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Hydrologic Conditions in Kansas, Water Year 2019

The U.S. Geological Survey (USGS), in cooperation with Federal, State, and local agencies, maintains a long-term network of hydrologic monitoring stations in Kansas. In water year (WY) 2019, this network included 217 real-time streamgages (fig. 1). A WY is the 12-month period from October 1 through September 30 and is designated by the calendar year in which it ends.

Real-time hydrologic data are verified by USGS personnel throughout the year providing regular measurements of streamflow, lake levels, and groundwater levels. These data and associated analyses provide a unique overview of hydrologic conditions and help improve the understanding of Kansas' water resources. Annual assessments of hydrologic conditions are made by comparing statistical analyses of current and past WY data for the period of record. Long-term monitoring of hydrologic conditions in Kansas provides important information for many functions including managing water resources, protecting human life and property, maintaining agricultural and industrial activities, the operation of reservoirs, the development of infrastructure, accurate ecological assessments, and recreational purposes.

Preceding Conditions and Precipitation

Despite some isolated, heavy precipitation events, overall streamflow and drainage basin runoff conditions decreased for the State of Kansas between WYs 2017 and 2018. During WY 2017, precipitation in most of the State was classified as normal to below normal, which resulted in drought conditions in much of central and eastern Kansas at the end of WY 2017 (fig. 2*A*). During WY 2018, most of the eastern half of the State experienced normal (average) to below normal precipitation, whereas parts of the western half of the State experienced above normal precipitation, particularly north-central Kansas (fig. 2*B*). South-central and eastern Kansas experienced below and much below normal precipitation, resulting in abnormally dry to extreme drought conditions at the end of WY 2018 (fig. 3) that continued into WY 2019.

Heavy rainfall events in October and November of 2018 ended drought conditions, and by the beginning of December, dry conditions were virtually nonexistent in Kansas and remained that way throughout WY 2019 (National Drought Mitigation Center, 2019). Overall, normal to much above normal precipitation occurred throughout WY 2019 (fig. 4*A*) (National Oceanic and Atmospheric

