

With the prevalence of surface and groundwater resources within the Equus-Walnut Regional Planning Area, a number of municipalities and public water suppliers have the opportunity to consider both local and regional water sources when evaluating current supply to meet current and future demand during periods of normal precipitation as well as periods of drought. In order to characterize current and future water supply demands within the region for individual municipalities and public water suppliers, development of comprehensive water supply plans which include conservation triggers during drought conditions as well as projected supply needs to meet future growth is viewed as valuable and a likely necessary at some point exercise by the Equus-Walnut RAC. Determining the current status of water supply planning efforts for municipalities and public water suppliers within the region and providing assistance to support updates or development of comprehensive water supply plans can help ensure that current and future demands are known and appropriate actions can be initiated to promote adequate water supply for generations to come.

Equus-Walnut Region

ALTERNATIVE SUPPLY SOURCES

The ASR project, developed in 2007, is one water supply alternative being employed to meet future demands for water for Wichita and other users in the area. Water is diverted from the Little Arkansas River when flow in the river exceeds base flow and then artificially recharged water into the Equus Beds Aquifer through injection wells and recharge basins. The water is treated to drinking water standards prior to recharge. An additional benefit of artificial recharge potentially includes creating a hydraulic high in the groundwater, thus slowing migration of chloride plumes from the Burrton oil field to the northwest into the aquifer region of the city well field.

Wichita ASR. Photo Credit: Alberici

In the Equus-Walnut Region, a total of six communities and commercial facilities are authorized to reuse treated wastewater.

Two industrial facilities, located in Colwich and Hutchinson, are authorized by KDHE to use wastewater effluent for irrigation. Four municipalities, including Newton and Park City, are authorized to use the wastewater effluent for the irrigation of golf courses and other public use areas such as parks, ball fields and cemeteries. Desalinization is an emerging technology that may add to available water due to the large amounts of brackish water in the region.

WATER QUALITY

All the counties within the region have adopted and are enforcing sanitary codes that can help manage bacteria and nutrient inputs into surface and groundwater. All conservation districts in the region have adopted nonpoint source pollution management plans.

The Clean Water Act requires states to conduct TMDL studies and develop TMDLs for water bodies identified on the state's List of Impaired Waters (Section 303(d) List) (Figure 10). TMDLs are quantitative objectives and strategies needed to achieve the state's surface water quality standards. In the Equus-Walnut Region, TMDLs have been developed to address dissolved oxygen; eutrophication; fecal bacteria; nitrates; total phosphorus; and total suspended solids.

Several sources of salt have been identified as contributing to groundwater contamination, including waste from past practices in salt mining or oil production. Some of the salt is naturally occurring, arising from the dissolution of salt deposits in the underlying bedrock. See *Improve the State's Water Quality* section for further information.

Equus-Walnut Region

Watershed Protection and Restoration

High priorities in the region include restoring watersheds with impaired water quality and protecting watersheds above public water supply reservoirs and groundwater sources.

Three main components guide watershed restoration and protection efforts: achievement of TMDL, development of Source Water Protection Plans, and restoration and protection of wetland and riparian areas. The Equus Walnut Region has six Watershed Restoration and Protection Strategy (WRAPS) projects with implementation underway: Cheney Lake; Grouse-Silver Creek; Little Arkansas; Lower Arkansas/River City; Upper Timber; and the Upper Walnut/El Dorado Lake.

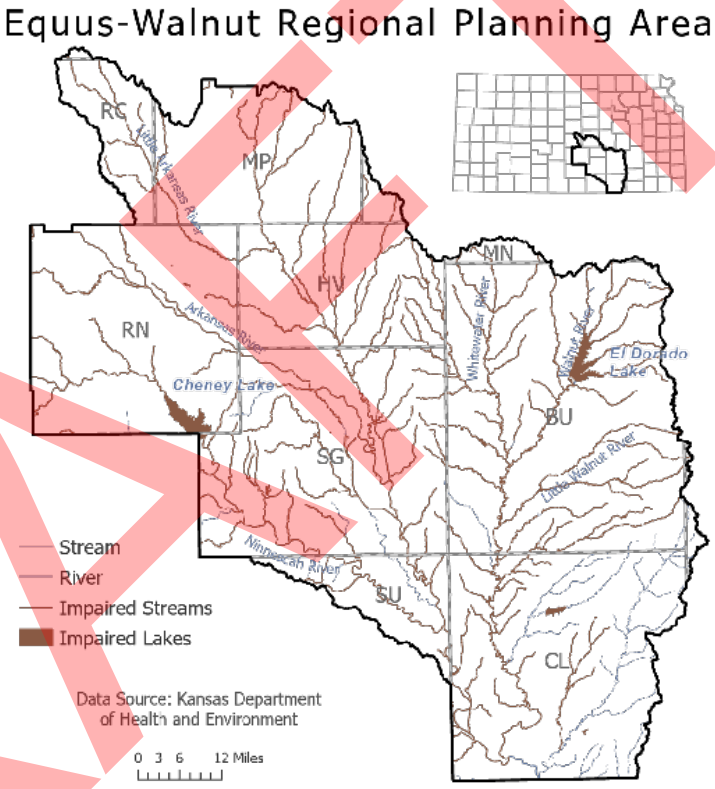


Figure 10. Impaired water resources in the Equus-Walnut Region

The Goals and Action Plans contained herein are as developed by the Regional Advisory Committee.

Equus-Walnut Advisory Committee

Regional Goals & Action Plans

Priority Goal #1:
Promote sustainable balance of groundwater withdrawals with annual recharge in the Equus Beds Aquifer. Ensure safe yield and recharge rate calculations in the Equus Beds Aquifer are accurate through a district wide, integrated groundwater and surface water model.

ACTION STEPS:

- Maintain the Equus Beds Groundwater Management District No. 2 model developed by the Kansas Geological Survey 2020 (GMD2 model).
- Utilize GMD2 model results to support refinement of aquifer recharge rates.
- Encourage application of the revised recharge rates to support safe yield calculations within GMD2 model boundaries.
- Support utilizing GMD2 model results to identify areas of over-appropriation within the Equus-Walnut Region.
- Promote an integrated approach to the management of all water resources, by non-domestic users within the Equus-Walnut Region, especially in over-appropriated areas.
- Continue to encourage communication and collaboration between all responsible agencies and organizations tasked to accomplish these actions.

Measuring success:

Goal 1: Increase utilization and maintenance of management tools and strategies supporting stable, long-term aquifer levels

Equus-Walnut Advisory Committee

Regional Goals & Action Plans

Priority Goal #2: Encourage the development and use of comprehensive water supply plans by major water users in the region. Plans should account for long-term supply and demand, vulnerabilities within a water supply system, and potential for improved water efficiency.

ACTION STEPS:

- Continue to support the Kansas Water Office (KWO) Assessment and Evaluation's technical assistance grant for water conservation planning while promoting additional planning assistance programs.
- Coordinate with the Kansas Department of Health & Environment(KDHE)-Bureau of Water and Kansas Department of Agriculture - Division of Water Resources (KDA-DWR) on the creation of a database of all public water suppliers within the Equus-Walnut Region that includes contact information for the chief responsible staff person and chief governance person for each supplier.
- The KWO will develop a survey document to ascertain the current state, practice, and plans of each public water supplier as to their long-term water supply plan, including the suppliers consideration of non-potable water and existing water supplies.
- If deemed appropriate, the results of this survey document will be made available to each public water supplier within the Equus-Walnut Planning Region.
- The RAC will work with the KWO to prepare a report to the Kansas Water Authority (KWA) that conveys the results of the survey and identifies any further actions that may be necessary in pursuit of the goal.
- Promote a regulatory framework for the use of graywater.
- The Equus-Walnut RAC, through the KWO and others, will promote water resource conservation strategies within the region by speaking with major water users, sharing success stories and organizing informational webinars, conference presentations, and other educational opportunities.

Measuring success:

Goal 2: Develop long-term water supply planning inventory focused on public water suppliers within the region and issues addressed from feedback provided.

Equus-Walnut Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- Utilize targeting strategies of WRAPS and KWO to identify appropriate locations for best management practice (BMP) programs or other watershed projects.
- Identify ways to leverage funds for BMP implementation through public and private entities.
- Support watershed education and BMP demonstration activities.

Priority Goal #3: Implement watershed protection measures to improve the reliability and health of surface water resources in the region.

Measuring success:

Goal 3: Document sediment and nutrient load reductions from the continued implementation of conservation measures.

Equus-Walnut Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- Maintain an inventory of contamination sites within the Equus Beds Aquifer.
- Identify and fill data gaps associated with inventoried contamination sites. This could include lack of definition regarding vertical or horizontal extent of contamination, concentration of contaminants or the source of contamination of an identified site.
- Install additional monitoring wells and piezometers as necessary to collect data where needs are identified.
- Complete pilot studies as required to facilitate groundwater remediation feasibility.
- Develop a process to test and promote new treatment technologies that address contaminated groundwater sites within the region and state.

Priority Goal #4:
Allocate necessary resources to accurately locate, characterize, prioritize and remediate contamination sites within the Equus-Beds Aquifer.

Measuring success:

Goal 4: Development inventory of groundwater contamination sites within the region and reclamation initiated on priority sites identified within inventory.

Equus-Walnut Advisory Committee

Regional Goals & Action Plans

Priority Goal #5:
Increase efforts to establish sustainable, water-conserving agricultural production practices.

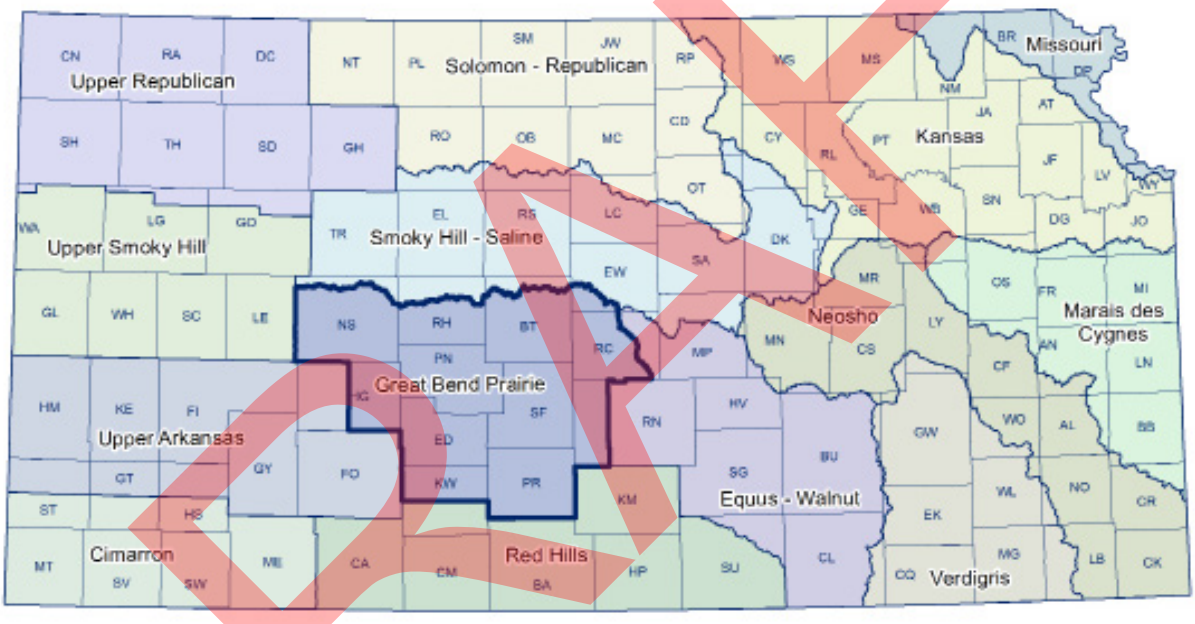
ACTION STEPS:

- Preserve water resources and coordinate programs to develop less water-intensive crops.
- Coordinate public/private research for the development of viable drought-tolerant crops.
- Identify and support markets for less water-intensive crops.
- Support federal and state programs that evaluate new irrigation technologies.
- Promote federal and state programs that offer incentives for operators to implement irrigation efficiency improvements.
- Support agriculture workshops and field days that demonstrate water-conserving practices.

Measuring success:

Goal 5: Increase adoption of water conservation management tools and strategies, additional funding sources secured for implementation secured for water management practices and document increase in participation in water education programs for all ages within the region.

Great Bend Prairie Region



Great Bend Prairie Region

Regional Description

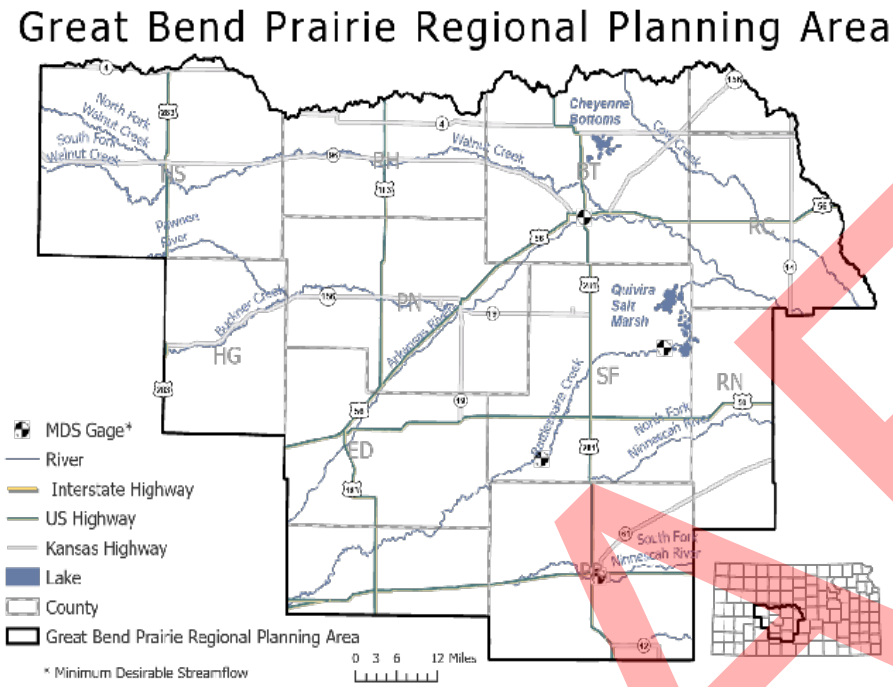


Figure 1. Great Bend Prairie Regional Planning Area

The Great Bend Prairie Regional Planning Area is located in central and South-central Kansas and covers approximately 6,769 square miles. It includes all or parts of Barton, Edwards, Ellsworth, Hodgeman, Kiowa, Ness, Pawnee, Pratt; Reno, Rice, Rush, and Stafford counties (Figure 1).

CLIMATE & LAND USE

As is common across all of Kansas, the climate of the Great Bend Prairie Region is characterized by extremes with highly variable precipitation and temperature. Average annual precipitation ranges between 20 and 32 inches (Figure 2). Normal annual mean temperatures for the region range from around 52 to 56 degrees Fahrenheit.

Land use activities can have a significant impact on the region. The two major land uses in this region are cultivated crops (61%) and herbaceous (32%) as derived from the National Land Cover Database (NLCD) 2016 dataset.

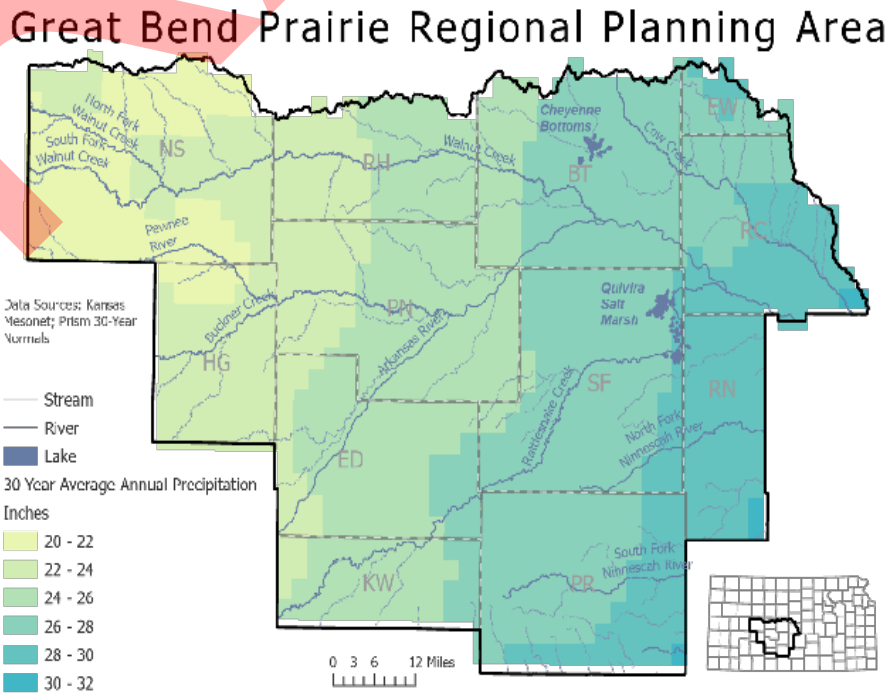


Figure 2. 30-year average annual precipitation in the Great Bend Prarie Region

Great Bend Prairie Region

Figure 3 lists the remaining land uses in the region, including: deciduous forest, developed/urban open space, and water.

The Great Bend Prairie Region is characterized by undulating to rolling sand plains. Windblown sand, sandy outwash, and dunes support native prairie grasses. Dryland farming of winter wheat and large areas of center-pivot irrigation of corn, soybeans, cotton, grain sorghum, and alfalfa crops now dominate the landscape.

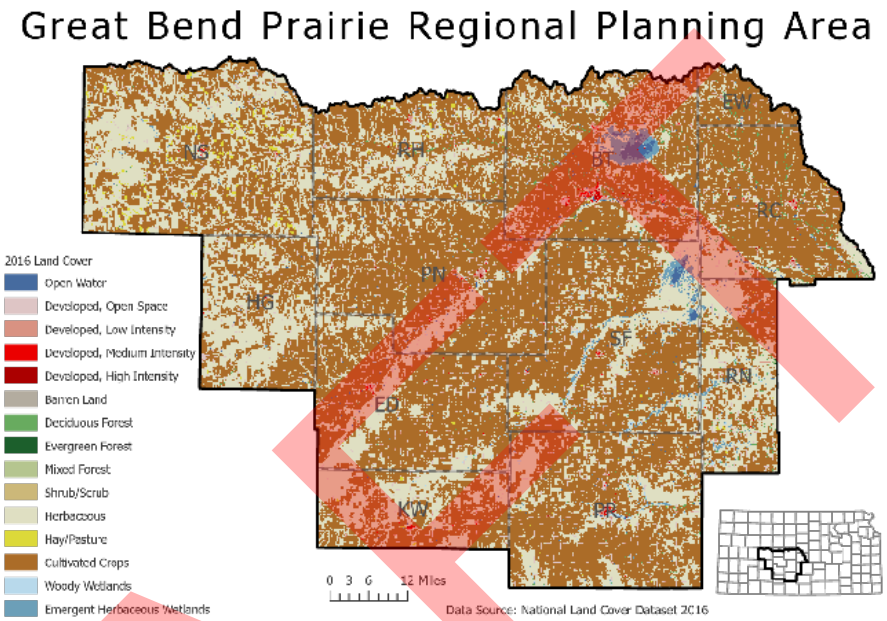


Figure 3. 2016 Great Bend Prairie regional land cover

POPULATION & ECONOMY

Based upon 2019 information derived from state-released information to the U.S. Census Bureau, there were an estimated 75,361 residents in the region (Figure 4). For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over or under represented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census.

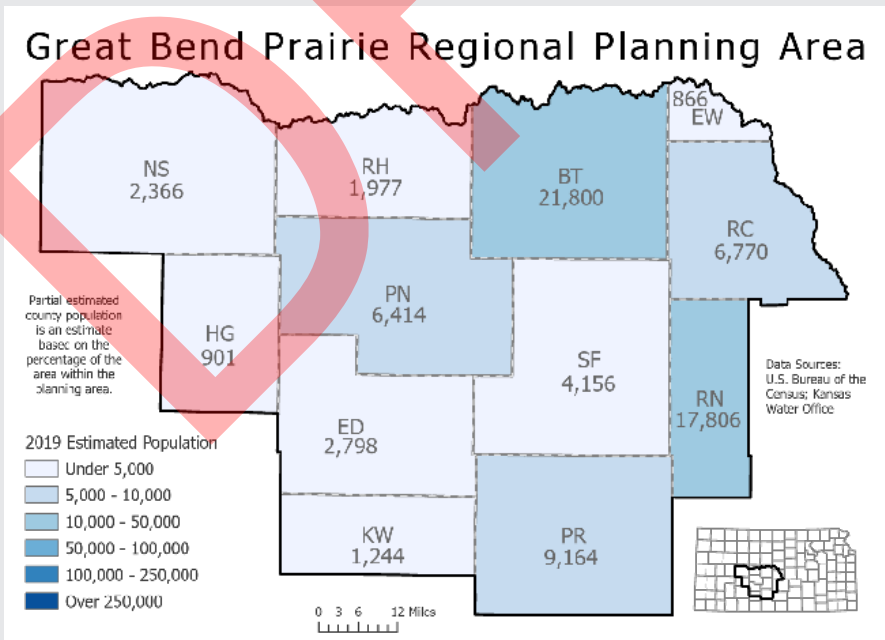


Figure 4. 2019 estimated population by county

Agriculture is a mainstay of the regional economy. Dry land farming began to give way to irrigated crops around 1970, though both types of production are still practiced. Wheat, corn, and livestock are the principal agricultural products. Recreation is an important part of the local economy. Quivira National Wildlife Refuge and Cheyenne Bottoms, both vast wetland complexes, draw thousands of hunters and bird watchers to the area. The population for the region by 2070 is predicted to remain stable or decline, with only Pratt County anticipated to see an increase.

Great Bend Prairie Region

Primary Water Resources in the Region

GROUNDWATER

Groundwater is the primary source of water in the region, principally from the Great Bend Prairie Aquifer and alluvial deposits along major streams. There are 54 public water suppliers in the region, including 4 rural water districts. 42 of the public water suppliers in the region have approved water conservation plans.

The primary aquifer within this region is the Great Bend Prairie portion of the High Plains Aquifer (Great Bend Prairie Aquifer). Other aquifers present within the region include the Dakota, along with alluvial aquifers along and near major tributaries within the region (Figure 5).

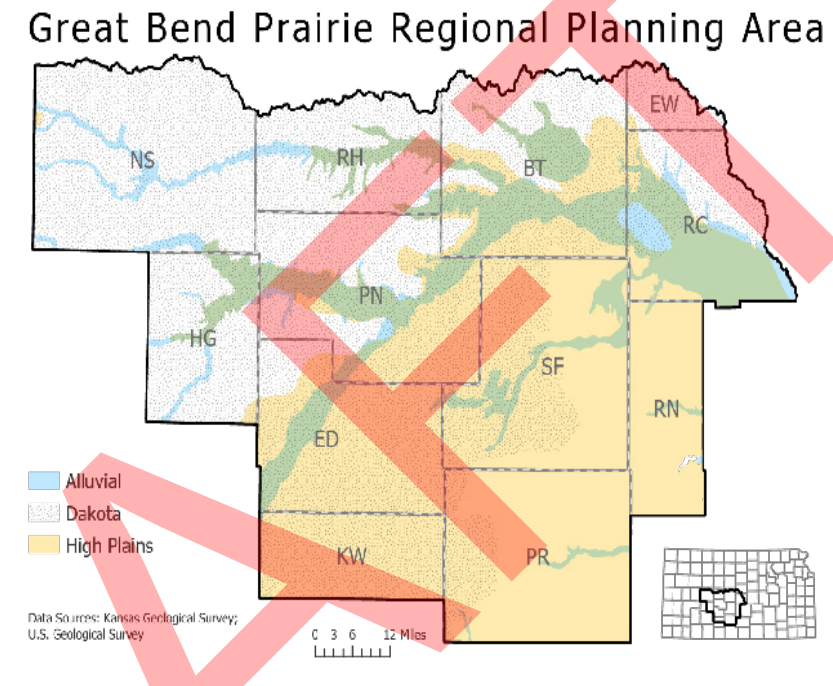


Figure 5. Principle aquifer boundaries in the Great Bend Prairie Region

SURFACE WATER

The principal tributaries in the Great Bend Prairie Region are the Arkansas River, Rattlesnake Creek, Walnut Creek, the Pawnee River, and Cow Creek (Figure 6).

There are also two additional areas of surface water in the region: Cheyenne Bottoms and Quivira National Wildlife Refuge.

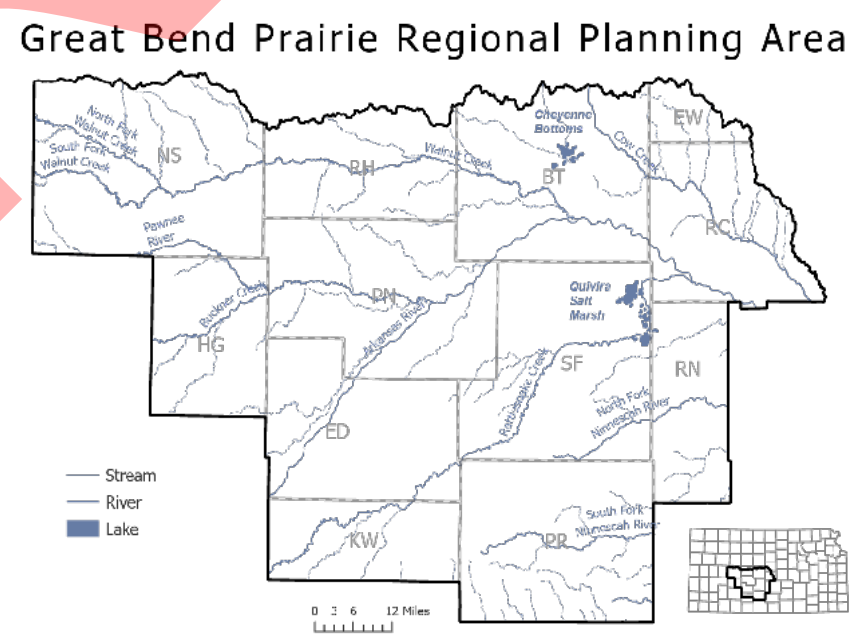


Figure 6. Major water resources in the Great Bend Prairie Region

Great Bend Prairie Region

Primary Water Use by Source

SURFACE WATER

Major rivers and streams in the region include the Arkansas River, Rattlesnake Creek, Walnut Creek, Pawnee River, and Cow Creek. Due to streamflows often being insufficient, surface irrigation is limited.

Important surface water features include the Cheyenne Bottoms in Barton County and Quivira National Wildlife Refuge in Stafford County. Cheyenne Bottoms is owned by the State of Kansas and managed by the Kansas Department of Wildlife and Parks (KDWP). The federally owned Quivira National Wildlife Refuge is managed by the U.S. Fish and Wildlife Service (USFWS). Both hold water rights that allow for management of the areas as wetlands, a recreational water use.

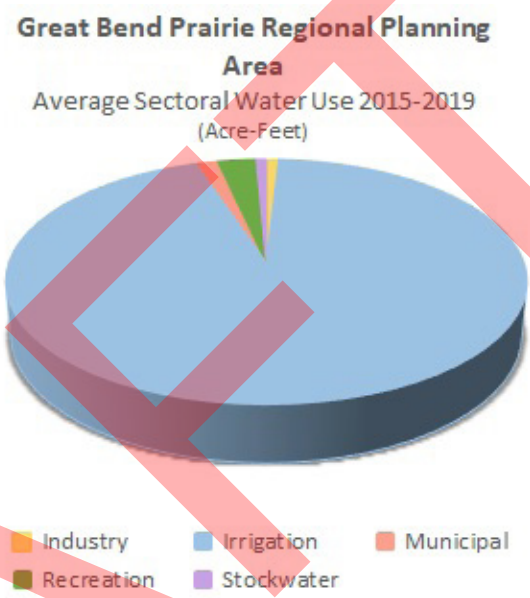


Figure 7. Average sectoral water usage

GROUNDWATER

Groundwater supplies 98% of water used in the region. Of that percentage, irrigation is the primary use, accounting for about 94% of reported usage. The remainder is accounted for by municipal (2%), industrial (1%), recreation (3%), and stockwater (1%) (Figure 7).

Big Salt Marsh area of Quivira National Wildlife Refuge, Stafford County, KS. Photo Credit: Jamil Moody

Great Bend Prairie Region

Regional Issues & Priorities

Groundwater in the region is managed for sustainability, with the local leadership of Big Bend Groundwater Management District No. 5 (GMD5) and the Kansas Department of Agriculture-Division of Water Resources (KDA-DWR). GMD5 operates under a "safe yield concept" in which appropriations are managed so that the quantity of groundwater withdrawn is approximately equal to the average annual recharge. A majority of the region is restricted or closed for new water appropriations. The entire portion of the region within GMD5 is closed to new appropriations by regulation.

In 1978, the Kansas Legislature amended statutes to enable the State's Chief Engineer to designate certain areas as intensive groundwater use control areas, or IGUCAs. An IGUCA is a groundwater management tool that works in conjunction with the Kansas Water Appropriation Act providing flexible solutions to the complex problem of groundwater declines. The IGUCA statutes allow the Chief Engineer to implement an IGUCA when local conditions require it, or when local stakeholders request it. There are two IGUCAs in the region: the Wet Walnut IGUCA and the Pawnee IGUCA (Figure 8).

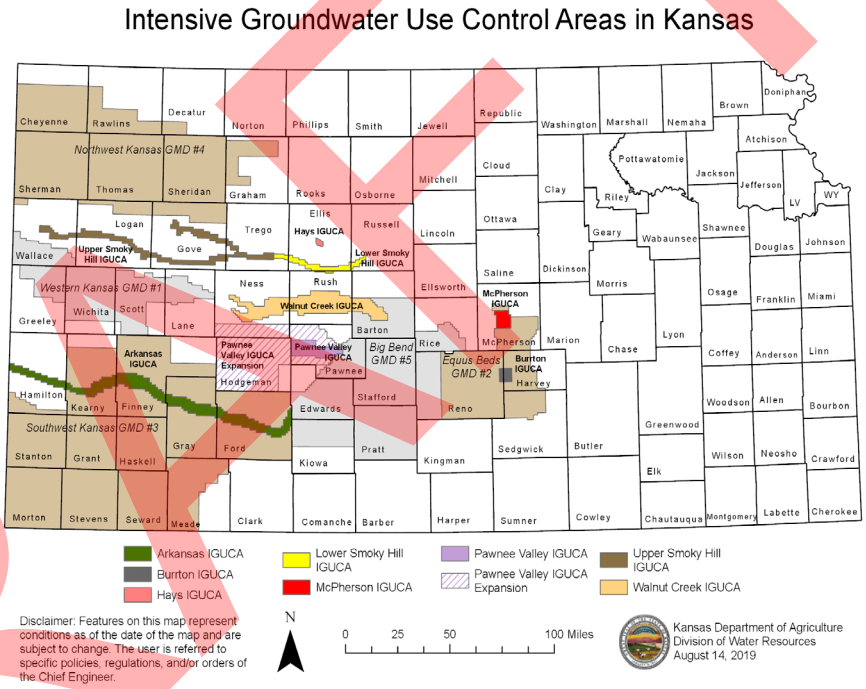


Figure 8. Intensive Groundwater Use Control Areas in Kansas, KDA

Water appropriations and use are overseen by the KDA-DWR. Minimum desirable streamflow thresholds have been set for sites on the South Fork Ninnescah, Rattlesnake Creek, and the Arkansas River. The Wet Walnut and Pawnee watershed districts cover portions of the region.

GROUNDWATER SUSTAINABILITY

Sustainable use of groundwater within the Great Bend Prairie Region is an identified priority of the Regional Advisory Committee. Analysis of groundwater levels indicates a slight declining trend within the GMD5 portion of the region, with portions of Edwards and Pawnee counties observing higher decline rates in In order to reach long term sustainability of groundwater water resources, the Regional Advisory Committee has identified a diverse set of actions including voluntary water conservation programs, education, protection of water quality, less water intensive crop production, and watershed structures to aid in water management. Ultimately, all are components thought to help reach sustainable water use while not adversely affecting the regional economy.

Great Bend Prairie Region

SURFACE WATER QUALITY

All the counties within the region have adopted and are enforcing sanitary codes that can help manage bacteria and nutrient inputs into surface and groundwater. All conservation districts in the region have adopted nonpoint source pollution management plans.

The Clean Water Act requires states to conduct Total Maximum Daily Load (TMDL) studies and develop TMDLs for water bodies identified on the State's List of Impaired Waters (Section 303(d) List). TMDLs are quantitative objectives and strategies needed to achieve the state's surface water quality standards. TMDLs have been developed in the region to address dissolved oxygen, fecal coliform bacteria, and eutrophic conditions as the highest priority impairments (Figure 8).

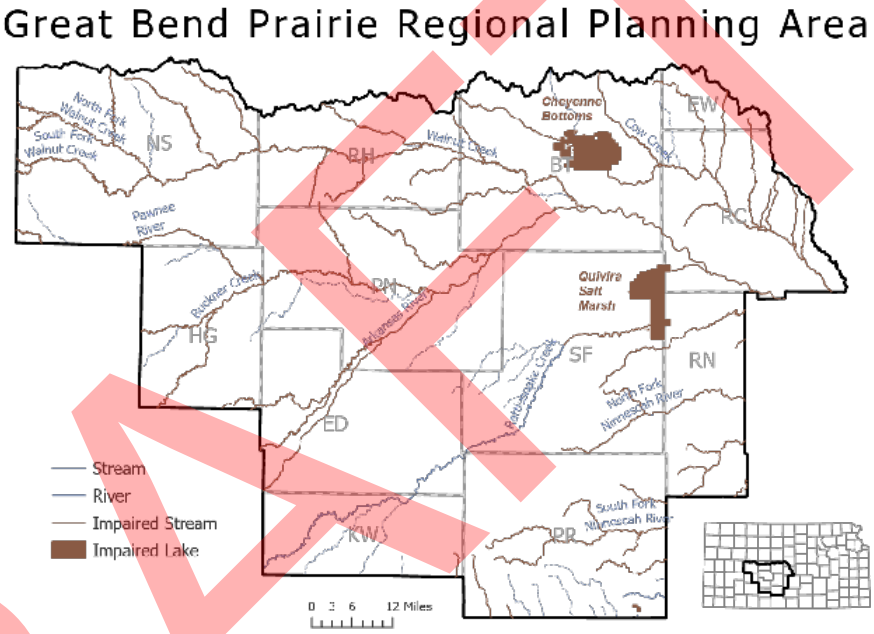


Figure 8. Impaired water resources in the Great Bend Prairie Region

Water quality and related water resource issues are addressed through a combination of Watershed Restoration and Protection Strategy (WRAPS) efforts utilizing voluntary, incentive-based approaches, as well as regulatory programs. Watersheds with WRAPS projects currently underway in the region, such as the Cheney Lake WRAPS Project, encompass high priority areas for TMDL implementation, areas with a high improvement potential index for nutrient reduction, source water assessment areas, and priority areas for wetland and riparian protection.

High nutrient loads (phosphorus and nitrogen) have contributed to Harmful Algal Blooms (HABs) in Kansas and Oklahoma. HABs, as discussed in the *Improve the State's Water Quality* section of the Kansas Water Plan, have caused pet and livestock deaths, however, no human mortalities can be attributed to the toxins created by these bacteria.

This worldwide problem has led to significant research on causes, treatments, and prevention of HABs, Since 2000, HABs have occurred more frequently and the duration of blooms have increased. Since 2010, public lakes in Barton and Hodgeman counties have experienced on numerous occasions KDHE-confirmed HABs. More information on HABs may be found on the Kansas Department of Health and Environment (KDHE) website." (https://www.kdheks.gov/algae-illness/index.htm)

Cheyenne Bottoms. Photo Credit: Flickr user Nick Varvel

Great Bend Prairie Region

GROUNDWATER QUALITY

Chlorides

Groundwater sources within the region contain high salinity, due to the conditions and composition of the aquifer and underlying bedrock (Figure 9). Based on water quality monitoring wells located within the region and maintained by the Kansas Geological Survey (KGS), the quality of the Great Bend Prairie aquifer ranges from saltwater in the northwest and central portions of the aquifer to fresh water in the southernmost area. According to KGS, the saltwater is caused by the intrusion of the underlying Permian bedrock, with varying salinity levels across the formation.

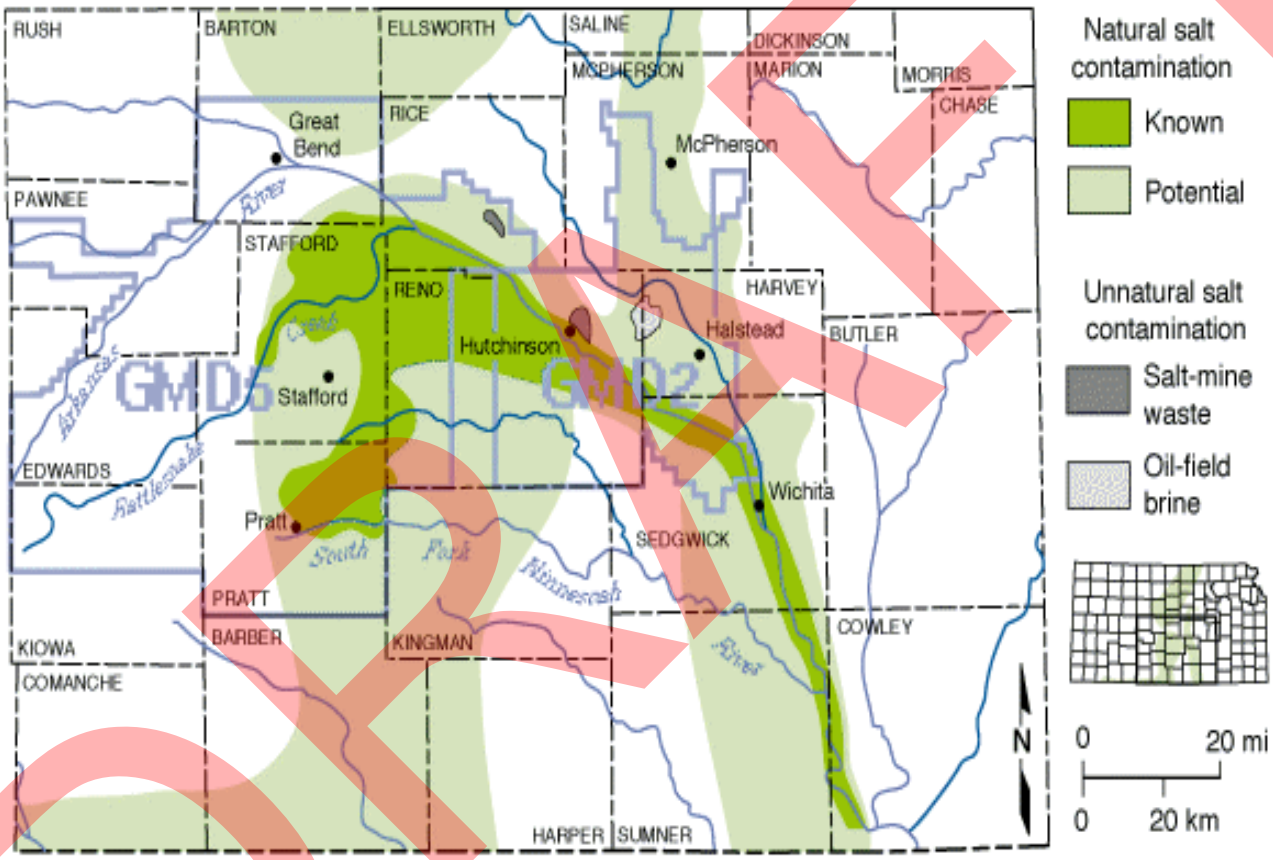


Figure 9. Areas affected by or vulnerable to salt contamination in south-central KS, KGS

Saline water intrusion to the shallow aquifer is mainly controlled by discharge along streams, especially Rattlesnake Creek and parts of the South Fork of the Ninnescah River and the Arkansas River, and in the Big and Little Salt marshes. In addition to the natural sources affecting the groundwater salinity, there is concern that oil-field brines and agricultural activities have affected the water quality of the aquifer.

Knowledge of the present distribution, concentration, and source of the saline waters and contaminated areas is necessary for the development of water-quality models of the region and for management of the groundwater resources to minimize salinity effects. As such, the maintenance and operation of the KGS monitoring well network continues in the region to monitor and document chloride levels.

Great Bend Prairie Region

Nitrates

In addition to elevated chloride levels within the region, rural water wells in the region have experienced a significant increase in nitrate levels over a 40-year period according to a study released by Kansas State University. The study, which included groundwater samples from 22 monitoring wells, revealed that nitrate levels measured in some wells within the region were above EPA standards. High nitrate levels in drinking water can cause health issues to humans and livestock. Elevated levels in the body interfere with the transport of oxygen by blood, and can increase the risk of cancer. While municipalities are required to test and provide safe drinking water to the public/city residents, private well owners are urged to test water quality at least annually.

As the data indicates, groundwater sources within the Great Bend Prairie region are vulnerable to contamination. Efforts to expand the adoption of management practices to protect source water within the region are vital.

LESS WATER-INTENSIVE CROPS

Increased utilization and adoption of feed wheat as well as other alternative crops provide the potential to lessen demand on groundwater resources within the region as well as provide sources of locally grown livestock feed for utilization within the Great Bend Prairie Region and elsewhere within and outside Kansas borders.

Continued research and development on livestock feeding with less water-intensive crops as well as advances in plant breeding provide the opportunity to improve water resource management within the Great Bend Prairie Region and enhance markets for regionally-grown feed produced with a low water footprint.

WATERSHED STRUCTURES

There are two active Watershed Districts within the Great Bend Prairie Regional Planning Area; Pawnee Watershed Joint District No. 81 and Wet Walnut Watershed Joint District No. 58. Previous analysis conducted by the Kansas Water Office reveals that approximately 30-35% of the drainage area within these two Watershed Districts is controlled at the present time.

Additional construction of planned structures within these Watershed Districts would further increase floodwater management potential within the region as well as provide increased alluvial aquifer recharge in locations where subsurface geology is conducive.

Watershed Dam in Kansas. Photo Credit: KDA

Great Bend Prairie Region

QUIVIRA NATIONAL WILDLIFE REFUGE/RATTLESNAKE CREEK

The Quivira National Wildlife Refuge (NWR) located 30 miles west of Hutchinson and 35 miles southeast was established in 1955. The refuge offers vital habitat for migratory birds, and is considered a wetland of international significance, due in part to its unique salt marshes created by the high salinity of the groundwater in the area. The United States Fish & Wildlife Service (USFWS) holds a surface water right (established in 1957) on Rattlesnake Creek to support the refuge and the habitat is provides (Figure 10).

For decades, the USFWS expressed concern that its senior water right on Rattlesnake Creek was being impaired by junior water right groundwater pumping. The Rattlesnake Creek/ Quivira Partnership was formed in 1993 with local residents, state and federal agencies working to provide voluntary solutions to the problem in an effort to maintain sustainable water supplies within the region. After decades of efforts to resolve the impairment concerns were unsatisfactory, in April 2013, the USFWS filed an impairment complaint with KDA-DWR. In 2016, KDA-DWR found that junior groundwater pumping impaired the USFWS from exercising its senior water right for Quivira NWR.

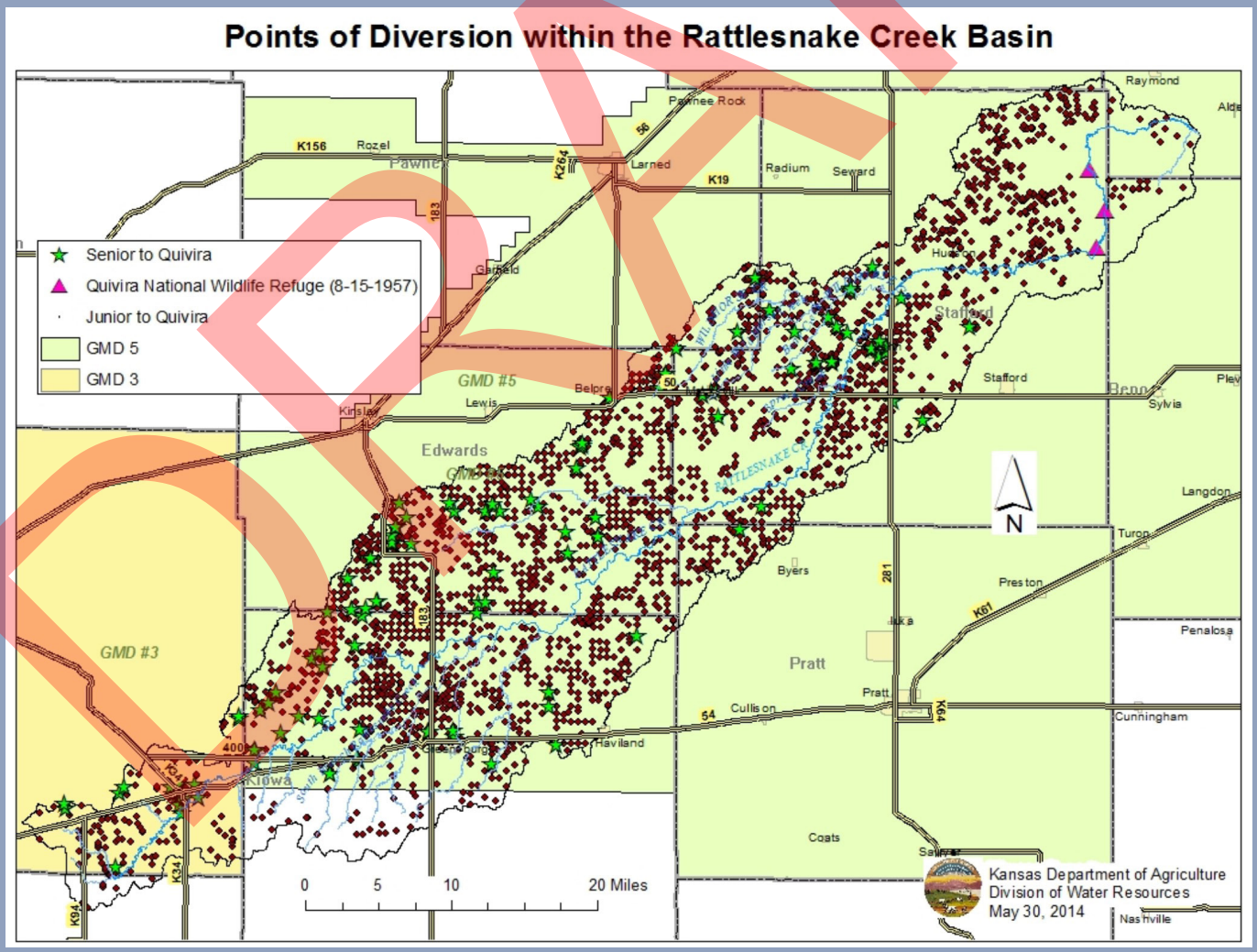


Figure 10. Points of Diversion within the Rattlesnake Creek Basin, KDA

Great Bend Prairie Region

From 2016 through July 2019, KDA-DWR worked with Big Bend Groundwater Management District (GMD No. 5 (GMD5), the groundwater district in the region, to find a solution to the Quivira NWR impairment that would minimize the adverse effect on the region's economy, focusing those efforts on the development of a Local Enhanced Management Area, or LEMA . During that time, no water right administration occurred.

The USFWS and GMD5 agreed that the development and implementation of an augmentation well field will be the primary mechanism to address the impairment. GMD5 applied for a grant to assist in paying for the augmentation well field, and also agreed that the development of a water rights purchase program, a water rights movement program, and a program to incentivize the removal of end guns within the district may be pursued to adjust the amount of water augmented for the refuge by the well field .

While local efforts to address the impairment continued to take shape, In January of 2021 the Audubon of Kansas filed suit in federal court against the U.S. Department of the Interior and various state and local officials alleging they had failed to protect the senior water rights belonging to the Quivira NWR. The lawsuit seeks an injunction that would ensure the refuge has sufficient water supplies by ordering the defendants to protect the refuge and its water right. The litigation is on-going as of July 2021.

0.00 cfs at Rattlesnake Creek near Macksville, KS on July 16, 2012. Photo Credit: Sonja McDanel, USGS

WATER BANKING

The first chartered and only currently active water bank in Kansas is the Central Kansas Water Bank Association (CKWBA) within the geographic footprint of GMD5. The CKWBA facilitates the sale or lease of water rights, providing an electronic bulletin board that helps bring sellers and buyers together. Three types of accounts are available within the CKWBA: 1) water deposit, 2) water lease, and 3) safe deposit boxes referred to as savings accounts. Water rights must be in good standing to participate water banking activities and must remain so, with Section 901 of the Bank Charter stating that violations of contract provisions shall result in a forfeiture of that water user's access to all future Bank activities.

Great Bend Prairie Region

R9 RANCH APPLICATION AND PROPOSED WATER TRANSFER

In 1995 the City of Hays purchased the R9 Ranch near Kinsley, KS (Figure 11), later selling an interest to the City of Russell. The cities have a cumulative water right authorization for irrigation use of approximately 7,700 acre-feet with a calculated consumptive use of 6,750 acre-feet, which could be requested to convert to municipal use. The proposed $80 million project would move water approximately 69 miles to support 35,000 people and a $2 billion economy.

Hays and Russell began the process to request permission to convert the water rights to municipal purposes and transfer the water. Based on a modeling analysis with the change application process, they have agreed to a 30% reduction in the quantity that would be diverted from those wells for municipal use. The 10-year rolling average amounts to 4,800 acre-feet which is sustainable allowing for aquifer recharge.

In 2019, following consideration of comments from local individuals and entities, including the local groundwater management district, the Chief Engineer of the KDA-DWR contingently approved the change applications submitted by Hays and Russell to convert the R9 Ranch irrigation rights to municipal use for the cities. In May 2019, the Water Protection Association of Central Kansas (WaterPACK) filed a request for judicial review of the contingent approval of the change application in Edwards County District Court where a legal ruling is still pending as of July 2021.

Figure 11. Map of R9 Ranch Location, KWO

Great Bend Prairie Advisory Committee

Regional Goals & Action Plans

Priority Goal #1:
Achieve water use sustainability within the Great Bend Prairie Regional Planning Area that includes a reasonable raising or lowering of the water table based on average weather conditions.

ACTION STEPS:

Short-term Actions

- Identify existing voluntary conservation programs and determine if new incentivized conservation programs are needed to compliment current programs.
- Work with the appropriate agencies to ensure that cost-shares are current and economically competitive.
- Hold stakeholder meetings in conjunction with the appropriate agencies to inform the public about the various programs available.

Long-term Actions

- Utilize the KDAMOD* to determine rate of withdrawal from the aquifer from all uses (irrigation, industrial, evapotranspiration, municipal, etc.) versus the rate of recharge to the aquifer from all sources (precipitation, streambank, infiltration, etc.) for the GBP Region.
- Compile the model data into presentation materials for area stakeholder groups/ agencies to identify appropriate management units for further analysis with BBGMDMOD*. This data will analyze the rate of depletion spatially across the area to assist with prioritization of projects and funding.
- Coordinate with state agencies & GMD5 to assess and implement appropriate management controls to bring areas of concern into balance.

** The Big Bend Groundwater Management District high-resolution hydrologic model (BBGMDMOD) was initially created with seven layers, each representing a geologic formation below the ground surface allowing for analysis of water movement between the layers. KDA–DWR unified the seven layers of the BBGMDMOD to create the KDAMOD for quick water quantity assessments for the region. Both variants are based on the same datasets. BBGMDMOD can track water quality between the geologic formations.*

Measuring success:

Goal 1: Increase adoption of water conservation, management tools, strategies and stabilize or improve trends in aquifer levels.

Great Bend Prairie Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- Work with state agencies, cities, rural water districts, and public water suppliers to ensure that the Clean Water Drinking Fee is being appropriately carried out.
- Continue to provide a minimum of 15% and increase more (up to 30%) of Clean Drinking Water Fee for technical assistance by the Kansas Rural Water Association for Public Water Suppliers.
- Work with Irrigation Associations to develop free training opportunities for municipal/residential/commercial irrigators and landscapers.

Priority Goal #2:
Developed for Municipalities and Rural Water Districts. Maintain annual training funds of 15% from Clean Water Drinking Fee and increase technical training support to Public Water Supply (PWS) systems to enhance new technology and increase water efficiently and effectively, thus reducing water loss. Utilize available municipal/residential/commercial irrigation training programs provided by the Irrigation Association.

Measuring success:

Goal 2: Maintain training funds and increase technical training for public water supply systems.

Great Bend Prairie Advisory Committee

Regional Goals & Action Plans

Priority Goal #3:
Enhance the monitoring of poor quality water to stop and minimize further contamination of fresh water sources. Areas of concern include regions which have salt water disposal lines, disposal wells, high nitrate levels, and areas with high salt sources.

ACTION STEPS:

- Establish a program if a problem is observed to ensure the problem does not get worse.
- Start using mapping techniques and disposal line maintenance and replacement to ensure this goal is met.
- Evaluate extent of Kansas Dept. of Health and Environment (KDHE) surface water monitoring network in petroleum producing areas and areas with high salt sources within Great Bend Prairie Regional Planning Area.

  a. Work with KDHE to modify surface water monitoring network if evaluation finds that necessary.
- Develop inventory of current active and legacy salt water disposal lines in Great Bend Prairie Regional Planning Area.
- Continue programs to evaluate current extent of salt water disposal well inventory.
- Evaluate effectiveness of current spill and escape notification requirements.

  a. Work with KCC to modify current spill and escape notification requirements if evaluation finds that necessary.

Great Bend Prairie Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

Priority Goal #3 Continued

- For all Sensitive Groundwater Areas in the Great Bend Prairie Regional Planning Area:

  a. Check the integrity of active and known legacy disposal systems.

  b. Investigate the integrity of plugged abandoned wells suspected of leaking.

  c. Continued programs to conduct Mechanical Integrity Tests on all injection or disposal wells.

  d. Develop a routine groundwater quality program to help determine extent and sources of contamination.

- Educate public in Great Bend Prairie Regional Planning Area about causes and trends of salinity and nitrate issues.

Measuring success:

Goal 3: Develop baseline of water quality conditions within the region and continue support for data collection/monitoring.

Great Bend Prairie Advisory Committee

Regional Goals & Action Plans

Priority Goal #4:
Initiate research and development of alternative feed sources and less water-intensive crops. Technology transfer from this research would have benefits in areas of Kansas where water is not available for production. Multiple research programs such as plant breeding and livestock feeding should be pursued.

ACTION STEPS:

- Achieve large scale feeding trials by 2025.
- Coordinate with the Kansas Department of Agriculture (KDA) to improve adoptability of feed wheat, along with other alternative crops, through marketing, commodity segregation, research and education as stated within the *Vision for the Future of Water Supply in Kansas.*
- Create a program to be able to roll out small- and large-scale feeding trials.
- Find several feedlots to help roll out program.
- Utilize membership of stakeholder groups to solicit interest.
- Coordinate with KDA to implement demonstration plots for yield evaluation.
- Coordinate with KDA to develop markets for feed wheat and other alternative crops for use feed sources.

Measuring success:

Goal 4: Demonstrate collaboration with producers and other entities resulting in implementation of small and large-scale feed trials with less water-intensive crops.

Great Bend Prairie Advisory Committee

Regional Goals & Action Plans

Priority Goal #5:
Work towards sustainability of watersheds so that flood control capacity is maintained while maintaining streamflow to meet downstream water needs. Progress towards sustainability would be to have 50% of the drainage area within watershed districts controlled by watershed structures by 2065. Best available information/data will be evaluated every 10 years to track progress towards meeting this goal.

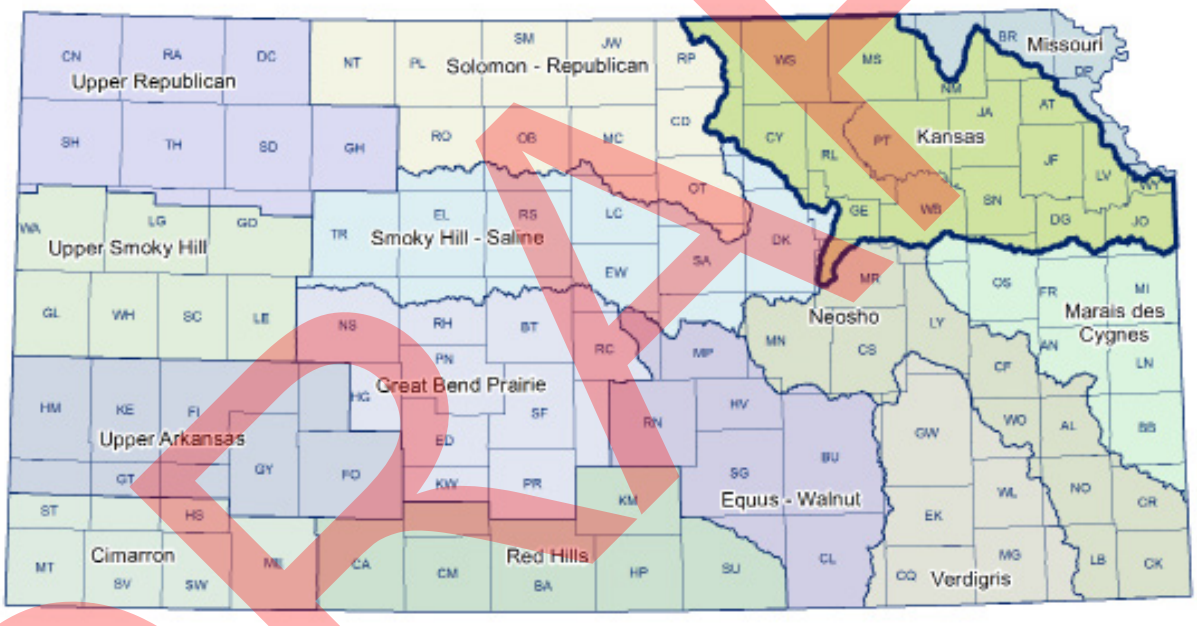
ACTION STEPS:

- Determine percent controlled by watershed structures within watershed districts in Great Bend Prairie Regional Planning Area.
- Work with landowners to promote watershed dams and the important role they have in the community and environment.
- Work with watershed boards and community leaders.
- Determine groundwater recharge potential of watershed structures through modeling efforts.
- Work with watershed districts to determine costs (needs inventory) associated with building additional structures leading up to 50% of drainage area within districts controlled by structures.
- Evaluate the potential of a Multipurpose Small Lake through KDA-DOC in the Great Bend Prairie Regional Planning Area.

Measuring success:

Goal 5: Continue the education efforts on the value of watershed dams with additional dams constructed or renovated in the region.

