INTRODUCTION

The purpose of this report is to describe the physical environment, availability, characteristics, distribution, movement, and quality of water in the lower Wisconsin River basin. In addition, water use and water problems are summarized to aid in water management within the basin. Detailed water studies will be necessary as the need for specific information increases.

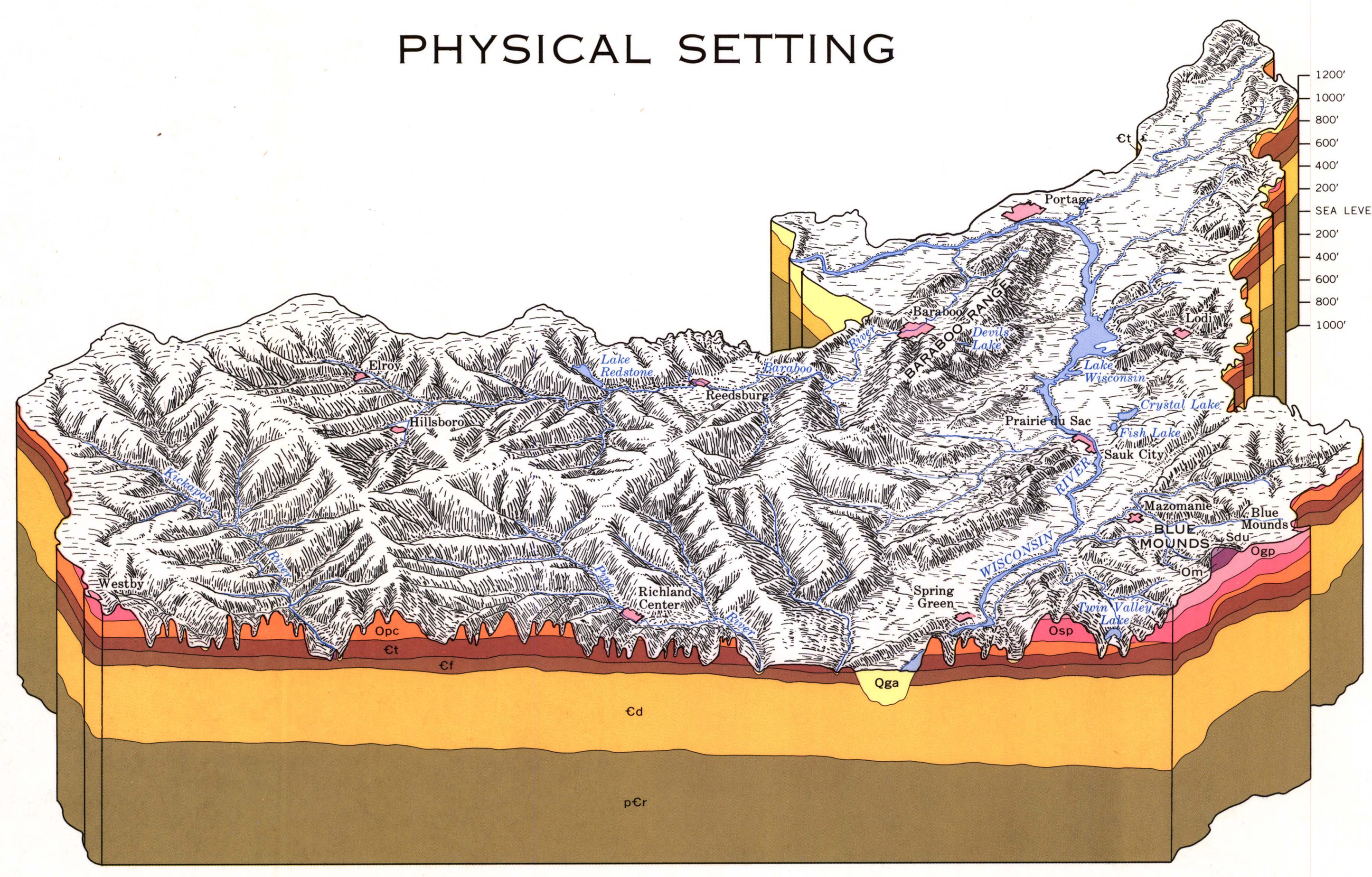
The lower Wisconsin River basin, as used in this report, includes all of the drainage area of the Wisconsin River downstream from the U.S. Geological Survey gaging station near Wisconsin Dells. It has an area of approximately 3,780 square miles, 6.7 percent of the State, and consists of all or parts of 11 counties in southwestern Wisconsin.