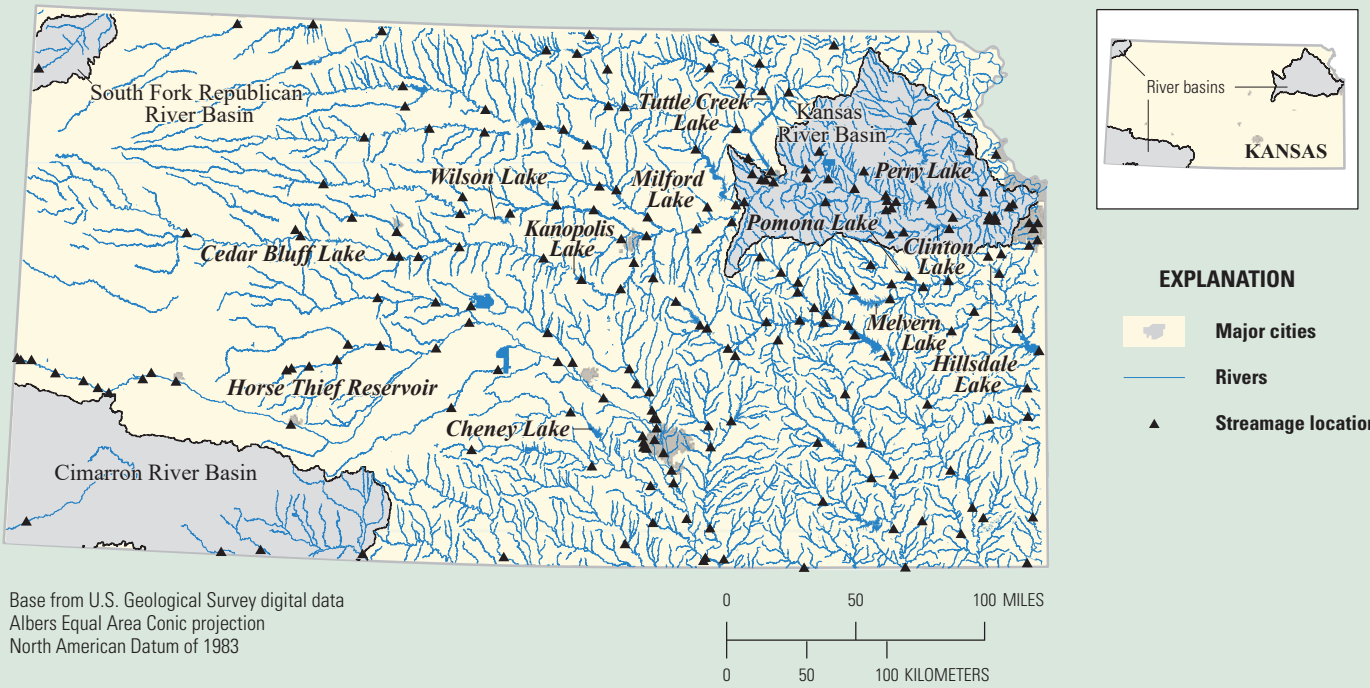


Figure 1. United States Geological Survey streamgages in Kansas and selected river basins.

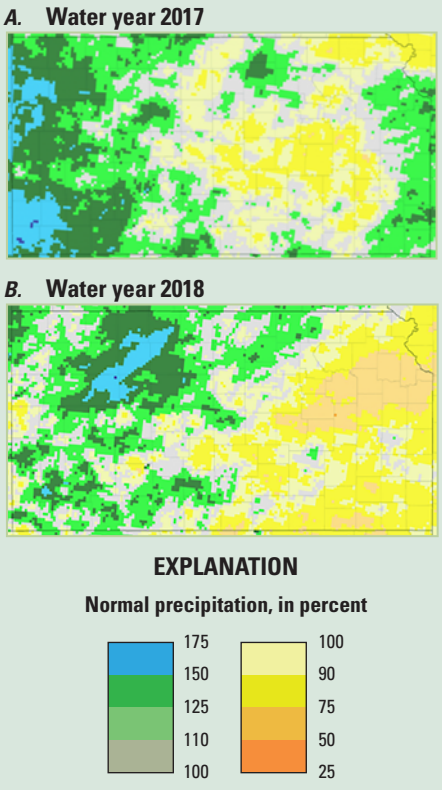


Figure 2. Comparison of statewide percentage of normal precipitation (1981–2010) (National Oceanic and Atmospheric Administration, 2019). *A*, Water year 2017. *B*, Water year 2018.

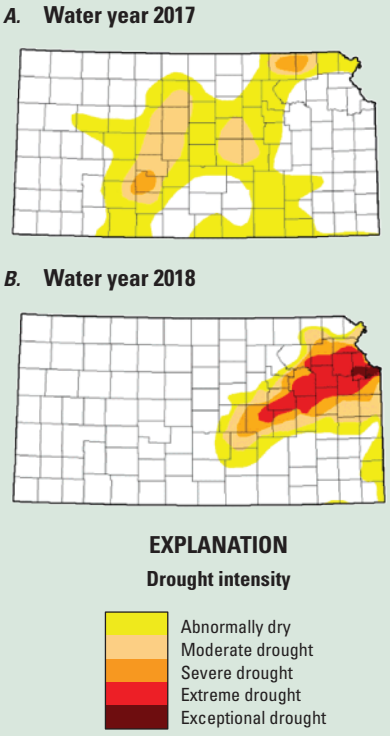


Figure 3. Comparison of drought conditions in Kansas (National Drought Mitigation Center, 2019). *A*, At the end of water year 2017. *B*, At the end of water year 2018.

Administration, 2019). The above normal precipitation for WY 2019 extended from the northeast portion of the State, with more than 20 inches of above normal annual rainfall occurring in places, down to the southwest portion of the State, with only a small area experiencing normal precipitation (National Weather Service, 2019) (fig. 4*B*).

Streamflow Conditions and Drainage Basin Runoff

Kansas experienced several record-breaking hydrologic conditions during WY 2019, including the most precipitation within a month on record; out of 125 years of record, the precipitation for May (10.26 inches) beat the 1951 record of 9.36 inches (National Weather Service, 2019). Additionally, in WY 2019, Kansas experienced the second largest amount of precipitation in a water year within 130-years of record (National Oceanic and Atmospheric Administration, 2019) and the most cumulative runoff on record (fig. 5*A*).