Kansas Region



Kansas Region

Regional Description

The Kansas Regional Planning Area covers nearly 9,114 square miles of northeast Kansas, making it the largest planning area in the state. The northwestern boundary is at the top end of significant drainage to Milford Lake; the remainder of the Republican River is contained in the Solomon-Republican Regional Planning Area. The portion of the Blue River drainage in Johnson County, which joins the Missouri River in Jackson County, Missouri, is also included in this region. The region includes all or parts of 23 counties (Figure 1).

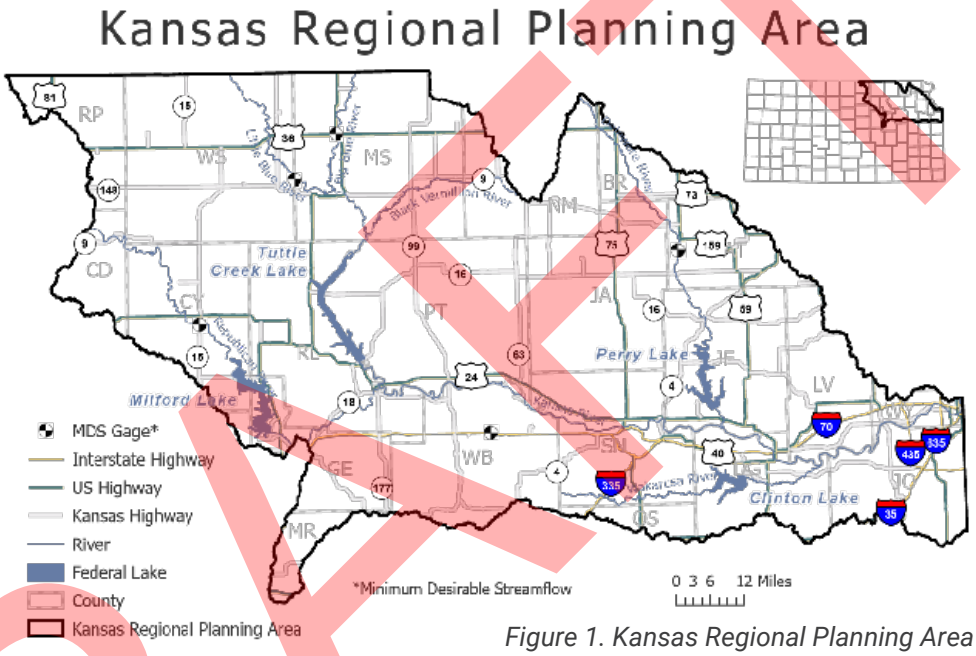


Figure 1. Kansas Regional Planning Area

The major rivers and streams in the region are: the Upper Kansas, including Black Vermillion River, Mill and Soldier Creeks; Blue, including the Little Blue River; Delaware and Lower Kansas, including the Wakarusa River and Stranger Creek. There are four major federal reservoirs in the region: Clinton Lake, Milford Lake, Perry Lake, and Tuttle Creek Lake. All four of these reservoirs store water supply. In addition, there are three multipurpose lakes in the region with water supply storage: Centralia Lake, Banner Creek Reservoir, and Mill Creek Lake.

Elevations in the region range from approximately 1,680 feet above sea level in Republic County to 740 feet above sea level in Wyandotte County.

Kansas Region

CLIMATE & LAND USE

The climate of the Kansas Region is classified as humid continental with cold winters and hot summers. Temperatures and rainfall are highly variable. Normal mean temperature generally increases from northwest to southeast across the region. The average annual temperature of the region is 53° F.

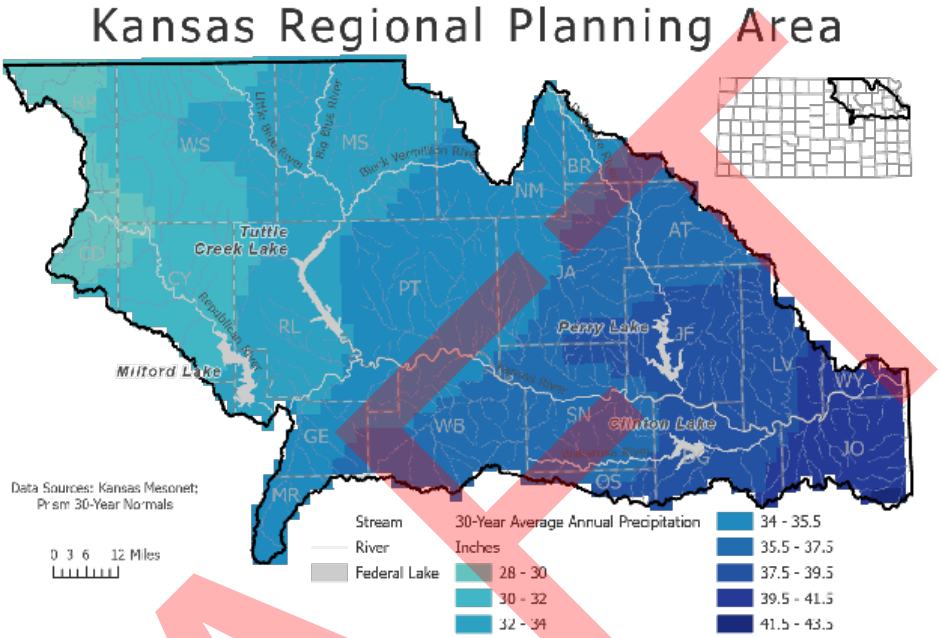


Figure 2. 30-year average annual precipitation in the Kansas Region

Most of the precipitation falls in the summer and spring, and June is typically the wettest month. The regional average annual precipitation is 34 inches (Figure 2). Flood events, such as in July 1993 and the drought experienced from 1952 to 1956, illustrate the variability in precipitation.

Land use activities can have a significant impact on the region. The three major land uses in this region are cultivated crops (33%), herbaceous (27%) and pasture/hay (18%) as derived from the National Land Cover Database (NLCD) 2016 dataset. Figure 3 lists the remaining land uses in the region, including: deciduous forest, developed/urban open space, and water. Pasture is more common in the eastern half of the region, and grasslands and crops dominate the western portion. Rich soils support extensive agriculture throughout the region, with cultivated crops particularly prevalent along river corridors.

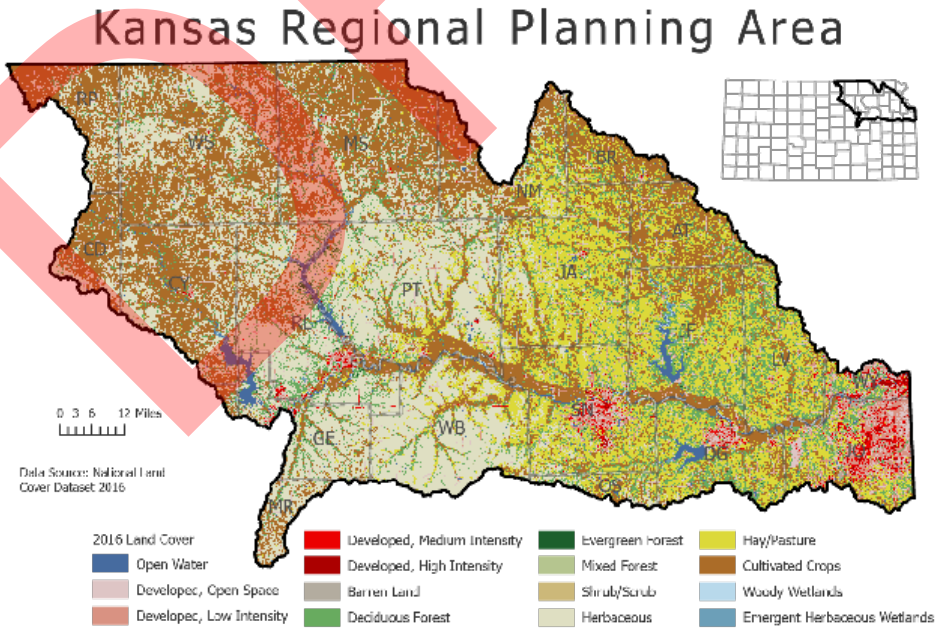


Figure 3. Kansas regional land cover, USGS National Land Cover Dataset

The region contains the major cities of Junction City, Manhattan, Topeka, Lawrence, Kansas City, Kansas, as well as Johnson County suburbs and many other smaller cities and towns. The U.S. Army installation, Fort Riley, is located north of Junction City. Tribal lands of the Prairie Band Potawatomi and Kickapoo nations are also located in the region.

Kansas Region

POPULATION & ECONOMY

The region has the largest population of the 14 Regional Planning Areas.

According to the 2010 Census, there were an estimated 1,147,016 residents in the Kansas Region. Based upon 2019 state-released U.S. Census Bureau information, there were an estimated 1,152,360 residents in the region, an increase of about half of a percent (Figure 4). For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over- or under-represented, so further refining of population information for water supply planning purposes will occur following certification and release of the 2020 Census.

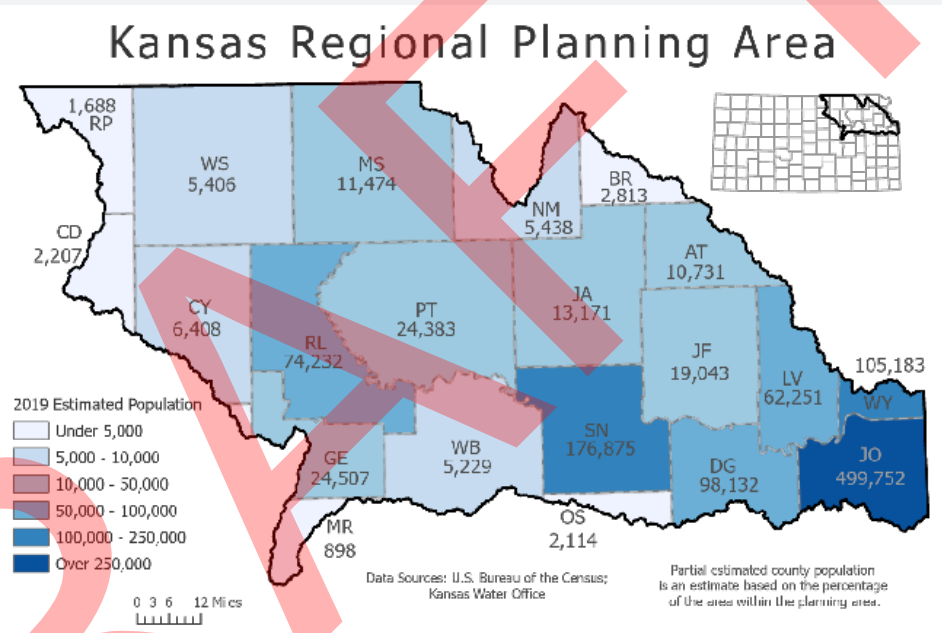


Figure 4. 2019 estimated population by county

Most residents within the region live in cities along the Kansas River. Reflecting trends across the state, urban and suburban cities are expected to grow in population in the future, while rural cities and counties are expected to continue to decline. Two examples demonstrate these trends. Johnson County, with an estimated population of 143,790 in 1960, had an estimated population of 499,752 in 2019. Washington County, with an estimated population of 10,734 in 1960, had an estimated population of 5,406 in 2019.

Of the counties throughout the basin, Pottawatomie, Johnson, Geary, Douglas, and Leavenworth counties are all projected to experience population increases of greater than 30% from 2014 to 2044. Most of the other region's counties within the basin are projected to remain relatively stable during that period with population changes of less than 15%. Republic and Atchison counties are expected to have the greatest relative population decreases with projected declines of greater than 30%.

Economic drivers in the region range from agriculture in the upper and western portion to more commercial and industrial in the lower, more eastern portion of the region. Most of the bottomland and about 50% of the uplands are planted to crops. The primary crops grown include wheat, corn, soybeans, and grain sorghum. Livestock are also a significant part of the economy, particularly beef production in the Flint Hills. The Jeffrey Energy Center has been an important economic driver in the center of the region. The most important mineral resources in the region are oil, natural gas, coal, building stone, sand, and aggregate materials.

Kansas Region

Primary Water Resources in Region

SURFACE WATER

There are four major federal reservoirs in the region: Clinton Lake, Milford Lake, Perry Lake, and Tuttle Creek Lake, as well as three multipurpose lakes, Centralia Lake, Banner Creek Reservoir, and Mill Creek Lake (Figure 5). These reservoirs were built to provide and serve multiple purposes, such as water supply, irrigation, recreation, and flood control. Reservoirs designed for multiple purposes typically possess a specific volume of water storage assigned for each purpose. The Kansas River serves as a critical drinking water supply for more than 800,000 people, in addition to being used for irrigation, municipal wastewater and industrial discharges, cooling water for three coal-fired power plants, and a source of commercial sand and gravel.

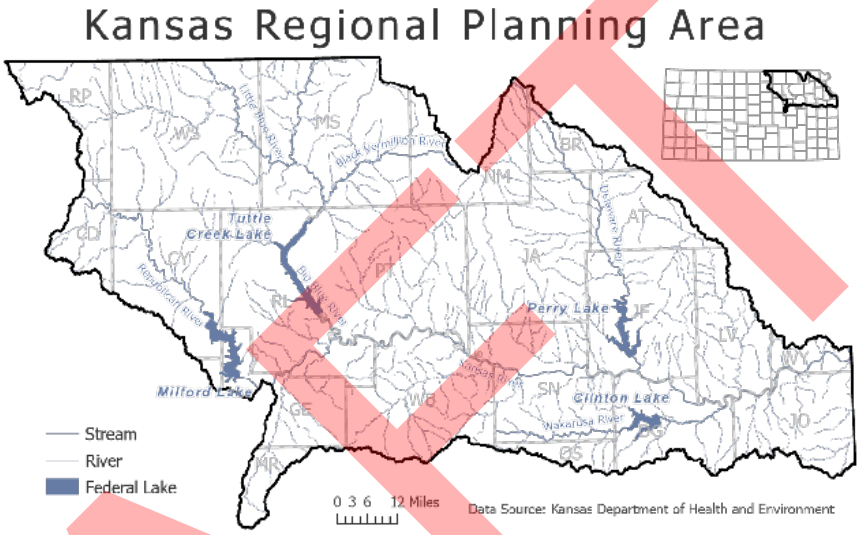


Figure 5. Major surface water resources in the Kansas Region

Water-based recreation is important to the economy of the region with 4 federal reservoirs, 10 state fishing lakes and 43 community lakes attracting boaters, anglers, hunters and campers. State parks and commercial marinas are located on the federal reservoirs in the region.

The Kansas River is one of the three rivers in the state open by law for public access. Interest in river recreation is expected to increase on the Kansas River due to its designation as a National Water Trail. This designation will bring federal funds to the state to develop additional facilities along the river, and additional outdoor recreation opportunities, bolstering local economies.

Tuttle Creek Lake Campground. Photo Credit: Kansas Office of Tourism & Travel

Kansas Region

GROUNDWATER

Groundwater is available throughout the region, located primarily in three aquifers: the Dakota, Glacial Drift, and Alluvial (Figure 6). The alluvial aquifers occupy the valleys of the Kansas, Republican, and Blue rivers and some tributaries. The Glacial Drift Aquifer occupies the area roughly north of the Kansas River and east of the Big Blue River. The Dakota Aquifer is found in Washington and Clay counties and westward.

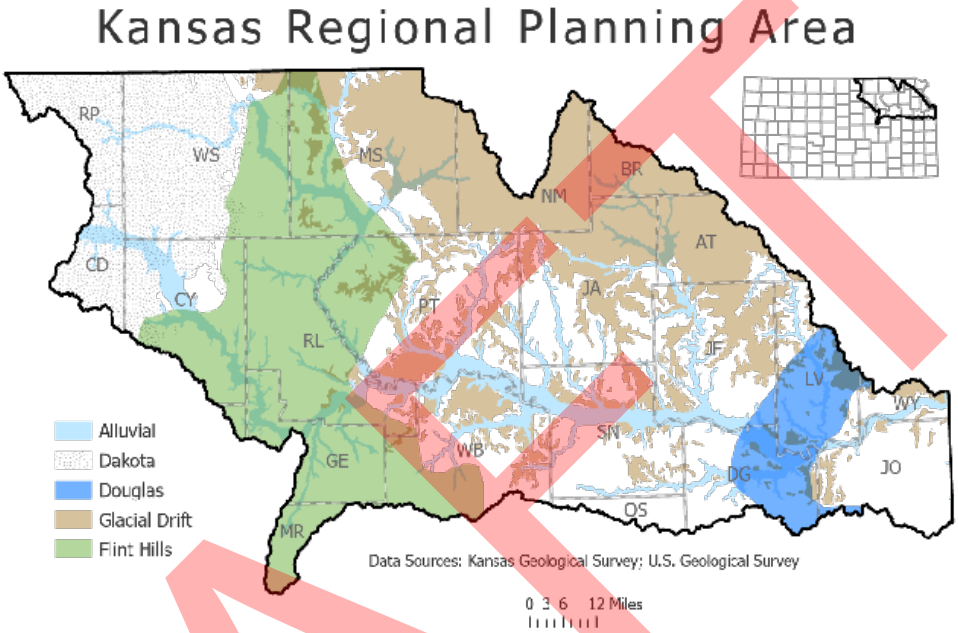


Figure 6. Principle aquifer boundaries in the Kansas Region

Primary Water Use by Source

Surface and groundwater are used equally in the region, with municipal use as the largest in the region at 57%, followed by irrigation (23%) and industrial (16%) (Figure 7).

Annual reported water use for the region fluctuates based on climate conditions, with higher water use resulting from periods of hot and dry weather during the growing season and lower water use taking place during periods of cooler and/or wetter weather.

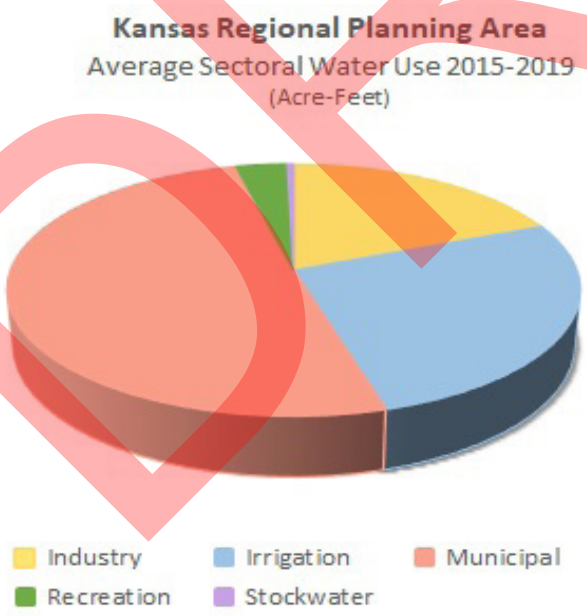


Figure 7. Average sectoral water usage

Kansas Region

Regional Issues & Priorities

WATER SUPPLY AVAILABILITY

Increasing population and development in portions of the Kansas River corridor, along with aging reservoirs and public water supply infrastructure, indicate a need to evaluate the river/reservoir system capacity to meet future water supply needs in the region (see *Secure, Protect, and Restore our Kansas Reservoirs*).

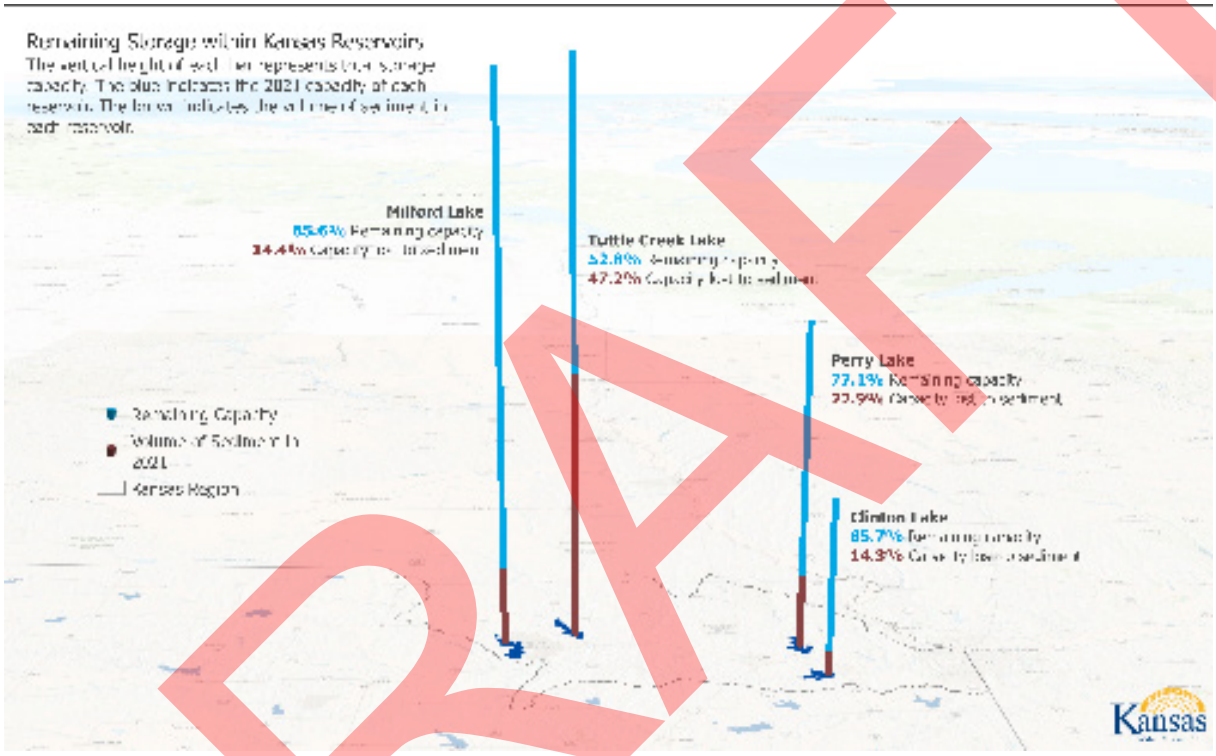


Figure 8. Remaining storage within Kansas reservoirs in the Kansas Region

Four federal reservoirs and three multipurpose lakes in the region currently provide dependable water supplies in streams with highly variable flow, in addition to providing flood control, recreation and other benefits. However, reservoir sedimentation is a major water quantity and quality concern, particularly in reservoirs where the state owns storage to support the Water Marketing Program or where a Water Assurance District owns storage. Soil type, land practices, and extreme rainfall events are the main causes that lead to excessive reservoir sedimentation. High flow events following heavy rainfall account for a large portion of the sedimentation that takes place in reservoirs. As this sediment accumulates in a reservoir's multi-purpose pool, the capacity for water supply storage is reduced.

With an annual sedimentation rate of approximately 3,800 acre-feet per year, the loss of capacity in Tuttle Creek Lake is the most pressing issue among the four federal reservoirs, as it is the key water supply reservoir for the Kansas River Basin (Figure 8). At the time of this writing Tuttle Creek Lake has already lost 47.2% of its storage capacity.

Kansas Region

Figure 9 shows the projected water supply storage given the historic rate of reservoir sedimentation based on the change in estimated volume indicated through bathymetric surveys (earliest survey versus most recent survey), along with the storage required to meet the system's demands and targets. The analysis was performed with current system operations using a Kansas River basin model, which simulates historic hydrologic conditions between 1950 and 2014, allowing for an estimate of required storage. Future water supply modeling for the Kansas River basin shows that in both low and high demand scenarios there will be insufficient reservoir storage to maintain low flow targets on the Kansas River through a 1950s-type drought event.

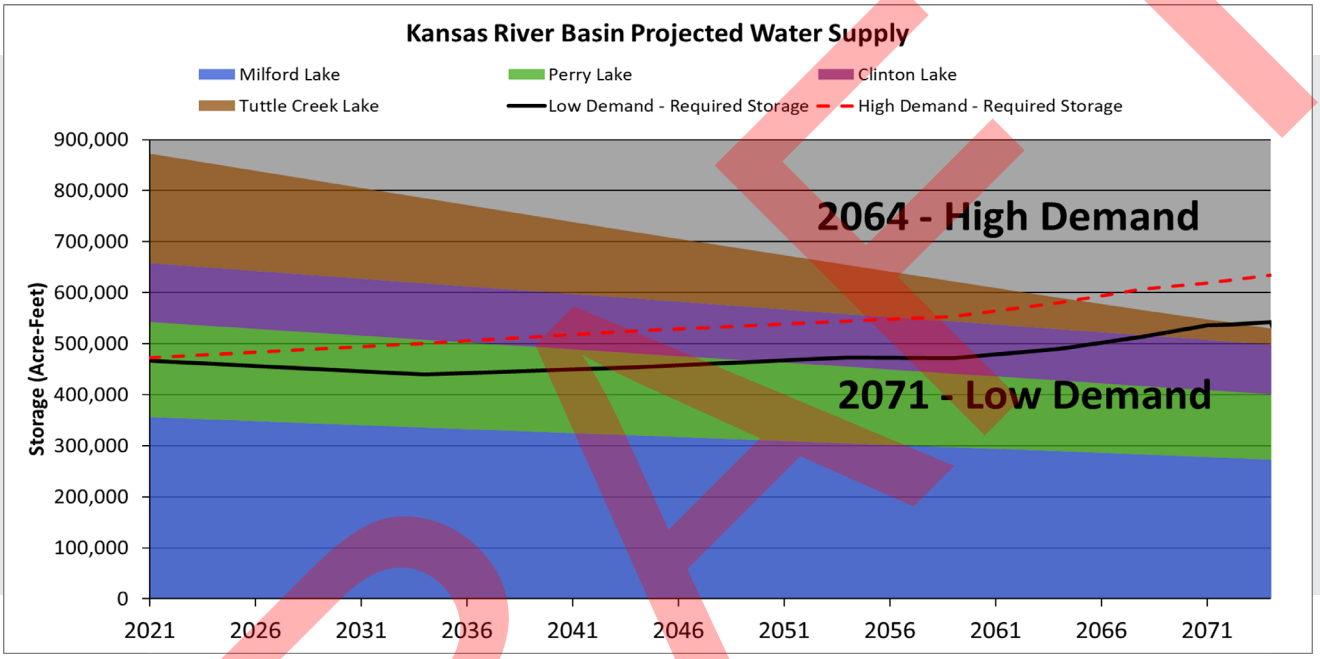


Figure 9. Projected water supply storage given historic rate of sedimentation based on the changed in bathymetric surveys and demand requirements

With continued sedimentation and loss of reservoir storage, the current Water Quality Pool storage allocation within Tuttle Creek Lake will be insufficient to maintain water quality flow targets, requiring the usage of increasing portions of reservoir Water Supply Pool allocations. Note that this estimate includes the storage currently owned by the State of Kansas, along with storage that is under contract but not currently being paid for (future-use storage). The low demand scenario incorporates the planned retirement timeline of power plants along the Kansas River and no new industrial users being added. The loss of reservoir storage volume, current water quality storage allocations, and potential for navigational releases of reservoir storage reduce the drought resiliency for the Kansas River system.

Options for protecting, securing and restoring storage were evaluated during 2013 and are incorporated in the Kansas-Lower Republican Basin section of the Reservoir Roadmap. The State has also worked with the U.S. Army Corps of Engineers (USACE) to evaluate and pursue innovative methods for managing sediment in reservoirs, such as hydrosuction and water-injection dredging (WID). The Kansas Water Office (KWO) and USACE are currently planning a WID demonstration at Tuttle Creek Lake to assess its viability as a long-term sediment management tool. In addition to in-lake efforts at managing reservoir sedimentation, the State has worked to implement practices upstream in the watershed aimed at reducing the amount sediment reaching the downstream reservoir.

Kansas Region

Streambank erosion upstream of the reservoirs significantly contributes to the sedimentation in the Kansas Region. As of 2021, there are 435 streambank hotspots above the four federal reservoirs in the Kansas Region, including all of the Milford watershed. Of the 435 sites, 160 have been stabilized, reducing the sediment load by an estimated 635,509 tons per year. There are 275 sites that remain to be completed, which, if completed, will reduce the sediment load by an additional estimated 500,697 tons per year (Figure 10). Additionally, Best Management Practices (BMPs), such as no-till agriculture and cover crops, are being promoted and implemented throughout the region, further reducing sedimentation.

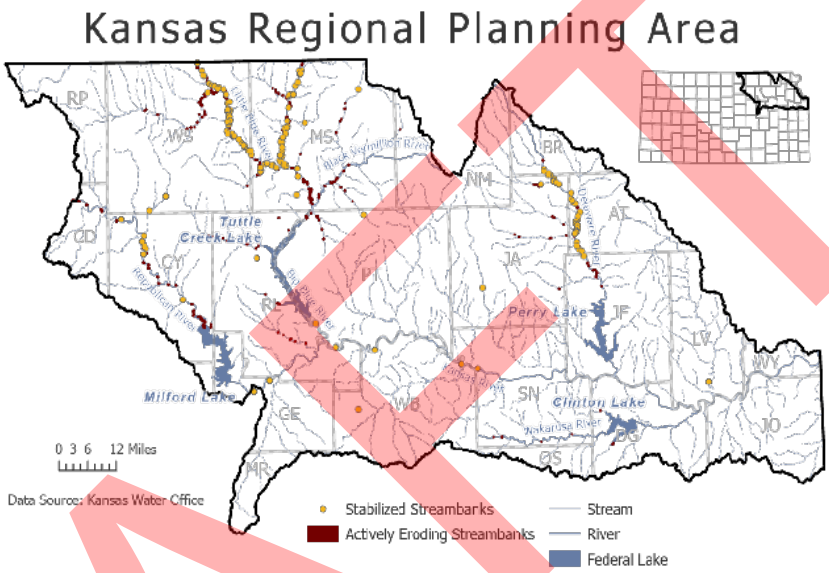


Figure 10. Actively eroding and stabilized streambanks within the Kansas Region

WATER QUALITY

The State of Kansas collects ambient surface water quality information throughout the region. Surface water not meeting water quality standards established for the designated uses of those water bodies are included on the 303(d) List of Impaired Waters. Water quality and related water resource issues can only be addressed through a combination of watershed restoration and resource protection efforts utilizing voluntary, incentive-based approaches, as well as some regulatory programs. Most of the water quality impairment is caused by land use runoff which is a non-point source pollutant and is not subject to regulations by the Federal or state government. The Clean Water Act requires states to conduct Total Maximum Daily Load (TMDL) studies and develop TMDLs for water bodies identified on the State's Section 303(d) List. TMDLs establish quantitative objectives and strategies needed to achieve the state's surface water quality standards. A list of all impaired/potentially impaired waters for the Kansas Region can be found on the Kansas Department of Health and Environment (KDHE) impaired waters website (Figure 11).

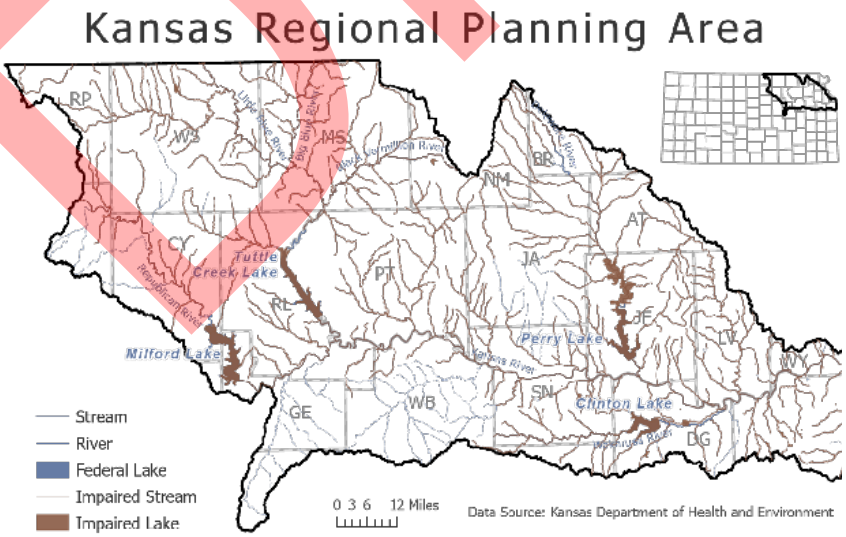


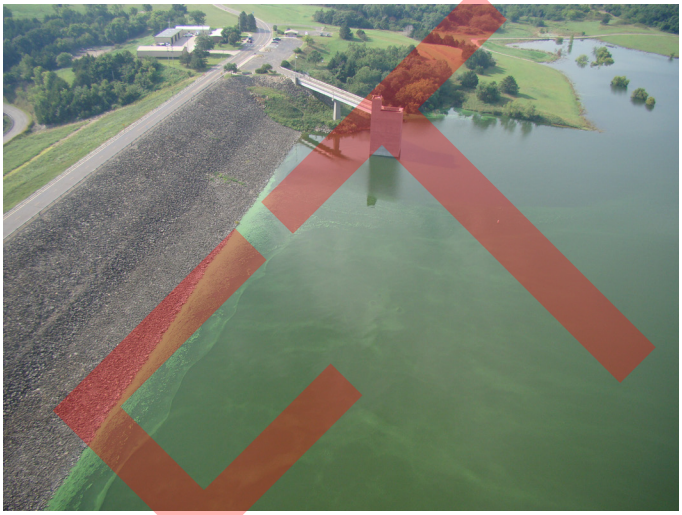
Figure 11. Impaired water resources in the Kansas Region, KDHE

TMDLs for high priority impaired surface waters have been developed to target implementation to address designated pollutants. There is no corresponding state groundwater quality monitoring network.

Kansas Region

HARMFUL ALGAL BLOOMS

Harmful Algal Blooms (HABs), as discussed in the *Water Quality* section of the *Kansas Water Plan (KWP)*, have caused pet and livestock deaths. While it can cause illness in humans, there have been no mortalities attributed to the toxins created by these bacteria. This worldwide problem has led to significant research on causes, treatments, and prevention of HABs, some of which is being conducted by the Kansas Biological Survey (KBS) using lake sediment cores from water bodies throughout the state to evaluate historical HAB event timing. Since 2000, HABs have occurred more often and the duration has been longer, particularly at locations within the Kansas Region. More information on HABs research can be found at the KBS website.



Milford Lake HAB , 2011. Photo Credit: KDHE

In the Kansas Region, reducing the occurrence of HAB events at Milford Lake is a top priority. KDHE has considered a number of HAB mitigation strategies at Milford Lake, including reservoir drawdown to reduce cyanobacteria habitat, vegetation to remove nutrients, peroxide based algaecide, ultrasound, and rough fish removal. Milford Lake has experienced some degree of HABs most years since 2011. The HAB in 2011 was largely due to a combination of conditions including the holding of nutrient rich flood waters for an extended period due to Missouri River flooding, coupled with extremely hot temperatures. There have been blooms in years since that have resulted in warnings and even lake area closures for at least part of the summer in all or parts of the reservoir. HAB events have not been limited to Milford Lake. Perry Lake, as well as a number of smaller lakes in the region, have also had issues with HABs. Both Milford Lake and Perry Lake had HAB advisories issued in 2020.

ECOSYSTEM/HABITAT PROTECTION AND RESTORATION

The benefits provided by riparian and fresh water aquatic ecosystems are critical for maintaining healthy and sustainable habitat and water supply within the Kansas Region.

Least Tern. Photo Credit: Bob Gress, BirdsInFocus.com

Conservation and restoration efforts, with an emphasis on natural solutions like wetlands and riparian reforestation to ensure adequate habitat for healthy ecosystems, are critical for preserving ecosystem services (benefits to human needs and culture) within the region. With this in mind, the goal of water resource management is to maximize the benefit of water resource infrastructure while limiting the ecological impacts. In some cases, it is possible to improve conditions for wildlife in the Kansas River that have been adversely impacted by alterations to the flow regime.

Kansas Region

Surveys conducted by the Kansas Department of Wildlife and Parks (KDWP), the University of Kansas, Ft. Hays State University, and the interagency Kansas Cooperative Fish and Wildlife Research Unit based at Kansas State University all indicate the decline of several fish species in the Kansas River. The pallid sturgeon is considered to no longer occur in the Kansas River and the once abundant plains minnow is absent in the lower reaches. In general, species previously adapted to the historic condition of the river, which was shallow and turbid, have declined while those with less specialized habitat needs have replaced them. Studies have indicated a shift to lake-like aquatic species below river mile 22, about 5 miles east of DeSoto.

The Kansas River is designated critical habitat for the piping plover and interior least tern. These bird species require sandbars free from vegetation for nesting habitat. Periodic high flows are necessary to scour sandbars of vegetation providing the necessary habitat conditions. Reservoirs on tributaries of the region have reduced the magnitude and frequency of high flows to the downstream system.

AQUATIC NUISANCE SPECIES

Zebra mussels, one of the Aquatic Nuisance Species (ANS) affecting Kansas waters, had been found in Clinton, Milford, and Perry lakes prior to 2017. In 2017, the presence of Zebra mussels was confirmed in Tuttle Creek Lake. These small non-native mussels are prolific producers of off-spring and can be transported very easily by recreationalists.

This particular invasive species has been linked to increasing HABs due to their feeding habits. ANS can diminish food supplies and degrade habitat for other species; reduce numbers and variety of desirable fish; reduce fishing, boating, and other recreational activities; lower property values and decrease quality of municipal water sources; foul water lines; clog intakes; burn out pumps; damage power generating facilities; and decrease water system efficiency, as well as increase the risk of flooding due to overcrowded biomass and clogging of lake outlets.

Asian Carp are common in the Missouri River and a limited number have made their way to Bowersock Dam at Lawrence. These invasive species compete with other native fish for food resources, consuming 40% of their body weight per day.

Zebra mussels. Photo Credit: Lauren Sopher, Lake Champlain Committee

The KDWP has worked diligently on education and management plans to mitigate the problem and work to slow the spread of these species. More information on ANS and their potential impacts can be found here.

Kansas Region

TRIBAL NATIONS

The Prairie Band Potawatomie Band Nation and the Kickapoo Tribe in Kansas reside in the Kansas Regional Planning Area. Both tribal groups place cultural and historic value on sites and natural resources throughout the region. In addition, the tribal groups have a federal water right linked to the establishment of their reservations: federal reserved water rights were recognized by the U.S. Supreme Court in *Winters v. United States* (1908).

In 2017, the Kickapoo Tribe became the first in the state to have its water rights quantified (Figure 12). The Kickapoo Tribe has been seeking to develop a more secure water supply for its current and future needs. The State of Kansas, the Kickapoo Tribe, and the federal government cooperated for the purpose of building a reservoir to satisfy the Kickapoo Tribe's water rights, under the United States Department of Agriculture's (USDA) Small Watershed Program from the 1970s-1990s. Cooperation broke down over securing land necessary for the reservoir. The Kickapoo Tribe filed a federal lawsuit in June 2006 asking the State of Kansas to condemn land and recognize the Tribal Water Right. The land issue was resolved by the court in early 2014. The parties (Kickapoo Tribe, State of Kansas, U.S.A) agreed to suspend active litigation to negotiate a resolution.

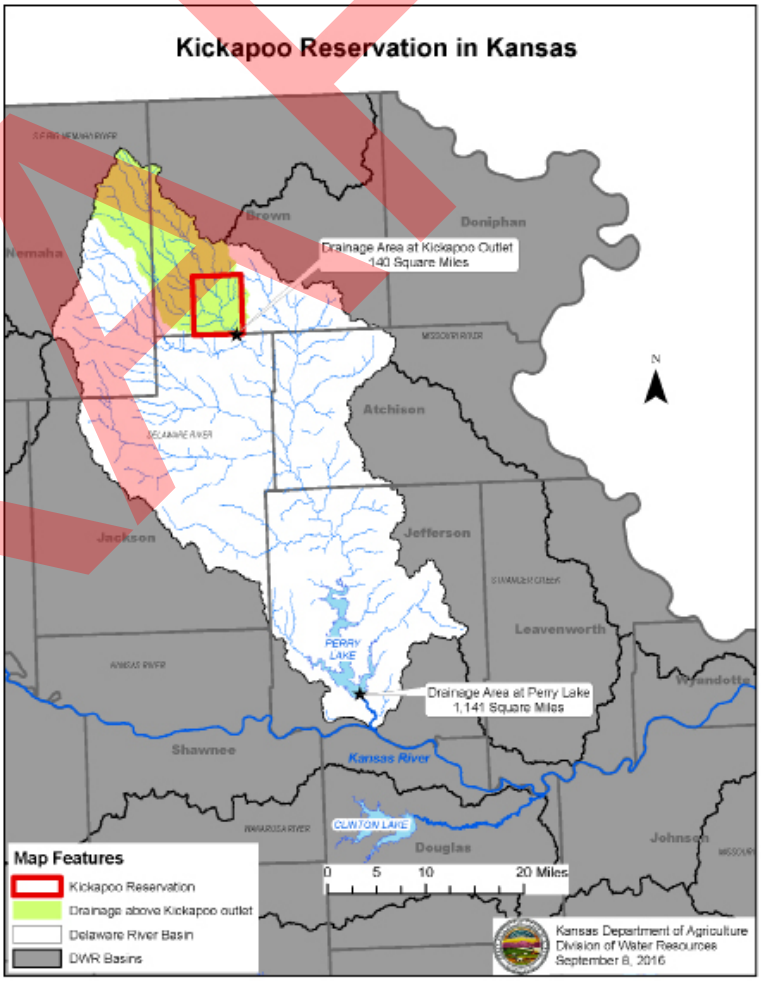


Figure 12. Kickapoo water resources map, KDA-DWR

The Kickapoo Tribe Water Rights Settlement Agreement was signed on September 8, 2016. The agreement is the culmination of the negotiations. On February 13, 2017, the Kickapoo Tribe, State of Kansas, and federal partners filed a Joint Stipulation for Dismissal of the litigation.

Under the Water Right Settlement Agreement, the Kickapoo Tribe may divert or redivert, as available, up to 4,705 acre-feet of water per year with a priority date of October 24, 1832 for any direct use for the tribe. Domestic use by members and allottees does not count against the Tribal Water Right. State of Kansas domestic water rights are exempt from administration to protect the Tribal Water Right. The Kickapoo Tribe may store water in one or more reservoirs, for the purpose of subsequent direct use, up to a combined volume of 18,520 acre-feet.

It is imperative that the Kickapoo Tribe's significant and vitally important water right be included in planning considerations to ensure water supply needs are met throughout the region.

The Goals and Action Plans contained herein are as developed by the Regional Advisory Committee.

Kansas Regional Advisory Committee

Regional Goals & Action Plans

PREAMBLE:
We recommend that KWO foster a collaborative partnership approach to water resource issues across Kansas by utilizing the following key principles.

KEY PRINCIPLES: *ALL GOALS AND ACTION PLANS IN THE KANSAS REGIONAL PLANNING AREA WILL FOLLOW THE FIVE KEY PRINCIPLES*

- Partnerships - Every federal, state and local agency will work together in partnership for the benefit of water resources. This will require these organizations to work cooperatively in order to coordinate programs, funding and technical resources to achieve shared water resource goals.

- Action is Grassroots – Actions to achieve water resource goals should initiate from and be carried out at the grassroots level (i.e. locally). Property owners in targeted regions must play an integral part of the process and their input informs the prioritization of projects for watersheds. "Action is Grassroots" means that all projects are voluntary, and that local landowners continue to work through existing systems to coordinate, encourage, and commit to high priority projects. Mechanisms that allow for bottom-up decision-making will be central to action in the Kansas Region as local landowners utilize their knowledge of the region to determine what projects are best and workable for the area.

- Watershed Based – All projects and associated funding are prioritized based on the needs in the watershed rather than on political boundaries.

- Prioritization Based on Data – All projects and associated funding are prioritized through a science-based system within the watershed that emphasizes targeting for the greatest impact.

- Outreach – Critical projects within a watershed are identified, and outreach is conducted to encourage and support participation by key (high priority in the watershed based on science-based analysis) property owners in the watershed.

Kansas Regional Advisory Committee

Regional Goals & Action Plans

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

ACTION STEPS:

- Increase water storage availability in federal reservoirs to supplement instream flow needs of the Kansas River. Streambank sites will be evaluated after the years with major flooding in the region.

  a. Complete necessary background work to support a request to reallocate storage from water supply to water quality in Milford and Perry Lakes. Move a sufficient amount of storage from water supply to water quality in support of Kansas River quality flow targets.

  b. Determine the amount of additional annual costs for calling into service the remaining water supply storage not needed to meet instream purposes, and request full funding from the state. When funding is secured, call into service storage not to be included within reallocation request.

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

- The Kansas Regional Advisory Committee (RAC) recommends the KWO pursue Forecast Informed Reservoir Operations and, as articulated in the "Basin Restoration Approach: Kansas Lower Republican," the Kansas RAC advises the KWO to improve coordination with the USACE on reservoir releases, management plans, and future actions to address resiliency to flood and drought conditions, water quality, and quantity issues.

- The 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.

Measuring success:

Goal 1: Secure and maintain adequate storage in federal reservoirs in order to meet water quality and quantity needs in the region.

Kansas Regional Advisory Committee

Regional Goals & Action Plans

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

ACTION STEPS:

The KWO will compile existing information and complete additional evaluation necessary to determine areas of water supply need for the following goals:

- Explore additional storage possibilities for construction of multipurpose small lakes so that new water sources can be brought online to alleviate specific regional issues.
- Work with Kansas Department of Agriculture-Division of Conservation (KDA-DOC), Natural Resource Conservation Service (NRCS) and local watershed districts to identify existing watershed structures that are in need of restoration that have potential to be made larger and provide supplemental water supply.
- Work with KDA-DOC, NRCS and local watershed districts to identify watershed dam and multipurpose small lake 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 including demonstrated need, return on investment, suitability of site for long-term use, taking into account potential for HABs and sedimentation, and other legal and logistical issues.
- Seek partnership and funding opportunities for proposed projects that meet the established criteria.
- Support the KWO and Kansas Department of Agriculture-Division of Water Resources (KDA-DWR) in their efforts to ensure all municipalities and rural water districts have updated water conservation plans that meet the 2007 Municipal Water Conservation Plan Guidelines.

Measuring success:

Goal 2: Complete evaluation of current water supply and demand in the Kansas River basin and areas of need identified. In collaboration with multiple partners, compile a list of potential solutions for areas lacking in water supply and criteria to determine projects with greatest anticipated benefit.

Kansas Regional Advisory Committee

Regional Goals & Action Plans

Priority Goal #3:
Reduce the cumulative sediment rate of federal reservoirs and other water supply lakes in the Kansas region to ensure adequate water supply for the region for the next 40 years.
Achieve individual reduction goals set by the Kansas Water Office for each lake as set forth by the nine-element watershed plan for each within 40 years.

ACTION STEPS:

- Establish a complete list of major reservoirs and water supply lakes in the Kansas Region.
- The KWO shall set individual sediment reduction goals for each major reservoir and water supply lake to be updated as new information becomes available.
- The sediment reduction goals for reservoirs and lakes will be achieved using Best Management Plans (BMPs) implemented in the watersheds of these reservoirs and lakes in the region. An estimated $5 million will be needed annually for implementing BMPs to achieve targeted watershed goals within 40 years.
- Reduce sediment load from out-of-state sources by working with neighboring states and supporting their efforts to implement BMPs.
- By 2024, all state and federal lands surrounding each federal reservoir and water supply lake in the Kansas Region must implement BMPs such as no-till, soil health practices, or buffers, at levels to support achievement of sediment reduction at each reservoir or lake.
- The KWO, in coordination with other state agencies, shall ensure individual Watershed Restoration and Protection Strategy (WRAPS) plans and conservation districts' goals for the Kansas Region include the concept of reservoir sustainability with the goal of maintaining storage capacity in Kansas Region reservoirs.
- Pursue innovative sediment management alternatives, such as Water Injection Dredging (WID) technology.
- The Kansas RAC will have representation on the Natural Resources Conservation Services (NRCS) Kansas Technical Committee to help ensure that reservoir sustainability and Kansas water supply issues are addressed in NRCS goal-setting and programs.

Kansas Regional Advisory Committee

Regional Goals & Action Plans

Priority Goal #3: Continued

ACTION STEPS:

- Establish programs with local universities to leverage relevant expertise and student resources that will address the sedimentation reduction goal.
- Obtain technical assistance and advisors (TA) at a level sufficient to meet the BMP implementation goals in the region. It is estimated that additional TA funding of at least $350,000 annually would be necessary.
- NRCS and local conservation districts, in coordination with other state agencies, should prioritize the completion of voluntary Comprehensive Conservation Plans for all land in the Kansas RAC Region and encourage landowners to develop such plans. These plans will be designed to address natural resource concerns on cropland, in riparian zones, on pastureland, livestock feeding areas and others on a whole land or farm unit basis, rather than on an individual crop field or a single resource concern basis. Information generated from these comprehensive plans will be used to aid in identifying BMP needs and prioritization of sub-watersheds in the basin, as well as assist with funding and implementation decisions. Eligibility for BMP cost-share programs should be prioritized for lands that have Comprehensive Conservation Plans.
- The KWO shall take the lead to create a partnership list of all BMP implementation programs available to the public from federal and state agencies, natural resource organizations and other groups. This list will be created and shared via a website hosted by KWO as well as in a 1-page flyer (or multiple page booklet as needed) that will be made available to the public. This information will be updated in real time on the KWO website and quarterly on the flyer by KWO staff and distributed widely to all agencies and partnersfor use and distribution. This document will be a key means to inform the public about all available cost-share and technical assistance available for BMP implementation.

Measuring success:

Goal 3: Document sediment load reductions from stabilization of streambank hot spots and expansion of BMPs provided through the Milford Watershed Regional Conservation Partnership Program (RCPP) and Kansas Reservoir Protection Initiative (KRPI). Complete a Water Injection Dredging (WID) demonstration at Tuttle Creek Lake to evaluate its potential to preserve reservoir storage.

Kansas Regional Advisory Committee

Regional Goals & Action Plans

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

ACTION STEPS:

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

- Identify and request natural solutions be incorporated for all appropriate applications.

  a. Examples of natural solutions include:

  i. Prescribed burns (reduces atmospheric carbon output by preventing larger fires later with smaller fires now, and encourages climate-adapted native vegetation);

  ii. Hardwood reforestation in riparian areas (reduces erosion, reduces surface runoff; lowers water temperature);

  iii. Reduced impact logging (leave hollow trees standing, minimize clear cutting, maintain age diversity in forest stand, preserve highest quality trees);

  iv. Using soil health/regenerative agriculture practices on cropland (no soil disturbance, diversity of species, living root in the soil at all times, keeping soil covered, allow livestock impact) and rangeland (short periods of intense grazing, leaving more than 50% of plant biomass ungrazed, long periods of rest);

  v. Wetlands and flood plains (pollution and erosion filtering, mitigation of pollutants, flood damage buffering);

  vi. For all of the above, see Proceedings of the Natural Academy of Sciences of the United States of America, "Natural Climate Solutions," October 31, 2017, 114 (44) 11645-11650.

Measuring success:

Goal 4: Document effectiveness of natural solutions currently in use and utilization of pilot demonstrations to evaluate the potential for additional measures to support sustainable water quality improvements.

Kansas Regional Advisory Committee

Regional Goals & Action Plans

Priority Goal #4: Continued

ACTION STEPS:

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

Measuring success:

Goal 4: Document effectiveness of natural solutions currently in use and utilization of pilot demonstrations to evaluate the potential for additional measures to support sustainable water quality improvements.

Kansas Regional Advisory Committee

Regional Goals & Action Plans

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

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

ACTION STEPS:

- The Kansas RAC shall recommend to the KWA that a minimum of $3 million per year shall be allocated towards HAB mitigation in the Kansas Regional Planning Area with a minimum of $1.5 million to be directed to BMP implementation in the Milford Lake Watershed.
- By 2024, all state and federal lands surrounding each federal reservoir and water supply lake in the Kansas Region must implement BMPs such as no-till, soil health practices, or buffers, at levels to support achievement of HAB reduction at each reservoir or lake.
- The KWO, in coordination with other state agencies, shall ensure individual WRAPS plans and conservation districts' goals for the Kansas RAC Region include the concept of minimizing nutrient inflow to lakes to reduce the potential for HABs with a focus on best management practices such as no-till, soil health and nutrient management practices, or buffers.
- Encourage stakeholders to engage in collaborative efforts that result in the reduction of nutrient loading in federal reservoirs (example, Milford RCPP). The Kansas RAC recommends that the KWO include management for HABs as part of the lake level management plan to mitigate HABs in reservoirs, as well as minimize downstream impacts.
- Support ongoing research for identification and remediation of the causes, prevention and treatment of HABs, including potential in-lake technologies.

Measuring success:

Goal 5: Collaborate with multiple partners to increase knowledge of HABs and reduce occurrence and duration.

Kansas Regional Advisory Committee

Regional Goals & Action Plans

Priority Goal #5: Continued

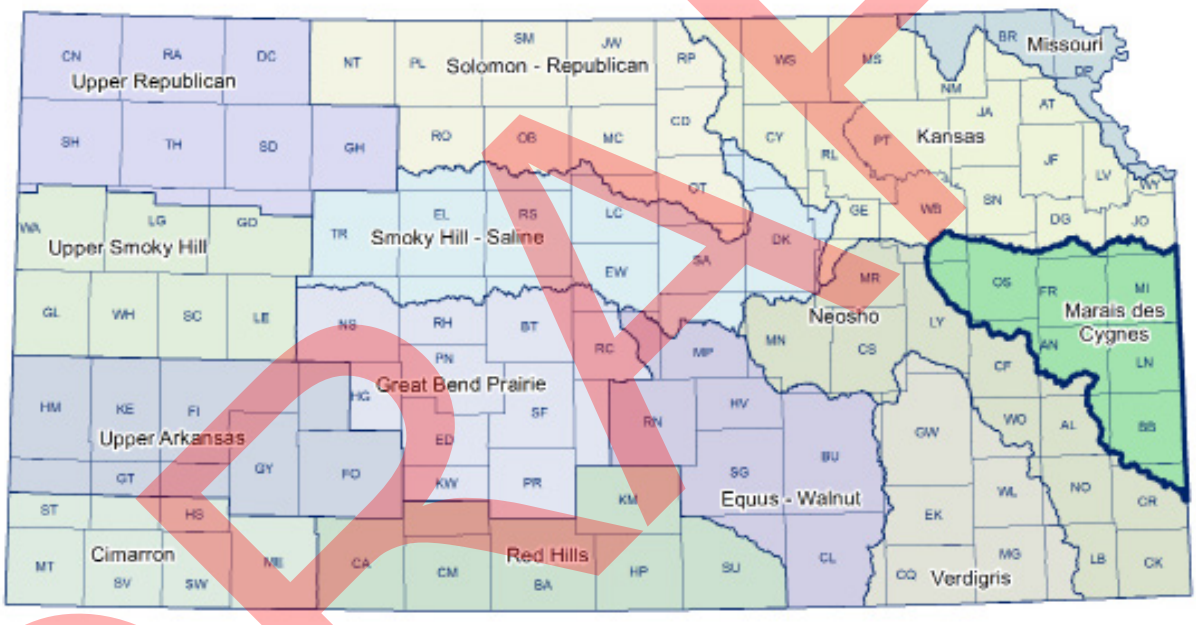
ACTION STEPS:

- Establish programs with local universities to leverage relevant expertise and student resources that will address the HAB reduction goal.
- NRCS and local conservation districts, in coordination with other state agencies, should prioritize the completion of voluntary Comprehensive Conservation Plans for all land in the Kansas RAC Region and encourage landowners to develop such plans. These plans will be designed to address natural resource concerns on cropland, in riparian zones, on pastureland, livestock feeding areas and others on a whole land or farm unit basis, rather than on an individual crop field or a single resource concern basis. Information generated from these comprehensive plans will be used to aid in identifying BMP needs and prioritization of sub-watersheds in the basin, as well as assist with funding and implementation decisions. Eligibility for BMP cost-share programs should be prioritized for lands that have Comprehensive Conservation Plans.
- Encourage KDHE and KDWP to continue providing funding to support roughfish removal.
- Obtain technical assistance and advisors (TA) at a level sufficient to meet the HAB reduction goals in the Region.

Measuring success:

Goal 5: Collaborate with multiple partners to increase knowledge of HABs and reduce occurrence and duration.

Marias des Cygnes Region



Marais des Cygnes Region

Regional Description

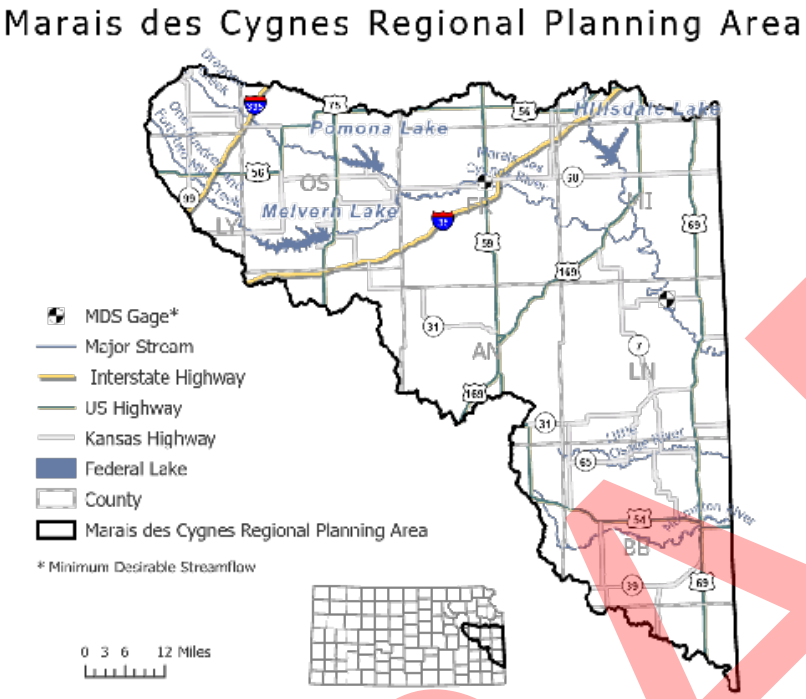


Figure 1. Marais des Cygnes Regional Planning Area

The Marais des Cygnes Region covers 4,255 square miles of east-central and southeast Kansas and includes all or parts of 13 counties (Figure 1). The region contains the headwater tributaries of the Osage River that forms in western Missouri. The Marais des Cygnes River, a major tributary to this system, begins near Eskridge in Wabaunsee County, Kansas, and flows east and south to join the Little Osage River in Bates County, Missouri. Dragoon Creek, Bull Creek, Pottawatomie Creek, and Sugar Creek are major tributaries to the Marais des Cygnes River in Kansas.

The Marmaton and Little Osage Rivers originate as headwater tributaries to the Osage River in the southern part of the region in Kansas and join in Missouri just above the confluence with the Marais des Cygnes to become the Osage River. Major cities in the region include Osage City, Ottawa, Garnett, Paola, Osawatomie, Louisburg, and Fort Scott.

