INTRODUCTION

PURPOSE AND SCOPE

The purpose of this report is to describe the physical environment, availability, distribution, characteristics, movement, quality, water problems, and use of water within the Rock-Fox River basin in order to aid in planning future water management within the basin.

This report presents general information on the basin that was derived from data obtained from Federal, State, and local agencies. In addition, new data were collected from areas where available data were scarce. The reader is referred to the section entitled "Agencies Having Additional Information" and to the list of selected references (sheet 4) for sources of more detailed information.

This atlas is one of a series of 12 river-basin studies designed to describe in general terms the water resources of the State. More detailed studies of problem areas will be required in the future as the need for additional information increases.

LOCATION AND EXTENT

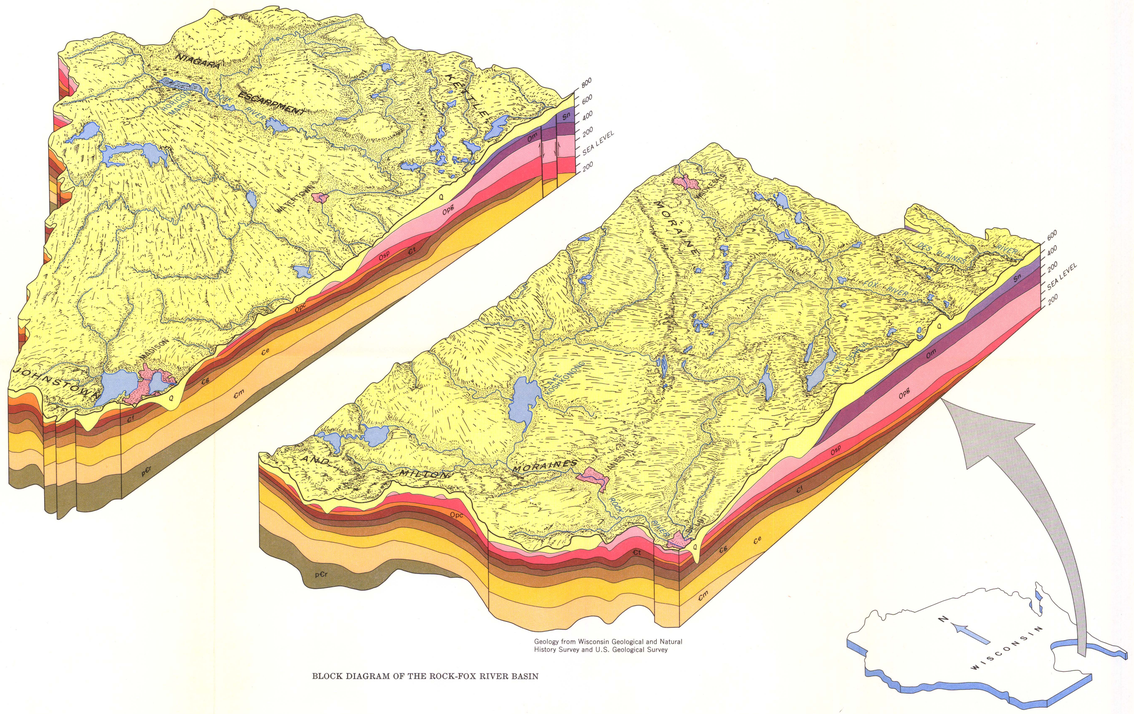
The Rock-Fox River basin in Wisconsin, covers about 4,750 square miles in the southeastern part of the State. It includes all or parts of the following 13 counties: Columbia, Dane, Dodge, Fond du Lac, Green Lake, Jefferson, Kenosha, Milwaukee, Racine, Rock, Walworth, Washington, and Waukesha. It includes the area drained by the Rock, Fox, and Des Plaines Rivers within the State of Wisconsin.

Although the basin boundary is the topographic divide, part of the streamflow is derived from ground water that drains from an area similar to, but not having the same boundaries as, the topographic basin. The ground-water basin covers about 4,350 square miles, 400 square miles less than the topographic basin. Most of the reduction in basin area is along the eastern side of the basin.