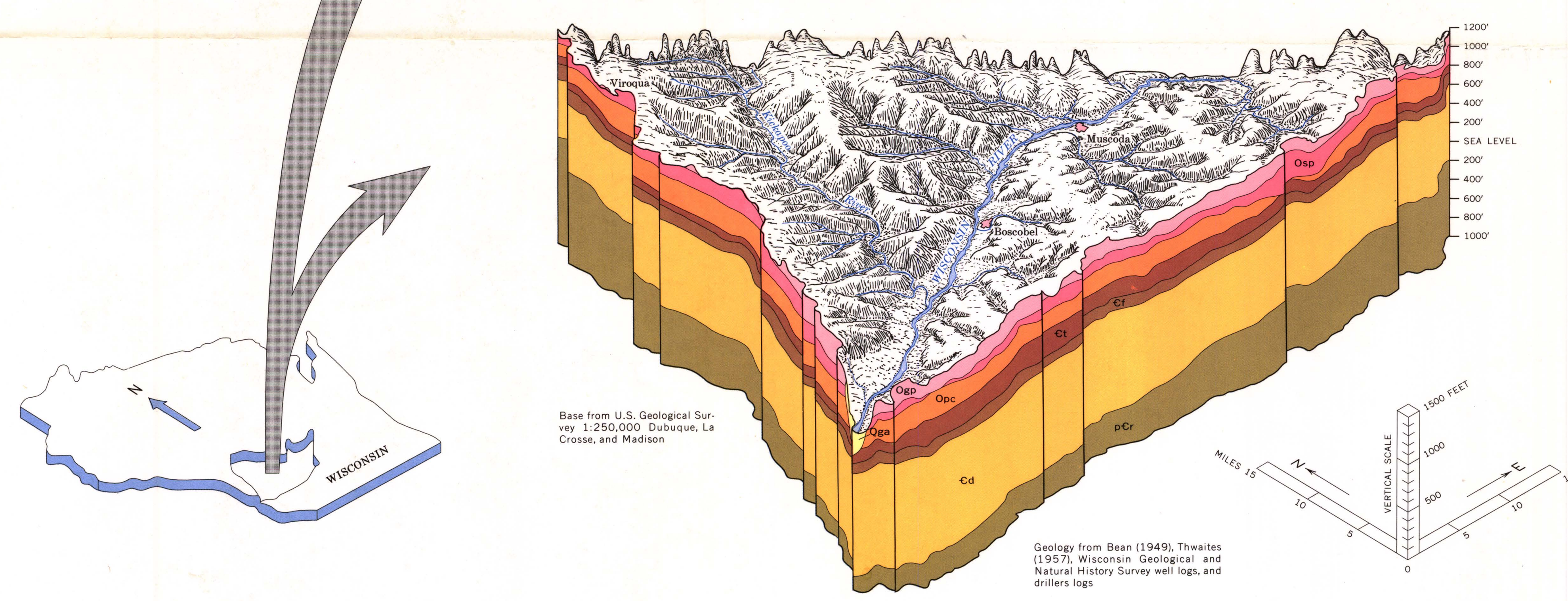
The 1970 population of the basin was estimated to be 133,000, a decrease of about 1,500 persons since 1960.

The economy of the area is primarily agricultural. Dairy farming and beef production are of primary importance, and the growing of specialty crops such as tobacco, fruits, and vegetables is of secondary importance. The major industry of the basin is manufacturing of dairy products. However, other manufacturing is important locally.

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

PHYSICAL SETTING





EXPLANATION

QUATERNARY
- Qga — Glacial deposits and alluvium

SILURIAN
- Sdu — Dolomites, undifferentiated

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

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

PRECAMBRIAN
- p€r — Crystalline rocks

Contact

BLOCK DIAGRAM OF THE LOWER WISCONSIN RIVER BASIN

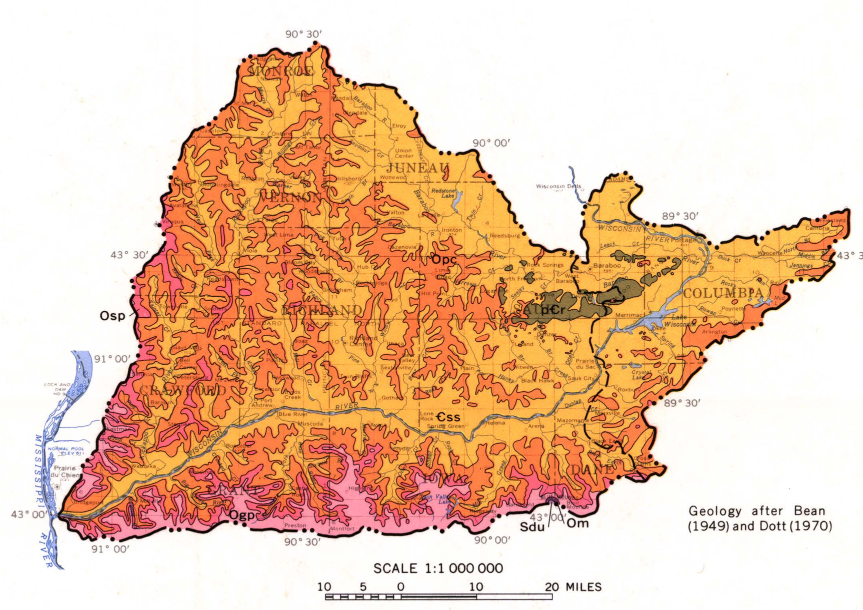
The two types of topography in the lower Wisconsin River basin resulted from two geologic environments. The rolling hills and wide, level valley floors in the eastern one-fourth of the basin were formed by unconsolidated glacial and alluvial deposits that overlie bedrock. The rugged, steep-walled valleys and high relief in the western three-fourths resulted from streams that cut deeply into the relatively flat-lying sedimentary bedrock. Unconsolidated glacial deposits are thin or absent in the western part, except along the Wisconsin River valley.

