

Minnesota Ground Water Association

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Newsletter

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MGWA President
Lanya Ross

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President's Letter

We who choose to study water choose work that never ends. As the year winds down, I am thinking of how we learn and then pass along what we know.

One of my favorite historical documents is Book VIII of de Architectura, written by Marcus Vitruvius Pollio (Roman author, architect and engineer) during the 1st century BC. Divided into ten books, it covers all aspects of Roman architecture. Book VIII discusses water:

"...since it is held by physicists and philosophers and priests that all things depend upon the power of water, I have thought that, as in the former seven books the rules for buildings have been set forth, in this I ought to write on the methods of finding water, on those special merits which are

due to the qualities of localities, on the ways of conducting it, and how it may be tested in advance. For it is the chief requisite for life, for happiness, and for everyday use." (source: *The Project Gutenberg EBook of Ten Books on Architecture, by Vitruvius*)

Book VIII reads like a MGWA conference: guidance for finding groundwater in various landscapes, discussion of the water cycle, description of methods for digging wells, and concerns for public health. There is also an interesting dose of information about what weird waters have been found where.

The document was then lost for almost 1,500 years, until it was rediscovered and went on to shape the Renaissance. It is perhaps most recognizable through Leonardo da Vinci's illustration of Vitruvius' discussion of sym-
— continued on page 4

Updates on the White Paper Initiative

Work continues on several fronts on behalf of the Association. Below are brief updates:

White Paper 1 – Manganese in Minnesota's Groundwaters

This white paper is complete! The final version is available to all on the MGWA website at [www.mgwa.org/documents/whitepapers/01_manganese/Manganese in Minnesotas Groundwaters.pdf](http://www.mgwa.org/documents/whitepapers/01_manganese/Manganese_in_Minnesotas_Groundwaters.pdf). The members of the work group researching and completing this white paper – Mindy Erickson, Bill Bangsund, Meghan Blair, Vanessa Demuth, Sarah Johnson, Linse Lahti, Dave Lowell, and Jim Lundy – deserve our thanks and gratitude for their efforts. Additional thanks to Mark Collins and Bruce Olsen for participating as liaison for the White Paper Committee. Additional contributors are listed in the paper. Please feel free to tell other colleagues about it, and if anyone has further questions, they can contact Bill Bangsund or Sarah Johnson via the website.

White Paper 2 – Groundwater Education Gaps in Minnesota

The Work Group has met four times since it was organized in August 2015. After becom-

ing familiar with and embracing the purpose and scope of the white paper, the group has had good discussions with representatives of the Minnesota Department of Education, the Freshwater Society, and a science teacher using an ESTEM program at a middle-school. Recently, the nine-person workgroup agreed to break into smaller teams to focus on information gathering by primary audience in education, namely K through 12, Post-secondary, and State-wide strategy for interested public. As MGWA White Papers are to reflect the values of the Organization, the workgroup intends to reach out to MGWA Members. As mentioned by Lanya Ross at the Fall Conference (joint with the Sinkhole Conference), some of your input for the next full-membership survey will relate to groundwater education needs, particularly post-secondary education needs for entry-level groundwater-related positions in Minnesota. Stay tuned for that opportunity sometime this winter. If you have other comments or suggestions for this topic, feel free to contact the workgroup members—Randal Barnes, Rachel Beise, Jonathan Carter, Ellen Considine, Gilbert Gabanski, Bruce Olson, Jeff Stoner (chairperson), Cathy Undem, or Karen Voz. Kelton Barr and Mark Collins are the liaisons to the MGWA Board for this paper.

MEMBER NEWS

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Newsletter Deadlines

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Ellen Considine Joins Minnesota DNR

Ellen Considine is now the Metro Area Groundwater Specialist at the Minnesota DNR. She previously worked at Barr Engineering Company for 9 years as a Hydrogeologist, where at various times she filled the roles of project manager, groundwater modeler, field geologist/hydrogeologist, and technical writer for projects including proposed and existing sand and metallic mines, Superfund sites, and power plants. Prior to working at Barr she was a groundwater modeler for MWH in Bishop, California after completing a Master's degree in Hydrogeology at the University of Nevada, Reno. Her bachelor's degree is in Geological Engineering from UW-Madison.



Ellen Considine

Crague Biglow Promoted to Supervisor

Crague Biglow was promoted to supervisor of the MPCA's Site Remediation Unit 2 on October 21, 2015. This position in the agency's Site Remediation & Redevelopment Section became vacant following Doug Beckwith's retirement in July.

Crague probably needs no introduction for most of you as he has already had a most distinguished career at the MPCA and in the Remediation programs. Crague comes to this supervisor position with 28 years of experience at the MPCA cleaning up RCRA and more recently Superfund sites. Crague's technical and administrative expertise in the RCRA Cleanup Program has been further enhanced by his work as the State Program Administrator Coordinator (SPAC) for the Site Remediation & Redevelopment Section over the past two years.

Crague has exhibited outstanding leadership and initiative, as well as the ability to handle



a diversity of challenges calmly and professionally in the SPAC position as well. Crague earned his BS degree in Geology from the University of Minnesota-Duluth, and his MS degree in Geology from Eastern Washington University.

In Memoriam

Professor Herbert E. Wright Junior

Herbert E. Wright, Jr., Regents Professor Emeritus of Geology, Ecology and Botany passed away on November 12, 2015 at the age of 98. Early in 2016, the University of Minnesota, College of Science & Engineering, and School of Earth Sciences will host an event to celebrate Herb's life and career.

