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SENSITIVITY OF THE PRAIRIE DU CHIEN–JORDAN AQUIFER TO POLLUTION

By

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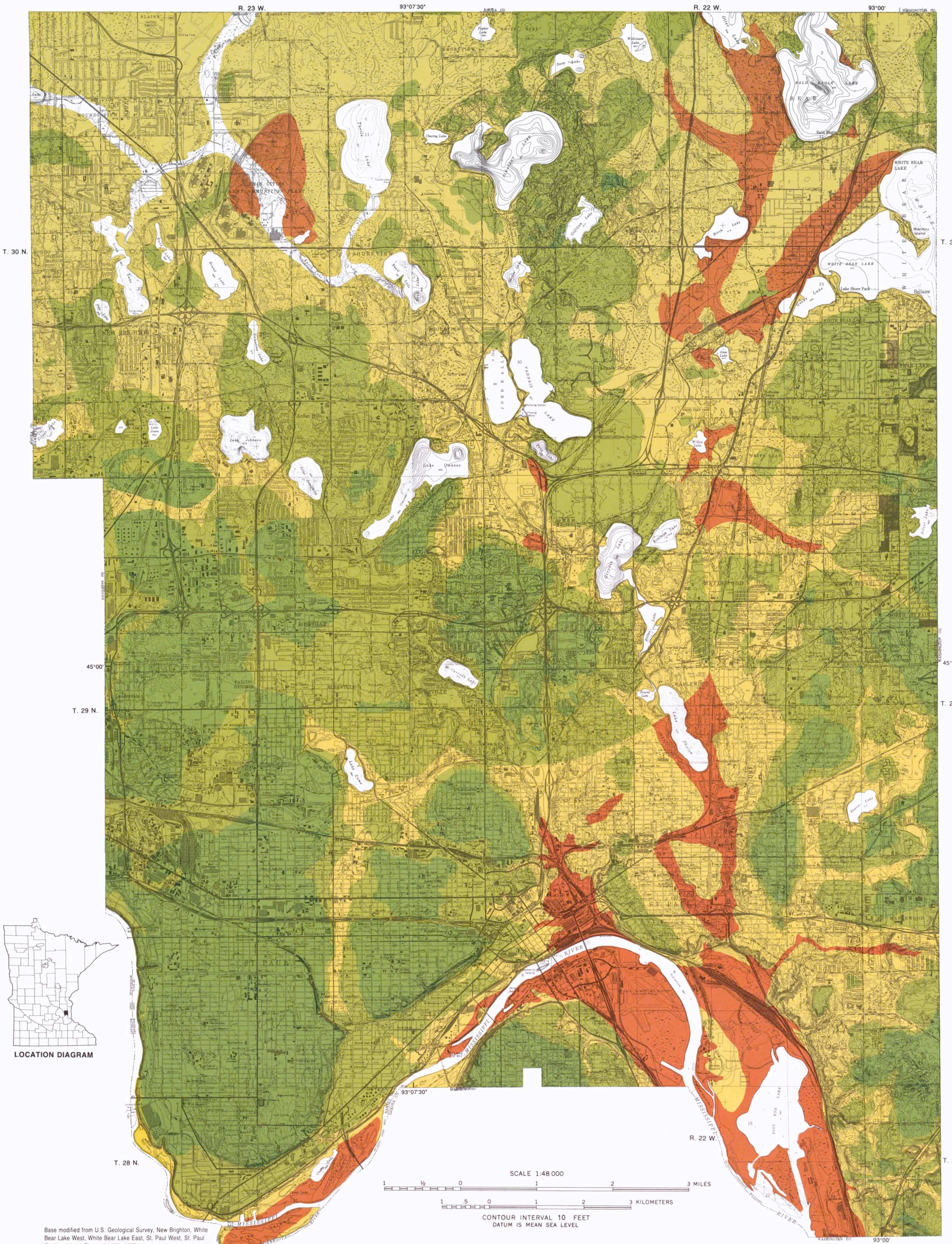

