INTRODUCTION

This report describes the physical environment, availability, distribution, movement, quality, and use of water in the Trempealeau-Black River basin and will aid in planning water management. Detailed studies of individual areas may be necessary in the future as the need for specific information increases.

The Trempealeau-Black River basin includes all drainage to the Mississippi River between the Chippewa and Wisconsin River basins, an area of 4,950 square miles in west-central Wisconsin. From north to south the major streams are the Buffalo River, Waumandee Creek, the Trempealeau, Black, and La Crosse Rivers, Coon Creek, and the Bad Axe River. The project area comprises 8.8 percent of the State and consists of all or parts of 13 counties.

Many persons and organizations assisted the study by providing data. Among the contributors were University Extension—the University of Wisconsin Geological and Natural History Survey, the Wisconsin Department of Natural Resources, the Public Service Commission of Wisconsin, and the Wisconsin Department of Transportation. Municipal water officials furnished water-supply information and well records. Many individuals and companies allowed access to their wells for water-level measurements and collection of water samples for chemical analysis.

PHYSICAL SETTING

EXPLANATION

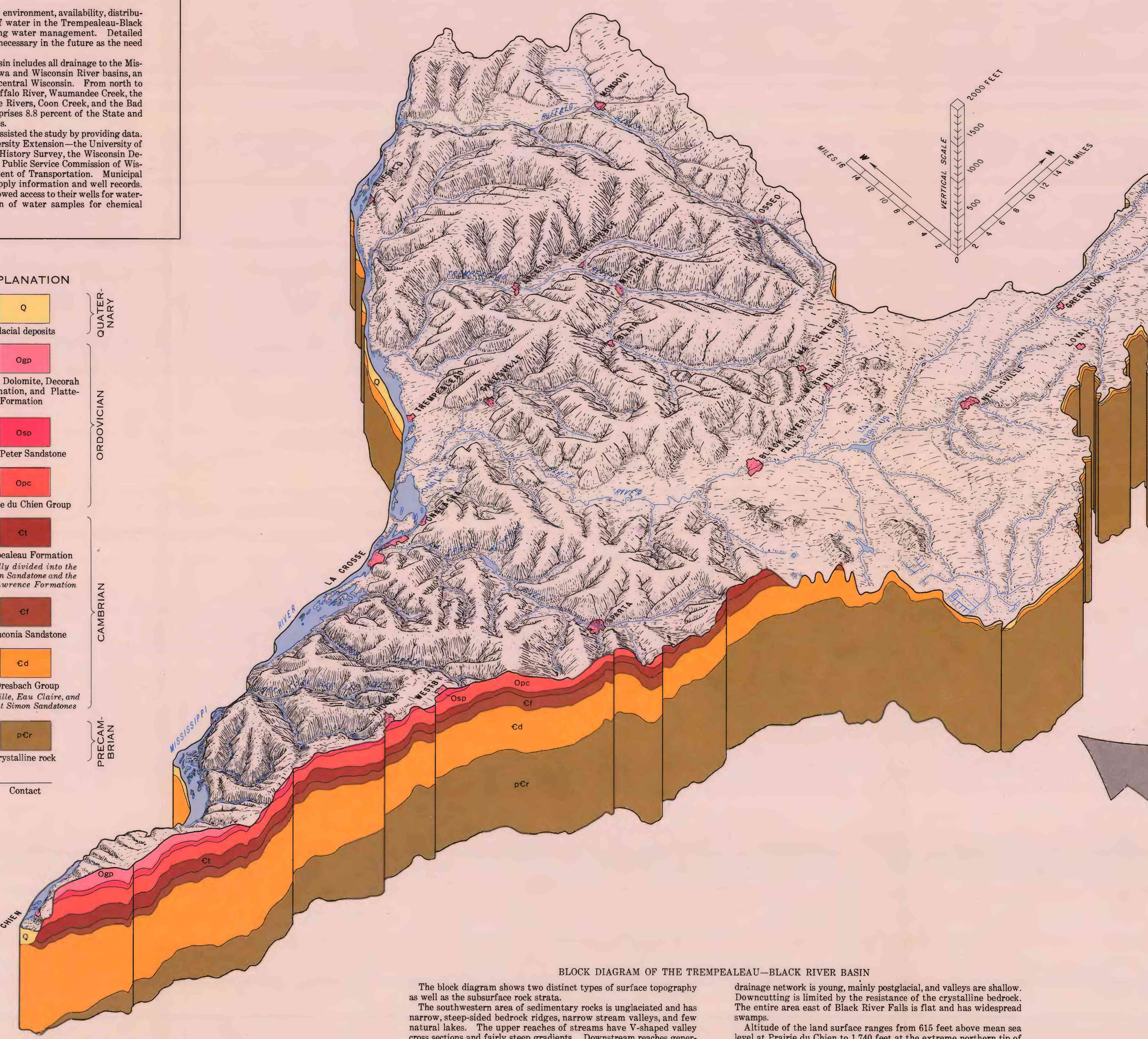
QUATERNARY
- Q — Glacial deposits

ORDOVICIAN
- Ogp — Galena Dolomite, Decorah Formation, and Platteville Formation
- Osp — St. Peter Sandstone
- Opc — Prairie du Chien Group

CAMBRIAN
- Ct — Trempealeau Formation. *Generally divided into the Jordan Sandstone and the St. Lawrence Formation*
- Cf — Franconia Sandstone
- Cd — Dresbach Group. *Galesville, Eau Claire, and Mount Simon Sandstones*

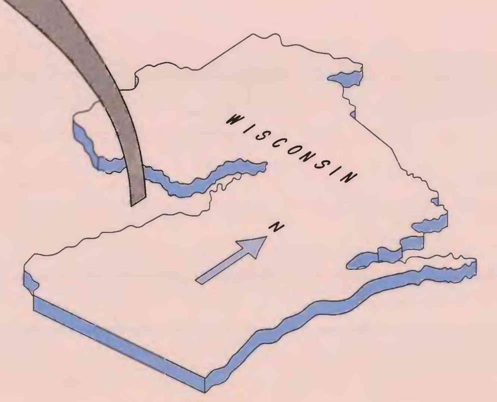
PRECAMBRIAN
- p€r — Crystalline rock

Contact



Geology compiled from Thwaites (1957 a and b), Bean (1949), Bell and Sherrill (1973), Wisconsin Geological and Natural History Survey well logs, and well drillers' logs.

Base from U.S. Geological Survey 1:250 000



BLOCK DIAGRAM OF THE TREMPEALEAU—BLACK RIVER BASIN

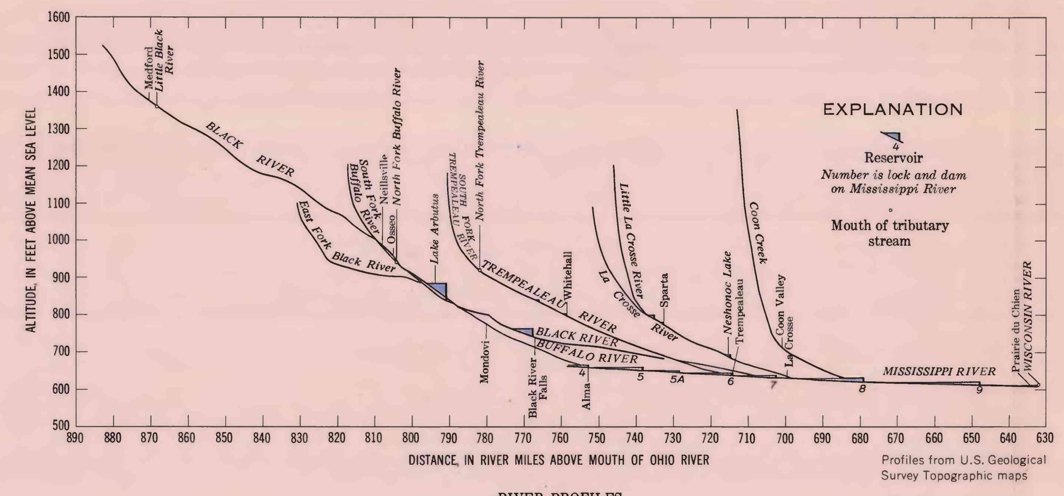
The block diagram shows two distinct types of surface topography as well as the subsurface rock strata.

