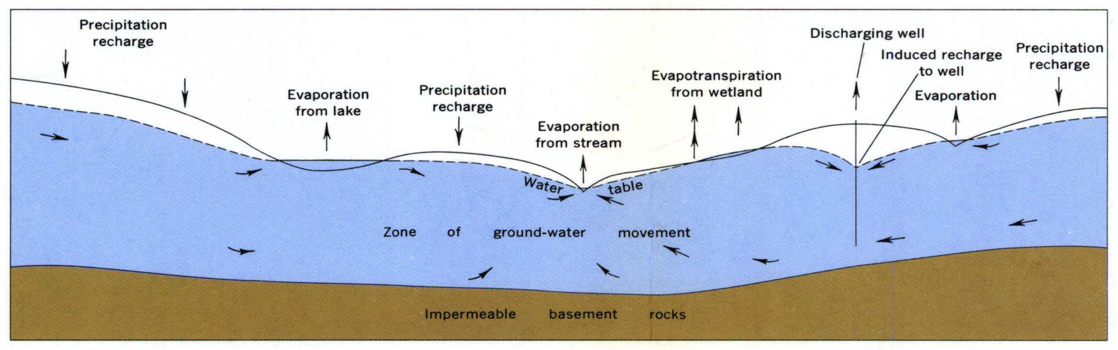
GROUND WATER



Ground water is a major resource of the central Wisconsin River basin; it is used exclusively for all public water supplies and for most of the domestic, stock, and irrigation uses. Ground water also contributes relatively constant flow of uniform temperature water necessary for trout streams in the southern and eastern parts of the basin.

Ground water in the central Wisconsin River basin is recharged by precipitation and by induced recharge from surface-water bodies; it is discharged to surface-water bodies, to the atmosphere, or to pumping wells. Below the water table, ground water moves slowly from areas of recharge to areas of discharge. (See diagrammatic section at the left.)

DEPTH TO WATER

Depth to the water table generally ranges from 0 to 20 feet in the outwash and glacial lake deposits, from 50 to 100 feet in pitted outwash, and as much as 170 feet in the end moraines. Depth to water in the area of ground moraine generally ranges from 20 to 30 feet.

MOVEMENT

The general pattern of ground-water movement is determined by the shape and slope of the water table, which is the upper surface of the saturated zone. The shape and slope are shown by contours on the map to the left. The direction of ground-water movement, which generally is at right angles to these contours, is shown by arrows. In the central Wisconsin River basin this movement typically is from the sides of the basin toward the streams and from north to south. Locally ground water moves toward discharge areas—springs, streams, lakes, and wetlands. Lakes and marshes lacking surface inflow and outflow locally interrupt the natural gradient of the water table. Ground water moves through the lakes, entering on one side and leaving on the other. Deep regional movement may occur below the shallow zone of local movement; in this case the water movement usually is toward the Wisconsin River.

