INTRODUCTION

LOCATION AND EXTENT OF STUDY AREA

The central Wisconsin River basin is the middle part of the entire Wisconsin River basin. The basin is about 5,050 square miles in area, and extends about 110 miles south from Merrill to Wisconsin Dells. The basin includes all or parts of the following counties: Adams, Clark, Columbia, Jackson, Juneau, Langlade, Lincoln, Marathon, Marquette, Monroe, Portage, Sauk, Taylor, Waushara, and Wood.

PURPOSE AND SCOPE

This study provides a background of hydrologic knowledge suitable for use by water-resource planners and managers, and it provides a framework for more detailed water-resource studies in the future. Specifically, the purposes of this report are to:

(1) Describe the geologic and hydrologic environments of the central Wisconsin River basin.

(2) Describe the water resources of the central Wisconsin River basin including their sources, uses, quality, interrelationships, availability, and behavior within the basin environment.

Much of the information in this report has been generalized to allow presentation in the atlas format. Liberal use was made of available data from many sources and interpretations from published reports. Additional material was collected and analyzed to allow a balanced presentation on water resources and the physical environment.

This study is part of an investigation of the water resources of the major river basins in Wisconsin. The completed basin studies and those being studied are shown on the cover envelope.

The information in this report should be adequate for the broad aspects of planning water-resource development and management. However, individual problems and water needs will require more specific information than is given in this report.

ACKNOWLEDGMENTS

Appreciation is extended to many people—well owners, well drillers, water superintendents, consulting engineers, county agents, irrigation farmers, and local officials—who aided this study by furnishing well logs, data on water levels and pumpage, and other pertinent information. Special acknowledgments are made to the Wisconsin Department of Natural Resources for supplying well records and to the Wisconsin State Laboratory of Hygiene for chemical analyses of water samples from some of the wells.

TOPOGRAPHY AND DRAINAGE

TOPOGRAPHY AND DRAINAGE

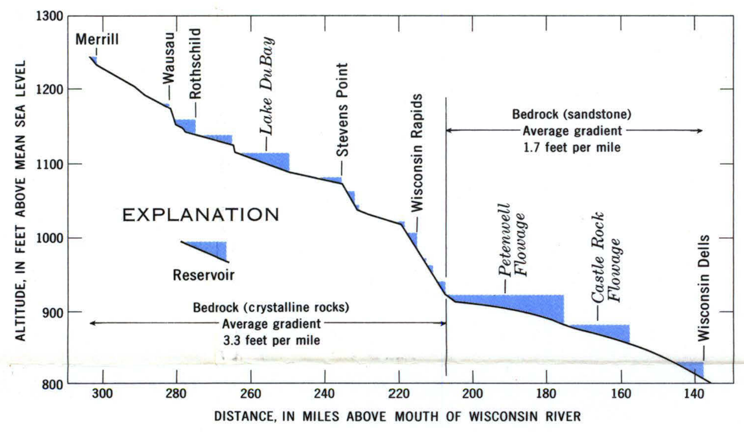
The central part of the Wisconsin River drains areas of contrasting geology and hydrology; the northern part of the study area has thin, poorly permeable till overlying crystalline rock, and the southern and eastern parts have thick and extensive deposits of outwash sand, gravel, and clay. Thick permeable beds of sandstone underlie the southern part.

In the northern part of the basin the topography is a gently rolling till plain slightly modified by stream erosion. This area has many crystalline rock outcrops that project through the glacial deposits. Major streams have branching drainage patterns, and there are fewer wetland areas or natural lakes than in the outwash plains to the south and northeast.

The southern part of the basin is a gently sloping plain consisting of outwash and glacial lake deposits underlain by outwash. It has extensive areas of wetlands, which result from a flat topography, a high water table, and impermeable layers of silt or clay within the lake deposits. Many small buttes or mounds of bedrock project as much as 300 feet above the plain.

Most of the surface drainage is toward the Wisconsin River. However, along the eastern and northeastern borders of the basin some of the surface drainage is into marshes or small lakes that lack surface outlets.