The southwestern area of sedimentary rocks is unglaciated and has narrow, steep-sided bedrock ridges, narrow stream valleys, and few natural lakes. The upper reaches of streams have V-shaped valley cross sections and fairly steep gradients. Downstream reaches generally have a thick alluvial fill in which the present stream channel is incised. The lower valley of the Black River was a major glacial drainageway across the "Driftless Area" to the Mississippi River and contains thick deposits of unpitted outwash.

The glaciated area in the northeast has flat to rolling terrain formed by thin ground moraine on sandstone or crystalline bedrock. The drainage network is young, mainly postglacial, and valleys are shallow. Downcutting is limited by the resistance of the crystalline bedrock. The entire area east of Black River Falls is flat and has widespread swamps.

Altitude of the land surface ranges from 615 feet above mean sea level at Prairie du Chien to 1,740 feet at the extreme northern tip of the basin. The eastern basin divide from Prairie du Chien to the vicinity of Sparta, a distance of 80 miles, has an altitude generally greater than 1,200 feet.

The sedimentary rocks that underlie the basin dip gently and thicken to the southwest, conforming to the surface of the underlying crystalline bedrock.



RIVER PROFILES

Profiles from U.S. Geological Survey Topographic maps

Most streams in the basin are characterized by moderate slopes of about 4-5 feet per mile in their lower reaches, but by very steep slopes of 15-30 feet per mile in their headwaters. Their lower courses are aggraded and are in equilibrium with the very flat gradient of the Mississippi River. The steep slopes in the headwaters result from continuing headward erosion of the sedimentary rocks.

The Black River is an exception to these general conditions; above Black River Falls its general slope of 6 feet per mile is controlled by the crystalline bedrock surface. From Black River Falls to its mouth the river channel meanders over a thick valley fill and has a slope of about 2 feet per mile.

The Mississippi River, the southwestern basin boundary, flows in a broad valley, meandering between bluffs several hundred feet high. Its water surface is a series of pools behind low dams which were built in the 1930's to provide a navigation channel of 9-foot depth. The average gradient is less than 0.5 foot per mile.

GEOLOGY

Bedrock in the basin consists mainly of sedimentary rocks of Cambrian and Ordovician age. Sandstones are predominant, but the Prairie du Chien Group and Galena-Platteville unit are mostly carbonates (dolomite and limestone, respectively). The greatest thickness of Cambrian and Ordovician rocks, about 1,200 feet, occurs in the southern tip of the basin where the youngest bedrock formations cap high ridges. The Cambrian sandstones have a broad outcrop area because they are nearly flat lying and have been uncovered by erosion.

Igneous and metamorphic crystalline rocks of Precambrian age form the basement complex under the sedimentary rocks and are the bedrock surface in the northern part of the basin. These rocks are exposed in the northern part of the Black River valley to a point about 8 miles south of Black River Falls.

Glacial drift covers only about one-fourth of the basin and consists mainly of thin ground moraine in the northeast and unpitted outwash sand and gravel in the Black and Mississippi River valleys.

Stream valleys in the "Driftless Area" contain thick deposits of unconsolidated material, mainly very fine-grained sediment ranging from clay to medium sand. Much of this material is alluvium derived locally by erosion of the Cambrian sandstones and, although not mapped by Thwaites (1956), its approximate extent is shown by the thickness lines on the map. Glacial lake sediments occur in the lower courses of the valleys near the Mississippi River. Permeability of the alluvium and lake sediments usually is too low to sustain large well yields.

