Kansas Field Conference
June 11–13, 2024

Northeast Kansas: Riley, Washington, and Marshall Counties

Innovative Solutions to Address Natural Resource Challenges in Kansas

Field Guide

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Kansas Geological Survey Open-File Report 2024-39

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Innovative Solutions to Address Natural Resource Challenges in Kansas

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Northeast Kansas: Riley, Washington, and Marshall Counties

Innovative solutions to address natural resource challenges in Kansas

June 11–13, 2024

Welcome to the 2024 Kansas Field Conference! This is our 29th tour since the conference began in 1995, and we have planned some extra-special events for this year. We hope that you take away new insights and information into not only the natural resources challenges we face in this portion of the state but also the innovative solutions and strategies our community members are developing in light of these challenges. The theme of this year's conference is "Innovation" to highlight several projects aimed at addressing the issues that threaten the state's natural resources.

The sites on the 2024 tour are organized around three major topics: water, climate change and natural hazards, and unique raw materials. Water will always be a critical topic in every part of the state, but the counties we're visiting this year face serious challenges that are further compounded by the effects of climate change. Climate change is also contributing to an increase in natural hazards, which affect the lives of hundreds of thousands of Kansans each year. But these challenges are being met with scientific advancement and community collaboration at the local, state, and federal level to protect and preserve this spectacular area where the Flint Hills uplands meet the glaciated region in the northeastern corner of the state.

Water

Six of the stops during this tour will highlight water and associated issues in this region. The opening reception at Konza Prairie on day one will include presentations from Scott Ishman and Erin Seybold of the Kansas Geological Survey. They will discuss new projects aimed at measuring groundwater quality across the state as well as a continuing project at Konza Prairie studying the effect of stream intermittency on water quality. On day two, will will visit Tuttle Creek Lake, where we will learn about a collaboration among the Corps of Engineers, U.S. Geological Survey, Kansas Water Office, and Kansas Department of Wildlife and Parks to test a new solution — water injection dredging — to address reservoir sedimentation. Reservoir sedimentation is contributing to the loss of storage space in almost all the reservoirs in Kansas, but Tuttle Creek is currently the highest at risk. After that, we will board boats for a live demonstration of how the KDWP surveys blue catfish populations. Blue catfish, a major commercial fish in the state, have been stocked in Kansas lakes since 1972. The health and growth of bluecat populations can be used as a bioindicator measure of water quality.

During the second half of day two, the USGS team will lead stops to see a streamgage (equipment that records water levels in a stream) along the Republican River and a tour of the USGS mobile lab at Milford Lake. In Kansas, 225 streamgages are part of a nationwide program to study stream height and streamflow. The USGS Kansas Water Science Center oversees the state's streamgage program and supports state agencies, including the Kansas Department of Health and Environment and KDWP, in monitoring harmful algal blooms in reservoirs and the streams that feed into reservoirs.

Day three will include stops at Mill Creek in Washington County to discuss the December 2022 oil spill that released almost 13,000 barrels of bitumen oil into Mill Creek. The Environmental Protection Agency declared the restoration work at the site complete almost

a year later, in October 2023. This stop will be followed by a visit to Marysville, where we will see a streambank stabilization project at the Blue River trailhead. Streambank stabilization projects, coordinated by the KWO, Kansas Department of Agriculture, and KDHE, are focused in three high priority watersheds: the Big Blue and Little Blue rivers above Tuttle Creek Lake, the Delaware River above Perry Lake, and the Cottonwood and Neosho rivers above John Redmond Reservoir. These projects aim to reduce the amount of sediment that enters streams and ultimately ends up in reservoirs, contributing to the reservoir sedimentation problem.

Climate Change and Natural Hazards

Climate change continues to create new challenges for Kansans. The first stop on day one will include a presentation about the Kansas Corporation Commission's abandoned oil and gas well plugging program. Unplugged wells release methane into the air, contributing to greenhouse gas emissions. Estimates of the number of unplugged wells in the United States range from 300,000 to 800,000; emissions from these wells comprise an estimated 3% of the 211 million tons of methane released from the U.S. oil and gas industry. Ensuring that these wells are identified and plugged can help prevent further increases in the amount of methane added to the atmosphere.

Day two will focus on how climate change magnifies natural hazards. May 2019 was the wettest month ever recorded in Kansas, which resulted in widespread and near-record-setting flooding across much of eastern Kansas. The effects of this flooding can still be seen at Tuttle Creek Lake and surrounding areas. Our discussion of natural hazards also will include induced seismicity, with a visit to a seismic monitoring station at Tuttle Creek Lake. Scientists from the KGS will provide updates on the Kansas Seismic Monitoring Network and the status of induced seismicity in the state.

Day three will provide an opportunity to visit the Kansas State University campus and learn about the innovative research done by University Distinguished Professor Charles Rice on soil microbiology, carbon cycling, and climate change. Dr. Rice was a co-winner of the 2007 Nobel Peace Prize for his work with the United Nations' Intergovernmental Panel on Climate Change. He oversees the Soil Microbial Agroecology Lab at K-State, whose vision is to support sustainable agricultural systems that are productive; efficient with water, nutrients and energy; resilient to climate change; and promote soil health.

Unique Raw Materials

This region of northeastern Kansas has an abundance of natural resources, including construction materials, industrial materials, and even the potential for diamonds from deep below Earth's surface. More than 50 mines and quarries are active across the three counties on this tour, producing limestone, sandstone, sand and gravel, and gypsum for industrial uses and construction aggregates. At the beginning of day three, we will visit a limestone quarry owned by Bayer Construction Company, which owns and operates six quarries near Manhattan and an asphalt plant in Junction City. On our way, we will drive by a deposit of kimberlites, an igneous rock formed by cooling molten lava that is thrust up to Earth's surface. Kimberlites are commonly found in South Africa but rare in North America, where only 200 deposits have been found. The kimberlite deposit in Riley and Marshall counties is the only one identified in Kansas. Finally, between stops 7 and 8, we will get to examine rock core that was extracted from the deepest well ever drilled in Washington County.

About the Kansas Field Conference

The Kansas Field Conference is designed to give policymakers the opportunity to explore and discuss natural resource issues. Participants have a chance to see what effects government and business decisions can have on natural resources and communities and to talk with government officials, business

owners, researchers, and others who are directly involved with the various sites. 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 also are posted on the KGS website (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 the intent of this conference is not to resolve policy or regulatory conflicts. By bringing together experts, we hope to go beyond merely identifying issues; we want the combination of firsthand experience and interaction 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 presented during the conference are not necessarily those of the Kansas Geological Survey or the field conference co-sponsors. Nonetheless, we believe it is important for participants to hear various viewpoints on complex issues. The Kansas Geological Survey and co-sponsors appreciate your attendance at this year's conference.

Sponsors

The Kansas Field Conference is made possible and kept affordable through the generous support of many groups. In addition to the co-sponsors listed below, the 2024 field conference received support for meals from Bayer Construction Company. 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. The KGS has no regulatory functions. Headquartered in the West District of the University of Kansas in Lawrence, the KGS also has a Kansas Geologic Sample Repository in Wichita.

The following KGS staff are participating in the 2024 field conference:

- Blair Schneider, Geologist/Outreach Manager
- Jay Kalbas, Director
- Scott Ishman, Associate Director of Geohydrology and Geohealth
- Ken Nelson, Associate Director of GIS and Information Technology
- Nikki Potter, Associate Director of Libraries, Outreach, and Business Operations
- Brendan Bream, Associate Director of Energy and Stratigraphy
- Andrew Connolly, Science Communications Specialist
- Brownie Wilson, Manager for Geohydrology Support Services
- Erin Seybold, Assistant Scientist
- Tony Layzell, Assistant Scientist

Kansas Geological Survey
1930 Constant Avenue
Lawrence, KS 66047-3724
785-864-3965
www.kgs.ku.edu

Kansas Geologic Sample Repository
4150 W. Monroe Street
Wichita, KS 67209-2640
316-943-2343
https://kgs.ku.edu/kgsr

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; federal program funding administration; and administrative support.

Kansas Department of Transportation
Dwight D. Eisenhower State Office Building
700 SW Harrison Street
Topeka, KS 66603-3754
785-296-3566
www.ksdot.org

Kansas Department of Wildlife and Parks

The Kansas Department of Wildlife and Parks (KDWP) 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 and associated recreational opportunities and providing public outdoor recreation opportunities through state parks, state fishing lakes, wildlife management areas, and recreational boating on the state's public waters.

Kansas Department of Wildlife and Parks
1020 S. Kansas Avenue, Rm 200
Topeka, KS 66612-1327
785-296-2281
www.ksoutdoors.com

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
agriculture.ks.gov

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 and a part of the KWO, advises the governor, legislature, and director of the KWO.

Kansas Water Office
900 SW Jackson, Suite 404
Topeka, KS 66612-1249
785-296-3185
www.kwo.org

Kansas Water Science Center, U.S. Geological Survey

The U.S. Geological Survey (USGS), an agency within the U.S. Department of the Interior, serves through its mission of providing reliable, unbiased scientific information on resource issues where natural science can make a substantial contribution to the well-being of the nation. USGS mission areas include climate and land use change, core science systems, ecosystems, energy, minerals, and environmental health, natural hazards, and water (http://www.usgs.gov/start_with_science/). The agency conducts hydrologic studies on national, regional, statewide, and local levels. The USGS in Kansas works cooperatively with more than 40 federal, state, and local agencies, such as the Kansas Water Office, the U.S. Army Corps of Engineers, and the city of Wichita.

Kansas Water Science Center
1217 Biltmore Drive
Lawrence, KS 66049
785-842-9909
https://www.usgs.gov/centers/kansas-water-science-center

The Nature Conservancy

The Nature Conservancy is a global environmental nonprofit whose mission is to conserve the lands and waters on which all life depends. Founded in 1951, it has more than a million members and more than 400 scientists on staff and impacts conservation in 79 countries and territories. The Nature Conservancy has permanently protected 190,000 acres in Kansas, including five preserves that are open to the public: Little Jerusalem Badlands State Park, Cheyenne Bottoms Preserve, Konza Prairie, Tallgrass Prairie National Preserve, and Smoky Valley Ranch.

Kansas Field Office
The Nature Conservancy
PO Box 4345
Topeka, KS 66604
785-233-4400
Kansas@tnc.org

Kansas Corporation Commission

The KCC, established in 1883 to regulate railroad activity, was one of the first state regulatory bodies in the nation. In 1911, the Kansas Legislature created a three-member Public Utilities Commission to regulate telegraph and telephone companies, pipeline companies, common carriers, water, electric, gas, and all power companies with the exception of those owned by municipalities. The present regulatory body, the KCC, was established by the legislature in 1933. Over the years, its jurisdiction was extended to include motor carriers, oil and gas conservation, and supervision of plugging abandoned wells to protect fresh and useable water from pollution.

Kansas Corporation Commission
1500 SW Arrowhead Road
Topeka, KS 66604-4027
785-271-3100
www.kcc.ks.gov

Friends of the Kaw

Friends of the Kaw (FOK) serves the Kansas River, known locally as the Kaw, the largest prairie-based river system in the world and a drinking water source for more than 800,000 Kansans. Friends of the Kaw members are dedicated to protecting the river from pollution sources, including municipal and industrial wastewater discharges, new pollution sources and in-river commercial

sand and gravel mining. Since its formation in 1991, the group more than tripled the number of boat ramps on the river and regularly leads paddle trips to educate the public. Since 2001, FOK has been a member of the Waterkeeper Alliance and sponsors the Kansas Riverkeeper as a full time, non-governmental public advocate to represent FOK and the Kansas River on every major river stakeholder group.

Friends of the Kaw
PO Box 1612
Lawrence, KS 66044-3502
785-312-7200
riverkeeper@kansasriver.org

Acknowledgments

The following people helped make this an informative and successful field conference: Brian McNulty, Operations Project Manager, Tuttle Creek Lake, U.S. Army Corps of Engineers; John Reinke, Assistant Director of Fisheries, Kansas Department of Wildlife and Parks; Leo Henning, Deputy Secretary and Director of Environment, Kansas Department of Health and Environment; Mike Beam, Secretary, and Earl Lewis, Chief Engineer, Kansas Department of Agriculture; Charles Rice, Kansas State University; Connie Owen, Director, and Matt Unruh, Assistant Director, Kansas Water Office; Ryan Hoffman, Director, Kansas Corporation Commission; Casey Lee, Director, and Brian Kelly, Associate Director, Kansas Water Science Center; Kyle Halverson, Chief Geologist, Kansas Department of Transportation; Ben Postlethwait, Kansas State Director, and Heidi Mehl, Director of Kansas Water and Agriculture Program, The Nature Conservancy; Dawn Buehler, Kansas Riverkeeper, Friends of the Kaw; and Kelly Briggs, Bayer Construction Company. The KGS extends our appreciation to the presenters at each of the stops, without whom this conference would not have been possible.

Tuesday, June 11, 2024

3–5 p.m. Check in
Fairfield Inn, Manhattan
300 Colorado Street
Manhattan, KS 66502

4 p.m. Depart hotel (on bus)

4:45 p.m. **Stop 1: KCC Well Plugging**
Ryan Hoffman, Director, Kansas Corporation Commission

5:15 p.m. Depart for Konza Prairie

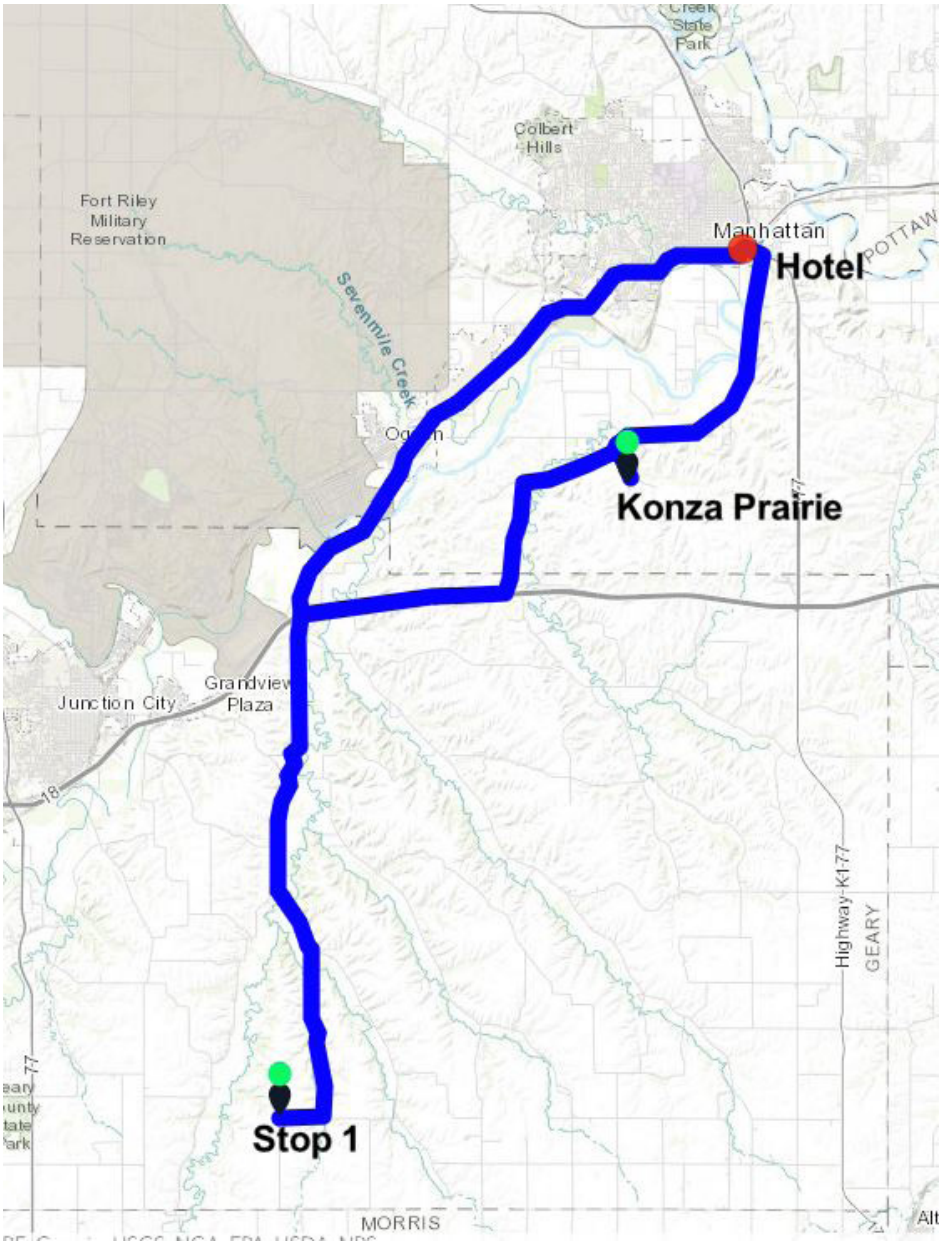
6 p.m. **Networking Dinner and Reception**

Welcome
Jay Kalbas, Director, Kansas Geological Survey
Blair Schneider, Outreach Manager, Kansas Geological Survey

Keynote Presentation: Clean Waters, Healthy Futures: Safeguarding Kansas's Groundwater for Public Health and Prosperity
Erin Seybold, Assistant Scientist, and Scott Ishman, Associate Director of Geohydrology and Geohealth, Kansas Geological Survey

Short hike around property (optional)
Ben Postlethwait, Kansas State Director, The Nature Conservancy
Heidi Mehl, Director of Kansas Water & Agriculture Programs, The Nature Conservancy

8:30 p.m. Depart for hotel



Route, day one.