The approximate thickness, sequence, and lateral extent of the rock units are shown on the faces of the diagram. The sedimentary rocks dip and thicken to the south and southwest, following the slope of the Precambrian surface.

Geologic structure completely controls the drainage pattern in the western three-fourths of the area (Palmquist, 1965). The location and trends of subbasin drainage divides are influenced by folds in the Cambrian and Ordovician rock formations. Fine details of the drainage patterns are influenced by smaller fold and joint trends. The area is well drained.

Drainage in the eastern glaciated area is controlled primarily by the topography of the underlying bedrock. Preglacial bedrock valleys, although nearly filled with glacial debris, form natural drainageways. The high areas are formed by ridges on the bedrock surface in most cases. This area also is well drained.

GEOLOGY



EXPLANATION

Bedrock geology and approximate thickness, in feet

SILURIAN
- Sdu — Dolomites, undifferentiated, 0–80

ORDOVICIAN
- Om — Maquoketa Shale, 0–240
- Ogp — Galena Dolomite, Decorah Formation, and Platteville Formation. *Mostly dolomite*. 0–230
- Osp — St. Peter Sandstone, 0–250
- Opc — Prairie du Chien Group. *Mostly dolomite*. 0–250

CAMBRIAN
- €ss — Sandstones, undifferentiated. *Includes Jordan Sandstone, St. Lawrence Formation, and Franconia, Galesville, Eau Claire, and Mount Simon Sandstones*. 0–1200

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

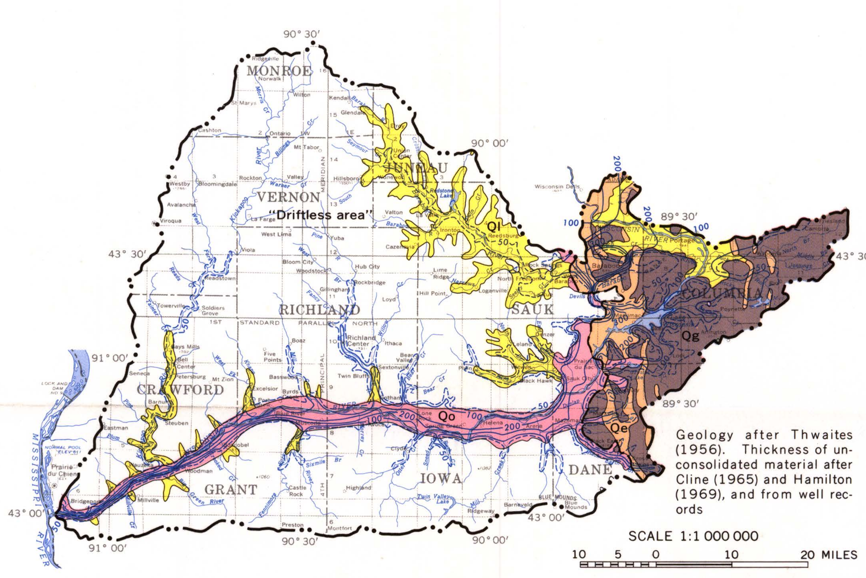
Contact

Western limit of glaciation

Surface-water divide

BEDROCK

The bedrock surface is shown on this map as it would appear if the surficial unconsolidated material were removed. Surficial bedrock in the study area consists of sandstone and dolomite of Cambrian and Ordovician ages, except for an erosional remnant of Silurian dolomite and Maquoketa Shale at Blue Mounds and exposed Precambrian crystalline rock in the Baraboo Range. In the northeastern part of the basin Cambrian sandstone is the dominant bedrock. In the western part of the basin the Cambrian sandstone is exposed in stream valleys, whereas the hills are generally capped with Ordovician dolomite. This pattern of exposure has been caused by stream erosion of gently dipping rock layers.



EXPLANATION

- Ql — Lake deposits. *Stratified clay, silt, and sand*
- Qg — Ground moraine. *Till, consists of unstratified clay, silt, sand, gravel, and boulders*
- Qe — End moraine. *Till and stratified sand and gravel*
- Qo — Outwash and alluvium. *Stratified sand and gravel*

Contact

Line of equal thickness of unconsolidated material. *Interval 100 feet, with dashed supplementary 50-foot lines*

