Groundwater Levels in Barron County, Wisconsin

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Explanation

Depth to water
(in feet below land surface)

- < 20
- 20 - 50
- 50 - 100
- > 100

- ● Data point (data not field checked)
- ⊙ Observation well
- 240+ Deepest water level encountered in a well (in feet below land surface)

Introduction

Effective management of groundwater in Barron County requires that up-to-date information relating to groundwater levels be readily available for efficient design of wells and water-supply facilities; for planning, land-suitability, and water-quality studies; for drought emergency preparedness; and for managerial decisions.

Extended periods of low levels deplete soil moisture and groundwater storage, which may result in crop damage, reduced crop production, and drying up of shallow wells and wetlands. In extreme cases, temporary water rationing, emergency well drilling, or hauling water to water-short areas may be required. High groundwater levels, on the other hand, may cause waterlogged soils in low areas and flooding of basements, septic tank systems, landfills, and construction sites, which may eventually create water-quality problems.

The U.S. Geological Survey (USGS) and the Wisconsin Geological and Natural History Survey (WGNHS) conduct a statewide groundwater-level monitoring program. Data from water-level measurements and their analysis are available at both surveys and are periodically published (Erickson and Cotter, 1983; Patterson and Zaporozec, 1985). Data on groundwater levels in Barron County are collected by the USGS from six observation wells (table 1); limited records are available for two other wells. Locations of the observation wells are shown in figure 1.

Table 1. Observation wells in Barron County

Well number	Well location	Measurement started	Measurement frequency*
Br 34	Town of Prairie Lake, SE SW sec. 9; 4 miles S of Cameron (stock water well)	1971 (Discontinued 1976)	M
Br 46	Town of Arland, NE NE sec. 21; 7 miles SW of Barron (unused domestic well)	1956	W
Br 48	Town of Turtle Lake, NE NE sec. 7; 2 miles S of Turtle Lake (unused school well)	1969	M
Br 62	Town of Stanley, NW SW sec. 25; 3,000 ft. WSW of Br 115 (school well)	1956 (Discontinued 1964)	Q
Br 115	Town of Stanley, NW NE sec. 25; 3 miles E of Cameron (unused irrigation well)	1968	C
Br 153	Town of Sumner, SW SE sec. 22; 7 miles E of Cameron (wayside well-USH 8 W)	1964	M
Br 402	Town of Dovre, SE SW sec. 22; 6 miles SE of Chetek (wayside well-USH 53 S)	1979	M
Br 492	Town of Maple Plain, NE NW sec. 8; 7 miles NW of Cumberland (domestic well)	1984	M

*C - continuous (recorder), W - weekly, M - monthly, Q - quarterly.

Monitoring of groundwater levels in Barron County began in October 1956 for two wells: Br 46 and Br 62. The longest continuous record (30 years) is available for well Br 46; however, the groundwater levels were measured at irregular intervals for the first six years. Monitoring of well Br 62 was discontinued after 8 years.

Depth to water table

The water table (the surface of a groundwater reservoir) is neither flat nor stationary and changes with location and time. Water levels in wells represent the water table. Depth to the water table is controlled by topography, permeability (the ability of earth materials to transmit water), and frequency and intensity of precipitation. The water table usually resembles a subdued form of the surface relief and tends to be closer to the surface in valleys or lowlands (discharge areas). It is deeper beneath hills and ridges (uplands, recharge areas).

Figure 1 shows the approximate depth to the water table in Barron County. It was compiled from well constructor's reports, which include static (non-pumping) groundwater levels at the time the wells were completed, and from soil-association maps, which show soil with water within 1 to 3 ft of the land surface. In areas that have good topographic control, the depth to water can be estimated with reasonable accuracy between widely spaced water-level data points following the land-surface contours. In the Blue Hills area of eastern Barron County, groundwater occurs in poorly interconnected joints and fractures; water levels in wells may vary in depth within short distances. In addition, there are only a few data points in this area. Therefore, the depth contours in figure 1 are only gross approximations in this area. Depth contours in parts of northwestern Barron County are also approximate. There, water may be found in till or sand-and-gravel deposits that are above, within, or beneath the till, and zones of perched water (water occurring above the water table) may exist where beds that have low permeability restrict percolation of rainwater through the thick unsaturated zone.

