Generalized Water-Table Elevation Map of Pierce County, Wisconsin

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Introduction

This map is part of the Pierce County Groundwater Resource Investigation, a joint project of the Wisconsin Geological and Natural History Survey and the Pierce County Board. The intent of this project was to compile and interpret hydrogeologic data for Pierce County. The resulting information can be used by Pierce County's soil-and-water-resource and land-use planners.

The water cycle

Gravity and solar energy play active roles in a continuous water recycling process called the *water cycle* (fig. 1).

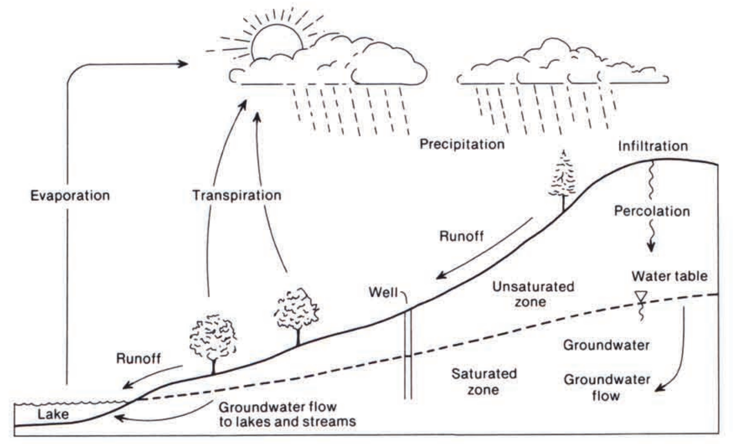


Figure 1. Schematic diagram of the water cycle.

Water falling on land flows downhill as runoff, evaporates, transpires through plants, or infiltrates into the ground. As this infiltrating water percolates downward through rock or soil, it travels through pore spaces and open cracks or fractures in the subsurface material. When these pores and cracks are completely filled with water, the material is said to be *saturated*.

The *water table* is the surface of this saturated zone, where hydraulic pressure is equal to atmospheric pressure. *Groundwater* is the water contained in the saturated zone below the water table. The amount of infiltrating precipitation partly determines the position, or elevation, of the water table, which fluctuates seasonally, and from one year to another. Above the water table, pores and cracks are partly or completely filled with air, and the material is said to be *unsaturated*. If a zone of saturated material is separated from an underlying main body of saturated material by an unsaturated zone, then the upper groundwater system is said to be *perched*. The upper water table is referred to as a *perched water table*.

Gravity moves groundwater slowly through pore spaces; eventually, the groundwater discharges to a well, the land surface, or a water body where solar energy evaporates some of it into the atmosphere, thus continuing the water cycle.

In Wisconsin, the water cycle generally operates with 30 to 32 inches of precipitation during an average year, from which about 75 percent (22 to 26 inches) returns to the atmosphere by evapotranspiration. The remainder either flows over the land surface and collects in surface water bodies or infiltrates into the ground as *recharge* to the groundwater system. The ratio of surface runoff to groundwater recharge varies considerably around the state, depending upon factors such as topography, soil type, vegetative cover, rainfall intensity, and individual farming and general land-use practices.

Movement of groundwater

If conditions in the saturated subsurface material allow a well to yield fresh water of sufficient quantity for domestic or commercial use, the material is called an *aquifer*. *Permeability* is a measure of the relative ease with which water can flow through an aquifer; it is dependent on the nature of the materials through which the water is flowing. Large pores or fractures in the subsurface can hold more water than small ones, but in order for water to flow, these pores or fractures must be interconnected.

Groundwater can move as quickly as several feet per day in porous sand, or as slowly as less than 1 inch per year in clay or in dense crystalline rock. However, no matter how rapidly or slowly the groundwater flows, its natural direction of movement is in response to gravity, from upland recharge areas (where water infiltrates into the subsurface) to lowland discharge areas (springs and seeps). Discharge areas are often associated with surface-water bodies, so groundwater has a significant role in the development and environmental health of lakes, streams, and wetlands.

