

**Kansas Water Resources and Supplies:  
A Statewide Perspective**

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## **Kansas Water Resources and Supplies:**

### **A Statewide Perspective**

**Kansas water resources and supplies are controlled primarily by three natural factors: climate, topography, and geology.**

**There is one more factor that affects our water supplies — man. Man's activities and structures sometimes speed up the movement of both groundwater and surface water in the water cycle or his activities and structures may slow down, divert, or temporarily store groundwater or surface water. Man has also tried to modify the weather, but the practicality of weather modification is still the subject of debate. Certainly man can seed a cloud and cause rain to fall from the cloud, but whether man can have a significant affect on the weather, a designed beneficial effect that is economically feasible, remains a question. However, the State's water resources are controlled primarily by the three natural factors.**

**Climate — Let us first consider the factor of climate. Climate controls the amount of water available to enter the groundwater and surface water systems. Kansas has a continental climate characterized by four seasons and rapid changes in weather. It ranges from humid continental in the east to semiarid in the southwest. The winters are mild to cold and are the driest part of the year. On the average the growing season, from April through September, receives about 75 percent of the year's total precipitation. Summers are sunny and temperatures are warm to hot with periods of summer having temperatures of 90°F or warmer. Average annual temperatures range from about 59°F in south-central and southeastern Kansas to about 52°F in northwestern Kansas. Winds average about 15 mph in the west and 10 mph in the east. Evaporation from lake surfaces or open bodies of water averages about 62 inches in southwestern Kansas to about 40 inches in the northeast corner of Kansas. In the western part of the**

State the evaporation from lakes may be 2 to 5 times as great as the average precipitation. Measurable amounts of precipitation fall on 90 to 100 days per year in the east, 60 to 80 days in the northwest and about 50 days per year in the southwest.

Average precipitation ranges from more than 40 inches annually in southeastern Kansas to less than 18 inches annually in southwestern Kansas (Fig. — Mean annual precipitation).

Knowing something about the climate, seasons, number of days of measurable rainfall, wind conditions, and amount of precipitation, let's look at what happens to this precipitation.

If we measure all the precipitation that falls on Kansas, we find that the average quantity is about 120.6 million acre-feet per year. What happens to this water? Fortunately, most of the precipitation, all across the State soaks into the ground and is available for growing plants. Only a small part of the water entering the soil percolates downward below the root zone and becomes groundwater recharge. A small part runs off the land to streams and a small part is directly evaporated from the land surface and plant foliage. The mean annual runoff (Fig. — Mean annual runoff) to streams ranges from less than 0.1 inch in western Kansas to more than 10 inches in eastern Kansas, a more than hundred fold increase across the state. We can immediately see that the areas of Kansas having the least precipitation, greatest average wind movement and greatest potential evaporation are the areas that have the least amount of stream runoff from which surface water supplies might be beneficially developed or which might be used to recharge depleting groundwater reservoirs.

As the factors of topography and geology are considered, we will see how these factors constrain the development of surface water supplies.

We have thus far discussed averages and means in our discussion of climate, but nature doesn't provide an "average" precipitation each year nor a "mean" runoff each year. Instead, there are some years which have much larger than average amounts of

precipitation, which may produce flooding and significantly larger runoff values than the mean. Other years or series of years may have significantly less than average precipitation, reduced runoff and drought conditions occur. Both are considered normal events in the hydrologic cycle. Floods and droughts may produce severe economic losses and distress in the affected areas.

**Topography** — The second factor that affects our water resources and supplies is topography. Given situations in which the geology and climate are similar, it is easy to depict a series of precipitation events in which runoff from nearly flat areas would be absent or nearly absent, but on steeply sloping land would be appreciable. Storm runoff and infiltration are both affected by the topography or slopes. Topography is also a factor in determining the suitability of a site for a dam and surface water impoundment. Topography also influences the length and depth of flow systems.

If we examine the regional topography of Kansas (Fig. — Geologic cross section on Geologic Map), we observe an eastward sloping plain having a slightly higher gradient or steeper slope in the western half and a somewhat more gentle slope in the eastern half. Much but not all of the western and south-central part of Kansas has a relatively smooth surface and includes physiographic regions called the High Plains and the Arkansas River Lowlands (Fig — Generalized Physiographic Map). North-central, and eastern Kansas includes more hilly topography and includes physiographic areas called the Smoky Hills, Flint Hills, the Glaciated Area and the Osage Cuestas. Our major streams flow generally from west to east.

