NAWQA NEWS
National Water-Quality Assessment Program

WESTERN LAKE MICHIGAN DRAINAGE BASIN

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focus on
GROUND WATER

Ground-Water Studies

The Western Lake Michigan Drainages (WMIC) study unit of the National Water-Quality Assessment (NAWQA) Program encompasses an area of about 20,000 square miles in eastern Wisconsin and the Upper Peninsula of Michigan (fig. 1). The ground-water component of the WMIC study includes analysis of existing data, and collection and analysis of data at three spatial scales.

Analysis of existing ground-water data resulted in the publication of three retrospective reports (Robertson and Saad, 1996; Saad, 1994; and Matzen and Saad, 1996) which summarize the nutrient and pesticide data collected in the study area. Collection and analysis of ground-water data in the study unit by the WMIC study unit team began in 1993. The NAWQA design for examining ground-water quality includes flowpath studies, land-use studies, and study-unit surveys (Gilliom and others, 1995). Flowpath studies are generally small in scale (fewer than 10 square miles) and are designed to examine ground-water quality along inferred flowpaths and interactions of ground and surface water. Land-use studies are intermediate in scale (several hundred to several thousand square miles) and are designed to examine natural and human factors that affect shallow ground-water quality in areas characterized by specific land use. Study-unit surveys are designed to provide an indication of water-quality conditions in the major aquifers or defined hydrogeologic settings in the study unit and typically cover an area ranging from several thousand to tens of thousands of square miles.

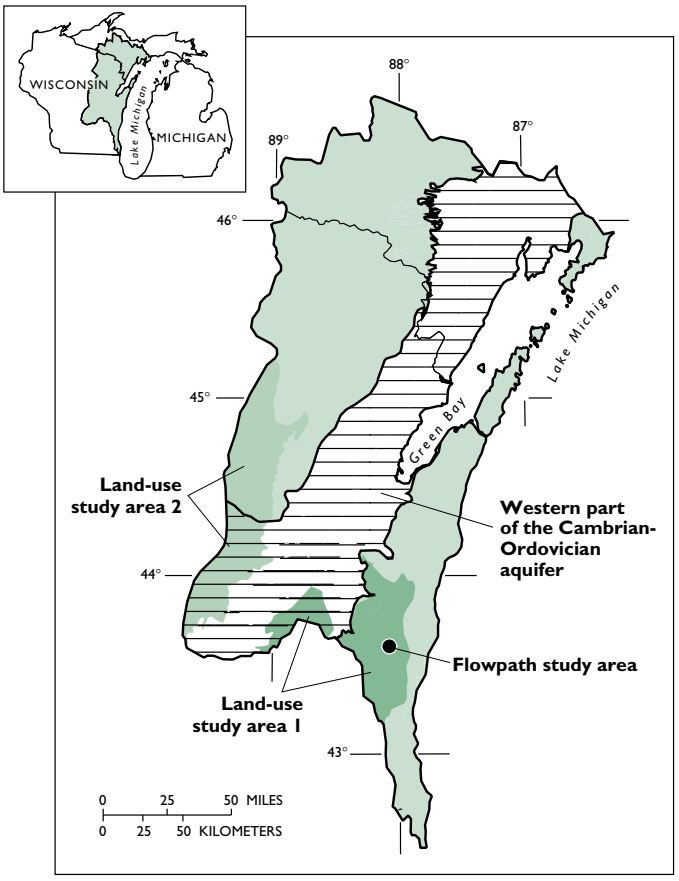

Figure 1. *Location of study unit survey, land-use studies and flowpath study area within the Western Lake Michigan Drainages study unit.*

Study-Unit Survey

The study-unit surveys for the WMIC were divided into three subunit surveys corresponding to the 3 major aquifers in the study unit, the sand and gravel aquifer, the Silurian-Dolomite aquifer, and the Cambrian-Ordovician aquifer. The first aquifer to be examined as part of the study-unit surveys was the Cambrian-Ordovician aquifer. The Cambrian-Ordovician aquifer underlies the eastern two-thirds of the study unit and, where it is sufficiently thick, can produce large yields of water. For this reason, it is the most used aquifer in the study unit and accounts for about 40 percent of the ground-water use. The western part of the aquifer (fig. 1) was further targeted for study because few wells exist in the eastern part where it is overlain by more readily accessible aquifers. Ground-water samples from domestic, institutional, and public-supply wells were collected during the summer of 1995 from 29 wells in the western part of the Cambrian-Ordovician aquifer. Analyses of ground-water samples from these wells were used to provide an indication of water-quality conditions in this heavily used part of the aquifer. Ongoing data collection efforts during the low-intensity phase (1997–2001) and the next high intensity phase (2002–04) will be used to define any trends in water-quality that may exist.