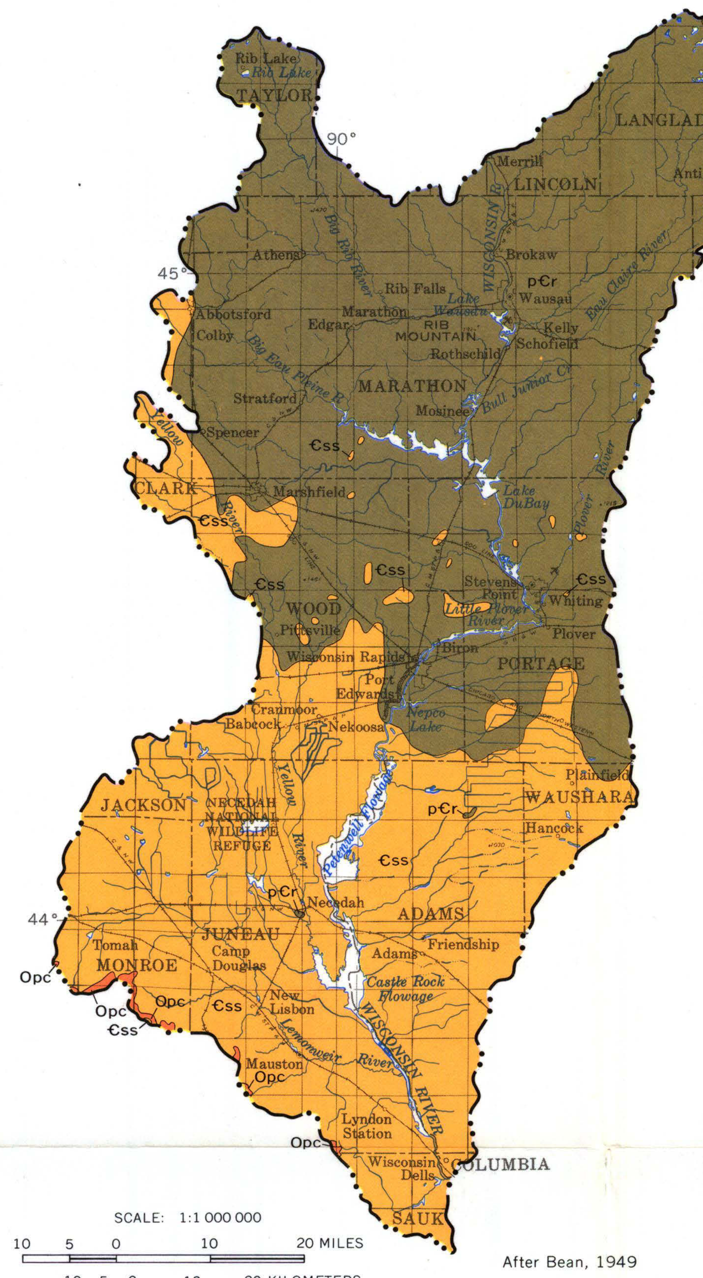
The total relief in the basin is 1,100 feet—from 1,940 feet at the top of Rib Mountain near Wausau to 840 feet at Wisconsin Dells.



PROFILE OF THE CENTRAL WISCONSIN RIVER

The relatively steady flow of the Wisconsin River is not a natural characteristic but results from numerous manmade control structures (reservoirs), as the above river profile shows. These reservoirs generally enable man to use more of the water more of the time, and they also reduce the possibility of flooding. With storage reservoirs, water that might have passed through the basin in only a few days can be stored for longer periods and is available for industry, hydroelectric generation, irrigation, recreation, and channel flushing. The profile shows the marked change in stream gradient near Wisconsin Rapids where the bedrock changes from crystalline rock to more easily eroded sandstone.