STOP 1

Unplugged: The Legacy and Cleanup of Abandoned Oil and Gas Wells in Kansas

Blair Schneider, Kansas Geological Survey

KEY FACTS

- Kansas House Bill 2022 merged two existing statutory abandoned well plugging funds so that all the abandoned well plugging funds would be available for KCC use. This change has attracted more state-approved abandoned well plugging vendors; lack of vendors was a significant barrier before.
- Even with the influx of federal plugging funds, abandoned wells that need to be plugged outnumber the amount of money available to plug them.
- Wells are ranked by priority as A (most serious), B, or C (less serious). Five wells currently are ranked as a Level A priority.
- The KCC is actively looking for abandoned oil and gas wells. Residents who know of or find an abandoned well may report it using a form on the KCC website (https://www.kcc.ks.gov/report-abandoned-well).
- At the close of 2023, the Kansas Abandoned Well database listed 5,285 wells as requiring action. The USGS nationwide dataset has records of more than 117,600 unplugged abandoned wells across 27 states.

The state of Kansas has a strong history of oil and gas production, beginning with the discovery of a giant natural gas field east of Paola in 1882.[1] With this discovery, Paola became the first Kansas town to use natural gas commercially west of the Mississippi River. In the search for more gas fields, William Mills made an unexpected discovery in 1892 in Neodesha: oil. His well, dubbed the Norman No. 1 well, was the first commercial oil discovery west of the Mississippi River (fig. 1). Today, a database maintained by the Kansas Geological Survey contains more than 500,000 oil and gas well records. Hundreds of oil and gas fields have been recorded across the state, as shown in fig. 2, although the majority of the larger fields in eastern Kansas were discovered by 1920.[2]

Unfortunately, detailed production records were not kept for discoveries before 1944 and comprehensive regulation of the industry didn't begin until the mid-1980s. This means that thousands of wells drilled from the late 1800s through the 1970s were abandoned without being properly plugged. Over time, trees, brush, and other vegetation have buried or grown over these locations, making them increasingly difficult to find and posing a serious risk to public health. The wells continue to leak greenhouse gas emissions and can contaminate groundwater even after they are no longer operational.[3] Unplugged wells also can lead to catastrophic events. In December 2023, an abandoned oil and gas well exploded on a Texas rancher's property, spilling a large amount of brine water onto his land and ruining his pasture and soil. Fortunately, no one was injured.[4]

Abandoned oil and gas wells are a problem across the United States. The U.S. Geological Survey recently compiled a dataset that found 117,672 unplugged orphaned oil and gas wells across 27 states.[5] A similar report compiled in 2021 by the Interstate Oil and Gas Compact Coalition documented 97,213 orphaned wells within its 32 IOGCC member and associate member states and five Canadian provinces.[6] The report also found 372,010 "idle wells" — wells that have not yet been plugged and are not producing, injecting, or otherwise being used for their intended purpose. Many idle wells have potential for future oil or gas production or associated uses, but if they are not properly maintained, they may pose a risk to the environment, public health, and safety. They also present an elevated risk of becoming orphaned wells.

In 1996, the Kansas Legislature created the Abandoned Well Plugging and Site Remediation Fund. The legislation established an annual reporting procedure whereby the Kansas

Corporation Commission must account for the number of abandoned wells in Kansas, detail the funds available to plug abandoned wells, and present a multiyear plan for addressing abandoned wells by creating a prioritization schedule.[7] A well is considered "abandoned" when it has been permanently taken out of production, it is not properly plugged to prevent possible air or groundwater pollution, and the rightful legal owner cannot be determined or located to take responsibility. Wells are ranked by priority as A, B, or C. Level A wells are the most serious cases while Level C wells are less serious. Five wells currently are ranked as a Level A priority.

The process of plugging an oil and gas well is relatively straightforward. Plugging prevents the movement of fluids either into or between permeable rock units or water saturation zones by setting cement plugs in the well. The plugs are designed to last indefinitely and are tailored to each well based on factors such

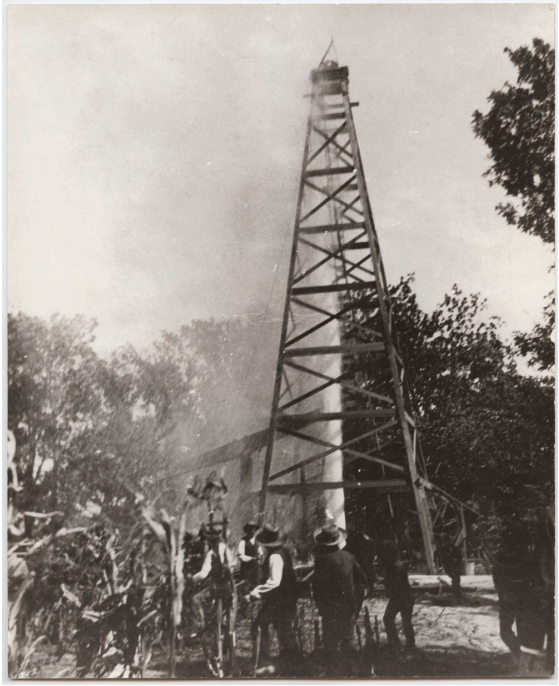


Figure 1. This photo, taken in 1893, shows a water spout shooting into the air at Norman No. 1 well. Today, you can see a 65-foot replica of the original oil derrick at the Neodesha Historical Museum. Photo: Kansas Memory/ Kansas Historical Society.

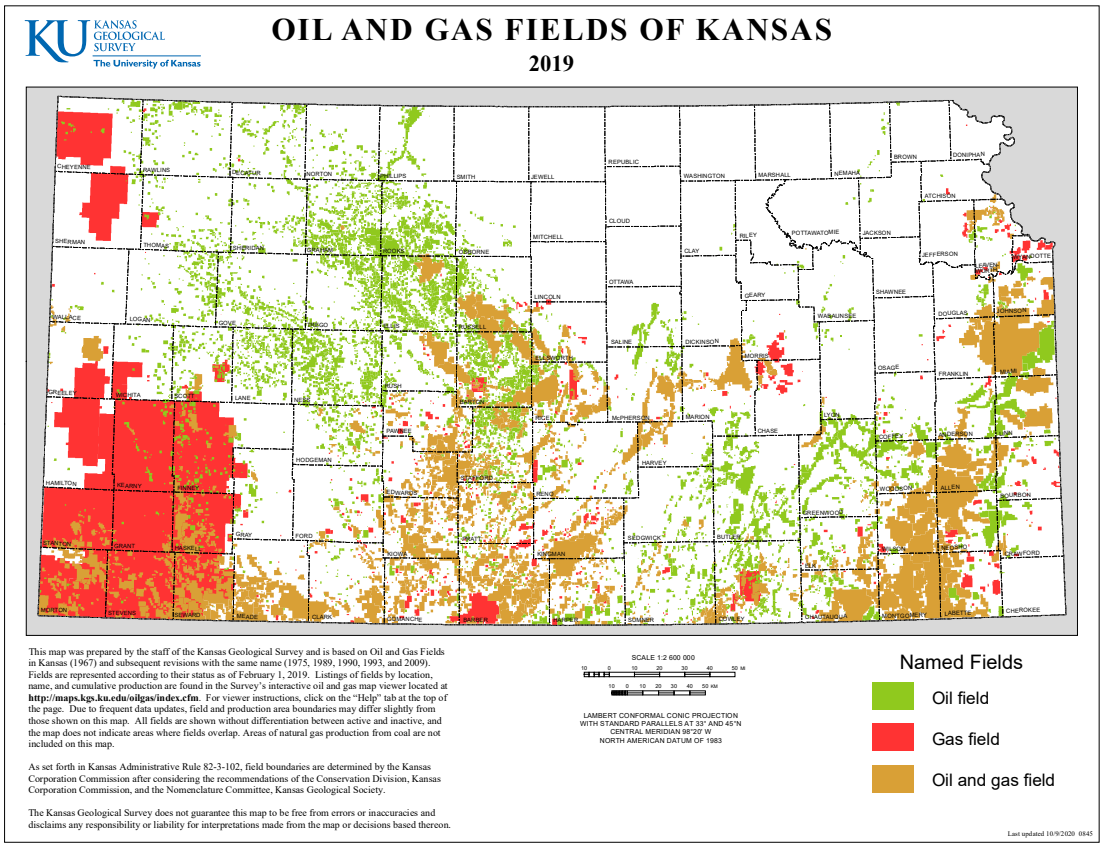


Figure 2. Oil and gas fields of Kansas.

as well construction details, geology, and the mechanical condition of the well (fig. 3). The cost to plug an abandoned well depends on these factors as well as the depth of the well. The cost to plug wells in Kansas ranges on average between $5,000 and $15,000.[7]

Three sources of funds are available to address the issue of unplugged wells.

On the state side, the KCC oversees the Abandoned Oil and Gas Well Fund. This fund receives revenue from a 50% share of monies received from the federal government under the Mineral Leasing Act and through a fee collected when operators apply for their licensure. Kansas House Bill 2022, signed into law on April 9, 2021, merged two existing statutory abandoned well plugging funds so that all the abandoned well plugging funds would be available for KCC use. This change has attracted more state-approved abandoned well plugging vendors; a lack of vendors was a significant barrier before.

On the federal side, the KCC applied for and received a $25 million grant under the Infrastructure Investment and Jobs Act to plug abandoned wells.[7] This grant will fund the plugging of 2,295 wells.

The state also sold salvage equipment from completed plugging projects and brought in enough revenue to add 218 wells to the plugging list, for a total of 2,513 wells (fig. 4).

In May 2024, the Department of Interior announced more than $650 million in Bipartisan Infrastructure Law funding to plug abandoned oil and gas wells. This funding is available to 27 states, including Kansas, but requires a match to maximize funding. The law provides for a grant of up to $30 million equal to the amount the state will spend during the grant period minus the average annual amount the state spent from 2010 through 2019. The KCC is investigating this new opportunity to tap additional funds to help address this issue for the state. The KCC is also actively looking for unknown abandoned oil and gas wells. Residents who know of or find an abandoned well may report it using a form on the KCC website at https://www.kcc.ks.gov/report-abandoned-well.

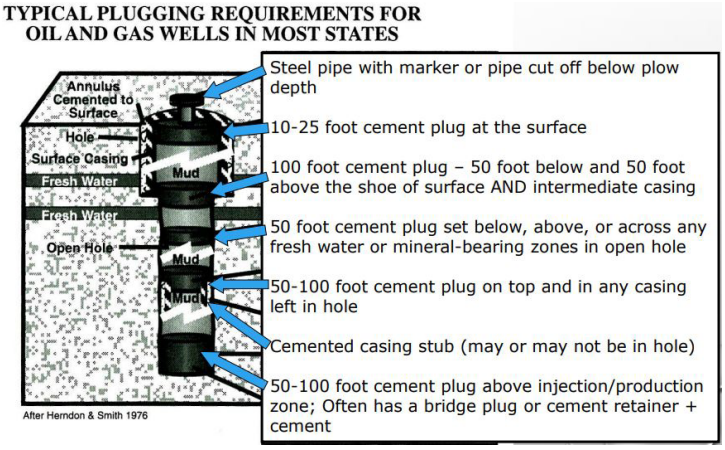


Figure 3: Diagram of a well casing hole with multiple cement plugs to prevent oil and gas from migrating into freshwater zones or above ground. Illustration: U.S. Environmental Protection Agency.

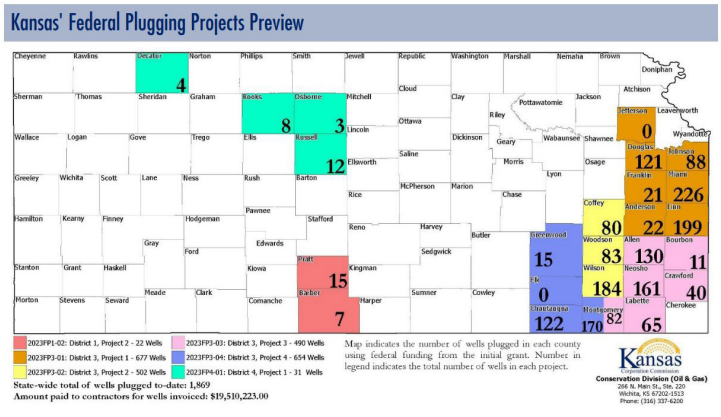


Figure 4: Abandoned wells plugged to date, by county, paid for using federal funding from the initial Infrastructure and Investment Jobs act. More than 80% of the 2,295 wells plugged supported by this funding were completed at the time of the Kansas Corporation Commission 2024 Legislative Report.

Resources

[1] First Kansas Oil Well (American Oil & Gas Historical Society)
https://aoghs.org/petroleum-pioneers/kansas-mid-continent-oil-fields/

[2] Stratigraphic and Spatial Distribution of Oil and Gas Production in Kansas (K. David Newell, W. Lynn Watney, Stephen W. L. Cheng, and Richard L. Brownrigg, 1987, Kansas Geological Survey, Subsurface Geology Series 9)
https://www.kgs.ku.edu/Publications/Bulletins/Sub9/index.html

[3] Orphan Wells (U.S. Geological Survey, 2024)
https://www.usgs.gov/centers/central-energy-resources-science-center/science/orphan-wells

[4] "Nobody really knows what you're supposed to do": Leaking, Exploding Abandoned Wells Wreak Havoc in West Texas (Carlos Nogueras Ramos and Martha Pskowski, 2024, The Texas Tribune)
https://www.texastribune.org/2024/02/28/abandoned-oil-wells-west-texas-railroad-commission/

[5] Analysis of the United States Documented Unplugged Orphaned Oil and Gas Well Dataset (Matthew D. Merrill, Claire A. Grove, Nicholas J. Gianoutsos, Philip A. Freeman, 2023, U.S. Geological Survey)
https://www.usgs.gov/publications/analysis-united-states-documented-unplugged-orphaned-oil-and-gas-well-dataset

[6] Idle and Orphaned Oil and Gas Wells: State and Provincial Regulatory Strategies (Interstate Oil and Gas Compact Commission, 2021)
https://iogcc.ok.gov/sites/g/files/gmc836/f/iogcc_idle_and_orphan_wells_2021_final_web.pdf

[7] Abandoned Oil and Gas Well Status (Kansas Corporation Commission, 2024)
https://www.kcc.ks.gov/images/PDFs/legislative-reports/2024_Abandoned_Oil_and_Gas_Well_Status_Report.pdf

CONTACTS

Ryan Hoffman
Director
Kansas Corporation Commission
r.hoffman@kcc.ks.gov
316-337-6200

Wednesday, June 12, 2024

7 a.m.	Breakfast provided at hotel
7:50 a.m.	Meet in lobby and board bus
8 a.m.	Depart hotel to Stop 2
8:30 a.m.	**Stop 2: Seismic Station at River Pond State Park** Rick Miller, Senior Scientist, Kansas Geological Survey
8:50 a.m.	Bus to Stop 3
9 a.m.	**Stop 3: Water Injection Dredging at Tuttle Creek Lake** Brian McNulty, Project Manager, U.S. Army Corps of Engineers Casey Lee, Kansas Water Science Center Director, U.S. Geological Survey Leo Henning, Deputy Secretary and Director of Environment, Kansas Department of Health and Environment Connie Owen, Director, Kansas Water Office
9:40 a.m.	Bus to Stop 4
	Bus Talk: 2019 Flooding Impacts Richard Rockel, Technical Services Lead, Kansas Water Office
10:15 a.m.	**Stop 4: Bluecat Demonstration** John Reinke, Fisheries Division Assistant Director, Kansas Department of Wildlife and Parks Martin de Boer, Government Relations Manager, Kansas Department of Wildlife and Parks
11:45 a.m.	Lunch at the Marina
1 p.m.	Bus to Stop 5
2 p.m.	**Stop 5: USGS Streamgage at Republican River** Casey Lee, Kansas Water Science Center Director, U.S. Geological Survey
2:30 p.m.	Bus to Stop 6
2:45 p.m.	**Stop 6: USGS Mobile Lab at Milford Lake** Casey Lee, Kansas Water Science Center Director, U.S. Geological Survey
3:30 p.m.	Bus back to hotel

(Continued)

4:50 p.m. Meet in hotel lobby for optional float trip

5 p.m. Bus to float trip

5:30 p.m. **Optional Float Trip down Kansas River and Dinner on Sandbar**
Dawn Buehler, Executive Director and Kansas Riverkeeper, Friends of the Kaw

7:30 p.m. Meet bus at Big Blue River boat ramp; back to hotel

Route, day two.

STOP 2

Shifting Ground: Understanding and Responding to Kansas's Earthquake Surge

Blair Schneider, Kansas Geological Survey

KEY FACTS

- More than 1,000 earthquakes occur around the world each day, but fewer than 2% of them occur within the interior of major tectonic plates.
- When an earthquake is linked to human activities, it is called induced seismicity.
- Prior to 2013, Kansas was generally considered low risk for felt earthquakes.
- Many studies have documented instances of earthquakes caused by human activity, including fluid injection for enhanced oil recovery, solution mining, hydraulic fracturing, geothermal stimulation, and disposal of waste fluids from industrial or oil and gas operations.
- Induced seismicity in Kansas corresponds with wastewater injection into deep rock formations.

For most of the state's history, earthquakes have not been a top cause of concern, especially compared to more often encountered natural hazards such as tornadoes and flooding. But the last decade has seen a sudden increase in the frequency and intensity of earthquakes in the state. At this stop, we will explore why earthquakes have become more prevalent in the midcontinent United States and the steps that the Kansas Geological Survey is taking to monitor them.