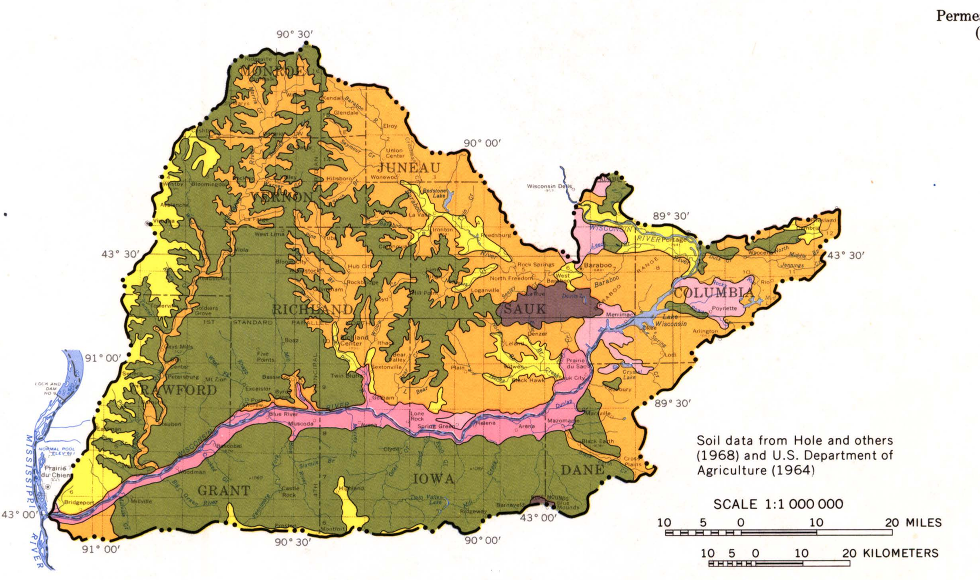
Western limit of glaciation

Surface-water divide

UNCONSOLIDATED DEPOSITS

Unconsolidated deposits consisting of glacial drift and alluvium occur throughout the basin. Glacial drift covers the eastern one-fourth of the basin and consists mainly of end moraine and thin ground moraine. The western three-fourths of the basin, part of the "Driftless area" of Wisconsin, has no drift except for thick, reworked sand and gravel deposits in the Wisconsin River valley and thin lake deposits in most of the tributary valleys. Unconsolidated deposits along the Baraboo and Wisconsin Rivers and their tributaries were not mapped as glacial deposits by Thwaites (written commun.), but the approximate thickness and extent of the unconsolidated deposits are shown by isopachs on the above map.

The entire basin is covered with a thin blanket of loess (windblown silt and sand). Over most of the basin the loess is largely silt and is 2–3 feet thick; in the extreme southwest it is 8–16 feet thick. In addition, some sandy areas along the Wisconsin River have active sand dunes.



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

Area boundary

Surface-water divide

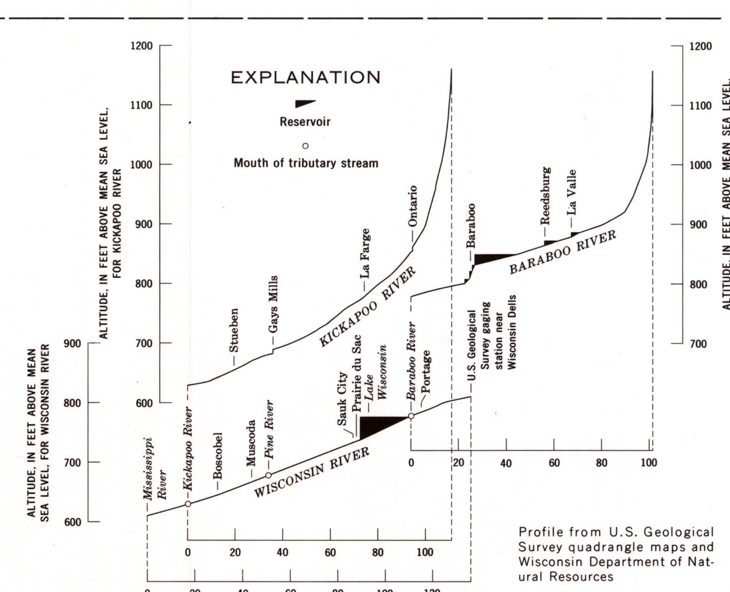
SOIL PERMEABILITY

Permeability is an important factor that determines the rate at which precipitation percolates through the soil. The soil permeability map shows generalized areas of permeability determined for the least permeable soil horizon under saturated conditions. The permeability rates represent the recharge potential to the ground-water reservoir.

Soils with a permeability greater than 2.5 inches per hour occur in only about 10 percent of the basin, whereas soils with a permeability less than 0.2 inch per hour cover about 45 percent. Almost all soil groupings in this basin have some loess as parent material. In the highly permeable soils the parent material is largely sand and gravel, and in low-permeability soils the parent material is commonly loess over clay or dolomite.

STREAM PROFILES

All major streams in the basin are characterized by gradients of about 1.5–2.0 feet per mile in their lower reaches, where they meander over alluvium-filled valleys, and gradients of about 19–20 feet per mile in their headwaters. Their flatter, lower reaches are controlled by aggraded valley floors, which are, in turn, in near equilibrium with the gradients of the Wisconsin and Mississippi Rivers. The steep headwater gradients result from the continuing headward erosion of the sedimentary rocks.



