Kansas Field Conference
June 10–12, 2019

South-Central Kansas

Oil, Salt, Wetlands, and Other Regional Resources

Field Guide

Susan Stover and Catherine S. Evans

This project is operated by the Kansas Geological Survey and funded, in part, by the Kansas Department of Agriculture, Kansas Department of Health and Environment, Kansas Department of Transportation, Kansas Department of Wildlife, Parks and Tourism, and Kansas Water Office.

KGS Open-File Report 2019-5

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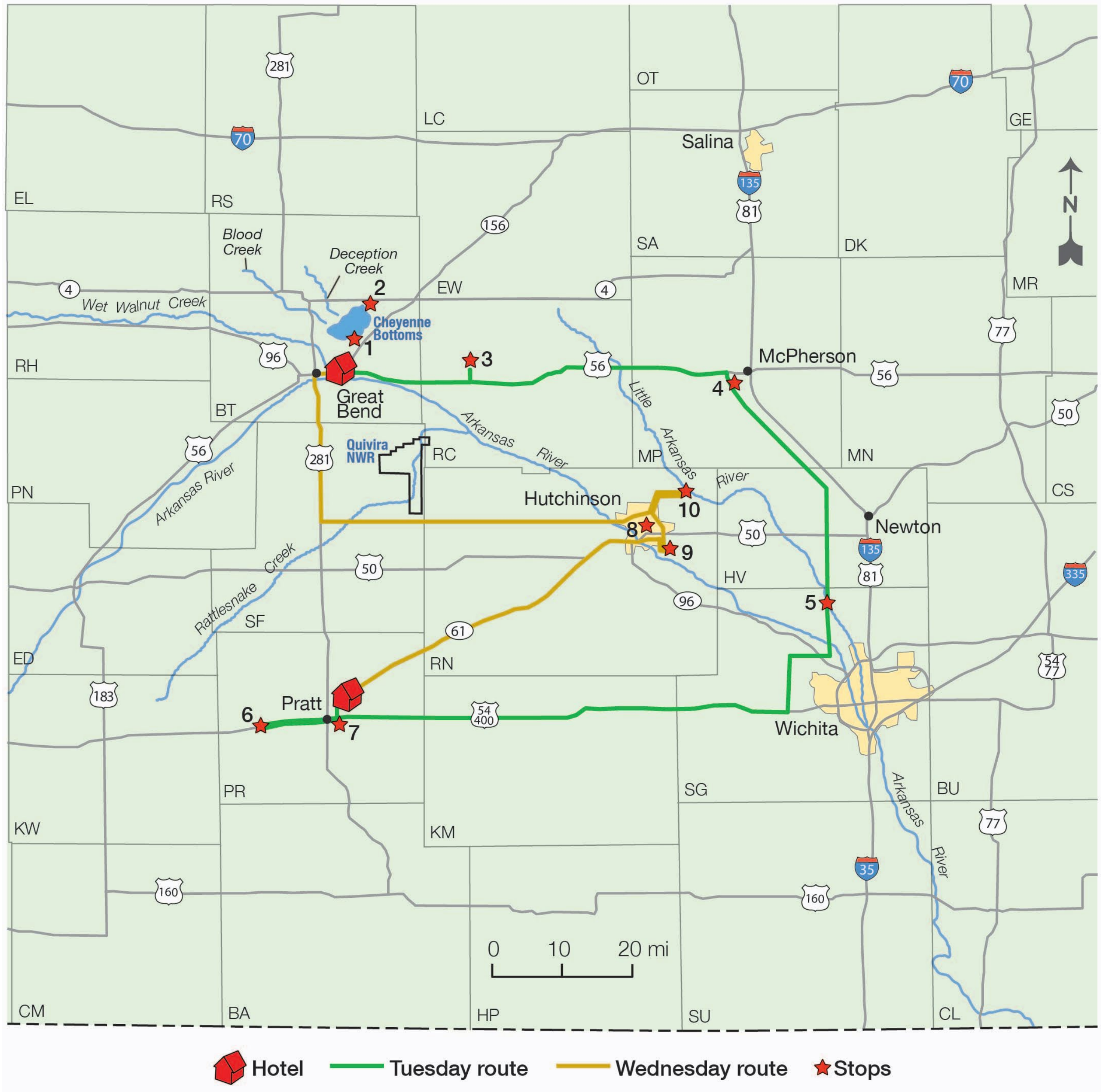
Cover photo: Dan Witt



Route map.

County abbreviations:

BA — Barber	*EL — Ellis*	*MN — Marion*	*RN — Reno*
BT — Barton	*EW — Ellsworth*	*MP — McPherson*	*RS — Russell*
BU — Butler	*GE — Geary*	*MR — Morris*	*SA — Saline*
CL — Cowley	*HP — Harper*	*OT — Ottawa*	*SF — Stafford*
CM — Comanche	*HV — Harvey*	*PN — Pawnee*	*SG — Sedgwick*
CS — Chase	*KM — Kingman*	*PR — Pratt*	*SU — Sumner*
DK — Dickinson	*KW — Kiowa*	*RC — Rice*	
ED — Edwards	*LC — Lincoln*	*RH — Rush*	

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NOTES

South-Central Kansas

Oil, Salt, Wetlands, and Other Regional Resources

June 10–12, 2019

Welcome to the 25th year of the Kansas Field Conference. We work to keep the field conference a relevant, informative tour as we visit different landscapes and evolving industries and discuss new ideas about how to manage Kansas's natural resources. The tour is also an opportunity to appreciate the beauty and natural diversity of our state.

The sites on the 2019 tour fall into three broad categories: water, industries, and protection. Water is always going to be a critical resource in a state that has had both severe drought and flooding at the same time. Industries are what keep our economy humming, and protection helps keep our people, communities, wildlife, and land healthy.

Water

Water is an emotional issue because lives, wildlife habitats, and economies are all at stake. Experts on our tour will provide updates about two intense debates related to water for farms, wetlands, and cities in south-central Kansas. On Monday night, a panel will discuss a state-ordered solution for water shortages at Cheyenne Bottoms Wildlife Refuge versus a much slower, voluntary approach taken to resolve shortages at the Quivira National Wildlife Refuge.

On Tuesday, we tour the city of Wichita's aquifer storage and recovery (ASR) project that has provided additional water for the city in response to a 1993 study that predicted future shortages. Under the project, excess stream flows are diverted, treated, and injected into the Equus Beds aquifer, where the water is stored until needed. The city now has enough water resources to meet projected needs but is at risk of shortages during an extended, severe drought. To address that risk, the city has requested changes to its ASR permit. City officials will explain the proposed changes, and Tim Boese, manager of Groundwater Management District 2, will describe why the permit changes are controversial for many area stakeholders.

Industries

We will visit four industries during this tour—an oil refinery, salt mine, egg production operation, and cotton gin.

CHS, parent company of the oil refinery in McPherson, is the largest cooperative refinery in the United States. The CHS Refinery in McPherson has a refining capacity of 100,000 barrels a day. A state-of-the-art coker completed at the refinery in 2016 added the capability to break down the heaviest portions of crude oil into lighter liquids and petroleum coke. CHS also actively manages its water use, including remediating a brine plume from an old oil field and using the resulting reclaimed water in its operations.

Salt underlies nearly all of the region on this tour. In Hutchinson, we will travel 650 feet below ground at the Strataca Underground Salt Museum to see a mined-out area remade into a tourist attraction. Over lunch, we'll hear from Jim Barta with the Hutchinson Salt Company about today's salt mining industry and from Lee Spence, CEO of Underground Storage and Vaults, about the company's storage of valuable documents and films in rooms left vacant by salt mining.

We also will visit the facilities of two growing agricultural industries in Kansas: poultry and cotton. Cal-Maine Foods, Inc., near Chase, is the largest egg production operation in Kansas. With nearly 2.5 million chickens, it produces both conventional and organic eggs.

Next GINeration, in Cullison is one of five gins built in Kansas since 1996 to accommodate the expansion of cotton production in the state. In 2018, Kansas cotton growers harvested a record 342,000 bales.

Protection

Monitoring natural processes and human activities that can alter or endanger the environment is essential for preserving the state's natural resources. Topics we will explore during the conference include disposal of liquid waste into a deep saline aquifer, tracking earthquakes, wetland management, and wildfire suppression.

Deep, highly saline aquifers are important disposal sites for liquid wastes. The primary formation for disposal in Kansas is the Arbuckle Group, about 4,000 feet below the surface in south-central Kansas. For decades, waste fluids have been injected into the Arbuckle. In recent years, however, the fluid levels in some disposal wells have been rising; if that trend doesn't change, in a few years, some disposal wells will no longer be fully functional, a serious concern. To learn more, representatives from the KGS, KDHE, and KCC are combining their research and regulatory expertise to examine what is known about disposal in the aquifer, identify areas of uncertainty related to the process, and determine what can be done to assure the Arbuckle remains a viable geologic disposal site.

Although Kansas is at low risk for large earthquakes, south-central Kansas has seen increased seismic activity related to the disposal of wastewater during oil and gas operations in recent years. To improve monitoring of Kansas's earthquakes, the KGS has expanded its seismometer network to 12 stations. One is near the Kansas Department of Wildlife, Parks and Tourism office in Pratt, our stop for dinner on Tuesday night. We will lead a short hike to see it for those interested.

Kansas is exceptional in having two wetlands of international importance—Cheyenne Bottoms Wildlife Area and Quivira National Wildlife Refuge. These wetlands along the Central Flyway that crosses North America provide feeding, resting, and nesting areas for a wide variety of birds and are home to a diversity of mammals, lizards, amphibians, and pollinators. During our stop at Cheyenne Bottoms, we will learn about wetland management.

As wildfires increased in size and frequency in the Great Plains, Kansas experienced its largest wildfire in 50 years in 2016 and an even larger fire in 2017. In those two years, hundreds of thousands of acres and miles of fencing burned, thousands of cattle died, and dozens of homes were destroyed. Further increased risk of wildfires is anticipated, in part due to changing weather patterns, no-till agricultural practices, and the encroachment of residential homes into vegetated areas. At Sand Hills State Park near Hutchinson—an area hit by wildfires in 2017—we'll hear from fire responders about how Kansas can better prepare to suppress fires.

About the Kansas Field Conference

The Kansas Field Conference is designed to give a diverse group of policymakers the opportunity to explore and discuss natural resource issues and talk directly with business owners, researchers, and other invested individuals. We aim to provide a broad, informed perspective that will be useful in formulating policies and programs.

The annual field guide furnishes background about each site and can serve as a useful reference long after the conference is over. Field guides are posted on the KGS website at www.kgs.ku.edu.

You are encouraged to ask questions and contribute to the discussions. The bus microphone is open to everyone. Please remember that in the course of the conference we do not seek to resolve policy or regulatory conflicts. By bringing together experts, we hope to go beyond merely identifying issues; we want the combination of first-hand experience and interactions among participants to result in a new level of understanding about the state's natural resources and concerns.

When possible, we attempt to provide a forum for all sides of a contentious issue. The opinions expressed during the conference are not necessarily those of the Kansas Geological Survey or the field conference co-sponsors. It is valuable for participants to hear various viewpoints about complex issues.

Sponsors

Organized by the Kansas Geological Survey, the 2019 conference has five co-sponsors: The Kansas Department of Agriculture, Kansas Department of Health and Environment, Kansas Department of Transportation, Kansas Water Office, and Kansas Department of Wildlife, Parks and Tourism. These co-sponsors help subsidize the cost of the conference and provide valuable input about issues, speakers, and sites. The 2019 field conference also received support from The Nature Conservancy in Kansas for the Monday night social and from Burns & McDonnell for lunch on Tuesday. We thank them for their support.

Kansas Geological Survey

The KGS is a research and service division of the University of Kansas. Its mission is to study and report on the state's geologic resources and hazards. Much of the KGS focus is on energy, water, and a better understanding of the state's surface and subsurface geology. By statutory charge, the KGS role is strictly one of research and reporting. Headquartered in the west district of KU's Lawrence campus, the KGS also has a Well Sample Library in Wichita.

Kansas Geological Survey
1930 Constant Avenue
Lawrence, KS 66047-3724
785.864.3965

Kansas Department of Agriculture

The Kansas Department of Agriculture (KDA) has a mission to support the agriculture sector in Kansas, including farmers, ranchers, food establishments, and agribusiness, and the consumers they serve. KDA has several divisions, including the Division of Water Resources (DWR) and the Division of Conservation. DWR regulates how water is allocated and used, the construction of dams and levees, Kansas's Groundwater Management District Act, and the state's interstate river compacts. It also coordinates the national flood insurance program in Kansas. The Division of Conservation works with the county conservation districts, organized watershed districts, and other special-purpose districts to improve water quality, reduce soil erosion and flood potential, conserve water, and provide local water supply.

Kansas Department of Agriculture
1320 Research Park Drive
Manhattan, KS 66506
785.564.6700

Kansas Department of Health and Environment

The Kansas Department of Health and Environment (KDHE) mission is to protect and improve the health and environment of all Kansans. KDHE has several divisions, including the Division of Environment, which has regulatory responsibility for air quality, environmental remediation, waste management, and water quality. The Division of Environment is the regulatory body that addresses harmful algal blooms, permits public water supply quality, permits industrial and municipal wastewater, and identifies quality-impaired lakes, streams, and wetlands. It also regulates underground hydrocarbon salt cavern storage and underground disposal wells unrelated to the oil and gas industry.

Kansas Department of Health and Environment
Curtis State Office Building
1000 SW Jackson Street
Topeka, KS 66612
785.296.1500

Kansas Department of Transportation

The Kansas Department of Transportation (KDOT) is charged with providing a statewide transportation system to meet the needs of Kansans. Its primary activities are road and bridge maintenance; transportation planning, data collection, and evaluation; project scoping, designing, and letting; contract compliance inspection of material and labor; and federal program funding administration.

Kansas Department of Transportation
Dwight D. Eisenhower State Office Building
700 SW Harrison Street
Topeka, KS 66603-3754
785.296.3566

Kansas Department of Wildlife, Parks and Tourism

The Kansas Department of Wildlife, Parks and Tourism (KDWPT) is responsible for managing the state's living natural resources. Its mission is to conserve and enhance Kansas's natural heritage, wildlife, and wildlife habitats. Its responsibilities include protecting and conserving fish and wildlife and their habitats while providing for the wise use of these resources. KDWPT also provides public recreation opportunities through state parks, state fishing lakes, wildlife-management areas, and recreational boating on the state's public waters.

Kansas Department of Wildlife, Parks and Tourism
1020 S. Kansas Avenue, Room 200
Topeka, KS 66612-1327
785.296.2281

Kansas Water Office

The Kansas Water Office (KWO) is the water planning, policy, coordination, and marketing agency for the state. The KWO evaluates and develops public policies, coordinating the water-resource operations of agencies at all levels of government. The KWO administers the Kansas Water Plan Storage Act and the Water Assurance Act and advises the governor on drought conditions. The KWO develops the Kansas Water Plan, which addresses the management, conservation, and development of water resources in the state. The Kansas Water Authority, statutorily within the KWO, advises the governor, legislature, and director of the KWO.

Kansas Water Office
900 SW Jackson, Suite 404
Topeka, KS 666120-1249
785.296.3185

Acknowledgments

The following people helped make this a successful field conference: Secretary Brad Loveless, and Steve Adams, Kansas Department of Wildlife, Parks and Tourism; Acting Director Earl Lewis, Kansas Water Office; Catherine Patrick, Larry Thompson, and Kyle Halverson, Kansas Department of Transportation; Secretary Mike Beam, Kansas Department of Agriculture; and Director Leo Henning, Mary Daily, and Carrie Ridley, Division of Environment, Kansas Department of Health and Environment. Mark Schoneweis at the KGS created the route map. A special thank you to our KGS editor, Julie Tollefson, for her work on the field guide.

Most of all, the KGS extends our appreciation to the speakers at each of the stops, without whom this conference would not be possible.

Susan Stover
Catherine S. Evans
Rolfe Mandel
Franek Hasiuk

Monday, June 10, 2019

3 p.m.	Check into Holiday Inn Express, Great Bend Park your car on far end of lot
3:45 p.m.	**Introductions and Orientation** *Holiday Inn lobby* Rolfe Mandel, Director, Kansas Geological Survey Susan Stover, Geologist, Outreach Manager, KGS
4:30 p.m.	Bus to Kansas Wetlands Education Center
5 p.m.	**Stop 1: Kansas Wetlands Education Center** **Welcome** Curtis Wolf, Director, Kansas Wetlands Education Center **Panel Discussion: Managing Water for Wetlands and Farms: Cheyenne Bottoms Wildlife Area versus Quivira National Wildlife Refuge** Moderator: Earl Lewis, Acting Director, Kansas Water Office David Barfield, Chief Engineer, Kansas Department of Agriculture, Division of Water Resources Keith Miller, producer near Cheyenne Bottoms Kent Moore, producer near Quivira Mike Oldham, manager, Quivira National Wildlife Refuge
6:15 p.m.	Social at Kansas Wetlands Education Center
6:45 p.m.	Dinner
7:45 p.m.	**Stop 2: Tour of Cheyenne Bottoms—Bird Watching and Improvements** Jason Wagner, Area Wildlife Manager, Cheyenne Bottoms Wildlife Area Rob Penner, Cheyenne Bottoms and Avian Programs Manager, The Nature Conservancy Joe Kramer, Ducks Unlimited
9 p.m.	Return to hotel

NOTES

Managing Water for Wetlands and Farms: A Tale of Two Approaches

STOP 1

KEY FACTS

- Cheyenne Bottoms and Quivira National Wildlife Refuge are wetlands of international importance.
- Both wetlands have very senior water rights, and both wetlands have had their water rights impaired by junior water-right users, primarily for irrigation.
- Prior appropriation, in which junior rights are curtailed to satisfy senior water rights, can be a harsh solution to impairment.
- The Kansas Legislature approved flexible water management tools: Intensive Groundwater Use Control Areas, Local Enhanced Management Areas, and Water Conservation Areas.
- The Cheyenne Bottoms impairment was resolved in 1992 with the Walnut Creek IGUCA, a "share the shortage" approach, although junior water rights were reduced drastically.
- Less drastic solutions to the Quivira wetland impairment have been sought since 1993; only modest reductions have been achieved and the wetland water right is still impaired.

Kansas is home to two wetlands of international importance: Cheyenne Bottoms Wildlife Area was designated in 1988 and Quivira National Wildlife Refuge in 2002. The wetlands provide the most important shorebird migration point in the U.S. Central Flyway. Located in Barton, Stafford, Rice, and Reno counties, the wetlands are surrounded by irrigated crop fields. During extended dry periods, and as demands grew with expanded irrigation, conflicts developed over water rights. Although Cheyenne Bottoms and Quivira both hold senior water rights, pumping by junior water-rights holders reduced streamflow before it could reach the wetlands. State officials, locals, and organizations addressed the issue at both wetlands but ended up taking different approaches at Cheyenne Bottoms and Quivira to resolve the conflicts.

Water-right permits

State legislators, long ago recognizing that Kansas would face competition for water, established a permit system through the Kansas Water Prior Appropriation Act (K.S.A. 82a-730). The system applies to all surface and groundwater rights permitted after June 28, 1945. Water rights established before this date are considered vested and have the most senior, equal priority. Priority of non-vested water rights is based on the time the right was established, not the type of use. In other words, Kansas is "first in time, first in right." When there isn't enough water to meet all demands, the available water first goes to the more senior water rights.

The Kansas Department of Agriculture, Division of Water Resources (DWR), issues water-right permits for the appropriation of water. The applicant must specify the proposed source of water, place of use, point of diversion, rate of diversion, and total quantity. The date the DWR accepts the application becomes the applicant's priority date. Before a water right is established, DWR reviews an application to make sure it follows regulations, would not impair a more senior water right, and would not unreasonably affect the public interest.

During shortages, if a senior right holder is being impaired and the owner believes it is due to diversions by more junior water rights, the owner can file an impairment complaint with DWR's chief engineer to limit the junior water right from pumping until the senior right is restored. An investigation by DWR determines whether a senior water right was impaired and whether

Figure 1. Nightfall at the wetlands. Photo by Dan Witt.

it would be restored by regulating the junior water rights.

The prior appropriation system can be complex in a groundwater system or a stream with a significant portion of baseflow from groundwater. Impacts may be from junior right wells pumping from many directions. Prior appropriation can also be harsh. To restore a senior groundwater right impaired in northwest Kansas, more than two dozen junior water rights would have been regulated through prior appropriation. In this situation, the complainant agreed instead to a "share the shortage" solution that wouldn't reduce his neighbors' water rights as severely.

Kansas legislature approves new water management options

The Kansas legislature worked to provide DWR's chief engineer more flexible tools, in addition to prior appropriation, to mediate solutions. In 1978, Intensive Groundwater Use Control Areas (IGUCA) language was added to the Groundwater Management District Act (K.S.A. 82a-1020). The IGUCA statutes allow the chief engineer to develop "share the shortage" solutions to the water conflicts.

The Groundwater Management District (GMD) language was amended again in 2012 to provide similar flexible tools through Local Enhanced Management Areas (LEMA). LEMAs place control at the GMD level, in contrast to the IGUCA process controlled by the chief engineer. With a LEMA proposal, the chief engineer's authority is limited to accepting, rejecting, or returning the proposal with suggestions to modify it.

Legislation was enacted in 2015 for Water Conservation Areas (K.S.A. 82a-745), which provide control at the land owner level to implement a water conservation plan. One or multiple landowners can submit a Water Conservation Area plan to the chief engineer. As with IGUCAs and LEMAs, Water Conservation Areas have flexible water management tools, such as multi-year water allocation, greater allowances on where water is diverted, and allowing for new uses of the water.