The water table generally is within a few tens of feet of the land surface in Barron County. It occurs at land surface in marsh areas but can be about 200 ft below the land surface beneath hills. The water table is generally high on the sand-and-gravel plains in central and southwestern Barron County, where it ranges from 5 to 20 ft below the surface. In upland areas of the county underlain by till, depth to the water table averages 50 ft. Beneath hills the depth to water is at least 75 ft and in many places, especially in the southwest and extreme northwest, is greater than 100 ft. The maximum reported depth is 240 ft in a well in the town of Arland. Generally, the depth to water does not exceed 200 ft in the county wells (fig. 2). In the majority of wells (66%) in Barron County, groundwater levels range from 10 to 60 ft below the land surface; in almost 80 percent of wells, groundwater levels are shallower than 75 ft (fig. 2).

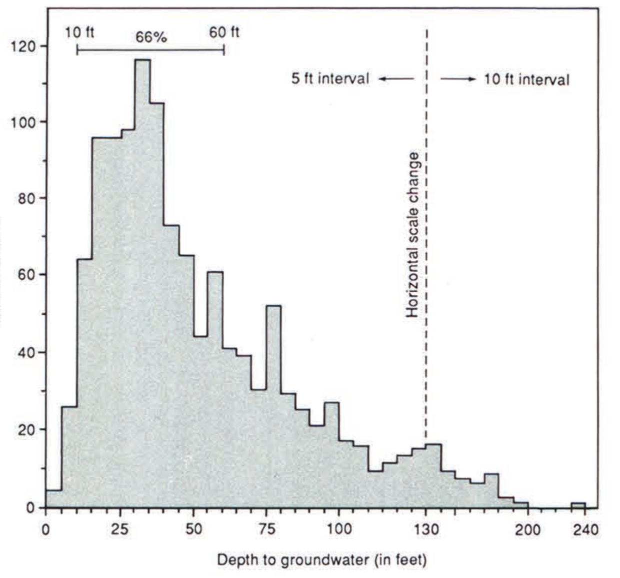

Figure 2. Distribution of depth to water table in Barron County wells.