Obituary: www.startribune.com/obituaries/detail/109797/?fullname=herbert-e-wright,-jr

Geoffrey Nash

Long-time geologist Geoffrey "Geoff" Nash died on October 8, 2015. More information is available at: www.startribune.com/obituaries/detail/104611/?fullname=geoffrey-hadon-nash

MEMBER NEWS

Officer Candidates

Evan Christianson – Candidate for President-Elect

Evan Christianson, candidate for President-Elect, is a hydrogeologist with Barr Engineering. His work focuses on implementing hydraulic models to solve complex water quality and water supply issues. Evan's interests include groundwater flow modeling, geographic information systems, aquifer characterization, and development of custom quantitative methods for various modeling applications. Evan also enjoys bridging the world of groundwater and surface water, and strives to break down artificial walls in our understanding and management of a single hydrologic system. Evan has a B.A. in geology from Gustavus Adolphus College and a M.S. in geology and environmental science from Iowa State University.



Evan says, MGWA is an important organization for disseminating scientific and policy advancements for both professionals and the general public. Maintaining active participation of consultants, academics, and resource managers is important to generate a unique blend of ideas and constructive collaboration that allow further development of each individual's practice and advancement in our understanding of groundwater resources in Minnesota. MGWA lead initiatives, such as recent white papers, also help to foster growth within the groundwater community, develop future groundwater professionals, and educate the public. I welcome the chance to keep MGWA a vibrant and respected source for scientific, policy, and educational advancement.

Andrew Retzler – Candidate for Secretary

Andrew Retzler, candidate for Secretary, is a Paleozoic bedrock geologist at the Minnesota Geological Survey (MGS). He joined the MGS in 2013 and specializes in carbonate sedimentology and stratigraphy, working alongside Tony Runkel and Julia Steenberg to produce bedrock geologic maps for the County Geologic Atlas program. Andrew is currently mapping the bedrock geology for Hennepin and Dodge Counties, and is a collaborator in a number of applied research projects focused on groundwater hydrogeology and Paleozoic stratigraphy in Minnesota. He and Julia Steenberg are also working to digitize and update the MGS's gamma-ray logs and database with funding from a National Geological and Geophysical Data Preservation Program Grant provided by the USGS. Andrew has a Bachelor of Arts in Geology from the College of Wooster and a Master of Science in Geosciences from Idaho State University. His undergraduate and graduate research has been published in *Cretaceous Research* and *Geosphere*, respectively. Andrew has diverse interests in earth sciences—including bedrock geology, paleontology, glacial geology and hydrogeology—and enjoys learning more about the groundwater system of Minnesota as a member of the MGWA.



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The primary objectives of the MGWA are:

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

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MGWA NEWS

A Successful Joint MGWA and 14th Annual Sinkhole Conference

By Sharon Kroening, MGWA Newsletter Team

The 14th Annual Sinkhole Conference (technically referred to as the Multidisciplinary Conference on Sinkhole and the Engineering and Environmental Impacts on Karst) was a resounding success! This year, the MGWA cosponsored the Sinkhole Conference instead of holding the usual Fall Meeting at the University of Minnesota. The conference was held at the Mayo Convention Center in Rochester from October 7 through 9, 2015, and attracted more than 225 participants from Minnesota and throughout the world. This was the first time the Sinkhole Conference collaborated with another professional organization, and it led to a large increase in the number of people who participated compared to the last meeting held in Carlsbad, New Mexico in 2013.

The first two days of the conference featured several short courses and a field trip. The short course topics included site characterization in karst, groundwater tracing, grouting in karst, and Minnesota rules, regulations, and permits

in the karst landscapes. The field trip was a tour of the karst bedrock in Southeastern Minnesota and was led by MGWA members Dr. Calvin Alexander (UM), Dr. Tony Runkel (MGS), Jeff Green (DNR) and John Barry (DNR).

The conference opened on Wednesday, October 7, 2015, with remarks from the Mayor of Rochester, the organizers of the conference, and Harvey Thorliefson from the MGS. Dr. Michael Osterholm from the Center of Infectious Disease Research and Policy at the University of Minnesota was the keynote speaker. He gave a very engaging talk, not on his traditional world of viruses and bacteria, but on his love for trout fishing and the efforts he has undertaken at considerable personal expense to restore the tallgrass prairie on karst land he owns in Northeast Iowa. The technical presentations on Wednesday focused on the karst aquifers in the Upper Mississippi River Valley and karst geology and hydrology, often featuring Minnesota karst experts.

On Thursday attendees from outside the U.S. took the podium and introduced us to some of the complexity in karst found throughout the

— continued on page 5

Abbreviations and Acronyms

- ◆ ASTM – American Society for Testing and Materials
- ◆ DNR – Minnesota Department of Natural Resources
- ◆ MDA – Minnesota Department of Agriculture
- ◆ MDH – Minnesota Department of Health
- ◆ MGS – Minnesota Geological Survey
- ◆ MPCA – Minnesota Pollution Control Agency
- ◆ USEPA or EPA – United States Environmental Protection Agency
- ◆ USGS – United States Geological Survey

President's Letter, cont.