WATER USE

WITHDRAWAL USE OF WATER IN 1969, IN MILLION GALLONS PER DAY

Use	Source and type of supply				
	Ground water			Surface water	Total
	Public supply		Private supply	Private supply	
	Municipal	Other			
Domestic	2.3	0.1	5.3	0.0	7.7
Industrial and commercial	2.1	<.1	6.6	47.3	56.0
Irrigation	0.0	0.0	.5	.1	.6
Stock	0.0	0.0	6.2	1.4	7.6
Other	1.8	.1	0.0	0.0	1.9
Subtotal	6.2	.2	18.6		
Total	25.0			48.8	73.8

About 27 billion gallons of water was removed from the ground or diverted from streams or lakes for use in the lower Wisconsin River basin in 1969. About 34 percent was ground water, and the rest came from streams, lakes, and manmade impoundments. The 27 billion gallons per year is equivalent to almost 115 cfs (cubic feet per second), which is 4.5 percent of the average runoff from the basin. Most of the water withdrawn was discharged to streams and was available for reuse downstream.

The largest withdrawal use was industrial, 56.0 mgd (million gallons per day). The Badger Army Ammunition Plant near Baraboo used 41.7 mgd from the Wisconsin River, but approximately 85 percent of the water was returned to the river with very little change in chemical quality. The remaining industrial and commercial use, 14.3 mgd, was 61 percent ground water. Consumption of water was low in industrial and commercial use, and most water withdrawn was discharged to streams through storm drains or waste-treatment plants.

Water for domestic purposes was the next largest withdrawal use and was supplied entirely by ground water. Consumption in this use was low, and most of the withdrawn water was discharged into streams through sewage-treatment plants or to the ground through septic systems.

Stock watering was the third largest withdrawal use, and about 80 percent of it was ground water. Consumption was high in this use.

In the withdrawal use column "other" includes losses from distribution systems, street washing, main flushing, and use by public buildings. Consumption of water was very low in this use because most of the water was discharged to streams through storm drains or returned to the ground.

Although irrigation is important economically in this basin, the smallest withdrawal use of water was for irrigation. Because irrigation uses a large amount of water during a short period, pumpage reported as an average daily figure is low. Most of the irrigation water was consumed by plants or evaporated from the soil.

MUNICIPAL WATER USE IN 1969 AND SOURCE OF WATER

Municipality	County	Population 1970 (Preliminary)	Average daily pumpage (mgd)	Use (million gallons per year)				Source of water[1]
				Domestic	Industrial and commercial	Public	Other	
Arena	Iowa	356	0.014	3.19	0.31	0.52	1.21	S.
Avoca	Iowa	376	.016	1.67	.37	1.04	2.66	S.
Baraboo	Sauk	8,012	.981	128.63	113.04	51.49	64.95	D, S.
Barneveld	Iowa	565	.057	7.26	2.21	1.61	9.75	L, S.
Black Earth	Dane	1,092	.046	12.72	1.68	1.97	.51	S.
Blue River	Grant	373	.021	3.50	.81	1.87	1.62	S.
Boscobel	Grant	2,499	.188	29.20	25.19	.04	14.27	S.
Cambria	Columbia	631	.162	7.49	24.09	3.30	24.31	S.
Cazenovia	Richland	335	[2].061	4.97	5.90	6.93	4.45	S.
Cross Plains	Dane	1,471	.088	19.99	5.53	2.24	4.49	S.
Elroy	Juneau	1,499	.139	18.10	10.51	7.13	15.08	S.
Friesland	Columbia	300	.014	3.09	1.37	.12	.41	S.
Gays Mills	Crawford	587	.060	7.90	4.68	6.32	3.14	S.
Highland	Iowa	765	.068	7.22	9.13	.37	7.99	L, S.
Hillsboro	Vernon	1,234	.106	5.70	17.60	.00	15.51	S.
Ithaca	Richland	75	.010	.80	1.85	.78	.24	S.
Kendall	Monroe	1,048	.043	4.35	2.41	4.99	4.04	S.
La Farge	Vernon	736	.065	8.37	12.32	.00	3.17	S.
La Valle	Sauk	406	.023	4.16	1.46	1.96	.89	S.
Lodi (Harmony Grove Sanitary District)	Columbia	1,810	.023	6.54	.95	.00	.96	S.
Loganville	Sauk	207	.005	.85	.31	.00	.77	S.
Lone Rock	Richland	503	.047	[2]6.00	[2]4.29	[2]1.71	[2]5.15	S.
Mazomanie	Dane	1,192	.080	15.65	6.25	1.52	5.67	S.
Merrimac	Sauk	364	.016	4.69	.57	.22	.42	D.
Montfort	Grant	508	.123	6.12	2.31	.00	36.32	L, S.
Muscoda	Grant	1,080	.115	14.83	12.77	1.40	13.13	D, S.
North Freedom	Sauk	599	.037	5.98	.97	.32	6.22	S.
Norwalk	Monroe	446	.086	5.71	21.11	.00	4.55	S.
Ontario	Vernon	389	.028	3.66	.80	1.44	4.39	S.
Plain	Sauk	716	.068	11.73	5.55	1.46	6.14	L, S.
Portage	Columbia	7,750	.922	138.20	136.71	19.10	42.58	D, S.
Poynette	Columbia	1,098	.095	15.14	8.76	3.81	6.92	D, S.
Prairie du Sac	Sauk	1,896	.201	42.52	21.70	6.30	2.86	D.
Readstown	Vernon	392	.037	2.77	.52	1.07	9.29	S.
Reedsburg	Sauk	4,568	.714	70.22	157.85	19.20	13.49	S.
Richland Center	Richland	4,981	.677	77.47	77.97	67.63	23.94	S.
Rio	Columbia	765	.072	12.11	6.64	.00	7.59	S.
Rock Springs	Sauk	438	.046	[2]5.81	[2]4.15	[2]1.66	[2]4.98	S.
Sauk City	Sauk	2,385	.237	42.91	32.20	.00	11.33	D, S.
Sextonville	Richland	250	[2].003	.36	[2].26	[2].10	[2].31	S.
Soldiers Grove	Crawford	544	.074	6.09	4.69	2.15	13.93	S.
Spring Green	Sauk	1,168	.097	17.02	6.16	5.15	6.98	S.
Union Center	Juneau	201	.012	2.30	1.42	.01	.56	S.
Wauzeka	Crawford	430	[2].027	4.92	.34	2.06	2.44	S.
West Baraboo	Sauk	597	[2].051	7.86	5.89	2.02	2.78	D, S.
Wilton	Monroe	502	.077	6.15	4.43	1.15	16.28	S.
Wonewoc	Juneau	813	.084	10.14	10.23	2.81	7.51	S.
Total			6,216	822.06	776.26	234.97	436.18	