Let us recall now the earlier illustrations showing precipitation and runoff. Precipitation more than doubled from west to east, runoff increased more than 100 times, resulting in an average surface water or stream discharge of 11.25 MAF from Kansas into Missouri and northeast Oklahoma. What a different perspective we would

have about water supplies and water problems if the topography sloped from east to west and we had 11 MAF of surface water flowing from eastern Kansas to western Kansas.

**Geology** — The third factor that is important to understanding our water resources and supplies is the geology of the State (Fig. — Geologic Timetable and Rock Chart). The availability of groundwater is directly related to the geology. The geology affects infiltration rates and the storage and transmission properties of aquifers. The geology affects the base flow characteristics and the base flow chemical quality of streams as well as the kind of sediment carried by the streams.

Essentially all of the fresh groundwater in Kansas occurs in the rocks we call sedimentary rocks. The sedimentary rocks are divided into two major groups. The first group is the unconsolidated or loosely packed rocks such as the stream-laid deposits, or alluvium, the wind-laid deposits such as loess and dune sand, and glacial deposits of various kinds. Groundwater is contained in the pore spaces in the rocks. Commonly 15-20 percent of a given volume of unconsolidated rock is pore space from which the water can be removed by gravity drainage and/or compressibility effects and is the water available to a well. The second kind of sedimentary rocks are called consolidated rocks such as limestone, dolomite, shale, sandstone, bedded salt, gypsum, anhydrite, and coal. These rocks are also called the bedrock. Referring again to the geologic map and cross section (Geologic Map), let me briefly summarize the general characteristics of the major bedrock units. The oldest and also some of the deepest fresh water occurs in the Cambro-Ordovician rocks consisting of sandstone and dolomite in four southeastern Kansas counties at depths of about 900 to 1300 feet. Yields range from 100-1000 gpm. Mississippian rocks yield some fresh water supplies to wells in parts of Cherokee County at depths generally less than 500 feet. Pennsylvanian rocks in eastern Kansas are mostly shale and limestone which yield meager groundwater supplies; however the Douglas Group sandstones locally yield 10-100 gpm to wells at depths up to 500 feet. Locally,

mineralized water may be encountered at depths as shallow as 50 feet. Permian rocks locally yield 10-500 gpm of fresh water from limestone aquifers in the Chase Group and gypsum aquifers in the Wellington Formation. Sandstones in the Permian redbeds of south-central Kansas locally yield 10-100 gpm of fresh water but in some areas yield highly mineralized water.

Jurassic rocks in southwest Kansas yield water from gypsum beds that is suitable for irrigation uses. Lower Cretaceous rocks include sandstone beds that yield irrigation, municipal, and industrial supplies in parts of central and western Kansas, but in some areas the water is highly mineralized. Groundwater in the consolidated rocks is generally less free to move except in open fractures and joints. In the case of sandstone, groundwater moves through both pore spaces and fractures and in the case of limestones, dolomite and gypsum, it moves through solution cavities and fractures.

It has been estimated that the unconsolidated rocks contain about 80 percent of our fresh water and the consolidated rocks about 20 percent. About 400 million acre-feet (MAF) of groundwater is stored in both the consolidated and unconsolidated rocks. From the geologic standpoint, the unconsolidated deposits contain the most important and generally the most prolific aquifers. More than 600 feet of saturated unconsolidated rocks are present in parts of southwestern Kansas where the Ogallala aquifer is thickest. In the Pleistocene alluvial aquifers of the Great Bend Prairie of south-central Kansas and the Equus Beds of central Kansas, the maximum saturated thicknesses are more than 200 feet. Parts of the glacial drift aquifer in northeastern Kansas have saturated thicknesses of 300 feet. Although not shown on this geologic map the Kansas River valley and its major tributaries and the Missouri River valley also have saturated thicknesses of 30-100 feet capable of yielding quantities adequate for irrigation, industrial and municipal use.

Some serious water quality problems are associated with groundwater flow in the Permian and Cretaceous rocks. One of these areas is associated with dissolution of the

Hutchinson Salt Member of the Wellington Formation between Saline County on the north and Sumner and Cowley counties on the south. Natural groundwater circulation causes salt water to discharge to the Smoky Hill River Valley east of Salina and the Arkansas River Valley in the vicinity of Guda Springs causing increased salt content in the streams and the associated unconsolidated aquifers.

