DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

Prepared in cooperation with the
STATE GEOLOGICAL SURVEY OF KANSAS
KANSAS STATE DEPARTMENT OF HEALTH
KANSAS STATE BOARD OF AGRICULTURE

HYDROLOGIC INVESTIGATIONS
ATLAS HA-516 (SHEET 2 OF 2)

HYDROLOGY

GENERAL HYDROLOGY

INTRODUCTION

According to records of the National Weather Service (formerly U.S. Weather Bureau) for a station near Syracuse, the average annual precipitation in Hamilton County is about 16 inches. Of this amount, 83 percent occurs during the growing season (March 15 to October 15). A part of the precipitation runs off as surface flow, part is evaporated or used by vegetation, and a small part percolates downward to recharge the ground-water reservoir. The average recharge from precipitation for Hamilton County is estimated to be 0.1 inch per year. Owing to the limited supply of water in most of the upland area of the county, dryland farming and grazing are the predominant land uses.

SURFACE WATER

The Arkansas River, which flows into the county from Colorado, supplies water for irrigation along the valley. Average annual diversion by the Alamo Canal is 1,430 acre-feet at a point 9 miles west of Syracuse and by the Fort Aubrey Canal is 4,740 acre-feet 4 miles west of Syracuse. The Frontier Ditch, which diverts water from the river west of the Kansas State line, returns an average of 3,960 acre-feet annually about 4 miles downstream from Coolidge.

According to records of the U.S. Geological Survey for 1950–70, the average annual flow of the Arkansas River was 166,570 acre-feet near Coolidge (Colorado-Kansas State line) and 172,500 acre-feet at Syracuse. Comparison of streamflow, return flow, and diversions indicates that the Arkansas River has an average annual net gain of 8,140 acre-feet from near Coolidge to Syracuse.

Monthly streamflow records for the Arkansas River near Coolidge and at Syracuse indicate that water moves from the river into the alluvium during periods of high flow and moves from the alluvium to the river during periods of low flow. The records show a seasonal trend, which suggests that increased evapotranspiration and a decline in water levels during the irrigation season result in a loss of streamflow. The gain in streamflow during the winter months probably results from reduced evapotranspiration, rising water levels due to discontinuation of withdrawals by wells, and a return of applied irrigation water.

The Arkansas River is the only perennial stream in the county. Numerous tributary streams may flow for several hours or several days after heavy rainfall. Short reaches of several spring-fed streams northwest of Syracuse contain water most of the time, but the small amount of water seeps rapidly into the sandy streambed.

GROUND WATER IN UNCONSOLIDATED AQUIFERS

Ground water in the unconsolidated Tertiary and Quaternary deposits in Hamilton County occurs in three general areas: (1) The upland area in the northern part of the county; (2) the valley of the Arkansas River; and (3) the area south of the Bear Creek fault. Outside of these areas, little water is available owing to the lack of saturated Tertiary and Quaternary sediments. However, water for domestic and stock use can be obtained from the alluvial deposits in the channels of some of the ephemeral streams. The yield of water to wells in each of the three areas differs significantly, as shown on the hydrologic map, because of differences in lithology and thickness of saturated material.

The differences in aquifer characteristics are given in the tables of average hydraulic properties and a summary of aquifer tests. The average hydraulic properties are estimated on the basis of the lithology and saturated thickness of the aquifer.

In the northern part of the county, ground water occurs mostly in the stratified fine- to medium-grained deposits of the Ogallala Formation. Water enters the aquifer by underflow from the northwest and from local precipitation. Ground water moves generally eastward where it enters Kearny County as underflow. However, part of the water moves southward to the Arkansas River valley through deep, partly buried tributary valleys. Water-level contours are not shown in the northern part of Hamilton County because the saturated material is thin and discontinuous. The saturated thickness ranges from a few feet to about 50 feet, but is less than 10 feet in most of the area. Considerable exploration may be needed to find a water supply for household and stock use except near the east edge of the county where the aquifer will generally supply 10 to 100 gpm (gallons per minute). Wells in a few channels containing coarse sediments may yield as much as 500 gpm.