A thin blanket of windblown silt (loess) covers the basin, and windblown sand occurs locally. Silt thickness increases generally toward the Mississippi River, reaching a maximum thickness of 8-16 feet on the river bluffs (Hole, 1950). Over most of the basin it is from 0.5 to 4 feet thick. The loess is the parent material for topsoil in most soil profiles. Some areas in southern Jackson and northern Monroe Counties are subject to blowing sand, and dunes are active near Alma and La Crosse on the Mississippi River valley floor.

EXPLANATION

Bedrock geology and approximate thickness, in feet

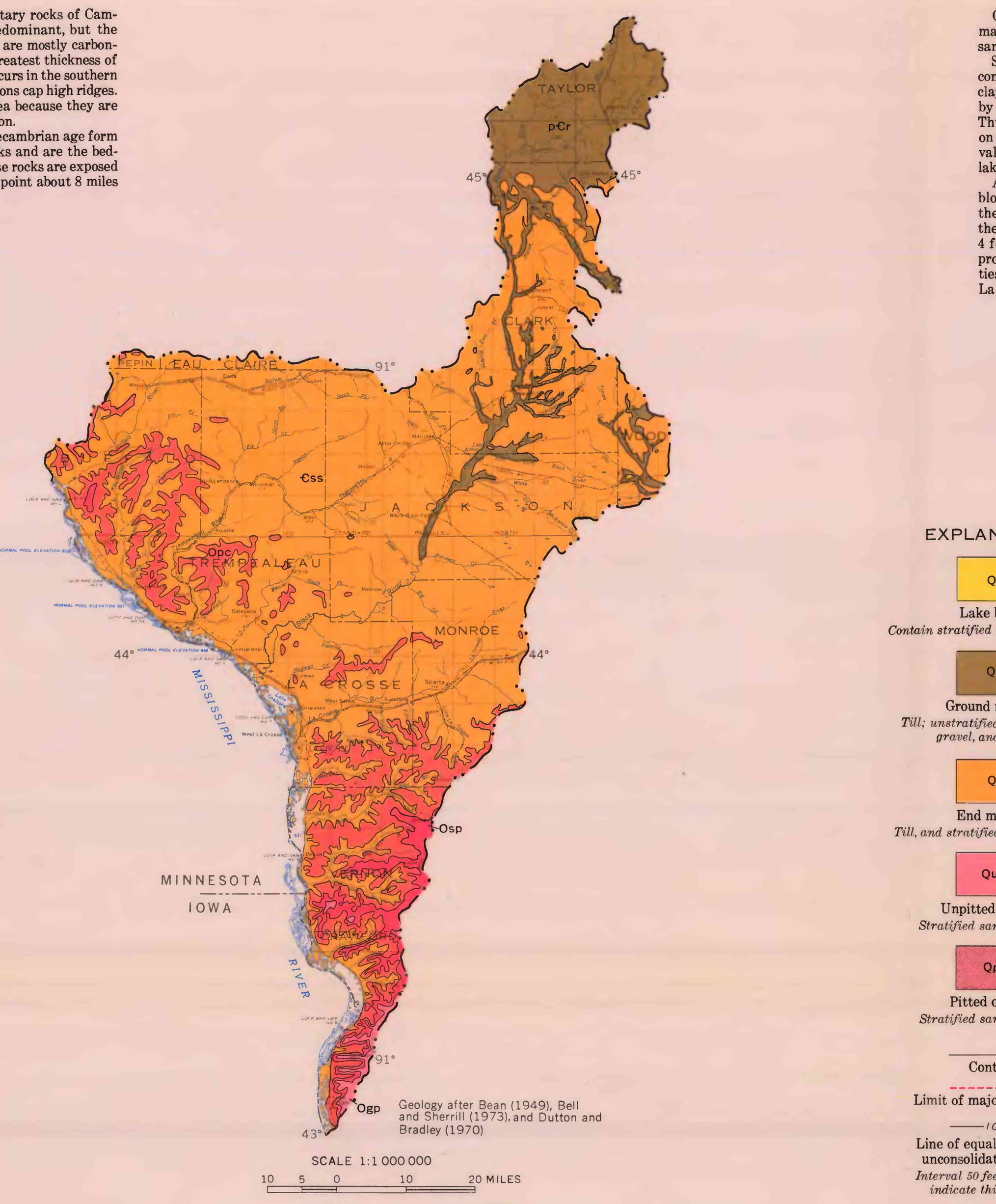
ORDOVICIAN
- Ogp — Galena Dolomite, Decorah Formation, and Platteville Formation. *Mostly limestone*. 0-200
- Osp — St. Peter Sandstone. 0-100
- Opc — Prairie du Chien Group. *Undifferentiated; includes Shakopee Dolomite, New Richmond Sandstone and Oneota Dolomite*. 0-200