Cartography by Philip Heywood

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SENSITIVITY RATINGS

Estimated travel time for water-borne contaminants at the land surface to reach the Prairie du Chien–Jordan aquifer

H — **High** — Weeks to years

M — **Moderate** — Years to decades

L — **Low** — Decades to a century

VL — **Very low** — More than a century

Not rated — Includes area where the first bedrock is the St. Lawrence Formation or the Franconia Formation, larger lakes, and the Mississippi River

ASSESSING THE SENSITIVITY OF THE PRAIRIE DU CHIEN–JORDAN AQUIFER TO POLLUTION

The relative time for water-borne contaminants to travel from the land surface to the Prairie du Chien–Jordan aquifer was estimated by considering the number and effectiveness of bedrock confining units between it and the land surface at any point, the depth to bedrock (Plate 5), and the composition of overlying unconsolidated deposits.

Several bedrock confining units provide geologic protection from contamination (Fig. 1). The Decorah Shale is the most effective bedrock confining unit over the Prairie du Chien–Jordan. However, as the Decorah is present only in some areas of southeastern and southwestern Ramsey County, it does not protect the entire aquifer. Next in degree of effectiveness is the shale of the Glenwood Formation, which extends through parts of southwestern, east-central, and central Ramsey County. The basal part of the St. Peter Sandstone, a series of nearly continuous (in Ramsey County), overlapping shale and siltstone beds, is the least effective bedrock confining unit, because the St. Peter is cut by numerous ancient and recent valleys, and the beds may be offset in places by faulting (see Plate 5, Confining units of the St. Peter Sandstone, for further information).

The bedrock confining units above the Prairie du Chien–Jordan aquifer were arranged into three groups, as shown in the matrix. Each group was assigned an initial sensitivity rating based on its permeability (see Plate 8 for a discussion of porosity and permeability). The rating for each group was then adjusted according to the type and thickness of the Quaternary deposits overlying bedrock. Increasing thickness of unconsolidated deposits provides increasing aquifer protection. Materials consisting mainly of clay substantially increase aquifer protection. Sandy tills commonly add protection only if they are thicker than 50 feet. Sand and gravel add only limited protection, regardless of their thickness. Areas where all bedrock above the Prairie du Chien Group has been eroded were rated solely on the type and thickness of overlying unconsolidated deposits.

The distribution of sediments at the surface is known in detail, as described on Plate 3. However, the characteristics of the lower part of the Quaternary section are not well known. In some places, the entire section is composed of the same sediment. Typically, however, the sequence is much more complex. Subsurface information from water-well logs was used to help determine the composition of Quaternary sediments at depth. The pre-late Wisconsinan Keewatin tills (see Plate 5, Quaternary stratigraphy) also provide significant protection from contamination where present. In addition, the buried glacial aquifer (see Plate 6) indicates the presence of a Quaternary confining unit, because the differences in static water levels show a distinct hydrologic separation from the overlying water-table aquifer. It is assumed that these Quaternary confining units provide additional protection to the Prairie du Chien–Jordan aquifer.

In general, the thicker the unconsolidated deposits, the greater the protection of the Prairie du Chien–Jordan aquifer. However, each sensitivity rating represents such a broad range of travel time that, in some instances, the types of the overlying deposits and their thickness will not alter the original ratings of the bedrock confining units. The overall mapping was conducted with a conservative approach; if data were either ambiguous or sparse, a higher sensitivity rating was assigned.