A second area of natural mineralized water discharge is from the Permian Redbeds in parts of Stafford, Reno, Pratt, Barber, Comanche, Clark, Meade, and Seward counties. The geohydrology of this flow system is not well understood or documented, but it is believed groundwater enters Permian redbeds that include sandstone, bedded salt, gypsum and anhydrite in southwest Kansas and flows eastward and southeastward to discharge into streams and the unconsolidated aquifers that occur in these counties.

The third area of natural mineralized water discharge affects segments of the Smoky Hill, Saline, Solomon and Republic rivers and the associated unconsolidated valley aquifers along the eastern edge of the Lower Cretaceous outcrop and involves sandstone beds in the Dakota and Kiowa formations.

Man's Activities — Through individual and governmental activities, man has modified parts of the natural hydrologic cycle. On the land where the precipitation falls, individuals have applied conservation measures such as stubble mulching, terracing, retention dams and other conservation measures which retain more of the precipitation where it falls, and reduces soil erosion. Governmental agencies have constructed dams and reservoirs to reduce flooding and provide water for conservation, municipal, industrial, and irrigation use.

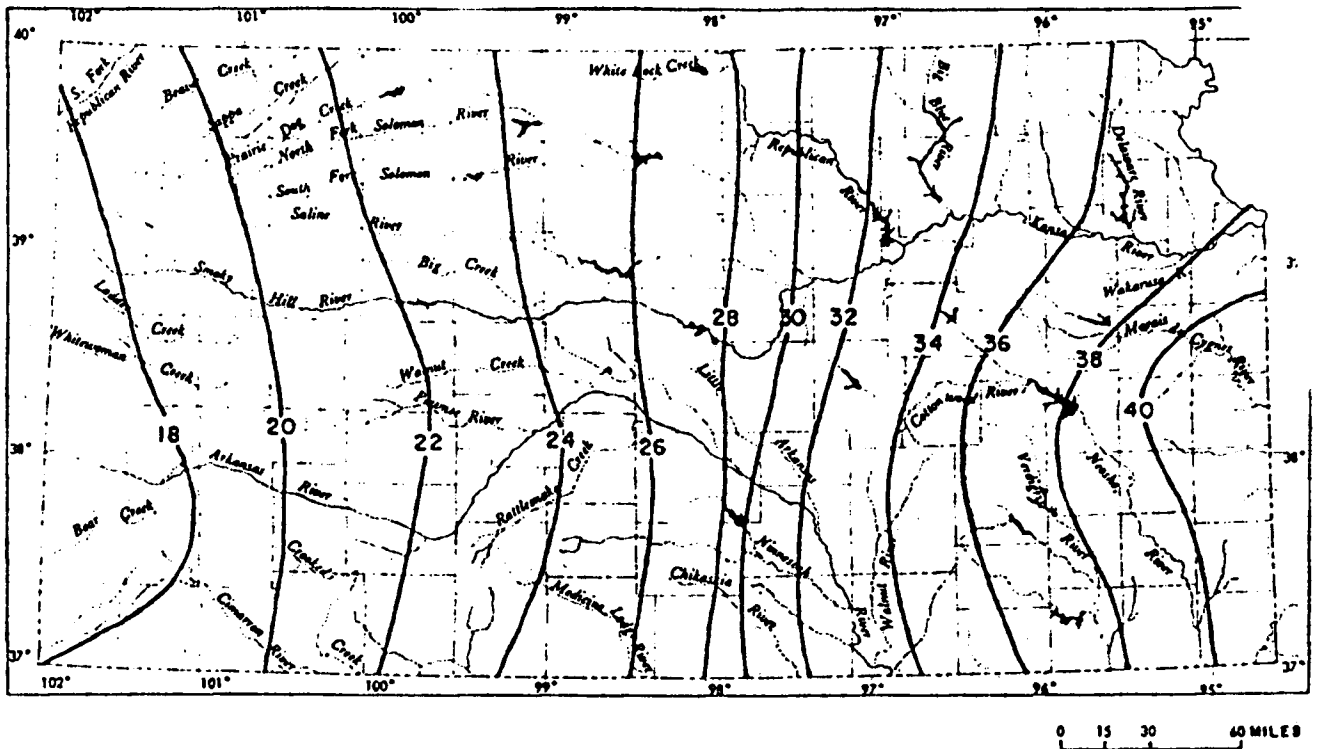
The Kansas Legislature, through the Kansas Water Office, has provided for inclusion of State-managed water supplies in 13 reservoirs constructed or planned in eastern Kansas (Fig. — Federal Reservoirs with State-managed water). When all are completed, there will be about 1 million acre-feet of State-managed water available for

beneficial use.