Wet Walnut Creek and Cheyenne Bottoms

Cheyenne Bottoms, fed by Blood and Deception creeks, has historically had variable water levels and often went dry. In 1948, the

Kansas Forestry, Fish and Game Commission obtained a permit to move 20,000 acre-feet of water from Wet Walnut Creek to the wetlands. A 23-mile series of diversion dams and ditches were constructed to transfer the water.

Despite the senior water right, by the 1980s Cheyenne Bottoms wasn't getting sufficient water. In 1989, DWR published "Availability of Water in Walnut Creek, Its Tributaries, Their Valley Alluviums and Hydraulically Connected Aquifers." The study documented that much of the streamflow decline was related to loss of baseflow due to increased groundwater pumping. As groundwater levels dropped, baseflow into streams was reduced and streamflows declined within the Walnut Creek basin. Junior water rights upstream were infringing on the more senior water right for Cheyenne Bottoms.

The conflict that ensued was seen as a battle between water for farms versus water for wildlife. State and national environmental organizations voiced increasing concern for the wetland, which spurred government action. In 1989, the Kansas Department of Wildlife and Parks asked DWR's chief engineer to initiate IGUCA action for areas affecting the Cheyenne Bottoms water right. In 1990, Big Bend Groundwater Management District 5 (GMD 5), which encompasses Cheyenne Bottoms and Quivira, requested that the chief engineer begin proceedings in the Walnut Creek basin in Barton County. In response, the chief engineer began IGUCA proceedings in portions of Barton, Ness, and Rush counties. During public hearings, DWR entered evidence that average groundwater withdrawals totaled 45,000 acre-feet, while sustainable yield was 22,700 acre-feet. The sustainable yield was used as the benchmark of available water for water-right demands.

The chief engineer issued an IGUCA order in 1992 and closed the area to new appropriations (fig. 3). Vested water rights were left alone. Non-vested, senior water rights within the Walnut Creek IGUCA were defined as those established before October 1, 1962; all water rights established after that date were junior. In the order, reasonable use for irrigation was defined as 12 inches per acre in Barton County, 13 inches per acre in Rush County, and 14 inches per acre in Ness County. Senior irrigation rights were reduced by 22 to 33 percent, depending on the area of the county. Junior water rights had the biggest reductions, sharing the remaining quantity of

Figure 2. Sunset at Cheyenne Bottoms. Photo by Dan Witt.

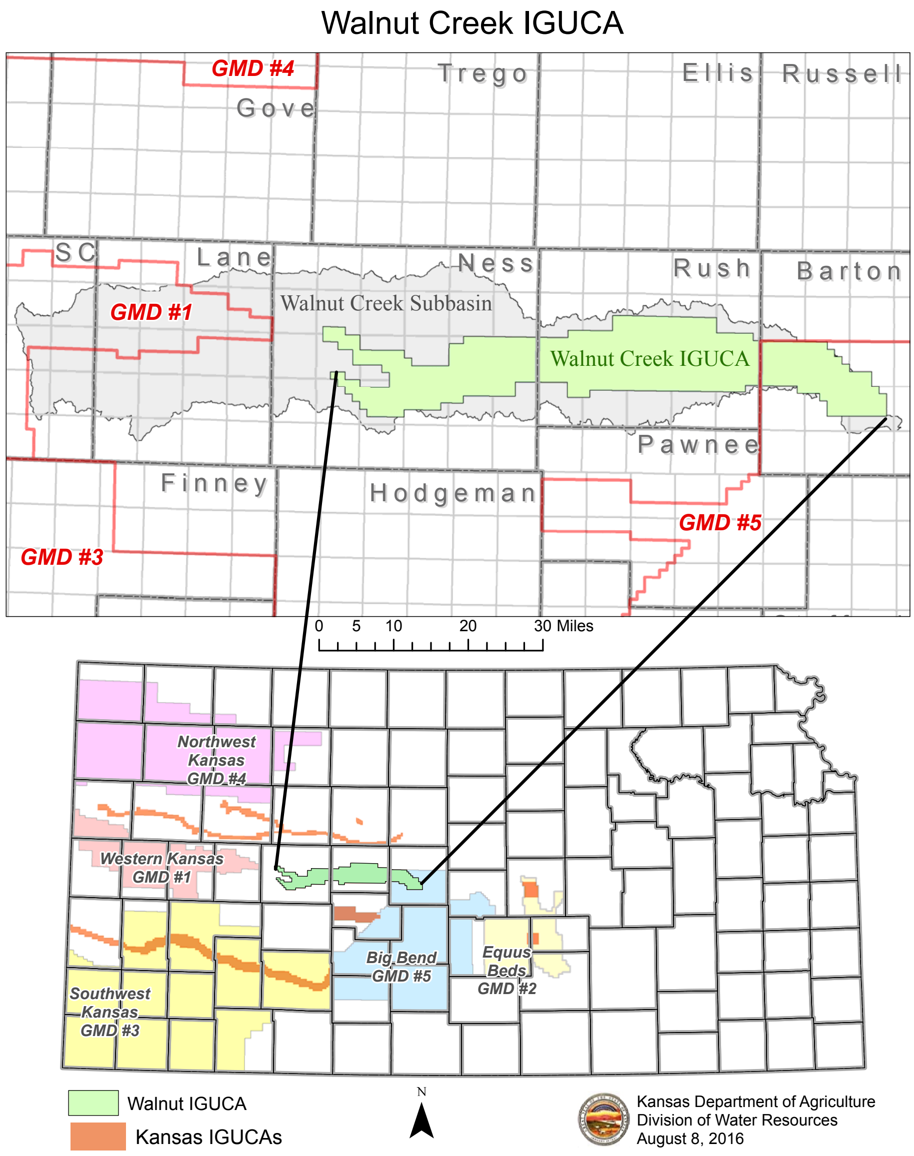


Figure 3. Walnut Creek Intensive Groundwater Use Control Area (IGUCA).

the sustainable yield. That amount was 5.5 inches per acre for Barton County, 5.75 inches per acre for Rush County, and 6.25 inches per acre for Ness County. Individual water-right allocations were determined based on senior or junior status, location, and the maximum number of acres irrigated between 1985 and 1990.

Flexibilities allowed in the IGUCA include a five-year allocation period, the ability to carry over unused portions from one five-year allocation to the next, an increased ability to shift water use among wells, and the ability to trade water rights.

In 2011, a Kansas State University study of the economic impact of the Walnut Creek IGUCA compared outcomes for producers within the IGUCA with producers near to, but outside, the IGUCA. The authors found a severe economic impact to producers in the IGUCA in the short run, but it diminished over time. They also identified a “learning by doing” phase, in which producers responded to the certainty of the water-right restrictions by developing new long-term strategies that made them successful with less irrigation. Those strategies included changes in crop mixes, applying more water to the high value crops on their best land, retiring or putting in dryland crops on marginal land, improving irrigation scheduling, and adopting new technologies. The reduced water allocations did expose producers to more risk of crop failure with deficit irrigation.

Rattlesnake Creek and Quivira National Wildlife Refuge

For more than 30 years, the U.S. Fish & Wildlife Service (USFWS) has had concerns that Quivira National Wildlife Refuge was suffering from lack of water, despite having a senior water right. The USFWS's 1957 water right is for 14,632 acre-feet annually. Water is diverted from Rattlesnake Creek, a tributary of the Arkansas River (fig. 4). Quivira is managed primarily to conserve habitat for migrating and wintering birds and to support nesting and resident wildlife, making not only the quantity but also the timing of water deliveries important. As with Cheyenne Bottoms, irrigation around Quivira has increased, drawing off water destined for the wetland.

Having watched the IGUCA proceedings north of them for three years, water users in the Rattlesnake Creek subbasin wanted a different, less contentious, process. In 1993, the Rattlesnake Creek/Quivira Partnership formed with a mission to implement solutions using water conservation as its guiding principal. The Water Protection Association of Central Kansas (WaterPACK, a farmers' organization), GMD 5, the USFWS, and DWR signed a cooperative agreement.

Since the partnership formed, a series of actions have occurred, water conservation programs have been implemented, and solutions have been proposed to minimize forced cutbacks on the surrounding agricultural community's junior water-right holders. As of May 2019, no final solution had been reached and Quivira's water right was still impaired. Some activity highlights are bulleted below.

- August 2000—The 12-year Rattlesnake Creek Management Plan began. Written

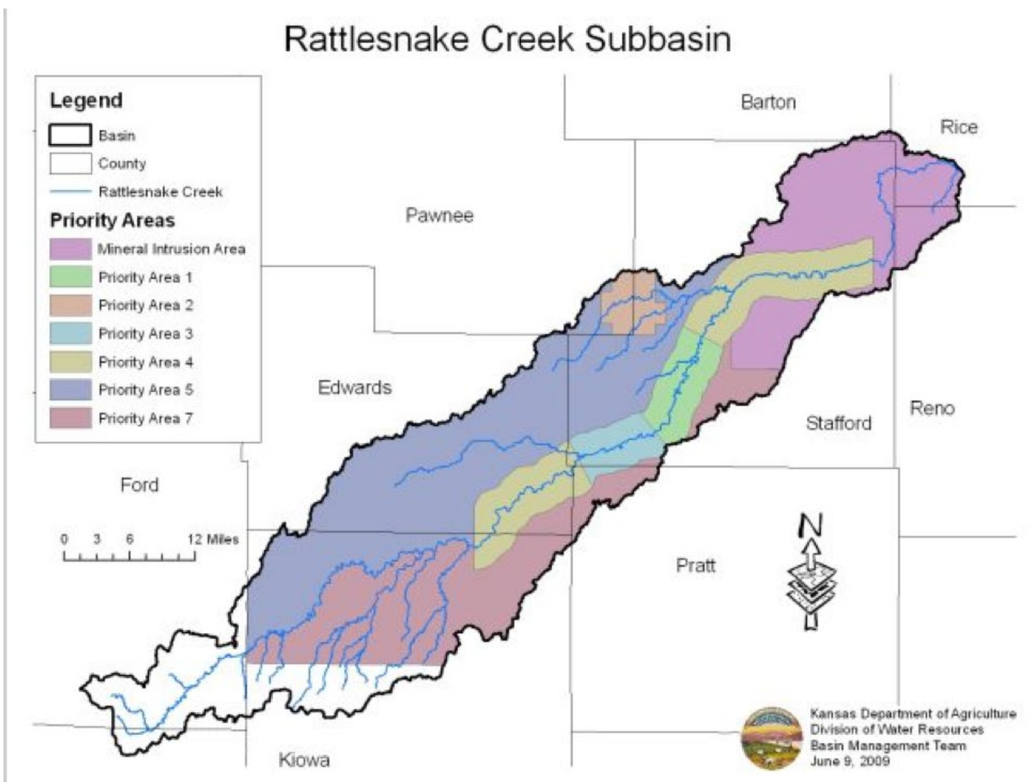


Figure 4. Study area from Rattlesnake Creek Management Plan with priority areas for water use reductions.

by the partnership, the plan laid out conservation programs, water-use reduction targets, and a timeline. Frequent partnership meetings were held.

- November 2012—DWR published the final draft of "Rattlesnake Creek Partnership, Third Four-Year Review of Management Program, 2009–2012." The report notes the considerable studies done for the region and increased understanding of the area's hydrology. It also noted that permanent annual water savings of 2,804 acre-feet was "far less than the goal of 27,346 acre-feet of savings laid out by the partnership…". The report remained in draft form because not all of the partners were willing to sign off on it.
- April 2013—The USFWS filed an impairment complaint with the chief engineer of DWR, which allowed DWR to begin an investigation.
- March 2016—The USFWS responded to questions from DWR regarding augmentation of Rattlesnake Creek, including the maximum capacity that should be considered, water quality, and shortages Quivira could endure in times of drought.
- July 15, 2016—DWR published the final impairment investigation report. DWR determined an impairment of the Quivira water right, primarily due to the effects of junior right groundwater pumping and the associated reductions in baseflow to the stream system. The report stated that long-term cuts to upstream, junior water-right groundwater pumping (perhaps in the 13–15% range), targeted reductions of 4,400 acre-feet, and augmentation to increase streamflow at Quivira by 3,000–5,000 acre-feet on a regular basis would remedy the impairment.
- December 2016–2018—GMD 5 proposed several water conservation measures, including reducing the number of acres irrigated, removing end guns from center pivot irrigation systems, stream augmentation, and a LEMA. GMD 5 worked with basin stakeholders and DWR to develop a long-term solution to remedy the impairment.
- August 17, 2018—Audubon of Kansas sent a letter to the chief engineer of DWR regarding Quivira impairment negotiations. Audubon of Kansas was concerned that negotiations were not addressing the federal law that prohibits any reduction of the Quivira water right.
- August 29, 2018— U.S. Senators Pat Roberts and Jerry Moran sent a letter to U.S. Secretary of Interior Ryan Zinke requesting USFWS's technical assistance for augmentation engineering, a piece of the impairment solution.
- October 10, 2018—The Quivira Working Group launched Quivira Acres Initiative to sustain the Quivira National Wildlife Refuge and the surrounding agricultural community. Working group members consist of GMD 5, Central Kansas Water Bank, Kansas Farm Bureau, The Nature Conservancy of Kansas, and WaterPACK.
- December 13, 2018—The USFWS filed a request to secure water regarding the Quivira water right, to resolve its impairment by junior water rights.
- February 22, 2019—GMD 5 submitted a Quivira National Wildlife Refuge LEMA plan to the chief engineer of DWR. The LEMA would run from January 2020 to January 2030. The plan includes a menu of incentive-based programs and requires removal of end guns from center pivot irrigation systems pumping with junior water rights.

Water Management and Restoration Efforts at Cheyenne Bottoms

Hundreds of wetlands, which provide vital habitat for migratory birds, once dotted the Central Flyway that crosses North America from Canada to Mexico. As development progressed in the 19th and 20th centuries, many disappeared. Between 1955 and 1978 alone, 40% of the wetlands in Kansas vanished. Of the 12 largest wetlands formerly found in the state, only three—Cheyenne Bottoms, Quivira National Wildlife Refuge, and Jamestown Wildlife Area—still function as reliable food and water sources for migratory birds and year-round habitat for non-migratory animals. Because of the loss, the populations of some shorebird species have shrunk as much as 80% due to lack of food, water, and nesting habitat.

Cheyenne Bottoms and Quivira are two of the 34 sites in the United States designated as Wetlands of International Importance because during migration, they often host more than 90% of the world's population of such species as stilt sandpipers and white-rumped sandpipers, as well as hundreds of thousands of geese and cranes.

STOP 2

KEY FACTS

- Cheyenne Bottoms is the largest wetland in the U.S. interior and is an essential stopover for migrating birds.
- Banded birds stopping at Cheyenne Bottoms have been tracked to the Arctic Circle and the tip of South America.
- Cheyenne Bottoms Wildlife Area, managed by the Kansas Department of Wildlife, Parks, and Tourism, covers about 20,000 acres.
- The nearby nearly 8,000-acre Cheyenne Bottoms Preserve is managed by The Nature Conservancy.
- KDWPT maintains the wildlife area as a year-round wetland with dikes, dams, and canals.
- The Nature Conservancy is restoring the preserve to its natural state as an intermittent wetland.
- Ducks Unlimited and KDWPT launched a two-year campaign in early 2019 to raise renovation funding.

Figure 1. Great egret at Cheyenne Bottoms Wildlife Area. Photo by Dan Witt.

Figure 2. Blue-winged teal at Cheyenne Bottoms Wildlife Area. Photo by Dan Witt.

Set in a natural 64-square-mile basin, Cheyenne Bottoms was an intermittent marsh before it was engineered in the 1950s. Some years it remained dry. In wet years it would expand, including in the summer of 1927 when nearly the entire basin was inundated. Early entrepreneurs tried unsuccessfully to make the area into a lake resort while others contemplated draining the land for farming. In the 1930s, the Kansas Forestry, Fish and Game Commission (KFFGC)—predecessor to Kansas Department of Wildlife, Parks and Tourism (KDWPT)—was given oversight of the wetland with a mission to create a permanent resting and nesting ground for wildlife.

Management of Cheyenne Bottoms, the largest wetland in the U.S. interior and one of the most important shorebird migration points in the Western Hemisphere, is now divided between the KDWPT and The Nature Conservancy (TNC). KDWPT manages the Cheyenne Bottoms Wildlife Area, which encompasses nearly 20,000 acres, and the non-profit TNC owns and manages the Cheyenne Bottoms Preserve, nearly 8,000 acres just north of the state's property. Although their management approaches differ—KDWPT maintains a year-round marsh using built structures while TNC aims to restore its property to a natural intermittent wetland—the two entities work together to ensure their techniques mesh.

Cheyenne Bottoms Wildlife Area development

KFFGC began work on the wetland in the 1950s. Dikes were built to divide the marsh into a series of pools. Control gates were installed to move water into the marsh, between pools, and to an overflow canal (fig. 3). Dams and canals were built to divert water from the nearby Arkansas River and Wet Walnut Creek to supplement the natural, intermittent flow from Blood and Deception creeks. Although the main goal was to create a permanent habitat for migratory birds and native species, recreational activities such as hunting, fishing, and bird watching were included in the plans. In 1957, the Cheyenne Bottoms Wildlife Area was dedicated.

Today KDWPT uses the system of dikes, pools, and canals to manipulate water levels in its portion of Cheyenne Bottoms. About 12,000 of the 20,000 acres in the Cheyenne Bottoms Wildlife Area are covered with shallow pools and the rest is marshland—wet soils and water plants intermittently covered with water—or grassland habitat (fig. 4).

Renovations and restoration campaign

After the Cheyenne Bottoms Wildlife Area was established, water availability still remained cyclical and the marsh's complex natural cycles caused unintended consequences. Dikes eroded, water in open canals evaporated or seeped into the ground before reaching the wetland, and wind-whipped waves in the deepest pool churned up sediment that killed off vegetation and invertebrates essential for migratory birds.

In the 1990s, a multimillion-dollar project was undertaken to improve water and vegetation management with the goal of maintaining at least 3,000 acres saturated for wildlife at any given time. Pumps were installed to transfer water between pools (fig. 5), large pools were broken into smaller units, dikes were improved to create deeper pools, and water measurement devices were installed.

Although the 1990s renovations were the last major undertaking, regular upkeep has continued. In 2009 the already outdated water-measurement devices were replaced by new flow meters, and in 2014 an open canal—beset with erosion, vegetation growth, and silting—that ran from the Arkansas River was replaced with a buried pipe.

To fund further needed renovations, Ducks Unlimited and KDWPT launched a two-year fund-raising campaign in early 2019. The money will be used to address the silting problem that plagues water control and has allowed cattails and other invasive species to overrun some of the area's habitats. Aging infrastructure also will be updated. To add to public funds available from KDWPT, Ducks Unlimited has pledged to raise $300,000 in private funding.

The Nature Conservancy's Cheyenne Bottoms Preserve

The goal of TNC at the Cheyenne Bottoms Preserve is to re-create natural wetland wet-dry cycles. The conservation organization began purchasing land in the northwest portion of Cheyenne Bottoms in 1990 to provide

Figure 3. Control gate and outlet canal at Cheyenne Bottoms Wildlife Area.

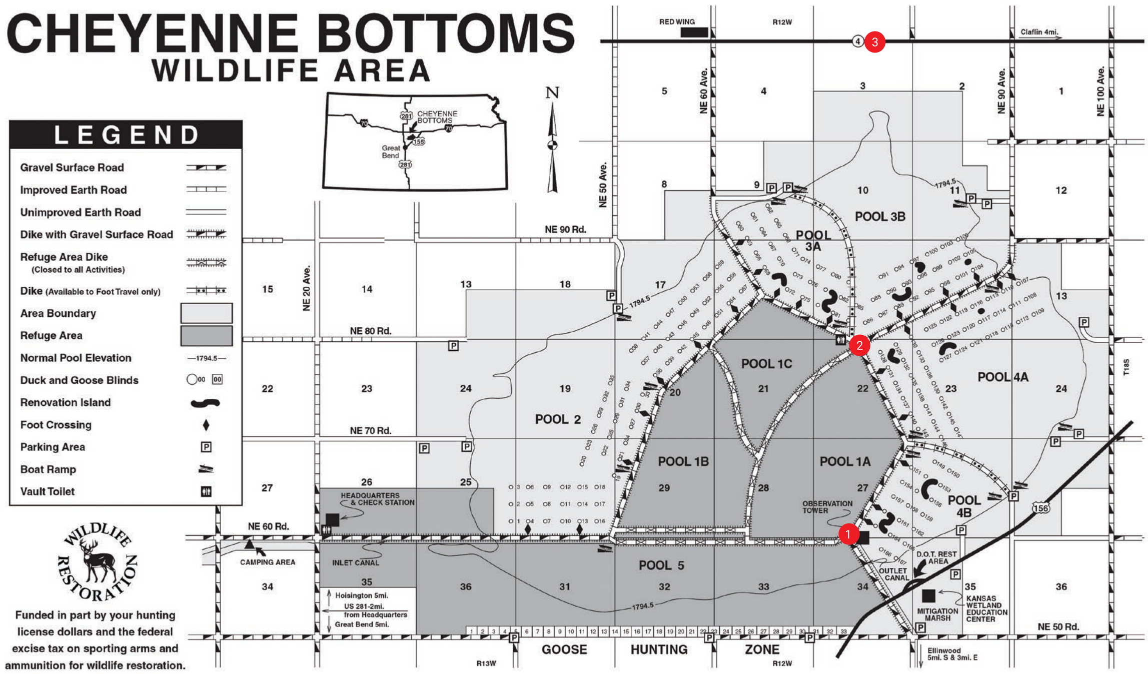


Figure 4. Map of Cheyenne Bottoms Wildlife Area (KDWPT) and stops on field conference tour.

additional habitat for migrating waterfowl and shorebirds by restoring the natural marshes, mud flats, and adjoining grasslands. TNC's property has since expanded to 7,848 acres. Unlike the shallow pools and wetland areas managed by KDWPT, TNC land is dry much of the year. During the spring and summer, controlled livestock grazing at the site replicates the role bison once played. The cattle eat dense and unwanted vegetation, compact the soil, maintain grass at a height desirable for shorebird use, and recycle nutrients.