Runoff, or streamflow per unit area, is a good indicator of precipitation and streamflow for a given drainage basin. The monthly average runoff graph shows the continuity of above normal hydrologic conditions during WY 2019 (fig. 5*B*). Streamflow conditions were much above normal in Kansas during the first quarter of the WY (October to

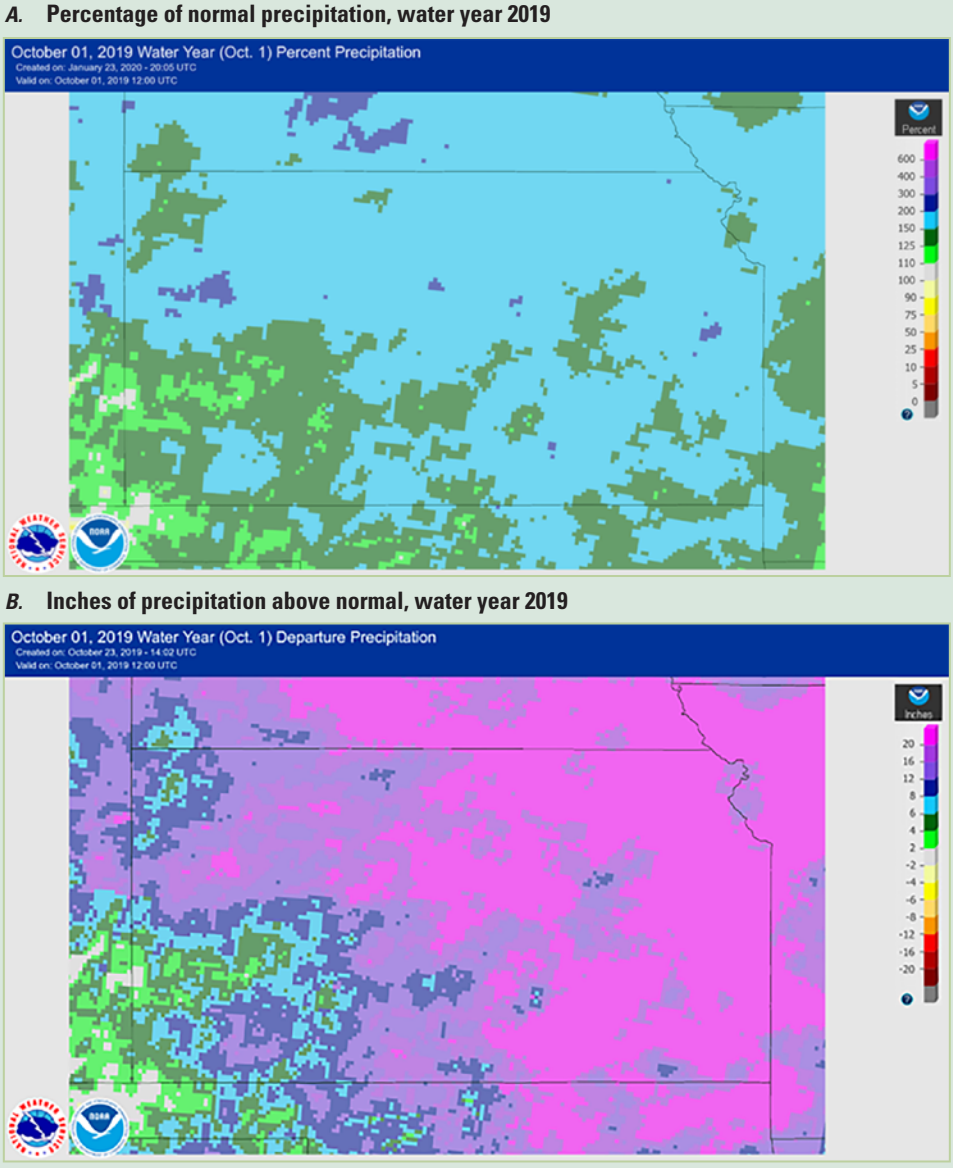
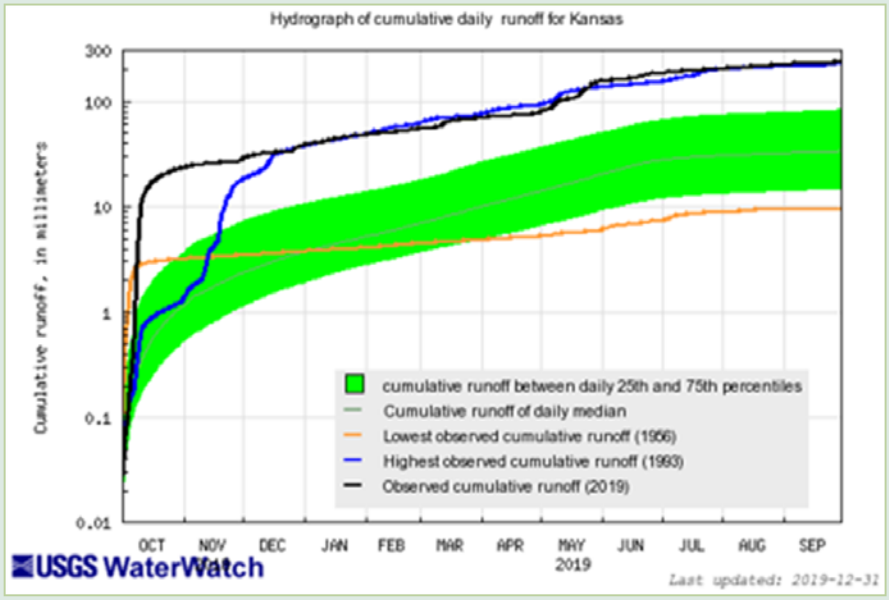
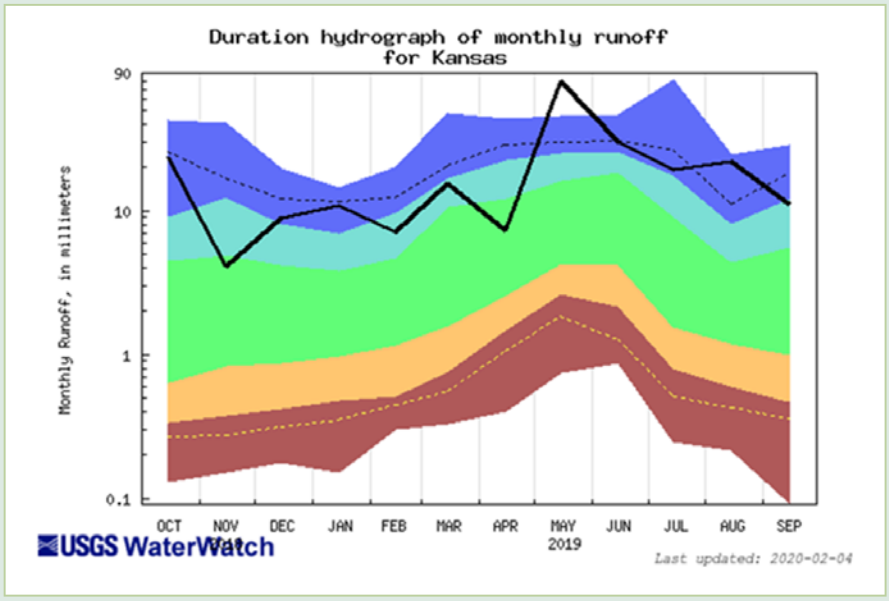