GEOLOGY



EXPLANATION

QUATERNARY

Quo — Unpitted outwash
Includes alluvium. Stratified sand and gravel with some clay and silt

Qpo — Pitted outwash
Well-sorted sand and gravel to unsorted sandy till. Permeable

Ql — Glacial-lake deposits
Mostly fine to coarse sand; may include clay layers. Partly underlain by and mixed with outwash deposits. Moderately permeable

Qe — End-moraine deposits
Sandy to clayey till. Moderately permeable

Qg — Ground-moraine deposits
Silty and clayey till, commonly thin. Relatively impermeable

ORDOVICIAN

Opc — Prairie du Chien Group
Predominantly dolomite rock; contains some sandy and shaly layers. Moderately permeable

CAMBRIAN

€ss — Sandstone
Fine to coarse-grained fractured sandstone. Carbonate and iron oxide cement. Permeable

PRECAMBRIAN

p€r — Crystalline rock
Igneous and metamorphic rocks; hard, dense; upper surface may be fractured or weathered. Impermeable

Contact

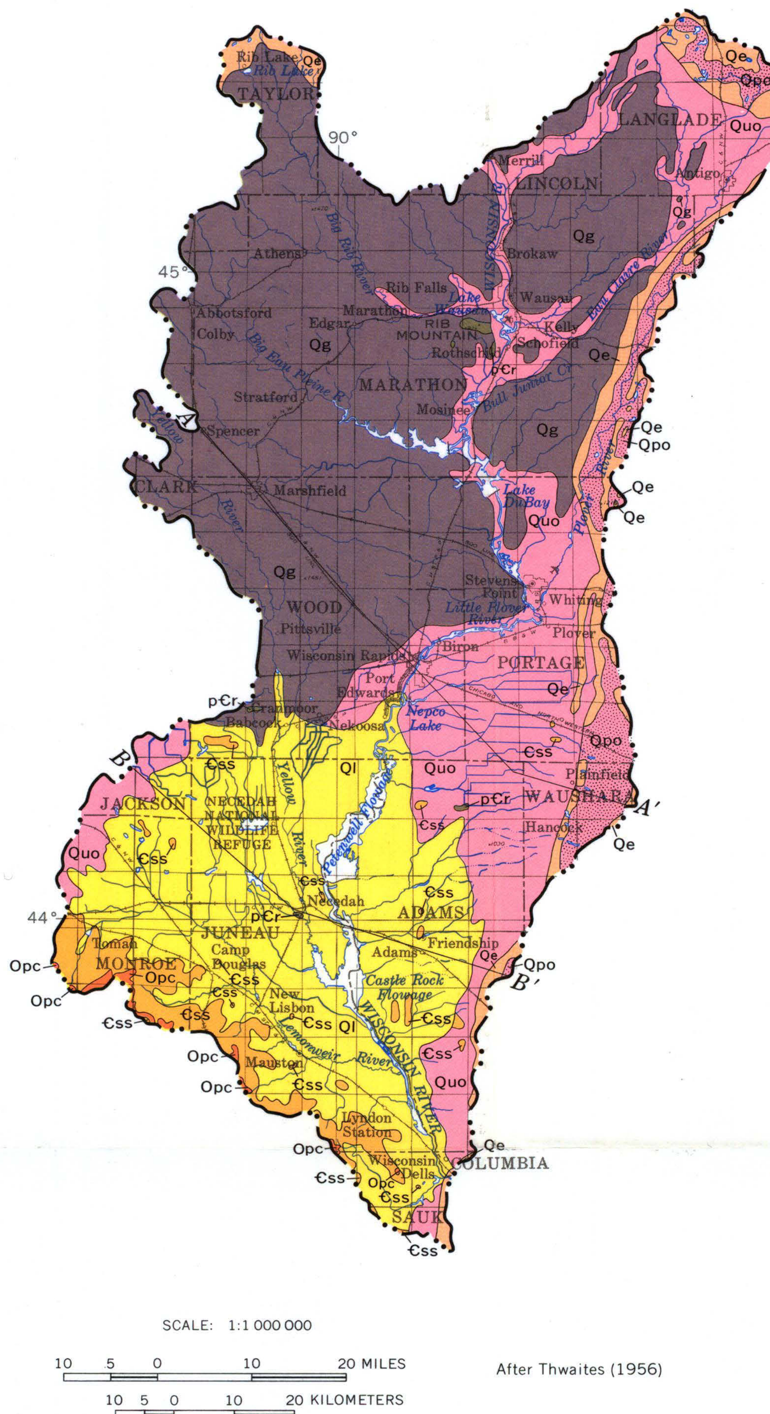
Basin boundary

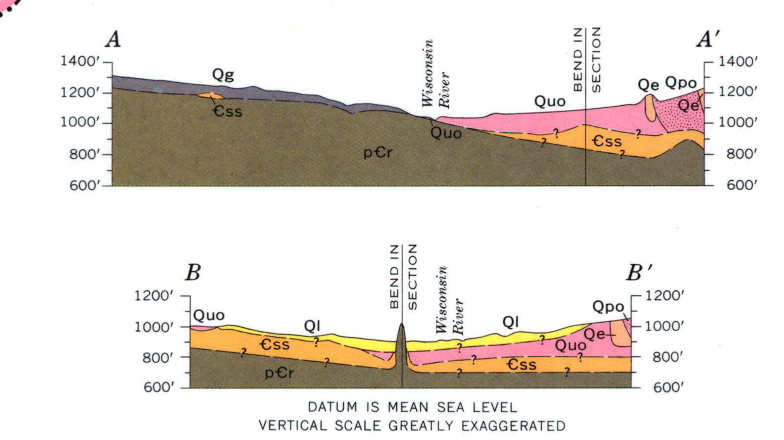
BEDROCK GEOLOGY

Ordovician rocks: These rocks are largely dolomite with some interbedded sandy and shaly layers. They are present only along the extreme southern border of the basin, capping some of the hilltops.

Cambrian sandstones: Sandstones overlie the crystalline rocks in the area south of Wisconsin Rapids, in an area generally west of Marshfield, and in a few small, isolated, and scattered localities over the remainder of the basin. The known thickness of the sandstones ranges from near zero along their northern extent to 440 feet at Wisconsin Dells.

Precambrian crystalline rocks: Crystalline rocks underlie the entire central Wisconsin River basin. They are at the surface or are covered with thin drift in the northern half of the basin. At Rib Mountain, these nearly impermeable rocks rise 780 feet above Lake Wausau. Farther south they are covered by layers of sandstone, shale, dolomite, and glacial drift. Locally, such as at Necedah, the crystalline rocks protrude through both the sandstone and the glacial drift.





SURFACE GEOLOGY

Unconsolidated deposits of glacial origin cover almost the entire central Wisconsin River basin. These deposits consist of unpitted outwash, pitted outwash, lake deposits, end moraines, and ground moraines.