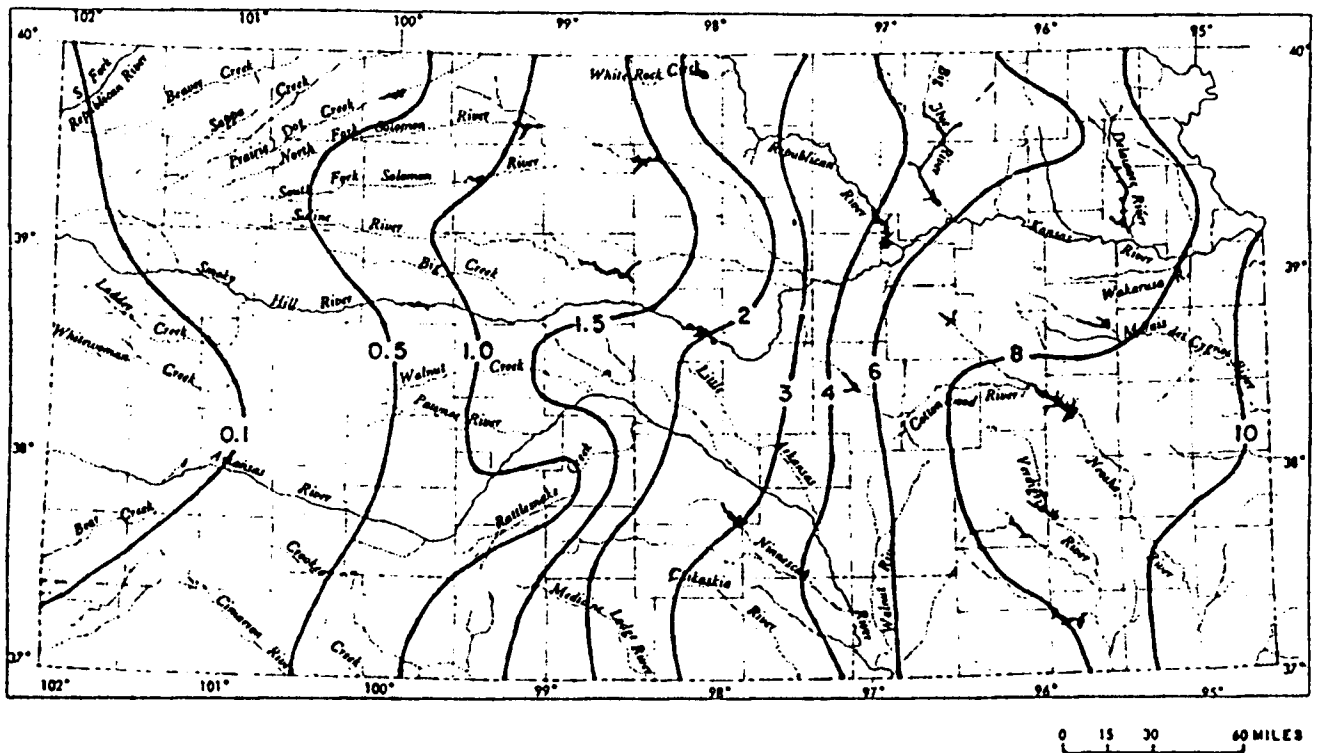
In western Kansas the planned mining of groundwater in the Ogallala aquifer is taking place. This has both beneficial and detrimental effects. It has been determined by the local people in western Kansas that the beneficial effects of mining the aquifer outweigh the detrimental effects. The long-term effects of this mining will create new problems. Proposed schemes for importation of water are being considered but a water source or sources and transfer plans that are politically and economically feasible has yet to be agreed on.

In summary, Kansas has a great many water assets, but we have some problems also. We received about 120 million acre-feet of water on the average from precipitation. Most of this water soaks into the soil and is returned to the atmosphere by evaporation and transpiration. A small amount becomes groundwater recharge and about 11.6 million acre-feet on the average flows out of the State. We have about 400 million acre-feet of groundwater in storage and have or will have about 1 million acre-feet of State-managed surface water stored in federal reservoirs built or planned.

It is essential that we manage our water resources wisely, particularly in those areas where groundwater supplies are being mined and in those areas where natural mineral intrusions occur. We must educate and promote water conservation and water quality protection. We can do a better job.

















