Minnesota Ground Water Association

www.mgwa.org

Volume 23, Number 1: March, 2004

Capillary Fringe — Cheaper than Dirt

— by Ray Wuolo and Steve Robertson

In the Land of 10,000 Lakes, with the major urban center straddling one of the greatest rivers in the world, we are a state that relies heavily on groundwater, not surface water, for our drinking water supply. Minneapolis and St. Paul each withdraw and treat water from the Mississippi River and a few communities (e.g, Roseville, Golden Valley, Richfield) buy their water from one of the Twin Cities. But the majority of the communities in the metro area obtain water supplies from groundwater. Why? Because groundwater is cheaper than surface water. In fact, it's cheaper than dirt – a lot cheaper.

Why is groundwater cheaper? Groundwater generally does not require treatment other than fluoridation for use as a public water supply. Iron and manganese removal is optional, as is softening and chlorination. There are no large intake systems to build, no centralized mains to convey raw water from source to treatment plant, and no seasonal variations in temperature, taste, or odor. Capacity of a groundwater system can be added incrementally over time by drilling new wells as a community grows.

Groundwater is also arguably a safer, more reliable source than surface water. If one well becomes contaminated, other existing wells can compensate or new wells can be drilled with minimal disruption to the customer. The de-centralized nature of a well system makes it a relatively poor target for terrorism. Moreover, groundwater is less affected by short-term droughts is surface water.

Despite the cost of treatment and issues of reliability, there are good reasons for using surface water

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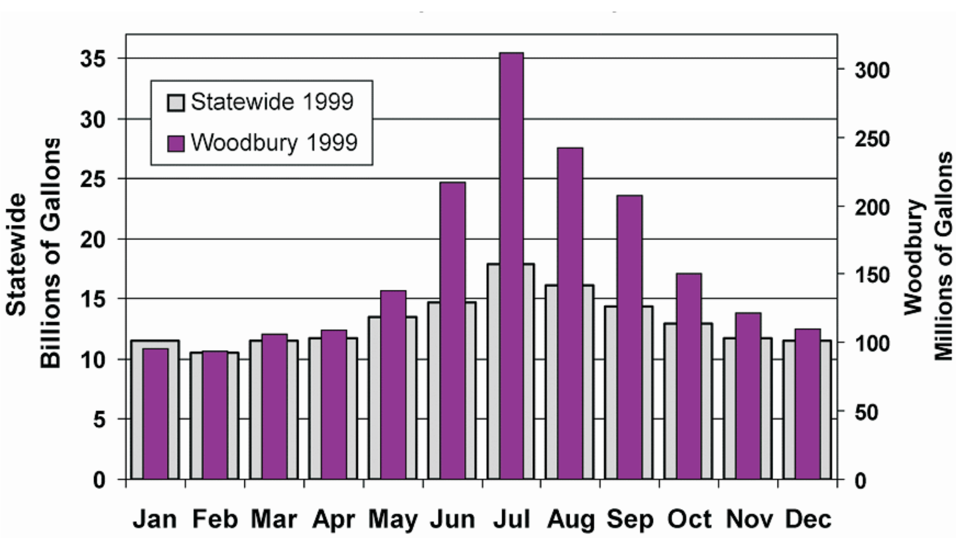

Figure 1: Public Water Supply Use by Month, Comparison of 1999 Public Water Supply Use Statewide to City of Woodbury, a growing suburban community. Source: Minnesota DNR Waters

President's Letter

— by Chris Elvrum

I am excited about my upcoming year as MGWA President. I welcome Laurel Reeves as President-Elect and welcome back Jon Pollock as Secretary. I would also like to thank Rob Caho for his hard work and dedication during his three years on the MGWA Board.

This is a time when despite recent cuts to ground-water-related programs, attention is being paid to our groundwater resources. Groundwater investigations and cleanups have been at the forefront of our business for some time and we are going to focus on this at the Spring Conference on May 4th. However, more recently the limitations on the quantity of ground water, contamination being one of them, have received much deserved attention. People are realizing that although we have relatively abundant supplies in Minnesota, there are limitations. The MGWA is in a position to provide decision makers with information about the ground-water resources in the state.

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2004 Newsletter Deadlines

Issue	To Editor
June	05/07/2004
September	08/06/2004
December	11/05/2004

President's Letter, cont.

Many thanks to all of you who have donated so far to the Science Museum's Groundwater display project. We have had a tremendous response to our fund raising efforts and now have enough to get the well drilled. The project did hit a speed bump when a local environmental organization decided not to contribute what was hoped to be a fairly significant donation. This is only a minor setback and now we are pursuing other avenues of funding to develop the display. We can always use more donations from our membership. Check out the article in this newsletter for more information on the project.

As I mentioned, the Spring Conference is going to focus on groundwater contaminant investigations and cleanups. If you have any ideas for speakers or topics or would like to help in the planning, please contact myself or another board member. The MGWA Board has decided not to continue planning the joint MGWA/AIPG Fall Field trips. With the two conferences and volunteer board it became too much for us to take on. We will still encourage our members to participate in the AIPG Field Trips and may plan one of our own in the future.

I encourage all of you to become involved in MGWA or some other volunteer organization at some time. All the small volunteer efforts add up to make a difference in the world and it gives oneself a sense of pride. If you have any comments or questions about the organization please don't hesitate to contact me. Thanks!

MGWA Newsletter Team Welcomes Kurt Schroeder

Kurt is currently employed at the MPCA as a senior Staff Hydrogeologist in the Superfund Program and is a licensed Professional Geoscientist. He has worked at the MPCA for 16 years in Solid Waste, Hazardous Waste and Water Programs. Before that, he worked five years as a project scientist for FX Browne Associates, a Pennsylvania water resources consulting firm. Kurt holds an M.A. in Physical Geography from Binghamton University (NY), and a B.A. from Penn State University. His current interests are in water supply, alternative transportation advocacy and transportation planning. He bikes, skis and plays music in his spare time—usually not all at once.

Cheaper than Dirt, cont.

instead of groundwater. The treatment of surface water involves softening, which removes calcium and magnesium and greatly improves clothes washing, color, odor, and taste. But more importantly, it does away with contentious issues of well interference, pumping impacts on wetlands, impacts to base flows of trout streams, and questions about the sustainability of aquifers. Except in very extreme drought conditions, withdrawals from the Mississippi or Minnesota Rivers can go pretty much unabated and customers can water their lawns to their heart's content.

Suburban communities want to water their lawns, too. Many of these lawns are new, large, and under warranty. Young, water-hungry trees are growing where corn stalks rustled only a few years ago. Peak summer usage

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Membership News and Information Update:

Now ground water information can flow two ways!
Our Newsletter can be a forum for every member to share information they encounter. Are you working on an interesting project? Have you come across an interesting fact?
Describe something you experienced or witnessed. What progress or developments is your organization making? Have you changed job positions recently? Let's keep our membership in touch with one another!

Selected comments will appear in the next issue.
Email any and all comments to: newsletter@mgwa.org

New Officers

President-Elect Laurel Reeves

Laurel Reeves is a hydrogeologist with the Minnesota Department of Natural Resources, Waters Division, where she has worked for over 20 years. Currently she manages the

state's ground water level monitoring network, which includes about 700 actively monitored locations. Previous duties at DNR include information systems supervision, water appropriation & public waters permits, dam safety grants, public waters inventory, environmental review, public drainage project review, etc. Her DNR career was interrupted for a few years to work on solid waste permits and superfund site investigation with the Minnesota Pollution Control Agency. Her career also includes ten years as a geologist with a private consulting company doing business throughout the Midwest. She earned a B.A. in Geology from Macalester College.

Secretary Jon Pollock

Jon has been MGWA's Secretary for the past two years and was elected to another two-year term.

Jon Pollock is currently President of Frontline Environmental, LLC providing environmental consulting and management service to the private and public sectors. His previous work experience includes eight years with the Minnesota Pollution Control Agency as a hydrologist, several years of laboratory experience, as well as environmental consulting and oil and gas exploration work. Jon's formal education includes a Bachelor's degree in Geology, a Bachelor's degree in Geophysics and a Masters Degree in Geological Sciences.

Jon also currently serves in several volunteer positions including the Dakota County Solid Waste Management Advisory Committee, MGWA Newsletter Team, and he is a Volunteer Firefighter for the City of Lakeville.

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The primary objectives of the MGWA are:

- Promote and encourage scientific and public policy aspects of ground water as an information provider;
- Protect public health and safety through continuing education for ground water professionals;
- Establish a common forum for scientists, engineers, planners, educators, attorneys, and other persons concerned with ground water;
- Educate the general public regarding ground water resources; and
- Disseminate information on ground water.

Cheaper Than Dirt, cont.

can be up to seven times greater than mid-January demand and as these communities grow, they need more wells (see Figure 1 on page 1). The DNR and Met Council worry about the demands being placed on groundwater sources. They worry that existing wells will be adversely impacted (e.g, Lakeville in 2002; MGWA Newsletter v. 22, no. 2, June 2003), that protected wetlands or trout streams will be hurt (e.g., Savage Fen), or that more water will be pumped out than is sustainable. Measuring and predicting these effects (which are often very small) is difficult and inherently fraught with uncertainty, even with the most sophisticated approaches. The burden is often placed upon the appropriation permit applicant to prove the negative by demonstrating that new wells or increased pumping will not result in adverse effects. The DNR is put in the predicament of determining what is an acceptable level of impact.

Those who regulate and those who are regulated share a common interest – they want people to have enough good water and they want to protect the natural resources of Minnesota. If a surface-water supply costs the same as a ground-water supply, both to build and to operate, most communities would opt for the surface-water supply. But groundwater is cheaper than dirt and the economics just don't work.

We believe there is another way for the State to provide incentives for conservation of groundwater and movement toward more use of surface water – make groundwater more expensive. Make it a lot more expensive. The individual communities or water utilities do not own the water – groundwater is a Water of the State. Groundwater is everybody's water. Put it this way, if we were talking about "Oil of the State", do you think a utility would be given a permit to pump millions of gallons per day at a "total fee of $500 per permit?" Ask Wyoming, which charges a fee for every gallon of oil pumped – their government operations are largely financed through a surcharge on pumping of a fluid out of the ground.

One of the water conservation measures that some communities employ is a graduated rate structure for water use. For example, the first 10,000 gallons per month costs the customer $2.50 per 1,000 gallons. The next 5,000 gallons might cost $ 4.00 per 1,000 gallons and anything above 15,000 gallons per month might cost $ 6.00 per 1,000 gallons. These graduated rates are designed primarily as incentives to keep lawn watering rates down without penalizing typical domestic water use. Experience has shown that graduated rate structures at these typical levels do almost nothing to curtail peak water use. While some fume over water rates, most people generally believe that water rates are not an issue and these small increases will not deter them from protecting the investment they have made in their lawns. One influential resident of a metro suburb recently told us, "I have a cabin in Red Wing and every weekend I put in 20 gallons of gas to go down there. If that gasoline is $1.50 per gallon or $4.00 per gallon, I would still fill my tank up. I view water in the same way – it's a small cost in the big scheme of things and increases per gallon won't change my behavior."

That attitude notwithstanding, it is reasonable to expect that increasing the cost of water will at some point change usage. The challenge is to develop a rate structure that is simultaneously protective of low volume/low income users, flexible so as not to discourage economic or industrial activity, and yet sufficiently stiff to change usage behavior at the upper end. How aggressively rates are set involves evaluating the value statement of how drastically it is desirable to curtail usage. What level of peak to average day use is appropriate? Perhaps this goal would vary by community. The point is that increasing rates will both encourage conservation and generate revenue. What to do with the extra revenue that would result from increasing rates? The municipal water utility is more than happy to receive the additional influx into their enterprise fund that results from increased rates, which is used to pay not only for water improvements but typically accounts for large portions of the operating budgets of finance and public works departments.

What if instead of $6.00 per 1,000 gallons of water use above base (i.e. winter) water demand, customers were charged $10.00 per 1,000 gallons? As an example, take a community with a population of 60,000 and a daily demand in January of about 8 MGD (million gallons per day). In July, their peak day may be as high as 40 MGD. At $10.00 per 1000 gallons above base demand, that would result in additional fees of about $320,000 a day. Of course, some conservation would take place as fees became higher but revenues would certainly grow. Imagine, if this went on for two months – about $20 million in additional revenue would be realized. That's $20 million above the cost of service to supply and deliver the water! A couple of years and we're talking about some real money – enough to finance a surface-water treatment plant and raw-water mains.

