UW Extension Impact Report

Wisconsin Geological and Natural History Survey
Mapping Bedrock Geology for Sustainable Three-dimensional Planning

Situation

In 2001, the U.S. Environmental Protection Agency (EPA) cut the 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 increases risk of skin cancer and tumors of the kidney, prostate, bladder, liver and lungs. Ingesting arsenic also increases risk of blood vessel damage, nerve damage, hypertension, depression, diabetes, digestive disorders, anemia, and changes in skin color and texture. Well water containing high arsenic levels—100 to 1,000 ppb—commonly contains high levels of iron, sulfate and other toxic heavy metals.

With less arsenic allowed in drinking water, unsafe levels of naturally occurring arsenic are found in wells statewide. Health studies found so many contaminated wells in the Fox River Valley that the Department of Natural Resources (DNR) declared Outagamie, Winnebago and the western half of Brown County as an Arsenic Advisory Area and set protective well construction guidelines. When Fox Valley well drillers were reluctant to follow these guidelines because of the added construction costs, in particular the soaring cost of steel well casing—DNR staff engaged their UW-Extension colleagues to help determine specific well construction requirements.

Response

A statewide group of experts formed to develop regulatory strategies for safeguarding public health where wells contain unsafe levels of natural arsenic. Led by the DNR Drinking Water and Groundwater Bureau and University of Wisconsin groundwater Coordinating Council, this partnership includes UW-Extension research faculty at The Wisconsin Geological and natural History Survey (WGNHS) and Central Wisconsin Groundwater Center at UW-Stevens Point, university researchers, state, county and tribal health departments, the National Institutes of Health, U.S. Geological Survey (USGS), and the Wisconsin Water Well Association. The joint DNR-UW Groundwater Coordinating Council reviews the work group's educational materials to ensure that clear and consistent messages reach the public.

With DNR research funding, UW-Extension outreach specialist Madeline B. Gotkowitz, WGNHS hydrogeologist and UW-Madison assistant professor of environmental sciences, found high arsenic levels where well bore holes allow in air and microorganisms to oxidize and dissolve sulfide minerals, releasing arsenic into drinking water. Overall, high arsenic concentrations cluster from south to north along the Fox River Valley where wells are drilled through sulfide mineral pockets in the St. Peter sandstone aquifer. Gotkowitz concludes that the only way for a private well owner to know the arsenic level in their drinking water is to have their well water tested regularly by a certified lab.

As Gotkowitz studies the geochemical conditions and hydrogeologic processes releasing arsenic in wells and aquifers, WGNHS senior geologist Bruce A. Brown and colleagues are mapping the bedrock under Outagamie and Winnebago counties with research funding from the USGS National Cooperative Geologic Mapping Program. To map bedrock depth, thickness and character, Brown and DNR geologist David M. Johnson examined and interpreted more than 4,000 well construction reports in the Arsenic Advisory Area. Combining that information with 6,000 regional well-drilling records in the WGNHS database, they mapped the depth to bedrock aquifers and the extent of the St. Peter

sandstone, which they found highly variable in thickness. Brown and Johnson were able to assemble and interpret the geology within one year thanks to a new method of matching DNR well reports to county address data developed with WGNHS senior cartographer Michael Czechanski and GIS specialist Peter Schoephoester. This new technique cut by months the time and effort preparing raw well data for a database the geologists can work with.

Mark Putra, DNR Private Drinking Water section chief, calls their efforts a “great exercise in historical detective work.” Reading a well construction report is not like reading a recipe—well drillers use different terms for the same thing, and interpretation requires experience. Once the well locations are confirmed, the elevations established and geologic interpretations made, the resulting geographic information system (GIS) becomes a powerful tool for planning and analyzing geologic resources.

Based on the geologic evidence, DNR identified specific well construction techniques required in Outagamie and Winnebago counties from 5 miles on either side of the St. Peter sandstone. The GIS was used to generate maps showing depth to the St. Peter and Cambrian sandstone bedrock layers. Wells must be completed above the St. Peter or encased into the deep Cambrian aquifer to avoid arsenic-releasing sulfide mineral deposits in the St. Peter sandstone. To make these maps easy for well drillers to use, minimum and maximum depths were assigned by quarter section throughout both counties.

For some rural wells with unsafe arsenic levels, an affordable solution may be a replacement well in shallow sand and gravel aquifers above the St. Peter sandstone. Also with national Cooperative Geologic Mapping Program funding, WGNHS Quaternary geologists Thomas S. Hooyer and John W. Attig are mapping the nature and distribution of Ice Age sediments through parts of 14 counties previously occupied by glacial Lake Oshkosh. Their maps and reports help DNR colleagues identify alternative groundwater sources, critical groundwater recharge areas, and water resources vulnerable to surface contaminants.

Hooyer and Brown used their geologic mapping to prepare local reports and a geology tour field guide. They worked with UW-Extension Winnebago County community resource development educator Catherine Neiswender on a tour for public officials and government decision-makers charged with completing a comprehensive plan. Brown concludes that land use planning must be 3-dimensional, and geologists offer key information on how safeguarding essential resources in that third dimension defines proper land use and excludes other uses on the surface. Brown, Czechanski and Schoephoester are developing 3-dimensional visualization tools to help local planning and zoning officials and government decision-makers understand the need to consider groundwater and other geologic resources below the surface as criteria for sustainable long-term planning.

Outcomes

WGNHS provided the science supporting DNR well construction requirements for the Arsenic Advisory Area. Brown helped DNR staff write the new rules and Gotkowitz reviewed them. Mark Putra reports that based on WGNHS research, bedrock maps and discussions with Gotkowitz and Brown, the DNR Drinking Water and Groundwater Bureau changed the Arsenic Advisory Area into a special well casing depth area covering Winnebago and Outagamie counties—the largest special casing area ever established. The new rules guide well drillers to safe drinking water, regulate depth of casing below arsenic bearing sandstone and require specific drilling methods that do not use air. Well drillers and DNR regional staff report this system is working, resulting in more arsenic-free wells.

Private well owners may choose to form community water systems, group wells or neighborhood cluster wells, and housing developers are urged to provide one common well for new subdivisions outside municipal wells. Private wells are already very expensive. With the rising price of steel and greater depth to groundwater, well costs nearly double for both drillers and owners. Wells that had been $5,000 to $7,000 become $10,000 to $12,000. As a consequence, the specific well construction guidelines for each quarter section mapped allow for a smaller well casing area concentrated along the densely populated U.S. Highway 41 corridor.

From new well construction records, researchers and regulators review and reevaluate mapping efforts and adjust for accuracy to accommodate aggressive development. They hope to lessen economic burdens by reviewing reports, keeping maps up to date, and funding replacement wells for income-eligible well owners. Mark Putra calls this new GIS-based geologic mapping “UW-Extension at its best, applied in the best meaning of applied research. DNR could never have done this alone.”

Contact

Bruce A. Brown
Senior Geologist
Wisconsin Geological and Natural History Survey
University of Wisconsin-Madison/Extension
608 263-3201
babrown1@wisc.edu
http://www.uwex.edu/wgnhs