CLIMATE & LAND USE

The climate of the region is classified as humid continental with cold winters and hot summers. Normal mean temperature generally increases from northwest to southeast across the region. The average mean temperature of the region is 54° F. Most of the precipitation falls in the summer and spring with June typically being the wettest month (Figure 2). A major flood event in 2007 and the drought experienced from 1952-1956 underscore the variability in precipitation.

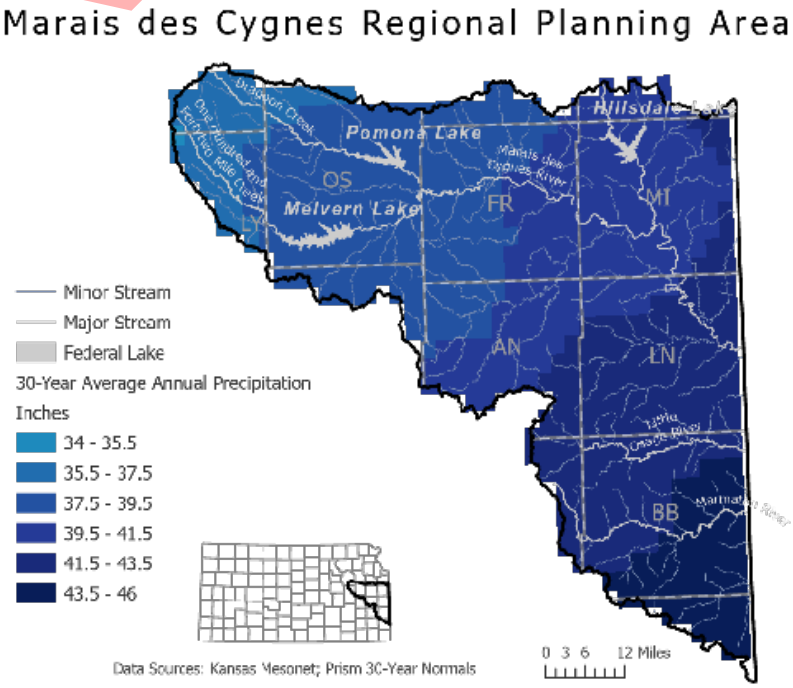


Figure 2. 30-year average annual precipitation in the Marais des Cygnes Region

Marais des Cygnes Region

Land use activities can have a significant impact on the region. The three major land uses in this region are pasture/hay (44%), cultivated crops (22%) and deciduous forest (13%) as derived from the National Land Cover Database (NLCD) 2016 dataset. Figure 3 lists the remaining land uses in the region, including herbaceous, developed/urban open space, and water.

Many regional highways provide transportation connectivity through the region. Interstates 35 and 335 cross the region from northeast to southwest. U.S. Highways 75, 59, 169, and 69 cross the region from north to south while U.S. 54 and 56 cross from east to west.

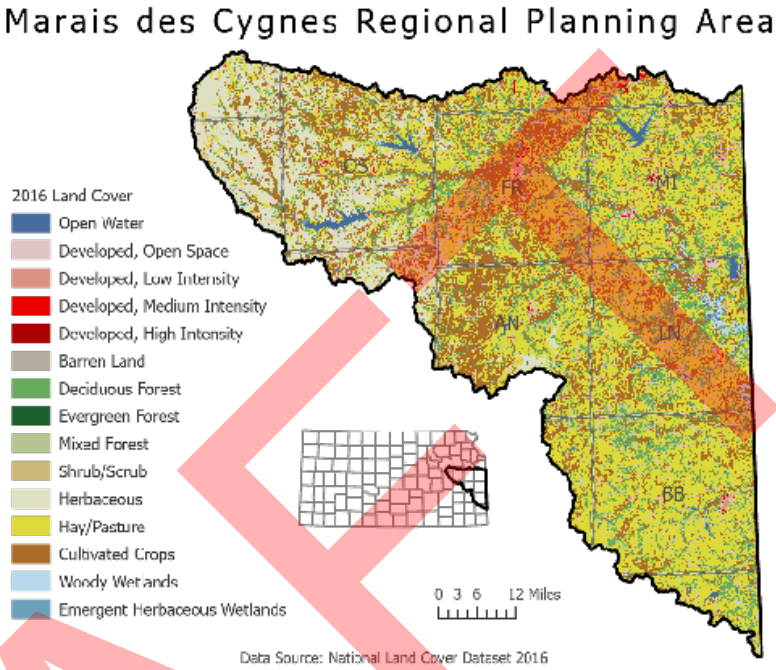


Figure 3. 2016 Marais des Cygnes regional land cover

POPULATION & ECONOMY

According to the 2010 Census, there were an estimated 131,844 residents in the region. Based upon 2019 information derived from state-released information to the U.S. Census Bureau, there were an estimated 249,919 residents in the region, an increase of about 90 percent. For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over or under represented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census (Figure 4).

The major cities and associated populations tend to be the county seats in the majority of the region, especially in the western and central portions. Many of these counties, reflecting a trend throughout the state, are losing population overall, though the county seats in each of them may be projected to grow. Miami County, in the northern part of the region, just south of rapidly growing Johnson County, is an exception and is poised for growth as urbanization of the Kansas City metropolitan area moves

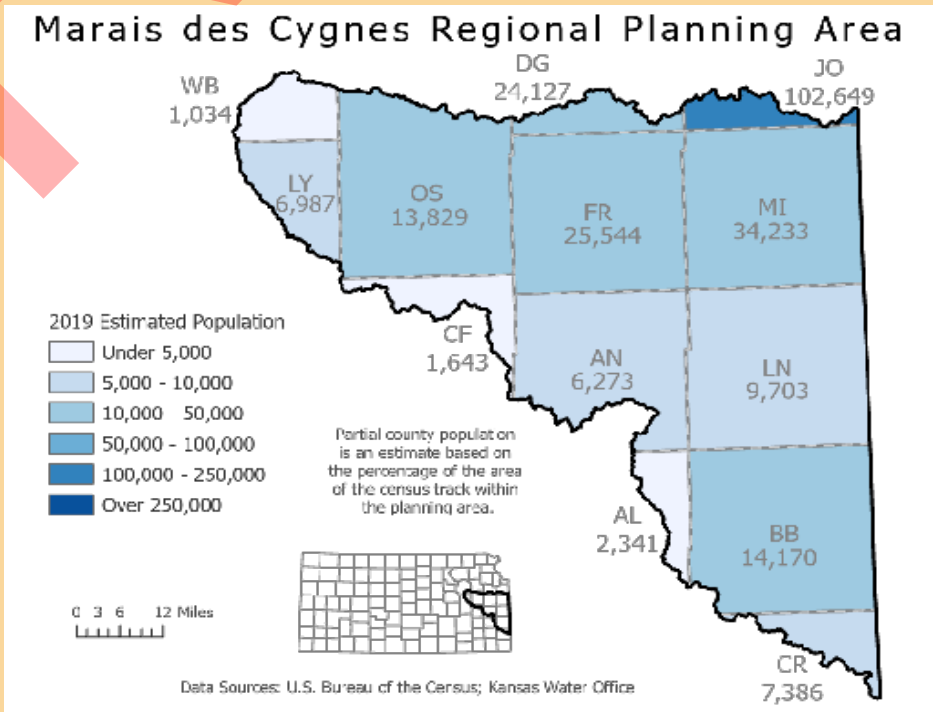


Figure 4. 2019 estimated population by county

Marais des Cygnes Region

south. With a population of 32,835 in 2013, Miami County has grown to 34,233 residents in 2019, a population increase of about 4.26%.

Despite the continuing urban growth in the eastern part of the region, the Marais des Cygnes Region maintains an agricultural industry comprised of feed grain operations, grazing lands, and confined animal feeding operations. Corn and soybean are the primary crops.

Two large retail distribution centers have been developed near Ottawa in Franklin County. The La Cygne Generating Station provides economic opportunity in Linn County. Development of a new 300-acre industrial park in Ottawa has been added to the basin.

Additionally, the BNSF Railroad constructed an Intermodal Facility in Edgerton, which is in the Bull Creek sub watershed. This facility provides connective transfer of all modalities, specifically transfers between trucks and trains. To accommodate the increase in population needed to run the large facility, the City of Edgerton built the Big Bull Creek Waste Water Treatment Facility and conveyance system. The Intermodal Facility covers 3,000 acres. Runoff from the facility is treated in a constructed wetland system, and then flows into Big Bull Creek. The Stakeholder Leadership Team (SLT) of the Hillsdale Lake Watershed are concerned with potential stormwater runoff issues degrading Big Bull Creek from the increased amount of concrete and buildings that are being constructed as noted in the Hillsdale WRAPS 9-Element Plan. Quantity of the stormwater runoff is not the only concern. The increase in runoff will also affect the quality of water in Bull Creek. More sediment will be present in the creek, which ultimately drains into Hillsdale Lake. The SLT would like to have low-impact development BMPs incorporated into all new development in the watershed.

Primary Water Resources in Region

The Marais des Cygnes Region contains 8,821 miles of intermittent and 2,011 miles of perennial streams, for a total of 10,832 stream miles. The density of 2.5 stream miles per square mile is typical among regions located in the eastern third of the state.

The three federal reservoirs in the Marais des Cygnes Region are Hillsdale Lake, Melvern Lake, and Pomona Lake, all operated by the U.S. Army Corps of Engineers (USACE), Kansas City District. Other significant impoundments include the La Cygne Power Station Lake and impoundments within the Marais des Cygnes Wildlife Management Area and Refuge. Four state multipurpose small lakes have been constructed in the region: Bone Creek, Xenia, Cedar Creek, and Little Sugar Creek (Figure 5).

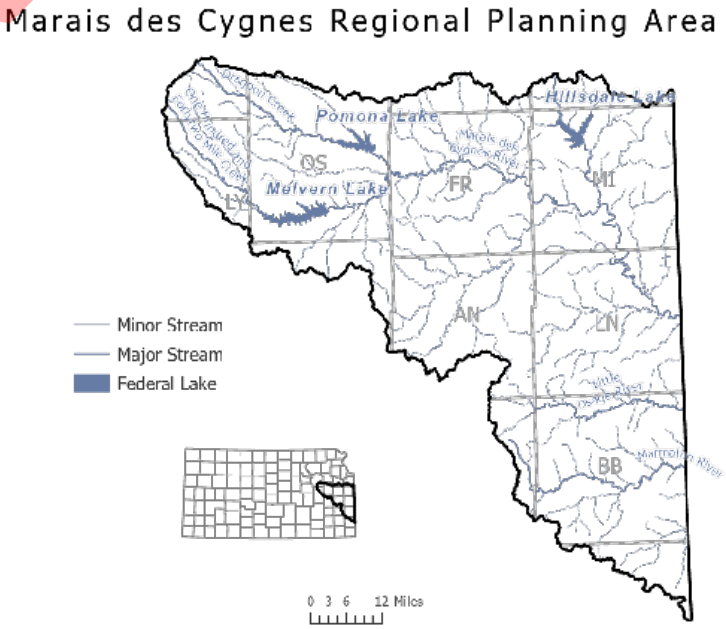


Figure 5. Major water resources in the Marais des Cygnes Region

Marais des Cygnes Region

GROUNDWATER

Groundwater resources in the region are associated with alluvial and terrace deposits along the larger stream valleys, including aquifers underlying the watershed portions of the Ozark and Glacial Aquifer and alluvial aquifers of the Marais des Cygnes River and its tributaries (Figure 6). Groundwater deposits in the Flint Hills in the upper region are characterized by thin, saturated zones and high levels of dissolved solids and hardness.

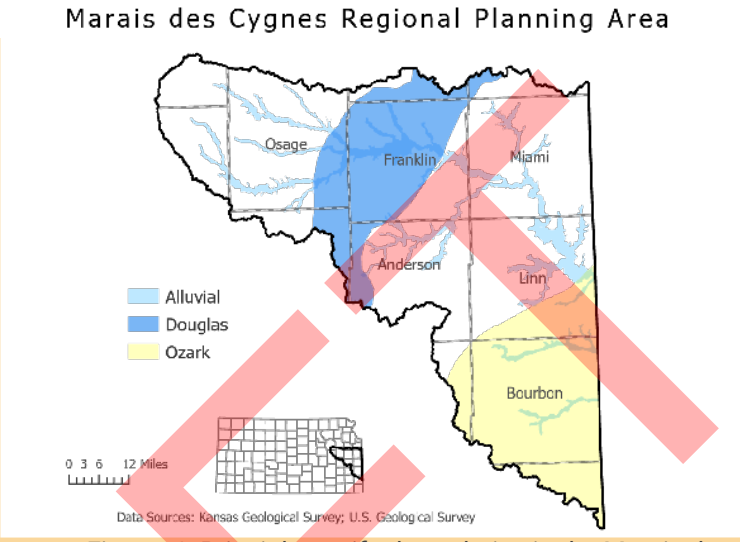


Figure 6. Principle aquifer boundaries in the Marais des Cygnes Region

The Douglas Aquifer system consists of fluvial sandstone that provides small quantities of water. The aquifer does not provide substantial amounts of water except for a few areas where sandstones are thick enough for fresh water to occur. It is an important source for a few smaller communities, rural water districts, and farms.

Primary Water Use by Source

SURFACE WATER

Water-based recreation is an important component of the regional economy with recreational development associated with the three federal reservoirs in the region, four state fishing lakes, and 20 community lakes, attracting boaters, anglers, hunters, and campers. State parks and commercial marinas are located at each federal reservoir in the region. Waterfowl hunting on private, state, and federal lands is a major activity, particularly in the lower region (Figure 7).

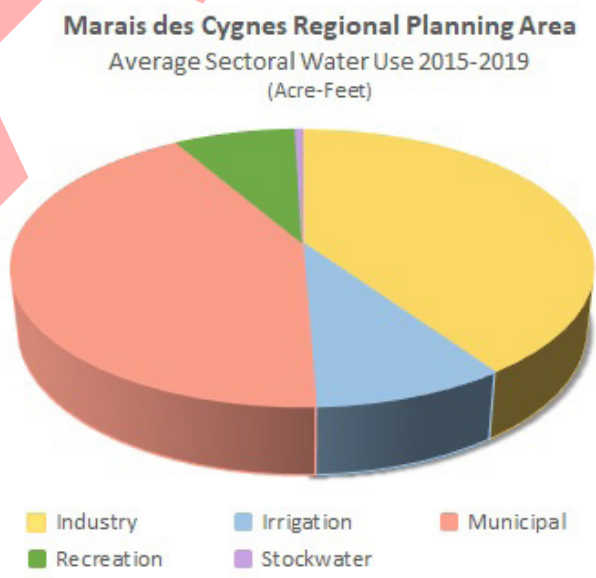


Figure 7. Average sectoral water usage

In 2019, the USACE performed an economic analysis of recreation at Hillsdale Lake, Melvern Lake, and Pomona Lake. Four components were analyzed to estimate economic effects: recreation spending, visitor use estimates, capture rates, and economic multipliers. The three reservoirs had a combined 1,053,282 visits in 2019. These visits were estimated to produce $29.85 million in total direct sales, along with $16.47 million in value added through wages, salaries, payroll benefits, profits, rents, and taxes. The three reservoirs were estimated to support 396 jobs in local communities.

GROUNDWATER

Groundwater sources within the region are the alluvial deposits along major streams and are not a primary water source, accounting for less than 4% of water resource use in this region.

Marais des Cygnes Region

Regional Issues & Priorities

Rivers and streams in the Marais des Cygnes Region have historically been prone to flooding during high rainfall events. Many communities and cities are situated near stream channels and Osawatomie and Fort Scott are located at the confluence of major drainages in the basin, making them especially vulnerable to flood damage. In the summer of 2007, widespread flooding of historic record occurred in the lower Marais des Cygnes Region and other parts of south central and southeast Kansas. Heavy precipitation fell downstream of the federal flood control reservoirs in the basin. The City of Osawatomie and other communities sustained considerable flood damage. Numerous flood control structures and levees in the basin were also damaged.

Major floods in the Marmaton River watershed impacted the City of Fort Scott in 1986 and 1998. Due to above average water levels being held in Melvern and Pomona Lakes, the Kansas City District, USACE and lake project personnel held public meetings to provide information on the impacts to stakeholders in the region of the high waters and the expected releases Flood Insurance Rate Maps have been prepared for most of the communities subject to flooding in the basin by the Federal Emergency Management Agency (FEMA). Dam breach inundation zone mapping has been conducted by the state. Development downstream of some small dams has resulted in changes in hazard class and necessitated upgrading of some structures.

Bourbon County, KS Flooding, 2017.
Photo Credit: Fort Scott Biz

Accumulation of debris within and behind bridges, culverts, and other structures can obstruct the flow of water and limit the ability of the stream to carry flood water through permitted stream obstructions. It is important that permitted obstructions be kept clear of log jams caused by trees, utility poles, and other debris that may wash into streams during high flows. Management of riparian areas to prevent debris from entering the system and causing blockages is an important part of a preventive and routine maintenance program. There are organizations within the region that do timber stand improvement that provide the management of riparian corridors.

Expansion of urban development in floodplains has increased the potential for flood damage. Future flood damages may be reduced by preventing inappropriate development in flood-prone areas. Local governments can implement floodplain management through use of planning and zoning authority. There is no state requirement for local units of government to implement floodplain management.

Nonstructural mitigation measures, including forecast and warning systems, as well as wetland and riparian areas, can reduce flood damages. The National Weather Service (NWS) provides river stage and flood forecasts for the basin through its Missouri River Basin Forecast Center located in Pleasant Hill, Missouri. The Kansas Mesonet Steering Committee selected priority counties to help guide expansion of new, automated weather stations in 2008. K-State Research and Extension (KSRE) weather stations are at the root of the Kansas Mesonet. These stations were established in 1986 at KSRE experiment facilities around the state. Most were co-located with NWS Cooperative Observing Stations. Since that time, stations have been established in Osage, Franklin, and Miami Counties.

Marais des Cygnes Region

RESERVOIR SEDIMENTATION

Reservoir sedimentation is a major water quantity and quality concern, particularly in reservoirs where the state owns storage for the Water Marketing Program or where a Water Assurance District (WAD) owns storage. This sedimentation is often caused by accelerated erosion due to human activities (deforestation, poor agricultural practices, construction, altering native prairie regions, etc.) (Figure 8).

As sediment accumulates in a reservoir's multi-purpose pool, the capacity for water supply storage is reduced (Figure 9). Sediment can also have a major impact on water quality, as it can carry with it pollutants like phosphorus, pesticides, bacteria and metals which ultimately end up in the aquatic system impacting downstream receiving waters.

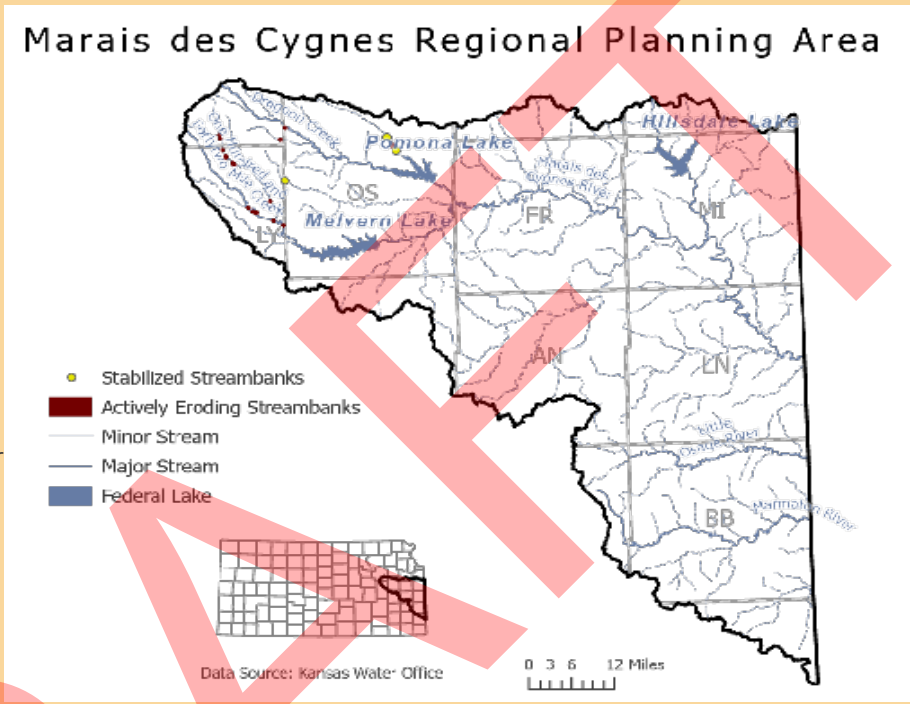


Figure 8. Actively eroding and stabilized streambanks in the Marais des Cygnes Region

The sedimentation rate within the Marais des Cygnes Region is partly due to streambank erosion above each reservoir. Best Management Practices (BMPs), such as no-till agriculture and cover crops, are being promoted and implemented throughout the region, further reducing the sedimentation rate.

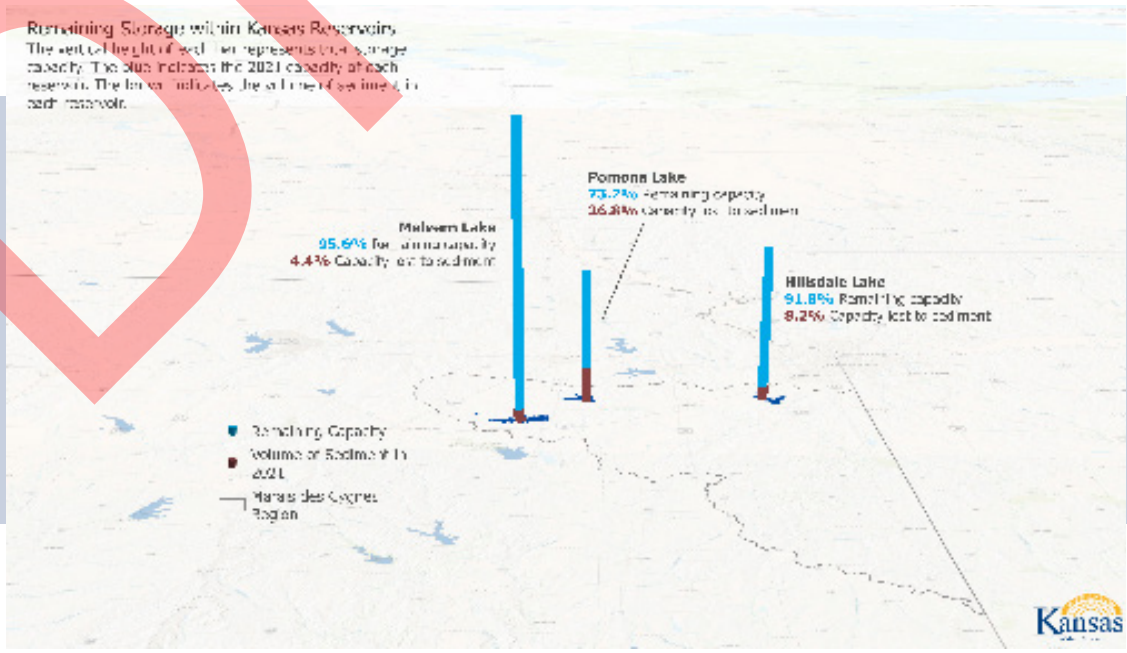
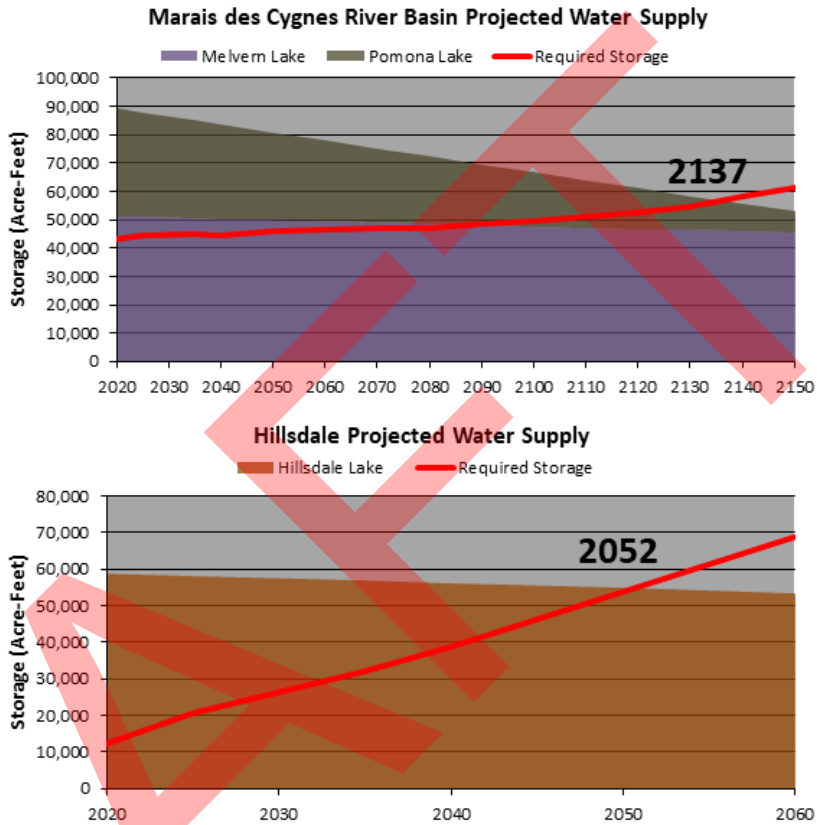


Figure 9. Remaining storage within Kansas Reservoirs in the Marais des Cygnes Region

Marais des Cygnes Region

Figure 10. Projected water supply storage given the historic rate of sedimentation based on the change in volume documented by bathymetric surveys (earliest survey versus most recent survey), along with the storage required to meet the system's demands and targets. The analysis was performed using current system operations using a Marais des Cygnes River basin model which simulated historic hydrologic conditions between 1950 and 2014, allowing for an estimate of required storage. Given the projected sedimentation and demands, results indicate that Hillsdale Lake storage will be insufficient to fully meet projected downstream demands through a 1950's-type drought by the year 2052.



WATER QUALITY

Fecal coliform bacteria and low levels of dissolved oxygen are the most prevalent stream impairments. Sedimentation and eutrophication are the primary water quality problems affecting reservoirs in this region. Reservoir sedimentation is also a major water quantity concern, particularly in reservoirs where the State owns water supply storage. The State owns storage in all three federal reservoirs in this region. As sediment accumulates in a reservoir's multipurpose pool, the capacity for water supply storage is reduced.

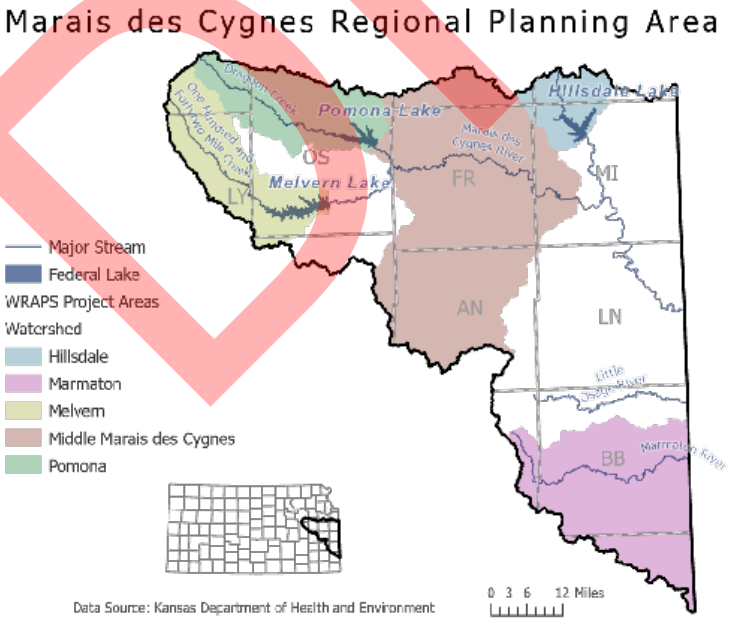


Figure 11. WRAPS project areas by watershed

Water quality and related water resource issues are addressed through a combination of Watershed Restoration and Protection Strategy (WRAPS) efforts utilizing voluntary, incentive-based approaches, as well as regulatory programs (Figure 11). The restoration and protection of watersheds, particularly those watersheds above public water supply reservoirs, is a priority in the Marais des Cygnes Region. Excess available nutrients can lead to Harmful Algal Blooms (HABs) which can be exacerbated by certain Aquatic Nuisance Species (ANS). The presence of zebra mussels have been identified as a cause of altered nutrient cycling in lakes and increases in the appearance of HABs of the cyanobacteria Microcystis.

Marais des Cygnes Region

Watersheds with WRAPS projects currently underway in the region target high priority areas for Total Maximum Daily Load (TMDL) implementation, areas with a high improvement potential index for nutrient reduction, source water assessment areas, and priority areas for wetland and riparian protection (Figure 12).

An important consideration for watershed restoration and protection in this region, particularly in the northern portion, is urbanization. Local land use planning and zoning efforts can provide cities and counties effective tools to minimize the potential impacts of development on water resources.

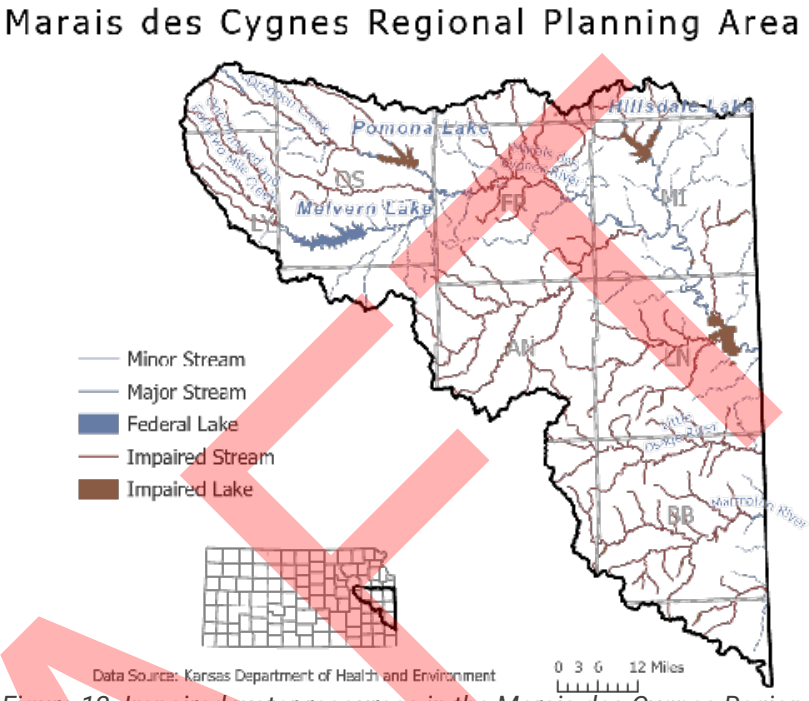


Figure 12. Impaired water resources in the Marais des Cygnes Region

Urban stormwater management programs can be implemented to manage the amount of impervious surface in urbanizing watersheds and properly control increased runoff resulting from urbanization. Programs, such as those provided by Kansas Department of Agriculture Department of Conservation (KDA-DOC), Sustainable Agriculture Research & Education, WRAPS, NRCS, etc., that offer technical assistance and education to urban residents regarding actions that can reduce or eliminate potential pollution sources also play an important role.

The 13 counties either wholly or partly within the region have adopted local sanitary/environmental codes. All conservation districts in the region have adopted nonpoint source pollution and wetland and riparian management plans. Of cities in the region, only Ottawa is subject to the Phase II Permitted Municipal Separate Storm Sewer System under the Environmental Protection Agency's (EPA) National Pollution Discharge Elimination System (NPDES) Stormwater Program.

Hillsdale Lake near Hillsdale, KS. Photo Credit: Mark Lysaught, USGS.

Marais des Cygnes Regional Advisory Committee

Regional Goals & Action Plans

Priority Goal #1: Reduce cumulative sediment loads entering Melvern Lake, Pomona Lake, and Hillsdale Lake by 10 percent every 10 years to extend the life of existing infrastructure.

ACTION STEPS:

- A collaboration between the Regional Advisory Committee (RAC), local producers, local WRAPS groups, local conservation districts, regional public water suppliers, the Kansas Water Office (KWO), the Kansas Department of Health and Environment (KDHE), and the Kansas Department of Agriculture-Division of Conservation (KDA-DOC) will secure funding and work to treat priority cropland, with no-till practices, cover crops, and other sedimentation and nutrient reduction farming practices by 2030 in the Marais des Cygnes Region above Melvern Lake, Pomona Lake, and Hillsdale Lake.
- This collaboration will provide education and share information concerning water and soil conservation and nutrient and sedimentation reduction; demonstration farms will be established in the region above these three reservoirs.
- Encourage state and federal entities to participate in best management practices above federal reservoirs on state and federal lands and create demonstration farm(s).
- The KWO will create baseline sedimentation rates and review sedimentation rate changes of these three reservoirs by conducting bathymetric surveys every 5 years to monitor the sedimentation rate and the progress and benefit of sedimentation reduction practices. The KWO will work to secure funding for this program.
- The KWO will evaluate possible technologies that may be feasible to remove sediment from the reservoirs.

Measuring success:

Goal 1: Improve BMP implementation trends and demonstrate progress demonstrated towards achievement of water quality milestones and sedimentation rates.

Marais des Cygnes Regional Advisory Committee

Regional Goals & Action Plans

Priority Goal #2: Ensure water supply storage in the Marais des Cygnes Region is able to supply for 110% of the projected demands through the year 2050.

ACTION STEPS:

- The KWO will refine population and demand growth projections to ensure accurate projections are being utilized.
- The KWO will evaluate the need and feasibility of creating an interconnection with municipalities within an adjacent region to be a backup water supply source.
- The RAC and the KWO will work with the Kansas Rural Water Association (KRWA) through their technical assistance contract to identify public water supplies that may not be sufficient to meet projected demands.
- The collaboration referenced in the Action Steps for Goal 1 will provide education and share information concerning water and soil conservation and water consumption reduction for the Marais des Cygnes Region.
- The KWO will evaluate possible technologies that may be feasible to remove sediment from the reservoirs as needed to maintain and protect water supply.

Measuring success:

Goal 2: Complete evaluation of current water supply and demand in the region and identify areas of need. In collaboration with multiple partners, compiled list of potential solutions for areas with projected water supply needs and criteria to determine projects with greatest anticipated benefit.

Marais des Cygnes Regional Advisory Committee

Regional Goals & Action Plans

Priority Goal #3: Continually work to prevent the spread of Aquatic Nuisance Species (ANS), including Zebra and Quagga mussels, into Kansas Lakes that are not currently infested, by working with the agencies focused on ANS.

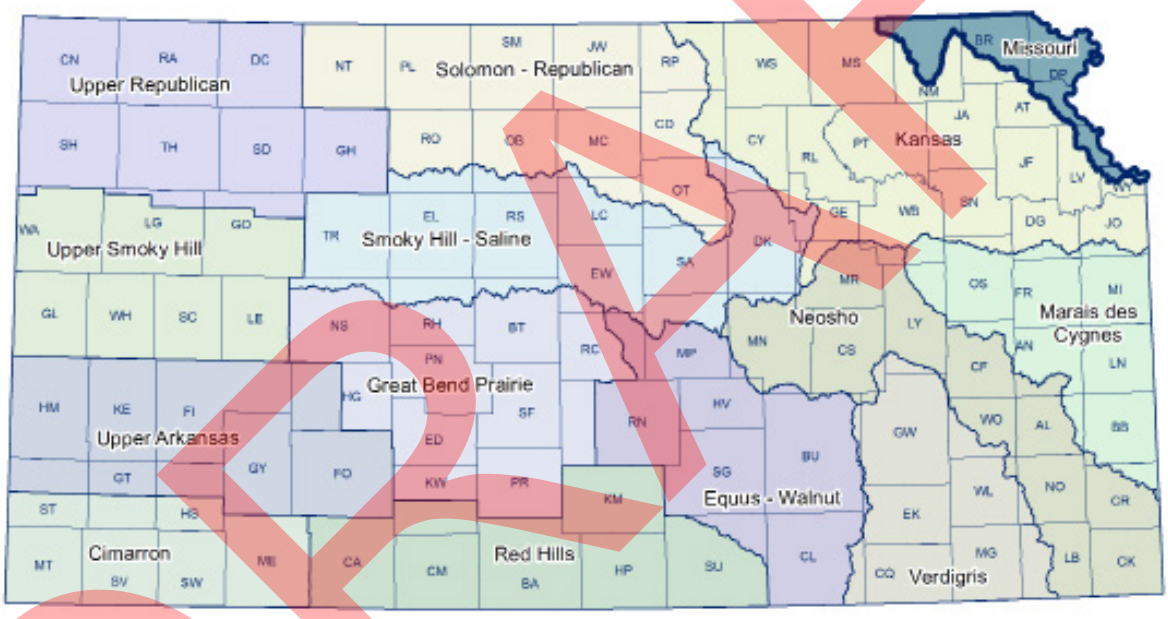
ACTION STEPS:

- The KWO and the RAC will work to prevent the spread of ANS into Kansas Lakes that are not currently infested, by working with the Kansas Department of Wildlife and Parks (KDWP) and the US Army Corps of Engineers (USACE) to install three watercraft inspection and decontamination stations near the federal reservoirs within the Marais des Cygnes Region.
- The RAC will work with the KDWP and USACE on an ongoing basis to provide education for lake users concerning the spread of ANS and how to prevent it.
- The RAC will encourage funding for the ANS Program through the State Water Plan Fund (SWPF).

Measuring success:

Goal 3: Demonstrate progress on installation of watercraft inspection and decontamination stations near the federal reservoirs, as well no additional ANS-infested waters within the region.

Missouri Region



Missouri Region

Regional Description

The Missouri Regional Planning Area covers 1,466 square miles of the northeastern corner of Kansas with the Missouri River forming the eastern boundary (Figure 1). As the smallest of the planning areas in Kansas, it also represents a small fraction of the entire Missouri River watershed, which covers all or part of 10 states and extends into Canada. Elevations in the region range from 1,340 feet above mean sea level (MSL) near Corning to 706 at the confluence with the Kansas River in Kansas City.

Figure 1. Missouri Regional Planning Area

CLIMATE & LAND USE

Most of the precipitation falls in the growing season, with June typically being the wettest month, having a region-wide average annual precipitation of 38 inches. Overall, precipitation ranges from 32 inches in the northwest portion of the region to nearly 42 inches in the southeast (Figure 2). Missouri River flood events have underscored the climate variability. The most notable events include those that occurred in 1993, 2007, 2011, 2018, 2019, and the drought experienced from 1952-1956.

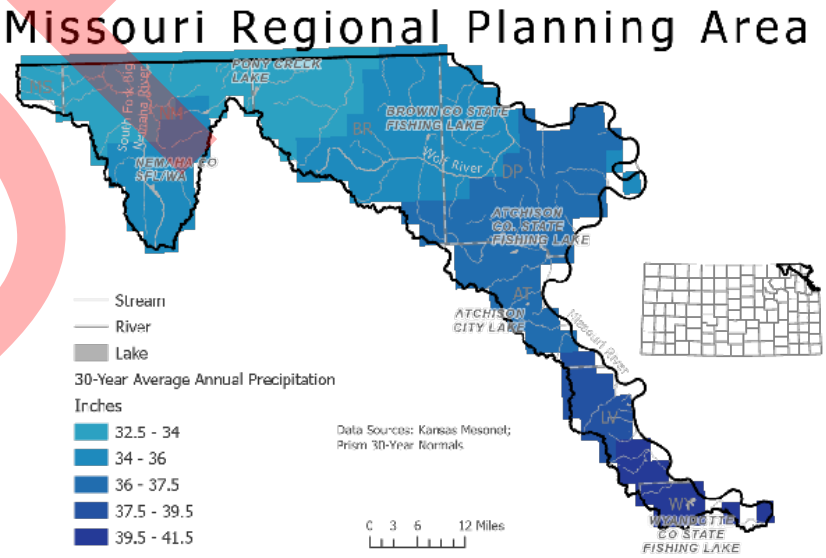


Figure 2. 30-year average annual precipitation in the Missouri Region

Missouri Region

Land use activities can have a significant impact on the region. The three major land uses in this region are cultivated crops (58%), pasture/hay (14%), and deciduous forest (12%) as derived from the National Land Cover Database (NLCD) 2016 dataset. Figure 3 lists the remaining land uses in the region, including: developed/urban open space, woody wetlands, and water.

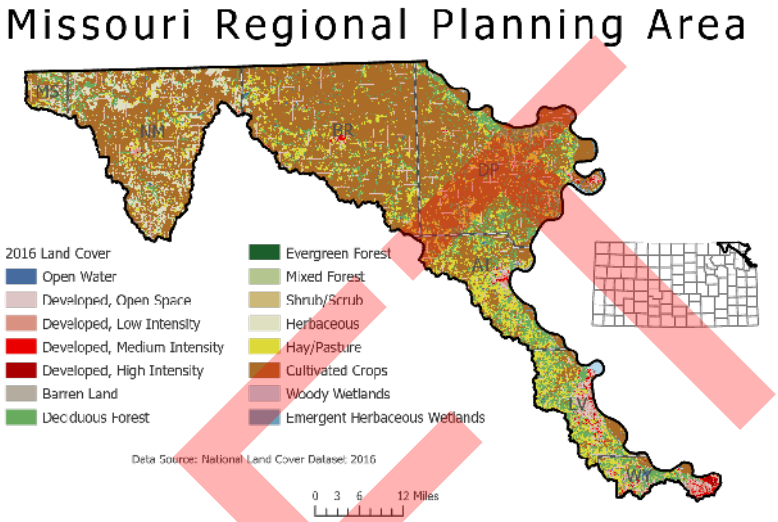


Figure 3. 2016 Missouri regional land cover

POPULATION & ECONOMY

Based upon 2019 information derived from state-released information to the U.S. Census Bureau, there were an estimated 104,649 residents in the region (Figure 4). For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over or under represented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census.

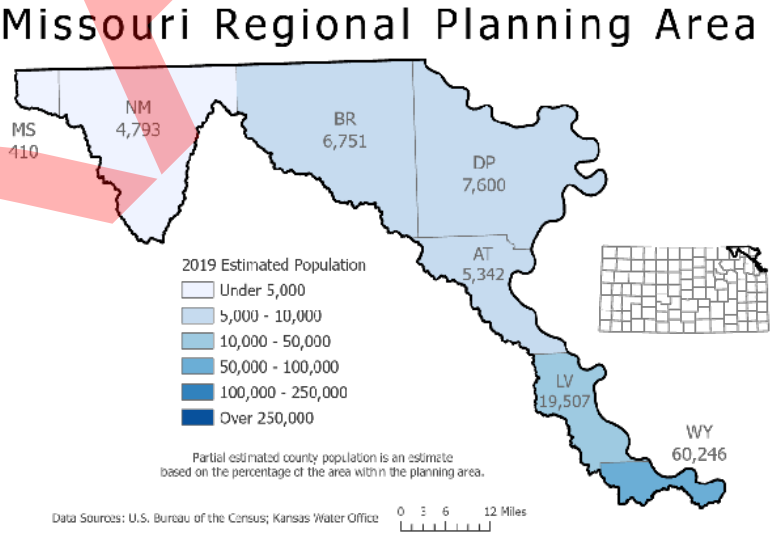


Figure 4. 2019 estimated population by county

However, this region demonstrates the statewide trend of population continuing to concentrate in larger cities while rural towns and counties decrease in population. Of the counties throughout the basin, only Wyandotte and Leavenworth counties are projected to have population growth through 2070.

The Iowa Tribe of Kansas and Nebraska and the Sac and Fox Nation of Missouri in Kansas and Nebraska reside in the Missouri Regional Planning Area. The tribes each place cultural and historic value on sites and natural resources throughout the region. In addition, federal reserve water rights exist for the tribes.

Missouri Region

With the rich loess soils in the region, local economies are based primarily on agriculture, general manufacturing, and retail trades, with the exception of Wyandotte County. Wyandotte County, the smallest sized county in the state, is one of the most heavily developed areas of Kansas with expanding retail, entertainment, and residential development.

The major crops grown in the region include corn, soybeans, and grain sorghum. Midwest Grain Products (MGP) of Atchison has a significant impact on the local economy purchasing corn to produce a variety of products. The production of beef cattle region-wide has diminished over the years, however, it remains an important part of the agricultural economy in certain communities. Beef cattle and hog production are concentrated in the northern counties with significant dairy production in Nemaha County.

While the region lacks large federal reservoirs and associated wildlife areas, there are two state fishing lakes and 10 county and city lakes that support public recreation. The Missouri River is one of 3 rivers in Kansas that is legally navigable and open to public recreation. The other 2 rivers open to the public are the Arkansas and Kansas. Access to these rivers is only allowed where a public access point exists. When these rivers flow through private land or if no public access exists, permission is needed to access the rivers through private property.

Missouri River near Atchison, KS. Photo Credit: KQ2

As of 2021, the Missouri River has 5 access points. Benedictine Bottoms is one of the Missouri River mitigation properties that provides thousands of acres along the Missouri River for recreational opportunities within the region.

Primary Water Resources in Region

SURFACE WATER

Tributaries of the Missouri River in Kansas include the Wolf River and numerous smaller creeks. The South Fork of the Big Nemaha River, along with other tributaries in Washington, Nemaha, and part of Brown County, drain northward into Nebraska. This system is part of the Big Nemaha River watershed, which enters the Missouri River just upstream of the Kansas border (Figure 5).

Surface water is the primary source for all uses in the region, accounting for more than 90% of the use. The Missouri River is a significant source of water supply to the Kansas City metropolitan area and other communities of northeast Kansas such as Atchison and Leavenworth (including water for cooling at power generation facilities).

Flow in the Missouri River bordering Kansas is greatly influenced by water releases from the six federal reservoirs located in Montana, North Dakota, South Dakota and Nebraska. Pony Creek

Missouri Region

Lake, a multipurpose small lake, serves as the water supply for the City of Sabetha, which is located just south of the Missouri region watershed divide. All the major streams in the region are open to new appropriations. There are no sites in the region where Minimum Desirable Streamflow (MDS) has been established.

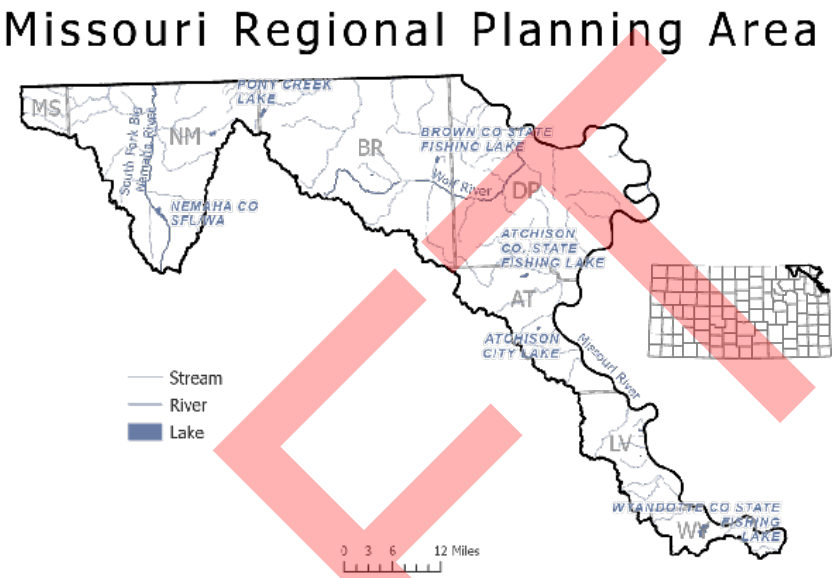
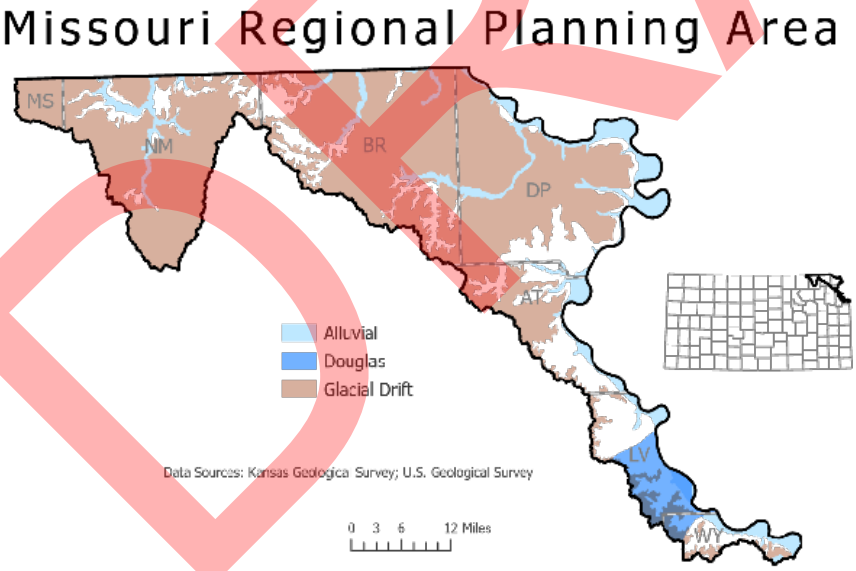


Figure 5. Major water resources in the Missouri Region

GROUNDWATER

The groundwater sources available in the region include alluvial and glacial deposits (Figure 6). The Glacial-Drift Aquifer is a source of groundwater in the region, providing generally good quality water. There are, however, potential problem areas were detected in the 2017 Kansas Geological Survey (KGS) study (Batlle-Aguilar, 2017), with ongoing evaluation with the current KGS study. The aquifer is highly variable in saturated thickness, depth to water, and connectivity.



The Douglas Aquifer system consists of fluvial sandstone that provides small quantities of water. The aquifer does not provide substantial amounts of water except for a few areas where sandstones are thick enough for fresh water to occur. It is an important source for a few smaller communities, rural water districts, and farms.

Figure 6. Principle aquifer boundaries in the Missouri Region

Missouri Region

Primary Water Use by Source

SURFACE WATER

Surface water is the primary source of water within the Missouri Region, accounting for approximately 92% of the total reported water use.

Municipal use (54%) is the primary use from surface water sources within the region, due to the water used for both Leavenworth and Kansas City. Other reported surface water use within the region includes municipal (33%), recreation (8%), irrigation (4%), and stockwater (<1%) (Figure 7).

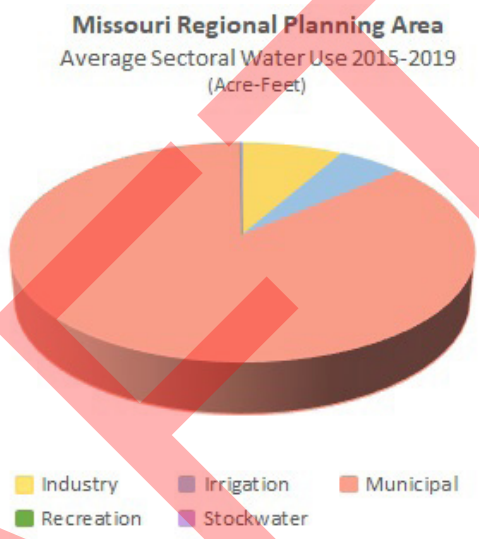


Figure 7. Average sectoral water usage

GROUNDWATER

The majority of groundwater sources within the upper region are from the Glacial-Drift Aquifer and alluvial deposits along rivers and major streams. The Douglas Aquifer system supplies little of the groundwater use primarily to agricultural producers.

Municipal use (81%) is the primary use from groundwater sources. Other reported groundwater use within the region includes irrigation (13%), industrial (3%), stock water (3%), and recreation (<1%).

Regional Issues & Priorities

WATER QUALITY

Several of the streams and tributaries connecting in the northern part of the region, are experiencing water quality impairments (Figure 8). The Kansas Department of Health and Environment's (KDHE) most recent list of impaired waters for the state can be found here.

Water quality issues are being addressed through a combination of watershed restoration and resource protection efforts utilizing voluntary, incentive-based approaches. These are noted in the *Improve the State's Water Quality* section of the *Kansas Water Plan (KWP)*.

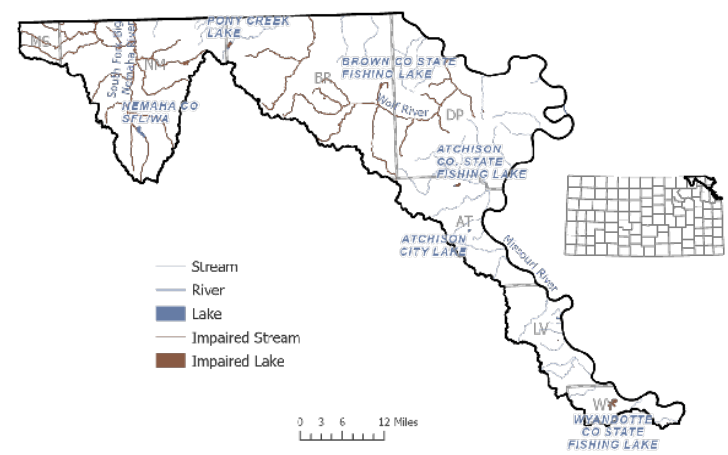


Figure 8. Impaired water resources in the Missouri Region

Missouri Region

HARMFUL ALGAL BLOOMS

Harmful Algal Blooms (HABs), as discussed in the *Water Quality* section of the *KWP*, have caused pet and livestock deaths. While it can cause illness in humans, there have been no mortalities attributed to the toxins created by these bacteria. This worldwide problem has led to significant research on causes, treatments, and prevention of HABs, some of which is being conducted by the Kansas Biological Survey (KBS) using lake sediment cores from water bodies throughout the state to evaluate historical HAB event timing. Since 2000, HABs have occurred more often and the duration has been longer, particularly at locations within the Missouri Region. More information on HABs research can be found at the KBS website.

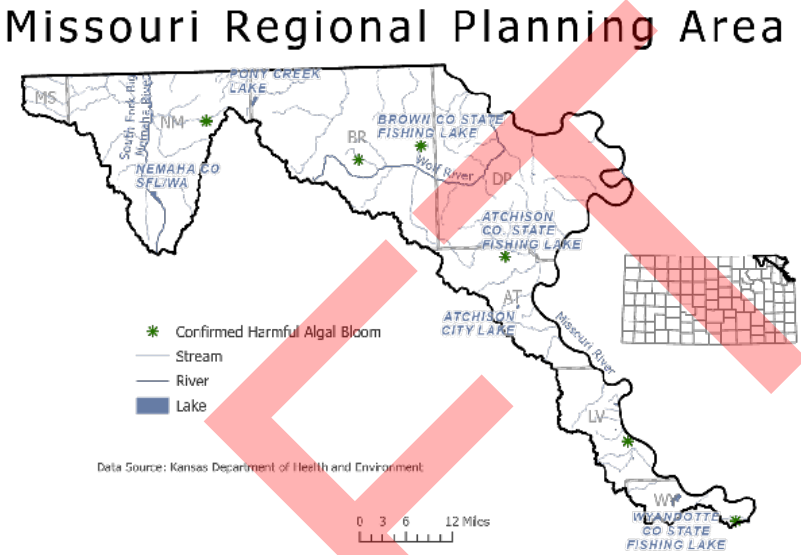


Figure 9. Confirmed Harmful Algal Bloom sites in the Missouri Region

WATER QUANTITY

The KGS completed a study in June 2017 that estimated bedrock elevation and thickness of unconsolidated material. However, only a few static water levels were available and one index well was documented for this large area.

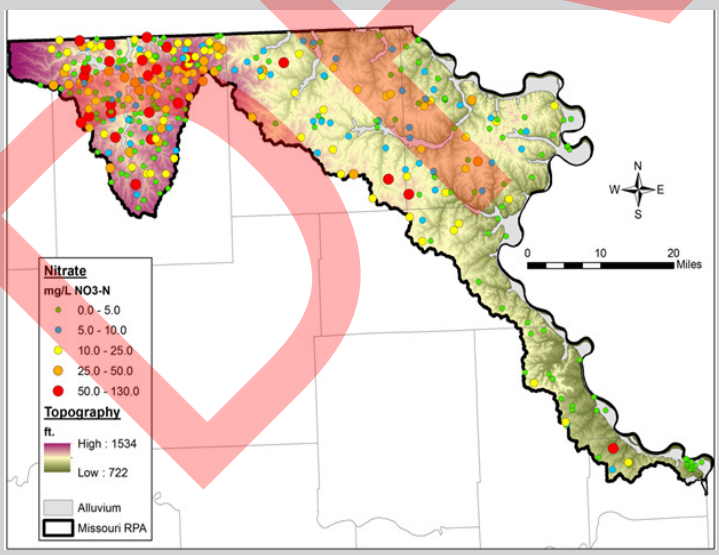


Figure 10. Nitrate and topography levels throughout the Missouri Region, KGS

The KGS study also documented an unexpected number of wells exceeding the 10 mg/l limit for nitrate. From the 371 wells that were analyzed, 142 were above the national standard, 25 were over 50 mg/l, 4 over 100 mg/l, and the highest sampled was 128 mg/l.

Phase II of the study is underway with development of an index well system that will help determine ground water quantity and provide real-time data on nitrate levels in the region. A website has been constructed as part of the study. Several maps have been generated using existing data, including Figure 10.

Missouri Region

FLOODING

The Missouri River is the longest river in North America and its basin covers one-sixth of the lower 48 states. The mainstem reservoir system includes six large federal dams with a storage capacity of 73.4 million acre-feet (Figure 11). These dams are operated by the U.S. Army Corps of Engineers (USACE) to provide flood control, navigation, irrigation, power, water supply, water quality control, recreation, and fish and wildlife benefits.

Devasting flooding over the past 20 years has resulted in loss of life, property and destruction of infrastructure, costing billions.

The bed degradation of the Missouri River, which has been eroding in some locations for decades, is an ongoing battle. The bed degradation has affected bank stability in certain areas, and could potentially undermine dikes, revetments, and levees designed to support navigation and to provide flood protection. The rate of the erosion accelerated in the early 1990s, leading to a multiyear Missouri River Bed Degradation Study focusing on the stretch of river in the Kansas City area.