[1]D, sand and gravel; L, dolomite; S, sandstone
[2]Estimated

The table above shows the source and amount of water used by municipalities and sanitary districts in 1969. Thirty-nine of the 47 municipalities obtained water from the sandstone aquifer (sandstone or sandstone and dolomite), and two obtained their water from the sand and gravel aquifer. Six municipalities used a combination of the sandstone and sand and gravel aquifers. Thirty-six percent of the total pumpage was used for domestic supplies; 34 percent was used for industrial and commercial purposes. About 20 percent of the total either was lost through storage and distribution systems or was used for street or water main flushing.

Public water supplies in unincorporated places, not included in the table, accounted for about 0.2 mgd of pumpage in 1969.

NONWITHDRAWAL USE OF WATER

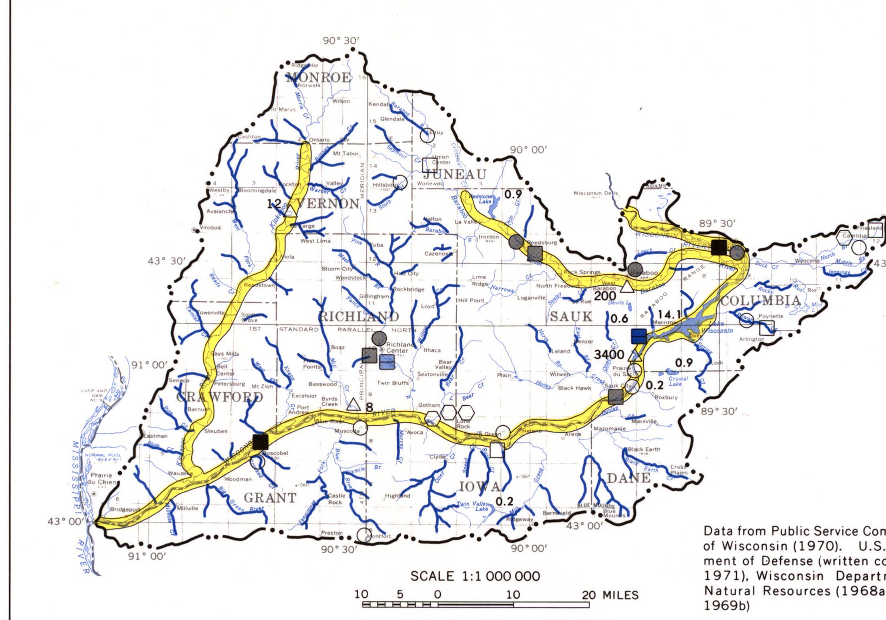
The most important nonwithdrawal uses in the lower Wisconsin River basin are hydroelectric power generation, waste transport and disposal, fish and wildlife habitat, and recreation. There is no removal or diversion of water in this use.

Hydroelectric plants in the basin use about 3,620 mgd to generate about 110 million kilowatt-hours of electricity. Although this use does not consume water, quality and temperature changes occur in reservoirs.

Many streams in the basin are used to transport waste water from many sources. Reaches of streams in areas of high water use and intense agriculture are subject to pollution from waste disposal and surface runoff.