MEAN ANNUAL PRECIPITATION, IN INCHES, 1941-70  
(Data from the Kansas Agricultural Experiment Station)

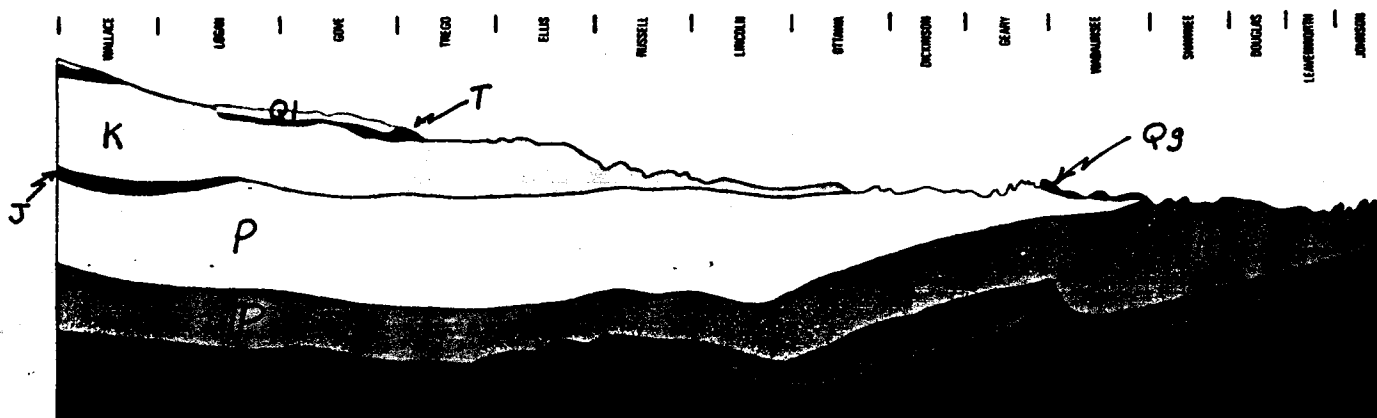
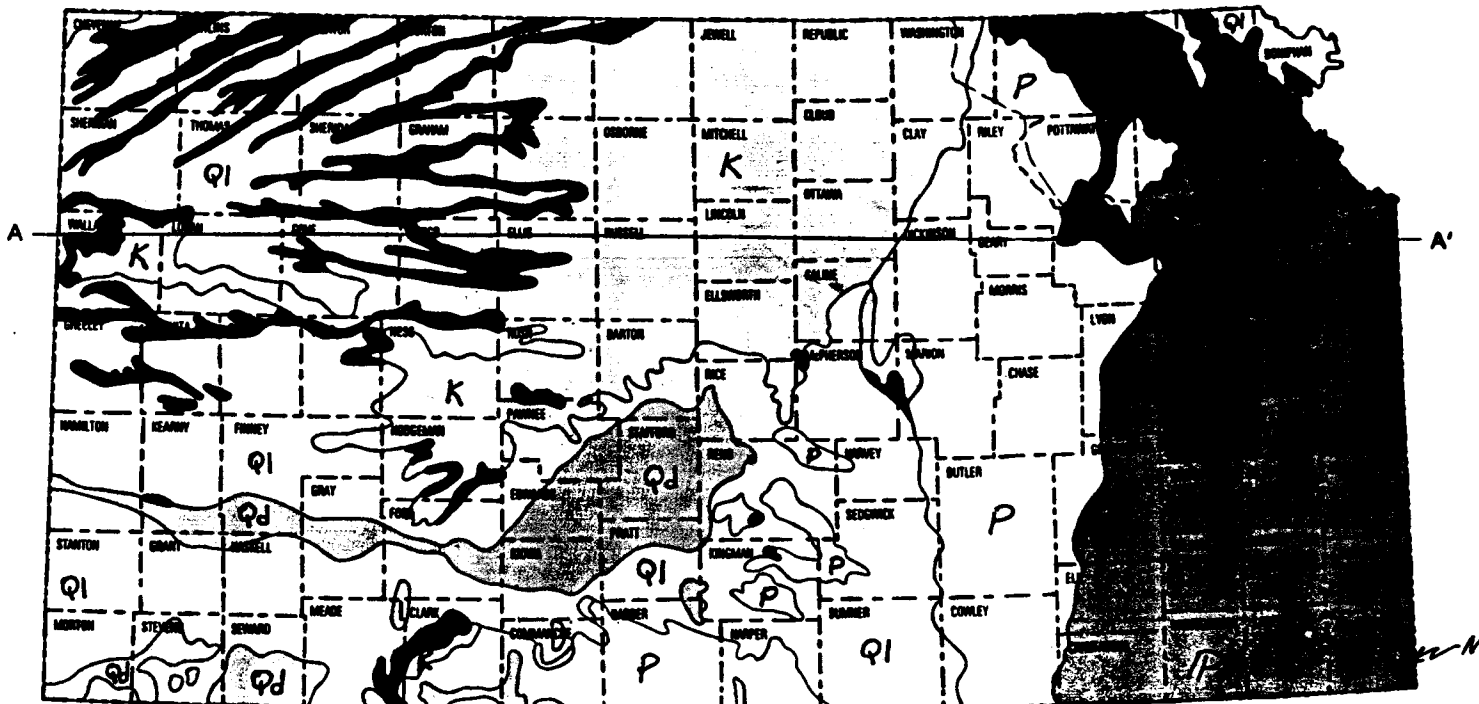