Outwash deposits: Thick deposits of stratified sand, gravel, and some silt and clay form extensive outwash plains. These plains are westward extensions of pitted outwash and underlie parts of the lake deposits (geologic section B–B′). Together, the lake and unpitted outwash deposits are referred to as the central sand plain. These deposits average about 100 feet in thickness, but they may be as thick as 250 feet over channels in bedrock.

Pitted outwash deposits: An elongated band of thick, pitted outwash occurs along the eastern border of the basin between glacial end moraines (geologic section A–A′). These deposits, including kame deposits, are composed of well sorted sand and gravel and poorly sorted sandy till. Their greatest known thickness is about 200 feet.

Lake deposits: Glacial-lake deposits of fine to coarse sand, silt, and clay make up the southwestern part of the sand plain. Along their eastern and northern borders they are partly covered by unpitted outwash. The lake clays, exposed in many stream cuts or penetrated by wells, are as thick as 25 feet in Adams County.

End-moraine deposits: Thick end-moraine deposits lie mainly in hummocky north-south ridges in the eastern part of the basin. End-moraine deposits include till and sorted sediments (kames) deposited near the glacial ice. Till deposits are composed mainly of sand; however, unsorted sediments range in size from clay to large boulders. End-moraine deposits are 200 to 400 feet thick.

Ground-moraine deposits: Ground moraine consists of clayey and stony till and contains fragments of nearby bedrock. The deposits cover most of the northern half of the basin. They generally are less than 50 feet thick, but they thicken where they overlie channels in the bedrock.

WATER BUDGET

AVERAGE LONG-TERM WATER BUDGET FOR THE CENTRAL WISCONSIN RIVER BASIN

	Inches per year	Cubic feet per second	Millions of gallons per day
Water gain:			
Precipitation	30.9	11,500	7,430
Water loss:			
Runoff	10.9	4,050	2,620
Evapotranspiration	19.7	7,340	4,740
Ground-water underflow	.3	110	70
Total	30.9	11,500	7,430

A generalized water budget of the central Wisconsin River basin accounts for the quantities of water in various environments within the hydrologic system, and it indicates in a general way the various relationships among the components of the system.