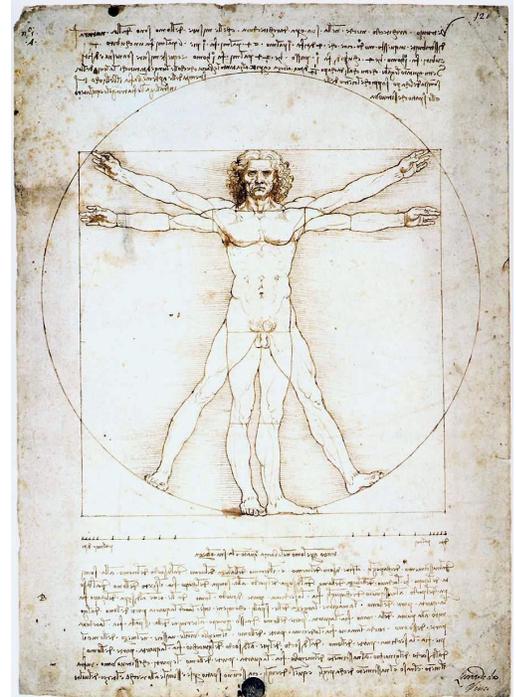
metry in temples and the human body - the Vitruvian Man. Da Vinci is also credited with the quote, "Water is the driving force of all nature", which may very well have come from his reading of Book VIII.

Five hundred years after da Vinci and two thousand years after Vitruvius, we are saying the same thing using modern Minnesota work-speak. The Minnesota Environmental Quality Board's Water 2015 Policy Report states that "water is the cornerstone of our state's economy and a vital resource for our citizens."

And we are still working to find water, conduct it to where it is needed, and test it to be sure it is safe. Some things change. Some things don't.

Organizations like ours provide a mechanism to transfer knowledge between disciplines and over the years. As much of our work transitions from paper to electronic documents, great work is 'lost'. The relationships and conversations that MGWA supports keep that information alive and transferable.

To our MGWA members, Board members, Foundation members, newsletter team, WRI management, scholarship and grant recipients, white paper committee members, conference volunteers, invited speakers, and friends: thank you for sharing what you know with me. I look forward to passing it on.



Note: The eBook 'Project Gutenberg eBook of Ten Books on Architecture, by Vitruvius' is for the use of anyone anywhere at no cost and with almost no restrictions whatsoever. You may copy it, give it away or re-use it under the terms of the Project Gutenberg License included with the eBook or online at www.gutenberg.org

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MGWA Joint Fall Conference, cont.

world. The technical presentations covered karst mapping and GIS databases; contamination of karst aquifers; karst management, regulations, and education; modeling of karst systems; and engineering and geotechnical investigations in karst. On Friday, presentations were dominated by discussions of the geophysical exploration of karst.

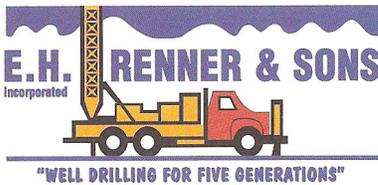
The conference also featured several fun and entertaining events in addition to the short courses and technical program. Receptions were held on Tuesday and Wednesday evenings for the conference participants that featured amazing appetizers as well as a keg of local craft beer donated by the MGWA! Shockingly, this keg survived first contact with the assorted geologists, spelunkers and hydrologists, reappearing at the next evening's reception. It then quickly disappeared under a determined assault by thirsty participants.

A banquet was held on Thursday evening and featured guest speaker David Rogers from the Missouri University of Science and Technology. In addition, a silent auction was held on Wednesday and Thursday to raise funds for the Barry F. Beck Scholarship, which provides funding for students to attend and present at the Sinkhole Conference. Several silent auction items were donated by MGWA members, including State Fair blue ribbon winning honey personally raised by MGWA Editor-in-Chief Tedd Ronning, several beautiful pottery items donated by Audrey Van Cleve, and delicious jam donated by Calvin Alexander.

For further reading, the proceedings from the conference are now available on the Sinkhole Conference's website at: www.sinkholeconference.com.

ROGER E. RENNER
President

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Dr. John Cherry Talk

By Andrew Streitz, MGWA Newsletter Team

A small army of MGWA members were on hand at the University of Minnesota's Minneapolis campus on October 22, 2015, to hear Dr. John A. Cherry talk of his life studying groundwater. Over 200 people gathered on a beautiful fall day in Smith Hall, where the subject of the talk was the history of contaminant hydrogeology. Because of Dr. Cherry's prominent role in this history his many personal anecdotes shed light on important developments within the growing field. Humorous and self-deprecating, he described how he built his career on a series of large-scale investigations. Once when faced with an intractable problem during a site investigation he called an old advisor at the University of Illinois to ask for suggestions. His advisor told him that when inspiration fails, drill holes and push pipes in the ground. Dr. Cherry has followed this advice ever since. Arguably best known for the book "Groundwater" that he coauthored with R.A. Freeze, Dr. Cherry retired from the University of Waterloo ten years ago. However, he has remained very active in the field at his current posting to the University of Guelph.



Minnesota Association of Conservation Districts Environmental Fair

By Vanessa Baratta and Meagan Harold

On September 22 and 23, 2015 we had the opportunity to present at the Southwest Minnesota Association of Conservation Districts Environmental Fair. This fair is a two day learning event in the "outdoor classroom" for fifth and sixth grade students from an 11-county area in Southwestern Minnesota. The Environmental Fair is supported by the participating soil and water districts, partnering agencies, as well as local businesses and organizations.