RECHARGE

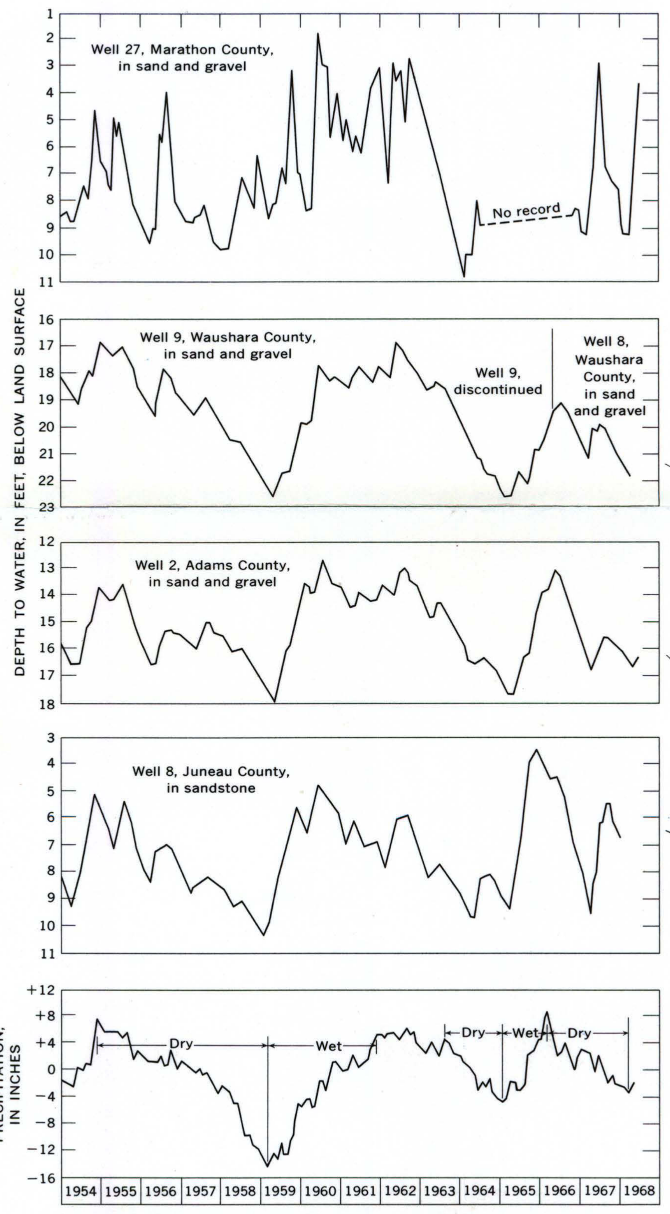
Ground-water recharge occurs where precipitation percolates to the water table, where the ground-water table is below the stream stage, or where ground-water pumpage induces recharge from a surface-water body. The absolute limit of ground-water availability is imposed by the limit of recharge, either natural or induced. Recharge to the ground-water reservoir in the sand plain area is approximately 10 inches during a year of normal rainfall (Holt, 1965, p. 49). Recharge should be slightly less in glacial lake deposits wherever they are well drained, and it should be much less in wetland areas where recharge is often rejected. Recharge in the area of ground moraine is probably about 1 to 2 inches, as estimated from the 2 inches of ground-water runoff on the Big Eau Pleine River (Holt, 1965, p. 52).

DISCHARGE

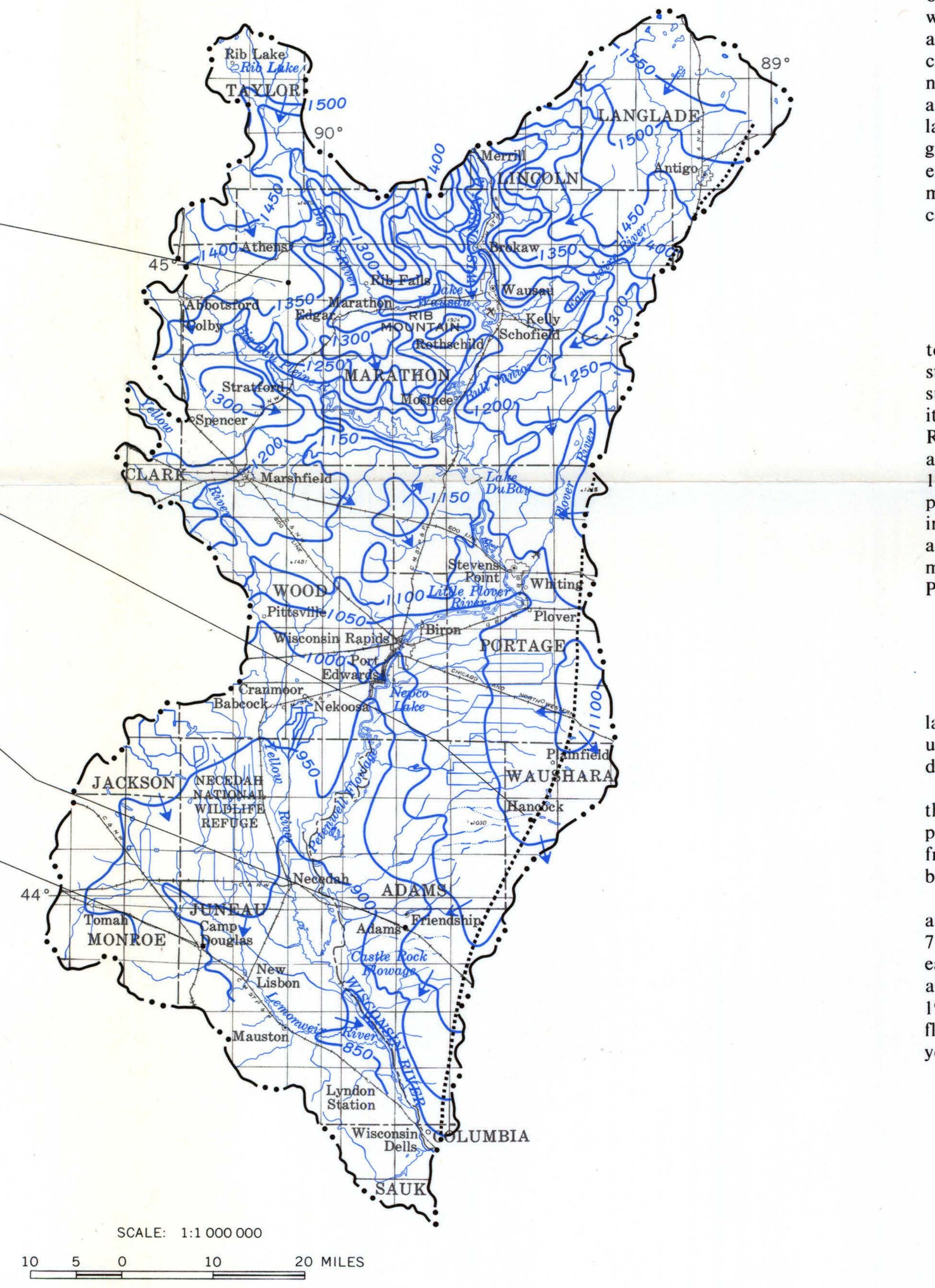
Natural ground-water discharge occurs at streams, marshes, lakes, and springs, or as underflow leaving the basin. The continued flow of perennial streams during long dry periods is natural discharge from the ground-water reservoir.