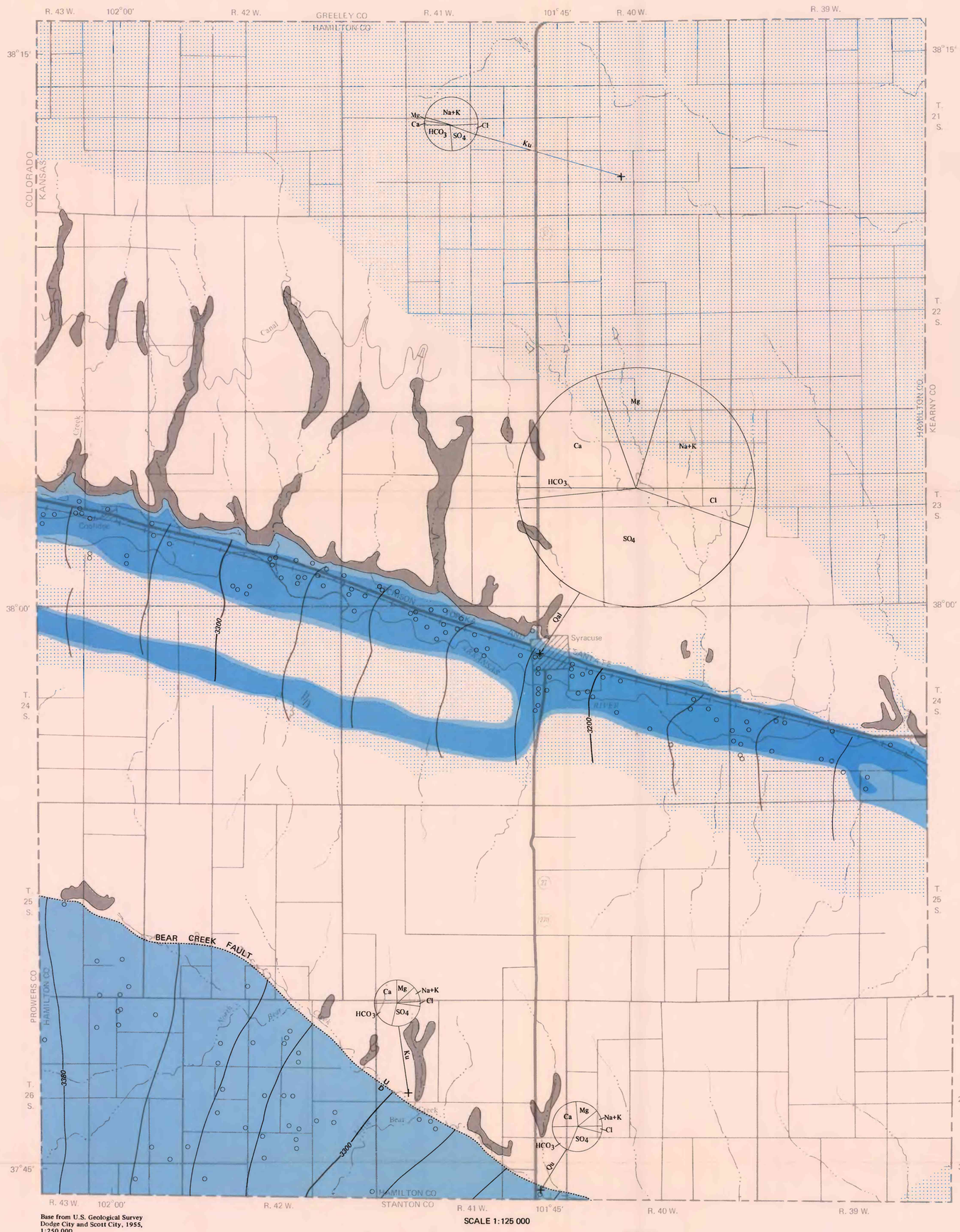
In the valley of the Arkansas River, ground water occurs in the coarse-grained Pleistocene deposits and fine-grained Holocene deposits. Water enters the aquifer by underflow from the west and by infiltration of local precipitation, of water from the river when ground-water levels are low and of water applied to the land for irrigation. A small amount of water also enters the valley by underflow from the upland area to the north. Ground-water movement is generally eastward, as indicated by the water-level contours. Water leaves the aquifer by underflow into Kearny County, by discharge to the river, by evapotranspiration in areas where the water table is shallow, and by pumping from wells. The depth to water ranges from less than 10 to about 25 feet, and the saturated thickness ranges from a few feet to about 80 feet. Owing to the high permeability of the coarse-grained deposits, wells in this area commonly yield more than 1,000 gpm. In areas of lower permeability, shallow wells commonly yield 300 to 500 gpm. In the Arkansas River valley, 99 large-capacity wells (capable of yielding more than 300 gpm) obtained water from the alluvium in January 1970, and the city of Syracuse had two municipal wells in the sandhill area. Many more wells probably could be utilized without serious depletion of the valley aquifer. However, a significant increase in the number of irrigation wells is unlikely because of poor quality of the ground water and the limited amount of irrigable land.