The fair has been taking place since 1992. This year, 37 schools and approximately 1,900 students attended. Students attended sessions of hands-on activities or demonstrations on a variety of topics including: trees, soil, water quality, wetlands, recycling, household hazardous waste, native prairie, watersheds, and creatures that share our environment. Presenters included staff from the Science Museum of Minnesota, Minnesota Zoo, Prairie Ecology Bus Center, Soil and Water Conservation Districts, Counties, University of Minnesota Extension, Minnesota DNR, and the Natural Resources Conservation Service.

Each day we presented to 7-8 different classroom-sized groups of students about how much water we use every day, where that water is stored in the ground, and how that water could become contaminated by both natural processes and human-introduced processes. We paid particular attention to discussing the geology of Southwestern Minnesota and the limited aquifer resources in the thick till sequences of that region.

The students were shocked to learn about how much water goes into things they use and eat every day. When we asked for ways they could use less water, they became animated and recommended things such as turning off the water when brushing their teeth, turning off lights and appliances, and fixing leaks.

At the end of our presentation, teachers told us that many of their students were interested in the outdoors and nature, so they asked us about our jobs working with the DNR and how we got here (e.g., educational background). We also were asked a variety of questions from the students ranging from: what is bedrock? Is my water safe to drink? to: What happens to water in our bodies when we drink it? They were very inquisitive students.

Overall, the students were engaged about groundwater and the resource where they live; we were engaged by the students, teachers, and presenters. It was exciting to see so many different environmental fields offering information pertinent to where the students and teachers lived. We are hopeful that this environmental fair has motivated the students and we look forward to hearing about or participating in another 20+ years of the event!

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Another Day in the Field

By Ruth MacDonald

A DNR hydrogeologist returned to this unexpected sight after a water sampling trip. He sent a photo to his manager by phone, who showed it to someone in the department who happened to be on the MGWA newsletter committee, who forwarded it to the committee to see if it could be used in the newsletter.

Another committee member forwarded it to her department, the manager of which was in charge of fleet. This manager called the original manager and left a message saying “I don’t mean to get your goat but I saw a picture of a baaaaaa’d accident involving your staff, you will need to fill out an incident report.”

Manager #1 became concerned and called manager #2 to clarify. Manager #2 said it would be clearer in a photo. The original “goats on the roof” photo returned full circle to the original manager and a chuckle was had by all.

In the meantime the unsuspecting hydrogeologist began getting confusing emails from seemingly unrelated people about incident reports.

Anything that can go viral, will.



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USGS Testing a Novel Technology for Measuring Arsenic in Minnesota Groundwater Samples

Dr. Mindy L. Erickson, USGS

Arsenic is a widespread, naturally occurring contaminant in Minnesota groundwater. Based on arsenic well testing results collected statewide by Minnesota state agencies, U.S. Geological Survey (USGS), and others through 2015, about 10 percent of all drinking water wells in Minnesota have arsenic concentrations higher than 10 micrograms per liter ($\mu\text{g/L}$), which is the Maximum Contaminant Level set by the U.S. Environmental Protection Agency (water.epa.gov/drink/contaminants/basicinformation/arsenic.cfm). In some Minnesota counties, however, more than 30 percent of newly constructed drinking water wells have arsenic concentrations exceeding 10 $\mu\text{g/L}$. The USGS and the Minnesota Department of Health (MDH) are cooperating on a research study to better understand the factors that lead to elevated arsenic in Minnesota well water.

In July 2015, USGS established a collaboration with the German Helmholtz Center for Environmental Research (www.ufz.de/arsolux/index.php?en=20706), which will augment the current arsenic research study. The purpose of the collaboration is to test the potential application of the Helmholtz Center's ARSOLux biosensor as a novel, quick-turnaround test of arsenic concentrations in Minnesota well water used for drinking water. Current laboratory methods cost approximately \$40 per sample, and results are not generally available until several weeks after samples are submitted to the laboratory. The new arsenic test method is less expensive and can give semiquantitative results the same day. Biosensor results will be compared to analyses completed by the MDH Public Health Laboratory to gauge their comparability to current methods.

The biosensor test kit uses genetically modified bioreporter bacteria to detect arsenic concentrations in water samples. The bioreporter bacteria respond to arsenic by emitting light. The light can be measured by a luminometer and correlated directly to arsenic concentrations as high as 80 $\mu\text{g/L}$, which is on the high end of concentrations found in Minnesota groundwater. Higher concentrations may be measured by diluting and rerunning the sample. Helmholtz Center scientists Andreas Kölsch and Dr. Konrad Siegfried spent a week in July 2015 working with and training USGS hydrologist Dr. Mindy Erickson and MDH hydrologist Emily Berquist on how to use the arsenic biosensors. Dr. Siegfried also presented three lectures about the arsenic biosensor technology and its past successful use at remote sites around the world.

To test a sample with the ARSOLux biosensor, a 1-milliliter sample of water is injected through the septum rubber stopper of the biosensor vial, and the sample is emptied into the vial. The freeze-dried lyophilisate containing the bioreporter bacteria is dissolved and bacteria are revitalized, after which the filled biosensors are incubated for just 2 hours at 30°C. After incubation, the biosensors emit light in correlation with the arsenic concentration in the sample. A luminometer is used to measure the light emission or luminescence after the incubation time. The measurement takes only 10 seconds per sample vial. The luminometer measurements are calibrated with biosensors filled with known concentration arsenic standards (i.e., 5, 20, 50, 200 $\mu\text{g/L}$) that are incubated with each batch of environmental samples. Dozens of samples may be analyzed in each batch. After testing, the biore-

porter bacteria inside of the biosensor vials can be deactivated either by using a disinfectant or autoclaving.