MEAN ANNUAL RUNOFF, IN INCHES

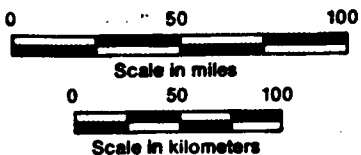
# GENERALIZED GEOLOGIC MAP OF KANSAS

## EXPLANATION

-  QUATERNARY SYSTEM  
Loess and river valley deposits
-  Sand dunes
-  Glacial drift deposits
-  Limit of Kansan Glacier
-  TERTIARY SYSTEM
-  CRETACEOUS SYSTEM
-  JURASSIC SYSTEM
-  PERMIAN SYSTEM
-  PENNSYLVANIAN SYSTEM
-  MISSISSIPPIAN SYSTEM
-  SILURIAN-DEVONIAN SYSTEMS
-  CAMBRIAN-ORDOVICIAN SYSTEMS
-  PRECAMBRIAN SYSTEM
-  Line of cross-section

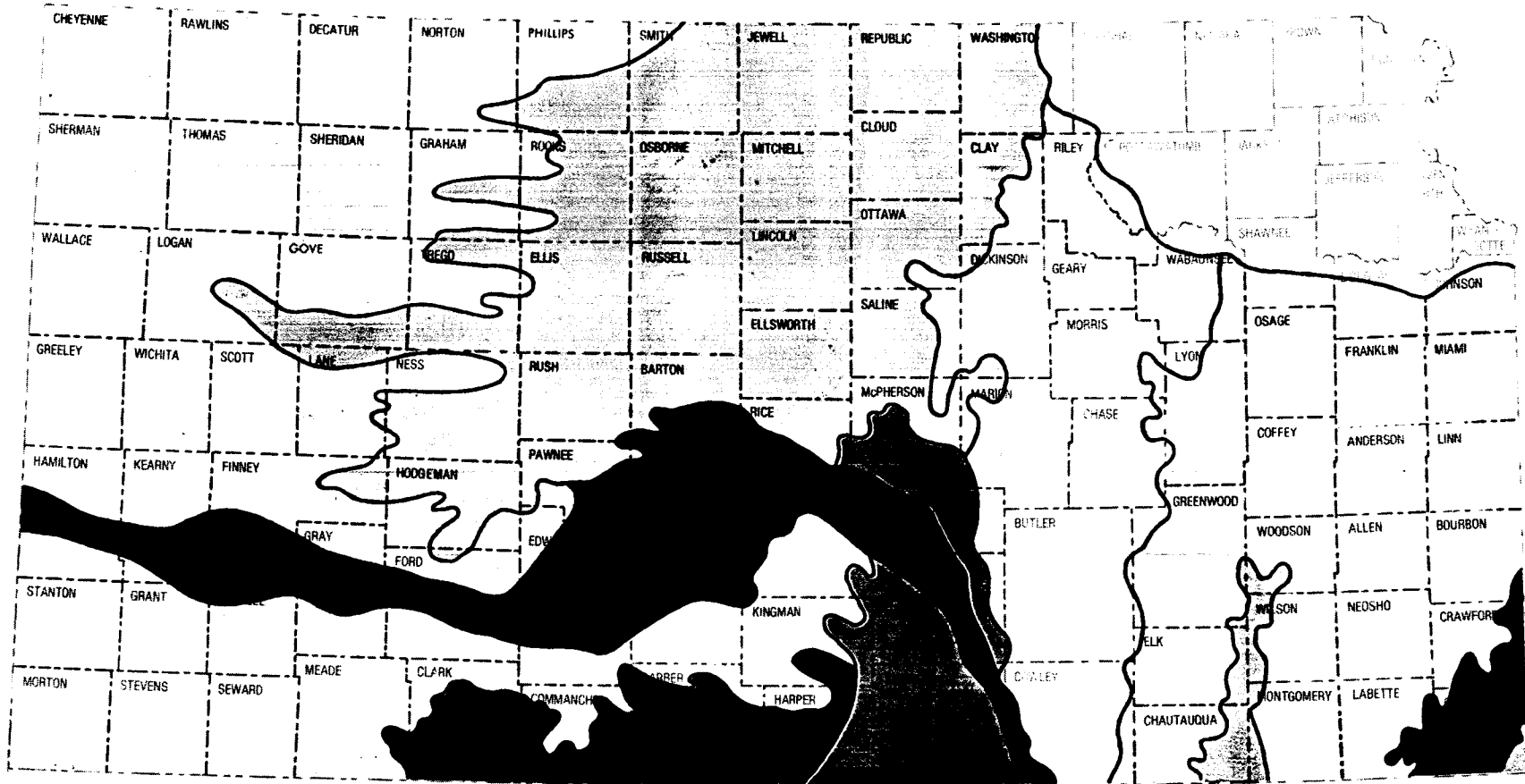


Geologic cross-section below I-70














# GENERALIZED PHYSIOGRAPHIC MAP OF KANSAS

Kansas Geological Survey  