Figure 4. Precipitation for water year 2019 (National Oceanic and Atmospheric Administration, 2019). *A*, Statewide percentage of normal (1981–2010) precipitation for water year 2019. *B*, Statewide inches of precipitation above normal (1981–2010) for water year 2019.

A. Cumulative daily average runoff



B. Monthly average runoff



EXPLANATION

Percentile class

lowest — 10th percentile	5	10 – 24	25 – 75	76 – 90	95	90th percentile — highest	Runoff
Much below normal		Below normal	Normal	Above normal	Much above normal		

EXPLANATION

[<, less than; >, greater than]

Percentile classes

Low	<10	10–24	25–75
	Much below normal	Below normal	Normal
76–90	>90	High	No data
Above normal	Much above normal		

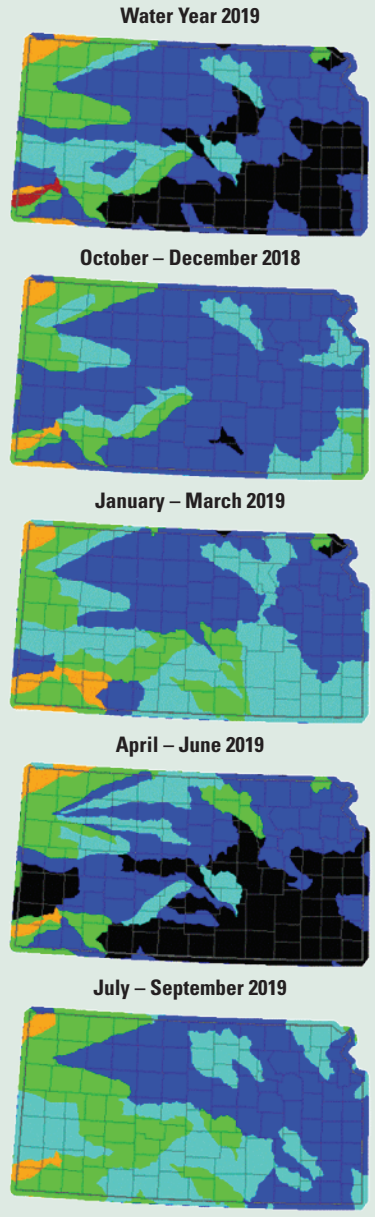


Figure 5. Graphs showing average runoff in Kansas for water year 2019 (U.S. Geological Survey 2019a). *A*, Comparison of cumulative daily average runoff. *B*, Monthly average runoff.

Figure 6. Comparison of monthly streamflow conditions across Kansas throughout water year 2019 (U.S. Geological Survey, 2019a).

December 2018), except for small areas in northwest and southwest Kansas, which were slightly below normal (fig. 6). By January to March, streamflow conditions in the northern and central portions of Kansas remained in the normal to much above normal percentile class. Above normal streamflow was maintained through March by a strong blizzard in the region. April through June maintained mostly above normal to high streamflow conditions from multiple widespread precipitation events. In July through September, the normal to above normal trend of streamflow conditions remained, ending the water year with the State in mostly normal to high streamflow conditions (fig. 6).

Due to large precipitation events, runoff conditions in most of Kansas were in the 90th percentile by May, with every county but one in northwestern Kansas experiencing normal to

record high runoff conditions (fig. 7). Precipitation events began decreasing in magnitude by July. In response to the heavy precipitation, Kansas reservoirs began releasing large outflows to decrease the elevation of water stored in the reservoir's respective flood pools (U.S. Army Corps of Engineers, 2019). This resulted in streamflow conditions that were continuously much above normal for rivers in the upper and lower Kansas River Basin (fig. 1) and normal to above normal conditions in most of the State. The eastern portion of the State, where most of the large reservoirs are located, had the highest percentiles of monthly streamflow conditions for the month of July. However, much of the western part of the State still experienced above normal conditions, with only the Cimarron and South Fork Republican River Basins (fig. 1) experiencing below normal streamflow conditions. By the end of WY 2019, most of the State was still experiencing above normal or normal conditions, which can be attributed to the above normal precipitation occurring throughout the WY and to reservoir releases.

Record Breaking High Water

WY 2019 was characterized by sustained high water in much of the State. For 69 percent of the WY, one or more streamgages were above National Weather Service flood stage, leaving 114 days without flooding in the State (U.S. Geological Survey, 2019b) (fig. 8). Photographs of flooding events taken by USGS personnel are shown in figure 9. WY 2019 observed 200 more days of flooding than WY 2018 and 194 more days of flooding than WY 2017 (U.S. Geological Survey, 2019b).