In the area south of Bear Creek fault, ground water occurs principally in the stratified fine- to medium-grained undifferentiated Pleistocene deposits. Water enters the aquifer by underflow from the west and by infiltration of precipitation and storm runoff in the tributaries of Bear Creek. Ground-water movement is southeastward, as indicated by the water-level contours.

Water is discharged from the aquifer by underflow into Stanton County, by pumping from wells, and probably by movement into the sandstones in the Lower Cretaceous rocks. The depth to water ranges from about 20 feet in the Little Bear Creek valley to about 150 feet in the southwest corner of the county. The saturated thickness ranges from about 100 to 200 feet. The yield of water from wells generally ranges from 500 to 1,000 gpm owing to the lithologic character of the stratified deposits and to the differences in permeability and thickness of the water-yielding zones. Where yields are less than 500 gpm and pumping lifts exceed 100 feet in this area, irrigation by wells generally is considered infeasible. In the area south of the Bear Creek fault, 46 large-capacity wells obtained water from the unconsolidated aquifer in January 1970. Additional irrigation wells could be utilized in this area; however, increased pumpage would be accompanied by greater water-level declines (1 foot per year from 1960 to 1970) and a resulting decrease in individual well yields.

The 147 large-capacity wells in Hamilton County in 1970 are an increase of nearly 450 percent over the 33 wells on record in 1945. Many of the new wells in the valley were drilled to supplement or replace unreliable surface-water supplies.

The general relationships of the water-yielding and non-water-yielding formations are shown on the block diagram.



HYDROLOGIC MAP SHOWING WATER-LEVEL CONTOURS, POTENTIAL WELL YIELD, LOCATION OF LARGE-CAPACITY WELLS (JANUARY 1970), AND SELECTED CHEMICAL ANALYSES OF WATER FROM WELLS

Average hydraulic properties

Aquifer	Area	Hydraulic conductivity[1] (ft per day)	Transmissivity[2] (ft² per day)	Storage coefficient[3]
Unconsolidated aquifers	Arkansas River valley	800	20,000	0.1
	South of Bear Creek fault	30	4,000	.0001
Bedrock aquifers	North of Arkansas River	.1	50	.0001
	South of Arkansas River	.5	250	.0001

[1]Cubic feet of water per day passing through a 1-foot-square section of aquifer at a gradient of 1 foot per foot.
[2]Cubic feet of water per day transmitted through a section of the aquifer 1 foot wide and the full saturated thickness of the aquifer at a gradient of 1 foot per foot.
[3]Volume of water an aquifer releases from or takes into storage per square foot of area per foot of change in head.