We would argue that it is not appropriate for communities to profit by selling water that belongs to everyone in Minnesota — a classic "tragedy of the commons". The cost of water to meet reasonable demand should be kept as low as possible and the municipal water utility should be able to charge for the cost of service, retire enterprise bonds, and fund capital improvement projects for water. Revenues that are realized beyond the cost of service rightly belong to the State of Minnesota. What should the State use this revenue for? Here is a user-fee source of revenue that could be used to help fund upgrades to public water supply infrastructure, to fund protection measures such as source water and wellhead protection, and basic groundwater research and monitoring (as well as providing in an ample manner for the education of Ray and Steve's children). There are any number of laudable uses, but, in the end, the uses must primarily benefit public water supply systems, as they would be the ones collecting the fee. For example, if some communities decide that they do not want to impose use restrictions, they could tap into the revenues that might allow them to build the necessary infrastructure to use a

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MGWA Foundation Update: Science Museum Water Park Funding

The generous support of many corporate and individual donors has generated the funds needed to install the water well at the Minnesota Science Museum's Water Park Exhibit. The contributions to date will enable the well installation as well as contributing to other portions of the exhibits. Visitors to the Water Park will be able to experience and learn about the source, value, and vital role that water entails in our lives and in our environment. With continued support from the members and participation of the MGWA Foundation the Water Park can develop and expand. More exhibits will be funded and learning experiences of the role of water will increase and serve to benefit the efficient use and protection of our water resources. The Foundation extends our sincere thanks to those corporate contributors and individuals who have made this funding program such a success. However, the installation of the supply well is only one step in the development of the Water Park. Further support is needed to complete other aspects of the exhibits. A well is simply a hole in the ground without the additional displays and equipment to complete the message. Support for other parts of the exhibit and hands-on activities and experiences for visitors are still needed. If you have not already done so, I encourage you to consider a contribution to the Science Museum funding effort. All contributions should be routed through the MGWA Foundation to assure their tax-deductible status and to ensure that donations are applied to the proper project at the Museum.

On another note, the position of Foundation Director is open at the present time. For personal reasons I will be stepping down as Foundation Director and the board is currently seeking volunteers to assume the role. We would like to find several participants to serve on the board. Is it a tough job? No, in fact it is one of the easiest jobs around. The generous support of the MGWA members and the excellent support of MGWA Officers and Board and the success of MGWA seminars do a great job of generating funds for the foundation. It's a job where you cannot help but be successful. The duties entail attending periodic MGWA board meetings, reviewing applications requesting funding from various educational entities and documenting the assignment and granting of moneys. There are no financial rewards, the pay back comes with the satisfaction of contributing to the education of our young people, supporting further training of our teachers and educators, and the chance to contribute to programs of the Science Museum. I hope that some of you will consider this opportunity to contribute and participate in the expansion and increase of public education on the issues of water and water value.

The board of the MGWA and the various committees and contributing groups that make up the MGWA as functioning organization are a tremendous resource and provide the means for the Association to carry out its mandated objectives. I hope that you will consider assuming a role in the Association. The only requirements are a desire to participate, contribute time and talent to the Foundation and its objectives, and see the educational role of the MGWA succeed in reaching and teaching in the most effective fashion. Please consider contributing your time and talent to this valuable and vital activity. If you have any questions regarding the Foundation or to volunteer please feel free to contact any of the MGWA Board officers or you can contact me directly. The simplest method is probably via e-mail to drgordo@comcast.net. I thank all of the MGWA members and corporate supporters for your part in making the Foundation grow and succeed during my tenure and I am confident that suppport will continue in the future. I look forward to working with the incoming Foundation Board members to continue the successes of the past.

— Gordie Hess, outgoing MGWA Foundation President

Arsenic in Drinking Water and Health

We all know that arsenic exposure at very high doses is acutely toxic, and can be lethal. In 1972, thirteen construction workers were poisoned by arsenic in drinking water from their worksite in Perham, Minnesota. All suffered gastrointestinal and/or neurological effects from exposure over two to three months to well water that measured 11,600 and 21,000 parts per billion (ppb) arsenic (Feinglass, 1973). Buried arsenical pesticides were found to be the source of the arsenic.

In many parts of the world, naturally occurring arsenic is found in drinking water and the health effects of arsenic in drinking water have been widely studied. Studies of populations in Taiwan, Chile, Argentina, and other countries have consistently found evidence that chronic ingestion of arsenic in drinking water causes cancers of the bladder, lung, liver, kidney, and skin. Exposures in these populations range from several hundred to several thousand ppb arsenic.

In addition, exposures in drinking water have been associated with increases in various non-cancer effects including diabetes, peripheral neuropathy, cardiovascular disease, blackfoot disease (peripheral vascular disease), skin lesions, and liver disease. Hyperkeratosis and hyperpigmentation of the skin are perhaps the most sensitive clinical indicators of chronic exposure. In Bangladesh, where large exposed populations have been studied, 20% of males and 13% of females exposed to levels less than or equal to 150 ppb had skin lesions (Tondel, 1999). Some researchers suspect that susceptibility to arsenic may be related to nutritional status. Genetic and metabolic factors are also likely to play a role.

In the U.S., however, skin effects have not been observed at these low levels of exposure. A U.S. Environmental Protection Agency mortality study (Calderon et. al., 1999) observed increased cardiovascular disease (hypertension) deaths in an exposed

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Question of the Quarter! ?

The Question of the Quarter is a new section in our newsletter. Each quarter a different question will be posed and all members are invited to offer their "two cents worth" Last quarter's question is discussed below. This quarter's question is: Gov. Pawlenty announced his Clean Water Initiative in the fall of 2003. In it he makes the following statement: “Minnesota has more than 14,000 lakes, 92,000 miles of river, 10.6 million acres of wetlands and a trillion gallons of ground water.”

How much ground water does Minnesota have?

a) Not Enough
b) Enough
c) Well over 1 trillion gallons
d) Nowhere near 1 trillion gallons
e) 1 trillion gallons
f) It depends…

Email your answer and your "two cents worth" to:

newsletter@mgwa.org

Arsenic in Drinking Water & Health, cont.

population. Several studies in the U.S. have found increased levels of inorganic arsenic and arsenic metabolites in the urine related to drinking water exposure. In Minnesota, elevated arsenic concentrations in hair samples were associated with drinking arsenic water concentrations in the range of 10-150 ppb. Information about the health effects of arsenic in drinking water and the Minnesota Arsenic Study can be found at: www.health.state.mn.us/divs/eh/wells/arsenic.html

References:

Feinglass EJ., 1973, *Arsenic Intoxication from Well Water in the United States*. N Engl J Med 288(16):828-30

Tondel M, Rahman M, Magnuson A, Chowdhury IA, Faruquee MH, Ahmad SA, 1999, *The Relationship of Arsenic Levels in Drinking Water and The Prevalence Rate of Skin Lesions in Bangladesh*, Environ Health Perspect. 107(9):727-9

Calderon RL, Lewis DR, Southwick JW, Ouellet-Hellstrom R, Rench J, 1999, *Drinking Water Arsenic In Utah: A Cohort Mortality Study,* Environ Health Perspect. 107 (5): 359-65

— submitted by Jean Johnson, Minnesota Department of Health

What is the Oldest Measured Groundwater Age in Minnesota?

— Scott C. Alexander, Karen Sherper Rohs, and E. Calvin Alexander, Jr., Dept. of Geology & Geophysics, University of Minnesota

Editor’s Note: Last issue, the Question of the Quarter asked: “What is the oldest ground water measured in Minnesota?” The choices were: a) Less than 100 years, b) 100 – 1000 years, c) 1000 – 10,000 years, d) 10,000 to 100,000 years, e) Really, really old. To answer the question, your newsletter team asked the very knowledgable folks at the University of Minnesota.

Estimating the age of groundwaters is an important but non-trivial exercise. Groundwater age dates are very important in constraining the transport velocity of contaminants and in the calibration of groundwater flow models. A variety of chemical and isotopic tools have been brought to bear on this enterprise.

An ideal tracer of groundwater flow would be naturally present, pervasive throughout the surface environment and move with the same diffusive and dispersive characteristics as water. To this end tritium is an ideal tracer. As an isotope of hydrogen, tritium is physically part of the water and therefore perfectly mimics the transport of water. Further, tritium is naturally produced in the upper atmosphere making it well distributed throughout the surface environment. Tritium is measured in groundwaters after electrolytic enrichment to about 0.8 Tritium Unit (TU) levels (one TU = one ^{3}H atom per 10^{18} atoms of hydrogen). Tritium is also, more recently, a by-product of hydrogen weapons testing. From Figure 1 it can be seen that tritium levels above about 10 TU

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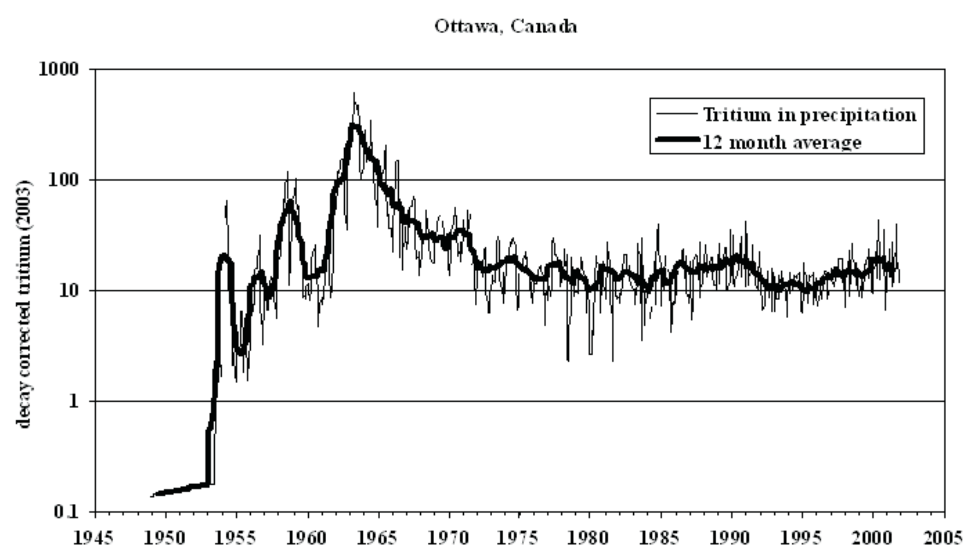

Figure 1. Tritium in precipitation, decay corrected to 2003, for Ottawa, Ontario from the IAEA/WMO GNIP database.

Oldest Water, cont.

indicate waters that recharged since 1953. Conversely, waters that recharged prior to 1953 have less than 0.2 TU. Unfortunately, tritium has a half-life of only 12.5 years which makes it a very good tracer of active flow systems over a time-scale of decades, but which limits its use over longer periods. The fact that we can find groundwaters with tritium levels pre-dating atmospheric nuclear weapons testing in the 1950's and 60's offers encouragement that there are "vintage" groundwaters out there.

The next tool brought to bear on the question of groundwater age is carbon-14 (^{14}C). ^{14}C has a half-life of 5,730 years and a useful dating range from about 100 – 200 years back to 30,000 to 50,000 years ago. The standard radiometric counting method requires 2 to 3 grams of carbon. When dating a piece of wood or charcoal this is readily attainable. The carbon found in groundwater as dissolved bicarbonate is present at concentrations of 200 to 300 mg/l as $CaCO_3$. At these concentrations up to 200 liters of water are required. The normal procedure is to collect 200 liters of water in plastic bag lined 55-gallon barrel. While filling the plastic bag, 500ml of NH_4OH are added to convert the bicarbonate to carbonate. Then 200g of $SrCl_2$ are added to precipitate the carbonate as $SrCO_3$. After allowing the precipitate to settle the excess water is siphoned off. The $SrCO_3$ precipitate is then sent off for analysis.

There are two main sources of inorganic carbon in groundwater, the first is from atmospheric carbon dioxide (CO_2) and the second is from carbonate rocks in the subsurface. A simple model assumes that about half the carbon is derived from atmospheric sources and half is from bedrock sources as in the following reaction:

$$H_2O + CO_2(gas) + CaCO_3(limestone) <=> Ca^{+2} + 2HCO_3^-$$

Natural production of ^{14}C in the stratosphere is balanced by decay and removal by burial of organic materials. Variations in the rates of burial and exhumation can alter the ^{14}C levels in the atmosphere in addition to changes due to cosmogenic production of ^{14}C. The burning of ^{14}C-depleted coal starting in the 1800's lowered atmospheric levels while nuclear weapons testing in the 1950's and 60's resulted in increases. All of this variation is elegantly preserved in tree rings dating back almost 12,000 years before present. Before 12,000 years ago records of atmospheric ^{14}C are preserved in corals and stalagmites.

^{14}C age estimates for groundwater are further complicated by interaction of carbon with the aquifer materials. Numerous geologic processes including matrix diffusion, sulfate reduction and methane production can further alter the concentration of 14C. All of these layered assumptions and corrections mean that ^{14}C ages of groundwater are probably no more than order of magnitude estimates.