Natural ground-water discharge from the central sand plain, the Antigo area, and the moraine area ranges from 0.5 to 1.0 cfs per square mile. Discharge from the ground moraine area ranges from 0.0 to 0.2 cfs per square mile. Discharge to wells, about 21.7 billion gallons in 1967, is discussed in the water-use section.

Small parts of the basin, the eastern edge adjacent to the Wolf and Fox River basins, where the ground-water divide is as much as 7 miles west of the topographic divide, and a small area south and east of Antigo, are losing ground water into the basins of the Wolf and Fox Rivers (Harder and Drescher, 1954; Holt, 1965; Summers, 1965; and Olcott, 1968). The total loss of water by eastward underflow from the basin is estimated to be at least 30 billion gallons per year.



HYDROGRAPHS OF WATER LEVELS IN OBSERVATION WELLS AND CUMULATIVE DEPARTURE FROM NORMAL PRECIPITATION AT HANCOCK, 1931-60. (PRECIPITATION FROM RECORDS OF U.S. WEATHER BUREAU.)



PIEZOMETRIC MAP

EXPLANATION

—1050— Approximate piezometric contour
Shows altitude of the piezometric surface. Contour interval 50 feet. Datum is mean sea level

← Direction of ground-water movement

········· Ground-water divide
Approximately located

• Water well

—··— Basin boundary

WATER-LEVEL FLUCTUATIONS

Ground-water levels fluctuate in response to intermittent recharge, to almost continuous discharge to streams and springs, and to discharge from wells. Seasonally, water levels generally rise sharply in the spring (see above hydrographs) in response to recharge from snowmelt and rainfall. Water levels generally decline slowly throughout the summer because most of the precipitation during this period is evaporated or transpired by plants and does not percolate to the ground-water reservoir. A small rise often occurs following recharge from fall rains, followed by a decline during the winter when precipitation is stored on the land surface as snow.

In addition to seasonal fluctuations, water levels also vary with long-term changes in precipitation. Hydrographs of selected observation wells unaffected by pumpage, shown above, correspond with the cumulative departure from the 1931–1960 normal of precipitation at Hancock. Water levels show long term declines during dry periods. They generally rise throughout the area during wet periods.

