The 2022

KANSAS WATER PLAN

Kansas Water Office | KANSAS WATER PLAN

Prepared by
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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 state agencies, local entities, individuals and stakeholders.

Many thanks go to Governor Laura Kelly, the Kansas Water Office staff and 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 and, 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 was 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 on a more frequent basis a status check on the various water issues and programs identified in the *KWP period.*

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 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 2022 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 (SWRPA): 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. This comprehensive planning must include the full spectrum of water needs of the state as a whole, including those of Kansans' health and welfare, as well as wildlife and habitat needs.

The SWRPA governs the Kansas Water Plan. K.S.A. 82a-901, *et seq*. The Kansas Water Plan, formulated by the Kansas Water Office, is to serve as a comprehensive plan for the management, conservation and development of the water resources of the state. By law (K.S.A. 82a-907), in formulating the plan, the Kansas Water Office shall consider:

The management, conservation and development of the water resources of the state for the benefit of the state as a whole;

The benefits to be derived from development of reservoir sites for the combined purposes of flood control, water supply storage and recreation;

The safeguards to public health, aquatic and animal life established in Kansas law and the Kansas water quality management plan;

Water development policies, whenever possible, consistent with the beneficial development of other natural resources;

The public health and general welfare of the people of the state;

Executive Summary

OF 2022 KANSAS WATER PLAN

All appropriation and other rights to the use of water pursuant to the Kansas Water Appropriation Act and the State Water Plan Storage Act;

The interrelationship of groundwater and surface water supplies and the effects of evapotranspiration on water supply;

The alternative plans, programs and projects in the interest of effective water resource management, conservation and development;

The means and methods for the protection of aquatic and other wildlife;

The use of waters to augment the flow of surface streams for the support of aquatic and other wildlife and to improve the water quality of the stream and to protect the public health;

The inclusion of conservation storage in reservoir development and planning for the regulation of streamflow for the purpose of quality control, such inclusion not to serve as a substitute for methods of controlling wastes at their sources;

The maintenance, preservation and protection of the sovereignty of the state over all the waters within the state;

Plans, projects, and recommendations of public corporations, the federal government and state agencies prepared pursuant to statutory authority;

Plans, recommendations and projects of private associations or organizations as they relate to the water resources of the state;

The need of the state to control storage in federal reservoirs by purchase or agreement; and

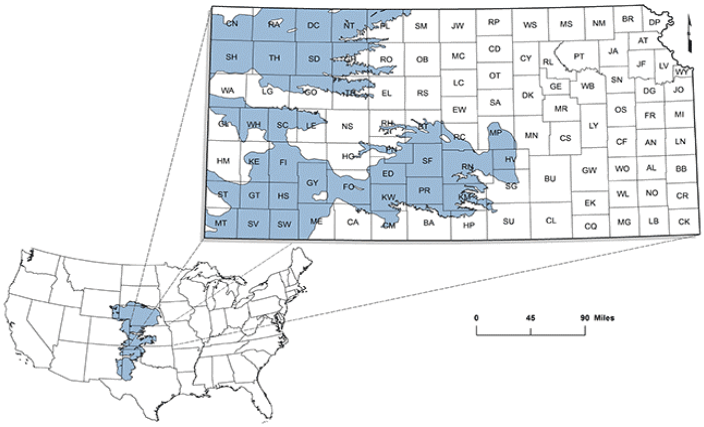
Such other matters as the Kansas Water Office deems proper or desirable.

Guiding Principles

OF THE KANSAS WATER PLAN

The *KWP* presents five guiding principles, which provide the foundation and framework for addressing water issues in Kansas, identifying the overarching challenges and the steps needed to meet those challenges.This updated version of the *KWP* incorporates relevant content from *A Long-Term Vision for the Future of Water Supply in Kansas*, creating a single comprehensive guide for short and long-term water planning in Kansas.

(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 using less groundwater if these populations and economies are to remain viable.

(2) Secure, Protect and Restore Our Kansas Reservoirs

Kansas has 14 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, 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. Innovative technologies may provide options for safely passing accumulated sediment downstream, while improved land use practices upstream help reduce excessive sedimentation and nutrient runoff from entering reservoirs.

(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 (with resulting stream and lake eutrophication and HABs), sedimentation, bacteria contamination and mineral intrusion (chloride, sulfate, selenium, uranium). Groundwater quality is threatened by mineralization (uranium, arsenic), 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 Watershed 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, 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 Vulnerability 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 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

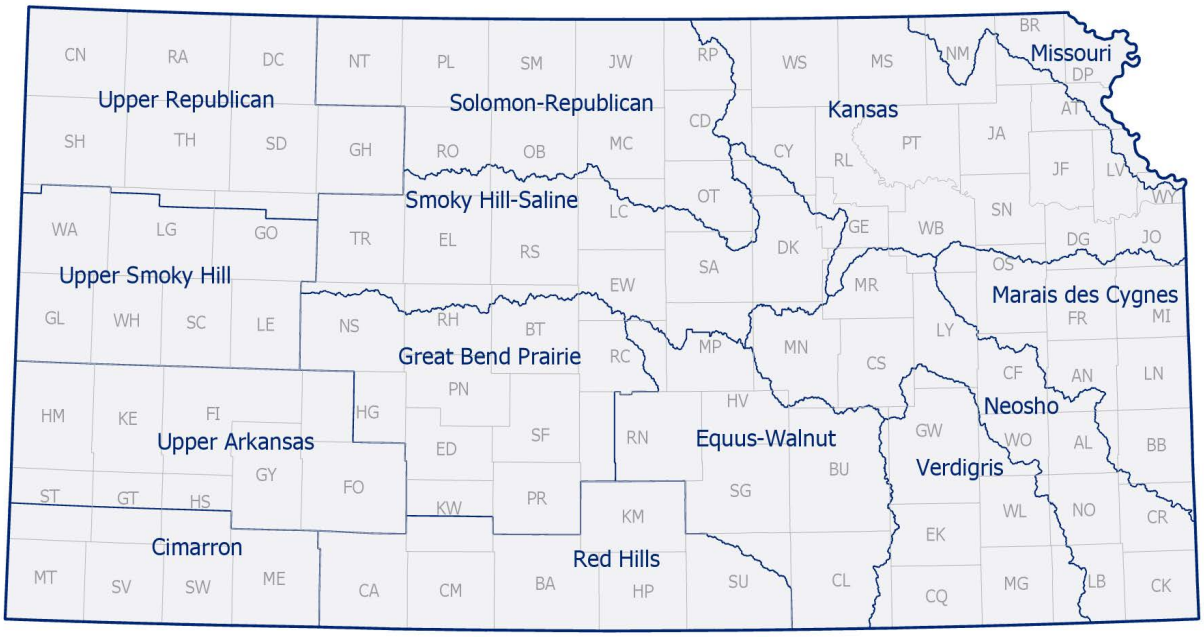
The water planning process relies heavily on public and stakeholder input. Perhaps the most consistent message received is the need for increased education and outreach. Success in dealing with water issues is far more likely to occur when the public is aware, concerned and engaged. Success is unlikely 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 introduced 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. In December 2014, the KWA established 14 Regional Planning Areas, in conjunction with *The Vision for the Future of Water Supply in Kansas (Vision)*. 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.

Another outcome of the *Vision* was the creation of Regional Advisory Comittees for each for each of these regional planning areas, made up of groups of local stakeholders representing the varied local water-related interests. The KWA approved committee membership for 14 RACs and 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.



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

Kansas Water Plan Development

In accordance with the SWRPA, the Kansas Water Office seeks and incorporates the input of citizens, Regional Advisory Committees (RACs), stakeholder groups and other state agencies, including the Department of Agriculture-Division of Water Resources (KDA-DWR), Kansas Department of Health and Environment (KDHE), Kansas Geological Survey (KGS) Kansas Department of Wildlife and Parks (KDWP), and the Kansas Department of Agriculture-Division of Conservation (KDA-DOC). All of these groups contribute to the development of the Kansas Water Plan. Ultimately, approval of the Kansas Water Plan lies with the Kansas Water Authority (KWA), a statutorily-established advisory board within the KWO. K.S.A. 82a-905.

The KWA, RACs, state agencies, partners, and 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. Recognizing the purpose of the SWPF is to implement the KWP, and the adoption of performance-based budgeting by the state in recent years, the KWA adopted a set of budget guidelines in early 2020. The guidelines, consisting of eight guiding principles, are utilized by the KWA Budget Committee to aid in making recommendations to the Governor and Legislature for how to spend the SWPF (Kansas Water Plan Budget Guidelines, 2020).

"Water Plan Funds should be allocated to maximize accomplishing the goals and objectives established by the Kansas Statutes, the Kansas Water Authority and the Regional Advisory Committees. "

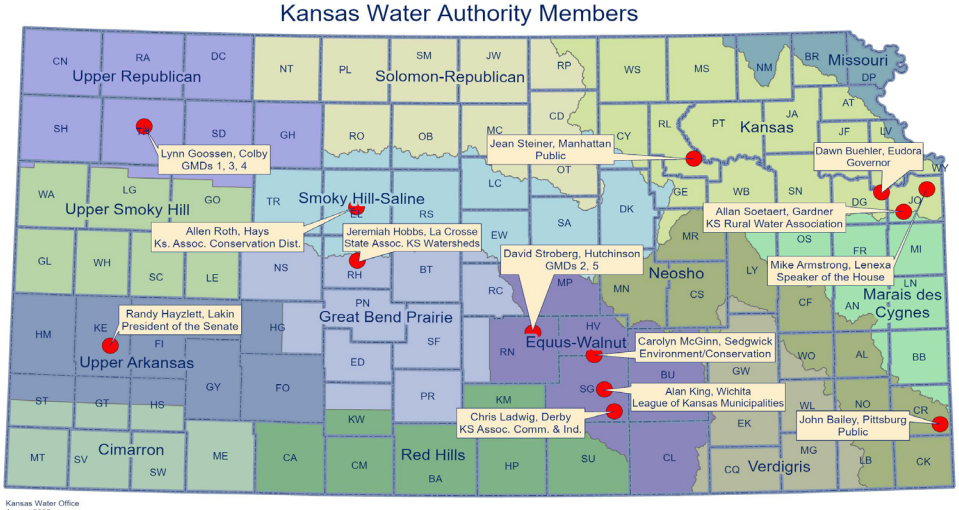
- Kansas Water Plan Budget Guidelines
KWA 1/29/2020

Kansas Water Authority

The Kansas Water Authority is an advisory board that is part of the Kansas Water Office. K.S.A. 74-2622. Of the 23 KWA members, 13 members are appointed by the Governor and legislative leadership, specifically representing a variety of water stakeholders (large and small municipal users, watershed, environment, conservation, public, commerce, industry, conservation districts, groundwater management districts). The other 11 members are ex officio members, representing state partners: KDA, KDHE, KDA-DWR, KDA-DOC, KDWP, KGS, Kansas Biological Survey (KBS), Kansas Department of Commerce (KDOC), the Kansas Corporation Commission (KCC), and the Kansas State University Agricultural Experiment Station.

The KWA's duties include making recommendations to the Legislature and Governor on expenditures of the State Water Plan Fund, approval of the KWP, approval of public water storage contracts with the federal government, and approval of membership in the RACs.

Kansas Water Authority Members



Kansas Water Authority Ex Officio Members

Earl Lewis Division of Water Resources KS Dept. of Agriculture	Dr. Ernie Minton Ag Experiment Station KS State University	Andrew Lyon Division of Conservation KS Dept. of Agriculture	Jay Kalbas KS Geological Survey
Brad Loveless KS Dept. of Wildlife & Parks	David Toland KS Dept. of Commerce	Sara Baer KS Biological Survey	Leo Henning KS Dept. of Health & Environment
Mike Beam KS Dept. of Agriculture	Connie Owen KS Water Office	Dwight Keen KS Corporation Commission	

State Water Plan Fund

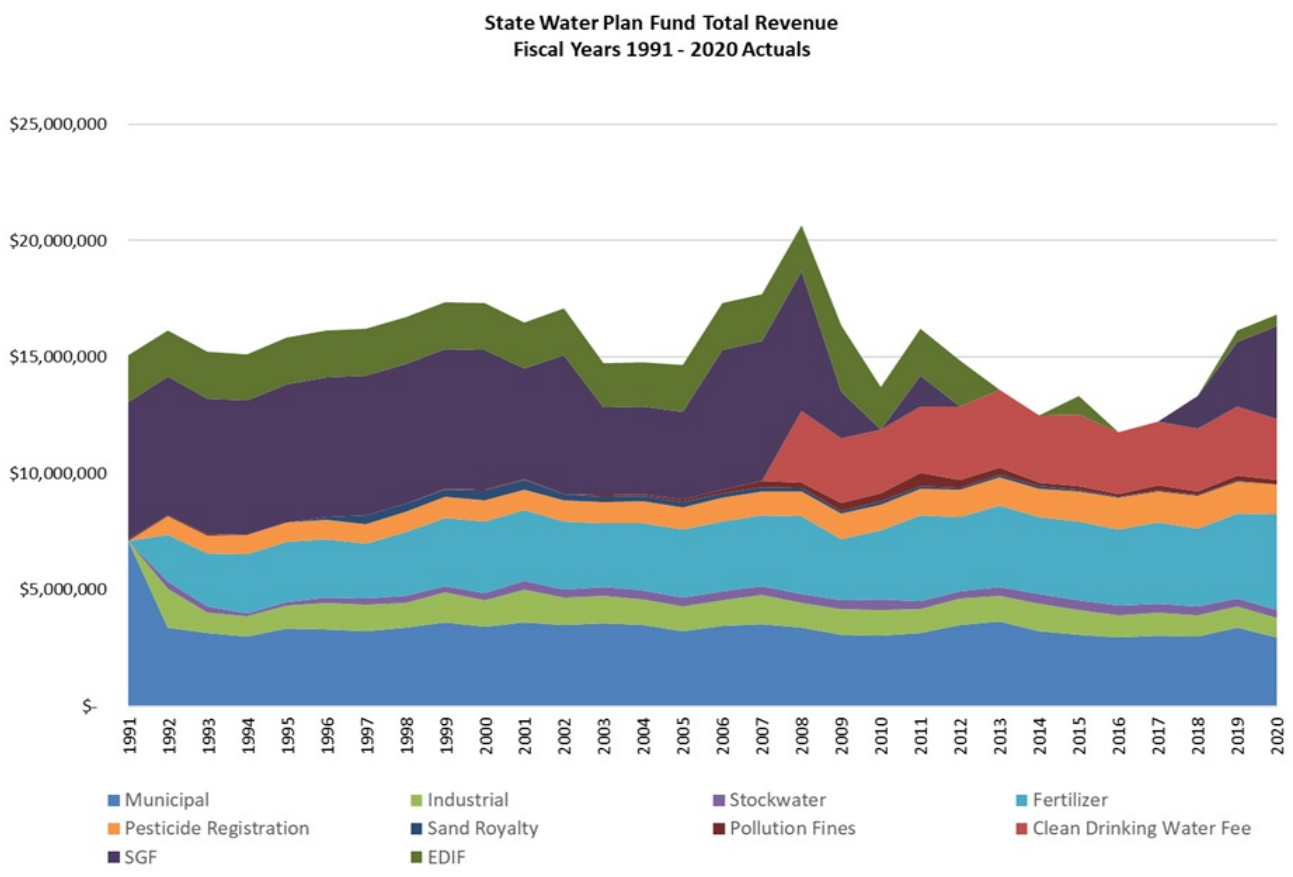
In 1989, the Kansas Legislature created the State Water Plan Fund (SWPF), a statutory fund specifically dedicated to implementing the programs and projects identified in the *KWP*. K.S.A. 82a-951.

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*.

The SWPF is designed to receive its revenue from a combination of user fees and two annual statutory transfers. Each year, the SWPF is to receive six million

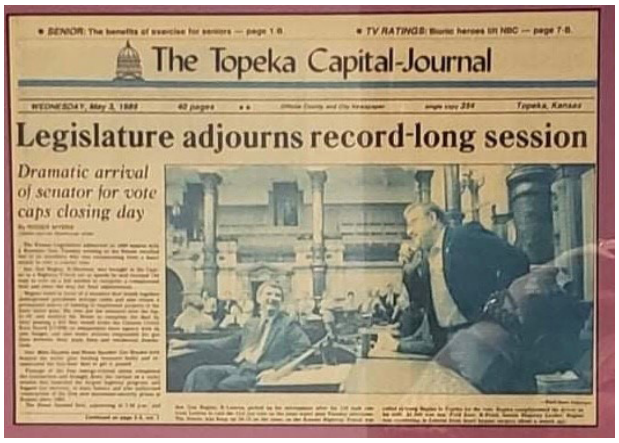
dollars from the State General Fund, and two million dollars from the Economic Development Initiatives Fund (K.S.A. 82a-953a and K.S.A. 79-4804, respectively). Historically, the SWPF has received around $17 to $20 million dollars annually, with the inclusion of revenue from fee funds. The full statutory transfers, however, had not been fully appropriated between 2008-2021. The cumulative amount of funding the SWPF should have received during this time, but did not, is approximately $80 million. In 2022, the Legislature restored the two statutory transfer appropriations to the full combined eight million dollars. It is important to note that, even with this restoration, the SWPF does not come close to providing the amount needed to meaningfully implement the necessary programs and efforts identified by Kansas Water Plan. To illustrate the point, the 2017 Blue Ribbon Funding Task Force Report estimated that $55 million would be needed to annually fund the comprehensive water needs identified in the *Vision* (A Long-term Vision for the Future of Water Supply in Kansas, 2015; Blue Ribbon Funding Task Force for Water Resource Management Final Report, 2017).

Among the public comments submitted for inclusion into this update of the KWP, perhaps the most commonly asserted request was to include a strong emphasis on the need for significantly more funding from the Legislature for KWP programs and initiatives. Some commenters urged the creation of a dedicated and protected fund that could not be underfunded as the SWPF historically had been. Indeed, without timely adequate funding, the ability to secure reliable and safe water supplies in Kansas will become more costly, and in some cases, hydrologically or economically impossible. Once it occurs, loss of a water supply or contamination of a water supply can be irreversible. Climate change is accelerating and exacerbating the threats. The situation is urgent. As urged by the public, stakeholders and partners alike, the Legislature must immediately prioritize, expand and protect funding for water needs. Revenue for the SWPF was historically generated from the following sources:



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 to the state agencies that implement the programs identified for funding, and as appropriated by the Kansas Legislature. The agencies 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). The Kansas Department of Wildlife and Parks has also received support from the SWPF. These agencies receive portions of the SWPF associated with the programs they respectively implement.

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 Topeka Capital-Journal

Legislature adjourns record-long session

Dramatic arrival of senator for vote caps closing day

The KDHE uses the SWPF for Contamination Remediation, Total Maximum Daily Load (TMDL) Initiatives, WRAPS, Nonpoint Source Program and for the Drinking Water Protection program, including mineralization studies of private wells in western stream alluvia, where mineral intrusion has been problematic. 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, and 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

Management of water in Kansas is primarily driven by statutory and regulatory frameworks for allocating the use of water and for addressing water quality. Additional statutory and regulatory rules govern a myriad of water-related activities, including water quality, water storage for public water supplies, use of water in emergencies, use of water for industrial purposes such as oil and gas production, construction and safety of dams, flood control and response, streambank projects, and many others. A few are discussed here, while others are addressed throughout this plan.

Kansas Water Appropriation Act

State policy regarding water management is governed in large part by the Water Appropriation Act, which establishes a mandatory permit system for virtually all uses (except domestic) based on the prior appropriation doctrine of "first in time is first in right." K.S.A. 82a-701, *et seq.* The Chief Engineer of KDA-DWR has authority over the permitting system. The date of a water right, and not the type of use, determines the priority to divert and use water when supply is not sufficient to satisfy all water rights.

The permit system governs the use of surface and groundwater, based on criteria that a proposed use or change in use will not cause impairment of an existing, more senior water right and not unreasonably affect the public interest. A water right does not constitute ownership of water, only the right to use it for beneficial purposes. Many areas of Kansas are closed to new permits because more permits and water rights have been approved and perfected than the given water supply can sustain.

Kansas Water Plan Storage Act

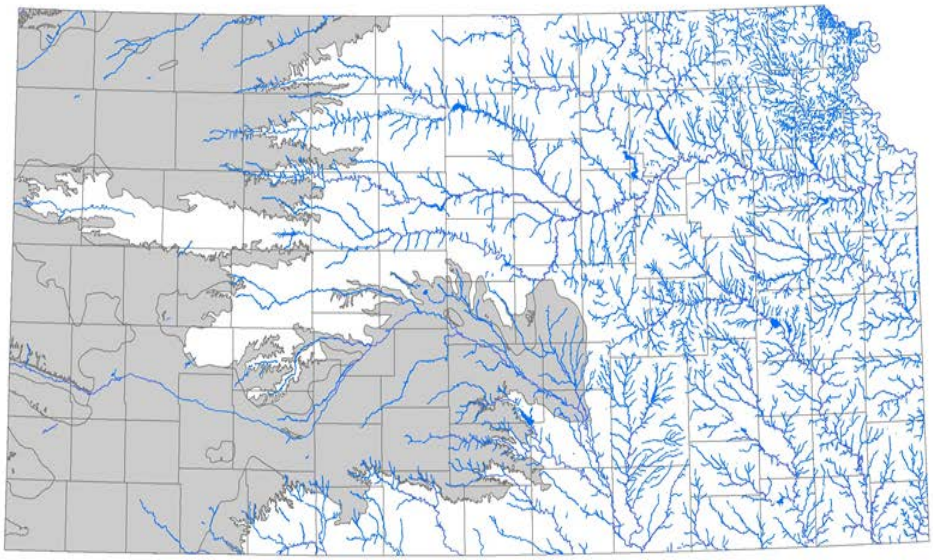
Water stored in federal reservoirs comes under another major management policy that is found in the State Water Plan Storage Act. K.S.A. 82a-1301, *et seq.* KWO has authority to claim a reservation right to collect and store water in space the state owns in 14 federal reservoirs pursuant to contracts between the KWO and the U.S. Army Corps of Engineers or the U.S. Bureau of Reclamation. KWO then contracts with municipal and industrial customers for a long-term water supply.

Kansas Water Resources Planning Act

The State Water Resources Planning Act SWRPA provides statutory authority for addressing water management in the *KWP*. K.S.A. 82a-901, *et seq.* The SWRPA, as outlined earlier in this report, details aspects of formulating the Kansas Water Plan and establishes the State Water Plan Fund, among other provisions. 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. K.S.A. 82a-927.

High Plains Aquifer and Perennial Surface Water Resources in Kansas



Source: Institute for Policy & Social Research, The University of Kansas; data from U.S. Geological Survey, National Hydrography Dataset and Kansas Geological Survey, Kansas Data Access & Support Center.

Perennial Rivers & Streams
Perennial Waterbodies (greater than one square kilometer)
High Plains Aquifer

Essential Partnerships

In addition to state agencies that plan, manage and regulate water use and water quality, there are other significant management entities including: Federal funding partners, Groundwater Management Districts (GMDs), public water suppliers, conservation districts, and watershed districts. Water management and water policy is also influenced and supported by many non-profit entities such as The Nature Conservancy, Ducks Unlimited, Friends of the Kaw, Pheasants Forever, Kansans for Conservation, Kansas Rural Center and the Kansas Soil Health Alliance, to name a few. Partnerships with private entities also enable implementation of KWP programs and projects.

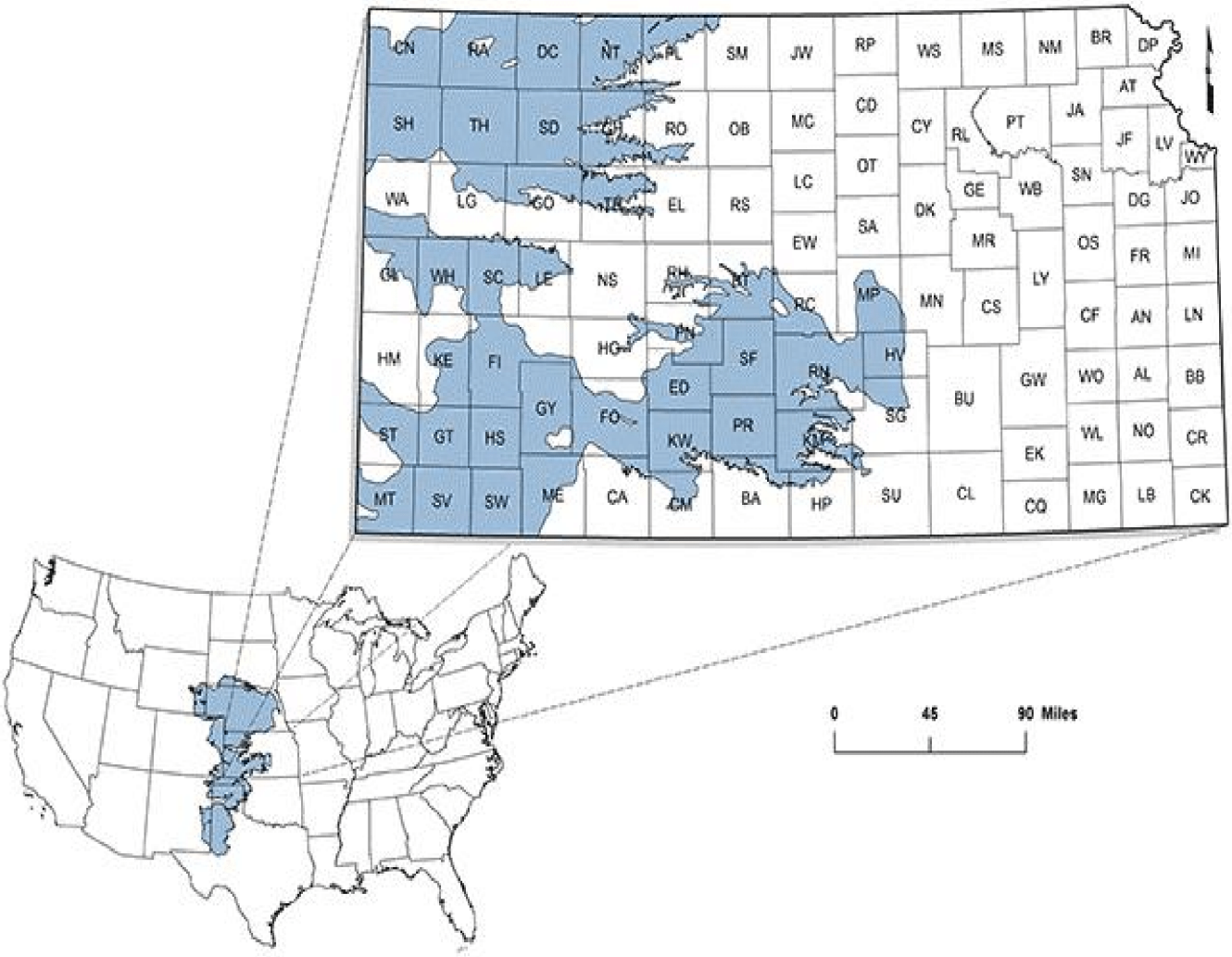
Overall, Kansas water resources present daunting challenges as to supply, availability and safe quality. Effective short and long-term management, including significant reduction in groundwater use and practices to improve surface water contamination, and address sedimentation are crucial to assure an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

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	15 Pages
Secure, Protect & Restore our Kansas Reservoirs	11 Pages
Improve our State's Water Quality	16 Pages
Reduce our Vulnerability to Extreme Events	19 Pages
Increase Awareness of Kansas Water Resources	6 Pages

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.

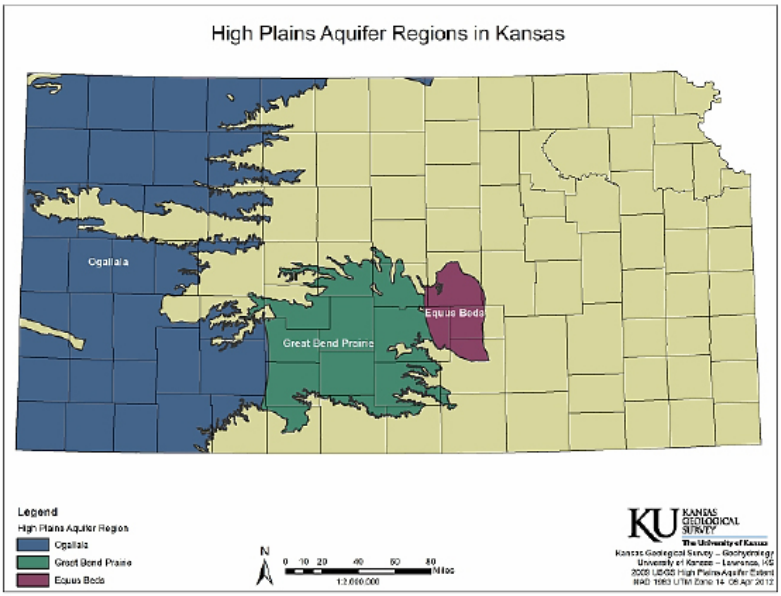


Figure 1. Map of the High Plains Aquifer in Kansas[1]

In Kansas, both groundwater use and surface water use have been regulated since 1945 under the first-in-time-is-first-in-right system created by the Kansas Water Appropriation Act, K.S.A. 82a-701, *et seq.* The use of groundwater (and surface water) is subject to an application process by which Kansas Department of Agriculture- Division of Water Resources (KDA-DWR) applies the law to determine if the proposed use will either impair an existing water right or adversely affect the public interest.(2) The public interest component generally asks if there is enough water in the given source to supply all prior water rights plus the proposed use. If an application can be approved, the approval is termed a permit.(3) The permit can be developed into a full right by actual use as authorized by the permit; this process is called "perfection".(4) At the point of perfection, a water right, which is real property right, comes into being.(5)

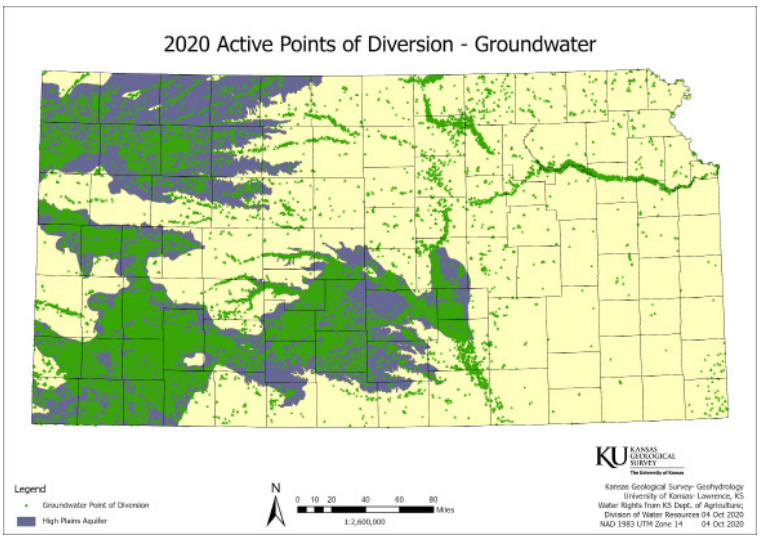


Figure 2. 2020 active groundwater points of diversion in Kansas[1]

In the case of the Ogallala Aquifer, many irrigation permits were approved, and the associated water rights developed, well beyond the amount of groundwater withdrawals the aquifer could sustain or that natural recharge could replace. This imbalance, known as "over-appropriation" has created an inevitable situation: continually declining and worsening aquifer levels such that the Ogallala Aquifer groundwater is being irreplaceably mined.

Conserve & Extend the High Plains Aquifer

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.[6] 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.[6] 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 pastures for cattle grazing.

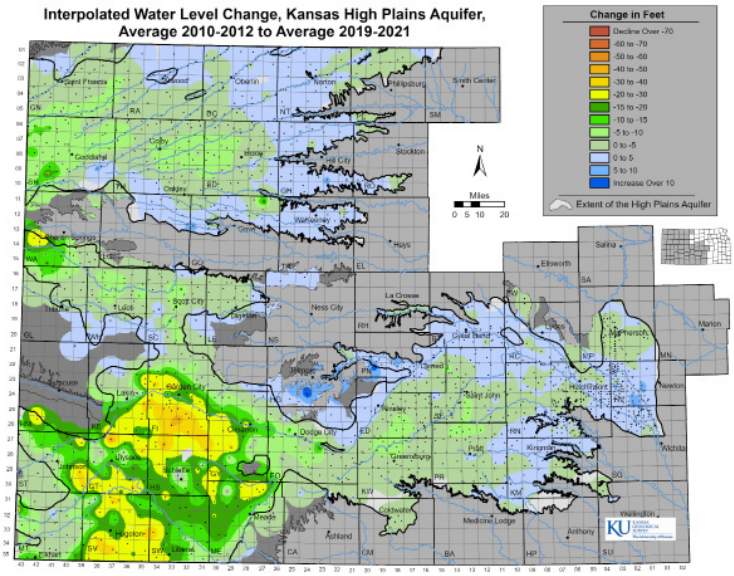


Figure 3. High Plains Aquifer region in Kansas showing the total water-level changes from 2010-2012 to 2019-2021[1]

When pumping exceeds the amount of water that recharges an aquifer, groundwater declines occur (Figure 3).[1] The KGS currently has over 25 "Index Wells" that have been installed in the HPA region and are recording water levels every hour (Figure 4).[7] The first three sites, located in Haskell (GMD3), Scott (GMD1), and southern Thomas (GMD4) Counties were drilled in 2007.[7] In addition to the index well program, the KGS, KDA-DWR and GMDs 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.[8] In addition, almost all of the 20,000 wells in the HPA and surface diversions are required to have a totalizing flow meter to accurately measure water pumped. Since the mid-1980s, every water right owner has been required by law to report their annual water use, using their water meter readings to KDA-DWR.

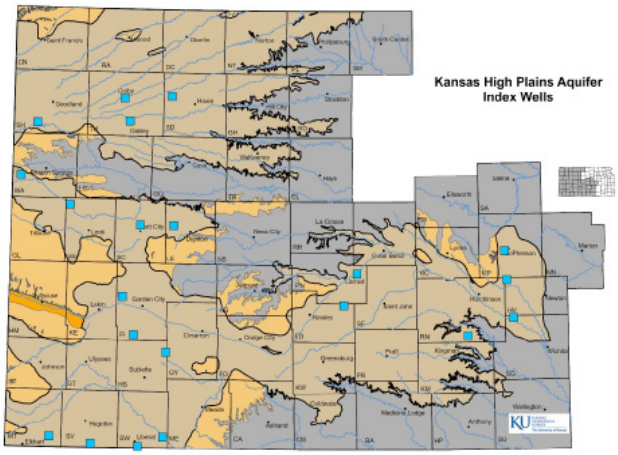


Figure 4. KGS Index Wells in the Kansas High Plains Aquifer. The blue boxes show the locations of each well[13]

According to the KGS, the average declines in groundwater levels in the Ogallala region since predevelopment are 25 feet, 56 feet, and 103 feet for Groundwater Management Districts (GMDs) 4, 1, and 3, respectively. The average aquifer thicknesses remaining in GMDs 4, 1, and 3 are 69 feet, 31 feet, and 151 feet, respectively.[6]

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 feet/year, cumulative 12.6 feet.
- GMD1. Steady decline rate: average 0.50 feet/year, cumulative 10.4 feet.
- GMD3. Increasing decline rate: average 1.69 feet/year, cumulative 35.4 feet.[6]

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 (GMD2 and GMD5, respectively) manage the aquifer based on safe yield policies, where the amount of water allowed for appropriation under water rights must, in the most basic sense, be equal to or less than the amount of recharge.[9] The safe yield restrictions pertain to applications processed prior to adoption of the safe yield regulations in the early 1980s.Allowing all or significant portions of recharge to be allocated has led to significant reductions in streamflows, creating conflicts in connected groundwater-surface water systems, for example in the GMD5 and Rattlesnake basin. 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.

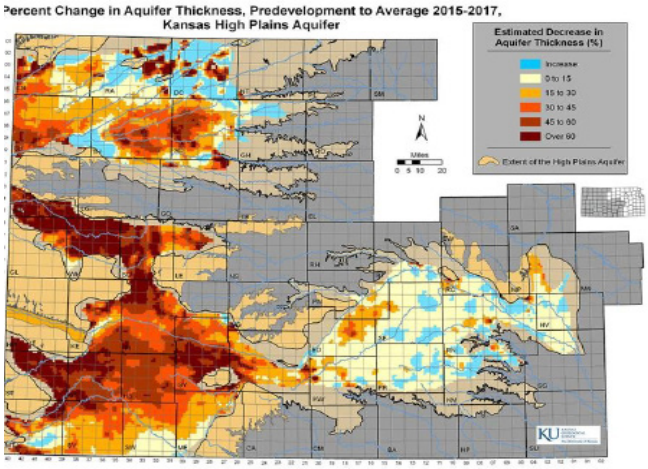


Figure 5. High Plains Aquifer region in Kansas showing the average depth to water for 2019-2021[1]

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.[6] 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 most of the water use from Ogallala Aquifer is for agriculture (irrigation and stockwatering), the widespread adoption of meaningful and feasible water-saving practices and water technologies is essential. Climate change further intensifies this crisis, with predictions for hotter and drier conditions.

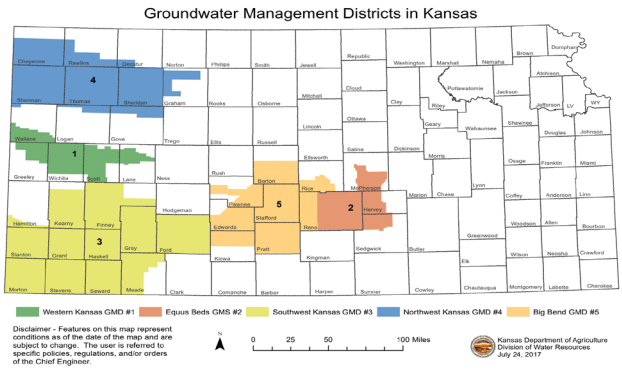


Figure 6. Groundwater Districts in Kansas[2]

The Ogallala Aquifer is needed to support not only the agricultural complex which currently includes irrigated crops, large cattle and dairy industry and biofuel plants, but all of western Kansas. This shrinking groundwater source is essential to municipalities, domestic well users, wildlife and ecosystems. Under the law, domestic water use differs from most others uses because it does not require a permit from KDA-DWR, although domestic uses may well qualify as water rights, with associated priority dates under the first-in-time-is-first-in-right system. Domestic use is basically the use needed for household purposes, and/or a small farm or livestock operation, as defined in statute.[10] The depletion of the Ogallala Aquifer jeopardizes all of these uses.

The over-appropriation of the High Plains Aquifer has led to conflicts between water users, even resulting in litigation between junior and senior water right owners. [11]

Conserve & Extend the High Plains Aquifer

Management Approaches

The fundamental problem with the HPA is that more water is being withdrawn than the system can supply, and over-appropriation in that there are more permits approved than the system can supply even though the area is closed to new appropriations.. This has been true for decades and has resulted in the severe declines described in this report. An inherent complication is the fact that these withdrawals are authorized by approved permits which have matured into water rights. Water rights are real property rights, so the matter of achieving reduced groundwater use is not a simple one. There are a number of voluntary cost-share and/or incentive-based programs to persuade (mostly agricultural) users to use less water. There are two relatively new options offered by KDA-DWR, described in the following section, which are leading the way in demonstrating how irrigators can use less water and retain economic viability.[12] There is also non-voluntary regulatory authority to secure the future of the HPA by mandating reductions in use (Intensive Groundwater Use Control Areas: KSA: 82a-1036 to 82a-1038).

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. Most available programs address agriculture because the majority of Ogallala groundwater usage is agricultural.

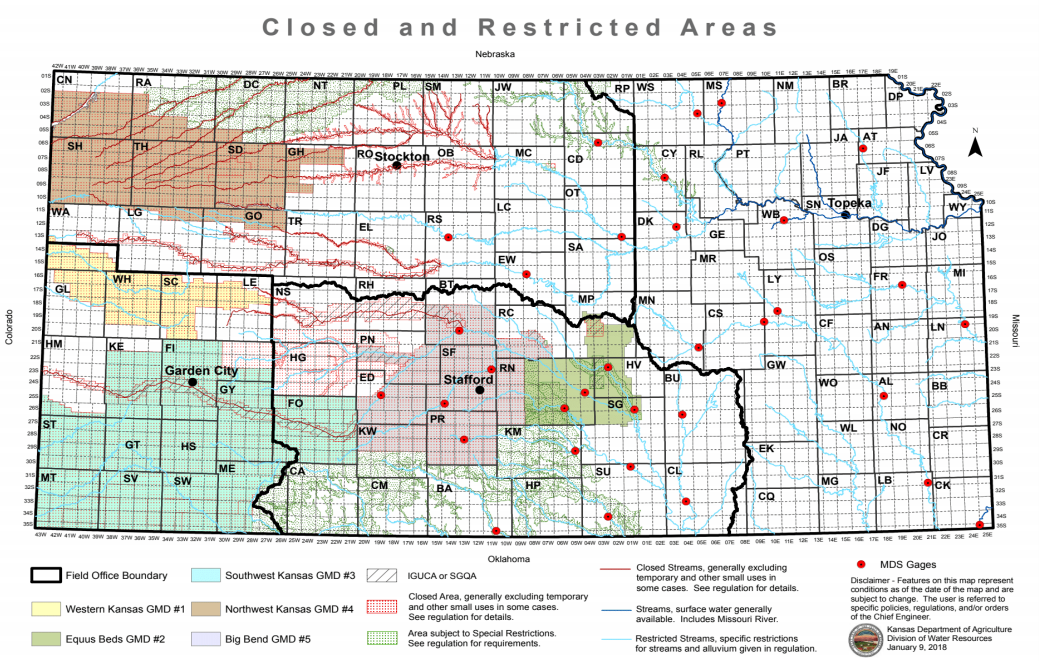


Figure 7. Closed and restricted areas in Kansas to new water appropriations and the Groundwater Management Districts.[12]

Conserve & Extend the High Plains Aquifer

LEMAs

Local Enhanced Management Areas (LEMAs) allow a GMD to present a locally-derived water-reduction plan to the Chief Engineer for approval. K.S.A. 82a-1041.[13] An approved LEMA contains details of water use reduction within its boundaries for a specified number of years and is enforceable by KDA-DWR. Because they are temporary, LEMAs do not permanently alter the affected water rights. Three LEMAs have been approved so far, two in GMD4 (Sheridan 6 and GMD4 district-wide) and one in GMD1 (Wichita County). Sheridan County 6 (SD-6) was the first approved LEMA in Kansas. In the first 5-year period, water-users almost doubled their conservation goal of 20%, reducing withdrawals by 39%. The LEMA was renewed for another 5-year cycle in 2018. GMD4 requested another LEMA that was approved in 2018, which regulates nearly their entire district, although to a lesser degree than the Sheridan LEMA. The success of GMD4's execution of LEMAs has motivated GMD1 to implement its first LEMA for Wichita County, which was approved in 2021. GMD1, as of 2022, is exploring options for additional LEMAs.

WCAs

Another promising state program allows water right owners to work with KDA-DWR to create Water Conservation Areas (WCAs). K.S.A. 82a-745. Established by law in 2015, WCAs are a voluntary flexible tool enforced by KDA-DWR, that allow any water right owner or group of owners to develop a management plan to reduce withdrawals. WCAs, like LEMAs, extend the usable life of the aquifer. As of 2021, KDA-DWR had approved 53 WCAs in the HPA, covering over 86,000 irrigated acres, representing a combined water savings of almost 12,000 acre-feet per year.

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.

IGUCAs

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. K.S.A. 82a-1036. IGUCAs mandate water use reductions according to terms and conditions specifically designed for the given area. There are currently eight IGUCAs, the most recent having been established in 1992 (Walnut Creek IGUCA). Although most IGUCAs have been created to address water quantity crises, the Burrton IGUCA in south central Kansas was established to address water quality issues. No IGUCAs have been established for the Ogallala Aquifer. This tool may need to be considered if other approachers do not sufficiently conserve and extend the HPA.

Water Technology Farms

Water Technology Farms are public-private partnerships that showcase the latest in irrigation technology, field-scale research, and water use reduction efforts.

Field Day at the Long Water Technology Farm, Wichita County, KS

Conserve & Extend the High Plains Aquifer

They focus on promoting scaled adoption of field practices, management techniques, equipment use, education and technical support that result in measurable soil and water conservation.[14] The elements focus on real-world solutions, research and management techniques that are scalable amongst producers within each region, while the education and technical support elements are geared toward continuing implementation over time. These approaches show promise for expansion involving numerous agricultural service providers, equipment retailers, agronomists, colleges, agencies, and producers, and may provide an opportunity for key research to be conducted by Kansas State University Research and Extension.

Northwest Kansas Technical College
Water Technology Farm, Sherman County, KS

The Water Technology Farm program supports and demonstrates the adoption of:

- telematic irrigation sensors and controls
- autonomous and variable rate pivot systems
- nozzle types and placement
- soil moisture probes
- sub-surface drip irrigation (SDI)
- mobile drip irrigation (MDI)
- climate and weather stations
- crop sensors
- dairy water reuse systems
- dairy animal cooling systems
- multi-spectral aerial imagery
- electroconductive and grid soil mapping
- flow meter sensors
- drought-tolerant crop hybrids and cover crops
- no-till and rotation farming practices
- variable-rate planting and nutrient zones

Playa Lake in Lane Co.

Conserve & Extend the High Plains Aquifer

The Certified Master Irrigator (CMI) program is an agricultural water management and irrigation curriculum comprised of 40 hours of combined online and in-field technical education for producers, managers and industry professionals.[15] The training encompasses scalable knowledge taught by a team of subject matter experts on how to maximize irrigation efficiency through the strategic use of equipment, technology, and conservation practices that work together to save water resources, build healthy soils, reduce energy use and enhance profitability. Graduates of the program gain key knowledge on how to use groundwater resources more efficiently, as well as, qualify for special equipment and service discounts, cost-share funding and allocation benefits.

The Kansas Watershed Partnership for Agricultural Conservation & Excellence (PACE) Farm program is an ongoing interagency effort between the Kansas Water Office, the Kansas Department of Health & Environment and the Kansas Department of Agriculture – Division of Conservation to work in collaboration with interested partners and producers to showcase and promote the adoption of the positive impacts conventional and innovative conservation practices can provide to farm profitability and surrounding water resources. Fundamental principles of PACE Farms include improving soil health and precision nutrient management, which help to decrease sediment and nutrient runoff impacting surrounding water quality conditions, as well as provide the potential to decrease on-farm input costs. Agricultural commodity/advocacy organizations, private industry, county conservation districts, local WRAPS projects, and institutions of higher education are just some of the groups and organizations who collaborate with state agency partners on PACE Farm efforts.
Each year, more producers are realizing the positive impact that water-smart technology can have on their operations, their return on investment and the water-saving benefits for future generations.

Playa Lakes

Playa lakes hold promise for helping to recharge the aquifer. Playas are round shallow depressions at the lowest point in the watershed. They fill with water from rainstorms and runoff which then infiltrates the Ogallala Aquifer or evaporates. A healthy playa has an intact clay basin – without excavated pits or ditches – that is not buried by sediments entering the playa from runoff. Water from the surrounding watershed freely enters the basin without being diverted from the playa by roads, terraces or other impediments, and passes through a native vegetative buffer which serves to remove contaminants and sediments from the water. 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% of these have been plowed and planted over.[16] The Playa Lakes Joint Venture works to conserve playas through a partnership with state and federal agencies, conservation groups and private industry.[17]

Conserve & Extend the High Plains Aquifer

Reductions in all uses

Although irrigated agriculture accounts for most of the groundwater usage from the HPA, other types of uses will need to reduce withdrawals from the aquifer, as well. Livestock operations, industry, and municipalities must adapt to water-reduction strategies. One example of a promising initiative is a water reuse effort in Garden City. The City of Garden City is working with industrial, agricultural and state partners to reuse treated wastewater to benefit the Ogallala Aquifer and provide water security for the community going into the future. The city has partnered with the United States Bureau of Reclamation on several grants to study the issue and they have jointly completed a water marketing plan that will create the city's water reuse utility framework. The project is the first of its kind in Kansas. Implementation of the project is expected to significantly benefit the city's water supply and support aquifer conservation.

Public-Private Partnerships

Recent studies show that by using less water and introducing new farming practices, producers can achieve equal or improved profitability.[19] 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 absorb more water, enhance drought and flood resiliency and boosting water quality.

The interest from the corporate world is driven by customer and investor demand for involvement in sustainability and climate change resilience. As climate change impacts our world, and reducing carbon emissions has become imperative, expanding soil health practices that sequester carbon into the soil 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.[18]

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, through 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.[19] Although these programs primarily focus on water quality benefits, they illustrate the growing potential for public-private partnerships that benefit the planet and the producer.

Producer in the Cheney Lake Watershed, General Mills & KDHE Partnership Program

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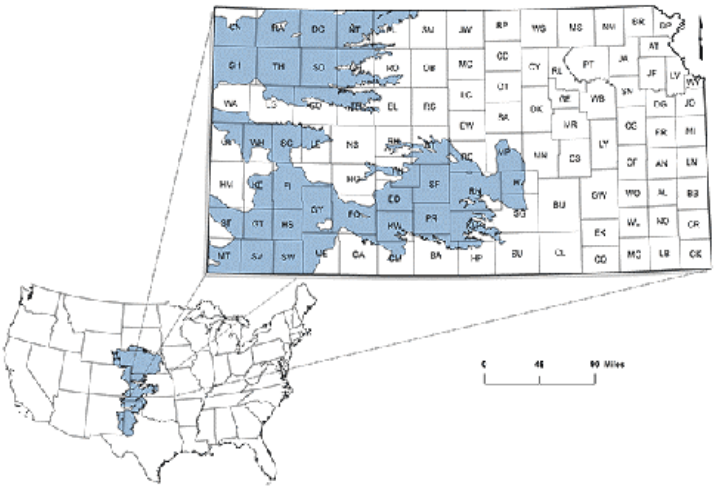
Interstate Partnerships

Further efforts that have taken place in the HPA region include 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). OWCAP provides multidisciplinary research and outreach focused on addressing issues related to groundwater declines and long-term agricultural sustainability in the High Plains region.[20] 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.

In 2018, OWCAP and the Kansas Water Office hosted the first Ogallala Aquifer Summit which brought individuals from all Ogallala states together to discuss this vital resource. A report summarized the ideas and input shared and identified next steps to continue interstate relationship-building and collaboration.[21]

Another Ogallala Summit took place in 2021 that was hosted virtually. 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.[22] Helping to educate and change the mindset of Kansans in the HPA region is crucial to the conservation of water.



Related Financial Incentives

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 necessary for either profitability or productivity. Current banking, insurance and property valuation influences can encourage and reward the unnecessary use of groundwater. For example, higher water use can currently boost property values, which, in turn, provide more highly-valued collateral for more favorable bank loans. Reversing this incentive would benefit producers and the banking industry; loans that reward water-saving practices help extend the life of the aquifer and, therefore, increase the likelihood of loan repayment.

Federal crop insurance programs can also create an incentive to use water unnecessarily. For example, a producer may use water to get a crop started, without the expectation of harvest, because the anticipated crop failure will result in a financially rewarding insurance payment. Such unintended consequences reflect policies that encouraged development, but continue to exist despite aquifer depletion 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.

Conserve & Extend the High Plains Aquifer

Cost-Share & Incentive Programs

- Water Transition Assistance Program (WTAP)[23]: A program offered by KDA-DOC that pays water right owners in targeted areas that are closed to new water rights appropriations. The purpose of the WTAP is to reduce historic consumptive water use in targeted areas by permanently retiring irrigation water rights with incentive-based cost-share. Priority areas are targeted and approved by the KDA-DOC, with recommendations from GMDs in applicable areas. WTAP differs from the Conservation Reserve Enhancement Program (CREP) in that the funding mechanism is solely state-driven, partial water rights can be retired and dryland farming is allowed.
- 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 plant a permanent cover (e.g. prairie grass or wildlife habitat mixture) on the contracted land.[24] This project provides other benefits such as soil conservation, water quality protection, energy savings, and wildlife habitat enhancement. CREP is a federal and state partnership; USDA pays about 80% of the costs.CREP now also applies to the Rattlesnake Creek basin.
- Irrigation Technology Initiative: KDA-DOC offers cost-share funds to assist landowners with irrigation efficiency technolog, automated soil moisture probes.[25]
- Environmental Quality Incentives Program (EQIP): USDA-NRCS program that provides financial and technical assistance to producers to implement water conservation practices.[26]

Recommended Actions, Strategies and other Available Approaches

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.

Recommendations

- Support implementation of groundwater use reduction measures for all uses.
- Support soil health/carbon sequestration practices and partnerships.
- Increase incentives for water conservation programs.
- Continue support of the KGS Index Well Program.
- Provide more financial and political support to KDA-DWR for Compliance and Enforcement.
- Provide greater financial and political 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.

Conserve & Extend the High Plains Aquifer

- Provide financial and political support for non-voluntary water use reduction intiatives when needed.
- Pursue collaboration with federal agencies to provide meaningful incentives for reuse and reduced water use by all users.
- Pursue collaboration with non-profit entities to provide services and partnership opportunities that enable water conservation.
- Educate the public on HPA depletion facts and the urgent need to adopt water-use reclamation behaviors.
- Develop a curriculum to be taught in schools explaining the past, present, and future of the HPA and the impact of climate change on aquifer depletion.
- Continue to bring the eight Ogallala states together to work on collaborative projects.
- Pursue opportunities to facilitate recycling and reuse of municipal 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.
- Collaborate with entities to continue outreach and educational opportunities concerning the benefits of playas.
- Develop career and technical education programming related to water resource management and technology to build the needed workforce.

Data, Research, and Studies

- Continue evaluation of emerging innovations in collaboration with KSU and other partners.
- Expand research on drought-tolerant crops to determine suitability for identified areas.
- Expand research on optimum plant development stages to determine the most efficient irrigation water application.
- Provide the public with reports that include studies and real world outcomes demonstrating the benefits of pumping significantly less water.

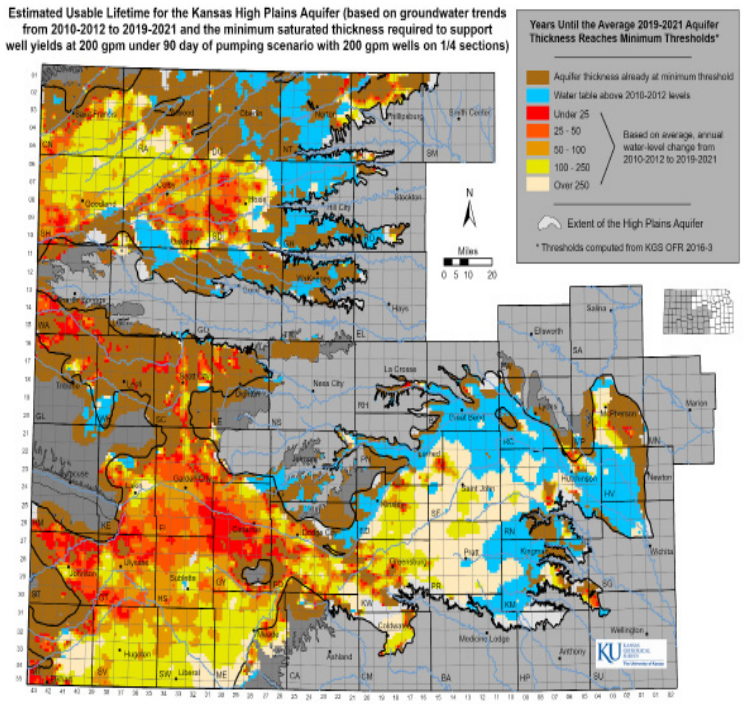


Figure 12. Estimated Usable Lifetime of HPA (KGS)

- Evaluate, identify, and encourage the most efficient system technologies for use by Kansas irrigators and other water users.
- Evaluate and identify ways to create new and strengthen existing markets for less water-intensive crops.
- Implement research-based technology aimed at better understanding our state's water supply.
- Expand research and continue exploring the effects of playa lakes on aquifer recharge and the effects of agriculture crop production on playa lakes' ability to provide recharge.
- Expand research on efficacy of water reuse programs.

Conserve & Extend the High Plains Aquifer

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 further water conservation and use water-efficient technologies.
- Support soil health and carbon sequestration practices and partnerships.
- Encourage the legislature to appropriate adequate funding to recruit and retain the best professional staff to manage water to ensure Kansans a safe future water supply.

Conserve & Extend the High Plains Aquifer

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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 reservoir storage will impact water supply for all water user groups including agricultural, domestic, industrial, municipal, and recreational water users.

Over two-thirds of the state's population is served from municipal water diversions downstream of reservoirs. These users are dependent on Kansas reservoirs (Figure 1) maintaining streamflow for diversions, maintaining sufficient water quality for human use, and providing drought resiliency. For many communities, the water supply supported by reservoir releases is the only source of water through periods of prolonged drought. Many communities and areas in the eastern half of the state receive water supply from rural water districts that obtain water from reservoirs and can distribute costs. Loss of reservoir water supply will inhibit future urban and rural development efforts and create a regressive expense burden for small-town residents, as water suppliers incur elevated costs for water sourcing.

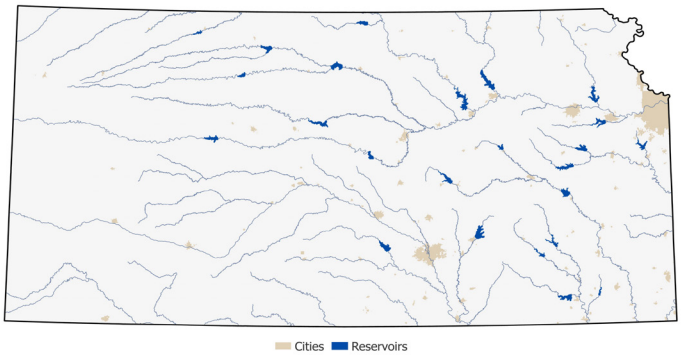


Figure 1. Reservoir locations within Kansas

Reservoirs support the water supply needs of a substantial amount of industry and commerce within the state, with a large portion 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 number of irrigated agricultural acres, all of which require reliable quantity and quality of water supply to continue providing economic benefits to the state.