TNC's preserve includes an overlook off Kansas Highway 4 between Claflin and Hoisington.

Kansas Wetlands Education Center and recreational opportunities

The Kansas Wetlands Education Center on Kansas Highway 156 at the southwest corner of Cheyenne Bottoms focuses on the Cheyenne Bottoms Wildlife Area, TNC's Cheyenne Bottoms Preserve, and nearby Quivira National Wildlife Refuge. Exhibits at the center highlight the diversity and benefits of wetlands to wildlife, humans, and the environment and also the management of wetland wildlife, vegetation, and water. The center was developed through a partnership of state and private entities, including KDWPT and Fort Hays State University, and provides educational programs. It is operated by Fort Hays State University as a branch of the Sternberg Museum.

Cheyenne Bottoms is one of the top-10 bird watching locations in the United States and is a popular spot for hunting, which is allowed in designated areas. Fishing and trapping also are permitted. Fish are not managed or stocked in the marsh and are limited to those entering the basin through waterways. Trapping requires a special permit and is prohibited in the refuge area and during waterfowl migration season. Cheyenne Bottoms gets between 20,000 and 90,000 visitors annually.

Birds and other wildlife

Migratory birds stopping at Cheyenne Bottoms have been tracked through banding as far north as western Alaska on the edge of the Arctic Circle and as far south as the tip of South America. Of the 477 bird species documented in Kansas, 352 have been recorded at Cheyenne Bottoms. Of those, 134 breed and nest in the area, 148 winter there, and 63 are permanent residents.

The migratory birds include snow geese, whooping cranes, pelicans, least terns, snowy and great egrets, big blue herons, long-billed dowitchers, piping plovers, godwits, mallard ducks, blue-winged teal, and American avocets. Raptors in the wetland include red-tailed hawks, Mississippi kites, osprey, bald eagles, peregrine falcons, and great horned owls. Non-migratory birds, such as the non-native ring-necked pheasant, winter and nest in the adjacent grasslands year-round.

Insects and other invertebrates also are an important part of the food chain and life cycle at Cheyenne Bottoms. Shorebirds, wading birds, breeding female waterfowl, and broods of waterfowl eat primarily invertebrates. In turn, invertebrates play an important role in the decomposition of vegetation, nutrient processing, and pollination, and pollinators depend on the habitat's native grasses and forbs.

Other wildlife thriving in the wetland environment include badgers, bobcats, beavers, bats, deer, armadillos, muskrats, mink, weasels, salamanders, snakes, carp, and channel catfish.

Cheyenne Bottoms geology

How Cheyenne Bottoms formed has long been debated. In 1897, Erasmus Haworth, later director of the State Geological Survey (now KGS), suggested that stream erosion carved out the elliptical hole in bedrock. Subsequently, geologists hypothesized that it was a sinkhole formed by the dissolution of an underlying salt layer. In the 1970s, KGS geohydrologist Charles Bayne undertook an investigation to determine whether the basin resulted from dissolution of the underlying Hutchinson salt member or whether it was the result of deeper structural movement. After compiling subsurface maps from geologic data collected during oil-and-gas drilling, Bayne identified structural changes beneath the salt layer that he asserted led to the formation of the basin.

Figure 5. Pumps used to move water between pools at Cheyenne Bottoms Wildlife Area.

Figure 6. Snowy egrets at Cheyenne Bottoms Wildlife Area. Photo by Dan Witt.

Tuesday, June 11, 2019

6:30 a.m.	Breakfast buffet at Holiday Inn Express, Great Bend
7:15 a.m.	Load luggage and check out of room.
7:30 a.m.	Bus to Cal-Maine Foods, Inc.
8 a.m.	**Stop 3: Cal-Maine Foods and the poultry industry in Kansas** Brian Ballard, General Manager
8:50 a.m.	Bus to CHS Refinery, McPherson
9:45 a.m.	**Stop 4: CHS Refinery at McPherson: Operations and Upgrades** Rhett Heflin, Environmental Manager Jake Hamlin, Government Relations
11 a.m.	Bus to Wichita's Aquifer Storage and Recovery Project river intake and treatment plant, Sedgwick, Kansas
Noon	**Stop 5: Wichita's Aquifer Storage and Recovery (ASR) Project** Joe Pajor, Public Works Deputy Director, City of Wichita Shawn Maloney, Environmental Division Manager, City of Wichita Scott Macey, Water Resources Engineer, City of Wichita Brian Meier, Project Manager, Burns and McDonnell Dan Clements, Project Manager, Burns and McDonnell
12:50 p.m.	Lunch at ASR treatment plant
2:45 p.m.	Bus to Next GINeration, Cullison
	Bus Talk: Equus Beds GMD2's perspective on Wichita's ASR Permit Requests Tim Boese, Groundwater Management District 2
	Restroom break at Love's truck stop, Cunningham
4:45 p.m.	**Stop 6: Next GINeration Cotton Gin** David Lingle, Manager Stuart Briggerman, Owner

5:45 p.m.	Bus to Kansas Department of Wildlife, Parks and Tourism office
6 p.m.	**Kansas Department of Wildlife, Parks and Tourism Pratt office**
	Welcome Jake George, Interim Assistant Secretary
	Social
	Stop 7: Seismic Station (optional—hike to back of fish ponds yard)
6:45 p.m.	Dinner
	Tour of KDWP&T Fish Hatchery (optional)
8 p.m.	Bus to Holiday Inn Express, Pratt

STOP 3

Cal-Maine Foods and the Poultry Industry in Kansas

KEY FACTS

- Cal-Maine Foods, Inc. houses up to 2.5 million chickens at its Chase, Kansas, facility.
- On average, the Chase facility produces 120,000 dozen eggs daily.
- The commercial poultry industry is one of the largest users of feed grain in the United States.
- Egg, turkey, and pullet production has expanded in Kansas over the last eight years.
- The potential for further commercial poultry industry expansion in Kansas is high.

The poultry industry in Kansas is dwarfed by the state's large beef cattle, dairy, and hog industries, and although Kansas ranks 34th out of 50 states in terms of poultry-related production, the industry is healthy in Kansas. Egg production, turkey farming, and replacement pullet production have expanded in Kansas over the past eight years. In 2016, egg and poultry meat sales generated a direct output of $65 million, and an economic contribution of more than $119 million through indirect and induced impacts, such as increased business and jobs for suppliers and increased personal income spent at local businesses. The poultry industry is one of the largest users of feed grain in the United States. Kansas State University experts see good potential for in-state expansion of the commercial poultry industry in part because feedstock (corn, soybeans, sorghum) is readily available and poultry operations require relatively little land. K-State researchers also note the growing importance of game bird production for hunting outfitters.

Figure 1. Inside a poultry house for organic eggs. Source: Big Dutchman.

Figure 2. Cage free chickens inside poultry house with artificial lighting. Source: Big Dutchman.

Poultry operations are subject to state regulations that require all Confined Animal Feeding Operations (CAFO) with a capacity of 300 or more animal units to obtain a state permit. One 700-pound beef cattle is one animal unit; one chicken is significantly less than one animal unit. In 2018, Kansas Senate Bill 405 defined each chicken as 0.003 animal unit at facilities that use a dry manure waste system. Operations that have 100,000 or more laying hens and a dry manure waste system must obtain a permit and, as required by the permit, meet minimum distances between chicken barns and other inhabitable buildings or property lines and follow regulations to protect against soil and water contamination. Most commercial chicken housing uses a dry manure system. The airflow in the building is designed to help dry the manure and reduce the amount of ammonia produced.

One challenge to the expansion of the poultry industry in Kansas is the lack of in-state processing facilities. Greater transportation distances to processors add to the cost of operation.

Cal-Maine's Kansas facility at Chase

The state's primary commercial egg production takes place in central Kansas at Cal-Maine Foods, Inc. There's a good chance you've eaten eggs produced by Cal-Maine, as the company's eggs are sold under the brand names Eggland's Best, Land O Lakes, and Farmhouse, among others. Cal-Maine is the largest shell egg producer in the United States, producing conventional and specialty eggs (organic range-free, Omega-3 enhanced). The Cal-Maine name refers to the company's ambition to provide eggs from California to Maine (fig. 1).

Cal-Maine's facility near Chase houses 1.2 million conventional layers, 800,000 organic layers, and about 500,000 pullets, for a total of nearly 2.5 million chickens on site. The company began operations at this facility in 1997 with about 200,000 birds and expanded to include organic eggs in 2008. Today, production can reach 120,000 dozen eggs per day, seven days a week, which averages out to five semi-loads daily. This facility, which includes a feed mill, buys corn and sorghum locally and also trucks in supplies. About 58 million gallons of water, the equivalent of about 178 acre-feet, is pumped yearly from 12 wells at this production facility. Waste water goes into lagoons and is then used to irrigate nearby wheat fields.

Conventional chicken houses at the Cal-Maine site are two stories; birds live on the second story and manure collects on the ground floor. The company uses swamp coolers in the hot summer months to cool the houses, and air baffles on the roofs can be adjusted to create a cross breeze. The hens lay eggs onto a sloped floor that rolls them onto a belt to be mechanically transported for washing, sorting, and packaging. Chicken litter on the ground floor is cleaned out annually, which helps control the odors and flies. The dry manure is sold within a two- to three-hour drive of the site.

The process in the organic chicken houses is a little different. There, the chickens are kept in an open, cage-free system. Nesting boxes are used to encourage hens to lay. From the nesting box, the egg rolls to a belt for processing. Automation of egg gathering in nesting boxes is about 92% efficient; the rest of the eggs not laid in the nesting boxes are gathered by hand and placed on the belt. During most of year, the birds have access to open air in a caged yard. In the winter, the houses are heated due to a lower bird density than in the conventional chicken houses. The organic houses employ technology designed in Germany to simulate nightfall, and a mechanical collector captures most of the manure on a moving belt that loads directly into trucks.

Housekeepers tend to the chicken houses daily. They collect any dead birds (mortality rate is about 0.08% weekly), check on the ventilation and feed lines, and perform maintenance. If a bird isn't happy, it isn't producing; it shows up quickly in egg yields. Old birds are sold live to a firm in Minnesota, where they are used to produce such items as whole chicken in a can.

The Cal-Maine facility in Chase has approximately 200 employees. As in most rural areas, finding and retaining employees is a challenge. Some of the positions come with on-site housing and trucks, a benefit that also assures someone is available to care for the birds even during a blizzard or other emergency. To meet their workforce needs, Cal-Maine hires about 40 inmates from the Hutchinson Correctional Facility.

Disease prevention and regulations

A significant risk to chickens is disease spread by migratory birds, a danger of particular concern because the Cal-Maine Chase operation is located in the Central Flyway. To reduce the threat of chickens contracting diseases from wild bird feces, a roof covers the open garden areas available to the organic chickens. Another major risk is contaminants or diseases brought into a house from humans. This facility practices bio-security measures to limit those risks.

Certainty about regulations is important for the poultry industry, and managers at Cal-Maine try to anticipate the direction of future legislation and plan accordingly. At the end of 2016, an accelerated federal approval of more restrictive rules for organic layers nearly halted organic egg production at the Cal-Maine Chase facility. The site's organic houses would not have met regulations related to the minimum required footage per animal, access to an uncovered outdoor space, or a requirement that the houses rely solely on natural light. In 2017, the new administration froze the rules, which were subsequently reviewed and then revoked.

NOTES

CHS Refinery at McPherson: Operations and Upgrades

STOP 4

KEY FACTS

- CHS Inc., parent company of the oil refinery in McPherson, is the largest cooperative refiner in the United States.
- CHS Refinery at McPherson can process up to 100,000 barrels of crude oil a day, up from 85,000 in 2015.
- The refinery purchases the majority of its crude oil from Kansas producers.
- An automated and safer coker used to break down heavy crude oil into marketable products went online at the refinery in 2016.
- The refinery cuts down on groundwater use by recycling city wastewater and water recovered from a groundwater-remediation site.

CHS Inc. is a global agribusiness owned by U.S. farmers, ranchers, and cooperatives. Diversified in energy, grains, and foods, its holdings include refineries in McPherson, Kansas, and Laurel, Montana. Combined output from the two refineries makes CHS the largest cooperative refiner in the United States. Before 2015, the McPherson refinery was owned by several regional cooperatives, including CHS, and operated under the name National Cooperative Refinery Association (NCRA).

In 2015, CHS took sole ownership of the NCRA refinery and its related pipelines and terminals. Now called CHS Refinery at McPherson, the facility purchases the majority of its crude oil from Kansas producers and has a refining capacity of 100,000 barrels a day (one barrel equals 42 gallons). Capacity is the maximum amount of crude oil that can be processed. Annually, CHS sells more than 3 billion gallons of refined fuels processed at the McPherson and Laurel plants, including gasoline and diesel piped throughout the upper Midwest. The company markets its products under the Cenex brand.

Plant and water-use upgrades at the McPherson refinery

Construction of a new coker at the McPherson refinery began in March 2013 and was completed in February 2016. The coker is used to break down the heaviest portions of crude oil into lighter liquids and petroleum coke, a solid carbon-rich material. The liquids are converted into gasoline, diesel, or other petroleum products, and the coke is sold as fuel for smelting iron ore or other industrial uses. Compared to its predecessor installed in 1953, the new coker can process a much greater variety of crude oils, including heavier Canadian crudes.

The fully automated decoking control system also provides a safer working environment because operators are now able to remove coke from the machinery in a protected area at a safer distance from the coker. As a result of overall updates, processing capacity at the refinery rose from 85,000 barrels per day in 2015 to the current level of 100,000.

After purchasing the refinery, CHS began using recycled wastewater provided by the city of McPherson rather than groundwater for its refining processes. That change reduced the demands the refining process made on the local aquifer, which has been in decline. Water removed from the viscous sludge at the city's wastewater treatment facility is discharged into a reaeration basin where oxygen is added, passed through a disinfection unit, and discharged to Dry Turkey Creek. What water the city doesn't divert from the creek for reuse in the treatment facility or for Turkey Creek Golf Course is pumped to CHS for use in its processing systems.

CHS also uses water recovered from a groundwater remediation project known as the East Refinery Groundwater Quality Improvement Project. Begun under NCRA, the project was established to reduce the migration of chloride-laden plume of brine, or saltwater, in the Equus

Bed aquifer. The brine plume resulted from saltwater-disposal practices during the early years of the Johnson oil field, which was discovered in the 1930s. Although the oil field activity was unrelated to the refinery operations, NCRA, and later CHS, agreed to provide remediation.

The remediation system consists of 12 recovery wells to the east of the refinery that are used to remove the chloride-impacted water from the Equus Beds aquifer, a main source of water for Wichita and surrounding communities. CHS treats the recovered water through a reverse osmosis system and then uses it in the refining process. Any treated water that still does not meet quality standards for refining is injected into a Class I non-hazardous disposal well.

Through other environmental-related measures, the refinery reduced its reported sulfur dioxide emissions by 95 percent and volatile organic compounds emissions by 70 percent over the past decade.

Crude oil vs. petroleum

Crude oil is a mixture of naturally occurring liquid hydrocarbons trapped in the pores of underground geologic formations. It comes in a variety of chemical compositions, colors, and densities. Colors range from black to brown to green.

Although the terms “crude oil” and “petroleum” are often used interchangeably, petroleum is a broad category that includes crude oil and other liquid hydrocarbons, gas and solid hydrocarbons, and products made from hydrocarbons. Petroleum products include gasoline, jet fuel, kerosene, petrochemical feedstocks, waxes, and asphalt. Petroleum also is used in the manufacture of footballs, telephones, nylon, crayons, bicycle tires, lipstick, perfumes, antihistamines, skis, guitar strings, toothpaste, food preservatives, and hundreds of other items.

Crude oil is referred to as fossil fuel because it is formed from the fossilized remains of plants, animals, and other organisms

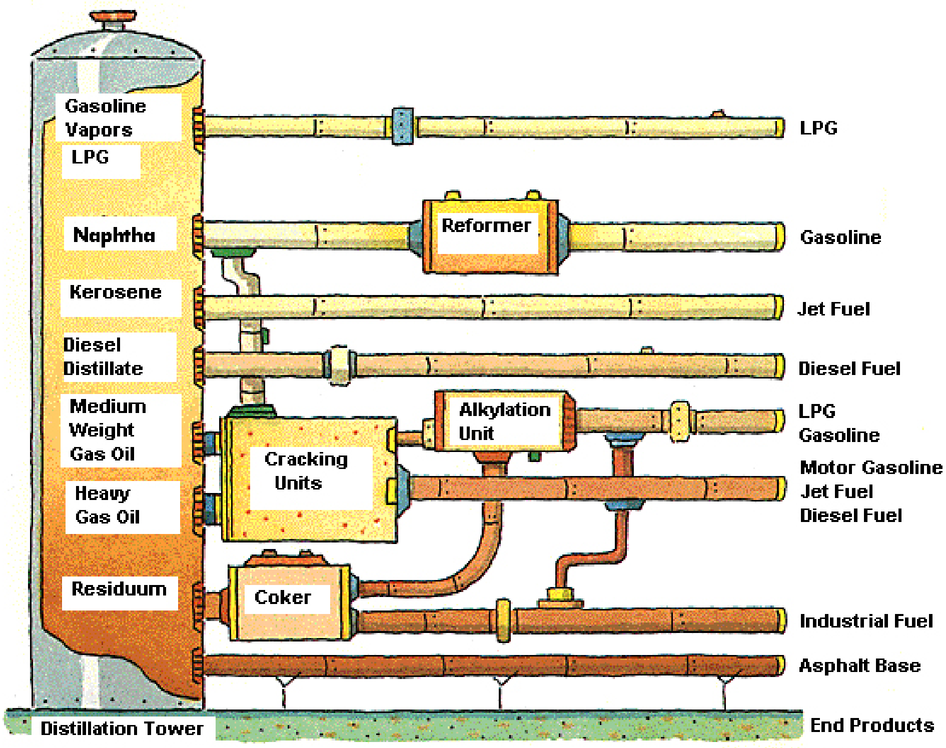


Figure 1. Simplified drawing of distillation and other refining processes. Source: U.S. Energy Information Administration.

that were subjected to underground heat and pressure over millions of years. The idea that dinosaur remains are a source of crude oil is a common misconception. Crude oil is actually derived from tiny or microscopic, and mainly marine, organisms.

The types of products a specific crude oil yields, such as gasoline or heating oil, are determined by the type of organic material from which it was derived and the subsurface conditions under which it formed. Crude oils from different production zones vary in content and density.

Crude oil is classified as light, medium, or heavy, based on its density. Lighter fluids with low viscosity are easier to refine and have more economic value. They often yield greater proportions of gasoline. Crude oil is also often described in terms of its sulfur content. If it has a small quantity of sulfur, it is sweet and if it has a large quantity, it is sour. Sweet crude is cheaper to refine because little excess sulfur has to be removed at the refinery.

Refining

The McPherson and Laurel facilities are two of the 142 oil refineries nationwide that, in total, process 17 million barrels of crude oil a day. In the United States, where crude oil is transported to refineries primarily through pipelines, more than 207,000 miles of liquid petroleum pipelines traverse the country.

During the refining process, crude oil is separated into its component parts (fig. 1) and impurities, such as sulfur, are removed. First, the crude oil is broken down into separate hydrocarbon components in a distillation unit, also called a crude unit. In the unit's distillation column, also known as a still, the different products boil off and are recovered at different temperatures. Lighter products, such as liquid petroleum gases (LPG), are recovered at the lowest temperatures. Mid-range products include jet fuel and diesel fuel. The heaviest products, such as residual fuel oil, are recovered at temperatures that may reach more than 1,000 degrees Fahrenheit (fig. 2).

These distillation products are then converted into usable products by changing the size and structure of the hydrocarbon molecules through cracking, reforming, and other conversion processes. The converted products are subjected to various treatment and

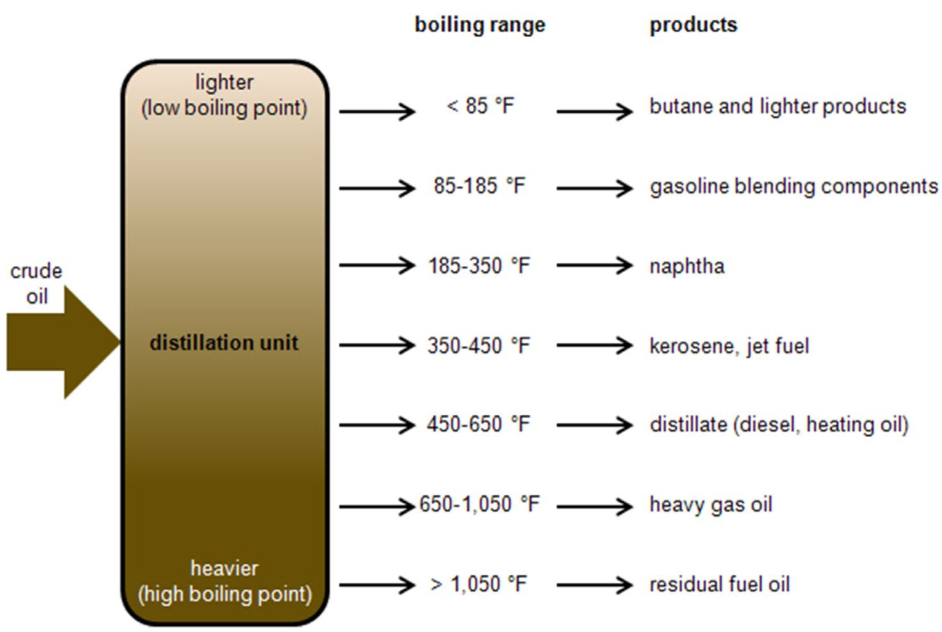


Figure 2. The boiling range of products separated out of crude oil in a distillation column, or still. Source: U.S. Energy Information Administration.

separation processes to remove impurities and improve quality.

