
Wisconsin Geological and Natural History Survey

Mapping glacial Lake Oshkosh for comprehensive land use planning

Situation

Arsenic is a natural element found throughout the world, and is particularly concentrated in Wisconsin's Fox River Valley. In 2001, the U.S. Environmental Protection Agency (EPA) cut the amount of arsenic allowed in drinking water from 50 parts per billion (ppb) to 10 ppb—a concentration similar to 10 drops of water in an Olympic-size swimming pool. EPA classifies arsenic as a carcinogen. Prolonged exposure to arsenic increases risk of skin cancer and tumors of the kidney, prostate, bladder, liver and lungs. With less arsenic allowed in drinking water, unacceptable levels of natural arsenic can be found in wells statewide. Wells with unsafe arsenic concentrations commonly contain high levels of iron, sulfate and toxic heavy metals such as cobalt, molybdenum, vanadium, cadmium, chromium, copper and nickel.

Health studies found so many contaminated wells in the Fox River Valley that the Wisconsin Department of Natural Resources (DNR) declared Outagamie and Winnebago counties through the western half of Brown County as an Arsenic Advisory Area and set protective well construction guidelines. For some owners of high-arsenic wells, a shallow well above arsenic-bearing bedrock may provide an affordable source of drinking water free of arsenic but limited in supply and vulnerable to contamination from certain land uses. Knowledge of geologic resources is critical for counties required to complete comprehensive plans by the end of the decade. County planning officials and the East-Central Wisconsin Planning Commission needed geologic information to identify and protect vulnerable water resources and plan for safe, sustainable drinking water.

Response

To meet local needs for geologic information, UW-Extension faculty at the Wisconsin Geological and Natural History Survey (WGNHS) are following a long-range plan to map the entire state, consulting annually with the Wisconsin Geologic Mapping Advisory Committee. Stakeholder advisors—U.S. Forest Service and Department of Agriculture Natural Resources Conservation Service, Wisconsin DNR and Department of Transportation, regional planning commissions, engineering consultants and construction companies—use geological maps to solve scientific and societal problems.

In the past decade, rapid development along U.S. Highway 41 from Oshkosh to Green Bay added more than 10,000 new wells in the aquifer—a geologic formation that transmits and stores groundwater. Research by UW-Extension geologists and hydrogeologists at the WGNHS found that *1 in 5 new wells* contained unsafe levels of naturally occurring arsenic. Overall, contaminated wells cluster where they have been drilled through arsenic-rich sulfide mineral pockets in the St. Peter sandstone aquifer, exposing sulfide minerals to oxygen, microbes and weathering, thus releasing arsenic and associated heavy metals into drinking water. Based on WGNHS research findings, the Wisconsin DNR now requires that wells in Winnebago and Outagamie counties be constructed above or below arsenic-bearing bedrock and according to stringent well-protection specifications.

The Wisconsin Geologic Mapping Advisory Committee affirmed the need for geologic mapping to address concerns over drinking water safety and sustainability in the Fox River Valley. For some owners of high-arsenic wells, an affordable solution may be a new well in a shallow sand and gravel aquifer above the arsenic-bearing St. Peter sandstone. To help DNR colleagues identify alternative groundwater sources, critical groundwater recharge areas, and water resources vulnerable to surface contaminants, WGNHS quaternary geologists Thomas S. Hooyer and John W. Attig collaborated with William N. Mode, chair of the UW-Oshkosh Department of Geology, to divide the region into three areas for mapping. Hooyer secured six years of research funding from the National Cooperative Geologic Mapping Program of the U.S. Geological Survey—around \$100,000 each year—and from the American Association of State Geologists to mentor undergraduate field researchers who drill bore holes, log core samples, analyze and compile data for mapping and electronic retrieval.

While the geologic Quaternary Period extends back 1.8 million years, the quaternary geologists are examining the composition and distribution of relatively recent glacial sediments in the region once occupied by a vast lake. Glacial Lake Oshkosh formed in front of the Laurentide Ice Sheet around 15,000 years ago. As climate warmed, the ice sheet receded northward and the large glacial lake emptied—leaving behind a landscape in east central Wisconsin similar to what residents see today. The geologists mapped the distribution of Ice Age sediments in and around glacial Lake Oshkosh—sand bars, shoreline features, deltas, beaches, and more than 600 sand dunes. They are also determining depths to bedrock through parts of 14 counties comprising the Fox River lowlands—from the Baraboo Hills' eastern edge in Columbia County to Green Bay's western edge in Marinette County.