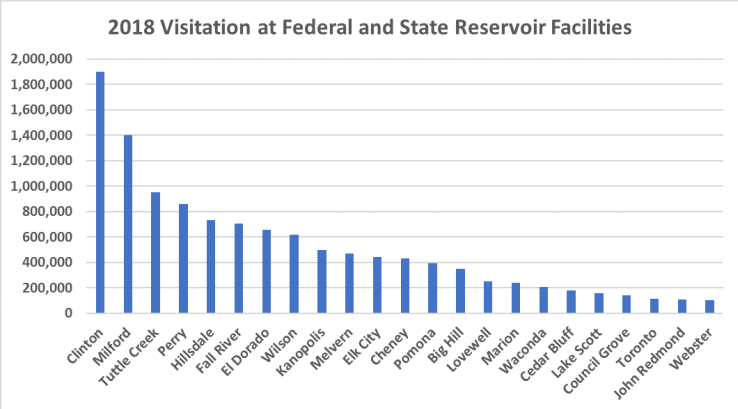


Figure 2. Number of people visiting federal and state reservoirs in Kansas in 2018, data derived from KDWP and USACE

Recreation is a growing economic role of reservoirs, with several million visitors annually (Figure 2) participating in on-water and on-shore activities.The COVID-19 pandemic accelerated the interest in outdoor recreation

Secure, Protect and Restore Kansas Reservoirs

even more. Water-related recreation 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 to support these river-based recreational activities.

The reservoirs serve to reduce the impacts of climate change in Kansas by reducing the impacts of flooding events that could otherwise cause widespread damage to municipalities, industries and agriculture, in addition to loss of homes, livelihoods, and life. At times, the reservoirs serve many Kansans as the sole source of water supply through prolonged drought by using stored water to support instream uses and maintain an adequate flow of water to users' intakes. See the *Kansas Water Plan (KWP)* Guiding Principle section on Reduce Vulnerability to Extreme Events for more information on the impacts of climate variability and climate change in Kansas.

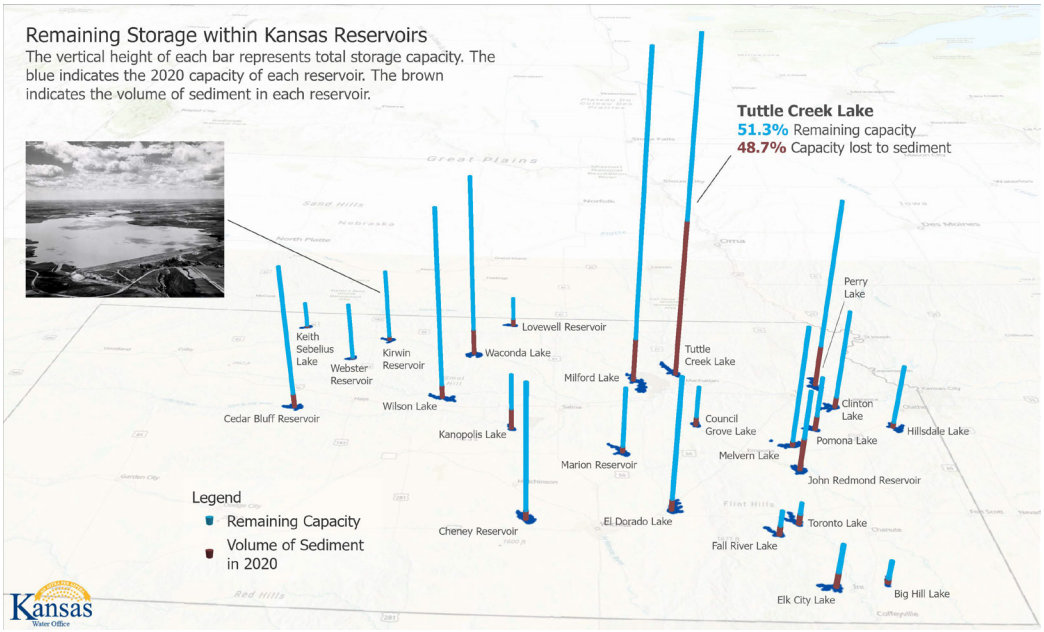


Figure 3. Projection of remaining reservoir storage in the year 2074 if the historical sedimentation pattern continues. It is projected that 92% of Tuttle Creek Lake's initial conservation storage volume will be lost to sedimentation without implementation of sediment and basin management actions.

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

1. Storage capacity is continually lost to sedimentation in reservoirs.(Figure 3) Lands within the watersheds of reservoirs lose soil, which is then transported to the reservoirs as a result of varied precipitation events. Soil is trapped in the reservoirs, reducing water supply available for current needs, 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.

Secure, Protect and Restore Kansas Reservoirs

2. A significant component of KWP funding is generated by fees that are paid by users who rely on reservoir water supply. The State's growing unfunded liability and inability 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] The 2022 Legislature appropriated $80 million to reduce the debt obligation at Big Hill, Clinton, and Hillsdale Reservoirs.

HAB at Milford Reservoir, August 2020

3. The quality of water in Kansas reservoirs is jeopardized by Harmful Algal Bloom events.[2] The presence and the proliferation of blue green algae, and its related toxicity to humans and animals, in Kansas reservoirs is primarily due to agricultural nutrient runoff (agricultural and animal waste) in the given drainage basin. Significant precipitation events further accelerate the runoff, exacerbating the effect on reservoirs, an effect that accumulates over time. (This topic is addressed in the KWP's Improving Water Quality section.) HAB contamination necessitates restricted use and/or closure of reservoirs, which negatively impacts municipal, industrial and recreational use, as well as local economies that benefit from the recreational activities on and around a reservoir.

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 Kansas. Specifically, a lack of reservoir storage management may lead to impeded development or control of sufficient supplies of water to meet the future needs of the people of the state.

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

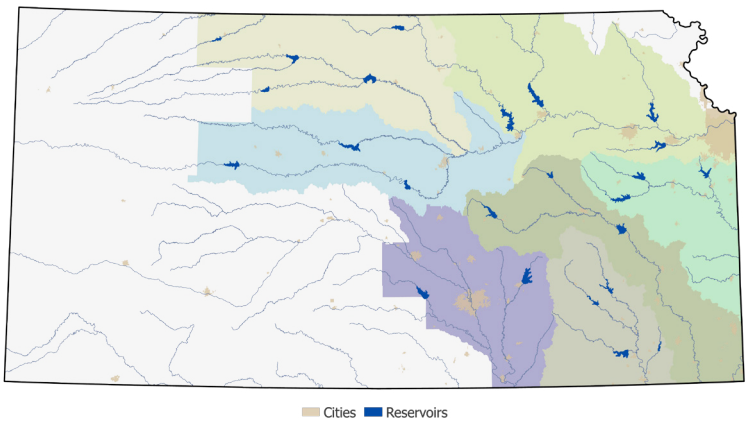
Reservoirs in Kansas play a key role in water security and drought resiliency planning, both by providing sufficient quantity of water to meet demands and by being a source of water to maintain water quality for drinking water, industrial, or environmental standards during times of degraded natural flow conditions.Water Control Manuals, overseen by the United States Army Corps of Engineers (USACE), incorporate the need to use reservoir stored water supply to provide dilution for 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.

Secure, Protect and Restore Kansas Reservoirs

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.

In addition to USACE Water Control Manuals, reservoir management is regulated by operations agreements with Water Assurance Districts, the Water Access District, and between state agencies during low flow conditions. Flood pool operations are 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 USACE reservoirs have been contracted for use by the State of Kansas. 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. Multiple cities and agricultural irrigation groups also have water storage agreements, such as the City of Wichita within Cheney Reservoir.

Costs associated with the State's contracted storage space include both capital investment costs, to repay the federal government for the inclusion of water supply storage in the original construction, and operations and maintenance (O&M) costs for the life of the reservoir.[3] Water Assurance Districts and the Water Supply Access District assume responsibility for capital and O&M costs of contracted storage space dedicated for their benefit. The Water Marketing Program and the State Water Plan Fund are also revenue sources to meet the cost obligations of the contracted storage. Revenue from the Water Marketing Program, long term raw water purchase contracts for municipal and industrial purposes, is the primary revenue stream but the State Water Plan Fund is needed as a supplementary contributor for storage that is not yet dedicated to the Marketing, Assurance, or Access programs. All funding sources will continue to be necessary and enhanced, not only to meet the contractually obligated costs with the USACE, but also to invest in reservoir sustainability.



Regional Planning Areas with water supply reservoirs located within their boundaries

As projected during initial design,the federal reservoirs of the state were built with expected operational lifespans for their conservation storage capacity. With many of these reservoirs now over 40 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. Future conflicts may arise 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.

Secure, Protect and Restore Kansas Reservoirs

As stated within the *Vision for Future Water Supply in Kansas (Vision)*, there have been targeted investments in the watersheds above multiple reservoirs used for water supply purposes.[4] Targeted investments have included implementation of best management practices 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 identified by the Blue Ribbon Water Funding Task Force additional funding support is necessary to adequately reduce sedimentation rates to protect future water supply.[5] The 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) 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 appropriate levels of reservoir research. Sufficient 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.

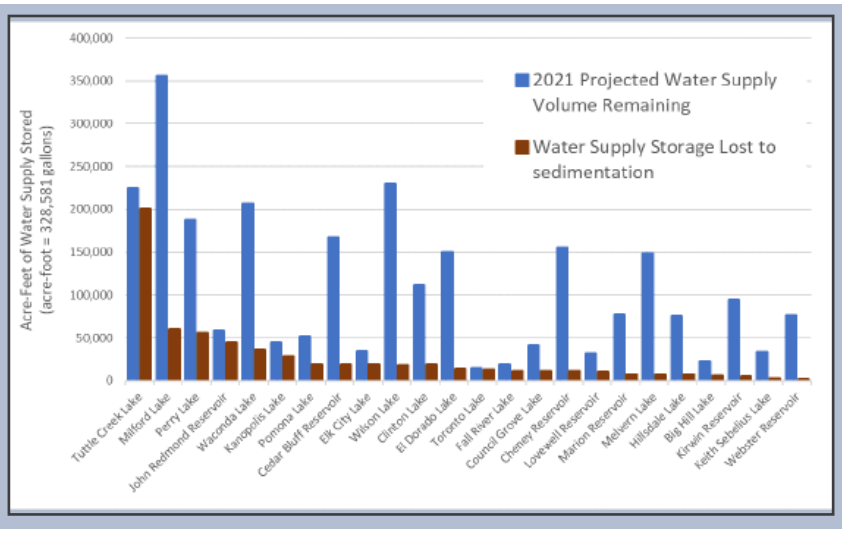


Figure 4. Amount of reservoir water supply storage remaining and lost to reservoir sedimentation

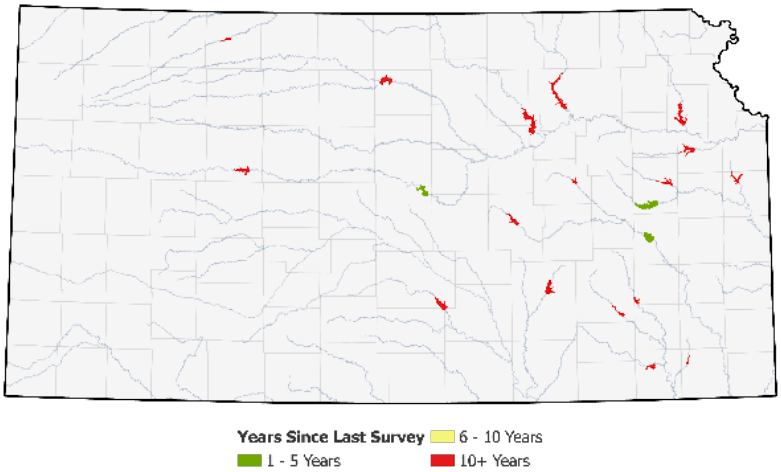
Reservoir data and research support is needed to:

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

Secure, Protect and Restore Kansas Reservoirs

- Better quantify the sedimentation issue through updated reservoir bathymetric surveys and surface water monitoring where feasible.
- Gauge and identify if the reservoirs are losing storage capacity at rates as initially projected and potential changes to these rates from behavioral changes within the watersheds.
- Identify impacts of large-scale climatic events, such as the extensive flood events of 2019.

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 *Reduce Vulnerability to Extreme Events* section for more information on flood impacts to Kansans and KWP recommendations on this issue.



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 evaluating the impacts of flood operations and what possible alternatives 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.

The ongoing Kansas River Reservoirs Flood and Sediment Study is a collaborative initiative between the USACE and State to review current reservoir conditions, needs, and operations, while also planning for future water supply needs, challenges, and limitations within the Smoky Hill-Saline, Solomon-Republican, and Kansas Regional Planning Areas.[6] Additionally, the study incorporates how future climatic variability may impact water supply and recreational reservoir uses, including an 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

In order to identify and measure the impact of investments supporting reservoir goals, there needs to be increased observation and measurement of reservoir conditions. 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. Additional reservoir monitoring and research will help to better predict, monitor, and respond to HAB events (Figure 5) 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 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 have been more regionally-supported budget initiatives incorporated into State Water Plan Fund (SWPF) proposals and development of performance metrics for expenditures.

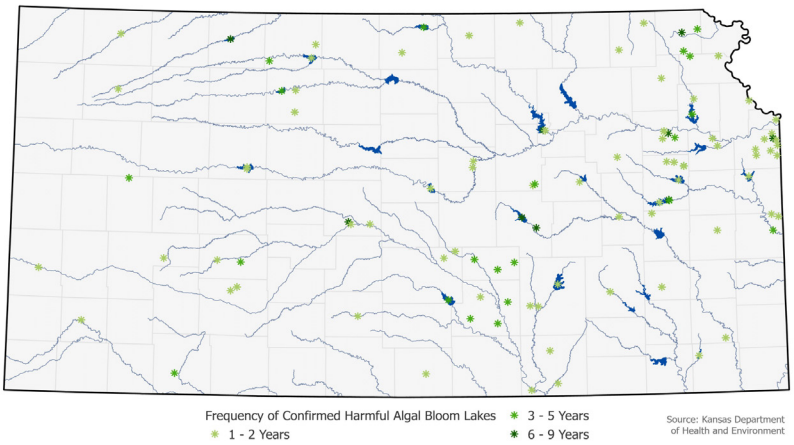
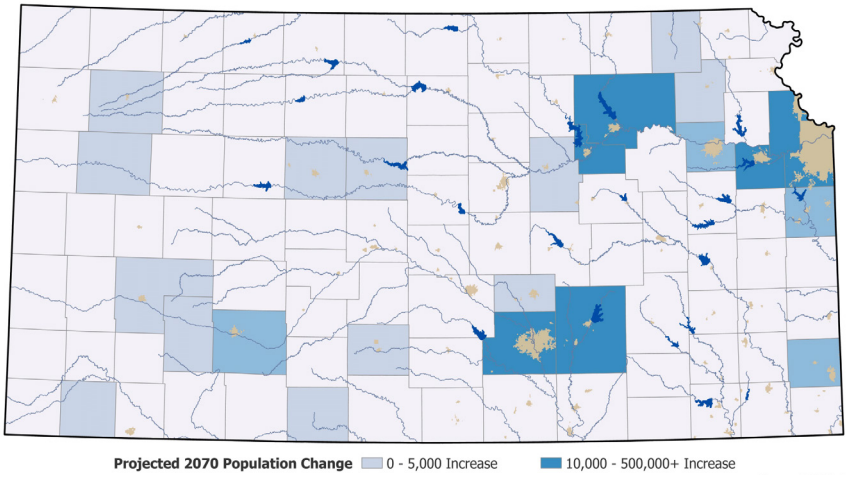


Figure 5. Reservoirs with Harmful Algal Blooms confirmed by Kansas Department of Health and Environment testing 2010 – 2020, KDHE

The Kansas Water Authority (KWA) approved the *KWP* Budget Guidelines in January 2020, prioritizing expenditure recommendations with the following criteria in mind:

- 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 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 as a in response to an emerging threat to water resources or public health.



Projected 2070 Population Change by County

Secure, Protect and Restore Kansas Reservoirs

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

Policy or Program Recommendations

- Support development and use of current groundwater and surface water modeling.
- Support RAC Goals that address reservoir issues (EW, KS, MdC, NEO, SHS, SR & VE).
- Support Kansas Department of Health and Environment (KDHE) in water quality management.
- Support nutrient reduction within the Natural Resources Subcabinet.
- Support reservoir research priorities as developed by the Kansas Water Research Coordination Group.
- Identify and overcome hurdles with federal permitting requirements for practices and structures that decrease sedimentation to federal reservoirs.
- Identify potential locations for additional Water Assurance Districts in order to expand and improve coordination of available Kansas reservoir supplies.
- 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

- Support watershed conservation practices, in particular 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.
- 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.

Data, Research, and Studies

- 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.
- 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.

Secure, Protect and Restore Kansas Reservoirs

- Increase the frequency of reservoir bathymetry to monitor progress on sedimentation trends, reservoir storage loss and future water supply planning projections.
- Research low- technology, process-based restoration of riverscapes, such as Beaver Dam Analogs and Post Assisted Log Structures as in-stream tools to reduce downstream reservoir sedimentation and improve water quality.

Funding and Resource Needs

- Fund sedimentation and nutrient reduction strategies supported by RACs.
- Provide funding for Blue Ribbon Funding Task Force water resource management conservation practices.
- Leverage federal financial resources.

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

Water quality refers to the water's capability to support all beneficial uses through a measurement of biological, chemical and physical characteristics.[1] Water quality standards that describe the desired condition of a water body and how that condition will be protected or achieved are established by each state.[2]

Cheyenne Bottoms. Photo Credit: The Nature Conservancy

Monitoring and Assessment

Under the section 303(d) of the Federal Clean Water Act (CWA), states must review, make necessary changes and submit to the EPA the list of waters not meeting water quality standards (or the 303(d) List). The Kansas Department of Health and Environment (KDHE) has primary responsibility for surface water chemical and biological monitoring and assessment. In addition to KDHE's statewide monitoring and assessment programs, many other entities, including federal, state, and local agencies and consultants, have conducted focused assessments and reports on water quality concerns in specific geographic areas.

KDHE maintains several ongoing programs that collectively fulfill the environmental surveillance and reporting requirements of the CWA and provides the technical data needed to identify and respond to existing and emerging water pollution problems.

KDHE's Monitoring, Assessment and Science Section (MASS) and the Policy, Planning and Standards Unit (PPS) maintains and administers several ongoing programs that collectively fulfill the environmental surveillance and reporting requirements of the CWA and other applicable federal and state laws.[3] The monitoring programs provide the technical data needed to identify and respond to existing and emerging water pollution problems. Information obtained through these efforts is applied to 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.

Improve the State's Water Quality

Surface Water Monitoring Programs

The Integrated Water Quality Assessment[5] is a compilation of water quality issues across the state. The MASS monitors water quality conditions in streams and publicly-owned lakes and wetlands throughout Kansas. The Integrated Water Quality Assesment 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 MASS 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 of pollutants[6] to the waters of the state. The 2019-2028 Kansas Water Quality Monitoring and Assessment Strategy[7] is a plan for directing water quality surveillance to use when reviewing regulatory expectations, budgetary realities and technological and methodological advances in environmental surveillance.

The 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. Likewise, United States Geological Survey (USGS) stream gage monitors real-time stream, lake, reservoir, precipitation, water quality, and groundwater conditions. Their National Water Dashboard offers mobile, interactive access to the information.

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 time 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 records (predominantly genus/species level) 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.

Improve the State's Water Quality

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 stream probabilistic monitoring program is the basis for the biennial Integrated Water Quality Assessment, but the KDHE list of impaired waters is largely informed by the routine monitoring networks.

A variety of additional reports, special publications, and peer-reviewed journal articles are generated by KDHE[8] to disseminate water quality information to the broader scientific community, elected officials, regulated entities, and the general public.

The KDWP manages a Stream Survey and Monitoring Program[9] 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.

Kansas no longer maintains a statewide groundwater quality monitoring program and funding for the renewal of such an effort appears unlikely anytime soon. 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. However, other agencies are still monitoring groundwater water quality. For example, GMD2 owns and maintains over 500 monitoring wells that are sampled, some every year, others less frequently. The Kansas Geological Survey (KGS) monitors about 1,400 wells, many of which are located in the High Plains aquifer and provides data from 210 well sites.

Improve the State's Water Quality

Fish Tissue Contaminant and Fish Consumption Advisory Programs

Working with other state and federal agencies, KDHE 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 well as collection according to the screening sampling design in support of the KDHE Stream Probabilistic Monitoring Program. Based on the data, KDHE, in partnership with KDWP, issues annual fish tissue consumption advisories that identify fish or other aquatic life that should be consumed in limited quantities or avoided altogether. Advisories are formulated using EPA risk assessment methods which account for contaminant level and length of exposure. The resulting Fish Consumption Advisories and the KDWP annual Fishing Regulations are published annually on KDHE's website. In some waters of the state, it is recommended that no fish is consumed.

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

Improve the State's Water Quality

Water Quality Issues and Management Approaches

SURFACE WATER

The Kansas 2020 303(d) list identified 486 water quality impaired/potentially impaired waters in impairment in lakes, wetlands, and stream systems (watersheds). The list encompassed 2,278 stream segment/pollutant combinations needing the development of TMDL plans to address the offending pollutants. The 2020 list also identified 514 monitoring stations/pollutant combinations of waters that were cited as impaired in prior lists but now meet water quality standards, with 44 newly identified 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. Best management practices such as vegetative riparian buffers, nutrient management plans, crop rotation, cover crops and vegetative buffer strips, to name a few, have demonstrated a reduction in surface runoff of contaminants.[10]

Wetlands have been long known to assist with water purification. 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[11] coordinating agency for the State, engaging with numerous partners across Kansas on wetland-related activities.

The 2019-2023 Wetland Program Plan (WPP) Wetland Program Plan for Kansas was developed by a diverse group of state agencies, interest groups and Kansas citizens with assistance from the EPA to help evaluate this natural resource. The WPP represents a compilation of recommendations made for wetland conservation since 1984. The core elements of the WPP involve voluntary restoration of wetland systems, increasing efforts to protect playa wetlands through partnerships, monitoring and assessment of public and private wetlands, use existing authorities to protect wetland areas, and protect wetlands through existing water quality standards.Wetlands are a key component of improving water quality and reducing vulnerability to extreme events. Kansas has lost almost half of its original wetlands - only 435,000 of the state's original 840,000 acres remain. Wetlands in key urban areas also serve as water awareness sites. When correctly designed and paired with proper native vegetation, wetlands are beneficial in trapping excess nutrients and sediment. Wetlands in both upland and floodplain locations serve as sponges to soak up runoff while slowing the flow of water over the land surface. Floodplain wetlands help reduce downstream peaks by storing floodwaters and then slowly releasing water as the river recedes.[12]

Improve the State's Water Quality

Aquatic Nuisance Species (ANS) are non-native species that threaten the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural, or recreational activities dependent on such waters. ANS are a source of significant ecological and socio-economic problems throughout North America. According to Kansas Department of Wildlife and Parks (KDWP), ANS can "reduce 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; pollute 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." [13]

In 2005, the Kansas ANS Management Plan was created and established within the Kansas Department of Wildlife and Parks (KDWP). Kansas' aquatic ecosystems have already been invaded by ANS such as zebra mussels, Asian carp, and Eurasian watermilfoil. Zebra mussels were first found in Kansas in 2003 at El Dorado Reservoir and now infest more than 30 Kansas waters (Figure 1). Another priority species, Asian carp, first appeared in Kansas in 987 and now constitute the majority of the fish community in the Missouri River and its tributaries, including the Kansas River up to the Bowersock Dam, and also occupy the Neosho River. Moving water, mud, animals, or vegetation between waterbodies risks spreading ANS. Examples include interbasin water transfers, boats/trailers, bait buckets, fire suppression equipment, construction equipment, irrigation systems, pet releases, and raw water line repair. Other ANS of concern include: Quagga Mussel, a close relative of the zebra mussel, but which is more problematic since it does not require hard substrates to grow on, and can thrive on sand, pebbles and silt, much like the silt deposition found in Kansas reservoirs; Snakehead, a predator fish, which is currently spreading from Arkansas throughout the Mississippi River basin and likely to be found in Kansas in the future; Black Carp, whose diet consists largely of mussels (many of which are already imperiled species), which are currently known to occur in the Missouri River in the state of Missouri and have no barrier preventing their spread into Kansas; and multiple species of crayfish that are likely to negatively impact native crayfish populations: Red Swamp Crayfish and Rusty Crayfish which have been documented in Kansas. [14]

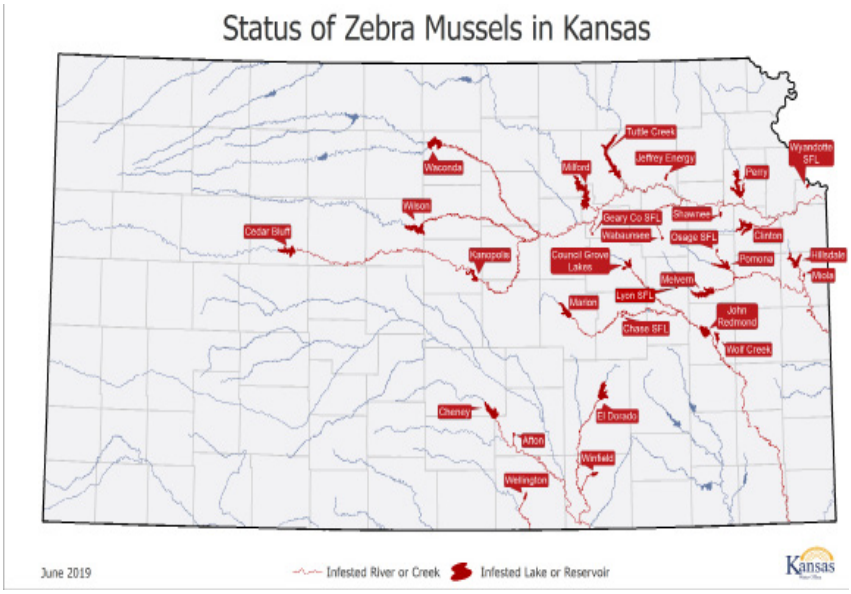


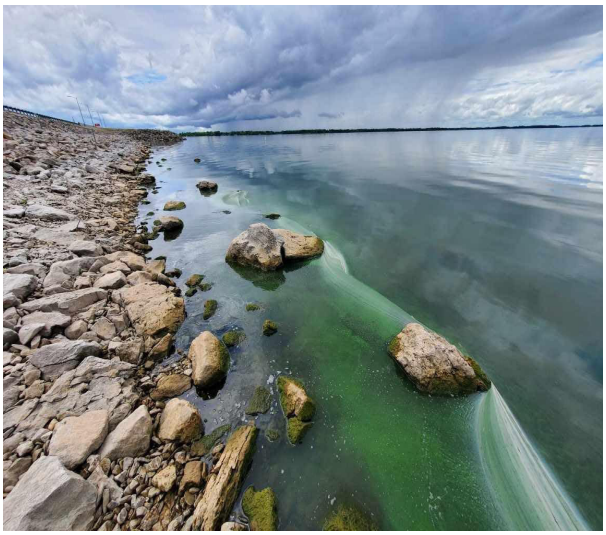
Figure 1. Zebra Mussel Infester Waters

Improve the State's Water Quality

In 1999, non-indigenous species (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.[15] 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.[16] There are multiple regional and national entities[17] working in collaboration to address ANS issues. For Fiscal Year 2023, the Kansas Legislature financially supported the ANS program.

Zebra Mussels. Photo Credit: NOAA

There are many different photosynthetic aquatic organisms that have historically been called "algae." Though there are some functional similarities among the different forms of "algae," these organisms have a wide range of physical attributes and origins. "Blue-green algae" are actually bacteria and are thus even more distinct from other types of algae. Blue-green algae are simple aquatic organisms that exist naturally in marine and freshwater waters, rivers, lakes, wetlands, and ponds. When they are present in low numbers, they are a normal part of a healthy ecosystem. Blue-green algae are also known as cyanobacteria. These bacteria are a world-wide problem. At times, blue-green algae can reproduce very rapidly, creating a dense growth known as a bloom.



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

A Harmful Algal Bloom (HAB), refers to a dense growth of algae that has the potential for creating toxins or other nuisance compounds. Some species and strains of blue-green algae produce a variety of toxins, which in some cases are released from healthy cells, but in other cases are released only when they become stressed and/or die. It is still not fully understood why these compounds are produced – whether they are adaptations that benefit the organism, or whether they are merely by-products of some other important process.Cyanotoxins can have acute and chronic effects on liver, kidney, lungs, and nervous system, and there are no known antidotes. The cyanotoxin most commonly found in Kansas lakes is a family of compounds called microcystins, which primarily affects the liver. Not all strains of a given species produce toxins, but a majority of the potentially harmful blue-green algae that have been seen in Kansas belong to one of three genus groups: Microcystis, Aphanizomenon, and Dolichospermum (formerly called Anabaena). These species become a problem when nutrients (phosphorus and nitrogen) are present in concentrations above what would occur naturally. Under these conditions, algae can "bloom," or grow very quickly to extreme numbers. Summer heat and calm, clear water can increase the likelihood of a bloom occurring, because blue-green algae are especially adapted to take advantage of such conditions. The water could be colored pea-green, blue, or bluegreen, and a cyanobacterial bloom can look like a vivid paint spill or floating grass clippings. Cyanobacteria can also cause taste and odor issues for the waterbody.[18]

Improve the State's Water Quality

The KDHE HAB Response Program was established in 2010. 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[19], with limited sampling and laboratory analysis being conducted on private waters[20] by Kansas State University. 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[21] has compiled information and research on HABs. KDHE has considered several of HAB mitigation strategies at numerous lakes, including Marion and Milford Lakes, such as reservoir drawdowns to reduce lakeshore nutrient loading, peroxide-based algaecide, ultrasound, rough fish removal and placement of barley straw bales along lake shore lines.

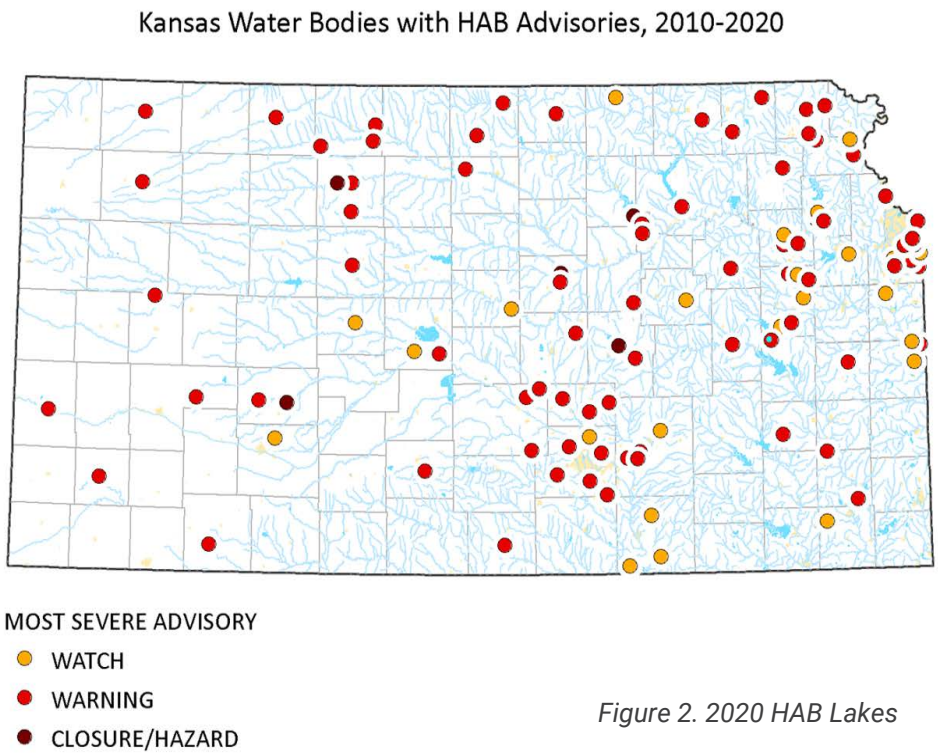


Figure 2. 2020 HAB Lakes

Improve the State's Water Quality

The Kansas Water Plan Guiding Principle: *Secure, Protect and Restore Kansas Reservoirs* highlights the use of stored water supply to provide dilution of naturally-occurring pollutants. 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 discharged from the Smoky Hill River alluvium after the 2019 flooding.

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 in order to improve water quality and protect water supply uses. The U.S. Geological Survey (USGS) has multiple gages in rivers across the state that monitor specific conductivity, which is related to the level of chlorides and other dissolved solids [22] in the rivers at several locations around the state. With the projected loss[23] 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.

WATERSHED RESTORATION AND PROTECTION STRATEGIES

The WRAPS [24] program is unique due to the involvement of many natural resource agencies and organizations in Kansas, supported by the Environmental Protection Agency, that seek citizen and stakeholder input on how to best manage and protect Kansas watersheds. Participation from stakeholders is essential to the success of the WRAPS program and the future of Kansas' waters. Interested stakeholders form local leadership teams that assess watersheds and develop WRAPS plans to restore and protect surface water resources in high-priority 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.

The objectives of WRAPS implementation projects are to provide information and education through informational meetings, workshops, tours, demonstration projects; securing human, financial and technical resources to implement best management practices to improve water quality; administer resources and execute the plan; evaluate the progress through ongoing monitoring of levels of pollution and changes in watershed conditions; and revising or updating the watershed action plans.

As of 2021, 36 WRAPS project areas are implementing their plans. The WRAPS program is funded through the EPA Section 319 and the Kansas State Water Plan Fund and is administered by a program advisory board. 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[24].

Improve the State's Water Quality

NONPOINT SOURCE POLLUTION MANAGEMENT PLAN

The Kansas Nonpoint Source (NPS) Pollution Management Plan[25] is the main strategic plan for NPS management in Kansas. The plan addresses the nine key program elements required by EPA as well as provides a framework for coordination and collaboration among agencies and organizations involved in NPS-related management activities. The plan continues to build upon past updates in order to develop watershed-based Total Maximum Daily Loads (TMDLs) for impaired water bodies, continue collaboration of targeted components of the Kansas Department of Agriculture Division of Conservation cost-share programs, complete statewide Source Water Assessments for public water supplies and to continue development and implementation of the Kansas WRAPS program.

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[26] 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.

GROUNDWATER

Though the ground serves as a great filtration system, chemicals and gases can still cause groundwater quality issues and contamination. Groundwater contaminants may be natural or human-caused.

Groundwater projects are conducted across the state to assess water quality concerns. The KWO has funded one such study in the Missouri Region Planning Area to evaluate groundwater quality[27] 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.[28] As increased chemicals, such as nitrates, are found in drinking water supplies, water treatment plants are forced to adapt and even upgrade equipment in order to meet federal drinking water standards. The costs far exceed what communities can afford.[29]

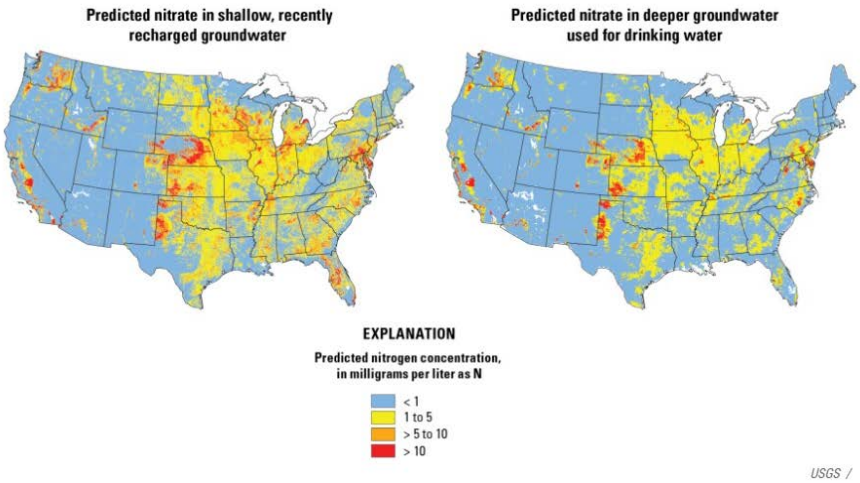


Figure 3. Predicted nitrate concentrations in shallow groundwater (left) and deeper groundwater used for drinking water. USGS.

Improve the State's Water Quality

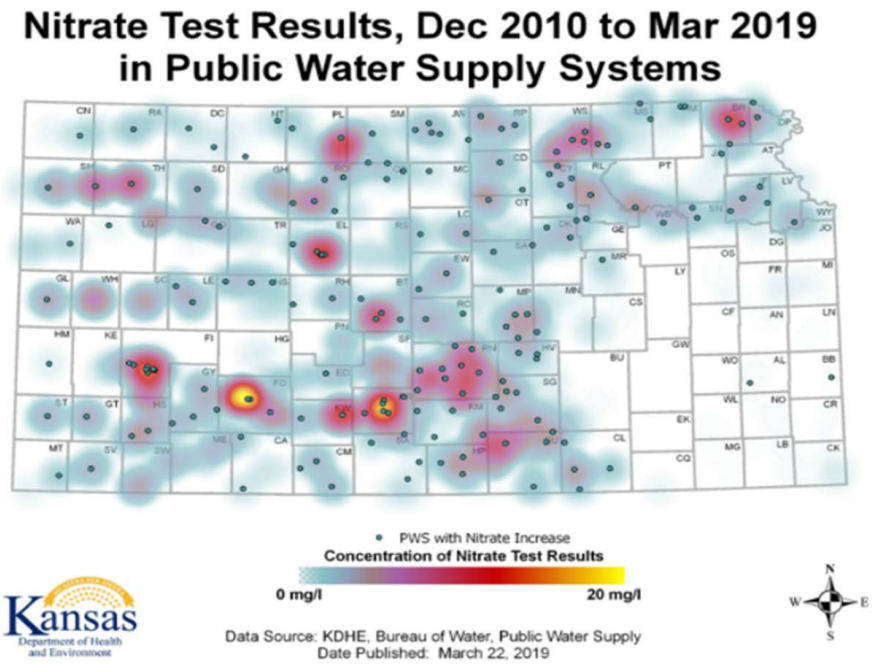


Figure 4. Nitrate Test Results in Public Water Supply Systems

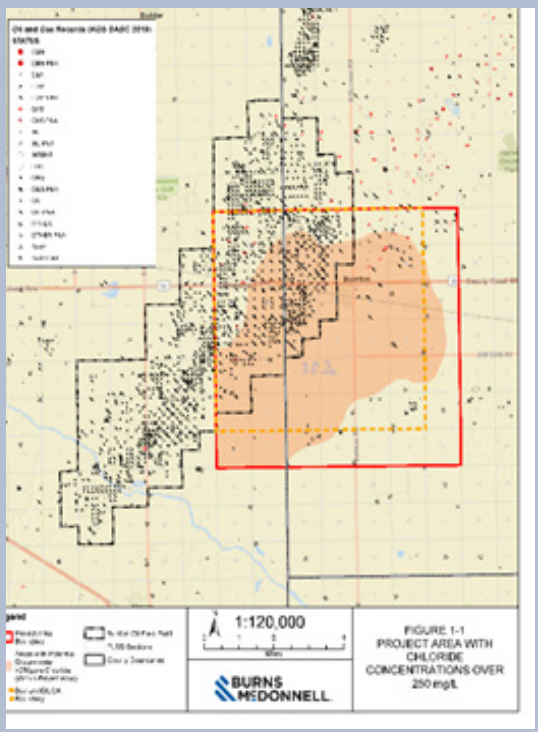


Figure 5. Project Area with Chloride Concentrations over 250 mg/L, Burns &

One groundwater quality issue of concern is the Equus Beds chloride plume.[30] This problem stems from past oilfield production, with produced water having been deposited into evaporation pits which allowed the 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. For public water supply systems, the EPA maximum drinking water level is 250 milligrams per liter.[31] 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[32].

In 1984, the Burrton Intensive Groundwater Use Control Area (IGUCA) was established in response to the letter of request from Groundwater Management District No. 2 (GMD2) identifying groundwater quality deterioration caused by chloride contamination. GMD2 continues to maintain a monitoring well network that is sampled annually by GMD2 with the cooperation of Kansas Corporation Commission funding.[33]

Improve the State's Water Quality

The KDHE is leading a group of agencies in continuing a 2009 groundwater study[34] 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 in water used for human consumption from private water wells within the Upper Arkansas Regional Planning Area.[35] The project invited homeowners within the study area (portions of Hamilton, Kearny, Finney, Gray, and Ford Counties) to provide voluntary water samples.

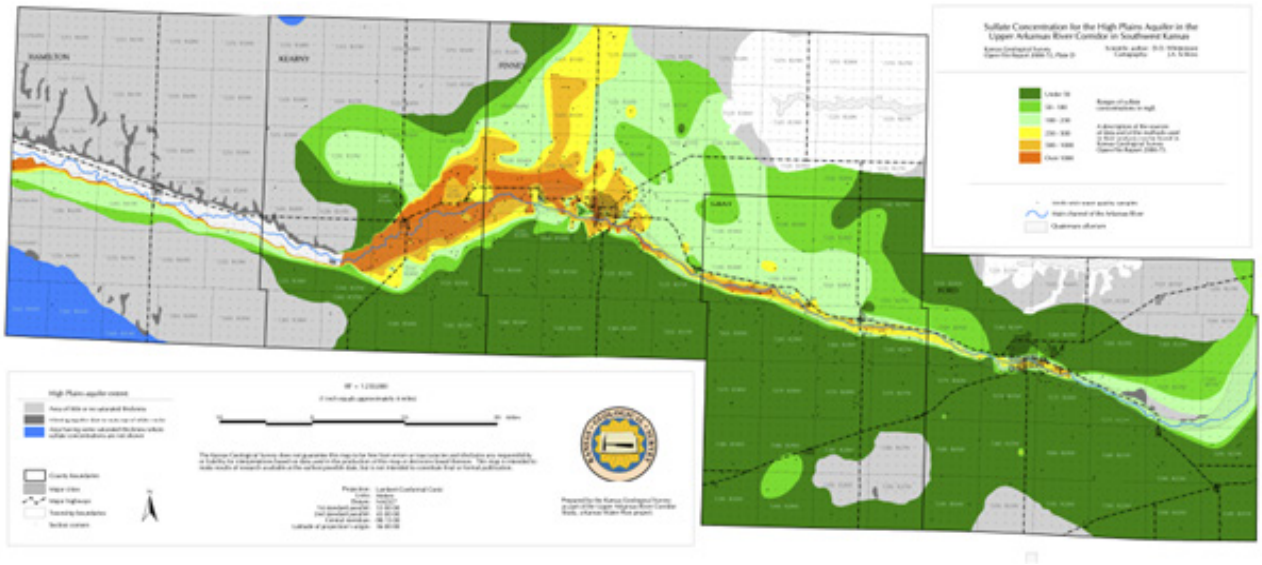


Figure 6. Sulfate Concentration for the High Plains Aquifer

In 2021, KDHE started collaborating with Fort Hays State University (FHSU) on a 2-year study in the northwestern[36] part of the state on a similar project. Private well owners within the study are 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 aims to analyze water samples for minerals including arsenic, selenium, nitrate, chloride, iron, manganese, sulfate, and uranium in potions of Norton, Phillips, Decatur, and Rawlins Counties. KDHE hosts the information regarding private water well testing and other information for private water well owners on their website.

Improve the State's Water Quality

Recommended Actions and Strategies

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 reduction efforts.
- Current Research Appropriations (Bathymetric Surveys, Kansas River Alluvium, Streambank Stabilization, and Real-Time Flood Mapping).
- Support collaborative efforts with Colorado and other neighboring states to address shared water quality problems, such as mineralization in the Arkansas River basin.

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.
- Encourage interstate cooperative efforts to improve regional water quality.
- Support projects that encourage collaboration between municipal & agriculture users to sustain/create a safe, clean water supply.
- Improve and expand conservation best management practice implementation that improves water quality.

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.
- Support mineralization studies including those conducted by KDHE and KGS 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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Reduce our 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

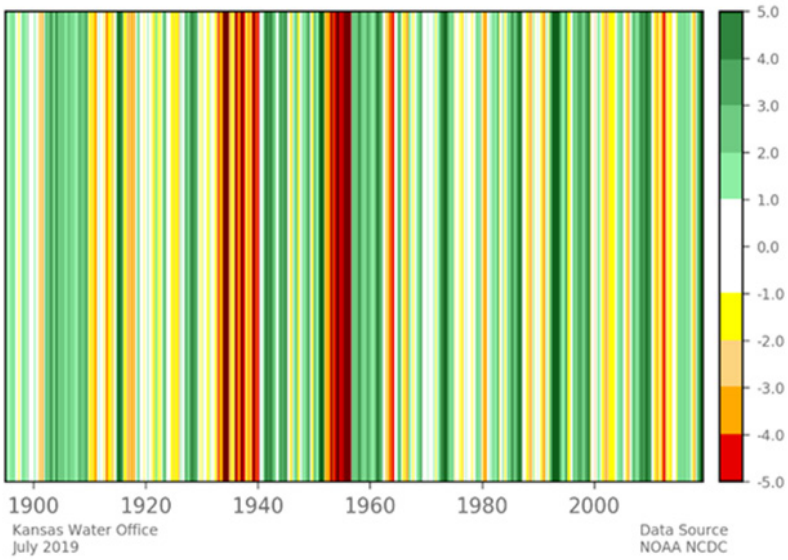


Figure 1. Historical Kansas Palmer Drought Severity Index (PDSI) values.

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 stated that climate change is occurring due to a global increase in anthropogenic greenhouse gas concentrations.[3] As a result, Kansas is facing a warming trend in the future accompanied by a potential increase in the frequency, duration, and intensity of extreme events. This is evidenced by temperatures in Kansas rising about 1.5°F since the beginning of the 20th century with temperature increases more pronounced in the winter (Figure 2) and spring (Figure 3).[4] 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.

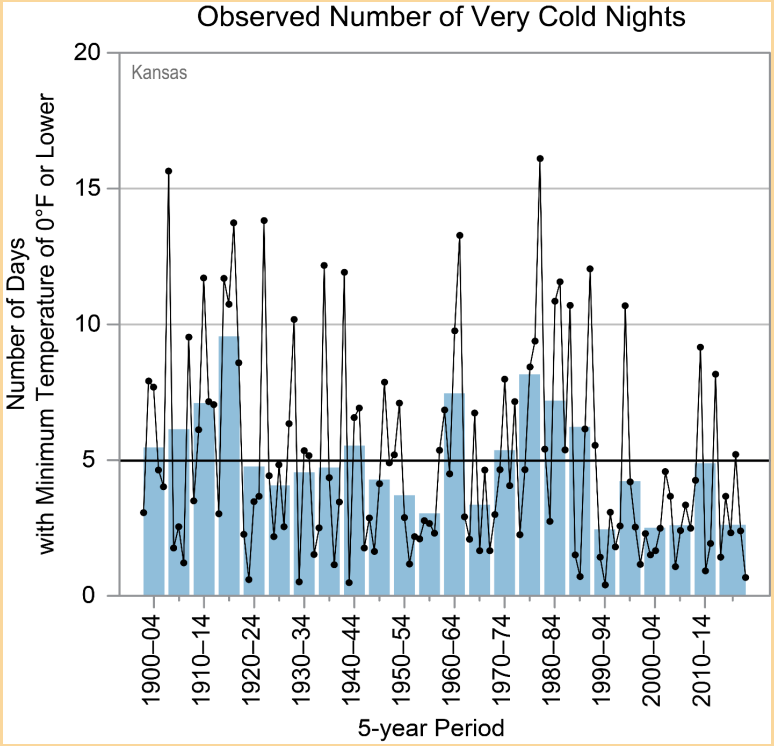


Figure 2. The blue bars represent average number of very cold nights (minimum temperature of 0 or below over 5-year periods. The horizontal black line represents the long-term yearly average of 5 very cold nights. The points represent number of very cold nights for individual years (CISESS and NOAA NCEI. Data: GHCN-Daily from 32 long-term stations). Note the trend of below average very cold nights since 1990. From "Kansas State Climate Summary 2022. NOAA Technical Report NESDIS 150-KS".[4]

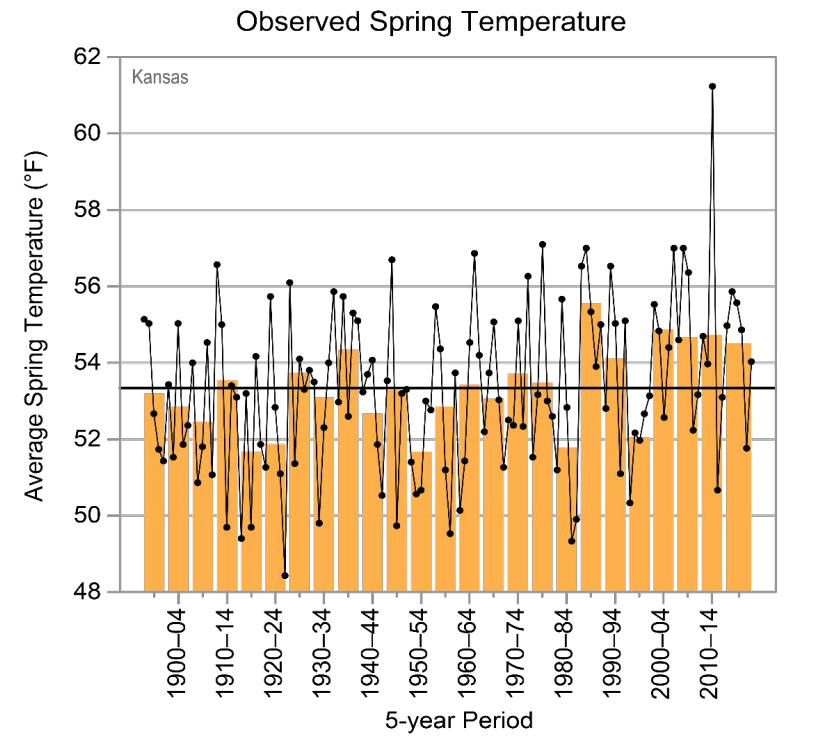


Figure 3. Observed spring (March-May) average temperature in Kansas from 1895 to 2020. The orange bars represent average spring temperatures over 5-year periods. The horizontal black line represents the long-term average temperature of 53.3°F. The points represent average spring temperatures for individual years. Note the particularly high average spring temperature of 2012 and above average spring temperatures experienced in recent decades.[4]

Reduce Vulnerability to Extreme Events

PRECIPITATION VARIABILITY

Precipitation in Kansas varies greatly from year to year as it lies in the transition zone from relatively abundant precipitation in the east to relatively little precipitation in the west. As a result, future predictions for average annual precipitation are somewhat uncertain, with projections indicating a slight increase in winter precipitation and decrease in summer precipitation.[4] However, since the 1950s, the frequency and intensity of heavy precipitation events has generally increased. From 2015-2020, the number of days with 2 or more inches of precipitation was well above average (Figure 5). The increase in extreme precipitation events has been particularly noticeable in eastern Kansas.[4] This trend, primarily driven by human-induced climate change, is projected to continue and 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.[5] Such conditions would have a direct, negative impact on agriculture and put a greater strain on water supply/resource management infrastructure.

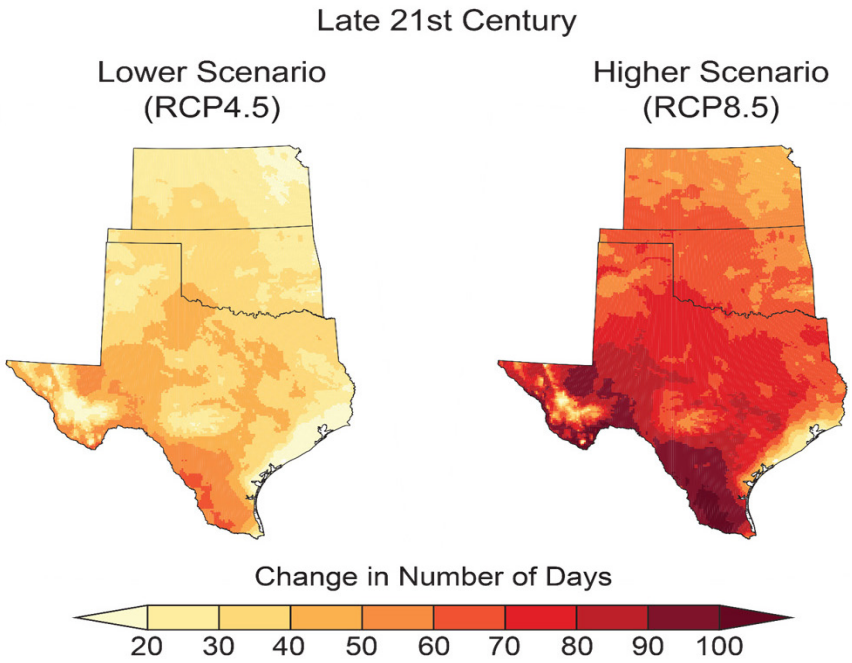


Figure 4. Projected increase in number of days above 100°F throughout the Southern Great Plains. The Representative Concentration Pathways (RCP) are greenhouse gas concentration trajectories used by the Intergovernmental Panel on Climate Change (IPCC) and are labeled based on projected radiative forcing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

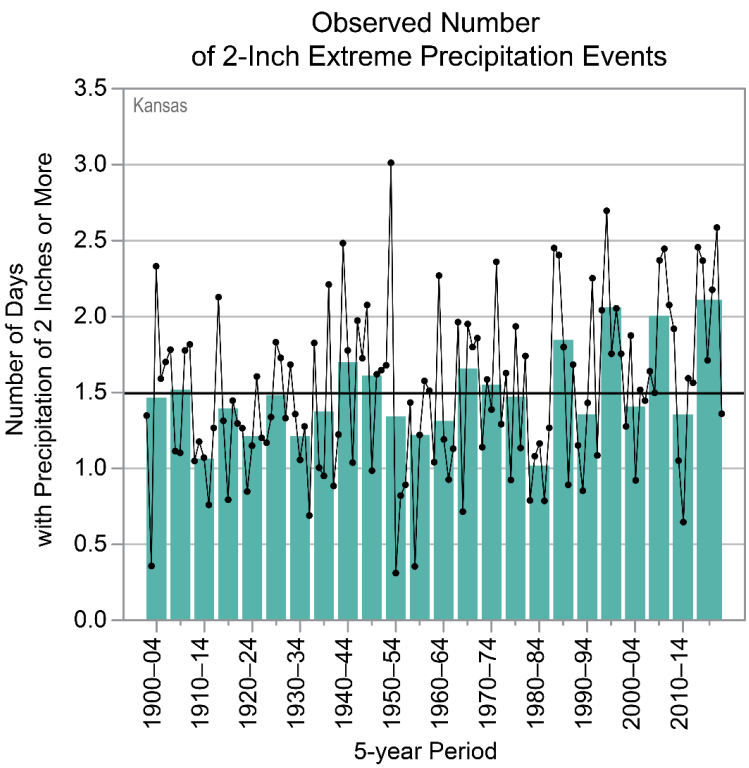


Figure 5. Observed number of 2-inch extreme precipitation events in Kansas from 1900-2020. The green bars represent the average number of annual extreme precipitation events over five-year periods. The last bar represents a six-year period from 2015-2020. The horizontal black line represents the long-term annual average of 1.5 extreme precipitation events. The points represent the number of extreme precipitation events for individual years.

Reduce Vulnerability to Extreme Events

Figure 6 illustrates the inherent variability and climatic challenges in our state. Monitoring and utilization of water resources has historically allowed the State of Kansas to grow and prosper in spite of extreme events. The State supports extensive monitoring, such as the Kansas Mesonet and the streamgaging partnership with the United States Geological Survey (USGS), to evaluate historical events and assess when current conditions are approaching a critical point.[5,6] The Kansas Mesonet, housed at Kansas 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 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.[7]

The USGS streamgaging network (Figure 7) 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.

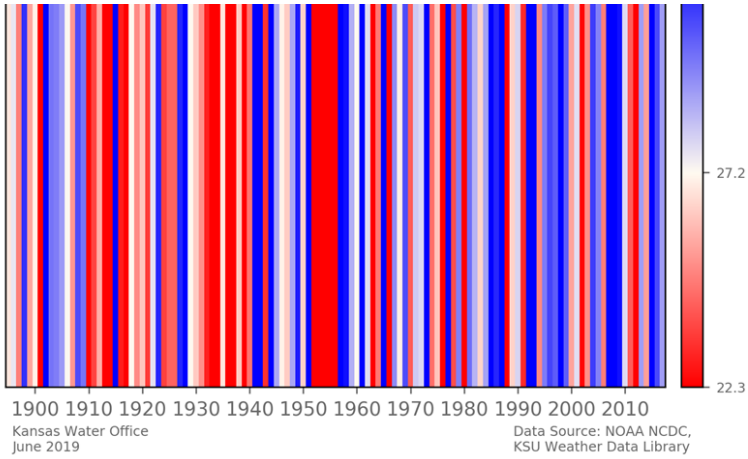


Figure 6. Statewide annual precipitation, inches (1895-2017). Blue stripes indicate years with above average precipitation (>27.2") and red stripes indicate years with below average precipitation (<27.2"). The variation in color patterns demonstrates the diverse range of water resource conditions, both in duration and frequency of wet and dry conditions. Kansas experiences.