1930 Avenue "A", Campus West  
The University of Kansas  
Lawrence, Kansas











## EXPLANATION

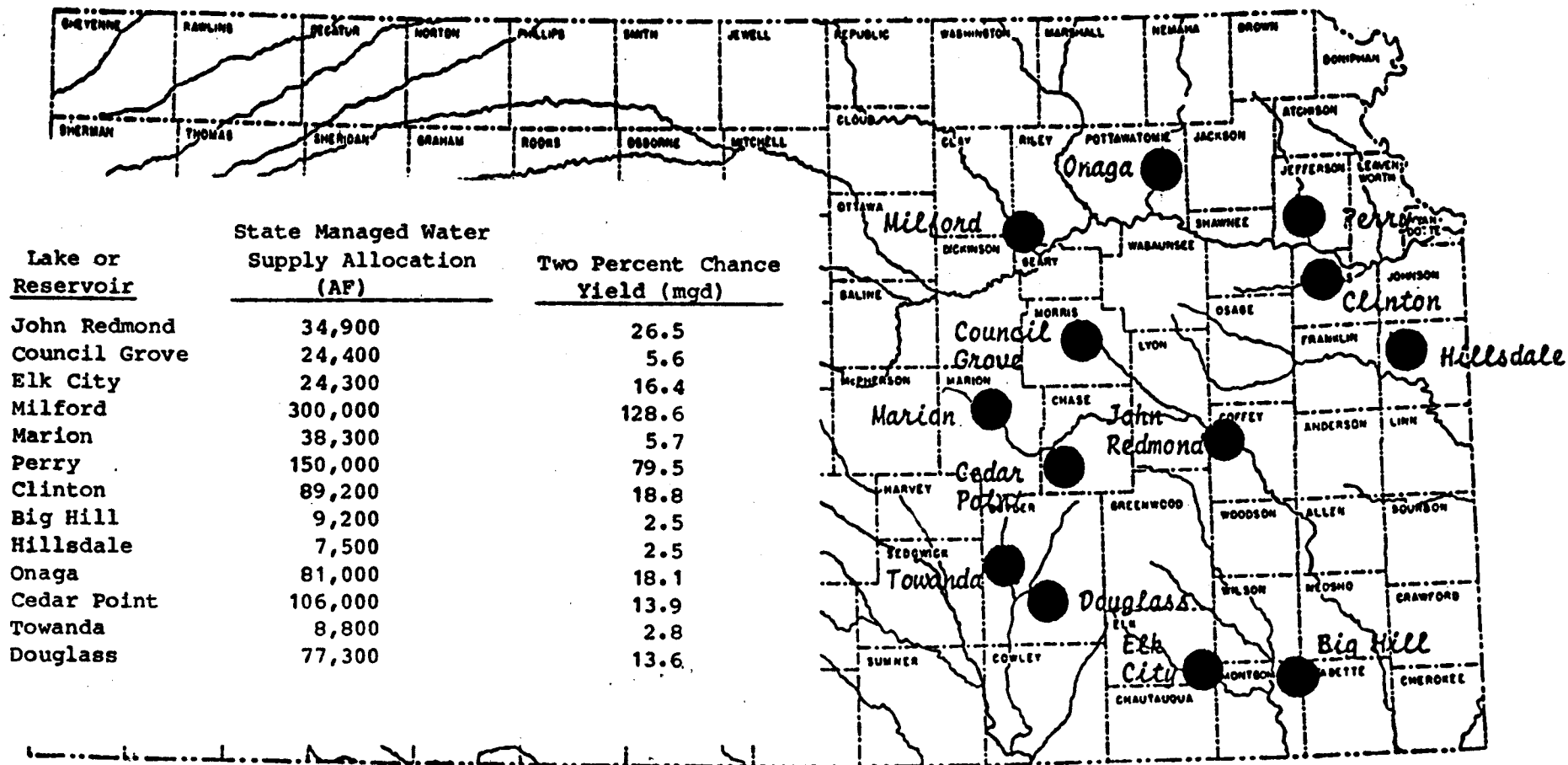
- |   |                               |   |                     |   |                   |
|---|-------------------------------|---|---------------------|---|-------------------|
|  | HIGH PLAINS                   |  | RED HILLS           |  | OZARK PLATEAU     |
|  | SMOKY HILLS                   |  | GLACIATED REGION    |  | CHEROKEE LOWLANDS |
|  | ARKANSAS RIVER LOWLANDS       |  | OSAGE CUESTAS       |  | CHAUTAUQUA HILLS  |
|  | WELLINGTON-MCPHERSON LOWLANDS |  | FLINT HILLS UPLANDS |   |                   |