Precipitation is the principal source of water in the central Wisconsin River basin—another source is Wisconsin River inflow at Merrill, which is also from precipitation. The average yearly precipitation in the central basin was 30.9 inches for the years 1931–60, ranging from about 30 inches in the south to about 34 inches in the extreme northwest.

Runoff is that part of precipitation that appears in surface streams. It includes precipitation that passes underground and discharges later to streams, and precipitation that runs off overland. Average runoff in the central basin was 4,050 cfs (cubic feet per second) for the years 1935–60 (computed as the difference between the discharge of the Wisconsin River at Wisconsin Dells (6,700 cfs) and the discharge at Merrill (2,650 cfs)). The basin drains 5,050 square miles.

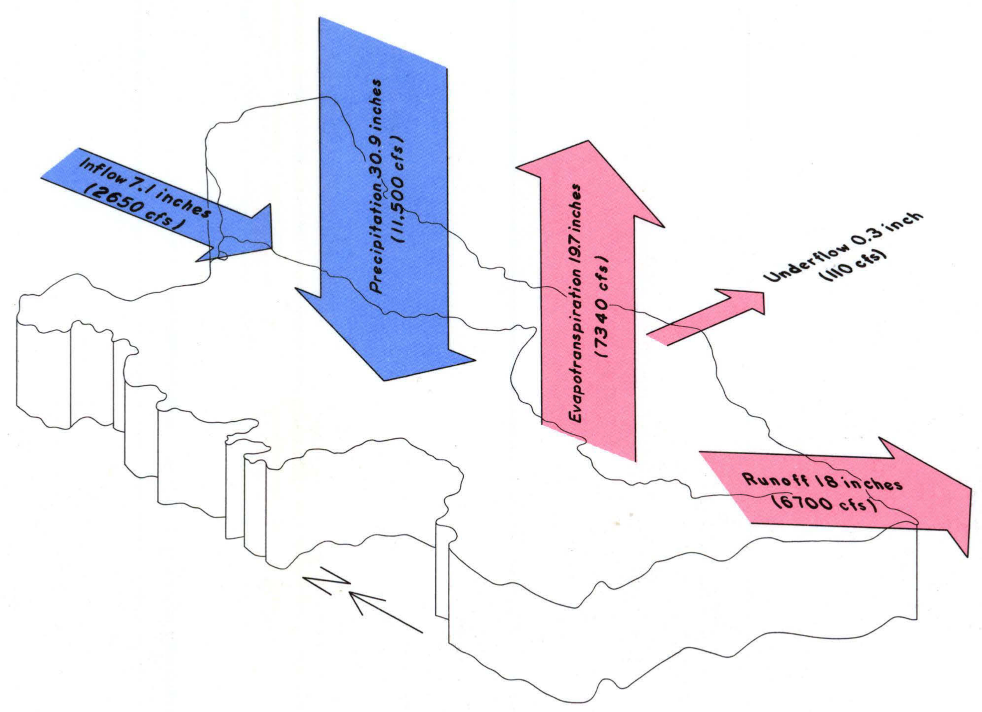
Gains or losses in storage balance over a long period so that the net change may be assumed to be zero. This includes water stored in lakes and surface reservoirs, in the ground-water reservoir, and in the soil zone.

Underflow is water that enters or leaves an area underground. The amount of underflow entering and leaving the basin is not balanced. About 110 cfs (0.3 inch per year) more underflow leaves the basin than enters it; most of this moves eastward out of the Wisconsin River basin through permeable sand and gravel in the east-central part of the basin into the adjacent Fox River basin. Underflow that enters the basin along the Wisconsin River at Merrill is assumed to be about equal to the amount that leaves the basin at Wisconsin Dells.