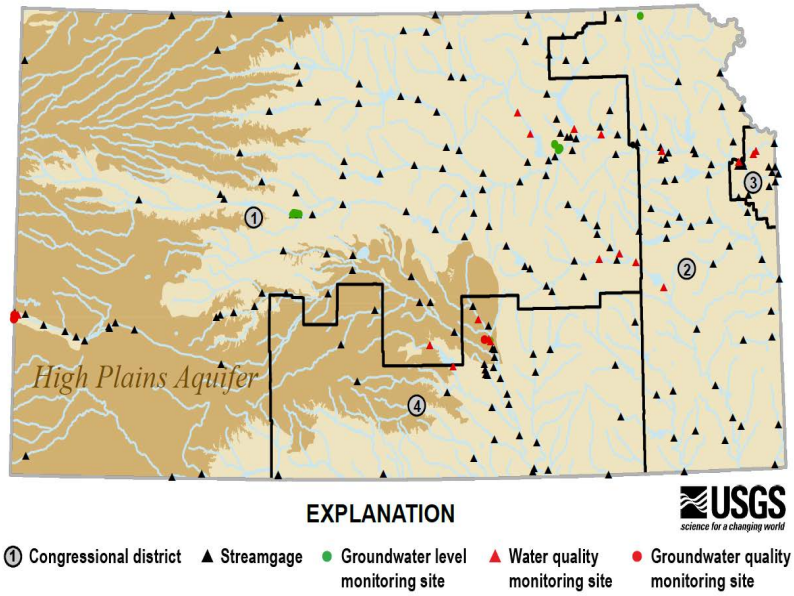


Figure 7. USGS monitoring network in Kansas.[8]

Reduce Vulnerability to Extreme Events

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.

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.[9]

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

Reduce Vulnerability to Extreme Events

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. Adding urgency to the situation, flood risk is projected to increase in the coming decades due to climate change and population growth with risk disproportionately concentrated in impoverished communities throughout the United States.[10] Ultimately, the effectiveness of real-time hydrology information is reliant on our ability to share the information with multiple user groups.

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, streamflow, reservoir storage, levee integrity and other items is 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.[11,12]

DROUGHT IN KANSAS

Kansas is one of the many states with a history of significant effects from drought, exemplified by the 1930s and 1950s. More recently, from late 2010 to late 2015, a multi-year drought occurred in Kansas (Figure 8). The drought peaked in 2012, the warmest and one of the driest years on record, averaging 4.9 inches of rain in May through July.[4] Each year, drought costs the United States an average of $8 to 9 billion, as estimated by the USGS.[13] 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.[14]

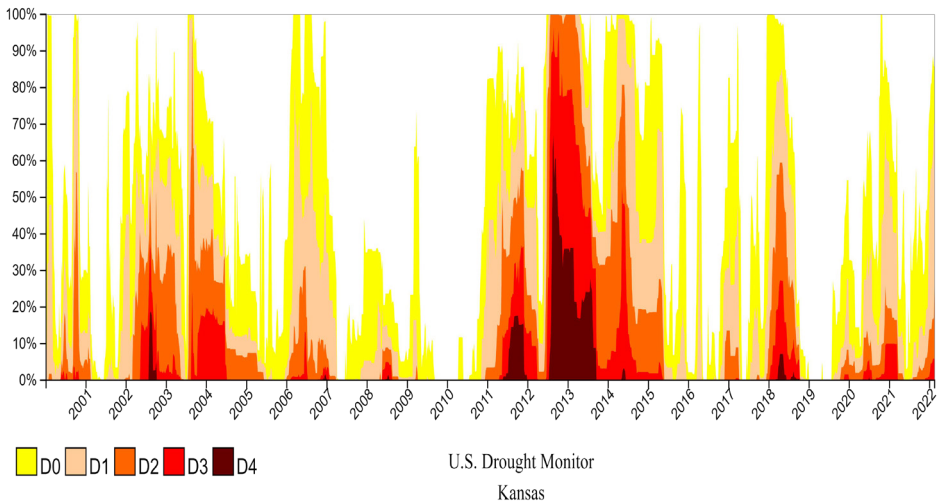


Figure 8. Drought in Kansas from 2000-Present (U.S. Drought Monitor: Kansas)

Reduce Vulnerability to Extreme Events

In 2011, 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.[15] 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.[16]

While temperature increases in the state are projected to increase drought, the frequency and severity of wildfires are also projected to increase. Warmer temperatures combined with dry vegetation and soil raises the potential for wildfires.[4] In December of 2021, the warmest December to date in Kansas, devastating wildfires swept central Kansas, burning over 165,000 acres of land.[16,17]

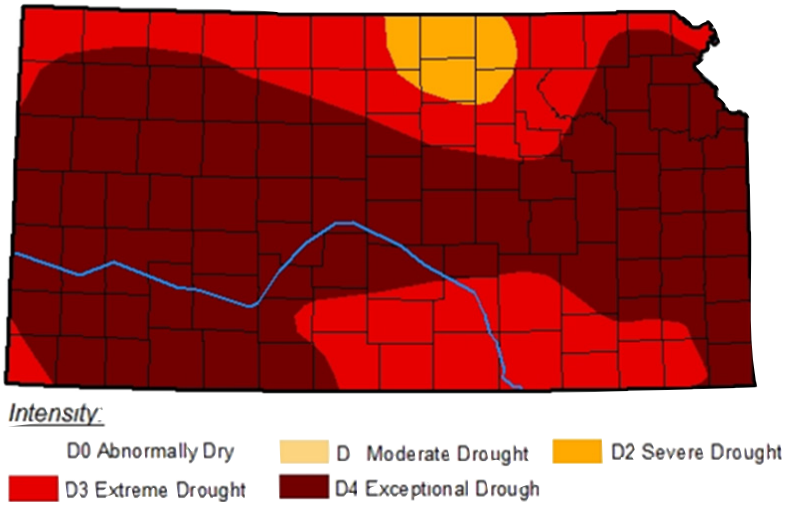


Figure 9. Kansas drought conditions in late August 2012.[18]

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.

Reduce Vulnerability to Extreme Events

Drought impacts are not limited to agriculture. 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. For example, the most recent severe drought of 2011-2013 led to the adoption of water restrictions in approximately 40 Kansas cities all across the state, large and small, urban, suburban and rural.[19] Those cities included Lawrence, Dodge City, Leawood, Emporia, Seneca and Topeka. Johnson County set a record for single day water use in July 2012.[20] Industry faced similar challenges; in 2012, oil companies struggled to obtain sufficient supplies of water necessary for drilling operations.[21]

Wildlife also suffers significantly, as was seen during the 2011-2013 drought, which dried up most wetlands in the state, depriving bird populations of necessary habitat.[22] The diminished grassland bird population, including pheasants, drew few hunters in the fall of 2012, causing a loss of many millions of dollars from the rural Kansas economy.[23] During the same time frame, monarch butterfly populations in northeast Kansas dwindled. Increased numbers of whitetail deer died in 2012 due to congregating around sparse water sources where they more easily contracted a hemorrhagic disease transmitted by biting midges.[24]

Media coverage of drought tour, 2012

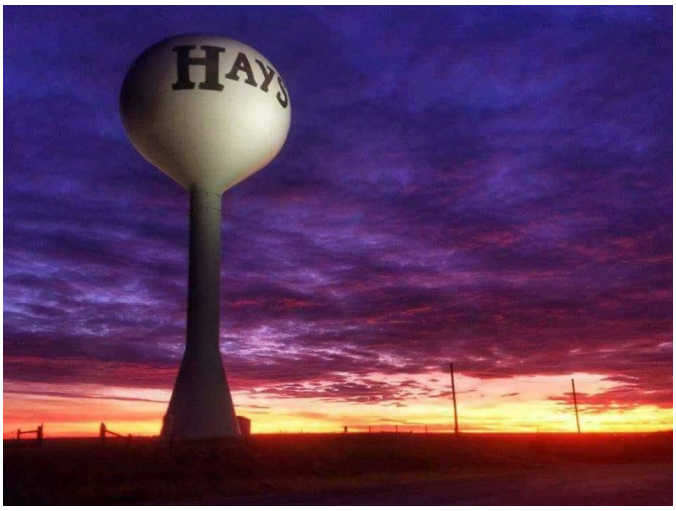
Maximizing conservation practices, such as increase in soil health practices, and efficient water use during a drought is critical.

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

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

Reduce Vulnerability to Extreme Events

MUNICIPAL WATER CONSERVATION PLANS[25]

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)[26]

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

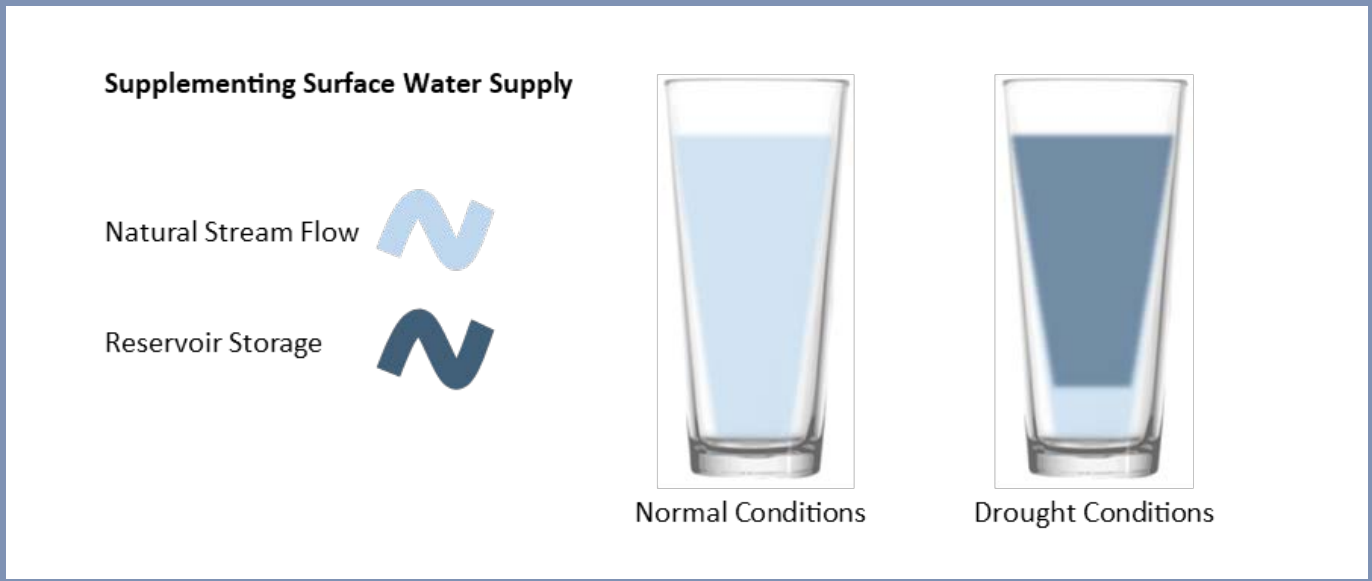
Management Approach

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 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.

WATER REUSE

According to the Kansas Health Institute, the term "water reuse" is often used synonymously with water reclamation and water recycling.[27] Water reuse is the process of reclaiming and converting wastewater from numerous sources and reusing it for a variety purposes such as irrigation, groundwater replenishment, industrial processes and environmental restoration.[28] Cities and industries are utilizing this resource as it provides both environmental and economic benefits. Garden City, with public and private partners and federal grant funding, enhances its municipal water supply through reuse. Most of the reuse water across the state is applied to ball fields, golf courses, or crops not for human consumption. In October 2017, the Kansas Health Institute published their assessment of municipal water reuse in Kansas and potential health effects. Included in the assessment was information regarding locations in Kansas of water reuse efforts and community perceptions of water reuse and water quality.[29]

ASSESSMENT, PREVENTION AND RECOVERY

The State of Kansas has developed programs within multiple agencies tasked with floodplain management and mapping, 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, the 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, six flooding and 17 drought billion-dollar (CPI-adjusted) disaster events affected Kansas (Figure 10).[30] 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.

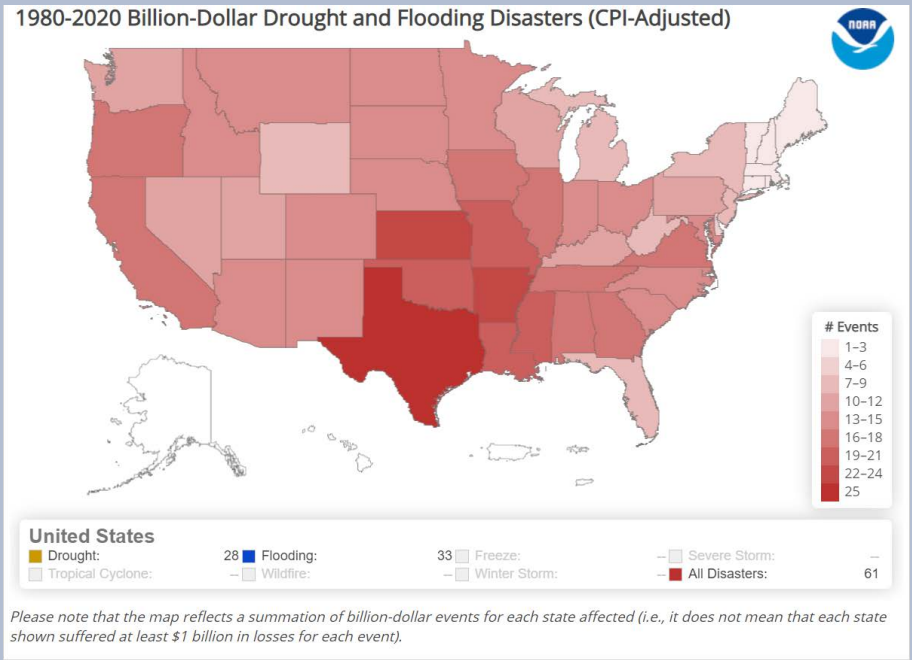


Figure 10. 1980-2021 U.S. billion-dollar drought and flooding disasters.[16]

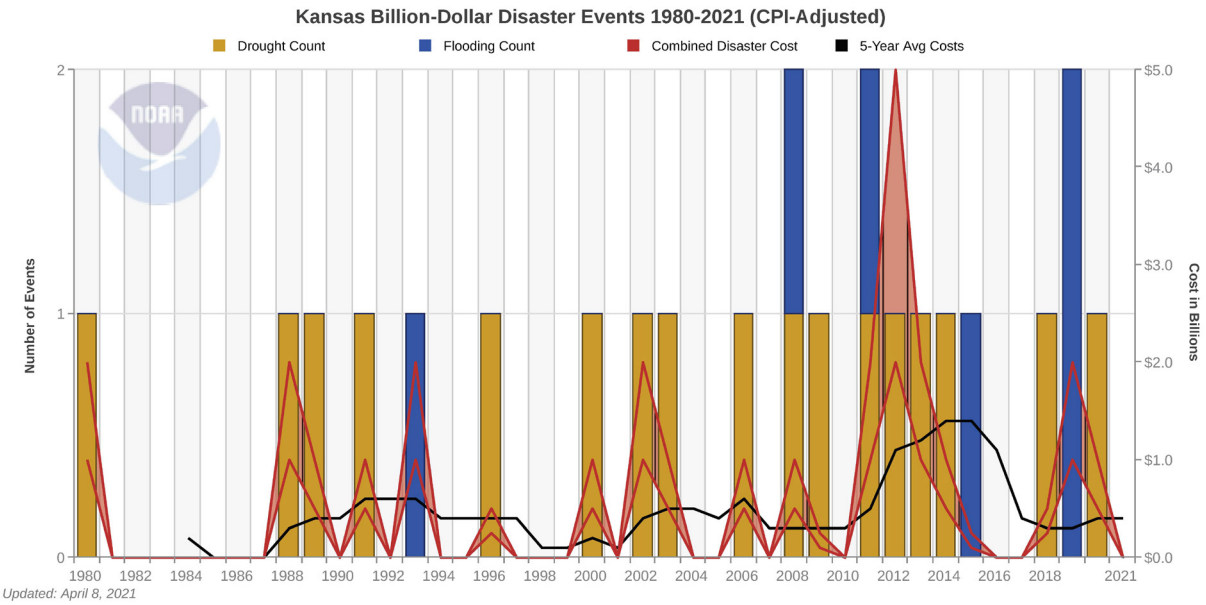


Figure 11. 1980-2021 Kansas billion-dollar disasters.[16]

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, nutrient runoff, and sedimentation 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.
- Implement urban stormwater runoff capture and reuse in areas where such

Reduce Vulnerability to Extreme Events

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.
- 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 all water users' participation in groundwater conservation programs.

Extreme events in Kansas have already increased in frequency and intensity due to climate change caused by anthropomorphic activity. Current predictions indicate droughts and floods will continue to increase into the future (in different parts of the state), magnifying the challenge of securing a safe, reliable water supply. Keeping this trend to the minimum possible will require re-aligning practices of all kinds (including municipal, individual, agricultural, recreational and industrial) so as to reduce the emission of greenhouse gases into our atmosphere. Solving the problem requires addressing the causes, as well as the effects.

Reduce Vulnerability to Extreme Events

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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 to better make the connection of Kansas users to their 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" website for information and learning resources.[1] To meet this goal, an interagency and interorganizational coordinating team was 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 that now serves as the foundation for the Kansas Water Plan Guiding Principle: *Increase Awareness of Kansas Water Resources*.

River seining workshop

No actions within this guiding principle are intended to displace current water education programs found throughout Kansas. 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 education programs, poster and essay contests through the County Conservation Districts; local community water festivals; Kansas Association of Conservation and Environmental Education (KACEE) Projects WET, WET in the City and other conservation education curriculum and workshops; 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, Groundwater Management Districts (GMDs), Kansas Association of Zoos and Aquariums, non-governmental organizations (NGOs) and many others provide an avenue for delivery of critical water conservation education and information.

The initiatives and concepts described are strategic in nature and, as such, do not detail implementation actions. The initiative implementation plans will be developed following the approval of the initiatives. Any local, regional or state agency, educational institution, NGO, private company or

Increase Awareness of Kansas Water Resources

individual stakeholder interested in water education programs is invited and encouraged to provide input and feedback regarding the 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 guiding 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 remain to strengthen Kansans' knowledge and awareness of water and water-related issues. Filling the gaps and success in the end will require everyone on all levels working together with a common goal of conserving and protecting Kansas 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 2021 Goals and Action Plans of the RACs across the state (Figure 1).[5]

Water Festival Field Day

Regional Advisory Committee Water Education & Outreach-Related Goals					
Region	Regional Goal				
	1	2	3	4	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		
Verdigris			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 related educational programs and research.
- Utilize existing youth clubs and youth education programs 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 education 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 programs.
- 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 of lower quality water.
- Develop workshops, programs, educational materials and professional development opportunities for 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.
- Share regional and statewide information about current groundwater, surface water, water quality, and water storage conditions to Kansans through education programs and various social media platforms.

Data, Research, and Studies

- Establish baseline knowledge of Kansans' comprehension of water issues and assess periodically.
- Continue evaluation and information sharing of the economic impacts of reduced water use, conservation practice implementation, land management, municipal and industrial conservation measures, and/or reuse for multiple user groups.

Increase Awareness of Kansas Water Resources

- Evaluate higher education institutions' current academic offerings, identify water-related courses and curricula currently offered, if any, and provide suggested curricular additions and content.
- Complete and evaluate U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA) funded grant projects.
- 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 an online water availability tool that may be used by individuals, organizations, local entities and consultants to evaluate potential water development or management projects.
- Conduct economic analyses to estimate the impacts to individual, regional, and statewide economies associated with a variety of 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 *Increase 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 for projects that implement the Kansas Water Plan, towards which funding may be directed as grant and other funding opportunities arise.
- Encourage the Governor and Legislature to increase funding to support the above recommendations.

Increase Awareness of Kansas Water Resources

Resources

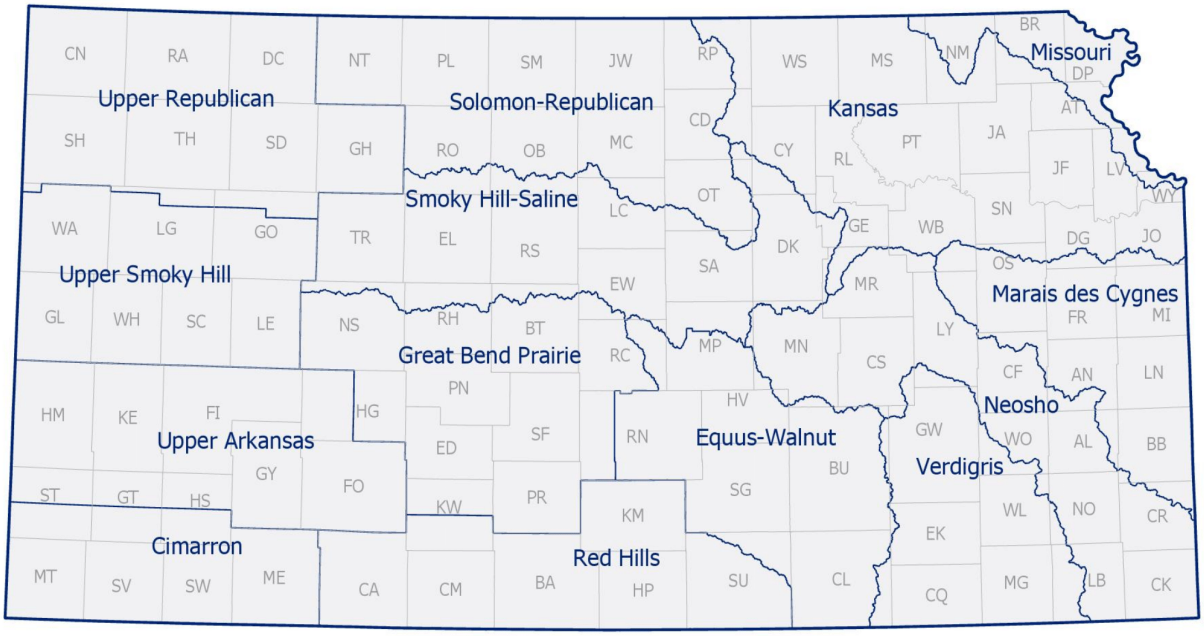
1. A Long-Term Vision for the Future of Water Supply in Kansas. January 2015. Pg 74. https://kwo.ks.gov/docs/default-source/water-vision-water-plan/vision/rpt_water_vision_reformatted_kf1d56e11da40b6667970cff000032a16e.pdf?sfvrsn=0
2. A Long-Term Vision for the Future of Water Supply in Kansas. January 2015. Pg 15. https://kwo.ks.gov/docs/default-source/water-vision-water-plan/vision/rpt_water_vision_reformatted_kf1d56e11da40b6667970cff000032a16e.pdf?sfvrsn=0
3. A Long-Term Vision for the Future of Water Supply in Kansas. January 2015. Pg 73. https://kwo.ks.gov/docs/default-source/water-vision-water-plan/vision/rpt_water_vision_reformatted_kf1d56e11da40b6667970cff000032a16e.pdf?sfvrsn=0
4. Vision Education Public Outreach Supplement. January 2015. Pg.76. https://kwo.ks.gov/docs/default-source/water-vision-water-plan/vision/rpt-vision-education-public-outreach-supplement-section.pdf?sfvrsn=4
5. Regional Planning Area Goals and Action Plans. https://kwo.ks.gov/docs/default-source/water-vision-water-plan/vision/rpt-vision-education-public-outreach-supplement-section.pdf?sfvrsn=4
6. A Long-Term Vision for the Future of Water Supply in Kansas. January 2015. Pg 15. https://kwo.ks.gov/docs/default-source/water-vision-water-plan/vision/rpt_water_vision_reformatted_kf1d56e11da40b6667970cff000032a16e.pdf?sfvrsn=0
7. Vision Education Public Outreach Supplement. Pg. 70-77. https://kwo.ks.gov/docs/default-source/water-vision-water-plan/vision/rpt-vision-education-public-outreach-supplement-section.pdf?sfvrsn=4

Regional Planning Areas - Overview

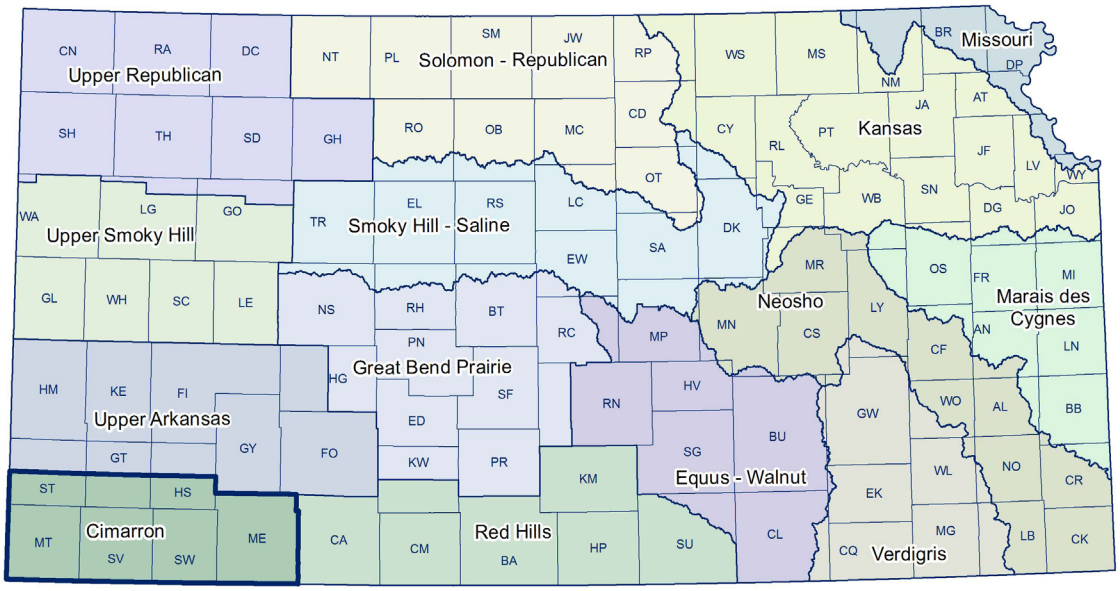
Fourteen regional planning areas were established in December 2014 by the Kansas Water Authority in conjunction with the Long-Term Vision for the Future of Water Supply in Kansas.

In August of 2015, Regional Advisory Committee members were approved for each of these 14 planning areas and began to establish priority goals for their region. These committees established their priority regional goals and began development of Regional Goal Action Plans. In September - October 2016 all regional goal action plans were presented to the Kansas Water Authority and approved. These Regional Goal Action Plans were updated by the respective RACs from 2020 through the first part of 2021 and can be found in Appendix A.

The Kansas Water Office formulates a comprehensive state water plan for the management, conservation and development of the water resources of the state. The Kansas Water Plan includes sections corresponding with water planning areas which are determined by the Kansas Water Office (K.S.A. 82a-903). Water planning is achieved by addressing issues in the regional areas of the state.



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.

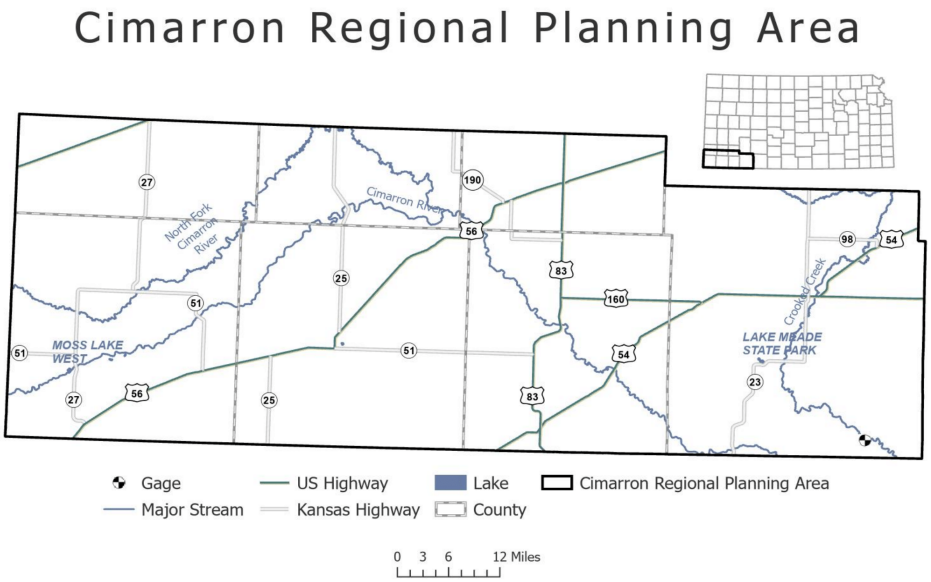


Figure 1. Cimarron Regional Planning Area

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.

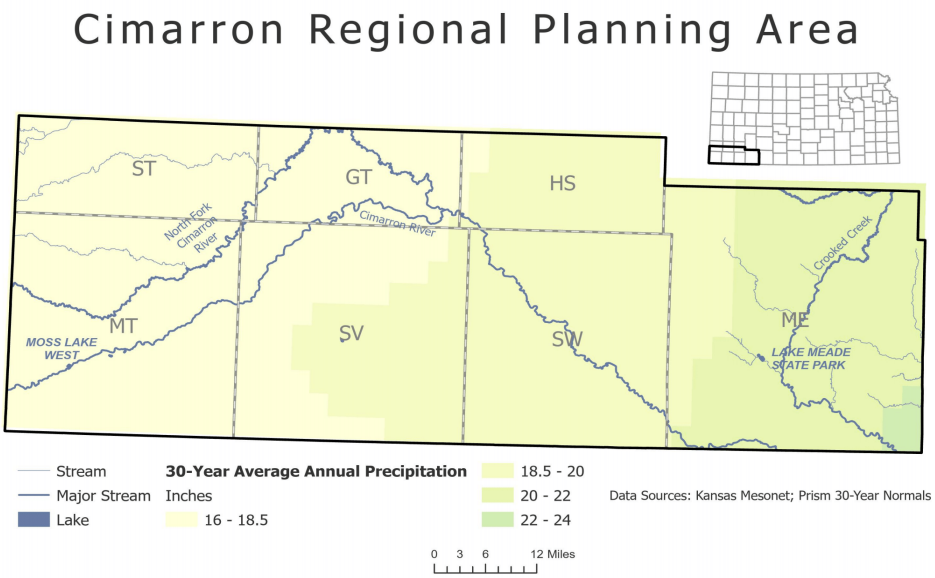


Figure 2. 30-year average annual precipitation in the Cimarron Region

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[1]. 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.[1] Figure 3 lists the remaining land uses in the region, including: developed/urban open space.

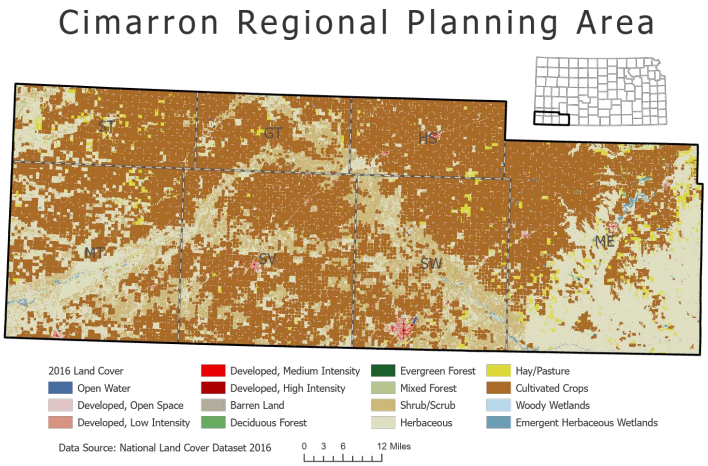


Figure 3. 2016 Cimarron regional land cover

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.[2] 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 release and analysis of the 2020 Census (Figure 4).

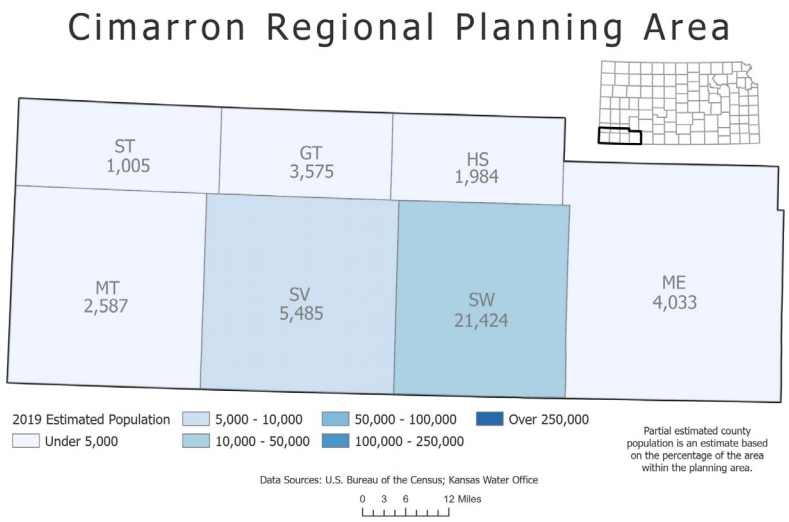


Figure 4. 2019 estimated population by county

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.

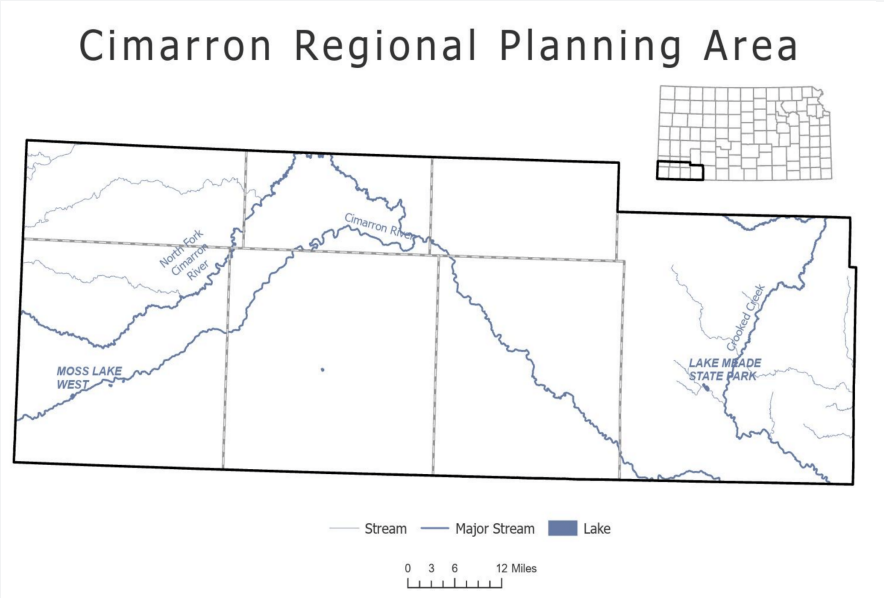


Figure 5. Major water resources in the Cimarron Region

Playa 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.

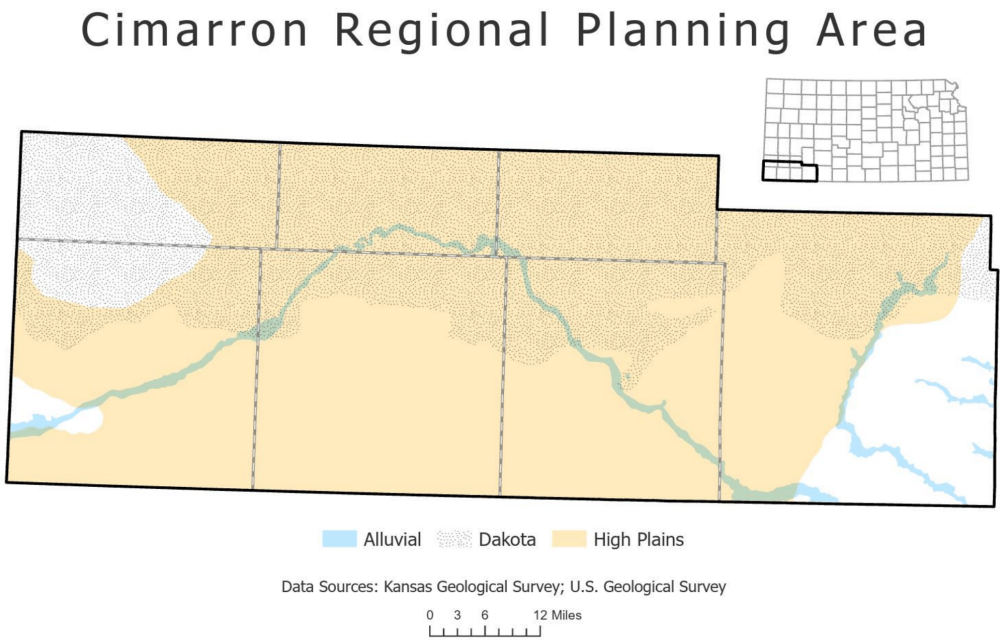


Figure 6. Principle aquifer boundaries in the Cimarron Region

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.[3]

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.

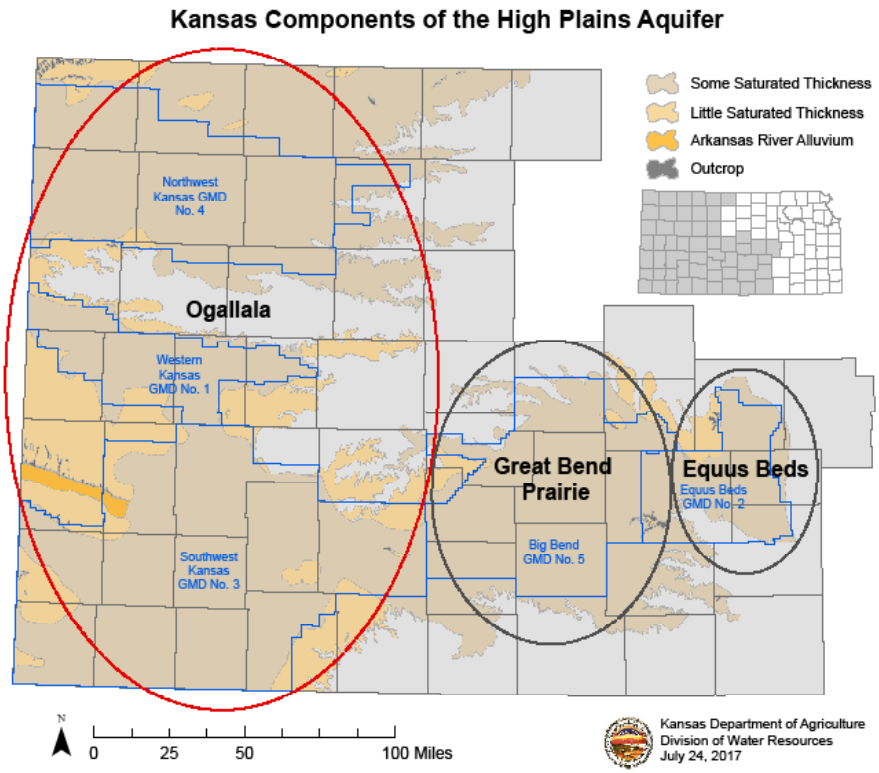


Figure 7. Kansas Components of the High Plains Aquifer.[4]

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 experiencing significant shortages in meeting demand.

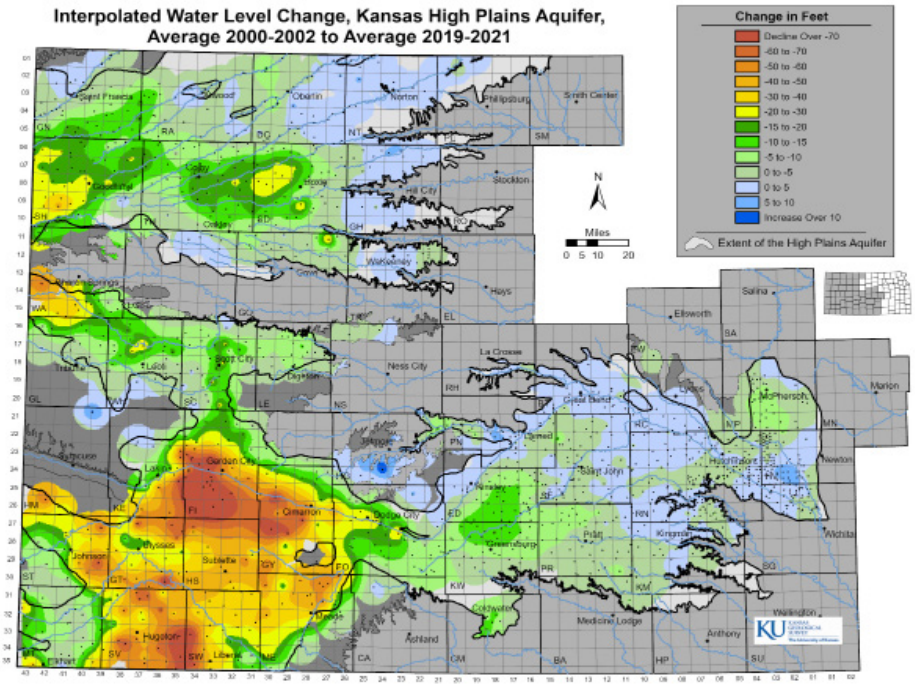


Figure 9. Water Level Change, Kansas High Plains Aquifer[6]

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.[5]

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 to achieve water conservation 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. Evaporative 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.

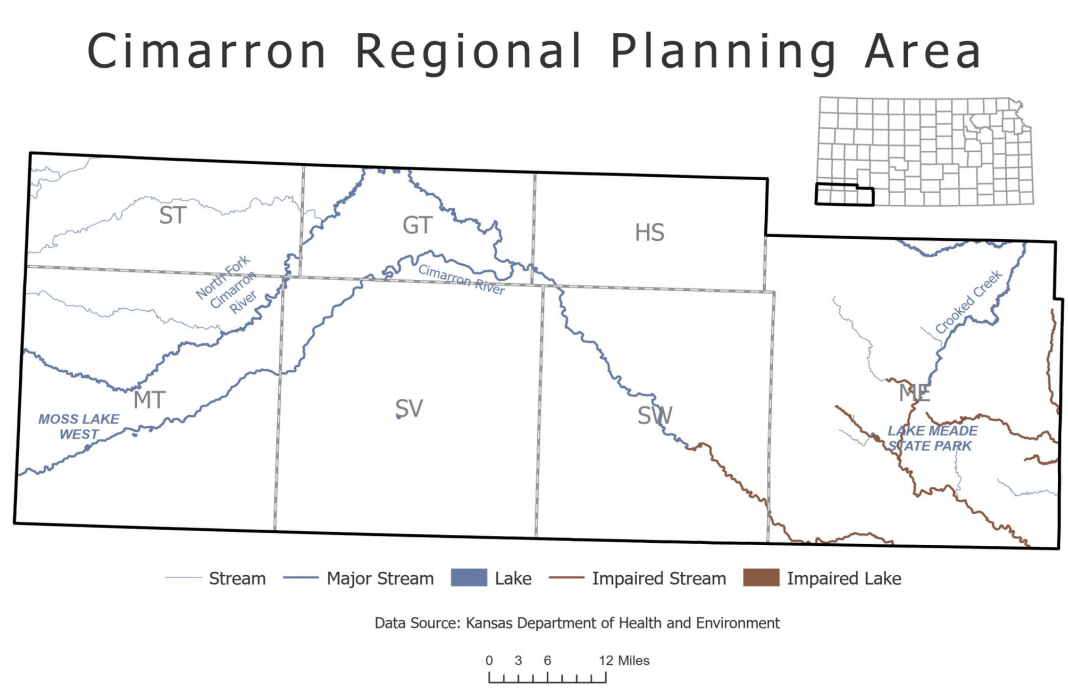


Figure 10. Impaired water resources in the Cimarron Region

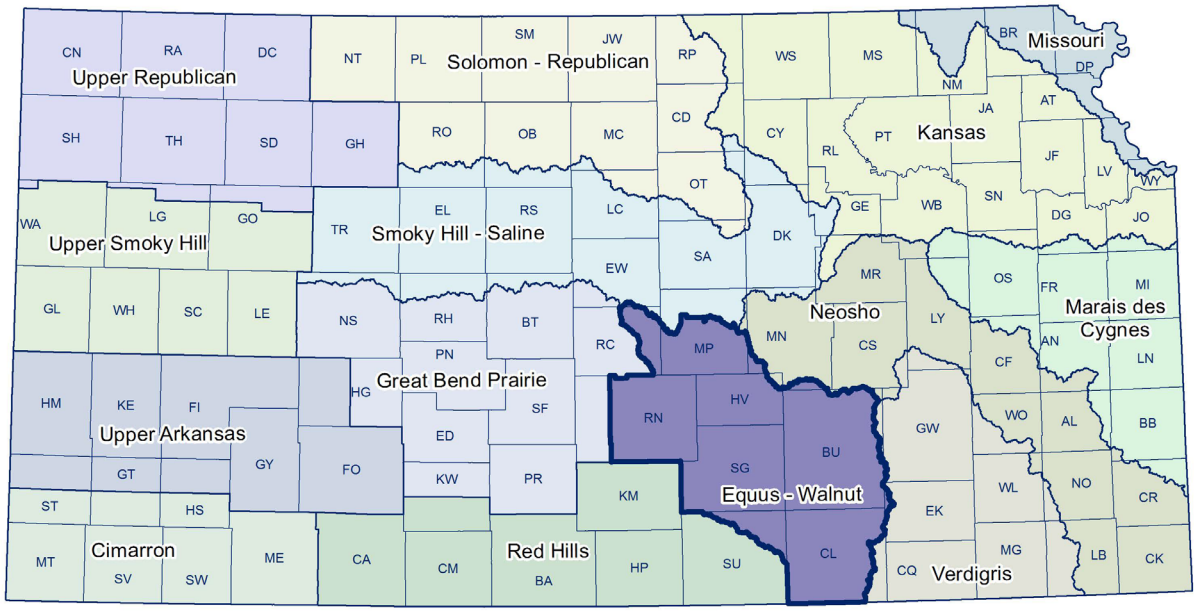
The saline groundwater discharges into the Cimarron River in southeast Seward County and southwest Meade County. River salinity has increased as fresh groundwater discharge is reduced with the decline of groundwater levels. Crooked Creek and some of its tributaries also have impaired use due to chloride 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).[7] 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

Equus-Walnut Region



Equus-Walnut Region

Regional Description

The Equus-Walnut Regional Planning Area is located in south-central 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).

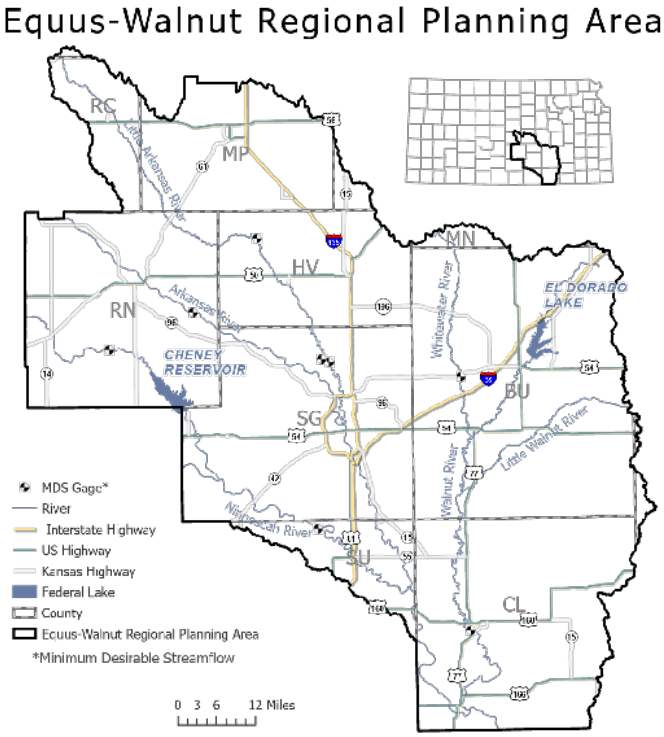


Figure 1. Equus-Walnut Regional Planning Area

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.

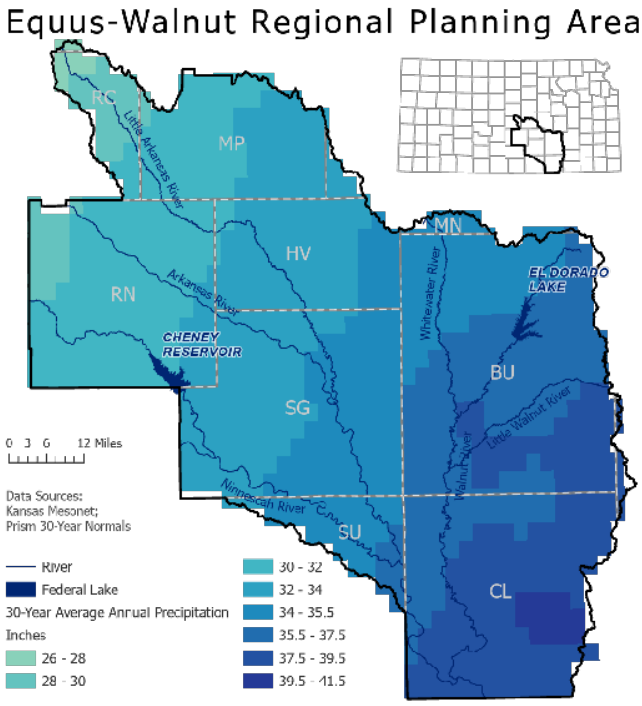


Figure 2. 30-year average annual precipitation

Equus-Walnut Region

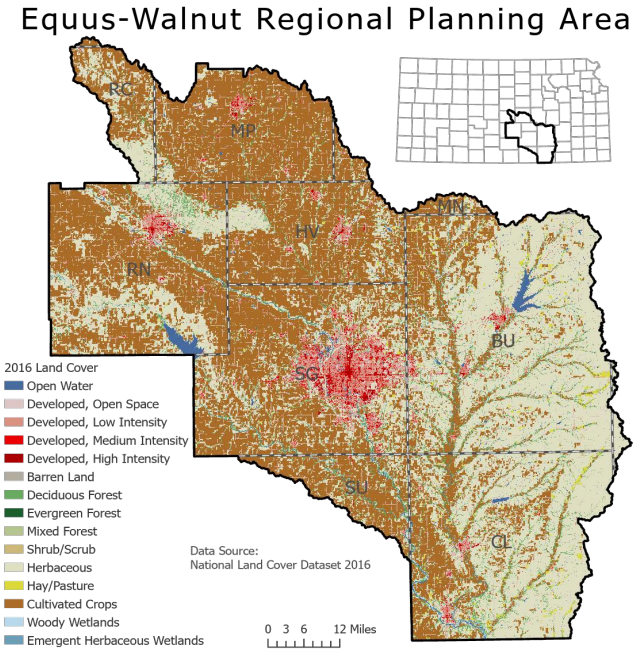


Figure 3. Equus-Walnut regional land cover

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.[1] 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).[2] 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, release and analysis 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 and McPherson.

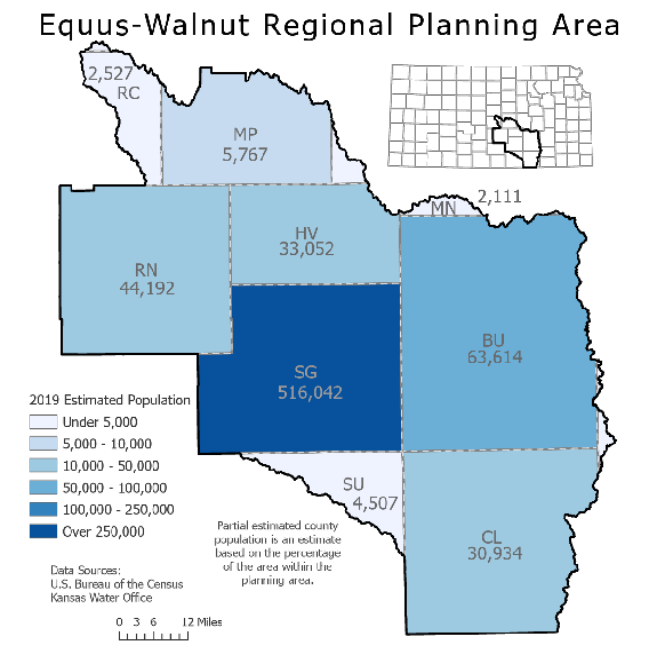


Figure 4. 2019 estimated population by county

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.

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).

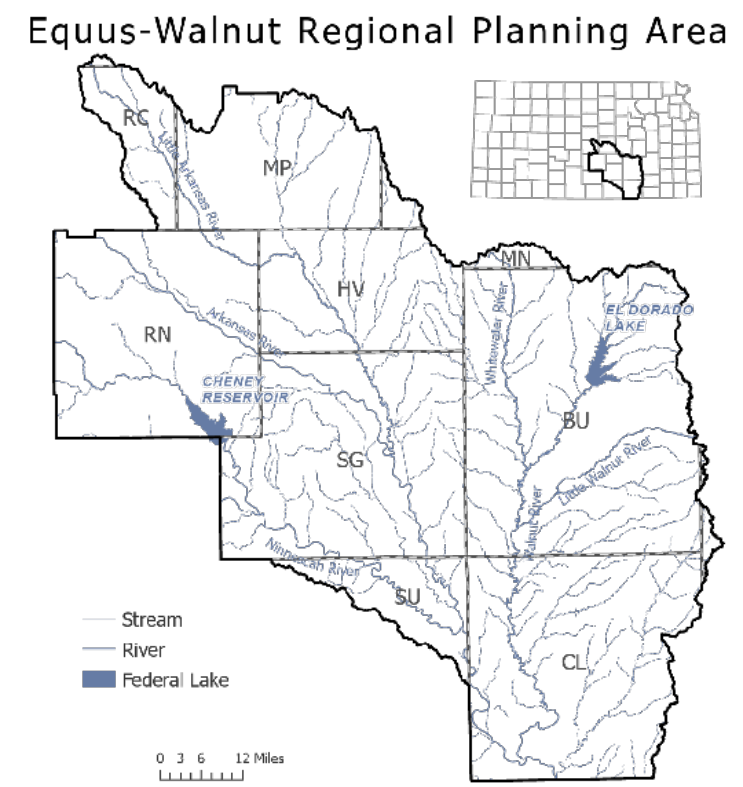


Figure 5. Surface water within the Equus-Walnut Region

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

Equus-Walnut Region

GROUNDWATER

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 supports irrigation, stockwatering and domestic water use. It also 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, especially during drought conditions, has led to water-level declines in isolated areas and concerns about future water supply. Depth to bedrock from land surface varies widely in the area. In some parts of GMD2, bedrock is at or near land surface. Nitrate contamination is present in identifies areas of the aquifer, such as Pretty Prairie in the southwest. Chloride plumes threaten multiple areas of the aquifer; the Burrton chloride plume advances east-southeast at a rate of 0.81' per day.

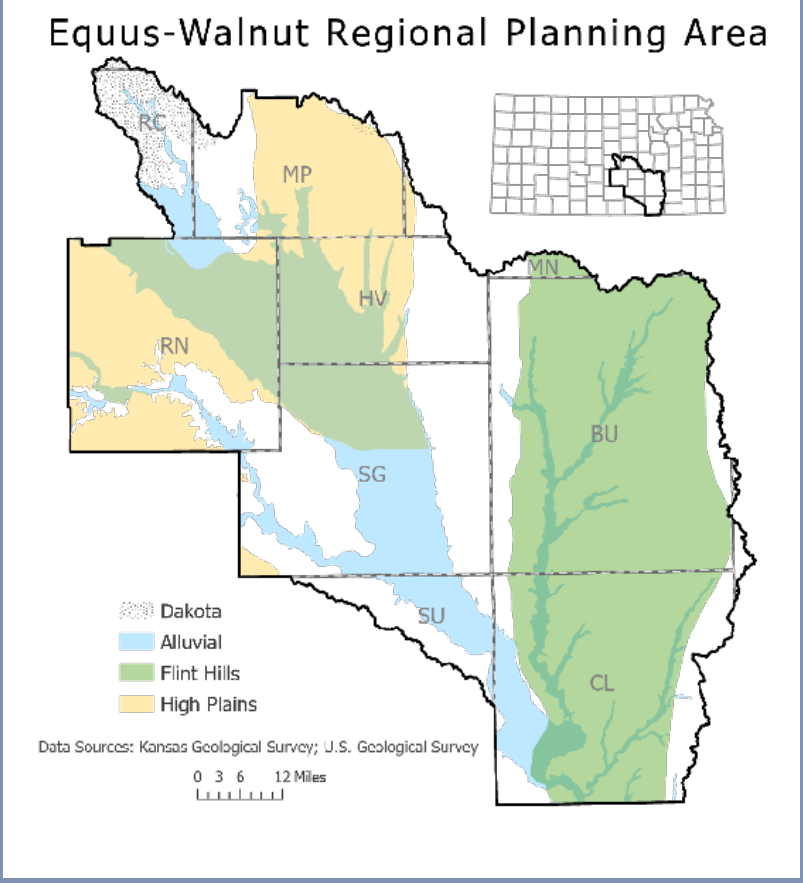


Figure 6. Principle aquifer boundaries in the Equus-Walnut Region

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. Most wells in the aquifer are utilized for 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 other municipalities, 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 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.

