INTRODUCTION

Sedimentary rocks of Late Cambrian through Early Cretaceous age in Kansas are part of a regional flow system of hydraulically connected aquifers and confining units. Future demands for water require that these deeply buried rocks be studied to describe hydrologic properties and ground-water flow conditions and to provide information that will serve as the basis for decisions concerning the protection and the management of the water resources contained therein. Toward this end, the U.S. Geological Survey, as a part of its Central Midwest Regional Aquifer-System Analysis (CMRASA), began a 5-year hydrologic investigation of this regional flow system in Arkansas, Colorado, Kansas, Missouri, Nebraska, New Mexico, Oklahoma, South Dakota, and Texas (Jorgensen and Signor, 1981).

This chapter is one of nine contained in Hydrologic Investigations Atlas HA–722, which present a description of the physical framework (Chapters B–F) and the geohydrology (Chapters G–I) of principal aquifers and confining systems in Upper Cambrian through Lower Cretaceous rocks in Kansas; the stratigraphic relations of these geohydrologic systems are discussed in detail in Chapter A (Wolf and others, 1990). This chapter (G) describes the geohydrology of the Great Plains aquifer system; the physical framework of the Great Plains aquifer system is presented in Chapter B (Spinazola and others, 1992).

The maps in this chapter are based on existing data from selected geophysical and lithologic logs, drill-stem tests, water-level measurements, water-quality analyses, and published maps of stratigraphically equivalent units. An index to the geohydrologic data compiled for the CMRASA in Kansas is presented in Spinazola and others (1987). For the most part, data used to construct the maps were collected over many years and do not reflect aquifer conditions for any specific time period.

CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
gallon per minute (gal/min)	0.06309	liter per second
cubic foot per second per square mile ($[ft^3/s]/mi^2$)	0.01093	cubic meter per second per square kilometer

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

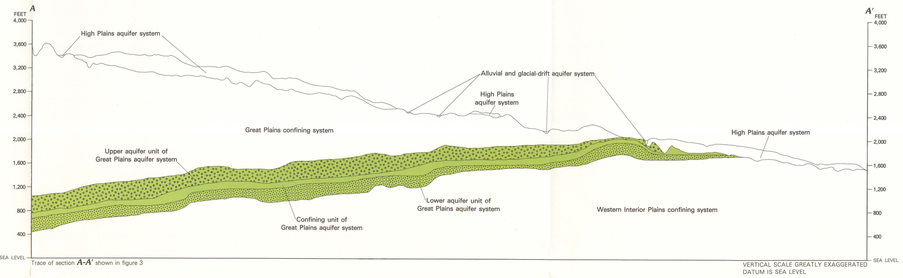
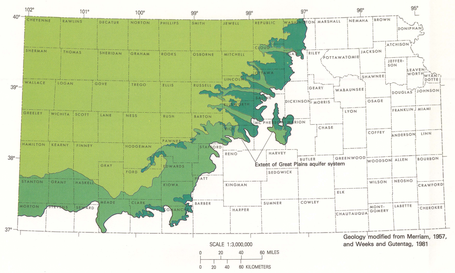


FIGURE 2.—Geohydrologic section showing relation of Great Plains aquifer system to other geohydrologic systems.