Earthquakes occur when rocks beneath the Earth's surface suddenly move along faults, or cracks, within the rocks. The rocks release energy when they move, and the intensity of the earthquake depends on the amount of energy released.[1] Most people don't realize that more than 1,000 earthquakes occur around the world every day because we seldom feel them. The majority of earthquakes (about 98%) occur along plate boundaries (fig 1.), and the remaining 2% occur within the interiors of major plates.[1] These interior earthquakes cannot be explained by plate tectonics, and new research has shown that some do have a link to human activities. When an earthquake is linked to human activities, it is called induced seismicity.[2]

The KGS Seismic Network

Earthquakes are measured based on their magnitude (M), or size, using the moment magnitude scale. The scale ranges from 1 to 12; however, most earthquakes below a

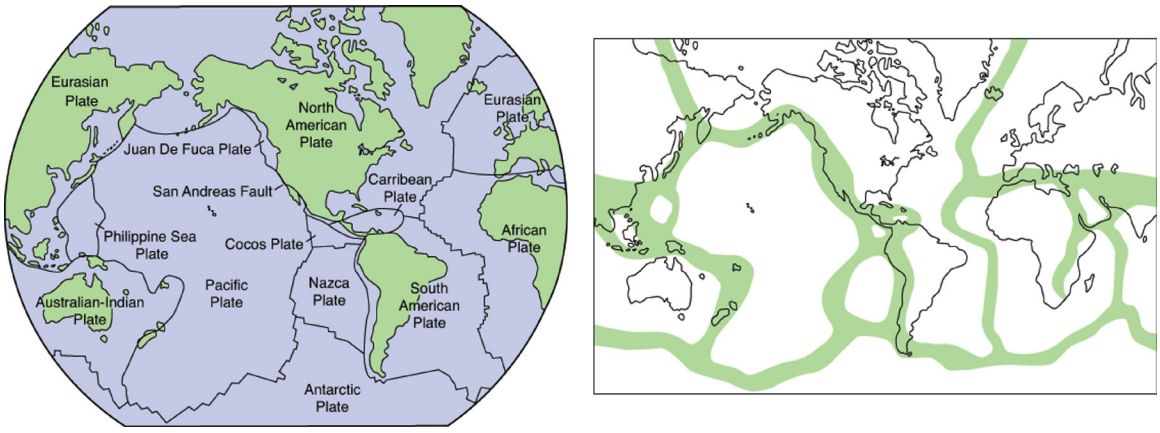


Figure 1. Left, a simplified map of Earth's plate tectonic boundaries. Right, principal earthquake zones, shaded in green. More than 98% of all earthquakes occur within this green zone.[1]

magnitude 4 cannot be felt or detected without special instruments designed to record earthquakes. Before 2013, the state of Kansas was generally considered low risk for felt earthquakes. Only 25 earthquakes were recorded as being felt in the state between 1867 and 1976. A baseline study conducted by the Kansas Geological Survey from 1977 to 1987 recorded more than 200 earthquakes across the state. Most were classified as microearthquakes and too small to feel.[1] These earthquakes were largely associated with known faults below the surface.

So what changed in 2013? Seismometers installed by the U.S. Geological Survey recorded 17 earthquakes of magnitude 2 or greater that year, predominantly in south-central Kansas. The number jumped to more than 100 in 2014, including a magnitude 4.9 event on November 12 in Sumner County. The Sumner County quake was the most powerful digitally recorded event in Kansas history.[2] In response to this increase, the Kansas Corporation Commission provided funding for the KGS to install a temporary seven-station seismic network in south-central Kansas to 1) provide a larger geographic area of coverage than the USGS network; 2) pinpoint earthquake depths and epicenters; 3) define zones of increased risk; 4) guide installation of a permanent KGS statewide network; 5) help guide future scientific and regulatory responses to the seismic activity; and 6) gather background geologic data in areas with potential earthquake activity (fig. 2). The KGS Seismic Network has produced significant new insights into earthquake activity within the state (fig. 3).

Figure 2. Seismometer installed in Sedgwick County. The seismometer is buried a few feet below the surface (right) and is powered by a solar panel (left). Real-time data are continuously sent to the KGS from every station and can be viewed on the KGS website (https://www.kgs.ku.edu/Geophysics/Earthquakes/network.html).

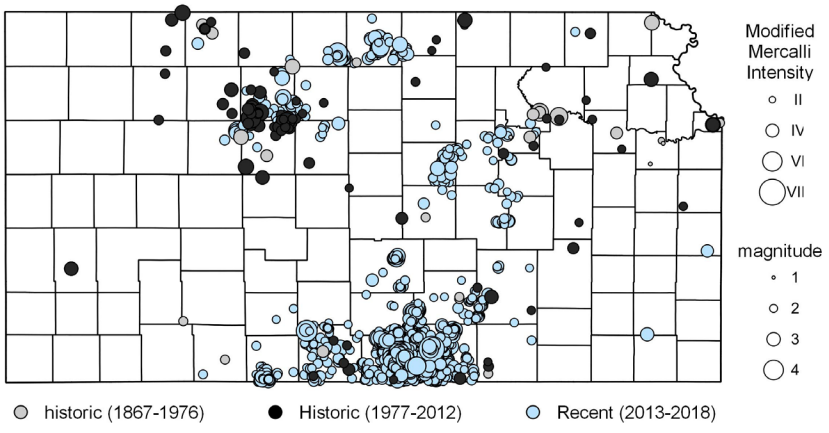


Figure 3. Summary of earthquakes recorded by the KGS Seismic Network from 2013 to 2018 compared to historic data collected by the KGS and USGS from 1977 to 2012 and reported earthquakes from 1867 to 1976.

Induced Seismicity in Kansas

Many studies have documented instances of earthquakes caused by human activity, including fluid injection for enhanced oil recovery, solution mining, hydraulic fracturing, geothermal stimulation, and disposal of waste fluids from industrial or oil and gas operations.[3] Several industries in Kansas use underground injection control wells to dispose of fluid. This includes 50 Class I wells, which are regulated by the Kansas Department of Health and Environment, and about 5,000 Class II wells, which are regulated by the Kansas Corporation Commission. Class I wells are used to inject hazardous and non-hazardous wastes into deep, isolated rock formations. Class II wells are used exclusively to inject fluids associated with oil and gas production.

The majority of earthquakes recorded in southern Kansas corresponded with injection of extracted oil field brine deep below Earth's surface.[4] This brine water, called produced water, is saltier than seawater and is a byproduct of oil and gas production. An estimated 2.5 billion gallons of produced water are extracted every day from oil and gas wells.[5] If the brine water is injected at rates faster than the force of gravity, the added pressure may lower the frictional resistance between rocks and allow them to slide and create earthquakes.[2] For example, the annual saltwater disposal volume in Harper County increased from a historic rate of 10 million barrels to more than 100 million barrels by 2015. The saltwater was injected into a deep rock formation, called the Arbuckle formation, which is not the same rock formation that produced the oil and gas. In response to this increased activity, the state developed a new response plan based on a seismic action score, a calculation incorporating magnitude, location, depth, risk, and clustering and timing of earthquakes greater than magnitude 3.5. In March 2015, the KCC ordered operators to reduce the rate of injection into the deep Arbuckle rocks in five areas of Harper and Sumner counties where the KGS had identified high seismic action scores.

Today, 30 seismometer stations operate across the state. Since the new response plan was enacted, the number of earthquakes in southern Kansas has decreased compared to the 2013–2015 numbers. However, a significant amount of possible induced seismic activity still occurs across the state (fig. 4). The KGS continues to study this issue and is investigating regional pressure changes within the Arbuckle formation.

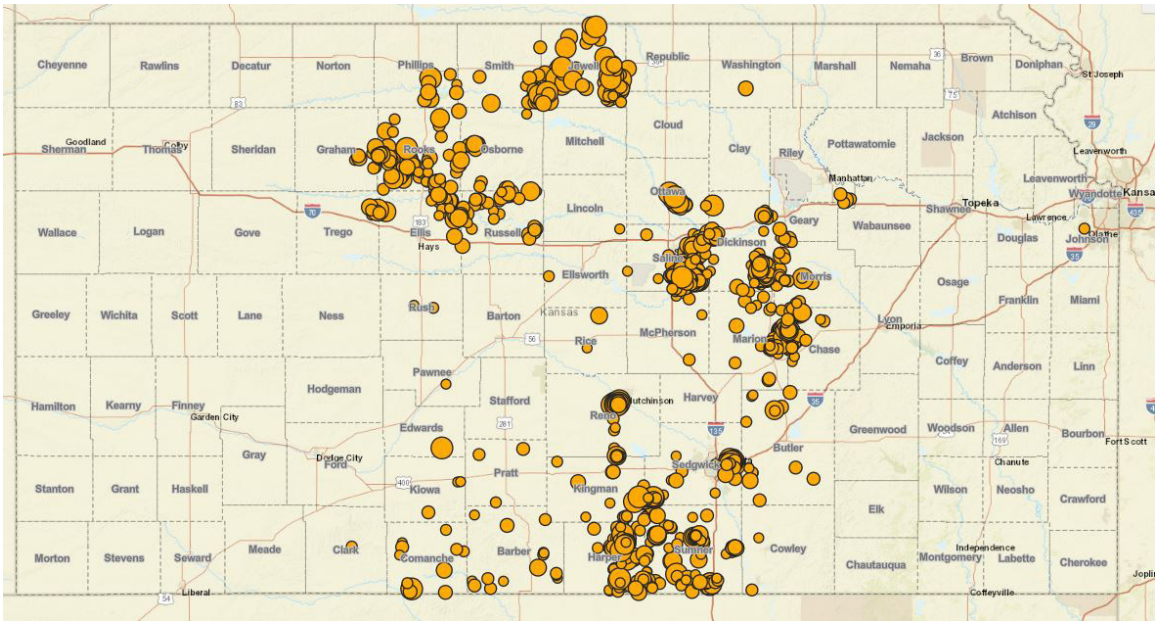


Figure 4. Recorded earthquakes in Kansas between 2019 and 2023 that measured a magnitude 2 or higher.

Resources

[1] Earthquakes (Don W. Steeples and Liz Brosius, 2014, Kansas Geological Survey Public Information Circular 3)
https://kgs.ku.edu/earthquakes

[2] Induced Seismicity: The Potential for Triggered Earthquakes in Kansas (Rex C. Buchanan, K. David Newell, Catherine S. Evans, Richard D. Miller, and Shelby L. Peterie, 2015, Kansas Geological Survey Public Information Circular 36)
https://kgs.ku.edu/induced-seismicity

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STOP 3

Water Injection Dredging: A New Approach to Address Reservoir Sedimentation

Blair Schneider, Kansas Geological Survey

In eastern Kansas, most water used for drinking, industry, and other purposes comes from surface water sources, mainly larger rivers and lakes. Because natural lakes in Kansas are rare and small (the largest natural lake in Kansas, Lake Inman, covers only about 160 acres), 24 federal reservoirs were constructed in the state between 1940 and 1982[1] (fig. 1) to help meet water supply needs. Kanopolis Lake was the first reservoir to be constructed, and Hillsdale Lake was the last one to be completed.

The Bureau of Reclamation owns and operates eight of the reservoirs, and the U.S. Army Corps of Engineers owns and operates the rest.

The state of Kansas owns or manages water conservation storage — the storage of water for later release for purposes such as municipal water supply, power, or irrigation — in 15 of the federal reservoirs operated by the Corps of Engineers. The Kansas Water Office is responsible for administering the state's Water Marketing, Water Assurance, and Water Supply Access programs, which use federal reservoirs to help meet water supply needs (table 1).

KEY FACTS

- The 1951 floods created catastrophic damage, affecting 116 cities and towns. Transportation, communication lines, radio stations, and electric power and water facilities were all disrupted; 85,000 persons were evacuated. More than 22,000 residences were inundated; nearly 2,500 demolished. More than 3,000 businesses were flooded, of which 336 were destroyed.
- The total cost to construct Tuttle Creek dam and reservoir was $80,051,031.
- At its current sedimentation rate, new modeling indicates only 36% of Tuttle Creek Lake will remain as a usable water source in the next 25 years without intervention.
- This demonstration project is estimated to cost $6 million. If it works, it will result in significant savings over traditional dredging.
- The environmental impacts of water injection dredging, including water quality within and downstream of the reservoir, will be monitored throughout the project with support from the Corps of Engineers, USGS, KDWP, KGS, K-State, and more.

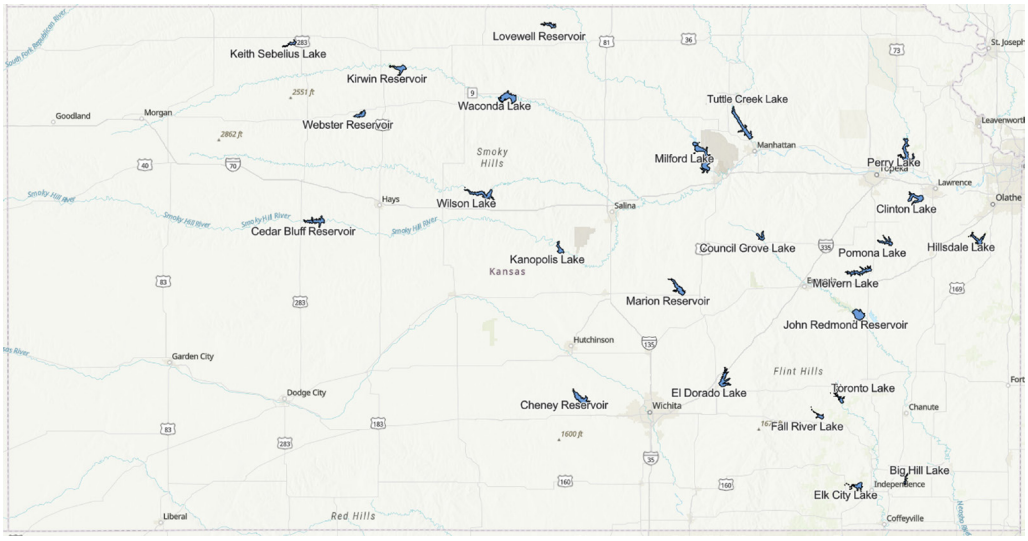

Figure 1. Federal reservoirs in Kansas.

Table 1: The three programs that the state administers in partnership with the federal reservoirs.[1]

Kansas Water Office Administration Program	Description
Water Marketing	The Water Marketing Program began in 1974 when the Legislature enacted the State Water Plan Storage Act, authorizing the KWO to contract with water purchasers for the sale of water from state-owned storage in federal reservoirs. The purpose of the program is to develop adequate water supply storage to meet present and anticipate future municipal and industrial water needs, in the best interests of the state.
Water Assurance Program	Enacted in statute in 1986, the purpose of the program is to allow for coordinated operation of state-owned or -controlled water storage space in federal reservoirs in a designated basin to satisfy downstream municipal and industrial water rights during drought conditions. The program enables the state to operate the participating reservoirs in a basin as a system, assuring downstream water right owners enhanced flow during times of drought.
Water Supply Access	The Lower Smoky Hill Water Supply Access Program was enacted in statute in 2011. The program is the same as the Water Assurance Program with two notable differences: Membership is voluntary, and membership eligibility is extended to recreation and irrigation, in addition to municipal and industrial water right owners.

Tuttle Creek Lake and the Sedimentation Problem

Tuttle Creek Lake, the largest reservoir in the Kansas City District, covers 10,900 acres[1] in the northern portion of the Flint Hills. With up to 300 feet of relief between the river and hilltops next to the lake, the total cost to construct the dam and reservoir was $80,051,031.[2] Tuttle Creek dam was constructed by the Corps of Engineers and began operation July 1, 1962 (fig. 2). The Corps manages the lake and 20,000 acres of surrounding land used for recreational areas and natural resources, including parks, campsites, boat ramps, and picnic grounds. The Kansas Department of Wildlife and Parks manages the River Pond State Park, Cedar Ridge State Park, Fancy Creek State Park, and Randolph State Park at the north and south end of the reservoir and adjacent wildlife areas for hunting to the north. Water from Tuttle Creek dam is released into the Big Blue River.

Dams and reservoirs serve multiple purposes, including flood control, recreation, fish and wildlife conservation, and water storage for use in drier seasons. Tuttle Creek reservoir and dam were constructed largely in response to the 1951 flood, which far exceeded in magnitude and damage all other flood records on the Kansas and lower Missouri rivers.[3] Transportation was brought to a standstill, communication lines were down, radio stations were inundated, and electric power and water facilities were disrupted. The flooding affected 116 cities and towns, and 85,000 persons were evacuated. More than 22,000 residences in the Kansas River basin were inundated, and nearly 2,500 were demolished. More than 3,000 businesses were flooded, of which 336 were destroyed. The Corps of Engineers estimates that Tuttle Creek Lake has prevented more than $12.4 billion in flood damages since construction. With regard to low flow in dry spells, releases from the reservoir were used to boost the quality and quantity of water downstream more than 1,100 times between 1968 and 2010.

Once a dam is constructed, sediment begins to accumulate behind the dam wall.

Figure 2. Cars at observation point, Tuttle Creek Lake, 1963. (Photo: U.S. Army Corps of Engineers.)

This is called reservoir sedimentation, and it is a significant issue for many federal reservoirs in the state. To address this issue, the Corps of Engineers created the Regional Sediment Management program, a collaboration between the Corps, the U.S. Geological Survey, and the Kansas Water Office.

Since Tuttle Creek dam was completed in 1962, more than 430 million cubic yards of sediment have accumulated within the reservoir.[4] That is equivalent to the size of three-and-a-half football fields piled with soil as high as the Empire State Building settling in the lake every year since 1962.[5] This sedimentation is filling up the reservoir and recent estimates indicate that almost 50% of Tuttle Creek Lake's original water storage capacity has been lost due to sedimentation.[6] New modeling shows that in the next 25 years, only 36% of Tuttle Creek will remain as a usable water source (fig. 3).