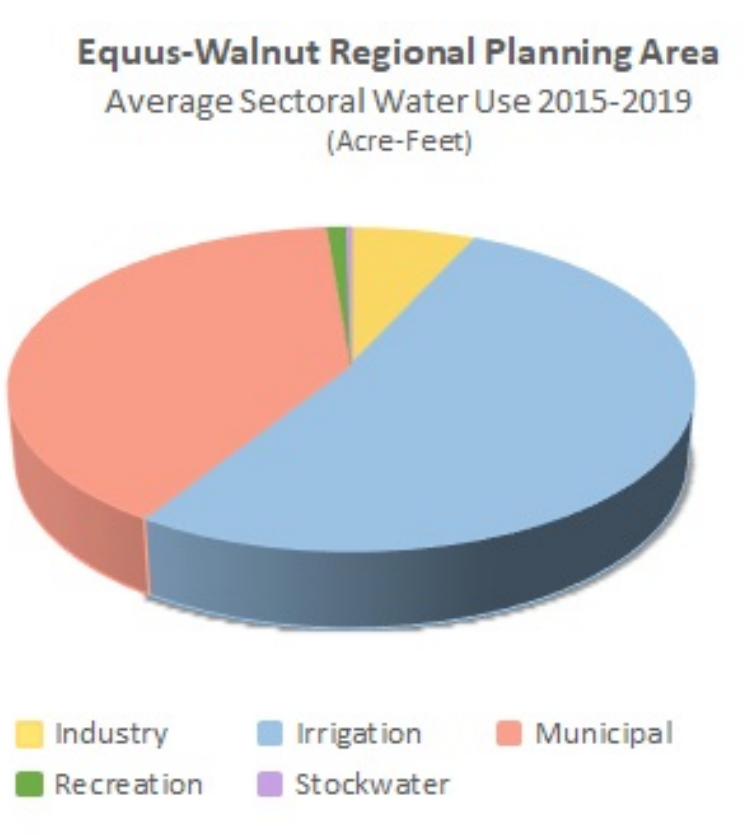


Figure 7. Average sectoral water usage

Regional Issues & Priorities

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. Areas of greater decrease exist in portions of McPherson County. In January 2017, the Kansas Geological Survey completed the Equus Beds Groundwater Management District No. 2 Sustainability Assessment, using their

Equus-Walnut Region

Qstable methodology to determine the average annual water use that would produce stable averaged water levels at the GMD, county, township, and other defined area intervals.[3] 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. 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 profitability.

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.

Wichita ASR. Photo Credit: Burns & McDonnell

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. In March 2018, Wichita submitted to KDA-DWR a proposal for modifications to the conditions associated with Wichita's existing Phase II ASR permits. After a process of public meetings and a formal phase of public hearings from 2018 through 2021, the Chief Engineer denied the City's request in 2022.

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. See *Improve the State's Water Quality* section for further information.

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 (Figure 8).

Pretty Prairie, Kansas has been affected by contaminated water since the 1990s. The contamination was primarily caused by nitrate fertilizers used on wheat, soybean, and sorghum crops in the area according to KGS Open-File Report 1999-44.

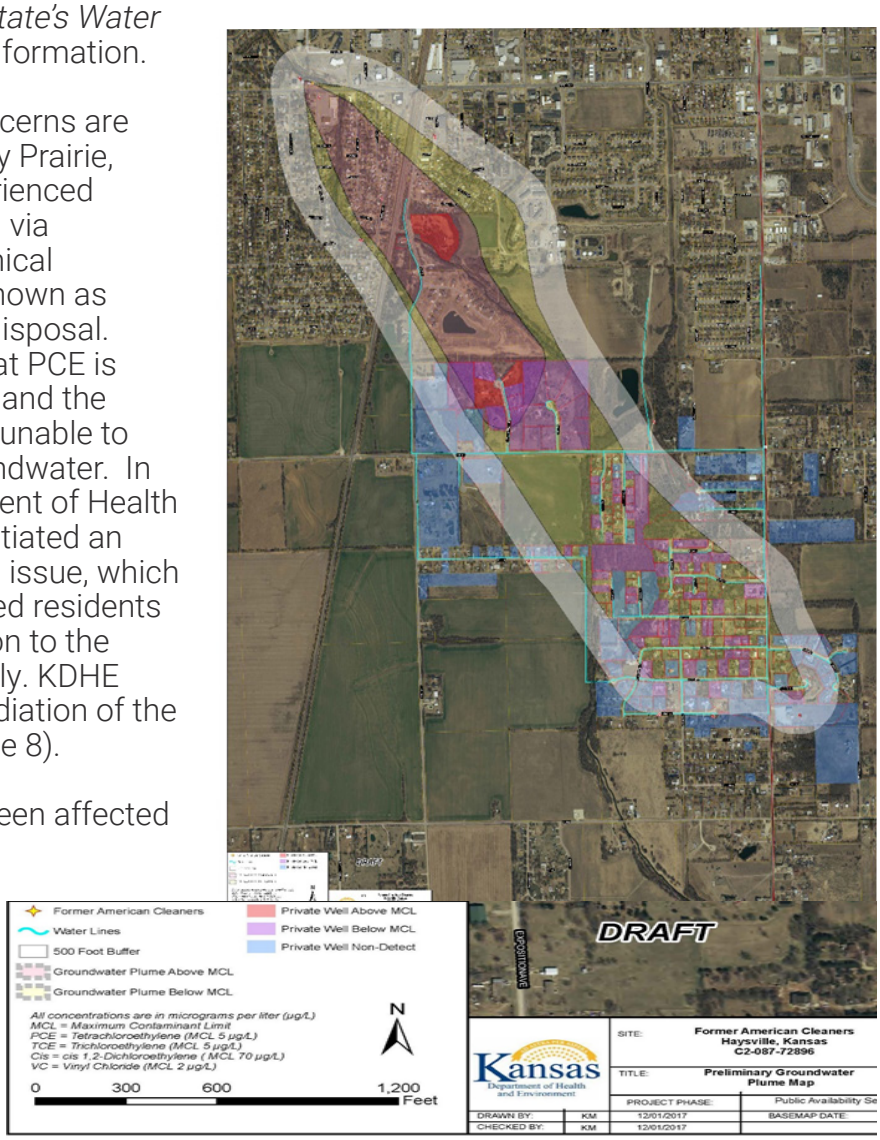


Figure 8. PCE and TCE contamination plume, Haysville.

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.

In the Equus-Walnut Region, communities and commercial facilities are authorized to reuse treated wastewater. Two industrial facilities, 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 may add to available water due to the large amounts of brackish water in the region.

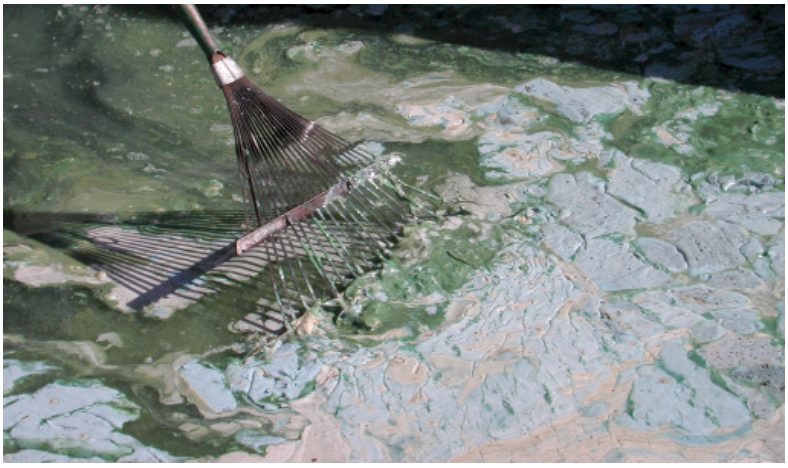
Equus-Walnut Region

SURFACE WATER QUALITY CONDITIONS IN THE REGION

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).[4] 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.

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.[5] 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, including nutrient management plans for producers, are key WRAPS projects being implemented. Excess agricultural nutrients can lead to Harmful Algae Blooms (HABs) which can be exacerbated by certain Aquatic Nuisance Species (ANS).

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.



Harmful Algal Bloom

Equus-Walnut Region

In 2020, General Mills launched a regenerative agriculture pilot project with producers in the Cheney Reservoir watershed, in conjunction with the KDHE WRAPS program. This watershed 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, creating a more resilient and clean water supply 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 increasing resilience to extreme weather events and the impacts of climate change. 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.[6]

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.

General Mills Field Day. Photo Credit: KDHE

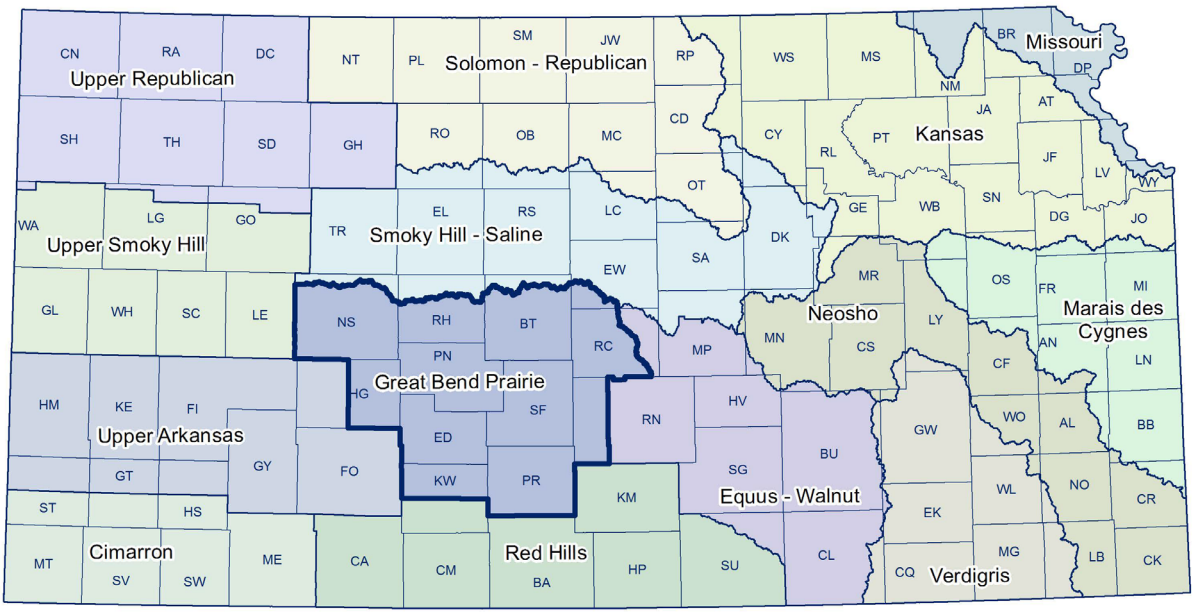
Equus-Walnut Region

COMPREHENSIVE WATER SUPPLY PLANNING

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. Development of comprehensive water supply plans which include conservation and resilience to climate change is essential for future water security. Determining the current status of water supply planning efforts for municipalities and public water suppliers within the region and providing assistance for those efforts can help ensure that appropriate actions can be initiated to promote adequate water supply for generations to come.

Wichita ASR. Photo Credit: Alberici

Great Bend Prairie Region



Great Bend Prairie Region

Regional Description

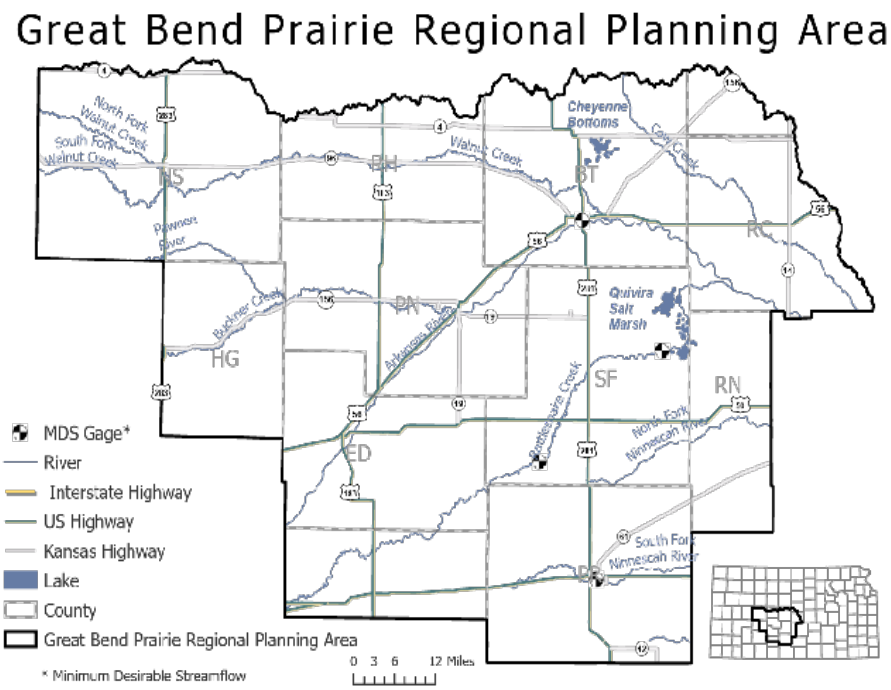


Figure 1. Great Bend Prairie Regional Planning Area

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.

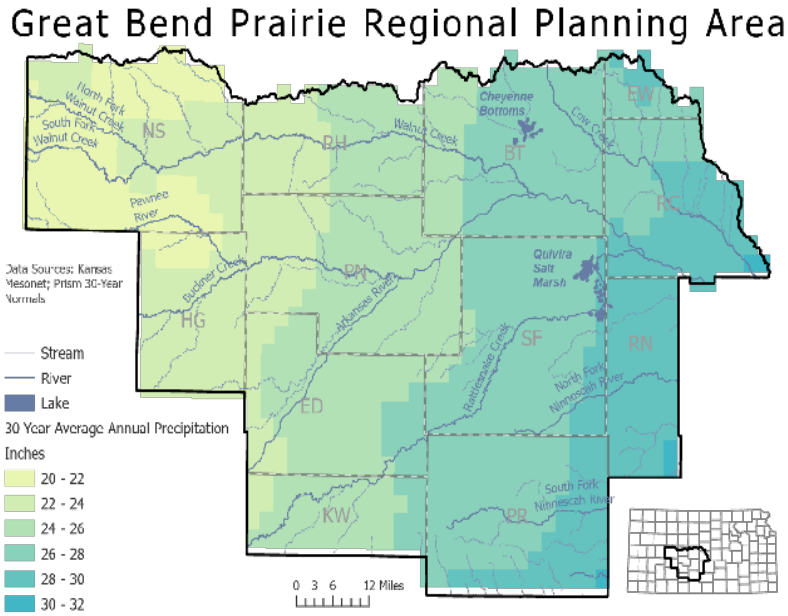


Figure 2. 30-year average annual precipitation in the Great Bend Prairie Region

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

Great Bend Prairie Region

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.

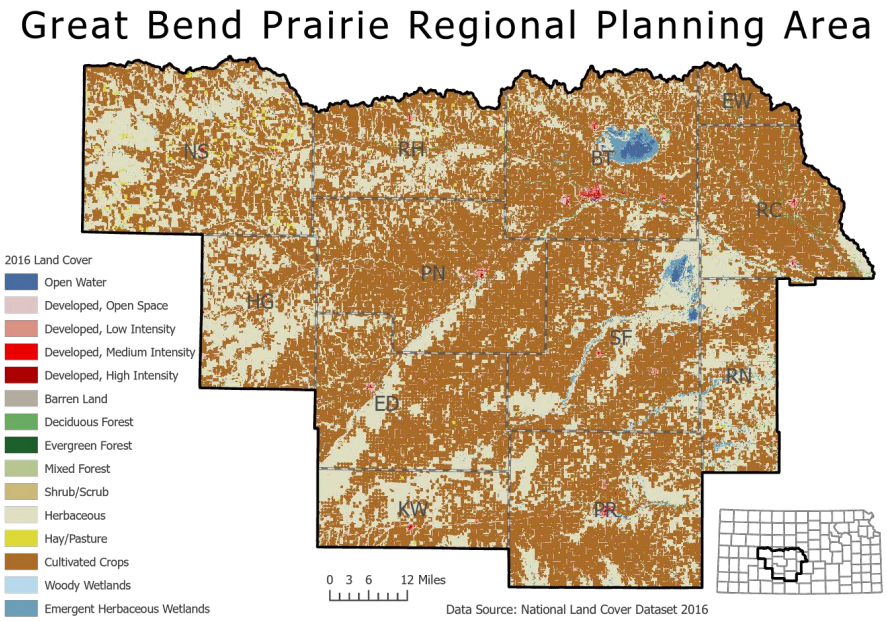


Figure 3. 2016 Great Bend Prairie regional land cover

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).[2] 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 underrepresented, so further refining of population information for water supply planning purposes will be possible following certification and release of the 2020 Census.

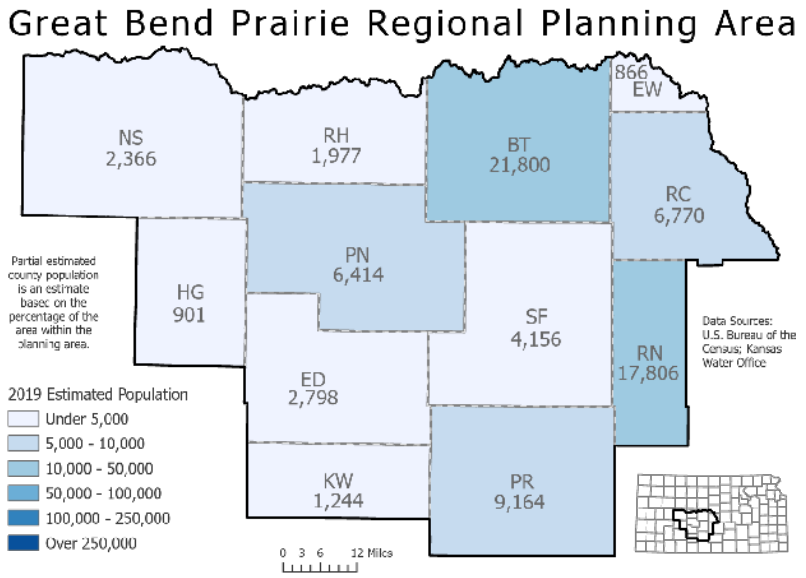


Figure 4. 2019 estimated population by county

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).

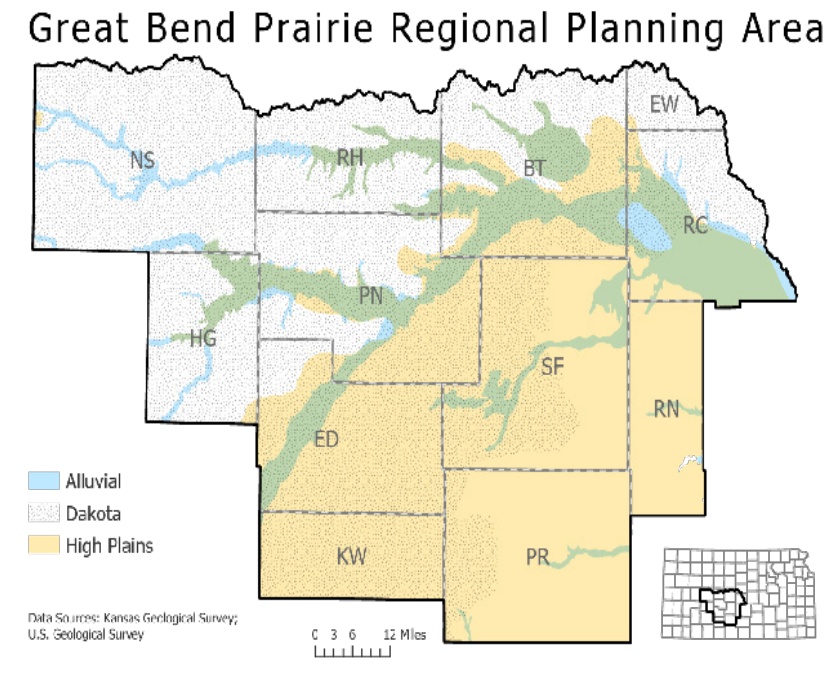


Figure 5. Principle aquifer boundaries in the Great Bend Prairie Region

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 two additional bodies of surface water of significant importance in the region: Cheyenne Bottoms and Quivira National Wildlife Refuge.

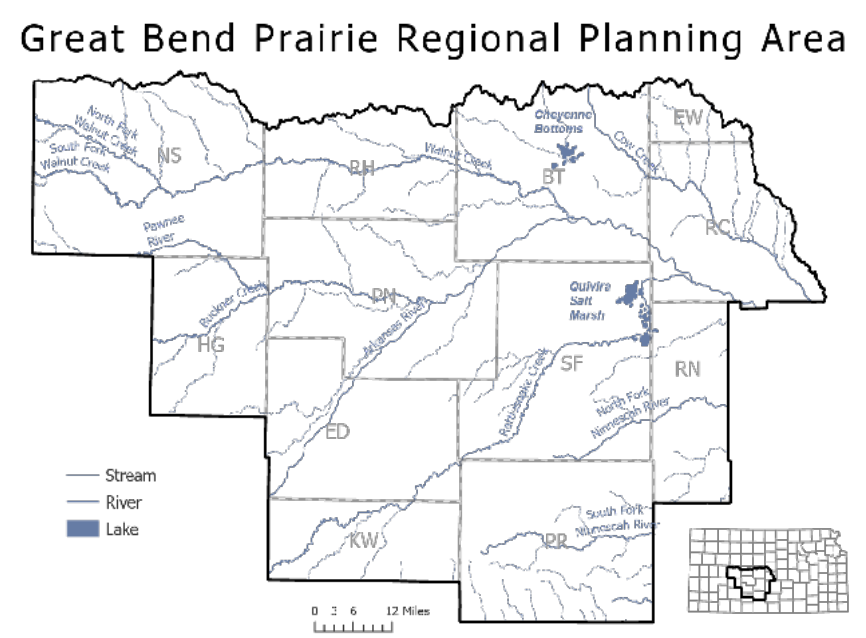


Figure 6. Major water resources in the Great Bend Prairie Region

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.

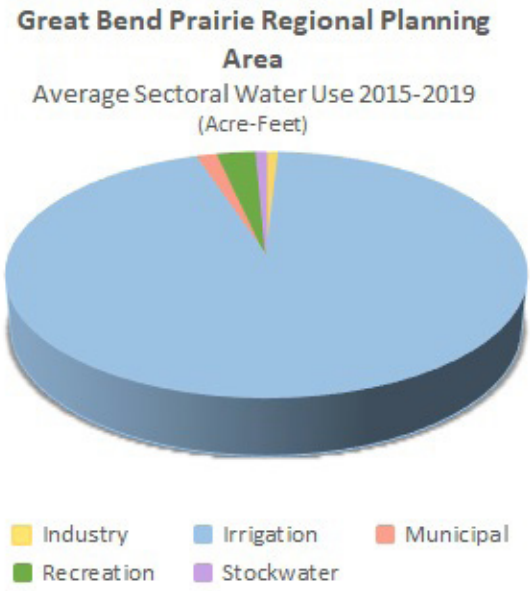


Figure 7. Average sectoral water usage

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).

Intensive Groundwater Use Control Areas in Kansas

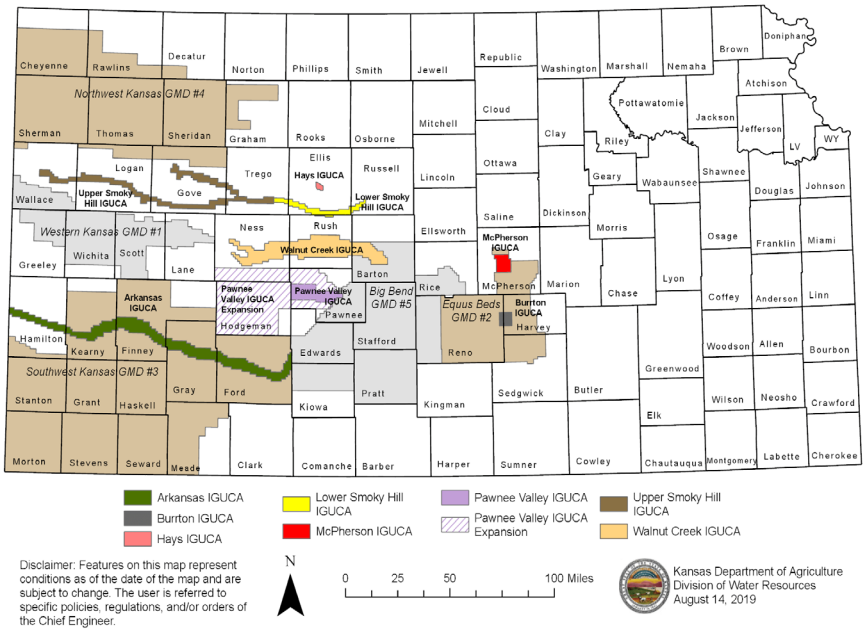


Figure 8. Intensive Groundwater Use Control Areas in Kansas[9]

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 order to reach long term sustainability of groundwater 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).[3] 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 9).

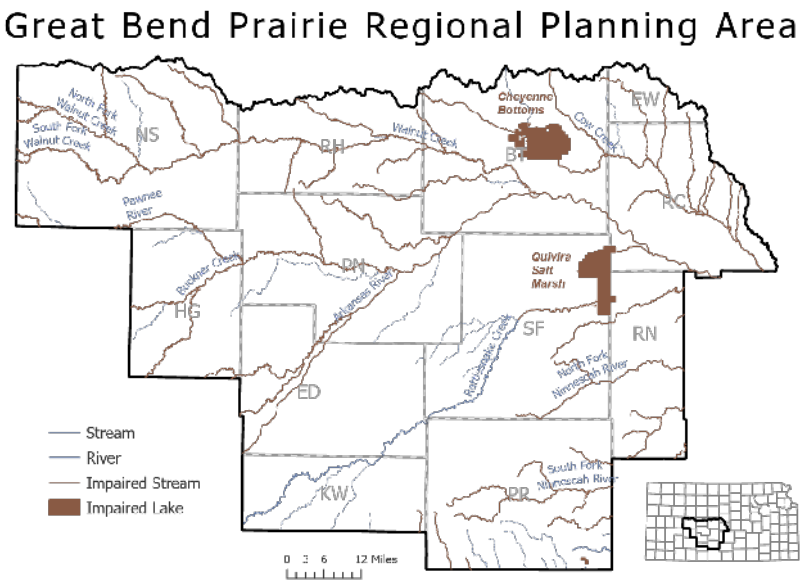


Figure 9. Impaired water resources in the Great Bend Prairie Region

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 have been 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.

Great Bend Prairie Region

GROUNDWATER QUALITY

Chlorides

Due to the conditions and composition of the aquifer and underlying bedrock, groundwater sources within the region contain high salinity (Figure 10). 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 variable salinity of the underlying Permian bedrock causes the intrusion of saltwater into the aquifer.[4]

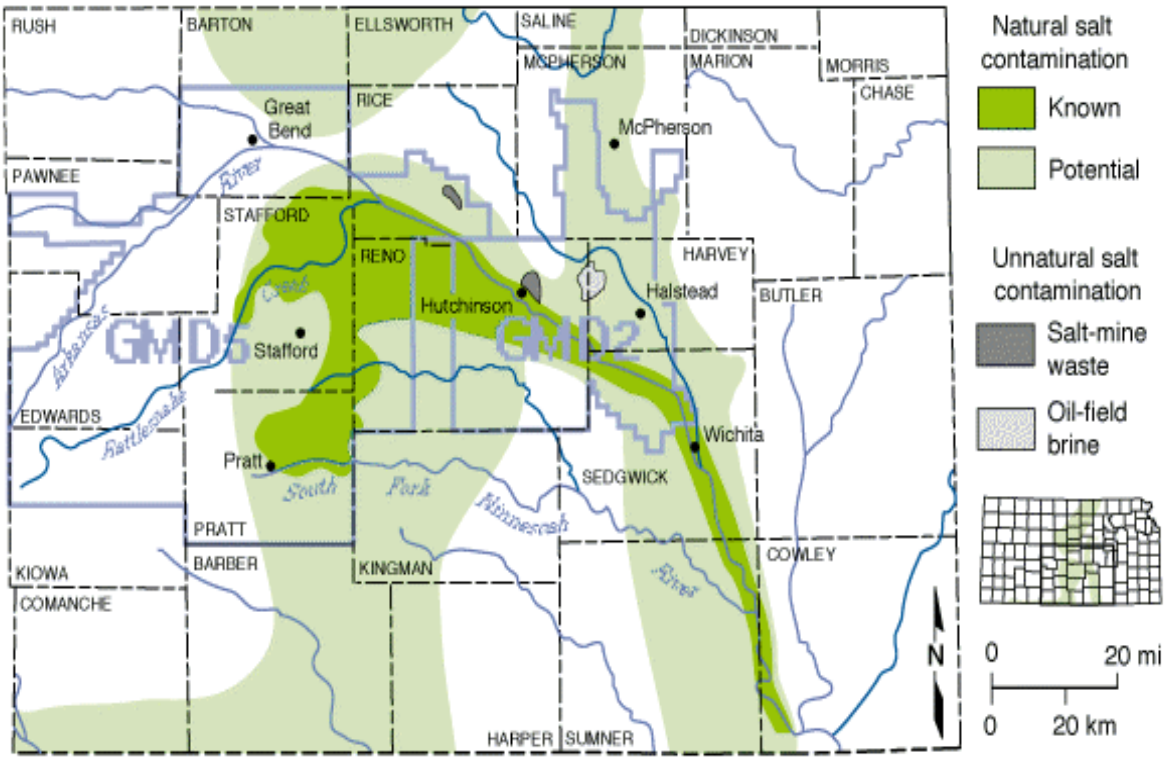


Figure 10. Areas affected by or vulnerable to salt contamination in south-central KS.[5]

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.[6]

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 in cooperation with GMD5. 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.[7]

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 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 11).

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. 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.

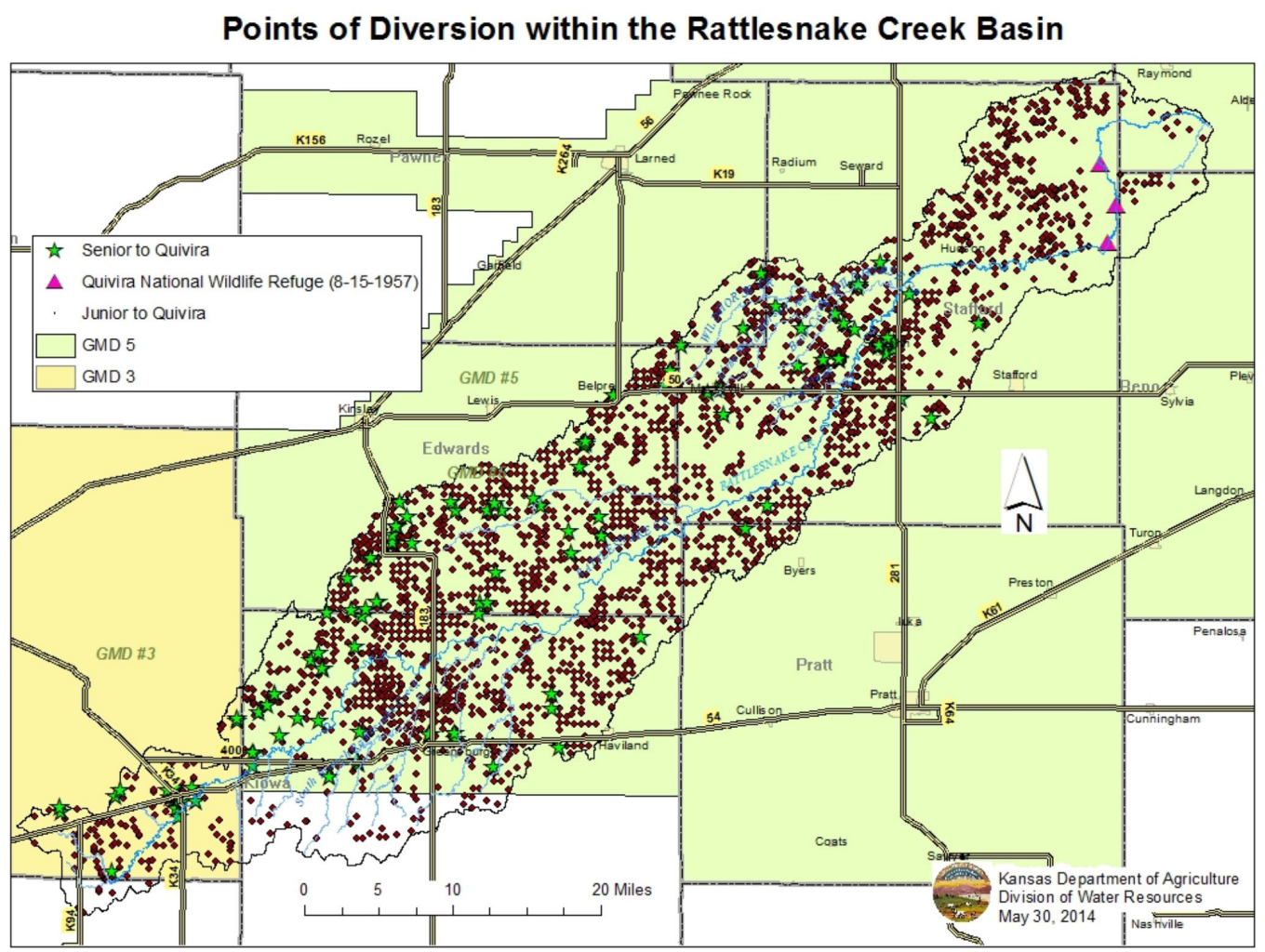


Figure 11. Points of Diversion within the Rattlesnake Creek Basin[8]

Great Bend Prairie Region

From 2016 through July 2019, KDA-DWR worked with 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 received federal funding through the Watershed Protection and Flood Prevention Act to complete a Watershed Plan-Environmental Assessment that meets NRCS requirements. Additionally, the USFWS and GMD5 agreed 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.

In January of 2021 after the proposed LEMA was found insufficient and the USFWS declined to pursue enforcement, the Audubon of Kansas filed suit in federal court against the U.S. Department of the Interior alleging they had failed to protect the senior water rights belonging to the Quivira NWR. The court dismissed the case against the state parties later that year.

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

WATER BANKING

The first and only 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. Two programs are available within the CKWBA: 1) water deposit/lease transfers and 2) safe deposit boxes referred to as savings accounts. Water rights must be in good standing to participate water banking activities. The CKWBA Evaluation Team's 2021 recommendations included the need to replace the "representative past period" (used for calculating net consumptive use) with a more relevant and data-driven period, and for applying flexibility to the consequences for noncompliance with one's water banking contract.

Great Bend Prairie Region

R9 RANCH APPLICATION AND PROPOSED WATER TRANSFER

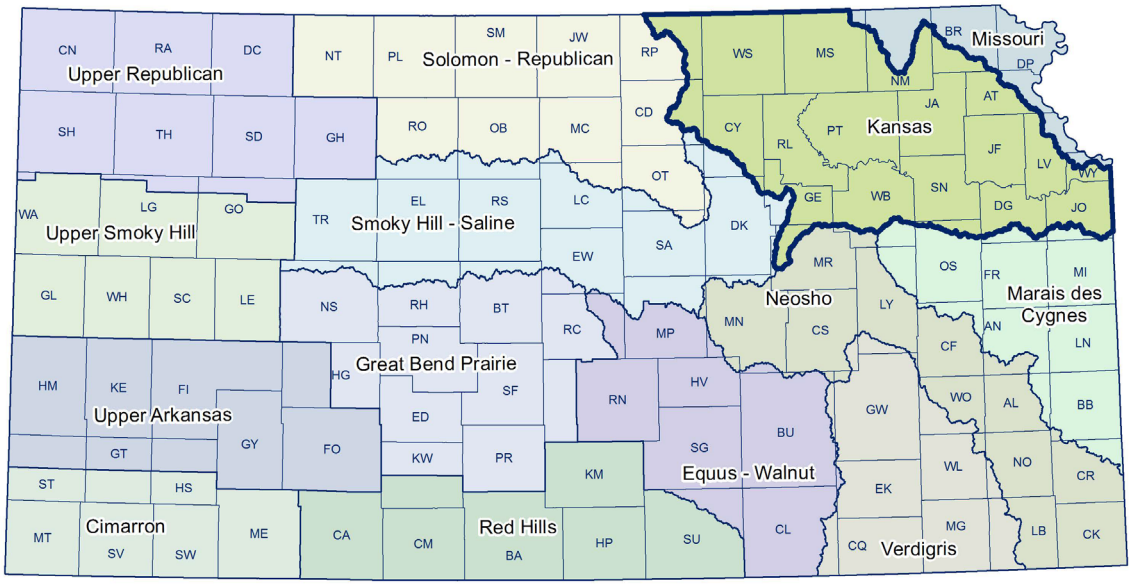
In 1995 the City of Hays purchased the R9 Ranch near Kinsley, KS (Figure 12), later selling an interest to the City of Russell. The cities have a cumulative water right authorization for irrigation use of approximately 7,700 acre-feet with a calculated consumptive use of 6,750 acre-feet, which could be requested to convert to municipal use.

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 GMD5, the Chief Engineer of the KDA-DWR contingently approved the change applications submitted by Hays and Russell to convert the R9 Ranch irrigation water 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. The court upheld the contingent approval of the change applications in late June 2022. The anticipated next step in the process would be the cities' request for approval under the Kansas Water Transfer Act (K.S.A. 82a-1501, *et seq.*).

Figure 12. Map of R9 Ranch location

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).

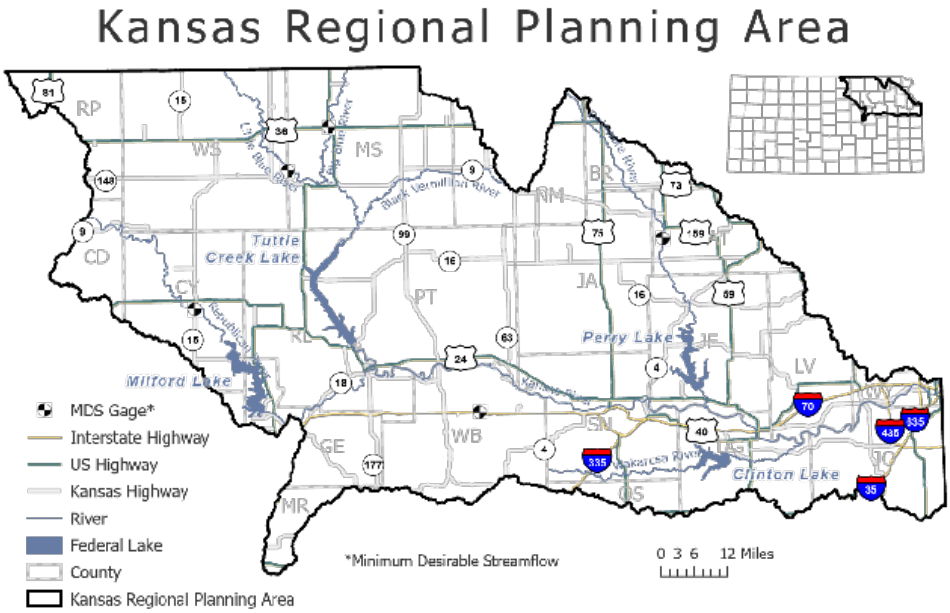


Figure 1. Kansas Regional Planning Area

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.

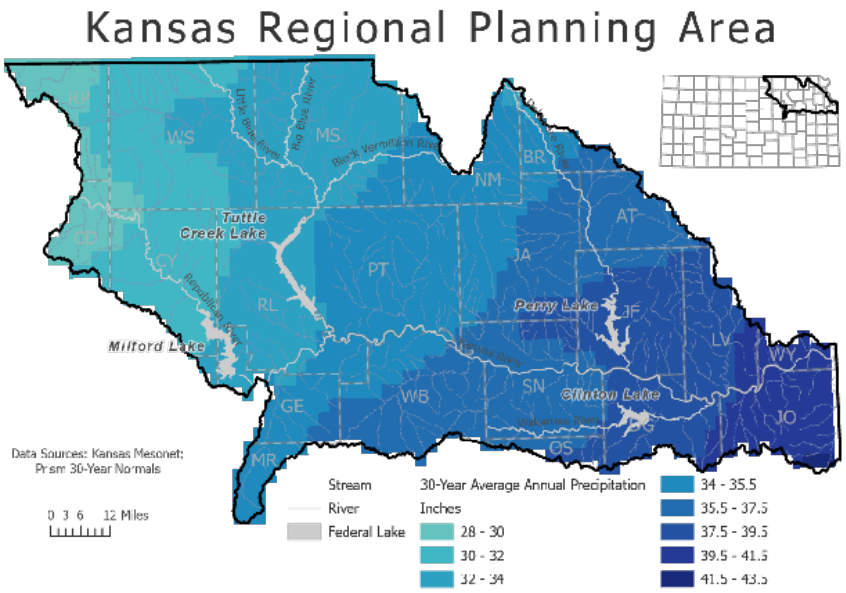


Figure 2. 30-year average annual precipitation in the Kansas Region

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.[1] 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.

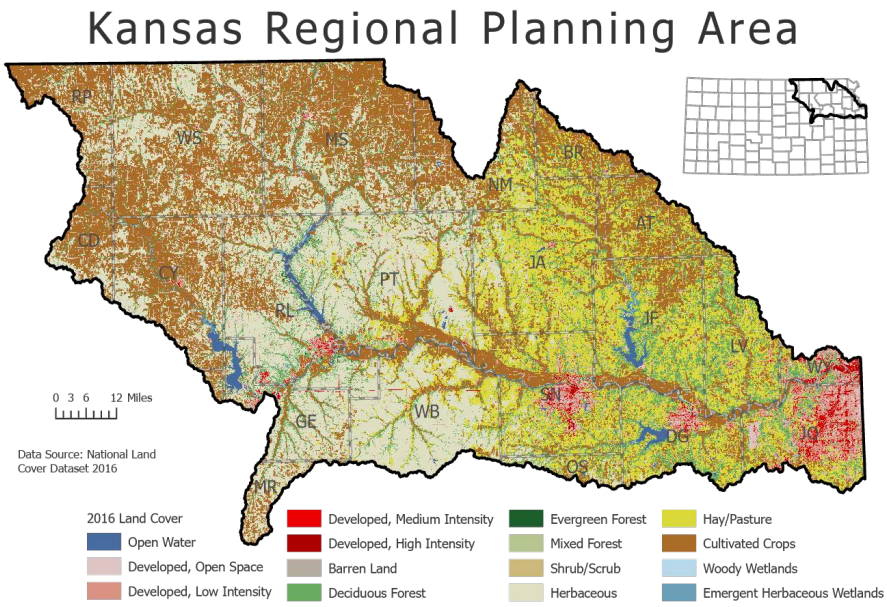


Figure 3. Kansas regional land cover, USGS National Land Cover Dataset

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 Kansas 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).[2] 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, release and analysis of the 2020 Census.

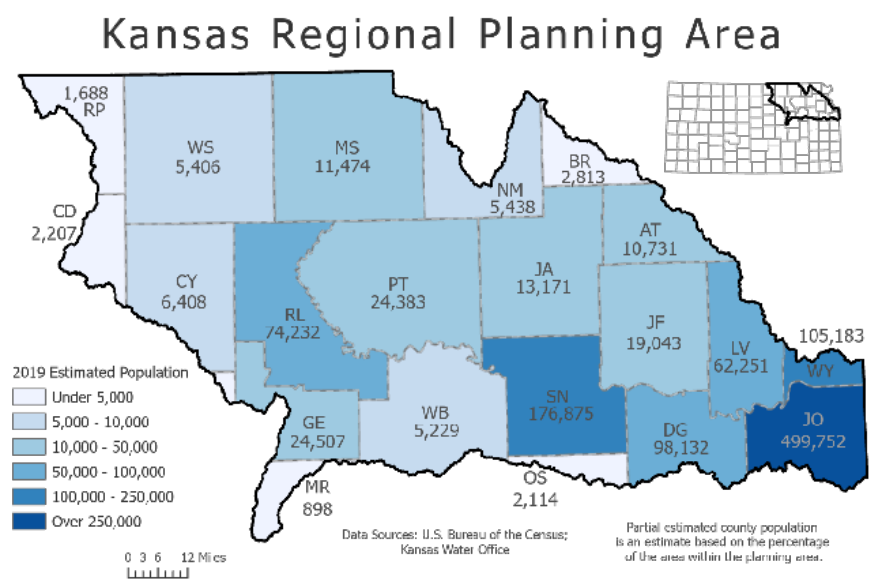


Figure 4. 2019 estimated population by county

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 counties within the region 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 region, 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 counties within the region 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.

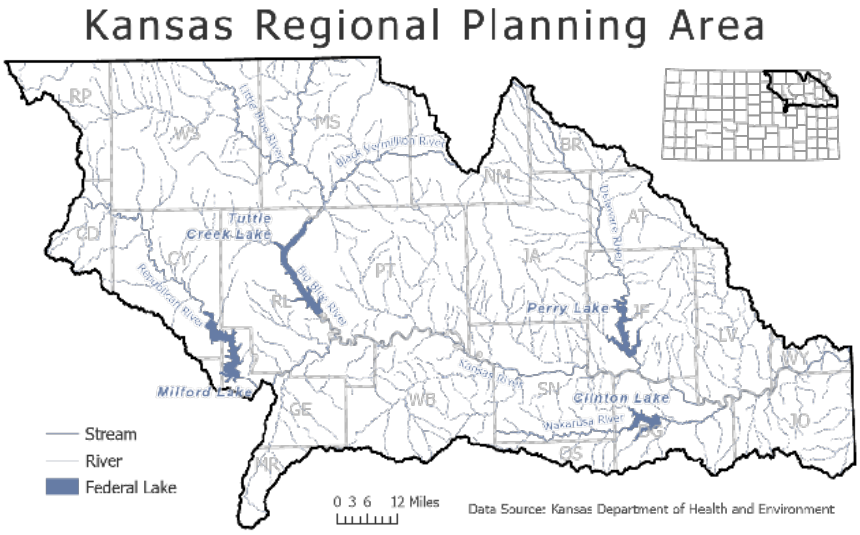


Figure 5. Major surface water resources in the Kansas Region

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.

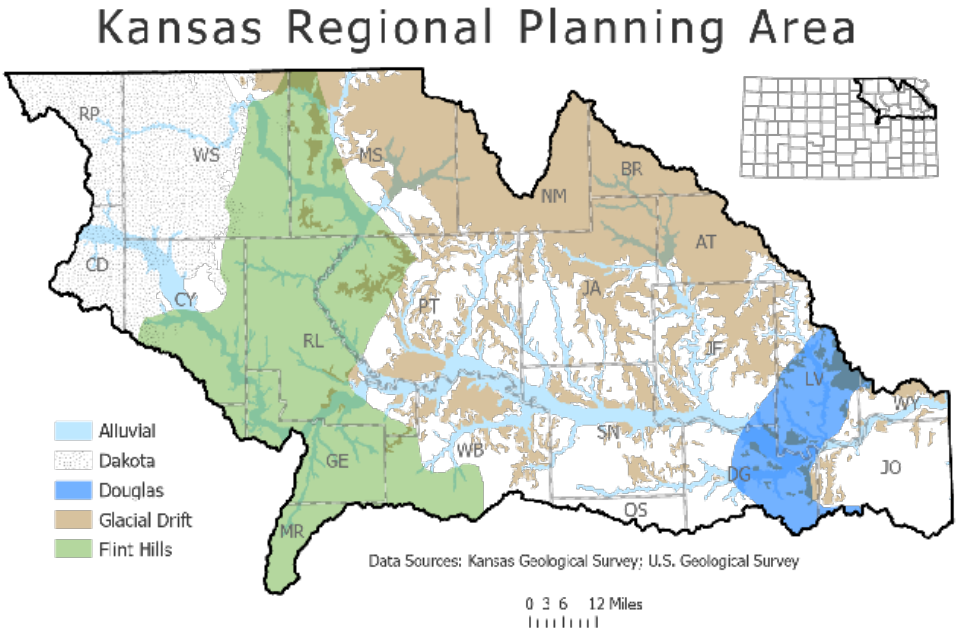


Figure 6. Principle aquifer boundaries in the Kansas Region

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).

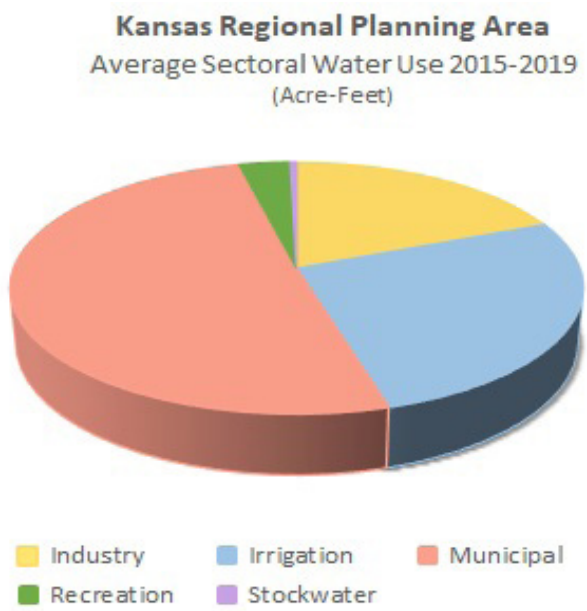


Figure 7. Average sectoral water usage

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.

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* Guiding Principle section).

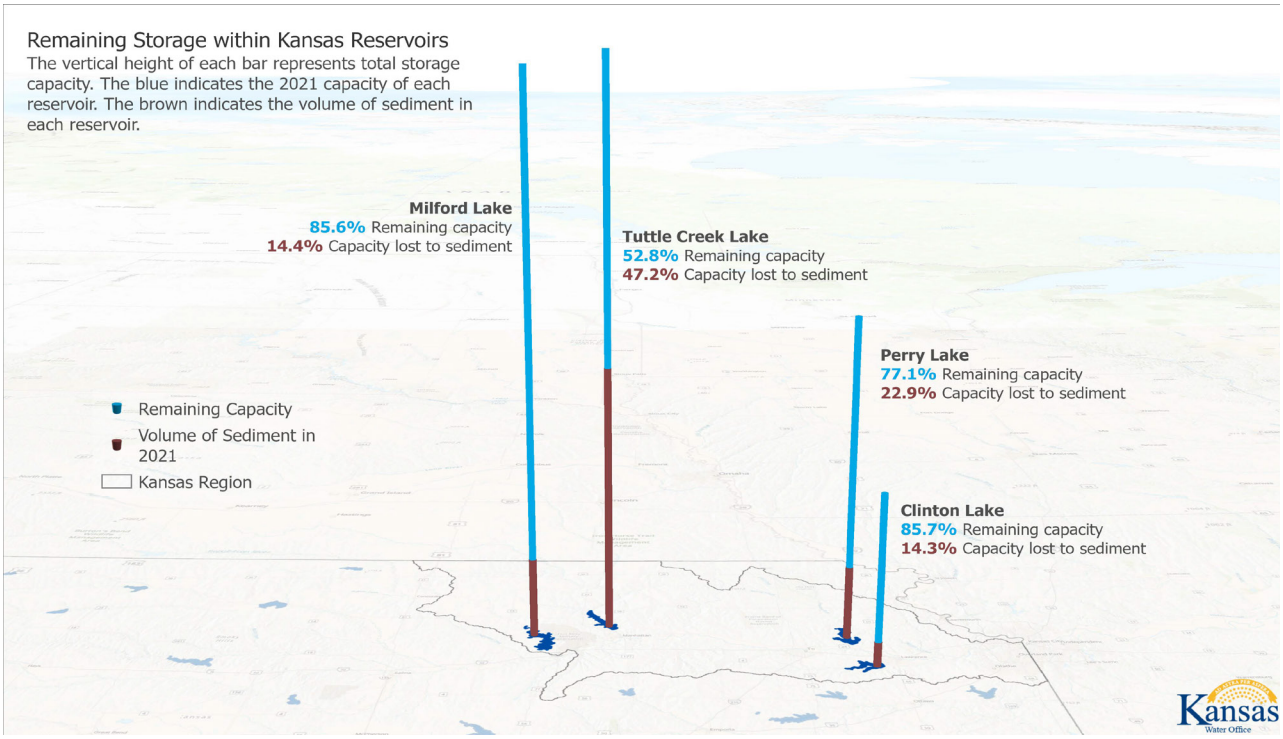


Figure 8. Remaining storage within Kansas reservoirs in the Kansas Region

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 within the region, 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 approximately 50% 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. Currently available 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 within the next 40 to 50 years.

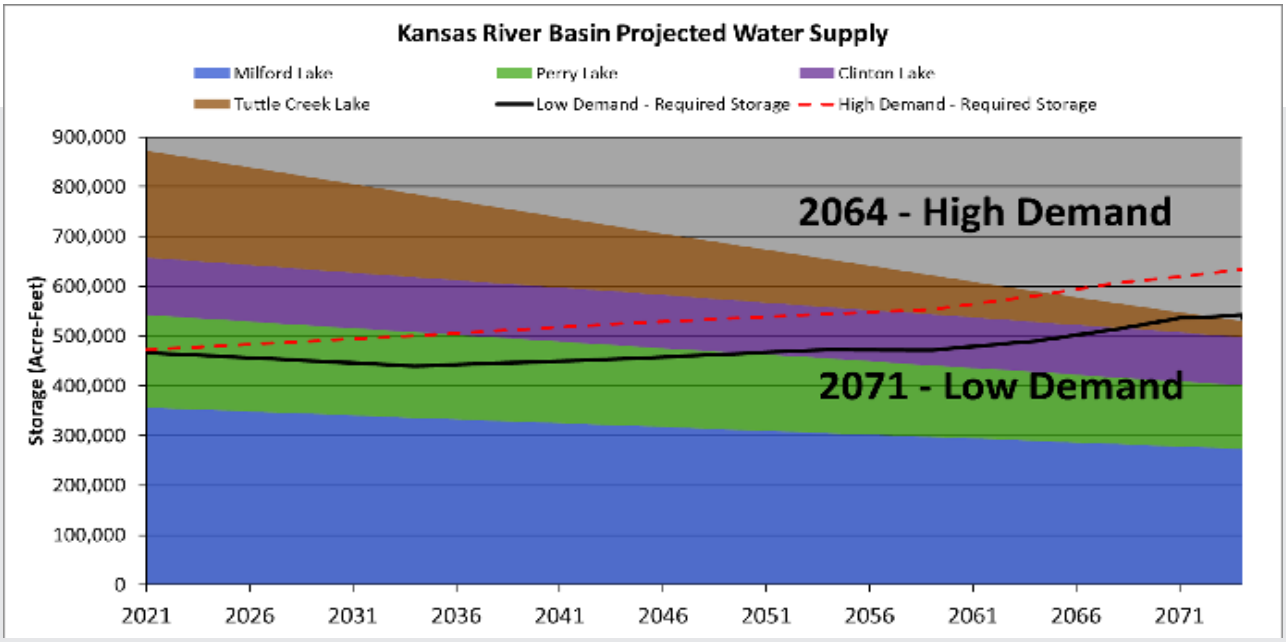


Figure 9. Projected water supply storage given historic rate of sedimentation based on the changed in bathymetric surveys and demand requirements

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 of 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 were 435 streambank hotspots above the four federal reservoirs in the Kansas Region, including all of the Milford watershed (figure 10). Of those 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 addressed, which, if completed, will reduce the sediment load by an additional estimated 500,697 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 sedimentation.

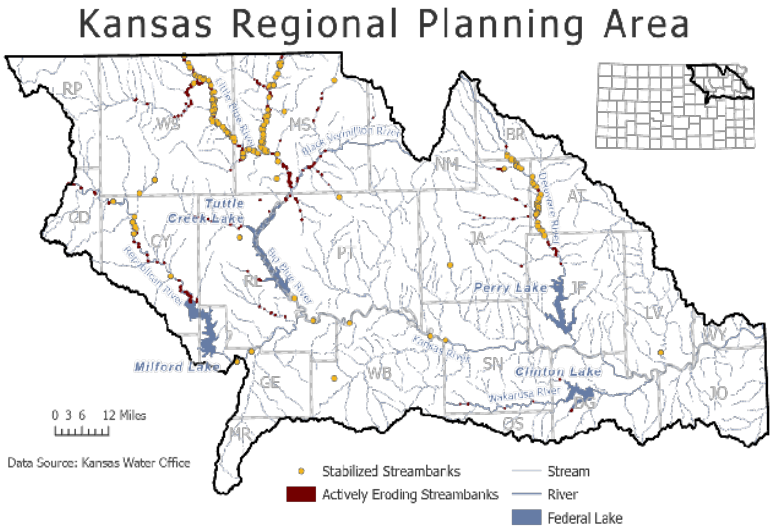


Figure 10. Actively eroding and stabilized streambanks within the Kansas Region

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).[3]

Figure 11. Impaired water resources in the Kansas Region

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

Milford Lake HAB , 2011. Photo Credit: KDHE

Harmful Algal Blooms (HABs), as discussed in the *Improve the State's Water Quality* Guiding Principle section 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.[4]

In the Kansas Region, reducing the occurence 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 recent years.

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 Kansas 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 up the Kansas River to Bowersock Dam at Lawrence. These invasive species compete with other native fish for food resources, consuming 40% of their body weight per day.

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.[5]

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

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 Nations 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 Tribal Nation within Kansas 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.