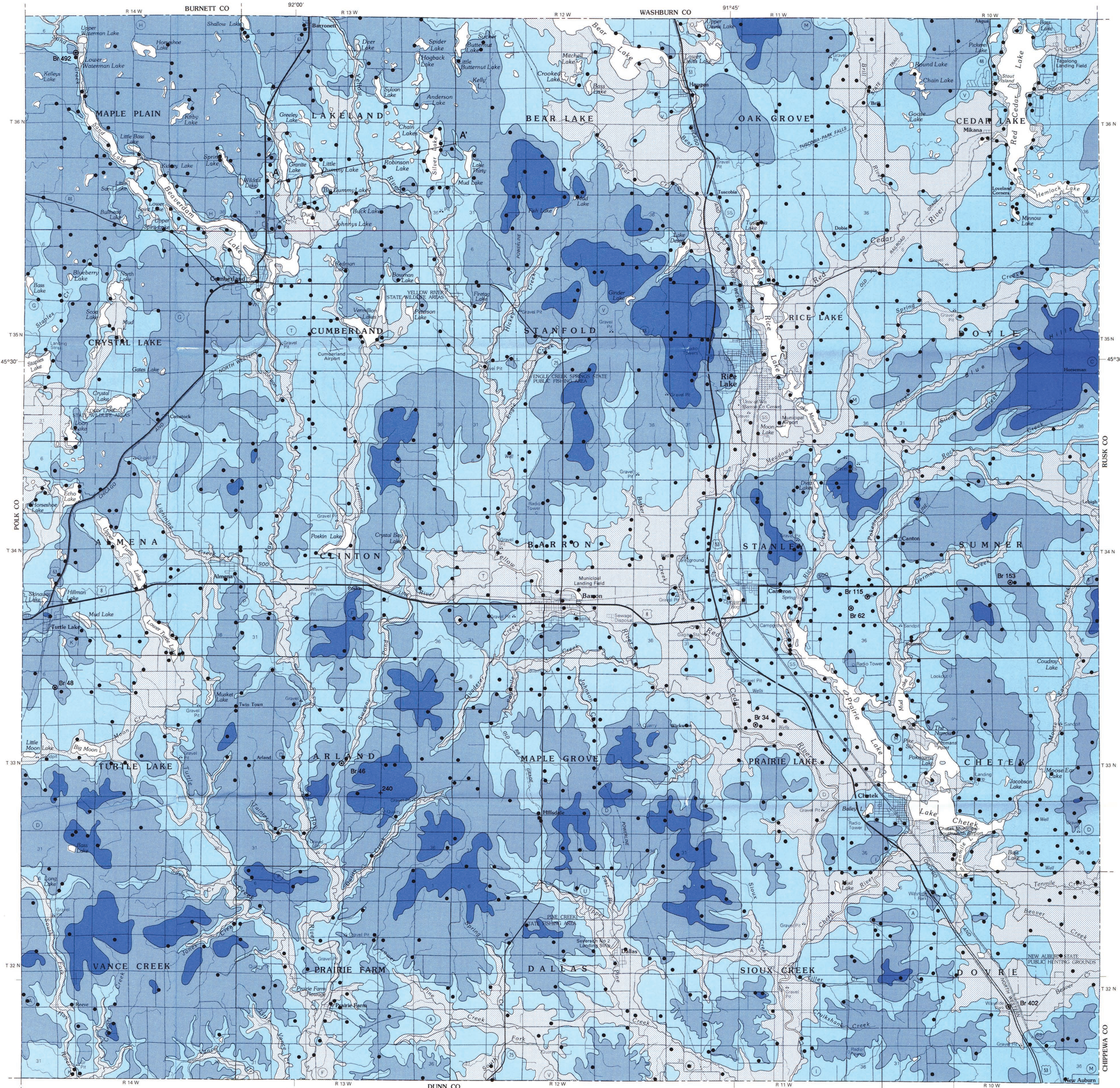

Figure 1. Approximate depth to water table in Barron County.

Base map from U.S. Geological Survey 1:100,000 map–Barron County,Wis.(1979).

Scale 1:100 000

KILOMETRES

MILES

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A part of the Barron County Atlas

Cartography by D.L. Patterson

Groundwater-level fluctuations

Groundwater levels fluctuate almost constantly; they can decline or rise within a relatively short period of time, mainly in response to changes in periodic recharge (amount of rainfall) and continuous discharge (contribution to streamflow, springs, and withdrawal of water from wells). Groundwater levels respond to changes in the amount of precipitation only after a certain period of time, depending on the type of rock that composes an aquifer, depth to water table, and proximity to rivers. This delayed response can be from a few days to a few years. Groundwater levels usually rise when recharge is greater than discharge. A continual decline in groundwater levels occurs when discharge of groundwater to streams, springs, and water wells exceeds recharge by precipitation.

Short-term fluctuations of groundwater levels last from several minutes to several days and can be caused by unusual events such as earthquakes, floods, quarry blasting, passing freight trains, or surge pumping. Groundwater levels drop or rise very rapidly and return to their previous position in a relatively short time.

Seasonal fluctuations result from variations in precipitation, streamflow, and evapotranspiration (loss of water from the soil by evaporation and transpiration from plants), and from withdrawal of water for irrigation and other seasonal industries. Groundwater levels rise relatively rapidly in the spring because of recharge from snowmelt and spring rains, and then gradually decline throughout the summer when evapotranspiration exceeds precipitation and very little water is available for infiltration. A second rise in groundwater levels occurs in the fall as a result of replenishment of groundwater by fall rains. This rise is followed by a decline during the winter, when precipitation is stored on the land surface as snow and the ground is frozen, thus limiting infiltration.

Gradual, long-term changes are produced by alternating series of wet and dry years or by human impact (such as drainage projects and urbanization).

Analysis of groundwater-level fluctuations can reveal important characteristics of groundwater in Barron County, such as the character of recharge and discharge periods. For example, monthly mean groundwater levels from observation wells (fig. 3) show the typical annual cycle of two low periods and two peak periods. The lows and highs in the spring are more pronounced than those in the fall. Minimum groundwater levels occur in February and September; maximum groundwater levels, indicating recharge period, usually occur in April, May, late October, and November.

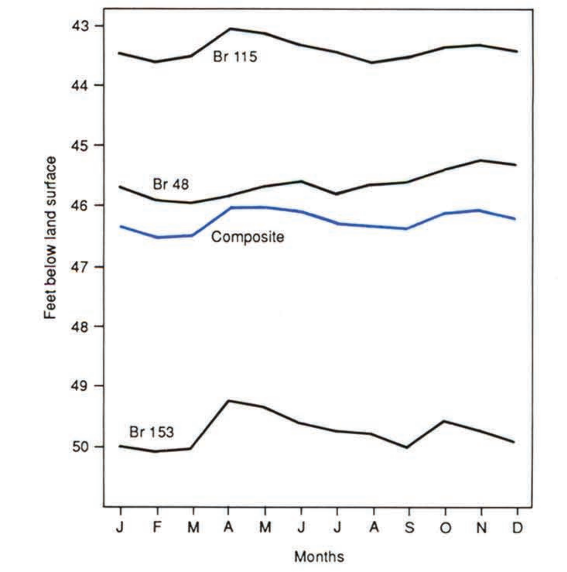

Figure 3. Monthly mean groundwater levels on observation wells in Barron County.