Almost half of the crude oil that flows into U.S. refineries is converted into gasoline and another quarter is processed as diesel fuel (fig. 3). The gasoline, diesel, and other refined products are transported from the refineries mainly by truck, pipeline, or barge. The final cost of the petroleum products takes into account the price of crude oil; refining, distribution, and marketing costs; and any applicable federal and state taxes (fig. 4).

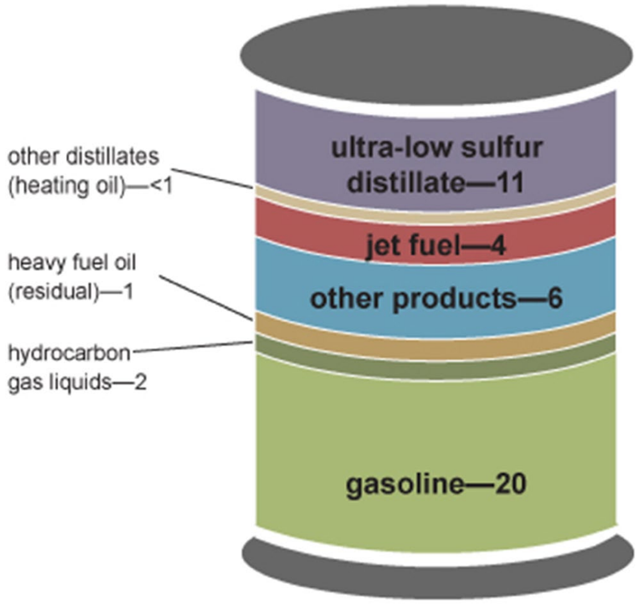


Figure 3. Gallons of petroleum products made from a 42-gallon barrel of crude oil. A 42-gallon barrel of crude oil yields 45 gallons of petroleum product because the density of the the output (the refined product) is different from the density of the input (the crude oil) due to the refining process. On average, 20 of the 45 gallons is gasoline. Source: U.S. Energy Information Administration.

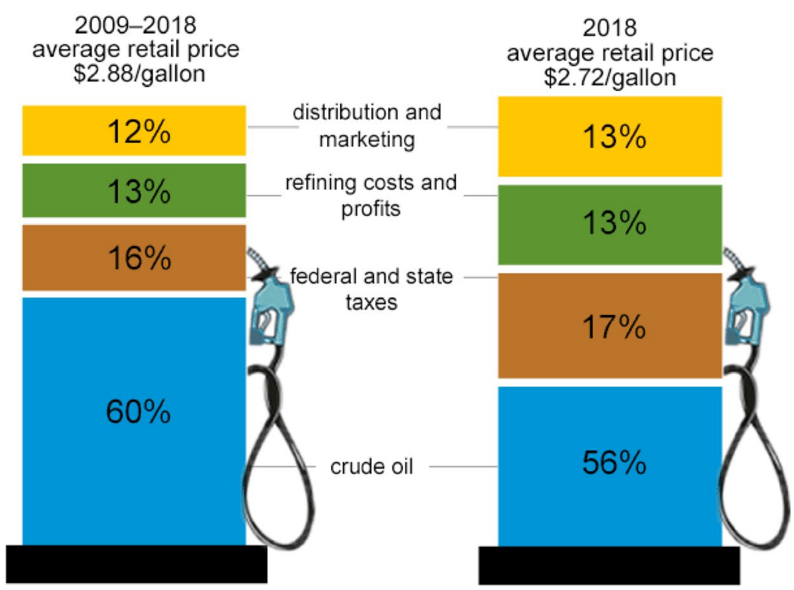


Figure 4. Approximately what consumers paid for when buying a gallon of gasoline from 2009 to 2018 and in 2018. Source: U.S. Energy Information Administration.

Securing Water for Dry Times: Proposed Changes to Wichita's Aquifer Storage and Recovery Project

STOP 5

KEY FACTS

- Wichita's Aquifer Storage and Recovery project (ASR) diverts excess flows in the Little Arkansas River, treats it, and stores it in the Equus Beds aquifer until needed.
- The city receives credits for the recharged water, which allows Wichita to pump from the aquifer when the water table is above a minimum elevation.
- Wichita is requesting a change to its permit to lower the minimum water level above which the city can pump.
- The Equus Beds aquifer is nearly full in the area of the recharge project, leaving limited underground storage space.
- Wichita is requesting a change to its permit to receive aquifer maintenance credits when diverted river flows are used without storage due to limited recharge space.
- Some area stakeholders are concerned that the proposed changes may harm their water rights or groundwater quality.

A 1993 study projected the city of Wichita would run out of sufficient water by 2015 without additional sources. In response, the city envisioned an Aquifer Storage and Recovery project (ASR), an innovative strategy to capture excess streamflows in a region already fully appropriated. The ASR process diverts water from the Little Arkansas River during high flows, treats it, and stores it in the Equus Beds aquifer for later use. In addition, the project creates an underground hydraulic ridge, which retards the Burrton oil field chloride plume that was moving toward the city's wellfield. The city now has sufficient quantities of water to meet projected normal demands and growth but would still be at risk during an extended, severe drought.

In March 2018, to improve its water security, Wichita proposed the following changes to its ASR permit: 1) lower the minimum standard water table elevation above which it is allowed to pump and 2) when there is insufficient underground storage space, receive aquifer maintenance credits for the direct use of diverted flows without first storing the water. These changes would help protect the city's water needs in an extended drought and reduce unnecessary pumping of the aquifer when not in a drought.

The permit changes must be approved by the chief engineer, Department of Agriculture, Division of Water Resources (DWR). A number of area stakeholders are concerned that, if approved, the changes requested by Wichita could jeopardize their water quantity or quality.

Basics

Wichita's water supply comes from Cheney Reservoir and the Equus Beds aquifer. The city has permitted water rights of 40,000 acre-feet in its Equus Beds wellfield. A 1993 study projected the city's appropriated quantity would not meet expected water needs in the 21st century. During the 1990s, Equus Beds aquifer pumping for irrigation and municipal demands had led to groundwater declines of up to 40 feet, and additional new appropriations were not an option. The ASR provides a creative solution to the city's potential water shortfalls by diverting unappropriated high flows from the Little Arkansas River, treating the water, and storing it in the aquifer for later use.

Phase I of ASR was completed in 2006 with a focus on retarding the Burrton chloride plume. Phase II began in 2013 with goals of both retarding the plume and extending the longevity of the aquifer. Construction costs for Phase I and II totaled about $247 million.

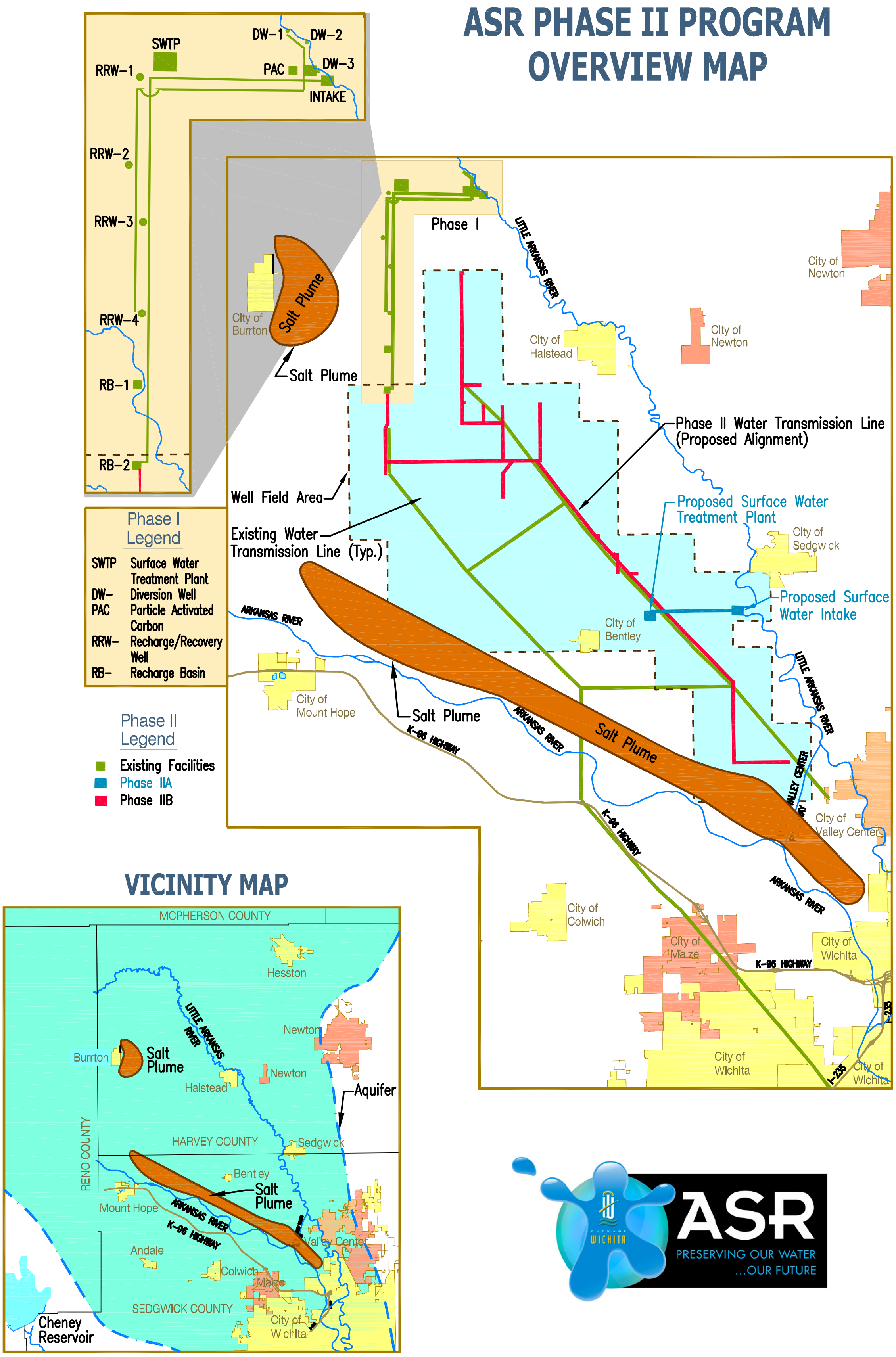


Figure 1. Wichita's aquifer storage and recovery project layout map. Source: City of Wichita.

Now operational, Phase II of ASR has the capacity to process 30 million gallons of water per day. There is one point of diversion, one treatment plant, one active recharge basin, and 30 recharge wells (fig. 1). Water diverted from the river is sent to a settling basin, where the sediment settles out and is returned to the river. The water is then treated using ultrafiltration membranes and advanced oxidation techniques (fig. 2). The river water is treated for any constituents of concern, such as atrazine, before the water is put into the aquifer.

The city receives recharge credits for water recharged into the aquifer, which allows the city additional water to pump to meet its needs. A groundwater-flow model is used to estimate the storage changes that can be attributed to artificial recharging of the aquifer. The total accumulation of recharge credits cannot exceed 120,000 acre-feet, which was the amount of aquifer storage space available within the ASR project area in 1993.

Through February 2019, the ASR project has recharged 12,762 acre-feet (4.1 billion gallons) into the aquifer through injection wells and an infiltration basin. By 2017, the Equus Beds aquifer levels had risen to near predevelopment levels (98% full). This meant there would be limited storage options, unless new recharge fields were developed.

The city is allowed to pump its recharge credits as long as the water table is above the minimum standard set at the lowest measured aquifer level in 1993, which was 88% of the predevelopment water level. Below that level, the city cannot use recharge credits to pump from the aquifer. This requires the city to anticipate a need for extra water and pump it before a decline in the water table makes it no longer legally accessible.

A 2014 comprehensive water supply evaluation study indicated that the city now had adequate water to meet existing needs and future demands but was at risk during a 1% drought, which is a drought of such severity that there is only a 1 in 100 chance of it occurring in any given year. The improved outlook for having sufficient water outside of the 1% drought was in part due to conservation through a revised water-use rate structure, a

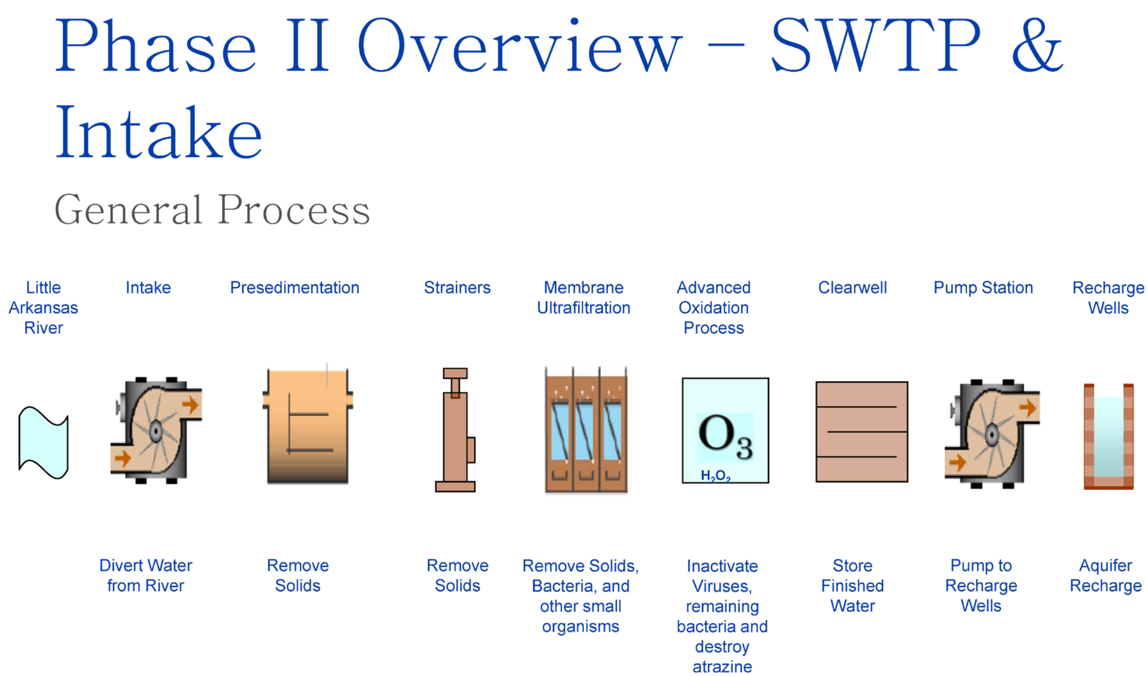


Figure 2. Wichita ASR process from river intake through surface water treatment plant (SWTP). Source: Burns & McDonnell.

city-financed conservation outreach effort, and consumers using more efficient appliances.

Proposed permit changes

Through the ASR permit modifications, the city is proposing an innovative strategy to buffer against the next extended severe drought. It is seeking changes to the ASR permit in two ways:

1. *Lower the minimum standard groundwater level.* The city is seeking to lower the minimum standard water table below which it can no longer access water through its recharge credits (fig. 3). Currently, that level is set at 88% of the predevelopment elevation of the aquifer. The city proposes to lower it to 80% of the predevelopment water table. During a drought, there is less recharge to an aquifer and an increased demand for groundwater for irrigation, municipalities, and other uses, leading to groundwater level declines. If the city's ASR permit allows Wichita to access their recharge credits at a lower level than currently allowed, this would provide more time for a drought to abate before the city determines whether to pump water under its recharge credits, while it is still legally accessible. A lowered minimum standard for the groundwater elevation would reduce the frequency of the city's accessing its groundwater credits and keep the aquifer levels higher more of the time.
2. Allow for recharge credit when the city uses river water diverted during high flows without first storing it in the aquifer. Instead of developing more land for aquifer recharge, when the recharge field is 95% full the city would like to treat the high river flows and send them directly for the city's use. This would meet demands that would otherwise be met from their appropriated water rights in the Equus Beds aquifer and is more efficient than developing a new wellfield for storage. While the Little Arkansas River is flowing above base flow and excess flows can be diverted, the city would like to continue to build up a buffer supply in the aquifer. The city proposes earning what are called aquifer maintenance credits (AMC) when the diverted high flows are used directly by the city due to lack of storage space in the aquifer. When water is actually recharged to the groundwater, it is called a physical recharge credit (PRC).

Other groundwater users' concerns

Equus Beds Groundwater Management District 2, Harvey County commissioners, and area landowners have expressed concerns with or have questions about the proposed ASR permit modifications, which they shared with the chief engineer, DWR. Comments and questions were raised about lowering the minimum standard water elevation above which the city could pump water allowed through recharge credits. Would this change harm the streamflow with a lower water table? Would it create a faster migration of the chloride plume with a greater hydraulic gradient? If the minimum elevation above which the city can pump its recharge credit water is revised down, would the aquifer be more stressed and shortages be more critical for all users?

Concerns also were expressed about the city receiving credits for aquifer storage when, in fact, the storage step was bypassed and the city used the water directly. The ASR permit specifically states that passive recharge credits should not be allowed.

Status

The public hearing on the ASR permit modification proposal scheduled for March 2019 was postponed and is expected to be rescheduled for the fall of 2019. After the hearing, the hearing officer will provide written recommendations for the chief engineer. The chief engineer decides whether or not to approve the proposed permit changes. He considers whether the proposed changes are reasonable, will not impair existing rights, and will not unreasonably affect the public interest.

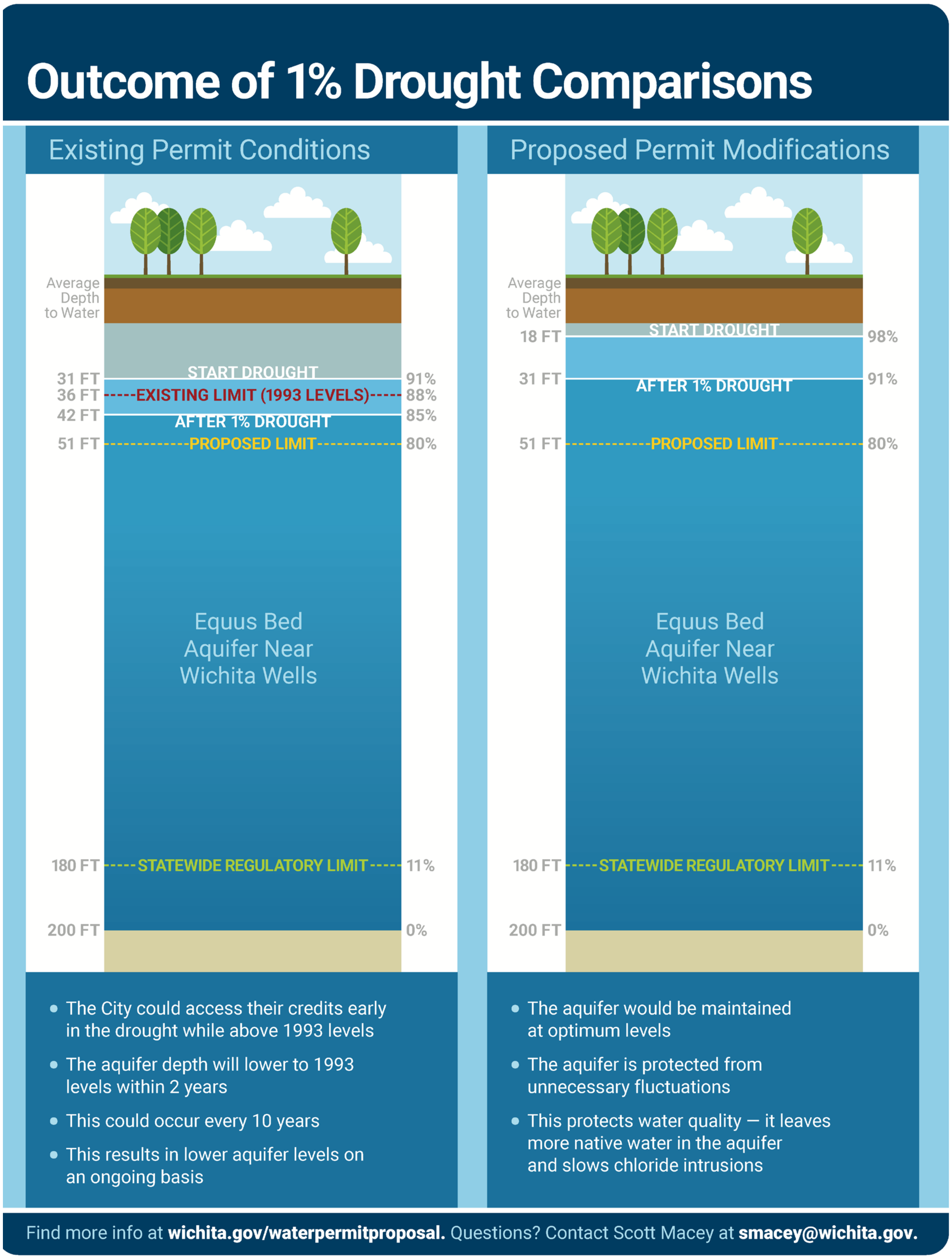


Figure 3. Schematic of groundwater levels during a 1% drought under current and proposed ASR permit modifications. Source: City of Wichita.