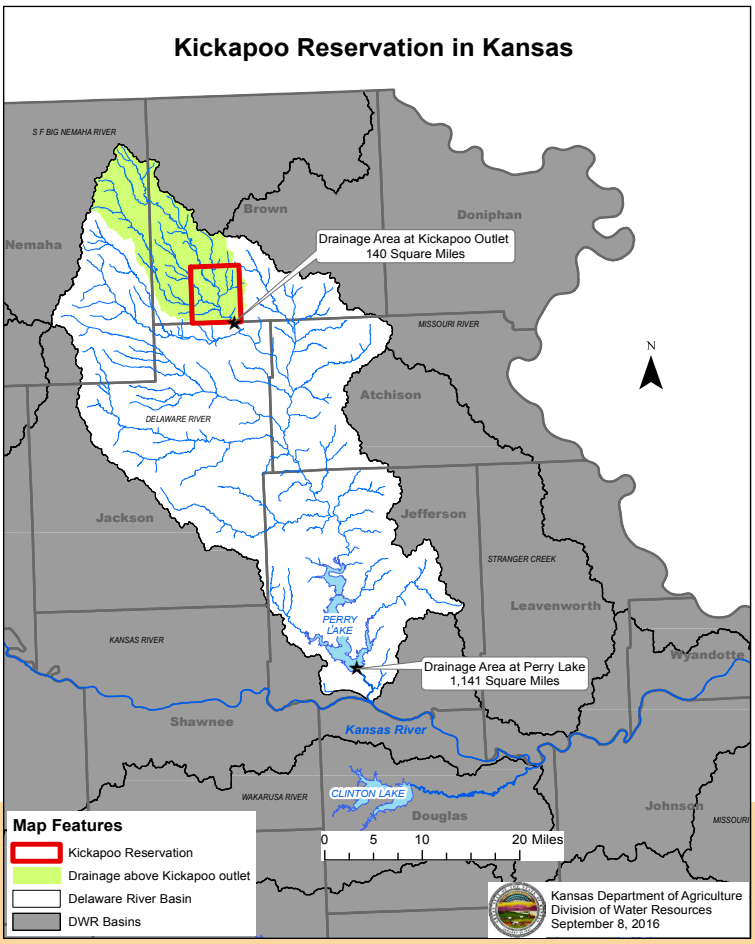


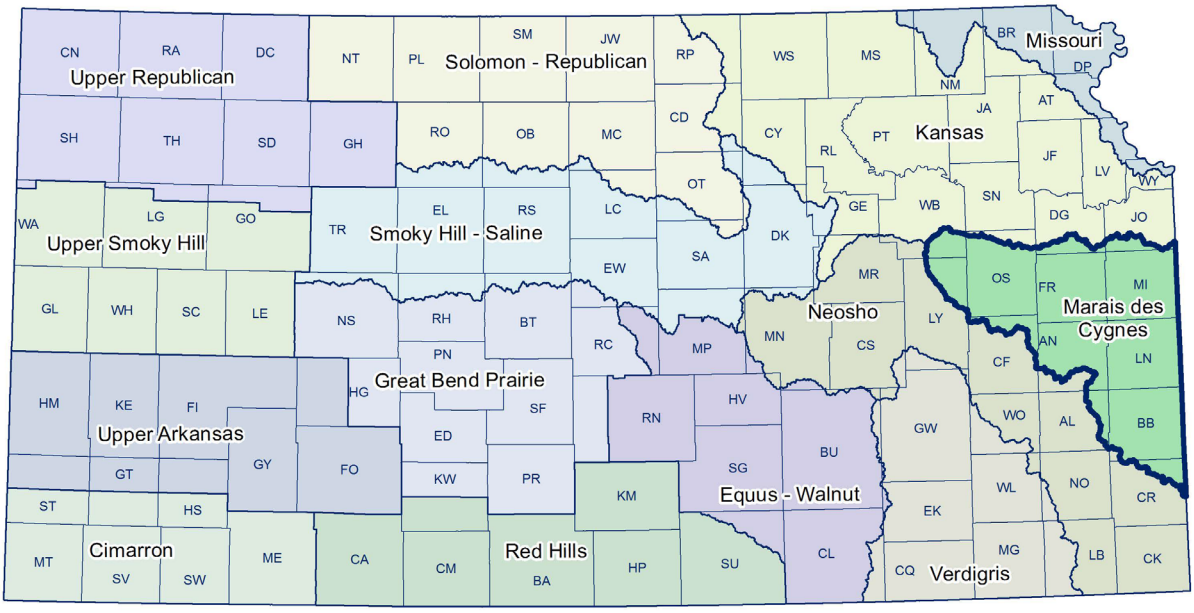
Figure 12. Kickapoo water resources map[6]

The Kickapoo Tribe Water Rights Settlement Agreement was signed on September 8, 2016, with the agreement being the culmination of those 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.

Marais des Cygnes Region



Marais des Cygnes Region

Regional Description

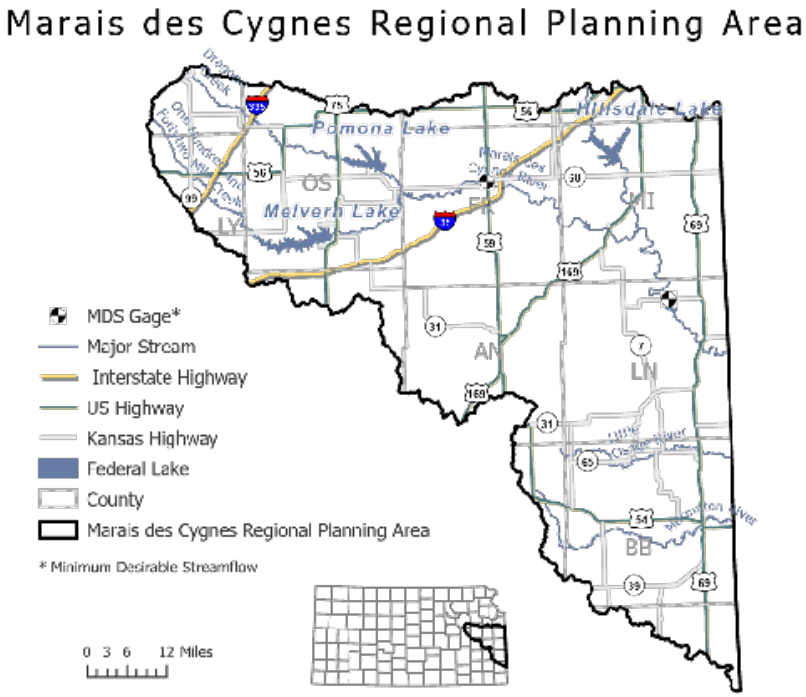


Figure 1. Marais des Cygnes Regional Planning Area

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.

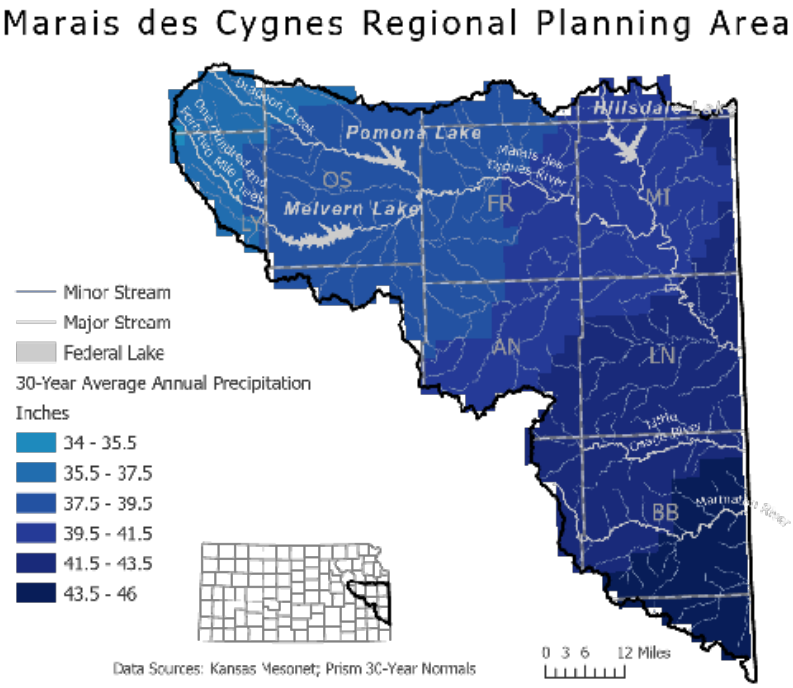


Figure 2. 30-year average annual precipitation in the Marais des Cygnes Region

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.[1] 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 (Kansas Turnpike) 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.

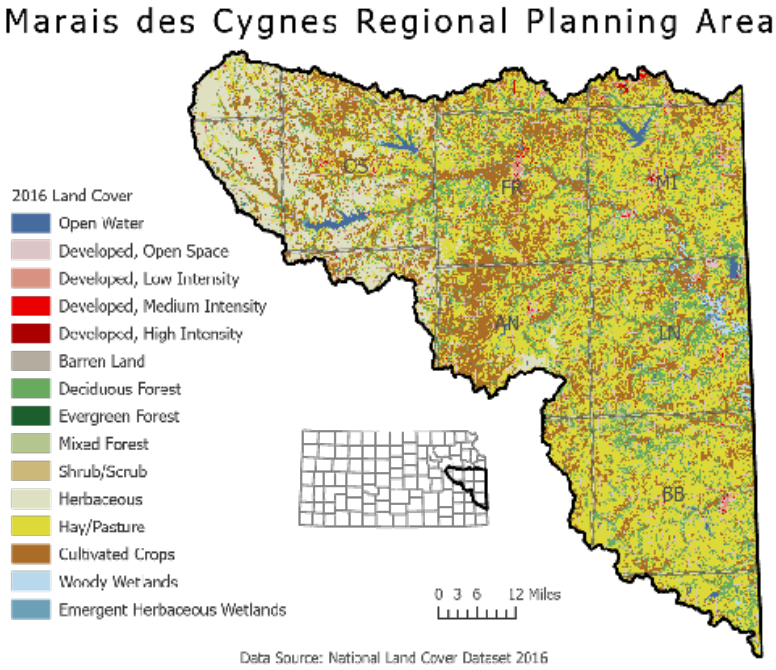


Figure 3. 2016 Marais des Cygnes regional land cover

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.[2] 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, release and analysis of the 2020 Census (Figure 4).

The major cities and associated population centers 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

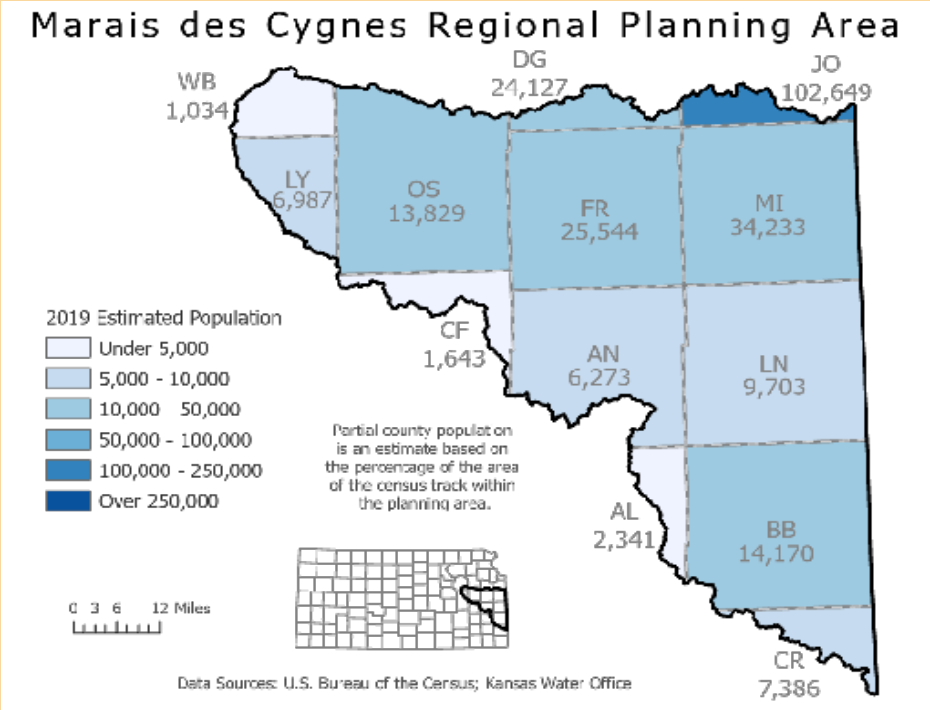


Figure 4. 2019 estimated population by county

Marais des Cygnes Region

metropolitan area moves 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 (Figure 5). 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.

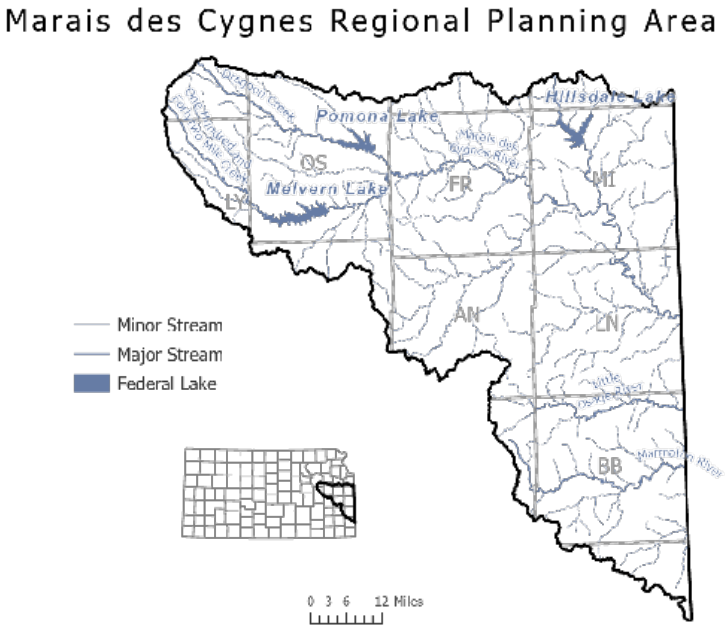


Figure 5. Major water resources in the Marais des Cygnes Region

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, Douglas 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.

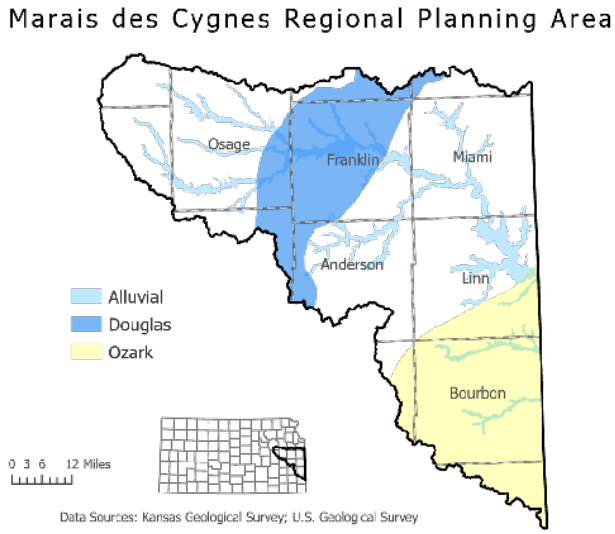


Figure 6. Principle aquifer boundaries in the Marais des Cygnes Region

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.

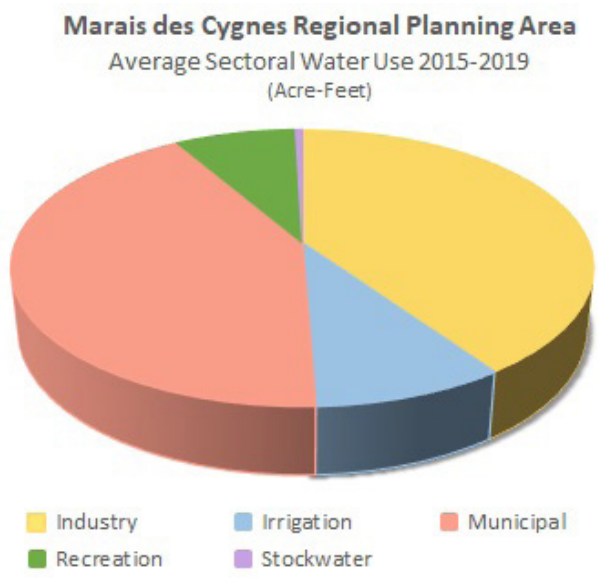


Figure 7. Average sectoral water usage

In 2019, the USACE performed an economic analysis of recreation at Hillsdale Lake, Melvern Lake, and Pomona Lake.[3] 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 of 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 assists 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.

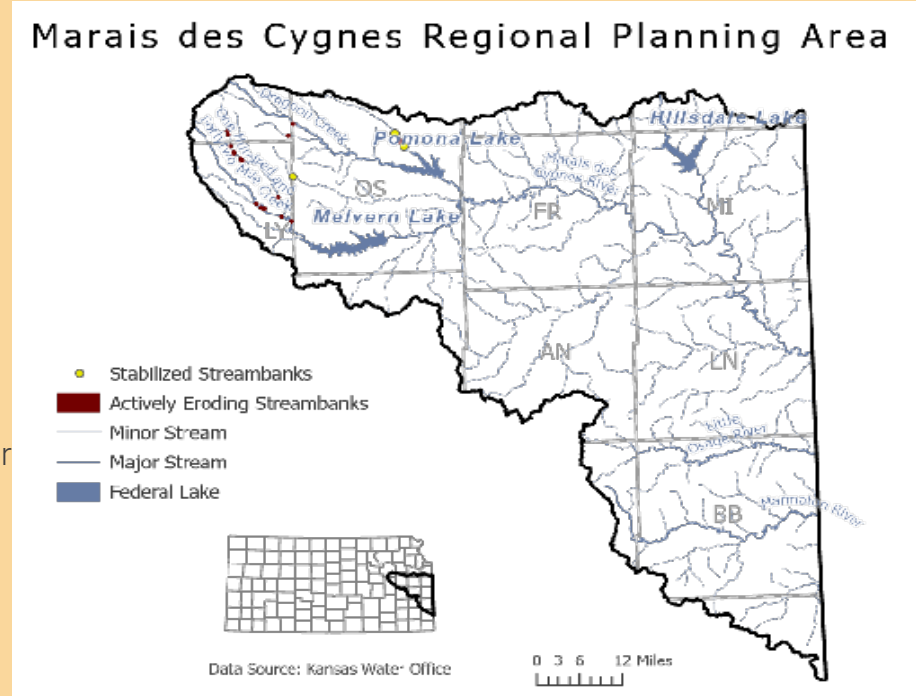


Figure 8. Actively eroding and stabilized streambanks in the Marais des Cygnes Region

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.

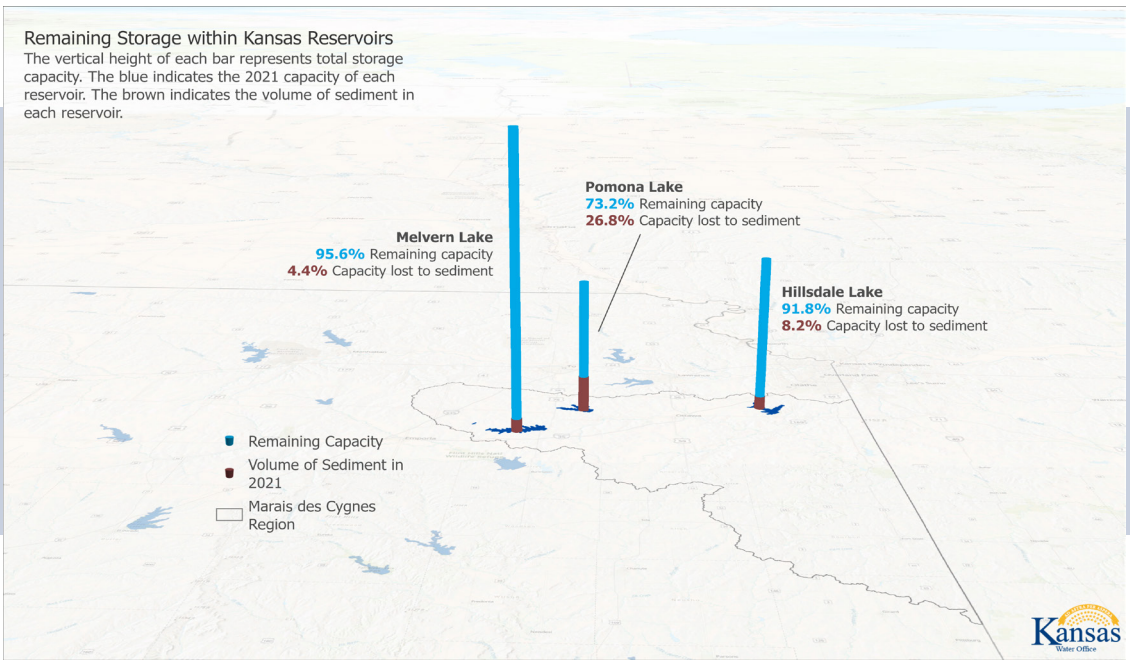
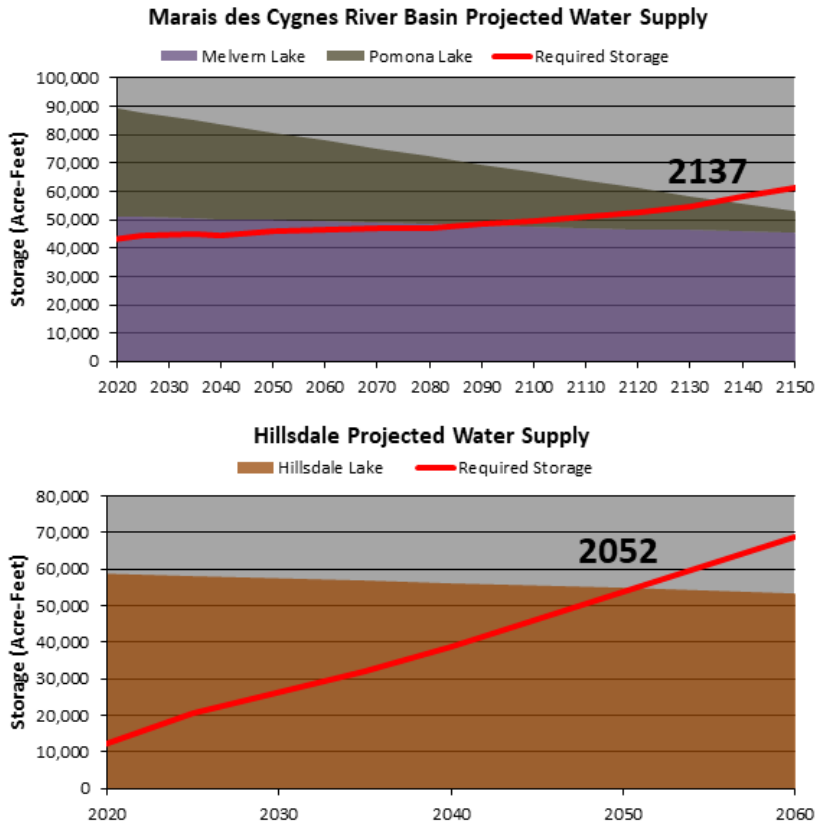


Figure 9. Remaining storage within Kansas Reservoirs in the Marais des Cygnes Region

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.

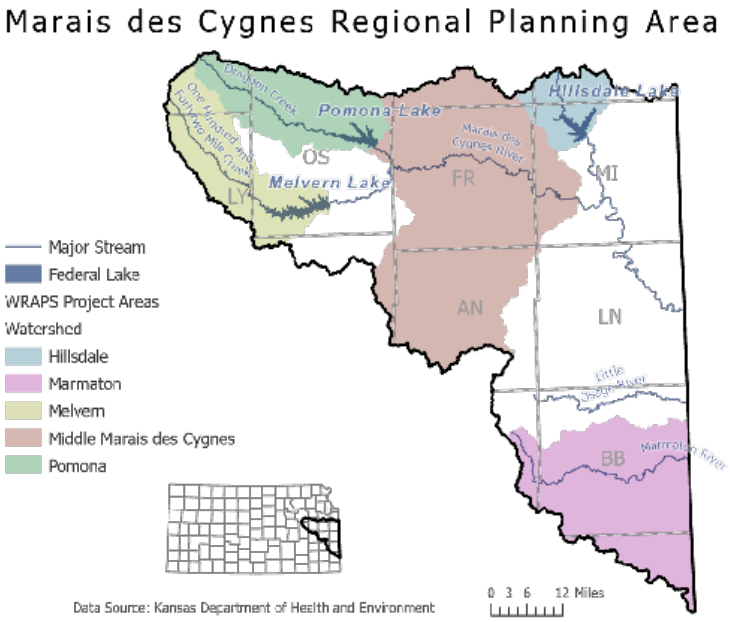


Figure 11. WRAPS project areas by watershed

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).[4] 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.

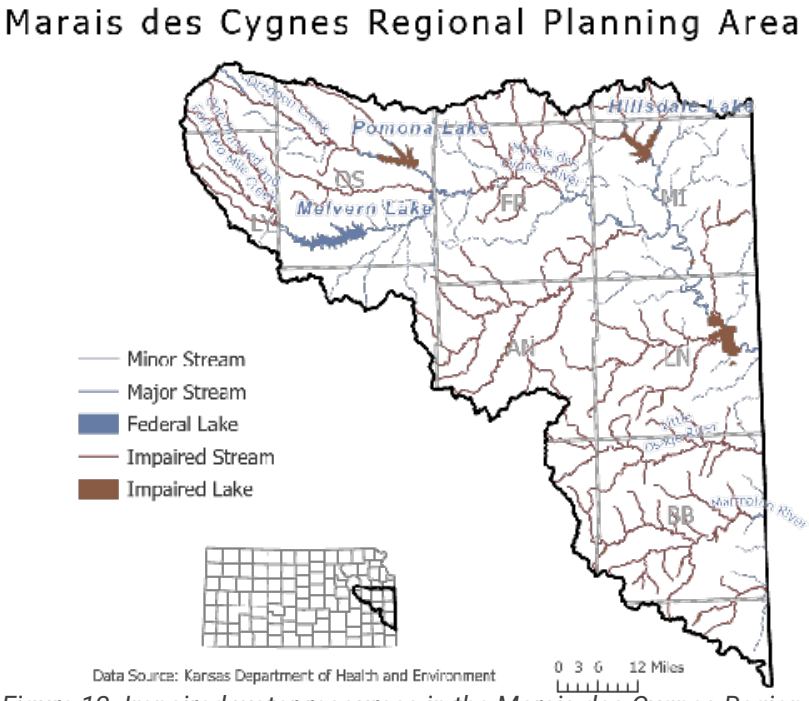


Figure 12. Impaired water resources in the Marais des Cygnes Region

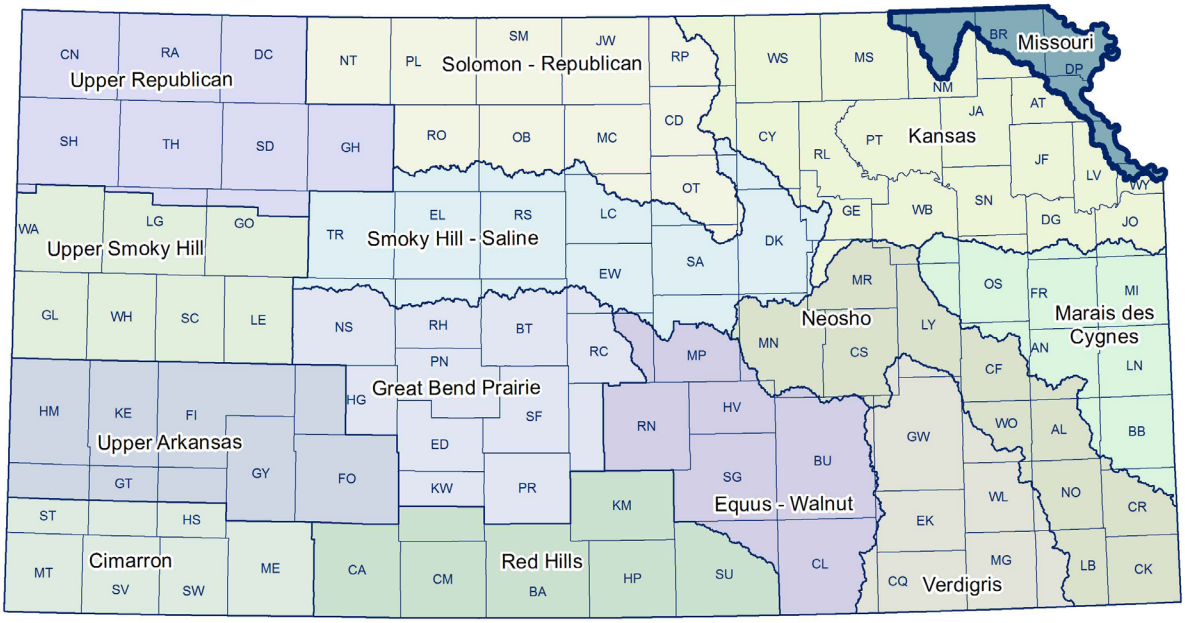
An important consideration for watershed restoration and protection in this region, particularly in the northern portion, is urbanization. Local land use planning and zoning efforts can provide cities and counties effective tools to minimize the potential impacts of development on water resources.

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

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.

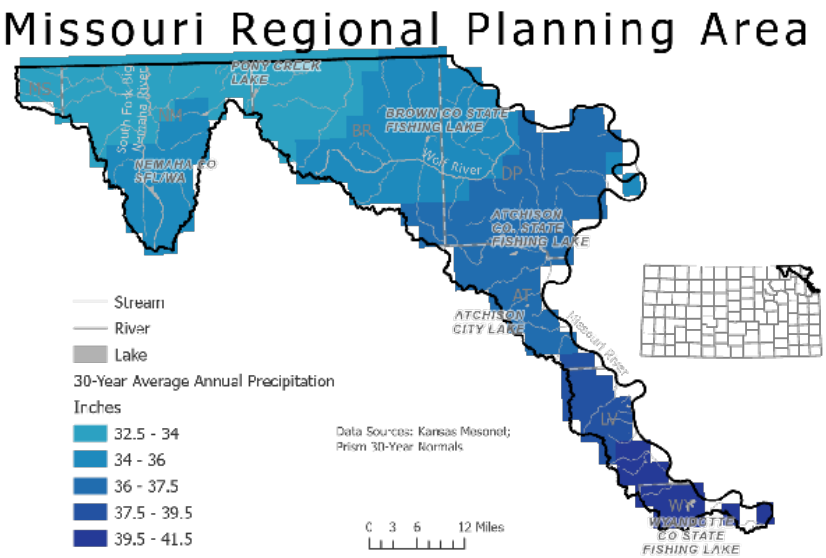


Figure 2. 30-year average annual precipitation in the Missouri Region

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.[1] Figure 3 lists the remaining land uses in the region, including: developed/urban open space, woody wetlands, and water.

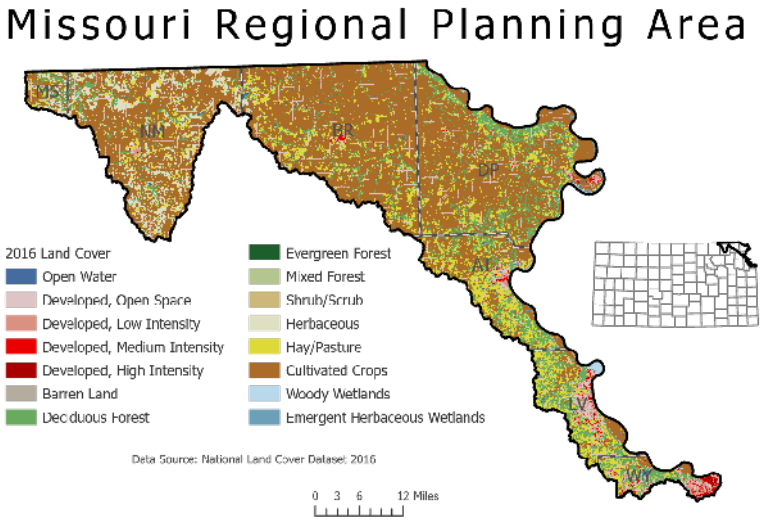


Figure 3. 2016 Missouri regional land cover

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).[2] 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, release and analysis of the 2020 Census.

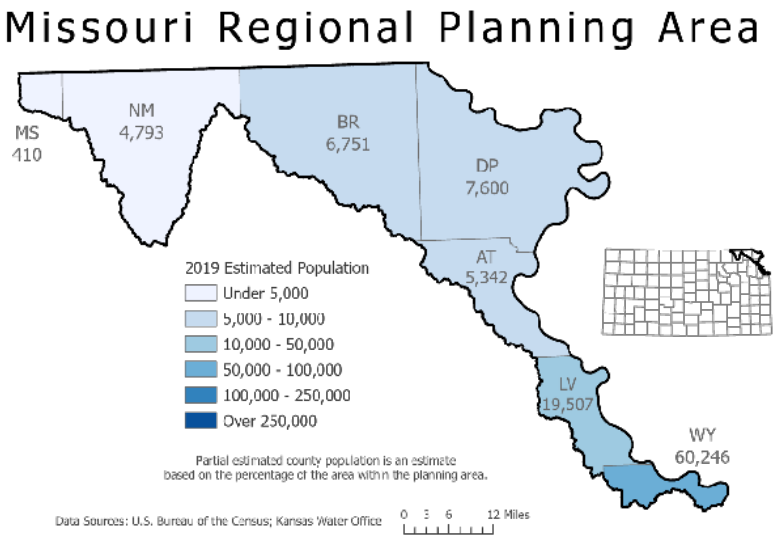


Figure 4. 2019 estimated population by county

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 region, 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. These Tribal Nations each place cultural and historic value on sites and natural resources throughout the region. In addition, federal reserve water rights exist for these Tribal Nations.

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 being the Kansas and Arkansas. 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 had 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 as well as a source of cooling water for power generations facilities.

Missouri Region

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 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.

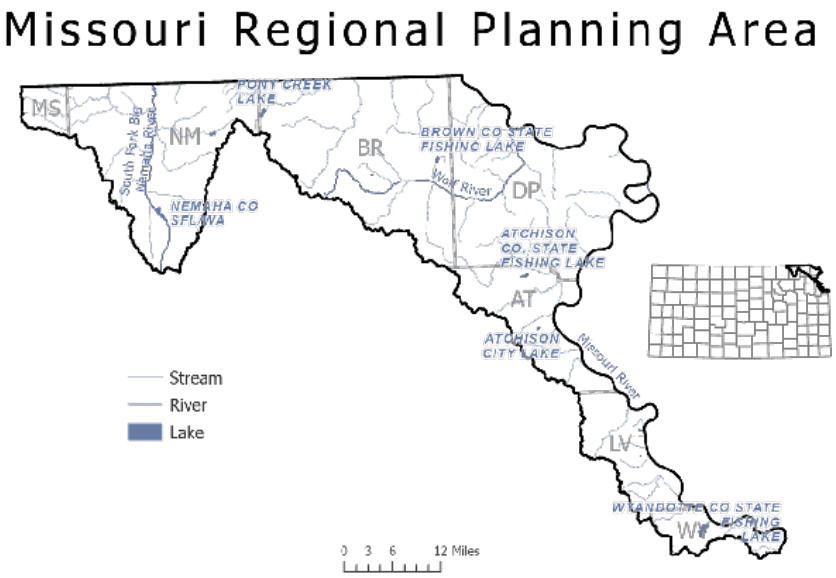
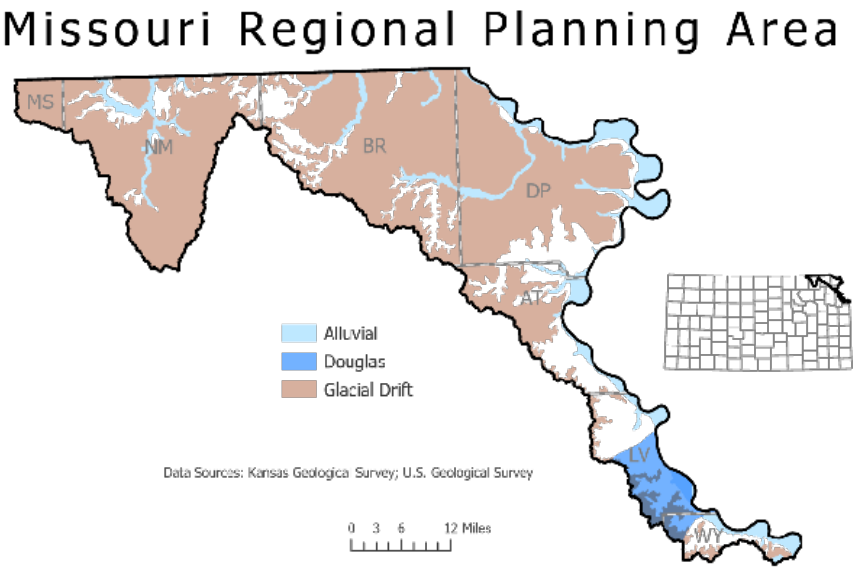


Figure 5. Major water resources in the Missouri Region

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. However, potential problem areas were detected in the 2017 Kansas Geological Survey (KGS) study (Batlle-Aguilar, 2017), with ongoing evaluation through the current KGS study.[3] 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).

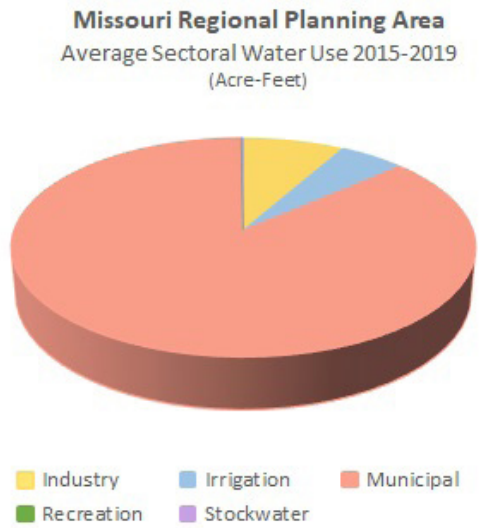


Figure 7. Average sectoral water usage

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.[4]

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* Guiding Principle section.

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.[5]

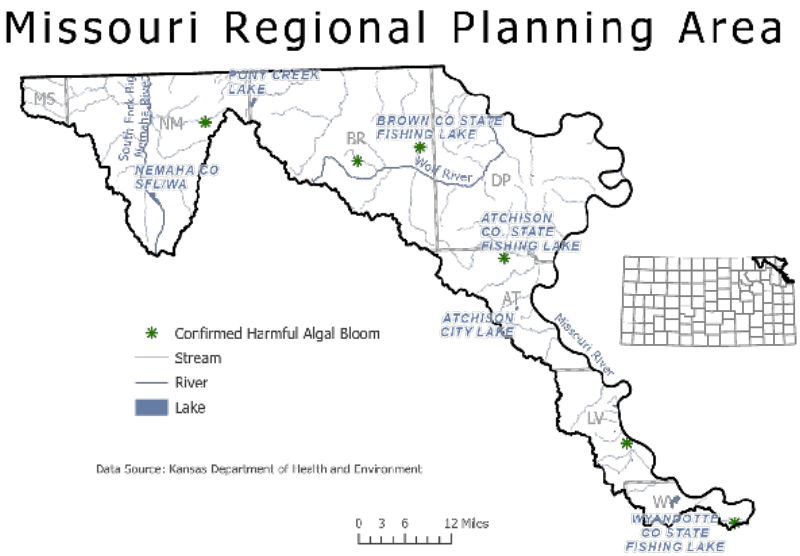


Figure 9. Confirmed Harmful Algal Bloom sites in the Missouri Region

GROUNDWATER QUALITY

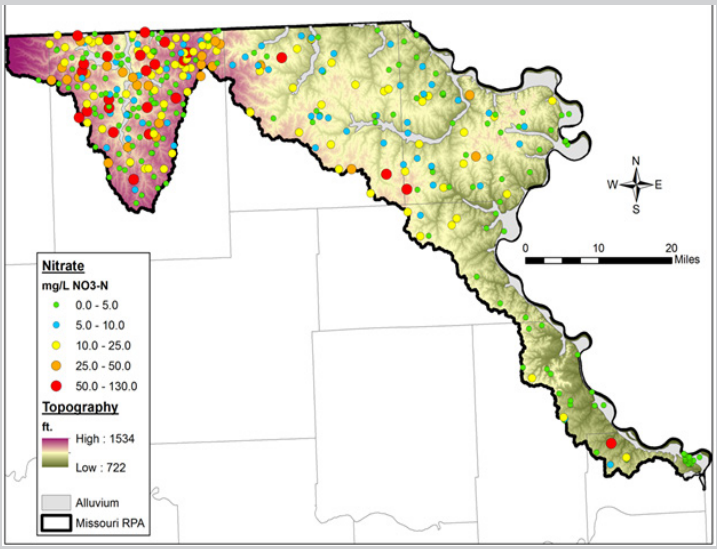


Figure 10. Nitrate and topography levels throughout the Missouri Region[6]

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.

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

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 along with other critical infrastructure. 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.

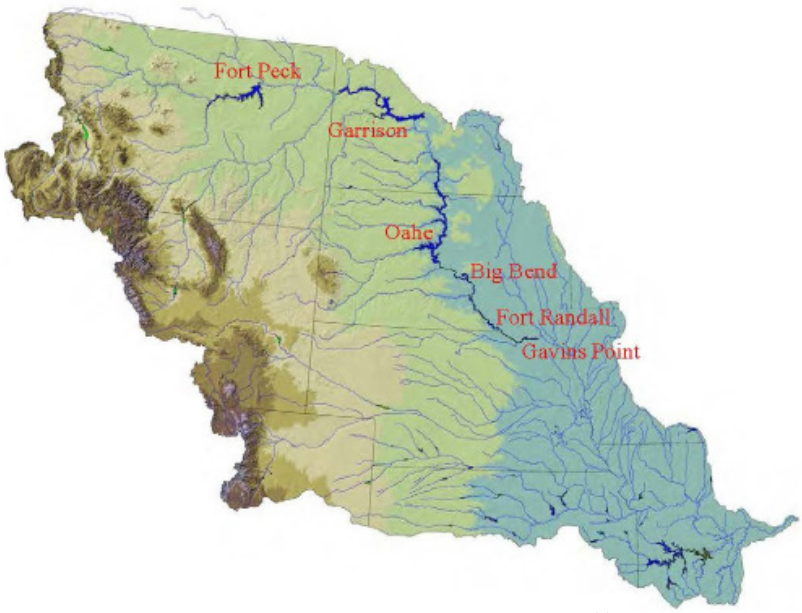


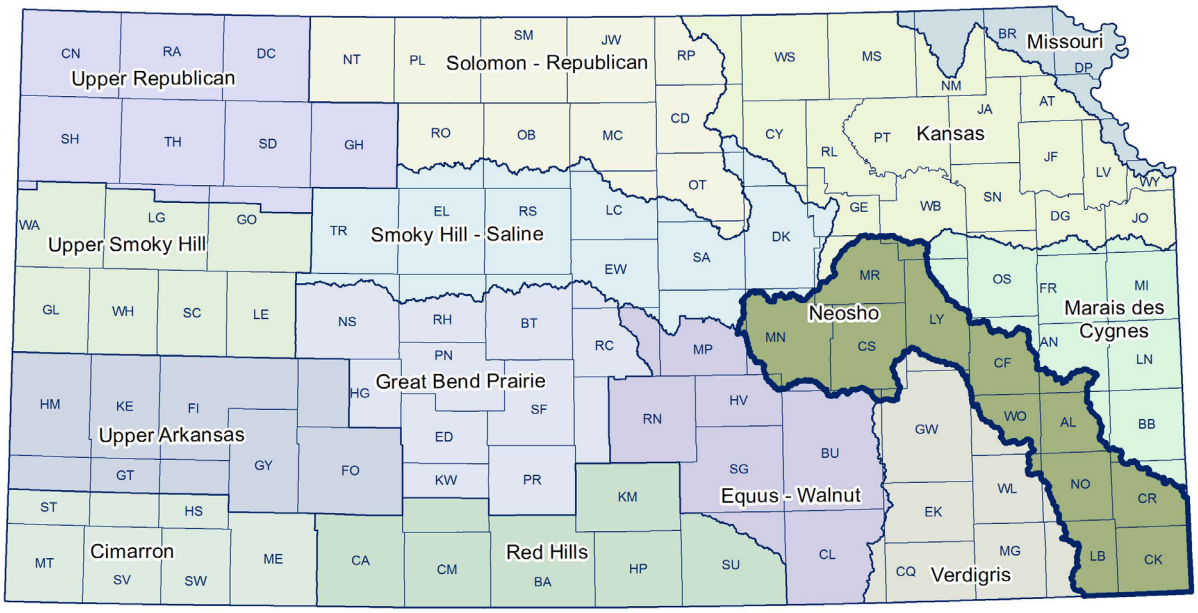
Figure 11. Missouri River Mainstem River System[7]

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 kind of education activity that has consistently been deemed “worthwhile and impactful” by educators in eastern Kansas is water festivals.

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

Neosho Region



Neosho Region

Regional

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 making water issues in the Neosho Region of interstate significance.

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.

Figure 1. Neosho Regional Planning Area

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

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 represents the area of the state with the most significant rainfall.

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.[1] Figure 3 lists the remaining land uses

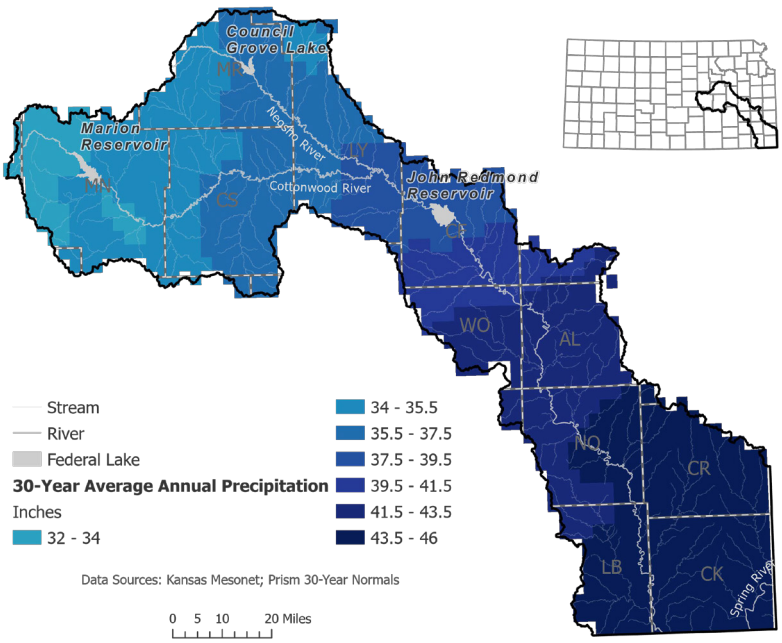


Figure 2. 30-year average annual precipitation in the Neosho Region

Neosho Region

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

Predominant land covers in the Region are herbaceous/ grasslands (31%), cultivated crops (30%), and hay/pasture (24%)

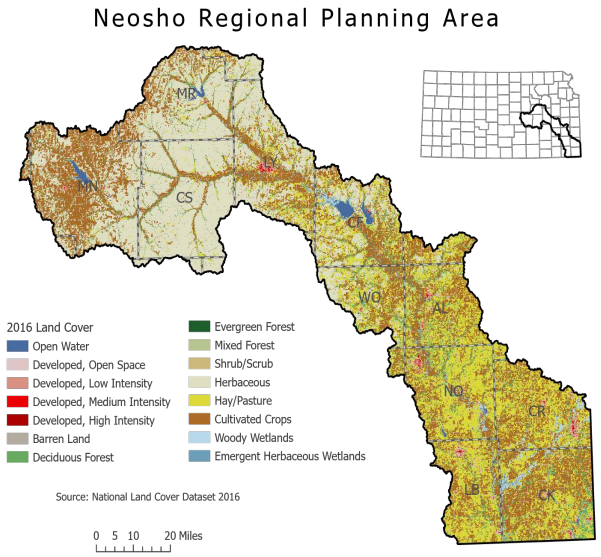


Figure 3. Neosho regional land cover

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.[2] 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, release and analysis 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.

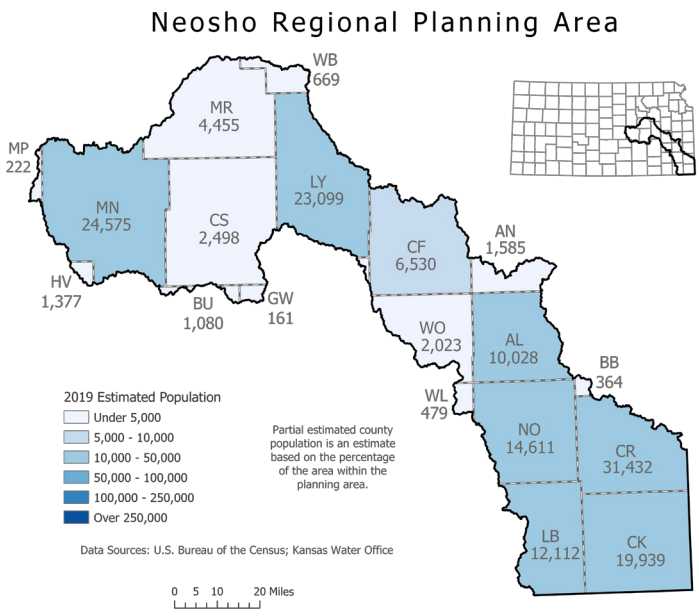


Figure 4. 2019 estimated population by county

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, which is the only nuclear-powered generating plant in Kansas. It depends on waters from the Neosho River released from 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.

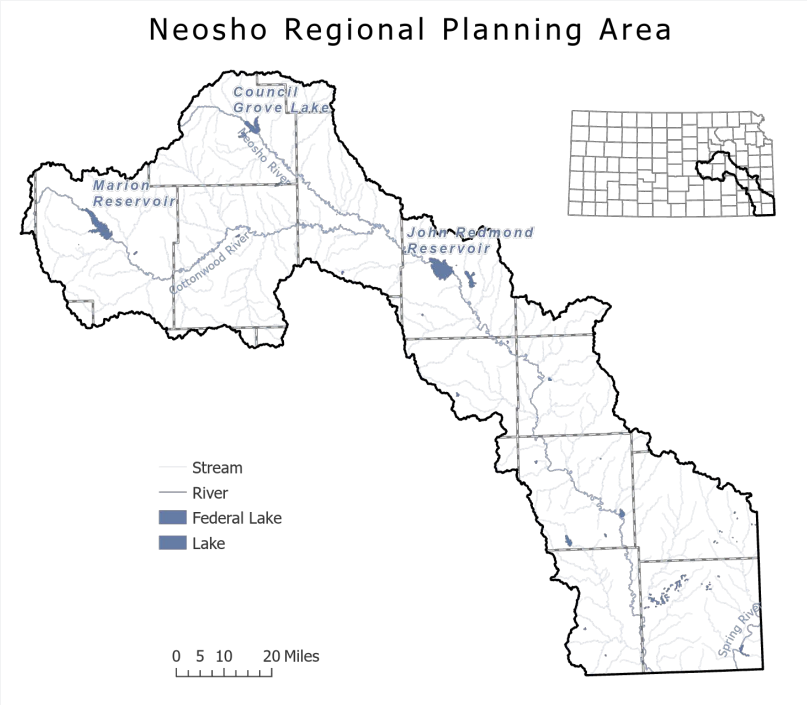


Figure 5. Major water resources in the Neosho Region

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.

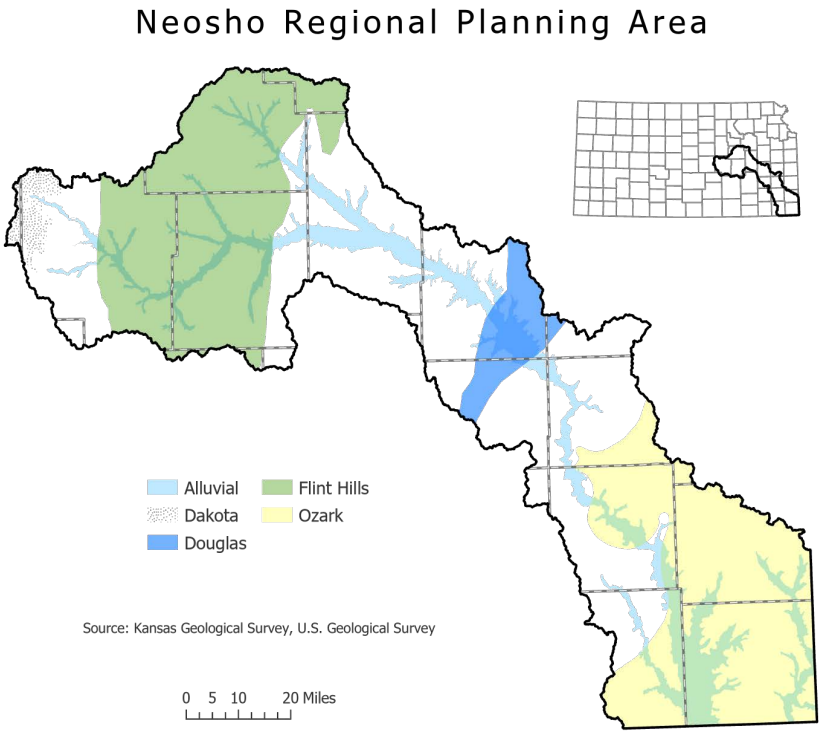


Figure 6. Principle aquifers boundaries in the Neosho Region

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.

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 portion of the 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 wet weather.

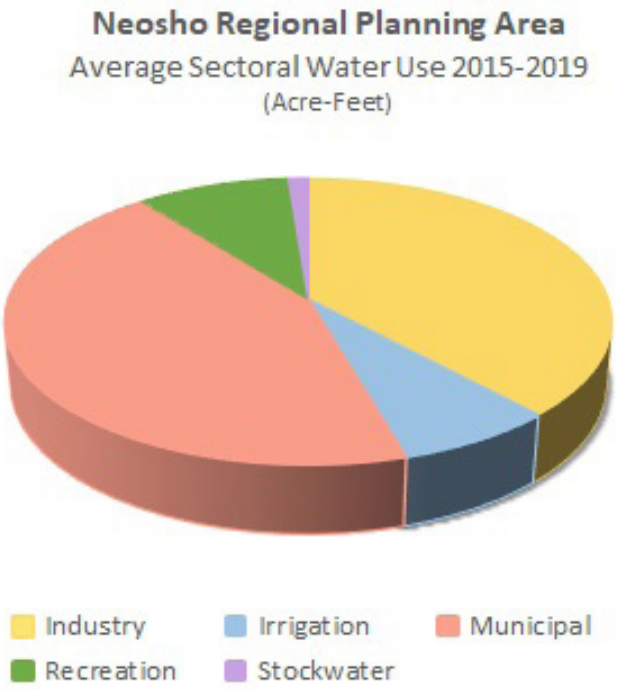


Figure 7. Average sectoral water usage

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. As of 2021 there were 363 streambank hotspots identified above the three reservoirs and 41 had been stabilized (Figure 8). A dredging operation which was conducted at the John Redmond Reservoir in 2016 removed over three million cubic yards of silt at a cost of $20 million, extending its useful life.

Eroding streambank on Neosho River

Neosho Region

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

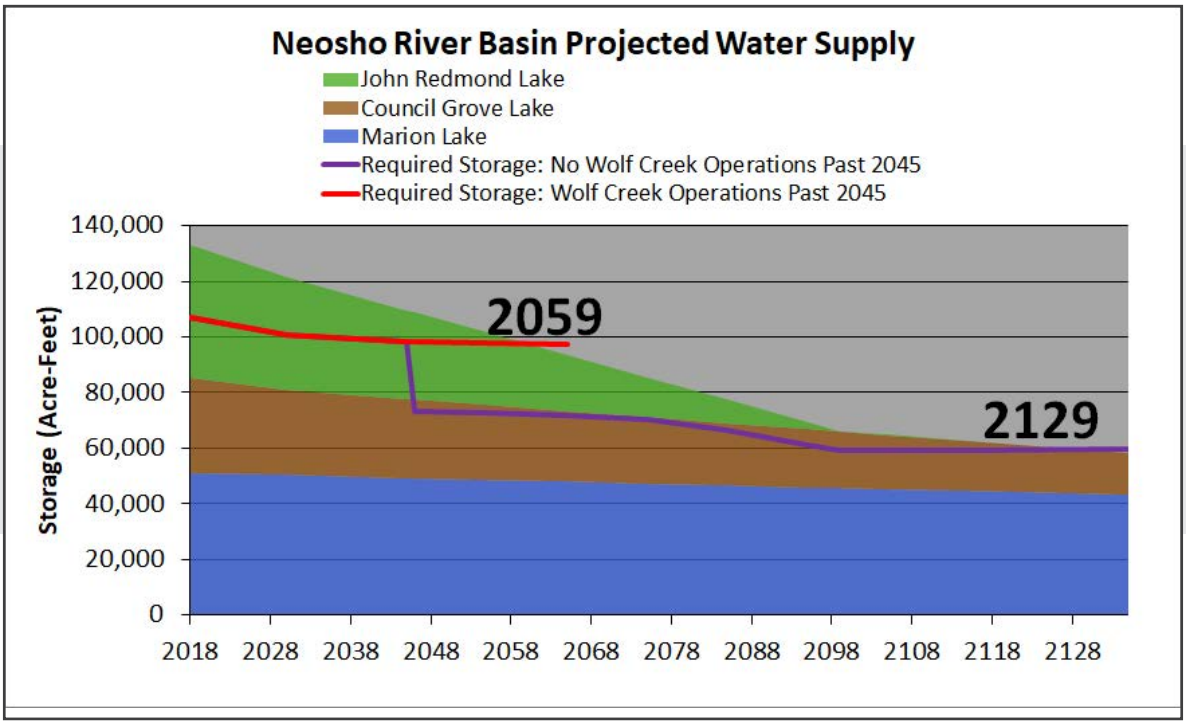


Figure 9. Projected water supply storage given the historic rate of sedimentation based on the change in bathymetric surveys

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.[3] 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.[4] 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.