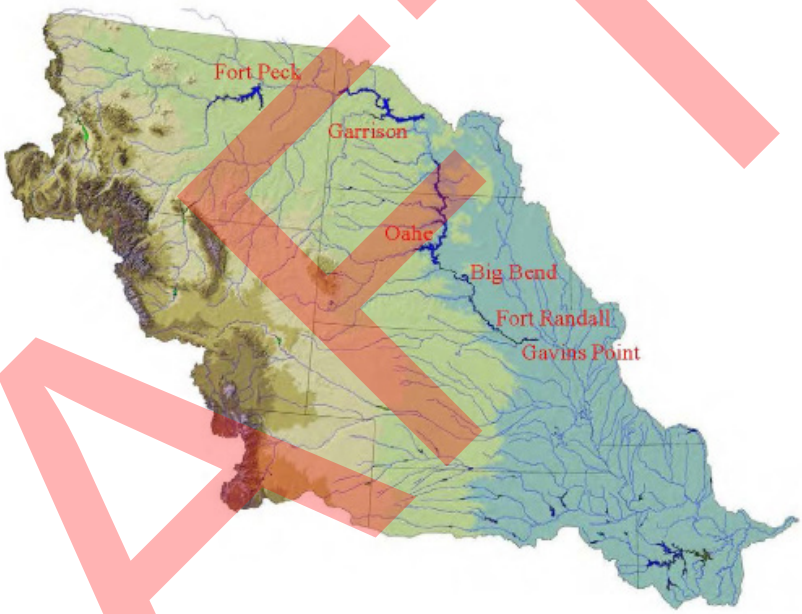


Figure 11. Missouri River Mainstem River System, USACE

EDUCATION

Water education for youth in the region is a priority for the Missouri Regional Advisory Committee (RAC), as the youth of today are the future leaders of tomorrow. Providing basic water knowledge starting at a young age and building upon those basic principles is key to providing a lifelong appreciation for water conservation. One education activity that has consistently been deemed "worthwhile and impactful" by educators in eastern Kansas are water festivals.

The RAC has formed an Education subcommittee, created an informational video, and promotes other educational activities throughout the region.

The Goals and Action Plans contained herein are as developed by the Regional Advisory Committee.

Missouri Advisory Committee

Regional Goals & Action Plans

KEY PRINCIPLE:

- Over the next 50 years, there needs to be an adequate, sustainable and affordable quality water supply in the Missouri Region, while protecting Tribal water rights and sacred and cultural sites. All government agencies, local through state, shall vigorously uphold and enforce all water conservation and management rules and regulations throughout the state.

Preamble:
Groundwater quality and groundwater quantity are closely related and the approaches to understanding each are similar. For that reason, Priority Goals 1 & 2 goals and the overall key principle are recognized in this action plan.

Missouri Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

THE FOLLOWING ACTION STEPS APPLY TO BOTH GOALS #1 AND #2.

Priority Goal #1:
Since groundwater quality is not well known, compile existing and collect additional data over the next 5 years to establish a baseline. Within 3 years after the baseline is established, a plan to implement best management practices develop to maintain and improve existing conditions. Monitoring and reevaluation of groundwater quality conditions and should continue at 5-year intervals.

- Evaluate what is known about groundwater quantity and quality in glacial, alluvial and bedrock aquifers in the Missouri Region.

  a. Any and all available information about groundwater quality and quantity will be collected and compiled.

  b. Digital database from the collected historical and online existing data would be constructed.

  c. Digital maps of updated bedrock surface topography, saturated aquifer thickness, pre-glacial drainage ways, water use, and groundwater quality from digital databases would be prepared.

  d. An assessment report would be prepared that includes:
     i. A determination of groundwater in storage and groundwater quality conditions in the glacial, alluvial and bedrock aquifers in the area.
     ii. A determination of the greatest needs for collection of additional data.
     iii. Recommendations on the need for, and number and location of wells, to allow for well level and quality monitoring on a continuing basis.

Measuring success:

Goals 1 and 2: Establish the groundwater quality and quantity baseline conditions and continue re-evaluations.

Missouri Advisory Committee

Regional Goals & Action Plans

Priority Goal #2: Collect additional information to improve safe yield estimate of groundwater and tributary streams within 3 years. Safe yield should be continuously monitored.

ACTION STEPS:

- Collection of additional data and re-evaluation of groundwater information.

  a. Based on needs as determined in the evaluation phase, obtain a scope of work on collection of additional data that would improve the characterization of the glacial, alluvial and bedrock aquifers. Main expected field activities would include: drilling, hydraulic testing, and groundwater sampling and analysis.

  b. Enter new data into databases developed in the evaluation phase.

  c. Re-evaluate groundwater recharge estimates at a more detailed scale than the currently available potential annual recharge estimates based on soils.

  d. Combine existing and new data to establish safe groundwater yields and a groundwater quality baseline.

  e. On the basis of future climate and water usage conditions, establish a plan to periodically update safe yield estimates of groundwater resources.

  f. Support Phase II of the KGS study documenting groundwater quality and quantity within the Missouri Region.

Missouri Advisory Committee

Regional Goals & Action Plans

Priority Goal #2: Continued

ACTION STEPS:

- Maintain and Improve groundwater quality conditions.

  a. Evaluate groundwater quality protection practices based on needs as determined in the assessment.

  b. Within 3 years after the baseline is established develop a plan to implement best management practices to maintain and improve existing conditions.

- Ongoing monitoring and evaluation.

  a. Expand groundwater level monitoring wells as determined during Assessment phase.

  b. Monitoring and reevaluation of groundwater quality conditions should continue at 5-year intervals.

Measuring success:

Goals 1 and 2: Establish the groundwater quality and quantity baseline conditions and continue re-evaluations.

Missouri Advisory Committee

Regional Goals & Action Plans

Priority Goal #3:
To ensure a reliable surface water supply in the future implement best management practices to maintain or improve surface water quality in identified drainages, using goals and milestones as identified in the Missouri Watershed Restoration and Protection Area 9 Element Plan.

ACTION STEPS:

- Collection of Additional Data.

  a. Collect data on a voluntary basis to evaluate the impacts of tile outlet terrace systems within the Missouri Region. Prior to proposing any design changes to outlets of tile terraces in the Missouri Region, conduct research on cropland field input amounts (rates, dates applied, how it was applied, etc.) and collect water samples to evaluate the water runoff into the streams in the region. Collect data working with interested local landowners with assistance of area conservation districts, KDHE, Natural Resources Conservation Service (NRCS) and other existing agencies. Collection sites will be: tile outlet terrace runoff, grass waterway runoff, land with no conservation work or no conservation tillage, and land with no conservation work but using no-till.

  b. Collect data on the benefits of capturing and reusing water on a producer's property.

  c. Gather existing information on the impact of extreme events (droughts and floods) on water quality and availability of water resources into the future in the Missouri Region.

  d. Assess what other interest groups, agencies and individuals locally and from states with similar topography and precipitation (Iowa, South Dakota, Nebraska, and Missouri,) can provide on alternative projects that could contribute to water quality in the Missouri Region.

  e. Encourage communication in the Missouri River Region through a developed communication network.

Missouri Advisory Committee

Regional Goals & Action Plans

Priority Goal #3: Continued

ACTION STEPS:

- Implementation.

  a. Support and encourage implementation of the best management practices (BMPs) in the adopted 9-Element Plan. Those BMPs are: no-till, cover crops, grassed and forested buffers, convert steep slopes, sediment basins, pasture management, nutrient management, livestock waste management, alternative watering supplies, streambank stabilization, onsite wastewater system repair, urban lawn management, pet waste management. The Plan should be updated every 5-years.

  b. Focus on finding local volunteers who are willing to adopt and promote new practices, including streambank stabilization.

  c. Through education and outreach ensure the value of maintenance of BMPs is understood to allow BMPs to have the desired long-term effects.

  d. Through education and outreach emphasize the value of protection of water quality.

  e. Prevent sedimentation by using existing cost-share programs through the Kansas Department of Agriculture, Division of Conservation (KDA-DOC); KDHE; and NRCS, to fund conservation practices in the Missouri Region.

  f. Continue to use the NRCS for technical assistance on implementation practices suited to the unique topography of the Missouri Region.

  g. Prioritize the existing ranking systems from agencies to secure funding for protecting water quality and water supply in the Missouri Region.

  h. Raise awareness about water quality and the importance of proper chemical (i.e. fertilizers, pesticides and selective herbicides) application urban lawns.

Missouri Advisory Committee

Regional Goals & Action Plans

Priority Goal #3: Continued

ACTION STEPS:

- Monitoring.

  a. Determine if additional monitoring sites are needed to better characterize and prioritize project priorities in the Region.

  b. Increase TMDL monitoring to every three years.

- Funding Needs.

  a. To ensure water quality is maintained and improved, the state should fully fund the Kansas Water Plan for implementation of best management practices through programs of the KDA-DOC, KDHE and others as needed.

  b. Ensure continued and improved coordination with the NRCS to access and make the best use of funding for priority projects for water quality protection in the Region.

  c. Assess possible involvement of other agencies, businesses and interest groups to determine interest and possible funding of water quality projects in the Region.

  d. Continue to ensure that funding from the Clean Drinking Water Fee Fund for technical assistance for small public water supply systems is maintained at least at the current level.

  e. Fully fund the Missouri River Basin Watershed Restoration and Protection Strategy (WRAPS) 9-Element Plan, including funding for implementation of streambank stabilization projects.

  f. Develop a funding strategy within the next year for additional data collection and implementation as identified above in a phased manner in conjunction with KDA-DOC, NRCS, and KDHE and others as appropriate. Funding needs will then be reviewed on an annual basis and brought to the KWA.

Measuring success:

Goal 3: Improve BMP implementation trends and demonstrate progress towards achievement of water quality milestones.

Missouri Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- The RAC will establish an Education Subcommittee to coordinate education efforts.
- Water technology farms and Partnership for Agricultural Conservation and Excellence (PACE) farms should be supported and utilized as part of the education program.
- Utilize partners who have education programs already developed to support water education initiatives. This includes but is not limited to schools, water providers, FFA, KACEE, Kansas Farm Bureau, Kansas Corn Commission, Kansas Soybean Commission, Kansas Tribes, Conservation Districts, and Envirothon.
- The RAC and the Kansas Water Office work together to reach out to other private and public entities to aid in funding the development of educational programming and outreach.
- The Kansas Water Office should reach out to American Royal.
- Prepare video and other printed information on the activities of the KWA and Missouri RAC for presentation to community organizations, schools and other interested groups.

Priority Goal #4:
The State of Kansas should implement a strategy that includes funding and materials to deliver a comprehensive education and outreach program by 2023; to understand the basics of the water cycle, know basic water conservation principles and understand that actions impact water quality and water quantity. A component of the comprehensive program should include enhancing information and outreach on research, technology and management practices using social media and public information outlets.

Missouri Advisory Committee

Regional Goals & Action Plans

Priority Goal #4: Continued

ACTION STEPS:

- Provide presentations on Kansas water issues to interested agencies, organizations and schools.

Funding Needs

- a. A line item for education should be included in the State Water Plan Fund (SWPF).

Measuring success:

Goal 4: Form education subcommittee and disseminate water education within the region.

Missouri Advisory Committee

Regional Goals & Action Plans

Priority Goal #5:
Provide insight to the Kansas Water Authority (KWA) on Missouri river issues by staying fully aware of management issues and problems concerning this largely untapped water resource. Over the next 3-5 years secure information from various agencies and groups in the region that provide financial, technical, and planning strategies for flooding issues.

ACTION STEPS:

- Request semi-annual updates from the United States Army Corp of Engineers (USACE) to secure information on the Public Assistance to States (PAS) agreement between USACE and the states of Iowa, Missouri and Nebraska on Missouri River management as it affects Kansas.
- Request state agencies keep the Missouri RAC informed of activities, permits or other actions taking place in the region and submit final results of any projects or demonstrations occurring.
- Allocate time at each Missouri RAC meeting for their Missouri River Subcommittee to report out on current issues, meetings or events:
    a. System-wide related meetings or events
- Lobby the Missouri River Recovery Implementation Committee (MRRIC) to hold a meeting in Atchison or Leavenworth Kansas by 2025, promoting the importance of the Missouri River.
- Request updates as needed from the Farm Service Agency (FSA) and NRCS on flood recovery programs and progress.
- Request updates from authorities on watershed dams in the Missouri River Region that will affect the Missouri River.

Missouri Advisory Committee

Regional Goals & Action Plans

Priority Goal #5: Continued

ACTION STEPS:

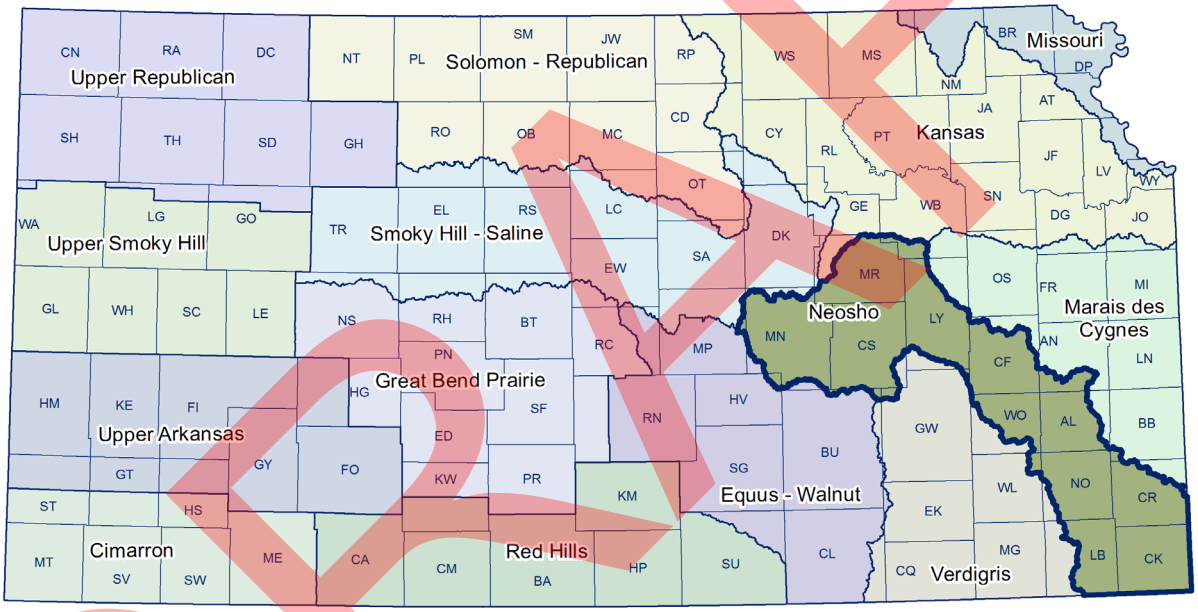
- Remain engaged with the recently formed Missouri River stakeholder group which is part of the Planning Assistance to States (PAS) study and continue to solicit public comments on River management.

  a. Establish a page on the Kansas Water Office website with information and valuable links for the Missouri River system.

Measuring success:

Goal 5: Continue involvement in Missouri River issues with partner agency reports to the RAC.

Neosho Region



Neosho Region

Regional Description

The Neosho Regional Planning Area covers approximately 6,300 square miles and encompasses all or part of 18 counties in southeastern and east central Kansas (Figure 1). The area is drained by the Neosho River and its tributaries, which also drain parts of Missouri, Arkansas, and Oklahoma.

The major streams in the region are the Neosho River and two major tributaries: the Cottonwood River and the Spring River. There are three major federal reservoirs in the region: Marion Reservoir is on the Cottonwood River, and Council Grove Lake and John Redmond Reservoir are on the mainstem of the Neosho River.

Elevations in the region range from 1,320 feet in Marion County to 826 feet in Cherokee County.

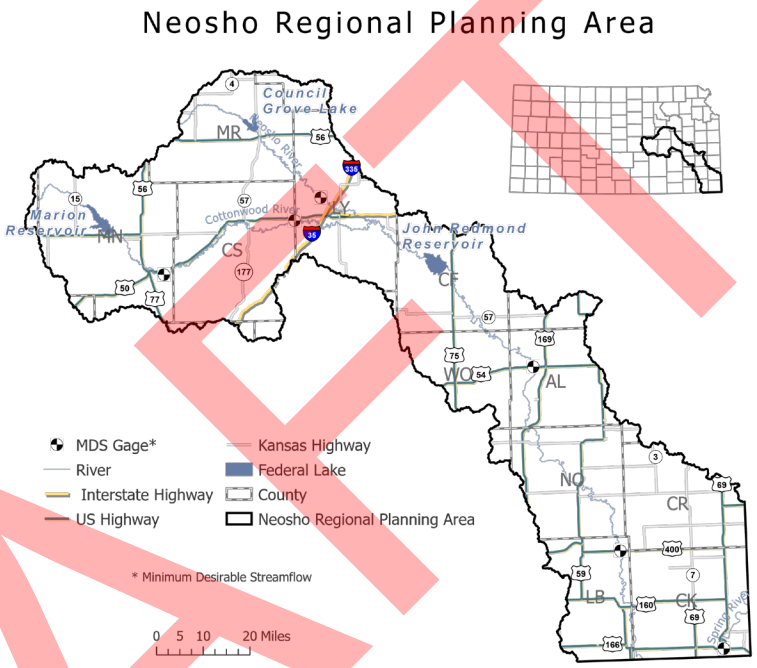


Figure 1. Neosho Regional Planning Area

CLIMATE & LAND USE

The climate of the region is characterized as humid in the southeastern half and sub-humid in the northwestern half. The annual precipitation in the region varies from approximately 32 inches in the westernmost part of the region to almost 46 inches in the southeast (Figure 2). This region includes portions of Kansas with the highest average annual rainfall. Average annual winter precipitation averages 10 to 16 inches of snow.

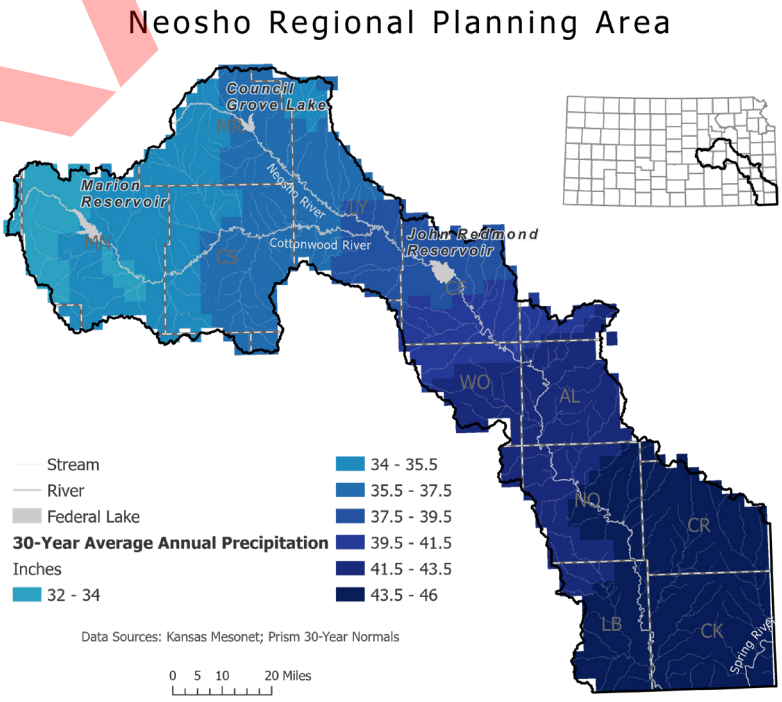


Figure 2. 30-year average annual precipitation in the Neosho Region

Land use activities can have a significant impact on the region. The three major land uses in this region are herbaceous (31%), cultivated crops (30%) and pasture/hay (24%) as derived from the National Land Cover Database (NLCD) 2016 dataset. Figure 3 lists the

Neosho Region

remaining land uses in the region, including: deciduous forest, developed/urban open space, and water.

Predominant features in the region are herbaceous/ grasslands (31%), cultivated crops (30%), and hay/pasture (24%)

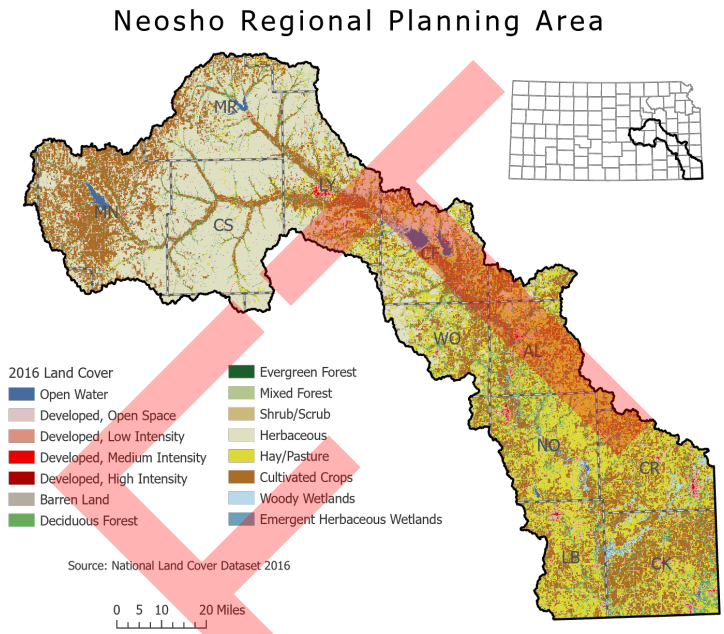


Figure 3. Neosho regional land cover

POPULATION & ECONOMY

According to the 2010 Census, there were an estimated 168,300 residents in the region. Based upon 2019 information derived from state-released information to the U.S. Census Bureau, there were an estimated 157,200 residents in the region, a decrease of about 7 percent. For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over or under represented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census (Figure 4).

Of the counties throughout the region, only Crawford, Butler, and Harvey counties are projected to have population growth through 2070. The rest of the region's counties are projected to remain stable or decline in population.

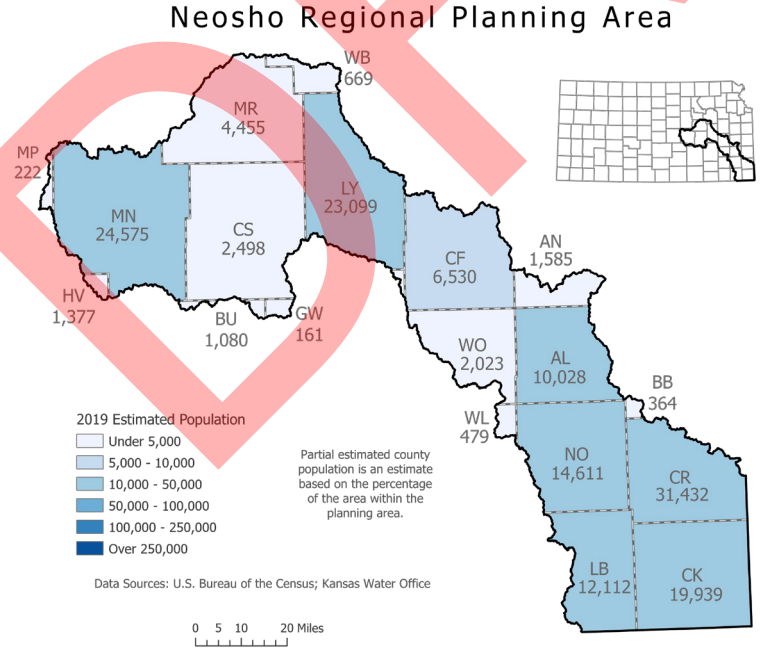


Figure 4. 2019 estimated population by county

Local economies are based primarily on agriculture, general manufacturing, and retail trades. The major crops grown in the region include wheat, grain sorghum, and soybeans. The production of beef cattle remains an important part of the area's agricultural economy.

Natural resources of economic importance are oil, gas, cement, ceramic materials, coal, lead, zinc, stone, and sand and gravel. The Neosho Region has a greater variety of minerals than any other area in Kansas. The production of oil and gas is a relatively small but important component of the regional economy.

Neosho Region

There are additional contributors to the local economy throughout the region. These include the Wolf Creek Nuclear Generating Plant (WCNGP) located near Burlington, KS, which is the only nuclear-powered generating plant in Kansas. It depends on waters from the Neosho River and John Redmond Reservoir for cooling. There is also a wide variety of water-based recreation that includes boating, fishing, hunting, wildlife watching, etc. These recreational opportunities are included at all three federal reservoirs, state fishing lakes in each county, community lakes, and the numerous private hunting establishments utilizing wetland resources, as well as the lands managed by United States Fish and Wildlife Service (USFWS) and Kansas Department of Wildlife and Parks (KDWP).

Wolf Creek Nuclear Power Plant; New Strawn, KS. Photo Credit: Kansas Travel

Primary Water Resources in Region

SURFACE WATER

There are three federal reservoirs in the region: Marion Reservoir, Council Grove Lake, and John Redmond Reservoir (Figure 5). These reservoirs were built to serve multiple purposes, such as water supply, irrigation, recreation, and flood control. Reservoirs designed for multiple purposes typically possess a specific volume of water storage assigned for each purpose.

Each county also contains a state fishing lake. Coffey County Lake (aka Wolf Creek Reservoir or Coffey County State Fishing Lake) provides cooling water for the WCNGP. Council Grove City Lake serves as a water supply for Council Grove. Other local water that provide support for water supply, recreation, and habitat include: Jones Park Pond, Olpe City Lake, Gridley City Lake, Altamont City Lake, Bartlett City Lake, Lake Kahola, Mined Land Resources Area and Lake, Parsons Lake, Pittsburg College Lake, Marion County Lake, New Strawn City Lake, and Playter's Lake.

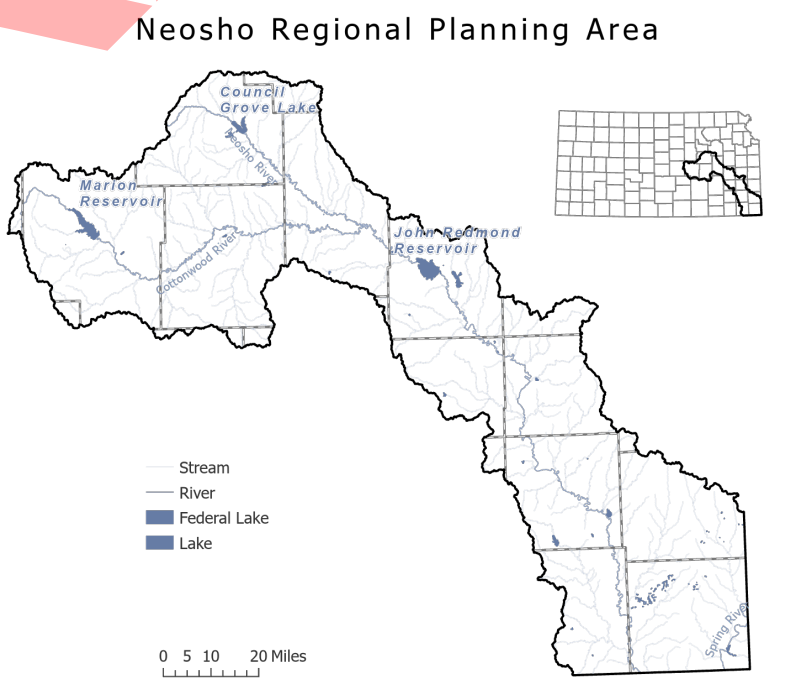


Figure 5. Major water resources in the Neosho Region

Neosho Region

GROUNDWATER

The Ozark Plateau Aquifer system and Spring River are water resources shared by Arkansas, Kansas, Missouri, and Oklahoma. Groundwater in the Ozark Plateau Aquifer system originates in Missouri and flows into the southeastern corner of Kansas and Oklahoma. The top of the aquifer is less than 500 feet below the land surface in most of the area and is, on average, 1,000 feet deep near the western boundary. Water in the aquifer flows west and northwest from southwestern Missouri into southeastern Kansas.

Increasing concentrated withdrawals in Missouri impact the amount of water available in Kansas and has decreased pumping heads in the Ozark Plateau Aquifer locally at Pittsburg, Kansas, and other surrounding towns. Drought conditions have been modeled, predicting shortages in the region. The determined safe yield for the aquifer is 36,000 acre-feet; the Kansas Department of Agriculture - Division of Water Resources (KDA-DWR) monitors levels in Kansas and the USGS monitors levels in all four states.

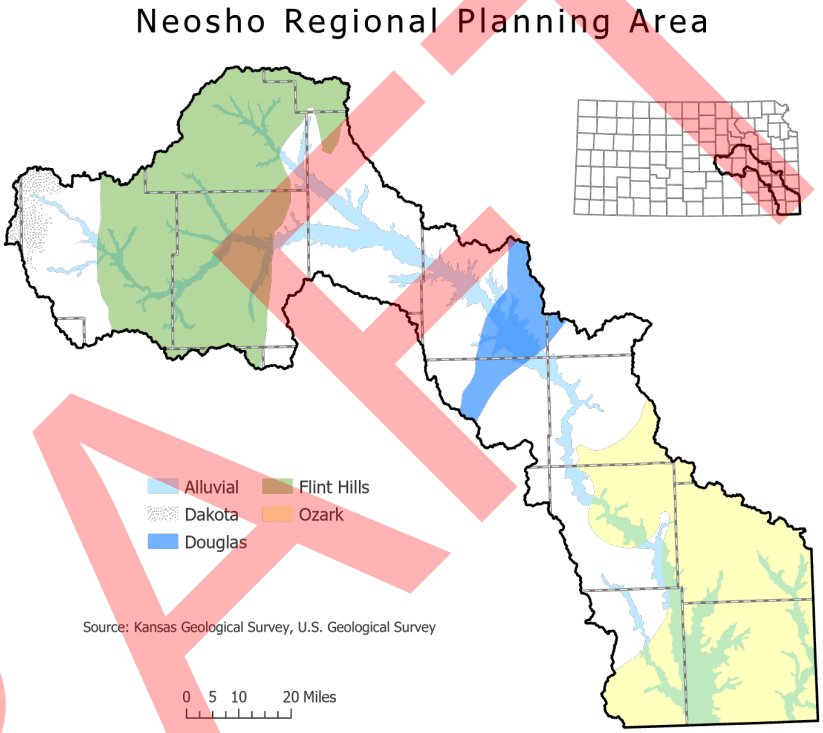


Figure 6. Principle aquifers boundaries in the Neosho Region

The Flint Hills Aquifer consists of limestone units that are water-bearing strata for many springs and limited public water supplies in the Flint Hills region. Most wells in the aquifer produce only small amounts of water for domestic and stockwater uses. However, the Crystal Spring that emanates from the aquifer in Marion County provides enough water to supply the municipal needs of Florence.

The Douglas Aquifer system consists of fluvial sandstone that provides small quantities of water. The aquifer does not provide substantial amounts of water except for a few areas where sandstones are thick enough for fresh water to occur. It is an important source for a few smaller communities, rural water districts, and farms (Figure 6).

Neosho Region

Primary Water Use by Source

Surface water is the primary source of water within the Neosho Region, accounting for approximately 82% of the total reported water use. Municipal use (44%) and industrial use (54%) are the primary uses within the region (Figure 7).

The majority of groundwater sources within the upper region are from the alluvial deposits along major streams. The Ozark Plateau Aquifer system supplies much of the groundwater used, especially for municipal use, within Crawford and Cherokee counties.

Annual reported water use for the region fluctuates based on climate conditions present, with higher water use resulting from periods of hot and dry weather during the growing season and lower water use taking place during periods of cooler and/or wetter weather.

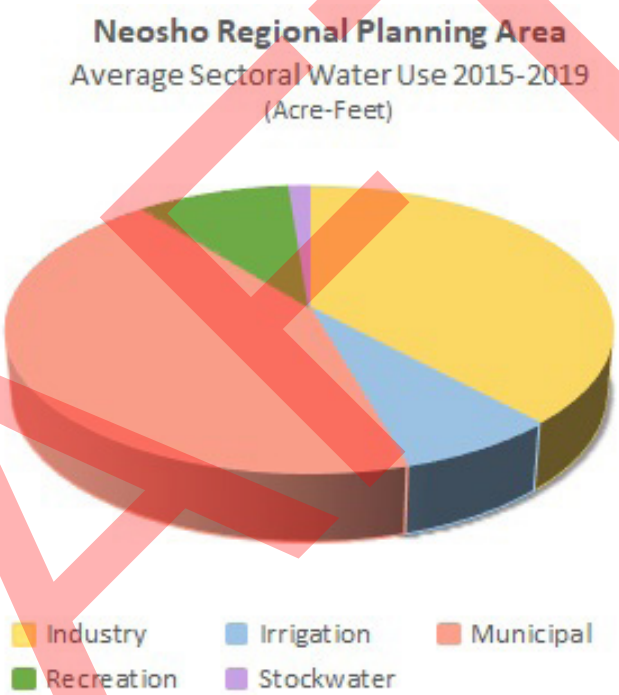


Figure 7. Average sectoral water usage

Regional Issues & Priorities

WATER SUPPLY AVAILABILITY

Reservoir sedimentation is a major water quantity and quality concern, particularly in reservoirs where the state owns storage for the Water Marketing Program, or where a Water Assurance District (WAD) owns storage. As sediment accumulates in a reservoir's multi-purpose pool, the capacity for water supply storage is reduced. The loss of capacity in John Redmond Reservoir is the most pressing issue among the three federal reservoirs within the region. Currently there are 363 streambank hotspots identified above the three reservoirs and 41 have been stabilized (Figure 8). A dredging operation which was conducted at the John Redmond Reservoir

Eroding streambank on Neosho River

Neosho Region

in 2016 removed over three million cubic yards of silt at a significant cost of $20 million, extending its useful life.

Figure 9 shows the projected water supply storage given the historic rate of reservoir sedimentation based on the change in volume documented by bathymetric surveys (earliest survey versus most recent survey), along with the storage required to meet the system's demands and targets. The analysis was performed using current system operations using a Neosho River basin model which simulated historic hydrologic conditions between 1950 and 2014, allowing for an estimate of required storage. Given the projected sedimentation and demands, results indicate that John Redmond Reservoir storage will be insufficient to fully meet projected downstream demands through a 1950s-type drought by the year 2023. However, with supplemental support from Marion and Council Grove reservoirs, the system as a whole will provide an adequate water supply through 2059.

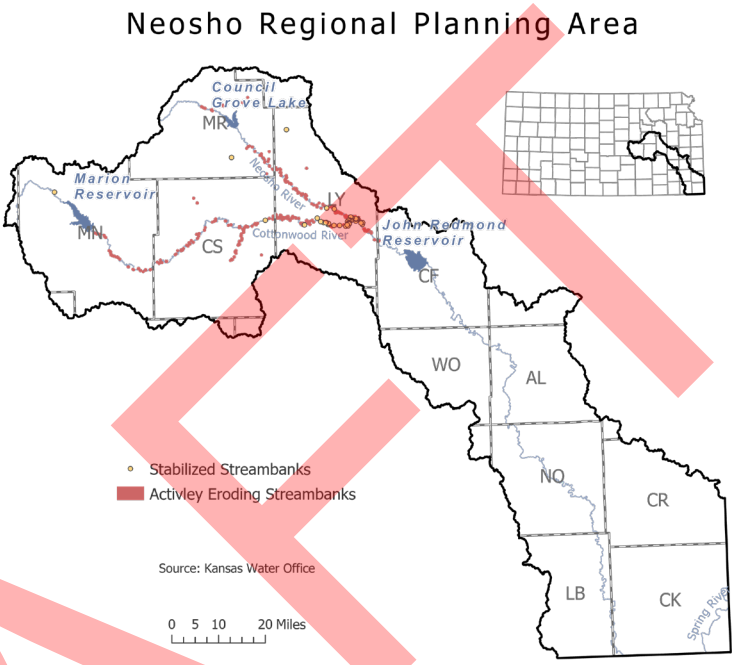


Figure 8. Actively eroding and stabilized streambanks in the Neosho Region

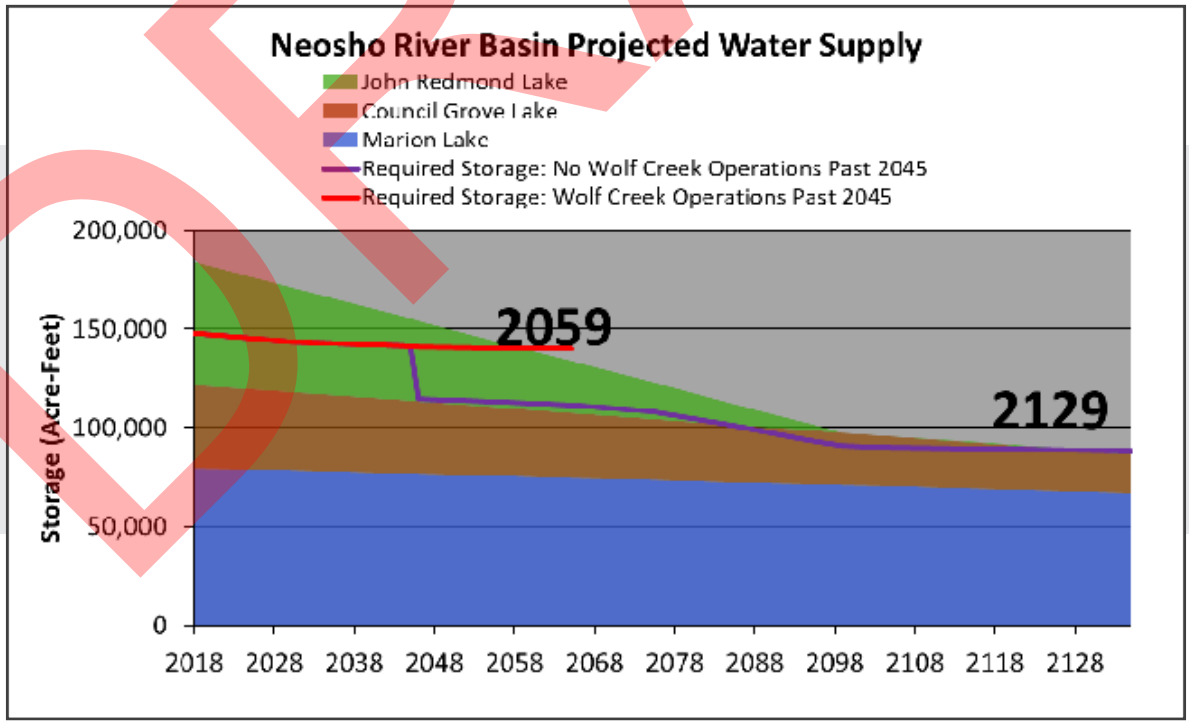


Figure 9. Projected water supply storage given the historic rate of sedimentation based on the change in bathymetric surveys

Neosho Region

Water Quality

All three federal reservoirs, and the many streams and tributaries that connect them, are experiencing water quality impairments (Figure 10). The Kansas Department of Health and Environment's (KDHE) most recent list of impaired waters for the state can be found here. Nutrient loading of phosphorus and nitrogen caused by land runoff along with reservoir sedimentation create substantial water quality challenges throughout the region.

Figure 10. Impaired water resources in the Neosho Region

Spring River and its tributaries are a valuable biological resource, providing habitat for many unique and some Threatened and Endangered (T&E) species. The KDWP maintains the current list of T&E species by county located here. Of particular concern are native mussel populations that have declined since the start of heavy metal mining. Due to historic mining activities in the area, these waters are contaminated by lead, zinc, copper, and cadmium. Total Maximum Daily Loads (TMDLs) for these contaminants have been developed for these streams.

Reservoir sedimentation is a major water quantity and quality concern, particularly in reservoirs where the state owns storage for the Water Marketing Program or where a WAD owns storage. This sedimentation is often caused by accelerated erosion due to human activities (deforestation, poor agricultural practices, construction, altering native prairie regions, etc.) As sediment accumulates in a reservoir's multi-purpose pool, the capacity for water supply storage is reduced. Sediment can also have a major impact on water quality, as it can carry with it pollutants like phosphorus, pesticides, bacteria and metals which ultimately end up in the aquatic system impacting downstream receiving waters.

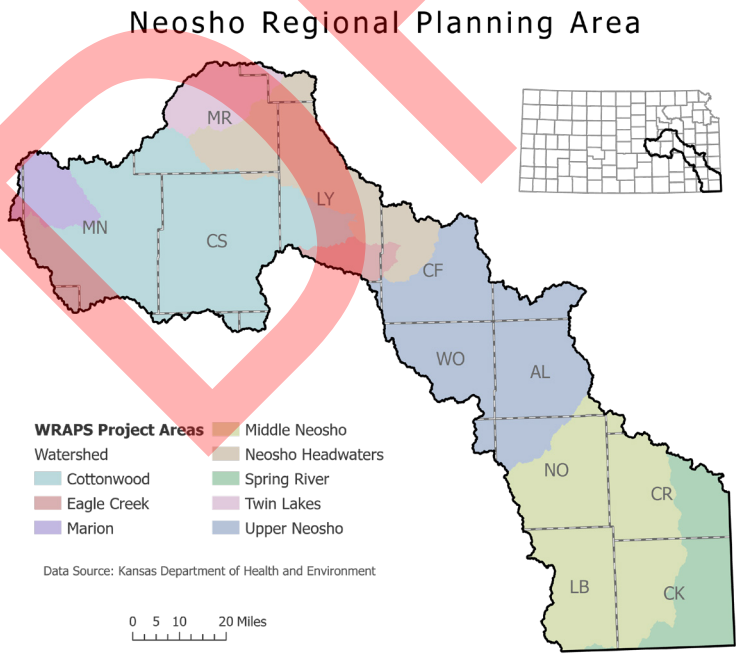


Figure 11. WRAPS project areas by watershed

Water quality and related water resource issues are addressed through a combination of Watershed Restoration and Protection Strategy (WRAPS) efforts utilizing voluntary, incentive-based approaches, as well as regulatory programs. The restoration and protection of watersheds, particularly those watersheds above public water supply reservoirs, is a priority in the

Neosho Region

Neosho Region. The Neosho and Spring Rivers drain south into Oklahoma and Grand Lake, so interstate water quality issues are also important to ensure high quality water crosses the state line.

Watersheds with WRAPS projects currently underway in the region target high priority areas for TMDL implementation, areas with a high improvement potential index for nutrient reduction, source water assessment areas, and priority areas for wetland and riparian protection (Figure 11).

Harmful Algal Blooms (HABs)

Marion Reservoir, Cottonwood Point Beach. Photo Credit: KWO.

High nutrient loads (phosphorus and nitrogen) have contributed to Harmful Algal Blooms (HABs) in Kansas and Oklahoma. Most of the nutrient loading is caused by land use runoff which is a non-point source pollutant and is not subject to regulations by the Federal or state government. HABs, as discussed in the *Water Quality* section of the *Kansas Water Plan (KWP)*, have caused pet and livestock deaths. While it can cause illness in humans, there have been no mortalities attributed to the toxins created by these bacteria. This worldwide problem has led to significant research on causes, treatments, and prevention of HABs, some of which are being conducted at Marion Reservoir. The Kansas Biological Survey (KBS) is using lake sediment cores of Marion Reservoir and other water bodies throughout the state to evaluate HAB timing throughout the years since the reservoir was impounded. HABs have occurred more frequently and the duration of blooms has increased. Since 2010, KDHE has confirmed HABs on public lakes in Coffey and Marion counties on numerous occasions. More information on HABs can be found at the KBS website.

Aquatic Nuisance Species (ANS)

Zebra mussels, one of the Aquatic Nuisance Species (ANS) affecting Kansas waters, can cause various issues for water users. Zebra mussels are found in all the federal reservoirs within the Neosho Region, as well as smaller county and public water supply (PWS) lakes (Figure 12). Unfortunately, ANS affect the quality of water and recreational opportunities within the state. More information on ANS and their potential impacts can be found here.

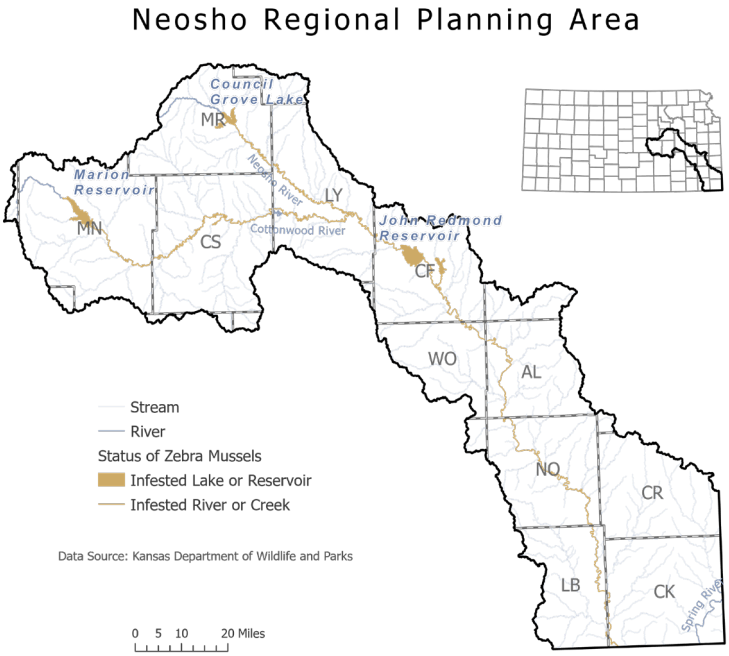


Figure 12. ANS infested water resources in the Neosho Region

Neosho Regional Advisory Committee

Regional Goals & Action Plans

Priority Goal #1: Prolong the water supply storage in John Redmond Reservoir to the year 2065 by reducing the sedimentation rate by an average of 300 acre-feet/ year.

ACTION STEPS:

- Stabilize all streambank hotspots, as defined by the Kansas Water Office (KWO), by 2030 in the Cottonwood-Neosho Region above John Redmond Reservoir. The Streambank Team (KDHE, KDA-DOC, and KWO) will secure funding for the stabilization of the streambanks each year to address reaches in order as they proceed from the reservoir.
- The Streambank Team will evaluate streambank sites in years following major flooding in the Region.
- A collaboration between the Regional Advisory Committee (RAC), local producers, local WRAPS groups, local conservation districts, regional public water suppliers (PWS), the KWO, the KDHE, and the Kansas Department of Agriculture-Division of Conservation (KDA-DOC) will secure funding and work to treat 80% of priority cropland with no-till practices, cover crops, buffer strips, soil health management principles, and other sedimentation and nutrient reduction farming practices by 2030 in the Cottonwood-Neosho Region above John Redmond Reservoir, Marion Reservoir, and Council Grove Reservoir. To provide education and share information concerning water and soil conservation and nutrient and sedimentation reduction, this collaborative effort will establish demonstration farms in the region above these three reservoirs using this.
- The KWO will conduct bathymetric surveys of these reservoirs every five years to monitor the sedimentation rate and the progress and benefit of sedimentation reduction practices. The KWO will secure funding for this program.
- The KWO will evaluate the feasibility of possible technologies to remove sediment from the reservoirs in order to maintain and protect water supply.

Measuring success:

Goal 1: Complete bathymetric surveys on the three federal reservoirs within the region every 5 years and document sediment load reductions to these reservoirs from the expansion of conservation measures.

Neosho Regional Advisory Committee

Regional Goals & Action Plans

Priority Goal #2: Reduce vulnerability to drought to ensure water supply available from storage and other sources exceeds projected demand by at least 10% through the year 2050 for the entire region.

ACTION STEPS:

- The KWO will evaluate operational efficiencies and potential additional storage and sources, including upstream and downstream options, by 2025.
- The KWO will continually work with the U.S. Army Corps of Engineers (USACE) on refining reservoir operations and developing Drought Contingency Plans.
- The KWO will evaluate costs associated with conservation pool rises and the benefits of increased supply, soliciting the USACE's advice when needed. Based on the evaluation, a reallocation study may be implemented.
- The KWO will use Forecast Informed Reservoir Operations (FIRO) forecasting to control storage to increase water supply and reduce flooding by looking at climate variability and creating long-term forecasting.

Measuring success:

Goal 2: Complete evaluation of current water supply and demand in the region and identify areas of need. In collaboration with multiple partners, compile a list of potential solutions for areas lacking in water supply and create criteria to determine projects with greatest anticipated benefit.

Neosho Regional Advisory Committee

Regional Goals & Action Plans

Priority Goal #3: Reduce overall nutrient loading, frequency of HABs, and potential ANS to improve water quality within the Region by 2035.

ACTION STEPS:

- The RAC will work with the KDHE to identify the highest nutrient loading areas and investigate what practices would be best implemented to reduce nutrient loading.
- The KWO will work with KDHE to investigate and demonstrate in-lake treatment options to reduce the frequency and duration of HABs and assess the effectiveness of in-lake treatment options at minimizing the impact of HABs.
- Implement best management practices (BMPs) above Marion Reservoir to reduce nutrients before they enter the reservoir as mentioned in Goal 1 Action Steps, thereby reducing HAB frequency to no more than every three years.
- The RAC will work with the regional public water suppliers and the Grand Lake partners to investigate nutrient crediting options for the entire Neosho Region (including areas in Oklahoma) to reduce nutrient loading from nonpoint sources.
- The RAC will encourage funding for the ANS Program through the State Water Plan Fund (SWPF). The RAC will encourage the consideration of ANS as part of the evaluation of interbasin water transfers.

Measuring success:

Goal 3: Demonstrate progress on installation of watercraft inspection and decontamination stations near the federal reservoirs as well no additional ANS-infested waters within the region. Collaborate with multiple partners to increase knowledge of HABs and reduce HAB occurrence and duration. Document nutrient load reductions within the region resulting from the expansion of conservation measures.

Neosho Regional Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

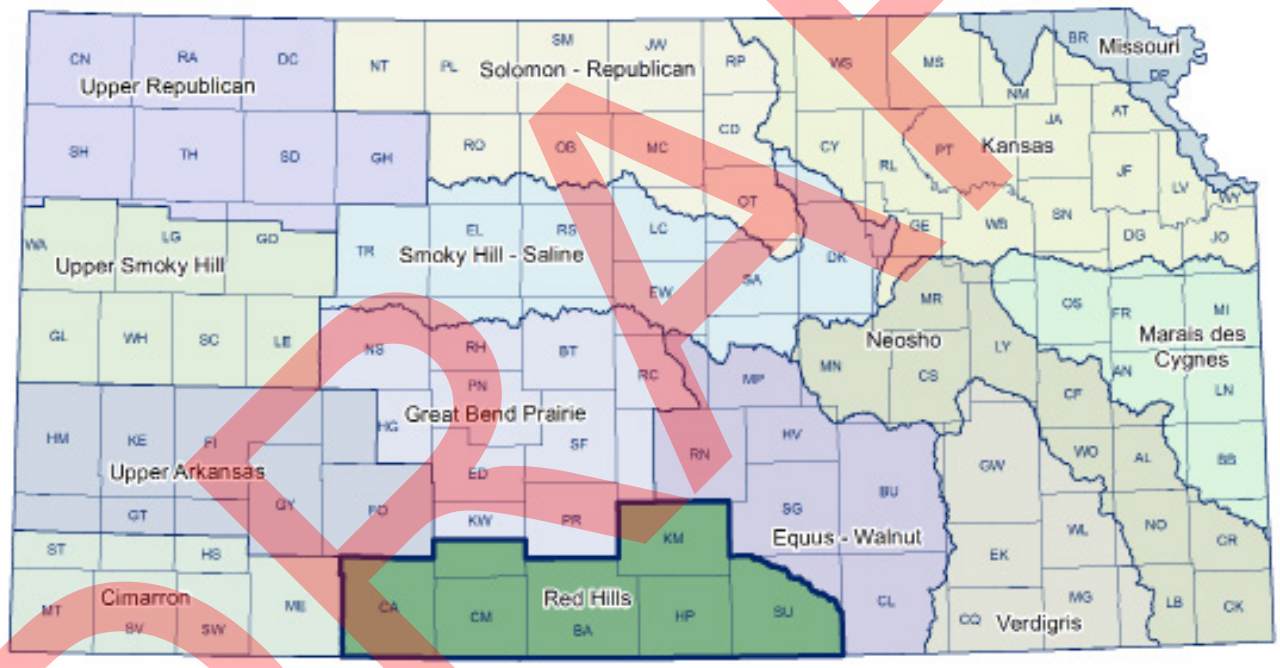
- The RAC will work with the KWO, The Nature Conservancy (TNC), and USACE to evaluate and research flooding within the region to determine possible option for off-stream storage during flood events.
- The KWO will determine the storage capacity within the floodplain.
- The KWO will use Forecast Informed Reservoir Operations (FIRO) forecasting to control storage, to increase water supply, and to reduce flooding by looking at climate variability and long-term forecasting.

Priority Goal #4: Reduce vulnerability to floods within the Region by 2050 to reduce negative impacts to water quality and infrastructure.

Measuring success:

Goal 4: Identify impacts, vulnerabilities and potential mitigation to water quality and infrastructure impacts resulting from flooding events and compile a list of potential solutions for flood mitigation projects with the greatest anticipated benefit created.

Red Hills Region



Red Hills Region

Regional Description

The Red Hills Regional Planning Area is located in south-central Kansas and is noted for its rugged hills, buttes, red soils, and gypsum deposits. The Red Hills Region is bordered by Oklahoma on the south and covers approximately 5,825 square miles. The region includes all of Barber, Clark, Comanche, Harper, and Kingman counties and parts of Kiowa and Sumner counties (Figure 1).

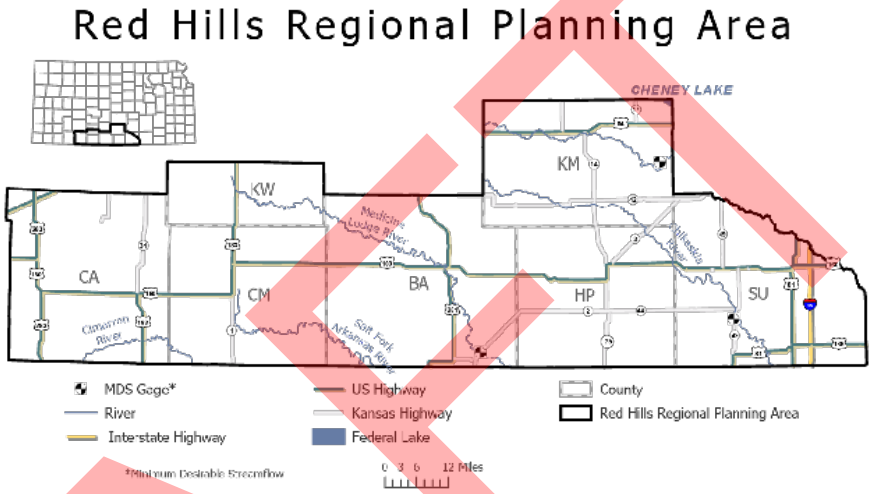
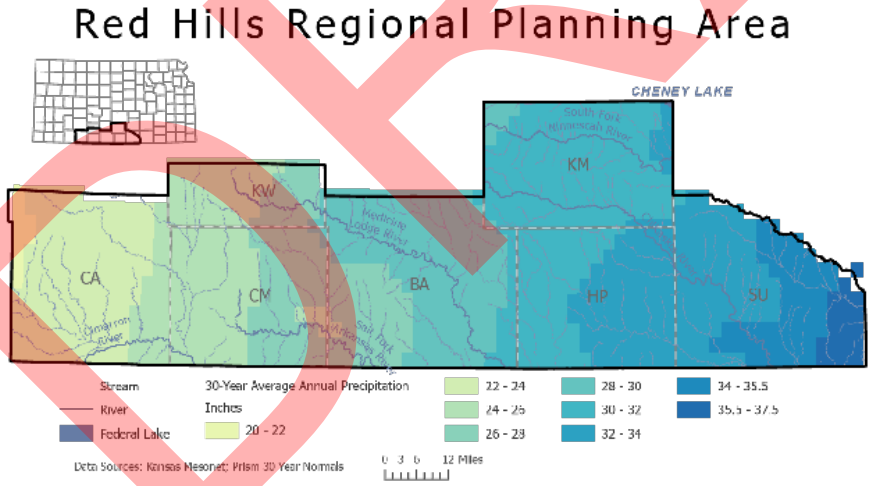


Figure 1. Red Hills Regional Planning area

CLIMATE & LAND USE

The climate of the region is characterized by moderate to low precipitation, relatively high wind velocities, rapid rates of evaporation, and a wide range of temperatures. Average annual precipitation amount varies from 20 inches in the west to 37.5 inches in the east (Figure 2). The high winds and low humidity of the region contribute to a high evaporation rate.



Land use activities can have a significant impact on the region. The three major land uses in this region are herbaceous (56%), cultivated crops (38%) and developed/urban open space (3%) as derived from the National Land Cover Database (NLCD) 2016 dataset. Figure 3 lists the remaining land uses in the region, including deciduous forest.

Figure 2. 30-year average annual precipitation in the Red Hills Region

Red Hills Region

Playa lake wetlands occur in northwest Clark County, providing habitat for migrating birds and the aquatic organisms that support them. Mixed grass and sand sage prairie ecosystems dominate the region. Key wildlife species include the bobwhite quail, lesser prairie chicken, pheasant, turkey, deer, and pronghorn antelope.

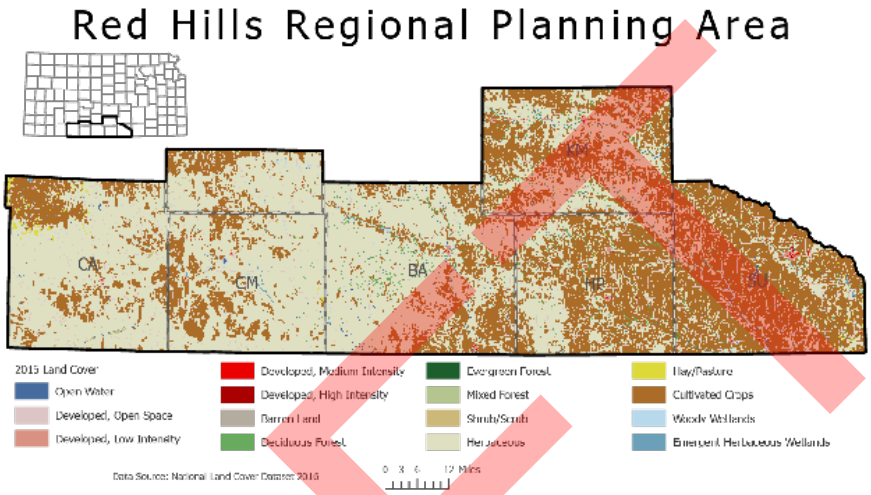


Figure 3. Red Hills regional land cover

POPULATION & ECONOMY

Based upon 2019 information derived from state-released information to the U.S. Census Bureau, there were an estimated 40,269 residents in the region (Figure 4). For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over or under represented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census.