ACKNOWLEDGMENTS

Much data was supplied by State agencies. University Extension—The University of Wisconsin Geological and Natural History Survey furnished well logs at the State and soils maps. Chemical analyses and water-use data were obtained from the Wisconsin Department of Natural Resources and from the Public Service Commission of Wisconsin. Municipal officials, county agricultural agents, and U. S. Soil Conservation Service personnel also supplied valuable information.

PHYSICAL SETTING



Geology from Wisconsin Geological and Natural History Survey and U.S. Geological Survey

BLOCK DIAGRAM OF THE ROCK-FOX RIVER BASIN

Viewed as a raised segment of the earth's crust, the Rock-Fox River basin has a rolling landscape shaped by the underlying bedrock surface and by glacial deposits of varying thickness. Hills and valleys on the bedrock surface have several hundred feet of relief. Dolomitic bedrock is exposed in many areas, the Niagara Escarpment being a prominent topographic feature in the northeast.

Continental glaciers, which moved across the basin from the northeast, transported large quantities of rock material in the ice. This unconsolidated material, dumped on the land surface by the melting glaciers, forms the present-day surface that contains glacial landforms such as kettles, moraines, and drumlins. A large group of drumlins (elongate hills that indicate the direction of ice movement) fan out from the northern end of the basin to the south and southwest. Most of the lakes in the basin lie within or behind the end moraines shown on the block diagram and the map of glacial geology.

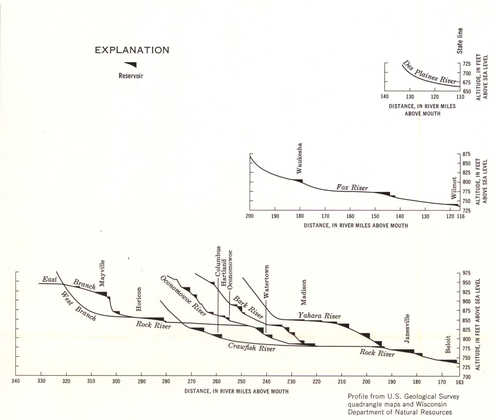
EXPLANATION

Q	Glacial deposits	QUATERNARY
Sn	Niagara Dolomite	SILURIAN
Om	Maquoketa Shale	ORDOVICIAN
Opg	Platteville Formation, Decorah Formation, and Galena Dolomite	ORDOVICIAN
Osp	St. Peter Sandstone	ORDOVICIAN
Opc	Prairie du Chien Group	ORDOVICIAN
Ct	Trempealeau Formation	CAMBRIAN
Cf	Franconia Sandstone	CAMBRIAN
Cg	Galesville Sandstone	CAMBRIAN
Ce	Eau Claire Sandstone	CAMBRIAN
Cm	Mount Simon Sandstone	CAMBRIAN
pCr	Crystalline rock	PRECAMBRIAN

Contact

Fault
Showing relative direction of movement

TOPOGRAPHY AND DRAINAGE



Profile from U.S. Geological Survey quadrangle maps and Wisconsin Department of Natural Resources

STREAM PROFILES

The Rock-Fox basin has a rolling topography and rather low relief—ranging from 664 feet above sea level on the Des Plaines River at the State line to 1,822 feet on a hilltop 5 miles southeast of Hartford. The topography is the result of bedrock and glacial deposits and of streams that cut into those formations to form the present river drainage system. The topography is also modified by man's use of the land and water resources.