Geology modified from Merriam, 1957, and Weeks and Gutentag, 1981

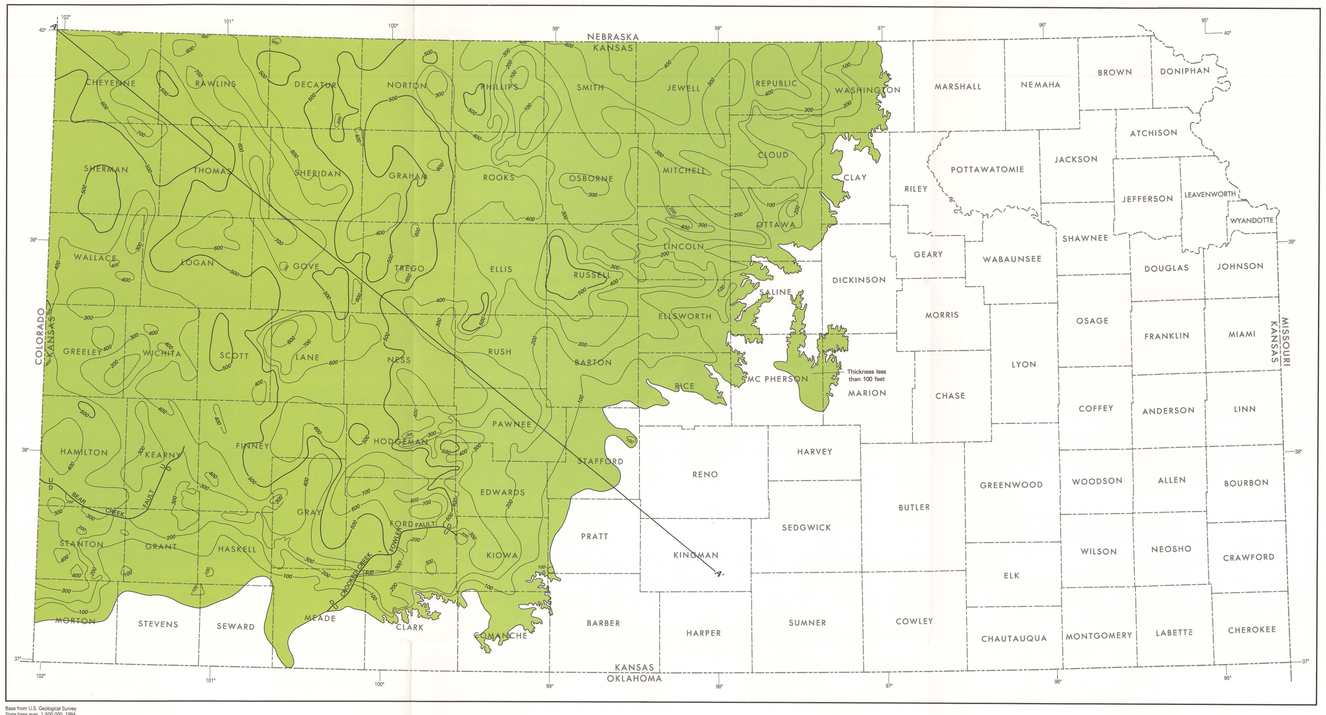
EXPLANATION

- OUTCROP OR SHALLOW SUBCROP OF GREAT PLAINS AQUIFER SYSTEM
- SUBCROP OF GREAT PLAINS AQUIFER SYSTEM BENEATH HIGH PLAINS OR ALLUVIAL AND GLACIAL-DRIFT AQUIFER SYSTEMS
- GREAT PLAINS AQUIFER SYSTEM COVERED BY GREAT PLAINS CONFINING SYSTEM

FIGURE 1.—Geohydrologic map showing extent, outcrop, and subcrop of Great Plains aquifer system.

TABLE 1. Generalized stratigraphic units and related geohydrologic systems

SYSTEM	Series	Provincial series	Geologic unit	Geohydrologic systems: Subdivisions	Geohydrologic systems: Major systems
QUATERNARY	Holocene Pleistocene		Undifferentiated Quaternary deposits		Alluvial and glacial-drift aquifer system
TERTIARY	Miocene		Ogallala Formation		High Plains aquifer system
CRETACEOUS	Upper		Undifferentiated Upper Cretaceous rocks		Great Plains confining system
	Lower		Dakota Formation	Upper aquifer unit	Great Plains aquifer system
			Kiowa Shale	Confining unit	
			Cheyenne Sandstone	Lower aquifer unit	
JURASSIC	Upper		Morrison Formation	Upper unit	Western Interior Plains confining system
			Undifferentiated Upper Jurassic rocks		
PERMIAN	Upper		Big Basin Formation	Lower unit	
	Lower		Day Creek Dolomite Whitehorse Formation Nippewalla Group Dog Creek Formation Blaine Formation Flowerpot Shale Cedar Hills Sandstone Salt Plains Formation Harper Sandstone Sumner Group Stone Corral Formation Ninnescah Shale Wellington Formation Chase Group Council Grove Group Admire Group		
PENNSYLVANIAN	Upper	Virgilian	Wabaunsee Group Shawnee Group Douglas Group		
		Missourian	Undifferentiated Missourian rocks		
	Middle	Desmoinesian	Undifferentiated Desmoinesian rocks		
		Atokan	Undifferentiated Atokan rocks		
	Lower	Morrowan	Undifferentiated Morrowan rocks		
MISSISSIPPIAN	Upper	Chesterian	Undifferentiated Chesterian rocks		
	Lower	Meramecian Osagean Kinderhookian	Undifferentiated Upper and Lower Mississippian rocks	Upper aquifer unit	
			Undifferentiated Lower Mississippian and Upper Devonian rocks	Confining unit	
DEVONIAN			Hunton Formation	Upper part of lower aquifer unit	Western Interior Plains aquifer system
SILURIAN					
ORDOVICIAN	Upper		Maquoketa Shale		
	Middle		Viola Limestone Simpson Group		
	Lower		Arbuckle Group	Lower part of lower aquifer unit	
CAMBRIAN	Upper				
PRECAMBRIAN			Igneous, metamorphic, and metasedimentary rocks		Basement confining system