Many streamgages observed a new peak of record for water elevation in WY 2019. A peak of record in this case is the highest water-surface elevation (referred to as "stage") in the streamgage's history observed by the USGS (U.S. Geological Survey, 2019a) (fig. 10). Out of 217 streamgages, 45 of them observed a new peak of record since their establishment by the USGS, which varies by site. Previously, the last significant water year with widespread and

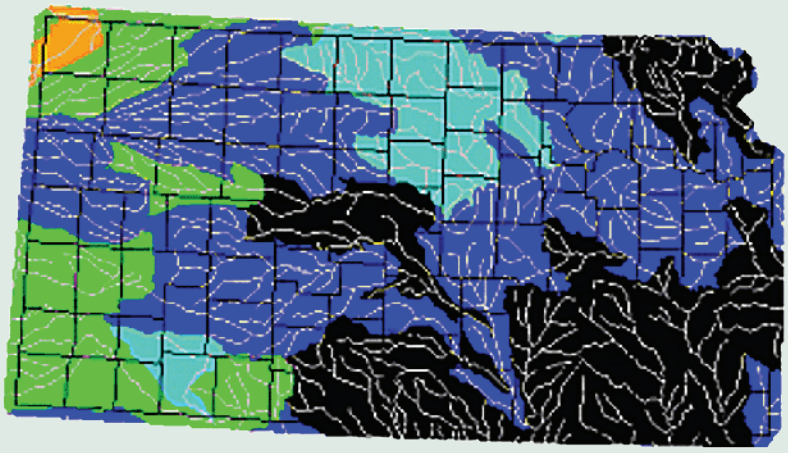


Figure 7. Streamflow conditions across Kansas throughout May 2019 (U.S. Geological Survey, 2019a).

persisting flood conditions was in 1993. Six streamgages that have been operated by the USGS prior to WY 1993 observed a new peak of record.

In WY 2019, rivers above flood stage for more than 30 days in stream reaches with a USGS streamgage included the Marias Des Cygnes, Arkansas, Neosho, Kansas, Republican, Big Blue, Black Vermillion, Fancy Creek, Cow Creek, Cottonwood, and Missouri Rivers (fig.1). Flood stage is determined by the National Weather Service, although not all USGS streamgages have a National Weather Service flood stage. The above average precipitation and runoff that occurred in WY 2019 caused backwater conditions at many sites in Kansas, resulting in peak of record and sustained high water-surface elevations at various streamgages. Backwater is a condition that occurs when high water-surface elevations downstream or from the main channel affect the height and flow of the water upstream. Streamgages with data above flood stage for more than 15 days because of backwater from Tuttle Creek Lake (06886900) and Milford Lake (06857050) included: Republican River at Clay Center (06856600), Big Blue River at Blue Rapids (06884700), Black Vermillion River near Frankfort (06885500), and Fancy Creek at Winkler (06886500) (fig. 1).

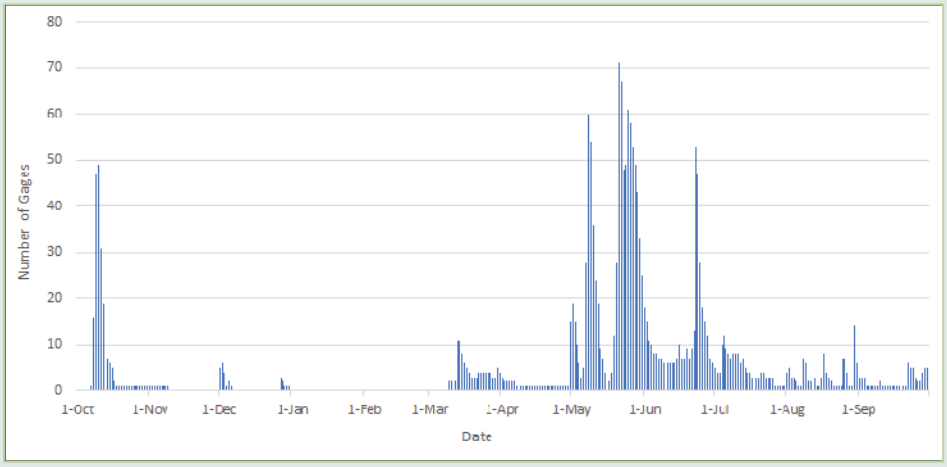


Figure 8. The number of U.S. Geological Survey streamgages above flood stage throughout water year 2019 (U.S. Geological Survey, 2019b).

In comparison, WY 2019 and WY 1993 were similar in that both were affected by multiple widespread precipitation events and prolonged regional flooding. There are 122 streamgages with data dating back to WY 1993 that are still in operation today. Out of the 122 streamgages, in WY 2019, 62 of them exceeded the peak water-surface elevation recorded in WY 1993.