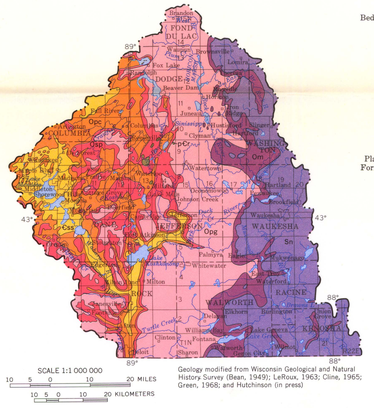
The rivers have relatively low gradients except in their headwaters. The gradient of the Rock River between Horicon and the State line averages only about 1 foot per mile; the Fox River has a similar gradient. In the Yahara River the stream gradient between Madison and Stoughton is less than 1 foot per mile across a chain of lakes developed behind an end moraine. An exception to streams having steep gradients in their headwaters is the East Branch of the Rock River where the stream is underlain by shale. The steep slopes of the Rock and Bark Rivers between an altitude of about 780 and 830 feet are probably a reflection of the slope of the underlying bedrock valley, which has cut into the easily eroded St. Peter and Cambrian sandstones in this reach after crossing the more resistant dolomite of the Platteville-Galena unit.

LAND USE

The Rock-Fox River basin area is about 97 percent land and 3 percent water. About 66 percent is in agriculture, 10 percent urban or built up, 8 percent in private, State, and Federal forests, and 13 percent "other land," which includes various county-owned lands and ungrazed marshlands.

(Personal communication, U.S. Dept. of Agriculture, Soil Conservation Service.)

GEOLOGY AND SOILS



Geology modified from Wisconsin Geological and Natural History Survey (Bean, 1949); LeRoux, 1963; Cline, 1965; Green, 1968; and Hutchinson (in press)

EXPLANATION

Bedrock geology and approximate thickness, in feet

Sn	Niagara Dolomite 0-450	SILURIAN
Om	Maquoketa Shale 0-225	ORDOVICIAN
Opg	Platteville Formation, Decorah Formation, and Galena Dolomite *(Mostly dolomite)* 0-400	ORDOVICIAN
Osp	St. Peter Sandstone 0-350	ORDOVICIAN
Opc	Prairie du Chien Group *(Mostly dolomite)* 0-200	ORDOVICIAN
Css	Sandstone *Undifferentiated; includes Mount Simon, Eau Claire, Galesville, Franconia, and Trempealeau Formations* 0-3000?	CAMBRIAN
pCr	Metamorphic rock *Mostly quartzite. Thickness very great, probably thousands of feet*	PRECAMBRIAN

Geologic contact

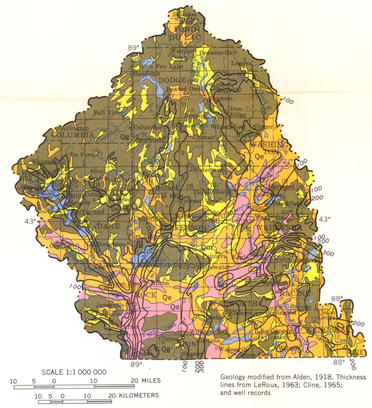
Surface-water divide

Bedrock, which furnishes most of the ground water for the basin, is shown on this map as it would appear if the glacial drift were stripped away. Precambrian rocks, the oldest rocks in the basin, are overlain by layered sedimentary rocks of marine origin, mostly sandstone and dolomite (a magnesium limestone).

The pattern of formations was created by erosion, which exposed older rocks, and by a regional dip of the formations to the east and southeast. This regional dip results in increasingly older rocks forming the bedrock surface from east to west (see also block diagram above).

The rock units are not uniform in thickness or composition throughout the basin. Rock thickness varies, especially in the Cambrian sandstones, which range from a few hundred feet in the northern part of the basin to an estimated 3,000 feet in the southeastern part of the basin. Rock composition is also variable within formations; for example, the Trempealeau Formation, mostly sandstone in the northwest, is largely dolomite in the southeastern part of the basin.