SCALE 1:1,000,000
0 10 20 30 40 MILES
0 20 40 60 KILOMETERS

EXPLANATION

- AREA OF GREAT PLAINS AQUIFER SYSTEM
- EXTENT OF GREAT PLAINS AQUIFER SYSTEM—Modified from Kansas Geological Survey (1964); Merriam (1963); and other published reports
- 100 LINE OF EQUAL THICKNESS OF GREAT PLAINS AQUIFER SYSTEM—Interval 100 feet
- U/D FAULT—U, upthrown side; D, downthrown side
- A—A' TRACE OF SECTION

FIGURE 3.—Geohydrologic map showing areal extent and thickness of Great Plains aquifer system.

DESCRIPTION OF PHYSICAL CHARACTERISTICS

The Great Plains aquifer system, which is generally known as the "Dakota aquifer" in hydrogeologic literature, is one of the most extensive aquifer systems in North America—from northern Canada to New Mexico in the United States. The aquifer system extends over a large part of western Kansas, as shown in figure 1, and consists mostly of Lower Cretaceous rocks. The aquifer system crops out along the eastern and the southern margins of the area. The aquifer system generally is overlain toward the west and the north by the Great Plains confining system (rocks of Late Cretaceous age). In parts of southwestern Kansas and in major river valleys, however, the Great Plains aquifer system is directly overlain by the High Plains aquifer system, which comprises deposits of Quaternary and Tertiary age, and the alluvial and glacial-drift aquifer system, which comprises Holocene, Pleistocene, and Miocene sediments. The Great Plains aquifer is underlain everywhere in Kansas by the Western Interior Plains confining system, which is a thick sequence of Jurassic, Permian, Pennsylvanian, and Upper Mississippian rocks. The stratigraphic relation of the Great Plains aquifer system to overlying and underlying geohydrologic systems is illustrated in figure 2 and listed with equivalent stratigraphic units in table 1.

Rocks of the Great Plains aquifer system are an interbedded sequence of sandstone, shale, and siltstone. The thickness of the aquifer system ranges from a few feet at the eroded edges in the east and the south to about 800 ft in the western part of the State (fig. 3). In general, thickness of the aquifer system increase toward the north and the west. Depth to the top of the aquifer system below land surface also increases from a few feet in the outcrop area to about 2,500 ft in the northwestern corner of the State (fig. 4).

The Great Plains aquifer system in Kansas is included within a sequence of rocks that consists of shale and siltstone with interbedded and lenticular sandstone. An examination of geophysical logs commonly indicates significant lithologic variability from site to site. The log from one site may indicate mostly thick beds of sandstone, whereas that from a nearby site may indicate mostly shale with a few thin beds of sandstone.

Lithologic and fossil evidence from rocks of the Great Plains aquifer system indicate marine and nonmarine sediments. Deposition probably occurred along the coastline of a sea that alternately advanced and retreated across the area (Keene and Bayne, 1977). Sand probably was deposited in shallow seas and deltas, on beaches and nearshore bars, and along river channels. As the location of the coastline continued to move, beds of sand may have been partly or completely removed by planation and replaced by other beds of shale or sand. Deposition of this type would not provide definable boundaries that were consistent throughout large areas.

The Great Plains aquifer system was divided into the following regional geohydrologic subdivisions during the CMRASA (D.G. Jorgensen, U.S. Geological Survey, written commun., 1985): (1) an upper sandstone aquifer unit named the "Maha aquifer," (2) a middle, predominately shale confining unit named the "Apishapa confining unit," and (3) a lower sandstone aquifer unit named the "Apishapa aquifer." The local names "upper aquifer unit," "confining unit," and "lower aquifer unit" are used in this report instead of the three CMRASA regional geohydrologic subdivisions. The relation between geohydrologic systems and equivalent stratigraphic units are shown in table 1.