Summary of aquifer tests

Well location	Stratigraphic unit	Depth to water (feet)	Saturated thickness (feet)	Pumping rate (gpm)	Transmissivity (ft² per day)	Storage coefficient
NW¼SW¼SW¼ sec. 35, T. 24 S., R. 39 W.	Undifferentiated Pleistocene deposits.	24	42	1,425	22,000	0.14
Center of SE¼ sec. 17, T. 24 S., R. 40 W.	Holocene and upper Pleistocene deposits.	10	30	1,400	36,000	.09
SE¼SW¼ sec. 22, T. 26 S., R. 42 W.	Undifferentiated Pleistocene deposits.	90	155	940	*7,500	*.0002

*Valid only for drawdown less than 30 feet.

EXPLANATION

Bedrock outcrop

U
D
Concealed fault
U, upthrown side; D, downthrown side

Potential yields of wells in the unconsolidated aquifers in gallons per minute

0-10

10-500

500-1000

More than 1000

Large-capacity well
Shows municipal or irrigation wells yielding more than 300 gallons per minute

3200
Water-level contours
Shows altitude of water level, 1970. Contour interval 20 feet. Datum is mean sea level

Water analyses represented by circular diagram subdivided on basis of percentage of total milliequivalents per liter

+ *Shows location of sampling site. Geologic source shown on connecting line: Qal, alluvium; Qu, undifferentiated Pleistocene deposits; Ku, undifferentiated Lower Cretaceous rocks*

0 2000 4000
SCALE OF RADII
(DISSOLVED SOLID IN MILLIGRAMS PER LITER)

GROUND WATER IN BEDROCK AQUIFERS

The loosely cemented sandstone beds in the Upper Jurassic and Lower Cretaceous rocks commonly yield small to moderate quantities of water to wells. The potential maximum yield from the sandstones is not known because of the meager amount of test data, but they yield at least 10 gpm to domestic and stock wells throughout the county. Estimated aquifer characteristics for the sandstone aquifers in the northern and southern parts of Hamilton County are given in the table of average hydraulic properties. In the southwestern part of the county, some wells are drilled into the sandstones for the purpose of augmenting the yield of water from the overlying unconsolidated aquifer. On the basis of data from these wells, as much as 400 gpm might be obtained at a few locations from wells in the sandstone. The minimum depth of wells obtaining water from these formations is indicated by the map showing depth to the top of Lower Cretaceous rocks. Shale and limestone of Late Cretaceous age yield water to wells only where the materials have been fractured or are highly weathered.

WATER QUALITY

Although ground water in sufficient quantities for domestic use is available throughout the county, the concentration of some chemical constituents may exceed the limits recommended by the U.S. Public Health Service (1962) for drinking water. Concentrations of dissolved solids in excess of 500 mg/l (milligrams per liter) are undesirable, especially when a high sulfate content causes the water to have a laxative effect. Examination of 62 chemical analyses of water from Hamilton County shows that the dissolved-solids content of ground water in most of the county ranges from 500 to 800 mg/l. Concentrations of dissolved solids in water from the alluvium beneath the river flood plain commonly exceed 1,000 mg/l, and concentrations in water beneath the adjacent sandhill area may be as low as 200 mg/l. Water from the bedrock aquifers and from the unconsolidated aquifers, where the saturated materials are thin, commonly contains high concentrations of total iron (more than 0.3 mg/l) and fluoride (more than 1.5 mg/l). A high concentration of iron imparts a bad taste to the water and tends to stain laundry and plumbing fixtures. High concentrations of fluoride cause mottling of tooth enamel during the formation of permanent teeth.

Where sufficient ground water is available from the unconsolidated aquifers, the water generally is very hard and the quality for irrigation ranges from poor to fair. Water in the southwestern part of the county has a low-sodium hazard and a medium-salinity hazard. Water beneath the Arkansas River flood plain has a medium-sodium hazard and a very high salinity hazard.