Having said all this there is still hope. By starting with aquifers that have simple hydraulics and a clean, low carbonate and low organic matrix, many of these complicating factors can be minimized. In Minnesota one such aquifer is the Mt. Simon Sandstone. Groundwater flow in this aquifer is generally from the northwest to the southeast with recharge along the edge of the Twin Cities Basin and discharge through the Paleozoic section

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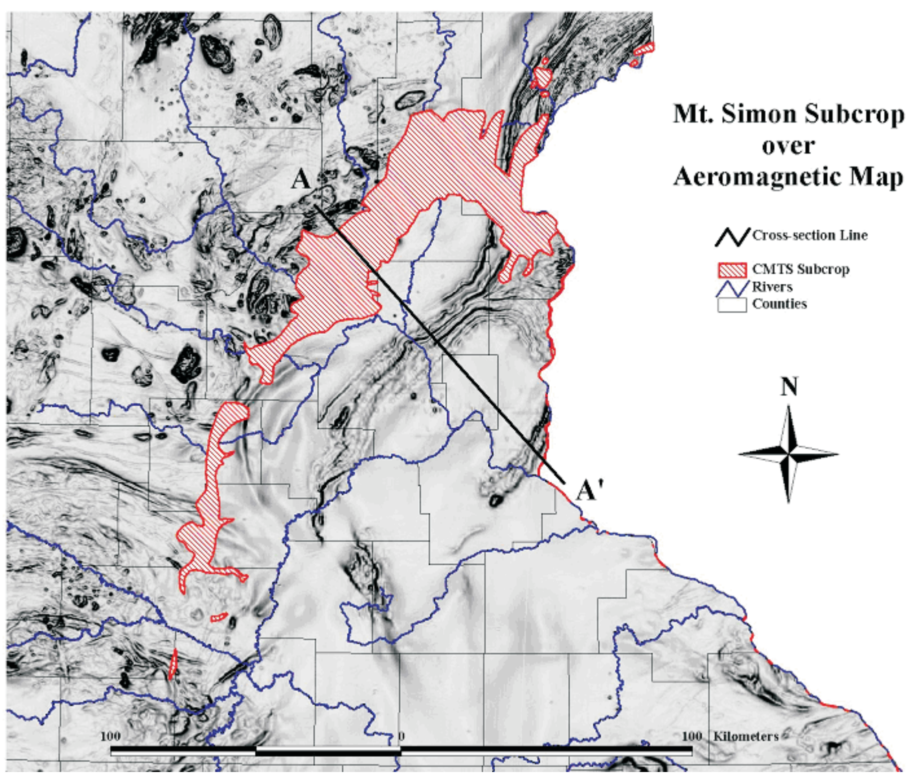

Figure 2. Mt. Simon Subcrop over Aeromagnetic Map.

Continuing Education Opportunities

The MGWA Web page has a section called "Calendar" that lists upcoming conferences and links to other web sites for educational opportunities. If you are interested in obtaining continuing education credits for driller or PG licensure renewal, this is a good source of information. The Board of Architecture, Engineering, Land Surveying, Landscape Architecture, Geoscience and Interior Design does not pre-approve continuing education credits for conferences or workshops. If you are aware of a conference or workshop that is not on the calendar, please contact MGWA at (651) 276-8208 or send an email to office@mgwa.org.

2001-2002 Water Year Data Summary Available from DNR Waters

The latest in the Water Year Data Summary series from DNR Waters is now available for the period October 1, 2000 to September 30, 2002, which includes Water Years 2001 and 2002. This review of basic hydrologic data gathered through DNR Waters programs covers climatology, surface water, ground water, and water use.

The report summaries data from more than 1400 precipitation observers, 1000 streamflow and lake level sites, more than 750 ground water level observation sites, and thousands of water appropriators. Copies of the report are available from DNR Waters by calling (651) 296-4800. Most data is available through the DNR Waters website at www.dnr.state.mn.us/waters.

MGWA Thanks its Corporate Members

Interpoll, Inc

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Oldest Water, cont.

to the Mississippi River. Figure 2 shows the recharge zone of the Mt. Simon overlying the Mid-Continent Rift system as exposed by the aero-magnetic map of Minnesota. The St. Croix Horst and the near-surface position of basalt flows is readily apparent in Figure 2 where they cross Anoka and Hennepin counties on the north side and in southern Washington county. The thick Hinckley Sandstone, deposited in the northern flanking basin and the thicker Mt. Simon of the Twin Cities basin are represented as magnetically quiet zones.

In Figure 3 the gamma log from a well in downtown St. Paul shows the Paleozoic stratigraphy. The first log is the entire section from the land surface and the second is zoomed in on the Mt. Simon. In particular, the Mt. Simon can be subdivided into several compartments. In the uppermost portions the Mt. Simon transitions into the Eau Claire formation with an increasing abundance of fine clastics. Below the transition zone, at 825 feet, there is a fine-grained caprock A (Runkel et al, 2003). Between caprock A and caprock B there is an upper Mt. Simon Sandstone. This upper unit is the regional flow unit and is laterally continuous to the subcrop or recharge zone as can be seen in Figure 4. Below Caprock B at 905 feet is the hydrostratigraphically isolated lower Mt. Simon Sandstone. Further evidence of the effectiveness of these caprocks as aquitards is

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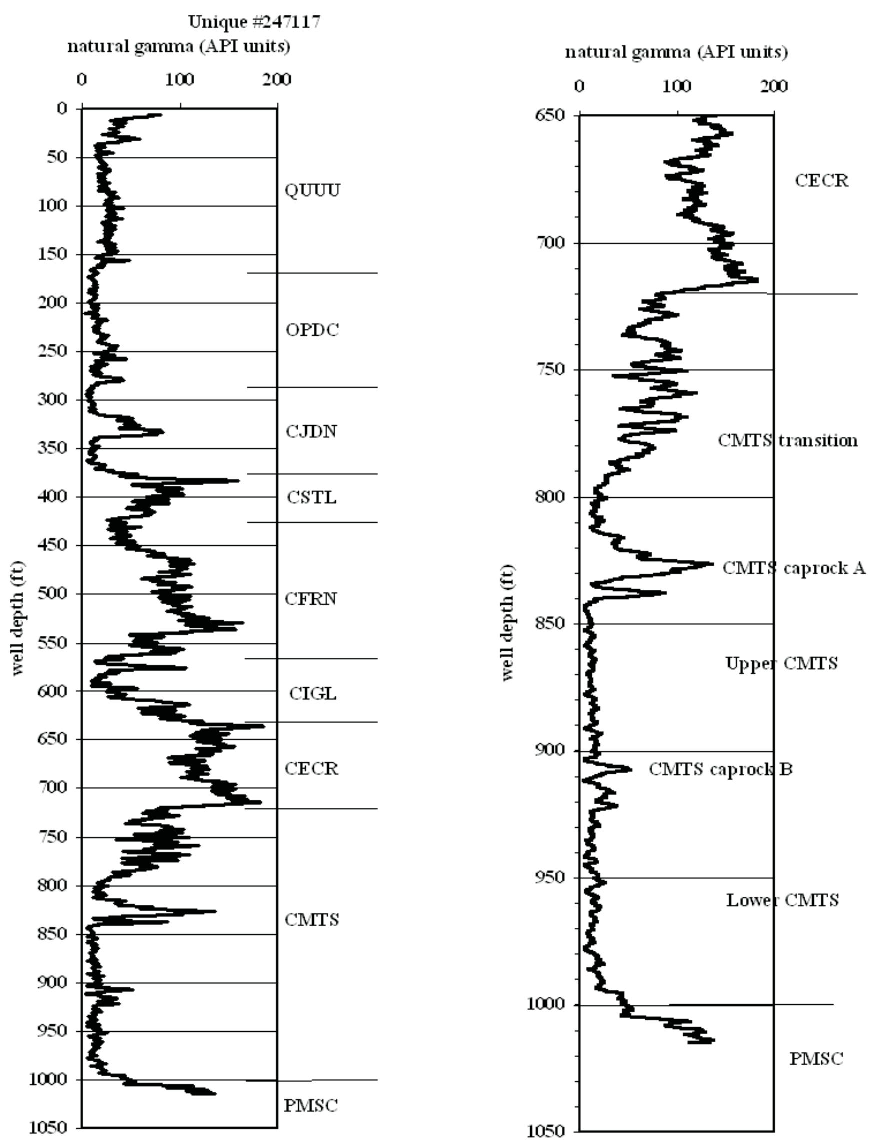

Figure 3. Gamma Log from downtown St. Paul Well located at New St. Paul Police Station data from Minnesota Geological Survey (second log is an expanded scale of the first).

Oldest Water, cont.

provided by their use by Minnegasco to store natural gas in the Waseca area since the 1980's.

Groundwater ages, as measured by ^{14}C dating, increase gradually from modern waters in the subcrop zone up to about 10,000 years old over the basalt. Within the Twin Cities Basin the apparent ^{14}C ages increase dramatically into the range of 20,000 years and older. Most wells within the Twin Cities Basin are open hole throughout the Mt. Simon. For example well 247117 is open from 751 to 1,064 feet. This means that the ^{14}C age includes water from the active flow in the upper Mt. Simon and water encapsulated in the lower Mt. Simon. This water in the lower Mt. Simon mixed with upper Mt. Simon water has ^{14}C ages that are off scale by more than 30,000 years (Lively et al, 1992).

Some effort has been made to date Minnesota groundwaters with Chlorine-36 (^{36}Cl) by Davis et al (2000). ^{36}Cl has a half-life of 301,000 years offering an interesting dating tool for very old groundwaters. Unfortunately, in application, the underlying assumptions are even greater than for ^{14}C dating. This work has only confirmed that some Mt. Simon waters are more than 10,000 years old.

Recent work by Lowenstein et al (2003) suggests that the calcium chloride brines found within deep basinal sediments of the Illinois basin may be related to secular variation in seawater chemistry. In particular, when sulfate concentrations in seawater are less than the calcium concentration, precipitation of gypsum rapidly depletes sulfate leading eventually to $CaCl_2$ brines. Modern seawaters, in contrast, run out of calcium first, leading to NaCl brines. This geochemical evidence leads to the conclusion that these deep basinal fluids originated from Silurian and Devonian or Cretaceous seawaters. A few Mt. Simon wells have traces of these older brines, in particular, several wells along the Mississippi River Valley in Red Wing, Lake City, and Winona and in Scott County along the Belle Plaine fault. Unfortunately wells that produce

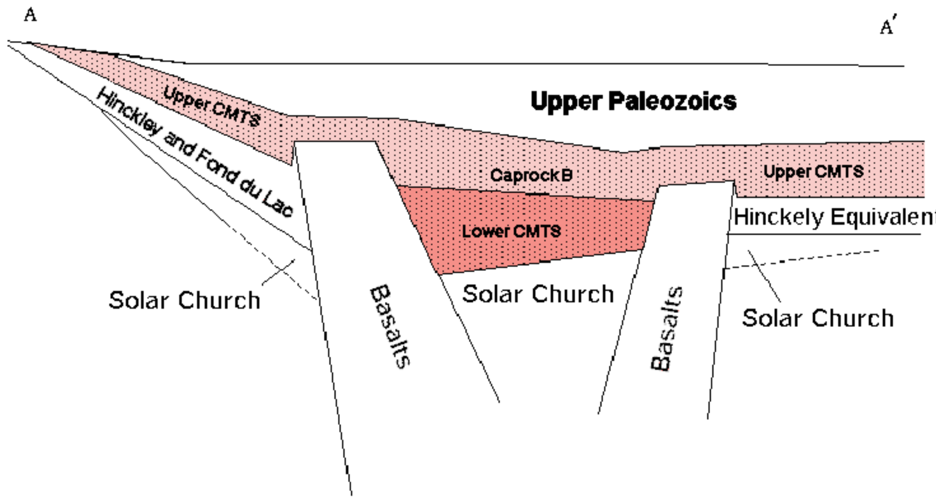

Figure 4. Schematic Cross-section through Twin Cities Basin showing caprock between upper and lower Mt. Simon, Hinckley Sandstone as a flanking basin deposit and Solar Church as rift valley deposit. Drawing after Allen, 1994, not to scale.

saline brines are usually quickly grouted and sealed. The wells available for chemical and isotopic sampling generally have chloride concentrations below about 500 ppm and slightly elevated calcium, representing a mixture of old multi-millennial waters and a small fraction of really old basinal fluids. The last time a $CaCl_2$ brine could have been generated in Minnesota was during the Cretaceous period.

The answer to the question of the quarter is therefore either E) really, really old, (think Cretaceous), or on a technicality D) between 10,000 and 100,000 years old since the "measurable" ^{14}C ages go off scale at 30,000 years.

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The New Arsenic MCL and Community Water Systems in Minnesota

— Karla Peterson, Minnesota Department of Health

Approximately 40 community water supplies in Minnesota have at least one entry point to the distribution system (well or treatment plant) that exceeds 10 micrograms per liter (µg/l) in arsenic. The Arsenic Rule, effective January 2006, requires that community supplies meet the Maximum Contaminant Level (MCL) of 10 µg/l. Most of these 40 public water supplies have already taken measures to reduce arsenic to less than 10 µg/l, and all of these supplies are required to find an alternative source, add treatment or provide blending to reduce the arsenic concentration in the distribution system.

The Minnesota Department of Health has taken quarterly samples at each entry point to the distribution system at these supplies. The results from those samples are averaged for each individual entry point to determine which are in exceedance. Once the rule is effective, a supply that has exceeded the MCL must continue quarterly monitoring and public notification until the result is reliably and consistently below the MCL.

Supplies have several options in meeting the MCL. Some may choose to find an alternative source (new well or connect to another supply), add treatment or blend water from multiple sources to reduce arsenic concentrations. Each compliance option must be carefully studied to find the most cost-effective option for that particular community. For example, a supply may choose to drill a new well with lower arsenic concentrations, but at the same time it may elevate concentrations of other contaminants. There are several treatment options available for arsenic removal, including lime softening, conventional treatment, anion exchange, activated alumina, adsorptive media, membrane filtration, reverse osmosis, and optimized iron/manganese filtration.