In the past, the only solution to address reservoir sedimentation has been dredging, the removal of sediments and debris from the bottom of lakes, rivers, harbors, and other water bodies.[8] Dredging is a time-consuming and expensive process. In 2016, the state spent $20 million dollars to dredge John Redmond Reservoir, which cleaned out about three years' worth of sedimentation.[5] Estimated costs to dredge Tuttle Creek Lake are $39 million, and it isn't the only reservoir in the state filling up. Scientists and engineers are investigating new ways to address this issue.

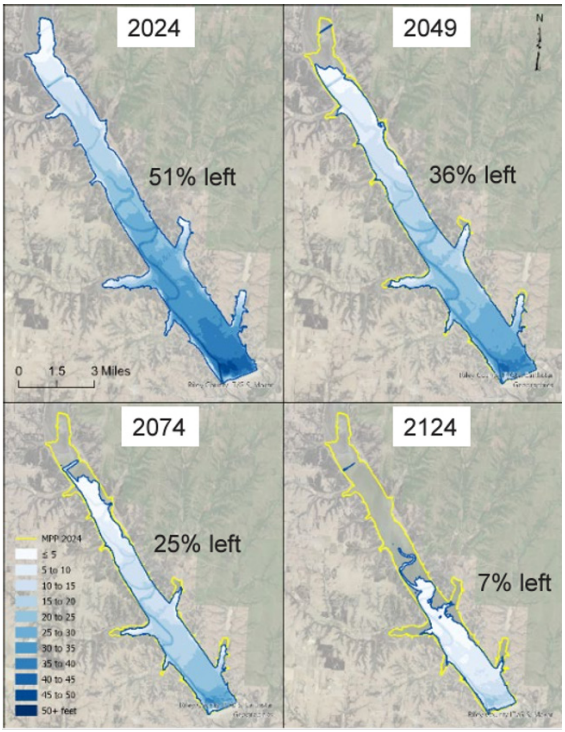

Figure 3. The projected amount of storage capacity remaining in Tuttle Creek Lake at current sedimentation rates.[7]

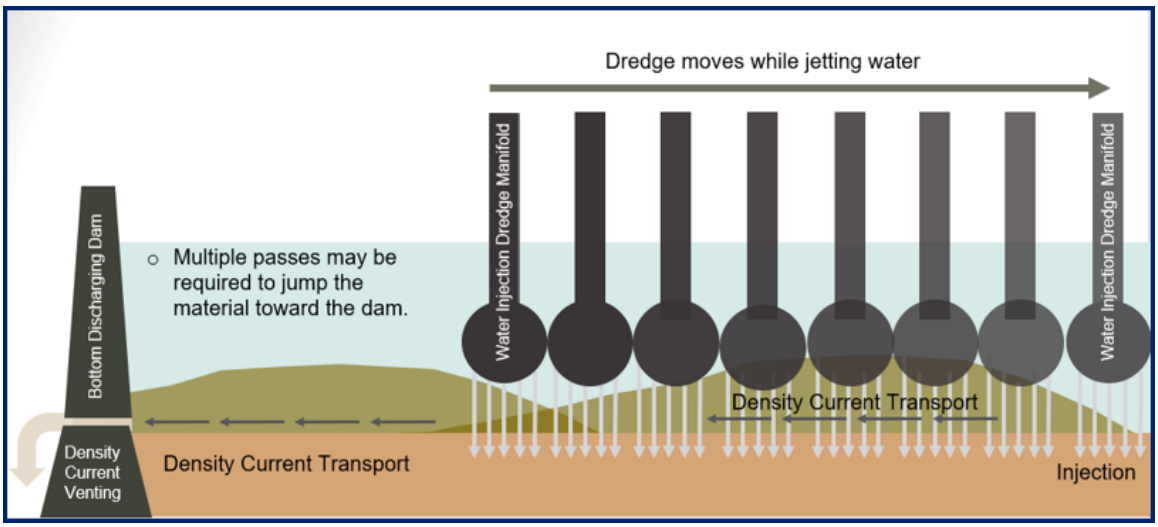

Figure 4. In the water injection dredging process, a dredge moves along the water surface and continually jets water, creating an underwater current that will transport sediment downstream by gravity.

Water Injection Dredging

Enter the Water Injection Dredging demonstration project. The purpose of this study is to evaluate the potential to use low-pressure, high-volume jets of water to stir up sediments and move them downstream and out of the lake.

During this process, a barge is outfitted with a special bar that can produce jets of water to mobilize the sediment (fig. 4).[4] Water is first drawn from the reservoir into the barge and then the jet bar is lowered into the lake and the jets are activated. The jets are expected to stir up a slurry of sediment and water and create an underwater current that, because of gravity, will flow naturally toward the dam's outlet and into the downstream channel in the Big Blue River. The estimated cost of this demonstration is $6 million. If it works, it will result in significant savings in contrast to traditional dredging.

Because this is the first time this technology is being implemented in a Kansas reservoir, plans are in place to monitor the environmental impacts of water injection dredging. Water quality will be monitored within and downstream of the reservoir throughout the project with support from collaborators at the Corps of Engineers, USGS, Kansas Department of Wildlife and Parks, Kansas Geological Survey, Kansas State University, and more. Researchers have already assessed baseline conditions in the Big Blue and Kansas rivers. Sediment and water samples will be monitored for nutrients, metals, and organochlorine pesticides. Scientists are also including ecological assessments upstream and downstream of the reservoir to evaluate any effects on macroinvertebrates and fish populations.

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NOTES

STOP 4

Bluecats and Electrofishing: Surveying Fish Populations in Kansas

Sunday Siomades, Kansas Geological Survey

KEY FACTS

- Blue catfish, one of the largest fish in Kansas, can grow up to five feet long and are popular among Kansas anglers.
- To meet demand, Kansas began stocking bluecats in state lakes and reservoirs in 1972.
- The Fisheries Division of the Kansas Department of Wildlife and Parks regularly conducts population surveys of Kansas fish to monitor population health and growth rates.
- Biologists use electrofishing to survey bluecats in Kansas.
- Fisheries Division funding comes primarily from user fees and taxes paid by Kansas anglers.

The Fisheries Division of the Kansas Department of Wildlife and Parks manages more than 400 bodies of water across the state, provides information about fishing locations and licenses, and is responsible for recommending regulations such as creel and length limits to the KDWP commission. The division also compiles species-specific reports that detail stocking, forecasts, and population trends for major commercial fish. One such species is the blue catfish, *Ictalurus furcatus,* colloquially known as the bluecat.

The Blue Catfish

Maturing at about two feet in length — and known to grow up to five feet — the bluecat is one of the largest fish in Kansas (fig. 1). This massive bottom-dweller mostly subsists on invertebrates (such as crayfish and insects) and the occasional small fish. They nest in holes and alcoves along shallow river banks and reservoir shores. Historically, old cream cans have been sunk in hatcheries as nesting locations to simulate this preferred confined environment. Bluecats reach maturity between four and five years of age and can live more than twenty years. Their size and longevity make the bluecat a real prize for Kansas anglers, who consistently rank them among their top four most preferred fish to catch.[1] The largest recorded Kansas bluecat

Figure 1. Bluecat consistently rank as one of the most popular fish among Kansas anglers. Photo: Kansas Department of Wildlife and Parks.

was caught by Robert Stanley in Olathe. The fish, found in the Missouri River in 2012, measured 56.75 inches from tip to tail and weighed 102.8 pounds.[2]

Because of this angling interest in blue catfish, Kansas began stocking the species in state lakes and reservoirs in 1972. Native bluecat populations were concentrated in northeast Kansas, as shown by the hashed area in fig. 2, though today these fish can be found throughout Kansas. The state's populations weren't initially large enough to meet public angling demands, so Kansas relied on fish stocks from other state fisheries management agencies. Lots of adult brood-stock originated from Lake Ouachita in Arkansas, though Missouri has also supplied fish in more recent years.[3] Today, Kansas has several self-sustaining bluecat populations — the KDWP Fisheries Division maintains bluecat hatcheries in Farlington and Milford — and it is likely the state will be in a position to export broodstock in coming years.

Fish Population Surveys

The Fisheries Division regularly conducts population surveys of Kansas fish, prioritizing extensively fished water bodies that contain the most popular angling species. These surveys aim to collect information on overall population size, fish dimensions, age distribution, and other parameters that are indicative of population health and growth rate. Studying micro and macrofauna, which includes fish, has been used for water monitoring and water quality management programs for years because they are sensitive indicators of both physical and chemical changes for habitat degradation, environmental contamination, migration barriers and overall ecosystem productivity. Fish are also affected by changes in temperature, dissolved oxygen, and pH. If water quality is changing, they will move to avoid the pollutants if they can. Scientists can use population information as an indication that something has changed within a local ecosystem.[4]

The division's biologists employ different survey methods at different times of year depending on the type of fish they seek to collect. Walleye and channel catfish populations, for example, are best surveyed using gill nets (walls of netting that are

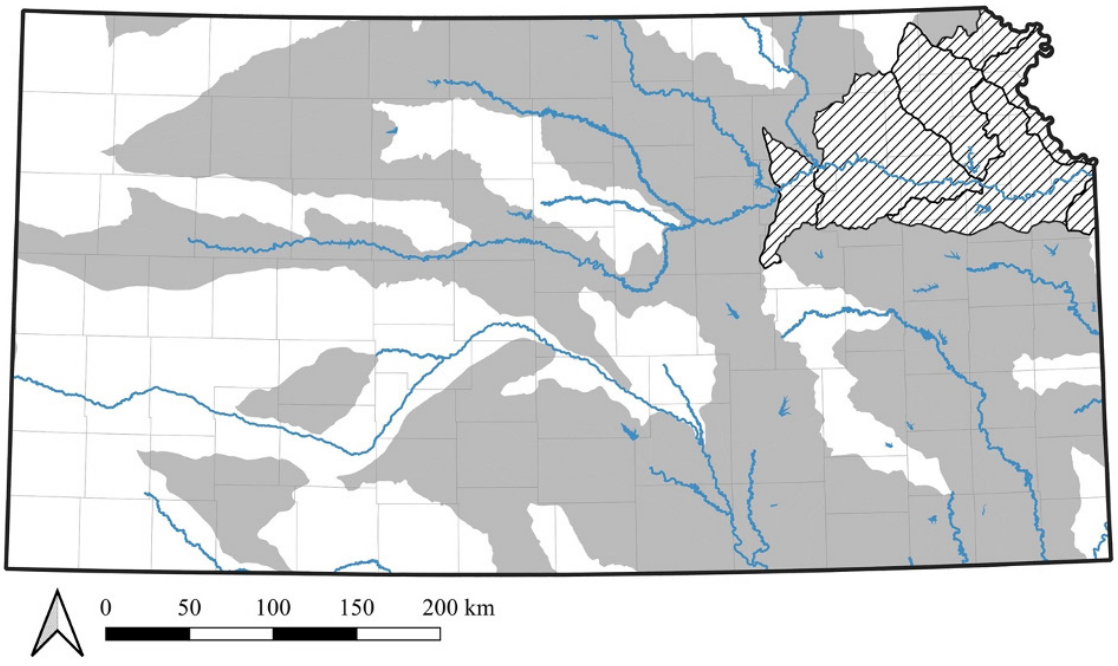

Figure 2. Blue catfish distribution map in Kansas. Gray areas indicate where blue catfish have been observed and the hashed area is considered the native range. From Miller et al.[3] (used with permission).

Figure 3. Electrofishing boat. Photo: Kansas Department of Wildlife and Parks.

submerged offshore and snare fish by their scales) during the fall. Crappie populations are also surveyed in the fall but are caught most effectively using trap nets (nets secured near the shore that create a maze-like impoundment). Blue catfish populations are best surveyed using a technique called electrofishing, which is far more species-selective and produces less bycatch than gill or trap netting methods.

Using Electrofishing to Survey Bluecats in Kansas

This method involves a specially equipped electrofishing boat (fig. 3) that emits a direct current into the water. The current travels to poles, called booms, at the front of the boat. Fish that swim near the booms are temporarily stunned (***not*** killed) and can be scooped from the water by researchers in smaller chase boats.[5]

Electrofishing relies on a specialized combination of amperage and voltage to affect specific fish species. For example, bass are another population that respond well to electrofishing; because of their scales, these fish require high-frequency, high-pulse currents for immobilization. Bluecats — which have skin, not scales — are most effectively surveyed using low-frequency, low-pulse currents. These two current types travel through the water very differently: The current used for bass extends to depths of only eight to ten feet, while the current used for bluecat can affect fish as deep as 40 feet.

Until recently, the Fisheries Division operated electrofishing boats from the 1980s. The electric output on these boats could not be regulated — and thus, could not be calibrated to affect specific species — and biologists had to work with whatever assortment of fish popped up. Electrofishing technology has since exponentially advanced in efficiency and safety. The electric currents emitted by new boats can be pre-programmed to account for water composition, temperature, and other conditions, vastly improving the productivity of survey efforts. The electric current is controlled by a foot pedal — as soon as pressure on the pedal is removed, the current stops flowing through the water. This innovation minimizes the safety hazard of electrified water for all researchers and observers in the vicinity of the electrofishing boat.

Depending on the water temperature and the size of the fish, the bluecats are stunned for anywhere from a few seconds to a few

minutes, so biologists must work quickly to complete their surveys.[3,5] Electrofishing for bluecats is best conducted in waters between 64 and 82 degrees Fahrenheit, as catch rates are lower in very cold or very warm water.[6] As such, bluecat surveys have a wide window of opportunity starting in spring and extending through early fall.

Funding for Fishing in Kansas

The KDWP Fisheries Division is funded by user fees. The 1950 Sport Fish Restoration Act (also known as the Dingell-Johnson Act) set up a financial pathway in which excise tax collected from the sale of sport fishing equipment is directed to the U.S. Fish and Wildlife Service, which then returns that money to state agencies.[7] In short, Kansas angling is primarily funded by Kansas anglers.

Funds from the Sport Fish Restoration Act comprise about 75% of the division's budget. This money is put toward managing fish populations, measuring water quality, restoring habitats, aquatic education programs, and other ventures that protect, maintain, and improve fishing in the state of Kansas.

Resources

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[2] State Record Fish (Kansas Department of Wildlife & Parks)
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[3] Blue Catfish Fisheries in Kansas: 50 Years of Research and Management (Brett T. Miller, Weston L. Fleming, Ernesto Flores, Don J. George, Josh L. Jagels, Craig M. Johnson, Nicholas W. Kramer, Seth A. Lundgren, Justin L. Morrison, Ben C. Neely, Connor J. Chance-Ossowski, John A. Reinke, Richard M. Sanders, Bryan J. Sowards, Ely N. Sprenkle, Susan F. Steffen, Micah J. Waters, and D. Scott Waters, Kansas, Transactions of the Kansas Academy of Science, 2022)
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STOP 5

Streamgaging the Republican River at Junction City

U.S. Geological Survey

KEY FACTS

- In 1895, seven streamgages were in operation in Kansas. Today, 225 streamgages operate across the state.
- Streamgages measure and record the water level of a stream and are used to calculate streamflow.
- Streamflow information is used for flood forecasting, reservoir management, water resources management, and more.
- The Federal Priority Streamgage network funds 35 percent of active streamgages throughout the country.
- The Republican River at Junction City streamgage has been in continuous operation since 1963.

The U.S. Geological Survey, recognizing the importance of water availability for settlement of the western United States, began the first federally operated streamgage at Embudo, New Mexico, in 1889. By 1895, seven streamgages were in operation in the state of Kansas, and a first-in-the-nation cooperative streamgaging agreement was established between the USGS and the Kansas Board of Irrigation, Survey, and Experiment (now Kansas Department of Agriculture, Division of Water Resources).

A streamgage is a structure installed beside a stream or river housing equipment that measures and records the water level of a stream (fig. 1). The water-level measurement is also referred to as the gage height or stage of the stream. An automated system in the streamgage records stream stage at regular intervals using a variety of instruments.[1] The data are then transmitted to the USGS hourly and published within minutes of receipt to the USGS National Water Information System (NWIS) webpage, where the data are publicly available.

Most streamgages are used to calculate streamflow, also known as discharge, which is the measure of the volume of water moving down a stream or river per unit of time.[2] Streamflow information is used for flood forecasting, reservoir management, water resources management,

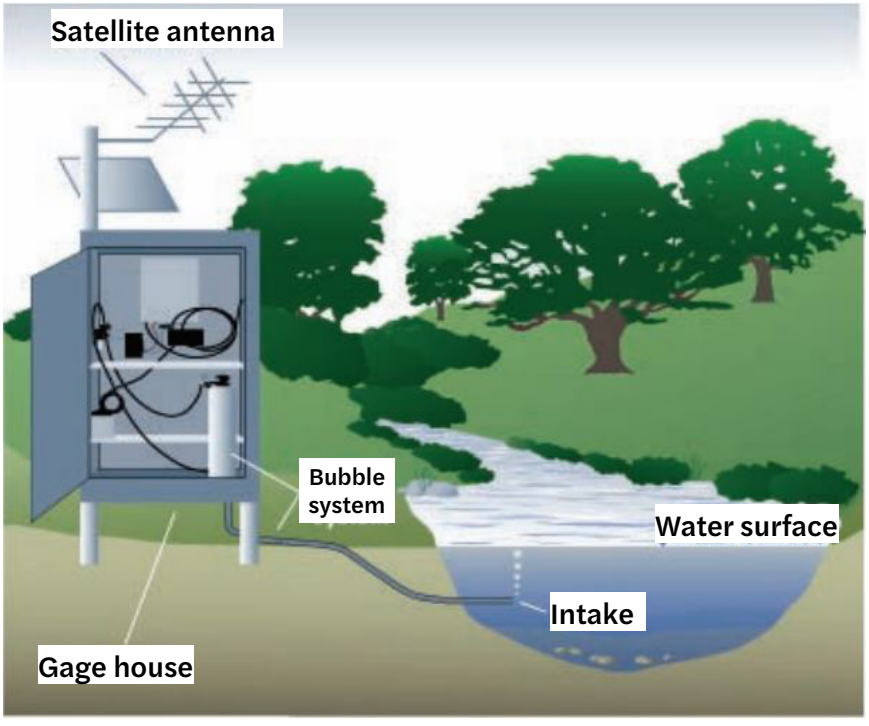

Figure 1: Diagram of a typical streamgage installation. To measure stream height, gas is continually pushed through the intake tube into the water. The pressure it takes to push the gas through the tube corresponds to the depth of the water above the tube opening — as the water height increases, more pressure is needed to push the gas out. Data are transmitted via satellite to the USGS.

and many other uses. It is a foundational data set relied on for water-quality and sediment transport studies of the stream.