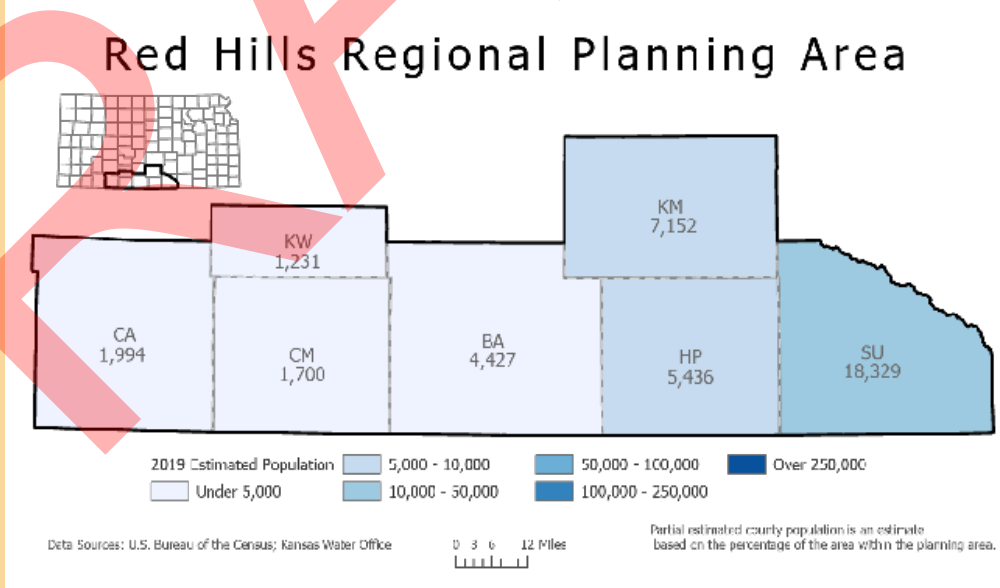


Figure 4. 2019 estimated population by county

Agriculture is the basis of the economy of the region. Crops grown include hay, wheat, grain sorghum, and soybeans. Livestock production is an important part of the area's agriculture, with beef cattle being the predominant livestock raised in the region. Oil and gas production is also an important contributor to the regional economy.

Red Hills Region

Primary Water Resources in Region

SURFACE WATER

The majority of the region is drained by four rivers: the Cimarron, Medicine Lodge, Salt Fork Arkansas, and the Chikaskia Rivers. The tributaries of these rivers include Crooked Creek, Two Bluff Creek, Bear Creek, Mule Creek, and Sandy Creek. These rivers flow into the Arkansas River in Oklahoma. The northern part of Kingman County is drained by the South Fork of the Ninnescah River (Figure 5).

Chikaskia River. Photo Credit: Legends of America

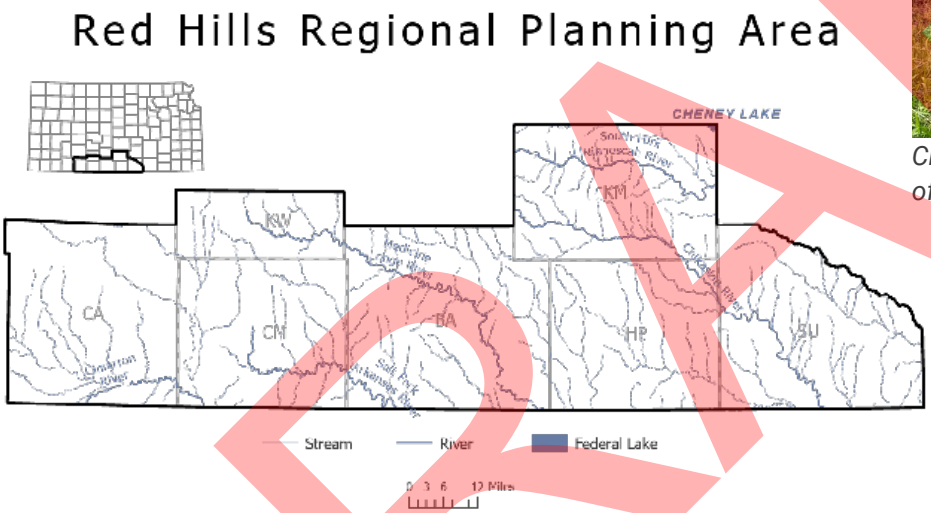


Figure 5. Major surface water resources in the Red Hills Region

GROUNDWATER

The principal aquifers include the High Plains and alluvial aquifers. The saturated portion of the High Plains Aquifer is only present in portions of Kiowa and northern Barber and Kingman counties (Figure 6).

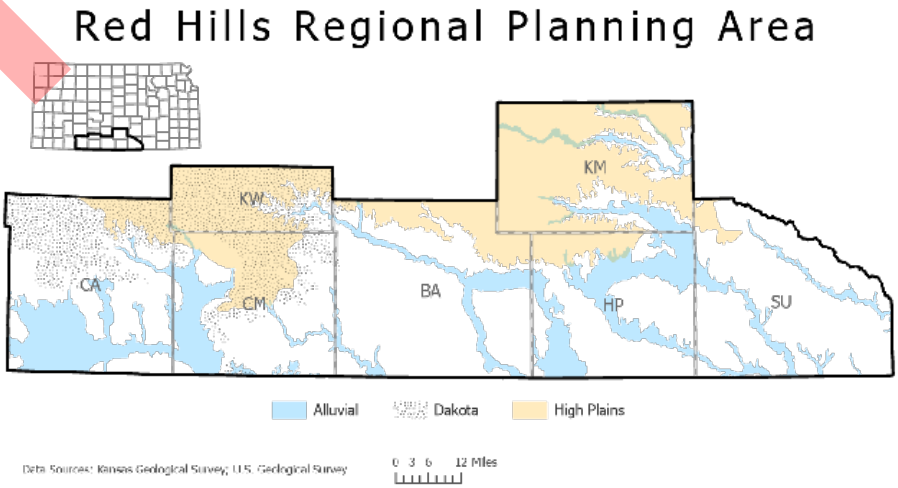


Figure 6. Principle aquifer boundaries in the Red Hills Region

Red Hills Region

Primary Water Use by Source

GROUNDWATER

Groundwater is the primary source of water in the region, accounting for 96% of the total supply, principally from the Great Bend Prairie-High Plains Aquifer and is part of the Great Bend Prairie alluvial deposits along major streams. Irrigation accounts for 84% of the reported water use of the region. Municipal represents approximately 11% of water use with the remainder accounted for by stockwater, recreation, industrial, and other uses (Figure 7).

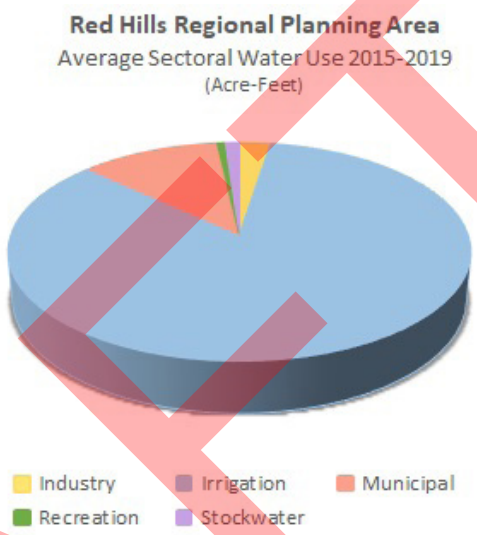


Figure 7. Average sectoral water usage

Regional Issues & Priorities

WATER SUPPLY AND ECONOMIC GROWTH

Water appropriations and use are regulated by the Kansas Department of Agriculture-Division of Water Resources (KDA-DWR). Streams and alluvial corridors in the region are open to new appropriations under KDA-DWR rules. Minimum desirable streamflow has been established at three sites in the region, though many streams now flow only during rainfall events. Increased oil and gas development within the region impacts water availability for other users.

Barber County, KS. Photo Credit: Barber County, KS.

In 2013, the U.S. Army Corp of Engineers (USACE) released a study on water supply and demand in portions of the region including Barber, Harper Kingman and Pratt counties in Kansas as well as Woods County in Oklahoma. The study found that existing demands for water supply in the study area were being met by groundwater sources. However, the resources of the region limit the development of larger permanent water users that could aid economic growth in the region.

Red Hills Region

Existing Resources

Since the 1970s, the High Plains Aquifer has been developed extensively. In the Red Hills Region, the High Plains Aquifer is very limited and varies widely in thickness. Some recharge does occur (3.8 inches/year), allowing some recovery during wet years. Dry times result in groundwater level decline, resulting in a loss of hydraulic connection with streams and the overlying alluvial aquifers and rivers, therefore diminishing contributions to base streamflow.

The region's alluvial aquifers play a large role for public water supply, but are relatively small in extent and saturated thickness. The exact amount of water stored depends on the sediments at any given location.

Clark State Fishing Lake and Wildlife Area, May 2019. Photo Credit: Red Beard.

Water Reuse

For areas of the state where water can be in short supply, such as the Red Hills Region, water reuse is being used to stretch this limited resource. The Kansas Health Institute (KHI) crafted a report on Potential Health Impacts of Municipal Water Reuse in Kansas . Municipalities or industry offer the greatest opportunity for water reuse, but large water users in both of these sectors are limited within the Region. In past years entities in Barber, Comanche and Sumner counties have used treated effluent for irrigation of crops and a golf course. The Kansas Department of Health and Environment (KDHE) permits water reuse projects on an individual basis due to no statewide policies being in place regarding water reuse. As treatment technology improves the reuse of oil and gas, produced water has the potential in this region to decrease the use of potable water.

Treating produced oil field water is not a new concept. Several other states have been using treated produced water to alleviate the need for disposal of this waste product. Currently, Kansas is injecting produced water into the Arbuckle Formation where remaining disposal capacity in areas is becoming a growing concern. The Kansas Water Office (KWO) submitted a WaterSMART grant proposal to the Bureau of Reclamation (BOR) for funding. The project will be located near Hardtner, KS, where a collection tank for an injection well is located. The proposed project will treat produced water for 60 days using a one of a kind piece of equipment to bring this water down to acceptable levels for irrigation or stockwater to help meet water demands.

Red Hills Region

Water Quality

Impairment due to nutrients affects some surface waters in the Red Hills Region including Big Basin/ St. Jacob's well in Clark County and Lake Coldwater in Kiowa and Comanche counties (Figure 8).

Chloride concentrations in segments of the Cimarron River and tributaries in Clark and Comanche counties cause impairment to domestic water supply and aquatic life support. The source of the high sulfate and chloride concentrations in the Cimarron River, south of Protection, and its tributaries is natural dissolution of the evaporite minerals (halite, anhydrite, and gypsum) in the underlying Permian bedrock. This mineralized water discharges into the overlying alluvial aquifers and then into the river. Chloride is also an impairment to domestic use in the Salt Fork Arkansas River in Comanche and Barber counties, also from natural sources (Permian bedrock).

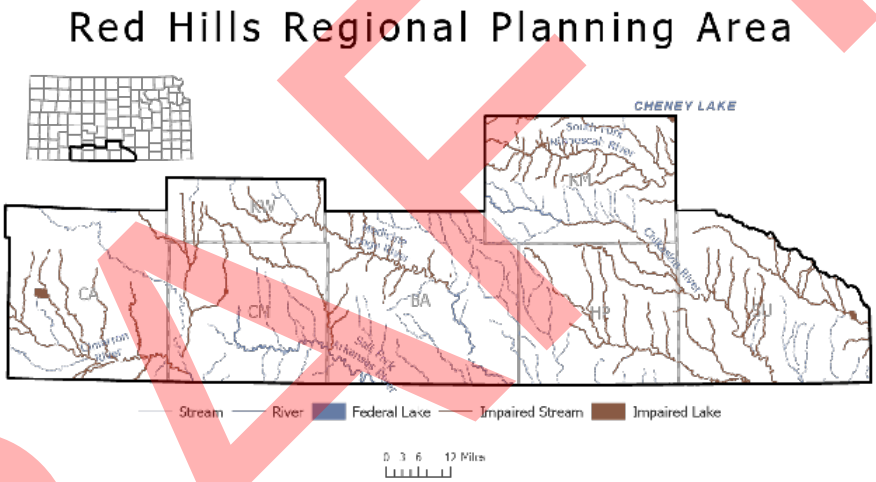


Figure 8. Impaired water resources in the Red Hills Region

Very high chloride concentrations from historic oil field brine contamination can be present in the Permian bedrock, making this water unusable and posing a significant risk to the environment if encountered. Groundwater high in chloride concentration may also be encountered in the overlying unconsolidated aquifer, limiting the use of this region's groundwater for most purposes.

In August 2015, KDHE issued a Saltwater Contamination Advisory due to high chloride levels in groundwater as the result of historic oilfield brine contamination in portions of south central Kansas within Barber County as well as a portion of Sedgwick County within the Equus-Walnut Region. As noted within this advisory, very high chloride concentrations can be present in the Permian bedrock, making this water unusable and posing a significant risk to the environment if encountered. Groundwater high in chloride concentration may also be encountered in the overlying unconsolidated aquifer, limiting the use of this groundwater for most purposes. Additional details regarding this advisory can be found on the KDHE Water Well Program website at https://www.kdhe.ks.gov/waterwell/index.html.

Red Hills Region

Additional Storage

Seasonal reclaimed water or seasonal high flows could be stored for later use in the region in aquifers or lakes. In the Red Hills Region there is little aquifer storage capacity, but lake storage could increase availability. The 2013 USACE study reviewed the development of the Elm Creek Reservoir and efforts continue to identify stakeholder water needs.

A multipurpose small lake could be developed to provide flood control storage, public water supply storage, or recreation features. If financial assistance from the state is sought, there must be an eligible sponsor as defined in K.S.A. 82a-1601, *et seq.* with taxing authority and power of eminent domain. Experience indicates strong local support and commitment, including funding, is necessary for such a project to be completed. Hydrologic studies, land purchase, water appropriation, and other permits are all needed prior to any construction.

Depending on lake specification and location, numerous state and federal permitting conditions must be met. Permits for stream obstructions, dam safety, stormwater runoff, threatened and endangered species, water appropriation, local construction, and Clean Water Act (U.S. Army Corps of Engineers-404), as well as an environmental impact statement are potential requirements.

Clark State Fishing Lake and Wildlife Area, May 2019. Photo Credit: Red Beard.

Red Hills Advisory Committee

Regional Goals & Action Plans

Priority Goal #1: Reduce water usage throughout the region. Conservation should be voluntary and encouraged, using incentive-based policies and programs.

ACTION STEPS:

- Identify data needed to determine if and where water (streamflow or groundwater levels) downtrends are occurring for focusing water conservation efforts.
- Identify reuse potential in the region.
- Identify barriers to reuse, such as limiting factors and water quality parameters.
- Develop appropriate policy, programs, data or education to address barriers to reuse.
- Add streamflow measurements to access changes in streamflow and baseflow contributions on Elm Creek and other priority locations, preferably continuous monitoring gages.
- Identify and promote state program to address Red Cedar invasion.
- Utilize education/information dissemination as previously developed for *The Vision* and region. Should include information on water resources, stresses, conservation tools and water use.
- Identify barriers to conservation in this region.
- Work with local, state and federal programs to offer water conservation programs, including cost-share opportunities.
- Address water conservation by water use category.

Measuring success:

Goal 1: Track annual water usage and streamflow in the region to quantify conservation achieved.

Red Hills Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- Determine level of support for a reservoir providing future water supply, flood control, and recreation.
- Gather public input on possible reservoir for recreation and future water supply.
- Define project and scope of work for detailed economic impact study to move ahead, if local support is sufficient.
- Initiate Economic Impact Study.
- Review Economic Impact Study and formulate future steps.

Priority Goal #2: Increase sources of supply through the use of a multi-purpose small lake to meet increased demand in specific growth or need areas by 2035.

Measuring success:

Goal 2: Establish regional need and support for an additional multipurpose and evaluate economic impact study.

Red Hills Advisory Committee

Regional Goals & Action Plans

Priority Goal #3: Work with oil and gas industry to have 10,000 barrels of fresh water per day recycled from oil production for regional use in the Red Hills.

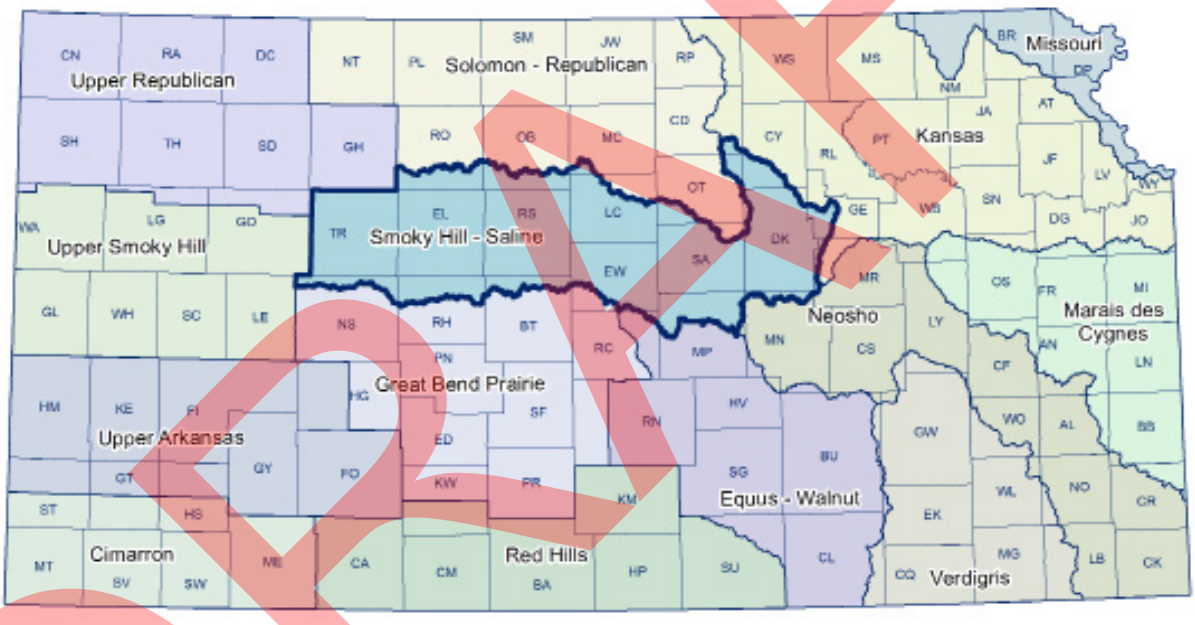
ACTION STEPS:

- Develop background/baseline data on the quantity of produced water, water usage and reuse in the region for use in education and development of appropriate actions.
- Work with industry to recycle/reuse flow back and production waters.
- Promote the produced water treatment project and other treatment technologies.
- Share results of Kansas pilot treatment project and other treatment projects.
- Identify sites for treated (freshwater) water storage for oil and gas industry access for fracking.
- Work with industry to use the lowest quality waters possible.
- Work with industry to reduce quantities of produced water injected underground.

Measuring success:

Goal 3: Quantify recycled produced water in the region.

Smoky Hill-Saline Region



Smoky Hill-Saline Region

Regional Description

The Smoky Hill-Saline Regional Planning Area is located in central Kansas (Figure 1). The regional area is bordered by the Great Bend Prairie, Equus-Walnut, and Neosho Regional Planning Areas on the south, the Kansas and Solomon-Republican Regional Planning Areas on the east and north, and the Upper Republican and Upper Smoky Hill Regional Planning Areas on the west. The Smoky Hill-Saline Regional Planning Area covers approximately 7,240 square miles and includes all of Trego, Ellis, and Russell counties and portions of Barton, Clay, Cloud, Dickinson, Ellsworth, Geary, Lincoln, Marion, McPherson, Mitchell, Morris, Ness, Osborne, Ottawa, Rice, Rooks, Rush, and Saline counties.

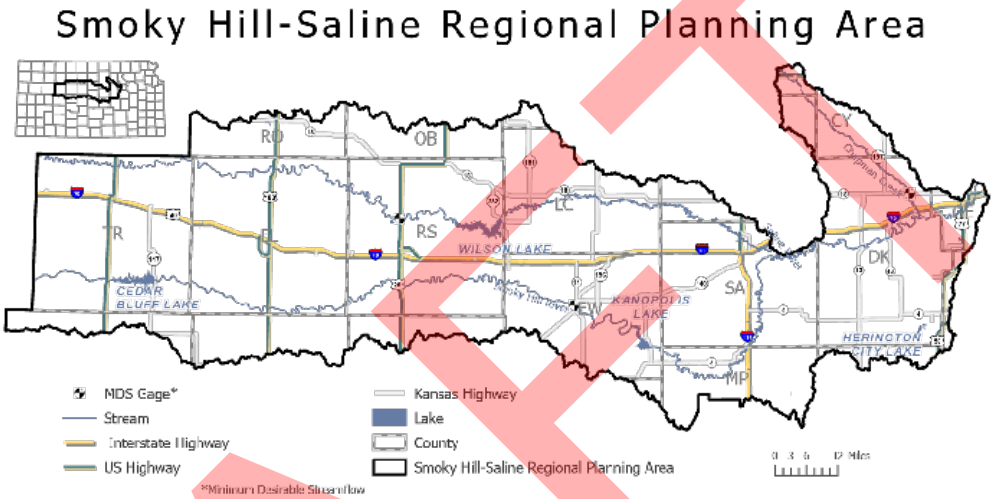


Figure 1. Smoky Hill-Saline Regional Planning Area

CLIMATE & LAND USE

As is common across all of Kansas, the climate of the Smoky Hill-Saline Regional Planning Area is characterized by extremes with highly variable precipitation and temperature. Average annual precipitation amount varies from around 20 inches in the west to about 35.5 inches in the east (Figure 2). Normal annual mean temperature for the region ranges from around 52 to 55 degrees (F).

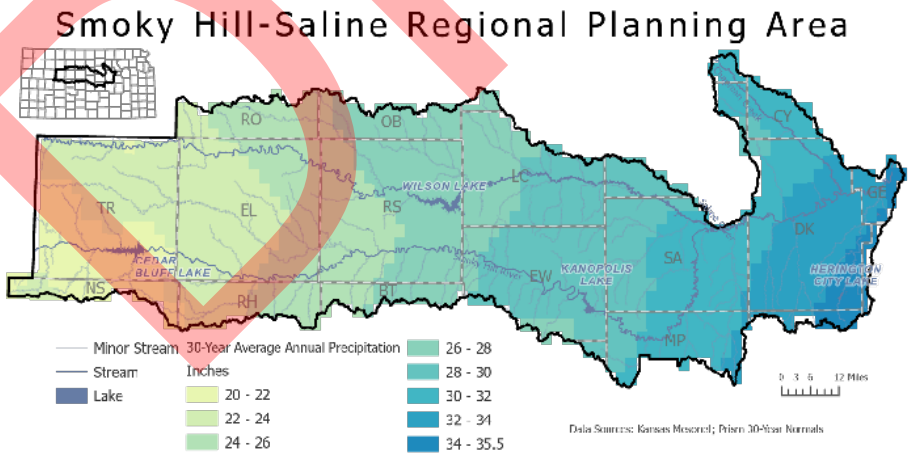


Figure 2. 30-year average annual precipitation in the Smoky Hill-Saline Region

Land use activities can have a significant impact on the region. The three major land uses in this region are herbaceous (50%), cultivated crops (41%) and developed/urban open space (4%) as derived from the National Land Cover Database (NLCD) 2016 dataset. Figure 3 lists the remaining land uses in the region, including: deciduous forest, pasture/hay, and water.

Smoky Hill-Saline Region

Topography within the region is flat to gently rolling, with narrow, shallow valleys and low relief.

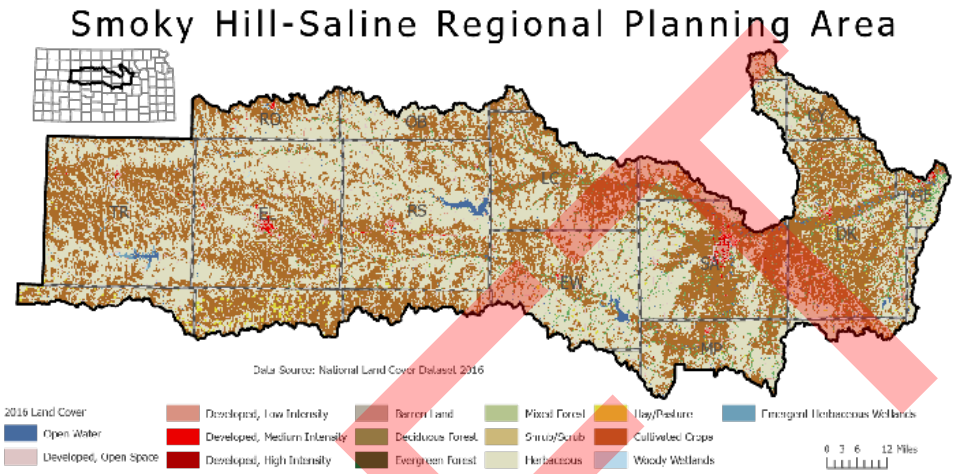


Figure 3. Smoky Hill-Saline regional land cover

POPULATION & ECONOMY

Based upon 2019 information derived from state-released information to the U.S. Census Bureau, there were an estimated 141,244 residents in the region (Figure 4). For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over or under represented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census.

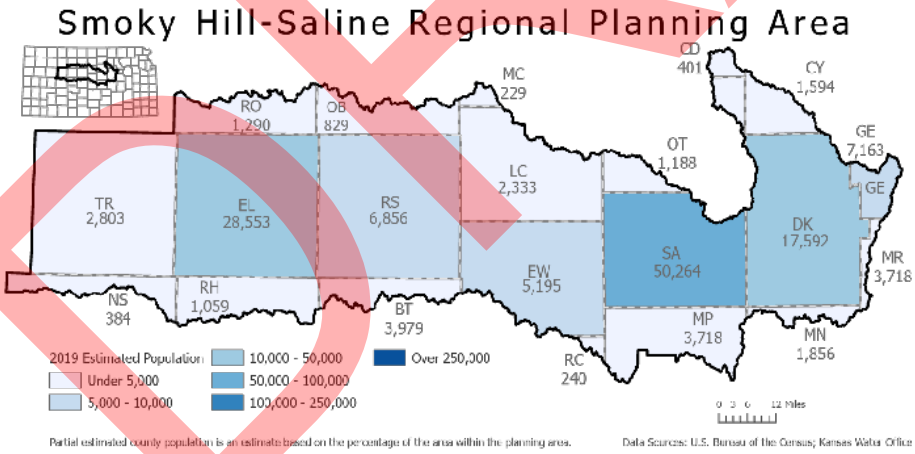


Figure 4. 2019 estimated population by county

Agriculture is the basis of the economy of the region. Crops grown include wheat, corn, grain sorghum, and alfalfa, with a sizable portion of this acreage being irrigated. Livestock production is an important part of the area's agriculture, with beef cattle the predominant livestock raised in the region. Oil production is also a prominent part of the regional economy. The cities of Salina and Hays serve as industrial hubs of the region with a variety of industry and manufacturing, along with large health care and education sectors.

Smoky Hill-Saline Region

Primary Water Resources in the Region

SURFACE WATER

The principal tributaries in the Smoky Hill River and the Saline River. Three federal reservoirs are also located within the region, with Cedar Bluff Reservoir and Kanopolis Lake located on the Smoky Hill River and Wilson Lake on the Saline River (Figure 5).

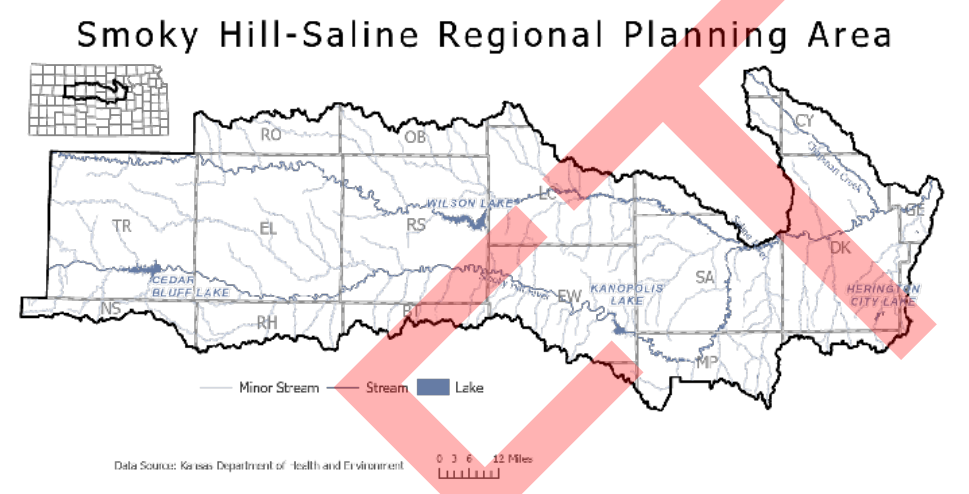
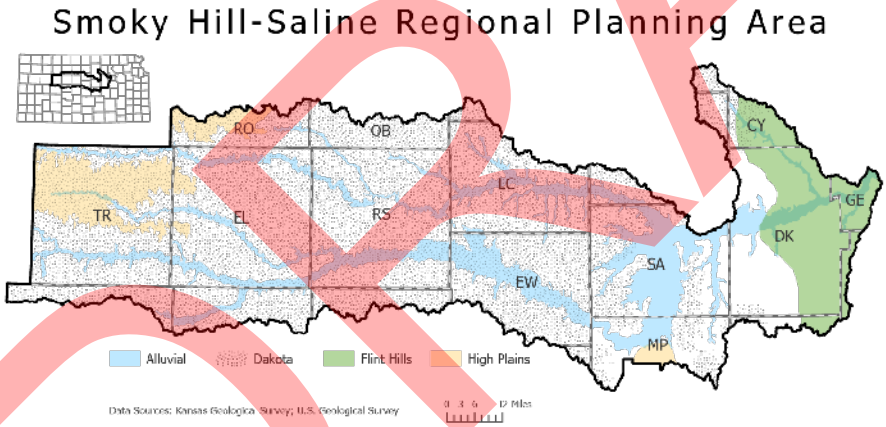


Figure 5. Major surface water resources in the Smoky Hill-Saline Region

GROUNDWATER

Groundwater is the primary source of water, which includes aquifers and alluvial deposits along major streams, with some High Plains-Ogallala Aquifer usage within the far western portion of the region. There are 82 public water suppliers in the region (Figure 6).



The principal aquifers include the alluvial aquifers and the Dakota Aquifer, on which Kansas Geological Survey (KGS) has done considerable research. The far western portions of the region are underlain by the Ogallala-High Plains Aquifer and far portions of the eastern part of the region are underlain by the Flint Hills Aquifer.

Figure 6. Principle aquifer boundaries in the Smoky Hill-Saline Region

Primary Water Use by Source

SURFACE WATER

Municipal water use is the primary use for surface water within the region (Figure 7). The principal rivers in the Smoky Hill-Saline Region are the Smoky Hill River and the Saline River. Reservoirs within the Smoky Hill-Saline Region serve as an important source of water supply and provide flood protection benefits. Three federal reservoirs are located within the region: Cedar Bluff Reservoir and Kanopolis Lake on the Smoky Hill River and Wilson Lake on the Saline River.

Kanopolis Lake serves as a principal water source for many in the Smoky Hill-Saline Region. Herington Reservoir in Dickinson County is a municipal-owned lake that serves as a source

Smoky Hill-Saline Region

of water supply for four communities. Cedar Bluff Reservoir and Wilson Lake mainly provide recreational opportunities for the region.

GROUNDWATER

Groundwater is the primary source of water used in the region, accounting for approximately 80% of reported use. Irrigation is the main reported use of groundwater. Annual reported water use for the region fluctuates based on climate conditions. Higher water use naturally occurs during periods of hot and dry weather in the growing season and lower water use during periods of cooler and/or wetter weather. Sources utilized within the Smoky Hill-Saline Region include the Ogallala-High Plains Aquifer in the far western portion of the region, Flint Hills Aquifer in the east, and alluvial deposits along major streams.

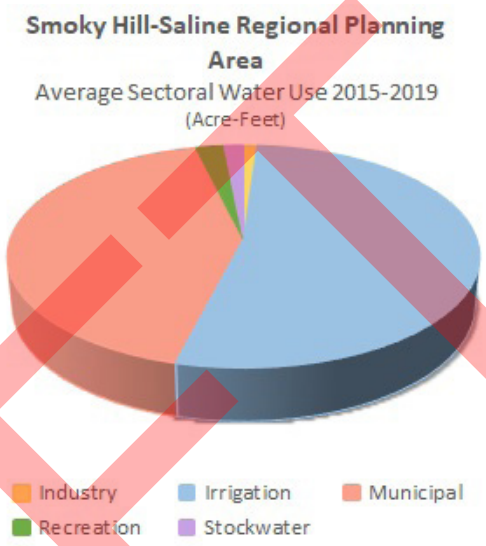


Figure 7. Average sectoral water usage

Regional Issues & Priorities

WATER SUPPLY AVAILABILITY

The majority of the population is heavily dependent on the Smoky Hill River and surface water storage to meet water use demands. Reservoir sedimentation is a major water quantity and quality concern, particularly at Kanopolis Lake. Soil type, land practices, and extreme rainfall events are the main causes that lead to excessive reservoir sedimentation. High flow events following heavy rainfall account for a large portion of the sedimentation that takes place in reservoirs. As this sediment accumulates in a reservoir's multi-purpose pool, the capacity for water supply storage is reduced. With an annual sedimentation rate of nearly 400 acre-feet per year, the loss of capacity in Kanopolis Lake is the most pressing issue among the three federal reservoirs, as it is the key water supply reservoir for the Smoky Hill-Saline Region (Figure 8).

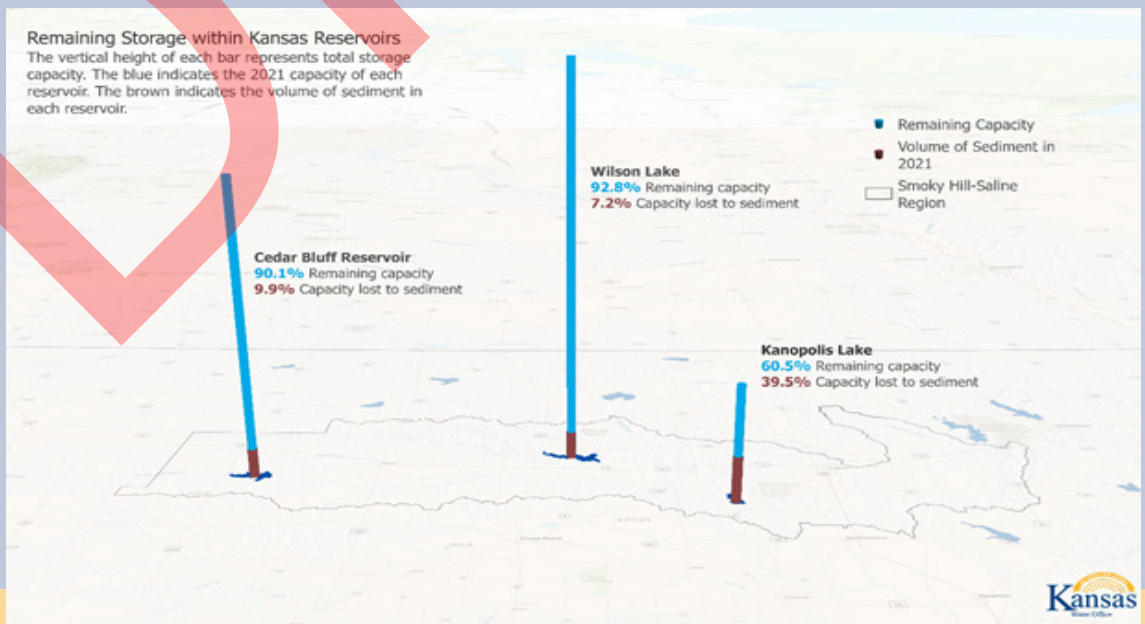


Figure 8. Remaining storage in region's reservoirs and lakes

Smoky Hill-Saline Region

Without the development and implementation of in-reservoir sediment management strategies to maintain storage capacity, modeling shows that the water quality storage will be insufficient to maintain sufficient in-stream flow through a drought with the severity of 1952 – 1957 as soon as the year 2043 (Figure 9).

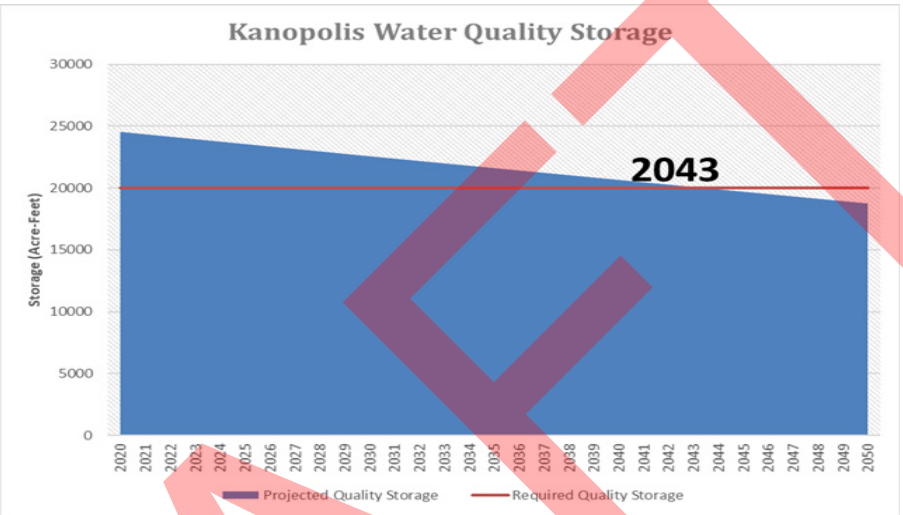


Figure 9. Water quality storage in Kanopolis Lake

Lower Smoky Hill River and Hays IGUCAs

The Chief Engineer ordered an IGUCA for two sections of the Smoky Hill River, closing the Smoky Hill River corridor to further ground or surface water appropriations. An IGUCA can provide more comprehensive water management tools than provided under strict water right administration based on priority.

The Lower Smoky Hill IGUCA was initiated in 1983 due to groundwater levels in portions of the Smoky Hill River Alluvium declining; streamflow declines were primarily due to effects of increased conservation practices and ground and surface water pumping out of the alluvial valley. Conditions existed that required regulation in the public interest (declining inflow of water into Cedar Bluff Reservoir contributing to declines in water levels and streamflow below the Reservoir). The alluvium of the Smoky Hill River Valley between Cedar Bluff Dam and a location four miles north and west of Sharon Springs, KS require regulation in the public interest. This area is closed to further surface and groundwater appropriations, but the Chief Engineer can amend the IGUCA if deemed to be in the public interest.

The Hays IGUCA was initiated in 1985 due to the following reasons: apparent preventable waste of water, expansion of issuance of private domestic water wells and their usage for outside discretionary activities, and existing conditions that required regulation in the public interest. This area requires registration of domestic wells and registered domestic wells are not subject to mandatory provisions of any water conservation plan adopted by the City of Hays. The Chief Engineer can ban or allow the City of Hays to ban the use of wells to water lawns, gardens, trees, shrubs, and other outdoor vegetation during the hours of 12 p.m. through 7 p.m., daily, from June 1 to September 30 inclusive, each year, if information shows that well users are not voluntarily avoiding the watering of the vegetation. Again, the Chief Engineer can amend the IGUCA if deemed to be in the public interest.

Smoky Hill-Saline Region

Lower Smoky Hill Water Supply Access District

The Lower Smoky Hill Water Supply Access District (Figure 10), comprised of the City of Salina and the Lower Smoky Hill Irrigation District, has purchased sufficient water supply storage to supplement their consumptive demands from the Smoky Hill River through the year 2060 (modeled with drought of record). However, water supply delivery may be impacted by additional transit losses without the contribution of total in-stream flow provided by releases from water quality storage.

In 2011, legislation was passed for the Lower Smoky Hill Water Supply Access Program (K.S.A 82a-2301 et seq., as amended), which was a step toward drought contingency for surface water users below Kanopolis Reservoir. Membership eligibility includes municipal, industrial, irrigation and recreation water right owners. The legislation allowed surface water right holders below Kanopolis Reservoir and the City of Salina to voluntarily join together to obtain storage in the lake to cover the desired portion of their authorized water right quantities.

In 2016, the Lower Smoky Hill Water Supply Access District was formed, and the Access District purchased a portion of the water supply pool from Kanopolis Reservoir through a lump sum payment to the State in accordance with the purchase contract between the Kansas Water Office and the Access District. The water supply storage in Kanopolis purchased by the Access District can be utilized to supplement the Smoky Hill River streamflow to provide the ability for Access District members to make use of their reasonable and justified authorized quantities under their water rights through drought conditions.

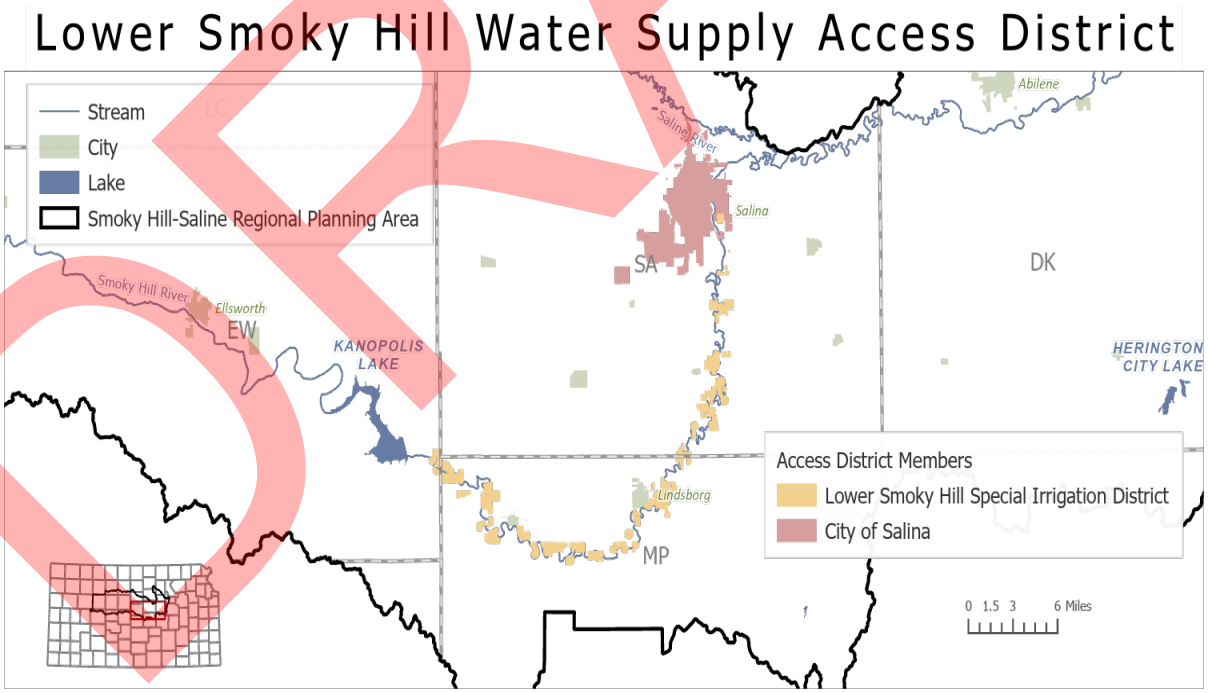


Figure 10. Lower Smoky Hill Water Supply Access District

Smoky Hill-Saline Region

R9 Ranch Application and Proposed Water Transfer

In 1995 the City of Hays purchased the R9 Ranch near Kinsley, KS, later selling an interest to the City of Russell. The cities have a cumulative water right authorization for irrigation use of approximately 7,700 acre-feet with a calculated consumptive use of 6,750 acre-feet, which could be requested to convert to municipal use. The proposed $80 million project would move water approximately 69 miles to support 35,000 people and a $2 billion economy.

Hays and Russell began the process to request permission to convert the water rights to municipal purposes and transfer the water. Based on a modeling analysis with the change application process, they have agreed to a 30% reduction in the quantity that would be diverted from those wells for municipal use. The 10-year rolling average amounts to 4,800 acre-feet which is sustainable allowing for aquifer recharge.

In 2019, following consideration of comments from local individuals and entities, including the local groundwater management district, the Chief Engineer of the KDA-DWR contingently approved the change applications submitted by Hays and Russell to convert the R9 Ranch irrigation rights to municipal use for the cities. In May 2019, the Water Protection Association of Central Kansas (WaterPACK) filed a request for judicial review of the contingent approval of the change application in Edwards County District Court where a legal ruling is still pending as of July 2021.

Figure 11. R9 Transfer map in the Smoky Hill-Saline Region

Public Water Supply Conservation

Fluctuations in precipitation impact available water supply at any given time throughout the year, with extend periods of dry conditions reducing available source water. The Smoky Hill-Saline Region has a number of public water supply systems which are vulnerable to drought conditions, so water conservation efforts are a priority for suppliers throughout the region. The City of Hays serves as one example of recognized water conservation within the region and statewide, with a combination of conservation incentive programs, ordinances and water reuse leading to lower water use than in years past.

Smoky Hill-Saline Region

WATER QUALITY

All the counties within the region have adopted and are enforcing sanitary codes that can help manage bacteria and nutrient inputs into surface and groundwater. All conservation districts in the region have adopted nonpoint source pollution management plans.

The Clean Water Act requires states to conduct Total Maximum Daily Load (TMDL) studies and develop TMDLs for water bodies identified on the state's List of Impaired Waters (Section 303(d) List). TMDLs are quantitative objectives and strategies needed to achieve the state's surface water quality standards. TMDLs have been developed to address dissolved oxygen, total phosphorus, and eutrophic conditions as the highest priority impairments. Other pollutants limiting use of Upper Smoky-Hill streams include fecal coliform bacteria, fluoride, selenium, pH, and sulfate (Figure 12).

As noted in the Guiding Principle: *Secure, Protect, and Restore our Kansas Reservoirs*, stored water supply is used to provide dilution of naturally occurring water quality concerns. As seen in 2018 and 2020 within the Kansas and Smoky Hill Rivers, the use of water stored within reservoirs was necessary to dilute chlorides and sulfates that naturally occur in the upper portions of the watersheds.

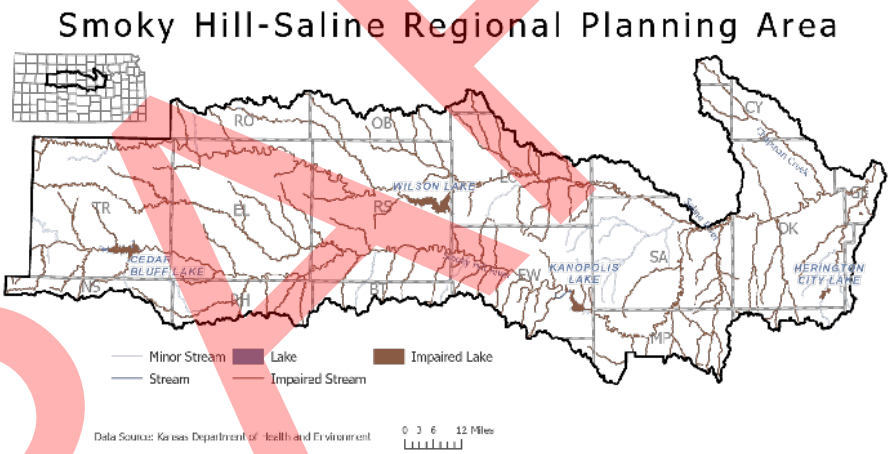


Figure 12. Impaired water resources in the Smoky Hill-Saline Region

In 2018, Tuttle Creek and Milford lake releases were required to dilute high chlorides released from Wilson Lake. In 2020, during periods of prolonged low flows in the Smoky Hill and Kansas Rivers, releases were also needed from Tuttle Creek and Milford lakes to dilute high chloride waters that were being discharged from the Smoky Hill River alluvium after the flooding experienced in 2019. The Tuttle Creek Lake Water Control Manual states that water stored within a water quality pool of Tuttle Creek Lake will be used to maintain downstream chlorides below 250 mg/L to improve water quality and protect water supply uses.

Smoky Hill-Saline Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- Support agencies in evaluating the possibility of a permanent conservation pool rise at Kanopolis Reservoir.
- Evaluate Kanopolis Reservoir to determine the feasibility of dredging and initiate project if deemed viable.
- Determine if there is a need for additional water supply reservoirs within the region.
- Explore control of phreatophyte ("deep rooted plants") control within riparian areas.
- Explore the possibility of direct potable reuse.
- Support agencies in developing and implementing a Certified Irrigator Program.

Priority Goal #1: Increase available water supply, water supply storage, and interconnectivity among public water supplies within the Smoky Hill – Saline Planning Region to ensure available water supplies exceed demand by at least 10% by the year 2060.

Measuring success:

Goal 1: Initiate a Certified Irrigator Program with the region. Conduct an evaluation of a permanent conservation pool rise at Kanopolis Reservoir.

Smoky Hill-Saline Advisory Committee

Regional Goals & Action Plans

Priority Goal #2: Support a statewide conservation education program/model applicable to all public water supplies to quantify water conservation efforts on customer usage.

ACTION STEPS:

- Develop a youth-based water conservation education program which is tied to school curriculum.
- Provide producers with tools and resources needed to make informed management decisions to improve water use efficiency.
- Educate all Planning Region stakeholders on the benefits of water conservation, thus working towards sustainable use of the region's surface and groundwater resources.
- Work with groups of interest to ensure Smoky Hill-Saline Planning Region stakeholders are educated on the benefits of water conservation.

Measuring success:

Goal 2: Work with state agencies to create a youth-based water conservation education program that is tied to school curriculum.

Smoky Hill-Saline Advisory Committee

Regional Goals & Action Plans

Priority Goal #3: Reduce sediment and total suspended solids (TSS) concentrations within the lakes and streams within the Smoky Hill – Saline Planning Region.

ACTION STEPS:

- Method of attaining goal can include the continued support of best management practice (BMP) implementation for practices which reduce sediment runoff.
- Focus BMP implementation within priority areas identified in the Big Creek Middle Smoky Hill River Watersheds 9 Element Watershed Protection Plan.
- Complete the 9 Element Watershed Protection Plan by 2034. Provide a reduction of 26% TSS concentrations on the Smoky Hill River at Ellsworth as noted within the 9 Element Watershed Protection Plan.
- Improve sediment-impaired waters to a level justifying removal from the Kansas Dept. of Health and Environment (KDHE) TMDL list.
- Continued support of locally led and driven efforts, such as the WRAPS program and projects within the region as noted for implementation within the 9 Element Watershed Plans.
- Continue to support NRCS programs/initiatives such as RCPP, EQIP, easement programs, WRP, CSTP, etc., which can be utilized to implement sediment-reducing BMPs as well as improve soil health. Identify sources of sediment contributing to TSS/ sediment in water bodies (i.e. streambank assessments, etc.).
- Continue to support KDA-DOC programs/initiatives such as the nonpoint source program, watershed program, water resource conservation program and the funding provided to KDA-DOC through the State Water Plan Fund.

Smoky Hill-Saline Advisory Committee

Regional Goals & Action Plans

Priority Goal #3 Continued.

ACTION STEPS:

- BMP implementation above water supply waters to help facilitate settling out of solids before entry into water supply water (i.e. forebays, settling basins). BMP implementation should continue to reduce sedimentation rate of Kanopolis Lake as well as other water supply sources.
- Enhance and continue to support information/educational (I&E) efforts focused towards landowners to help reduce sediment runoff on their respective properties.
- Include consideration of Wilson Lake and the upstream watershed of sediment sources which could impact capacity, including bathymetric survey analysis to help quantify current capacity of the lake.
- Evaluate sediment and nutrient loading originating from the watershed above Herington Reservoir which could impact its viability as a public water supply source. Utilize the June 2008 bathymetric surveys on Herington Reservoir and Herington City Lake as baseline characterization of current capacity lost in lakes due to sedimentation.

Measuring success:

Goal 3: Support local WRAPS programs and projects within the region's watersheds and support the BMPs noted for implementation within the nine Element Watershed Plans.

Smoky Hill-Saline Advisory Committee

Regional Goals & Action Plans

Priority Goal #4: Increase water use efficiency achieved by public water suppliers within the region.

ACTION STEPS:

- Method of attaining this goal can include the promotion and development of new or updated water conservation program plans for public water supplies within the Smoky Hill–Saline Planning Region.
- Implementation of conservation measures which lead to all public water supplies in the Smoky Hill–Saline Regional Planning Area operating in the bottom one-third of gallons per capita per day (GPCD) when compared to other public water supplies within respective Regions used for GPCD comparison.
- Complete by 2025. The results of the efforts will be obtaining the same or increased outputs within participating municipalities while utilizing the same or less amounts of water.
- All public water suppliers follow the 2007 Kansas Municipal Water Guidelines and have a recently updated conservation plan.
- Public water suppliers evaluate the feasibility of water conservation rates.
- Public water suppliers develop and promote rebate programs geared towards water conservation efforts by water customers.
- Develop a "tool box" of educational information public water suppliers could utilize to pass information along to customers.

Smoky Hill-Saline Advisory Committee

Regional Goals & Action Plans

Priority Goal #4 Continued.

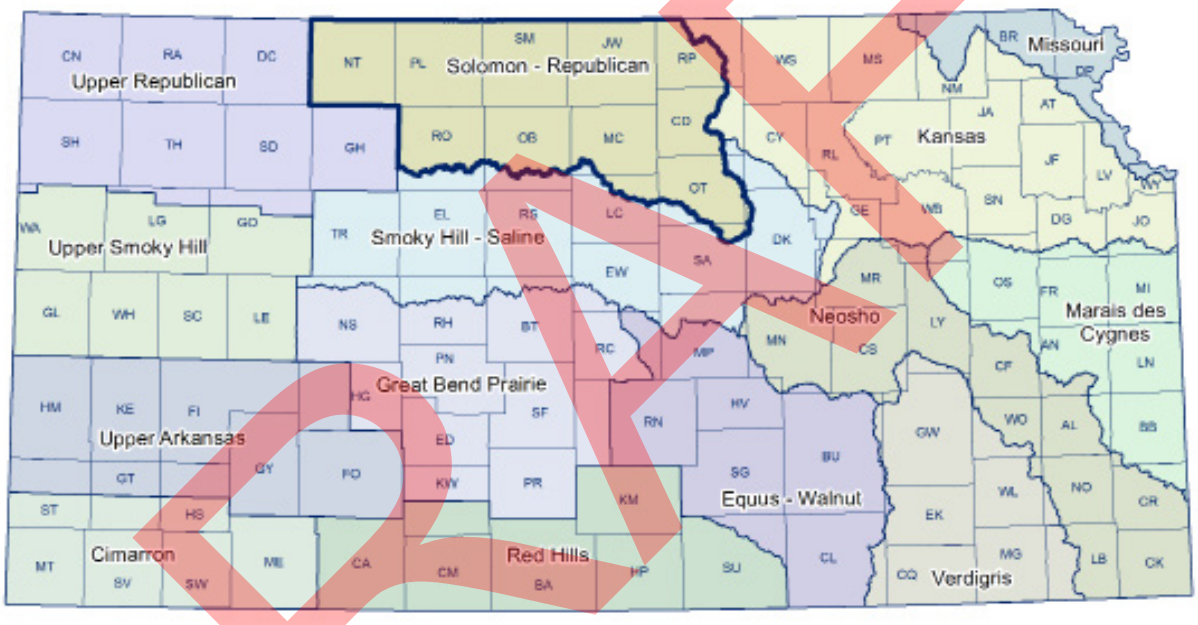
ACTION STEPS:

- Work through the framework of existing statewide education efforts to develop region-wide outreach campaign promoting water conservation efforts.
- Report GPCD values on an annual basis at RAC meetings.
- Develop an independent technical task force to help large water users within public water supply systems to improve water use efficiency.
- Hold annual public water supply "field days" to share current water conservation efforts. Making sure media is involved with promotion of these events.

Measuring success:

Goal 4: Promote and track the development of new or updated water conservation program plans for public water supplies within the region.

Solomon-Republican Region



Solomon-Republican Region

Regional Description

The Solomon-Republican Regional Planning Area is located in north-central Kansas, overlaying a portion of the Dakota Aquifer. The regional area is bordered by Nebraska on the north and covers approximately 7,298 square miles. It includes Jewell, Norton, Phillips, Smith, and portions of Cloud, Dickinson, Lincoln, Mitchell, Osborne, Ottawa, Rooks, Republic, and Saline counties (Figure 1).

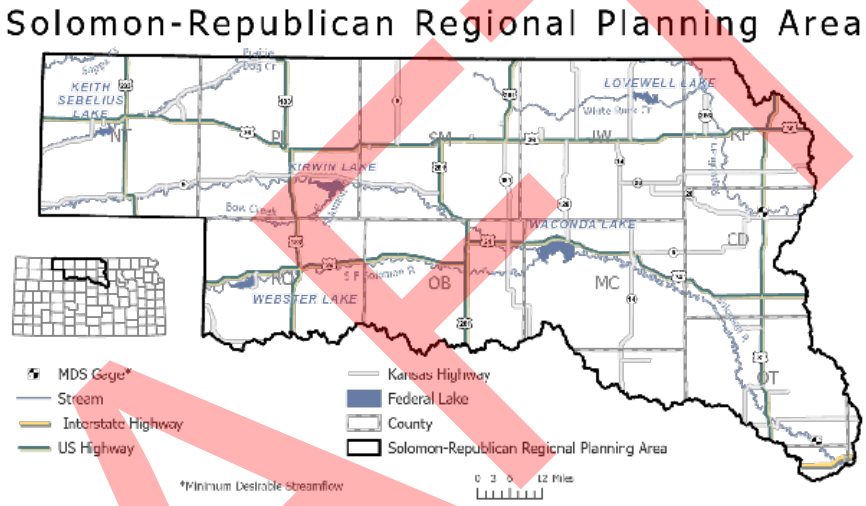


Figure 1. Solomon-Republican Regional Planning Area

Major rivers and streams within the region include Prairie Dog Creek, White Rock Creek, Republican River, Bow Creek, Solomon River, and the North and South Fork Solomon Rivers. Principal federal reservoirs include Bureau of Reclamation (BOR) reservoirs Keith Sebelius Lake, Kirwin Reservoir, Lovewell Reservoir, Waconda Lake, and Webster Reservoir.

Elevations in the region range from approximately 2,630 feet above sea level in Norton County to 1,160 feet above sea level in Saline County.

CLIMATE & LAND USE

The climate of the region is characterized by moderate to low precipitation, relatively high wind velocities, high evaporation rates, a wide range of temperatures, and abrupt changes in weather. Average annual total precipitation varies from 20 - 32 inches, west to east (Figure 2).

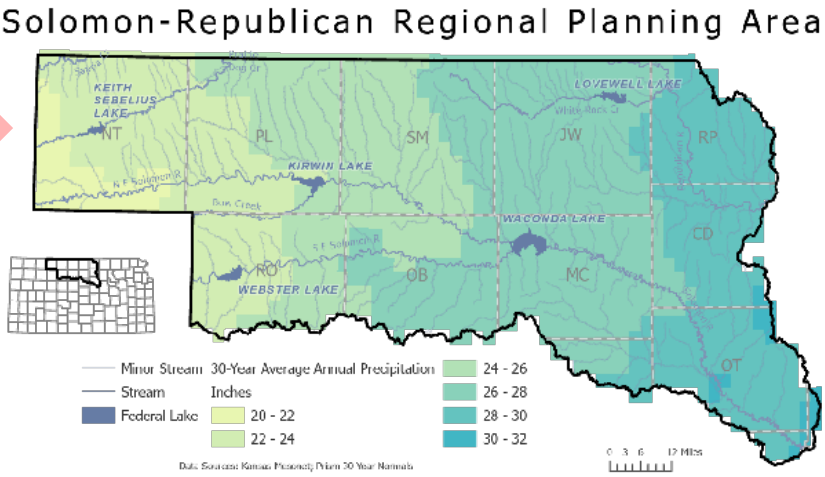


Figure 2. 30-year average annual precipitation in the Solomon-Republican Region

Land use activities can have a significant impact on the region. The three major land uses in this region are cultivated crops (51%) and herbaceous (41%) as derived from the National Land Cover Database (NLCD) 2016 dataset.