BEDROCK GEOLOGY



Geology modified from Alden, 1918. Thickness lines from LeRoux, 1963; Cline, 1965; and well records

EXPLANATION

Qm	Marsh *(Peat and muck)*	
Qg	Ground moraine *(Till; consists of clay, silt sand, gravel, and boulders)*	
Qe	End moraine *(Till, sand, and gravel)*	
Qo	Outwash *(Sand and gravel)*	

Contact

Line of equal thickness of glacial drift *Interval 100 feet*

Surface-water divide

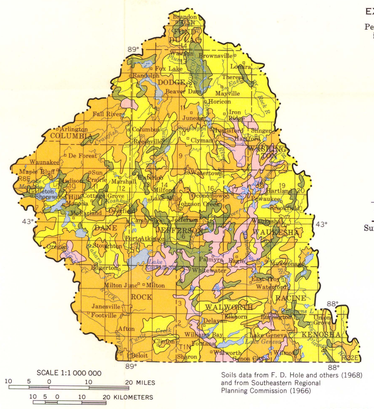
Glacial drift, which stores water for release to wells and streams, overlies the bedrock throughout the basin except for small rock exposures on hilltops, hillsides, streambanks, and roadcuts. The character of drift determines the recharge, storage, and discharge of ground water. The type of drift controls the type of soil developed on its surface, the shape of its surface controls the drainage pattern.

Glacial deposits are composed of sediments deposited in water at the ice margins, or beneath the ice. Water-laid material is sorted as to size by the water, but ice-laid till is an unsorted mixture of clay, silt, sand, gravel, and boulders. Although not shown on the map, most of the area is covered by a few feet of loess, a windblown silt.

Ground moraine was deposited beneath advancing glacial ice. End moraines, thick unsorted deposits, were formed at maximum advance and where the ice front paused in its retreat. Beyond the ice front, melt water from the glacier commonly deposited outwash composed of sorted sand and gravel.

The drift has a maximum thickness of nearly 500 feet near Mukwonago. Generally, however, it is thin in the northern and western parts of the basin and thick in the southeastern part. The drift is thickest where it fills valleys in the bedrock surface and beneath prominent end moraines.

GLACIAL GEOLOGY



Soils data from F. D. Hole and others (1968) and from Southeastern Regional Planning Commission (1966)

EXPLANATION

Permeability rate in inches per hour

	0.05-0.2
	0.2-0.8
	0.8-2.5
	2.5-5.0

Area boundary

Surface-water divide

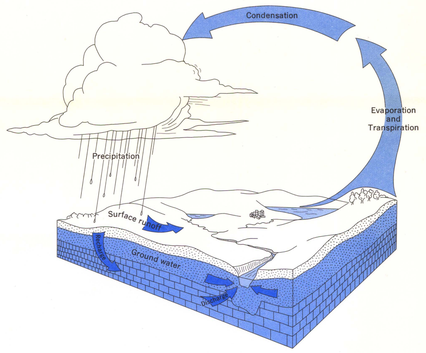
Soils are important to the hydrology of an area because they affect runoff and infiltration of precipitation. Part of this infiltration becomes ground-water recharge. Low soil permeability contributes to rapid surface runoff and low infiltration; high soil permeability allows rapid infiltration of precipitation and decreases surface runoff.

Permeability of soils, a major soil characteristic, is related to the underlying glacial deposits and bedrock. In general: soils with a permeability of "0.05-0.2" inch per hour are either peat or muck soils, or are soils developed on lake clay or clayey till; the "0.2-0.8" and "0.8-2.5" soils are mostly silt loams developed on loess or sandy, silty drift, with the "0.8-2.5" soils having sandier parent material; and "2.5-5.0" soils are loams developed on outwash or sandy drift.

The soil-permeability map is based on the least permeable soil horizon as determined in laboratory analyses.