Knowledge of geologic resources is critical for counties required to complete comprehensive plans by the end of the decade. Wisconsin Statutes 66.1001 require that if a town, village, city or county does official mapping, subdivision regulation, or zoning after January 1, 2010, those actions must be consistent with the community's comprehensive plan. The East-Central Wisconsin Planning Commission notes that the extent and distribution of geologic resources guides the economic development, land use, natural resources and transportation elements of comprehensive planning. For example, geologic mapping locates easily accessed construction materials so communities can choose not to build over limited supplies. Understanding the glacial deposits that overlie bedrock aquifers helps the DNR identify alternative groundwater sources. Knowing the nature of sediments over shallow aquifers indicates their vulnerability to contamination from landfills, stormwater runoff, pesticides, and nitrates from fertilizer or agriculture.

As mapping progresses, UW-Extension map makers are teaching local citizens, professionals, government planners and decision-makers about research results, implications, groundwater and non-metallic mineral resources. Since EPA lowered the arsenic limit for drinking water, Hooyer has co-lead educational field trips on Fox River Valley geology for 50 professionals of the Wisconsin Groundwater Association, for 70 soil scientists from 13 Midwest states at the North Central Region Cooperative Soil Survey Conference, for 70 people at the 65th bi-annual Tri-State Geological Field Conference, and for 15 UW-Madison graduate students. He reports on-going research results at university seminars, co-wrote a lab exercise for geology undergraduates, a research abstract on ancient hydrology of Eastern Wisconsin and a poster on Wisconsin's large glacial lakes for the Geological Society of America.

In Waushara County, Hooyer presented talks on southern county sand and gravel sources for town of Aurora board members. In Winnebago County, with UW-Extension community resource development educator Catherine Neiswender, Hooyer prepared a county map and report, wrote a guide book, initiated and co-led a field trip on geologic resources for 40 state, county and local officials, and summarized the importance of geology for county and town board members. He submitted maps to the U.S. Geological Survey, to colleagues for peer review, and for WGNHS open file reports. Outreach scholarship includes: 1) Hooyer, Thomas S., and Catherine Neiswender, 2004. *General Geology and Natural Resources of Winnebago County, Wisconsin Field Trip Guide Book*. WGNHS Open File Report 2004-03 and 2) Hooyer, T.S., J.W. Attig and Lee Clayton, 2004. *Preliminary Quaternary Geologic Map of the Central Fox River Lowlands, Wisconsin*. WGNHS Open-File Report 2004-04.

Outcomes

UW-Extension work by Hooyer with geoscience and county colleagues integrates basic and applied research, inter-agency and interdisciplinary cooperation and new GIS-based geologic mapping into educational outreach to government officials, regulators, planning commissions, educators, and citizen groups. Winnebago County geology field trip participants found the information especially useful for managing natural resources in comprehensive planning. Local governments are learning how land use decisions affect public health, how to use geologic information to safeguard groundwater resources, and how to work across county lines on long-term sustainable land use planning. Success can be measured by state support from the Wisconsin Geologic Mapping Advisory Committee and federal funding from the National Cooperative Geologic Mapping Program. Continued support from both groups indicates mapping is progressing according to plan.

Winnebago County: Hooyer and colleagues joined county community resource development educator Catherine Neiswender in developing an educational tour of geologic resources, a field guide explaining mapped features, and other educational materials examining how land use affects water resources. Tour participants—government, health, planning and zoning officials, educators, consultants and resource managers—discussed land use planning tools that local governments can use to reduce well contamination from naturally occurring arsenic. Neiswender shared the geology field guide and tour summary with county and town board members. She also wrote to the County Planning and Health Departments, summarizing research results and encouraging collaboration on land use planning and public education. A follow up survey shows that government planners and decision-makers:

- Gained knowledge about new geology research and mapping.
- Gained knowledge about using land use planning tools to reduce arsenic levels in drinking water.
- Incorporated groundwater into the comprehensive plan.

As a result of these efforts, local governments and decision-makers are more aware of the connection between land use and local geology. Incorporating groundwater into comprehensive planning provides evidence that County Departments have raised their awareness and made a decision to address drinking water issues. In November 2005, the Winnebago County Planning and Zoning Committee approved the final comprehensive plan from the County Planning Department. At their March 2006 meeting, the Winnebago County Board of Supervisors voted to approve the ordinance to adopt the Winnebago County Comprehensive Plan, effective January 1, 2007: See <http://winnebago.uwex.edu/wcplanning/index.html>

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