If a public water supply chooses treatment as a solution, most treatment options require that arsenic be oxidized prior to removal, since soluble arsenic is difficult to remove by most treatment methods. For those supplies that currently have iron/manganese filtration, removal of arsenic may be a matter of modifying existing treatment (adding chemical feed and coagulation/flocculation). Disposal of treatment residuals is also a significant concern for supplies. The supply needs to thoroughly review disposal costs, as it can be an expensive part of water treatment.

Some community water supplies have already taken the steps to reduce arsenic and have either installed treatment (Andover, Dawson, and Green Isle), installed a watermain interconnection (Dilworth, Echo, and Sunnyside Care Center), or constructed a new well (Marshall-Polk Rural Water Supply and Ottertail Nursing Home). At the same time, other community water supplies are working to meet the new MCL and are in the design or construction phase to meet the rule by January 2006 (Climax, Cokato, Fisher, Fosston, Hamburg, Hanley Falls, Nielsville, Northome, Sabin, Stewart, Ulen, and Winsted). There are also some communities that have relied on individual private wells with elevated arsenic. They are making plans to construct new public water supplies to provide residents with safe drinking water.

For those homeowners interested in removing arsenic at the tap, effective treatment options include activated alumina, adsorptive media, anion exchange, distillation, membrane filtration, and reverse osmosis. However, it may require multiple treatment units to adequately remove arsenic. It is important that if a homeowner is interested in treatment, he or she needs to look for either NSF International or Underwriters Laboratory certification, ask for a performance guarantee, and maintain the treatment units on a regular basis.

To comment on this article, e-mail newsletter@mgwa.org or karla.peterson@health.state.mn.us

Arsenic in Minnesota Ground Water: Recent Research and Implications for Minnesota

— Melinda L. Erickson, Water Resources Science, University of Minnesota, and Randal J. Barnes, Civil Engineering, University of Minnesota

Abstract

The United States' federal drinking water standard for arsenic recently changed from 50 micrograms per liter (µg/l) to 10 µg/l. Approximately 100 Minnesota public water supplies do not comply with the new rule. Additionally, results of recent private well sampling studies in Minnesota indicate that thousands of private wells have arsenic concentrations exceeding 10 µg/l.

Recent arsenic research provides regulatory agencies with results to support development of potential new rules and guidance concerning drilling wells in high arsenic areas, testing new wells for arsenic, and implementing low-cost compliance strategies.

Arsenic contamination in upper Midwestern ground water is widespread, naturally occurring, and associated with the lateral extent of Des Moines lobe till. Although this till does not have particularly high arsenic concentrations, it does have specific physical characteristics (fine-grained matrix and entrained organic carbon) that create a geochemical environment favorable to regional scale mobilization of arsenic.

In west-central Minnesota, private wells that have screens less than 8 feet long set within 4 feet of the upper confining till unit have an average arsenic concentration of 20 µg/l, with 58% of wells exceeding 10 µg/l. Private wells with longer screens set farther from the upper confining unit average only 12 µg/l arsenic, and 40% of wells exceed 10 µg/l.

The variability of arsenic concentrations over time in newly constructed wells is similar to concentration variability observed in older wells; there is no temporal trend.

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Arsenic in Ground Water, cont.

Two procedures have been developed and tested for screening low-cost compliance options. A 'site investigation' evaluates the option of drilling a new well. A site investigation can identify different, low-arsenic aquifers at a different elevation and/or a different location. Sampling a well several times over a period of a few hours evaluates the feasibility of changing well operations. Changing well operations may be a viable compliance option for communities with arsenic concentrations that predictably fluctuate around 10 µg/l.

Introduction

In 2001, the United States' federal drinking water standard, or Maximum Contaminant Level (MCL), for arsenic was changed from 50 µg/l to 10 µg/l. Public water suppliers have until January 2006, to comply with the new, stricter standard. A significant number of public water supplies in the upper Midwest have arsenic exceeding 10 µg/l. In Minnesota alone; approximately 100 public water supplies exceed the new standard. Construction and operation of standard arsenic treatment facilities can cost $1,000,000 per facility. Minnesota's small water suppliers, primarily located in economically challenged rural communities, are faced with a disproportionate financial burden in complying with the new MCL.

Minnesota's private wells also have widespread arsenic contamination from natural sources. The Minnesota Arsenic Study (MARS), a recent study of arsenic occurrence and exposure in western Minnesota, found that 50% of the 900 sampled private drinking water wells had arsenic exceeding 10 µg/l. Statewide sampling results indicate that approximately 14% (or about 50,000) of the state's private wells may exceed 10 µg/l arsenic.

State and local governmental agencies are evaluating potential low-cost ways for public water suppliers to meet the new MCL and to decrease private well owners' exposure to arsenic. Low-cost options for public water suppliers include drilling a different well or changing well operation practices. However, very little is known about the mechanisms causing the observed high-arsenic concentrations and the significant spatial and temporal variations in arsenic concentrations. Without a better understanding of the mechanisms causing arsenic release from solids into ground water, a public water supplier cannot implement a low-cost option with any assurance that it will be a long-term solution. Overall, lack of mechanistic understanding prohibits prediction of ground water arsenic concentration, interferes with the formulation of sound public policy, and inhibits the development of effective regulation. Results from the recent research provide some of the missing information and aid understanding.

Arsenic Occurrence in the Upper Midwest

The MARS study postulated that high arsenic in ground water in Minnesota may be linked to Des Moines lobe glacial till, which is a Late Wisconsin-aged glacial till.

The hypothesis was tested by compiling a comprehensive database of arsenic concentrations in public water supplies, mapping the extent of Late Wisconsin till in the upper Midwest, and statistically examining arsenic concentrations in public water supplies located inside of and outside of the footprint of the Late Wisconsin till. Figure 1 presents the compilation of arsenic concentrations in public water supplies and the extent of Late Wisconsin till in the upper Midwest.

A statistical analysis was performed to evaluate the percentage of public water supplies that exceed 10 µg/l and are located within the footprint of the Late Wisconsin till versus those located outside of the footprint. The analysis reveals that 10.7% of public water supplies that are located within the footprint of the Late Wisconsin exceed 10 µg/l. Only 2.4% of public water supplies located outside of the footprint exceed 10 µg/l. A t-Test

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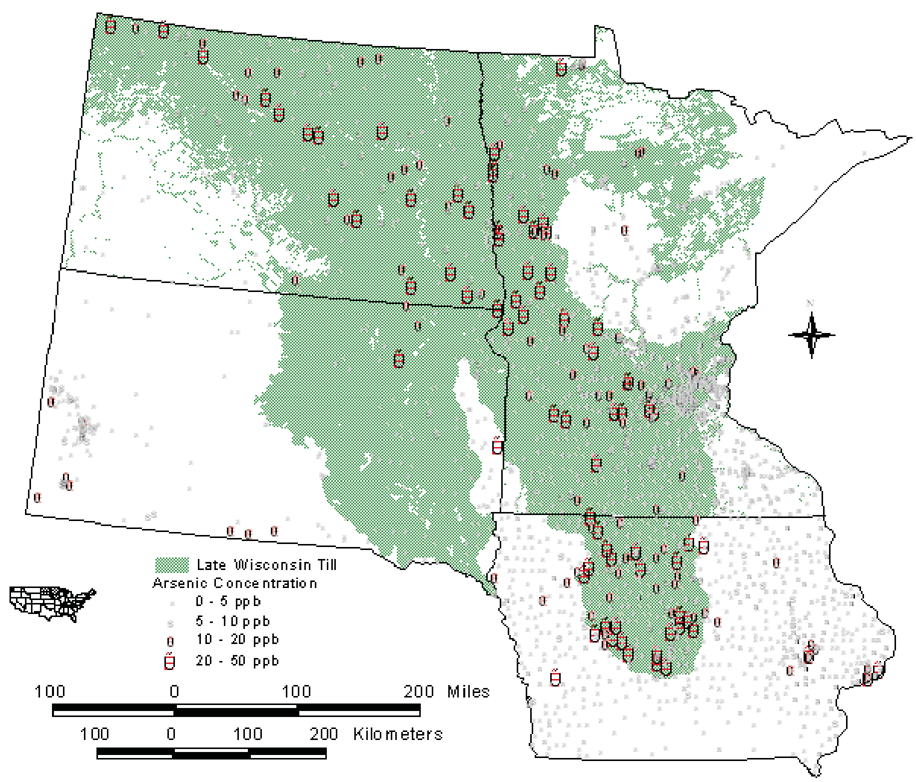

Figure 1 - Arsenic concentrations in municipal water supplies in the upper Midwest, USA. Within the footprint of Late Wisconsin till 10.7% of municipal water supplies exceed 10 µg/l arsenic; outside of the footprint of Late Wisconsin till, only 2.4% of municipal water supplies exceed 10 µg/l arsenic. Measured sediment arsenic concentrations are similar across the region.

Arsenic in Ground Water, cont

assuming unequal variance was used to compare the means of the two data sets. The t-Test results indicate that these two means are not same; thus the two populations are different (p>99.99%).

The observed difference in the populations can be explained by geology and the geochemical mechanisms that mobilize arsenic. Late Wisconsin till has several distinct characteristics associated with arsenic mobilization mechanisms discussed in the literature: it has a large fraction of fine-grained material, has widespread organic entrainment, and has active anaerobic biological activity.

Sediment analyses performed in our related work indicate that arsenic concentrations in Late Wisconsin aquifer sediments in Minnesota range from 0.6 to 4.0 mg/kg, and that 0.4 to 0.8 mg/kg of the arsenic is adsorbed to sediment grains. Adsorbed arsenic is susceptible to mobilization via metal oxide reduction processes. Reduction of solid-phase metal hydroxides to aqueous metals, particularly reduction of iron hydroxides to aqueous Fe^{2+}, can coincidentally mobilize arsenic.

Arsenic is ubiquitous in the environment. The average crustal concentration in rock and sediment is approximately 2 mg/kg of arsenic. The arsenic concentrations measured in Late Wisconsin sediment are not particularly high. Rather, the specific physical characteristics of the Late Wisconsin till, such as its fine-grained matrix and entrained organic carbon, create a geochemical environment that is favorable to a regional scale mobilization of arsenic in ground water. Mobilization of a fraction of a percent of the arsenic in sediment yields water arsenic concentrations exceeding 10 µg/l.

Well Construction

Statistical analysis of the MARS water quality and well construction data indicates that certain well characteristics may influence the arsenic concentration in private wells. Cost-effective well construction results in the shallowest well with the shortest screen that will provide adequate water quantity. This construction practice often results in private wells with short screens set just below the upper confining till unit. Figure 2 provides an illustration of two different types of wells: a well with a short screen set adjacent to the confining unit, and a well with a longer screen set further from the confining unit.

Table 1 and Figure 3 provide statistical summaries comparing arsenic concentrations in private wells with short screens set near the upper confining till unit

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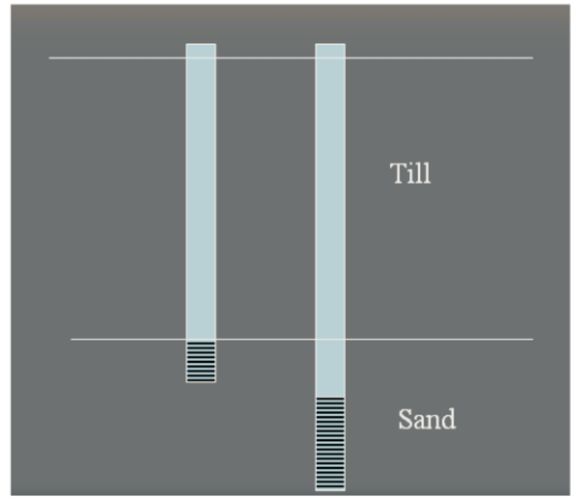

Figure 2 – Schematic of well characteristics. The left well illustrates an example of a well with a short screen set in proximity to the confining till unit. The right well illustrates an example of a longer screen set further from the upper confining unit.

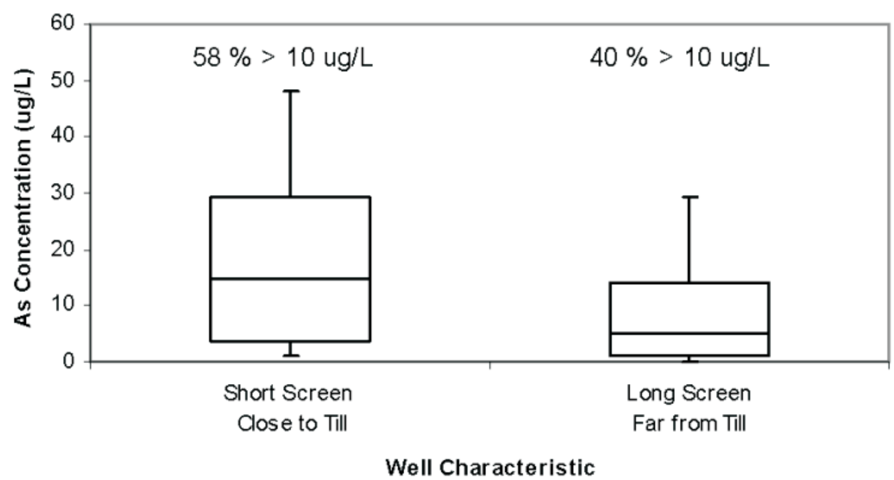

Figure 3 – Arsenic concentration measured in MARS wells, segregated by well characteristic. Wells constructed with short screens set close to the upper confining till unit have higher average arsenic concentrations, and a higher percentage of these wells exceed 10 µg/l.