A continuous record of streamflow can be determined by scientists who take discharge measurements at a streamgaging location and relate the measured volume to the corresponding stage at the time of the measurement. USGS scientists calibrate this relation using periodic discharge measurements taken at various flow conditions and making note of changes to the physical characteristics of the stream. Discharge measurements are performed using a variety of techniques based upon flow conditions. Low-flow measurements are often made by the scientist wading in the stream to measure the area of the cross section of water manually and the velocity of the water with a hand-deployed acoustic velocity sensor. Higher flow measurements can be made using an acoustic Doppler current profiler deployed from a floating platform to measure three-dimensional velocity, width, and depth (fig. 2). Scientists are researching newer methods using image velocimetry data collected via unmanned aircraft systems.

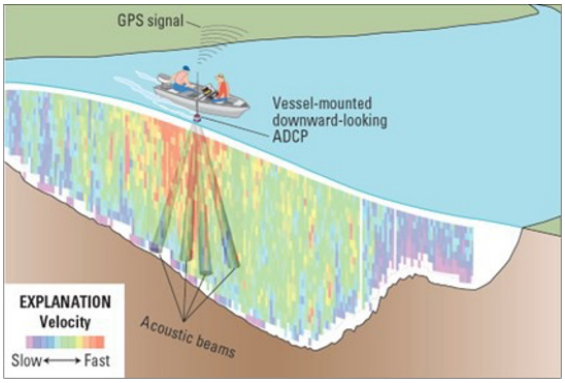

Figure 2. Modern high flow streamflow measurement using acoustic Doppler current profiler.

The Federal Priority Streamgage Program

Today, more than 11,800 streamgages operate in all 50 states and U.S. territories, with 225 streamgages in operation throughout Kansas (fig. 3). Most streamgages are funded in partnership with one or more federal, state, local, or tribal agencies or organizations. Streamgages can be funded solely by the USGS if they meet the criteria for and have been registered as part of the Federal Priority Streamgage network. The FPS program funds approximately 35 percent of the active streamgages throughout the country, including a similar proportion of the streamgages in Kansas.[3] Although additional sites meet the criteria for inclusion in the FPS network both nationally and statewide, the funding available for the program has been limited and not all sites considered as federal priority streamgages are in active operation.

The FPS was formed in 1999 to support streamgages deemed to provide data of general benefit to the nation. Five priorities were established for the original FPS program (table 1). The USGS launched a review of these priorities in 2022, and updated priorities were released in spring of 2023 (table 2). The new priorities include

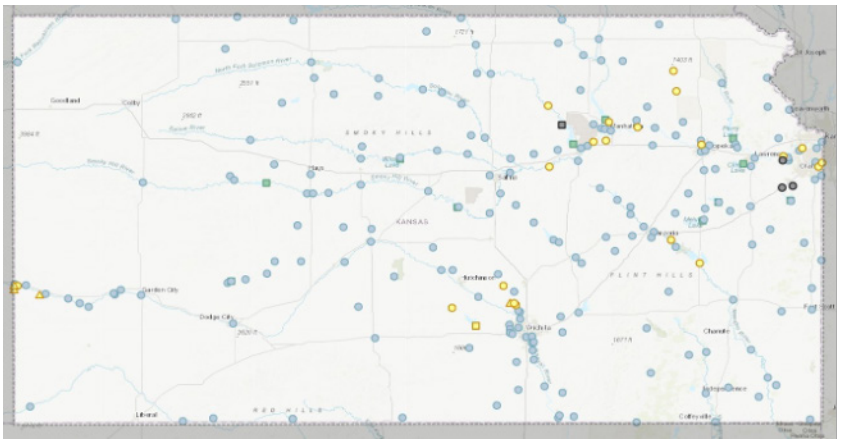

Figure 3. USGS streamgage locations in Kansas.

Table 1. Original federal priorities for the FPS. Table reproduced from Dillow et al., 2023.[4]

Original Federal Priority	Description
National Weather Service flood-forecast sites	Supply essential data used for flood alerts, flood and drought forecasts, and assessment and modeling of streamflow conditions (primarily by the National Weather Service) to mitigate water hazards and supply shortages and allow science-based decision making by federal water managers.
Compacts and decrees	Support interstate, international, and tribal border water agreements, compacts, court decrees, and treaties.
Water budgets	Monitor streamflow in large rivers and water volume in key receiving waters such as the Great Lakes.
Long-term changes	Track sentinel trends at long-term streamflow gages associated with major land uses and ecoregions to support water modeling and management.
Water quality	Support federal water-quality assessments of major rivers and estuaries.

Table 2. Updated FPS priorities. Table reproduced from Dillow et al., 2023.[4]

Updated Federal Priority	Description
Water forecasting and operations	Supply essential data used for flood alerts, flood and drought forecasts, river navigation, federal reservoir operation, and assessment and modeling of streamflow conditions to mitigate water hazards and supply shortages and allow science-based decision making by federal water managers.
Boundaries, compacts, treaties and federal lands	Support interstate, international, and tribal border water agreements, compacts, court decrees, treaties, and water-use/water-rights management involving federal lands.
Water budget	Monitor streamflow in major rivers and water volume in key receiving waters such as the Great Lakes.
Long-term hydrologic trends and extremes	Monitor long-term streamflow conditions associated with major land uses and ecoregions, including at springs making significant contributions to base flow in streams and in coastal-zone environments impacted by sea-level rise, to identify and track long-term hydrologic trends and support federal water modeling and management.
Water quality	Support federal water-quality assessments of major rivers and estuaries, public-health risk assessment and warning relating to impaired streams and ecosystem health management on federal lands.

support for water-rights issues relating to federal land management, stream-ecosystem health affected by stream restoration or management on federal lands, and federal reservoir operational effects on water supply.[4] A new network design is being formulated this year to reflect these updated priorities.

Republican River at Junction City Streamgage

The Republican River at Junction City site (USGS station number 06857100) is funded entirely through the FPS program in large part due to the important information it provides for management of Milford Lake. In addition

to the streamflow values, the data acquired at this streamgage include information dating back to 1964 about macroinvertebrate populations, the microbiology of the river, and the levels of inorganics such as metals and non-metals (figs. 4 and 5).

The site, under its current station name and number, has been in continuous operation since 1963; however, a record of streamflow data directly upstream from the Kansas River dates to 1895 as one of the original seven streamgages in Kansas. In current form, this site reports stage with readings taken by a radar stage sensor mounted below the deck of the bridge every 15 minutes and transmitted via satellite each hour (fig. 5). Hydrologic technicians collect streamflow measurements about every six weeks, or on a more frequent basis when conditions require. These measurements are used to calibrate the stage-discharge relation and assure the quality of the streamflow record. Automated readings by the streamgage are verified with manual readings of a wire weight gage, a reference gage mounted on the handrail of the bridge.

The median streamflow for June 12 since the closure of Milford Dam is about 500 cubic feet per second (cfs). The highest streamflow at the site occurred during the flood of 1993 with a peak streamflow of 33,700 cfs, although higher peak streamflows were recorded in five different years between 1895 and 1964 prior to construction of Milford Dam.

Figure 4. Cableway for making high flow streamflow measurements. Republican River at Junction City, 1969.

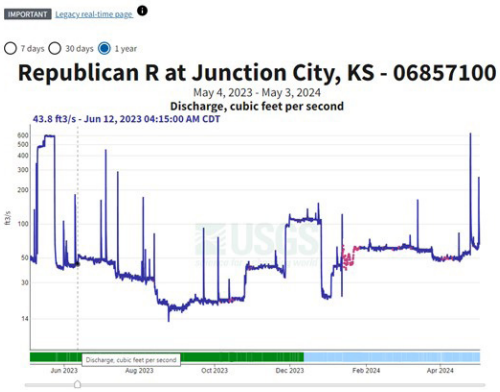

Figure 5: Snapshot of streamflow data available on the USGS website for the Republican River streamgage.

Resources

[1] Streamgaging Basics (USGS Water Resources Mission Area, 2019) https://www.usgs.gov/mission-areas/water-resources/science/streamgaging-basics#overview

[2] How Does a U.S. Geological Survey Streamgage Work? (USGS Texas Water Science Center, 2011) https://pubs.usgs.gov/fs/2011/3001/pdf/fs2011-3001.pdf

[3] Federal Priority Streamgages (FPS) (USGS Water Resources Mission Area, 2019) https://www.usgs.gov/mission-areas/water-resources/science/federal-priority-streamgages-fps

[4] Re-Prioritization of the U.S. Geological Survey Federal Priority Streamgage Network, 2022 (J. A. Dillow, B. E. McCallum, and C. E. Angeroth, 2023, Open-File Report 2023-1032, 7 p.) https://doi.org/10.3133/ofr20231032

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STOP 6

Milford Lake, the Slow-Moving Waters Project, and Harmful Algal Blooms

KEY FACTS

- Milford Lake is the largest reservoir in Kansas with approximately 15,700 surface acres of water and 163 miles of shoreline.
- Milford Lake has been under KDHE cyanobacteria harmful algal bloom (cyanoHAB) advisories and warnings from 2011 through 2017 and from 2020 through 2023 for cyanobacteria and cyanotoxins.
- Lake closures caused by cyanoHABs have resulted in revenue losses of up to 40% due to restriction of recreational use.
- The Kansas Water Science Center, in cooperation with the KDHE, KWO, KDWP, and Water One, is conducting a study on cyanoHAB initiation in wetlands, small tributaries, and other slow-moving waters near affected lakes.
- A continuous water-quality monitor is deployed at Milford Lake from May through November to provide real-time water-quality data.

The Kansas Water Science Center is the home of national-scale research designed to improve the understanding of factors that cause harmful algal blooms (HABs) and their associated risks to human and environmental health. Within Kansas, active study of the causes, effects, and transport of HABs are underway in the Kansas River and in Milford, Perry, and Cheney reservoirs. These studies are also being used to provide ground-to-space verification of satellite imagery through the Cyanobacteria Assessment Network (CyAN). This network is designed to create an early warning system to detect potentially toxic HABs nationwide.

Milford Lake (the largest reservoir in Kansas with approximately 15,700 surface acres of water and 163 miles of shoreline) has been under Kansas Department of Health and Environment cyanobacteria harmful algal bloom (cyanoHAB) advisories and warnings from 2011 through 2017 and from 2020 through 2023[1,2] for cyanobacteria and microcystins, a class of cyanotoxins. In 2015, KDHE developed new guidelines for the issuance of public warnings related to cyanoHABs in Kansas.[3] The guidelines delineate microcystin concentration and cyanobacteria cell count criteria for public health watches, warnings, and hazards.

Lake closures caused by cyanoHABs have resulted in revenue losses for the surrounding communities of up to 40 percent due to restriction of recreational use. Instances of human and animal illnesses being directly caused by HABs in Milford Reservoir have been reported.[4]

The Republican River drainage basin, including Milford Reservoir, contributes to flow in the lower Kansas River, which provides drinking water for about 800,000 people in northeastern Kansas.[5] Public drinking-water suppliers regularly adjust their water-

Confluence of Gathering Pond Outlet and Republican River below Milford dam. Photo: Ryan Waters.

Milford Lake during a cyanoHAB event. Photo: Justin Abel.

treatment processes in response to cyanoHAB formation in reservoirs and reservoir-affected streamflow.

The Kansas Water Science Center, in cooperation with the KDHE, Kansas Water Office, Kansas Department of Wildlife and Parks, and Water One, is conducting a study on cyanoHAB initiation in wetlands, small tributaries, and other slow-moving waters near cyanoHAB-affected lakes. The following are the primary objectives of the Slow-Moving Waters project:

1. Characterize the hydrologic, water-quality, and biological conditions present during the formation and transport of potentially toxic cyanobacteria blooms in selected slow-moving streams, wetlands, and oxbows to receiving reservoirs and rivers. This includes sample collection of nutrients, chlorophyll a, toxins, phytoplankton, picoplankton, and taste and odor compounds.
2. Investigate the temporal and spatial relation between the formation of potentially toxic cyanobacteria blooms in slow-moving streams, wetlands, and oxbows to subsequent development of blooms in downstream reservoirs and large rivers.
3. Validate the use of satellite imagery from CyAN, Landsat, and Sentinel-2 for identifying potentially toxic cyanobacteria blooms in slow-moving streams, wetlands, and oxbows.
4. Provide water managers important and integral findings of this research through collaboration, presentations, journal articles, or U.S. Geological Survey reports.

Additionally, Milford Lake has a seasonal continuous water-quality monitor that is deployed from May through November to provide real-time water-quality data for water temperature, specific conductance, pH, dissolved oxygen, phycocyanin, and chlorophyll. All data collected are available to the public on the USGS website (Milford Lake Near Wakefield, KS — USGS Water Data for the Nation, https://bit.ly/3KyJAvq). A continuous water-quality monitor is also located on the inflow to Milford Lake on the Republican River near Clay Center, Kansas (Republican R at Clay Center, KS — USGS Water Data for the Nation, https://bit.ly/45tXqsF).

The YSI EXO multi-parameter water-quality monitor measures water temperature, specific conductance, pH, dissolved oxygen, turbidity, and algal fluorescence. Pictured are examples of monitors with heavy biofouling (algal and sediment build up) versus a clean monitor. Photos: Nick Van Nevel.

Resources

[1] Milford Lake – Learn About the Lake (U.S. Army Corps of Engineers) https://www.nwk.usace.army.mil/Locations/District-Lakes/Milford-Lake/Learn-About-the-Lake/

[2] KDHE HABs Historical Data (Kansas Department of Health and Environment) https://www.kdhe.ks.gov/829/KDHE-HABs-Historical-Data

[3] Policy: Guidelines for Addressing Harmful Algal Blooms in Kansas Recreational Waters (Kansas Department of Health and Environment, 2015, KDHE Internal Directive 1101.1) http://www.kdheks.gov/algae-illness/download/HAB_policy.pdf

[4] Human Illnesses and Animal Deaths Associated with Freshwater Harmful Algal Blooms–Kansas (I. Trevino-Garrison, J. DeMent, F. S. Ahmed, P. Haines-Lieber, T. Langer, H. Menager, J.Neff, D. van der Merwe, and E. Carney, 2015, , Toxins, v. 7, p. 353–366)

[5] Fate and Transport of Cyanobacteria and Associated Toxins and Taste-and-Odor Compounds from Upstream Reservoir Releases in the Kansas River, Kansas, September and October 2011 (J. L. Graham, A. C. Ziegler, B. L. Loving, and K. A. Loftin, 2012, U.S. Geological Survey Scientific Investigations Report 2012–5129, 65 p.)