Ground-water samples were analyzed for major ions, nutrients, dissolved organic carbon, pesticides, volatile organic compounds, radon-222, and tritium, as well as field measurements of temperature, pH, specific conductance, dissolved oxygen, and bicarbonate. The results of water-quality analyses (Saad, 1996a) indicate that where the Maquoketa-Sinnipee confining unit overlays the study area relatively high concentrations of dissolved solids (up to 2,800 mg/L) and relatively lower concentrations and fre-

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quency of detections of nitrate and pesticides occur. The water from the study area is a calcium-magnesium-bicarbonate type. High sulfate concentrations exist where the aquifer is regionally confined. Radon was detected in all samples and two thirds of the wells had concentrations exceeding the USEPA proposed maximum contaminant level of 300 pCi/L. The highest nitrate concentrations were detected in samples from the agricultural southwestern part of the study area from relatively shallow wells that produced modern water (recharged since 1955). Seven pesticides were detected in ground water samples, and at least one pesticide was detected in seven of the wells. Most of the pesticides were detected in low concentrations. Atrazine was the most commonly detected pesticide.

Land-Use Studies

Agricultural effects on shallow ground-water quality was the focus of the first land-use studies in the WMIC. Water-quality and geohydrologic data were collected between September, 1993 and September, 1994 from 56 wells and 2 springs, in two agricultural areas in the study unit. These data were used to study the effect of land use and geohydrology on shallow groundwater quality. The two areas chosen for study had similar agricultural land uses but different geohydrologic characteristics. Water samples were analyzed for the same constituents as the study-unit-survey wells in addition to oxygen and hydrogen isotopes, uranium, and chlorofluorocarbons. Slug tests were performed on most of the wells to estimate hydraulic conductivity of the surficial deposits in the vicinity of the well.

Sampled wells and springs were located down gradient from farm fields having similar crop-rotation patterns, mainly corn and alfalfa. Area 1 is characterized by sand and clay surficial deposits overlying carbonate bedrock, and area 2 by sand and gravel deposits overlying sandstone or crystalline bedrock. The depth to water was significantly deeper and hydraulic conductivity significantly higher in area 2.

Results of water-quality analyses indicate that agricultural land use has affected the groundwater quality of the study areas, however, Wisconsin ground-water-quality enforcement standards were exceeded in only 22 percent of samples for dissolved nitrate and 2 percent of samples for dissolved atrazine and its breakdown products. The more permeable and lower organic matter content of surficial deposits in area 2 resulted in significantly higher concentrations of dissolved nitrate and atrazine and its breakdown products in shallow ground water than area 1. Ground-water recharge dates (estimated using chlorofluorocarbons and trium) showed that historic patterns of atrazine concentrations in ground water mimic historic patterns of atrazine use on corn.

Flow-Path Study

The focus of the flow path study was to determine changes in nutrients and pesticides along a ground-water flow path in an agricultural area. Water samples were collected and analyzed in 1994 and 1995 from 8 wells, 8 suction lysimeters, and 8 minipiezometers located along a 2,500-ft transect from near a local ground-water divide to the North Branch Milwaukee River in Sheboygan County, Wisconsin (fig. 1). Water samples were analyzed for the same constituents as the land-use wells (except samples were not collected for volatile organic carbon, radon-222 and uranium). Additionally, nitrogen isotope and gas composition samples were collected. The wells and lysimeters were located at three sites along the length of the transect (UW, MW, and DW). The minipiezometers (MP) were installed in the stream bottom at four locations at the downgradient end of the transect. The land use and land cover both change along the length of the transect. The upgradient area of the transect is farmed in a 2-4 year rotation of alfalfa, corn and oats and is the only part of the transect where pesticides have been applied. The middle part of the transect is mainly used to grow alfalfa and has had no pesticide applications for over thirty years. The down gradient part of the transect is unused lowland covered with grasses and small trees (fig. 2).