NOTES

Cotton in Kansas

STOP 6

KEY FACTS

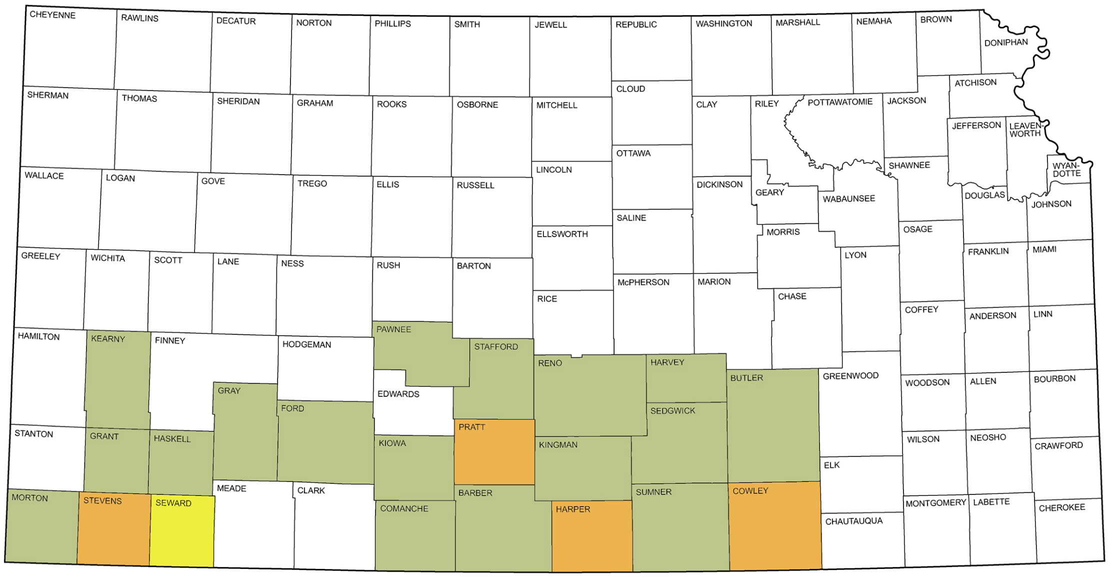
- The number of acres in Kansas planted in cotton rose 77% from 2017 to 2018 and more than 900% since 2015.
- With cotton growing in 22 Kansas counties in 2018, the state ranked 14th in production.
- Cotton was first grown in Kansas during the civil war, but notable production didn't occur until the 1990s.
- All five of the state's cotton gins and a warehouse have been built since 1996.
- The United States is the third highest producer and lead exporter of cotton worldwide.
- Several factors influence cotton production, from shifting government policies to the fluctuating price of oil used to make polyester.

Cotton production first came to Kansas during the Civil War when cotton from the South was no longer available. After the war, production in Kansas diminished, became sporadic, and evaporated by the early 20th century. In the 1980s, limited production reappeared but not until the mid-1990s did production start to gain strength, spurred by a policy change introduced in the 1996 U.S. Farm Bill.

Informally known as the Freedom to Farm Act, the 1996 bill made cotton eligible for benefits previously restricted to other crops. With increased production, a gin was built that year in Winfield. Since then, production numbers in the state have fluctuated, swayed by environmental, regulatory, herbicide resistance, and economic factors.

By 2018 cotton was growing in 22 Kansas counties, gins were running in Winfield, Anthony, Moscow, and Cullison, and a cotton warehouse facility was operating in Liberal (fig. 2). The state ranked 14th in the United States in production (table 1) as a record 165,000 acres were planted and 342,000 480-pound bales were produced (figs. 3 and 4). At the same time, the United States was the lead exporter of cotton and the third highest producing country (fig. 5).

Figure 1. Cotton boll. Photo by Michael Bass-Deschenes.



Counties with cotton production
Counties with cotton production and a cotton gin
Counties with cotton production and a warehouse

Figure 2. Kansas counties with cotton production, cotton gins, and warehouse facilities in 2018. Data from the Kansas Department of Agriculture.

Table 1. 2018 U.S. cotton production by state (number of 480-pound bales). Data from USDA, National Agricultural Statistics Service.

Texas	6,935,000
Georgia	1,950,000
Mississippi	1,430,000
Arkansas	1,150,000
California	902,000
Alabama	860,000
Missouri	835,000
Tennessee	780,000
Oklahoma	750,000
North Carolina	700,000
Arizona	469,000
South Carolina	440,000
Louisiana	410,000
Kansas	342,000
Virginia	195,000
New Mexico	122,000
Florida	120,000
U.S. Total	**18,390,000**

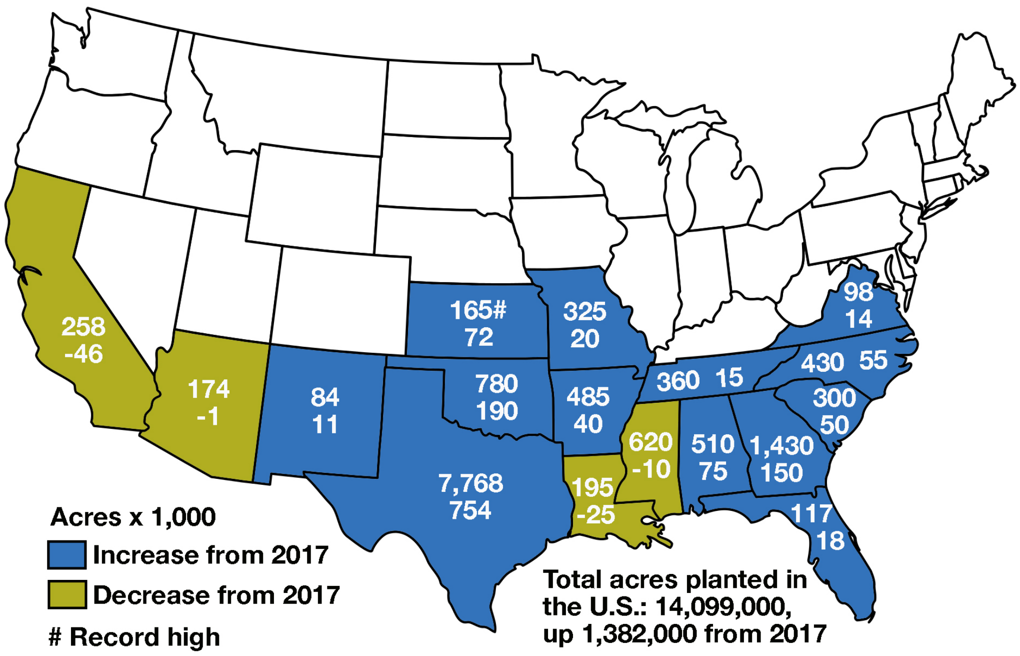


Figure 3. Number of acres (x 1,000) planted in 2018 by state and the increase or decrease of acres planted from 2017. Data from the USDA National Agricultural Statistics Service.

Figure 4. Numbers of 480-pound bales of cotton produced annually in Kansas from 1995 to 2018. Data from the USDA National Agricultural Statistics Service.

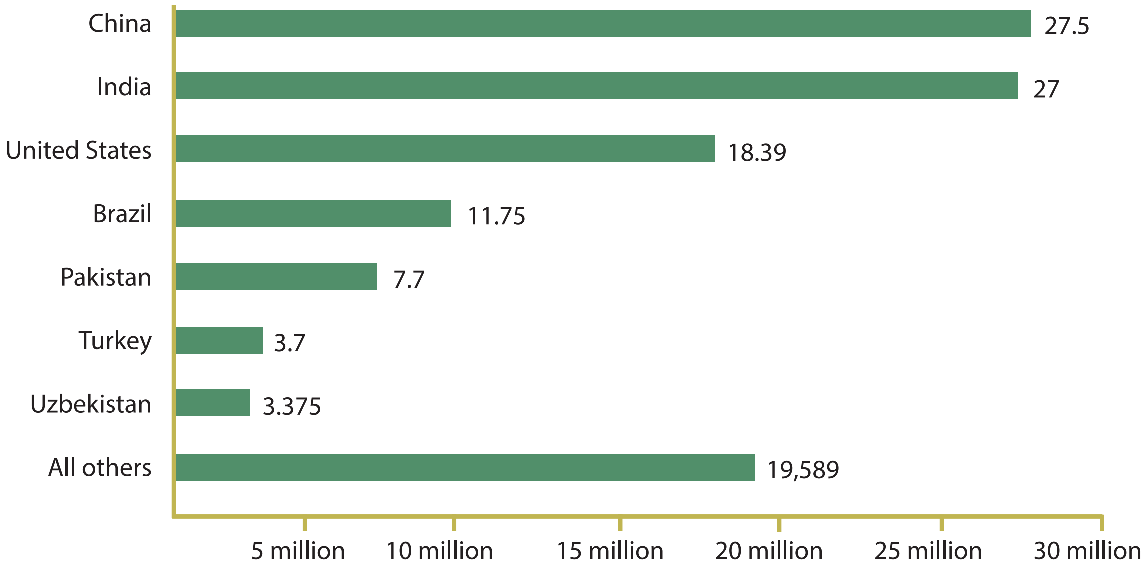


Figure 5. Number of 480-pound cotton bales produced by country for marketing year 2018–2019 (August–March). Data from USDA Foreign Agricultural Service.

Cotton farming and ginning

In Kansas, cotton is planted from mid-May to early June and harvested between mid-October and December or even into January, depending on the weather. Cotton bolls are removed from plants by a machine called a picker that shapes the raw cotton into 5,000-pound round bales.

At the gin, the raw cotton is separated into four products: lint, motes, seeds, and trash. The lint, used for clothing and other higher-quality goods, is pressed into 480-pound bales. Samples from each bale are sent to the USDA to be evaluated based on length, thickness, color, and cleanliness. The amount a farmer receives in payment is based on the USDA's assessment.

The motes—mainly fuzzy fibers from immature seeds—are used for mops and other products. In Kansas, the seeds are separated out and sold as dairy feed, although in other states they may be sent to crushing plants where the oil is squeezed out to be sold as cooking oil to Frito-Lay and other companies, and the meal is pressed into pellets for livestock feed. The trash, mainly hulls, stems, and leaves, is composted.

Although two types of cotton are produced in the United States—upland and higher-quality pima—only upland cotton is grown and ginned in Kansas.

Kansas cotton gins and warehousing

The gin at Next GINeration, Inc. at Cullison in Pratt County was built in 2004

The number of each item made from one bale of cotton

215	pairs of jeans	**765**	men's dress shirts	**3,085**	diapers
1,256	pillowcases	**2,104**	boxer shorts	**4,321**	mid-calf socks
249	sheets	**2,419**	men's briefs	**21,960**	handkerchiefs
690	bath towels	**6,436**	women's underwear	**313,600**	$100 bills
1,217	T-shirts				

Data from the National Cotton Council

Figure 6. Cotton bale production at Next GINeration, Inc. at Cullison in Pratt County.

(fig. 6). Originally operated as the High Plains Cotton Gin, it was purchased and renamed by a group of area producers in 2016. After a fire in 2017, the gin was repaired and equipment was upgraded to speed up the ginning process and add efficiencies that would reduce the number of employees required to operate it. Plans are underway in 2019 to add new gin stands and modernize the control system.

Fire is a perpetual concern at cotton gins, with dozens of fires reported in Kansas, Oklahoma, and Texas in 2017. Hot, dry, and windy conditions are often a contributing factor, and sparks from harvesting equipment can create a smoldering fire in a field bale's core that goes undetected until it bursts into flame when exposed to air at the gin.

The Southern Kansas Cotton Growers Cooperative, which owns the gins in Winfield and Anthony, has upgraded fire detection and suppression equipment and added computer automation. In addition, the cooperative is expanding its Anthony gin, built in 1998, to double capacity. Northwest Cotton Growers Coop built its first gin in Moscow in 2002. In 2018–2019, it built a second gin and began to make improvements for fire detection and suppression in the first gin.

Kansas gins work with the Plains Cotton Cooperative Association (PCCA), a marketing cooperative based in Lubbock, Texas. The PCCA's warehouse division encompasses six facilities, including one in Liberal, that serve as storage, sorting, and shipping points for PCCA members.

Opportunities and challenges for cotton producers in Kansas

Climate, limited water availability, herbicide-resistant seeds, and price variability are prime factors influencing the cotton-production decisions of Kansas farmers. The climate of the southern third of Kansas is suitable for cotton production, and advantageously, boll weevils that plague growers in the south don't thrive in colder weather here. In a region with sparse precipitation and declining groundwater levels, cotton has the advantage of being profitable with only one-half to one-third the amount of irrigation water needed to grow corn, alfalfa, or soybeans. However, if prices of those commodities increase and cotton prices don't keep up, they could become more profitable than cotton, despite its water-savings advantage. The price of non-agricultural products is also a consideration. For example, when the price of oil drops, polyester goods manufactured using petroleum become cheaper, making cotton less competitive.

Government policy and pest-control regulations play into farmers' decisions, too. In the 2014 Farm Bill, cotton again lost its status as a covered commodity before regaining coverage in 2018. Also in 2018, a U.S. court of appeals ordered a ban on the sale of chlorpyrifos, a commonly used product that controls cotton-wrecking insects but also kills other insects, birds, and fish. A more positive change was the approval in 2016 of a cotton variety less susceptible to crop loss due to wind drift from the herbicides 2,4-D and dicamba. Used successfully with other crops to control weeds, the herbicides can kill cotton.

Although cotton production in Kansas is a small percentage of the national total, production and ginning in the state have made large strides since 1996 when 4,000 480-pound bales were produced by a small group of growers in four counties, compared to the 342,000 produced in 2018 by more than 400 growers in 22 counties. As development of new varieties of cotton and technological production and ginning options continues, southern Kansas farmers will have more incentive to include cotton in their crop rotation management systems and diversify their marketing opportunities.

Earthquake Monitoring in Kansas

When earthquake activity accelerated in south-central Kansas in 2014, scientists suspected there was a link between the uptick and increased oil and gas activities in the region. In response, the governor established a task force to develop a plan to address induced seismicity, or earthquakes caused by human activities.

Leading the task force, the Kansas Geological Survey (KGS) was joined by the Kansas Corporation Commission and Kansas Department of Health and Environment in developing a plan to enhance seismic monitoring and determine the best way to respond to induced seismicity. Among the group's major findings, as outlined in the "Kansas Seismic Action Plan," was the need for a permanent state-supported seismic network.

At that time, the only seismic monitors that provided data for the state were two operated by the U.S. Geological Survey (USGS) in Kansas and a network of Oklahoma Geological Survey (OGS) monitors across the state line. Although the Oklahoma monitors picked up some of the new activity in south-central Kansas, the USGS monitors—at Cedar Bluff Reservoir in western Kansas and the Konza Prairie Biological Station near Manhattan—were too far away to record anything but the largest events.

STOP 7

KEY FACTS

- Disposal of wastewater associated with oil and gas drilling caused an uptick in earthquakes in south-central Kansas.
- To monitor those and other earthquakes in Kansas, the Kansas Geological Survey installed a permanent network of seismometers around the state.
- The KGS receives real-time data from its seismometers, which are sensitive enough to detect earthquakes lower than magnitude 1.0.
- Kansas is not at high risk for natural earthquakes, although some associated with subsurface geologic structures and fault zones have occurred.
- Increased activity in the state is due to induced seismicity, or earthquakes caused by wastewater disposal, reservoir impoundment, and other human activities.

The KGS network

In 2014, the USGS set up a temporary network of seismic monitoring stations in south-central Kansas in the vicinity of the increased earthquake activity, and the KGS soon installed its own temporary sub-regional network there. Then in 2016, the KGS established a seven-station permanent network throughout the state (fig. 1).

The KGS seismometers are sensitive enough to detect earthquakes lower than magnitude 1.0. In comparison, people rarely feel earthquakes below magnitude 2.5, which releases about 178 times more energy than a magnitude 1.0 earthquake.

During just one six-month period in 2016, the seismometers recorded 1,858 events between magnitude 0.0 and 3.1 in 20 Kansas counties, far more than had previously been recorded. Although some of the events were natural, most of the ones in south-central Kansas were induced by human activities. Before the KGS installed the network, most of those earthquakes would have gone undetected.

Data collected from the KGS networks were used to establish a connection between the earthquakes in south-central Kansas and nearby disposal of wastewater produced with oil and gas. About 85% of the earthquakes recorded were in Harper and Sumner counties during 2015, where much of the disposal was occurring. As a result of the findings, the Kansas Corporation Commission

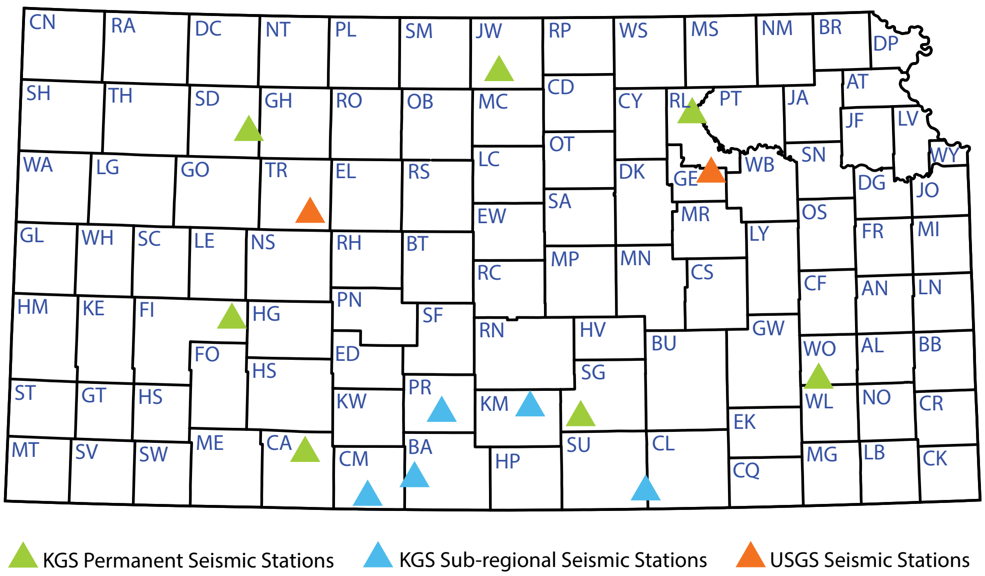


Figure 1. KGS and USGS seismic monitoring stations in Kansas.

required oil and gas companies operating in specified areas to reduce the rate at which they injected wastewater back into the ground. About the same time, oil prices dropped, leading to decreases in exploration and wastewater disposal. The earthquakes subsided.

Recent increased fluctuation of earthquake activity in the state as a whole (fig. 2) has been linked mainly to the increase and decrease of wastewater disposal in south-central counties near the Oklahoma border. Even a delayed uptick in earthquakes more than 50 miles north of the disposal sites has been tied in. In 2017, two years after disposal was scaled back and earthquakes subsided, they unexpectedly increased around Hutchinson. At the time, scientists thought earthquakes could not migrate that far from a disposal site. In a subsequent study, however, KGS researchers identified a pattern of northward-progressing epicenters recorded by the KGS seismic network and concluded that wastewater disposal had a much wider seismic reach than previously thought. Increased fluid pressure, they determined, could travel large distances over months, even years, before triggering earthquakes on far-off critically stressed faults.

Seismic data are available on the KGS earthquake webpage (http://www.kgs.ku.edu/Geophysics/Earthquakes/index.html). The site includes an up-to-date interactive map that shows the location of earthquakes greater than magnitude 2.0 and lists magnitude, date and time, and latitude and longitude for each event.

Seismic monitoring equipment

Seismometers are used to detect mechanical waves traveling on and beneath the earth's surface. They are typically installed on flat surfaces in underground vaults (fig. 3) to reduce interference from seismic noise created by nearby traffic and other sources, protect the sensor from the elements, and minimize the effects of fluctuating temperature and humidity. KGS seismic stations (fig. 4) include a seismometer (fig. 5) and digitizer; a cellular modem and antenna for real-time communications; and a solar panel and deep-cycle marine batteries to supply power (fig. 6).

The arrival times of waves recorded by a seismometer are used to calculate an earthquake's depth and epicenter as well as the surface location directly above the epicenter. Characteristics of the recorded seismic waves (fig. 7) can be analyzed to determine magnitude and the movement of subsurface rocks during an earthquake.

Natural earthquakes in Kansas

Natural earthquakes in the midcontinent are associated with subsurface structures and

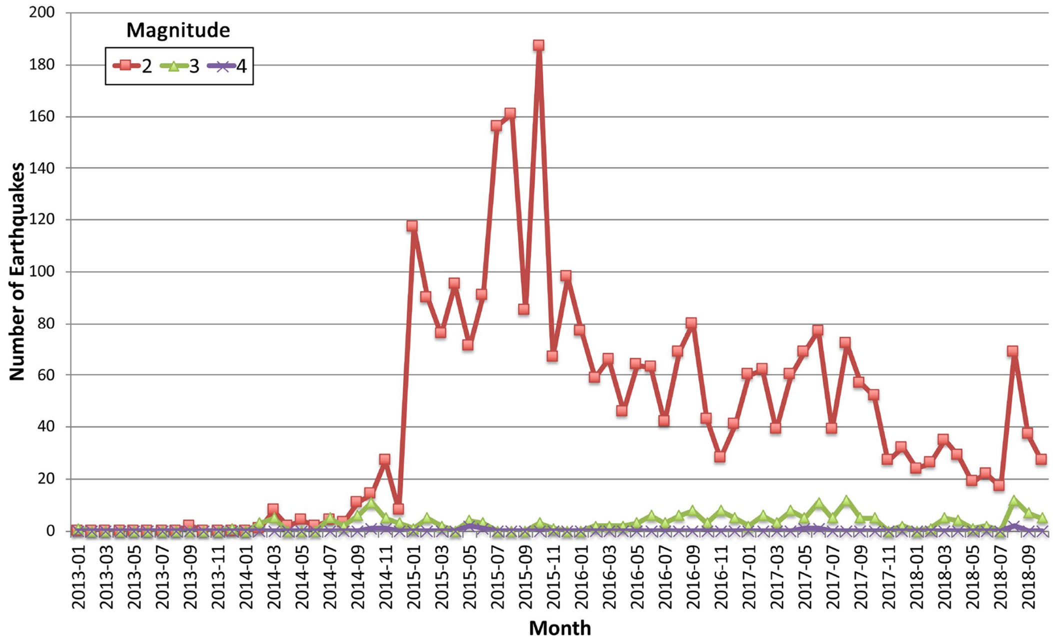


Figure 2. The number of earthquakes in Kansas, per month, between January 1, 2013, and December 17, 2018.