CAMBRIAN
- €ss — Sandstone. *Undifferentiated; includes Jordan Sandstone, St. Lawrence Formation, and Franconia, Galesville, Eau Claire, and Mount Simon Sandstones*. 0-1000

PRECAMBRIAN
- p€r — Crystalline rock. *Undifferentiated igneous and metamorphic rocks. Thickness very great, many thousands of feet*

Contact

Surface-water divide



Geology after Bean (1949), Bell and Sherrill (1973), and Dutton and Bradley (1970)

SCALE 1:1 000 000

BEDROCK

EXPLANATION

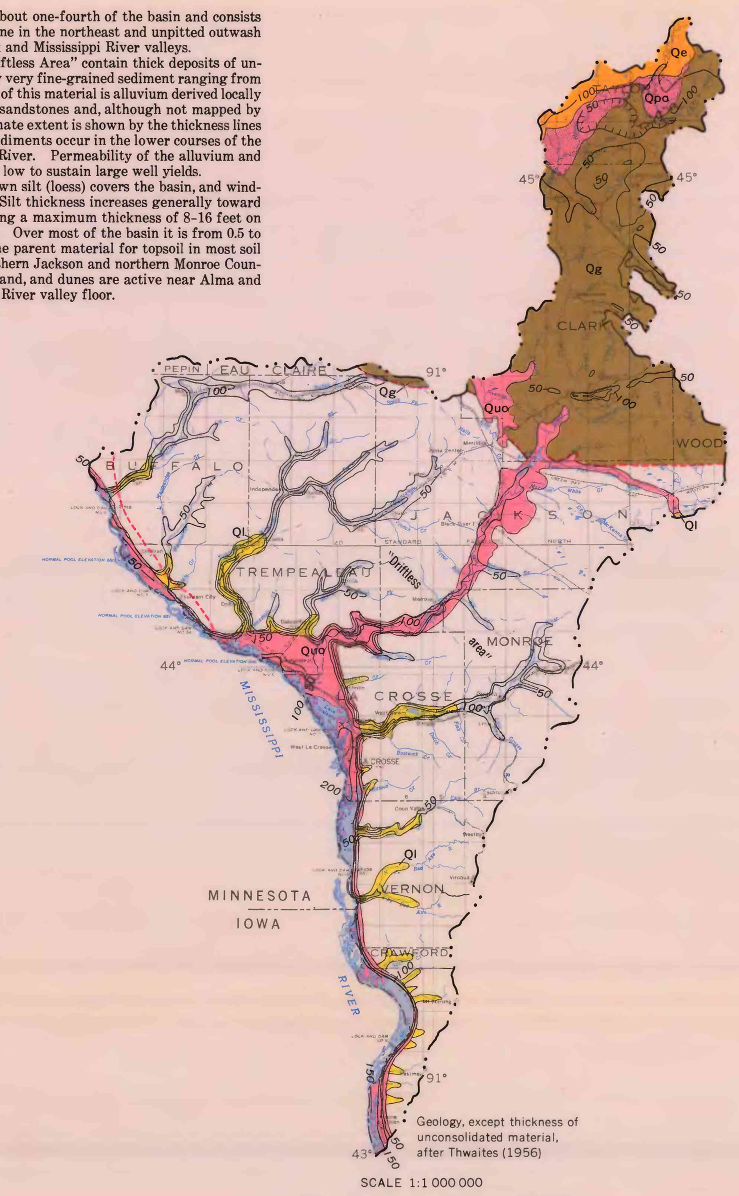
QUATERNARY
- Ql — Lake basins. *Contain stratified clay, silt, and sand*
- Qg — Ground moraine. *Till, unstratified clay, silt, sand, gravel, and boulders*
- Qe — End moraine. *Till, and stratified sand and gravel*
- Qun — Unpitted outwash. *Stratified sand and gravel*
- Qpo — Pitted outwash. *Stratified sand and gravel*