Reservoirs

Many of the USGS monitored reservoirs in Kansas were at normal levels at the beginning of WY 2019 (U.S. Geological Survey, 2019b) (fig. 11). In 11 of 12 USGS monitored reservoirs in Kansas in WY 2019, normal conservation pool elevation was exceeded. Cedar Bluff Reservoir was the only USGS monitored reservoir that did not exceed its conservation pool elevation in WY 2019. Reservoir releases were restricted due to high streamflow conditions downstream on the Missouri, Arkansas, and the Mississippi Rivers, which resulted in prolonged flood conditions upstream of the reservoirs throughout WY 2019. When downstream flood conditions subsided and release restrictions were removed, nearly all USGS monitored reservoirs released higher outflows, with higher annual streamflow observed at the downstream streamgages than the previous year, in order to reach the respective target water-surface elevation. Five reservoirs monitored by the USGS had a water-level elevation record set in WY 2019. For Tuttle Creek Lake, the peak storage in WY 2019 was 830 percent above normal storage. Three USGS monitored reservoirs ended the WY with less water than at the beginning of the WY, three reservoirs ended WY 2019 with more than twice the percent water storage, and six other reservoirs ended WY 2019 with more water (fig. 11).

Summary

After the normal (average) conditions in water year (WY) 2017 and the below normal conditions in WY 2018, above normal to much above normal hydrologic conditions existed across much of the State in WY 2019. Above

Figure 9. Photographs from water year 2019 flooding. *A*, Neosho River near Neosho Rapids, Kansas (07182390). *B*, Cottonwood River near Plymouth, Kansas (07182250). *C*, Slate Creek at Wellington, Kansas (07145700). *D*, Little Arkansas River near Sedgwick, Kansas (07144100). *E*, Little Arkansas River at Alta Mills, Kansas (07143665). *F*, Slate Creek at Wellington, Kansas (07145700).

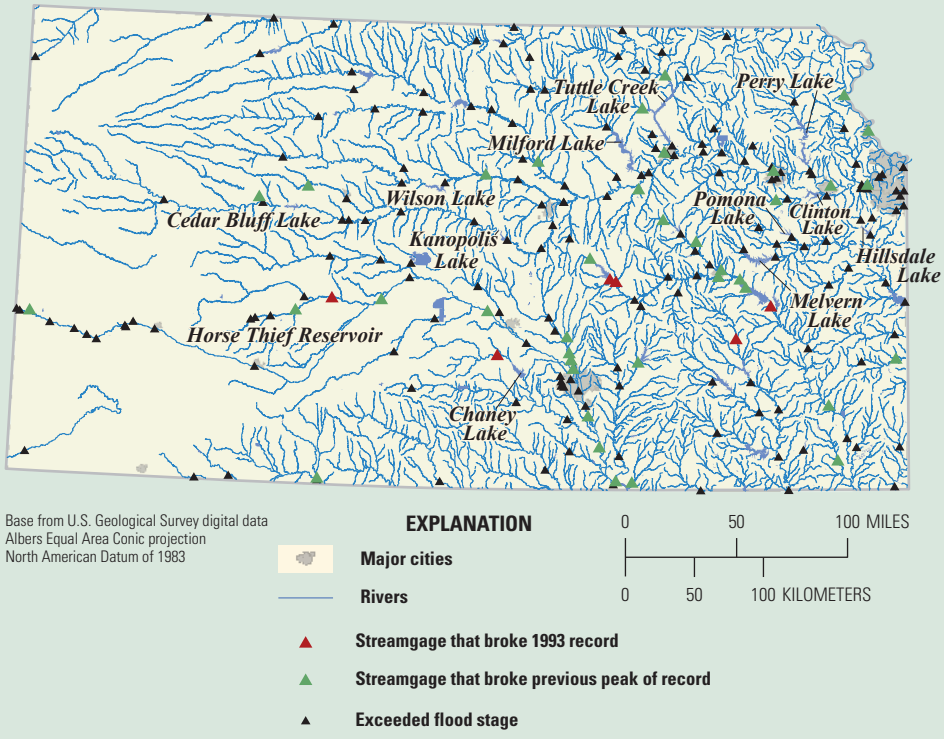


Figure 10. Historical record comparison of U.S. Geological Survey streamgages for water year 2019 (U.S. Geological Survey, 2019a).

