

Hydrochemical Regions of Similar Water Quality in the Glacial Aquifer, Northern United States

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Abstract

The Glacial aquifer covers a large area of the United States from Maine to Alaska and from Canada to Kentucky. Materials that compose the aquifer were deposited by various advances and retreats of glaciers in the northern United States over the last 1 or 2 million years. This large aquifer contains areas of varying characteristics including natural vulnerability, intrinsic susceptibility, and hydrogeologic conditions. The natural vulnerability of the aquifer may be affected by the source of the glacial materials whereas the intrinsic susceptibility is most related to the coarse- or fine-grained texture of surficial materials. The areas of similar hydrogeologic conditions are broadly categorized as buried sand-and-gravel deposits in bedrock valleys and the more continuous layers and lenses within the surficial glacial drift. These three characteristics (natural vulnerability, intrinsic susceptibility, and hydrogeologic conditions), in combination, contribute to the variability in water quality across the Glacial aquifer.

As part of the U.S. Geological Survey's National Water-Quality Assessment Program, ground-water-quality data were collected at over 1,700 domestic, public, and monitoring wells from representative parts of the Glacial aquifer. Statistical analysis of these data shows the variability of water quality in the Glacial aquifer, which can be divided spatially into various hydrochemical regions by grouping areas with similar water quality. Principal components analysis and correlation analysis indicate that some water-quality constituents may contribute to most of the variability. These constituents include the major ions--magnesium, fluoride, calcium, nitrate plus nitrite, silica, and sulfate; the trace elements--iron, manganese, uranium, arsenic, and nickel; and dissolved oxygen. Sites with similar water quality were grouped together using cluster analysis (a statistical method that groups data to maximize the between-group variability and minimize the within-group variability). After validating the groups that resulted from cluster analysis, kriging, a geostatistical technique, was utilized to create hydrochemical regions based on the spatial distribution of the groups. Discriminant analysis was used on the hydrochemical regions to identify geologic and environmental factors that may contribute to the spatial variability of water quality in the Glacial aquifer.

The hydrochemical regions spatially define areas of similar ground-water quality across the Glacial aquifer. Understanding the water-quality differences in the Glacial aquifer and knowing the geologic and environmental factors that affect the spatial variability will help in facilitating the transferability of this information to other water-quality studies.

Biographical Sketches

Terri L. Arnold is the GIS Specialist for the U.S. Geological Survey, National Water-Quality Assessment (NAWQA) Program's Upper Illinois River Basin Study Unit. She received her BS in Geography from the University of Illinois. Her responsibilities include spatial and geostatistical analysis and mapping of water samples and environmental data.

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George E. Groschen attended the University of Minnesota, and received a MSc. in 1981. He has worked for the U. S. Geological Survey for 26 years. Research interests in water resources are aqueous geochemistry and contamination. Since 1994 he has been in Urbana, Illinois as the chief of the Lower Illinois River Basin NAWQA study. In 2001 he also became chief of the Upper Illinois River Basin study.

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Stephen J. Kalkhoff has been investigating the occurrence, distribution, and transport of nutrients and pesticides in ground and surface water in Iowa since 1986. Since 1994, he has been the project chief of the Eastern Iowa Basins Study Unit of the NAWQA Program. In addition to analysis and interpretation of water-quality data, current duties include planning, budgeting, and supervising ongoing NAWQA studies in Iowa.

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