Solomon-Republican Region

Figure 3 lists the remaining land uses in the region, including: deciduous forest, developed/urban open space, and water.

There are eight wildlife areas maintained by state or federal agencies near each of the federal reservoirs. Key wildlife species include ring-necked pheasants, bobwhite quail, whitetail and mule deer, with Rio Grande turkey and greater prairie chicken being less prevalent.

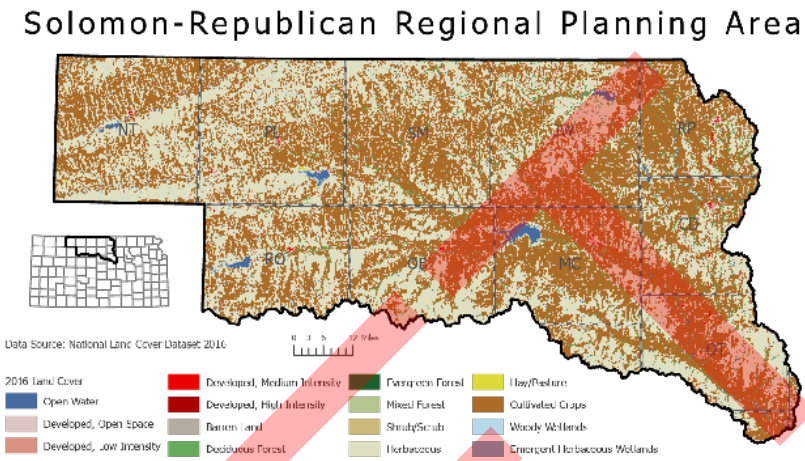


Figure 3. Solomon-Republican regional land cover

POPULATION & ECONOMY

Based upon 2019 state-released U.S. Census Bureau information, there were an estimated 47,713 residents in the region (Figure 4). For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over-or-under represented, so further refining of population information for water supply planning purposes will occur following certification and release of the 2020 Census.

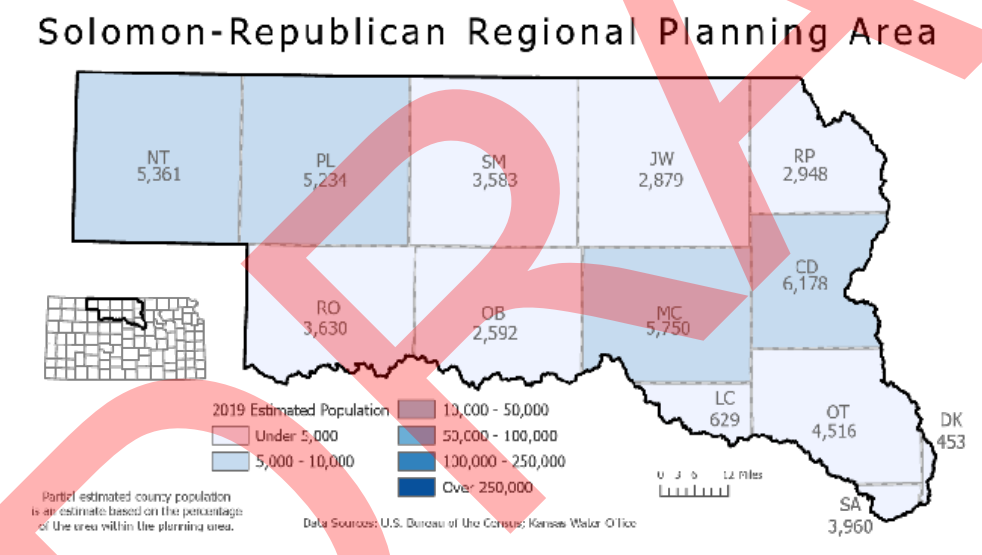


Figure 4. 2019 estimated population by county

As with many other central and western regions, the population peaked in the early 1900s and has been in decline ever since. Based on projections for population change from 2014-2044, these trends are expected to continue for nearly all counties in the basin. Dickinson and Saline counties are the only counties with populations that are expected to stay relatively stable. The other counties are all projected to experience population reductions with the most significant anticipated in Republic, Jewell, and Smith counties.

Agriculture, largely irrigated, remains the predominant economic activity throughout the region. Livestock is also an important part of the region's agriculture, with beef cattle as the primary production. Recreation is also an increasing part of the economics of the region. However, periodic drought conditions in the region can cause reservoir declines that limit recreational opportunity. The federal reservoirs and associated recreation and wildlife areas draw hunters, fishermen, and boaters to the area. In addition, the state offers fishing and limited hunting at Jewell State Fishing Lake, Ottawa State Fishing Lake, and Rooks State Fishing Lake.

Solomon-Republican Region

Primary Water Resources in the Region

SURFACE WATER

Principal federal reservoirs include BOR reservoirs Keith Sebelius Lake, Lovewell Reservoir, Webster Reservoir, Kirwin Reservoir, and Waconda Lake. The principal tributaries in the Solomon-Republican Region are Prairie Dog Creek, White Rock Creek, Republican River, Bow Creek, Solomon River, and the North and South Fork Solomon Rivers (Figure 5). Streamflow is dependent upon runoff and climatic factors that cannot be regulated and vary widely year to year. The reservoirs within the region help to supplement streamflow during periods of below-average precipitation.

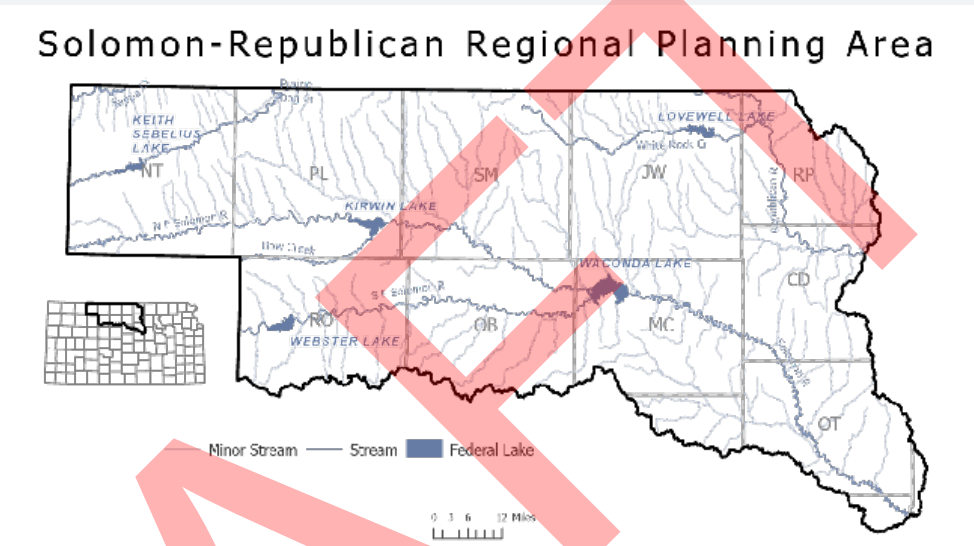


Figure 5. Major surface water resources in the Solomon-Republican Region

GROUNDWATER

The principal aquifers in this region are the Dakota, Ogallala portion of the High Plains Aquifer (Ogallala Aquifer), and alluvial aquifers (Figure 6). The Ogallala Aquifer is present in the most northwestern edge of this region. Water levels in the Ogallala Aquifer, which are monitored by the Kansas Geological Survey (KGS) and shared on their website, have shown declines of over 5 feet in some localized areas in the region over the past 20 years. Groundwater is the primary water source for most public water suppliers in the region, principally from alluvial deposits along major streams and tributaries. Additionally, the Dakota Aquifer underlays this region, but provides very saline water to only a few stock and domestic farmstead wells.

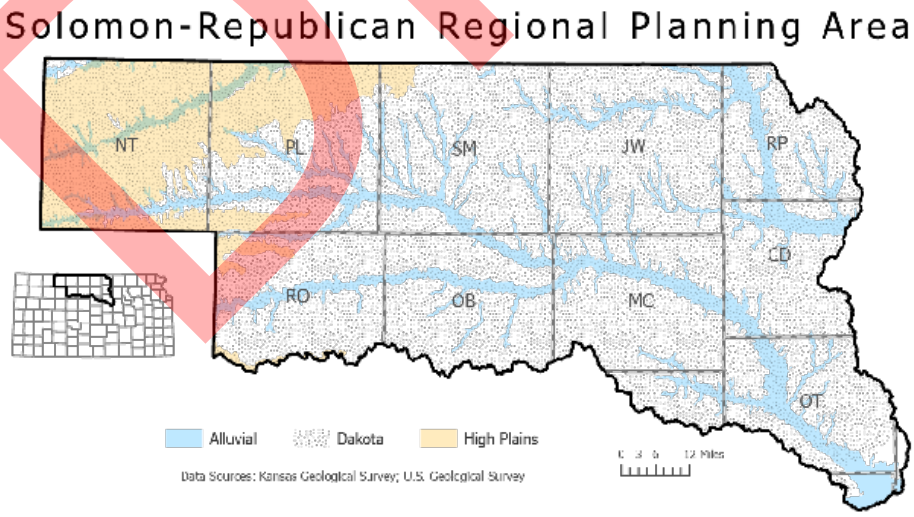


Figure 6. Principle aquifer boundaries in the Solomon-Republican Region

Solomon-Republican Region

Primary Water Use by Source

Surface water is the primary source of water within this region, accounting for approximately 58% of the total reported water usage over the last 5 years. Groundwater, however, is the primary source for most public water suppliers. Irrigation use accounts for 91% of all reported water use; the second largest use is municipal, which serves 50 communities and multiple rural water districts. Recreation, industrial, and domestic uses are all less than 1 % combined (Figure 7).

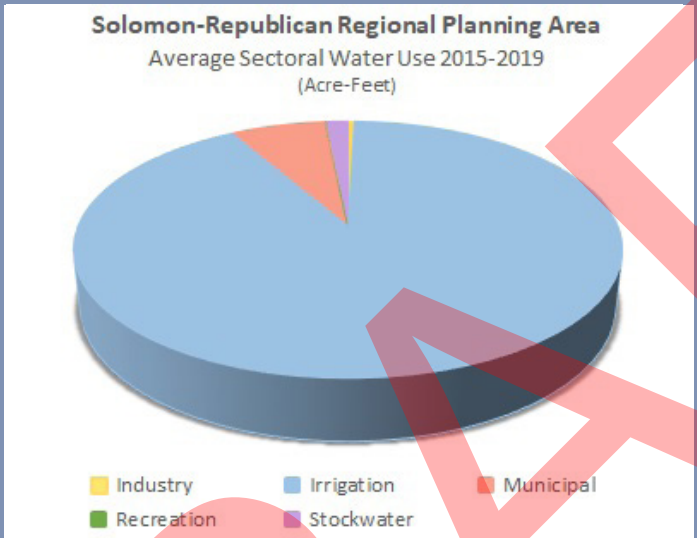


Figure 7. Average sectoral water usage

Regional Issues & Priorities

SEDIMENTATION

Sedimentation in lakes is a major problem in Kansas. Soil type, land practices, and extreme rainfall events are the main causes that lead to reservoir sedimentation. High flow events following heavy rainfall account for a large portion of the siltation that takes place in reservoirs. Periodic bathymetric surveys are necessary to monitor the loss of capacity. The five federal reservoirs in the region are Keith Sebelius Lake, Kirwin Reservoir, Lovewell Reservoir, Waconda Lake, and Webster Reservoir. Given the projected sedimentation and water supply demands, results show relatively low sedimentation rates in Keith Sebelius Lake, Webster Reservoir, and Kirwin Reservoir, as compared to the higher rates in Lovewell Reservoir and Waconda Lake.

Waconda Lake. Photo Credit: City of Glen Elder

Solomon-Republican Region

The sedimentation rate in the Solomon-Republican Region is primarily the result of runoff and not of streambank erosion. However, as of the 2017 aerial review, there are currently 21 streambank hotspots identified within the region. These streambank hotspots are located on the Lower Republican River, above Milford Lake in the Kansas Region. One site has been stabilized, reducing the sediment load by an estimated 1,125 tons per year. There are 20 sites that remain, which, if completed, will reduce the sediment load into Milford Lake by an estimated 17,400 tons per year.

Best Management Practices (BMPs) are a focus for both sediment and nutrient load reduction goals in the region. Annual sedimentation reductions by total volume from the implementation of load reduction practices for reservoirs in this region are greatest at Waconda Lake. However, relative impacts and percent change in historical reservoir sedimentation rate show the most significant reductions in the Keith Sebelius Lake and Kirwin Reservoir watersheds. These high load-percentage reductions are related to comparatively low sedimentation rates, meaning fewer BMPs need to be implemented to have a larger relative effect on sedimentation.

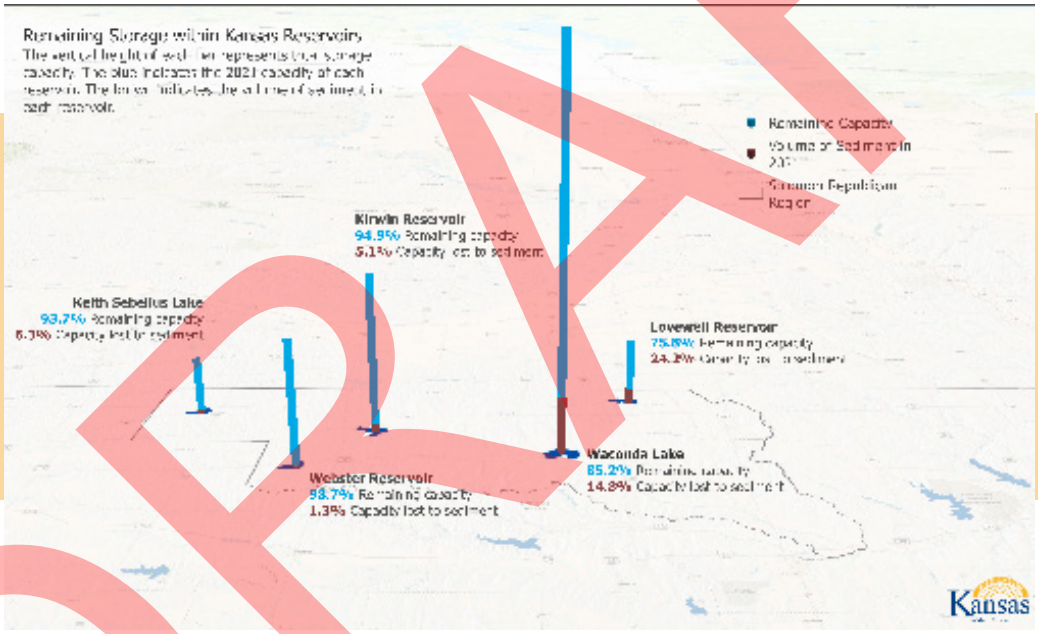


Figure 8. Remaining storage within Kansas Reservoirs in the Solomon-Republican Region

REPUBLICAN RIVER COMPACT AND SETTLEMENT

The Republican River and its tributaries are important water resources to Kansas. State interests in the basin include groundwater and surface water rights in the Solomon-Republican Region and water supply to the Kansas Bostwick Irrigation District (KBID).

In an effort to ensure equitable distribution of surface water in the Republican River basin, the Republican River Compact (RRC) was formally signed on December 31, 1942, by the states of Colorado, Kansas, and Nebraska and became federal law. The RRC makes specific allocations to each of the three states in 14 different subbasins and includes provisions related to the federal government's ability to develop projects within the basin.

In May 1998, Kansas filed a lawsuit before the U.S. Supreme Court alleging Nebraska had

Solomon-Republican Region

breached terms of the RRC by allowing proliferation and use of groundwater wells connected to the Republican River and its tributaries and failing to protect the surface flows from other unauthorized appropriations. As a result, the Republican River Compact Administration (RRCA) groundwater model was developed. This tool is used to quantify groundwater consumptive use by each state as part of the Compact's accounting procedures. Kansas has never received its total allocated water share and negotiations are ongoing between the three states.

Republican River Sign. Photo Credit: Republican River Compact Administration

In 2010, Kansas filed suit again asking for $80 million, which was reduced to $11.1 million. The judge in the case awarded Kansas $5.5 million. Of the $5.5 million, $2 million went to the Attorney General for the interstate water litigation fund. The remaining $3.5 million was designated for water improvement projects in the Republican River Basin. The stakeholder group representing multiple interests within the Lower Republican came to a consensus that $2.5 million of the original $3.5 million from the Republican River Water Conservation Projects-Nebraska Moneys Fund should be used for projects within the KBID and the remaining $1 million should be used for projects that are not part of the KBID system. KBID has converted 116 miles of open irrigation canal systems to buried pipe systems and is continuing to convert significant portions of remaining canals within the district.

Planning and coordination is needed for the Republican River system in the Upper Republican Basin for efficient water use, compliance with the RRC and the beneficial use of settlement payments.

WATER QUALITY

Water quality and related water resource issues are addressed through a combination of watershed restoration, resource issues and protection efforts utilizing voluntary, incentive-based approaches, as well as regulatory programs. Programs like the Watershed Restoration and Protection Strategy (WRAPS), include a planning and management framework that engages stakeholders within a watershed to identify watershed restoration and protection needs, establish watershed management goals, create a cost-effective action plan to achieve those goals, and implement the action plan. There are three Kansas Association of Conservation District (KACD) WRAPS partnership grant projects within the region. BMPs implemented through the projects have an emphasis on nutrient and sediment load reductions.

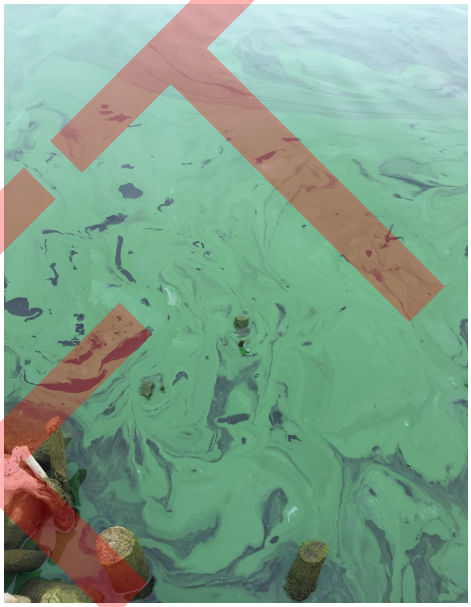
All the counties within the region have adopted and are enforcing sanitary codes that can help manage bacteria and nutrient inputs into surface and groundwater. All conservation districts in the region have adopted nonpoint source pollution management plans. Most of the water quality problems in this basin are caused by land use runoff which is a non-point source pollutant and is not subject to regulations by the Federal or state government.

The Clean Water Act requires states to conduct Total Maximum Daily Load (TMDL) studies and develop TMDLs for water bodies identified on the state's List of Impaired Waters (Section 303(d) List). TMDLs are quantitative objectives and strategies needed to achieve the state's surface water quality standards. TMDLs have been developed to address dissolved oxygen, total phosphorus, and eutrophic conditions as the highest priority impairments. A list of all impaired/potentially impaired water for the Solomon-Republican Basin can be found on the Kansas Department of Health and Environment (KDHE) impaired waters website.

Solomon-Republican Region

HARMFUL ALGAL BLOOMS

Harmful Algal Blooms (HABs) are common in bodies of water when nutrient loading is excessive during periods of elevated temperatures. Health effects of HABs are well documented from flu-like symptoms in humans to the death of pets and livestock. Algal problems have historically been reported on four of the five federal reservoirs in this region: Keith Sebelius Lake, Kirwin Reservoir, Webster Reservoir, and Lovewell Reservoir. Recently, Keith Sebelius Lake and Webster Reservoir have been the most frequently impacted, experiencing HABs each of the last four years.



Webster Reservoir boat dock

THREATENED AND ENDANGERED SPECIES

With the decline of native prairie and playa wetlands resulting from habitat losses over time, numerous native species with range within the region have become threatened or endangered. These include the northern long-eared bat, whooping crane, piping and snowy plover, Topeka shiner (historic range), least tern, eastern spotted skunk, plains minnow, shoal and silver chub, and western prairie fringed orchid.

Riparian lands have been impacted by infestation of non-native phreatophytes, though not to the degree as in more western regions. As the level of the Ogallala Aquifer has declined and in some areas severely. This has resulted in loss of native riparian habitat and phreatophytes have gained an advantage due to their very long root systems that can more easily access the remaining water. Of greatest concern, are the effects tamarisk (saltcedar) and Russian olive have on native riparian ecosystems. Numerous strategies to control phreatophytes have been tested, including harvesting, chemical application, and biological controls to varying degrees of success.

Saltcedar with buds and a pollinator, 2017
Photo Credit: USGS

Solomon-Republican Advisory Committee

Regional Goals & Action Plans

Priority Goal #1:
Maintain and continue to develop a clearinghouse of technical tools, agreements and agency personnel for use alternatives for Solomon-Republican region waters. An example could be the marketing contract for Keith Sebelius Reservoir/ Almena Irrigation District to convert irrigation to recreation use.

ACTION STEPS:

- Support Kansas Department of Wildlife and Parks (KDWP) in their effort to renegotiate the Keith Sebelius Reservoir Minimum Pool Agreement to maximize recreational benefit with the Almena Irrigation District.
- Use the Keith Sebelius contract as a model for negotiations on other BOR Reservoirs (Kirwin, Webster).
- Use KBID's knowledge on capturing BOR grants to help improve Webster and Kirwin irrigation efficiency.
- Exhaust all possible funding sources necessary to improve water efficiency.
- Work with KDWP on an economic study to determine the value of keeping as much water in the western Kansas reservoirs as possible.
- Investigate the benefits of raising the conservation pool at both Kirwin and Webster.

Measuring success:

Goal 1: Complete an evaluation of the possibility of using the Keith Sebelius Lake contract as a model for potential agreements to achieve maximized recreation and irrigation benefits at other reservoirs in the region.

Solomon-Republican Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- Use KDHE to evaluate sources of sediment entering Lovewell Reservoir.
- Use Kansas and Nebraska data to evaluate suspended solids and nutrients.
- Use data to evaluate the effects of the Courtland Canal on reservoir loading.
- Utilize BMPs in the Lower Republican River Basin to reduce sediment and nutrient loads to Milford Reservoir and encourage landowner participation in programs that support BMP implementation, such as the Milford Regional Conservation Partnership Program (RCPP).

Priority Goal #2: Reduce inbound sediment loads, through conservation measures, with a focus on White Rock Creek to Lovewell Reservoir, by 25% every 10 years.

Measuring success:

Goal 2: Document sediment load reductions to reservoirs in the region, with an emphasis on Lovewell Reservoir, from the expansion of conservation measures. Document sediment and nutrient load reductions to the Lower Republican River Basin from the expansion of conservation measures.

Solomon-Republican Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- Work with the Kansas Water Office (KWO) to complete bathymetric survey of Waconda Reservoir.

Priority Goal #3: Complete a bathymetric assessment every 10 years on all reservoirs in the Solomon-Republican Region. This goal will be a tool to periodically monitor sediment accumulation and rates. If sediment loads exceed 10%, actions should be initiated to determine the source watersheds and remedies within a twelve-month period from assessment report.

Measuring success:

Goal 3: Complete bathymetric survey of Waconda Reservoir and formulate timeline for future surveys at the remaining reservoirs.

Solomon-Republican Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- Quarterly presentation by KWO staff on RRC outcomes.

Priority Goal #4:
Continue initiative that will maintain and annually fund a Kansas Administrative Team to facilitate Republican River Compact (RRC) compliance. An annual report of progress and activities should be prepared and presented to the Solomon-Republican Regional Advisory Committee.

Measuring success:

Goal 4: Annual update of progress and activities related to Republican River Compact (RRC) compliance provided to the RAC.

Solomon-Republican Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

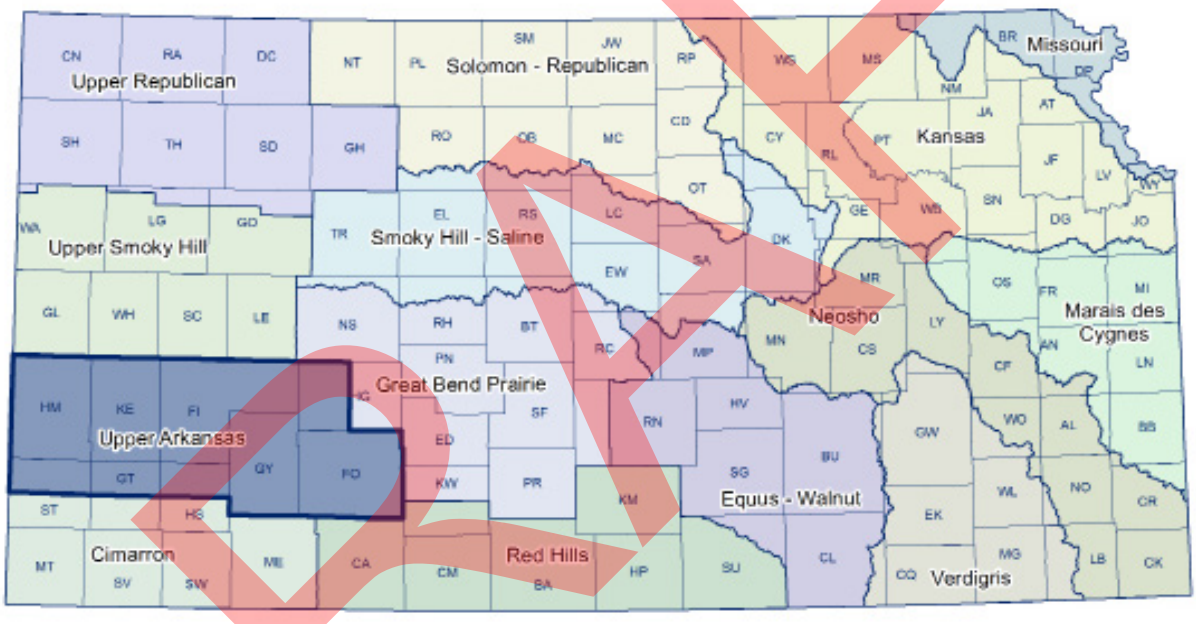
- Research streambank and ditch erosion to the extent that data is already available.
- Identify areas of major streambank and ditch erosion.
- Coordinate efforts with local county engineers and public works departments, conservation districts, WRAPS, NRCS, and the KWO.

Priority Goal #5: Complete an annual assessment of stream-bank and ditch erosion within the Solomon-Republican region.

Measuring success:

Goal 5: Complete an updated assessment of streambank erosion in the region, including work with local entities to determine areas of concern for ditch erosion.

Upper Arkansas Region



Upper Arkansas Region

Regional Description

The Upper Arkansas Regional Planning Area is located in southwest Kansas, covering 6,417 square miles, including all of Finney, Ford, Gray, Hamilton, and Kearny counties, the northern portions of Grant, Haskell, and Stanton counties, and the western half of Hodgeman County (Figure 1). The region is bordered by Colorado on the west.

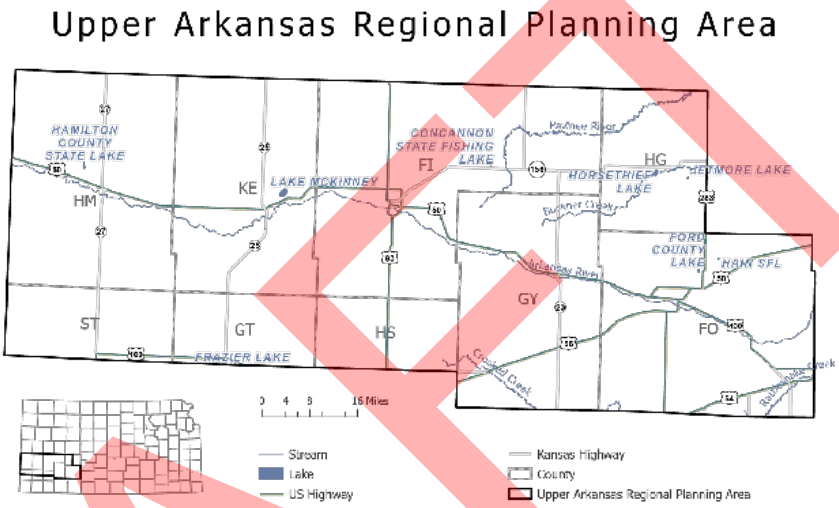


Figure 1. Upper Arkansas Regional Planning Area

CLIMATE & LAND USE

The climate of the region is characterized by moderate to low precipitation, relatively high wind velocities, a wide range of temperatures, and abrupt weather changes. Average annual precipitation amount varies from 16 inches in the west to 26 inches in the east (Figure 2). The high winds and low humidity of the region contribute to a high evaporation rate.

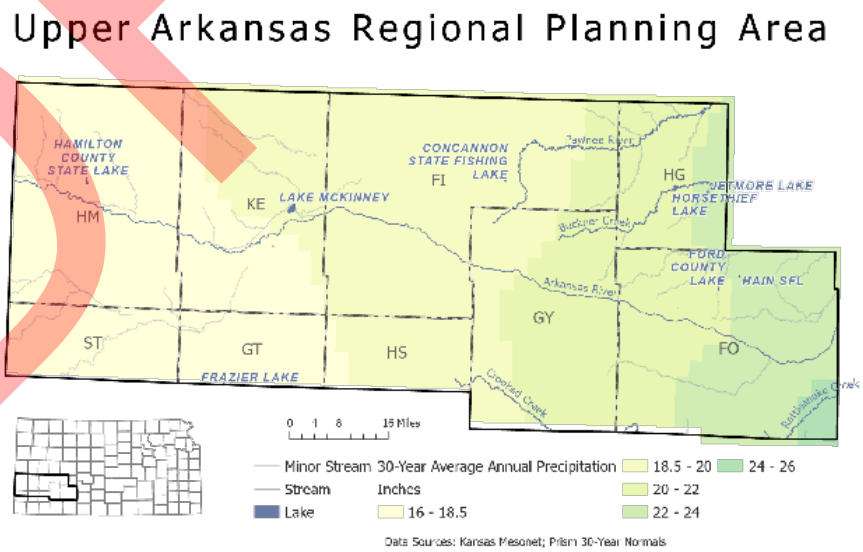


Figure 2. 30-year average annual precipitation in the Upper Arkansas Region

Upper Arkansas Region

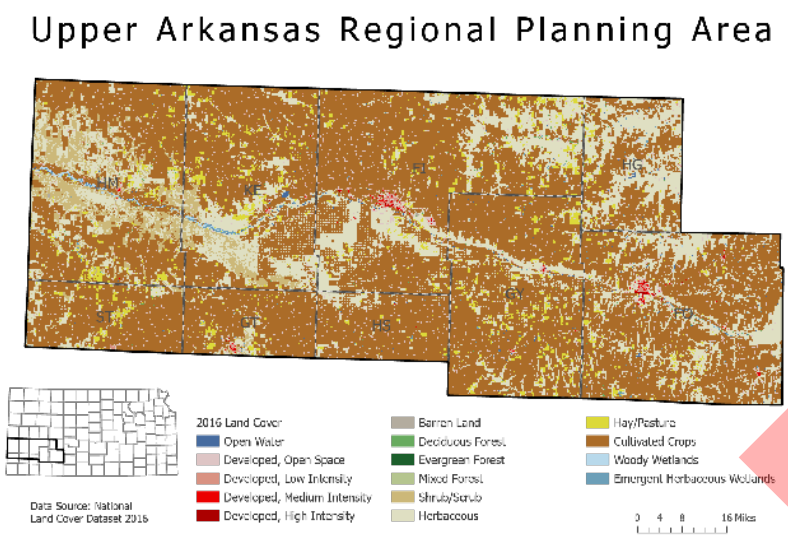


Figure 3. Upper Arkansas regional land cover

Land use activities can have a significant impact on the region. The three major land uses in this region are cultivated crops (66%), herbaceous (21%) and shrub/scrub (4%) as derived from the National Land Cover Database (NLCD) 2016 dataset. Figure 3 lists the remaining land uses in the region, including: developed/urban open space.

Playa lake wetlands occur in the region and provide habitat for migrating birds and the aquatic organisms that support them. Mixed grass and sand sage prairie ecosystems dominate the region.

POPULATION & ECONOMY

Based upon 2019 information derived from state-released information to the U.S. Census Bureau, there were an estimated 89,904 residents in the region (Figure 4). For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over or under represented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census.

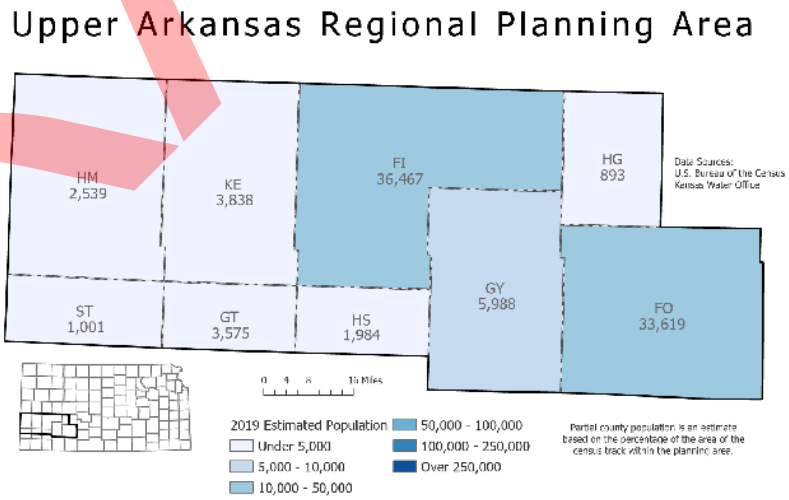


Figure 4. 2019 estimated population by county

Agriculture and manufacturing are the basis of the economy of the region. Crops grown include corn, cotton, hay, wheat, grain sorghum, and soybeans. Livestock production, both feedlots and ranching, is an important part of the area's agriculture with both cattle and hogs raised in the region. Beef processing and a growing dairy industry are major manufacturing contributors to the economy. Energy production, including oil, gas, and biofuel production, is also an important contributor to the regional economy.

Upper Arkansas Region

Primary Water Resources in the Region

GROUNDWATER

The principal aquifers in the area include the Ogallala portion of the High Plains Aquifer (Ogallala Aquifer), alluvial aquifers, and the Dakota Aquifer (Figure 5).

The High Plains Aquifer consists of several hydraulically connected aquifers, the largest of which is the Ogallala (Figure 6).

The Ogallala Aquifer is distinctive from other aquifers in Kansas in that it generally has low annual recharge. West of Bear Creek fault (Hamilton and Kearny counties), alluvial sediments overlie Cretaceous bedrock and the High Plains Aquifer is not present.

The Dakota Aquifer is present in the region and is used where the mineral content is acceptable. The Dakota is hydraulically connected to the Ogallala in some areas.

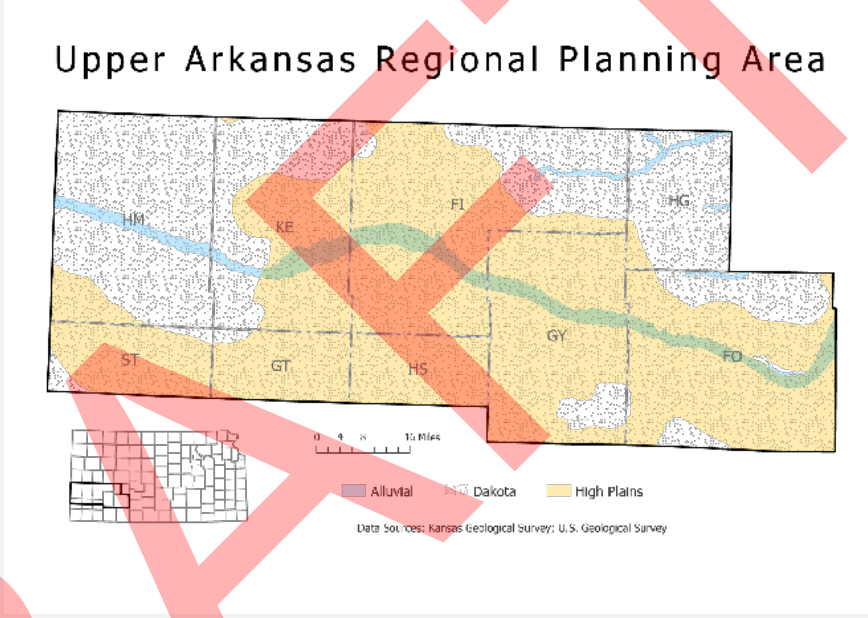


Figure 5. Principle aquifer boundaries in the Upper Arkansas Region

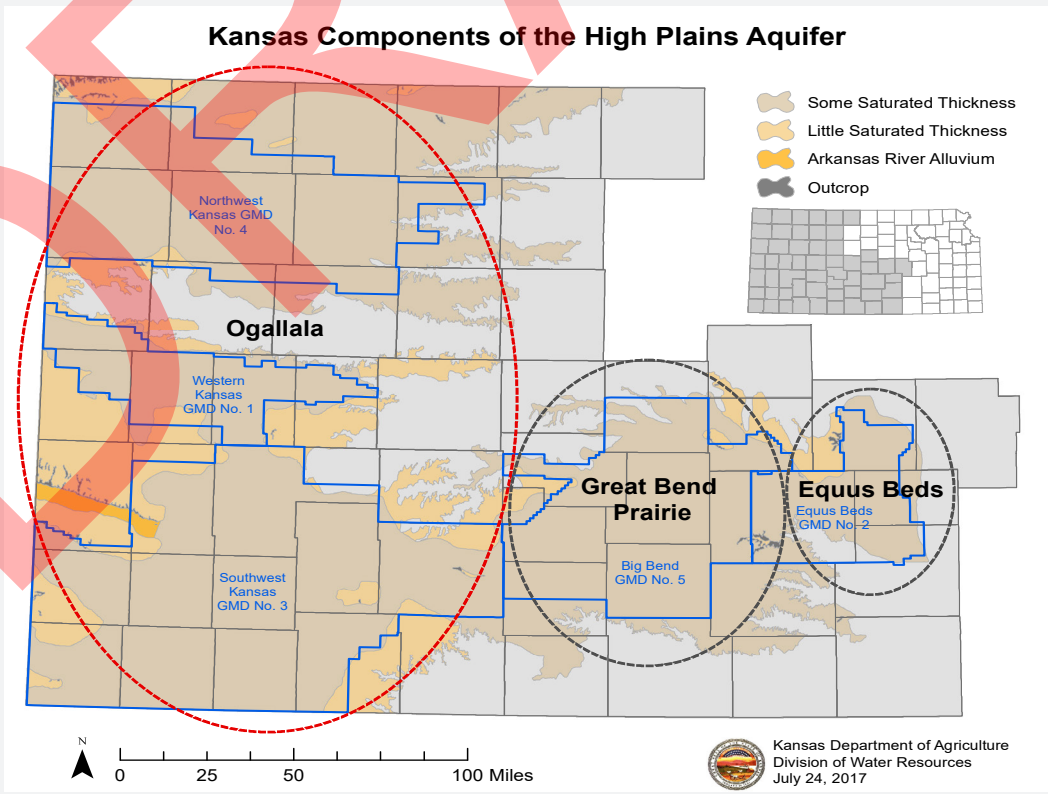


Figure 6. Kansas Components of the High Plains Aquifer, KDA

Upper Arkansas Region

SURFACE WATER

The majority of the region is within the drainage of the Arkansas River. Streamflow in the Arkansas River is dependent on flows entering from Colorado and runoff from storm events and small tributaries. Mulberry Creek is a major tributary in Ford County. The Pawnee River, Buckner Creek, Crooked Creek, and Rattlesnake Creek also drain areas of the region. HorseThief Reservoir is located on Buckner Creek, west of Jetmore (Figure 7).

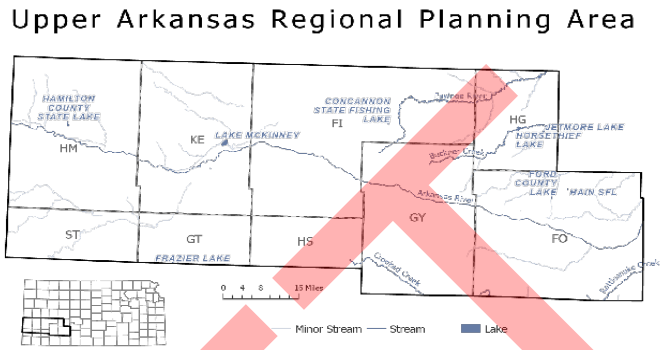


Figure 7. Major surface water resources in the Upper Arkansas Region

Primary Water Use by Source

SURFACE WATER

Sources of surface water in the Upper Arkansas Region include the Arkansas River from the Colorado-Kansas border to the eastern edge of Ford County and a few small lakes and surface impoundments. Use of surface water is limited to the flows of the river, which is now generally an intermittent stream downstream of Garden City, as well as Kansas water designated by the Arkansas River Compact with Colorado. Compact waters are used by owners of senior water rights of the river, which are the irrigation ditch companies in Hamilton, Kearny, and Finney counties. Surface water in the Arkansas River is used for irrigation, when available.

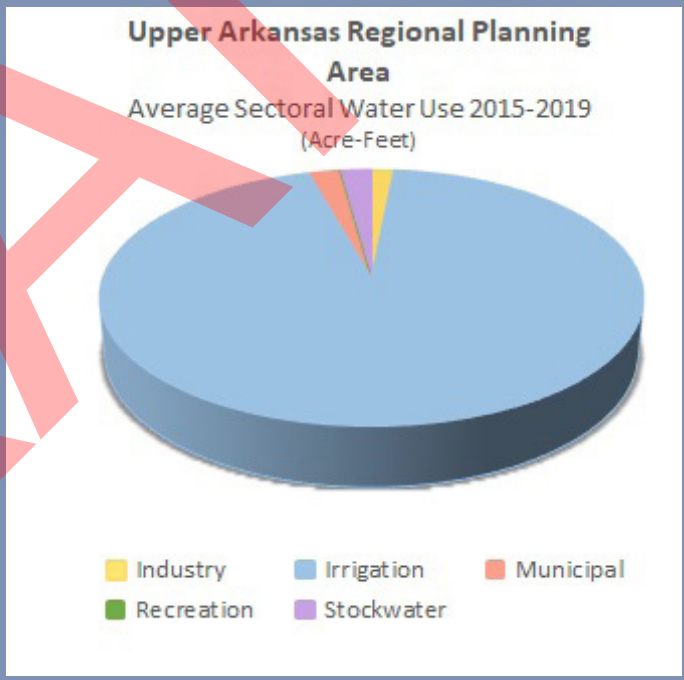


Figure 8. Average sectoral water usage

GROUNDWATER

Groundwater is the primary source of water in the region, accounting for 93% of the total supply, principally from the High Plains Aquifer and alluvial deposits along major streams. Irrigation use accounts for 94% of the reported water use of the region, with municipal usage representing 2% of water use followed by stock water at 2% (Figure 8).

WATER-BASED RECREATION

With the Jetmore City Lake and the newly constructed HorseThief Reservoir, more than 500 surface acres of water are available for various types of recreation. The state fishing lakes and associated wildlife area provide additional recreational opportunities.

HorseThief Reservoir. Photo Credit: ABT Films

Upper Arkansas Region

Regional Issues & Priorities

OGALLALA AQUIFER LEVEL DECLINES

Since the 1970s, the Ogallala Aquifer, as detailed in the *Conserve & Extend the High Plains Aquifer* section, has been developed so extensively that the amount of water withdrawn annually is significantly more than the recharge, resulting in groundwater declines. Some areas are already experiencing shortages in meeting demand.

As groundwater level declines (Figure 9), the aquifer loses hydraulic connection with the overlying alluvial aquifers and rivers and no longer contributes much, if any, base streamflow. This loss of hydraulic connection between surface and groundwater within the region has caused streams to dry up between rain events. Kansas Geological Survey (KGS), in an effort to help develop a better understanding of the aquifer dynamics at a scale that would be appropriate for management, created the Index Well Program: a network of well-monitoring systems that aids in tracking water level changes while providing real-time data.

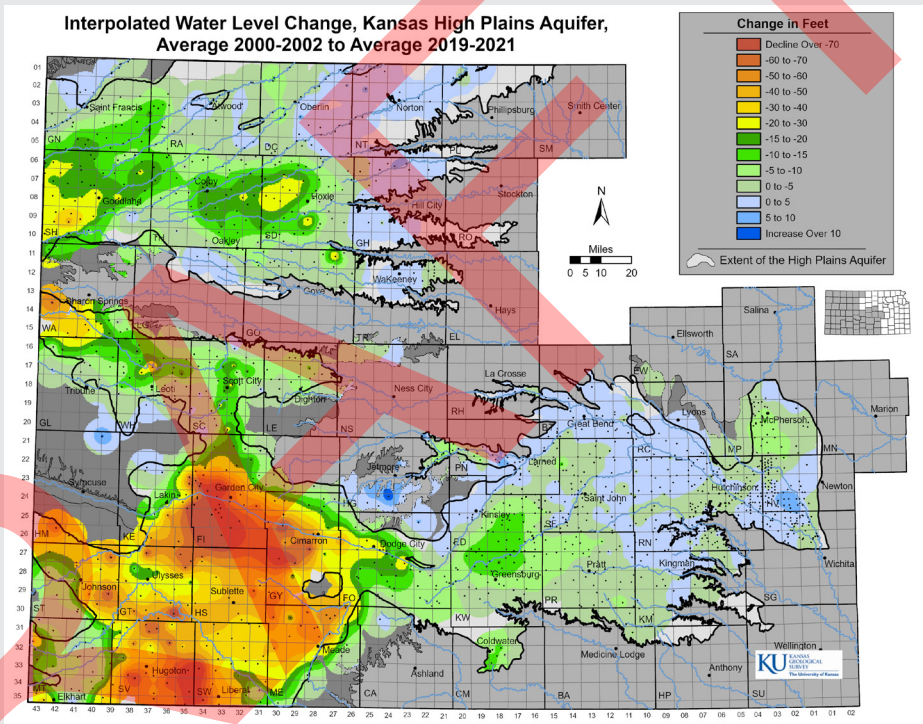


Figure 9. Water Level Change, Kansas High Plains Aquifer, KGS

The Ogallala Aquifer is characterized by low recharge and high declines. The expected "usable life" of the aquifer, when the aquifer is no longer able to support the current high rates of pumping, varies widely due to differences in the amount of saturated thickness, hydraulic conductivity, withdrawals, and other variables.

Water appropriations and use are overseen by the Kansas Department of Agriculture-Division of Water Resources (KDA-DWR). All of the streams and alluvial corridors in the region are either closed or restricted to new appropriations. Minimum desirable streamflow has not been established at any sites in the region, though many streams now flow only during rainfall events. Generally, the Ogallala Aquifer has no new appropriations available. In limited cases, a new water appropriation for groundwater, limited to quantities under 15 acre-feet, can be obtained within Southwest Kansas Groundwater Management District No. 3 (GMD3).

GMD3 is a water management entity in the region, overlying the Ogallala Aquifer in Grant, Haskell, Meade, Morton, Seward, Stanton, and Stevens counties. GMD3, incorporated in 1976, is charged with developing local water policy to conserve the aquifer that is compatible with state laws while promoting voluntary, incentive-based water conservation efforts with available tools and resources.

Upper Arkansas Region

ARKANSAS RIVER COMPACT COMPLIANCE

The Arkansas River Compact, ratified in 1948, is an agreement with the force of federal law. It provides apportionment of Arkansas River waters between Colorado and Kansas (Figure 10). The Arkansas River Compact Administration (ARCA), comprised of Kansas, Colorado, and federal representatives administers the Compact provisions. In 1980, an operating plan was developed that stated water stored in John Martin Reservoir, under the Compact, would be allocated 40% to Kansas and 60% to Colorado. This allocation is accomplished through the use of separate accounts for each state. These separate accounts have allowed both states to improve the efficiency of the use of water stored in John Martin Reservoir. Compact waters must be put to beneficial use by Kansas between the state line and the United States Geological Survey (USGS) stream gage at Garden City.

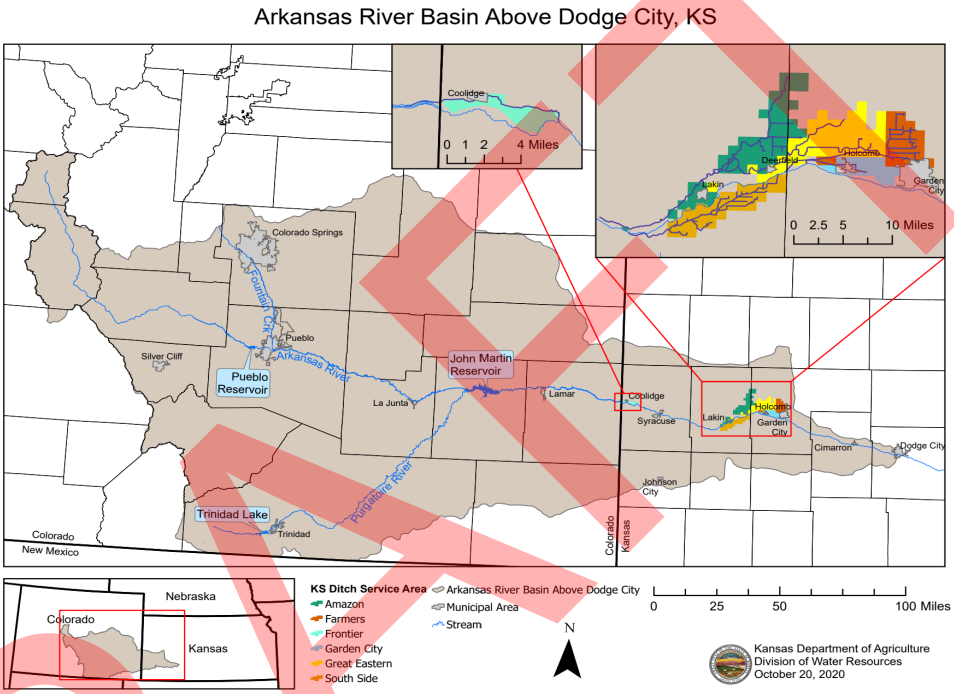


Figure 10. Arkansas River Basin Above Dodge City, KS, KDA

There are six active Kansas irrigation ditches that divert surface water from the Arkansas River between the Colorado-Kansas state line and the USGS streamflow gage in Garden City. These ditches benefit under the terms of the operating plan, as they can call for water at any time and any rate, while being assured 40% of the water stored under the Compact. This allows the Kansas ditches to call for water during peak growing demand of summer crops, typically in July. Water called for by the six Kansas irrigation ditch companies must be put to beneficial use in Hamilton, Kearny, and western Finney counties, as permitted under their vested water rights.

KDA-DWR staff and technical experts continue to monitor Colorado's compliance on an annual basis. Colorado has complied for each 10-year period to date. There are often changes in Colorado water use that KDA-DWR reviews to assure Kansas receives its share. Some of the current issues are Colorado's Pueblo Winter Water Storage Program, Lower Arkansas Water Management Association (LAWMA) Water Court Decrees, Agricultural Temporary Transfers, NEPA Ark Valley Conduit (AVC), and the Trinidad Operating Plan 10-year review. More information on the Arkansas River Compact and current issues is available through KDA-DWR.

Arkansas River at Syracuse, KS, July 2012.
Photo Credit: Travis See, USGS.

Upper Arkansas Region

REGIONAL WATER CONSERVATION EFFORTS

WATER CONSERVATION AREAS & LOCAL ENHANCED MANAGEMENT AREAS

The State of Kansas has developed a number of tools and resources to provide water rights owners multiple mechanisms to conserve and extend the High Plains Aquifer. Two such tools include Water Conservation Areas (WCAs) and Local Enhanced Management Areas (LEMAs). WCAs were signed into law in April 2015 and are a simple and flexible tool that allows any water right owner or group of owners the opportunity to develop a management plan to reduce withdrawals in an effort to extend the usable life of the Ogallala-High Plains Aquifer. As of late 2020, there were over 28,000 irrigated acres under conservation within the Upper Arkansas Region Planning Area enrolled as a WCA.

LEMAs are plans initiated by groundwater GMDs, based on input from the local community of farmers, ranchers and other water users, to conserve water and extend the useful life of the High Plains aquifer. To ensure these plans are enforceable and consistent with state law, the plans require approval from the Division of Water Resources chief engineer through a public hearing process. LEMAs give Kansas farmers and ranchers the opportunity to develop water conservation plans that meets their needs. LEMAs are an alternative to an Intensive Groundwater Use Control Area (IGUCA). In 2017, local water rights owners in northern Finney and Kearny counties explored options to establish a LEMA within this portion of the Upper Arkansas RPA, with a final proposal ultimately not submitted to the Chief Engineer by GMD3.

KWO WATER TECHNOLOGY FARMS

KWO Water Technology Farms (Water Tech Farms) are pilot public-private partnerships with producers where irrigation technology is demonstrated, related research is conducted on the field scale, and water conservation is supported. There are currently three Water Tech Farms in the region. The Garden City Company-Roth Family Farms and T&O Farms, both located in Finney County, were the first in the region to participate in the program starting in 2016. In 2020, Westside Dairy in Stanton County was the third to join the program. All three of the Water Tech Farms have been crucial to the region in providing valuable information on expanding the conversation and education of producers and decision makers on water conservation in the area.

The Roth brothers at one of the Garden City Company-Roth Family KWO Water Tech Farm fields near their Holcomb, KS
Photo Credit: KWO

Upper Arkansas Region

MUNICIPAL WATER CONSERVATION

The primary objective of municipal water conservation is to achieve more efficient use of the state's limited water resources. Municipalities in the region, such as Dodge City and Garden City, have taken steps to implement water conservations plans, offer rebates on water saving updates, and install water reclamation systems.

The water supply for the City of Garden City, located within this region, is solely through groundwater resources, consisting of 17 wells, with 3 of the wells pumping from the Ogallala Aquifer. The City's supply is supplemented by water purchased from Wheatland Electric Cooperative, Inc.

The community of Garden City has undertaken numerous steps to ensure a dependable water supply for its residents, including offering rebates to residents who install WaterSense Irrigation Controllers, which serve to make more efficient use of water through the monitoring of weather data and soil moisture conditions through the irrigation season. In 2019, Garden City initiated a feasibility study for water reuse that was approved by the Bureau of Reclamation. Currently, the City is developing a marketing plan for reuse of treated water through a reclamation system.

WATER QUALITY

The Arkansas River in western Kansas is among the most saline in the country, with elevated levels of Total Dissolved Solids (TDS), especially sulfate, limiting its use. The saline water from the Arkansas River seeps into the subsurface alluvial aquifer and the Ogallala Aquifer, thereby contaminating the groundwater with high sulfate and uranium concentrations. Uranium concentrations in the river during saline low flows generally exceed the Environmental Protection Agency (EPA) drinking water standards.

The contamination originates from eastern Colorado as the high levels of sulfate, sodium, chloride, selenium, uranium, and other minerals are carried by the river into Kansas. Selenium concentrations are high during summer (April to September) when deliveries to Kansas irrigation ditches are made by Colorado pursuant to the Arkansas River Compact. Concentrations during the irrigation off-season (October to March) remain elevated with the onset of drier conditions. The greatest concentrations of selenium are seen in the immediate vicinity of the river where large-scale irrigation diversion of ground water begins east of the Bear Creek fault in Kearny County.

The Kansas Water Office (KWO) along with the Kansas Department of Health and Environment (KDHE) and Kansas Department of Agriculture (KDA) have partnered with the Kansas Geological Survey (KGS) and GMD3 in a two-year Mineralization Study to collect current data on areas adjacent to the Arkansas River and surface irrigation canals in Hamilton, Kearny, Finney, Gray, and Ford counties in response to a legislative resolution passed in 2019.

The Clean Water Act requires states to conduct Total Maximum Daily Load (TMDL) studies and develop TMDLs for water bodies identified on the state's List of Impaired Waters (Section 303(d) List). TMDLs are quantitative objectives and strategies needed to achieve the state's surface water quality standards. TMDLs have been developed in the region to address fecal coliform bacteria, selenium, dissolved oxygen, and eutrophic conditions as the highest priority impairments.

Upper Arkansas Region

Sediment and nutrient impairments affect portions of the region's surface waters, mainly the Pawnee River and tributaries in the eastern part of the region (Figure 11). Sediment is also considered to impair use for the Arkansas River in Hamilton and Kearny counties, as well as the Hamilton County State Fishing Lake and the Hamilton Wildlife Refuge.

All counties within the region have adopted sanitary codes that can help manage bacteria and nutrient inputs in surface and groundwater. All conservation districts in the region have adopted nonpoint source pollution management plans.

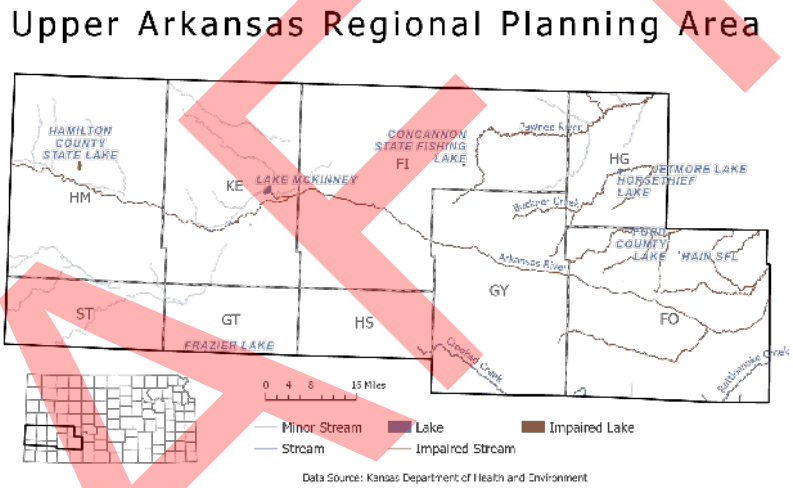


Figure 11. Impaired water sources in the Upper Arkansas Region

The Goals and Action Plans contained herein are as developed by the Regional Advisory Committee.

Upper Arkansas Advisory Committee

Regional Goals & Action Plans

Priority Goal #1: Establish a diversified, usable water supply by 2030, to motivate a vibrant growing economy with conservation-minded stewardship focused on increasing the life of the aquifer, reestablishing streamflow in the Arkansas River, and accelerating recharge; benefiting: economic prosperity, wildlife, habitat, recreation, and all water users while protecting property rights and providing safe drinking water.