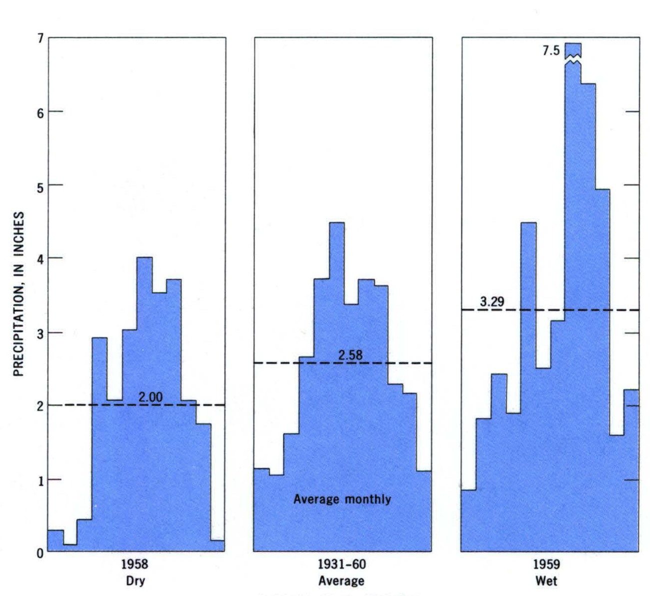
Evapotranspiration is the combined evaporation of water from land and water surfaces and the transpiration of water by plants. Most of this water loss occurs during the warm summer months. In this area the period of high evapotranspiration coincides with the period of high precipitation; of the two, the evapotranspiration rate is higher. Although evapotranspiration is considered to be a water loss, much of the lost water is used by beneficial plants.

The consumptive use of water is included in the evapotranspiration rate, although not all of it is evaporated or transpired. An example of this use is water incorporated into a product such as beer.

Average evapotranspiration is about 19.7 inches per year, which is the computed difference between precipitation, underflow, and runoff.



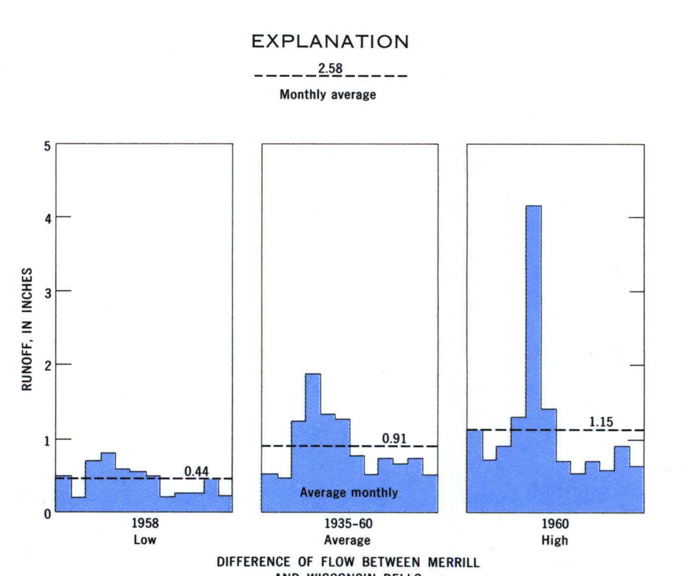
DIAGRAMMATIC WATER BUDGET



MONTHLY PRECIPITATION FOR THE CENTRAL WISCONSIN RIVER BASIN

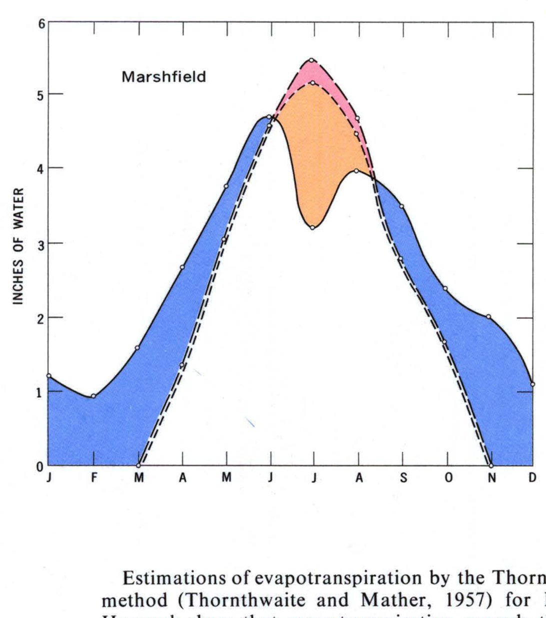
Precipitation from records of U.S. Weather Bureau

The average monthly precipitation ranges between about 1 inch in the cold months of December through February to about 4 inches during the growing season of May through September. Extremely dry or wet years depart from these averages, but all years have relatively dry winters and moist summers.