EXPLANATION

Anticipated yield, in gallons per minute, from unconsolidated deposits

0-50

50-500

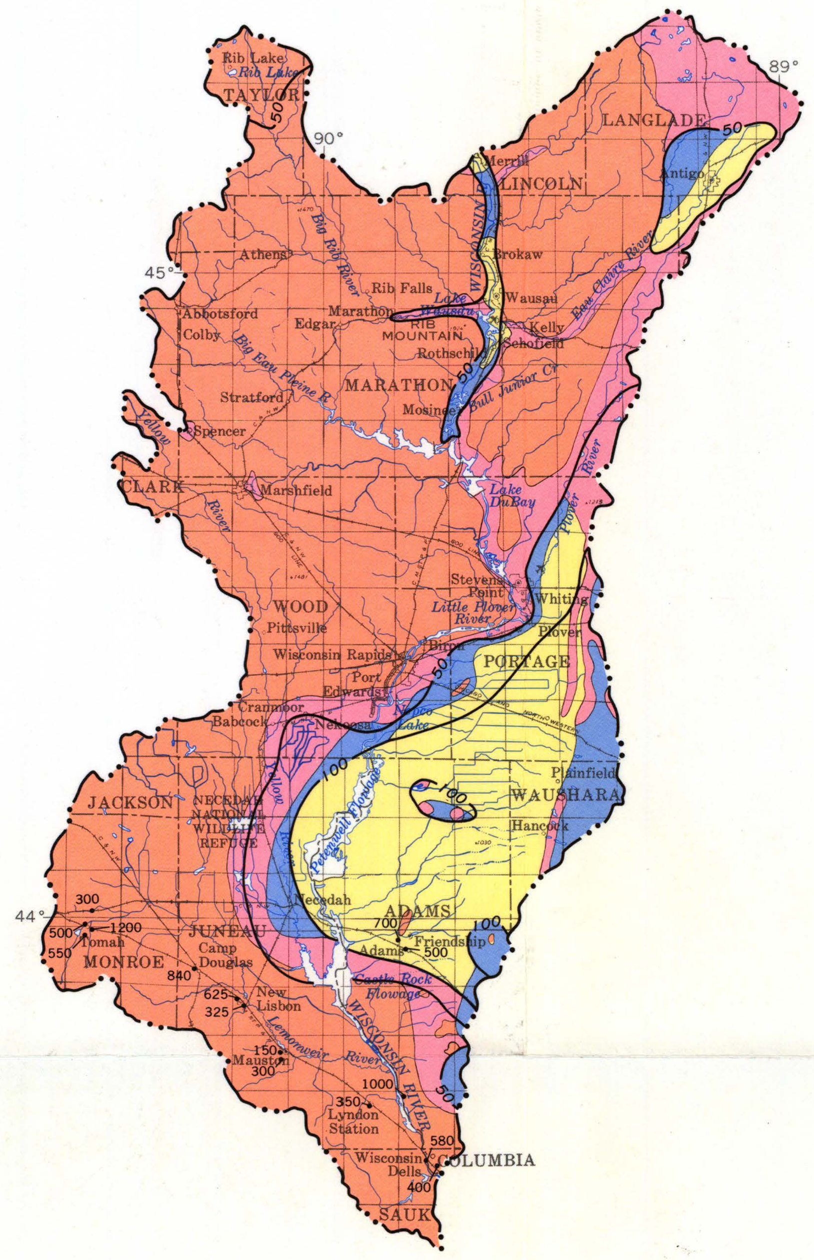
500-1000

More than 1000

•300 Water well in sandstone
Number is reported yield, in gallons per minute

—100— Line of equal saturated thickness of the unconsolidated deposits
Interval 50 feet

—··— Basin boundary



GROUND-WATER AVAILABILITY

AVAILABILITY

The highest well yields are from areas underlain by thick, permeable deposits of saturated sand and gravel or by thick beds of sandstone (see map to the left). Yields ranging from 500 to more than 1,000 gpm (gallons per minute) may be expected from the central sand plain, the Antigo area, the northeastern part of the glacial lake sands, pitted outwash deposits to the east wherever saturated thicknesses exceed 50 feet, and from sandstone in the southern part of the basin wherever its thickness exceeds 150 feet. Yields of this magnitude also may be expected from wells in permeable deposits less than 50 feet thick that induce recharge from nearby large streams. The cities of Wausau, Antigo, Brokaw, Rothschild, Port Edwards, and Stevens Point all have wells that produce more than 1,000 gpm because the wells induce recharge from nearby rivers.

Yields between 50 and 500 gpm may be expected in the area of end moraines, in most of the area of outwash and alluvium in the eastern part of the basin, and along the periphery of the high-yield areas.

Yields under 50 gpm may be expected throughout the area covered by thin ground moraine and in the southwestern area of lake deposits where the saturated thickness of unconsolidated deposits is less than 50 feet.