In Wisconsin the management of water for fish and wildlife habitat and recreation are extremely important because the State derives great economic gain from tourism. The headwaters of all the major streams provide good trout habitat.

Water-related recreational facilities in the basin show increasing daily and weekend use by area residents and visitors. Fishing, canoeing, water skiing, swimming, and pleasure boating are the major water-related recreational activities in this area.



EXPLANATION

Water pumpage in million gallons per day

- 0.1–0.5
- 0.5–1.0
- 1–5
- 5–10
- 10–50

Municipal ground water

Self-supplied industrial ground water

Self-supplied industrial surface water

Irrigation ground water

Hydroelectric power plant. *Number is 1969 water use, in million gallons per day*

Large recreational lake or reservoir. *Number is area, in square miles*

Trout streams

Wisconsin water trail. *Suitable for recreational boating*

Surface-water divide

DISTRIBUTION OF USE

The highest water use is along the Baraboo and Wisconsin Rivers, where large supplies of water and gentle topography have promoted development. Irrigated fields, hydroelectric plants, industries, and most of the basin's urban population are located along these watercourses. Of the 14 municipalities in the basin that withdrew an average of 0.1 mgd or more, six are on the Wisconsin River and four are on the Baraboo River.

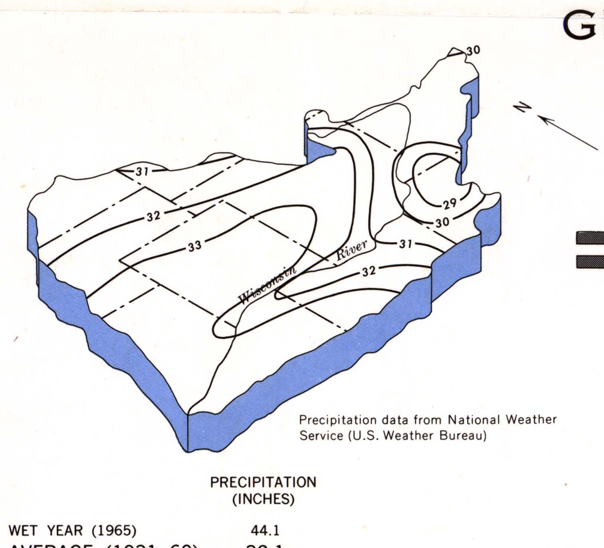
Beneficial use, from stock watering in the headwater streams to recreation and commercial use of the largest rivers, is made of surface water in the basin. Redstone Lake is the product of a private developer. Lake Wisconsin, although created as a reservoir for hydroelectric power generating, is rimmed by summer homes and is heavily used for water sports. Besides the lakes and reservoirs shown on the map, numerous farm ponds have recreational value. The lower reaches of the Baraboo and Kickapoo Rivers and all of the Wisconsin River in the study area are considered interesting canoe trails (Wisconsin Department of Natural Resources, 1968d). Trout streams are concentrated in the western and southern two-thirds of the basin where the base flow is high and springs are numerous.

GENERALIZED HYDROLOGIC BUDGET

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

Man's effect on the hydrologic budget is almost negligible in the lower Wisconsin River basin. A very small part of the ground and surface water withdrawn by man is consumed, and part of the water stored on the surface is evaporated.

Average conditions for 1931–60 are illustrated on the budget maps. Average budget quantities are presented for that period, and extremes are given for a wet year (1965) and for a dry year (1958).



PRECIPITATION (INCHES)

WET YEAR (1965) 44.1
AVERAGE (1931–60) 32.1
DRY YEAR (1958) 18.8

From one-half to two-thirds of the annual precipitation occurs from April through July. Droughts are rare and usually are not severe; lack of rainfall usually does not become critical until late summer. About 12–15 percent of the mean annual precipitation falls as snow.

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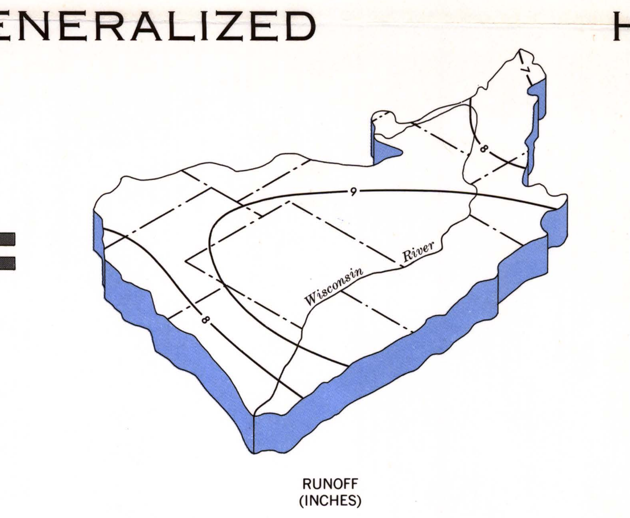

RUNOFF (INCHES)

11.7
8.9
5.5

Average annual runoff from the basin equals 8.9 inches of water on the basin (about 2,500 cfs), and is relatively uniform throughout the basin.