For example, sandy soils may have relatively large pore spaces that are well connected with each other, allowing water to seep more easily than it can in clayey soils that have small and poorly connected pores. Rocks such as limestone and dolomite are usually highly fractured; if these fractures are open and interconnected, water can flow quickly. Caves and sinkholes develop in areas where these fractures are enlarged by solution, and groundwater flow may become complex. Other rocks, such as crystalline granite, commonly have fewer and less well connected fractures than limestone and dolomite, and they commonly have a lower permeability and transmit less water.

A *groundwater mound* is a local mound-shaped elevation in a water table that builds up as a result of a zone or zones of material such as clay or shale that has much lower permeability than surrounding materials. The groundwater cannot drain as quickly from these materials; consequently, the water table is *mounded* at a higher elevation than in surrounding more permeable materials.

A *surface-water divide* is a line of separation, commonly a ridge or narrow tract of high ground that divides the surface waters that flow naturally in one direction from those that flow naturally in a different (often opposite) direction. It is a line across which no surface water flows. The surface-water divide in Pierce County separates the streams and rivers that flow directly into the St. Croix and Mississippi Rivers (west of the divide) from those that flow into the Chippewa River to the east.

A *groundwater divide* is similar to a surface-water divide in that it is a ridge defined by contours of the water table. Shallow groundwater moves away from the divide in different (often opposite) directions. A groundwater divide does not necessarily coincide with a surface-water divide. Because data are especially scarce in the area of Pierce County where the groundwater divide occurs, it can only be approximately located. The groundwater divide appears to coincide with the surface-water divide in most areas except in and around the Rock Elm Disturbance, and in the northern part of the town of Maiden Rock.

Contamination of groundwater

Because groundwater comes from water that percolates down from the land surface, any water-soluble material or any liquid that is put on or in the ground has the potential to be transported to the groundwater. Soil is usually a good natural filter, removing many harmful materials from the recharging water as it moves downward. Areas of thin or sandy soils over a rock aquifer or thin or sandy soils with a shallow water table are especially susceptible to groundwater contamination from land-use activities. Thin or sandy soils do not effectively remove many potential contaminants contained in liquid or solid waste products, or in other materials — such as road salt, manure, chemical fertilizers, pesticides, and herbicides — that are applied to the land surface. Once a contaminant reaches the water table, very little attenuation takes place; dilution will reduce the concentration of contaminants but will not remove them.

Because groundwater can move as slowly as a few inches per year, contamination that occurs today may not become evident for several or even hundreds of years. Once contaminated, groundwater is difficult to purify and may take many years, decades, or centuries to clean itself by the dilution process.

Data compilation and interpretation

Data were compiled at a scale of 1:24,000, using United States Geological Survey quadrangles (7.5-minute series, topographic) as base maps. All available Wisconsin Geological and Natural History Survey geologic logs were plotted onto these base maps. The Wisconsin Department of Natural Resources well constructor's reports were examined and checked against each other, and the most representative, reliable, and useful data available for each section were plotted. For some areas, there were no reports, and for others, only a few; however, for most areas west of the Rush River at least one report per 2 square miles was available. Data were much scarcer east of the Rush River, and in many areas there was only one report per 6 square miles.

The Rock Elm Disturbance is an anomalous area of complex local geology whose origin is unclear (Cordua, 1987). It is located within the shaded area of eastern Pierce County. The rock within this area contains significantly more shale than does the surrounding rock. The shale can locally cause perching or mounding of groundwater.

Because well constructor's reports provide measurements taken at different times of the year and in different years, a water level determined from a well constructor's report was not usually used as an exact data point. Instead, the water level was considered to be part of a range of values. The elevations of springs, groundwater seepage areas, seepage lakes, and rivers were used as data points in most areas. In areas where the elevations of surface-water features differ greatly from the elevations of water levels in most nearby wells, the surface-water features may be perched or mounded, or may be higher due to strong downward hydraulic gradients. Wells in these areas often have water levels more than 100 feet below surface-water elevations. In these cases the surface-water features were not used, and the water table was based on the well data. Except for the area within the Rock Elm Disturbance, data are too sparse to delineate these areas, which may be local in their extent. Site-specific investigations beyond the scope of this study are necessary to determine which condition—perching, mounding, or strong downward hydraulic gradients—causes the difference between the surface-water elevations and the water levels in nearby wells.