Rock Unit	Hydrogeologic Properties
Quaternary deposits	Aquifer & confining unit
Decorah Shale	Confining unit
Platteville Formation	Aquifer
Glenwood Formation	Confining unit
St. Peter Sandstone	Aquifer
Shaly beds	Confining units
Prairie du Chien Group	Form a single aquifer
Jordan Sandstone	
St. Lawrence Formation	Confining unit
Franconia Formation	Form a single aquifer
Ironton, Galesville Sandstones	
Eau Claire Formation	Confining unit
Mt. Simon Sandstone	Aquifer

Figure 1. *Sequence of Quaternary and bedrock aquifers and their confining units in Ramsey County. The Platteville, St. Peter, Franconia-Ironton-Galesville, and Mt. Simon aquifers are not rated on the sensitivity map.*

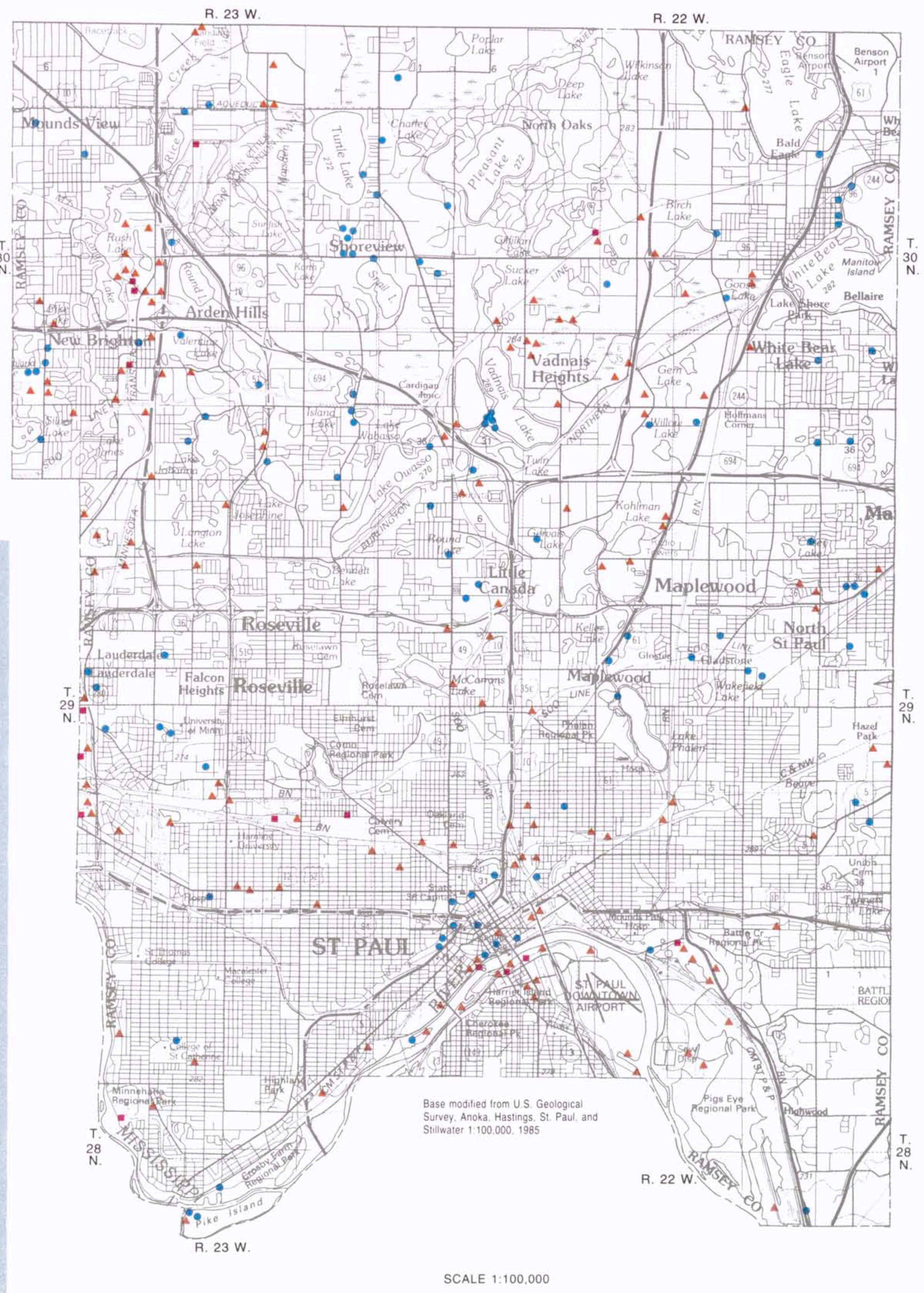
Matrix for Rating the Sensitivity of the Prairie du Chien–Jordan Aquifer in Ramsey County