Results of analyses show that phosphorous concentrations are low everywhere, and that nitrogen occurs in several forms, differing horizontally and vertically along the transect. Nitrogen and Oxygen isotope analyses indicate that nitrogen probably comes from a combination of several sources (fertilizer, nitrification of soil ammonium and animal waste). The pesticide atrazine and its metabolite (deethyl atrazine) were found throughout the transect even though they have only been applied at the upgradient end of the transect.

Ground-water flow and geochemical modeling is currently being done to better define the flowpath and the mechanisms for flow and transport along this transect.

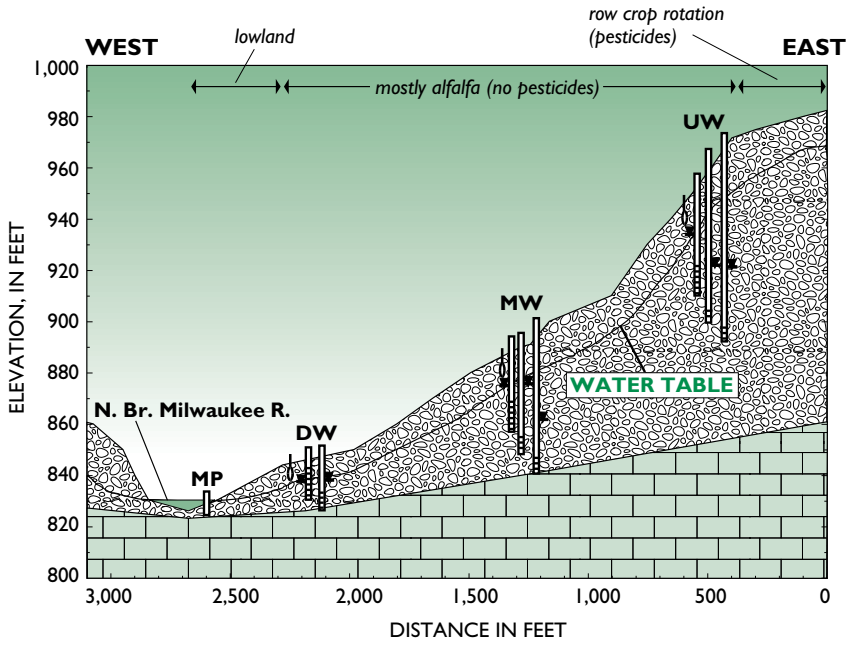

Figure 2. *Cross-section at flow-path study area.*

Study Unit Publications

The ground water component of NAWQA will be described in national, regional, and study unit reports. The focuses of the national reports are study design, methods protocols and compilations of results from NAWQA study units. The regional reports will summarize findings from a number of study units on specific regional issues and the WMIC study unit reports will summarize results associated with the basin-wide ground water effort.

Below is a list of published and planned reports for the WMIC study unit, followed by a list of some of the reports published at the national level.

Published Ground-Water Reports

Matzen, A.M. and Saad, D.A., 1996, Pesticides in Ground Water in the Western Lake Michigan Drainages, Wisconsin and Michigan, 1983-1995: Fact Sheet 192-96. 4 p.

Robertson, D.M., and Saad, D.A., 1996, Water-Quality Assessment of the Western Lake Michigan Drainages - Analysis of Available Information on Nutrients and Suspended Sediment, Water Years 1971-90: Water- Resources Investigations Report 96-4012. 165 p.

Saad, D.A., 1994, Nitrate in Ground Water in the Western Lake Michigan Drainage Basin, Wisconsin and Michigan: Fact Sheet 070-94, 2 p.

Saad, D.A., 1996a, Ground-Water Quality in the Western Part of the Cambrian-Ordivician Aquifer in the Western Lake Michigan Drainages, Wisconsin and Michigan: Water-Resources Investigation Report 96-4231, 40 p.

Saad, D.A., 1997, Effects of Land Use and Geohydrology on the Quality of Shallow Ground Water in Two Agricultural Areas in the Western Lake Michigan Drainages, Wisconsin, U.S.Geological Survey Water-Resources Investigations Report 96-4292, 69 p.