Table 1 – Well Characteristics and Arsenic Concentration

Description	Average As (ug/L)	Percent > 10 ug/L	Count (N)
Well screen ≤ 8 feet and Distance from screen to till ≤ 4 feet	20	58	282
Well screen > 8 feet and Distance from screen to till > 4 feet	12	40	75

versus private wells with longer screens set further away from the till unit. Private wells that have screens less than 8 feet long set within 4 feet of the upper confining till unit have an average arsenic concentration of 20 μg/l, with 58% of wells exceeding 10 ug/l. Private wells with longer screens set further from the upper confining unit average only 12 μg/l arsenic, and 40% of wells exceed 10 μg/l.

The previous section described the confining till unit in western Minnesota. Late Wisconsin till has physical characteristics (organic material and biological activity) that can create geochemical conditions favorable to arsenic mobilization. The widespread presence of organic material and biological activity in the till is suggestive that geochemical conditions favorable to arsenic mobilization are likely to be present in proximity to the upper portion of an aquifer.

We hypothesized that arsenic concentration in a new well would change over time because constructing a well changes the geochemical environment of the aquifer. This hypothesis has been shown to be false. The variability of arsenic concentrations over time in newly constructed wells is similar to concentration variability observed in older wells; there is no temporal trend.

Changing routine well drilling practices in known high-arsenic areas of the state may have the benefit of reducing the number of families exposed to concentrations of arsenic over 10 μg/l from their drinking water. Although effective point-of-use treatment technologies are available for private well users, eliminating the source of arsenic exposure eliminates the expense of ongoing maintenance and reduces the need for further water testing.

Testing new wells for arsenic also has the potential benefit of reducing arsenic exposure. Additionally, testing new wells for arsenic will provide valuable water quality information for continuing research.

Site Investigation to Evaluate the Viability of Drilling a New Well

A 'site investigation' methodology has been developed in collaboration with the Minnesota Department of Health (MDH) to search for and identify alternate aquifers around high-arsenic public water supply wells. Finding a low-arsenic aquifer may permit a community to use the low cost compliance option of drilling a new well.

The technique of site investigation has been widely and successfully used at hazardous waste sites to delineate the extent of contamination around an anthropogenic release, often with the goal of remediation design and implementation. A typical site investigation includes tasks such as land use review, soil/sediment boring and analysis, monitoring well installation, ground water and surface water sampling and analysis, and three-dimensional synthesis of results to quantify the extent of contamination.

A similar approach can be applied to investigate naturally occurring contamination. However, rather than identifying a 'source', or where the contamination is, the goal of a site investigation around high-arsenic public water supply wells is identifying where the arsenic isn't, more specifically, where the arsenic is not mobile. Our type of site investigation seeks to use existing private wells to identify a different aquifer, either at a different elevation or in a different nearby geographic location, which will not have high arsenic due to different geochemical conditions. An outline of the site investigation procedure used successfully is presented in the following sections.

Identify nearby private wells and owners, and sample wells. Minnesota maintains a public database of wells, which is known as the County Well Index (CWI). The CWI is a database of approximately 350,000 water well logs; geologic information is available for about two thirds of the wells. The CWI contains well owner information from the date of well drilling, but ownership changes are not tracked. Current well owners must be identified by using a combination of the initial well ownership records, well location information, county plat maps, local phone directories, and the personal knowledge of local collaborators (e.g., the county clerk, water operator, or city council members). Current well owners are contacted by letter informing them of their community's public water supply arsenic problem, the effort to identify another aquifer for a new well, and the desire to sample their private well. Well owners are then contacted by phone to ask permission to sample and arrange a time for sampling. Local collaborators collect samples and send them to MDH for analysis. Samples are identified by the unique well number.

Identify potential alternate aquifer(s) and evaluate water quality and projected water quantity. After receiving all of the water quality results, the results are analyzed in conjunction with known and inferred geologic information. If another aquifer is identified that consistently has low arsenic and the aquifer has the potential capacity to supply the community's needs, additional water quality testing is performed on one or more of the low-arsenic private wells. Additional water quality testing involves measuring all primary and secondary water quality parameters to ensure that a community will not be trading one water quality problem for another.

Install a test well and evaluate water quality and water quantity. If all primary and secondary parameter concentrations meet the community's requirements and the capacity of the aquifer is estimated to be adequate, then a test well is installed to verify preliminary water quality results and aquifer capacity estimates.

Install the permanent public water supply well. If water quality results and pumping test results from the test well are consistent with expectations, then the permanent water supply well can be installed and put into service.

Case study

The small, rural Minnesota community of Nielsville is an example of

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Arsenic in Ground Water, cont.

successful application of a site investigation finding a low-arsenic aquifer. Nielsville is located in northwestern Minnesota, in southwestern Polk County, in the valley of the Red River of the North. The average arsenic concentration for the Nielsville wells is 32 µg/l.

Existing private wells with construction information were identified using the CWI. Identified wells were grouped into two different depth ranges. One depth range was similar to the existing city wells, about 150 feet (45 m); the other depth range was substantially deeper, about 300 feet (91 m) deep. Community leaders identified current well owners, publicized the research project and its potential benefits to the community, and enlisted citizen cooperation for well sampling. Each potential project participant was also sent a letter from MDH explaining more about the project. Each potential participant was contacted by phone, and a convenient time for well sampling was scheduled. The combination of local community leader contact and MDH contact with potential participants was very successful; all contacted well owners agreed to participate in the project. The identified wells were sampled for arsenic. Two wells were sampled a second time for all primary and secondary contaminants. Geologic information was gathered, as were water quality and water quantity information for other communities in the area. Sampling results are shown in section view in Figure 4.

There is a clear correlation between well depth and ground water arsenic concentration in Nielsville. Shallower wells are screened in the Quaternary sediment, which is known to have physical characteristics that are conducive to arsenic mobilization. The deeper wells' screens, however, although also in Quaternary sediment, are very near to deep bedrock aquifers that are discharging to the Red River of the North. Therefore, the deeper wells are more affected by the water quality in the bedrock than by the Quaternary sediment. Results of the sampling for primary and

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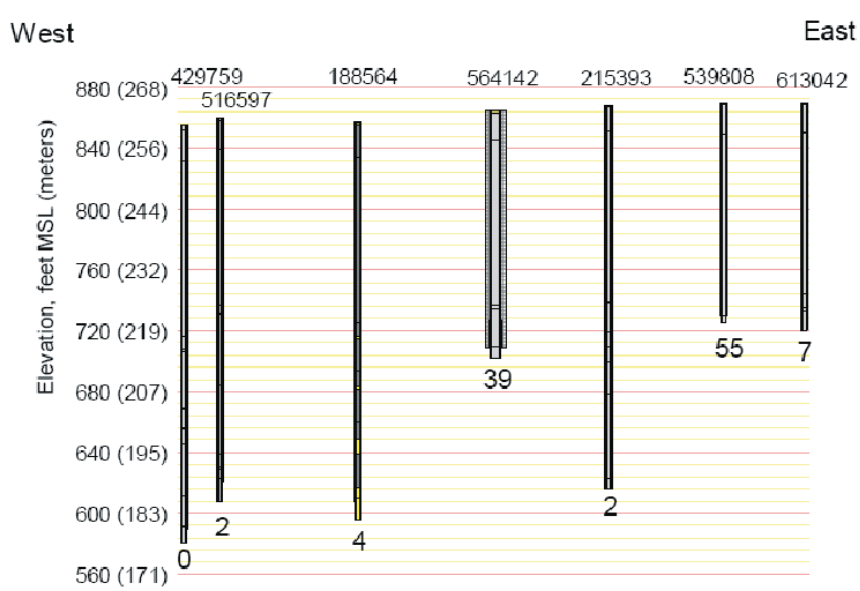

Figure 4 - Nielsville site investigation results, section view. Unique well number is shown above each well, and arsenic concentration (µg/l) is shown below each well.

Arsenic in Ground Water, cont.

secondary contaminants at two deep wells show that all constituents are within an acceptable range. Additionally, a town 30 miles south of Nielsville uses a deep Quaternary aquifer for its municipal water supply. The deep Quaternary aquifer provides the neighboring community with both good water quality and good water quantity. Based on the preliminary sampling results, the geologic information, and water quality and water quantity information from surrounding communities, Nielsville will drill a test well in Spring 2004.

MDH is actively working with arsenic-affected communities to apply this site investigation technique. A small investment of staff time and money by MDH to identify nearby private wells and to cover analytical costs, along with a small investment of time by community leaders, has the potential for enormous financial benefit. A few hundred dollars and a couple days of time can potentially save $1,000,000 or more per community.

Temporal Variability Sampling to Evaluate the Viability of Operations Changes

Many Minnesota public water supplies have variability in measured arsenic concentrations. In some instances, the arsenic concentration variability was anecdotally reported to depend upon the sample collection timing. Samples collected after purging the well for a period of time seemed to have a higher arsenic concentration than those samples collected after just a few minutes of well purging.

Research was conducted to examine the reported arsenic concentration variability and identify an arsenic mobilization mechanism, if possible. Seven Minnesota public water suppliers that currently exceed the new arsenic MCL participated in the research project. The participating public water suppliers are geographically spread throughout the state and

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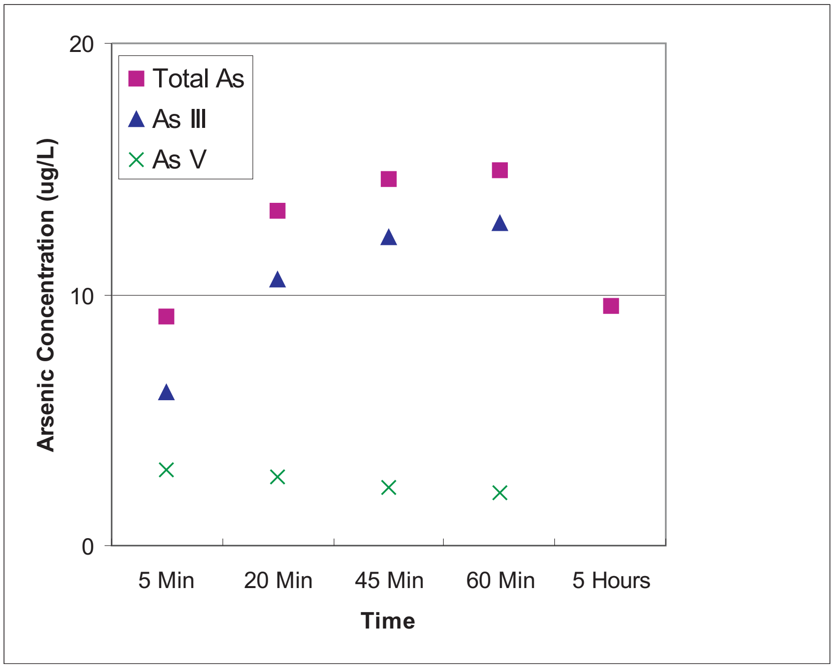


Figure 5 – Temporal arsenic sampling results for Winsted Well #2, central Minnesota. The well pump was started at T=0 minutes and stopped at T=60 minutes. The well was allowed to rest without pumping for 4 hours prior to collecting the sample at T=5 hours.

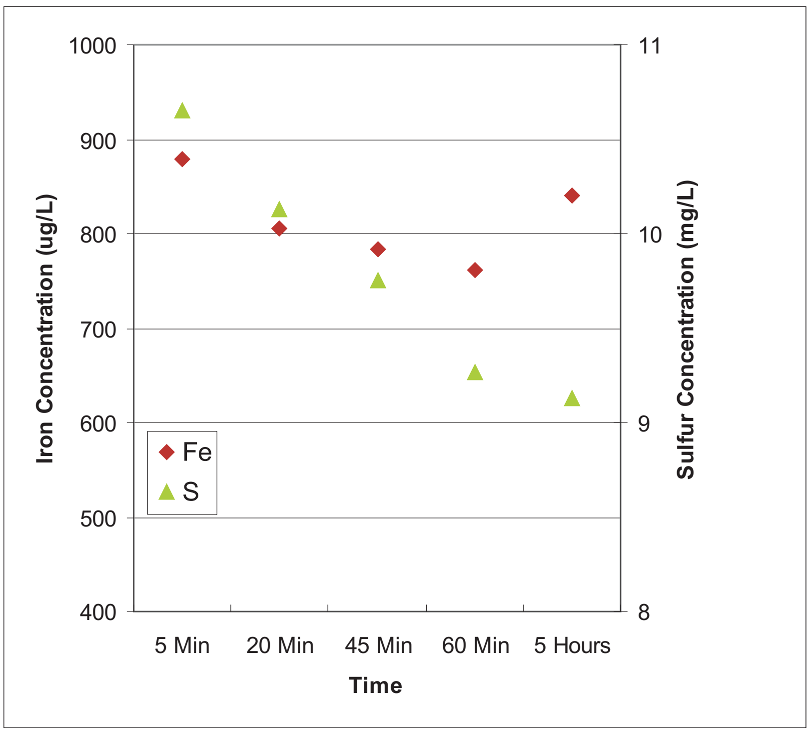


Figure 6 - Temporal iron and sulfur sampling results for Winsted Well #2, central Minnesota. The well pump was started at T=0 minutes and stopped at T=60 minutes. The well was allowed to rest without pumping for 4 hours prior to collecting the sample at T=5 hours.