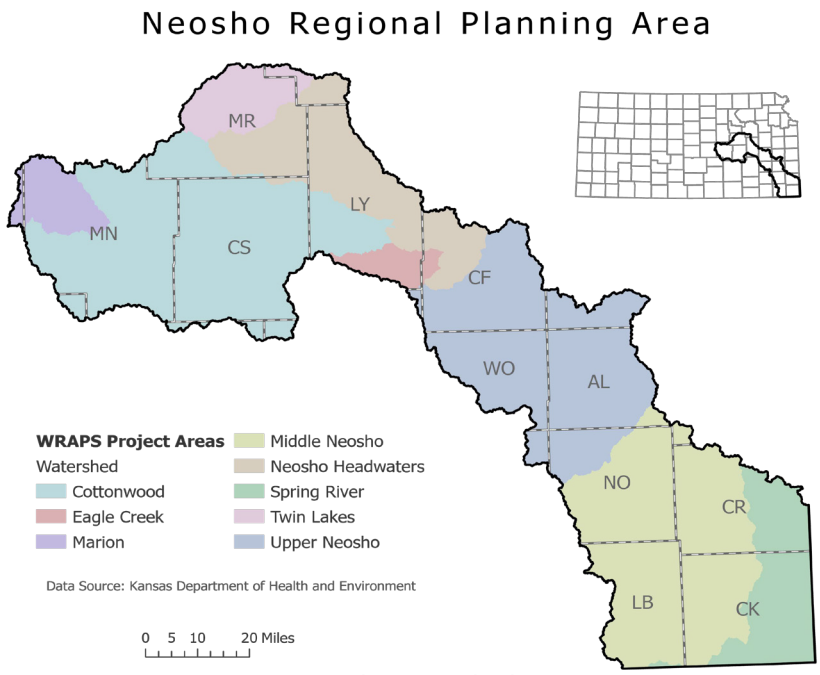


Figure 11. WRAPS project areas by watershed

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.[5]

Neosho Region

Harmful Algal Blooms (HABs)

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 previously in 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.[6]

Marion Reservoir, Cottonwood Point Beach

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.

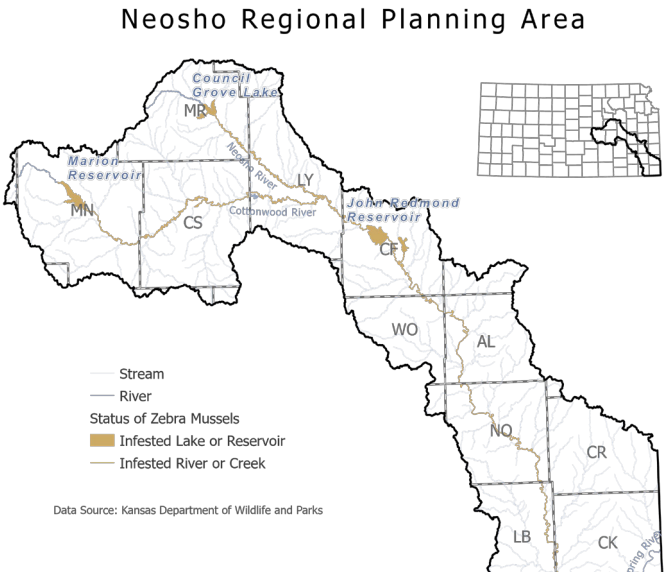
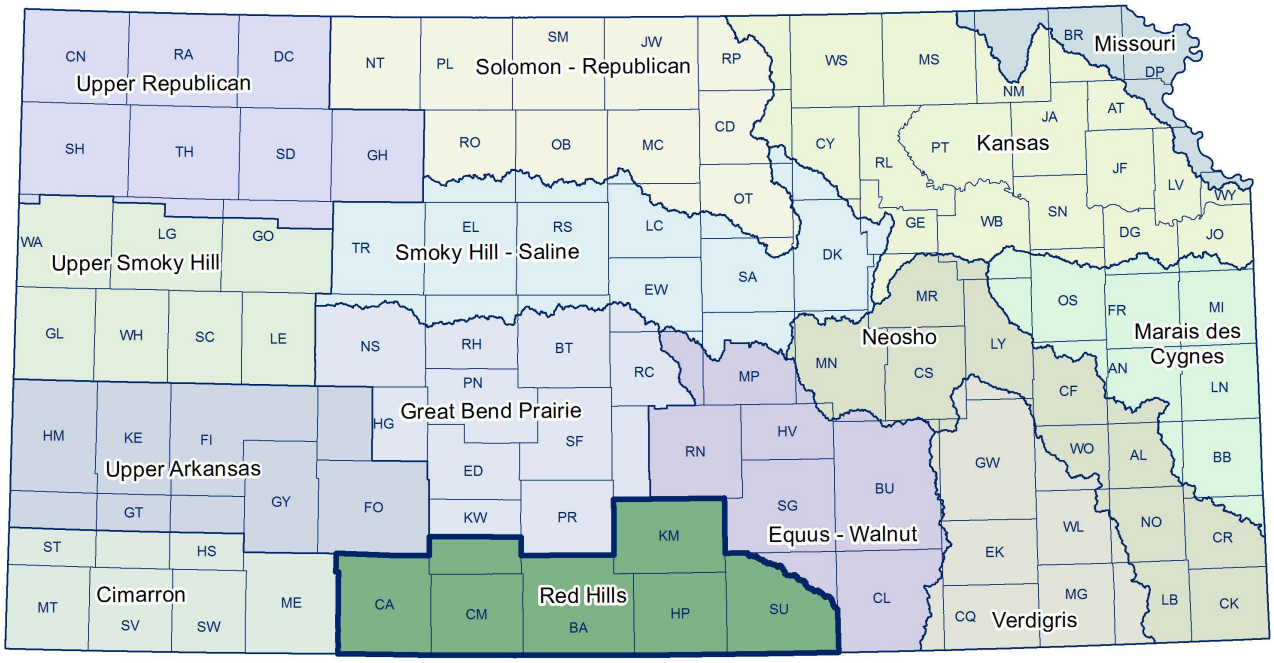


Figure 12. ANS infested water resources in the Neosho Region

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).

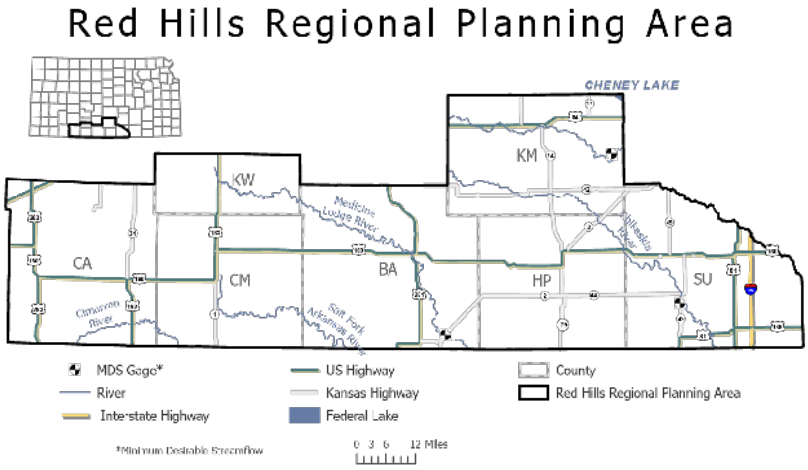


Figure 1. Red Hills Regional Planning Area

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.[1]

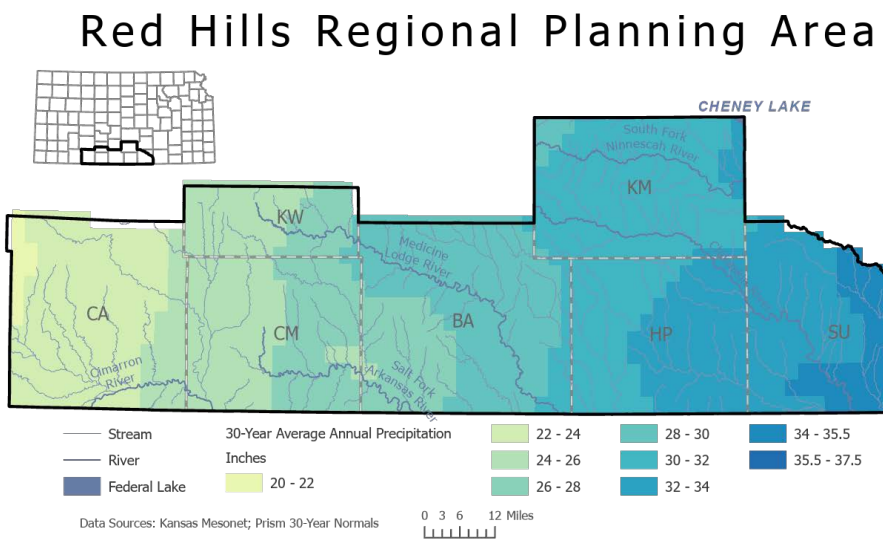


Figure 2. 30-year average annual precipitation in the Red Hills Region

Red Hills Region

Figure 3 lists the remaining land uses in the region, including deciduous forest.

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.

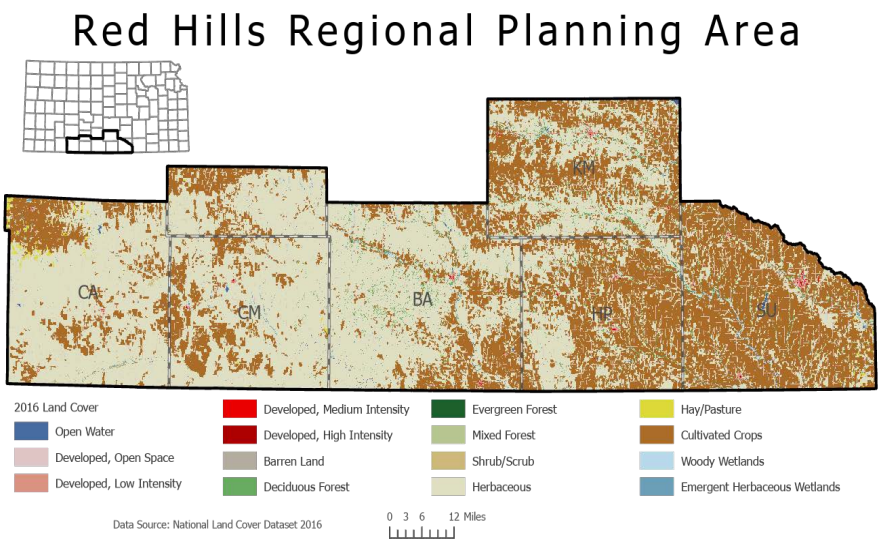


Figure 3. Red Hills regional land cover

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).[2] 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, release and analysis of the 2020 Census.

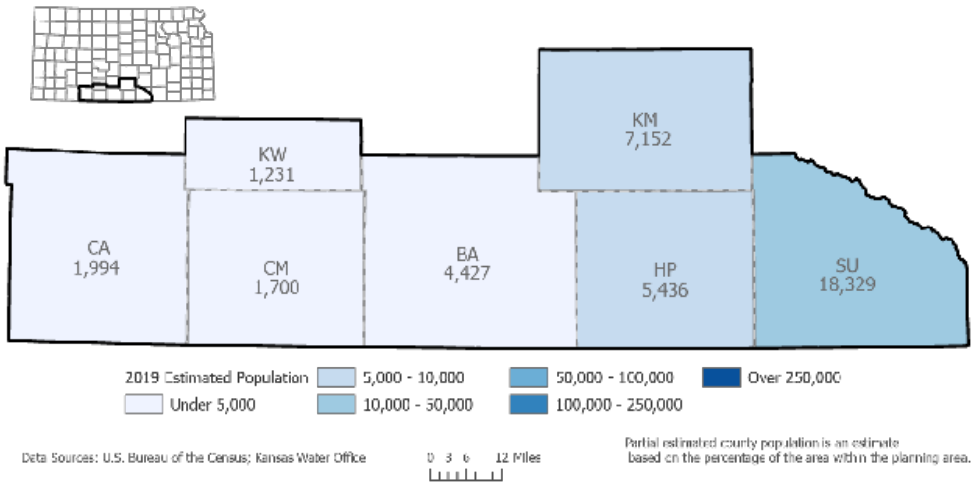


Figure 4. 2019 estimated population by county

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

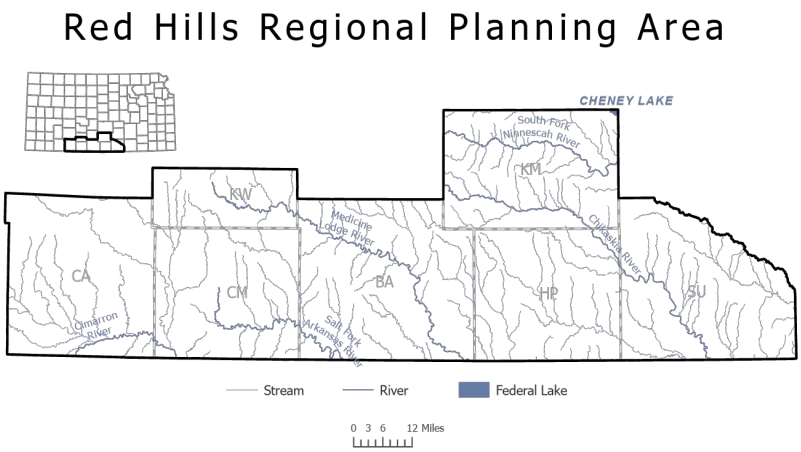


Figure 5. Major surface water resources in the Red Hills Region

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).

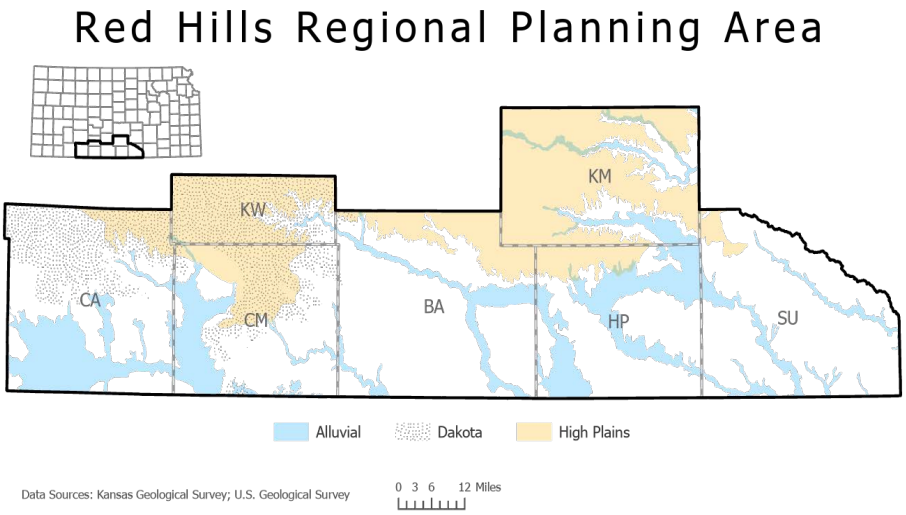


Figure 6. Principle aquifer boundaries in the Red Hills Region

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 portion of the High Plains Aquifer as well as 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).

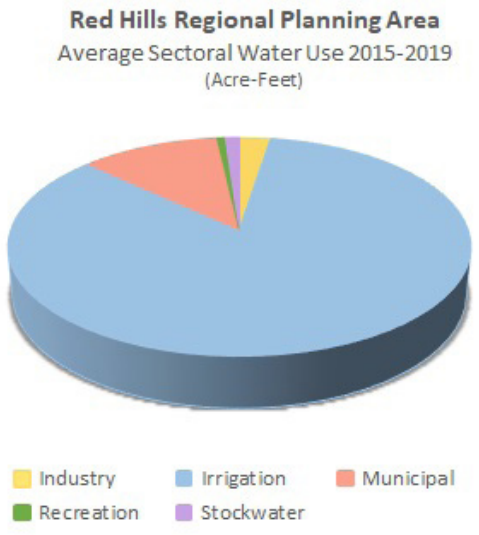


Figure 7. Average sectoral water usage

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.

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.[3] This analysis found that existing demands for water supply in the study area were currently being met by groundwater sources. However, the existing water 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.

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

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.

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 some extent to stretch limited available water resources. The Kansas Health Institute (KHI) crafted a report on Potential Health Impacts of Municipal Water Reuse in Kansas.[4] 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. In 2019, the Kansas Water Authority recommended, and Governor Laura Kelly created, an Arbuckle Study Group to obtain more facts about the status of the Arbuckle formation and impacts of fluid disposal within it.

Red Hills Region

Water Quality

Impairments due to nutrients affect 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 and its tributaries in the Protection area 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). Very high chloride concentrations from historic oil field brine contamination can be present in the Permian bedrock.

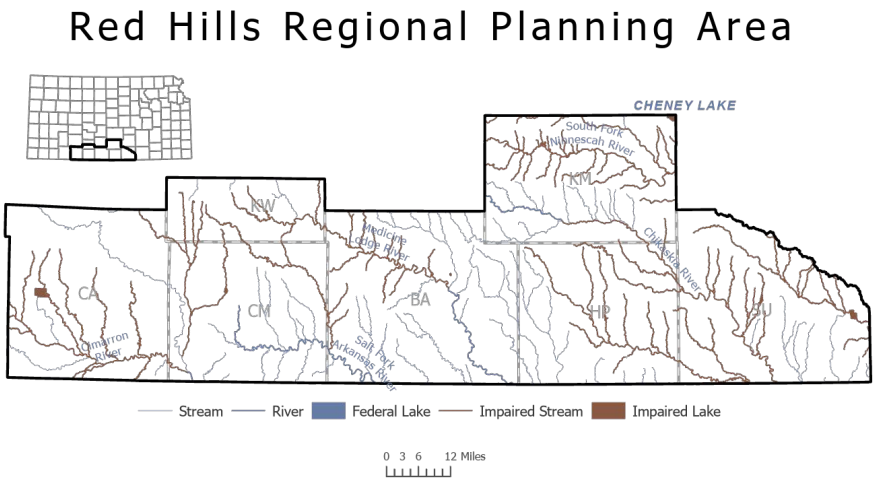


Figure 8. Impaired water resources in the Red Hills Region

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.[5]

Red Hills Region

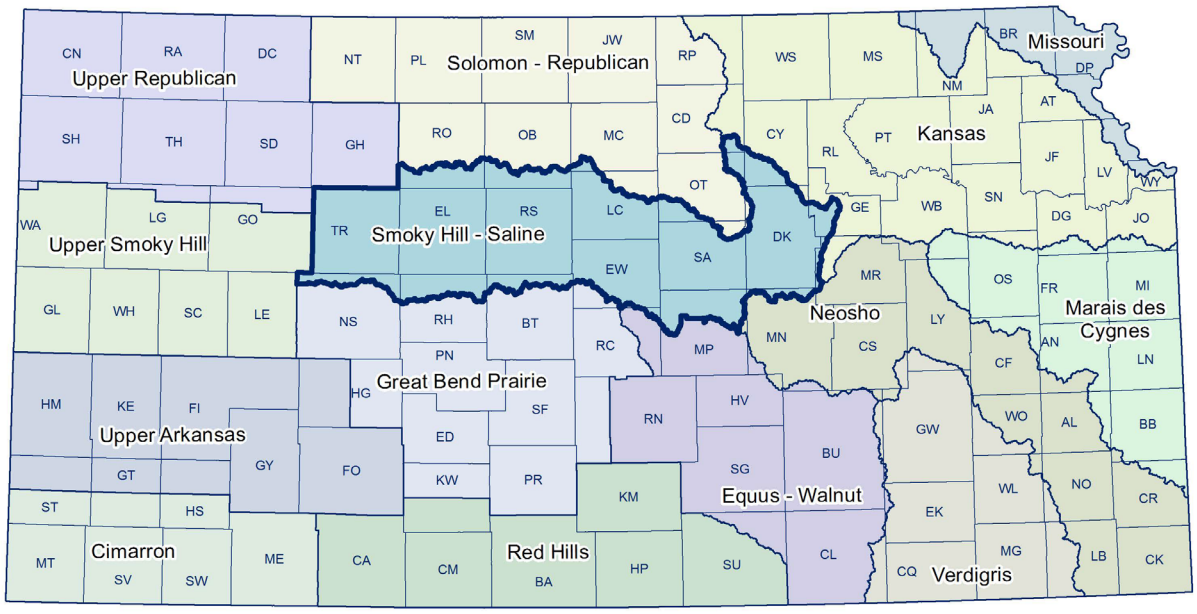
Additional Storage

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.[6] 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 Section 404), as well as satisfaction of National Environmental Policy Act (NEPA) are all potential considerations which must be addressed before any new project could advance to a construction phase.

Smoky Hill-Saline Region



Smoky Hill-Saline Region

Regional Description

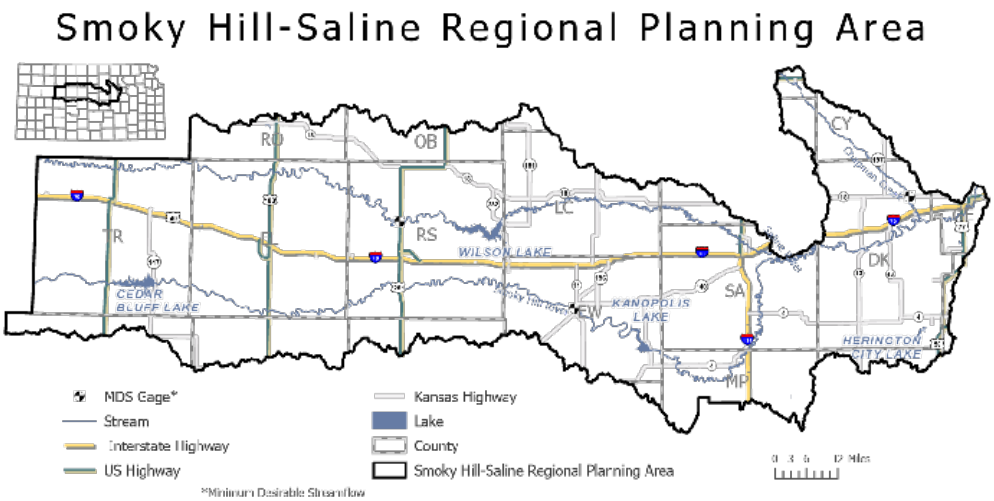


Figure 1. Smoky Hill-Saline Regional Planning Area

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 as well as 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 as well as portions of Barton, Clay, Cloud, Dickinson, Ellsworth, Geary, Lincoln, Marion, McPherson, Mitchell, Morris, Ness, Osborne, Ottawa, Rice, Rooks, Rush, and Saline Counties.

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).

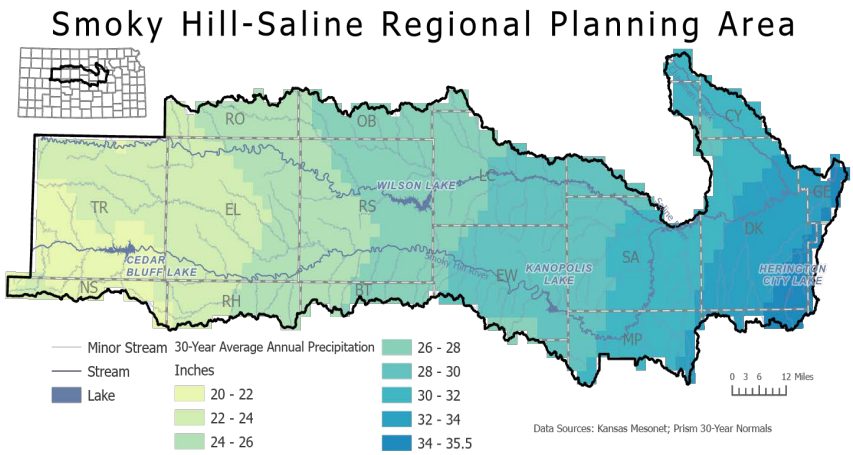


Figure 2. 30-year average annual precipitation in the Smoky Hill-Saline Region

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.[1] 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.

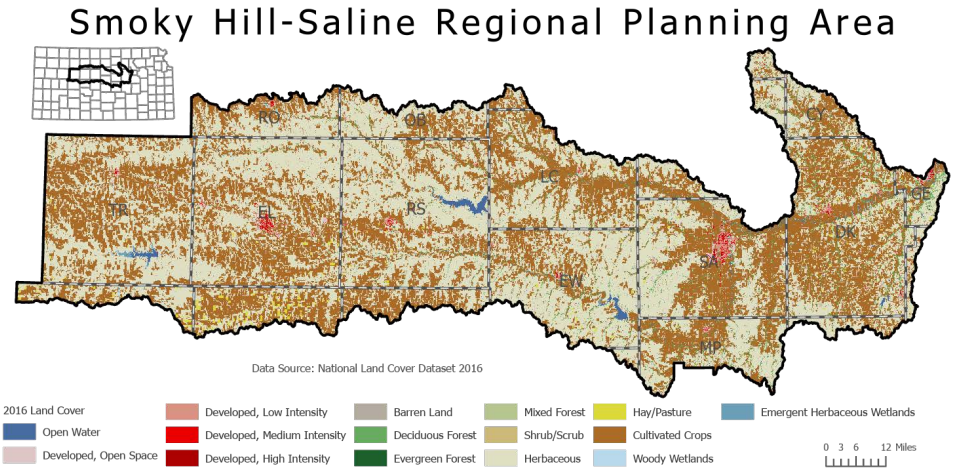


Figure 3. Smoky Hill-Saline regional land cover

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).[2] 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, release and analysis of the 2020 Census.

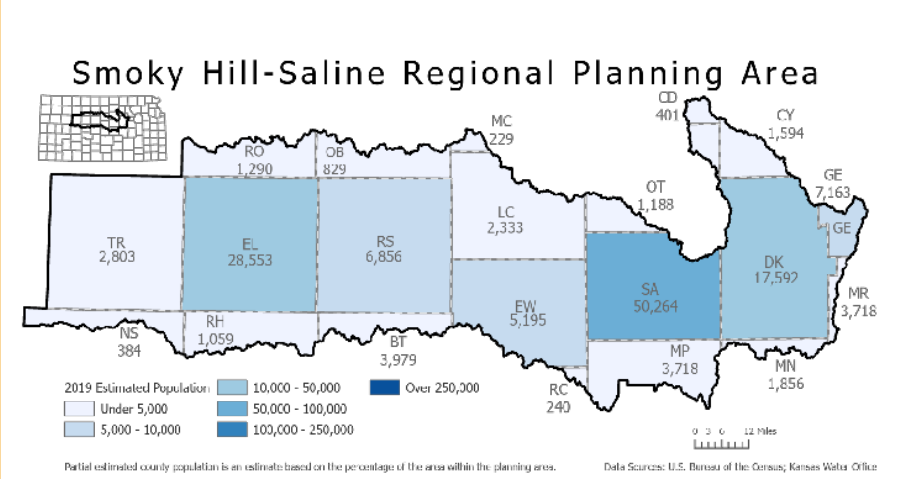


Figure 4. 2019 estimated population by county

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-Saline Region are 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).

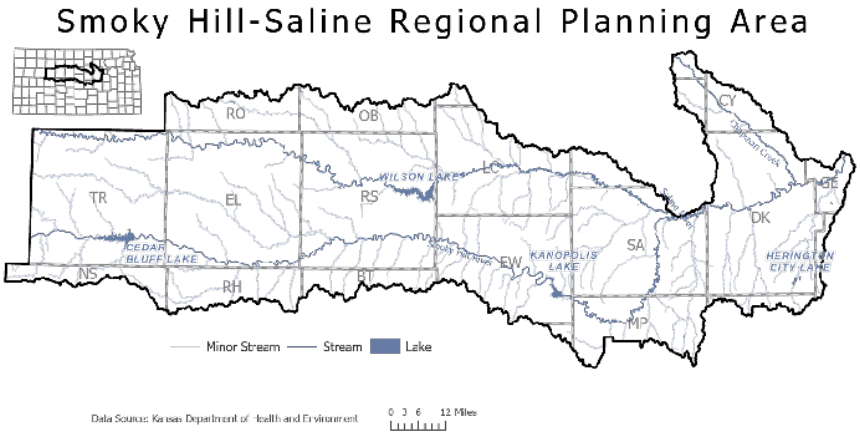


Figure 5. Major surface water resources in the Smoky Hill-Saline Region

GROUNDWATER

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

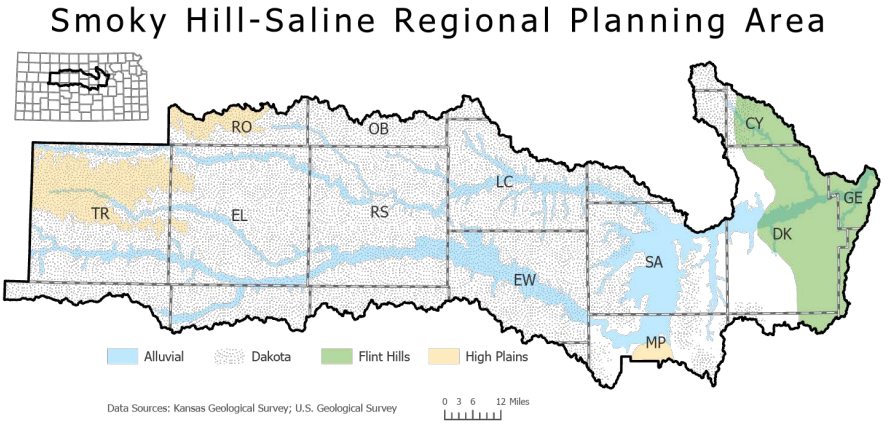


Figure 6. Principle aquifer boundaries in the Smoky Hill-Saline Region

The principal aquifers include alluvial aquifers and the Dakota Aquifer, on which Kansas Geological Survey (KGS) has done considerable research.[3] The far western portions of the region are underlain by the the Ogallala Portion of the High Plains Aquifer and far portions of the eastern part of the region are underlain by the Flint Hills Aquifer.[4]

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 important sources 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. Cedar Bluff Reservoir and Wilson Lake mainly provide recreational opportunities for the region.

Smoky Hill-Saline Region

Kanopolis Lake serves as a principal water source for many in the Smoky Hill-Saline Region. Also within the Smoky Hill-Saline Region, Herington Reservoir in Dickinson County is a municipal-owned lake that serves as a source of water supply for four communities.

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 wet weather. Sources utilized within the Smoky Hill-Saline Region include the Ogallala Portion of the High Plains Aquifer in the far western portion of the region, Flint Hills Aquifer in the east, and alluvial deposits along major streams.

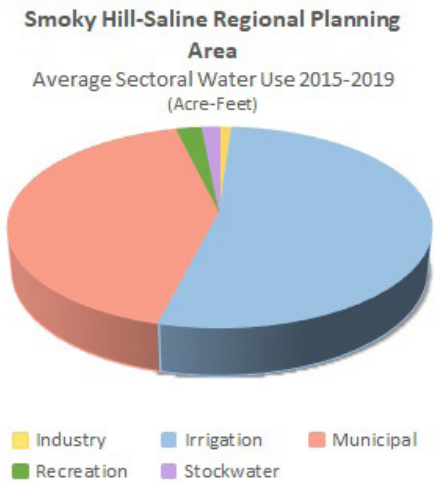


Figure 7. Average sectoral water usage

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 with its place as the key water supply reservoir for the Smoky Hill-Saline Region (Figure 8).

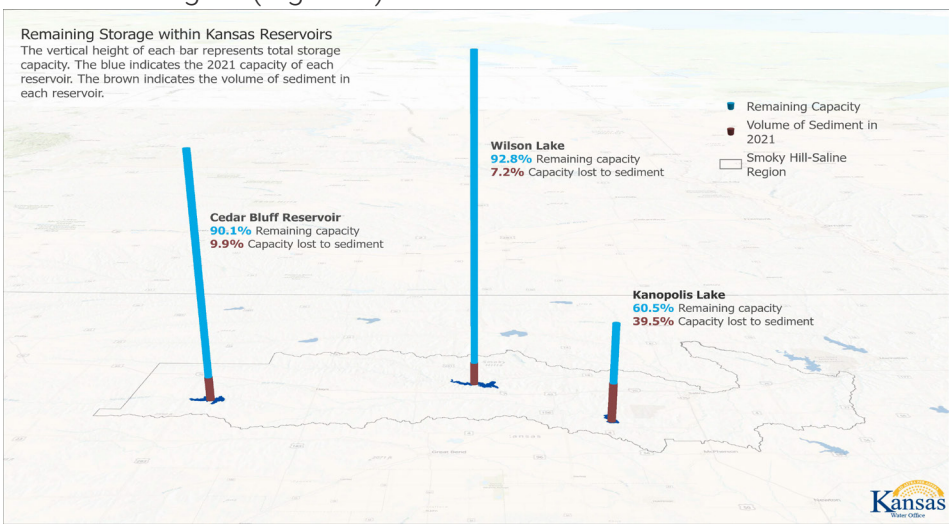


Figure 8. Remaining storage in region's reservoirs and lakes

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).

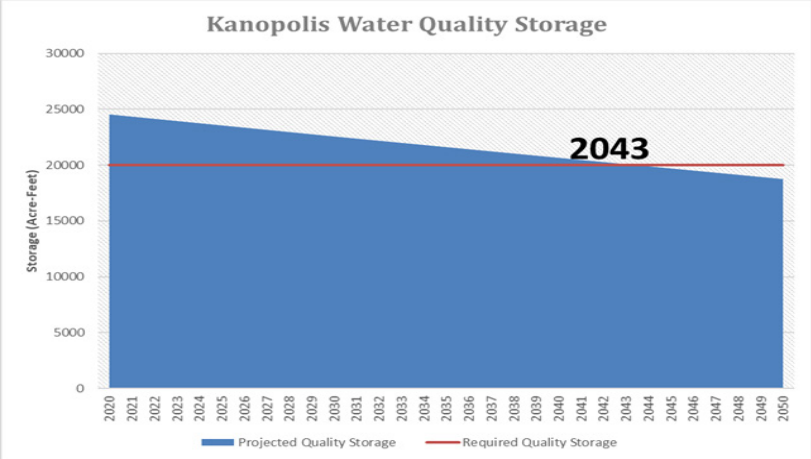


Figure 9. Water quality storage in Kanopolis Lake

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, with streamflow declines being 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, which were identified to be 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.

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 as modeled through the 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.

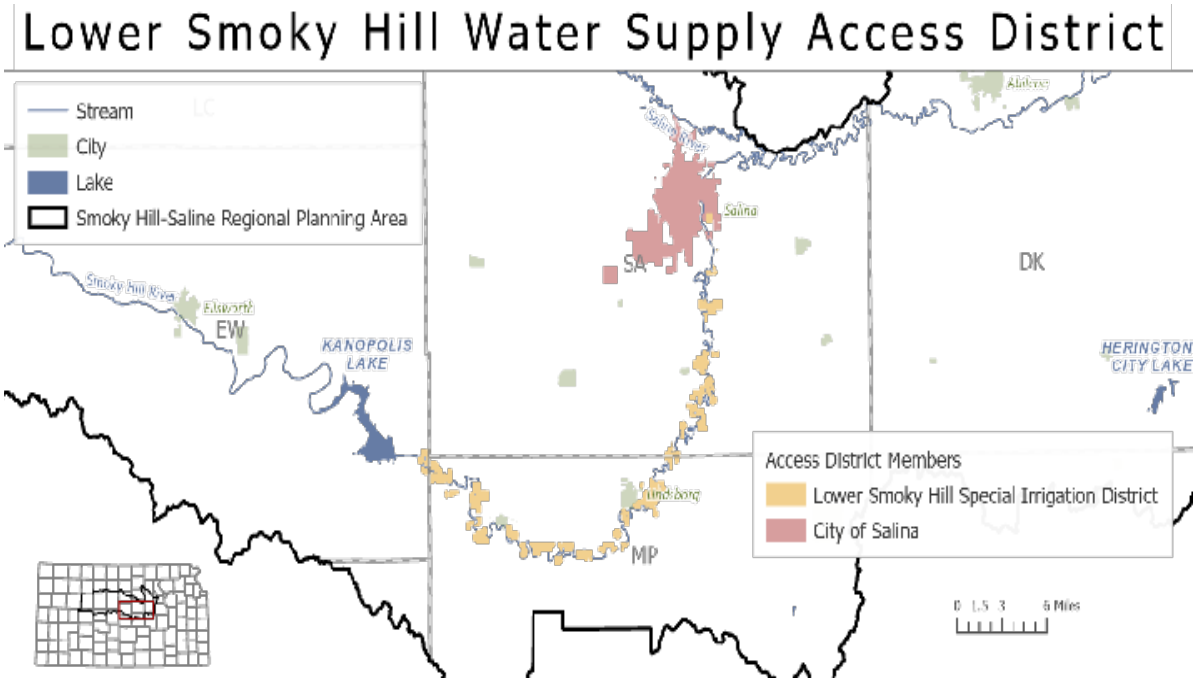


Figure 10. Lower Smoky Hill Water Supply Access District

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.

Figure 11. Ranch overview map.

In 2019, following consideration of comments from local individuals and entities, including GMD 5, 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. The court upheld the contingent approval of the change applications in late June 2022. The anticipated next step in the process would be the cities' request for approval under the Kansas Water Transfer Act (K.S.A. 82a-1501, *et seq.*).

Public Water Supply Conservation

Fluctuations in precipitation impact available water supply at any given time throughout the year, with extended 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 municipal example of recognized water conservation within the region and statewide, with a combination of conservation incentive programs, ordinances and water reuse leading to reduced gallons per capita per day over time.

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).[5] 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 Smoky-Hill Saline 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, the use of water stored within Kansas River Basin reservoirs was necessary to dilute chlorides and sulfates that naturally occur in the upper portions of the watershed.

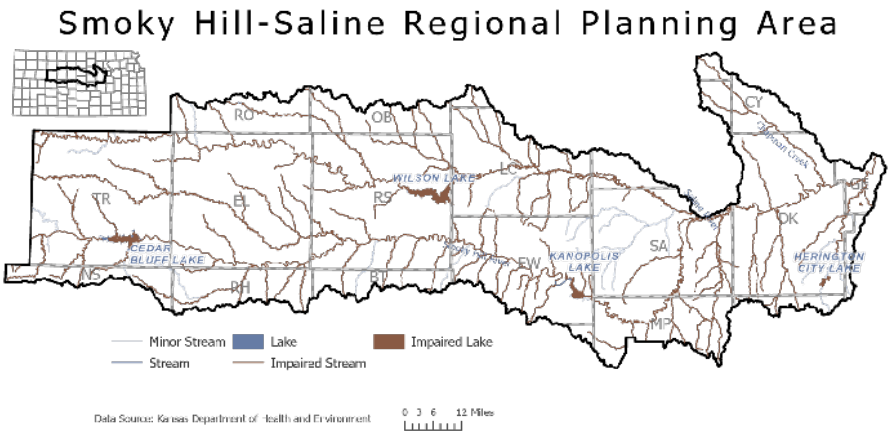
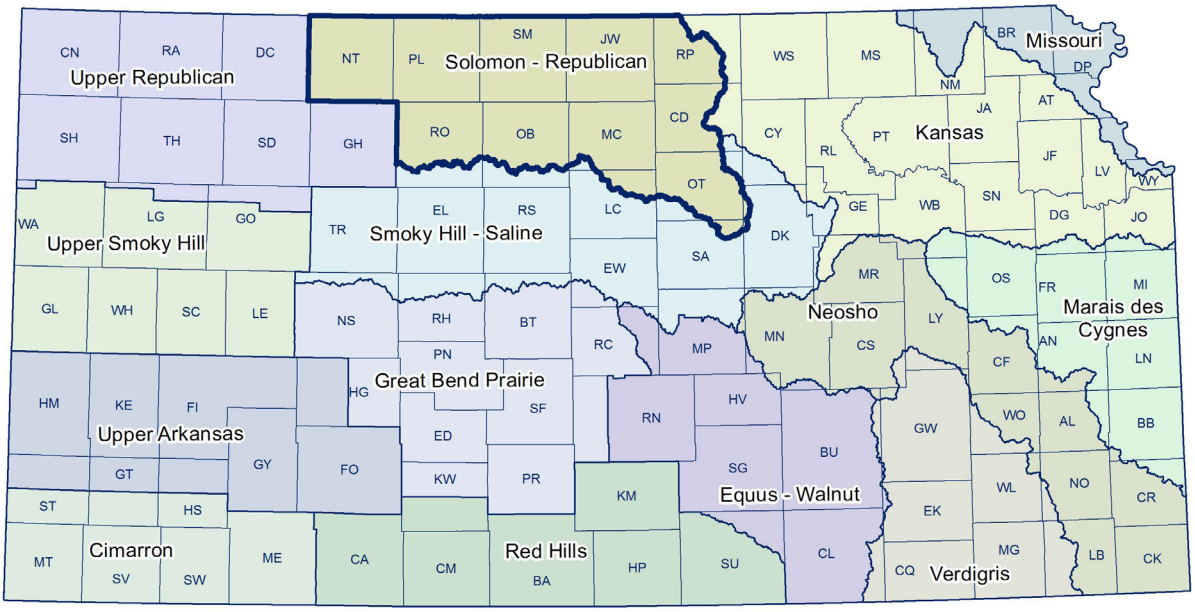


Figure 12. Impaired water resources in the Smoky Hill-Saline Region

In 2018, Tuttle Creek and Milford Lake releases were required to dilute high chlorides released downstream into the Saline River 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.

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).

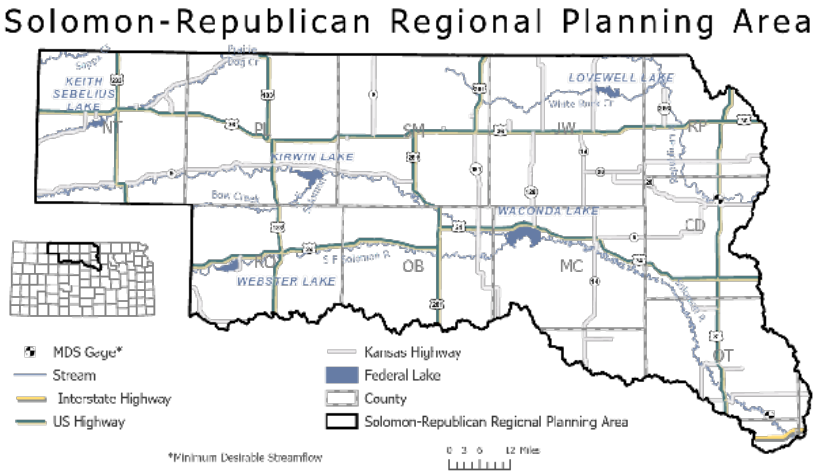


Figure 1. Solomon-Republican Regional Planning Area

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).

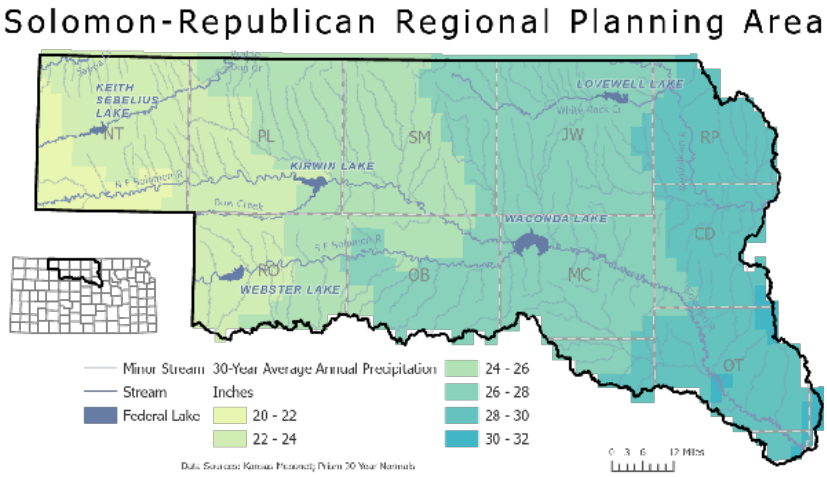


Figure 2. 30-year average annual precipitation in the Solomon-Republican Region

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.[1]

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.

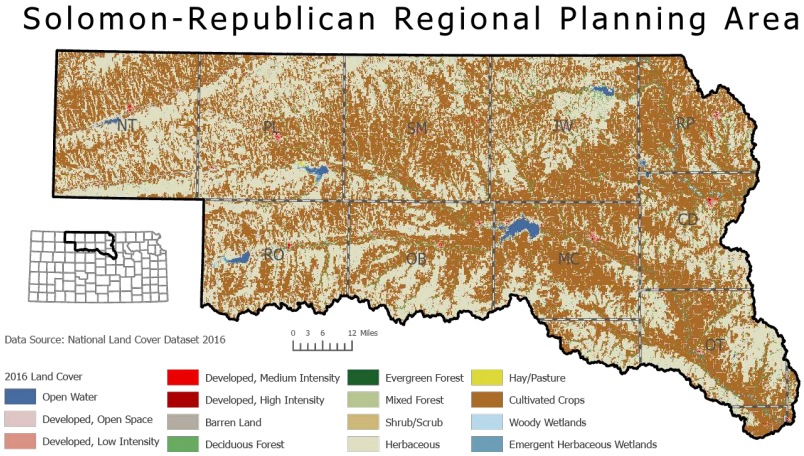


Figure 3. Solomon-Republican regional land cover

POPULATION & ECONOMY

Based upon 2019 state-released U.S. Census Bureau information, there were an estimated 47,713 residents in the region (Figure 4).[2] 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.

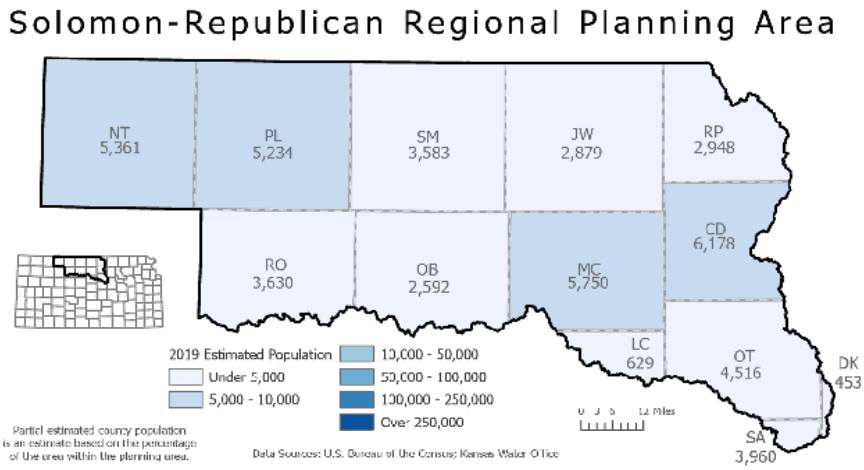


Figure 4. 2019 estimated population by county

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.

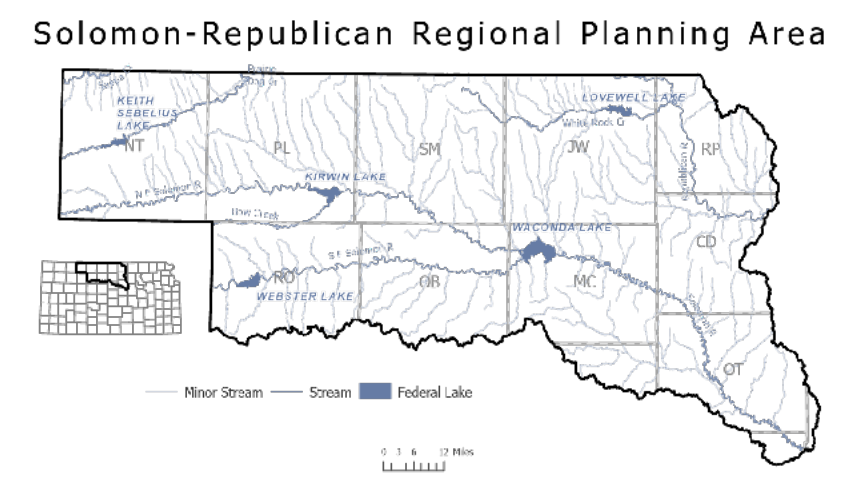


Figure 5. Major surface water resources in the Solomon-Republican Region

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.[3] 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.

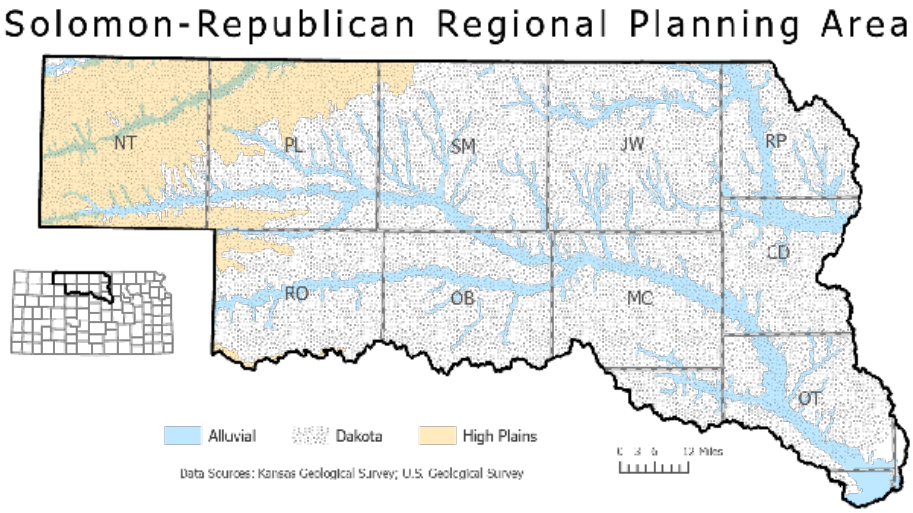


Figure 6. Principle aquifer boundaries in the Solomon-Republican Region

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).

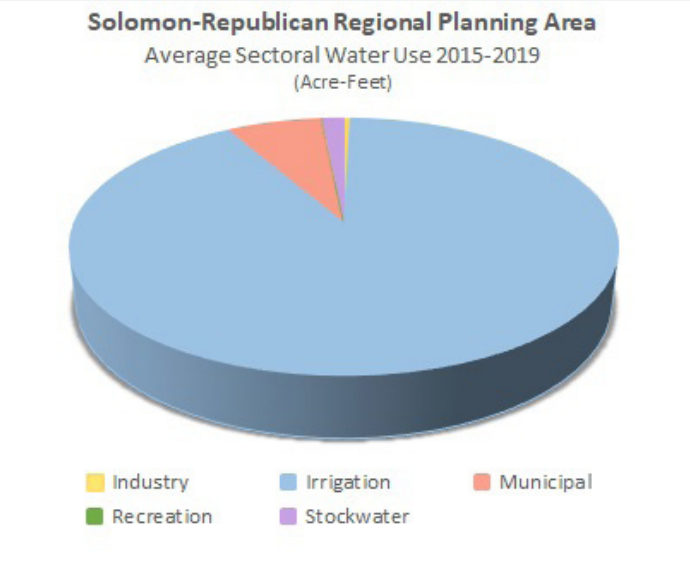


Figure 7. Average sectoral water usage

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.

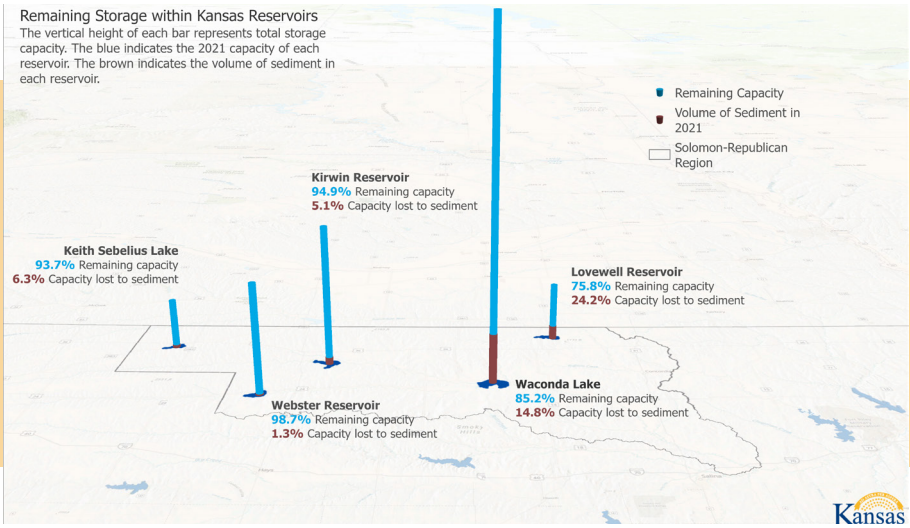


Figure 8. Remaining storage within Kansas Reservoirs in the Solomon-Republican Region

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 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

Solomon-Republican Region

(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.[4] 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.

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).[5] 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.[5]

Solomon-Republican Region

HARMFUL ALGAL BLOOMS

Harmful Algal Blooms (HABs) are common in bodies of water when nutrient loading from fertilizer runoff 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

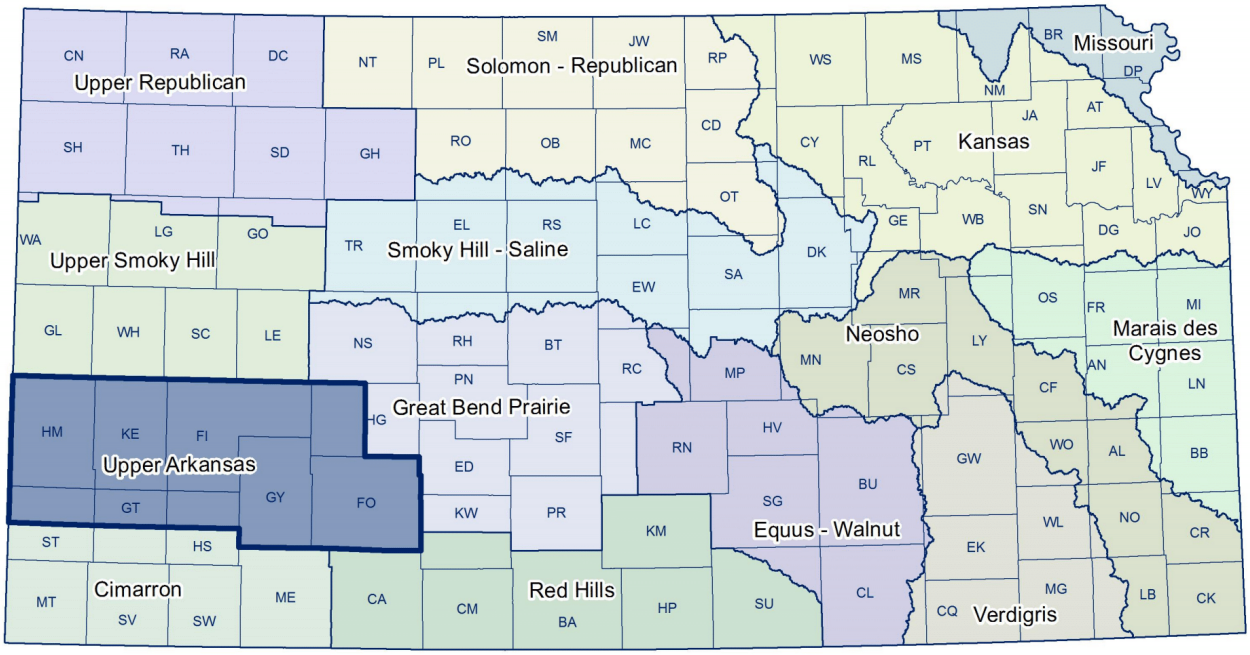
THREATENED AND ENDANGERED SPECIES

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. 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.[6] Numerous strategies to control phreatophytes have been tested, including harvesting, chemical application, and biological controls with varying degrees of success.

Saltcedar with buds and a pollinator, 2017
Photo Credit: USGS

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.

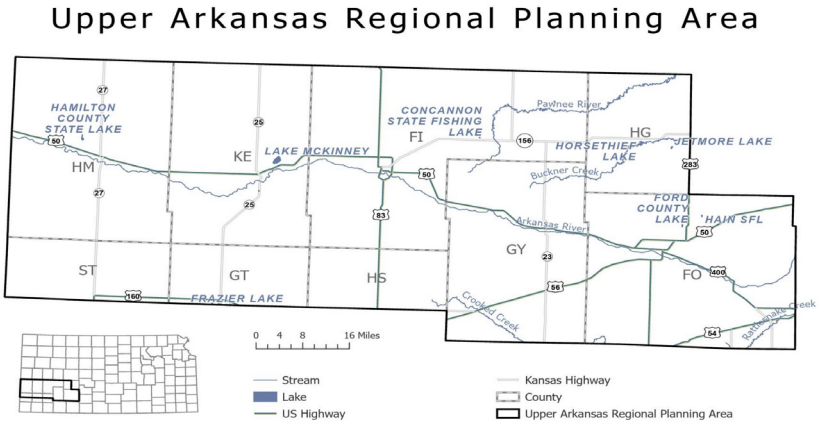


Figure 1. Upper Arkansas Regional Planning Area

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.