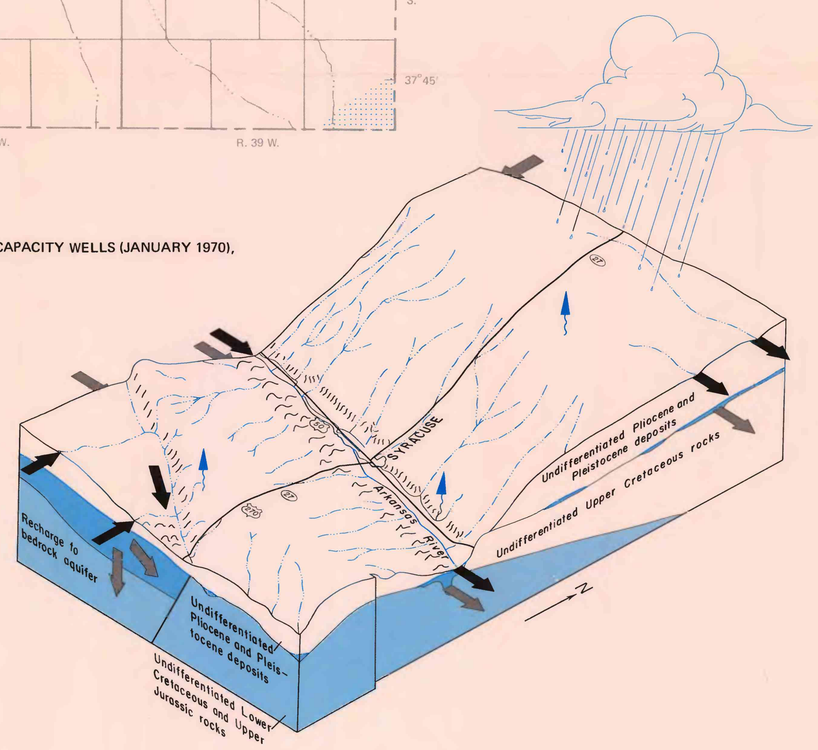
Water in the sandstone aquifers near the outcrop or source of recharge is very hard and similar in quality to water in the unconsolidated aquifers. The water becomes softer at greater depths and distances north of the recharge areas, probably as a result of the exchange of calcium and magnesium ions for sodium ions. However, the high sodium concentration causes the water to be of poor quality for irrigation.

Surface water available from the Arkansas River is generally of poor quality for irrigation. The sodium hazard ranges from low to medium and the salinity hazard ranges from high to very high. Water of this quality can be used successfully for irrigation on well-drained coarse-textured soils. Its use requires that an excess of water be applied to prevent salt buildup in the soil.

SELECTED HYDROLOGIC REFERENCES

Hem, J.D., 1970, Study and interpretation of the chemical characteristics of natural water: U.S. Geol. Survey Water-Supply Paper 1473, 2d ed., 363 p.
U.S. Geological Survey, 1970, Water resources data for Kansas, pt. 1, Surface water records, 1969: Lawrence, Kans., Water Resources Div., 216 p.
U.S. Public Health Service, 1962, Drinking water standards: U.S. Public Health Service Pub. 956, 61 p.
U.S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: U.S. Dept. Agriculture Handb. 60, 160 p.
Walton, W.C., 1962, Selected analytical methods for well and aquifer evaluation: Illinois State Water Survey Bull. 49, 81 p.

Additional information on drillers' logs and well production is available in the office of the U.S. Geological Survey, Garden City, Kans., and may be examined there.



BLOCK DIAGRAM SHOWING GENERAL HYDROLOGIC FEATURES

Interior—Geological Survey, Reston, Va.—1974

WATER RESOURCES OF HAMILTON COUNTY, SOUTHWESTERN KANSAS

By
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1974