Science Museum of Minnesota Ground Water Exhibit Update

The total raised thus far for the ground water exhibit at the Science Museum of Minnesota (SMM) outdoor science park, The Big Backyard, is over $18,000! The Minnesota Water Well Association recently made a large donation, and many smaller donations continue to be received from individuals. Over 50 individuals and 20 organizations have donated to this exhibit, which is fantastic. All donations, no matter the amount, are welcomed and will be put to good use.

Unfortunately the large donation that we and the SMM had hoped to receive from a local environmental group did not come through. This donation would have been used to construct the courtyard and displays around the water well. We intend to proceed with the well installation despite this delay. We will continue to seek grants from other organizations and are confident that over time, sufficient funds will be raised. However, some parts of the display may not be installed until 2005 or later depending on when additional funds are received. Please let us know if you have ideas for corporate sponsors or other potential donors to the exhibit.

A groundwater sample was collected in October 2003 from a bedrock well finished in the Jordan Sandstone at a depth of 257 feet located several hundred feet northeast of The Big Backyard at the District Energy plant. No volatile organic compounds, diesel range or gasoline range organics, pentachlorophenol, or selected pesticides were detected in water samples collected from this well. Polynuclear aromatic hydrocarbons were not detected with the exception of phenanthrene detected at a concentration below its Health Risk Limit. Of the fifteen metals tested, only manganese (103 milligrams per liter (mg/l)) was detected at a concentration slightly above its Health Risk Limit (100 mg/l). Although additional testing will be needed once the bedrock well in The Big Backyard is installed, it appears that the ground water in the Jordan Sandstone will be of adequate quality for display purposes.

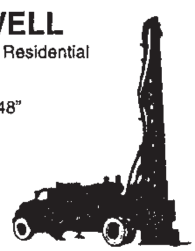
Our goal is to install the bedrock well at the Science Park in the Jordan Sandstone, which is under artesian conditions in this area. Recently, geothermal wells installed into the Jordan in the museum's outdoor park flowed at the surface. However, the bedrock well for the ground water exhibit would not be allowed to flow all the time, so as not to waste the ground water resource and not to endterfere with the other exhibits in The Big Backyard. A rainwater garden is being adapted to handle water from the well which would be generated when museum visitors explore the ground water display.

In addition, we are working with the Minnesota Department of Transportation to obtain bedrock cores of the Prairie du Chien Dolomite, the Jordan Sandstone and possibly the St. Peter Sandstone for the ground water exhibit. These cores samples are from nearby MnDOT projects that are in construction.

Please send financial contributions to the MGWA Foundation, 4779 126th St. N., White Bear Lake, MN, 55110. Please write SMM Ground Water Exhibit on the check so that it can be added to the SMM fund. If you have ideas for corporate sponsors or other potential donors, please contact Cathy Villas-Horns at 651/297-5293 or Gil Gabanski at 763/550-3982.

Thanks again for your support on this project!

— contributed by Cathy Villas-Horns and Gil Gabanski.



Arsenic in Ground Water, cont.

have reported average arsenic concentrations in at least one well ranging from 11 to 35 μg/l.

Each well that was sampled was 'rested' (not pumped) for a minimum of 12 hours prior to sampling. After the resting period, the well pump was turned on at a normal operational pumping rate. Water samples were collected at time intervals ranging from 5 to 120 minutes after the well started pumping. The well pump was then shut off. A final sample was collected after a rest period of several hours.

Wells in five of the participating communities did not exhibit any significant arsenic concentration variability over the period of sampling.

The wells for two communities had notable arsenic concentration variability over time. Figures 5 and 6 present arsenic and iron/sulfur results, respectively, for one of these communities. The geochemical results from both communities are consistent with one another. Both of the wells have high pumping rates, as is common in public water supply wells. The arsenic concentration increases over time with pumping, reaches a plateau, and then decreases again after the well pump stops for a period of time. During the same pumping time, both the iron and sulfur concentrations decrease. After a period of no pumping, the iron concentration increases again, and the sulfur concentration remains lower. The Eh, which is a measure of redox potential, decreases significantly over the period of time that the well pumps, indicating that the redox state of the water is higher before the well is pumped.

The following mechanism is proposed to explain the observed water quality changes in these two wells as they are pumped.

The well's presence and operation creates a zone of higher redox potential immediately surrounding the well. The higher redox zone fosters the presence of iron and other metal hydroxides. The iron hydroxides

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Minnesota Superfund and Ground Water: Reflecting on the Past and Looking to the Challenges Ahead

Editor's Note: This and related topics will be addressed at MGWA's Spring Conference May 4th at the University of Minnesota's Continuing Education and Conference Center (same place as always, different name)

Past activities at many Minnesota Superfund sites have resulted in potential or actual ground-water contamination. One of the more serious examples is the Perham arsenic site, where a cache of toxic pesticide was buried and forgotten (in the county fairgrounds) until a new property owner installed a well and eleven unsuspecting people drank the water and became seriously ill. At least one became permanently disabled. Since the Superfund Program identifies, investigates, and determines appropriate cleanup plans for abandoned or uncontrolled hazardous waste sites, the Minnesota Pollution Control Agency (MPCA) decided to take action. The Superfund Program replaced a threatened nearby water supply, excavated buried arsenic, and partnered with the Environmental Protection Agency to install a ground-water pump-out system to remove the contaminated water. Superfund will fund the pumping for several more years. The Perham arsenic site is one of 84 sites remaining on the state Superfund list.

With two years left in a five-year plan to bring Minnesota's Superfund Program to a maintenance level, completion of the work at remaining sites is the program's top priority. Because of Minnesota's early and aggressive action to address contaminated sites posing a risk to public health and the environment, MPCA is on track to reduce the number of active sites on the state Superfund list to 25 by 2006. Many site remedies have included excavation of hazardous source materials to effectively reduce the threat of ground-water contamination.

After 2006, a maintenance-level program is expected to have a rolling average of 25 sites, with two sites added and two sites removed each year. The MPCA also plans to reduce the number of Minnesota sites on the federal Superfund list (21 sites have been removed, 24 sites remain). There have been 147 sites cleaned up and taken off the state Superfund list since the program's creation in 1983. Remedies at some of the remaining sites have addressed ground water contamination by excavation of the source areas, but include long-term pump-and-treat remedies to prevent contaminant migration and make the ground water drinkable.

The challenges ahead.

A new breed of emergencies may include:

- methamphetamine lab explosions and dumping;
- anthrax-contaminated sites;
- outbreaks of foot and mouth or chronic wasting disease; or
- other unexpected environmental or public health threats.

Another challenge that faces the Superfund Program is ghosts from Superfund's past. There are some sites where contamination remains after cleanup that took place in the program's early days. These sites are being periodically reviewed to see if they need additional study or cleanup. At some sites, the technology and science of 20 years ago suggested that some contaminants did not pose a risk to the public or the environment. However, more precise testing methods and more research suggest that the risk posed by these contaminants may have increased. Additional study or cleanup may also be needed especially if contaminants migrate farther off-site than anticipated.

— continued on page 20

USGS Real-Time Ground-Water Level Monitoring Network

— Geoff Delin, U.S. Geological Survey

The U.S. Geological Survey (USGS) is in the process of developing a pilot network of ground-water level wells within Minnesota that are monitored continuously, with the data posted essentially "real-time" on the web. The purpose of this network is to provide State, local, and Federal water managers, as well as the public, with readily available ground-water level data that can be utilized for a variety of planning activities, such as for drought preparation and awareness.

The wells are being equipped with data loggers, pressure transducers, and modems, with solar panels for power. Data from some of the wells will also be collected via satellite hookup. The "real-time" wells fall into two general categories: (1) climate response, and (2) aquifer stress related to anthropogenic factors.

The climate response wells are intended to monitor the effects of droughts and other climate variability on ground-water levels. These types of wells are: (a) located in unconfined aquifers, or near-surface confined aquifers, that respond to climatic fluctuations, (b) minimally affected by ground-water withdrawals, and (c) essentially unaffected by irrigation and other potential sources of artificial recharge. USGS has two such wells in the network at this time, near Bemidji and at Camp Ripley (http://waterdata.usgs.gov/mn/nwis/current/?type=gw). A third well will be added soon. It wasn't until after the Camp Ripley well was instrumented for this climate response network that we noticed the effects of pumping from a nearby high-capacity well. This well will be replaced in the near future with a well more suited for monitoring climate response. You may be also interested to know that USGS has a national network of climate response ground-water observation wells. These data are displayed at the following web site http://groundwaterwatch.usgs.gov/.

The "anthropogenic area" wells are located in areas where an aquifer is being "stressed" by ground-water withdrawals. In addition to wells located in areas of existing ground-water development (such as the Twin City Metropolitan area or Rochester), these wells could also be located in areas of future ground-water withdrawals, such as the growth corridor from the Twin Cities to St. Cloud. Wells in both confined and unconfined aquifers will be included. Monitoring for these wells hopefully will be funded jointly by USGS and a State or local cooperator with interest in the water resources of that area.

And last but not least, we will propose locating wells from sites of opportunity. These wells typically will be installed as part of a ground-water investigation and then incorporated into the real-time network following completion of the study. For example, the USGS currently is conducting a study in northwestern Minnesota where we have instrumented several wells (http://waterdata.usgs.gov/mn/nwis/current/?type=gw). At the completion of this study it is anticipated that a subset of these wells will be permanently included in our real-time network. The advantage of incorporating wells into the network in this manner is that much, if not all, of the startup costs of instrumenting a well will be incurred by the initial project. Any existing wells around the State could be candidates for wells in this category.

To get an idea of how the Minnesota real-time ground-water level network might look once it's fully implemented you might want to take a look at a similar network that USGS established in Pennsylvania http://groundwaterwatch.usgs.gov/StateMaps/PA.html. We envision that in Minnesota the wells might be installed more by principal aquifer or region rather than by county, however.

Because this program is in its infancy we do not have an accurate estimate of operational costs. We anticipate that startup (equipment) costs for most wells to be on the order of $2,000-$5,000 (depending on equipment needs and availability of existing equipment). For existing wells established as sites of opportunity, much of this startup equipment may already be in place, which will result in savings. We estimate that annual operational/maintenance costs will be about $2,000-$3,000 per well. Thus, the annual operational/maintenance cost to a State or local entity would be only $1,000-$1,500 per well, when funded as part of a USGS coop project.

We are very interested in working with State and local entities in establishing new wells within this real-time ground-water level monitoring network. If you have any wells that you would like us to consider including in our real-time network please contact Geoff Delin (763-783-3231; delin@usgs.gov). Please also contact Geoff with any questions regarding the network.

ILSG 2004

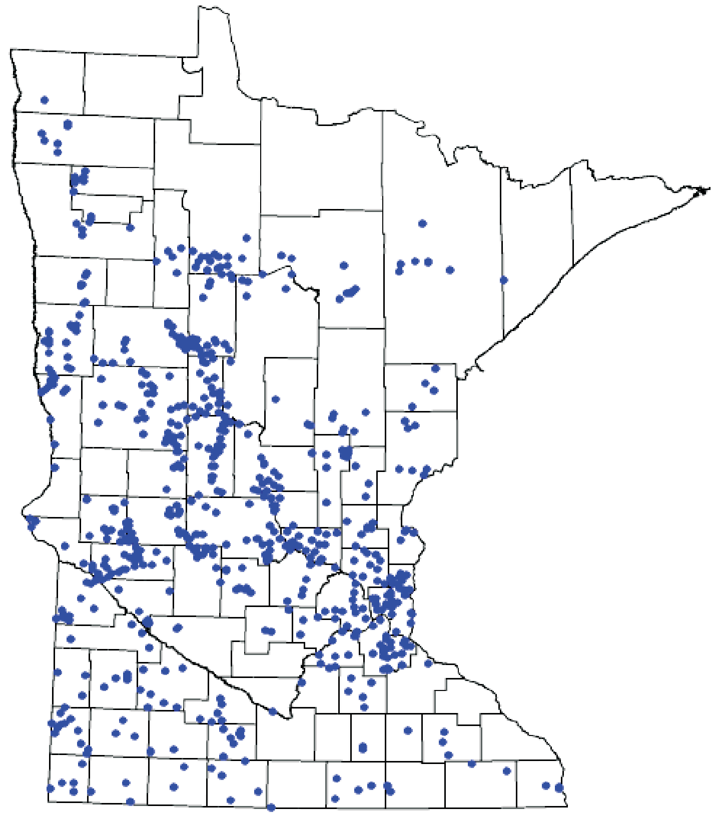
50th Annual Institute on Lake Superior Geology, Duluth, May 4-9, 2004. Focus of conference is Precambrian and Quaternary geology of the Lake Superior Region. For more information, check www.ilsg2004.org

Update on Ground Water Level Monitoring in Minnesota

Organized monitoring of ground water levels in Minnesota began in 1942 and, starting in 1947, was expanded by a cooperative program between the Department of Natural Resources Waters Division (DNR) and the United States Geological Survey (USGS). In the early 1990s the direct participation of the USGS ended. Soil and Water Conservation Districts (SWCD) and other cooperators under agreement with DNR Waters measure the wells and report the readings to DNR Waters. Readings are also obtained from volunteers at other locations. Data from these wells are used to assess ground water resources, determine long term trends, interpret impacts of pumping and climate, plan for water conservation, evaluate water conflicts, and otherwise manage the water resource.