Exceptions to the yields described above occur where localized geologic conditions differ from the general conditions. As an example, seven wells tapping a relatively thick deposit of sand and gravel in a buried bedrock channel in a generally water-poor area near Marshfield yield between 400 and 500 gpm; but well yields are low in outwash areas where the bedrock is locally near the surface.

Detailed knowledge is lacking of the thickness and water-bearing properties of glacial lake and outwash deposits in western Juneau and eastern Monroe Counties. The few sample logs available indicate that these deposits become finer grained toward the southwest. Further exploration is needed to define well yields in unconsolidated deposits in this part of the basin.

Sandstone in the southern part of the basin is an important source of water, particularly for public supplies. Well yields in the sandstone range between 300 and 1,000 gpm. Most of the towns from Wisconsin Dells northwest to Tomah, including Necedah and Adams, obtain water from the sandstone, which ranges in thickness from 130 feet at Adams to 440 feet at Wisconsin Dells. A few irrigation wells in the southern part of Adams County produce water from the sandstone.

INFLUENCE OF PUMPING

Proper development of ground-water resources and proper well spacing may prevent localized problems of well interference. A pumping well removes water from the aquifer surrounding it. Given sufficient time and pumping rate, the influence of water removal may extend to other wells or to surface-water bodies. In either case the pumping well may interfere with another well by competing for ground water or with a surface-water body by diverting some of the surface water underground and toward the well.

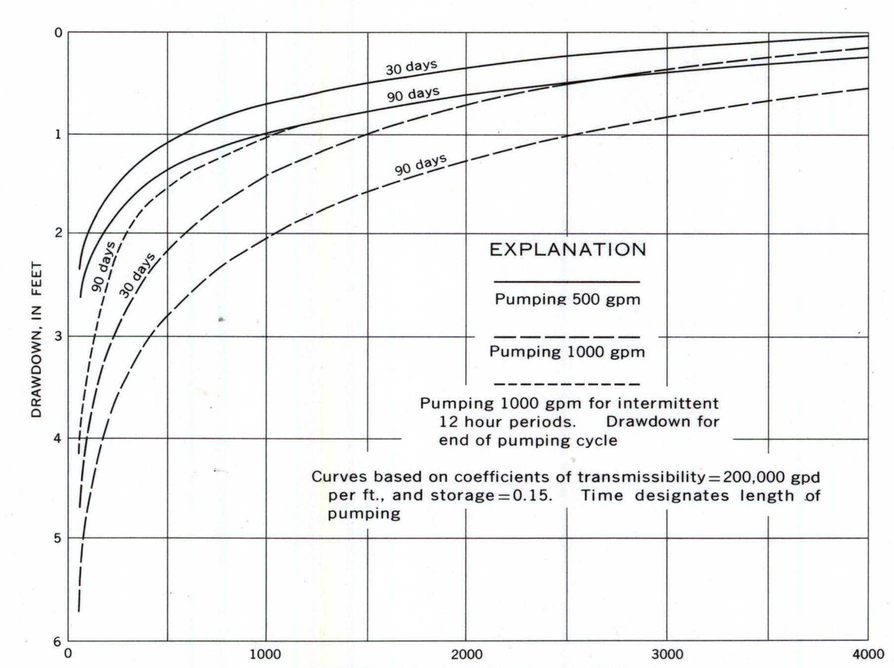
The amount of mutual water-well interference may be calculated from hydraulic characteristics derived from aquifer tests. Sufficient test data are available to estimate well interference in the sand and gravel deposits near Antigo and in outwash deposits in the central sand plain. These estimates, which are based on values of transmissibility adjusted for average aquifer thickness and average values for the storage coefficient rather than values calculated for any specific aquifer test, are plotted in the two graphs to the left. The curves may be used to predict the water-level drawdown for different distances from the pumping well and for different durations of pumping.

For example, a well in the central sand plain pumping 1,000 gpm continuously during the 90-day irrigation season will cause about 1.6 feet of drawdown in a well 1,500 feet away. Drawdown is proportional to the pumping rate, so that the interference will increase with increased pumping and decrease with decreased pumping. The effects of other nearby pumping wells are additive and can be found in the same manner.