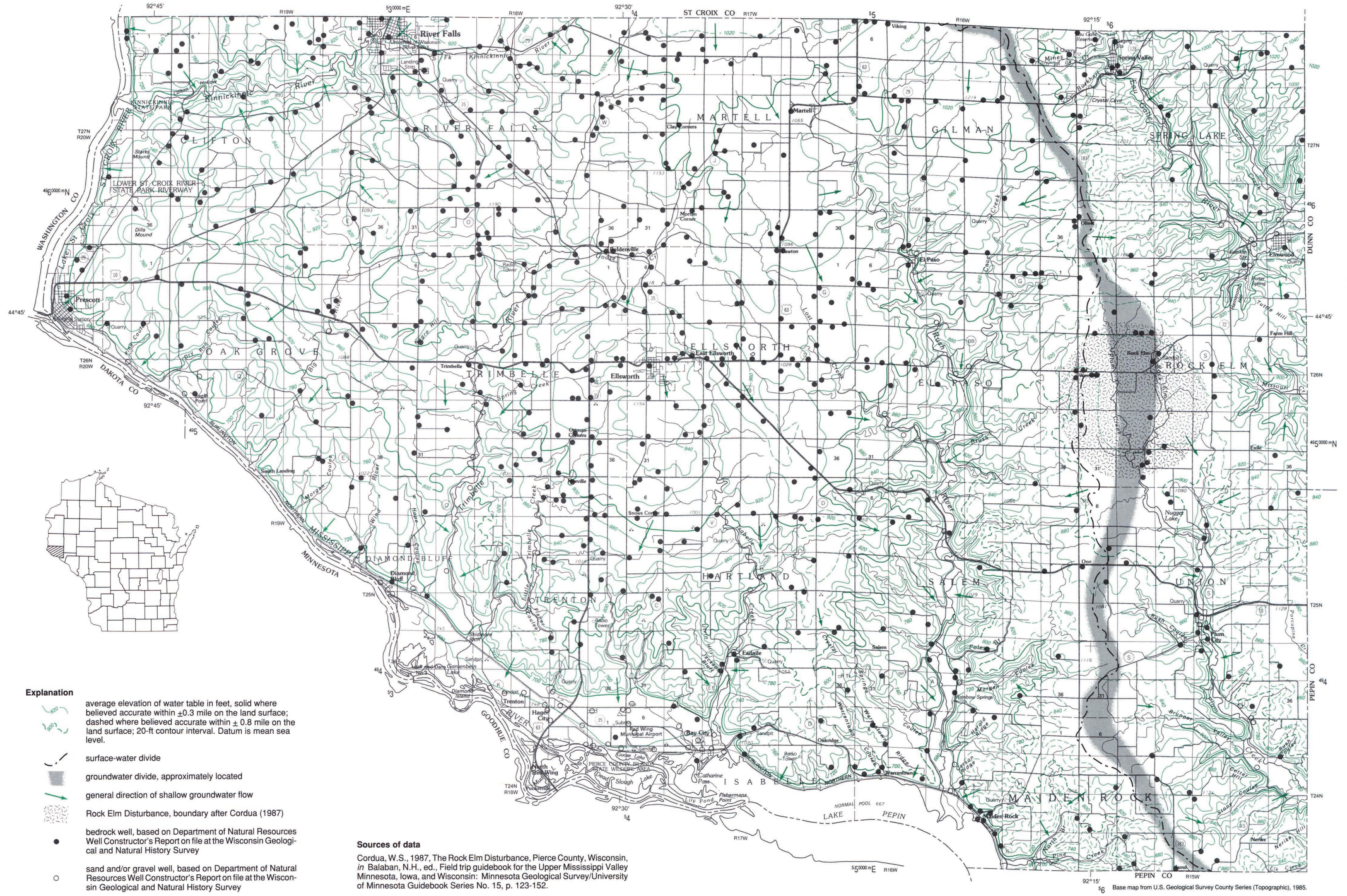
A *potentiometric surface* is a surface that represents the elevations of water levels in tightly cased wells that penetrate a given aquifer. A water table is a special type of potentiometric surface where hydraulic pressure is equal to atmospheric pressure. By using water levels in wells as water-table elevations, it is assumed that the aquifer is *unconfined* (that is, the upper boundary of the aquifer is the water table, not a confining layer of relatively impermeable material such as clay or shale) and that vertical hydraulic gradients are negligible. Because these assumptions may not be valid in some areas of Pierce County, parts of this map that are based solely on data from deep wells may more specifically represent a potentiometric-surface map rather than a true water-table map, but this difference should not affect the utility of this map for planning and management purposes.