Upper Aquifer Unit

The upper aquifer unit of the Great Plains aquifer system in Kansas is stratigraphically equivalent to the Dakota Formation (table 1). This unit comprises shale and siltstone with an abundance of interbedded and lenticular sandstone. Thickness and character of the sandstone may differ significantly throughout the area. The fine to coarse sand may be loose to well cemented and may contain small to large percentages of silt and clay. Hydraulic conductivity, which is a measure of rock permeability, is estimated to range from 1 to 41 ft/d for the upper aquifer unit in southwestern Kansas (Kume, 1984; Kume and Spinazola, 1985). Permeability of the sandstone in the upper aquifer unit mostly depends on the degree of cementation and the percentage of included silt and clay. Although the sandstone in the upper aquifer unit may be in separate beds in some parts of the study area, generally, there is sufficient interconnection between the beds to permit the movement of water. Fine-grained shale and siltstone, which have relatively low permeability, commonly retard local groundwater flow.

The upper aquifer unit is in an area to the north and the west of an irregular line from Washington County in the northeast to Morton County in southwestern Kansas (fig. 5A). The upper aquifer unit crops out along stream valleys in the northeastern part of the area and mostly underlies the shale and limestone of the Great Plains confining system elsewhere. In southwestern Kansas, however, the unit subcrops directly beneath unconsolidated deposits of the High Plains aquifer system. Thickness of the upper aquifer unit ranges from a few feet in the outcrop and the subcrop areas to about 400 to 500 ft in scattered areas mostly in northern and northwestern Kansas (Spinazola and others, 1992).

Confining Unit

The confining unit of the Great Plains aquifer system in Kansas is stratigraphically equivalent to the Kiowa Shale (table 1). This unit predominantly comprises shale with some siltstone and thin beds of sandstone. Lenses of sandstone are most abundant in central and southwestern Kansas. In parts of central Kansas, sandstone constitutes as much as 80 percent of the confining unit (Zeller, 1968). Generally, the fine-grained shale and siltstone have relatively low permeability and retard the vertical movement of water between the upper and the lower aquifer units. Where the percentage of sandstone increases relative to the silt and clay content, some water probably flows between the aquifer units as a result of the greater vertical flow through the confining unit.

The confining unit is in an area that nearly coincides with the area of the upper aquifer unit (fig. 5B). The confining unit extends beyond the upper aquifer unit in some areas along the eastern and the southern margins where it may subcrop beneath the High Plains or alluvial aquifer systems but is missing in the northern parts of Norton, Phillips, Smith, Jewell, Republic, and Washington Counties. Thicknesses of the confining unit range from a few feet to the outcrop and subcrop areas to about 200 to 300 ft in north-central and south-central Kansas (Spinazola and others, 1992).

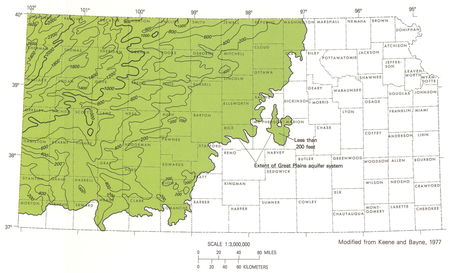
Lower Aquifer Unit

The lower aquifer unit of the Great Plains aquifer system in Kansas is stratigraphically equivalent to the Cheyenne Sandstone (table 1). This unit predominantly comprises a sequence of sandstone at the base and sandstone with lenses of sandy shale and siltstone. Fine to medium sand in the unit may be loose to well cemented and may contain small to large amounts of silt and clay. Permeability of the lower aquifer unit probably is similar to that of the upper aquifer unit. Leakage between the upper and the lower aquifer units is retarded wherever they are separated by shale sequences of the confining unit.