Published Abstracts

Saad, D.A., 1994, A Comparison of Nitrate Concentrations in Ground Water and Surface Water of the Western Lake Michigan Drainages Study Unit, (abstract): American Water Resources Association —Wisconsin Section annual meeting, p. 16

Saad, D.A., 1995, Nutrients and Pesticides in Ground Water of Two Agricultural Land Use Areas in the Western Lake Michigan Drainages NAWQA Study Unit, (abstract), American Water Resources Association - Wisconsin Section annual meeting, p. 32

Saad, D.A., 1996b, Using Chlorofluorocarbons to Determine the Recharge Date of Shallow Ground Water in the Western Lake Michigan Drainages, Wisconsin and the Upper Peninsula of Michigan, (abstract): American Water Resources Association —Wisconsin Section annual meeting, p. 52

Ground-Water Reports Published by National NAWQA

Alley, William M., and Cohen, Philip, A Scientifically based Nationwide Assessment of Ground-Water Quality in the United States, 28th International Geological Congress, Washington, D.C., July 10, 1989, 21 p.

Barbash, J.W., and Rezek, E.A., 1995, Pesticides in Ground Water, U.S. Geological Survey Fact Sheet -244-95, 4 p.

Delzer, Gregory C., Zogorski, John S., Lopes, Thomas J., and Bosshart, Robin L., 1996, Occurrence of the Gasoline Oxygenate MTBE and BTEX Compounds in Urban Stormwater in the United States, 1991-1995, Water-Resources Investigations Report 96-4145, 6 p.

Gilliom, Robert J., Alley, William M., and Gurtz, Martin E., 1995, Design of the National Water-Quality Assessment Program: Occurrence and Distribution of Water-Quality Conditions, U.S.Geological Circular 1112, 33 p.

Koterba, Michael T., Wilde, Franceska D., and Lapham, Wayne W., 1995, Ground-Water Data-Collection Protocols and Procedures for the National Water-Quality Assessment Program: Collection and Documentation of Water-Quality Samples and Related Data, Open-File Report 95-399, 113 p.

Lapham, Wayne W., Wilde, Franceska D., and Koterba, Michael T., 1995, Ground-Water Data-Collection Protocols and Procedures for the National Water-Quality Assessment Program: Selection, Installation, and Documentation of Wells, and Collection of Related Data, Open-File Report 95-398, 69 p.

Lapham, Wayne W., 1996, Plan for Assessment of the Occurrence, Status, and Distribution of Volatile Organic Compounds in Aquifers of the United States, Open-File Report 96-199, 44 p.

Mueller, David K., Hamilton, Pixie A., Helsel, Dennis R., Hitt, Kerie J., and Ruddy, Barbara C., 1995, Nutrients in Ground Water and Surface Water of the United States — An Analysis of Data through1992, Water-Resources Investigations Report 95-4031, 74 p.

Nolan, Bernard T., Ruddy, Barbara C., 1996, Nitrate in Ground Waters of the United States — Assessing the Risk, Fact Sheet 092-96, 4 p.

Raese, Jon W., Rose, Donna L., and Sandstrom, Mark W., 1995, U.S. Geological Survey Laboratory Method for Methyl tert-Butyl Ether and Other Fuel Oxygenates, Fact Sheet 219-95, 4 p.

Squillace, Paul J., Zogorski, John S., Wilber, William G., Price, and Curtis V., 1995, A Preliminary Assessment of the Occurrence and Possible Sources of MTBE in Ground Water of the United States, 1993-1994, Open-File Report 95-456, 16 p.

Squillace, Paul J., Price, Curtis V., 1996, Urban Land-Use Study Plan for the National Water-Quality Assessment Program, Open-File Report 96-217, 19 p.

Squillace, Paul J., Pankow, James F., Korte, Nic E., and Zogorski, John S., 1996, Environmental Behavior and Fate of Methyl tert-Butyl Ether (MTBE), Fact Sheet 203-96, 6 p.