ACTION STEPS:

- Develop alternative sources of supply by 2030.

  a. Collaborate and coordinate with local shareholders, stakeholders, policymakers, organizations, agencies, (i.e. GMD3, KWO, KDA, KDHE, Kansas Dept. of Commerce, and other State agencies) surrounding States, and federal agencies and authorities.

  b. Research, study, and initiate any changes necessary to current or new statutes, to develop and perfect new or existing water rights to serve as alternative sources of supply.

  c. Explore multi-state support for an interstate water transfer system.

  d. Evaluate potential intrastate water transfers.

  e. Initiate and participate in research to determine the value an alternative source of supply would generate directly and indirectly for local, regional, state, & federal areas and agencies.

  f. Develop a fact-based education initiative to inform Kansans and our neighbors how we can plan and prepare for tomorrows challenges related to the shortages or excess of water for everyone.

  g. Support alternative sources of supply.

Measuring success:

Goal 1: Increasing trend in participation in WCAs and LEMAs as well as increase in adoption of water conservation-promoting tools and technologies.

Upper Arkansas Advisory Committee

Regional Goals & Action Plans

Priority Goal #1 Continued.

ACTION STEPS:

- Educate all water users on the importance of water saving, increased water use efficiencies, and the supporting data (static water levels, static water level change rates, conservation targets, etc.).

  a. Support the educational efforts through the *Kansas Runs on Water* Campaign.

  b. Support educational activities through the Conservation Districts such as (The Ark Water River Festival, Earth Day at The Zoo, Safety Days, Poster contests at the schools, The Bottom Line Conference, and other informational meetings or conferences) put on by the Conservation Districts.

  c. The Water Authority supports these activities by funding the budget line item, Aid to Conservation Districts, to the full matching amount indicated by Kansas law.

  d. Support educational meetings hosted by the K-State Extension, the GMD3, and other agencies or organizations.

  e. Encourage the Kansas Water Authority's continued support and funding for the irrigation technology farms.

  f. Formalize a list to add to a calendar on the Water Authority, Kansas Association of Conservation Districts, GMD3, and K-State Extension web sites to help inform landowners, producers, and the general public of events throughout the year.

Measuring success:

Goal 1: Increasing trend in participation in WCAs and LEMAs as well as increase in adoption of water conservation-promoting tools and technologies.

Upper Arkansas Advisory Committee

Regional Goals & Action Plans

Priority Goal #1 Continued.

ACTION STEPS:

- Promote irrigation conservation.

  a. Support voluntary decreased water consumption in the Upper Arkansas RAC geographic area per the Kansas Geological Survey (KGS) recommendations.

  b. Encourage adoption of water conservation programs such as LEMA's and WCA's.

  c. Support producer incentives through the KDA-DOC, KDHE, KDA-DWR, and other state agencies to reduce usage through proven technologies and best management practices.

    i. These may include programs such as CREP, Playa Lake restoration, cost-share on reduced irrigation systems, cost-share on soil moisture probes, and other technologies that reduce water usage.

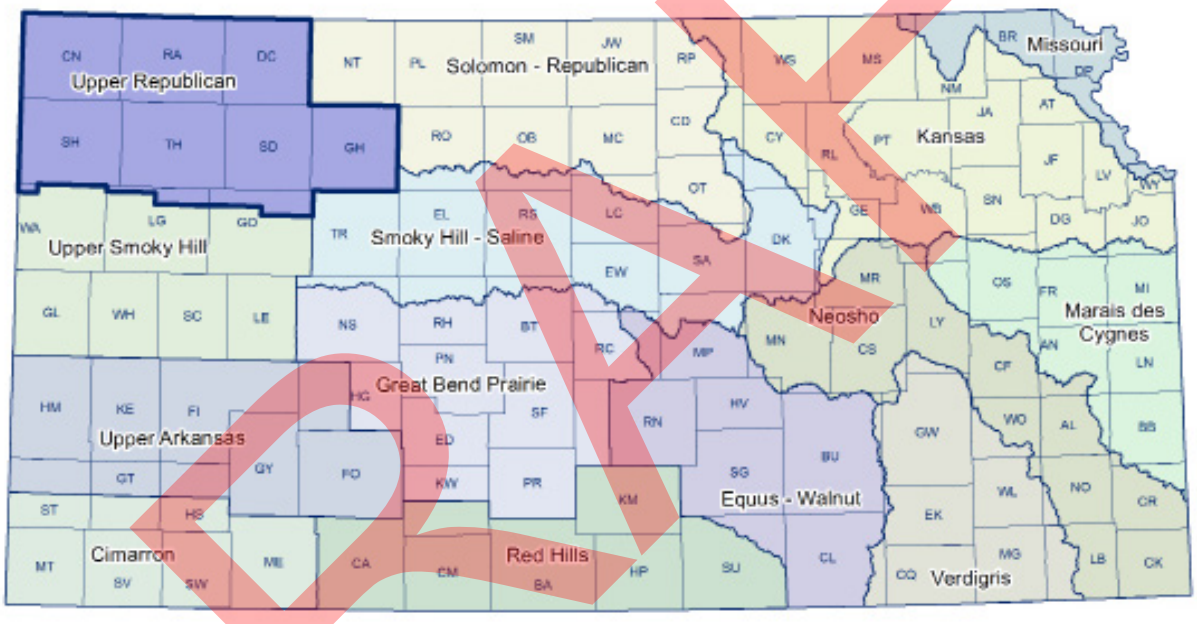
  d. Promote conservation of municipal and industrial water use through incentives and education.

  e. Recognizing distinct differences between domestic, irrigation, stockwater, municipal, industrial, and other types of beneficial use.

Measuring success:

Goal 1: Increasing trend in participation in WCAs and LEMAs as well as increase in adoption of water conservation-promoting tools and technologies.

Upper Republican Region



Upper Republican Region

Regional Description

The Upper Republican Regional Planning Area is located in northwest Kansas, overlying portions of the Ogallala Aquifer. The Upper Republican Region is bordered by Colorado on the west and Nebraska on the north and covers approximately 7,342 square miles. It includes all of Cheyenne, Rawlins, Decatur, Sherman, Thomas, Sheridan, and Graham counties and portions of Gove, Logan, and Wallace counties (Figure 1).

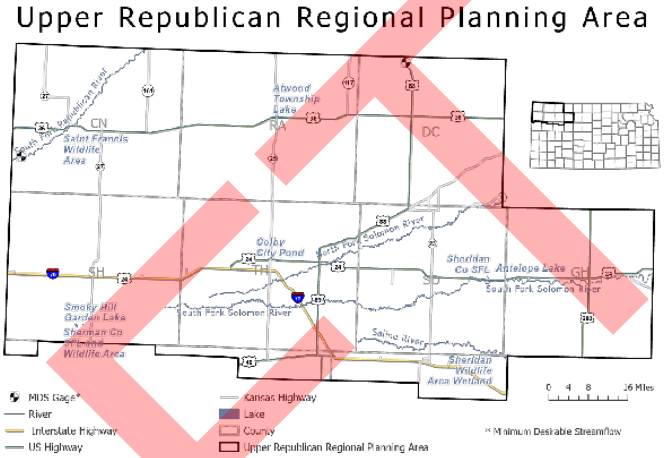


Figure 1. Upper Republican Regional Planning Area

CLIMATE & LAND USE

The climate of the region is characterized by moderate to low precipitation, relatively high wind velocities, rapid rates of evaporation, and a wide range of temperatures. Average annual precipitation amounts vary from 16 inches in the west to 24 inches in the east (Figure 2). The high winds and low humidity of the region contribute to a high evaporation rate from both surface water and land surfaces.

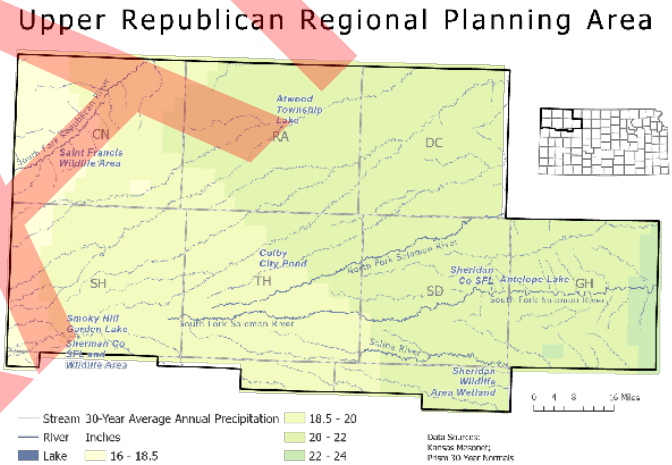


Figure 2. 30-year average annual precipitation in the Upper Republican Region

Land use activities can have a significant impact on the region. The three major land uses in this region are cultivated crops (60%), herbaceous (35%) and developed/urban (3%) as derived from the National Land Cover Database (NLCD) 2016 dataset. Figure 3 lists the remaining land uses in the region, including: pasture/hay.

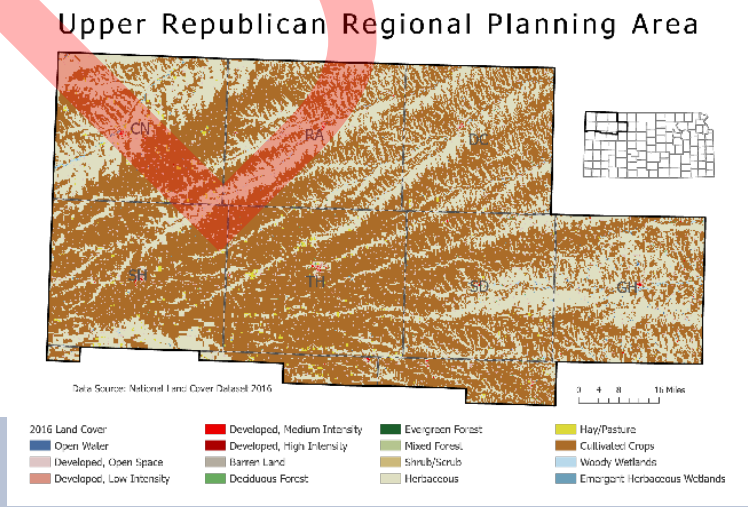


Figure 3. Upper Republican regional land cover

Playa lake wetlands are prominent in the western portion of the region and provide habitat for migrating birds and the aquatic organisms that support them. Key regional wildlife species include ring-necked pheasants, greater prairie chicken, bobwhite quail, whitetail, and mule deer.

Upper Republican Region

POPULATION & ECONOMY

Based upon 2019 information derived from state-released information to the U.S. Census Bureau, there were an estimated 27,778 residents in the region (Figure 4). For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over or under represented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census.

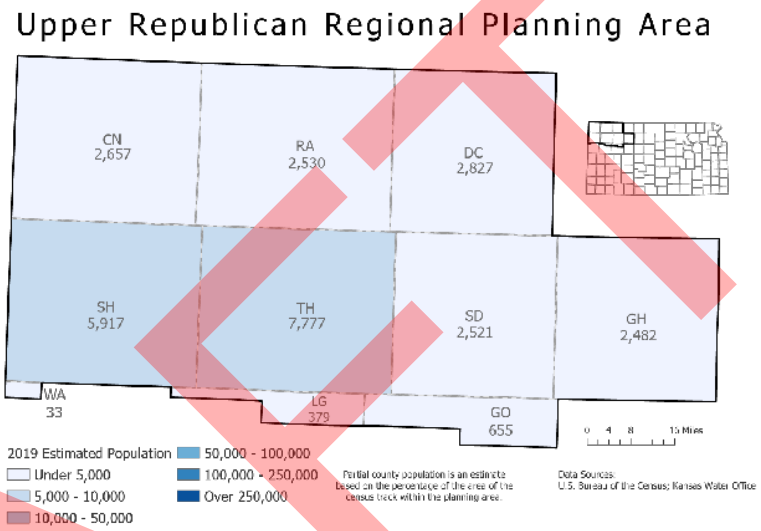


Figure 4. 2019 estimated population by county

Agriculture, largely irrigated, is the basis of the economy of the region. Crops grown include wheat, corn, grain sorghum, soybeans, forage sorghum, alfalfa, and sunflower. Livestock production is an important part of the area's agriculture with beef cattle the predominant livestock raised in the region. community lakes, and the numerous private hunting establishments utilizing wetland resources, as well as the public wildlife refuges in the region.

Primary Water Resources in the Region

SURFACE WATER

The principal tributaries in the Upper Republican Region are the South Fork Republican River, Beaver Creek, Sappa Creek, Prairie Dog Creek, North and South Fork Solomon Rivers, the Saline River, and Bow Creek (Figure 5).

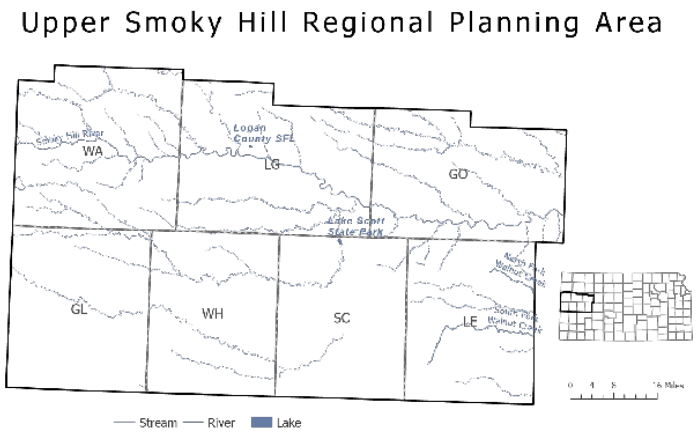


Figure 5. Major surface water resources in the Upper Republican Region

Upper Republican Region

GROUNDWATER

The principal aquifers in the region include the Ogallala portion of the High Plains Aquifer (Ogallala Aquifer) and other alluvial aquifers (Figure 6).

The High Plains aquifer consists of several hydraulically connected aquifers, the largest of which is the Ogallala (Figure 7).

The Ogallala Aquifer is distinctive from other aquifers in Kansas in that it generally has low annual recharge. The Dakota Aquifer is present in the region but is seldom used due to high mineral content.

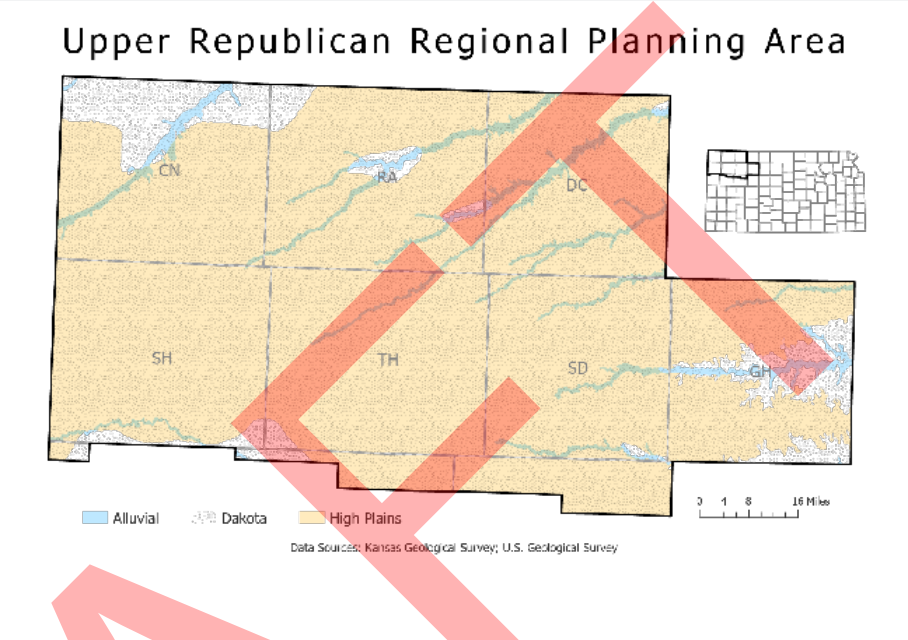


Figure 6. Principle aquifer boundaries in the Upper Republican Region

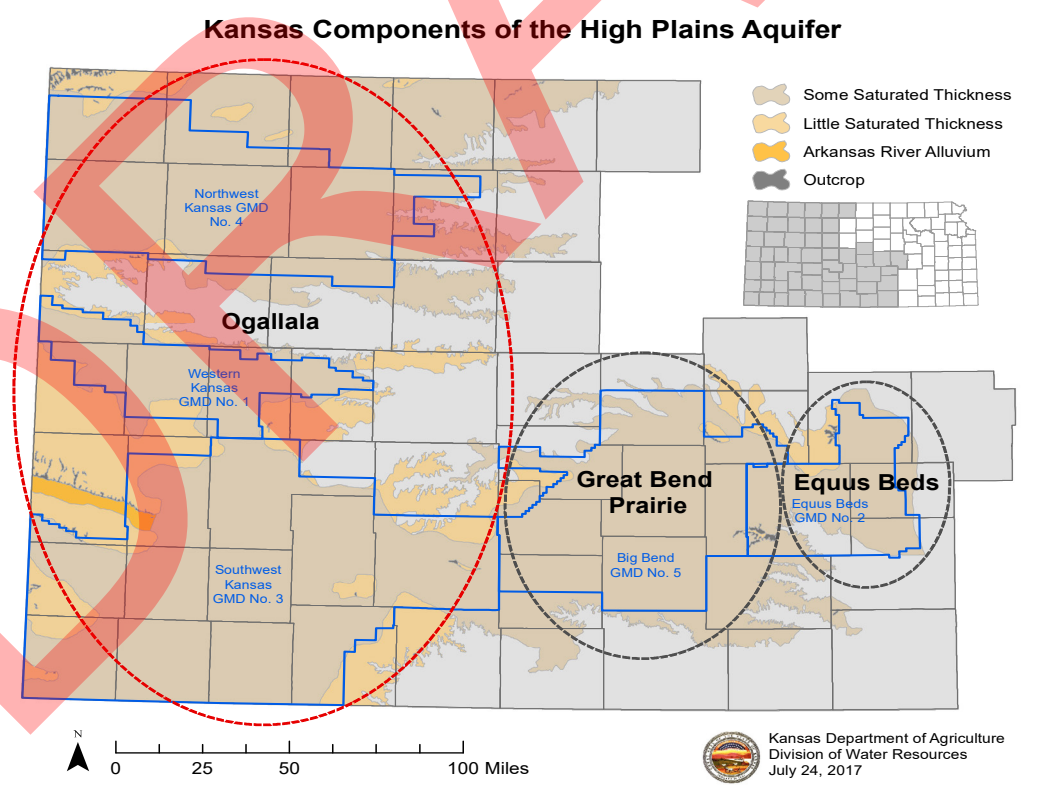


Figure 7. Kansas Components of the High Plains Aquifer, KDA

Upper Republican Region

Primary Water Use by Source

GROUNDWATER

Groundwater is the primary source of water in the region, accounting for nearly 100% of the total supply, principally from the Ogallala Aquifer and alluvial deposits along major streams with very limited use of the Dakota Aquifer. Irrigation use accounts for 94% of the reported water use of the region, with 5% used for stock water, and 1% used for municipal use (Figure 8).

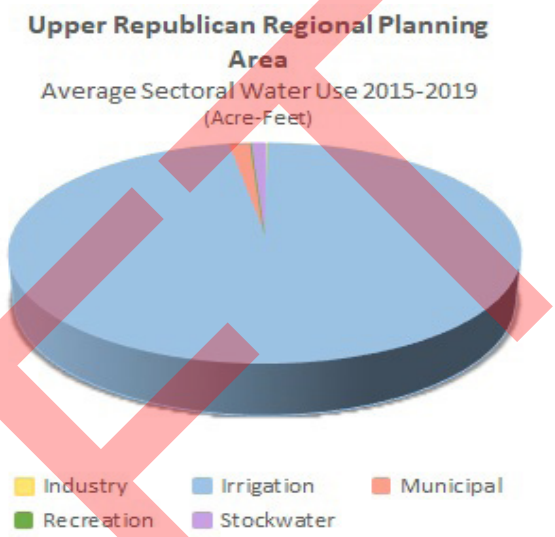


Figure 8. Average sectoral water usage

Regional Issues & Priorities

OGALLALA AQUIFER LEVEL DECLINES

Since the 1970s, the Ogallala Aquifer, as detailed in the *Conserve & Extend the High Plains Aquifer* section, has been developed so extensively that the amount of water withdrawn annually is significantly more than the recharge, resulting in severe groundwater declines. Some areas are already experiencing shortages in meeting demand.

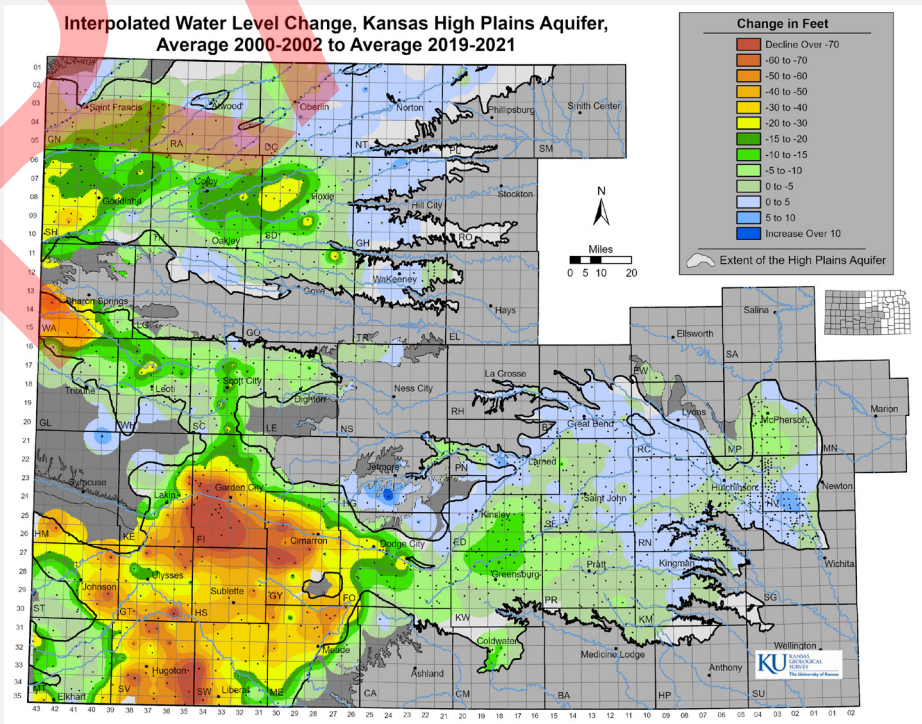


Figure 9. Water Level Change, Kansas High Plains Aquifer, KGS

As groundwater levels decline (Figure 9), the aquifer loses hydraulic connection with the overlying alluvial aquifers and rivers and no longer contributes much, if any, base streamflow. This loss of hydraulic connection between surface and groundwater within the region has caused streams to dry up outside of rain events. Since the early 2000s, Ogallala Aquifer water levels have declined by 20 feet or more across portions of Sherman, Thomas, and Sheridan counties.

Upper Republican Region

The Kansas Geological Survey (KGS), in an effort to help develop a better understanding of the aquifer dynamics at a scale that would be appropriate for management, created the Index Well Program: a network of well-monitoring systems that aids in tracking water level changes while providing real-time data.

The Ogallala Aquifer is characterized by low recharge and high declines. The expected "usable life" of the aquifer, when the aquifer is no longer able to support the current high rates of pumping, varies widely due to differences in the amount of saturated thickness, hydraulic conductivity, withdrawals, and other variables.

Water appropriations and use are overseen by the Kansas Department of Agriculture-Division of Water Resources (KDA-DWR). All streams and alluvial corridors in the region are either closed or restricted to new appropriations. Minimum desirable streamflow has not been established at any sites in the region, though many streams now flow only during rainfall events. Generally, the Ogallala Aquifer has no new appropriations available. In limited cases, a new water appropriation for groundwater, limited to quantities under 15 acre-feet, can be obtained within Northwest Groundwater Management District No. 4 (GMD4).

GMD4 is a water management entity in the region, overlying the Ogallala Aquifer in Sherman, Thomas and Sheridan counties and portions of Cheyenne, Rawlins, Decatur, Wallace, Logan and Gove counties. GMD4, formed in 1976, is proactive in developing local water policy to extend the life of the Ogallala Aquifer compatible with state laws (Figure 9). In 2013, GMD4 established the Sheridan 6 (SD-6) Local Enhanced Management Area (LEMA), the first LEMA in the state. The goal of the SD-6 LEMA is to reduce water used for irrigation by 20% to extend the life of the aquifer in the Sheridan County area, thus helping to maintain the economic base of the region while conserving additional water for future use.

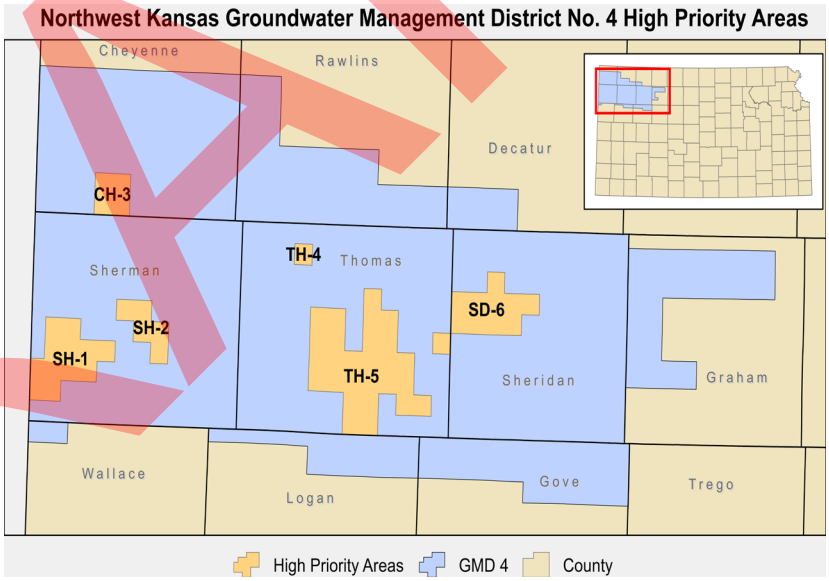


Figure 9. GMD4 boundaries and high priority areas within the Upper Republican Region, KDA-DWR

REGIONAL WATER CONSERVATION EFFORTS

WATER CONSERVATION AREAS & LOCAL ENHANCED MANAGEMENT AREAS

The State of Kansas has developed a number of tools and resources to provide water rights owners multiple mechanisms to conserve and extend the High Plains Aquifer. Two such tools include Water Conservation Areas (WCAs) and LEMAs.

The first approved LEMA in Kansas was the Sheridan-6 LEMA which covers 99 square miles in Sheridan County and a small portion of Thomas County. The first five-year term of the Sheridan-6 LEMA expired at the end of 2017 but the success in water conservation while maintaining the economy led producers to requested renewal of the LEMA. Initially, the Sheridan-6 LEMA limited

Upper Republican Region

water use to no more than 55 acre inches per irrigated acre covered by the water right over the five-year period; these terms also apply to the second five-year term (2018-2022).

In April 2018 the GMD4 LEMA, which encompasses nearly the entire district, was approved by the Chief Engineer. This LEMA sets irrigation user allocations by townships in the district. The allocations are based on the overall impact of past pumping. If a township showed historically larger groundwater declines, the township was given an allocation less than others where pumping did not impact the aquifer as drastically. This LEMA is also a five-year term from January 2018 until December 2022 with potential to renew.

WCAs were signed into law in April 2015 and are a simple and flexible tool that allows any water right owner or group of owners the opportunity to develop a management plan to reduce withdrawals in an effort to extend the usable life of the Ogallala-High Plains Aquifer. As of summer 2021, there were over 12,000 irrigated acres under conservation within the Upper Republican Region Planning Area enrolled as a WCA, many of which are also LEMA participants as well.

KWO WATER TECHNOLOGY FARMS

KWO Water Technology Farms (Water Tech Farms) are pilot public-private partnerships with producers where irrigation technology is demonstrated, related research is conducted on the field scale, and water conservation is supported. There are currently three Water Tech Farms in the region. Northwest Kansas Technical College, located in Sherman County, was the first in the region to participate in the program starting in 2017.

In 2020, McCarty Dairy and Goossen Farms, both located in Thomas County, enrolled in the program. All three of the Water Tech Farms have been crucial to the region in providing valuable information on expanding the conversation, educating producers and decision-makers on water conservation in the area and demonstrating profitable outcomes from the use of technology and practices .

Northwest Kansas Technical College Field Day.

GMD4 CERTIFIED IRRIGATOR PROGRAM

GMD No. 4 is currently developing a Certified Irrigator program that will include an online format with video modules containing information about water-saving technology and management strategies. Producers will be able to complete the modules at their own pace. Following completion of the online curriculum, producers will be invited to attend local in-person discussions with other participants, as well as question-and-answer sessions with experts.

Upper Republican Region

REPUBLICAN RIVER COMPACT

The South Fork Republican River Basin in Northwest Kansas has historically not received the water to which it is entitled under the Republican River Compact (RRC) due to overdevelopment in Colorado (Figure 10). In August 2018, the states of Kansas and Colorado reached a settlement regarding past compact violations in Colorado. That agreement resulted in a transfer of $2 million in funds from Colorado to Kansas during Fiscal Year 2019.

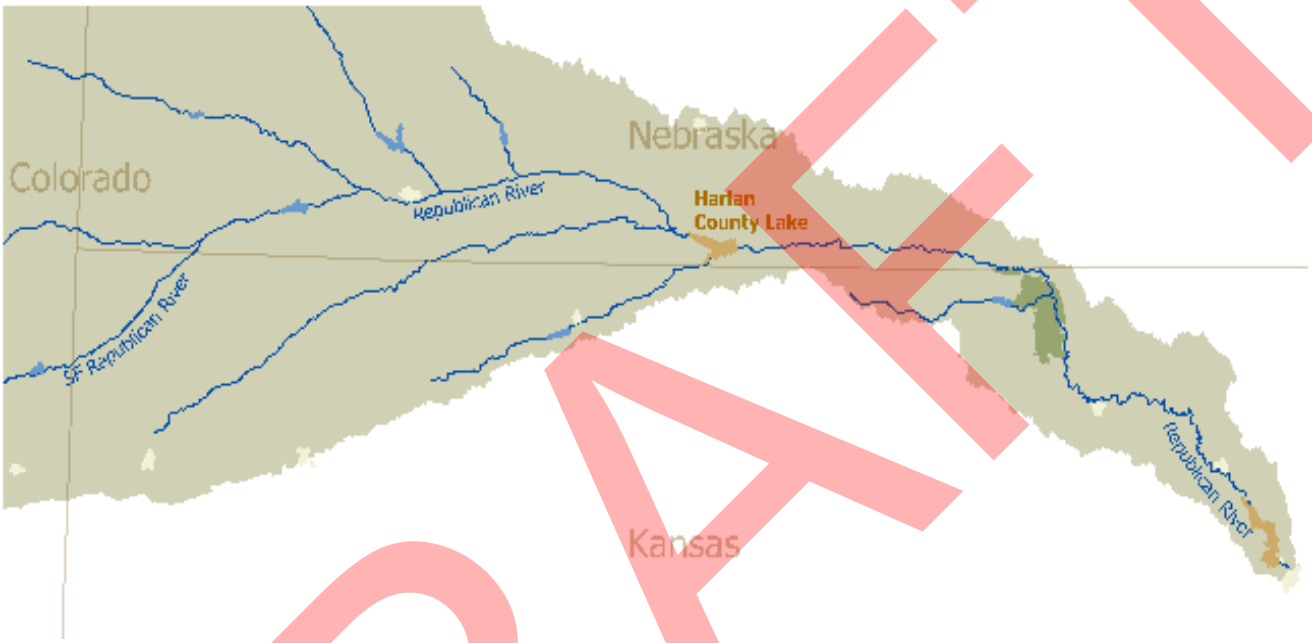


Figure 10. RRC area in Colorado, Nebraska, and Kansas

A stakeholder group was formed in 2019 to develop and plan for utilizing funds from the settlement. The primary purpose of the stakeholder group is to help implement water conservation projects, water-use efficiency upgrades, water management plans by water right holders, and cost-share programs within the South Fork Republican River Basin in Kansas. In 2020 and 2021, cost-share opportunities for the implementation of irrigation technologies was offered to eligible applicants. Ongoing efforts of the stakeholder group continue, including the identification of other suitable projects within the region.

In October 2020, $500,000 of the original $2 million was transferred to Cheyenne County Conservation District. The Conservation District, utilizing the funds received, applied for a Regional Conservation Partnership Program (RCPP) through NRCS, which was approved in 2021. As part of the project, the District plans to leverage funding to expand the implementation of projects supporting the goal of improving efficiency and reducing water use in the South Fork basin.

Upper Republican Region

WATER QUALITY

NW KANSAS MINERALIZATION STUDY

KDHE has partnered with Fort Hays State University to determine the distribution and concentrations of uranium and other minerals in private drinking water wells completed in alluvial aquifers along Sappa Creek in Decatur County, Beaver Creek in Rawlins County within the Upper Republican Region and Prairie Dog Creek in Norton and Phillips Counties within the Solomon-Republican Region (Figure 11).

This study provides private well owners the opportunity to have wells tested for common mineral contaminants and allows for a better understanding of the extent of mineral contamination issues in the area. Other minerals in the study include: Arsenic, Selenium, Nitrate, Chloride, Iron, Manganese, and Sulfate. The project is to be conducted over a two-and-a-half-year period beginning in 2021, with public outreach by KDHE and sampling by FHSU scheduled to begin in summer 2021.

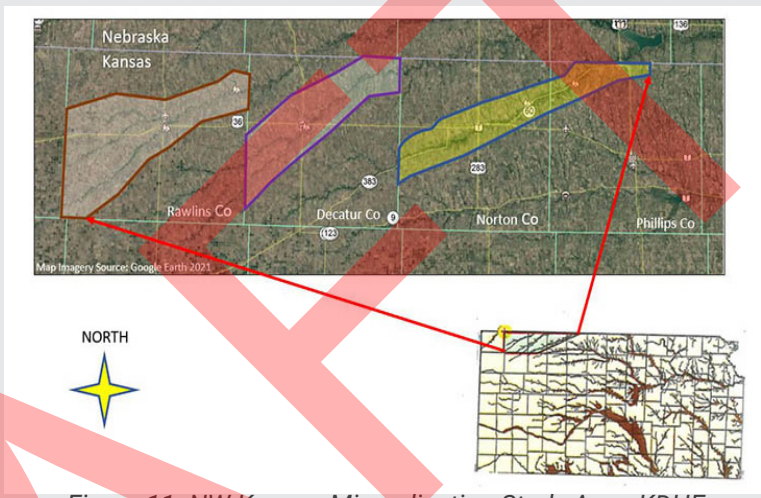


Figure 11. NW Kansas Mineralization Study Area, KDHE

All the counties within the region have adopted and are enforcing sanitary codes that can help to manage bacteria and nutrient inputs in surface and groundwater. All conservation districts in the region have adopted nonpoint source pollution management plans. A group is currently in the early stages of putting together an Upper Republican Custom Watershed Committee to help address area nutrient issues.

The Clean Water Act requires states to conduct Total Maximum Daily Load (TMDL) studies and develop TMDLs for water bodies identified on the state's List of Impaired Waters (Section 303(d) List) (Figure 12). TMDLs are quantitative objectives and strategies needed to achieve the state's surface water quality standards. TMDLs have been developed to address dissolved oxygen, total phosphorus, and eutrophic conditions as the highest priority impairments. Other pollutants limiting use of Upper Republican streams include fecal coliform bacteria, fluoride, selenium, pH, and sulfate. Nonpoint source pollution associated with run off from land use promotes nuisance growths of algae and detracts from the recreational and drinking water supply uses of surface water. Most of the water quality impairments caused by non-point source pollutants are not subject to regulations by the Federal or State government.

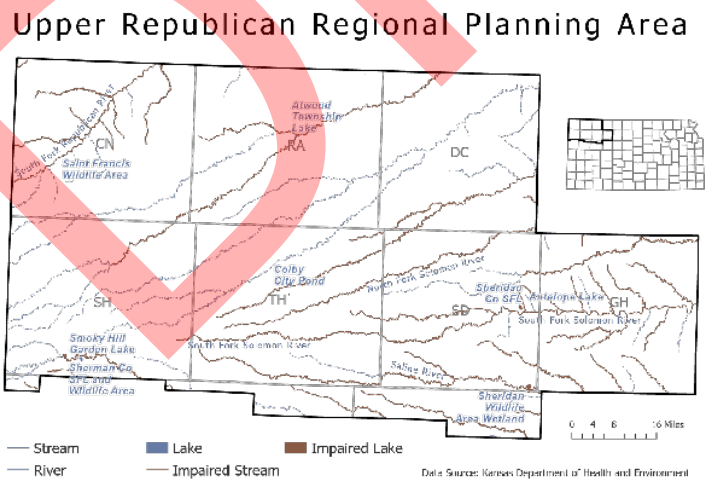


Figure 12. Impaired water resources in the Upper Republican Region

Upper Republican Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- Support GMD4 LEMA plan.
- Look outside the box for other possible funding sources necessary to improve water efficiency.
- Find samples of water conservations plans for the Upper Republican Regional Advisory Committee (RAC) to consider.

Priority Goal #1:
In collaboration with other water agencies, the RAC will assist in developing and recommending a water conservation management plan that provides maximum flexibility while reducing overall actual use throughout the Upper Republican Region to extend aquifer life and economic wellbeing. To adopt conservation measures to lessen economic impacts and allow user transition, the Conservation Plan shall address all types of use while considering flexibility tools and overall actual reduction.

Measuring success:

Goal 1: Increase adoption of water conservation and management tools and strategies, slow the rate of aquifer decline or improve trends, and secure additional funding sources for implementation of water management practices in the region.

Upper Republican Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- Continue to support the Kansas Water Office (KWO), Kansas Department of Agriculture (KDA), GMD4, and other entities in increased education about water technology farms.
- Support KDA in education about WCAs.
- Work with NRCS to evaluate effectiveness of RCPP program and find efficiencies.
- Participate with water agencies and schools in events for education about water conservation.
- Support GMD4 on the development of an certified irrigator education program.

Priority Goal #2:
In collaboration with other water agencies, the RAC will assist in enhancing current efforts on education of all water users for all age groups on sources of supply, water quality, quantity of supply, best management practices, etc. to help stakeholders understand, conserve and extend the life of the aquifer.

Measuring success:

Goal 2: Document increase in participation in water education programs for all ages within the region and establish the GMD's Certified Irrigator Program.

Upper Republican Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- Ensure KDA continually updates the RAC on the RRC, especially if any changes occur within the area.

Priority Goal #3:
In collaboration with other water agencies, the RAC will encourage the Republican River Compact administration to maintain compliance in the Republican River Basin.

Measuring success:

Goal 3: The Upper Republican Regional Advisory Committee is provided regular updates on the Republican River Compact.

Upper Republican Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- Support and promote conservation programs that offer incentives such as water savings technology cost-share programs, water technology farms, LEMAs, and increased data collections and disseminations.
- Actively assist in seeking annual funding to ensure successful achievement of goal.

Priority Goal #4:
In collaboration with other water agencies, the RAC will actively encourage all water users to increase utilization and adoption of water conservation technologies and practices.

Measuring success:

Goal 4: Increase participation in GMD4 Certified Irrigator Program. Increase utilization of state and federal financial assistance on irrigation water management tools and technologies. Groundwater levels as adoption of water conservation technologies and practices increases.

Upper Republican Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

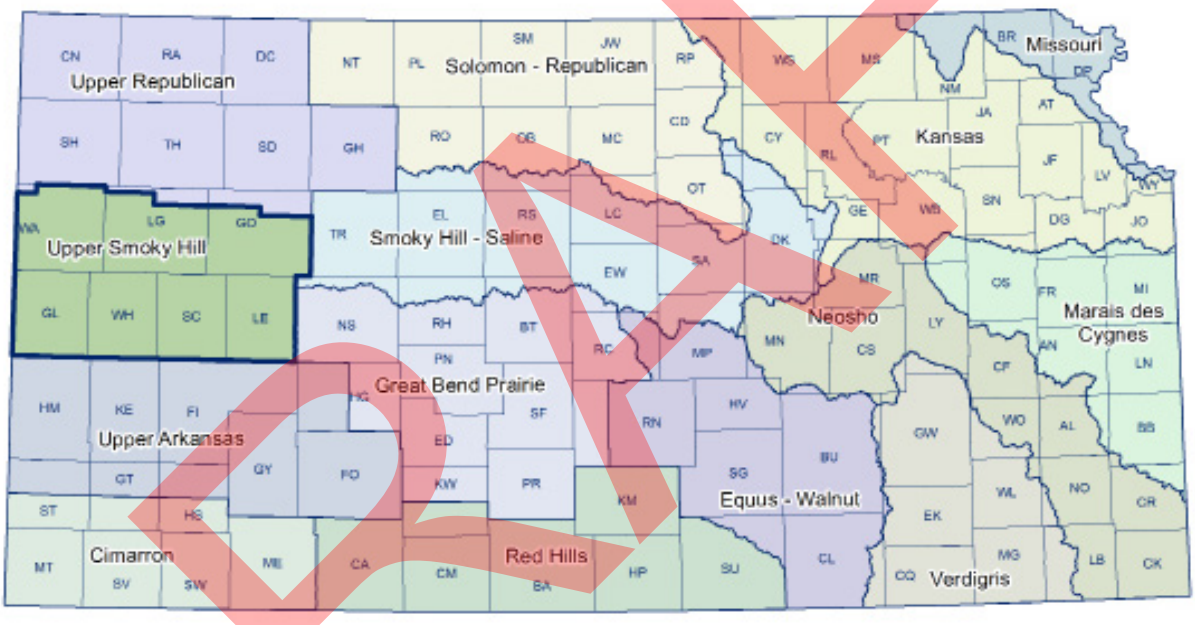
- Support Kansas Department of Health and Environment (KDHE) to help establish a baseline of potable of water quality within the region.

Priority Goal #5:
In collaboration with other water agencies, the RAC will work to increase awareness about source water protection to improve the long-term water quality in the region.

Measuring success:

Goal 5: Increased utilization of state and federal financial assistance on irrigation water management tools and technologies within the region.

Upper Smoky Hill Region



Upper Smoky Hill Region

Regional Description

The Upper Smoky Hill Regional Planning Area is located in west central Kansas. The Regional Area is bordered by Colorado on the west and covers approximately 5,498 square miles. It includes Greeley, Lane, Scott, Wichita, and portions of Gove, Logan, and Wallace counties (Figure 1).

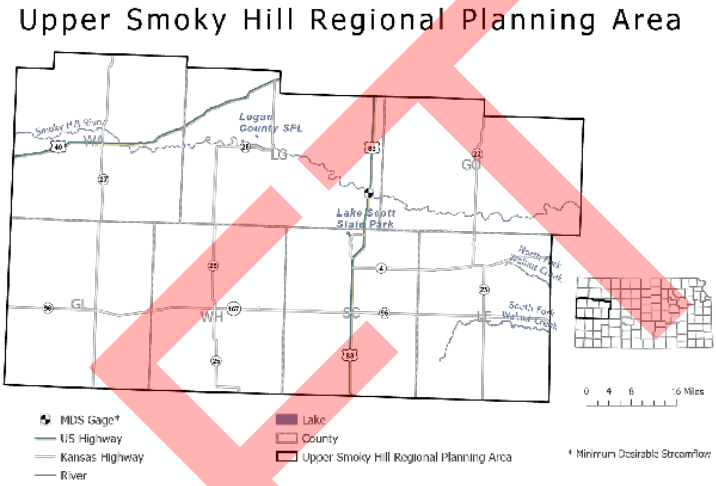


Figure 1. Upper Smoky Hill Regional Planning Area map

CLIMATE & LAND USE

The climate of the region is characterized by the highly variable precipitation and temperature common to mid-continent locations. Evapotranspiration consumes the majority of the moisture in the basin. Average annual precipitation amount varies from 16 inches in the west to about 24 inches in the east (Figure 2).

Land use activities can have a significant impact on the region. The three major land uses in this region are cultivated crops (61%), herbaceous (33%) and pasture/hay (3%) as derived from the National Land Cover Database (NLCD) 2016 dataset. Figure 3 lists the remaining land uses in the region, including: developed/urban open space.

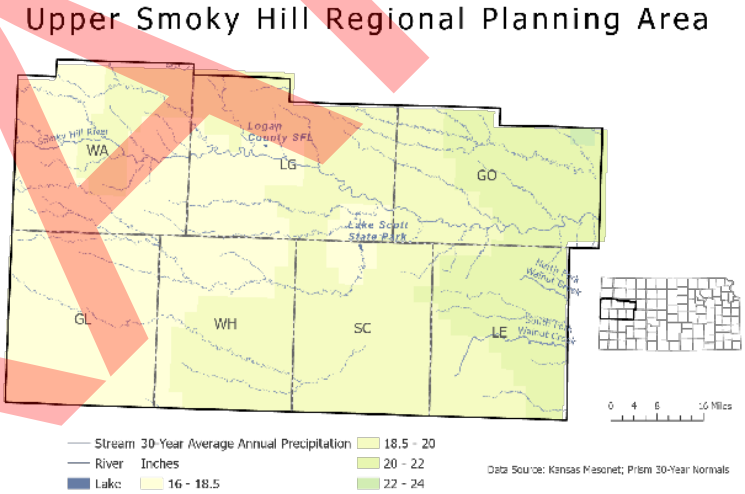


Figure 2. 30-year average annual precipitation in the Upper Smoky Hill Region

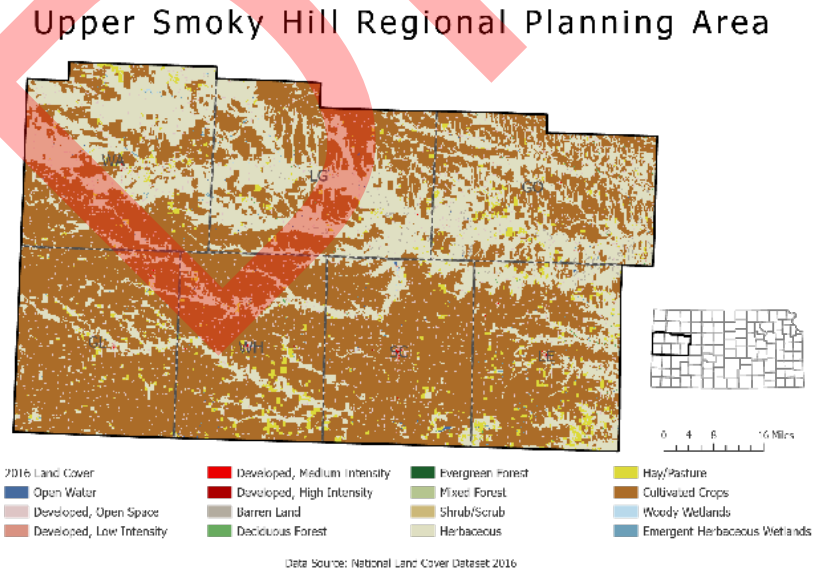


Figure 3. Upper Smoky Hill regional land cover

Topography within the region is flat to gently rolling, with narrow, shallow valleys and low relief. Mount Sunflower, the highest point in Kansas, is 4,039 feet above mean sea level (MSL) and is located in northwestern Wallace County.

Upper Smoky Hill Region

POPULATION & ECONOMY

Based upon 2019 information derived from state-released information to the U.S. Census Bureau, there were an estimated 15,590 residents in the region (Figure 4). For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over or under represented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census.

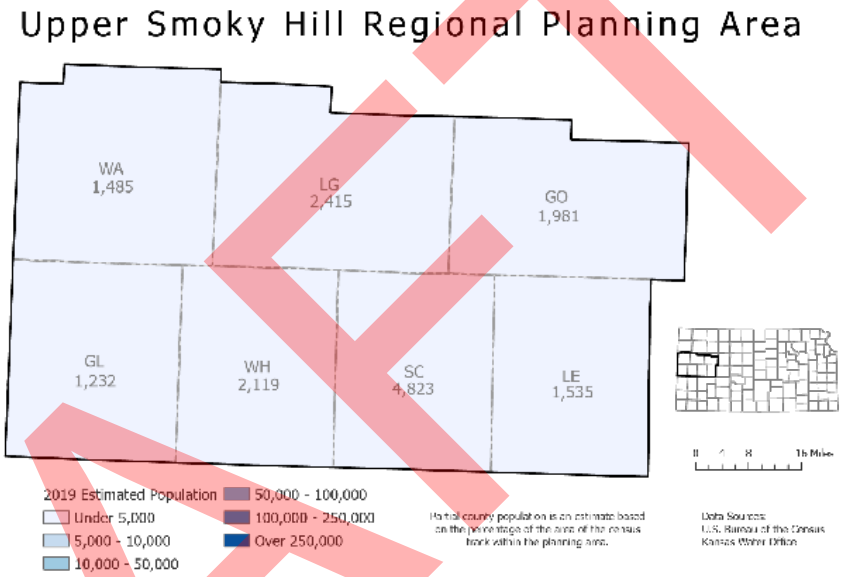


Figure 4. 2019 estimated population by county

Agriculture is the basis of the economy of the region. Crops grown include wheat, corn, grain sorghum, and alfalfa, with a sizable portion of this acreage being irrigated. Livestock production is an important part of the area's agriculture with beef cattle the predominant livestock raised in the region. The growing industrial contribution to the region's economy is primarily related to energy production, including a dry mill ethanol plant in Gove County.

Primary Water Resources in the Region

SURFACE WATER

The principal tributaries in the Upper Smoky Hill Region are the Smoky Hill River and the North and South Fork Walnut Creeks (Figure 5). Lakes in the region include Logan County State Fishing Lake and Lake Scott State Park.

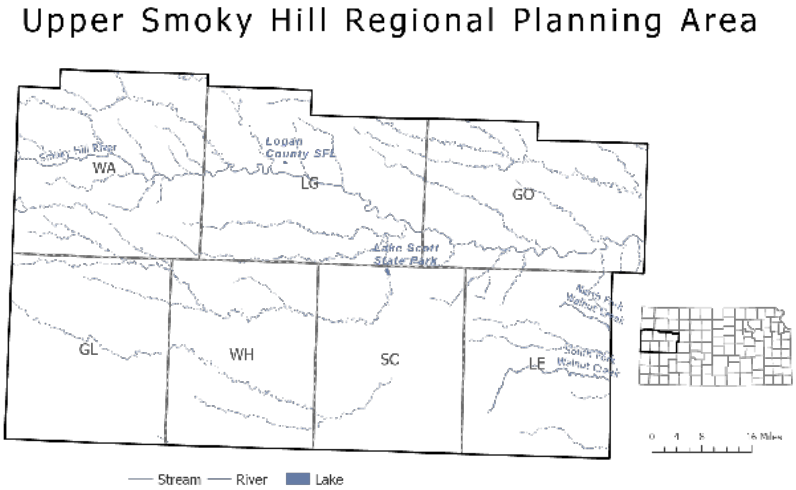
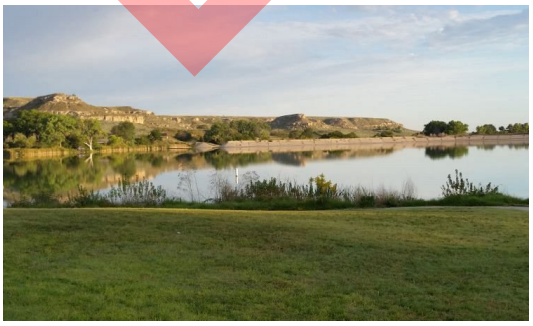


Figure 5. Major surface water resources in the Upper Smoky Hill Region



Lake Scott State Park. Photo Credit: KDWP

Upper Smoky Hill Region

GROUNDWATER

The principal aquifers include the Ogallala Portion of the High Plains Aquifer (Ogallala Aquifer) and other alluvial aquifers (Figure 6). The High Plains Aquifer consists of several hydraulically connected aquifers, the largest of which is the Ogallala (Figure 7). The Ogallala Aquifer is distinctive from other aquifers in Kansas in that it generally has low annual recharge. The Dakota Aquifer is present in the region but is seldom used due to high mineral content.

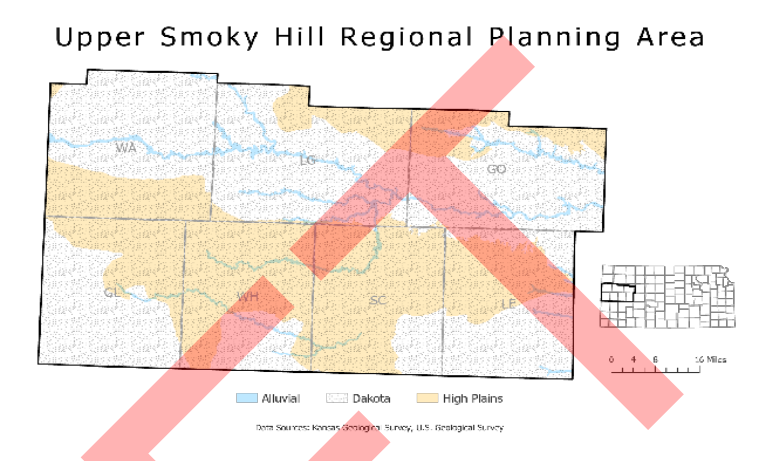


Figure 6. Principle aquifer boundaries in the Upper Smoky Hill Region

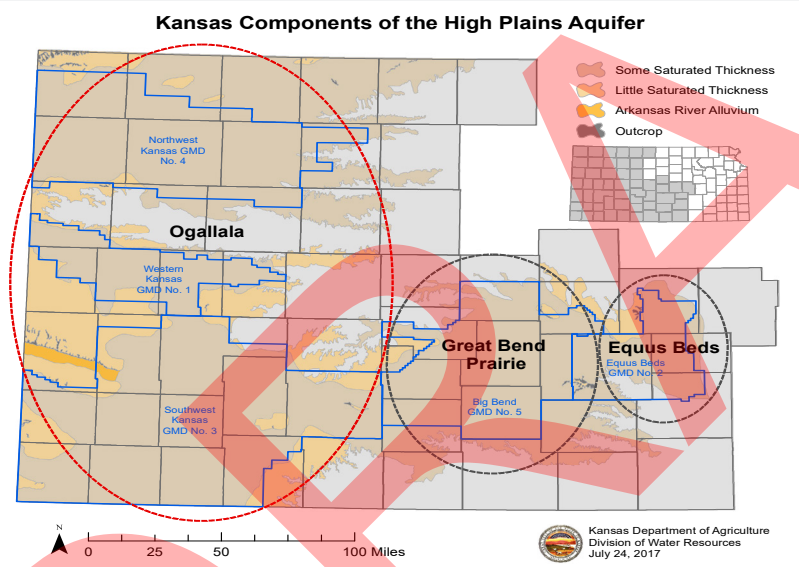


Figure 7. Kansas Components of the High Plains Aquifer, KDA

Primary Water Use by Source

GROUNDWATER

Groundwater is the primary source of water in the region, accounting for nearly 100% of the total supply, principally from the Ogallala Aquifer and alluvial deposits along major streams with very limited use of the Dakota Aquifer. Irrigation use accounts for 94% of the reported water use of the region, with 5% used for stockwater, and 1% used for municipal use (Figure 8).

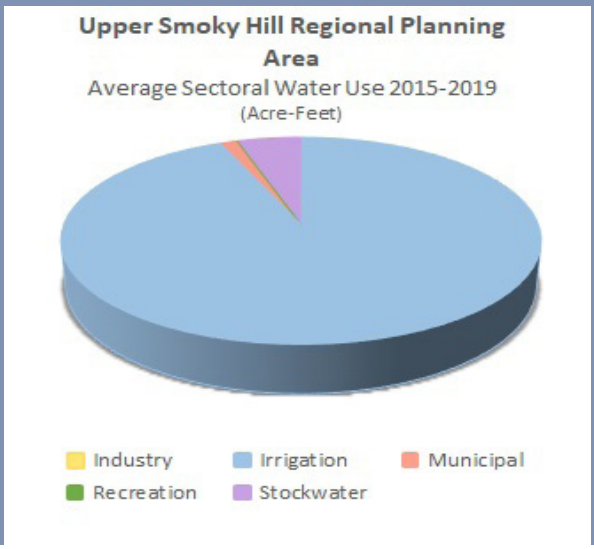


Figure 8. Average sectoral water usage

Upper Smoky Hill Region

Regional Issues & Priorities

Water resource management challenges in the Upper Smoky Hill Region include management of the Ogallala Aquifer and the administration of the Upper Smoky Hill River Intensive Groundwater Use Control Areas (IGUCA).

OGALLALA AQUIFER LEVEL DECLINES

Since the 1970s, the Ogallala Aquifer has been developed so extensively that the amount of water withdrawn annually is significantly more than the recharge, resulting in severe groundwater declines. Within the Upper Smoky Hill Region declines over the last 20 years have ranged from 20 to 50+ feet in portions of Scott, Wichita, Greeley and Wallace counties (Figure 9). Some areas are already experiencing shortages in meeting demand. As groundwater levels decline, the aquifer loses hydraulic connection with the overlying alluvial aquifers and rivers and no longer maintain much, if any, base streamflow. This loss of hydraulic connection between surface and groundwater within the region has caused streams to dry up outside of rain events.

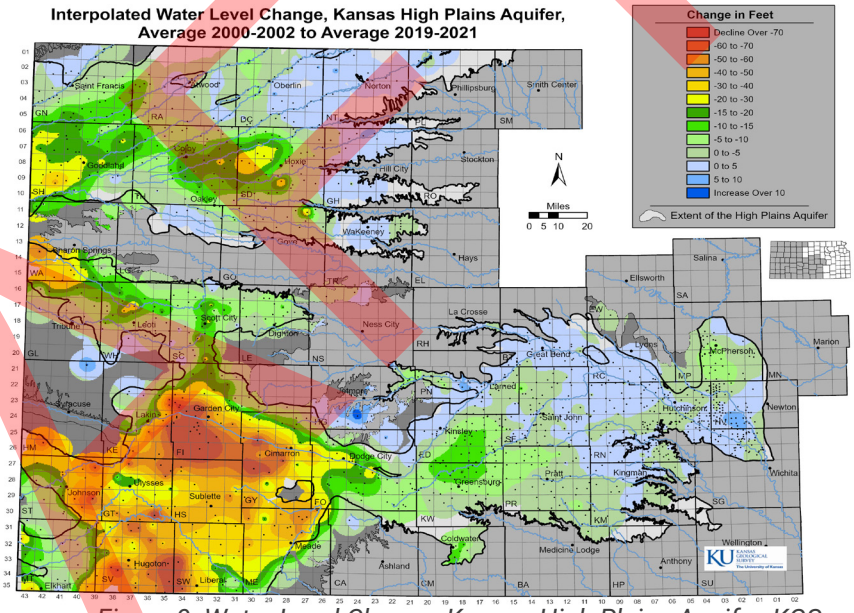


Figure 9. Water Level Change, Kansas High Plains Aquifer, KGS

Groundwater Management District No. 1 (GMD1) is a water management entity in the region, where it overlies the Ogallala-High Plains Aquifer in Wallace, Greeley, Wichita, Scott, and Lane counties. GMD1, formed in 1972, is proactive in developing local water policy to conserve water compatible with state laws.