Contact

Limit of major ice advance

Line of equal thickness of unconsolidated material. *Interval 50 feet. Hachures indicate thinner areas*

Surface-water divide



Geology, except thickness of unconsolidated material, after Thwaites (1956)

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UNCONSOLIDATED DEPOSITS

SOIL PERMEABILITY

Soil permeability is the capacity of the soil to transmit water under certain standard conditions and, hence, is a factor in ground-water recharge. The soil permeability map shows areas of estimated permeability rates of the least permeable soil horizon. Map areas are generalized, and each includes several soil types and soil associations. Soil-moisture content, vegetative cover, land slope, depth to the water table, and frequency and duration of precipitation are additional factors that affect infiltration.

Soils with high permeability, greater than 2.5 inches per hour, cover 20 percent of the basin. These soils, which are loamy sands, sands, and sandy loams, are formed largely on outwash and alluvium in valleys.

Soils with permeability rates of 0.8-2.5 inches per hour cover 40 percent of the basin and consist mainly of silt loams. These soils are developed primarily on loess or sandstone.

Soils with permeability rates of 0.2-0.8 inch per hour cover 20 percent of the basin and are mainly silt loams developed on loess or alluvium.

The remaining 20 percent of the basin has silt loams and some peat and muck soils, all with permeabilities less than 0.2 inch per hour. The silt loams are developed on thin loess, which overlies glacial till, clay residuum, or sandstone.

EXPLANATION

Permeability rate, in inches per hour, under a 0.5-inch head

- Less than 0.05
- 0.05-0.2
- 0.2-0.8
- 0.8-2.5
- 2.5-5
- 5-10

Surface-water divide

Compiled from Hole and others (1968) and U.S. Soil Conservation Service (1964)

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WATER SYSTEM

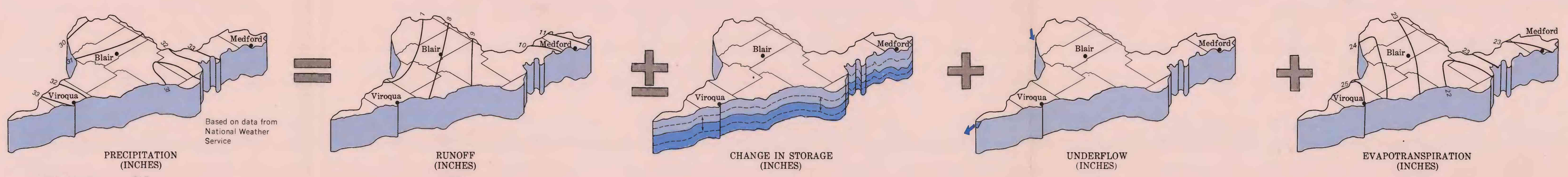
Precipitation is the source of all water in the basin. Some water runs rapidly off the land surface to nearby streams and lakes (surface runoff); some water evaporates (evaporation); some water reaches the ground-water reservoir (recharge), which supplies base flow to streams (ground-water runoff); and some water returns to the atmosphere through plants (transpiration). This circulation of water is called the hydrologic cycle.