In individual years, however, the behavior of monthly groundwater levels differs slightly from the average trend. Our examination of annual minimum and maximum levels in observation wells in Barron County (1966-87) showed that most minimum levels were recorded in February and March (45%) and to a lesser degree in August (12%) and December (13%). The annual peaks were almost equally distributed between the spring and the fall, with the fall peaks slightly prevailing. Most maximum levels occurred from October to December (42%); the spring months of April through June accounted for 37 percent of maximum levels. This suggests that, at least during the last 21 years, late fall rains are equally, if not more important in replenishing groundwater in Barron County as spring rains and snowmelt. This is also apparent on the graphs of monthly means (fig. 3), especially the graph of well Br 48, which shows that the monthly means in the fall are higher than in the spring.

The maximum fluctuations in Barron County wells are small compared to the saturated thickness of the aquifers. We estimated that these fluctuations do not occupy more than 10 percent of the saturated thickness. For the observation wells in Barron County, the fluctuations range from 2 to 7 percent of the saturated thickness, with no difference between wells developed in the sand-and-gravel or sandstone aquifer. Shallow wells developed in glacial deposits in southern Barron County, where the saturated thickness is very small, may lose water during the prolonged periods of dry weather because the fluctuations may be greater than the saturated thickness. However, most of the wells there are developed in the sandstone aquifer, which has a great saturated thickness and is not significantly affected by fluctuations.

The maximum amplitude (difference between record low and record high levels) of 15.4 ft was recorded at well Br 48; it was about 11 ft at wells Br 46 and Br 48, and less than 3 ft. at the remaining observation wells. Within a single year, the fluctuations are much smaller. For observation wells in Barron County, fluctuations range from less than 0.5 ft (Br 48) to about 5 ft (Br 153). The average annual fluctuation was less than 2 ft -- from 1.3 ft in Br 115 to 3.1 ft in Br 153. The range of annual fluctuations in well Br 153 fluctuates more than the other observation wells in Barron County. There is no apparent difference in fluctuations between wells completed in the sand-and-gravel or sandstone aquifer, which corresponds with the fact that these aquifers are hydraulically connected. There appears to be no tendency for annual fluctuations to have greater amplitude in dry years as compared to wet years. Most of the minimum levels were recorded in 1968, 1970, and 1977; most maximum levels, in 1986 and 1984.

Relationship of precipitation to groundwater-level fluctuations

Long-term records from observation wells show that groundwater levels are closely related to recharge by precipitation and to natural discharge. The similarity of the groundwater-level record for well Br 46 (fig. 4) during the last 21 years (when the groundwater levels have been regularly measured monthly and later weekly) and the cumulative departure (the difference between measured rainfall and average value for a selected period of time -- in this case, a month) from normal monthly precipitation shows the dominant role that precipitation plays in groundwater-level fluctuations (fig. 4). Between 1966-86 the precipitation and groundwater levels have been increasing, although the groundwater-level increase has not been as dramatic as that of precipitation.

Seasonal and long-range fluctuations shown by the hydrograph for observation well Br 46 reflect differences between recharge and natural discharge during the year and from year to year. Seasonal fluctuations again show the role of fall rains in groundwater recharge in Barron County. For most of the last 21 years, fall precipitation that occurred after vegetation was killed by the first frost was great enough to overcome soil-moisture deficiencies, to recharge groundwater, and to result in rising groundwater levels. Such groundwater level recoveries are especially apparent for the years 1968, 1970, 1977, 1985, and 1986 (fig. 4).

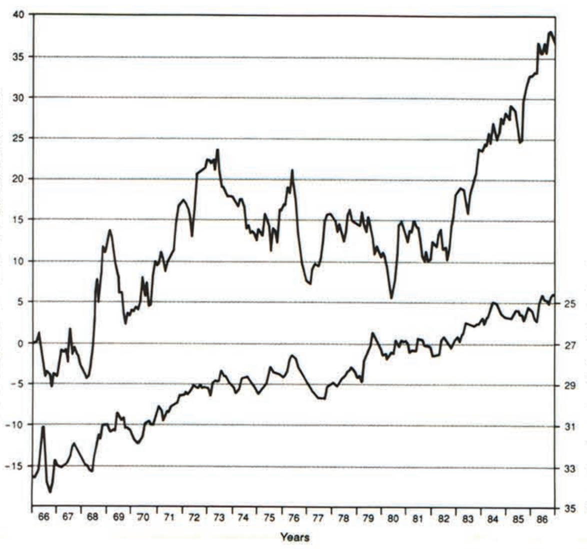

Figure 4. Relationship of groundwater levels of observation well Br 46 to precipitation at Rice Lake.