Arsenic continues to be a widespread public health concern across Minnesota and other parts of the Midwest. The arsenic biosensor is a promising technology for reliable, cost-effective, and rapid field applications so that researchers and well owners can more quickly assess health risks associated with high arsenic levels in drinking water wells. This study would be the first application of the ARSOLux biosensors in the United States. Results from the USGS-Helmholtz Center-MDH collaboration will be reported in a future newsletter article. A more detailed description of the arsenic biosensor test kit can be found in a 2012 ES&T journal article, and a description of the current USGS-MDH arsenic research study was featured in a recent edition of the USGS GeoHealth Newsletter.

For more information about the current arsenic research project or general questions about arsenic in Minnesota groundwater, contact Dr. Mindy Erickson, merickso@usgs.gov. Hypertext links and other references to non-USGS products and services are provided for information only and do not constitute endorsement or warranty by the USGS, U.S. Department of the Interior, or U.S. Government, as to their suitability, content, usefulness, functioning, completeness, or accuracy.



Helmholtz Center scientist Andreas Kölsch demonstrates arsenic biosensor reading to USGS scientist Dr. Mindy Erickson



Arsenic biosensor collaborators (left to right) Andreas Kölsch and Dr. Konrad Siegfried (Helmholtz Center), Emily Berquist (MDH), and Dr. Mindy Erickson (USGS)

Chisago County Geologic Atlas, Part B County Atlas Series C-22

By John Barry

Paper and digital versions of the Chisago County Geologic Atlas Part B are now available. The Part B report includes four map plates that describe the county's groundwater conditions and pollution sensitivity. The report is a companion product to the Part A report previously published by the Minnesota Geological Survey (MGS). The MGS Part A report contains six map plates describing the county's surficial and bedrock geology. Part A reports provide the geological framework that underpins the Part B hydrogeological investigations.

The groundwater resources of Chisago County include a surficial sand and gravel aquifer, six buried sand and gravel aquifers, and five sedimentary bedrock aquifers. Groundwater from bedrock units primarily comes from the Upper Tunnel City, the Wonewoc, or the Mt. Simon aquifer. Approximately 79 percent of wells in Chisago County extract water from sand and gravel aquifers; nearly 19 percent extract water from bedrock aquifers. Nearly 90 percent of the wells constructed in bedrock aquifers are used for residential domestic water supply. However, the largest volume of groundwater use from bedrock aquifers in the county is by large municipalities; with over half of these using the Mt. Simon aquifer for water supply.

The downward recharge of water from the land surface to deeper aquifers ranges across Chisago County. In general, younger (recent or mixed tritium age) groundwater is found in or downgradient of areas in the county where surficial sand is at the land surface or in areas where vertical hydraulic gradients are steepened due to high volume groundwater appropriation (municipal pumping centers).

Water Table

The water table occurs in both surficial sand and gravel deposits and in the non-aquifer sediments such as till in Chisago County (Figure 1). Roughly one third of the county has coarse-grained (aquifer) sediments at the land surface (shown in the stipple pattern in Figure 1). The water table, in general, follows the surficial landform. The elevation of the water table is highest (hot colors-reds) in the northwestern townships of Nessel and Fish Lake and in the southeast near the cities of Almelund and Taylors Falls. The water-table elevation is lower (cool colors-blues) along the eastern border of the county near the St. Croix River and in the central region of the county near the city of Sunrise.

Quaternary Buried Sand and Gravel Aquifers

Six Quaternary buried sand and gravel aquifers are mapped in Chisago County,

ranging in average depth below ground surface from roughly 30 feet to greater than 200 feet. Groundwater levels from the County Well Index were used to construct a potentiometric surface for each of the buried sand and gravel aquifers. **Figure 2** shows the potentiometric surface elevation of the **SX** buried sand and gravel aquifer. A potentiometric surface represents the elevation to which water will rise in a well cased in a confined aquifer (Fetter, 2000). The potentiometric surfaces of the mapped buried sand and gravel aquifers in Chisago County have similar elevations. They vary widely from west to east; with potentiometric elevation highs in the west and potentiometric elevation lows in the east along the St. Croix River.

Multiple sand and gravel aquifers of the county directly overlie each other or are separated by till units less than 10 feet thick. Digital elevation surfaces of geologic layers created by the Minnesota Geological Survey were used to calculate pollution sensitivity maps for each buried aquifer (Barry, 2014). Pollution sensitivity maps developed for each of the six buried sand and gravel aquifers highlight areas where vertical recharge can occur rapidly. The pollution sensitivity map of the **SX** aquifer is shown in **Figure 3** with colors that represent pollution sensitivity conditions. Red colors represent very high pollution sensitivity.