Bedrock Confining Units Above the Prairie du Chien–Jordan Aquifer		Composition and Thickness of Unconsolidated Quaternary Deposits Overlying Bedrock							
		Loam to clay-loam till, clay till, lake clay *Provides greatest protection*			Sandy loam till, lake silt, colluvium *Provides moderate protection*			Sand and gravel, organic deposits *Provides minimal protection*	No Quaternary deposits *Provides no protection*
		10–50 feet	>50–100 feet	>100 feet	10–50 feet	>50–100 feet	>100 feet	10 to more than 100 feet	less than 10 feet
Decorah Shale, Glenwood Formation, basal St. Peter Sandstone	VL	VL	VL	VL	VL	VL	VL	VL	VL
Glenwood Formation, basal St. Peter Sandstone	L	L	VL	VL	L	VL	VL	L	L
Basal St. Peter Sandstone	M	M	L	VL	M	L	VL	M	M
No bedrock confining unit		M	L	VL	M	M	L	H	Not applicable

Figure 2. *Public water-supply wells in the Prairie du Chien–Jordan aquifer and sites of existing and potential ground-water contamination in Ramsey County.*

EXPLANATION

- ● Public water-supply wells in the Prairie du Chien–Jordan aquifer
- ■ Minnesota Pollution Control Agency Superfund contamination sites
- ▲ U.S. Environmental Protection Agency sites under consideration for Superfund designation



RATING THE SENSITIVITY OF OTHER AQUIFERS

The accompanying matrix can be used to estimate the sensitivity of aquifers other than the Prairie du Chien–Jordan. Aquifers above the Prairie du Chien–Jordan (Fig. 1) will have higher sensitivity ratings, and aquifers below will have lower ratings. For example, an area with a Moderate rating for the Prairie du Chien–Jordan would have a Low rating for the underlying Franconia-Ironton-Galesville aquifer and a Very Low rating for the Mt. Simon aquifer. The aquifer overlying the Prairie du Chien–Jordan, the St. Peter, would have a High rating and the uppermost bedrock aquifer, the Platteville, a Very High rating. The sensitivity of the Quaternary buried aquifer can be assessed by using the matrix and the criterion of no bedrock confining unit. Some protection is assumed for the buried aquifer, however, because its artesian condition indicates the presence of overlying deposits of low or moderate permeability.

THE POTENTIAL FOR GROUND-WATER CONTAMINATION

The water table is the first aquifer in Ramsey County's ground-water system, and in some places it is in direct connection with deeper aquifers, including the Prairie du Chien–Jordan. In many cases, protection of the water-table system is paramount to the protection of ground-water resources below it. The water–table system is predominated by areas of Very High and High sensitivity, because of the high permeability and shallow water-table depths of most of the unconsolidated surficial deposits. Across much of the county, recharge to the water-table aquifer is probably occurring at a fast rate and the travel time for a contaminant to reach the ground water is short. However, because of the urbanization of Ramsey County, the widespread construction of impervious surfaces has reduced the rate, volume, and distribution of recharge to the ground-water system. Although no longer a primary source of drinking water, the water-table aquifer is still an important water source, especially because of its connection with lakes and streams throughout the county.

The Prairie du Chien Group and Jordan Sandstone combine hydrologically to form the most important aquifer in Ramsey County. High sensitivities tend to be in buried valleys eroded into the Prairie du Chien; Low and Very Low ratings are assigned where overlying bedrock confining units are intact. Most of the Prairie du Chien–Jordan aquifer has Moderate and Low sensitivity ratings. This degree of protection bodes well for the county's most heavily used ground-water source. However, most of these well-protected areas are in parts of southwestern, central, and west-central Ramsey County, where the Prairie du Chien–Jordan is not a major source of drinking water. The northern part of the county, which relies heavily on the aquifer for residential water supply, is significantly more sensitive to contamination. Pollution has occurred in the past and could occur in the future if sources of ground-water contamination are not controlled.

