

**Title:** A Study of Well Construction Guidance for Arsenic Contamination in Northeast Wisconsin

**Project ID:** DNR Project #127

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**Period of Contract:** July 1996 - June 1998

**Background/Need:** Naturally occurring arsenic in groundwater at levels above the Drinking Water Standard (DWS = 50 mg/L) in East Central Wisconsin has resulted in the identification of an Arsenic Advisory Area (AAA). In a relatively large geographic area covering several counties, a guidance document is in place that recommends 80 feet of casing extending through the upper portion of the Ordovician St. Peter Sandstone Formation.

**Objectives:** The objectives of the study were threefold: 1) to evaluate if the Wisconsin Department of Natural Resources (WDNR) recommendations for well construction within the AAA provide adequate protection from the presence of arsenic in drinking water above the drinking water standard, 2) to determine if arsenic concentrations increase over time, and 3) to examine if, when faced with a contaminated well, it is best to replace it with a new one or to reconstruct the existing well with a liner sealing off the arsenic bearing zone.

**Methods:** Seventy-four private wells constructed during a two-year period (1994 - 1995) in the AAA within Outagamie and Winnebago counties were sampled during four different seasons (Spring, Summer, and Fall of 1997, and Winter of 1998). Upon appropriate purging of pressure tank systems, samples were collected from untreated water faucet sources and were immediately preserved with nitric acid. Seasonal samples were also collected from three monitoring wells constructed during an earlier investigation in the AAA near a site with extreme arsenic well water contamination. Samples were analyzed for arsenic and iron at the State Laboratory of Hygiene. In addition, pH and conductivity were recorded at the time of sample collection.

**Results and Discussion:** It is hypothesized that a chemical reaction similar to acid mine drainage occurs when a mineralized zone at the contact of the St. Peter Sandstone (SS) and the Galena Platteville (GP) is oxidized. Oxygen reaches this contact either by regional recharge, vertical leakage through the GP, or directly by oxygenation of the water in the open borehole either by air rotary construction of the well or a fluctuating water table. The series of chemical reactions that lead to the presence of iron and arsenic in the groundwater are believed to start with the oxidation of iron (II) to iron (III) which in turn dissolves pyrite and causes a general acidification of the water near the mineralized zone. The acidic conditions further liberate dissolved arsenic into groundwater thereby contaminating drinking water supplies. In addition to East Central Wisconsin, the occurrence of elevated arsenic in drinking water supplies has been recorded in West Bengal, Argentina, Taiwan, Northern Mexico, and the states of New York and Washington.

The long term health concerns associated with arsenic in groundwater are not well known. However, some researchers believe ingested arsenic may increase the risk of skin cancer. Exposures to high levels of arsenic in groundwater in Taiwan appear to increase the occurrence of cancer of the liver, lung, bladder, and kidney. A report on the effects of arsenic in groundwater in West Bengal, India, described the presence of various arsenical skin lesions such as hyperkeratosis and gangrene. In New York, researchers report impairment of bone marrow function, diarrhea, vomiting, liver toxicity, fatigue, and tingling in extremities from exposures to arsenic.

A review of several hundred well construction reports for 1994 and 1995 indicated that the majority of well drillers in Outagamie and Winnebago counties did not follow the AAA guidance. Based on the sampling results, 9.5% (7 of 74) of the wells included in the study produced water that exceeded the DWS on at least one occasion. The highest number of exceedances were recorded for wells in Algoma Township having less than five feet of casing through the upper sandstone layer. The percentage of exceedances observed during this study is approximately three times higher than that seen in other studies of arsenic in Wisconsin. Perhaps this is because wells chosen for this study were known to have penetrated the SS whereas previous studies sampled a more random distribution of wells.

The results of over 300 water samples collected during this study do not show a strong correlation between arsenic and expected seasonal groundwater fluctuations. Statistical analyses using least squares regression showed that trend lines did not fit the data very well (low  $R^2$  values), however the trend line directions were consistent between all four collection events and between various correlations. In other words, the trend lines in all graphical presentations of the data do show a correlation between increasing arsenic concentrations, decreasing pH, and increasing conductivity and iron concentrations. Finally, there didn't appear to be any rise in arsenic concentrations in the 74 wells or the three monitoring wells over the span of the research project. However, it should be kept in mind that the sample population is quite small in comparison to the thousands of wells constructed in the AAA. Despite the results of the study, ongoing contacts between WDNR drinking water staff and homeowners in the AAA indicate that arsenic concentrations in numerous wells do appear to increase over time.

**Recommendations:** Results of the study appear to indicate that the recommended 80 feet of casing through the upper portion of the SS may not be necessary in the AAA; a recommendation of **40 feet** of casing would probably suffice. Additionally because of the prevalence of problems, 40 feet of casing should be a *requirement*, rather than a *recommendation* in the Towns of Algoma (Winnebago County) and Osborn (Outagamie County). Local health agency staff who routinely sample and monitor arsenic levels in drinking water wells should be in close contact with WDNR to alert staff about new problem areas. Drillers should be educated about encountering black or gray sandstone (easily seen as darker water flowing from the borehole during drilling or as dark cuttings). This likely indicates that a mineralized, arsenic-bearing stratum has been penetrated and additional casing should be installed to seal this zone. Certain chlorination aids (used for iron problems) should be discouraged because chlorine may act as an oxidizer and accelerate the oxidation process that liberates arsenic. Future research should be conducted to determine if pump depth has an effect on the concentration of arsenic in groundwater.

### Related Publications:

- Burkel, 1993, Arsenic as a Naturally Elevated Parameter in Water Wells in Winnebago and Outagamie Counties, Wisconsin, MS Thesis, UW Green Bay
- Pelczar, 1996, Groundwater Chemistry of Wells Exhibiting Natural Arsenic Contamination in East Central Wisconsin, MS Thesis, UW Green Bay
- Simo, et al., 1996, Geologic Constraints on Arsenic in Groundwater with Applications to Groundwater Modeling, UW Madison Groundwater Research Report
- Simo, et al., 1996, Stratigraphic and Geochemical Controls on Mobilization and Transport of Naturally Occurring Arsenic in Groundwater, UW Madison, Alumni Newsletter

**Key Words:** Arsenic, St. Peter Sandstone, Groundwater, Northeast Wisconsin, Drinking Water Wells

**Funding:** WDNR

**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 53706, ☎ (608) 262-3069.