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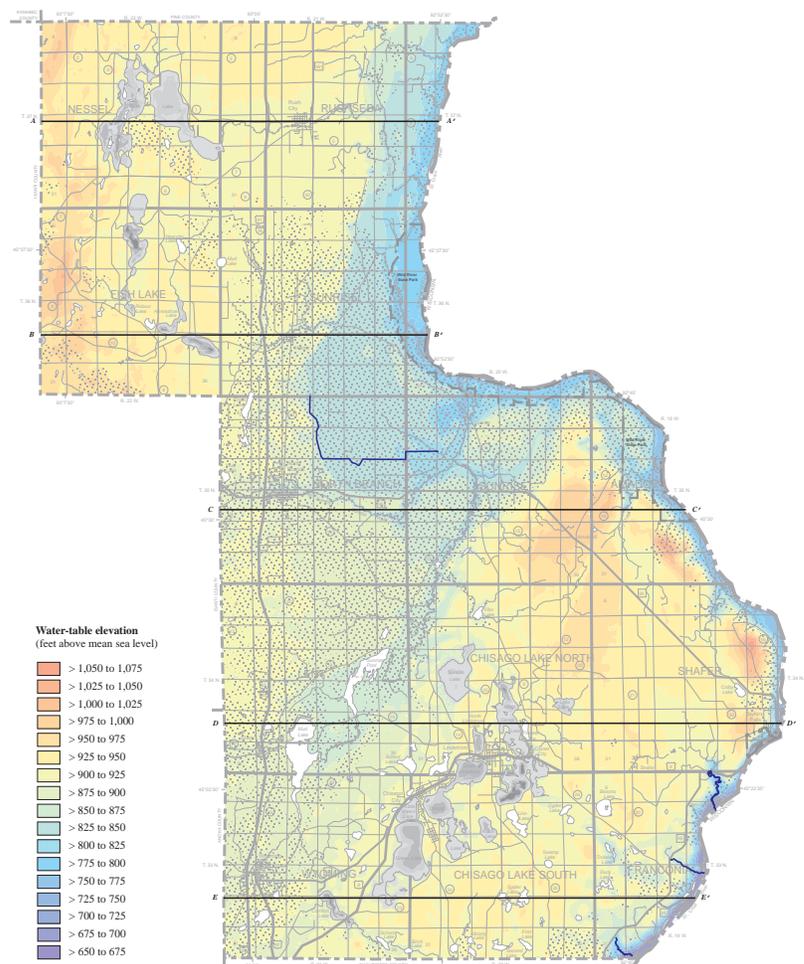


Figure 1: Estimated water-table elevation in the surficial sediment of Chisago County (Part B, Plate 7, Figure 1).

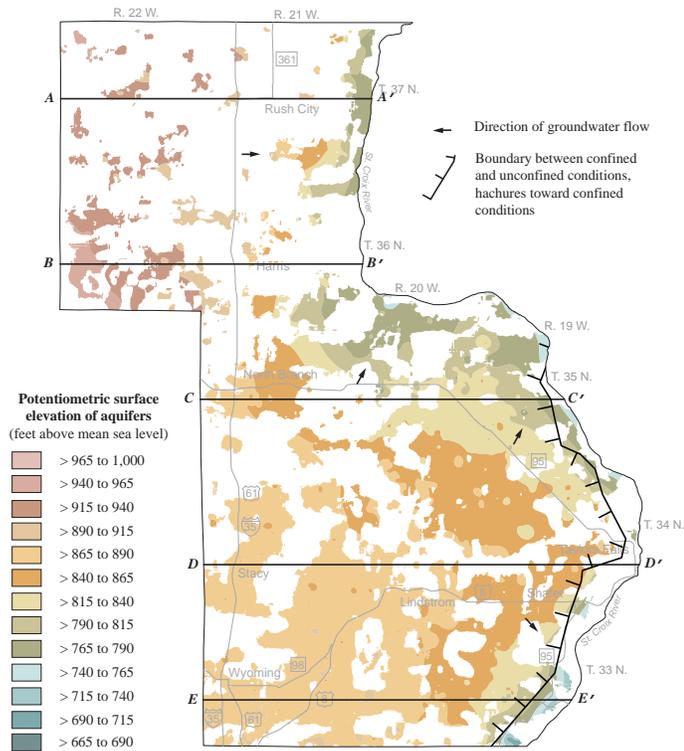


Figure 2: Potentiometric surface elevation and extent of the buried sand and gravel aquifer (Part B, Plate 8, Figure 4).

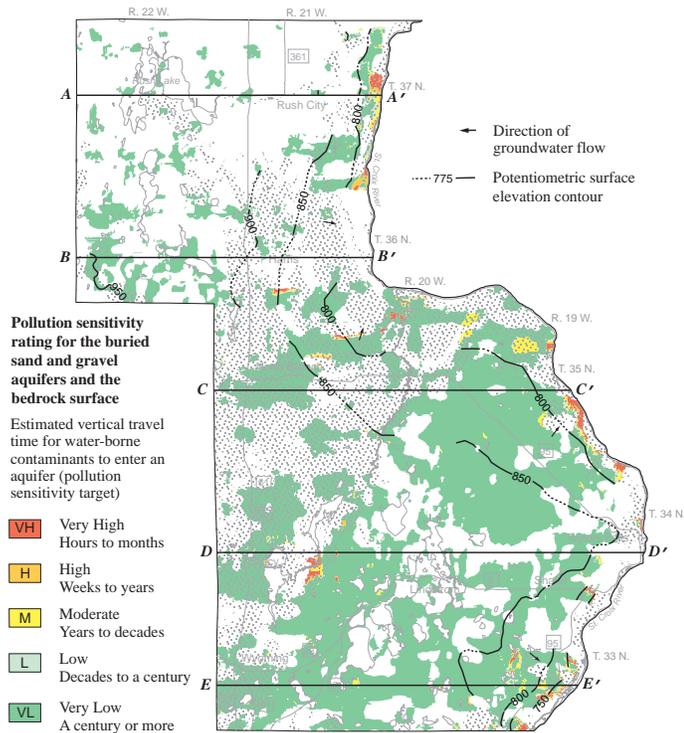


Figure 3: Pollution sensitivity of the buried sand and gravel aquifer (Part B, Plate 10, Figure 9).