HYDROLOGIC BUDGET

The hydrologic budget for the basin is a simplified equation of the components of the hydrologic cycle. Excluding Mississippi River flow along the basin boundary, water input (precipitation on the basin) equals the algebraic sum of water output and change in storage. Water output includes runoff, ground-water underflow, evapotranspiration (sum of evaporation and transpiration), and consumptive use by man. Small yearly changes in storage occur in ground and surface water and in soil moisture. Major fluctuations occur only in precipitation, runoff, and evapotranspiration.

Man's effect on these budget items is almost negligible in the Trempealeau-Black basin. A very small part of the ground and surface water withdrawn is consumed, and part of the water stored on the surface is evaporated.

Average conditions and budget quantities for 1931-60 are illustrated on the budget diagrams. Also shown are budgets for a dry year (1958) and for a wet year (1968).



	PRECIPITATION (INCHES)	RUNOFF (INCHES)	CHANGE IN STORAGE (INCHES)	UNDERFLOW (INCHES)	EVAPOTRANSPIRATION (INCHES)
DRY YEAR (1958)	24.7	4.5	Loss 2.3	0	22.5
AVERAGE (1931-60)	31.6	8.3	0.0	0	23.3
WET YEAR (1968)	41.4	9.6	Gain 2.2	0	29.6

Average annual precipitation on the basin is 31.6 inches and ranges from more than 33 inches in the northeast and south to less than 30 inches in the west. Annual precipitation on the basin was 6.9 inches below average in 1958 and 9.8 inches above average in 1968. Average annual snowfall, which is about 15-20 percent of the annual precipitation, ranges from less than 40 inches in the west to more than 50 inches in the northeast.

An average of about 3,020 cfs (cubic feet per second), 8.3 inches of water per year, runs off the basin to the Mississippi River. More than half of the runoff is from the Black River, and all but 400 cfs is from the four major streams: Black, Trempealeau, La Crosse, and Buffalo Rivers.

Average runoff ranges from less than 7 inches per year in the west to more than 11 inches in the north. In the dry year, runoff was 3.8 inches below average, but in the wet year, it was only 1.3 inches above average. The map of average annual runoff is based on streamflow records of about 30 U.S. Geological Survey gaging stations in and near the basin.

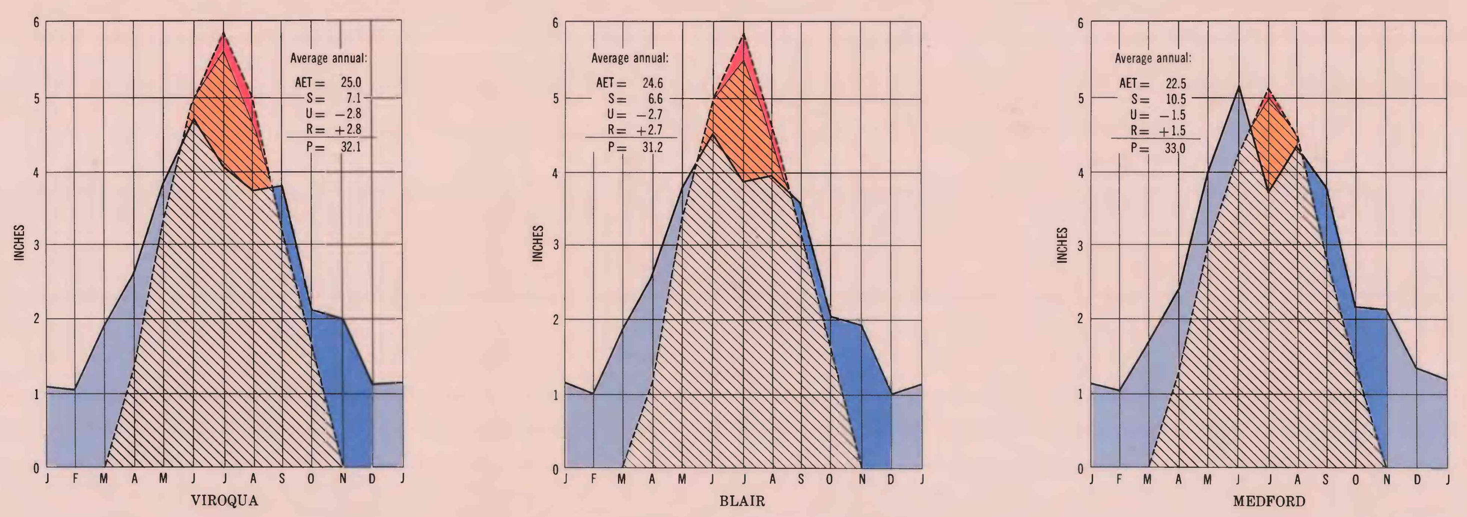
Water stored in the basin is primarily ground water and the long-term net change in quantity is negligible. Annual gains or losses of water, as shown by ground-water hydrographs, are nearly equal over a long-term period.