In some parts of the county, there are no bedrock or Quaternary confining units above the Prairie du Chien–Jordan aquifer. Such areas are mostly along deep buried bedrock valleys that are filled with highly permeable sand and gravel. The Grantsburg till is thin or absent over some of the higher parts of the county, leaving unprotected places like the Twin Cities Army Ammunition Plant in northwestern Ramsey County (see Plate 3, Surficial geology). The absence of Grantsburg till allows contaminants to enter the underlying Prairie du Chien–Jordan aquifer, and, even more critically, allows contaminants to migrate vertically through permeable deposits and then to travel laterally to areas less sensitive to vertical contamination.

The Phalen channel, the largest buried valley in northwestern Ramsey County, also affects ground-water sensitivity. The Prairie du Chien Group and Jordan Sandstone compose the valley walls. Because the two units were above the water table during valley formation, they were probably subjected to erosion and leaching, which increased their permeability (Thiel, 1944). The Quaternary deposits that now fill the valley are a mixture of sediments, including highly permeable sand and gravel. Aquifer pumping tests indicate that recharge to the Prairie du Chien–Jordan is probably faster along the valley than in surrounding areas. There is probably a greater potential for aquifer contamination within and adjacent to the valley.

The sensitivity maps for the Prairie du Chien–Jordan aquifer and the water-table system (Plate 8) are important tools for protecting the quality of ground water in Ramsey County. They serve as warning signs and help to identify areas where special precautions may be needed to protect aquifer resources and act as screening tools for making land-use decisions. Areas with Very High and High ratings should be given special attention; certain land uses and pollution-causing activities should be strictly regulated or, in some cases, banned in these areas. Areas of Very Low and Low sensitivity are a lower priority for pollution concerns; such areas may be suitable for hazardous land-use activities.

The potential for aquifer contamination does not depend solely on geologic sensitivity. The likelihood of pollution relates to many factors, including the presence of potential contamination sources, and whether such sources are properly managed. When combined with other ground-water information, the sensitivity maps can be used to assess the type and degree of ground-water protection needed throughout the county.

Figure 2 shows locations of municipal and other public-supply wells pumping water from the Prairie du Chien–Jordan aquifer. A comparison of the well locations with the sensitivity map shows that the wells are in several sensitivity settings. Precautions should be taken where wells are in areas of High and Moderate sensitivity, such as developing special zoning ordinances, requiring permits to handle hazardous materials, and delineating protected areas around water-supply wells. In areas of Low sensitivity, a thorough search for abandoned wells would be one step to prevent possible future contamination.

Existing and potential pollution sources, documented by the Minnesota Pollution Control Agency and the U.S. Environmental Protection Agency, are widespread throughout the county (Fig. 2). Thousands of underground storage tanks and other common sources of hazardous waste also exist within the county. The possibility of even more undocumented contamination sources is of concern. Many potential sources are in High-sensitivity areas and close to water-supply wells. However, there are potential sources in areas with every sensitivity rating; thus, no part of the county is immune from the threat of contamination.

The expense and legal liabilities associated with remediating a ground-water contamination site far exceed those of proper management of environmentally hazardous materials. There is a need for a county-wide inventory of all potential contamination sources. Even more important is the need to develop controls to monitor and regulate activities that cause ground-water pollution. Ground-water protection requires a coordinated effort on both the local and regional levels.

The Prairie du Chien–Jordan is a vital aquifer in Ramsey County for water supply. Several municipalities, residential areas, and industries use the Prairie du Chien–Jordan and other aquifers for drinking water and other uses. The information in this atlas is intended to aid wise management and planning decisions. Ground-water contamination is often foreseeable and preventable. Identifying sensitive geologic areas is one method of protecting this essential natural resource.

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