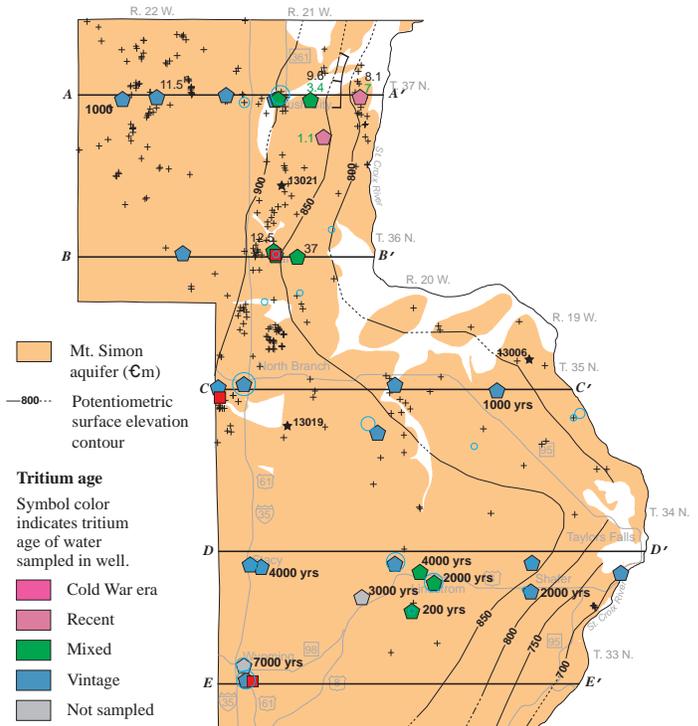


Figure 4: Potentiometric surface elevation contours and extent of the Mt. Simon aquifer (Part B, Plate 8, Figure 8).

Bedrock Aquifers

Groundwater from bedrock units in Chisago County primarily comes from the Upper Tunnel City, the Wonewoc, or the Mt. Simon aquifer. It is also common for bedrock wells in Chisago County to intersect multiple bedrock aquifers. **Figure 4** depicts the lateral extent and groundwater potentiometric surface elevation contours of the Mt. Simon aquifer. In Chisago County, two regional aquitards, the St. Lawrence Formation and the Eau Claire Formation, are used in some locations for residential well supply. These units likely contain high permeability bedding plane fractures that are conductive enough to yield enough water for residential use. The potentiometric surface contours of the Mt. Simon and other principal aquifers indicate that groundwater flow is generally from west to east, draining to the St. Croix River.

Cross Sections

Five detailed hydrogeologic cross sections are shown in the Chisago County Geologic Atlas, Part B, Plate 9. Portions of two cross sections are shown in this article. The pink, green, and blue areas shown on these cross sections represent the groundwater residence time as determined by the presence of tritium (³H). Groundwater residence time estimated by the amount of tritium present in the water is broadly shown as blue for waters that entered the ground before approximately 1953, pink for water that entered the ground since the early 1950s, or green for water that is a mixture of vintage and recent waters.

The western third of cross section A-A' shows the Quaternary section overlying bedrock aquifers in northwestern Chisago County (**Figure 5**). Tills near the surface in this area of the county (shown as darker gray hues) limit the rapid downward movement of water. Buried sand and gravel aquifers in this setting that are greater than 100 feet below ground surface have

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Chisago Atlas Part B, cont.