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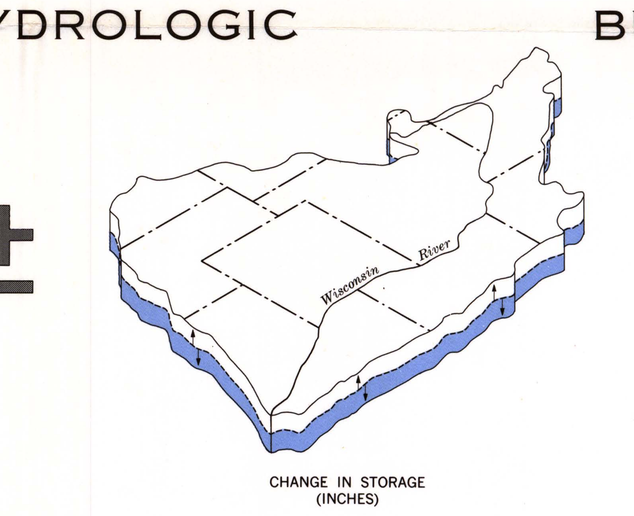

CHANGE IN STORAGE (INCHES)

GAIN, +2.6
0.0
LOSS, −3.1

Over a long period of time the net change in storage (primarily ground water) in the basin is negligible, and annual gains or losses of water are balanced.

A study of water-level records for wet and dry years shows that ground-water levels generally respond to changes in precipitation. The resulting net annual rise or fall during extremely wet or dry years is estimated to be about 1.4 feet and 1.7 feet, respectively. These changes in water level equal about 2.6 inches gain of water in storage for the wet year and 3.1 inches loss for the dry year.

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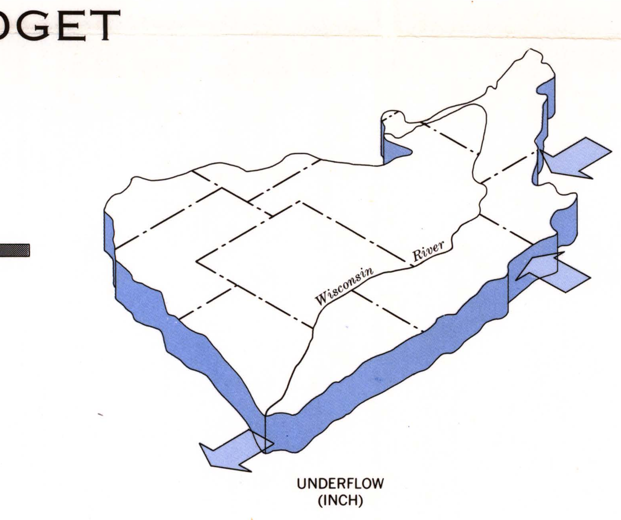

UNDERFLOW (INCH)

GAIN, 0.1
GAIN, 0.1
GAIN, 0.1

Underflow is water entering or leaving a basin through the ground-water reservoir. More underflow enters the basin than leaves it, and most of the water enters through the southeastern edge of the basin where the ground-water divide is displaced to the southeast. A small amount of underflow leaves the basin through valley alluvium at the Wisconsin River mouth. The estimated net amount of underflow into the basin (0.1 inch) does not change significantly during wet or dry years.

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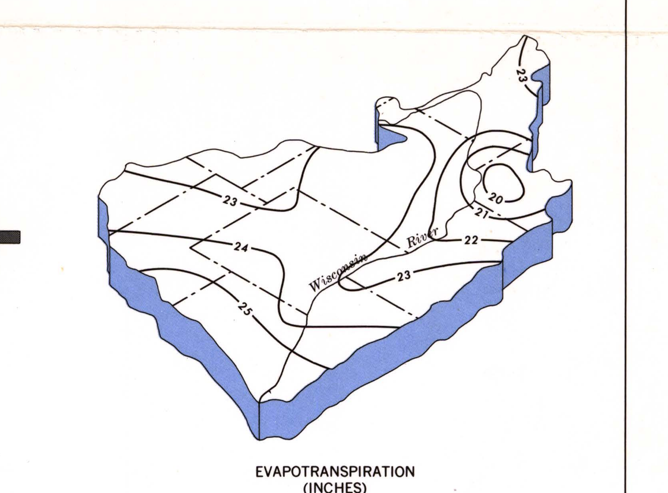

EVAPOTRANSPIRATION (INCHES)

29.9
23.3
16.5

Evapotranspiration, the return of water to the atmosphere by evaporation and plant transpiration, is estimated here as the difference between precipitation and the sum of runoff, change in storage, and underflow. Evaporation from open water surfaces accounts for less than 1 inch of the total evapotranspiration. Man's consumptive use of water has been included in evapotranspiration but is probably less than 0.5 percent of the total.

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

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA.—1974

WATER RESOURCES OF WISCONSIN—LOWER WISCONSIN RIVER BASIN

By
S. M. Hindall and R. G. Borman
1974

For sale by U.S. Geological Survey, Reston, Va. 22092, price $2.50 per set