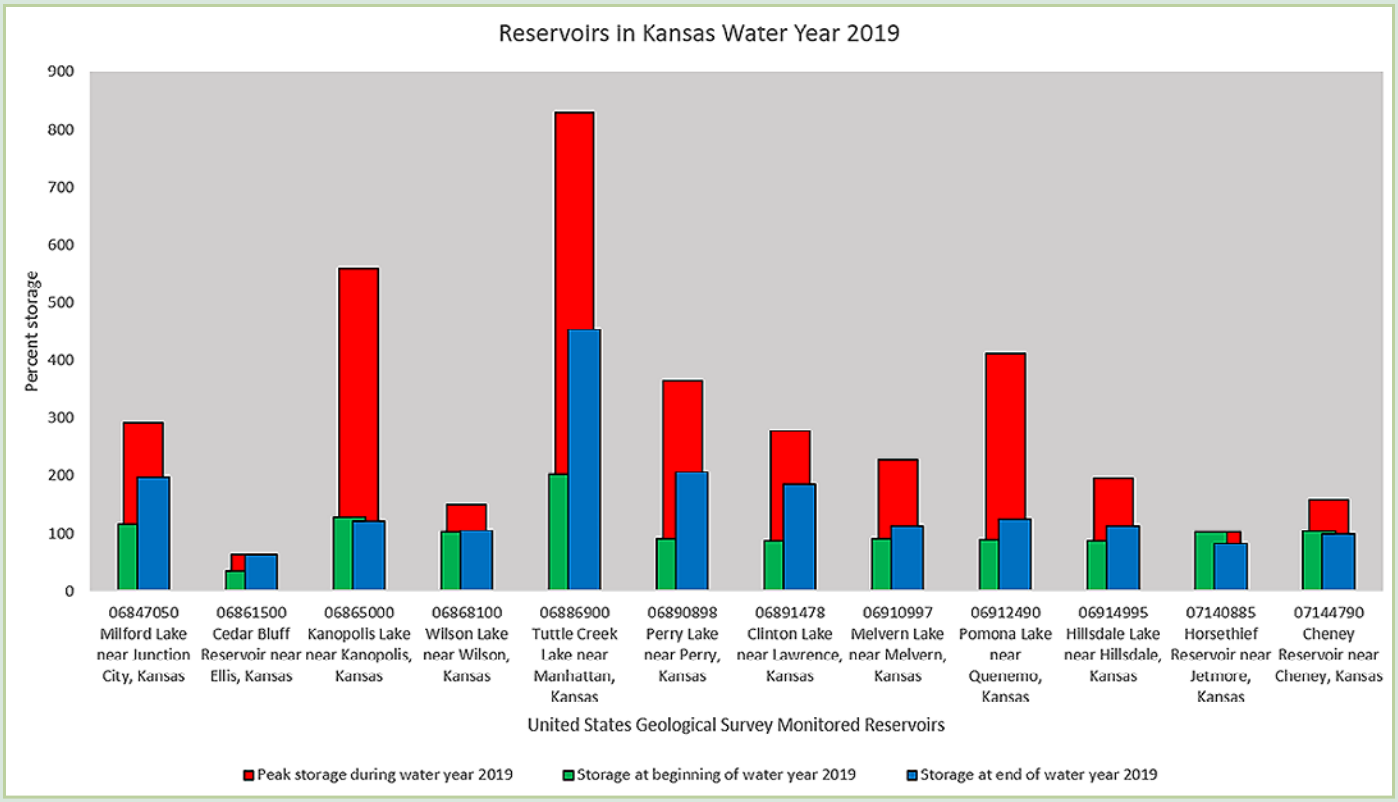


Figure 11. Comparison of U.S. Geological Survey monitored reservoirs in Kansas in water year 2019 (U.S. Geological Survey, 2019b).

normal precipitation throughout the State was responsible for the increased streamflow, runoff, and record-breaking events. The WY ended with normal to much above normal streamflow across most of the State because of continued reservoir releases and precipitation events in September. All USGS monitored reservoirs, except Cedar Bluff Reservoir, filled their conservation pools; three reservoirs ended WY 2019 with more than double the normal conservation storage. Despite the extreme precipitation in WY 2019, three reservoirs ended WY 2019 with slightly less water than at the beginning of the WY.

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