Of the 758 wells currently monitored statewide, the SWCDs monitor about 700 wells. Until recently, the SWCD readings were taken monthly except in winter. Although the number of months monitored has recently been reduced, the timing of the remaining readings is intended to coincide with seasonal climate and water use fluctuations. The rest of the wells are monitored by volunteers or directly by the DNR, often with continuous recorders.

One of the primary purposes of DNR Waters' ground water level monitoring network is to assess long term trends. For this purpose, low frequency readings over the very long term provide the desired information about water level changes over time even though the highest and lowest levels may not be acquired. The 340 wells that have a period of record of at least 20 years provide valuable records during several precipitation cycles. These wells also reflect changes in land and water use. The locations of the network wells shown on the accompanying illustration reflect historic water use patterns. DNR Waters' network data are available at http://www.dnr.state.mn.us/waters/groundwater_section/obwell/waterleveldata.html



The DNR is also considering the use of the U.S. Geological Survey's real-time monitoring technology at select locations including a remote location and another with multiple monitoring points, see page 18. This technology should readily augment the current network. It is hoped that others whose water use needs require continuous monitoring will also take advantage of this new technology.

For more information contact Laurel Reeves, DNR Waters, (651)296-9231, laurel.reeves@dnr.state.mn.us

Future of Superfund, cont.

A number of Superfund sites have institutional controls in place that govern site use because of remaining contamination in soil or ground water. These will need to be tracked. Some ground-water contamination is inaccessible or pervasive and it is not feasible to conduct remediation. The challenge will be to minimize the public health and environmental risk at sites that are undergoing development where contamination remains. At some sites, contaminated underwater sediments need to be cleaned up without stirring up toxins that can damage natural resources. Technologies continue to be evaluated to determine which might be the most effective environmentally and economically.

These important challenges will require both the state and federal Superfund programs to find creative ways to succeed in these efforts. Success achieved with help from local units of government, businesses, and communities will help ensure our own health and that of future generations. Communities like New Brighton, Long Prairie, and Waite Park have tackled the contaminated drinking water issue and found treatment methods that protect their citizens. More recently, state agencies, local units of government and citizens are employing various strategies to minimize the risk from TCE to those living near the Baytown Township Groundwater Contamination Site.

Protection of ground water, one of Minnesota's most valuable resources, requires good management practices by companies and individuals. Such protection must include ongoing educational efforts to prevent contamination from taking place and a quick response when contamination does occur.

— Submitted by Michael Rafferty and Maureen Johnson, Minnesota Pollution Control Agency

Cheaper than Dirt, concluded

surface-water source. Even if some systems decided to switch to surface-water sources, excessive water use could still be a huge revenue generator for the metro area. Using very conservative estimates for groundwater use by municipalities in the metro area, a peak-demand:base-demand ratio of 2 for three months, and assuming a surcharge of only $2.00 per thousand gallons above base demand, about $70 million per year could be realized. Can you say new baseball stadium? Don't want to fund a new stadium? – don't water your lawn as often. The additional cost per 1,000 gallons comes into play only if one's demand exceeds normal base conditions.

The bottom line is this: groundwater in this State is way too inexpensive and people have no respect for things they perceive as cheap.

We may not be there yet, but eventually we in the metro area may pump more groundwater than is recharged. The DNR places limits on the amount of groundwater many growing suburban communities can use in an effort to encourage conservation measures. Many communities resent this, perceiving it as a clash of values. They are willing to pay a premium as long as they are not restricted in their use of water. Given this area's great wealth of flowing surface waters, there should be no need for water restrictions, except under extraordinary circumstances.

Ray Wuolo is a Vice Presdient and hydrogeologist at Barr Engineering. Steve Robertson is a hydrogeologist at the Minnesota Department of Health (this article does not reflect the views of the MDH)

Minnesota and Wisconsin Ground Water Associations Share Common Threads

by Tom Clark, MPCA

With the Vikings and Packers, Gophers and Badgers, the states of Minnesota and Wisconsin have always had their "border battles" in sports and elsewhere. But taking a closer look, you'll find these two states that form the heart of the upper Midwest really have a lot of agreement with one another when it comes to appreciation for and protection of their natural resources. The Ground Water Associations in both states have had a long-standing practice of exchanging quarterly newsletters with one another, and I thought it would be interesting to take a look at WGWA's latest newsletter (Fall 2003; v. 17, no. 4) versus MGWA's (December 2003; v. 22, no. 4) and see what are the hot topics being reported in each. Before I get to that, however, here are a few comments about how the two associations are organized.

Simple demographics have resulted in some differences in structure of the two associations. The large population center of the Twin Cities has historically meant that most MGWA board members and association activities are concentrated there. WGWA also has a central board and several committees, most of whose activities are located in the Milwaukee-Madison areas. But they also have five area coordinators who serve as contacts for the association in the west (Eau Claire, La Crosse), south (Madison, Janesville), north-central (Stevens Point, Wausau), northeast (Green Bay, Fond du Lac) and southeast (Milwaukee, Kenosha) areas. The statewide board meets quarterly via conference call and meeting minutes, as approved, are published in the WGWA newsletter and posted to their website at http://www.wgwa.org.

The WGWA reports 327 individual members as of November 2003, and 180 corporate members. Annual dues are $30 for individuals, $15 for students, and corporate memberships are $25 per person for six or more persons per company. The WGWA account balance as reported by the Treasurer in the Fall 2003 newsletter was $15,595. The WGWA offices are similar to MGWA's, with positions of Past President, President, President-Elect, Secretary, and Treasurer (who also serves as membership chair). In addition, WGWA has three at-large board members, a newsletter committee chairperson, an education committee, and a liaison to the national Groundwater Guardian program. A scan of the WGWA's 2003 officer list shows four of the five are from private industry, while two of the three at-large board members work for private firms. A quarter page ad in the WGWA newsletter costs $35/issue, or $100 annually.

A look at both newsletters shows a number of similarities. Both were 23 pages in length. Both associations prefer the two-word spelling of "ground water". Both had feature reports on their respective fall field trips, with pictures and stop descriptions. WGWA's one-day trip had 47 attendees and began at Devil's Lake State Park in the south-central part of the state. The trip was led by Dr. Robert Dott of the University of Wisconsin and John Attig. Stops included the Badger Army Ammunition Plant south of Baraboo, Natural Bridge State Park, Ableman's Gorge at Rock Springs, and Van Hise Rock. The day concluded with a barbeque ribs and chicken dinner.

Interestingly, another common thread was that both newsletters reported on Well Advisory Areas (or Special Well Casing Depth Areas, as they are known in Wisconsin). The MGWA gave an update on the Baytown Township Well Advisory Area established because of trichloroethylene (TCE) contamination from an as yet unknown source. The limits of the TCE plume were superimposed on a topographic map (page 10, MGWA Newsletter, v. 22, no. 4). Likewise, the WGWA reported on a TCE plume downgradient of an old industrial landfill near the Rock River in the Town of Fulton in Rock County. The limits of the Special Well Casing Depth Area are superimposed on a topographic map (page 9, WGWA Newsletter, v. 17, no. 4). One well, located 1300 feet southeast and downgradient of the landfill to near the top of the bedrock (reported as Prairie du Chien Dolomite in this case), had a TCE concentration of 36 micrograms/liter, which exceeds the Wisconsin Code NR 140 Ground Water Enforcement Standard of 5 micrograms/liter. The article specifies construction methods for new wells installed in the delineated area and requires that they be cased to a depth of at least 225 feet below the ground surface and 30 feet into the bedrock, and grouted into either the Prairie du Chien Dolomite or the underlying Cambrian Sandstone.

Old-timers will find one more interesting common thread between the two newsletters. Some will remember Lee Trotta, hydrogeologist for Johnson Screens and the local USGS office, long-time MGWA member, and editor of this newsletter from 1987-1990. Lee returned to his native Wisconsin a few years back and has been working as a private consultant in the Milwaukee area. The Fall 2003 WGWA Newsletter reports that Lee has taken over the editorial reins, and several of his photos of the WGWA fall field trip appear with the field trip article in the newsletter. You can't keep an old editor down! MGWA members wanting to correspond with Lee electronically may do so at:

lctrotta53072@yahoo.com

Minnesota Environment Magazine to Feature Ground Water

The Spring 2004 issue of the Minnesota Pollution Control Agency's popular magazine, Minnesota Environment, will be devoted to ground water, with articles showing the increasing threat to the quantity and quality of this valuable resource and what we can do to protect it. Available in late April from MPCA, look for interviews with some of the state's ground water policy-makers in government agencies, academia and elsewhere. A Web version will also be available on the MPCA Web site at http://www.pca.state.mn.us. On the home page, click on Minnesota Environment magazine in the top right corner.

Searching for Water on Mars

The exploratory mission to Mars has captured our imagination with brilliantly haunting pictures of an alien landscape in red. Previous space missions have already offered us evidence of water on Mars. The current mission of the rovers, Spirit and Opportunity, seeks to establish additional signs of water that might tell us about the planet's past potential for sustaining life.

Astrobiology Magazine's website has some excellent photos and summaries on the search for water on Mars. Take a look at Water on Mars:
www.astrobio.net/news/article769.html
Read about the soils that Spirit and Opportunity are encountering:
www.astrobio.net/news/article811.html

Peruse the website for the latest details on the progress of the Mars mission.

50th Midwest Friends of the Pleistocene Field Conference

The Midwest Friends of the Pleistocene sponsored by the Minnesota Geological Survey and hosted by St. John's University/College of St. Benedict will meet Friday, June 4 to Sunday, June 6 in central Minnesota on the St. John's University campus. This will not only be the 50th Midwest Friends of the Pleistocene meeting but it will commemorate 50 years since Herb Wright and Al Schneider led the 5th FOP in central Minnesota in 1954.

The field trips on June 5 and 6 will visit outcrops exposing Late Wisconsinan Des Moines, Superior, and Wadena lobe deposits and also deposits of at least three pre-late Wisconsinan ice advances. These sites include exposures in eskers, drumlins, moraines, thrust blocks, tunnel valley fans, and also an exposure of a buried soil.

For more information contact Alan Knaeble at knaeb001@umn.edu or 612-627-4780 ext. 210.

Why is Ground Water Biodiversity Important?

NOTE: In December 2003, Tim Thurnblad, a Senior Hydrologist with the Minnesota Pollution Control Agency, circulated the following information to a listserver of MPCA hydrologists and some selected others. We have edited the e-mail slightly and are reproducing it here to provide additional information about the little-known (at least in the United States) but potentially important topic of ground water biodiversity and to promote further discussion. Persons wishing to correspond with Tim may contact him at the MPCA at tim.thurnblad@pca.state.mn.us.

I submit this information to readers to share the interest I developed when I came upon a website indicating the serious effort being undertaken in Europe to evaluate ground water biodiversity. I claim no particular expertise in this subject or other subject areas discussed below. I simply composed this email to share with you the thoughts provoked by briefly scanning the content of the following web site:

http://www.pascalis-project.com/home/innovation.html

It has been quite a few years since I have heard discussion of ground-water biodiversity or ground-water ecology in Minnesota. If ground water is often ignored because it is out of sight (and thus out of mind) then, it would be no surprise that the importance of (mostly microscopic) ground water biodiversity would be almost completely 'out of mind' (overlooked). After reviewing this web site, my thoughts were: if this subject is that important to the Europeans, why have I been hearing no discussion about it here?

Biodegradation - Our Ally at Clean Up Sites

Over the last fifteen to twenty years, we have become accustomed to rely quite heavily on biodegradation as a solution to contamination of our soils and ground water by a variety of chemicals at sites of concentrated contamination (e.g., Superfund sites, tank leak clean up sites, etc.). At first, at various large industrial contamination sites, we were surprised at how well natural biological systems in the subsurface could attenuate contamination. Many people were surprised to learn that anything actually lived in the deeper soil zones and in ground water. Later, we tried to enhance natural biodegradation with nutrients, 'improved' species, etc. As we tried to get more mileage out of biodegradation, we also learned more about its limitations. But long before the days of Superfund clean up projects, natural biological systems in the subsurface were helping to reduce contamination of the subsurface by both natural processes and human activities.

Biodegradation of Non-Point Sources of Pollution in the Subsurface

Today in Minnesota, we realize that non-point pollution sources can have a substantial negative impact on the state's soils and ground water. In turn, the ground water, as it does its part to sustain lakes, streams and wetlands, can contribute substantial concentrations of contaminants to surface water. But these non-point sources of contamination, such as fertilizers and pesticides spread throughout vast acreages of Minnesota farm land or the diverse suite of industrial and domestic contaminants that are picked up by urban storm water runoff, cannot be cleaned up like a Superfund site. Their distribution is just too dispersed.

As we (hopefully) continue to work toward improved 'best management practices' that reduce the load of non-point sources of pollution reaching the subsurface, we will be counting on the subsurface biological systems described above to continue to do their magic of helpful biodegradation.