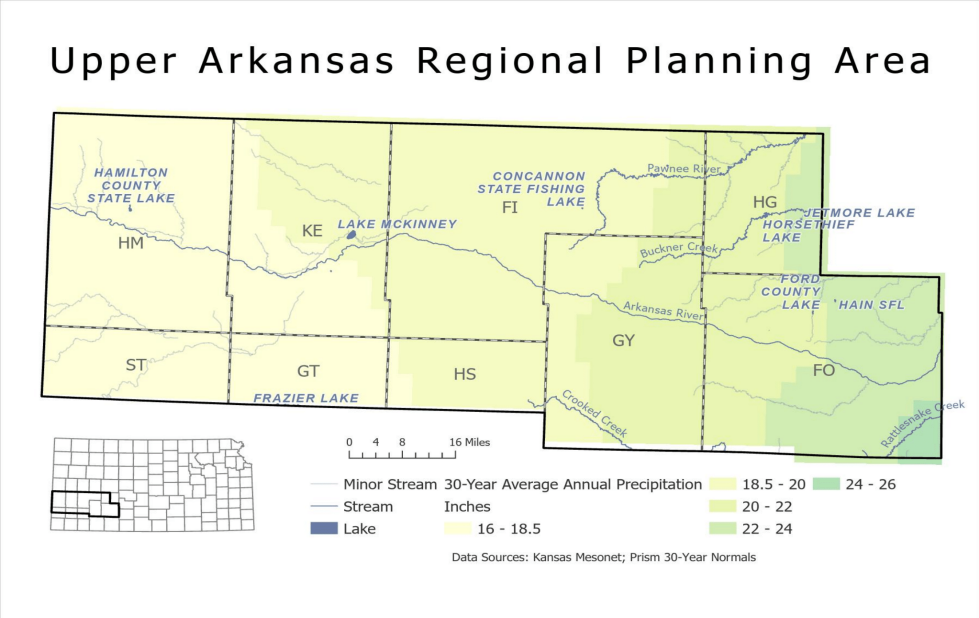


Figure 2. 30-year average annual precipitation in the Upper Arkansas Region

Upper Arkansas Region

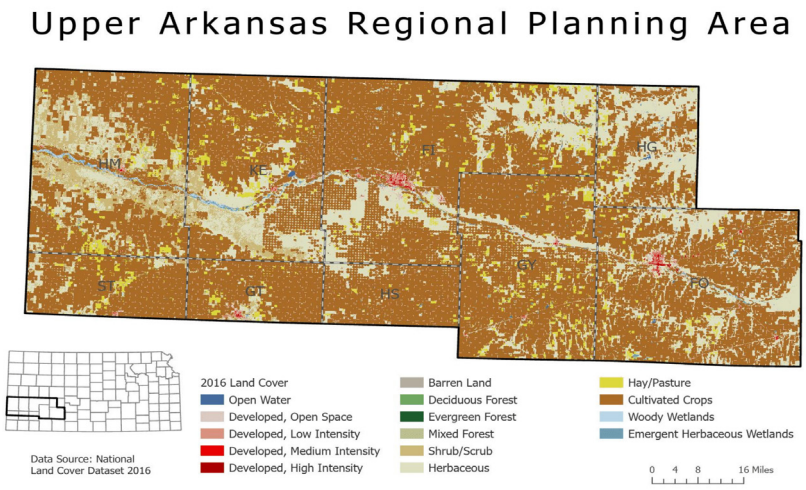


Figure 3. Upper Arkansas regional land cover

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.[1] 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.[2] 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).[3] 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 release and analysis of the 2020 Census.

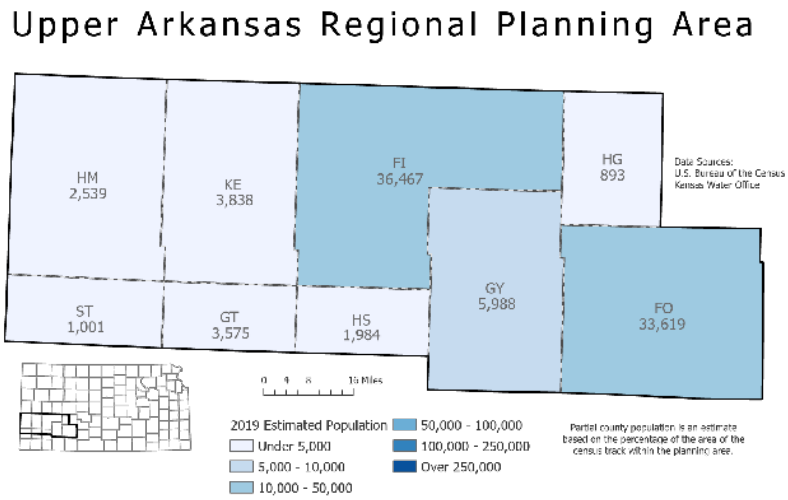


Figure 4. 2019 estimated population by county

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.

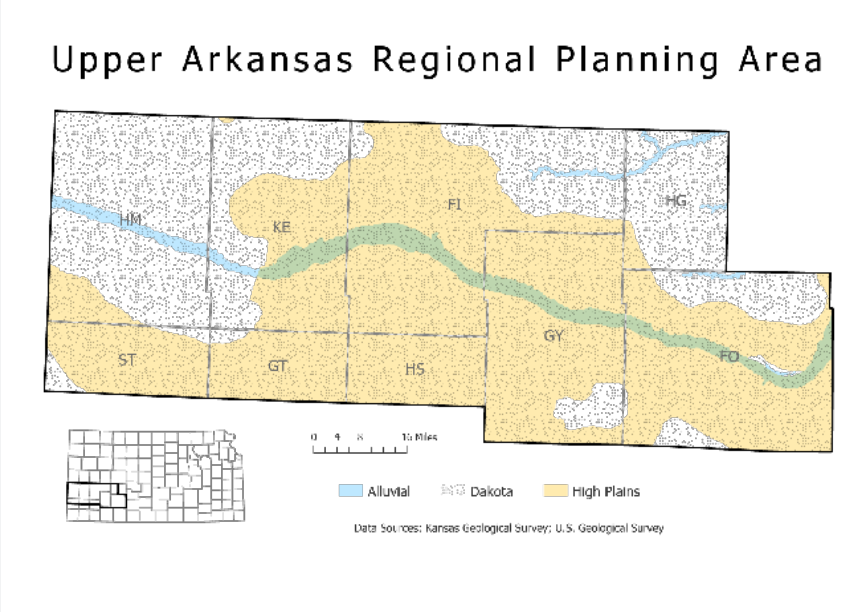


Figure 5. Principle aquifer boundaries in the Upper Arkansas Region

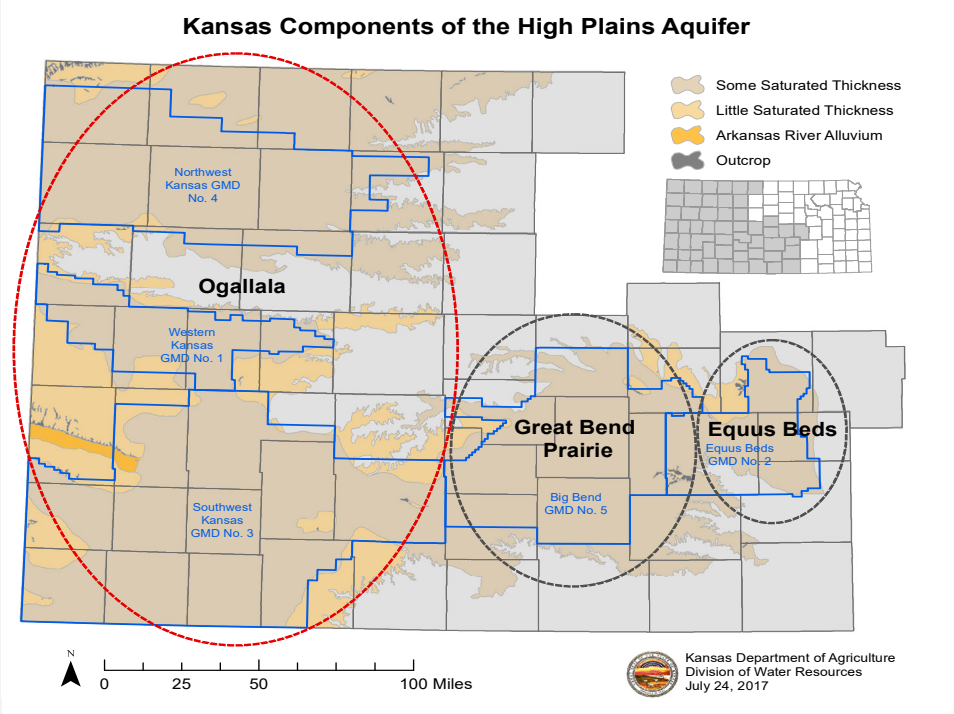


Figure 6. Kansas Components of the High Plains Aquifer[4]

Upper Arkansas Region

SURFACE WATER

The majority of the region is within the drainage of the Arkansas River (Figure 7). 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.

Upper Arkansas Regional Planning Area

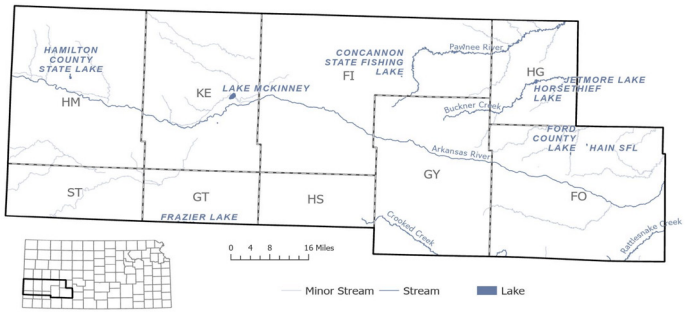


Figure 7. Major surface water resources in the Upper Arkansas Region

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.

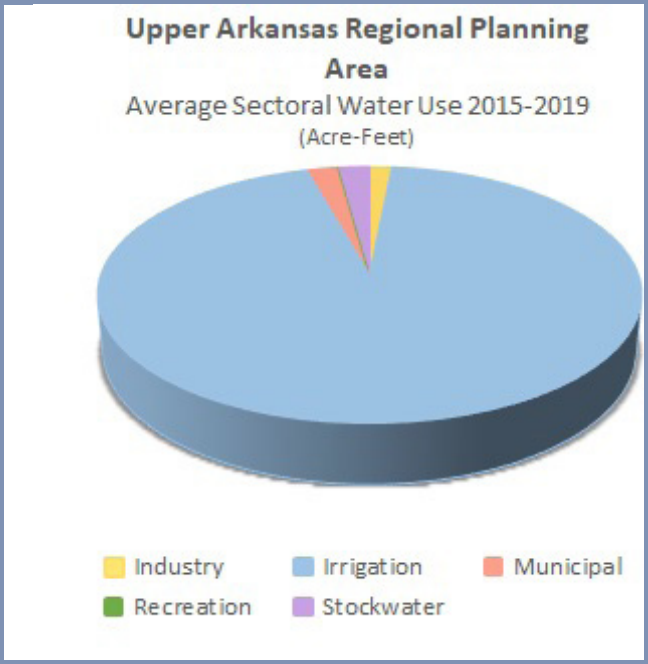


Figure 8. Average sectoral water usage

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.[5]

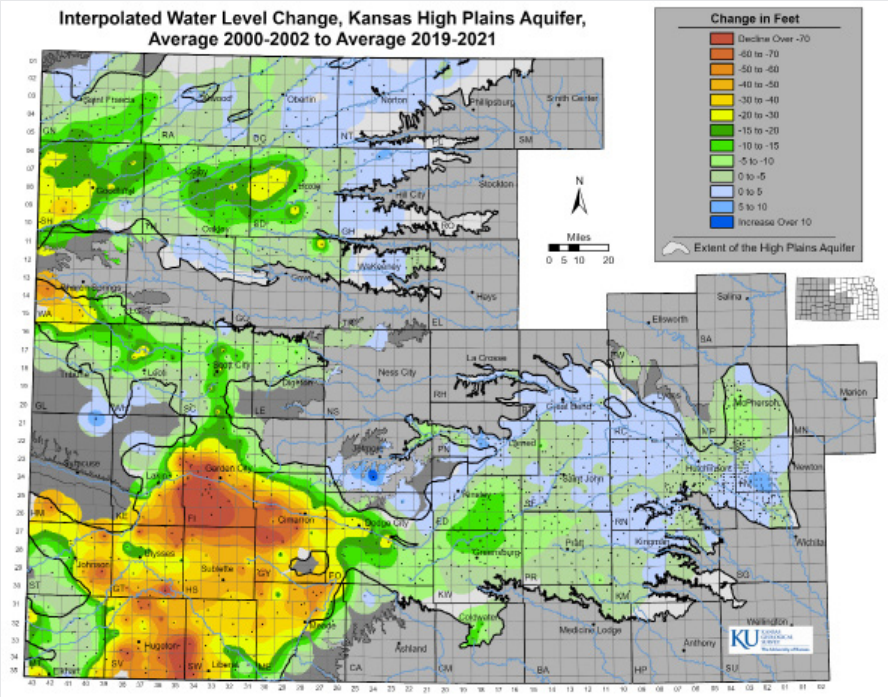


Figure 9. Water Level Change, Kansas High Plains Aquifer[6]

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 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.

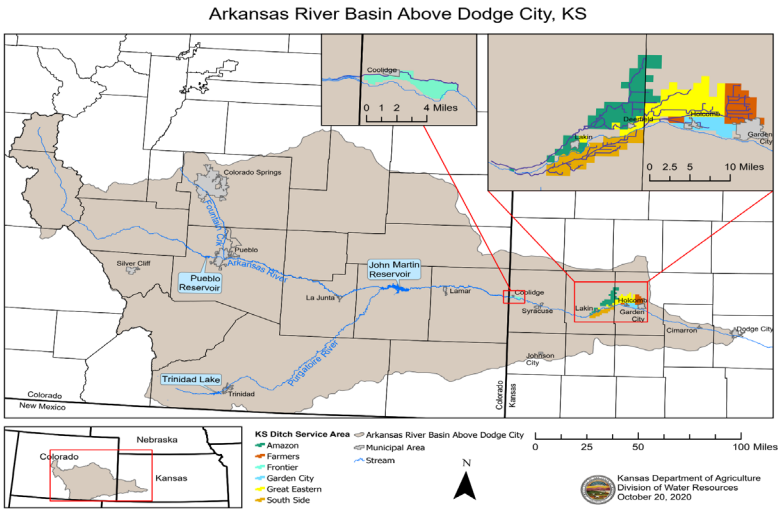


Figure 10. Arkansas River Basin Above Dodge City, KS[7]

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 for water rights owners 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, but no final proposal was 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.[8] 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 Holcomb, KS

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,[9] 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. Garden City has begun implementing a water reuse project in partnership with the Bureau of Reclamation, the State and private entities; the project is proving successful and has earned national recognition.

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 and moderate 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 Selenium concentrations are higher, though, in the winter than the summer due to summer irrigation deliveries from John Martin Reservoir for dilution to the Kansas ditches. In the winter, those releases cease and the highly mineralized groundwater return flows made by Colorado comprise most of the water arriving at the state line. Concentrations during the irrigation off-season (October to March) remain elevated with the onset of drier conditions. The highest surface water concentrations of selenium are seen at the state line up to the Bear Creek Fault, as regional irrigation induces migration of river water into the surrounding alluvium and underlying High Plains Aquifer.

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.

Upper Arkansas Region

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).[10] 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.

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 impairing use of 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.

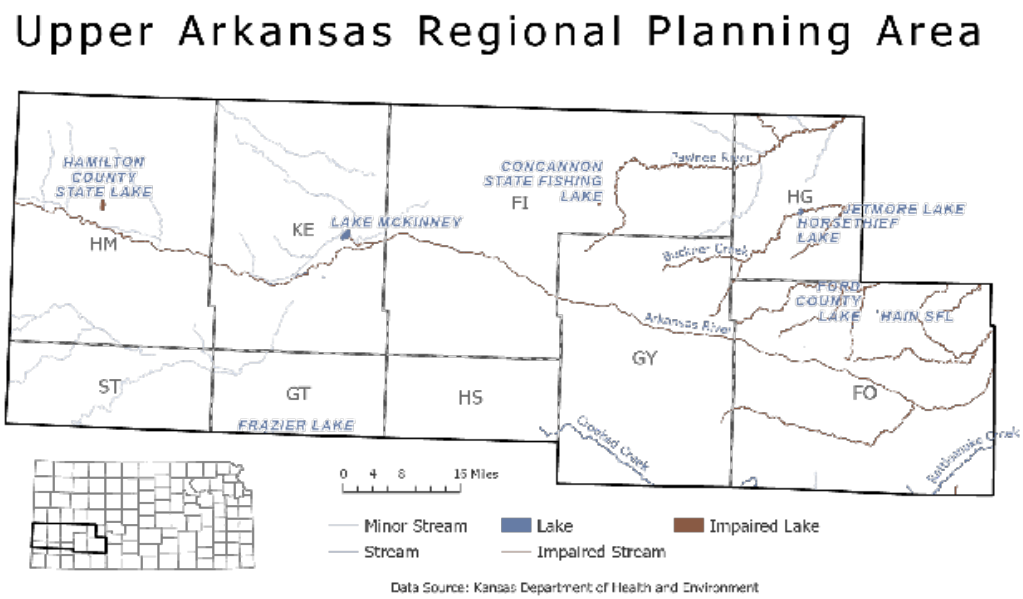
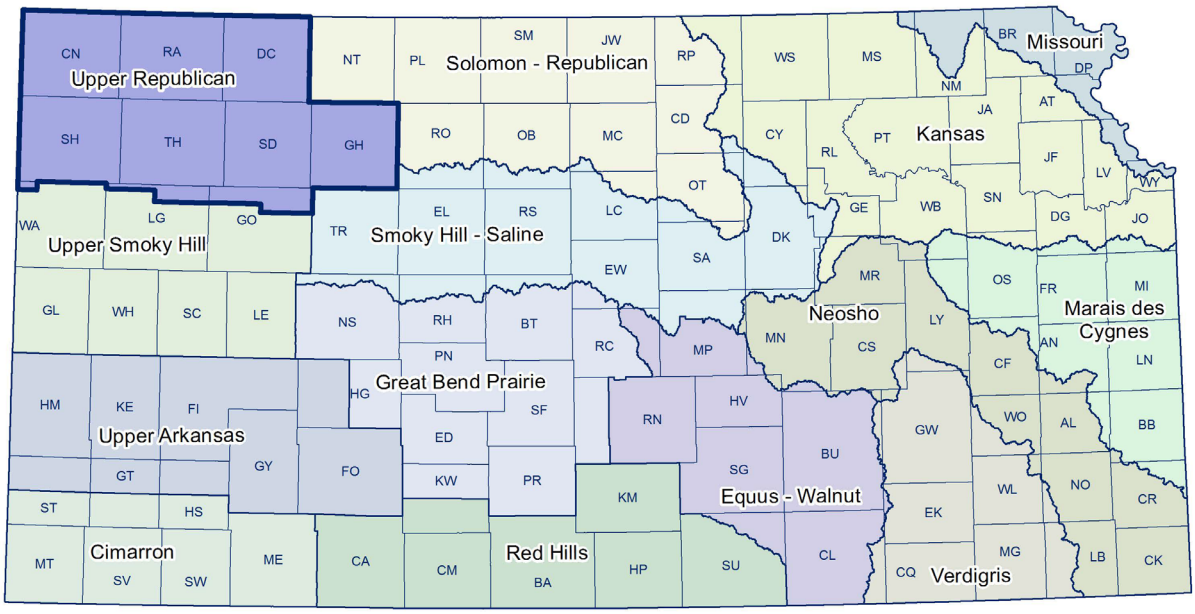


Figure 11. Impaired water sources in the Upper Arkansas Region

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).

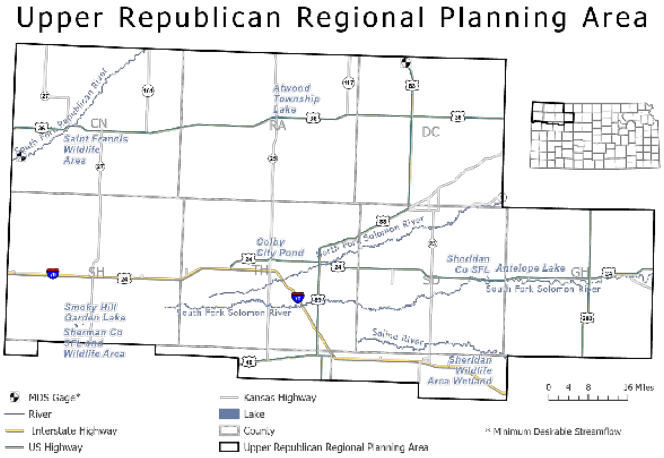


Figure 1. Upper Republican Regional Planning Area

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.

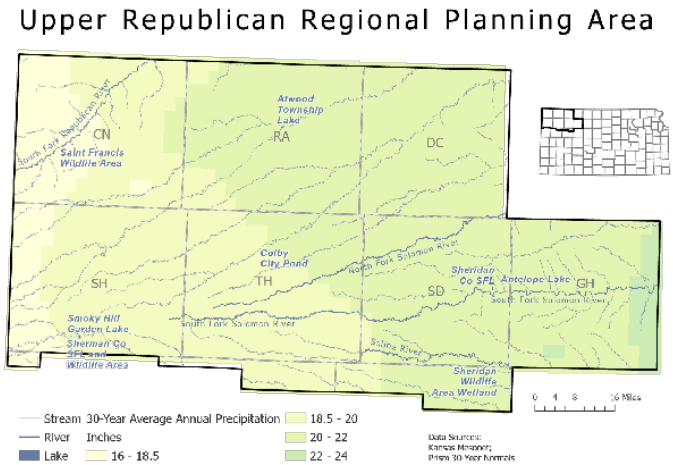


Figure 2. 30-year average annual precipitation in the Upper Republican Region

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.[1] Figure 3 lists the remaining land uses in the region, including pasture/hay.

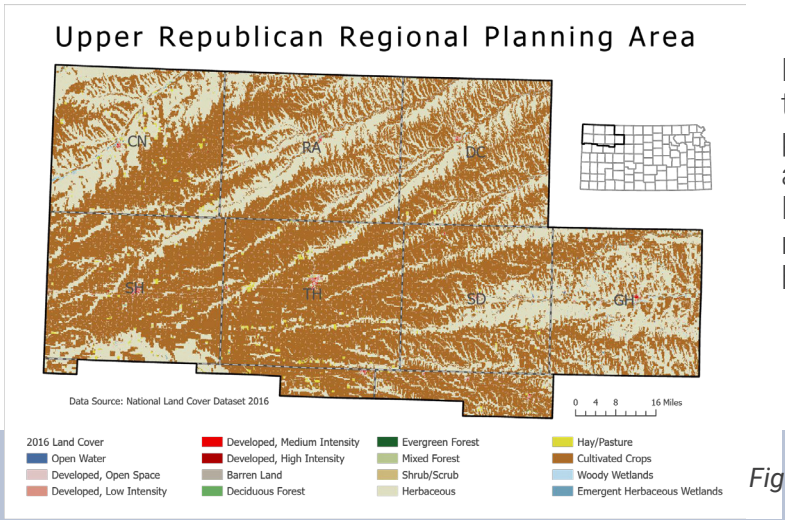


Figure 3. Upper Republican regional land cover

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.[2] 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).[3] 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, release and analysis of the 2020 Census.

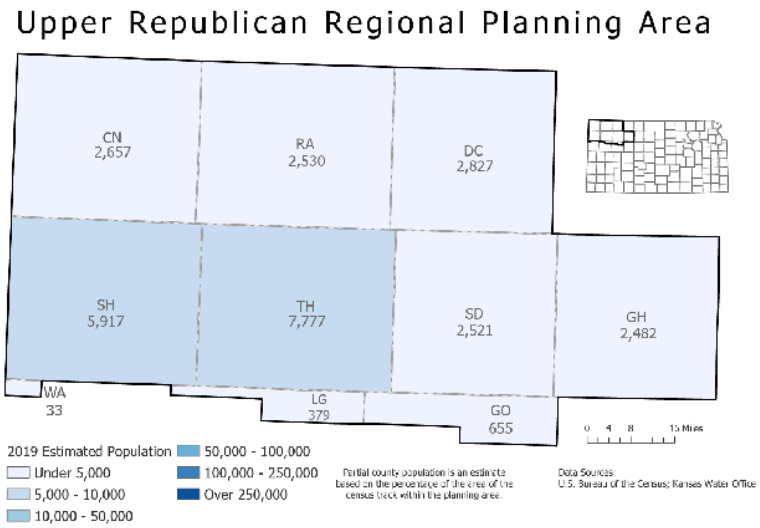


Figure 4. 2019 estimated population by county

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, numerous private hunting establishments and public wildlife refuges utilize wetland resources.

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).

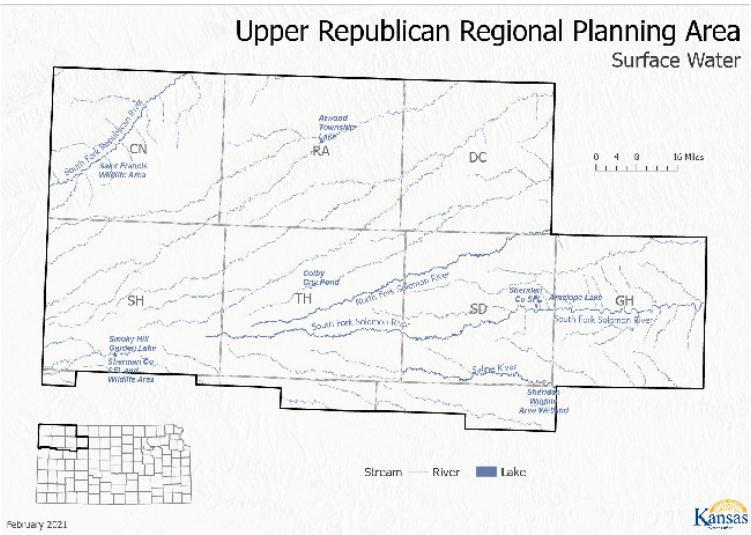


Figure 5. Major surface water resources in the Upper Republican Region

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.

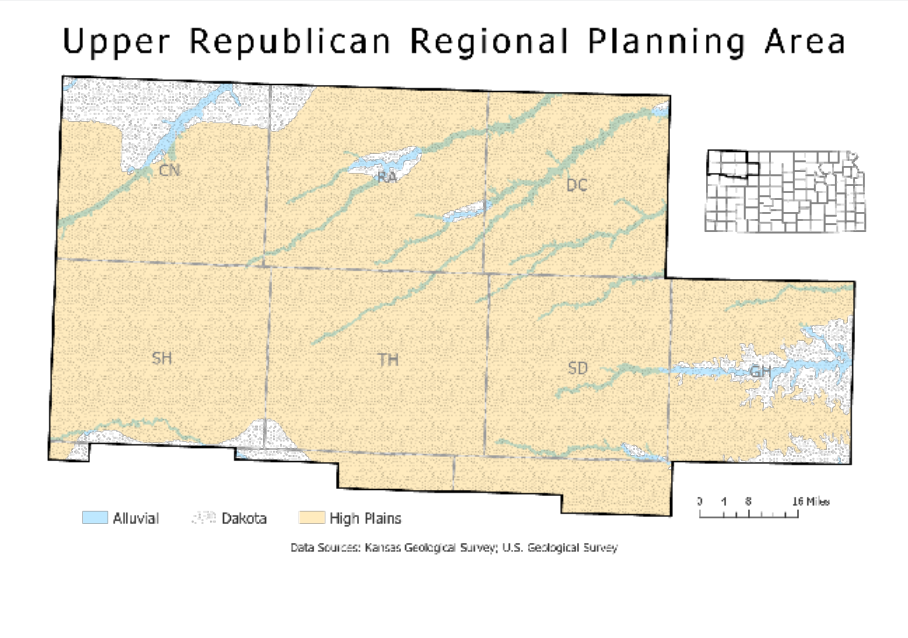


Figure 6. Principle aquifer boundaries in the Upper Republican Region

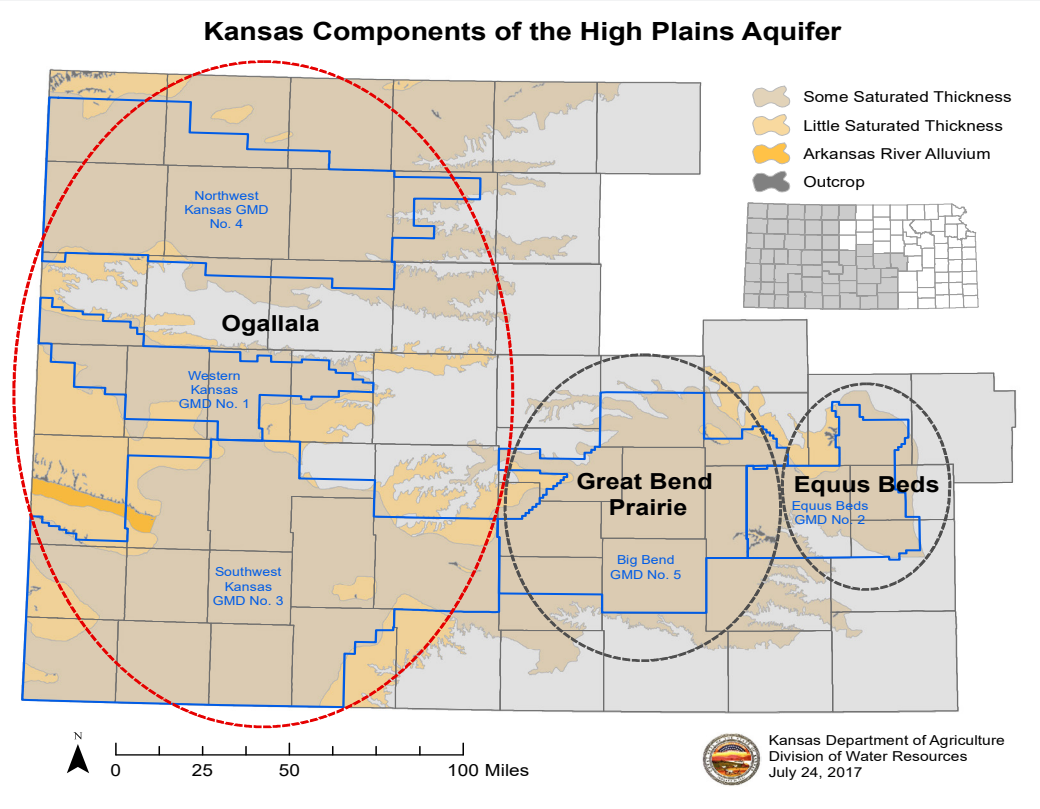


Figure 7. Kansas Components of the High Plains Aquifer[4]

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).

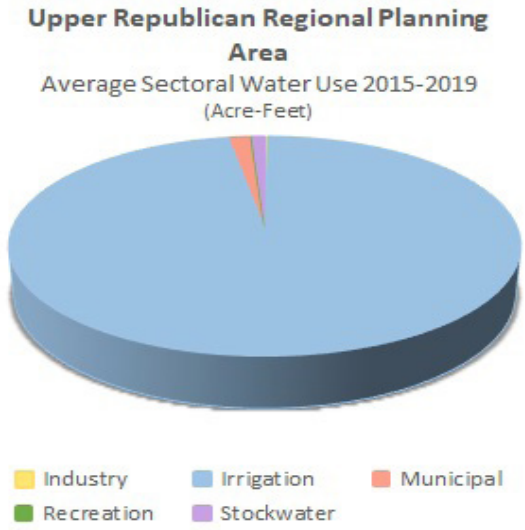


Figure 8. Average sectoral water usage

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 experiencing severe shortages in meeting demand.

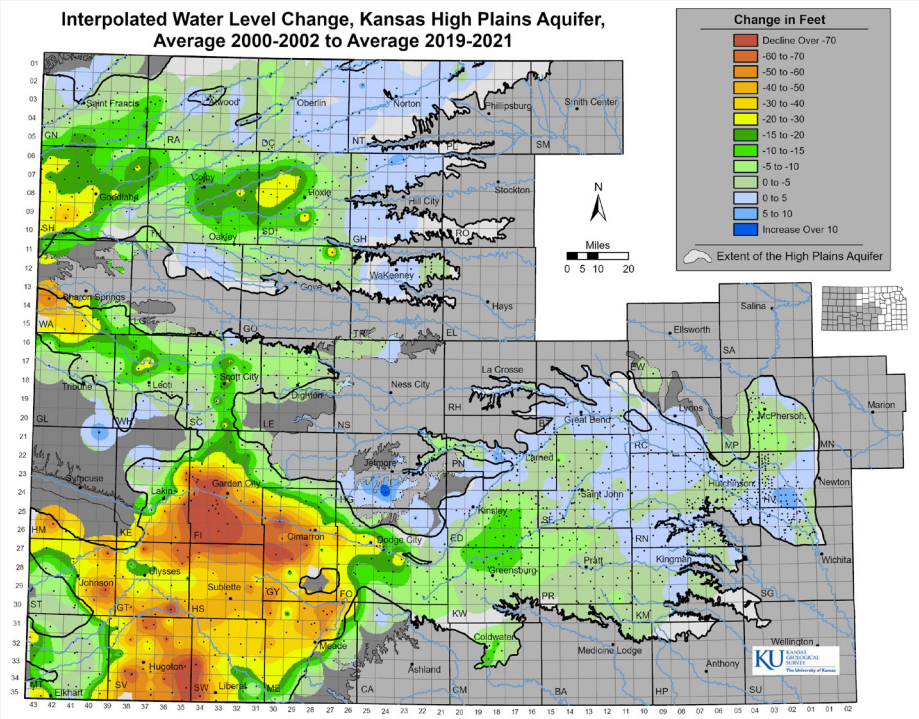


Figure 9. Water Level Change, Kansas High Plains Aquifer[5]

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.[6]

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 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 Kansas 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 to reduce water used for irrigation by 20%; reductions significantly exceeded that amount and the producers found the use of new practices and technologies, coupled with lower input costs, led to equal or higher profitability.

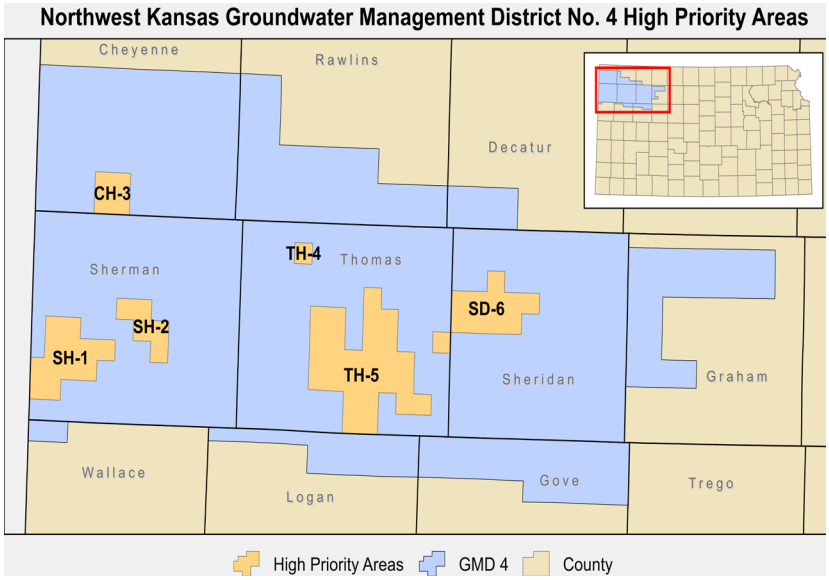


Figure 9. GMD4 boundaries and high priority areas within the Upper Republican Region[7]

REGIONAL WATER CONSERVATION EFFORTS

WATER CONSERVATION AREAS & LOCAL ENHANCED MANAGEMENT AREAS

The State of Kansas has developed a number of tools and resources for water rights owners 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 profitability led producers to request renewal of the LEMA for two additional terms, with future

Upper Republican Region

renewals expected. Initially, the Sheridan-6 LEMA limited 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, encompassing nearly the entire district, was approved by the Chief Engineer. 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. In 2021, GMD1's first LEMA was approved and, at press time, a second LEMA in GMD1 was under consideration.

WCAs were signed into law in April 2015, providing a simple and flexible tool that allows any water right owner or group of owners the opportunity to develop a management plan, subject to approval by the KDA-DWR, 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.

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.[8] 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 includes 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. Beginning in 2020, cost-share opportunities for the implementation of irrigation technologies have been available 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 leverages funding to expand the implementation of projects supporting the goal of improving efficiency and reducing water use in the South Fork basin.[9]

Upper Republican Region

WATER QUALITY

NORTHWEST KANSAS MINERALIZATION STUDY

KDHE has partnered with Fort Hays State University (FHSU) to determine the distribution and concentrations of uranium and other minerals in private drinking water wells 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.

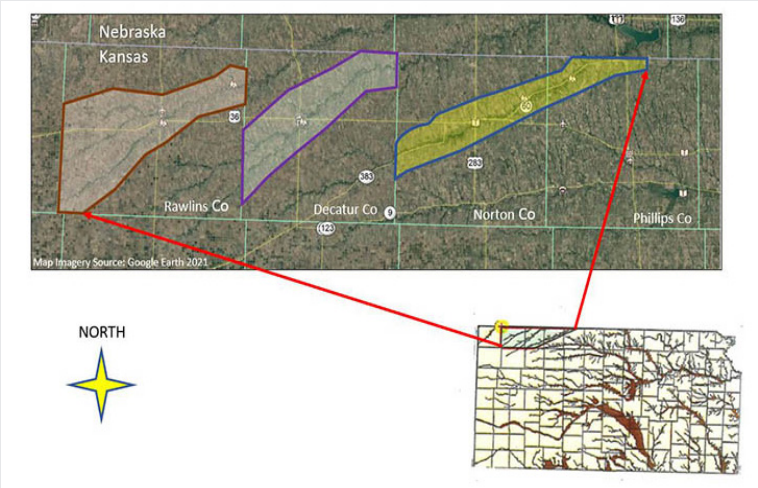


Figure 11. Northwest Kansas Mineralization Study Area, KDHE

In 2022, the Upper Republican RAC provided an official statement of concern to the KWA about water quality contamination and its related costs. The RAC's message reflected concern over the significant cost of treatment needed for nitrate (and other) contaminants caused largely by agricultural fertilizer use, such costs to be born by users reliant on affected public water supplies.

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).[10] 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 caused primarily by run off from agricultural land use promotes growths of toxic algae and impacts 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 regulation by the federal or state government.

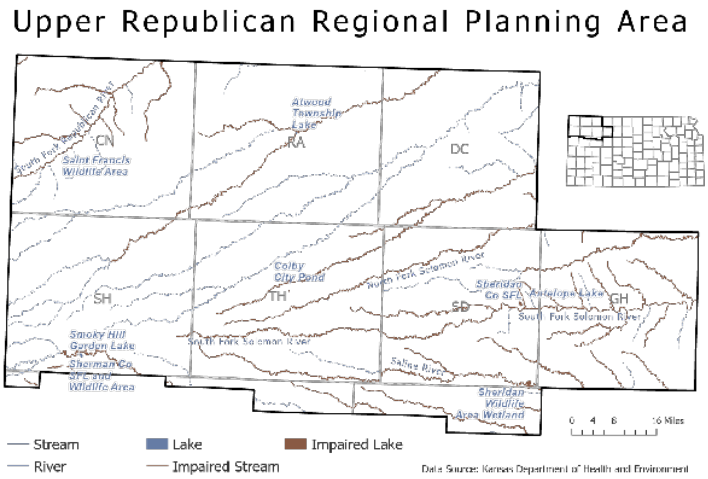
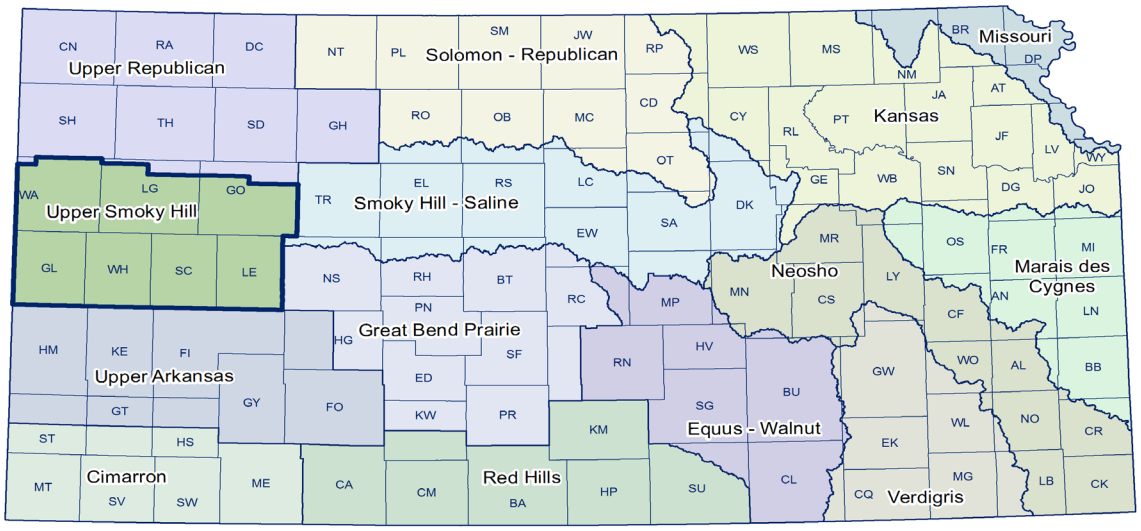


Figure 12. Impaired water resources in the Upper Republican Region

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).

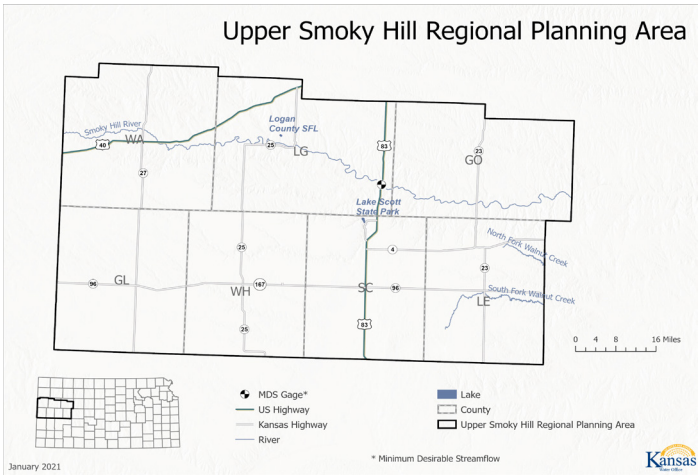


Figure 1. Upper Smoky Hill Regional Planning Area map

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).

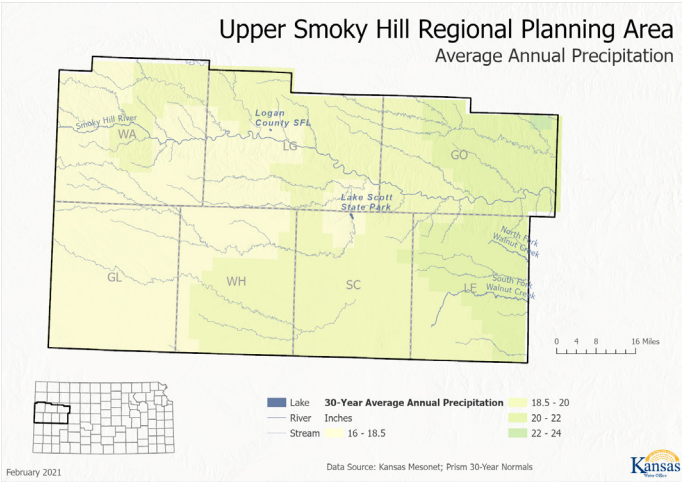


Figure 2. 30-year average annual precipitation in the Upper Smoky Hill Region

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.[1] Figure 3 lists the remaining land uses in the region, including: developed/urban open space.

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.[2]

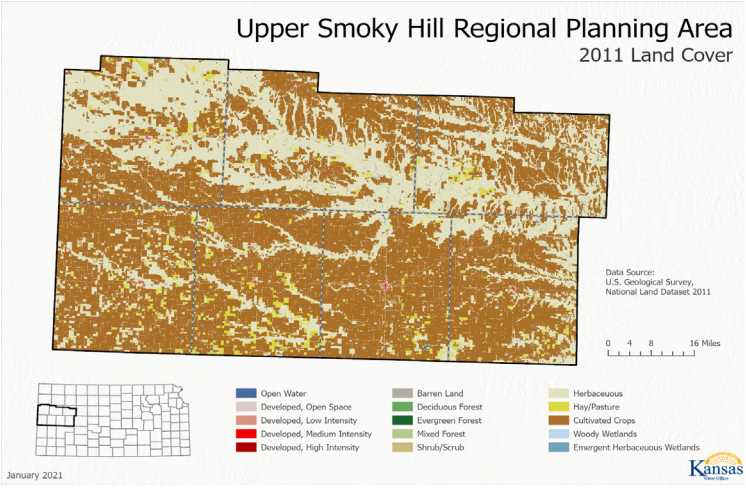


Figure 3. Upper Smoky Hill regional land cover

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).[3] 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, release, and analysis of the 2020 Census.

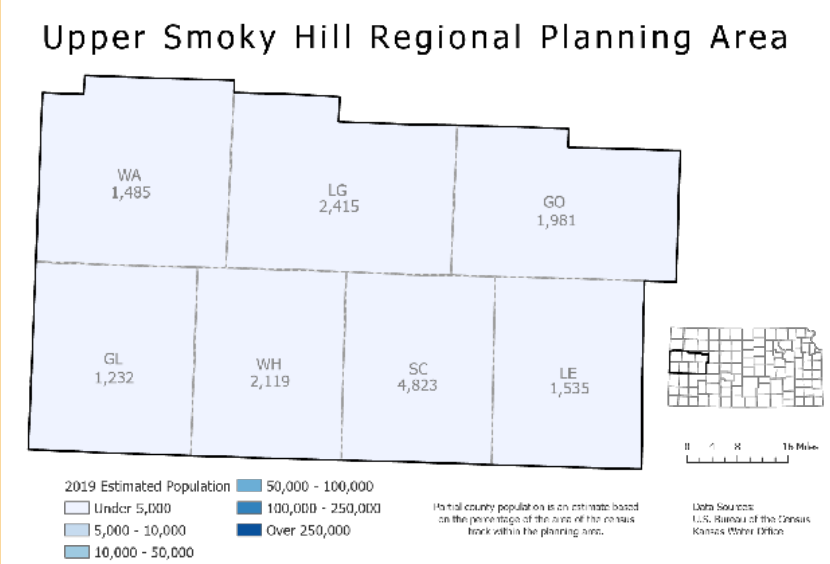


Figure 4. 2019 estimated population by county

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.[4]

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.

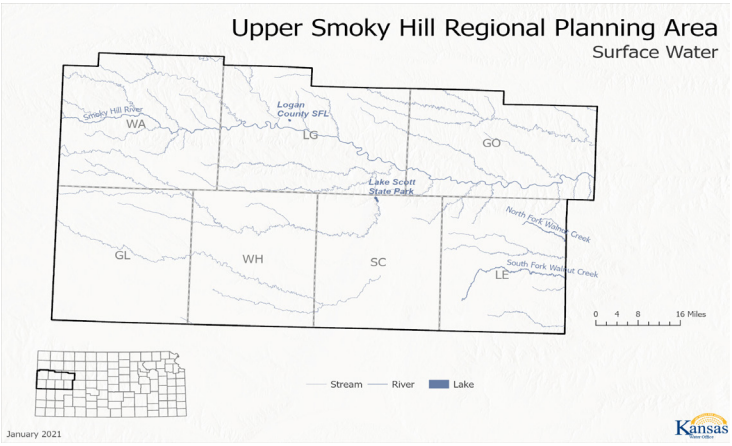


Figure 5. Major surface water resources in the Upper Smoky Hill Region

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.

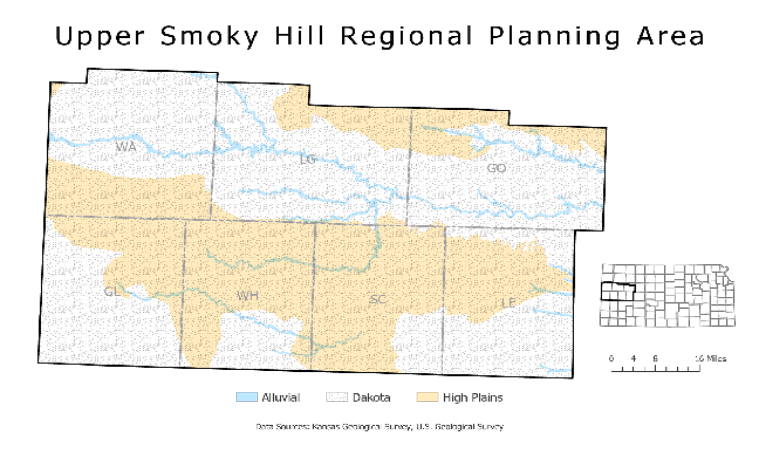


Figure 6. Principle aquifer boundaries in the Upper Smoky Hill Region

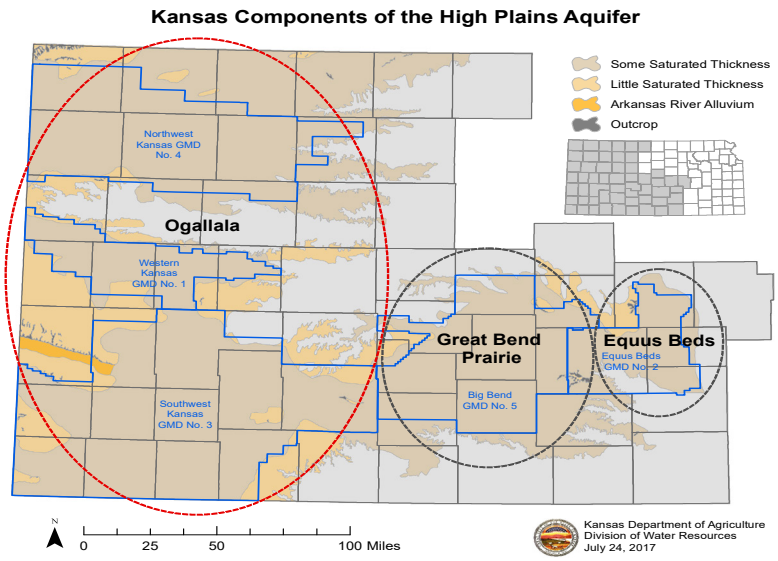


Figure 7. Kansas Components of the High Plains Aquifer[5]

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).

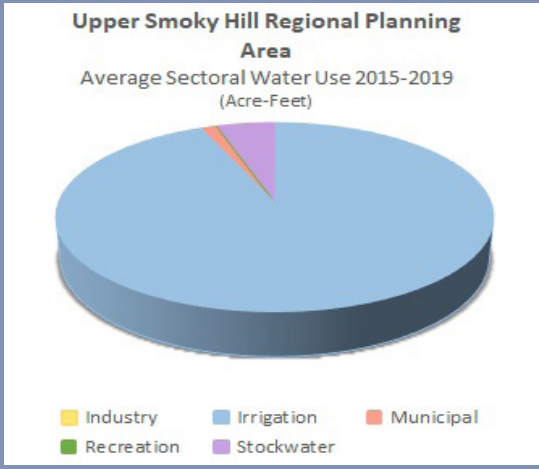


Figure 8. Average sectoral water usage

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 Area (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.[6] 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.

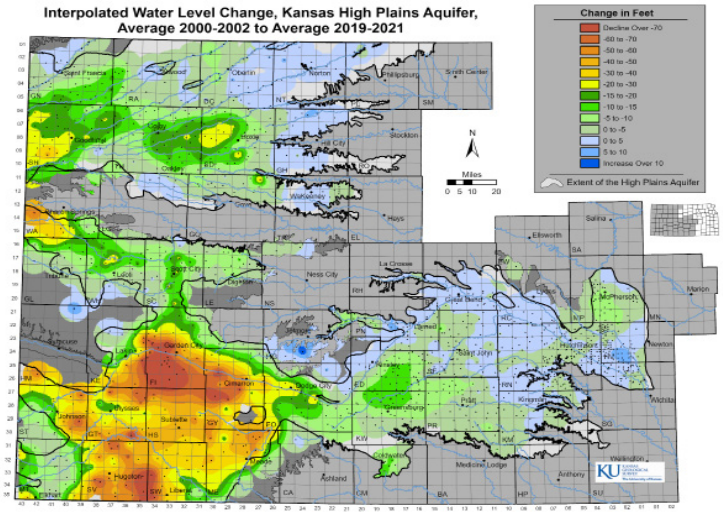


Figure 9. Water Level Change, Kansas High Plains Aquifer[7]

Western Kansas 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 responsible for being proactive in developing local water policy to conserve water compatible with state laws.

Water appropriations and use are regulated by the 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 to conserve and extend the High Plains Aquifer. Two such tools include Water Conservation Areas (WCAs) and Local Enhanced Management Areas (LEMAs).

Upper Smoky Hill Region

WCAs were signed into law in April 2015, providing a simple and flexible tool that allows any water right owner or group of owners the opportunity to develop a management plan, subject to approval by KDA-DWR, 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.

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. GMD1 is currently pursuing a second LEMA.

Field Day at Circle C Farms, 2019

Upper Smoky Hill Region

UPPER SMOKY HILL RIVER IGUCA

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 (Figure 10).[8] An IGUCA can provide more comprehensive water management tools than provided under strict water right administration based on priority.

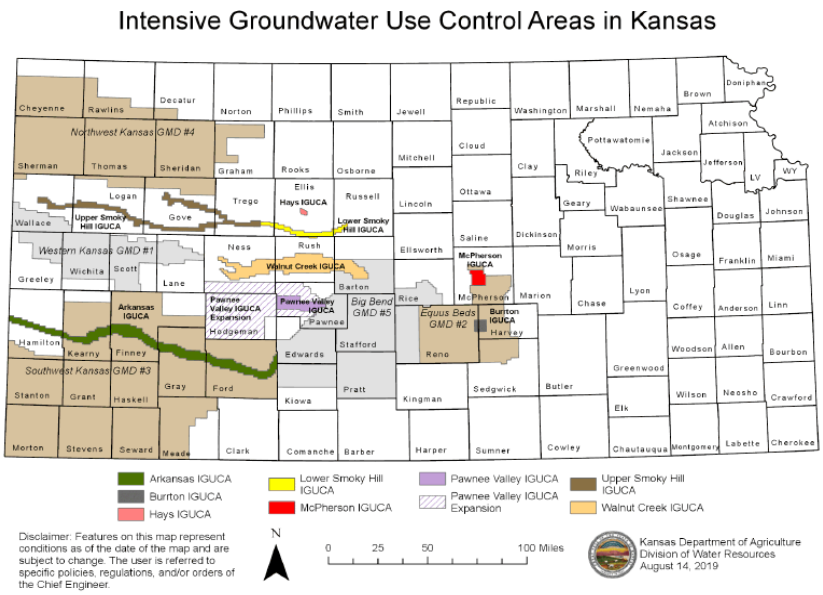


Figure 10. IGUCAS within Kansas

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 precipitation events. Conditions such as these decreased overall recharge opportunities to the alluvium in the area, creating conditions which required regulation. 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.

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.[9] 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.

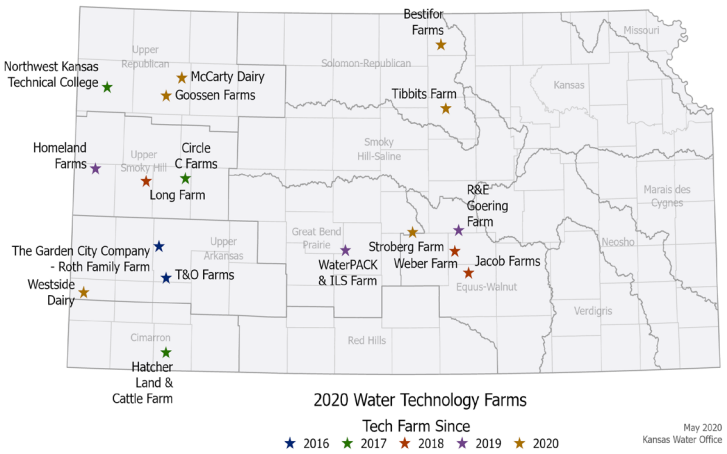


Figure 11. Water Technology Farm locations within Kansas

Upper Smoky Hill Region

GROUNDWATER RECHARGE AND SUSTAINABILITY PROJECT (GRASP)

Groundwater Recharge and Sustainability Project (GRASP) is a partnership formed in Greeley and Wichita Counties to help address the declining water supply in the region from a local effort.[10] 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, reduce 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 is intended to 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.

Livestock Water Recycling/Reuse

Confined Animal Feeding Operations (CAFO) play a vital role in the region economically. Over the years CAFOs in the region have increased in numbers, with several expanding in size. With such growth, utilization of resources has increased, requiring 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.[11] Poky Feeders currently utilizes a water tank overflow recycling system that catches overflows. The captured overflows are filtered and treated for reuse.

Increased utilization of alternative crops that require less water and are more drought tolerant lessens demand on groundwater resources within the region and provides locally grown livestock feed within the Upper Smoky Hill Region. Continued research and development on livestock feeding with less water-intensive crops and 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.