A study of water-level records for the wet and dry years shows that the water table generally responded to extremes in precipitation. The resulting net annual rise or fall of the water table in these years is estimated to be about 1.2 and 1.3 feet, respectively. Assuming a storage coefficient of 0.15, these changes in water level represent about 2.2 and 2.3 inches of water, respectively.

Subsurface underflow in and out of the basin is very small because the surface-water divide generally corresponds to the ground-water divide. Underflow in the valley fill of the Mississippi River is very small due to the extremely flat gradient of the water table along the river.

Evapotranspiration annually returns an average of 23.3 inches of water to the atmosphere. It is computed here as the difference between precipitation and the sum of runoff, changes in storage, and underflow. Evaporation from open-water surfaces is negligible in the basin because of the sparsity of lakes.

The pattern of evapotranspiration corresponds to the distribution of precipitation. Evapotranspiration is greatest in the south where air temperatures are highest. In the dry year evapotranspiration was only 0.8 inch below average, but in the wet year it was 6.3 inches above average.



AVERAGE WATER BALANCE, 1931-60

EXPLANATION

- Precipitation (P)
- Potential evapotranspiration
- Actual evapotranspiration (AET)
- Soil-moisture surplus (S)
- Soil-moisture utilization (U)
- Soil-moisture recharge (R)
- Soil-moisture deficit

Based on data from National Weather Service

An empirical method (Thornthwaite and Mather, 1957) for estimating average monthly values of "actual" and "potential" evapotranspiration has been used in the adjoining diagrams to illustrate the monthly water balance in the northern, central, and southern parts of the basin at Medford, Blair, and Viroqua, respectively.

The relation of soil moisture to evapotranspiration and precipitation varies throughout the year, as shown for these three points in the basin. Winter snow accumulation and spring rainfall maintain a soil-moisture surplus through spring. The monthly surplus decreases as evapotranspiration increases during the spring, until evapotranspiration exceeds precipitation in early summer; then soil moisture is withdrawn from storage. A moisture deficit exists when soil moisture in storage is depleted and potential evapotranspiration exceeds actual evapotranspiration. In the fall, as air temperature declines and transpiration by vegetation ceases, precipitation recharges soil moisture until the winter phase of surplus moisture resumes.

Soil-moisture deficit and utilization from storage are less in the northern part of the basin because the air temperature is lower and the growing season is shorter than in the central and southern parts.

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

WATER RESOURCES OF WISCONSIN—TREMPEALEAU-BLACK RIVER BASIN

By
H. L. Young and R. G. Borman

1973

For sale by the U.S. Geological Survey, price $1.25 per set