What other method or entity can we expect to attack non-point source pollution on such a grand scale - and for free? All we have to do is to avoid terminating these helpful (mostly microscopic) little wonders and let them thrive in their natural state of biodiversity. With this combination of less contamination reaching our soils and ground water and a continuation of a healthy rate of natural

— continued on the next page

Ground Water Biodiversity, cont.

biodegradation, we can have hope for improving the quality of Minnesota soils, ground water and surface water.

But among the underlying assumptions in the preceding paragraph is one we know little about. How are the health and the diversity of subsurface biological systems in Minnesota? Are we harming this resource? Do these biological communities continue to adapt and even thrive, at times, on some contaminants or is the biodiversity of these systems being decimated by the continual onslaught of modern chemicals?

You may find it interesting that European nations are quite concerned about these questions and are taking action to answer them.

European Commission Efforts to Advance the Assessment and Conservation of Groundwater Biodiversity

I selected an excerpt from their web site to provide a taste of what they are doing: "The present project is resolved to fill this gap and will provide new data and innovative methods that are of critical importance in advancing the assessment and conservation of groundwater biodiversity. Major creative products will concern both the way to look at, to assess, to predict and to conserve biodiversity in European groundwater."

You can find more details here:

http://www.pascalis-project.com/home/innovation.html

"PASCALIS (Protocols for the ASsessment and Conservation of Aquatic Life In the Subsurface) is a research project supported by the European Commission under the Fifth Framework Programme and contributing to the implementation of the Key Action "Global Change, Climate and Biodiversity" within the Energy, Environment and Sustainable Development ... "

I have included one of the objectives of this project here: "to reinforce public and regional manager awareness of the necessity to conserve groundwater biodiversity by emphasising its economic, social, and scientific value ..."

You can see more about their objectives here:

http://www.pascalis-project.com/home/objectives.html

Assessment of Ecosystem Health Through Biological Indicators

Their ground-water-focused work has some interesting parallels to the work the MPCA and others are doing to look at biodiversity to assess the health of surface waters. "In particular, biodiversity data from selected regions may provide reference conditions against which the effect of anthropogenic disturbances can be evaluated and serve as a basis for the development of biological indicators of groundwater ecosystem heath."

This begs the question, should we not also be looking at ground-water ecosystem heath in Minnesota with the same vigor with which we look at surface water ecosystem health?

Links

Their web site also has an interesting set of web links for those interested in ground-water ecology:
http://www.pascalis-project.com/links/links.html

Final Thoughts

If you are still reading and you do water quality monitoring or (above ground) biodiversity assessments (e.g., for stream assessment) as part of your work, I wonder if this web site might prompt you to consider doing some subsurface biodiversity assessments to complement your normal work? Of course, there is the reality of budgets, both time and money that may make it difficult. But at least consider budgeting for this type of work the next time you have the opportunity to make a work plan. It may be by then, this European project will be much further along and will have more enlightening information available. I would suspect that, by better understanding the ground-water ecology of a particular area, the interpretation of the rest of your data will become much clearer. In turn, this will help us to better understand the environmental outcomes of our efforts to protect Minnesota's environment and of activities that continue to load our environment with contaminants.

Tim Thurnblad, Hydrogeologist, Minnesota Pollution Control Agency, to comment on this article, e-mail the author at tim.thurnblad@pca.state.mn.us or e-mail the editors at newsletter@mgwa.org

MGWA Board Meeting Minutes

November 6, 2003

Place: Keys Cafe, on Lexington in St. Paul, Minnesota

Attending: Marty Bonnell, President; Chris Elvrum, President Elect; Eric Hansen, Treasurer; Jennie Leete, WRI; Sean Hunt, WRI; Norm Mofjeld, Newsletter Editor; Jon Pollock, Secretary; Rob Caho, Past President.

Approval of Minutes: The Board approved minutes for the Regular Board Meeting held on October 2, 2003.

Treasurer's Report: Current cash balance is $29,045.27. Field Trip net income was about $1000. Field trips are not profitable for MGWA: liability insurance costs are borne soley by MGWA as are bad checks and accounts and any expenses that occur after the trip's profit is split with AIPG. Prior to the 2000 agreement profits from joint AIPG-MGWA field trips were split with AIPG while losses were borne by MGWA alone.

Membership: A draft membership dues renewal sheet was passed out for review. Science Museum project listed at bottom. Can renew on line. Information will get to members about mid November.

Web Page: Updated conference page to recent agenda.

Foundation: Recap of local stipends: $500.00 to UW River Falls and $750.00 to Metro Children's Water Festival

Education: Meeting today.

Newsletter: Scanning of newsletter back issues has started. Photos will be taken at conference.

Old Business

<u>Fall Conference:</u> 167 people registered, schedule passed out.

<u>Foundation:</u>

Science Museum: Mn Rural Water Association check for $500.00 has been received. Current total is $6,825.00 including $2,000.00 from MGWA Foundation.

Motion: Re-designate $8,000.00, previously allocated to the MGWA Foundation Endowment in May of 2003 to Foundation Unrestricted Funds. Approved by Board. Motion passed 5-0-0

<u>Fall Field Trip:</u>

Motion: Discontinue agreement between AIPG and MGWA regarding the fall field trip. At AIPG's request remit all profits from the 2003 fall field trip to the AIPG Minnesota Section. Motion passed 4-0-1 (1 abstained).

Marty will write a letter to AIPG acknowledging MGWA's withdrawal from the Memorandum of Agreement between the MGWA and the AIPG (Minnesota Section) regarding field trips dated December 4, 2000.

December 4, 2003

Place: Keys Cafe, on Lexington in St. Paul, Minnesota

Attending: Marty Bonnell, President; Chris Elvrum, President Elect; Eric Hansen, Treasurer; Jennie Leete, WRI; Sean Hunt, WRI; Norm Mofjeld, Newsletter Editor; Rob Caho, Past President.

Board Minutes, cont.

Approval of Minutes: The Board amended minutes for the Regular Board Meeting held on November 6, 2003 with changes: verify that cash on hand balance reported in October was only Wells Fargo business account, add “draft” in front of Membership form; change “scheduled” to “underway” on newsletter scanning by WRI. Motion to approve by Caho, second by Hansen, approved.

Treasurer’s Report: Current cash balance is $26,368.87. Field Trip net income was $1002.00 with three Department of Health invoices outstanding. Fall conference earnings $6047. The use of these earnings can be evaluated.

Membership: Membership renewal notices have been sent out. 68 paid to date for 2004. Science Museum mailer was included. 4 of 7 past corporate members are paid for 2004.

Web Page: The on-line store is open for renewals. This feature is being used with 4 or 5 renewals in last 2 days.

Foundation: Review of Science Museum donations received to date, $8,266. This money will be needed in a few months. No other funding requests have been received.

Education: No report.

Newsletter: Awaiting bio’s for election and 1 column. Will go out shortly. Plan is to insert the election ballot in newsletter as usual. Will be posted on web site for email recipients and mailed to members without email addresses on file. Risk of corruption due to downloading multiple ballots deemed low. Thank you was received from UW River Falls for field trip financial support ($500 from Foundation).

Old Business: Fall Conference: 181 attendees. ~40 comments received. These will be compiled and distributed. Facilities continue to improve. Good feedback on speakers – especially national people. Handouts were not available for most speakers. Attendees must contact them directly for copies.

Science Museum: Freshwater Foundation has been asked to pledge significant funds.

Fall Field Trip: A letter is drafted to AIPG. Need to send. Check is also ready to be sent for earnings when final registration fees are collected from MDH.

Letter will be written to AIPG acknowledging MGWA’s withdrawal from the Memorandum of Agreement between the MGWA and the AIPG (Minnesota Section) regarding field trips dated December 4, 2000.

New Business: Spring Conference: Ideas being solicited. General thought to focus on technology rather than policy (status of contamination cleanups?, technologies, closure goals?) We will strive to distribute CD with conference information. Kick off planning in January.

January 8, 2004

Place: Keys Cafe, on Lexington in St. Paul, Minnesota

Attending: Chris Elvrum, President; Laurel Reeves; President Elect; Eric Hansen, Treasurer; Jon Pollock, Secretary; Jennie Leete, WRI; Sean Hunt, WRI; Norm Mofjeld, Newsletter Editor; Gordie Hess, Foundation.

Approval of Minutes: Minutes for the Regular Board Meeting held on December 4, 2003, were approved by the Board.

Treasurer’s Report: Current cash balance in business and money market accounts is approximately $28,600.00. 2003 earnings were approximately $9,000.00.

Membership: Membership information passed out by Sean. Currently 305 members – appears that the membership will be similar to the previous year.

Web Page: Sean is working on e-mailing issues and online store. Interest in finding a volunteer to cosmetically improve website. Discussion of continuing education events on website. Sean indicated that there is an area for this and that any announcements can be sent to him.

Foundation: Gordie will be resigning from the Foundation, will write article for newsletter looking for replacement. Approximately $53,000.00 in Foundation with approximately $17,000.00 for science museum well.

Education: No report.

Newsletter: Kurt Schroeder joined Newsletter Team. Will need his picture for newsletter along with a picture of Laurel Reeves. Science museum project and AIPG/MGWA field trip information will be in President’s Column.

New Business: Spring Conference: Focus on state of groundwater cleanup in Minnesota. Will be held on May 4, 2004.

WRI Contract: Motion by Chris to approve Contract for 2004. Motion seconded by Eric and passed unanimously. Contract for 2004 signed by Treasurer and Secretary.

Scanning Old Newsletters: Approximately 2/3 finished with approximately 650 pages scanned.

Next Meeting: The next Board Meeting will be 0730 on February 5, 2004 at Keys Cafe on Lexington in St. Paul, Minnesota.

Arsenic and Ground Water, cont.

provide adsorption sites for arsenic species, thus creating a zone of lower dissolved arsenic and higher adsorbed arsenic.

Outside of the zone of the well’s influence, the aquifer is reduced. The reduced aquifer is an environment favoring precipitation of iron and sulfur minerals; thus the dissolved concentrations of iron and sulfur in the reduced aquifer are lower than near the well.

After the well pump starts, reduced water is drawn to the well. The reduced water has lower iron and sulfur concentrations. The reduced water may itself also have low arsenic, although it is impossible to measure directly. As the reduced water flows into the zone influenced by the well, arsenic adsorbed to sediment grains near the well is desorbed. The increase in arsenic concentration is primarily due to an increase in As^{3+},

— continued on the next page

Arsenic in Ground Water, cont.

the more reduced form of arsenic. As^{3+} adsorbs less strongly to iron oxides than As^{5+}, and As^{3+} does not adsorb appreciably to other metal oxides. The As^{3+} desorption mechanism may be simple desorption, or the mechanism may be reductive desorption: As^{5+} is reduced to As^{3+} and then desorbs due to reduced adsorption capacity.

After the well pump stops, the dissolved arsenic concentration decreases slightly due to adsorption. The dissolved iron concentration increases as some iron hydroxides dissolve in the temporarily reduced aquifer environment. After the higher redox zone around the well equilibrates, both the arsenic concentration and the iron concentration return to their equilibrium concentrations.

Communities that have predictable temporal variability in arsenic concentration may consider changing well operations as a compliance option. Using variable-concentration wells on a scheduled basis may be a viable virtually no-cost compliance option. Once again, a small, targeted investment of time and money for specific water sampling has the potential for enormous cost savings.

Conclusions

Recent research results have the potential to influence development of new Minnesota guidelines and regulations related to the presence of arsenic in ground water in the state. The following areas of guideline and regulation development and implementation may be influenced by these research results:

- Requiring testing of new private wells for arsenic, either statewide or in certain parts of the state
- Recommending testing of existing private wells for arsenic, either statewide or in certain parts of the state
- Changing suggested standard private well drilling practices
- Exploring appropriate low cost compliance options at affected public water supplies

For More Information

Although specific references were not provided in this newsletter article, many other scientists' research results contributed to this work. A list of references and related readings can be obtained from Mindy Erickson, eric0984@umn.edu.

Acknowledgments

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To comment on this article, send e-mail to the author at eric0984@umn.edu or to newsletter@mgwa.org.

2003 Financial Report

	Jan - Dec 03
Income	
Total 3100 Contributions	pass through
Total 3200 Dues	13,211.00
Total 3300 Ads	1,971.25
3400 Interest	62.37
3500 Prog. Fees	
3510 Spring Conference	20,755.00
3520 Fall Conference Fees	16,315.00
3530 Field Trip Fees	11,530.00
Total 3600 Products	801.16
Total Income	64,645.78
Total COGS	10.00
Gross Profit	64,635.78
Expense	
4000 Admin	
Total 4100 Fin. Admin.	2,593.08
Total 4400 Board of Directors	287.55
Total 4500 Dues	1,486.43
Total 4600 DB Maint	2,700.00
Total 4000 Admin	7,067.06
5000 Programs	
Total 5100 Spring Conf	12,337.96
Total 5200 Fall Conf	11,060.41
Total 5300 Field Trip	11,530.00
Total 5500 Networking Event	85.19
Total 5000 Programs	35,013.56
6000 Mem Services	
Total 6100 Newsletter	9,675.08
Total 6200 Directory	736.81
Total 6300 Member Corresp.	106.50
Total 6000 Mem Services	10,518.39
7000 Public Service	
Total 7200 MGWAF	717.10
Total 7300 Public Education	2,355.00
Total 7000 Public Service	3,072.10
Total Expense	55,671.11
Net Income	**8,964.67**