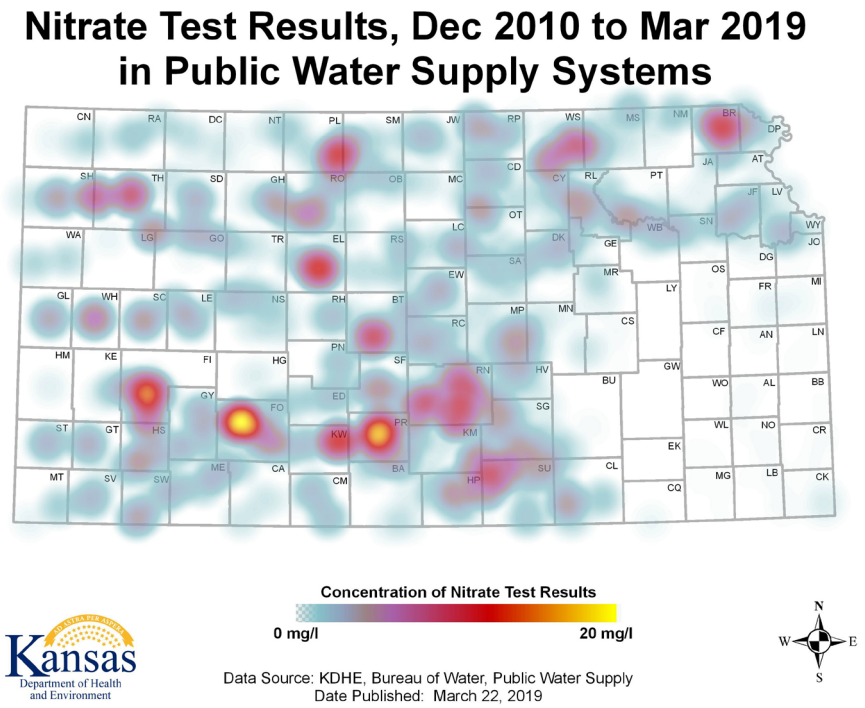
Upper Smoky Hill Region

WATER QUALITY

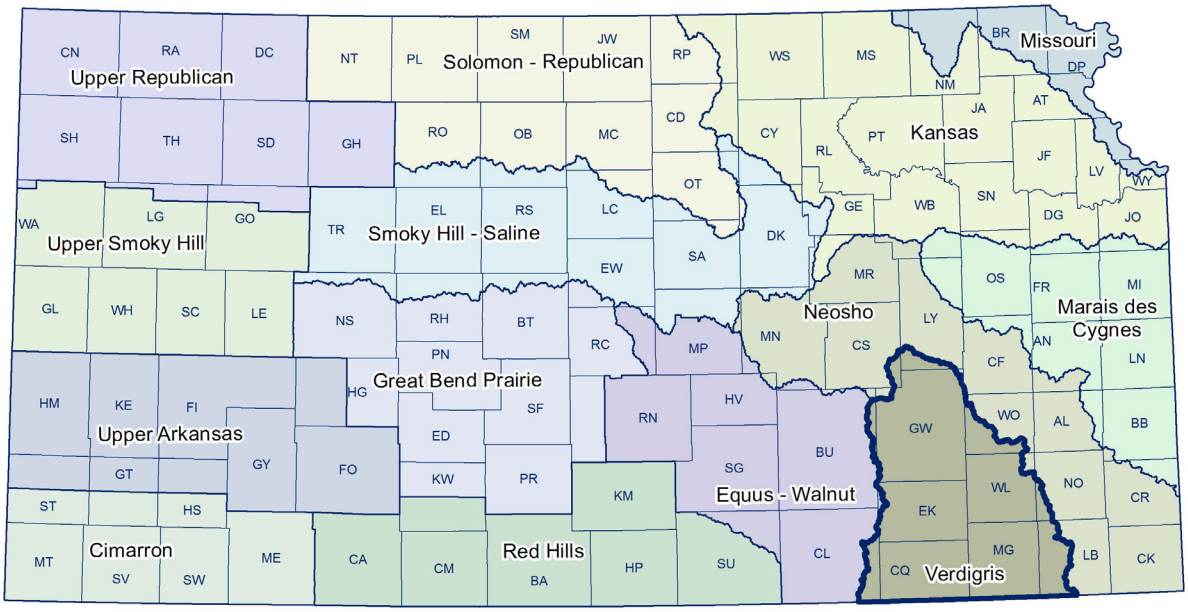
A groundwater quality concern within the region is the elevated levels of nitrates being detected in public water supply wells. The Environmental Protection Agency (EPA) Drinking Water Regulations set a limit of 10 mg/L for nitrate, which is monitored and enforced by the Kansas Department of Health and Environment (KDHE). Nitrate contamination is predominantly caused by runoff of agricultural fertilizers, chemical and manure-based. The significant cost of treatment falls to the users of the affected water supply.

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).[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 Smoky-Hill streams include fecal coliform bacteria, fluoride, selenium, pH, and sulfate.



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.

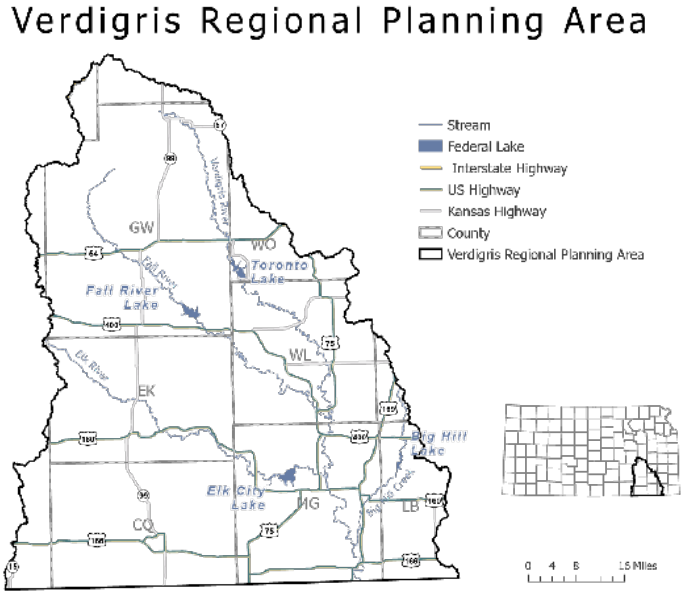


Figure 1. Verdigris Regional Planning Area map

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.

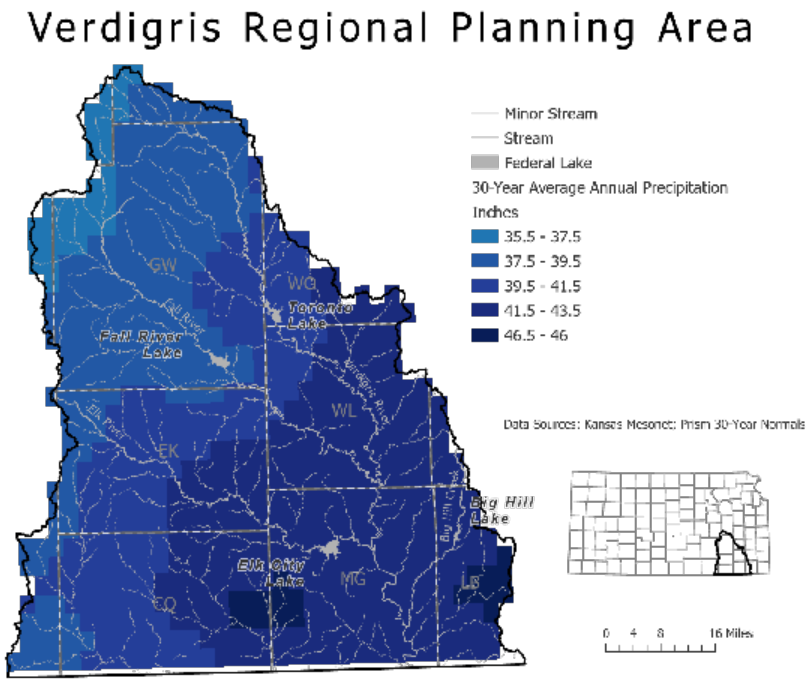


Figure 2. 30-year average annual precipitation in the Verdigris Region

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.[1] 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 (Figure 3). Most of the cropland is within 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.

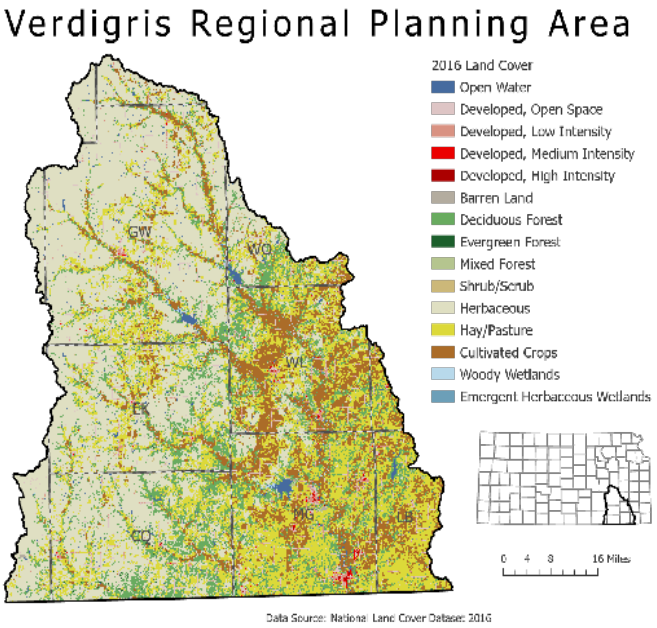


Figure 3. Verdigris regional land cover

POPULATION & ECONOMY

According to the 2010 Census, there were an estimated 63,651 residents 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.[2] 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, release and analysis of the 2020 Census (Figure 4).

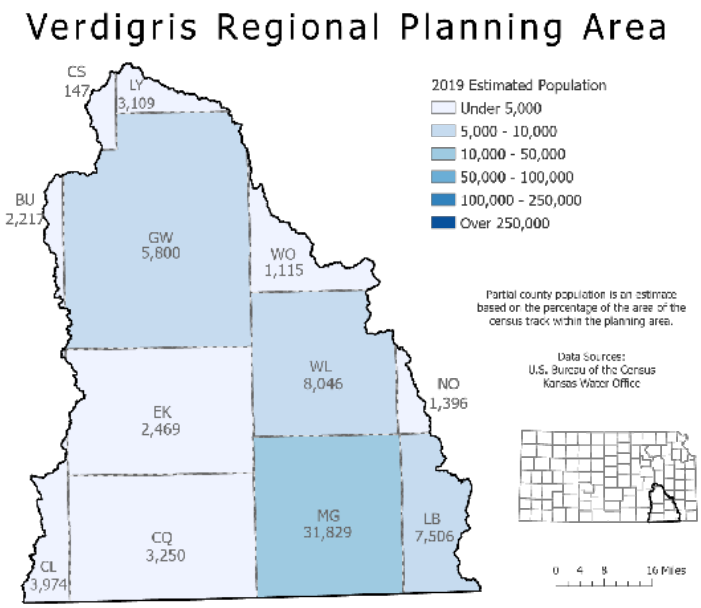


Figure 4. 2019 estimated population by county

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.

Verdigris Region

In December 2019, Phoenix Investors LLC purchased an 880,000 square-foot warehouse on 105 acres in Coffeyville. Array Technologies Inc., a designer and manufacturer of solar tracking systems based in Albuquerque, N.M., planned to 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 regional 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.

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.

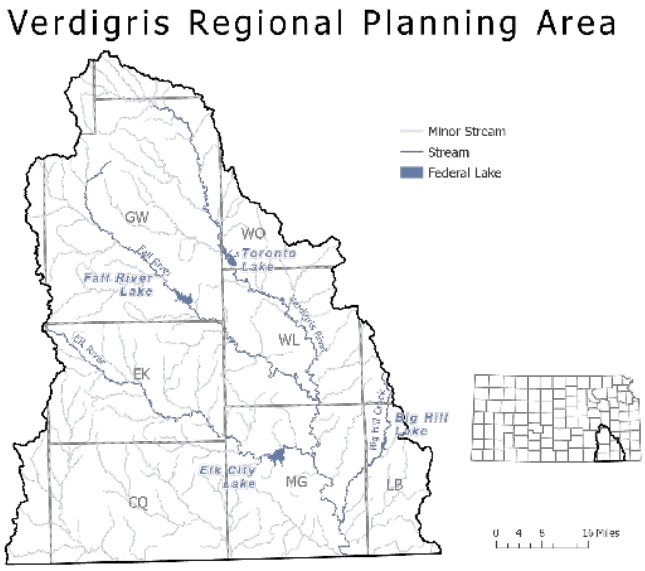


Figure 5. Major surface water resources in the Verdigris Region

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.[3] 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.

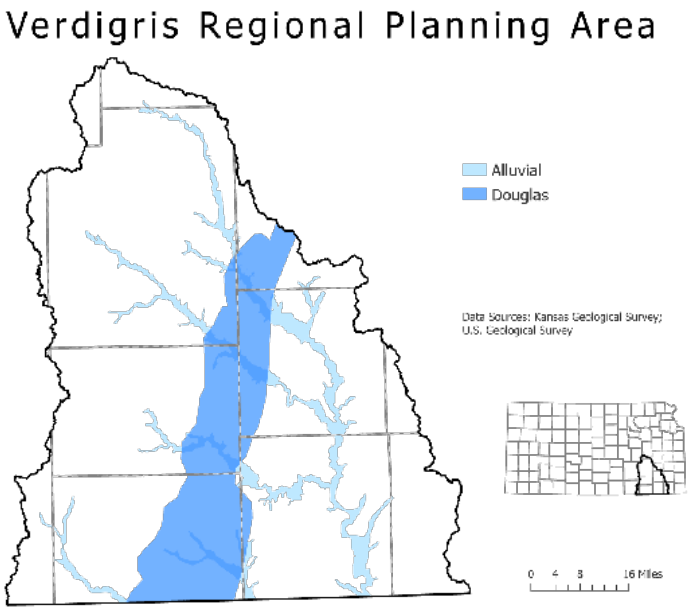


Figure 6. Principle aquifer boundaries in the Verdigris Region

Verdigris Region

The Douglas Aquifer is composed of several alternating layers of sandstone, 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).

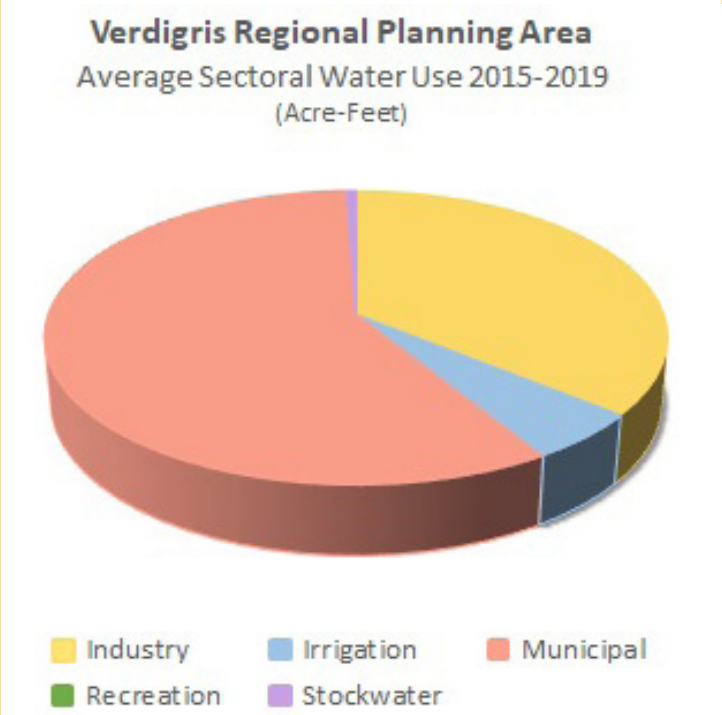


Figure 7. Average sectoral water usage

Regional Issues & Priorities

WATER SUPPLY AVAILABILITY

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 reduced low-flow requirements in the lower Verdigris River. Current system operations require support of a 35 cfs low-flow target below the confluence of the Verdigris River and the Elk River. Reducing the low-flow target to 20 cfs would extend the supply/demand crossover by 29 years. In order to implement this efficiency, improvements to the raw water intake of Coffeyville Resources must be designed and constructed.

Verdigris Region

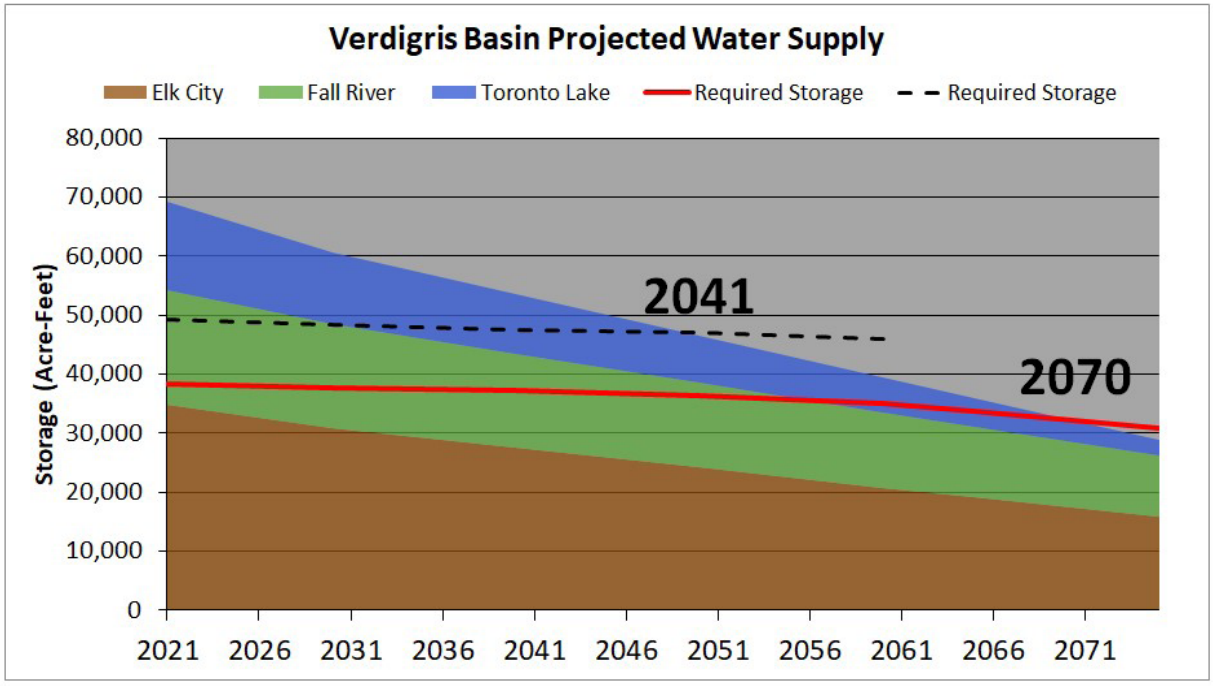


Figure 8. Verdigris Basin Projected Water Supply

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.

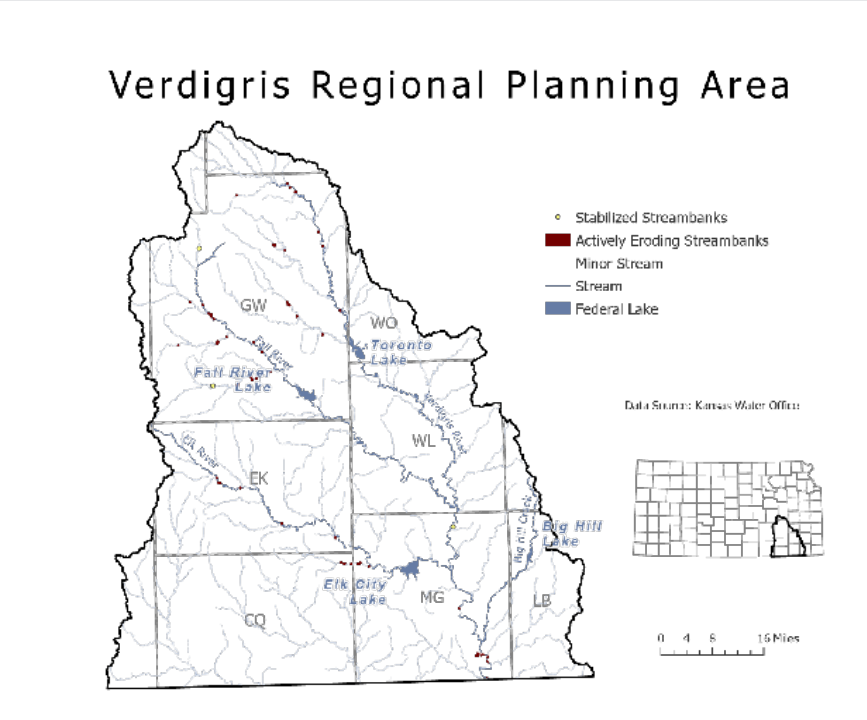


Figure 9. Actively eroding and stabilized streambanks in the Verdigris Region

Verdigris Region

Where there are water users that depend on reservoir storage as water supply, sufficient water quantity and good water quality 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. These silt and clay materials also impact water quality through being a primary carrier of adsorbed chemicals, especially phosphorus, chlorinated pesticides and most metals, into downstream aquatic systems.

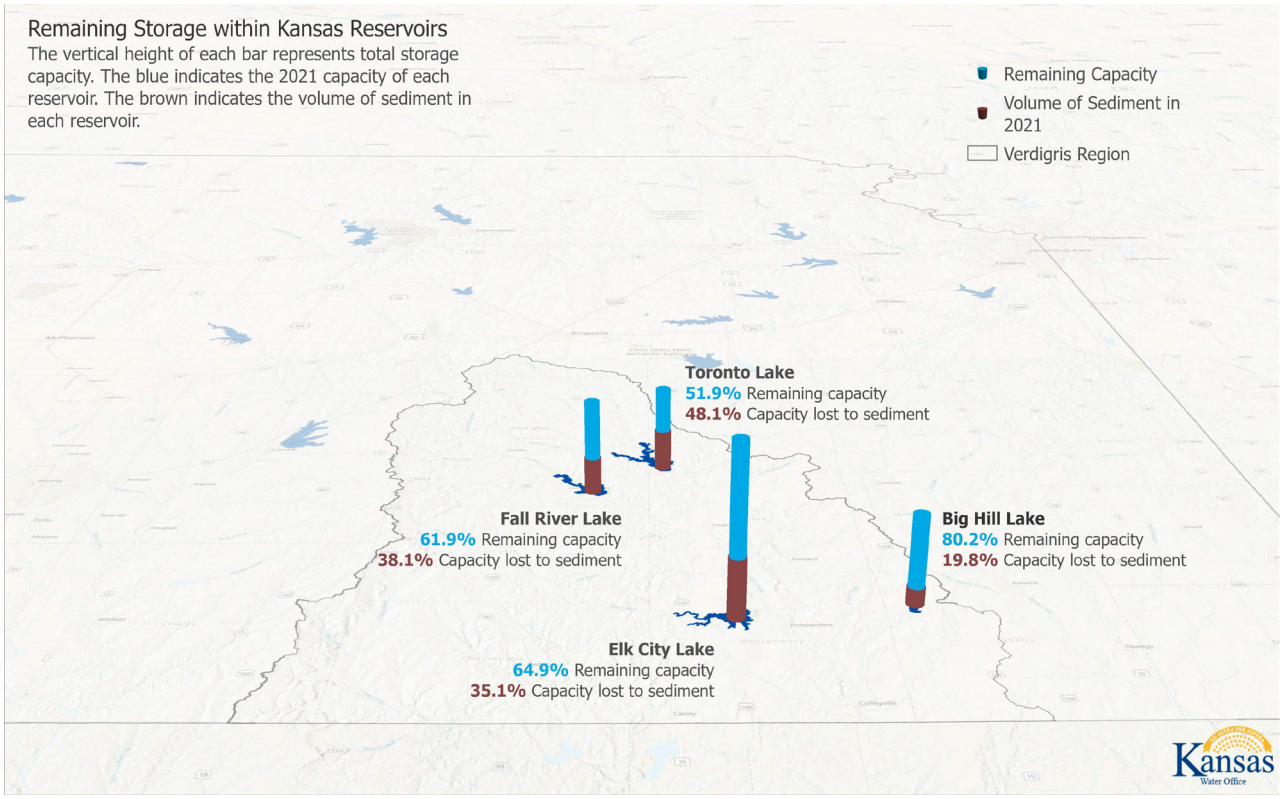


Figure 10. Remaining storage within Kansas reservoirs in the Verdigris Region.

Verdigris Region

WATER QUALITY

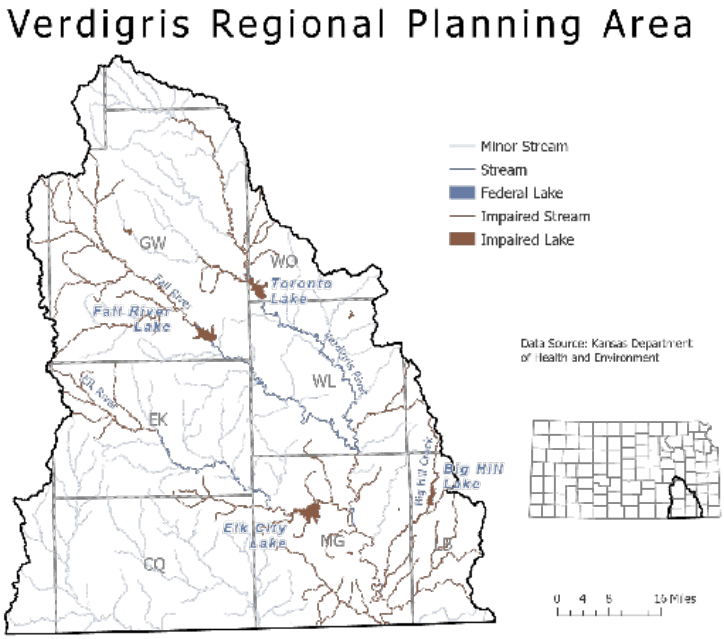


Figure 11. Impaired water resources in the Verdigris Region

The State of Kansas collects ambient surface water quality information throughout the basin. Surface waters 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.[4]

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.[4] 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 the current information on their website.[5]

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.[6] 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

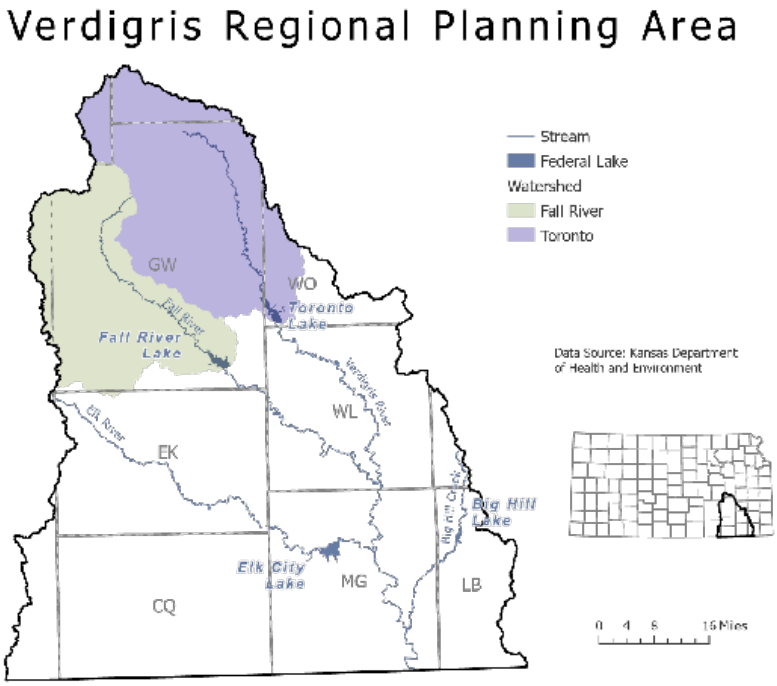


Figure 12. WRAPS areas by watershed in the Verdigris Region

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 Kansas. The Kansas Department of Wildlife and Parks (KDWP) has worked diligently on their ANS education and management plan in order to mitigate this problem and work to slow ANS 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 waters. The KDWP has a full list of infested waters and information on how to stop the spread of ANS on their website.[7]

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Appendix A - Regional Planning Area Goals & Action Plans

Cimarron Regional Advisory Committee (RAC) Goals & Action Plans

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.

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.

Goals 1 and 2 seek to reduce water use in the region therefore the following actions apply to both Goals. Goals 3 and 4 are strategies to address Goals 1 and 2.

Action Plans:
I. Define and quantify the regional aquifer decline, establishing a baseline for comparison.

II. 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).

III. Monitor/promote/protect water coming into or protect water leaving the area (similar to 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).

IV. Work with partners, including Kansas Department of Agriculture (KDA) and Natural Resources Conservation Service (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 reporting system, producer surveys and other means to identify water saving efforts if needed.

V. Secure funding, including statutory State General Fund (SGF) transfer to State Water Plan Fund (SWPF), to support water conservation programs and evaluation of technologies, crop varieties and water management to save water.

VI. Provide water users with information on available tools and programs, including but not limited to: Local Enhanced Management Areas (LEMAs), Water Conservation Areas (WCAs), Multi-Year Flex Accounts, Water Banks, Irrigation Scheduling, Regional Conservation Partnership Program (RCPP)-Soil Probe program through Groundwater Management Districts (GMDs), K-State Extension tools, K-State Research farms and additional tools and programs as made available.

VII. Change producer perception from a “use it or lose it” mentality.

VIII. Use demonstration projects to educate producers to economically reduce water used. (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.)

IX. GMD3 and DWR work with producers to establish LEMAs and WCAs.

X. 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.

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

a. Support 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 water technology farm 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 programs.

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

XII. Use positive press releases to spread the word as WCAs are developed.

XIII. Public water suppliers and industrial users should consider alternative uses of non-potable water and existing water supplies before developing any new water supplies.

XIV. Public water suppliers should consider water rate structures to promote water conservation.

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

Action Plans:
I. Increase adoption of water conservation through education by those who are currently using the technology and adaption of a Master Water Manager program.

II. Identify existing conservation success stories and share with area producers, industry or municipalities as applicable.

III. Initiate demonstration projects with willing producers in the region (technologies, crop varieties and management techniques) to reduce water use.

IV. Develop format/program to allow water users to document current water savings, if not in an approved program.

V. Work with municipalities to educate customers on beneficial water use.

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.***

Action Plans:
I. Educate water users on new technologies through local papers, extension, meetings of producer groups, irrigation organizations, conservation districts, GMD3 and other means.

II. Develop and disseminate results from the use of water savings tools by those who have adopted technology and management tools to economically reduce water usage.

III. Use local demonstrations of technology/demo farms in region to share techniques.

IV. Provide WCA information, including dissemination with water use reports.

V. Develop widespread awareness of Environmental Quality Incentives Program (EQIP), Conservation Reserve Program (CRP), Regional Conservation Partnership Program (RCPP), Conservation Innovation Grant (CIG) and other program availability and increase participation.

VI. Encourage improvement of municipal conservation plans, municipal rate structures and other means to encourage water use reductions.

Equus-Walnut RAC 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 Plans:
I. Maintain the Groundwater Management District 2 model developed by the Kansas Geological Survey 2020 (GMD2 model).

II. Utilize GMD2 model results to support refinement of aquifer recharge rates.

III. Encourage application of the revised recharge rates to support safe yield calculations within GMD2 model boundaries.

IV. Support utilizing GMD2 model results to identify areas of over-appropriation within the Equus-Walnut planning region.

V. Promote an integrated approach to the management of all water resources, by non-domestic users within the Equus-Walnut planning region, especially in over-appropriated areas.

VI. Continue to encourage communication and collaboration between all responsible agencies and organizations tasked to accomplish these actions.

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 Plans:
I. Continue to support the Kansas Water Office (KWO) technical assistance grant for water conservation planning while promoting additional planning assistance programs.

II. Coordinate with the Kansas Department of Health & Environment (KDHE) - Bureau of Water and Kansas Department of Agriculture - Division of Water Resources (KDA-DWR) on a database of all public water suppliers within the Equus-Walnut RAC planning area that includes contact information and chief responsible staff person and chief governance person for each supplier.

III. 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 their consideration of non-potable water and existing water supplies.

IV. If deemed appropriate, the results of this survey document will be made available to each public water supplier within the Equus-Walnut Planning Region.

V. 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.

VI. Promote a regulatory framework for the use of graywater.

VII. 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.

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

Action Plans:
I. Utilize targeting strategies of Watershed Restoration and Protection Strategy (WRAPS) and KWO to identify appropriate locations for best management practice (BMP) programs or other watershed projects.

II. Identify ways to leverage funds for BMP implementation through public and private entities.

III. Support watershed education and BMP demonstration activities.

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

Action Plans:
I. Maintain an inventory of contamination sites within the Equus Beds Aquifer.

II. 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.

III. Install additional monitoring wells and piezometers as necessary to collect data where needs are identified.

IV. Complete pilot studies as required to facilitate groundwater remediation feasibility.

V. Develop a process to test and promote new treatment technologies that address contaminated groundwater sites within the region and state.

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

Action Plans:
I. Preserve water resources and coordinate programs to develop less water-intensive crops.

II. Coordinate public/private research for the development of viable drought-tolerant crops.

III. Identify and support markets for less water-intensive crops.

IV. Support federal and state programs that evaluate new irrigation technologies.

V. Promote federal and state programs that offer incentives for operators to implement irrigation efficiency improvements.

VI. Support agriculture workshops and field days that demonstrate water-conserving practices.

Great Bend Prairie RAC 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 Plans:
Short-term Actions

I. Identify existing voluntary conservation programs and determine if new incentivized conservation programs are needed to compliment current programs.

II. Work with the appropriate agencies to ensure that cost-shares are current and economically competitive.

III. Hold stakeholder meetings in conjunction with the appropriate agencies to inform the public about the various programs available.

Long-term Actions

I. 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 Great Bend Praire RAC area.

II. 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.

III. 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.

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 "LAWN" irrigation training programs provided by the Irrigation Association.

Action Plans:
I. 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.

II. 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.

III. Work with Irrigation Associations to develop free training opportunities for LAWN irrigators and landscapers.

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 Plans:
I. Establish a program if a problem is observed to ensure the problem does not get worse.

II. Start using mapping techniques and disposal line maintenance and replacement to ensure this goal is met.

III. Evaluate extent of Kansas Department 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.

IV. Develop inventory of current active and legacy salt water disposal lines in Great Bend Prairie Regional Planning Area.

V. Continue programs to evaluate current extent of salt water disposal well inventory.

VI. Evaluate effectiveness of current spill and escape notification requirements.

a. Work with Kansas Corporation Commission (KCC) to modify current spill and escape notification requirements if evaluation finds that necessary.

VII. 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.

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

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 Plans:

I. Achieve large scale feeding trials by 2025.

II. Coordinate with the Kansas Department of Agriculture (KDA) to improved adoptability of feed wheat, along with other alternative crops, through marketing, commodity segregation, research and education as previously stated within the Vision for the Future of Water Supply in Kansas.

III. Create a program to be able to roll out small- and large-scale feeding trials.

IV. Find several feedlots to help roll out program.

V. Utilize membership of stakeholder groups to solicit interest.

VI. Coordinate with KDA to implement demonstration plots for yield evaluation.

VII. Coordinate with KDA to develop markets for feed wheat and other alternative crops for use feed sources.

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 Plans:
I. Determine percent controlled by watershed structures within watershed districts in Great Bend Prairie Regional Planning Area.

II. Work with landowners to promote watershed dams and the important role they have in the community and environment.

III. Work with watershed boards and community leaders.

IV. Determine groundwater recharge potential of watershed structures through modeling efforts.

V. 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.

VI. Evaluate the potential of a multipurpose small lake through Kansas Department of Agriculture - Division of Conservation (KDA-DOC) in the Great Bend Prairie Regional Planning Area.

Kansas RAC Goals & Action Plans

Preamble:
We recommend that the Kansas Water Office (KWO) foster a collaborative partnership approach to water resource issues across Kansas by utilizing the following 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.

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

Action Plans:
I. Increase water storage availability in federal reservoirs to supplement instream flow needs of the Kansas River.

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

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

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

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

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

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

Action Plans:
I. The KWO will compile existing information and complete additional evaluation necessary to determine areas of water supply need.

II. Explore additional storage possibilities for construction of multipurpose small lakes so that new water sources can be brought online to alleviate specific regional issues.
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III. Working with Kansas Department of Agriculture-Deparment of Conservation (KDA-DOC), Natural Resources Conservation Service (NRCS) and local watershed districts, identify existing watershed structures that are in need of restoration and have potential to be made larger and provide supplemental water supply.

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

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

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

VII. Support the KWO and Kansas Department of Agriculture-Division of Water Resources (KDA-DWR) in their efforts to ensure all municipalities and rural water districts have updated water conservation plans that meet the 2007 Municipal Water Conservation Plan Guidelines.

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

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

All goals and action plans in the Kansas Regional Planning Area will follow the FIVE WATERSHED PRINCIPLES.

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

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

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

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

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

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

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

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

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

X. 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.

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

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

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

Action Plans:
I. 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.

II. 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.

III. Pursue pilot projects for identified natural solutions.

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

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

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

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

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

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

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

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

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

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

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

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

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

Marais des Cygnes RAC 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 Plans:
I. A collaboration between the RAC, local producers, local Watershed Restoration and Protection Strategy (WRAPS) groups, local conservation districts, regional Public Water Suppliers (PWS), 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.

II. This collaboration will provide education and share information concerning water and soil conservation and nutrient and sedimentation reduction, and demonstration farms will be established in the region above these three reservoirs.

III. Encourage state and federal entities to participate in best management practices above federal reservoirs on state and federal lands and create a demonstration farm.

IV. The KWO will create a baseline sedimentation rate and review the 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.

V. The KWO will evaluate possible technologies that may be feasible to remove sediment from the reservoirs.

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 Plans:
I. The KWO will refine population and demand growth projections to ensure accurate projections are being utilized.

II. 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.

III. The RAC and the KWO will work with the Kansas Rural Water Association (KRWA) through their technical assistance contract to identify PWS that may not be sufficient to meet projected demands.

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 Plans:
I. 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 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.

II. The RAC will work with the Kansas Department of Wildlife and Parks (KDWP) and USACE on an ongoing basis to provide education for lake users concerning the spread of ANS and how to prevent it.

III. The RAC will encourage funding for the ANS Program through the State Water Plan Fund (SWPF).

Missouri RAC Goals & Action Plans

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

Guiding 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.

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 will be developed to maintain and improve existing conditions. Monitoring and reevaluation of groundwater quality conditions and should continue at 5-year intervals.

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 Plans for goals #1 and #2:
I. 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 quality 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.

II. 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. The Phase II 5-year study that is being conducted by the KGS which started in March of 2018 and will conclude in 2024 with an anticipated cost of $121,700.

III. 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, a plan to implement best management practices will be developed to maintain and improve existing conditions.

IV. 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.

Priority Goal #3: To ensure a reliable surface water supply in the future, best management practices will be implemented so surface water quality in identified drainages is maintained or improved using goals and milestones as identified in the Missouri Watershed Restoration and Protection Strategy (WRAPS) 9-Element Plan.

Action Plans:
I. Collection of Additional Data

a. Collect data on a voluntary basis to evaluate the benefits 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, Kansas Department of Health and Environment (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.

II. 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 that are willing to adopt and promote new practices, including streambank stabilization.

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

d. Recognize the value of protection of water quality through education and outreach.

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

g. Raise awareness about water quality and the importance of proper urban lawn application.

III. 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.

IV. 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 assess 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. Include funding for streambank stabilization projects as identified in the WRAPS 9-Element Plan.

f. Fully fund the WRAPS 9-Element Plan implementation (approximately $140,000/year).

g. 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.

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.

Action Plans:
I. The RAC will establish an Education Subcommittee to coordinate education efforts.

II. Water technology farms and Partnership for Agricultural Conservation and Excellence (PACE) farms should be supported and utilized as part of the education program.

III. Utilize partners that have education programs already developed to support water education initiatives. This includes but is not limited to schools, water providers, FFA, Kansas Association of Conservation & Environmental Educators (KACEE), Kansas Farm Bureau, Kansas Corn Commission, Kansas Soybean Commission, Kansas Tribes, Conservation Districts, and Envirothon.

IV. 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.

V. The Kansas Water Office should reach out to American Royal.

VI. Prepare video and other printed information on the activities of the KWA and Missouri RAC for presentation to community organizations, school and other interested groups.

VII. Provide presentations on Kansas Water issues to interested agencies, organizations and schools.

VIII. Funding Needs:

a. A line item for education should be included in the budget.

Priority Goal #5: Provide insight to the Kansas Water Authority (KWA) on the Missouri River by keeping 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 Plans:
I. Request semi-annual updates from the U.S. Army Corp of Engineers (USACE) to secure information on the Planning Assistance to States (PAS) agreement between USACE and the states of Iowa, Missouri and Nebraska on Missouri River management as it affects Kansas.

II. 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.

III. Allow the Missouri River subcommittee time to update the Missouri RAC on pertinent Missouri River information at each RAC meeting:

a. System-wide related meetings or events

IV. Lobby to hold a Missouri River Recovery Implementation Committee (MRRIC) meeting in Atchison or Leavenworth Kansas by 2025, promoting the importance of the River.

V. Request updates as needed from the Farm Service Agency (FSA) and NRCS on flood recovery programs and progress.

VI. Request updates from authorities on watershed dams in the Missouri River Region that will affect the Missouri River.

VII. Remain engaged with the recently formed Missouri River stakeholder group which is part of the 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.

Neosho RAC 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 per year.

Action Plans:
I. Stabilize all streambank hotspots, as defined by the Kansas Water Office, by 2030 in the Cottonwood-Neosho Region above John Redmond Reservoir. The Streambank Team (Kansas Department of Health and Environment (KDHE), Kansas Department of Agriculture-Division of Conservation (KDA-DOC), and the Kansas Water Office (KWO)) will secure funding for the stabilization of the streambanks each year to complete reaches in order as they proceed from the reservoir.

II. The Streambank Team will evaluate streambank sites after the years with major flooding in the Region.

III. A collaboration between the Regional Advisory Committee (RAC), local producers, local Watershed Restoration and Protection Strategy (WRAPS) groups, local conservation districts, regional public water suppliers (PWS), the KWO, the KDHE, and the 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, demonstration farms will be established in the region above these three reservoirs using this collaboration.

IV. The KWO will review the sedimentation rate of these three reservoirs by conducting bathymetric surveys 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.

V. The KWO will evaluate the feasibility of possible technologies to remove sediment from the reservoirs in order to maintain and protect water supply.

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 Plans:
I. The KWO will evaluate operational efficiencies and potential additional storage and sources, including upstream and downstream options, by 2025.

II. The KWO will continually work with the U.S. Army Corps of Engineers (USACE) on refining reservoir operations and developing Drought Contingency Plans.

III. 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.

IV. 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.

Priority Goal #3: Reduce overall nutrient loading, frequency of Harmful Algal Blooms (HAB), and potential for Aquatic Nuisance Species (ANS) to improve water quality within the Region by 2035.

Action Plans:
I. The RAC will work with the KDHE to identify the highest loading areas and investigate what practices would be best implemented to reduce nutrient loading.

II. The KWO will work with KDHE to investigate and demonstrate in-lake treatment options to reduce the frequency and duration of HAB and assess the effectiveness of in-lake treatment options at minimizing the impact of HAB.

III. 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.

IV. The RAC will work with the regional PWS and the Grand River Dam Authority (GRDA) to investigate nutrient crediting options for the entire Neosho Region (including areas in Oklahoma) to reduce nutrient loading from nonpoint sources.

V. The RAC will encourage funding for the ANS Program through the State Water Plan Fund (SWPF). As well, the RAC will encourage the consideration of ANS for interbasin water transfer.

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

Action Plans:
I. The RAC will work with the KWO, The Nature Conservancy (TNC), and USACE to evaluate and research the flooding within the Region to determine possible off-stream storage to utilize during flood events.

II. The KWO will determine the storage capacity within the floodplain.

III. The KWO will use FIRO forecasting to control storage, to increase water supply, and to reduce flooding by looking at climate variability and long-term forecasting.

Red Hills RAC Goals & Action Plans

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

Action Plans:
I. Identify data needed to determine if and where water (streamflow or groundwater levels) downtrends are occurring for focusing water conservation efforts.

II. Identify reuse potential in the region.

III. Identify barriers to reuse, such as limiting factors and water quality parameters.

IV. Develop appropriate policy, programs, data or education to address barriers to reuse.

V. Add streamflow measurements to access changes in streamflow and baseflow contributions on Elm Creek and other priority locations, preferably continuous monitoring gages.

VI. Identify and promote state program to address red cedar invasion.

VII. Utilize education/information dissemination as developed for the Vision and region. Should include information on water resources, stresses, conservation tools and water use.

VIII. Identify barriers to conservation in this region.

IX. Work with local, state and federal programs to offer water conservation programs, including cost-share opportunities.

X. Address water conservation by water use category.

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

Action Plans:
I. Determine level of support for a reservoir providing future water supply, flood control, and recreation.

II. Gather public input on possible reservoir for recreation and future water supply.

III. Define project and scope of work for detailed economic impact study to move ahead, if local support is sufficient.

IV. Initiate Economic Impact Study.

V. Review Economic Impact Study and formulate future steps.

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 Plans:
I. 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.

II. Work with industry to recycle/reuse flow back and production waters.

III. Promote the produced water treatment project and other treatment technologies.

IV. Share results of Kansas pilot treatment project and other treatment projects.

V. Identify sites for treated (freshwater) water storage for oil and gas industry access for fracking.

VI. Work with industry to use the lowest quality waters possible.

VII. Work with industry to reduce produced water underground injection quantities.

Smoky Hill-Saline RAC Goals & Action Plans

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 the water supplies available exceeds demand by at least 10% by the year 2060.

Action Plans:
I. Support agencies in evaluating the possibility of a permanent conservation pool rise at Kanopolis Reservoir.

II. Evaluate Kanopolis Reservoir to determine the feasibility of dredging and initiate project if deemed viable.

III. Determine if there is a need for additional water supply reservoirs within region.

IV. Explore control of phreatophyte, “deep rooted plants”, control within riparian areas.

V. Explore the possibility of direct potable reuse.

VI. Support agencies in developing and implementing a Certified Irrigator Program.

Priority Goal #2: Support a statewide conservation education program/model which is applicable to all public water supplies which quantifies water conservation efforts on customer usage.

Action Plans:
I. Develop a youth-based water conservation education program which is tied to school curriculum.

II. Provide producers with tools and resources needed to make informed management decisions which improve water use efficiency.

III. Educate all Planning Region stakeholders on the benefits of water conservation, thus working towards sustainable use of the region’s water surface and groundwater resources.

IV. Work with groups of interest to ensure Smoky Hill-Saline Planning Region stakeholders are educated on the benefits of water conservation.

Priority Goal #3: Support a statewide conservation education program/model which is applicable to all public water supplies which quantifies water conservation efforts on

Action Plans:
I. Method of attaining goal can include the continued support of best management practice (BMP) implementation for practices which reduce sediment runoff.

II. Focus BMP implementation within priority areas identified in the Big Creek Middle Smoky Hill River Watershed's 9 Element Watershed Protection Plan.

III. Complete by 2034 - Final year of 9 Element Watershed Protection Plan is 2034. Provide a reduction of 26% TSS concentrations on the Smoky Hill River at Ellsworth as noted within the 9-Element Watershed Protection Plan.

IV. Remove sediment-impaired waters from the Kansas Department of Health and Environment (KDHE) Total Maximum Daily Load (TMDL) list.

V. Continued support of locally led and driven efforts, such as the Watershed Restoration and Protection Strategy (WRAPS) program and projects within the region, within watersheds and the BMPs noted for implementation within the 9-Element Watershed Plans.

VI. Continue to support Natural Resources Conservation Service (NRCS) programs/initiatives such as Regional Conservation Partnership Program (RCPP), Environmental Quality Incentives Program (EQIP), easement programs, Wetlands Reserve Program (WRP), Conservation Stewardship Program (CStP), etc., which can be utilized to implement sediment-reducing BMPs as well as improve soil health. Identify sources of sediment contributing to total suspended solids (TSS)/sediment in water bodies (i.e. streambank assessments, etc.).

VII. Continue to support Kansas Department of Agriculture-Division of Conservation (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 (SWPF).

VIII. 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 Reservoir as well as other water supply sources.

IX. Enhance and continue to support information and educational (I&E) efforts focused towards landowners to help reduce sediment runoff on their respective property.

X. Include consideration of Wilson Reservoir and the upstream watershed of sediment sources which could impact capacity including bathymetric survey analysis to help quantify current capacity of lake.

XI. Evaluate sediment and nutrient loading originating from 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.

Priority Goal #4: Increase public water supply water use efficiency for suppliers within the region.

Action Plans:
I. Method of attaining goal can include the promotion of development of new or updated water conservation program plans for public water supplies within the Smoky Hill – Saline Planning Region.

II. Implementation of conservation measures which lead to all public water supplies in the Smoky Hill – Saline Planning Region operating in the bottom 1/3rd of gallons per capita per day (GPCD) when compared to other public water supplies within respective Regions used for GPCD comparison.

III. 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.

IV. All public water supplies follow the 2007 Kansas Municipal Water Guidelines and have a recently updated conservation plan.

V. Public water supplies evaluate the feasibility of water conservation rates.

VI. Public water supplies develop and promote rebate programs geared towards water conservation efforts for water customers.

VII. Develop a “tool box” of educational information PWSs could utilize to pass information along to customers.

VIII. Work through the framework of existing statewide education efforts to develop region-wide outreach campaign promoting water conservation efforts.

IX. Report GPCD values on an annual basis at RAC meetings.

X. Develop an independent technical task force to help large water users within public water supply systems to improve water use efficiency.

XI. Hold annual public water supply “field days” to share current water conservation efforts. Making sure media is involved with promotion of these events.

Solomon-Republican RAC 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 that reached agreement to convert irrigation to recreation use.

Action Plans:
I. Support Kansas Department of Wildlife and Parks (KDWP) in their effort to renegotiate the Keith Sebelius Reservoir Minimum Pool Agreement with the Almena Irrigation District.

II. Use the Keith Sebelius contract as a model for negotiations on other Bureau of Reclamation (BOR) Reservoirs (Kirwin, Webster).

III. Use Kansas Bostwick Irrigation District's (KBID) knowledge on capturing BOR grants to help improve Webster and Kirwin irrigation efficiency.

IV. Exhaust all possible funding sources necessary to improve water efficiency.

V. Work with KDWP on an economic study to determine the value of keeping as much water in the Western Reservoirs as possible.

VI. Investigate the benefits of raising the conservation pool at both Kirwin and Webster.

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.

Action Plans:
I. Use Kansas Department of Health and Environment (KDHE) to evaluate sources of sediment entering Lovewell Reservoir.

II. Use Kansas and Nebraska data to evaluate suspended solids and nutrients.

III. Use data to evaluate the effects of the Courtland Canal on Reservoir loading.

IV. Utilize best managment practices (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 #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.

Action Plans:
I. Work with the Kansas Water Office (KWO) to complete bathymetric survey of Waconda Reservoir.

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.

Action Plans:
I. Quarterly presentation by KWO staff on RRC outcomes.

Priority Goal #5: Complete an annual assessment of streambank and ditch erosion within the Solomon-Republican region.

Action Plans:
I. Research extent that data is already available.

II. Identify areas of major streambank and ditch erosion.

III. Coordinate efforts with local county engineers and public works departments, conservation districts,Watershed Restoration and Protection Strategy (WRAPS), Natural Resources Conservation Service (NRCS), and the KWO.

Upper Arkansas RAC 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 Plans:
I. Develop alternative sources of supply by 2030.

a. Collaborate and coordinate with local shareholders, stakeholders, policymakers, organizations, agencies, (i.e. Groundwater Management District 3 (GMD3), Kansas Water Office (KWO), Kansas Department of Agriculture (KDA), Kansas Department of Health and Environment (KDHE), Kansas Department 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.

II. Educate all water users on the importance of water saving, increased water use efficiencies, and the supporting data (static water levels (SWLs), SWL 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 River Water 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 Kansas Water Authority (KWA) supports these activities by funding the budget l 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 KWA's continued support and funding for the irrigation technology farms.

f. Formalize a list to add to a calendar on the KWA, 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.

III. 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 Local Enhanced Management Areas (LEMAs) and Water Conservation Areas (WCAs).

c. Support producer incentives through the Kansas Department of Agriculture-Division of Conservation (KDA-DOC), Kansas Department of Health and Environment (KDHE), Kansas Department of Agriculture-Division of Water Resources (KDA-DWR), and other state agencies to reduce usage through proven technologies and best management practices.

i. These may include programs such as Conservation Reserve Enhancement Program (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.

Upper Republican RAC Goals & Action Plans

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 Basin to extend the 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.

Action Plans:
I. Support Groundwater Management District 4 (GMD4) Local Enhanced Management Area (LEMA) plan.

II. Look outside the box for other possible funding sources necessary to improve water efficiency.

III. Find samples of water conservation plans for the Upper Republican RAC to consider.

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.

Action Plans:
I. Continue to support Kansas Water Office (KWO), Kansas Department of Agriculture (KDA), GMD4, and other entities in increased education of water technology farms.

II. Support KDA in education of Water Conservation Areas (WCAs).

III. Work with Natural Resources Conservation Service (NRCS) to evaluate effectiveness of Regional Conservation Partnership Program (RCPP) program and find efficiencies.

IV. Participate in events for education of water conservation that involve water agencies and schools.

V. Support GMD4 on the development of an irrigator/education program.

Priority Goal #3: 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.

Action Plans:
I. Ensure KDA continually updates the RAC on the Republican River Compact, especially if any changes occur within the area.

Priority Goal #4: 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.

Action Plans:
I. 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.

II. Actively assist in seeking annual funding to ensure successful achievement of goal.

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.

Action Plans:
I. Support Kansas Department of Health and Environment (KDHE) to help establish a baseline of potable water quality within the region.

Upper Smoky Hill RAC 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 Plans:
I. Support implementation of the Wichita County Local Enhanced Management Area (LEMA) submitted by Groundwater Management District 1 (GMD1).

II. Support implementation of the Groundwater Recharge and Sustainability Project (GRASP) Regional Conservation Partnership Program (RCPP) that was recently approved.

III. Continue to support enrollment in the Wichita County Water Conservation Area (WCA).

IV. Provide recommendations to GMD1 for additional LEMAs based upon the information developed by Kansas Geological Survey (KGS) for the proposed revision of Goal #1.

V. 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.

VI. Establish methods for local producers that will identify provisions within United States Department of Agriculture (USDA) farm programs that conflict with Goal #1. This would include crop insurance and loan programs.

VII. 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.

Priority Goal #2: 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 Plans:
I. Assemble information about programs and grants that are available from state agencies and related entities (Kansas Water Office (KWO), Kansas Department of Health and Environment (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.

II. Provide information and education on how rate structures can provide incentives for water conservation.

III. Education may include presentations to city governing bodies on remaining aquifer life and the process for acquiring water rights and changing beneficial use to municipal use.

Priority Goal #3: Encourage the implementation of water conservation measures at confined animal feeding operations (CAFOs) in the region.

Action Plans:
I. 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.

II. 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.

III. 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.

Verdigris RAC Goals & Action Plans

Priority Goal #1: Increase drought tolerance in the Verdigris Basin by optimizing reservoir releases and maintaining storage capacity.

Action Plans:

I. Encourage agencies and private entities to work with water users to improve intake and utilization efficiencies.

II. Evaluate ways to pass acuumulated sediment through reservoirs.

III. Continue to promote the use of sediment-reducing best management practices (BMPs) above water supply reservoirs.

IV. The Kansas Water Office (KWO) will continue to find ways to optimize reservoir operations and mitigate the effects of drought.

Priority Goal #2: Protect watershed dam functions.

Action Plans:

I. This goal has been made into a statewide goal.

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 Plans:
I. 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 United States Army Corps of Engineers (USACE) to install four watercraft inspection and decontamination stations near the federal reservoirs within the Verdigris Region.

II. 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.

III. The RAC will encourage funding for the ANS Program through the State Water Plan Fund (SWPF).

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.

Appendix B - Frequently Used Acronyms

KANSAS WATER PLAN 2022

ANS: Aquatic Nuisance Species
ARCA: Arkansas River Compact Administration
ASR: Aquifer Storage and Recovery Project
AVC: Ark 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 Operations
CIG: Conservation Innovation Grant
CM: Cimarron
CREP: Conservation Reserve Enhancement Program
CRP: Conservation Reserve Program
CStP: Conservation Stewardship Program
CWA: Clean Water Act
EQIP: Environmental Quality Incentives Program
EPA: Environmental Protection Agency
ERPs: Emergency Response Plans
EW: Equus-Walnut
FEMA: Federal Emergency Management Agency
FHSU: Fort Hays State University
FIRM: Flood Insurance Rate Maps
FIRO: Forecast Informed Reservoir Operations
GBP: Great Bend Prairie
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
KDWP: Kansas Department of Wildlife and Parks

KGS: Kansas Geological Survey
KRPI: Kansas Reservoir Protection Initiative
KRWA: Kansas Rural Water Association
KS: Kansas
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)
LPKC: Logistics Park Kansas City
MCL: Maximum Contaminant Level
MdC: Marais des Cygnes
MDI: Mobile Drip Irrigation
MDS: Minimum Desirable Streamflow
MEKRO: Multi-Basin Evaluation of Kansas Reservoir Operations
MGP: Midwest Grain Products
MO: Missouri
MOA: Memorandum of Agreement
MRRIC: Missouri River Recovery Implementation Committee
MSL: Mean Sea Level
NCEI: National Centers for Environmental Information
NEO: Neosho
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
PDSI: Palmer Drought Severity Index
PWS: Public Water Supply
RAC: Regional Advisory Committee
RCPP: Regional Conservation Partnership Program

RH: Red Hills
RRC: Republican River Compact
RRCA: Republican River Compact Administration
SD-6: Sheridan 6
SDI: Sub-surface Drip Irrigation
SGF: State General Fund
SHS: Smoky Hill Saline
SWQUA: Special Water Quality Use Area
SR: Solomon Republican
SWAT: Soil and Water Assessment Tool
SWPF: State Water Plan Fund
SWRPA: State Water Resouces Planning Act
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
UA: Upper Arkansas
UR: Upper Republican
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
USGS: United States Geological Survey
USH: Upper Smoky Hill
VE: Verdigris
WAD: Water Assurance District
Water Tech Farms: Water Technology Farms
WCA(s): Water Conservation Area(s)
WCNGP: Wolf Creek Nuclear Generating Plant
WID: Water Injection Dredging
WPMAS: Watershed Planning, Monitoring and Assessment Section
WQ: Water Quality
WRAPS: Watershed Restoration and Protection Strategy
WRP: Wetlands Reserve Program
WTAP: Water Transition Assistance Program

Appendix C - 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.

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.

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.

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

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.

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 Natural Resource Conservation Service (USDA-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 inter-agency 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

Consolidation continued to be evaluated, however and during the 1981 legislative session the KWRB was replaced by the Kansas Water Office (KWO) and the Kansas Water Authority (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; and
- 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 in 1989 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.

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. It focused on ensuring adequate quantity. The KWA and RACs, among others, referenced the *Vision* during 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 2022 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*

In December 2014, the KWA established 14 Regional Planning Areas, each with its own Regional Advisory Committee. 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.