TITLE: Evaluation of the confining properties of the Maquoketa Formation in the SEWRPC region of Southeastern Wisconsin

PERIOD OF CONTRACT: July 1, 1997 - August 31, 1998

INVESTIGATORS: Timothy T. Eaton and Kenneth R. Bradbury, Wisconsin Geological and Natural History Survey

PROJECT I.D.: DNR Project # 139

BACKGROUND/NEED: The Maquoketa Formation is the most important aquitard in Wisconsin and it isolates the heavily-used upper Silurian dolomite aquifer from the lower Cambrian-Ordovician "sandstone" aquifer in southeastern Wisconsin. A historic reversal in hydraulic gradient across this confining unit makes its role as a protective cover for the sandstone aquifer very important. A multi-year study of the hydrogeology of the SEWRPC area, including the construction of a 3-dimensional groundwater flow model, will require the determination of the hydraulic parameters of the Maquoketa,which has received little study in the past. Previous estimates of these parameters have not involved any fieldwork, and the basic lithology of the formation was not very well known, since no core samples were available south of Fond du Lac.

OBJECTIVES: The objectives of this project were to obtain reliable estimates of hydraulic properties, flow rates and leakage of the shale; to characterize stratigraphy based on core study and downhole geophysical logging; to analyze porewater geochemistry, and to estimate flow rates using naturally-occurring isotopes of hydrogen and oxygen.

METHODS: Two field sites were selected in Waukesha County, and coreholes were drilled through the Maquoketa Formation in fall 1997 and spring 1998, recovering a complete set of core at each site. These cores were fairly similar and a detailed description was made of one of them. Complete suites of geophysical logs were taken, which were used to design a packer and monitoring system for the corehole at one site: Minooka County Park.

Hydraulic head was continuously monitored at six different intervals in the Minooka Park corehole and water samples were collected for geochemical and isotopic analysis in spring and summer of 1998. Drawdown and recovery, caused by pumping the porewater samples from each interval, was monitored and analyzed to obtain hydraulic parameters for each interval. Lithology from core study, downhole geophysical logs and hydraulic parameters were correlated for the Minooka Park corehole.

RESULTS AND DISCUSSION: Downhole geophysical logs show the Maquoketa to be remarkably uniform within the area of the two field sites, with thesame vertical distribution of lithologies and two prominent horizontal fracture zones in the upper half of the formation. Heat©pulse flowmeter logging shows the fracture zones at the Minooka Park site to be much more important flow features than at the DOT site. The upper 2/3 of the formation consists of interbedded dolomite and mudstone or siltstone, with a sulfide-rich middle bed in which tar was observed. The lower third of the formation is very fine greenish-gray shale.

The vertical distribution of horizontal hydraulic conductivity ranges over five orders of magnitude, from 1.7E-9 ft/s inthe lower shale to 8.5E-5 ft/s in the interbedded dolomite and siltstone. Some of the higher values were attributed to fracture permeability in two intervals.

Estimates of composite vertical hydraulic conductivity for the Maquoketa Formation, using reasonable values of anisotropy, ranged from 4.9E-12 ft/s to 9.5E-12 ft/s and pore velocities ranged from 4.2E-10 ft/s to 8.1E-10 ft/s. Geochemistry of the porewater in the Maquoketa Formation differs significantly from that of

the groundwater in the overlying Silurian aquifer. The Maquoketa contains significantly more calcium, sodium, bicarbonate and strontium, and is more saturated in CO2. No trace constituents were found to exceed Wisconsin drinking water standards. Deviations in concentrations of major ions, indicator parameters and isotope results were found at the level of one of the horizontal fracture zones.

CONCLUSIONS/IMPLICATIONS/RECOMMENDATIONS: New information on the lithology, downhole geophysical signature, hydraulic properties and geochemistry of the Maquoketa Formation in southeastern Wisconsin has been obtained by fieldwork at two sites in Waukesha County, from detailed study of recovered core, and geochemical and isotopic analysis of sampled porewater. Lithology is remarkably similar between the two sites and vertical lithological variations correspond to a range of measured hydraulic conductivities over 5 orders of magnitude throughout the thickness of the formation. This heterogeneity in hydraulic properties is due partly to prominent horizontal fracture features, but these appear to be significant flow features at only one of the two sites.

Geochemical and isotopic trends vertically through the formation imply long residence times, and slow downward flow. The distribution of measured heads indicates a significant contrast in confining properties with the underlying Sinnipee Group dolomite, where heads were several hundred feet lower. However, significant deviations in geochemical and isotopic trends at the level of a horizontal fracture feature show that preferential fracture flowpaths may be locally important. Ongoing investigations by various investigators will add to our knowledge of the sedimentology and hydraulic properties of this very important regional confining unit.

RELATED PUBLICATIONS: Wisconsin Geological and Natural History Survey Open-File Report 98-11

FUNDING: Funding was provided by the Wisconsin Department of Natural Resources

FINAL REPORT: A final report containing more detailed information on this project is available for loan from Wisconsin's Water Library, University of Wisconsin -Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262©3069