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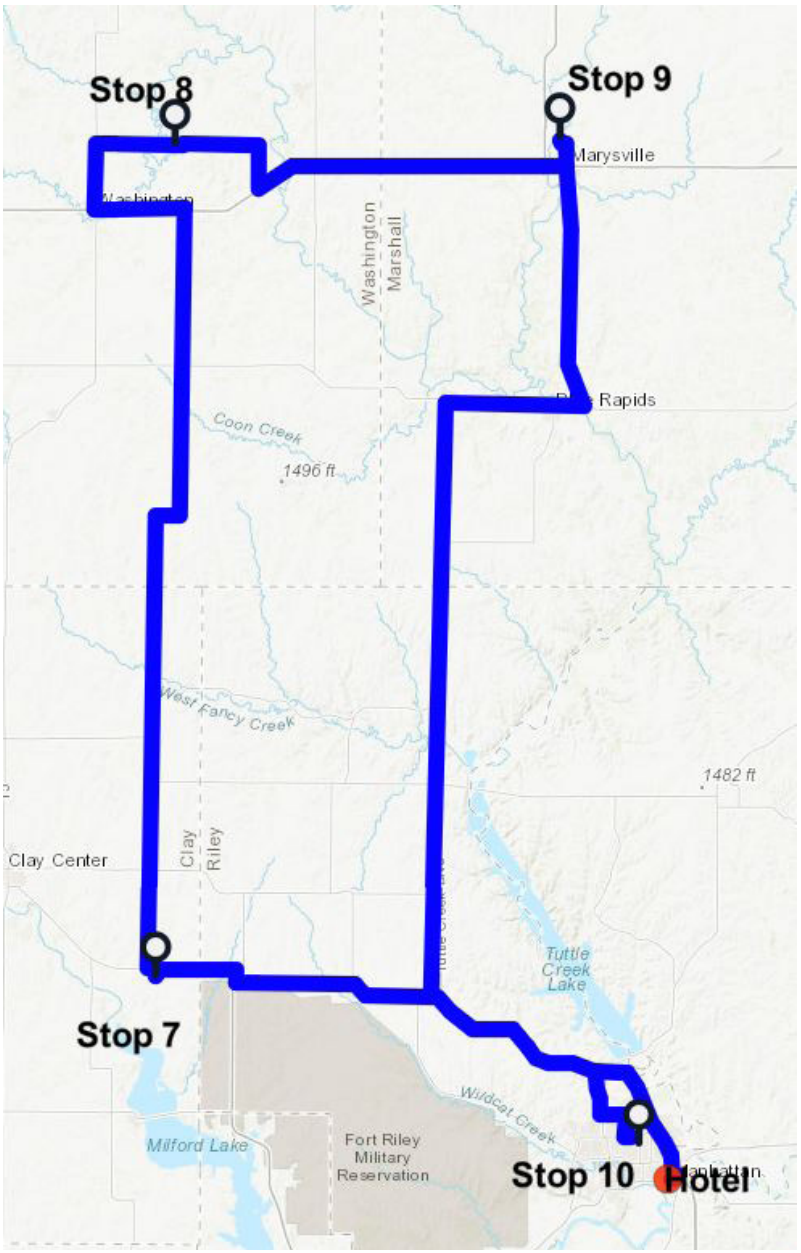
NOTES

Thursday, June 13, 2024

7 a.m.	Breakfast provided at hotel
7:45 a.m.	Check out of hotel and meet at bus
8 a.m.	Bus to Stop 7
8:45 a.m.	**Stop 7: Martin Quarry, Clay Center** Kelly Briggs, President, Bayer Construction Randy Hattesohl, Vice President of Materials, Bayer Construction Jerry Younger, Managing Director, Kansas Aggregate Producers Association Kyle Halverson, Chief Geologist, Kansas Department of Transportation
9:15 a.m.	Bus to Stop 8
	Restroom break in Washington
	Bus Talk: Riley County Kimberlites Don Steeples, Professor Emeritus, University of Kansas
10:30 a.m.	**Stop 8: Mill Creek Oil Spill** Leo Henning, Deputy Secretary and Director of Environment, Kansas Department of Health and Environment
11 a.m.	Bus to Stop 9
	Bus Talk: Deepest Well Drilled in Washington County Nikki Potter, Associate Director and Library Manager, Kansas Geological Survey
11:30 a.m.	**Stop 9: Streambank Stabilization** Tony Layzell, Assistant Scientist and Stratigrapher, Kansas Geological Survey
Noon	Bus to lunch
12:45 p.m.	**Lunch, Agronomy Education Center, Kansas State University** Charles Rice, Distinguished Professor, Kansas State University Josh McGinn, Assistant Secretary, Kansas Department of Agriculture
1:45 p.m.	Bus to Stop 10
2 p.m.	**Stop 10: Tour of Soil Testing Labs and Agronomy Farm** Charles Rice, Distinguished Professor, Kansas State University
3 p.m.	Bus to hotel End of 2024 Kansas Field Conference



Route, day three.

STOP 7

Seasonal Stone: Mining Aggregates at Martin Quarry

Blair Schneider, Kansas Geological Survey, and Kyle Halverson, Kansas Department of Transportation

KEY FACTS

- Mining activities contributed more than $437 million to the Kansas economy in 2022.
- Bayer Construction Co. operates six quarries across the Flint Hills region and an asphalt plant in Junction City.
- Martin Quarry opened in the 1960s and quarries into rock formations that were deposited during the Permian Period, 299–252 million years ago.
- KDOT is responsible for providing inspections at mines and quarries across the state to test aggregate quality.
- At Martin Quarry, the Towanda Limestone can only be produced during spring and summer. Fortunately, we are visiting during rock picking season!

Mining (not including oil and gas production) contributes a significant amount to the U.S. gross domestic product, more than $572 billion in 2023 alone.[1] Mining activities contributed more than $437 million to the Kansas economy in 2022.[2] At Martin Quarry in Clay County, Bayer Construction Co. actively mines limestone to produce aggregate materials used in road construction and as base material under foundations.

History of Bayer Construction Co.

Bayer Construction Co. was founded in 1935 by Henry Bayer after the passage of the Works Progress Administration infrastructure program, created in 1935 to help boost the United States out of the Great Depression. Bayer's work focused on the construction of public buildings and roads until the 1950s, when it expanded to include civil site preparation, water and sewer line construction, and heavy highway construction material.[3] Today the company, headquartered in Manhattan, operates six quarries across the Flint Hills region and an asphalt plant in Junction City (fig. 1).

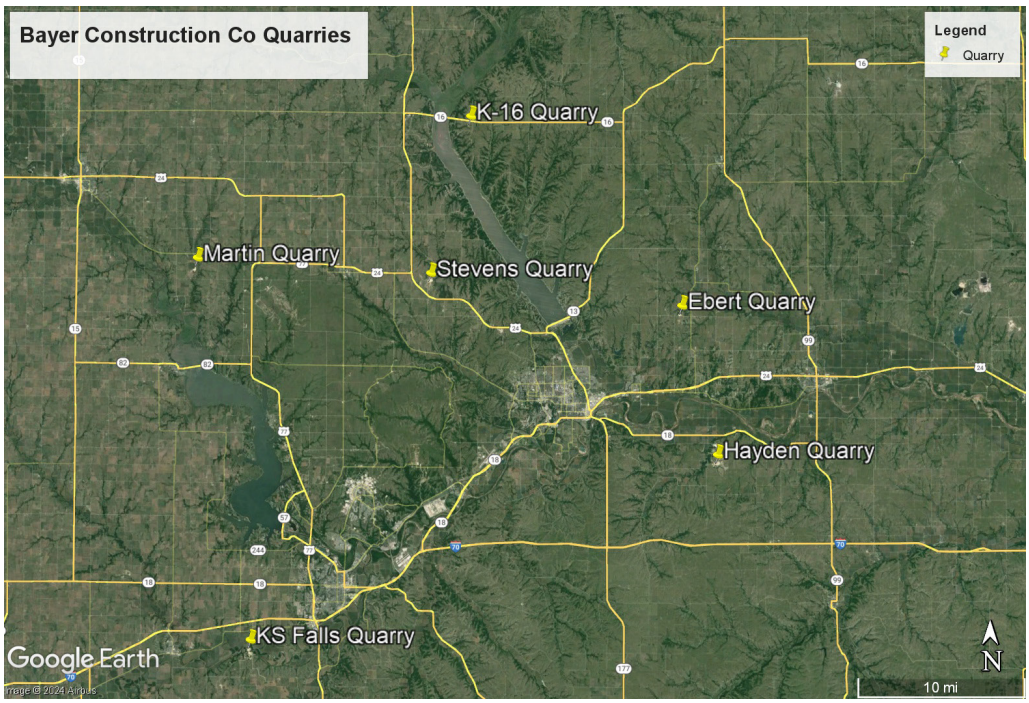


Figure 1. The six quarries operated by Bayer Construction Co. across the Flint Hills region.

Site Geology

Martin Quarry opened in the 1960s (fig. 2). Its mining activities target the Doyle Shale, a formation consisting of two shale members and one limestone member (fig. 3). The Doyle Shale is part of the Chase Group, which is made up of roughly 335 feet of alternating limestones and shales.[4] These rock formations were deposited during the Permian Period, 299–252 million years ago, when Kansas consisted of shallow seas, tidal flats, and periods of dry land.

Mining the Towanda at Martin Quarry

Martin Quarry actively mines from the Towanda Limestone Member (fig. 4), a light bluish gray to tan-gray limestone. Common thicknesses range from 5 feet to 15 feet, but here the Towanda unit is 15.5–16.5 feet thick. The five-year average for aggregate mined at this quarry is 300 to 350 tons per year.

Bayer Construction Co. produces various aggregate material from this unit. Its largest production is for base stone and road stone for rock roads. The company's biggest customers are counties and townships, contractors who use the aggregate for constructing roads, and some commercial applications where the rock becomes the base material under foundations. The majority of its business is within the state of Kansas, but it has worked with other states, such as Nebraska, as well.

The Kansas Department of Transportation has worked with Bayer Construction over the years to ensure material from this location meets specifications as outlined in

Figure 2: Aerial view of the Martin Quarry in Clay County.

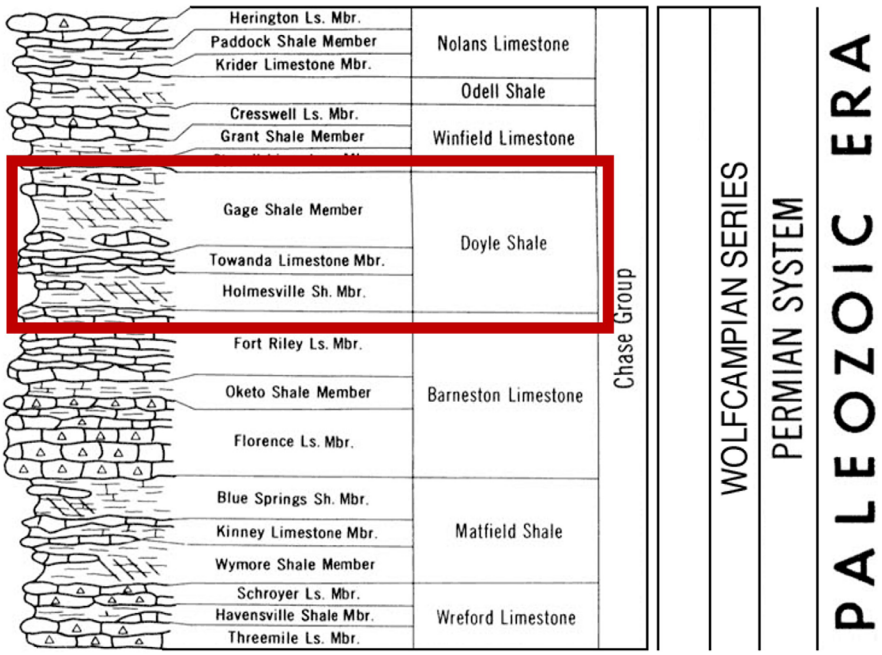


Figure 3: Stratigraphic section of the Chase Group in Kansas, with the Doyle Shale outlined in red.

the Kansas Department of Transportation Standard Specifications to ensure that aggregate materials are predictable and uniform and maintain consistent properties. When aggregates don't match KDOT standard specifications, they could fail after construction.

One type of aggregate material produced at Martin Quarry can be used for rip-rap and ditch liner. Rip-rap consists of larger stones, cobbles, or boulders used to protect soil from erosion or to stabilize construction sites. Ditch liner is a predominantly durable rock of uniform size that helps prevent erosion, protect road shoulders, and facilitate water drainage.

In 2017, a KDOT observation of the performance of this aggregate material noted that rip-rap and ditch liner produced during the late fall and winter months from Martin Quarry did not perform as well as material produced during the spring and summer months. This difference in performance is attributed to the effects of freeze-thaw exposures on the aggregate material, which changes how the rocks can be crushed onsite at the quarry (fig. 5). Aggregates are often mined, crushed, washed, and separated onsite and each of those steps can affect the quality before they are exported for use. As a result, KDOT determined that the Towanda Limestone Member from this location could not produce rip-rap and ditch liner material from November 16 to April 14 each year. Looking to the future, however, this period of non-production could be reduced as Kansas continues to see higher temperatures and cold spells grow shorter and less intense. The freeze-free season in Kansas has already become longer by nine days in the 21st century in comparison to the 20th century.[5]

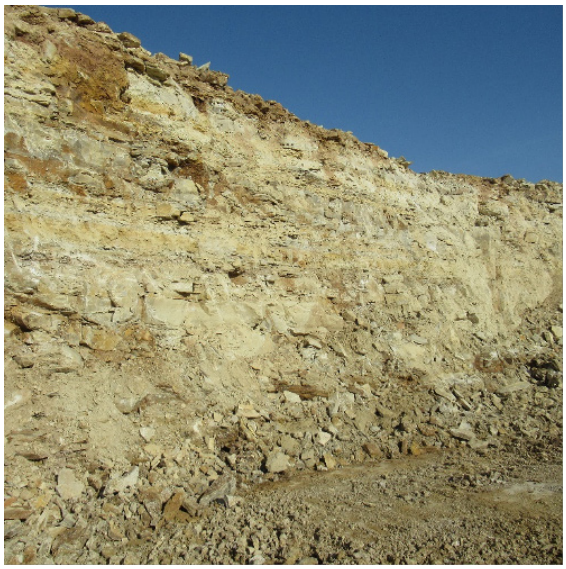


Figure 4. Towanda Limestone Member.

Figure 5: Side view of the portable crusher used on site.

Resources

[1] Gross Output by Industry (U.S. Bureau of Economic Analysis, accessed June 3, 2024)
https://bit.ly/4aM9x5i

[2] SAGDP2N Gross Domestic Product (GDP) by State1 (U.S. Bureau of Economic Analysis, accessed June 3, 2024)
https://bit.ly/3KrYMKH

[3] Company History (Bayer Construction Co., 2024)
https://www.bayerconst.com/about

[4] Stratigraphic Succession in Kansas (D. E. Zeller, 1968, Kansas Geological Survey Bulletin 189)

[5] Health and Climate Change in Kansas (S. Corbett, 2019, Kansas Health Institute)
https://www.khi.org/articles/2019-health-and-climate-change-in-kansas/

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STOP 8

Mill Creek Oil Spill

Andy Connolly, Kansas Geological Survey

KEY FACTS

- In December 2022, a rupture in the Keystone Pipeline released 12,937 barrels of bitumen oil into Mill Creek.
- 3.74 miles of Mill Creek were inundated with oil.
- A faulty weld combined with stress from repeated bending caused the rupture.
- The EPA, KDHE, and TC Energy worked day and night to remove the oil.
- By October 2023, the EPA declared restoration work complete and turned Mill Creek monitoring over to the KDHE, which will continue to monitor the area until 2028 or the creek's conditions achieve acceptable, natural levels.

In 2022, Mill Creek, a perennial stream in Washington County whose waters eventually flow into Tuttle Creek Lake near Manhattan, was the site of the largest oil spill in the United States in almost a decade and the largest leak ever for Keystone Pipeline, owned by TC Energy. A rupture in the pipeline released 12,937 barrels of oil into Mill Creek. In response, TC Energy and state and federal agencies worked together to return the creek to its natural conditions.

On December 7, 2022, TC Energy reported a sudden pressure drop in its 36-inch pipeline near Washington, Kansas. The pipeline carries diluted bitumen, also referred to as "dilbit," oil; this is oil that's been diluted as its natural state is too viscous for pipe transportation. TC Energy immediately shut down the pipe and sent crews to locate the potential leak. The U.S. Environmental Protection Agency and Kansas Department of Health and Environment also mobilized a response and discovered the spill the next day.[1] Oil from the pipeline discharged over the land, stained vegetation, and spilled into Mill Creek (fig. 1).

Figure 1. Bitumen oil leak from the Keystone Pipeline at Mill Creek. Photo: TC Energy.

A TC Energy report later found that faulty welding at the factory caused a weakness in the pipe. Repeated bending caused the pipe to crack, allowing the oil to leak out.[2] However, independent investigators found that TC Energy had known about the pipe defect since 2012.[3] When the pipe was installed in 2010, it deformed into an oval shape, stressing the welding. A cleaning routine discovered the deformation in 2012, and TC Energy inspected the pipe. Although the welding was flawed, TC Energy decided it could handle the pipe's usual low oil pressure and took no further action. Repeated temperature and pressure swings eventually led the pipe to rupture.[3]

Spill Response and Recovery Efforts

The EPA, KDHE, and TC Energy worked together to monitor, contain, and clean up the oil. In all, more than 800 workers responded to the spill. Crews implemented six overlapping phases to successfully recover the area.

Phase 1

In phase 1, bulk clean-up, TC Energy brought in oil containment booms, vacuum trucks, light stands, and skimmers; built access points; and worked 24 hours a day, seven days a week, for seven weeks to remove the oil (fig. 2).

As part of this process, TC Energy constructed an underflow dam roughly four miles downstream of the rupture to halt further movement of oil.[4] An underflow dam (fig. 3) consists of a pipe inserted into a dam at an angle, with the upstream end lower than the downstream end. Because oil floats on water, this configuration allows water, but not oil, to flow through the pipe.

By the end of January, more than 90 percent of the oil had been removed.[2] As a comparison, on December 15, oil covered the stream from bank to bank for 1.5 miles with oil depth exceeding 10 inches in places. By January 25, the bank-to-bank oil extended 500 feet with less than an inch of oil depth.[1]

Figure 2. A construction worker uses skimmers to pump oil out of Mill Creek. Photo: Environmental Protection Agency.