MONTHLY RUNOFF FOR THE CENTRAL WISCONSIN RIVER BASIN

Runoff, like precipitation, varies from year to year as well as from month to month. Years of greater-than-average runoff generally reflect years of increased precipitation, and years of low runoff reflect years of decreased precipitation. But, partly because of ground-water storage, soil moisture, and regulation of surface streams by man, monthly (and shorter) runoff variations may not wholly reflect monthly precipitation variations.



EXPLANATION

Precipitation

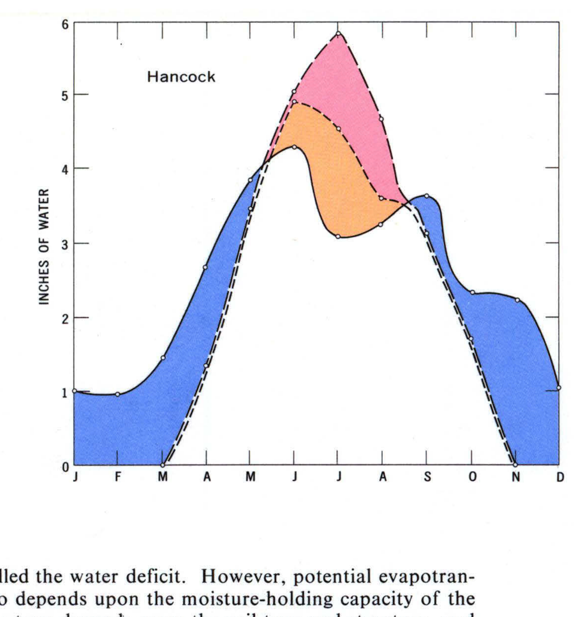
Potential evapotranspiration

Estimated evapotranspiration

Water potentially available for soil moisture, ground-water recharge, and runoff

Soil moisture utilization

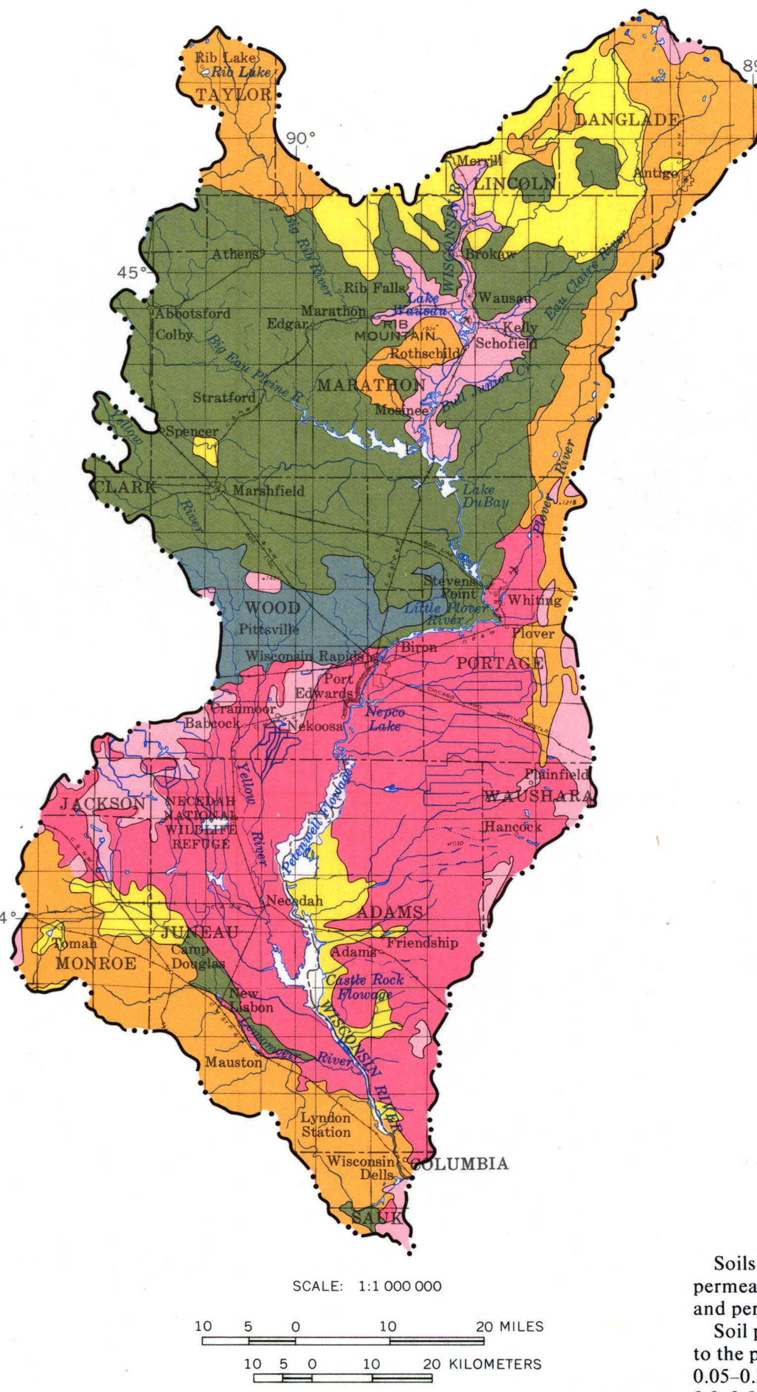
Water deficit



Estimations of evapotranspiration by the Thornthwaite-Mather method (Thornthwaite and Mather, 1957) for Marshfield and Hancock show that evapotranspiration exceeds the average precipitation during the summer months. The moisture from the soil is used along with precipitation to support plant growth, and the amount of moisture in the soil zone decreases during the summer until the growing season ends.

Potential evapotranspiration is the amount of water that could be evaporated from the soil and transpired from the plants if it were available. During the hot summer months the potential exceeds the estimated evapotranspiration. The difference between the two is called the water deficit. However, potential evapotranspiration also depends upon the moisture-holding capacity of the soil, which in turn depends upon the soil type and structure, and on the type of vegetation and depth of the root zone. The graph for Hancock was computed using values for moderately rooted crops grown in fine sand, using a soil-moisture retention of 3 inches. The graph for Marshfield was based on values for moderately rooted crops grown in silt and clay loams, using a soil-moisture retention of 8 inches. Because the potential evapotranspiration is nearly constant from year to year and estimated evapotranspiration varies with precipitation, the water deficit varies from year to year.