SOIL PERMEABILITY

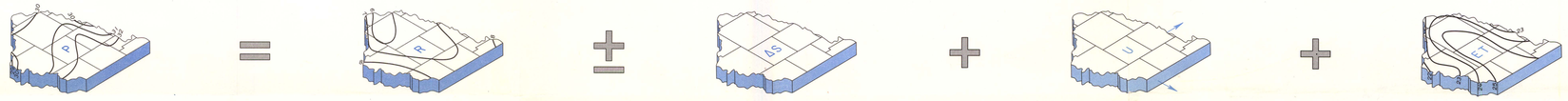
WATER CYCLE



Precipitation, the source of all water in the basin, falls on the land surface, streams, and lakes and commences the cycle of circulation called the water cycle. Some of the water runs rapidly off the land surface to nearby streams and lakes (surface runoff); some water evaporates immediately from the surface soil and plants (evaporation); some water enters the soil and is transpired by plants (transpiration); and some water seeps down through the soil, eventually recharging the ground-water reservoir (recharge) and contributing base flow to streams and lakes (discharge). Ground water also discharges through pumping wells.

The cycle may not be complete within an area as small as a river basin; usually large parts of the earth are involved. Within the Rock-Fox River basin most precipitation results from storms from the west and southwest, and moisture returned to the atmosphere leaves the basin on winds from the same direction.

WATER BUDGET



PRECIPITATION—31.4 INCHES

RUNOFF—6.6 INCHES

CHANGE IN STORAGE—0

UNDERFLOW—0.1 INCH

EVAPOTRANSPIRATION—24.7 INCHES

The average annual precipitation is 31.4 inches, based on U.S. Weather Bureau records for the period 1931-60. Precipitation is greatest in the southern part of the basin (more than 32 inches) and least in the northern and northeastern parts (less than 30 inches).

Average annual runoff leaving the basin is 6.6 inches. This figure was computed from gaging-station records on the Rock, Fox, and Des Plaines Rivers for the period 1931-60. Runoff is least in the northern part of the basin (less than 6 inches), primarily because precipitation is low (less than 31 inches). It is greatest in the western and southeastern parts of the basin (more than 8 inches) because of higher precipitation (more than 32 inches).

The amount of water stored in lakes and reservoirs, in the soil zone, or in the ground-water reservoir may increase or decrease over a given year. However, the net change is negligible (assumed equal to zero) when averaged over the 30-year period of this budget.

The total amount of water in storage in the Rock-Fox basin is more than 1,000 inches, of which less than 5 inches are in lakes and streams; the remainder is stored underground.

Underflow is that water entering or leaving the basin through the ground-water reservoir. No significant underflow enters the basin. About 6 mgd leaves the basin to the south, largely within the glacial outwash of the Rock River valley; and about 10 mgd leaves the basin to the east, within the sandstone aquifer. At this rate, about 0.1 inch of underflow leaves the basin each year.

Evapotranspiration is the return of water to the atmosphere by a combination of evaporation from open water, foliage surfaces, and the land surface, and transpiration from plants. Average annual evapotranspiration is estimated to be 24.7 inches, which is the difference between precipitation and the sum of runoff, changes in storage, and underflow. Evapotranspiration is greatest in the central part of the basin, where precipitation is highest and where wetlands and shallow water tables are common; it is least in the hilly western and eastern parts of the basin.

The water budget of the Rock-Fox River basin is a quantitative statement of the balance between the total water gains and losses of the basin for a period of time. The average annual water budget for a 30-year period (1931-60) shows that of the 31.4 inches of precipitation entering the system, only 6.6 inches is available for man's use. This 6.6 inches includes ground water discharged to streams as well as overland flow, and it is equivalent to about 2,300 cfs (cubic feet per second) or 1,500 mgd (million gallons per day). This amount could be increased by salvaging some of the water now being returned to the atmosphere or by obtaining water from outside the basin.

The quantities of these budget items fluctuate from year to year. Underflow remains fairly constant, changes in storage and evapotranspiration fluctuate somewhat, but proportionately, precipitation and runoff show the greatest changes.

In 1964, a dry year, basin precipitation was only about 25 inches, runoff was about 2.4 inches, and the amount of water in storage continued to decline from 1963 when precipitation was only about 24 inches.

Base from U.S. Geological Survey
1:500,000, 1968

WATER RESOURCES OF WISCONSIN—ROCK-FOX RIVER BASIN

By
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