The lower aquifer unit occurs in an area that nearly coincides with the upper aquifer and the confining units (fig. 5C). The lower aquifer unit extends beyond the overlying units mostly along the southeastern margin in Barton, Comanche, Kiowa, and Stafford Counties. The lower aquifer unit is missing beneath overlying units in all or parts of the counties east of Norton, Osborne, Russell, Ellsworth, and Barton Counties. The lower aquifer unit is underlain everywhere by the Western Interior Plains confining system. Thicknesses of the lower aquifer unit generally increase northward and range from a few feet at the outcrop or subcrop to about 300 ft in northwestern Kansas (Spinazola and other, 1992).

Thickness of Sandstone in Aquifer System

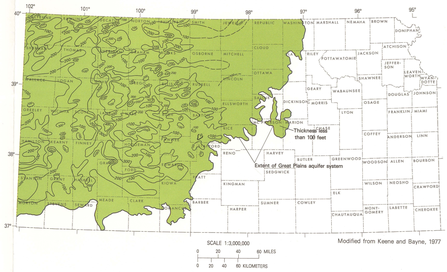
A generalized map (fig. 6), which is based on interpretations from geophysical logs, shows the total thickness of sandstone in Lower Cretaceous rocks. Sandstone thicknesses in the eastern one-half of the Great Plains aquifer system commonly are less than 100 ft and range from about 200 to 300 ft in the western one-half. The increased sandstone thickness suggests that increased quantities of water may be available from storage in the western part. However, the thickness values do not indicate the degree of cementation or the percentage of silt and clay that may be included.



EXPLANATION

200 LINE OF EQUAL DEPTH TO TOP OF GREAT PLAINS AQUIFER SYSTEM—Interval 200 feet

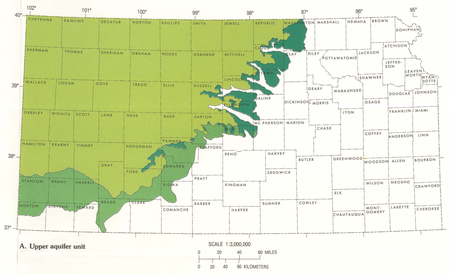
FIGURE 4.—Geohydrologic map showing depth to top of Great Plains aquifer system.



EXPLANATION

100 LINE OF EQUAL THICKNESS OF SANDSTONE IN GREAT PLAINS AQUIFER SYSTEM—Dashed where approximately located. Interval 100 feet

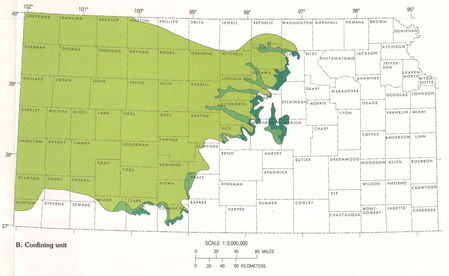
FIGURE 6.—Geologic map showing thickness of sandstone in Great Plains aquifer system.



A. Upper aquifer unit

EXPLANATION

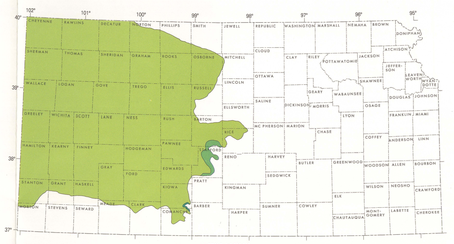
- OUTCROP OR SHALLOW SUBCROP OF UPPER AQUIFER UNIT
- SUBCROP OF UPPER AQUIFER UNIT BENEATH HIGH PLAINS AQUIFER SYSTEM
- UPPER AQUIFER UNIT



B. Confining unit

EXPLANATION

- OUTCROP OR SHALLOW SUBCROP OF CONFINING UNIT
- SUBCROP OF CONFINING UNIT BENEATH HIGH PLAINS OR ALLUVIAL AND GLACIAL-DRIFT AQUIFER SYSTEMS
- CONFINING UNIT



C. Lower aquifer unit

EXPLANATION

- OUTCROP OR SHALLOW SUBCROP OF LOWER AQUIFER UNIT
- SUBCROP OF LOWER AQUIFER UNIT BENEATH HIGH PLAINS AQUIFER SYSTEM
- LOWER AQUIFER UNIT

FIGURE 5.—Geohydrologic map showing areal extent of (A) upper aquifer unit, (B) confining unit, and (C) lower aquifer unit of Great Plains aquifer system.

GEOHYDROLOGIC SYSTEMS IN KANSAS—GEOHYDROLOGY OF THE GREAT PLAINS AQUIFER SYSTEM

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