**GEOLOGIC TIME AND KANSAS ROCK CHART**

*(Not scaled for geologic time or thickness of deposits)*

ERAS	PERIODS	EPOCHS	EST. LENGTH IN YEARS*	TYPE OF ROCK IN KANSAS	MILLION YEARS PAST
CENOZOIC	QUATERNARY	HOLOCENE 	10,000 +	Glacial drift; river silt, sand, and gravel; dune sand; wind-blown silt (loess); volcanic ash.	0.010
		PLEISTOCENE	1,990,000		2
	TERTIARY	PLIOCENE	3,000,000	River silt, sand, gravel, fresh-water limestone; volcanic ash; bentonite; diatomaceous marl; opaline sandstone.	5
		MIOCENE	19,000,000		24
		OLIGOCENE 	14,000,000		38
		EOCENE	17,000,000		55
		PALEOCENE	8,000,000		63
MESOZOIC	CRETACEOUS 		75,000,000	Limestone, chalk, chalky shale, dark shale, varicolored clay, sandstone, conglomerate. Outcropping igneous rock.	138
	JURASSIC		67,000,000	Sandstones and shales, chiefly subsurface. Siltstone, chert, and gypsum.	205
	TRIASSIC		35,000,000		240
PALEOZOIC	PERMIAN 		50,000,000	Limestone, shale, evaporites (salt, gypsum, anhydrite), red sandstone; chert, siltstone, dolomite, and red beds.	290
	PENNSYLVANIAN 		40,000,000	Alternating marine and nonmarine shale, limestone, sandstone, coal; chert and conglomerate.	~330
	MISSISSIPPIAN		30,000,000	Limestone, shale, dolomite, chert, oolites, sandstone, and siltstone.	360
	DEVONIAN 		50,000,000	Subsurface only. Limestone, predominantly black shale; sandstone.	410
	SILURIAN 		25,000,000	Subsurface only. Limestone.	435
	ORDOVICIAN		65,000,000	Subsurface only. Dolomite, sandstone.	500
	CAMBRIAN 		70,000,000	Subsurface only. Dolomite, sandstone, limestone, and shale.	~570
			1,930,000	Subsurface only. Granite, other igneous rocks, and metamorphic rocks.	2,500
		1,100,000 +			



Location of Thirteen Reservoirs on which Assurances Have Been Provided by the 1961 Legislature in House Concurrent Resolution #5 or by the Kansas Water Resources Board Under Provisions of K.S.A. 82a-910 and 82a-933