Figure 3. KGS seismic station installation.

Figure 4. KGS seismic station in Sedgwick County.

Figure 5. *Seismometer at a KGS seismic station in Sedgwick County.*

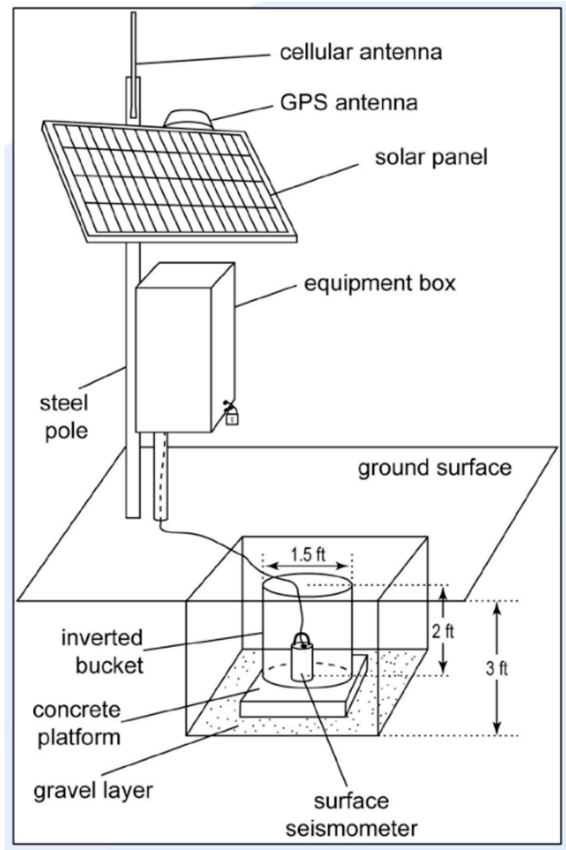


Figure 6. Illustration of a seismic station.

faults. Because the subsurface geology in Kansas is not conducive to large earthquakes, it is not considered a high-risk state.

The Nemaha Ridge, a buried mountain range that formed about 300 million years ago, runs below the surface from about Oklahoma City through eastern Kansas to Omaha. Associated with low-level seismic activity, the Humboldt fault zone along the eastern edge of the Nemaha Ridge was probably the source of the largest documented earthquake in Kansas—in 1867. Centered near Wamego east of Manhattan, the tremor rocked buildings, cracked walls, stopped clocks, broke windows, and was felt as far away as Dubuque, Iowa. Based on damage and reports, it likely would have measured between magnitude 5.0 and 5.5 if equipment to measure magnitude had been available at that time.

At least 31 felt earthquakes in Kansas were documented in newspaper accounts and other sources from 1867 to 1976. Those narratives would not have included earthquakes smaller than magnitude 2.5, which were too small to feel, and even some larger ones with epicenters in sparsely populated areas. Between 1977 and 1989, the KGS monitored a temporary network of seismometers throughout the state to study earthquakes and identify seismic risk. The equipment recorded more than 200 earthquakes during that time, ranging from magnitude 0.8 to magnitude 4.

Induced seismicity

All earthquakes linked to human activities are referred to as “induced seismicity.” Besides oil and gas production, activities associated with induced seismicity include mining, geothermal energy production, construction, underground nuclear testing, and impoundment of large reservoirs. Linking a specific earthquake to a specific human activity, such as wastewater disposal at a single well, is difficult. Complex subsurface geology and limited data about that geology make it hard to pinpoint the cause of many seismic events in the midcontinent. However, an established pattern of increased earthquake activity in an area over time can indicate a correlation between human activity and seismic events.

Most of the earthquakes in Kansas since 2013 have been caused by induced seismicity. However, more earthquakes, in general, have been recorded in the state in the past few years than in previous decades because the KGS seismic monitoring network is recording smaller ones that previously would have gone undocumented (fig. 8).

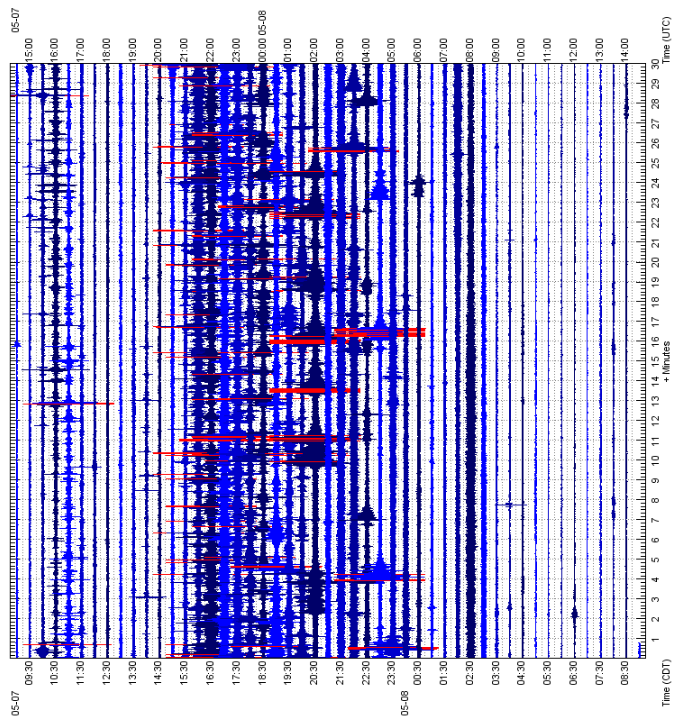


Figure 7. Seismogram of data received at the KGS seismometer in Clark County, May 7–8, 2019.

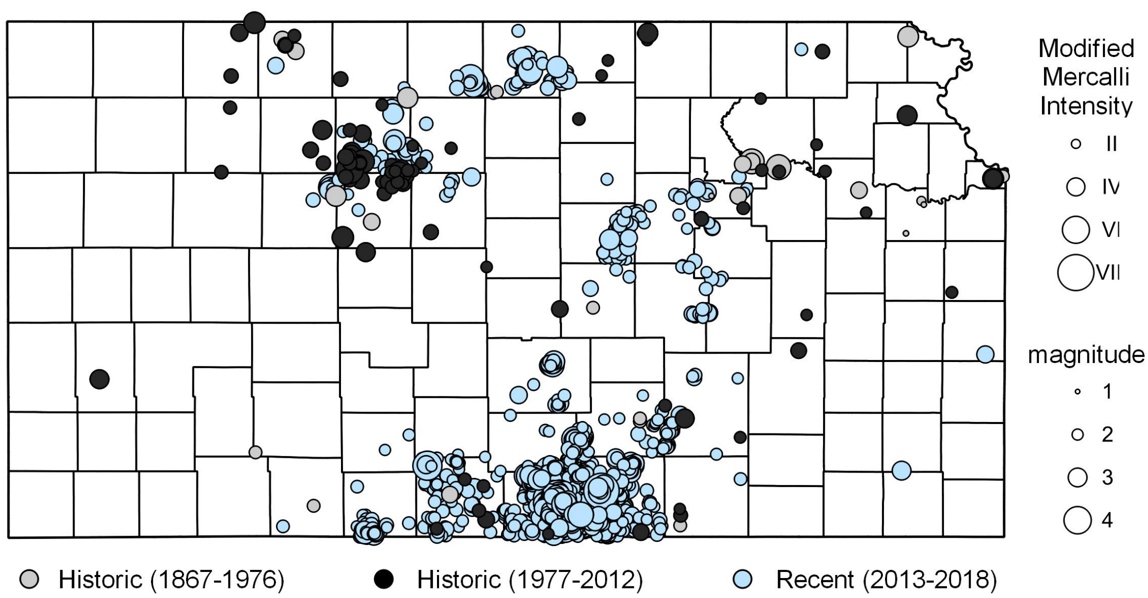


Figure 8. Earthquakes in Kansas from 1867 to 2018. The Modified Mercalli Intensity scale gages an earthquake size by its effect on people and structures. Magnitude is measured using a seismometer.

NOTES

Wednesday, June 12, 2019

6:30 a.m.	Breakfast buffet at Holiday Inn Express
7:15 a.m.	Load luggage and check out of room.
7:30 a.m.	Bus to City of Hutchinson's Class I wells
	Bus Talk: Maintaining Roads in Unique Settings in KDOT's District V Kyle Halverson, Kansas Department of Transportation
8:30 a.m.	**Stop 8: City of Hutchinson's Class I disposal wells** Joel Davenport, Superintendent of Water/Waste Water
9 a.m.	**Water Treatment Plant, City of Hutchinson** Brian Clennan, Director of Public Works
	Panel Discussion: Monitoring, Regulation and Challenges with Underground Waste Disposal Rick Miller, Kansas Geological Survey Tom Stiles, Kansas Department of Health and Environment Ryan Hoffman, Kansas Corporation Commission
10:20 a.m.	Bus to Strataca
10:30 a.m.	**Stop 9: Strataca Underground Salt Museum** Mary Clark, Interim Director Tonya Gehring, Operations Manager Myron Marcotte, Mine Specialist
Noon	Lunch in Permian Room
	Underground Storage and Vaults Lee Spence, President
	Hutchinson Salt Company Jim Barta, General Manager
1:20 p.m.	Bus to Sand Hills State Park
	Bus Talk: Fighting Hutchinson's 2017 Fire Rodney Redinger, Kansas Forest Service, Fire Program

1:40 p.m.	**Stop 10: Wildfires and Fire-Fighting, Sand Hills State Park** Mike Satterlee, Park Manager, KDWPT Doug Hanen, Division Chief of Operations, Hutchinson Fire Department Steve Beer, Fire Chief, Hutchinson Fire Department
2:15 p.m.	Bus to Great Bend **Bus Talk: Steps to Improve Fire-Fighting Coordination in Kansas** Larry Biles, Kansas Forest Service
3:15 p.m.	**Quivira National Wildlife Refuge** Restroom break and wildlife viewing (weather permitting)
4 p.m.	Bus to Great Bend
5 p.m.	Return to Holiday Inn Express, Great Bend

STOP
8

Deep Underground Disposal of Waste: Its Importance, Growing Cautions, and a Hutchinson Case Study

KEY FACTS

- Underground disposal is an important liquid waste solution for industries, municipalities, and oil and gas producers.
- Underground disposal mostly targets the deep saline aquifer of the Arbuckle Group.
- Class I and Class II are the primary types of disposal wells. Although both dispose into the Arbuckle, they operate under very different regulations.
- A surge in midcontinent earthquakes is related to an increase in underground disposal.
- The long-term capacity of the Arbuckle to accept unlimited volumes of fluids is questioned.

For more than 50 years, waste liquids—brine from oil and gas fields and hazardous and non-hazardous waste from industries and municipalities—have been disposed of deep underground into highly saline aquifers. Underground disposal is an important method, especially for industries and municipalities that rely on the long-term use of nearby disposal wells. Large industrial facilities plan their waste stream management years in advance and must factor in considerable expenses for transporting waste fluids. Public water treatment plants are generally unable to clean the waste fluids to acceptable levels without additional, expensive remedial treatment. On-site remediation of oil field brine is not yet economical for most locations. Although underground storage is the most viable method for disposing of waste fluids in these and similar situations, concerns about the practice are growing for some regions of Kansas.

The primary zone for underground disposal in the Midcontinent, including Kansas, is the Arbuckle Group, a porous rock formation 3,000 to 5,000 feet deep and up to 1,000 feet thick in south-central Kansas. In south-central and western Kansas, the Arbuckle contains a very saline, unpotable aquifer, separated by many impermeable shale layers from the shallower, freshwater

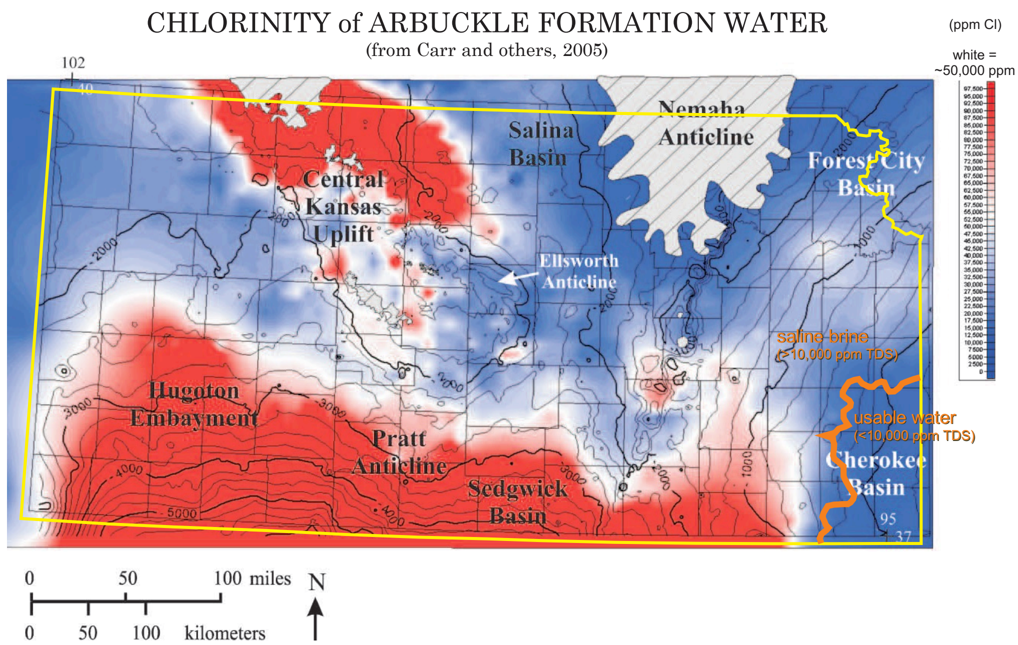


Figure 1. Salinity levels in the Arbuckle Group, Kansas.

aquifers. The Arbuckle has been considered to have an effectively unlimited capacity to accept fluids; it is laterally extensive, thick and permeable, and mostly underpressured. An underpressured aquifer will readily take additional fluids by gravity feed. In far southeastern Kansas, the Arbuckle aquifer becomes less saline and is usable (fig. 1). The Arbuckle Group is also a major source of oil.

The primary concerns with disposal into the Arbuckle are safety and storage capacity. Earthquakes (seismicity) increased in frequency and magnitude in areas of Kansas where underground pressures rose after increases in underground disposal volumes. Additionally, the capacity of the Arbuckle to store fluids is being questioned, as certain areas of Kansas have seen a rise in the static fluid levels in disposal wells. For underground injection wells to remain a viable waste disposal solution, decision makers need an improved understanding of earthquake-vulnerable areas in Kansas and the disposal capacities of the Arbuckle.

Class I and Class II disposal wells

Underground disposal wells are subject to federal Underground Injection Control (UIC) regulations through the Safe Drinking Water Act. UIC wells are divided into six classes, based on the types of waste to be disposed of or the purpose of the well. The most common underground injection wells are Class I and Class II. Class I wells dispose of a range of

Comparison of Class I and Class II Disposal Wells

	Class I	Class II
Regulating entity	Kansas Department of Health & Environment	Kansas Corporation Commission
Types of waste	Hazardous & non-hazardous waste; mostly industrial waste	Brine, hydraulic fracturing and other fluids from oil and gas production
Number in Kansas	50 active wells; 49 into Arbuckle	4,424 active wells; 2,736 into Arbuckle
Type of injection	Gravity feed of waste fluid	Pressurized and gravity feed injection of fluids allowed (below a pressure that would fracture the rock)
Reporting frequency	Metered disposal volume reported monthly	Disposal volume reported annually
Monitoring	Static fluid level in well measured and downhole pressure tested annually. Mechanical integrity of well tested every 5 years	Mechanical integrity of well tested every 5 years
Injection zone	Below the lowermost formation containing fresh or usable water	Normally below lowermost formation containing fresh or usable water; exception may occur when a zone is flooded for enhanced oil recovery.
Targeted depth	Usually entire depth of Arbuckle	Primarily upper Arbuckle
Disposal volumes	Individual Class I well disposal volumes can be large	Collective and individual Class II well disposal volumes can be large
Annual volume	Annual collective disposal volume is nearly constant	Annual collective disposal volumes vary with energy price
Total disposal volumes into Arbuckle 2010–2018	789.2 million barrels	7,986.7 million barrels

Modified from Newell et al. (in progress).

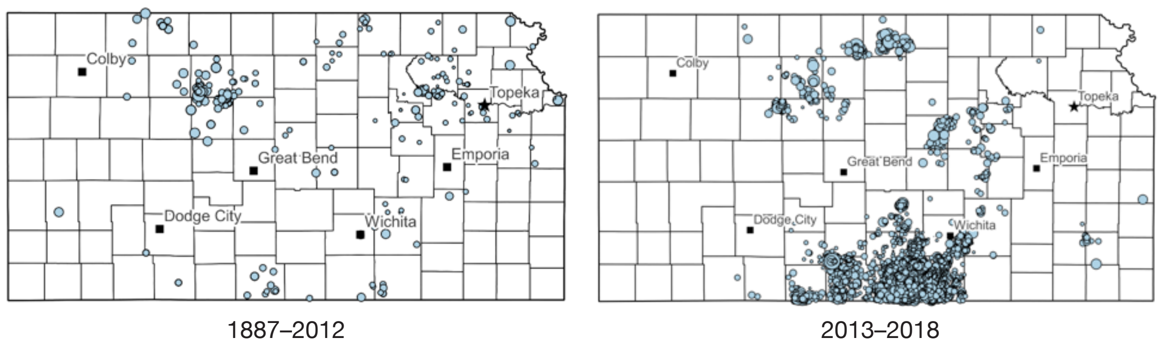


Figure 2. Historical earthquake activity compared to a new frequency and location pattern which began abruptly in 2013.

waste from chemical-industrial toxic waste fluids to nearly fresh storm drainage water. Class II wells dispose of waste associated with oil and gas production, which includes brine produced from the formation and fluids injected to recover oil and gas. Most Class II wells are for enhanced oil recovery, a process that typically injects produced water from previous oil production back into the formation from which it came.

The State of Kansas has primacy on regulating Class I and Class II wells, which means the state government has the authority to permit, inspect, keep records about, and regulate the wells at a level of safety at least as protective as federal regulations. Class I wells are regulated by the Kansas Department of Health and Environment. Class II wells are regulated by the Kansas Corporation Commission.

Disposal wells and induced earthquakes

A surge in earthquakes in Kansas has been linked to underground wastewater disposal from the oil and gas boom in Oklahoma and south-central Kansas. Before 2013, Kansas was not known for frequent earthquakes, when only one magnitude (M) 3 or larger earthquake occurred every couple of years. Earthquakes can be felt at M 2.5 or greater, and damage to structures may occur around M 5.0. After 2013, Kansas's earthquake pattern changed in both frequency and epicenter location (fig. 2). Between 2013 and 2016, Kansas had 127 earthquakes of M 3 or higher, with 90% of them occurring in Sumner or Harper counties near the Oklahoma border. Oklahoma had an even greater increase in earthquakes, including a M 5.8 in 2016.

Class II brine disposal volumes injected into the Arbuckle sharply spiked in 2013 with oil and gas development of the Mississippian limestone in south-central Kansas. Disposal peaked in 2014 at more than 840 million barrels (a barrel holds 42 gallons) and has since dropped as production slowed with the decline in oil prices (fig. 3). The number of earthquakes also has declined. Kansas had only 11 earthquakes of M 3 or greater during the past year, including a M 4.5 in Sumner County on January 16, 2019. This decline roughly correlates with a decline in the total volumes of brine disposal.

Class I wells dispose of about 90 million barrels annually, roughly 11% of the total volumes disposed of into the Arbuckle. The disposal volumes for Class I wells are fairly constant throughout the year. Although the volumes per well often are much higher in Class I than Class II brine wells, the total volumes from Class I wells are much less than the brine disposal wells; there are roughly 55 brine wells for every Class I well disposing into the Arbuckle. Class I wells generally are drilled much deeper into the Arbuckle than Class II wells. It isn't clear whether disposal depth makes a difference in inducing earthquakes, but fluid connection with the underlying crystalline "basement" rocks may be a factor. (Crystalline rocks are more rigid than the overlying sedimentary "soft" rocks.)