The trend of groundwater levels for well Br 46 has been generally increasing during the last 21 years, with several lows and peaks (fig. 4). Overall, groundwater levels gained almost 9 ft during that period. After the low in 1965, groundwater levels rose at the steady pace of 0.5 to 1 ft per year. The generally upward trend was interrupted in 1970 and 1977. After the biggest drop in 1976-77 (more than 2 ft), groundwater levels recovered very quickly and rose more than 3 ft in 1978-79. From 1979 to 1982 groundwater levels leveled off at around 27 ft below land surface, and then rose again 2 ft in 2 years. Since 1984 they have remained around 25 ft below land surface. The all-time high of 24.47 ft below land surface was recorded on November 5, 1986.

The period of record for Barron County observation wells is not long enough to properly evaluate the long-range trends. However, longer records are available for wells in other counties of northwestern Wisconsin; these records can be used for estimating the trends in Barron County prior to 1956 (Zaporozec, 1980).

Relationship of groundwater to surface water

Groundwater and surface water do not represent isolated systems as is commonly believed. The water table is usually interconnected with streams, marshes, and lakes (fig. 5). Groundwater-level fluctuations are closely related to surface-water-level fluctuations.

The cross section through the town of Lakeland (fig. 5) illustrates the various positions of lakes in a groundwater flow system (the pattern of groundwater movement from recharge to discharge). The arrows in figure 5 showing the general direction of groundwater flow are only conceptual and do not indicate actual flow lines. The cross section starts just east of USH 63 in section 29 at Granite Lake and runs east to the town line east of Silver Lake (for location, see fig. 1).

Four types of lakes are shown in figure 5: discharge, recharge, flow-through, and perched. The water levels in lakes may or may not be contiguous with the water table (Born and others, 1974). Discharge lakes, such as Granite, Little Granite, and Little Dummy Lakes, are located in groundwater discharge areas and gain water through the entire lake bottom. Recharge lakes are situated in groundwater recharge areas and contribute to the groundwater through the entire lake bottom. A small unnamed recharge lake is shown approximately in the center of the cross section. In areas of lateral groundwater flow, lakes gain groundwater on one side and lose to the groundwater on the other side and are called flow-through lakes; Silver Lake at the E end of the cross section is an example.

Using piezometers and water-level measurements, Young and Hindall (1972) studied the groundwater flow system around Silver Lake to determine its relationship to groundwater. The lake receives groundwater in the northern part and most of the western part. Water from the southern part of the lake recharges groundwater and then discharges to the Yellow River, which is about 70 ft below lake level.

Some lakes in the county may be isolated from the groundwater by an unsaturated zone, that is, perched above the water table. Perched lakes probably are uncommon in Barron County; their existence is difficult to document. A hypothetical lake, west of Little Silver Lake in figure 5, is presented only as an example of how a perched lake would be located in a groundwater flow system. Little Silver Lake may be a recharge, discharge, flow-through, or perched lake; no investigation was conducted to determine the character of this lake.

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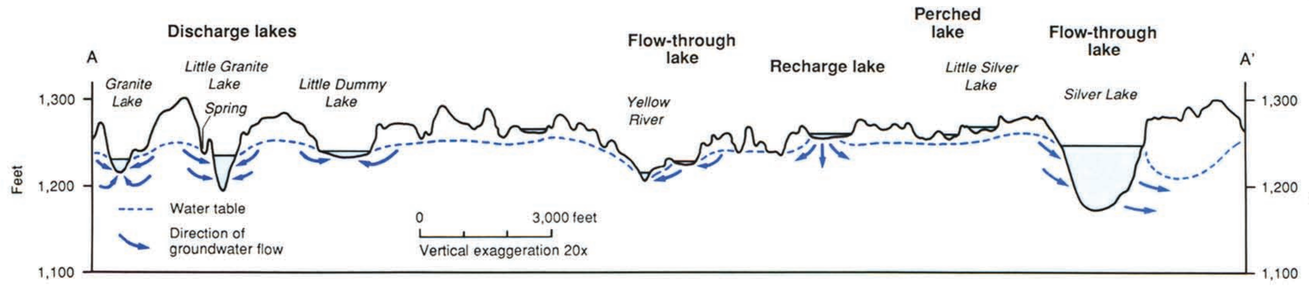

Figure 5. Position of lakes in a groundwater flow system (sec. 24-29, Lakeland Township).