SOIL PERMEABILITY



From Engineering Test Data for Major Soils of Wisconsin, U.S. Dept. of Agriculture, Soil Conservation Service, 1964, and Hole and others, 1968

EXPLANATION

Approximate soil permeability rates, in inches per hour

Rate	Description
Less than 0.05	Generally silty or clayey; some stony soils
0.05–0.2	Generally silty or clayey; some stony soils
0.2–0.8	Generally silty and sandy loams. May contain some peat soils
0.8–2.5	Generally silty and sandy loams. May contain some peat soils
2.5–5	Generally loamy sands or sandy loams. Also includes some peat soil
5–10	Generally loamy sands or sandy loams. Also includes some peat soil

Area boundary

Basin boundary

SOILS

Soils partly control the amount of runoff and infiltration. More permeable soils allow greater amounts of precipitation to infiltrate and percolate to the ground-water reservoir.

Soil permeability, as shown on the map above, is closely related to the parent material of the soil. In general, soils with <0.05 and 0.05–0.2 rates are developed on lake clay or clayey till; 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 more sandy parent material; and 2.5–5.0 and 5.0–10 soils are loams developed on outwash or sandy lake deposits. Permeability values on the map are those of the least permeable soil zone.

The suitability of soils for irrigation, as related to physical characteristics of the soils, is shown on sheet four.

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

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WATER RESOURCES OF WISCONSIN—CENTRAL WISCONSIN RIVER BASIN

By

R. W. Devaul and J. H. Green

1971

For sale by U.S. Geological Survey, price $1.75 per set