Phases 2 and 3

Phases 2 and 3, spanning December 2022 to June 2023, involved the construction and implementation of a creek diversion system and water treatment facility. Pumps diverted untainted water upstream from the spill site to a spot downstream from the underflow dam (fig. 4). Additionally, water was pumped out of the contaminated portion of Mill Creek to a newly constructed water treatment facility, which eventually cleaned and tested 5.4 million gallons of water before diverting it back to Mill Creek downstream of the underflow dam.[1]

Phase 4

Pumping in phases 2 and 3 eventually dried out the contaminated section of Mill Creek, allowing responders to initiate phase 4 of recovery efforts. From January to June, workers removed and scrubbed contaminated stream banks and sand tainted by the oil (fig. 5). Low pressure water spraying on the contaminated sand and banks allowed oil to seep out and further be scrubbed.[1] The oil-soaked sands, along with disposable cleaning equipment, were eventually sent to a waste site near Omaha, Nebraska.[6]

Phase 5

Phase 5, initiated in March and continuing to September, involved restoring Mill Creek to its natural state. Crews brought in clean sediment to replace the removed oil-soaked sands. They also completed bank stabilization projects to minimize stream erosion (fig. 6); planted native trees, shrubs, and grasses;

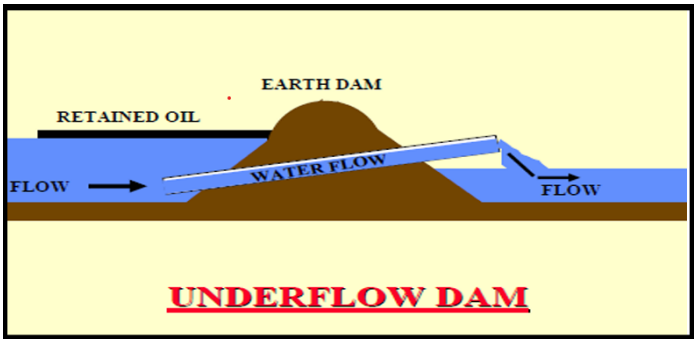

Figure 3. An underflow dam is built when water flow is too strong to allow for a complete blockage of a stream. Illustration and information courtesy of Canada Energy Regulator.[5]

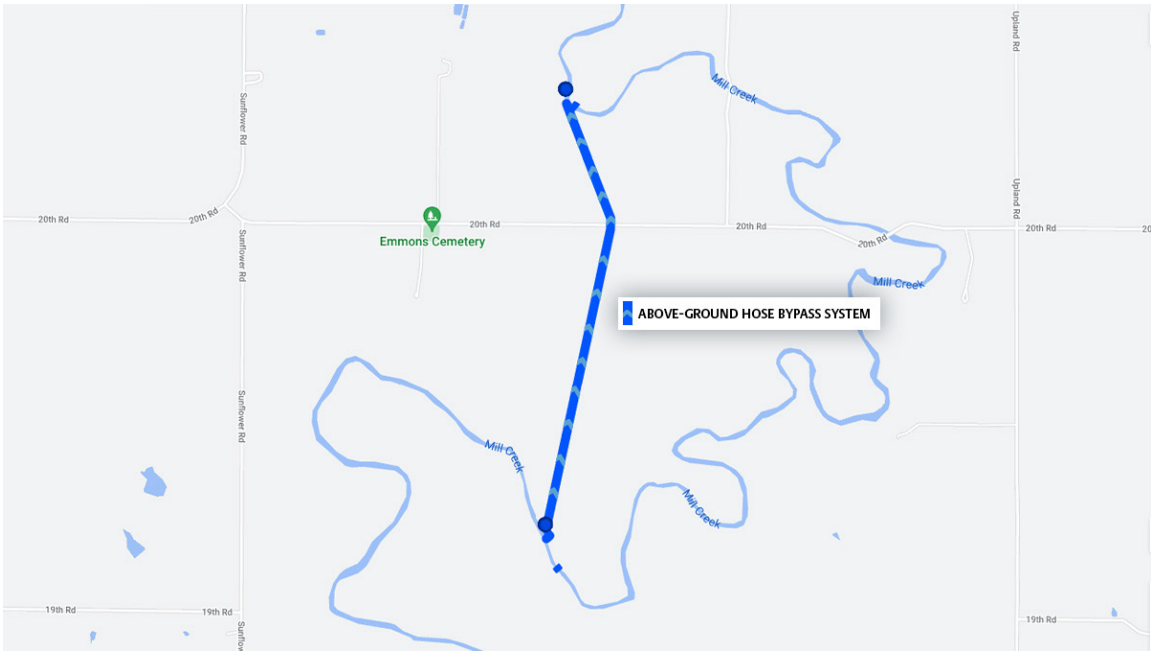

Figure 4: A pipe system diverted water from the upstream portion of Mill Creek to the downstream portion, bypassing the contaminated section. Illustration: TC Energy.

Figure 5: Construction workers remove and treat contaminated soil at Mill Creek. Photo: Environmental Protection Agency.

Figure 6: Bank stabilization projects aim to minimize erosion from potential flooding. Photo: Environmental Protection Agency.

and reintroduced native mammals, reptiles, amphibians, and fish. These changes restored 11 acres of riparian habitat. When the waters returned in the spill area, no obvious signs of contamination (for example, sheening, or light oil drizzle on the water surface) were noted. In October 2023, the EPA inspected Mill Creek, approved the quality of the site, and transferred resource management to the KDHE and TC Energy.[1,4]

Phase 6

The spill area has now entered phase 6, long-term monitoring. The KDHE will monitor the groundwater at sites in and around the spill area for contamination and will monitor the aquatic life of the area to ensure healthy stream quality. If Mill Creek's aquatic standards are not achieved by 2026, the KDHE will continue to monitor the area until 2028.

Although the Mill Creek oil spill was one of the largest spills in the country, the swift response by agencies and TC Energy minimized its effects in the area. Additionally, low water levels at the time of the spill slowed oil movement and allowed crews to quickly isolate the contaminated section of the creek. These factors meant that the Little Blue River, into which Mill Creek empties, and local drinking water wells were unaffected.[7] In less than a year, crews completed the restoration work and the natural processes of recovery began, though a full return to pre-spill conditions will take many years.[4]

Resources

[1] Site Profile — OPA — TC Energy Mill Creek — UCGPE23702 — EPA OSC Response (Environmental Protection Agency, 2023)
https://response.epa.gov/site/site_profile.aspx?site_id=15891

[2] Milepost 14 Incident (TC Energy)
https://www.tcenergy.com/incident/milepost-14-incident/

[3] How Deciding Not to Fix a Pipe in Kansas 10 Years Ago Led to the Keystone Pipeline's Biggest Spill (Celia Llopis-Jepsen, Kansas News Service, May 22, 2023)
https://www.kcur.org/news/2023-05-22/how-deciding-not-to-fix-a-pipe-in-kansas-10-years-ago-led-to-the-keystone-pipelines-biggest-spill

[4] Milepost 14 Oil Spill Response (Jennifer Nichols and Dan Wells, Kansas Department of Health and Environment Conference Presentation, 2023)
https://www.kdhe.ks.gov/DocumentCenter/View/30548/Milepost-14-Oil-Spill-Response--Jennifer-Nichols-and-Dan-Wells-KDHE-BEFS-PDF

[5] Canada Energy Regulator, Government of Canada.
https://apps.cer-rec.gc.ca/REGDOCS/File/Download/965092

[6] Ice, Muck and a $480 Million Price Tag: the Keystone Oil Spill Cleanup Carries on in Kansas (Celia Llopis-Jepsen, Kansas News Service, February 15, 2023)
https://www.kcur.org/news/2023-02-15/ice-muck-and-a-480-million-price-tag-the-keystone-oil-spill-cleanup-carries-on-in-kansas

[7] TC Energy pipeline oil discharge near Washington, Kansas | US EPA, News Update #2 (Environmental Protection Agency, December 9, 2022)
https://www.epa.gov/newsreleases/news-update-2-tc-energy-pipeline-oil-discharge-near-washington-kansas

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NOTES

Reading Ancient History in Drill Core

Nikki Potter, Kansas Geological Survey

KEY FACTS

- The KGS is home to one of the most extensive collections of drill cores in the United States.
- The Noel Poersch 1 well in northeast Kansas is the deepest well ever drilled in the state.
- The Poersch 1 is one of the few wells to penetrate the Midcontinent Rift, a deeply buried structure important to understanding Earth's crust structure and plate tectonics.
- The well penetrates Precambrian basement rocks, formed 600 million to 3 billion years ago, and allows scientists to study the environments and processes that formed them.

The Kansas Geological Survey is home to one of the most extensive public collections of drill cores in the United States, housing approximately 70,000 boxes containing hundreds of thousands of feet of rock samples. These cores offer a glimpse into the hidden layers beneath Earth's surface.

Collected as cylindrical tubes during drilling operations, drill cores serve as invaluable tools for studying the geological history of our planet and identifying sources of such crucial materials as coal, crushed rocks necessary to make concrete, and rare earth elements used in cell phones, batteries, computers, and other technology.

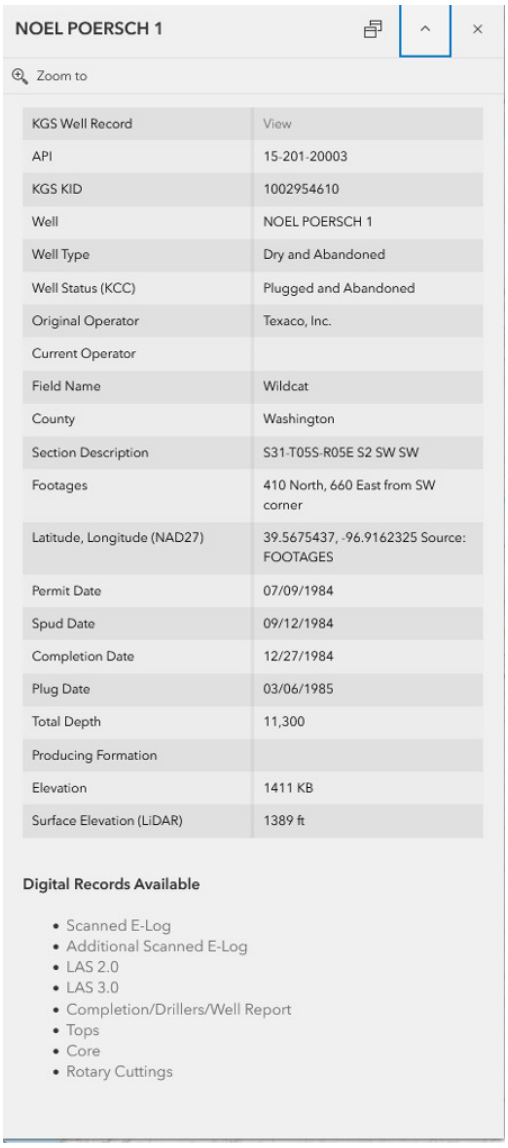
Retrieving rock core from the subsurface involves the use of specialized equipment known as a drill rig, outfitted with a coring bit attachment and hollow steel pipes (drill stem) that employ circular motions to penetrate the earth. The drill stem can delve hundreds, if not thousands, of feet deep. Due to the considerable cost and time involved in this process, typically only specific depths or particular rock formations are cored and brought to the surface.

Once freed from the drill stem, the core is carefully placed in boxes for transportation so it may be studied and ultimately preserved. The KGS's collection comprises donated core from private oil and gas companies and the Kansas Department of Transportation or drilled by our staff or in collaboration with other companies for research purposes.

The Noel Poersch 1 Well Drill Core

One example of a rock core preserved at the KGS comes from the Noel Poersch 1 well, the deepest well drilled in the state of Kansas (fig. 1). Drilled by Texaco in 1984 on the Washington-Riley county line, this core is 11,300 feet, or more than 2 miles, long. Previously, the record for the deepest well in Kansas was 8,714 feet, drilled in 1964 in Stevens County.[1] Although 11,300 feet is not uncommon for an oil and gas well in other states, the well's location within the Midcontinent Rift System and the type of rocks recovered in the core make the Poersch 1 particularly interesting.

The Midcontinent Rift, formed when North America began to split apart about 1.1 billion years ago, holds significant plate tectonic (related to Earth's crust structure) importance and spans from Michigan to the heart of Kansas.[2] Its magnetic anomaly helps explain our planet's movement and volcanic activity. Although the split ultimately failed, and North America remained intact, it is the largest known healed rift and created a basin thousands of feet deep in some places that filled with glacial deposits, basalt lava flows, and erosion of nearby sandstones, siltstones, and shales. These rock types provide valuable resources, including important minerals.



NOEL POERSCH 1

Zoom to

KGS Well Record	View
API	15-201-20003
KGS KID	1002954610
Well	NOEL POERSCH 1
Well Type	Dry and Abandoned
Well Status (KCC)	Plugged and Abandoned
Original Operator	Texaco, Inc.
Current Operator	
Field Name	Wildcat
County	Washington
Section Description	S31-T05S-R05E S2 SW SW
Footages	410 North, 660 East from SW corner
Latitude, Longitude (NAD27)	39.5675437, -96.9162325 Source: FOOTAGES
Permit Date	07/09/1984
Spud Date	09/12/1984
Completion Date	12/27/1984
Plug Date	03/06/1985
Total Depth	11,300
Producing Formation	
Elevation	1411 KB
Surface Elevation (LiDAR)	1389 ft

Digital Records Available

- Scanned E-Log
- Additional Scanned E-Log
- LAS 2.0
- LAS 3.0
- Completion/Drillers/Well Report
- Tops
- Core
- Rotary Cuttings

Figure 1. Well page information and documentation from the KGS Oil and Gas Database.

The Poersch 1 penetrates Precambrian basement rock, the oldest geological formations dating to 600 million to 3 billion years old. Because this type of rock is often buried deeply beneath Earth's surface, it is not easily accessible to study. The Poersch 1 core samples offer an opportunity to examine a diverse array of formations, minerals, fossils, and rock patterns, shedding light on the environments and processes that shaped them. Of particular interest are its Precambrian rocks, which include basalt — formed from rapid cooling of magma near the Earth's surface — and gabbro — developed from slow-cooling magma deep underground.

Precambrian Rocks in Poersch 1

The Poersch 1 core contains several rock types, including shale and sandstone dating from the Paleozoic, but the Precambrian rocks portion has the most unusual composition. The upper part of the Precambrian portion of the core, from around 2,800 feet underground, contains predominantly basalt and gabbro. Gabbro can be identified by its dark green or black coloring and coarse grain size. The more rapid cooling of basalt produces fine or smaller grains. Its color ranges from dark gray to black (fig. 2).

Deeper in the well (about 7,500 ft to 11,300 ft), the core contains arkose and subarkose sandstone, alongside more basalt formations (figs. 3 and 4). Arkose, tinted pink or reddish due to the inclusion of feldspar and quartz minerals, arises from the erosion of quartz-rich rocks. Subarkose, having more of the mineral feldspar, occupies a middle ground between sandstone and arkose. The presence of basalt at greater depths suggests processes of rock oxidation, or the breakdown of rock due to oxygen and water.[3]

Despite initial disappointment over the well's lack of oil production, Poersch 1 has yielded invaluable data. After three years of anticipation, the findings were released to the Kansas Geological Survey, followed by a public release three months later.[1] Today, researchers from across the country continue to study this unique core, aiming to unravel the mysteries of the Midcontinent Rift and its ancient basement rock.

Figure 2. Example of mafic or dark volcanic rock from the Poersch 1 well at 2,909–2,911 ft below ground.

Figure 3. Example of subarkose to arkose rock from the Poersch 1 well at 10,510–10,512.5 ft below ground.

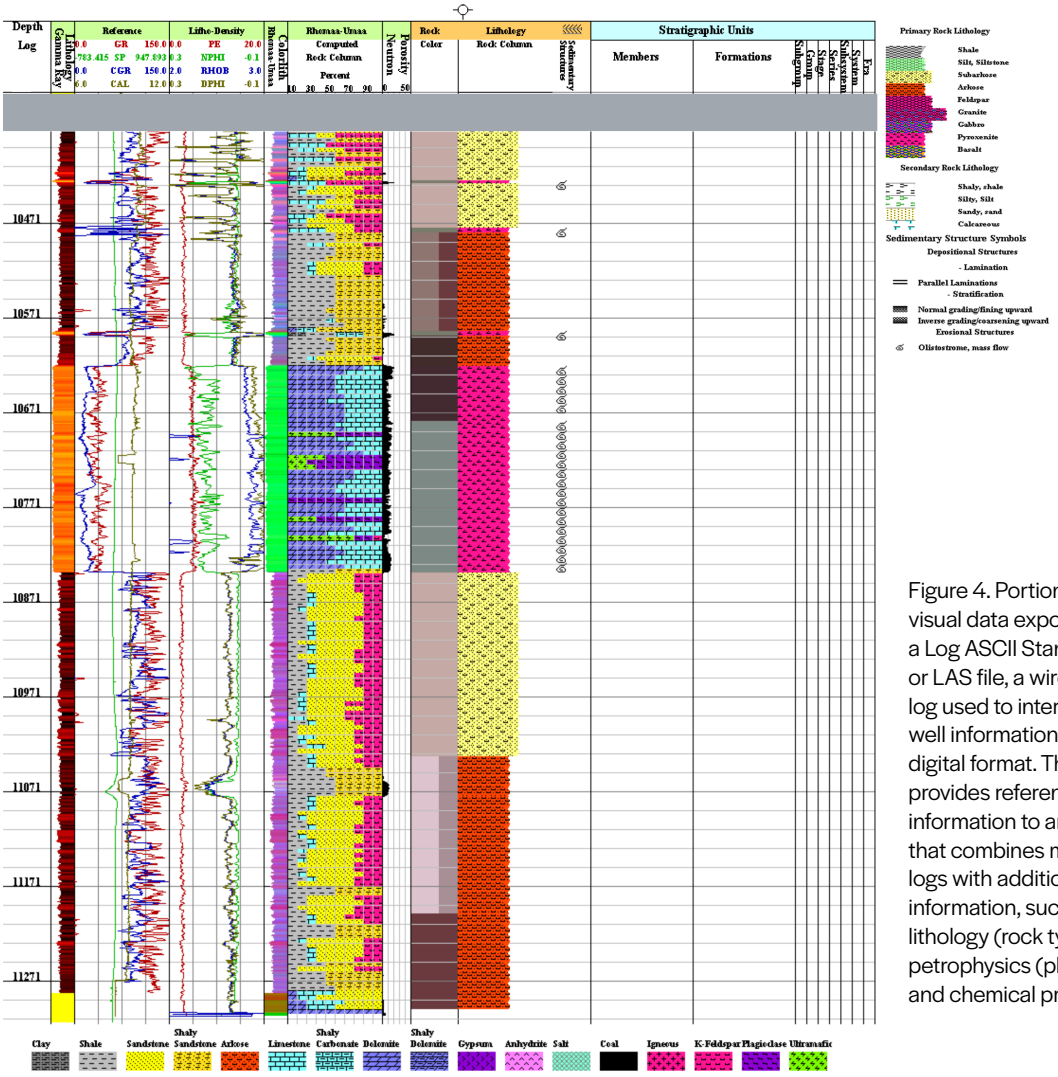


Figure 4. Portion of a visual data export for a Log ASCII Standard or LAS file, a wireline log used to interpret well information in a digital format. This figure provides reference information to an LAS file that combines multiple logs with additional information, such as lithology (rock type) and petrophysics (physical and chemical properties).