Where to Find NAWQA Reports

Western Lake Michigan Drainages ground water reports can be obtained from:

District Chief
U.S.Geological Survey
6417 Normandy Lane
Madison,WI 53719
(608) 276-3815

or can be found on the WMIC NAWQA home page on the internet at:

http://wwwdwimdn.er.usgs.gov/nawqa/index.html

National NAWQA Ground Water reports can be obtained from:

U.S.Geological Survey
Earth Science Information Center
Open-File Reports Section
Box 25286, MS 517
Denver Federal Center
Denver, CO 80225
(303) 236-7476

or can be found on the National NAWQA home page on the internet at:

http://wwwrvares.er.usgs.gov/nawqa

Low-Intensity Phase

The low-intensity phase of the WMIC study unit investigation began in 1996 and will continue through 2001 (Table 1). During the low-phase, data collection activities will be significantly reduced and reports detailing the high-phase investigations will be completed. The data collection effort during the low-phase will include continued collection of surface-water samples at two or three of the Basic Fixed Sites (BFS). The two BFS currently planned for sampling are: Milwaukee River at Estabrook Park (integrator site), and Duck Creek near Howard (indicator site). The Popple River near Fence (reference site) may also be a part of the low-phase network. Low-phase sampling will include bi-monthly and storm event sampling for surface water quality (major ions, nutrients, pesticides, DOC, and field parameters). Annual ecological assessments of algae, macro invertebrate, and fish communities will be done, as will triennial sampling of bed sediment and tissues for contaminants. Additionally, a subset of the ground-water flowpath, land use and study unit survey wells, and a few "reference" wells, may be sampled for water quality (similar to the constituent list for the specific survey during high-phase) biennially.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Planning Phase	▨										▨			
Retrospective-Analysis Phase	▨	▨	▨								▨			
High-Intensity Sampling Phase			▨	▨	▨							▨	▨	▨
Reports Phase						▨	▨							
Low-Intensity Sampling Phase						▨	▨	▨	▨	▨	▨			

Table 1. *NAWQA implementation schedule*

Water-Quality Data and Publications Available on the World Wide Web

The World Wide Web home page for the Western Lake Michigan Drainages NAWQA study continues to evolve. Hopefully, these changes will continue to make the information therein more relevant and useful to users. Recent additions to the pages are designed to make our data and publications more accessible than ever.

First, a Web-accessible Oracle database has been linked to the NAWQA home page. The Oracle database is a queryable database that, when complete, will contain all the water- quality and ecological data collected during the NAWQA study. It now contains a number of tables of water-quality data, both for surface water and ground water, and more will be added as data are checked and entered. Users can select specific tables for viewing and/or downloading. In addition, with the use of SQL (simple query language) commands, users can select parts of one or more tables for customized data selection. Instructions for using SQL commands are included on the NAWQA web pages.

Our publications page continues to grow. New reports are put on the Web as soon as printed versions are completed. A new feature is that Fact Sheets are now available for downloading in portable document software (PDS) versions. PDS takes the original file, including graphics, tables and rich text (bold, italicized, colored text) and converts it to a specially coded file. The fidelity of the PDS file to the original is remarkable. Users with color printers can thus print out copies of fact sheets that look exactly like the original versions; those with black and white printers lose only a little detail. In the future our longer reports may also be available in PDS if demand warrants it.

The URL for the Western Lake Michigan Drainages NAWQA home page is

<http://wwwdwimdn.er.usgs.gov/nawqa/index.html>

Please send us feedback; we'd like to know if our pages can be improved and made more useful.

1997 Liaison Committee Meeting

We have decided to delay our annual liaison committee meeting until late summer so that it can be held at our new offices in Middleton, Wisconsin. We are anticipating moving from our current Madison office sometime in early summer 1997. The new location is about ten minutes from our current office, west of the beltline off University Avenue in the Middleton Industrial Park. Having the meeting at our new offices will allow us to introduce you to our new office location and facility. If you have any thoughts on the format of that meeting or specific information you would like presented, please call Charlie Peters at (608) 276-3810 or send email to capeters@usgs.gov.

This newsletter was prepared by the Western Lake Michigan Drainages study unit team. The purpose of the newsletter is to help keep the state and local water-resources community informed of our activities. The newsletter represents the views of the WMIC NAWQA team and is intended for informational purposes. It is not intended for redistribution or republication. If you would like your name added to or removed from the mailing list for this newsletter, or if you have any comments regarding this newsletter or our workplans, call Charlie Peters at (608) 276-3810, or write to: WMIC NAWQA, U.S. Geological Survey, 6417 Normandy Lane, Madison, Wisconsin, 53719 or send email to: capeters@usgs.gov

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