Water appropriations and use are regulated by the Kansas Department of Agriculture-Division of Water Resources (KDA-DWR). All of the streams and alluvial corridors in the region are either closed to new appropriations or new appropriations are restricted. Minimum Desirable Streamflow (MDS) has not been set at any sites in the region, though many streams now flow only during rainfall events. Generally, the Ogallala Aquifer has no new appropriations available. In limited cases, a new water appropriation for groundwater, limited to quantities under 15 acre-feet, can be obtained by meeting some very specific criteria within GMD1.

REGIONAL WATER CONSERVATION EFFORTS

WATER CONSERVATION AREAS & LOCAL ENHANCED MANAGEMENT AREAS

The State of Kansas has developed a number of tools and resources to provide water rights owners multiple mechanisms to conserve and extend the High Plains Aquifer. Two such tools include Water Conservation Areas (WCAs) and Local Enhanced Management Areas (LEMAs).

WCAs were signed into law in April 2015 and are a simple and flexible tool that allows any water right owner or group of owners the opportunity to develop a management plan to reduce withdrawals in an effort to extend the usable life of the Ogallala Aquifer. As of late 2020, there were nearly 17,000 irrigated acres under conservation within the Upper Smoky Hill Regional Planning Area enrolled as a WCA.

Upper Smoky Hill Region

LEMAs are plans initiated by groundwater GMDs, based on input from the local community of farmers, ranchers and other water users, to conserve water and extend the useful life of the High Plains aquifer. To ensure these plans are enforceable and consistent with state law, the plans require approval from the Division of Water Resources chief engineer through a public hearing process. LEMAs give Kansas farmers and ranchers the opportunity to develop water conservation plans that meets their needs.
LEMAs are an alternative to an Intensive Groundwater Use Control Area (IGUCA).

In March 2020, GMD1 submitted an initial request to establish a LEMA covering Wichita County within the district's boundary with a goal of reducing water usage within the LEMA boundary by 25%. The formal LEMA process moved forward from submittal of this initial request, with Chief Engineer ultimately signing the Order of Designation to create the Wichita County LEMA on February 2, 2021, effective through December 31, 2025.

Field Day at Circle C Farms, 2019.

UPPER SMOKY HILL RIVER IGUCA

The Chief Engineer ordered IGUCA for two sections of the Smoky Hill River, closing the Smoky Hill River corridor to further ground or surface water appropriations (Figure 10). An IGUCA can provide more comprehensive water management tools than provided under strict water right administration based on priority.

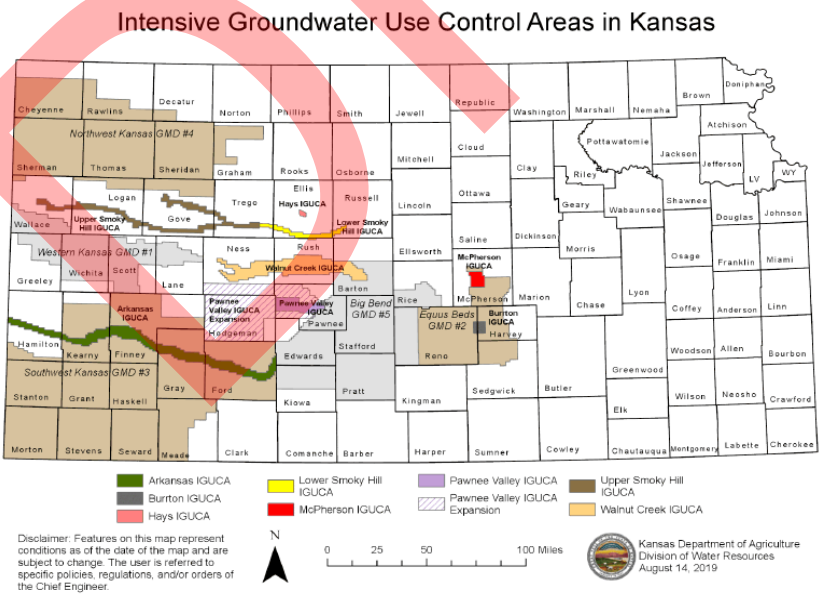


Figure 10. IGUCA within Kansas

The Upper Smoky Hill IGUCA was initiated in 1988 due to groundwater levels in portions of the Smoky Hill River Alluvium declining, such as the reduced flow seen above Cedar Bluff Reservoir. Streamflow declines were primarily due to hydrologic effects of pumping from the alluvial valley, as well as conservation practice implementation limiting runoff during precipitations events. Conditions such as these decreased overall recharge opportunities to the alluvium in the area, creating conditions which

Upper Smoky Hill Region

Water Technology Farms

KWO Water Technology Farms (Water Tech Farms) are pilot public-private partnerships with producers where irrigation technology is demonstrated, related research is conducted on the field scale, and water conservation is supported. There are currently three Water Tech Farms in the region (Figure 9). Circle C Farms, located in Scott and Lane Counties, was the first in the region to participate in the program, starting in 2017. The following year, Long Farm, located in Wichita County, enrolled. In 2019, Homeland Farms in Greeley County was the third to join the program. All three of the Water Tech Farms have been crucial to the region in providing valuable information on expanding the conversation and education of producers and decision makers on water conservation in the area.

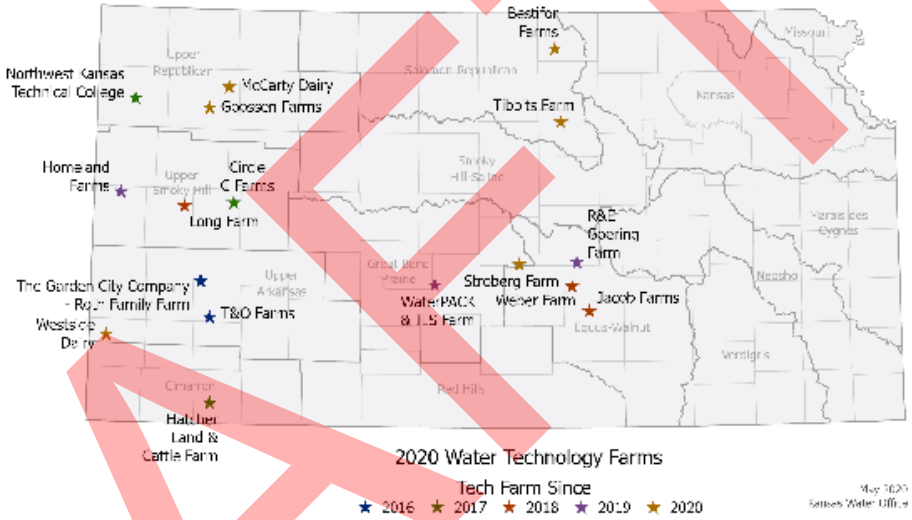


Figure 11. Water Technology Farm locations within Kansas

GROUNDWATER RECHARGE AND SUSTAINABILITY PROJECT (GRASP)

Groundwater Recharge and Sustainability Project (GRASP) is partnership formed in Greeley and Wichita counties to help address the declining water supply in the region from a local effort. They were approved for a Regional Conservation Partnership Program (RCPP) from Natural Resources Conservation Service (NRCS). The project helps landowners voluntarily restore playas near municipal and domestic wells, improve irrigation efficiency, reducing pumping, retire wells, and transition to dryland cropping systems. It is designed to work with the existing water conservation efforts in the region, like the Wichita County Water Conservation Area (WCA) and the Wichita County LEMA. By restoring and protecting playas, GRASP believes it will help recharge the aquifer and provide cleaner water through natural filtration processes, as well as, provide habitat for wildlife and create an environment for recreational activities.

Upper Smoky Hill Region

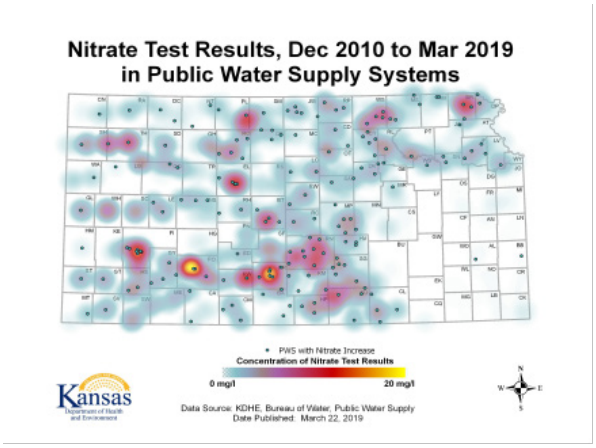
Livestock Water Recycling/Reuse

Confined Animal Feeding Operations (CAFO) play a vital role in the region economically. Over the years CAFO's in the region have increased in numbers, with several expanding in size. With such growth, utilization of resources has increased causing operations to look into exploring ways to help conserve and implement water reclamation systems. One of the largest commercial feedlots in the region is Poky Feeders., located in Scott County. Poky Feeders currently utilizes a water tank overflow recycling system that catches overflows. The captured overflows are filtered and treated for reuse.

Increased utilization and adoption of alternative crops that require less water and are more drought tolerant, provide the potential to lessen demand on groundwater resources within the region as well as provide sources of locally grown livestock feed for utilization within the Upper Smoky Hill Region and elsewhere within and outside Kansas borders. Continued research and development on livestock feeding with less water-intensive crops as well as advances in plant breeding provide the opportunity to improve water resource management within the region and enhance markets for regionally-grown feed produced with a low water footprint. There have been some discussions in recent years between cattle feeders and producers within Wichita County about the possibility of producing much greater quantities of sorghum silage as an alternative to corn silage. Sorghum silage is generally more drought tolerant and acceptable yields can be achieved with less water application. Economic considerations are a very important factor in this decision and can vary significantly from year to year.

WATER QUALITY

A groundwater quality concern within the region is the elevated levels of nitrates being detected in public water supply wells. The Environmental Protection Agency (EPA) Drinking Water Regulations set a limit of 10 mg/L for nitrate, which is monitored and enforced by the Kansas Department of Health and Environment (KDHE).



All counties within the region have adopted and are enforcing sanitary codes that can help to manage bacteria and nutrient inputs in surface and groundwater. All conservation districts in the region have adopted nonpoint source pollution management plans.

The Clean Water Act (CWA) requires states to conduct Total Maximum Daily Load (TMDL) studies and develop TMDLs for water bodies identified on the state's List of Impaired Waters (Section 303(d) List). TMDLs are quantitative objectives and strategies needed to achieve the state's surface water quality standards. TMDLs have been developed to address dissolved oxygen, total phosphorus, and eutrophic conditions as the highest priority impairments. Other pollutants limiting use of Upper Smoky-Hill streams include fecal coliform bacteria, fluoride, selenium, pH, and sulfate.

The Goals and Action Plans contained herein are as developed by the Regional Advisory Committee.

Upper Smoky Hill Advisory Committee

Regional Goals & Action Plans

Priority Goal #1:
Work with agencies to identify areas within the region that have similar aquifer characteristics and establish long-term use levels that will extend the useful life of the aquifer in those areas until 2070.

ACTION STEPS:

- Support implementation of the Wichita County LEMA submitted by GMD1.
- Support implementation of the Groundwater Recharge and Sustainability Project (GRASP) RCPP that was recently approved.
- Continue to support enrollment in the Wichita County Water Conservation Area (WCA).
- Provide recommendations to GMD1 for additional LEMAs based upon the information developed by KGS for the proposed revision of Goal #1.
- Support Kansas Department of Agriculture (KDA) and other agencies in exploring options on ways to help citizen groups submit conservation proposals for LEMAs and other tools to the Chief Engineer.
- Establish methods for local producers that will identify provisions within USDA farm programs that conflict with Goal #1. This would include crop insurance and loan programs.
- Education:
  a. Provide education and outreach to crop consultants concerning specific information on water use reductions and technologies available to achieve water conservation related to irrigated crop production.
  b. Conduct seminars with local agricultural lenders to explain the purpose and implementation of Goal #1.
  c. Publish an annual report for the region showing annual water use and trends in irrigation use and aquifer levels.

Measuring success:

Goal 1: Increase adoption of irrigation technology within the region as well as Future WCA and LEMA establishment to help create a positive impact on the aquifer.

Upper Smoky Hill Advisory Committee

Regional Goals & Action Plans

Priority Goal #2: Encourage public water supplies within the planning region to complete studies of municipal water consumption and develop goals and plans for conservation by 2025.

ACTION STEPS:

- Assemble information about programs and grants that are available from state agencies and related entities (Kansas Water Office (KWO), KDHE, Kansas Rural Water Association (KRWA)) to evaluate water consumption and quality; identify sources of waste; plan and fund infrastructure improvements; and provide incentives to establish landscaping with lower water requirements.
- Provide information and education on how rate structures can provide incentives for water conservation.
- Education may include presentations to city governing bodies on remaining aquifer life and the process for acquiring water rights and changing existing beneficial use to municipal use.

Measuring success:

Goal 2: Determine number of public water suppliers with some form of water conservation-related goals and/or plans currently, track progress on efforts over the course of KWP implementation.

Upper Smoky Hill Advisory Committee

Regional Goals & Action Plans

Priority Goal #3: Encourage the implementation of water conservation measures at confined animal feeding operations (CAFOs) in the region.

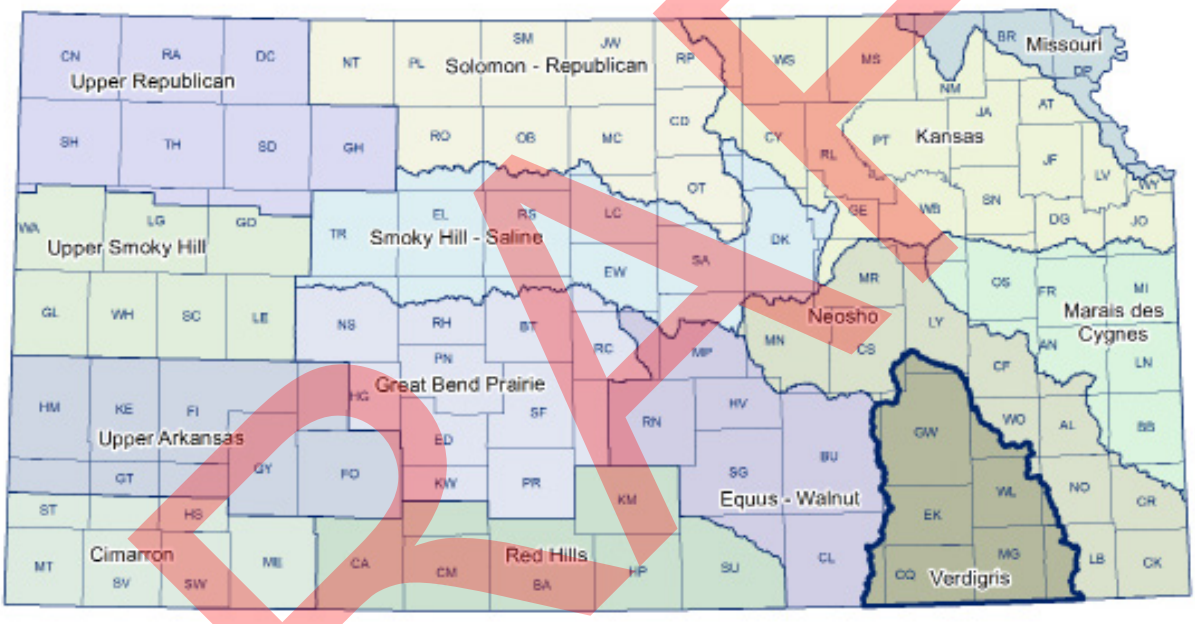
ACTION STEPS:

- Investigate and determine the most effective format for sharing information about water treatment and recycling systems with CAFO owners and managers. Note that this may include field days, online posts and videos, and presentations to companies and producer organizations.
- Provide information on existing technology and vendors for water conservation systems:
  a. Water tank overflow treatment and recycling systems.
  b. Water tanks and fountains that do not require continuous overflow.
  c. Devices that regulate overflows based on water temperature.
- Determine the availability of programs and funding for research of technology for wastewater treatment and reuse for livestock consumption. This includes evaluation of livestock health impacts associated with such systems.

Measuring success:

Goal 3: Education/Outreach on water treatment and recycling systems with CAFO owners and managers. Establish baseline adoption of water conservation efforts in place - track change in conservation measures over time.

Verdigris Region



Verdigris Region

Regional Description

The Verdigris Regional Planning Area in Kansas covers approximately 4,372 square miles and encompasses all or parts of 11 counties in southeast Kansas (Figure 1). The Verdigris Region originates in the Tallgrass Prairie ecoregion and continues into Oklahoma's Oolagah Reservoir, a major drinking water supply storage for the City of Tulsa, Oklahoma. Approximately two-thirds of the watershed above this reservoir is in Kansas, making discharge of quality water across the state line a priority for the Verdigris Region.

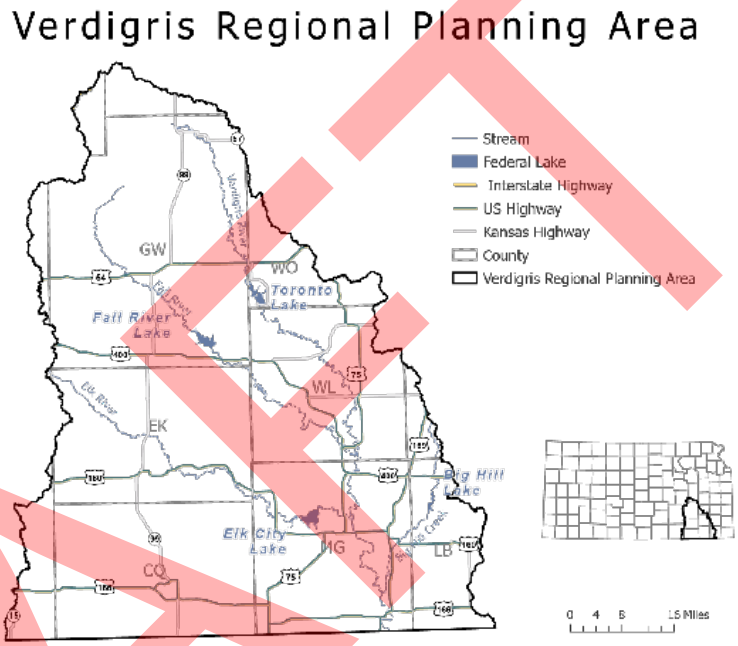


Figure 1. Verdigris Regional Planning Area map

CLIMATE & LAND USE

Annual precipitation in the Verdigris Region varies from approximately 35 inches in the west to almost 46 inches in the southeast corner of the region (Figure 2). Approximately 70% falls between April and September. The region has an average annual snow fall of between 11 and 18 inches. The average temperature varies from 34 degrees in the winter to 79 degrees in the summer. Surface and groundwater resources within the Verdigris Region suffered from lower than normal precipitation from 2010 to 2016. Due to drought conditions in 2011, water use peaked at almost 21,000 acre-feet for the region.

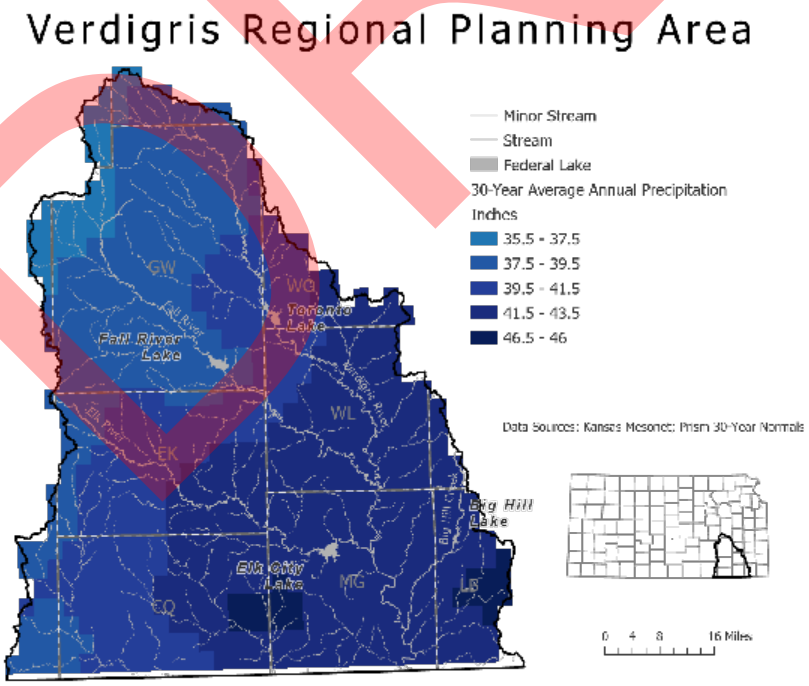


Figure 2. 30-year average annual precipitation in the Verdigris Region

Land use activities can have a significant impact on the Verdigris Region. The three major land uses in this region are herbaceous (43%), hay/pasture (25%) and deciduous forest (13%) as derived from the National Land Cover Database (NLCD) 2016 dataset. Figure 3 lists the remaining land uses in the region, including: cultivated crops, developed/urban open space, and water.

Verdigris Region

Most of the land use is agriculture, either grazing, haying or crop production (see Figure 3). Most of the crops are grown in the floodplains of the Verdigris River and its tributaries. Natural vegetation transitions from mostly tallgrass prairie in the west to a combination of tallgrass prairie and oak hickory woodland in the east. Upland forests are dominated by shagbark hickory, bitternut hickory, red oak, white oak, and black oak, with Ohio buckeye, American bladderpod, and pawpaw common understory trees. A remnant of the Cross Timbers Forest, a complex mosaic of upland deciduous forest, savanna, and prairie that occur across central Oklahoma north into Kansas and south into Texas, are found in the region.

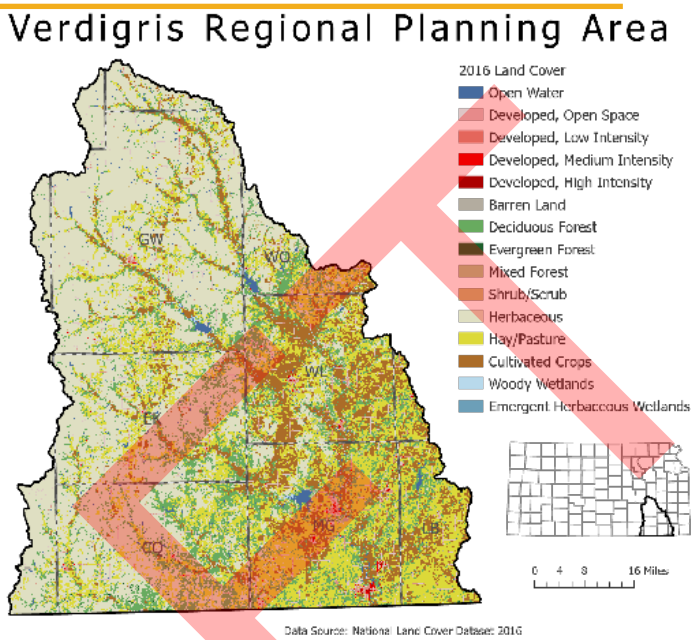


Figure 3. Verdigris regional land cover

POPULATION & ECONOMY

According to the 2010 Census, there were an estimated 63,651residents in the Verdigris Region. Based upon 2019 information derived from state-released information to the U.S. Census Bureau, there were an estimated 70,858 residents in the region, an increase of about 11 percent. For counties in which only a portion of the area falls within the region, the population estimates were calculated by first determining the total area and estimated population of the respective county then multiplying that population by the proportion of the county within the Regional Planning Area. For these areas, population estimates could be over or under represented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census (Figure 4).

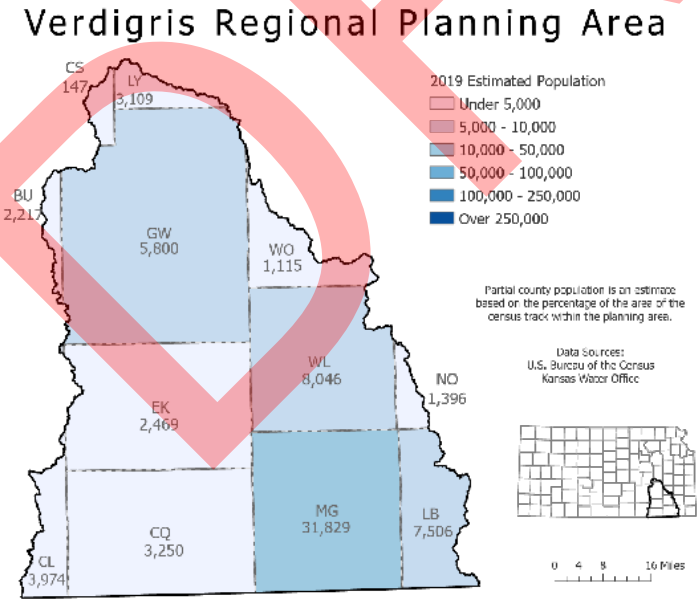


Figure 4. 2019 estimated population by county

Major population centers include Independence, Coffeyville, Eureka, Neodesha and Fredonia. Outside of major population centers, the population remains generally rural with small agricultural communities.

The economy is primarily agriculture-based with some manufacturing and industrial contributions. Such industrial facilities include Cobalt Boats production facility in Neodesha and Coffeyville Resources oil refinery in Coffeyville. In December 2019, Phoenix Investors LLC purchased an 880,000 square-foot on 105 acres warehouse in Coffeyville.

Verdigris Region

Array Technologies Inc., a designer and manufacturer of solar tracking systems based in Albuquerque, N.M., will lease the entire Coffeyville building to distribute its equipment that tracks sunlight to orient solar cells. Agriculture has become less diverse, with the major crops grown being wheat, corn, and soybeans. The production of beef cattle remains an important part of the agricultural economy.

Education, health and social services, forestry and mining also contribute to the region economy. Another significant contributor is the production of oil and gas. Brine scars continue to be an issue and are a priority focus for the Toronto and Fall River Watershed Restoration and Protection Strategy (WRAPS) areas. Likewise, injection wells are used to dispose of oil-field brines and, in a few cases, industrial wastes by injecting them into deep, brine-containing aquifers where there is no significant probability that they will contaminate usable groundwater. Underground injection is currently regulated by the Kansas Corporation Commission (KCC) (disposal of produced oil brines) and the Kansas Department of Health and Environment (KDHE) (disposal of hazardous and industrial fluid wastes) with oversight from the U.S. Environmental Protection Agency (EPA). Many abandoned wells dot the landscape in the region. The Caney River Wind Farm, with 111 turbines on 14,000 acres, was developed in Elk County starting the autumn of 2011 and is an economic contributor to the region.

Toronto Lake Overlook Trail. Photo Credit: Tim Gillen, October 2017

The four federal reservoirs in the region, Fall River Lake, Toronto Lake, Elk City Lake, and Big Hill Lake, offer water-based recreation, hunting and other opportunities for experiencing natural environments. The recreational resources these reservoirs provide are important to the local economy as visitors purchase amenities while in the area.

Primary Water Resources in the Region

SURFACE WATER

Located in southeast Kansas, the Verdigris River is a tributary of the Arkansas River. The Verdigris River mainstem rises to the east of the Arkansas mainstem in the southeastern corner of Chase County and flows in a south-southeasterly direction for about 350 miles to its junction with the Arkansas River near Muskogee, Oklahoma, after leaving Kansas south of Coffeyville (Figure 5).

Four federal reservoirs were constructed in the region between 1949 and 1981; from oldest to youngest they are Fall River, Toronto, Elk City and Big Hill. Other major streams in the region are the Elk, Fall, Caney and Little Caney rivers, and Big Hill and Caney creeks. Elk and Fall rivers and Big Hill Creek are tributaries to the Verdigris River in Kansas, while the Caneys join the river in Oklahoma.

Verdigris Region

Releases are made from federal reservoirs in the region to satisfy downstream water supply needs in accordance with a Memorandum of Agreement (MOA) between the Kansas Water Office (KWO) and the Kansas Department of Agriculture-Division of Water Resources (KDA-DWR). The MOA specifies that water needs in the upper portion of the region are satisfied with releases from Fall River and Toronto reservoirs. Water needs in the lower part of the region, below the confluence of Elk River with the Verdigris River, are satisfied with releases from Elk City Reservoir. Water supply storage in Elk City Reservoir is used by the City of Coffeyville and Coffeyville Resources through water marketing contracts. Development of a Water Assurance District has been discussed periodically since the authorizing legislation was passed. No district has been formed at this time.

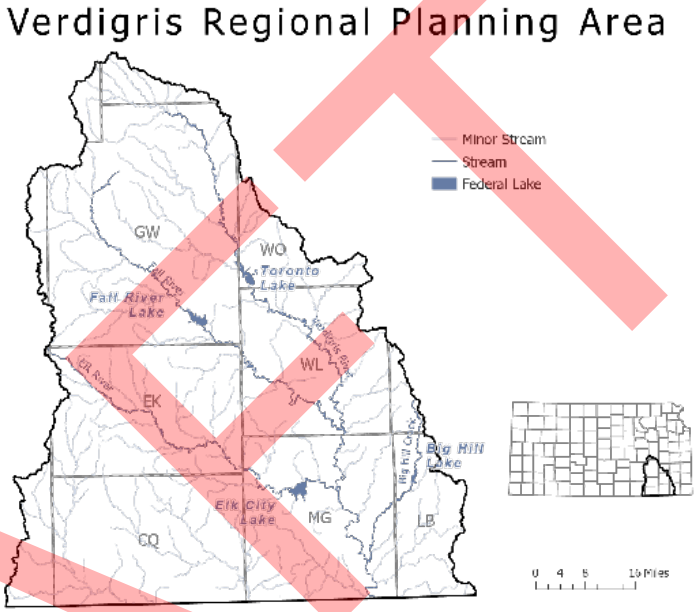


Figure 5. Major surface water resources in the Verdigris Region

In 2019, the U.S. Army Corps of Engineers (USACE) performed an economic analysis of recreation at three reservoir projects within the region: Elk City Lake, Fall River Lake, and Toronto Lake. Four components were analyzed to estimate economic effects: recreation spending, visitor use estimates, capture rates and economic multipliers. These three reservoirs had a combined 402,174 visits in 2019. These visits were estimated to produce $9.90 million in total direct sales along with $4.38 million in value added through wages, salaries, payroll benefits, profits, rents and taxes. The three reservoirs were estimated to support 138 jobs in local communities.

GROUNDWATER

Groundwater supplies are quite limited in the basin, occurring mostly in alluvial aquifers. Water for municipal, industrial, and irrigation supplies generally can be obtained in limited quantities from the alluvial deposits in the stream valleys. Except for water in the alluvial deposits in the stream valleys and in the outcrop areas of the bedrock aquifers, the groundwater generally has poor chemical quality. Due to the generally poor chemical quality of water and low yields to wells, an increase in the use of groundwater is improbable.

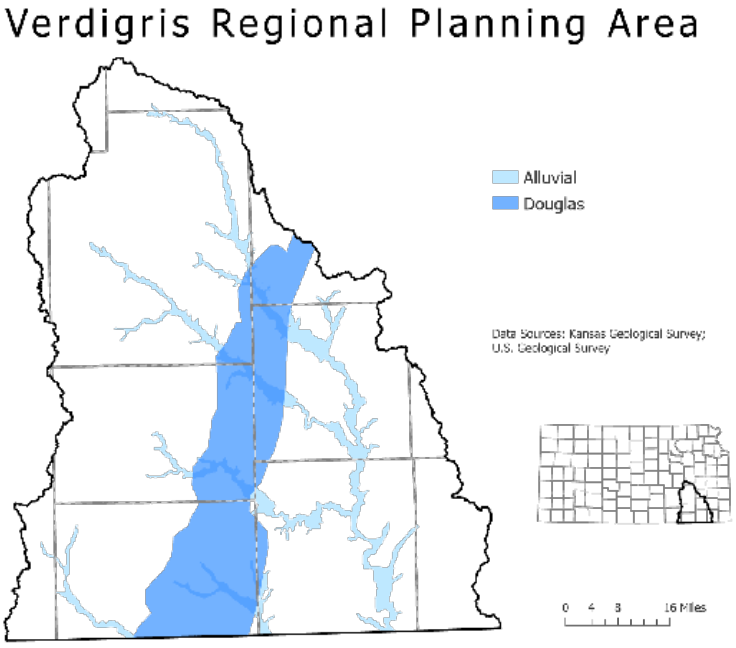


Figure 6. Principle aquifer boundaries in the Verdigris Region

The Douglas Aquifer is composed of several alternating layers of sandstone,

Verdigris Region

limestone, and shale. The aquifer system consists of fluvial sandstone that provide small quantities of groundwater (Figure 6). The aquifer does not provide substantial amounts of water except for a few areas where sandstones are thick enough for fresh water to occur. The Douglas Aquifer is utilized mostly for domestic and stock wells, and other relatively isolated, low-volume uses.

Primary Water Use by Source

SURFACE WATER

Reservoirs, community lakes, and streams in the Verdigris Region provide water for municipal and industrial water supply, irrigation, recreation, and aquatic life.

Surface water is the primary source of water within the Verdigris Region, accounting for approximately 99% of the total reported water use. Groundwater sources within the region are the alluvial deposits along major streams and are not a primary water source (<1%).

Municipal use (58%) is the primary use for surface water sources within the region. Other reported surface water use within the region includes industrial (36%), irrigation (5%), and stockwater (<1%) (Figure 7).

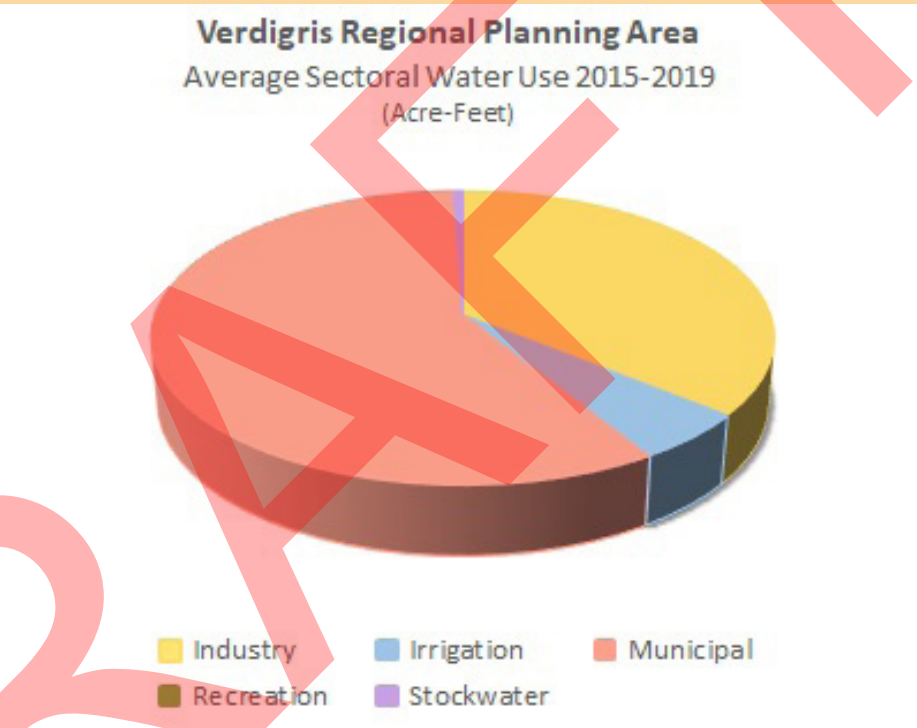


Figure 7. Average sectoral water usage

Regional Issues & Priorities

WATER SUPPLY AVAILABILTY

All streams in this region are restricted so that no new direct diversion appropriation rights are available from July to September (typically the irrigation season) unless an alternate source of water is available (usually a pond or other off-stream storage device). This pertains to regulation K.A.R. 5-3-15, which went into effect on November 28, 1994. KWO supply and demand analysis indicates that demand for water could exceed existing supplies in the region within the next 50 years during a two percent probability drought similar to the 1950s.

The black dashed line in Figure 8 represents current system operations, resulting in insufficient storage as early as 2041. The red line represents improvements and efficiencies that have been identified and are being pursued by the KWO.

Verdigris Region

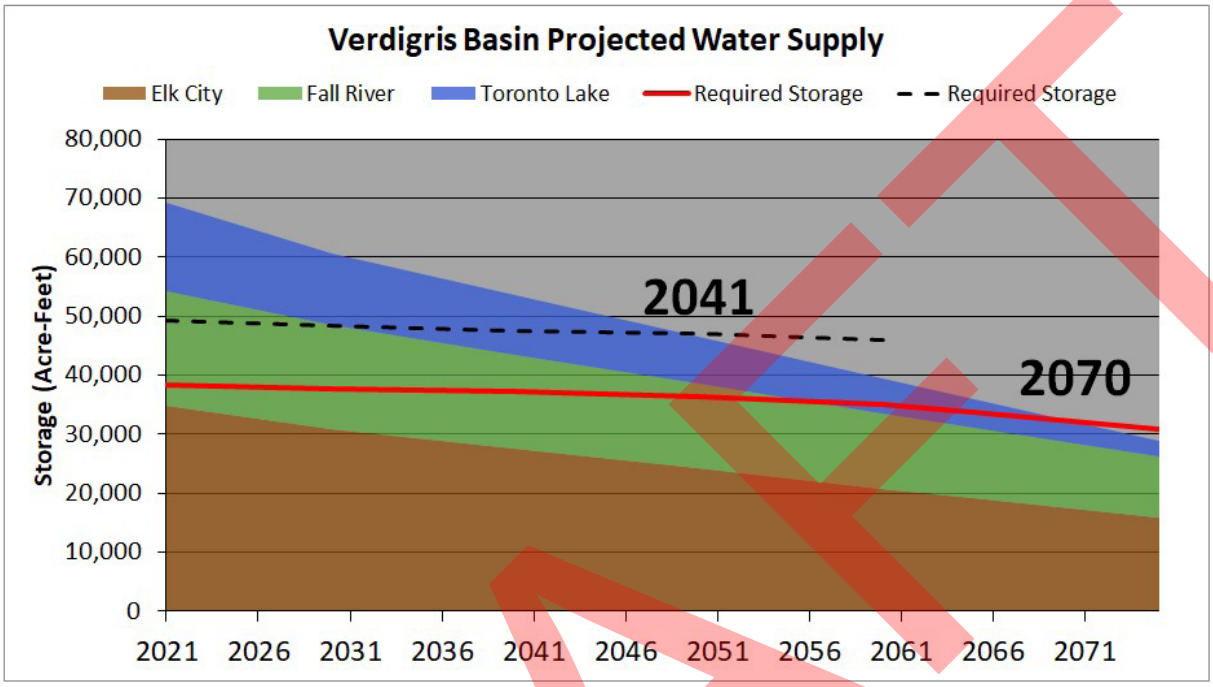


Figure 8. Verdigris Basin Projected Water Supply

The sedimentation rate within the Verdigris Region is partly due to streambank erosion above each reservoir (Figure 9). Currently, there are 68 streambank hotspots within the region and two of these 68 sites have been stabilized, reducing the sediment load by an estimated 246 tons per year. There are 66 sites that remain to be completed and if completed, will reduce the sediment load by an additional estimated 79,333 tons per year. Additionally, Best Management Practices (BMPs), such as no-till agriculture and cover crops, are being promoted and implemented throughout the region, further reducing the sedimentation rate.

Where there are water users that depend on reservoir storage as water supply, sufficient water quantity and good water quality

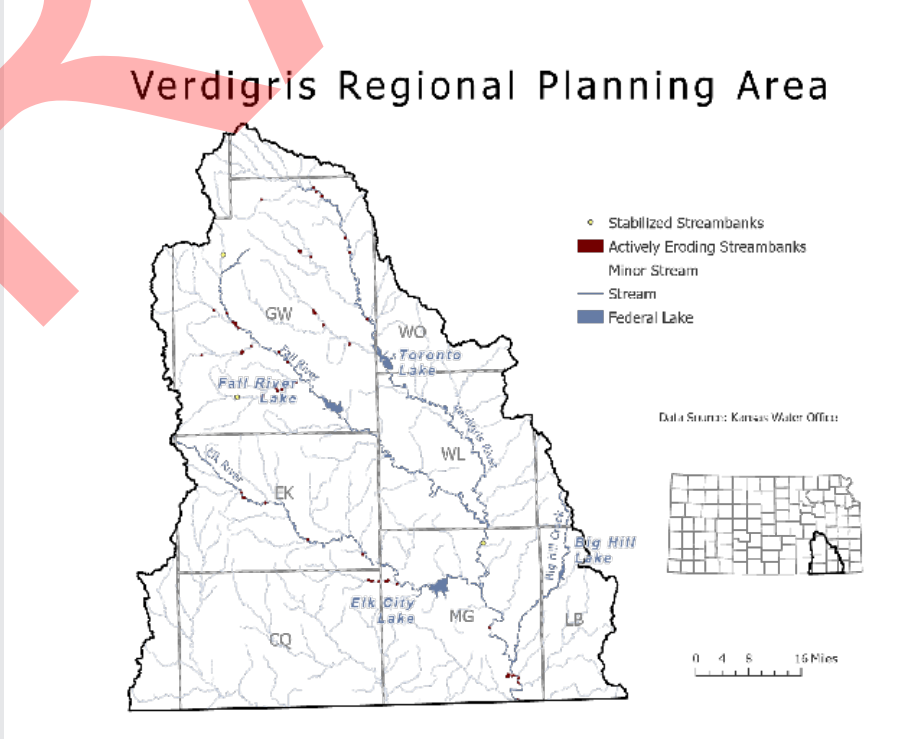


Figure 9. Actively eroding and stabilized streambanks in the Verdigris Region

Verdigris Region

are important. Sedimentation of the reservoirs is an issue in the region (Figure 10). This sedimentation is often caused by accelerated erosion due to human activities (deforestation, poor agricultural practices, construction, altering native prairie regions, etc). As sediment accumulates in a reservoir's multi-purpose pool, the capacity for water supply storage is reduced. The water quality dimension derives from the silt and clay fraction as a primary carrier of adsorbed chemicals, especially phosphorus, chlorinated pesticides and most metals, which are transported by sediment into the aquatic system.

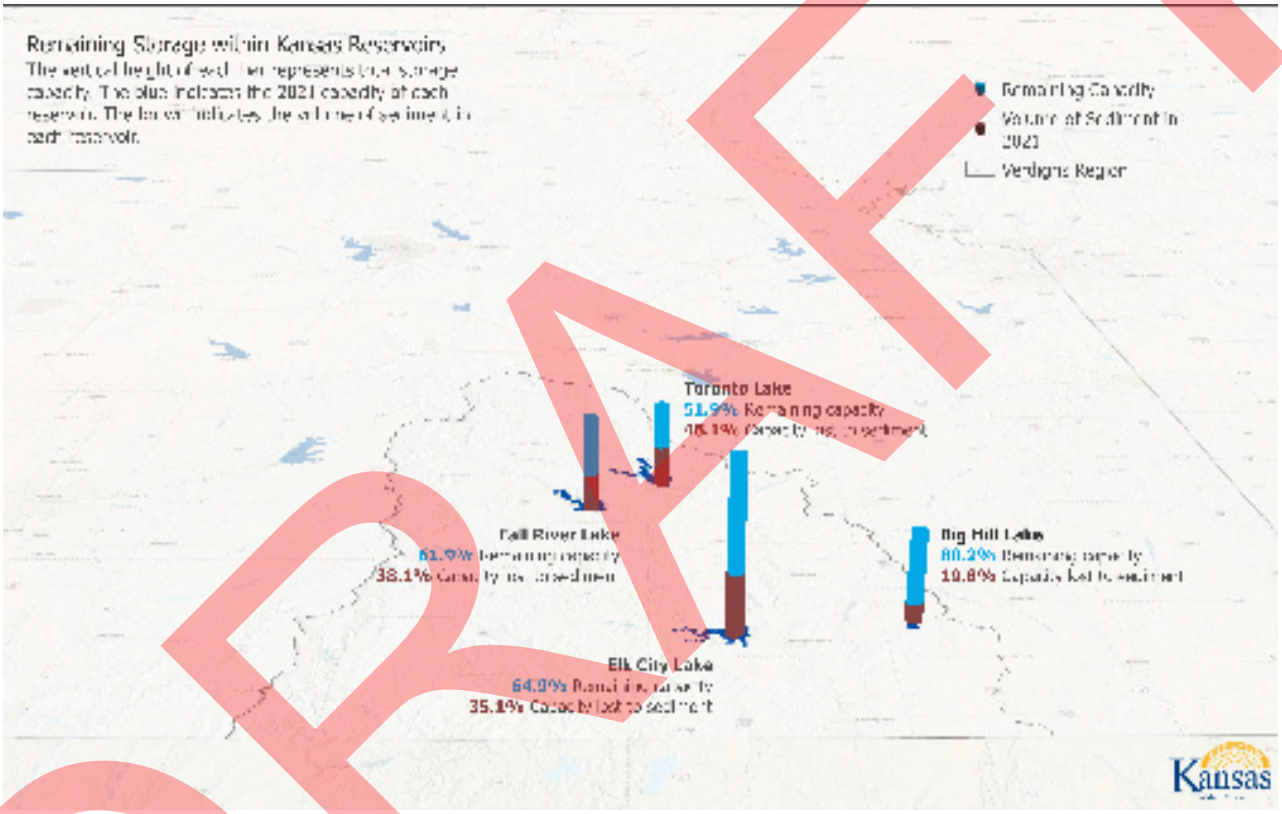


Figure 10. Remaining storage within Kansas reservoirs in the Verdigris Region.

Verdigris Region

WATER QUALITY

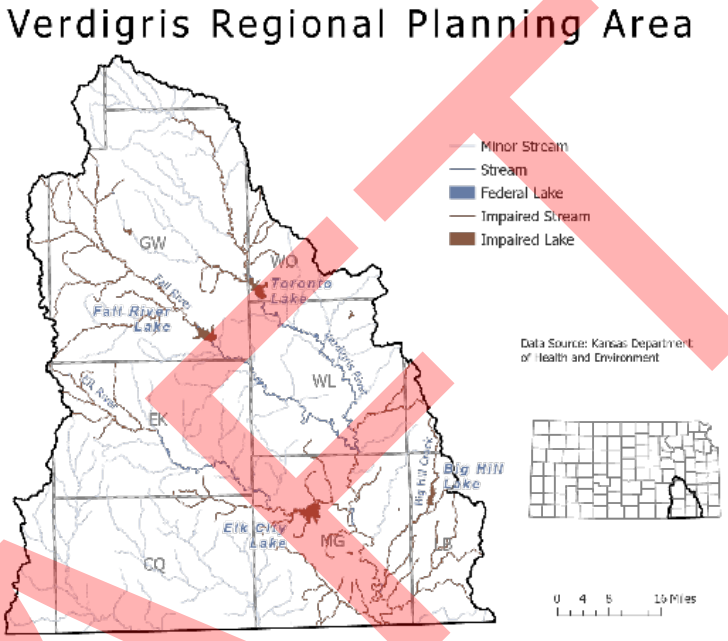


Figure 11. Impaired water resources in the Verdigris Region

The State of Kansas collects ambient surface water quality information throughout the basin. Surface water not meeting water quality standards established for the designated uses of those water bodies are included on the State's list of impaired waters. Water quality and related water resource issues are addressed through a combination of watershed restoration and resource protection efforts utilizing voluntary, incentive-based approaches, as well as regulatory programs. The Clean Water Act requires states to conduct Total Maximum Daily Load (TMDL) studies and develop TMDLs for water bodies identified on the State's List of Impaired Waters (Section 303(d) List). TMDLs are quantitative objectives and strategies needed to achieve the state's surface water quality standards. A list of all impaired/potentially impaired water for the Verdigris Region can be found on the KDHE impaired waters website.

Many streams within the region are experiencing water quality impairments (Figure 11). E. coli bacteria and low levels of dissolved oxygen are the most prevalent stream impairments. The 2020 303(d) list for the Verdigris Region had 23 stream impairments and 28 lake impairments. KDHE, under the directive of EPA, continues to monitor and work to delist the waterbodies In the Verdigris Region, all four of the federal reservoirs have a TMDL. Big Hill Lake has an eutrophication TMDL, Elk City Lake has both siltation and eutrophication TMDLs, Fall River has fecal coliform bacteria, dissolved oxygen, siltation, and eutrophication TMDLs, and Toronto Lake has dissolved oxygen, siltation, and eutrophication TMDLs. The KDHE Watershed Planning section of the Bureau of Water **maintains** current information on their website.

Verdigris River Bridge, Independence. Photo Credit: John Marvig Railroad Bridge Photography

Verdigris Region

WATERSHED RESTORATION AND PROTECTION STRATEGY (WRAPS)

Water quality and related water resource issues are addressed through a combination of Watershed Restoration and Protection Strategy (WRAPS) efforts utilizing voluntary, incentive-based approaches, as well as regulatory programs. The restoration and protection of watersheds, particularly those watersheds above public water supply reservoirs, is a priority in the Verdigris Region (Figure 12). The Verdigris and Caney rivers drain south into Oklahoma so interstate water quality issues are also important to ensure high quality water crossing the state line.

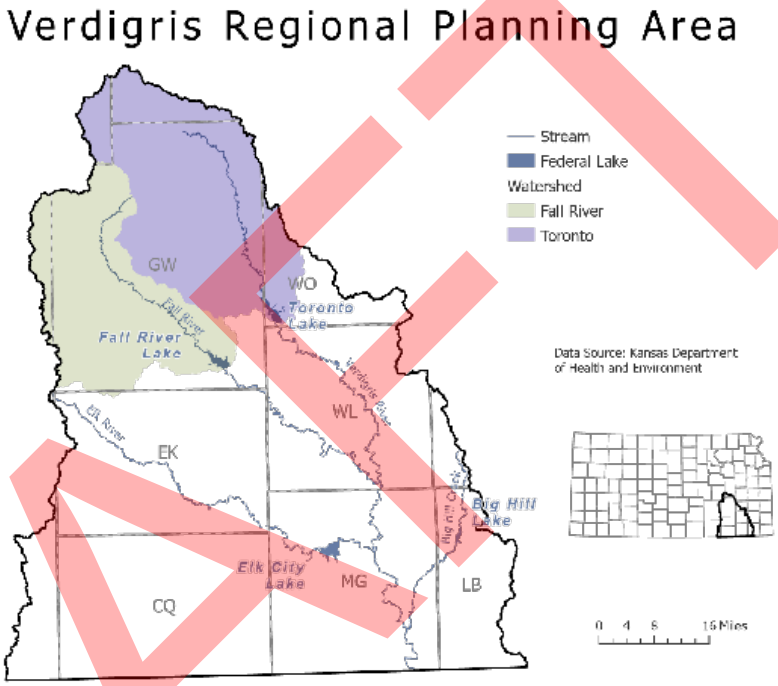


Figure 12. WRAPS areas by watershed in the Verdigris Region

WILDLIFE HABITAT

The Verdigris River and associated tributaries have been experiencing increasingly frequent occurrences of low flow conditions. Low flows have caused aquatic life stress and impaired water quality. Threatened and endangered species, especially native mussels, in the Verdigris River system are impacted by these conditions.

Zebra mussels, one of the Aquatic Nuisance Species (ANS) affecting Kansas waters, are not found in the federal reservoirs within the Verdigris Region. ANS affect the quality of water and recreational opportunities within the State of Kansas. The Kansas Department of Wildlife and Parks (KDWP) has worked diligently on their ANS education and management plan in order to mitigate the problem and work to slow the migration. Since the Verdigris Region is one of the few regions that are not infested with Zebra mussels, those using the water resources in the region need to be diligent about not spreading Zebra mussels from other regions to uninfested water. The KDWP has a full list of infested waters and how to stop the spread of ANS on their website.

The Goals and Action Plans contained herein are as developed by the Regional Advisory Committee.

Verdigris Regional Advisory Committee

Regional Goals & Action Plans

Priority Goal #1: Increase drought tolerance in the Verdigris basin by optimizing reservoir releases and maintaining storage capacity.

ACTION STEPS:

- Encourage agencies and private entities to work with water users to improve intake and utilization efficiencies.
- Evaluate ways to pass accumulated sediment through reservoirs.
- Continue to promote the use of sediment-reducing BMPs above water supply reservoirs.
- The KWO will continue to find ways to optimize reservoir operations and mitigate the effects of drought.

Measuring success:

Goal 1: Improve BMP implementation and demonstrate progress towards achievement of water quality milestones and reservoir sediment management.

Verdigris Regional Advisory Committee

Regional Goals & Action Plans

Priority Goal #2: Protect watershed dam functions.

ACTION STEPS:

- Evaluate the structural and financial health of watershed districts within the region.
- Utilize results of the evaluation to identify ways to maintain or improve the functionality of existing structures.

Measuring success:

Goal 2: Demonstrate structural and financial health of watershed districts within the region.

Verdigris Regional Advisory Committee

Regional Goals & Action Plans

ACTION STEPS:

- The KWO and the Regional Advisory Committee (RAC) will work to prevent the spread of ANS into Kansas lakes that are not currently infested, by working with the KDWP and the USACE to install four watercraft inspection and decontamination stations near the federal reservoirs within the Verdigris Region.
- The RAC will work with the KDWP and USACE on an ongoing basis to provide education for lake users concerning the spread of ANS and how to prevent it.
- The RAC will encourage funding for the ANS Program through the Kansas Water Plan Fund.

Priority Goal #3: Continually work to prevent the spread of Aquatic Nuisance Species (ANS), including Zebra and Quagga mussels, into Kansas Lakes that are not currently infested, by working with the agencies focused on ANS.

Measuring success:

Goal 3: Demonstrate progress on installation of watercraft inspection and decontamination stations near the federal reservoirs, as well no additional ANS-infested waters within the region.

Verdigris Regional Advisory Committee

Regional Goals & Action Plans

NO ACTION STEPS

- Regional and state-level entities will collaborate to share water conservation information on all available media and participate in public education and outreach events.
- Regional and state-level entities will partner with K-12 education institutions to develop and execute water conservation curriculum.

Priority Goal #4:
Improve water conservation through a public education campaign, with priority given to youth, to increase awareness and protect water supply for future generations.

Measuring success:

Goal 4: Document increase in media information-sharing, participation in water education programs for all ages within the region, and development of K - 12 water conservation curriculum.

Acronyms

KANSAS WATER PLAN

ANS: Aquatic Nuisance Species
ARCA: Arkansas River Compact Administration
ASR: Aquifer Storage and Recovery Project
AVC: Arkansas Valley Conduit
BBGMDMOD: Big Bend Groundwater Management District Model
BMP(s): Best Management Practice(s)
BNSF: Burlington Northern Santa Fe
BOR: Bureau of Reclamation
CAFO(s): Confined Animal Feeding Operation(s)
CIG: Conservation Innovation Grant
CREP: Conservation Reserve Enhancement Program
CRP: Conservation Reserve Program
CWA: Clean Water Act
EQIP: Environmental Quality Incentives Program
EPA: Environmental Protection Agency
ERPs: Emergency Response Plans
FEMA: Federal Emergency Management Agency
FHSU: Fort Hays State University
FIRM: Flood Insurance Rate Maps
FIRO: Forecast Informed Reservoir Operations
GMD(s): Groundwater Management District(s)
GPCD: Gallons Per Capita per Day
GRASP: Groundwater Recharge and Sustainability Project
HAB(s): Harmful Algal Bloom(s)
HPA: High Plains Aquifer
I&E: Information & Education
IGUCA: Intensive Groundwater Use Control Areas
KACEE: Kansas Association for Conservation & Environmental Education
KCC: Kansas Corporation Commission
KDA-DOC: Kansas Department of Agriculture-Division of Conservation
KDA-DWR: Kansas Department of Agriculture-Division of Water Resources
KDEM: Kansas Division of Emergency Management
KDHE: Kansas Department of Health & Environment

Acronyms

KANSAS WATER PLAN CONTINUED

KDWP: Kansas Department of Wildlife and Parks
KGS: Kansas Geological Survey
KRPI: Kansas Reservoir Protection Initiative
KRWA: Kansas Rural Water Association
KSRE: Kansas State Research & Extension
KSROW: Kansas Runs on Water
KSU: Kansas State University
KSWQS: Kansas Surface Water Quality Standards
KWA: Kansas Water Authority
KWO: Kansas Water Office
KWP: Kansas Water Plan
LAWMA: Lower Arkansas Water Management Association
LEED: Leadership in Energy and Environmental Design
LEMA(s): Local Enhanced Management Area(s)
MCL: Maximum Contaminant Level
MDI: Mobile Drip Irrigation
MDS: Minimum Desirable Streamflow
MEKRO: Multi-Basin Evaluation of Kansas Reservoir Operations
MOA: Memorandum of Agreement
MRRIC: Missouri River Recovery Implementation Committee
MSL: Mean Sea Level
NCEI: National Centers for Environmental Information
NFIP: National Flood Insurance Program
NGOs: Non-Governmental Organizations
NLCD: National Land Cover Database
NOAA: National Oceanic and Atmospheric Administration
NPDES: National Pollution Discharge Elimination System
NPS: Nonpoint Source
NWS: National Weather Service
OWCAP: Ogallala Water Coordinated Agriculture Project
PACE: Partnership for Agricultural Conservation and Excellence
PAS: Public Assistance to States

Acronyms

KANSAS WATER PLAN CONTINUED

PDSI: Palmer Drought Severity Index
PWS: Public Water Supply
RAC: Regional Advisory Committee
PDSI: Palmer Drought Severity Index
PWS: Public Water Supply
RAC: Regional Advisory Committee
RCPP: Regional Conservation Partnership Program
RRC: Republican River Compact
RRCA: Republican River Compact Administration
SD-6: Sheridan 6
SDI: Sub-surface Drip Irrigation
SGF: State General Fund
SWQUA: Special Water Quality Use Area
SWAT: Soil and Water Assessment Tool
SWPF: State Water Plan Fund
TA: Technical Assistance
TDS: Total Dissolved Solids
T&E: Threatened and Endangered
TMDL: Total Maximum Daily Load
TNC: The Nature Conservancy
TSS: Total Suspended Solids
USACE: United States Army Corps of Engineers
USBR: United States Bureau of Reclamation
USDA-FSA: United States Department of Agriculture-Farm Service Agency
USDA-NIFA: United States Department of Agriculture-National Institute of Food and Agriculture
USDA-NRCS: United States Department of Agriculture-Natural Resources Conservation Service
USDA-RMA: United States Department of Agriculture-Risk Management Agency
USFWS: United States Fish and Wildlife Service
WRAPS: Watershed Restoration and Protection Strategy
WRP: Wetland Reserve Program