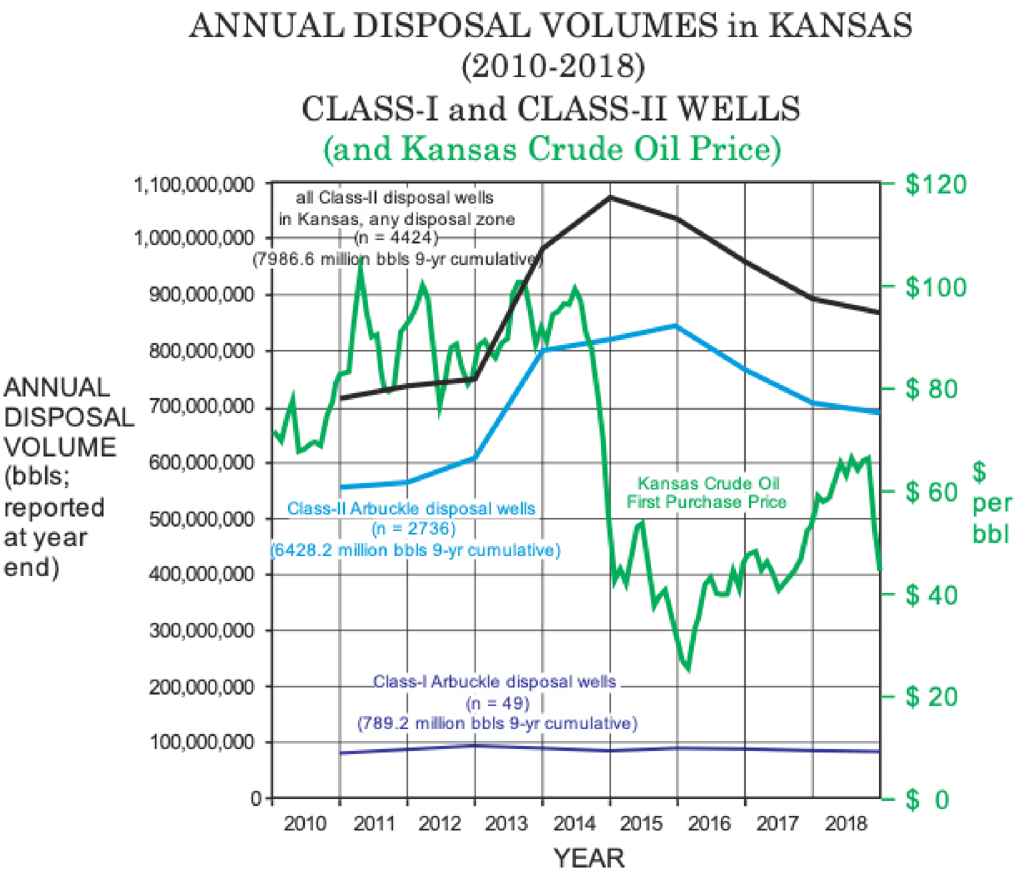


Figure 3. Disposal volumes in Kansas from Class I and Class II well.

The increase in recent earthquakes in Kansas is mostly due to fault motion in the basement rocks below the Arbuckle, which suggests a hydraulic connection between the Arbuckle where waste fluids are stored and the deeper basement rocks. That is, changes in pore pressures and pressure diffusions caused by fluid disposals in the Arbuckle lead to old basement faults giving way to movement. Very small changes in pore pressures (87.02 psi) in the crystalline basement rocks may be enough to reactivate an old fault, if it is also oriented optimally and critically stressed. The increase in the pore pressures associated with injection of waste fluids radiates 15 miles or more from the injection well. In addition to unprecedented high volumes of disposal into the Arbuckle in Kansas, wastewater disposal in Oklahoma near the Kansas border also contributes to increased pressures.

After the initial upswing in earthquakes linked to fluid disposals in south-central Kansas subsided, an unforeseen increase in earthquakes occurred farther north around Hutchinson, starting in 2017. To identify the cause, the Kansas Geological Survey looked at fluid-pressure measurements taken at the bottom of Class I wells around Hutchinson. With these data, the KGS had an opportunity to study the increase in earthquakes far from the activity near Oklahoma. The KGS researchers found that fluid pressure measurements in Class I wells around Hutchinson rose, even as local disposal operations remained fairly steady. Based on their findings, KGS researchers determined that the cumulative effects of high-volume injection along the state line caused earthquakes to migrate dozens of miles—much farther from the disposal wells than had been thought possible.

Rise in fluid levels in disposal wells

Static fluid level, determined by pressure within a geological formation, is the elevation of the fluid in a well when opened to the atmosphere. The density of fluid injected into a well also influences its static fluid level; brine has a high density and will sink more than a less-dense freshwater or petroleum product. Although the Arbuckle has been considered underpressured and able to take additional fluids with little rise in static fluid levels, recent changes have raised questions about the long-term viability of the Arbuckle for wastewater disposal. A rise in static fluid levels in some wells suggests the Arbuckle has a limited capacity to accept fluids at the current volumes and rates of disposal. In some wells, the static fluid level has risen to within 100 feet of the land surface and continues to rise, rather than stabilizing at a typical depth for the Arbuckle.

Most borehole pressure and static fluid level data in Kansas are collected in Class I wells, as regulations require more data from these wells than from Class II wells. However, they may not be representative of what is occurring at Class II well disposal sites. Brines disposed of in Class II wells are typically denser than Class I fluids. In addition, Class II wells dispose primarily into the upper 50 feet of the Arbuckle, whereas the Class I wells dispose deeper in the Arbuckle.

Case study: Hutchinson's Class I disposal wells

The City of Hutchinson owns two of the several Class I wells in the wider Hutchinson region. The city's wells, in the southeast portion of the city, are an integral part of its groundwater treatment system. They are used to dispose of contamination removed from the city's groundwater, which has been affected by several contamination plumes (fig. 4). The contaminants include highly saline water that has moved into the freshwater horizon through sinkholes, chloride plumes from past salt mining activities, carbon tetrachloride used to fumigate grains, and chlorinated solvents from past industry degreasers and dry cleaning operations.

The high concentration of chlorides extracted through the remedial wells (shown as yellow triangles in fig. 4) is sent directly to the Class I wells for disposal. The solvent and fumigant plumes, in contrast, are first treated at the city's water treatment plant using reverse osmosis and air stripping, which reclaims 75% of the groundwater treated. The 25% waste stream is sent to the Class I wells. This has been a successful strategy for treating groundwater contamination and protecting the

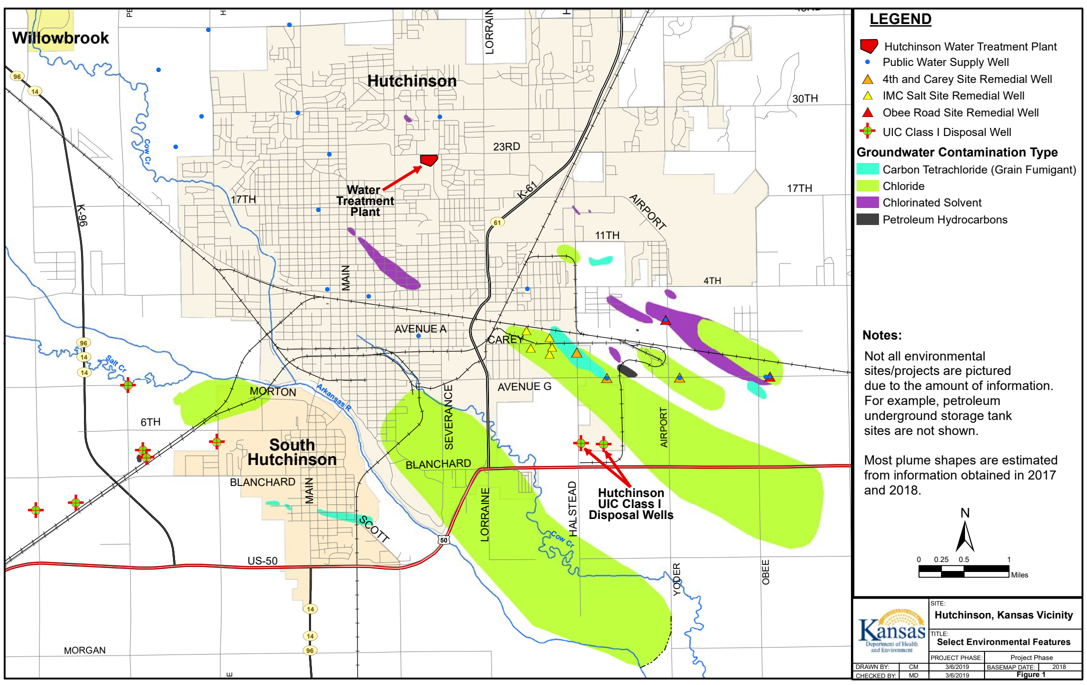


Figure 4. Groundwater contamination plumes and location of Class I wells in and near Hutchinson. Source: KDHE.

city's water supply. However, it has resulted in the highest volume per well disposed of into the Arbuckle in Kansas, roughly 24,000 barrels per day per well. The volume has become a serious concern as static fluid levels have risen in the disposal wells. If fluid levels continue to rise, the city could lose the use of those disposal wells.

The city commissioned a study to evaluate cost-effective options to reduce the disposal volumes. Among the solutions that may be considered are reducing the waste stream from the water treatment plant from 25% to 10% of the water treated or treating and reclaiming some of the chloride plume, if salinity levels have decreased sufficiently.

Hutchinson's concern about static fluid level rises in the Class I wells is not an isolated situation. Other Kansas industries and communities are concerned about the future viability of their Class I wells to handle waste disposal. Likewise, the future viability of Class II wells to dispose of oil brine may also be at risk. Closure of disposal wells could have serious economic impact on industries and the communities that rely on them. To keep apprised of static fluid levels and current knowledge about pore pressures and to discuss possible options, Class I and Class II well owners in Kansas have joined the Arbuckle Working Group.

STOP 9

KEY FACTS

- The Hutchinson Salt underlies an area of roughly 37,000 square miles in Kansas, Oklahoma, and Texas.
- Hutchinson Salt deposits reach nearly 400 feet in thickness.
- Salt mining, underground storage, and tourism are Kansas industries built on the salt.
- Most of the Hutchinson Salt is used on roads.

Permian Salt Beds and Salt Mining in Kansas

Salt is a defining feature of central and south-central Kansas (fig. 1). It is a region with salt marshes, salt springs, and salt flats. It is a region with sinkholes that appear after overlying roof rock collapses under its own weight into underground caverns formed by dissolution of the deeply buried salt (fig. 2).

Because the shallow eastern edge of the Permian salt beds is actively dissolved by groundwater, salt beds do not crop out at the surface. Natural sinkholes, however, do often occur along the eastern edge where the salt comes into contact with freshwater in the subsurface. Lake Inman in McPherson County, the largest natural lake in Kansas, is a sinkhole along that front. The salt marshes at Quivira National Wildlife Refuge are the result of a natural upwelling of saline groundwater.

The primary Permian-aged salt deposit, the Hutchinson Salt Member of the Wellington Formation, is nearly 400 feet thick in some parts of the state. Industries built on this salt deposit include mining, liquid petroleum gas (LPG) storage, film and document storage, and most recently, tourism.

Geologic history

Salt layers in the subsurface of central and south-central Kansas formed during the Permian Period, roughly 275 million years ago. It is widely thought the salt formed from the evaporation of an arm of an inland sea that was cut off from the main sea. Recently, however, that scenario is being more closely examined as some evidence suggests the salts were deposited on land or in a

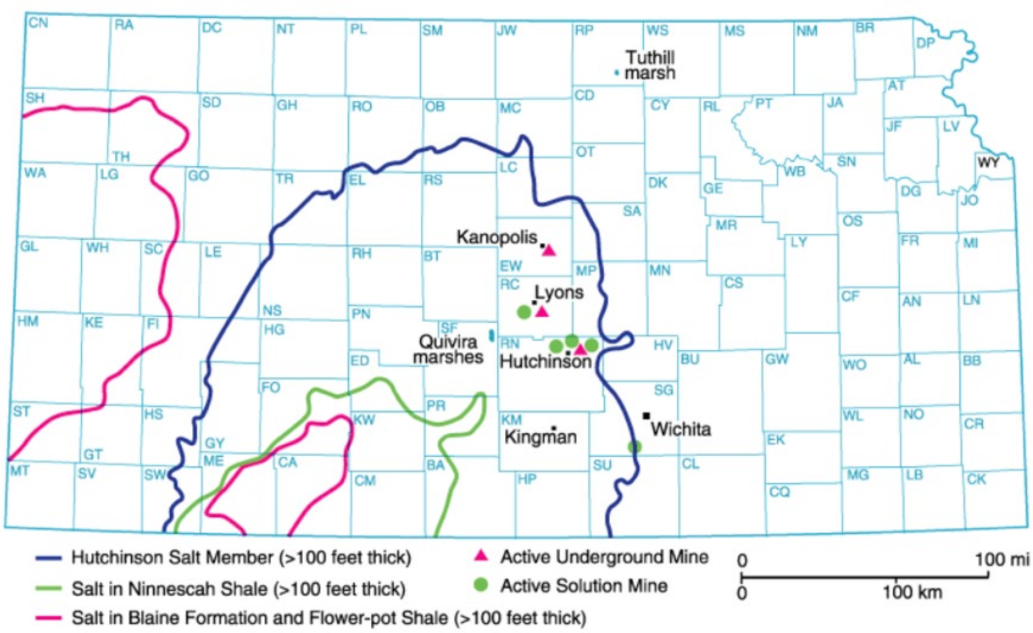


Figure 1. Geographic extension of salt beds in Kansas. Source: Sawin and Buchanan, 2002.

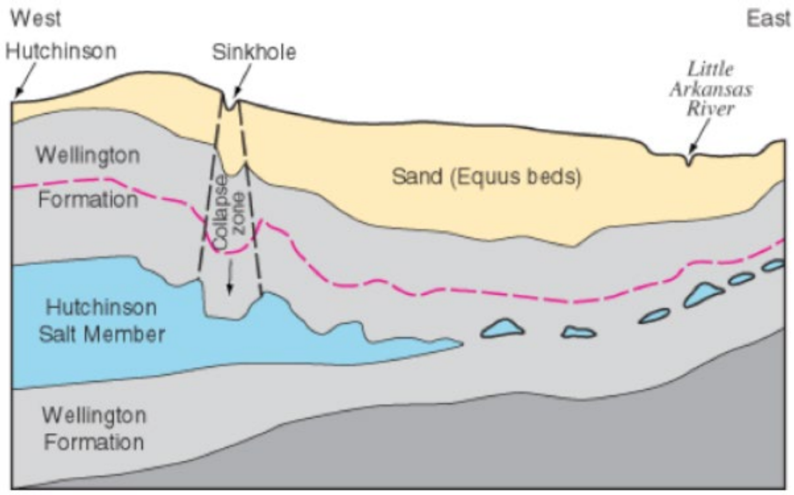


Figure 2. Schematic of how a sinkhole forms. Source: Sawin and Buchanan, 2002.

transitional environment, rather than a marine environment. Preserved ripple marks, plant fossils, and mud cracks in the interbedded shale in the salt deposits and the types of crystal formations in the salt itself suggest the salt underlying central Kansas may have formed in a terrestrial environment. It may have formed when shallow land features trapped water, perhaps salt-rich groundwater, and underwent cycles of evaporation and salt deposition.

Whether the salt was deposited in a land or marine environment, the process would have repeated itself innumerable times over thousands of years.

Salt mining in Kansas

Salt production in Kansas dates back to the mid-1800s at Osawatomie Salt Works in Miami County, at Solomon in Dickinson County, and at the Tuthill marsh in Republic County. Large kettles were used to boil the brine collected from seeps or scraped from salt scale formed in the marsh. Rock salt was discovered in central Kansas by speculators drilling for coal gas, oil, or other valuable minerals. By 1891, there were underground salt mines at Lyons, Kingman, and Kanopolis. The Carey Salt Mine, now the Hutchinson Salt Company, began underground mining of rock salt in Hutchinson in 1923.

Although the Permian-aged rocks contain several thick salt beds, the Hutchinson Salt is the only deposit that has been mined to any extent. It is closer to the surface than the other salt deposits and is thicker and purer in halite, or sodium chloride (commonly known as table salt). The salt layers in the Hutchinson Salt are interbedded with thin layers of shale and other evaporite minerals, such as gypsum, which are considered impurities for salt mining (fig. 3). The Hutchinson Salt impurities make it mostly suitable for road salt and animal feed, including salt licks. The purest layers of salt are found in the lower portions of the deposit. Only the solution mining method produces food grade salt from the Hutchinson Salt.

Salt is mined in Kansas using one of two methods: dry underground mining and solution mining. Underground mining employs a room-and-pillar design in which salt is removed from a series of roughly 40-foot-wide rooms supported by thick pillars of salt left in place between the rooms. At the Hutchinson Salt Company (formerly Carey) salt mine, about 75% of the salt is mined and 25% is left as pillars. To mine the salt, a gash is cut into the wall face near the bottom, then a series of holes 6- to 9-foot deep drilled across the wall are filled with blasting caps and ammonium nitrate. The caps are tied to one fuse and sequenced, so an entire wall face is blasted at a time. The salt rock is then crushed and put on a conveyer belt to haul to the surface (fig. 4).

Solution mining was the earliest type of mining in Kansas and continues today.

Freshwater or unsaturated brine is injected through a cased well into a salt deposit. The solution is pumped back to the surface, and the saturated brine is then evaporated to recover the salt. Compass Mineral uses solution mining of the Hutchinson Salt at its Lyons plant.

Salt produced by both methods is moved to markets by trucks and railroads.

LPG storage

Liquid petroleum gases (LPG) are stored in the Hutchinson Salt. Gaseous at atmospheric pressure, LPG is pressurized and condensed into a liquid for storage in underground salt caverns until there is demand for it. The caverns are created specifically for this storage. The shape of a salt cavern is created by the rate and depth of injection of fresh or slightly saline water. Sonar and gamma tools are used to monitor the cavern shape, size, and roof thickness. Extracted brine is saved to refill the cavern as LPG is removed. Brine has a much higher density than LPG, so the two do not mix. LPG is transported in liquid form by pipes, railroads, and trucks. A typical salt cavern can contain 100,000 to 300,000 barrels of LPG. Enterprise Products and ONEOK provide LPG storage in the wider Hutchinson area.

Many people will recall the 2001 natural gas explosions in Hutchinson. The explosions killed two people, destroyed two downtown businesses, and caused geyser-like spouts of water and gas. The cause was the migration of natural gas from an LPG storage site known as Yaggy Field, northwest of Hutchinson. The non-reactive, impermeable, and annealing properties of the Hutchinson Salt and its compressive strength similar to concrete make it well suited for LPG storage. Problems occurred when a migration pathway was created by a hole in a pipe used to transport the gas in and out of a salt cavern. The pressurized gas migrated through that hole and miles underground, until it found pathways upward through long abandoned brine wells. The explosions led to the Kansas Department of Health and Environment establishing tighter regulations and monitoring.

Figure 3. Beds of layered salt with a pure halite pipe.

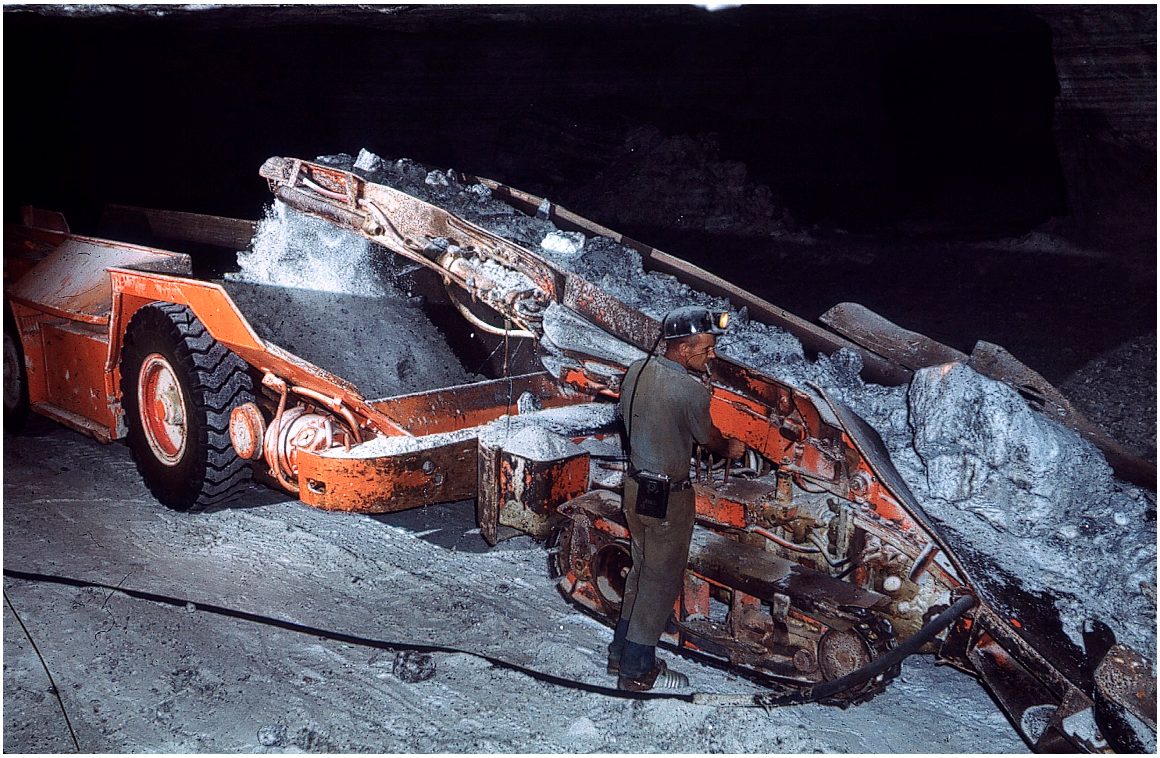


Figure 4: Rock salt conveyor, Reno County.

Underground Vaults and Storage

Room-and-pillar mining have left large open areas ideal for humidity- and temperature-controlled storage 650 feet below the city of Hutchinson. In 1959, Underground Vaults and Storage (UV&S) entered a 99-year lease with Carey Salt (now Hutchinson Salt Company) for the mined-out space. This company has 1.7 million square feet, roughly 35 football fields, of storage space.

