Title: **Monitoring and Predictive Modeling of Subdivision Impacts on Groundwater in Wisconsin**

Project ID: DNR Project # 178

Investigators: Dr. Kenneth R. Bradbury, Hydrogeologist/Professor, Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension

Dr. Jean M. Bahr, Professor, Department of Geology & Geophysics, University of Wisconsin – Madison

Jeffrey D. Wilcox, Research Assistant, Department of Geology & Geophysics, University of Wisconsin, Madison

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Background/Need: Population growth and urban expansion near many Wisconsin cities has resulted in residential development on agricultural land in rural areas. While developments closer to urban centers typically use city water and sewer services, rural developments usually rely on private wells and septic systems. Septic tank and leach field treatment of wastewater can release contaminants including nitrate, bacteria, viruses, and household chemicals to the subsurface; at the same time, rural residents depend upon groundwater for a clean, reliable drinking-water source. In some areas, zoning ordinances discouraging unsewered residential development – or prohibiting them altogether – have been passed by local officials concerned about groundwater quality. However, there is currently little information available about the long-term impact of unsewered residential use on groundwater quality and quantity.

Objectives: The goals of this project were to collect groundwater quality and water-level data at a developing subdivision near Madison, WI, and use the data to draw preliminary conclusions and construct predictive groundwater flow models to assess subdivision impacts.

Methods: This project required collecting water samples, analyzing water-level fluctuations and rainfall/runoff relationships, and developing computer models in order to identify the effects of subdivision development on groundwater quantity and quality and predict future impacts under different development scenarios.

Results and Discussion:

Nitrate concentrations decreased in shallow groundwater beneath the subdivision site after agricultural loading sources were removed, and a mass balance model showed that nitrogen loading from septic systems may be similar, or even less than during previous agricultural land use. Acetaminophen, a caffeine metabolite, two hormones, and elevated concentrations of nitrate and chloride were detected in septic effluent, and nine of ten septic samples contained estrogenically-active compounds. No target organic compounds or estrogenicity have been detected in groundwater at the site, but the possibility of future detections cannot be ruled out at this

point. Flow through the recently-installed drainage basins and a subsurface drain tile responds rapidly to storm events and to spring snow melt. We estimate a 10% decrease in annual recharge across the site due to the diversion of precipitation and snow melt as surface drainage.

Groundwater modeling shows that drinking-water wells may pump at least some water that was recharged within the subdivision boundaries. Well location, well depth, and the vertical conductivity of soil or bedrock at the site play a significant role in determining whether septic plumes will intersect the open borehole of a drinking-water well. Net transfer of water from deeper to shallow aquifers occurs when water pumped at depth is recharged as septic effluent to the vadose zone. Model simulations indicate that switching from shallow individual wells to deep community water-supply wells would have little impact on groundwater levels across the site. From a water-quality standpoint, municipal or community wells may be preferable because these wells can be drilled deeper than is economically feasible for most individual homeowners. Finally, we found that seasonal and year-to-year variations in recharge have much more impact on groundwater levels in this area than any changes caused by residential development.

Conclusions/Implications/ Recommendations:

For this study, we monitored water quality and quantity at a developing rural subdivision site in south-central Wisconsin and constructed groundwater flow models to simulate the effects of subdivision development on groundwater. Data collected thus far do not indicate that the subdivision will significantly affect regional groundwater quality or quantity relative to predevelopment conditions, but groundwater monitoring should continue at the site as more homes are built and septic systems come into use. On a more local scale, septic effluent plumes could eventually intersect the open borehole of nearby water-supply wells within the subdivision. Additional research focusing on processes affecting contaminant mobility – including denitrification, sorption, and microbial degradation – in the unsaturated and saturated zones beneath septic systems would be useful for improved assessment of drinking-water quality in unsewered areas.

Related Publications:

Wilcox, J.D., K.R. Bradbury, C.L. Thomas, and J.M. Bahr, 2005, Assessing background ground water chemistry beneath a new unsewered subdivision: Ground Water, vol. 43, no. 6, *(in press)*.

Key Words: Subdivisions, septic systems, nitrate, pharmaceuticals, hormones, groundwater modeling

Funding: 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.