On the basis of well constructor's reports on file at the Wisconsin Geological and Natural History Survey, more than 60 percent of the wells in Pierce County obtain their water from the Prairie du Chien dolomite. Less than 20 percent of the wells obtain their water from Pleistocene alluvial deposits, mainly sands and gravels in river valleys. The remaining wells are either in the St. Peter sandstone, which overlies the Prairie du Chien unconformably, or are completed in deeper sandstone units such as the Jordan or Tunnel City Group, which underlie the Prairie du Chien dolomite.

In Pierce County, groundwater recharge occurs mainly in the north central and northeastern parts of the county. West of the groundwater divide, groundwater flow is predominantly south or southwest into the Mississippi River, or west into the St. Croix River. East of the groundwater divide, discharge points include the Eau Galle River and Plum Creek, which flow into the Chippewa River, to the southeast.

Limitations of the map

Because shallow groundwater flow is primarily perpendicular to the lines of equal water-table elevation, this map shows a generalized picture of the direction of shallow groundwater flow. "Shallow" refers to depth below the water table, and not to depth below the land surface. As stated previously, this map does not address the problem of local perched or mounded groundwater flow systems or of areas with steep vertical gradients. The accuracy of the interpretation varies throughout the study area, increasing with greater data density, and decreasing with greater hydrogeologic complexity. The water-table elevation lines are solid where enough data are available to enable the lines to be located with a reasonable degree of confidence. The horizontal position of the line is believed to be accurate to within ±0.3 mile. The lines are dashed where reliable data are less abundant. Their horizontal position is believed to be accurate to within ±0.8 mile.



Explanation

- average elevation of water table in feet, solid where believed accurate within ±0.3 mile on the land surface; dashed where believed accurate within ± 0.8 mile on the land surface; 20-ft contour interval. Datum is mean sea level.
- surface-water divide
- groundwater divide, approximately located
- general direction of shallow groundwater flow
- Rock Elm Disturbance, boundary after Cordua (1987)
- ● bedrock well, based on Department of Natural Resources Well Constructor's Report on file at the Wisconsin Geological and Natural History Survey
- ○ sand and/or gravel well, based on Department of Natural Resources Well Constructor's Report on file at the Wisconsin Geological and Natural History Survey

Data have not been field checked. Water-table elevation data were generalized from information collected over a period of approximately 50 years.

It was beyond the resources of this study to field check the locations and water levels given on the Department of Natural Resources well constructor's reports that were used to construct this map. This map is a summary of available water-level data for Pierce County. It is intended for use at the published scale of 1:100,000, but should not be considered definitive for site-specific applications.

Sources of data

Cordua, W.S., 1987, The Rock Elm Disturbance, Pierce County, Wisconsin, *in* Balaban, N.H., ed., Field trip guidebook for the Upper Mississippi Valley Minnesota, Iowa, and Wisconsin: Minnesota Geological Survey/University of Minnesota Guidebook Series No. 15, p. 123-152.

United States Geological Survey quadrangles (7.5-minute series, topographic; 1967-74)

Water-level observation wells from the Groundwater Level Monitoring Network operated and maintained by the United States Geological Survey and Wisconsin Geological and Natural History Survey

Wisconsin Department of Natural Resources well constructor's reports (1936-87)

Wisconsin Geological and Natural History Survey published and unpublished geologic logs (1896-1989)

Scale 1:100 000

KILOMETRES

MILES

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Miscellaneous Map 31