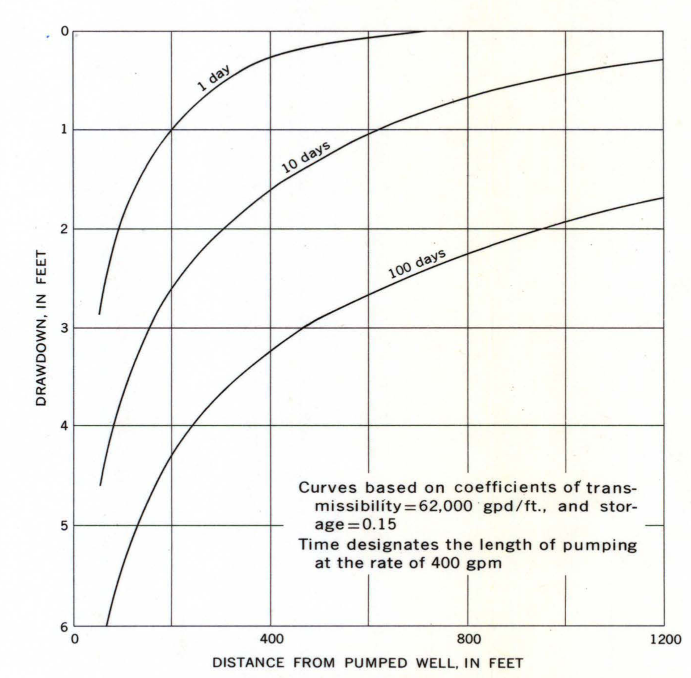
From the curves it is estimated that seasonally pumped irrigation wells that tap sand and gravel deposits in the central sand plain and Antigo areas need to be spaced no more than about 1,000 feet apart to avoid excessive interference. However, industrial or municipal wells that are pumped throughout the year will have greater effects on nearby wells and should be spaced at greater distances. Additional aquifer testing would be worthwhile in specific areas of planned irrigation, industrial, or municipal ground-water development.

Wells tapping thin ground moraine should be pumped at lesser rates and should be spaced greater distances apart to assure minimum well interference. Again, proper testing would aid in selecting a practical pumping rate and well spacing interval.

Water-well interference with a surface-water body induces recharge by diverting some surface water underground. Generally this results in a better sustained yield of the pumped well and a decreased rate of water-level decline. However, the flow of a stream at the point of diversion is reduced by the amount of the diversion. An excessive reduction in flow may be detrimental to fish environment and to other downstream uses of the water. Several municipal and industrial wells along the Wisconsin and Plover Rivers supplement their ground-water supplies by induced recharge (see availability).



THEORETICAL DISTANCE-DRAWDOWN CURVES FOR A WELL IN OUTWASH DEPOSITS IN THE CENTRAL SAND PLAIN
After Weeks and others, 1965
Not adjusted for hydrologic boundaries



THEORETICAL DISTANCE-DRAWDOWN CURVES FOR A WELL IN SAND AND GRAVEL DEPOSITS AT ANTIGO
After Harder and Drescher, 1954
Not adjusted for hydrologic boundaries

HYDRAULIC CHARACTERISTICS OF THE OUTWASH DEPOSITS DETERMINED FROM PUMPING TESTS

County	Well number	Township, range, section T	R	S	Rate of pumping (gpm)	Duration of test (hours)	Drawdown in pumped well (feet)	Hydraulic constants: Coefficient of transmissibility (gpd per ft)	Coefficient of storage	Coefficient of permeability (gpd per sq ft)	Saturated thickness (feet)	Depth of well (feet)	Diameter of well (inches)
Langlade	[1]La- 39	31	11	29	411	20	19.7	67,300	0.19	----	24+	54	12
	La- 43	31	11	29	1,000	8	6.4	40,700	.09	----	45+	41	18
Marathon	Mr- 44	29	7	11	1,000	72	28.6	340,000	.18	5,600	61	98	16
	Mr- 43	27	8	24	1,000	8	13.5	90,000	.10	1,200	77	100	16
	Mr-130	27	7	30	350	48	5.8	160,000	.30	1,900	84	50	18
Portage	Pt- 60	21	9	9	520	12	17	330,000	.14	2,400	[2]140	144	12
	Pt- 28	21	9	15	470	12	22	270,000	.15	1,800	[2]150	112	12
	Pt-279	23	9	18	1,060	74	20	140,000	.15	1,800	80	87	18
	Pt-111	24	8	34	1,700	24	--	100,000	.20	2,000	49	50	24
Wood	[3]Wd- 70	22	5	22	165	48	12	21,000	.05	1,000	20	35	18
	[4]Wd- 30C	22	6	28	425	72	--	59,800	--	1,200	48	68	12
	[4]Wd- 30B	22	6	28	305	72	--	59,500	--	1,700	35	63	12
	[4]Wd- 30D	22	6	22	365	72	--	75,100	--	1,600	48	58	12