Resources

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STOP 9

Streambank Stabilization Efforts and Sedimentation Rates at Tuttle Creek Lake

Tony Layzell and Julie Tollefson, Kansas Geological Survey

KEY FACTS

- Sedimentation is a serious threat to the state's reservoirs.
- Streambank stabilization efforts have successfully reduced erosion at streambank hotspots.
- Unmanned aircraft systems — drones — allow scientists to monitor erosion rates in streams.
- Continued monitoring and sediment tracing studies are necessary to assess the effectiveness of sediment-reduction efforts.

Sedimentation caused by streambank erosion is a serious threat to the lakes and reservoirs constructed to manage the state's surface water supply. Three of the 24 federal reservoirs in Kansas are expected to lose more than half of their water storage capacity to sedimentation by the end of the decade; others are similarly threatened over the long term.[1]

To address the problem, the Kansas Water Office has targeted three high priority watersheds — the Big Blue and Little Blue rivers above Tuttle Creek Lake, the Delaware River above Perry Lake, and the Cottonwood and Neosho Rivers above John Redmond Reservoir — to identify and address erosion hotspots.[2]

Of the three, the Tuttle Creek Lake watershed is the largest,[3] encompassing 9,628 square miles in Kansas and Nebraska, including portions of Clay, Marshall, Nemaha, Pottawatomie, Republic, Riley, and Washington counties (fig. 1). The reservoir provides up to half of the water flow in the Kansas River, the main source of public drinking water for a large part of northeast Kansas, including Kansas City, Topeka, and Lawrence.[4]

The U.S. Army Corps of Engineers built Tuttle Creek Lake for flood control, water supply, navigation, water quality, recreation, and fish and wildlife management. Construction of the 10,900-acre lake[5] began in 1952 and was completed a decade later. A bathymetric survey in 2009 concluded that more than 41% of the lake's storage capacity had been lost to sedimentation.[4]

Streambank Stabilization Methods and Assessment

The KWO has identified more than 270 streambank erosion "hotspots" above Tuttle Creek Lake and completed streambank stabilization projects at 35% of them.[6] The agency coordinates its hotspot response with the Kansas Department of Health and Environment's Watershed Management Section and the Kansas Department of Agriculture's Division of Conservation.

Typical techniques used to mitigate or prevent erosion involve flattening the slope of the streambank, reinforcing the base of the bank with rocks, installing rock vanes or stream barbs (structures that slow or redirect the flow of water), and planting native trees and grasses along the stream (fig. 2).[7]

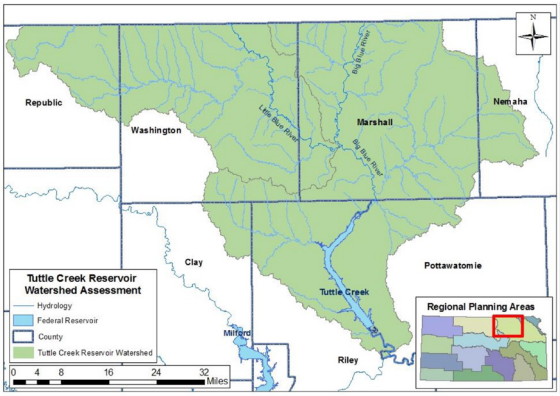

Figure 1. Tuttle Creek Lake watershed. Illustration: Kansas Water Office.[4]

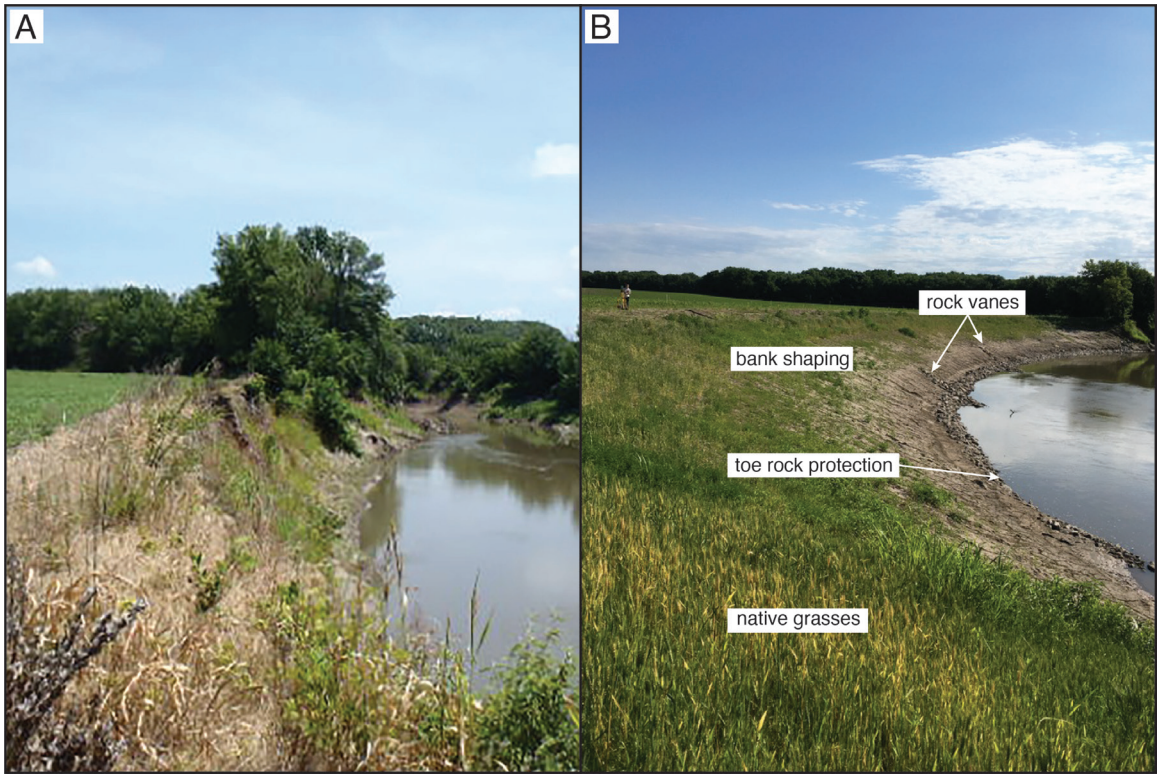

Figure 2. Example of a streambank stabilization site in the Cottonwood River valley (A) before construction and (B) after construction. Photos courtesy of The Watershed Institute Inc.

KWO estimates that streambank stabilization projects completed to date have prevented nearly 950,000 tons of sediment from entering reservoirs in the three priority watershed areas. More than 700 hotspots remain, though, contributing an estimated 1,065,000 tons of sediment to downstream reservoirs.[3]

Using Unmanned Aircraft Systems to Monitor Streambank Hotspots

Long-term monitoring is necessary to assess the effectiveness of these projects in meeting the goal of reducing the amount of sediment washed into lakes and reservoirs.

The Kansas Geological Survey began using unmanned aircraft systems, commonly known as drones, to assess the stability of streambanks along the Cottonwood River above John Redmond Reservoir in 2018. Researchers conducted more than 18 flights during three "campaigns" — in early 2019, late 2019, and early 2021 — to collect high-resolution images from 14 sites where streambank stabilization projects had been completed, two sites where future projects were proposed, and six unmodified sites. Each flight yielded 500 to 899 images with a resolution of about 3 cm. Control points on the ground allowed researchers to stitch the pictures together to create seamless images of an entire stretch of riverbank under study.

Using specialized software to compare the images from the three campaigns, researchers were able to determine the erosion rates at streambanks between flights (fig. 3).

The results of the study determined that erosion continued after the completion of streambank stabilization projects but at lower rates, about a third of the rate before construction.[7] Researchers also determined that erosion rates at the stabilized sites were much lower than at unmodified sites.

Future Monitoring

Though streambank stabilization efforts have been effective at reducing erosion at targeted hotspots, long-term monitoring

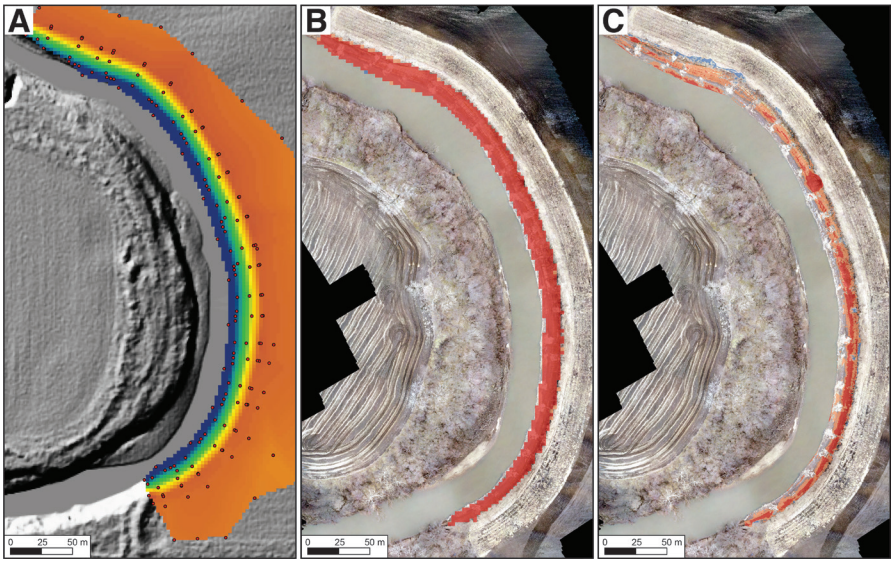

Figure 3. (A) Example of 3-D digital elevation models (DEMs) created from as-built total station survey point data (red dots) at a streambank stabilization site on the Cottonwood River. Background imagery is 2010 LiDAR. (B) DEMS of difference (DoD) images showing material loss (red) and gain (blue) at the same site between April 2015 and March 2019. (C) DoD showing areas of material loss and gain from March 2019 to October 2019.[7]

will be needed to watch for changes in streambanks over time.

In the Cottonwood River, for example, the vast majority of hotspots occurred along the outer banks of meander bends. Over time, meanders migrate downstream, so stabilizing a site may fix an immediate erosion problem, but it could reoccur downstream.

Our studies also found, in some cases, signs of erosion above and between some of the rock structures constructed to stabilize the streambank. In at least one case, analysis found steepening of the bank (fig. 4).

Further studies are underway to determine the answer to the bigger question: Do localized streambank stabilization efforts significantly reduce watershed-scale sediment loads and slow the loss of water storage capacity in the state's reservoirs? The answer to this question is much more complex and requires consideration of factors beyond the effectiveness of mitigating local hotspots. For example, assessing sediment contributions from different sources throughout priority watersheds is needed.

Transported sediment is a mixture of multiple sources (channel banks, cropland, and grassland, for example) throughout a watershed in various proportions. Sediment tracers and mixing models can be used to "un-mix" a sediment sample and determine the various proportions contributed from different sources. For example, a recent analysis of reservoir sediment samples from Perry Lake found that 38% of the sediment came from channel banks.[8]

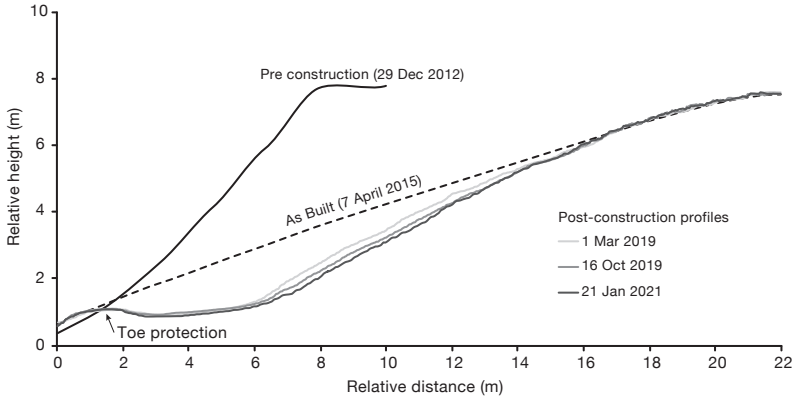

Figure 4. Cross-sectional profiles from a streambank stabilization site on the Cottonwood River showing bank evolution after construction. Pre-construction and as-built profiles from total station data provided by The Watershed Institute Inc. Post-construction profiles generated from UAS flight survey DEMs.[7]

Determining the different sediment source contributions allows for the development of tailored mitigation strategies for individual watersheds and reservoirs. Such strategies can maximize the return on investment so that watersheds that are dominated by channel bank erosion can be prioritized for streambank stabilization while watersheds that stand to benefit the most from land-use best management practices can be prioritized for conservation. Land-use best management practices include planting cover crops or adopting no-till methods for cropland, for example, or conducting prescribed burns or planting riparian buffers in grassland.

The KGS began a sediment tracing study in 2023 for the Cottonwood-Neosho watershed above John Redmond reservoir and will expand this work to eight priority reservoirs later this year.

Resources

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STOP 10

Agroecology: Designing and Managing Sustainable Farming and Food Systems

Sunday Siomades, Kansas Geological Survey

KEY FACTS

- Agriculture contributed $53 billion to the Kansas economy in 2022.
- Agroecology is the interdisciplinary study of agriculture and ecology that explores ways to design and manage sustainable farming and food systems.
- Understanding soil and soil health is key to sustainable farming.
- The Soil Microbial Agroecology Lab at Kansas State University researches ways to improve soil quality and the effects of water, nutrients, energy, and climate on soil health.
- Agroecological data can help farmers manage their land, crops, and livestock more efficiently.

Agronomy is central to the industry of Kansas — 88% of the state is farmland, and our agriculture, food, and food processing sectors were collectively responsible for contributing more than $53 billion to the state economy in 2022.[1] Agroecology, the interdisciplinary study of agriculture and ecology, explores ways to design and manage sustainable farming and food systems. The discipline evolved over recent decades in response to demands for agricultural solutions that prioritize the needs and health of both humans and the natural environment. Agroecology seeks to foster solutions by connecting farmers, food distributors, policymakers, scientists, and other groups involved in agriculture.[2]

The Soil Microbial Agroecology Lab (SMAL) in Kansas State University's Department of Agronomy studies ways to improve soil quality and the effects of water, nutrients, energy, and climate on soil health (fig. 1). Under the direction of Chuck Rice, the lab studies soil fungi,

Figure 1. Chuck Rice (center) and SMAL researchers in the field.

bacteria, enzymes, soil water infiltration capability, soil carbon and nitrogen, and soil aggregate formation and stability, among other topics — everything that influences soil's ability to support life. Using these biological indicators, SMAL researchers seek to identify practices that support and improve soil health.[3,4]

Among its many projects, the lab has investigated how the productivity of rainfed agricultural systems in the semi-arid southern Great Plains might be increased by more efficiently using nitrogen and water resources. In addition to publications and conference presentations, this initiative included "field days" in which SMAL researchers visited fields in a farmer-to-farmer network to demonstrate the outcomes of intensive cropping systems and share the benefits and challenges associated with introducing new farm technologies.[5]

The lab also participated in the Kansas Soil Health Partnership, which brought the National Corn Growers Association, federal agencies, universities, and environmental groups together to measure and communicate the economic and environmental benefits of different soil management strategies to synthesize case-specific recommendations for farmers. This partnership project was extended to investigate the effects of different cover crops on soil health and crop yields, as well as the associated long-term economic benefits.[4]

More recently, the lab has shifted its focus to the rhizosphere, the region of soil that surrounds — and is influenced by — the community of microorganisms that dwell in plant roots. These communities, also known as microbiomes, were the subject of the SMAL's most recently completed project: Microbiomes of Aquatic Habitats, Plants, & Soils (MAPS). The project explored microbiome interactions across various agriculturally dominated habitats across Kansas, such as grasslands and fields. The project paid special attention to the drastically differing rainfall levels in the east and west regions of the state and investigated this precipitation gradient as a means of anticipating agricultural system responses to environmental change.[3]

Carbon produced and stored in soils is released into the atmosphere when soils are intensively tilled. The cumulative results of the SMAL's projects confirm that this soil nutrient loss results in decreased crop yields. The 30-year findings of the lab's various studies suggest that the combination of no-tillage and organic compost dramatically enhances the production and retention of soil carbon and improves the health of soil microbiomes so they are better able to support crops. Implementing no-till practices and introducing organic compost to fields are the Soil Microbial Agroecology Lab's key recommendations to Kansas farmers looking to increase and stabilize their yields.

Agroecology represents a very literal ground-up approach to pursuing sustainable agriculture practices. Research results obtained by SMAL researchers and others like them enhance understanding of soils and how to best cultivate them and can help farmers manage their land, crops, and livestock more efficiently. Agroecological data-driven recommendations provide policymakers and other interested parties a foundation upon which to craft mutually beneficial agricultural policies for producers, distributors, and consumers.

Resources

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