UV&S, which employs 120 people, stores a range of objects, including art, movie films, movie costumes, medical records, and Fortune 500 business documents. Customers include Wolf Creek Nuclear Power Company, Warner Brothers, and the Walt Disney Company.

Strataca

In 2007, the Reno County Historical Society began Strataca: Kansas Underground Salt Museum in space leased from UV&S. Both UV&S and Hutchinson Salt Company have helped support Strataca. The museum's above-ground visitors' center and below-ground exhibits present the history of mining in the region, information about the geologic history of the salt, and the cultural impact of salt mining. Visitors are taken on trams deep into the mine to view abandoned equipment and re-create the mining experience.

The only salt museum in North America, Strataca has expanded its offerings to foot and bicycle races, youth group overnights, Murder Mystery dinners, concerts, and other types of entertainment. It was named one of the "eight wonders of Kansas" by the Kansas Sampler Foundation.

Wildfire Management and Suppression in Kansas

STOP 10

KEY FACTS

- The two largest Kansas wildfires in the last 50 years occurred in 2016 and 2017.
- Together the two fires burned 822,000 acres and killed nearly 5,000 cattle in Barber, Comanche, Meade, and Clark counties in south-central Kansas.
- More than 200 agencies and 2,100 responders from across the state helped out during two other 2017 wildfires in the sand hills of Reno County.
- Hutchinson fire, law enforcement, and emergency entities conducted a review of the response to the Reno County wildfires.
- The Legislative Post Audit (LPA) reviewed Kansas wildfire management practices after two heavy wildfire seasons in a row stretched state resources.
- The LPA review compared five Great Plains states. All had wildfire-management responsibilities under one agency except Kansas, which divided it among three agencies.
- North Dakota, South Dakota, Texas, and Oklahoma all have more funding for wildfire management than Kansas does.

A March 2016 wildfire that consumed 313,000 acres in Barber and Comanche counties and killed at least 750 cattle was, by far, the largest wildfire in Kansas in 50 years. Just one year later, another inferno topped it in both size and destruction, burning 509,000 acres in Meade, Clark, and Comanche counties and killing one person and at least 4,000 cattle.

Besides causing extensive agricultural losses, the 2016 wildfire, known as the Anderson Creek fire, destroyed 11 homes and 2,700 miles of fence. The 2017 wildfire—the Starbuck fire (fig. 1)—destroyed 26 homes and 3,700 miles of fence in Kansas and also wreaked havoc in Oklahoma, where it started.

Outpacing the previous record-breaker that burned 38,000 acres in Stanton County in 2011, the Anderson Creek and Starbuck fires were just two of dozens of wildfires in the state during 2016 and 2017. In total, the two seasons resulted in hundreds of millions of dollars in damages.

A 2017 University of Nebraska study found wildfires in the Great Plains region increased in both number and total acres burned by about 400% from 1985 to 2014. The study identified multiple causes, including drought combined with high-risk weather conditions; the practice of no-till planting, which increases vegetation to fuel fires; and encroachment of communities and residential areas into vegetated areas, which also increases fuel for fires.

Reno County wildfires, March 2017

At the same time the Starbuck fire was burning a wide swath along the Oklahoma line, wildfires were igniting near Hutchinson. Between March 3 and March 10, 2017, fire services in Reno County responded to four large fires, including one that turned into a major blaze on Monday, March 6. Known as the Highlands fire, the big one was driven by strong northwest winds through a populated area in sand hills covered with overgrown red cedar trees and plum thickets.

A difficult terrain for firefighting equipment, the sand hills posed a challenge for responders, who also were tasked with keeping the flames from spreading south toward Hutchinson. By Tuesday morning, the Highlands fire had consumed more than 5,000 acres in Reno and Rice counties and destroyed 10 homes and a number of outbuildings. About 10,000 people had to be evacuated. An earlier March 4 blaze, known as the Jupiter Hills fire, had already burned about 1,200 acres northeast of the city, including acreage in Sand Hills State Park.

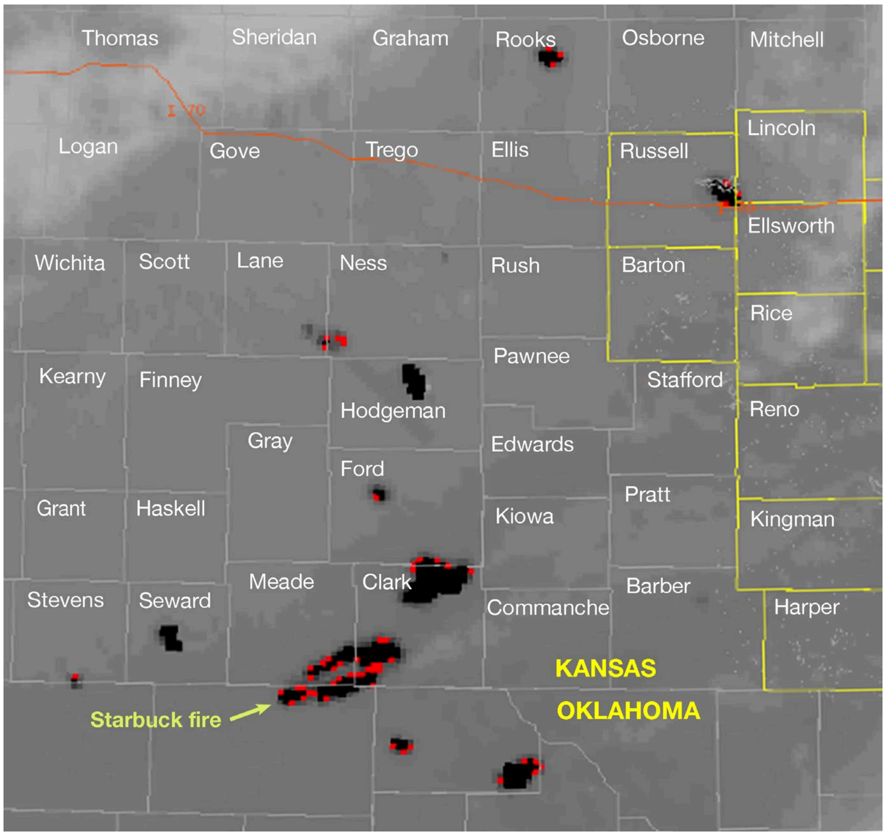


Figure 1. Satellite image showing the location of the Starbuck fire and other wildfires in Kansas and Oklahoma on March 6, 2017. Source: National Weather Service.

More than 200 agencies (fig. 2) and 2,100 responders from around the state arrived over several days to help manage and extinguish the Highlands fire, control the perimeter, and provide fire coverage for the city of Hutchinson. At the same time those entities were helping fight the Highlands fire in Reno and Rice counties, others were responding to the Starbuck and other wildfires across the state.

Legislative Division of Post Audit report on Kansas wildfire management

The magnitude of the 2016 and 2017 wildfires in south-central Kansas and the two extreme wildfire seasons in a row throughout much of the state tested the readiness, response, and coordination of state and local firefighting, law enforcement, and emergency management services.

In response to problems exposed during the major wildfires, a group of state legislators requested a review of the state's wildfire-management capabilities by the Legislative Division of Post Audit. The resulting report, "Kansas Wildfire Management: Evaluating the Adequacy of Kansas' Wildfire Suppression System," summarized the current state system under the jurisdiction of multiple state agencies, outlined its strengths and weaknesses, and compared it to systems in other Great Plains states.

Of the five states surveyed—Kansas, North Dakota, Oklahoma, South Dakota, and Texas—Kansas was the only state that divided its wildfire suppression system among three agencies. Kansas also had less funding, fewer resources, and less staffing than the others (fig. 3).

The three Kansas agencies with joint responsibility for wildfire management are the Kansas Office of the State Fire Marshal, the Kansas Forest Service (KFS), and Kansas Division of Emergency Management (KDEM). Each entity's role is defined in state law and the Kansas Response Plan drafted by KDEM. Because of Kansas's home rule doctrine, none of the agencies can intervene during a wildfire until local authorities request help.

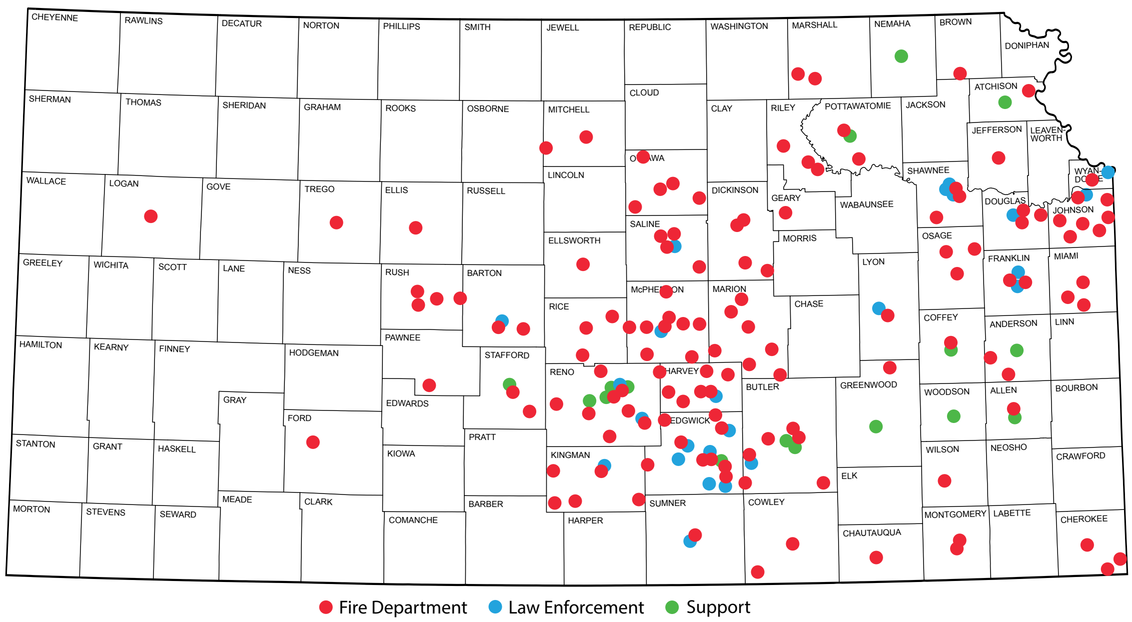


Figure 2. Location of Kansas agencies that provided equipment, personnel, and support for the March 2017 Highlands fire near Hutchinson. Source: Hutchinson Fire Department.

	Primary wildfire suppression agency	Total state funding for all agency functions (a)	State area (square miles)	Amount per square mile
ND	Forest Sevice North Dakota State University (b)	$2,200,000	71,230	$30.89
OK	Forestery Services Division Department of Agriculture (b)	$6,100,000	69,960	$87.19
SD	Wildland Fire Division Department of Agriculture (c)	$1,500,000	78,116	$19.20
TX	Forest Service Texas A&M University (d)	$38,900,000	268,597	$144.83
KS	Forest Service Kansas State University (e)	$370,000	82,278	$4.50

	Fire management staff	Fire engines	Other equipment
ND	4 full time, 14 seasonal	5	Various equipment and vehicles
OK	84 full time (f)	42	42 bulldozers
SD	8 full time, some seasonal	12	Several additional vehicles
TX	353, including 267 who fight fires	18	114 bulldozers and other equipment
KS	4 full time, some part time	4	Some all-terrain vehicles

(a) State appropriations for all agency functions, not just wildfire managment. Additional spent during fire response not included
(b) Legislative Post Audit (LPA) estimate
(c) South Dakota's Wildland Fire Division engages only in wildfire management, no other forestry-related functions
(d) Fiscal year 2019
(e) Kansas Forest Service is not the primary agency in Kansas but has wildfire suppression resources and expertise analogous to the other state agencies. Kansas' primary agency, the Office of the State Fire Marshal, has no wildlife suppression resources.
(f) When fully staffed
Source: State officials and LPA analysis of state budget documentation

Figure 3. State funding and resources of primary wildfire suppression agencies in five Great Plains states for fiscal year 2018. Source: Legislative Division of Post Audit Kansas Wildfire Management report.

The Office of the State Fire Marshal, the coordinating agency for the Kansas wildfire suppression system, acts as liaison between local authorities and the state, coordinates delivery of the state's firefighting resources, and communicates with federal officials when necessary. The office does not help fight wildfires.

The KFS, part of Kansas State University Research and Extension, provides firefighting resources and professional wildfire management services. It owns a limited amount of firefighting equipment and provides certified wildfire management staff for state and local emergencies. Only KFS can order firefighting resources from the U.S. Forest Service and other federal agencies or from other states through the Great Plains Interstate Fire Compact, which Kansas signed in April 2017.

The KDEM, in the Adjutant General's Department, oversees the state emergency operations center. It determines when the state needs to respond and has principle responsibility for any type of emergency in the state. KDEM staff develop the statewide mutual aid system and can request deployment of emergency response resources from other states.

Besides noting that Kansas devoted fewer state resources to wildfire response than the four other states, the LPA report concluded that Kansas's more complex three-agency suppression system often left local jurisdictions not knowing when or whom to call for state assistance. Figure 4 illustrates the different steps that must be taken when requesting and deploying resources in the Kansas system compared to the Texas single-agency system.

The LPA report recommended amending state law to designate a single entity to lead the state's wildfire suppression system. The KFS generally concurred with the report's findings and recommendations. The Adjutant General's Department and the Office of the State Fire Marshal disagreed with parts of the report and provided additional information and context. Minor changes were made based on their assessments but the overall substance of the report was not changed.

In its annual report to the 2019 Kansas Legislature, the Joint Legislative Budget Committee recommended that the KFS take the lead on fire suppression for the state in coordination with the Adjutant General's Office and the State Fire Marshal. The committee also recommended a separate state general fund line item for the KFS within the Kansas State University section of the appropriations bill, with a proviso that specifies how much of the KFS budget would be used for fire suppression.

Hutchinson/Reno County after action review

After the Highlands and Jupiter Hills fires, the Hutchinson Fire Department, Reno County Sheriff's office, and Reno County Emergency Management produced an "after action review" to address local and state responses.

The report noted that no fatalities or major injuries resulted from the fires due, in large part, to the assistance of local volunteers, organizations, and businesses as well as communities across the state. However, the process of requesting and organizing mutual aid from other communities was challenging, communication problems occurred, and available equipment and large trucks were not ideal for fighting fires in the sand hills environment.

Three groups organized by local agencies in Kansas were instrumental in garnering firefighting, crowd control, and logistical support. These mutual-aid groups—the Fire Operations Response Coordination (FORCe), Law Enforcement Assistance Deployment (LEAD), and Major Emergency Response Group (MERGe)—had been established in prior years to furnish personnel and equipment until state and federal resources arrived.

The local jurisdictions, according to the after action review, had difficulty securing state resources. Although the state entities were good at providing logistics related to fuel, food, and lodging for responders, they were lacking in fire support. The review noted that both local jurisdictions and state agencies needed to develop better communication and ways to work on common objectives.

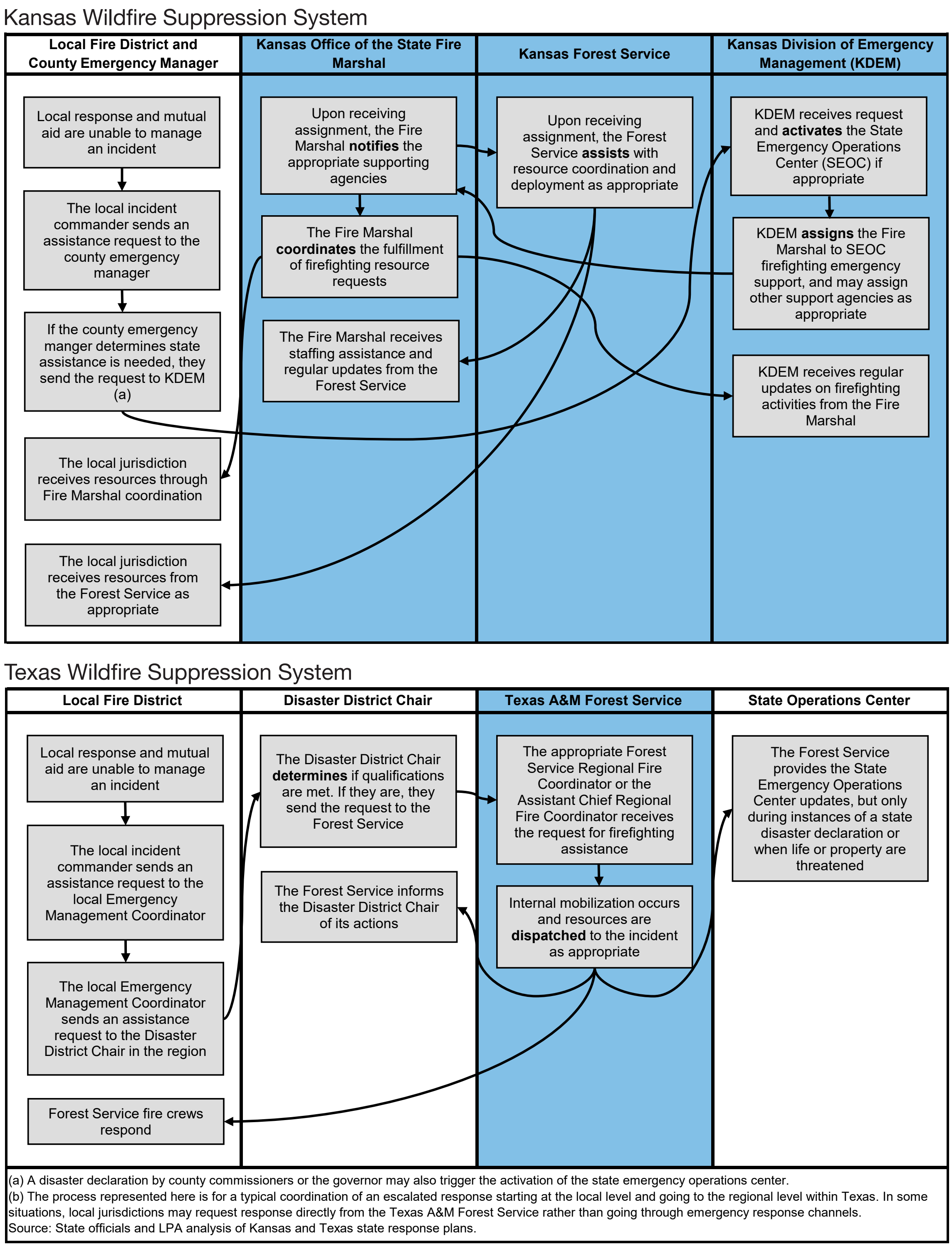


Figure 4. Comparison of wildfire suppression systems in Kansas and Texas. Source: Legislative Division of Post Audit Kansas Wildfire Management report.

Because state and local entities lacked experience suppressing fires of great magnitude, local authorities requested that the state call in a federal incident management team (IMT). Because the call went out so late, the federal IMT's main contributions were helping the evacuated residents return to their homes in a timely manner and helping individuals who lost property rather than the team's specialty of fire suppression.

KFS Fire Management Program resources

The resources, educational opportunities, and assistance available from the KFS's Fire Management Program increased significantly after rural fire districts began to take shape across the state.

- Between 1861—when Kansas became a state—and 1963, only two counties established fire-protection authorities outside incorporated towns.
- In 1963, the KFS began organizing rural fire districts through a cooperative agreement with the U.S. Forest Service.
- Today, Kansas has 488 organized fire districts and 13,000 volunteer firefighters.
- The KFS has more than 600 pieces of motorized equipment, mostly excess from the U.S. Department of Defense, that can be used by fire departments.
- The KFS administers Volunteer Fire Assistance cost-share programs in which matching funds are available from the U.S. Forest Service for fire and communication equipment and safety gear.
- Public education opportunities available through the KFS include fire prevention and prescribed fire management instruction.
- KFS training for rural fire districts includes wildfire preparedness, fire suppression, and response.
- The KFS offers planning assistance to help communities improve their fire suppression operations, receive matching grant funding for education and planning, assess potential fire hazards, and promote community awareness.

Figure 1. Aerial view of Sand Hills State Park.

Sand Hills State Park and Arkansas River Valley Dunes

Sand Hills State Park in the Arkansas River Lowlands is one of the best places in the state to see sand dunes on public property. Just northeast of Hutchinson in Reno County, the 1,123-acre area has 14 miles of hiking, interpretive, and horseback riding trails that loop through sand dunes, grasslands, marshlands (with wildlife observation blinds), and woodlands. Dunes in the park range in height from 10 to 40 feet.

Vegetation in the park includes bluestem grass, cottonwood trees, dogwood bushes, and, in the spring, native wildflowers. Wildlife includes ducks, geese, songbirds, deer, and muskrats.

Over millions of years, streams that created the Arkansas River valley carried sand and other sediment eroded off the Rocky Mountains into Kansas. Southwesterly winds picked up the fine sand and sculpted it into a narrow band of dunes. After grass and other vegetation took hold, the shifting sand became relatively stabilized.

Residential areas to the north of the Arkansas River around Hutchinson have spread into sand hills where the terrain and overgrown vegetation make firefighting with traditional trucks and equipment difficult. As a result of the obstacles responders encountered during the 2017 Highlands and Jupiter Hills wildfires in Reno County, local fire services made adjustments to their response plans and equipment resources.

Figure 2. Sand dunes in Reno County.

Figure 3. Aerial view of a blowout in a Reno County sand dune.

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SAND HILLS STATE PARK AND ARKANSAS RIVER VALLEY DUNES

Sand Hills State Park
https://ksoutdoors.com/State-Parks/Locations/Sand-Hills

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