[1]Well numbers indicate, in order, the county abbreviation, township, range, section, and the serial number within the county.
[2]Estimate.
[3]Test run by Becher-Hoppe Engineers, Inc., Schofield, Wis. (Written commun., 1962).
[4]Test run by Ramney Method Water Supplies, Inc., Columbus, Ohio. (Written commun., 1953).

HYDRAULIC PROPERTIES OF OUTWASH

The hydraulic properties of outwash, determined from nine tests performed by the U.S. Geological Survey in cooperation with the Wisconsin Geological and Natural History Survey and from four tests performed by private consulting firms, are listed in the table to the left. Values for the coefficient of permeability[1] listed in the table may be used to estimate the results of aquifer tests in nearby areas. For example, assume that a value of the coefficient of transmissibility[2] is desired for outwash at a test-hole site near well Pt–279. If the test hole penetrated 100 feet of saturated outwash where the coefficient of permeability was 1,800 gpd (gallons per day) per square foot, the transmissibility at the test-hole site would be estimated at 180,000 gpd per foot.

Values for the coefficients of transmissibility and of storage[3] may be used to determine the effects of long-term pumping and to estimate interference between pumping wells (see text on influence of pumping). These values also may be used to compute optimum spacing for production wells, and to determine the spacing within wetland areas.

[1] The permeability coefficient is the rate of flow of water, at a temperature of 15.5°C (60°F), in gallons per day through a cross-sectional area of 1 square foot under a hydraulic gradient of 1 foot per foot. The field coefficient of permeability, listed in the table above, represents the permeability coefficient at the prevailing ground-water temperature.

[2] Transmissibility coefficient is the rate of flow of water in gallons per day through a vertical strip of the aquifer 1 foot wide extending the full saturated height of the aquifer under a hydraulic gradient of 100 percent, and is equal to the coefficient of permeability times the aquifer thickness.

[3] Storage coefficient of an aquifer is the volume of water released or taken into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

SPECIFIC CAPACITIES

Specific capacity is the ratio of the amount of water produced by a well to the amount of drawdown of water level in the well, expressed in gallons per minute per foot. The specific capacity of a well is influenced both by the water-bearing properties of the aquifer and by well construction and development. As the water-bearing properties of a given aquifer often are nearly constant over sizeable areas, average specific capacities, such as those in the table, indicate the specific capacity that might be anticipated from a typically constructed high capacity well in a given aquifer and county.

Specific capacities of wells tapping outwash decrease from northeast to southwest, but specific capacities of wells tapping outwash in Portage and Waushara Counties exceed those of wells tapping pitted outwash in the eastern part of the basin. In turn, specific capacities of wells tapping pitted outwash are greater than those of wells tapping glacial lake deposits in Juneau County and deposits of till in Marathon County. Specific capacities of wells tapping outwash deposits generally exceed those of wells tapping sandstone.

AVERAGE SPECIFIC CAPACITIES OF GROUPS OF AREALLY SELECTED HIGH CAPACITY TUBULAR WELLS BY COUNTY AND AQUIFER

County	Aquifer	Number of wells	Length of test (hours)	Average pumping rate (gpm)	Average specific capacity
Unconsolidated deposits					
Adams	Outwash	8	2–8	914	39.4
Juneau	Outwash?	1	24	1,150	26.1
Langlade	Outwash	10	3–20	914	53.6
Marathon	Outwash	7	12–48	1,470	85.5
Do	Till	3	8–45	135	18.9
Portage	Outwash	52	2–135	1,066	60
Do	Pitted outwash	14	3–24	747	35
Waushara	Outwash	18	2–74	811	47
Do	Pitted outwash	21	1–10	874	33
Wood	Outwash	4	5–24	435	25.7
Consolidated deposits					
Adams	Sandstone	3	4–6	737	9
Columbia	Sandstone	2	?–12	473	15.8
Juneau	Sandstone	6	?–24	470	22.1
Monroe	Sandstone	3	?–36	417	7.8
Waushara	Sandstone	1	---	525	33

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