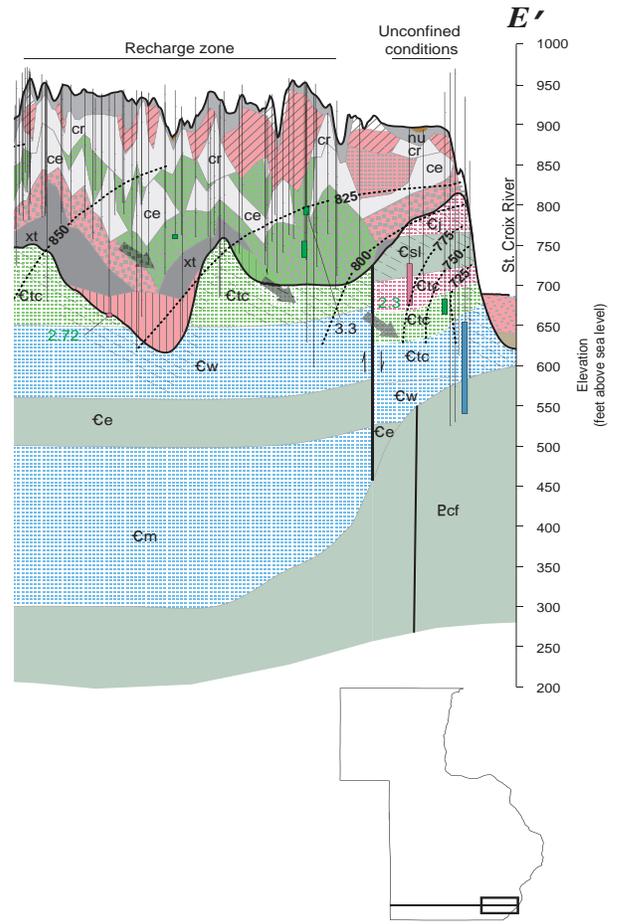
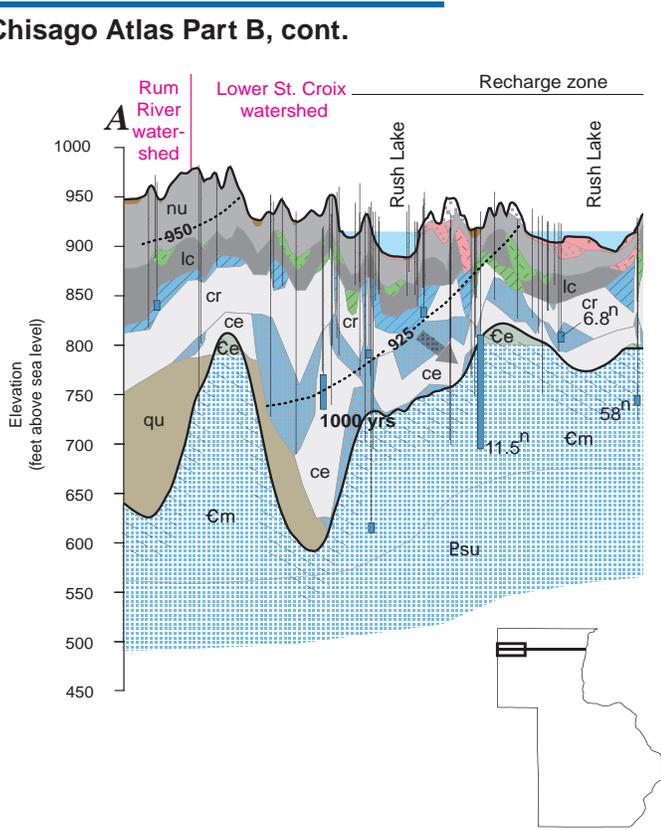


Figure 5 (above): Close up of cross section A-A' (Part B, Plate 9).

Figure 6 (right): Close up of cross section E-E' (Part B, Plate 9).

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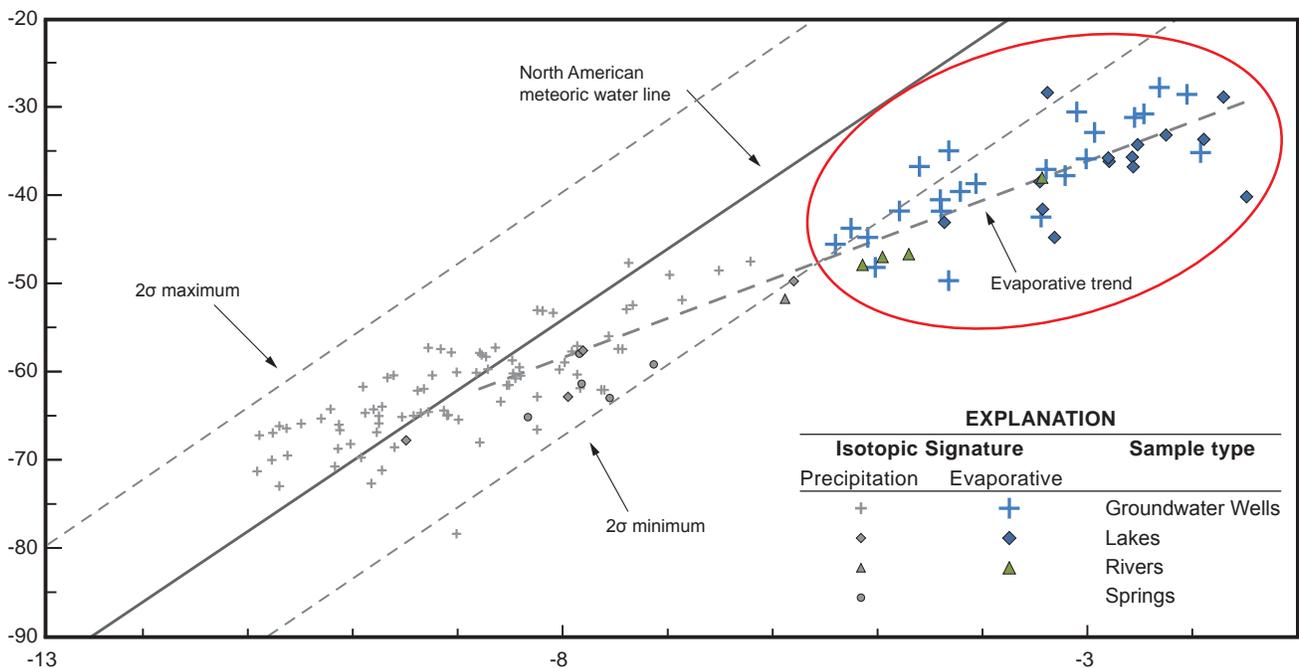


Figure 7: Graph of stable isotope values of groundwater, lakes, springs, and rivers sampled in the study area compared to the North American meteoric water line (Part B, Plate 7, Figure 4).

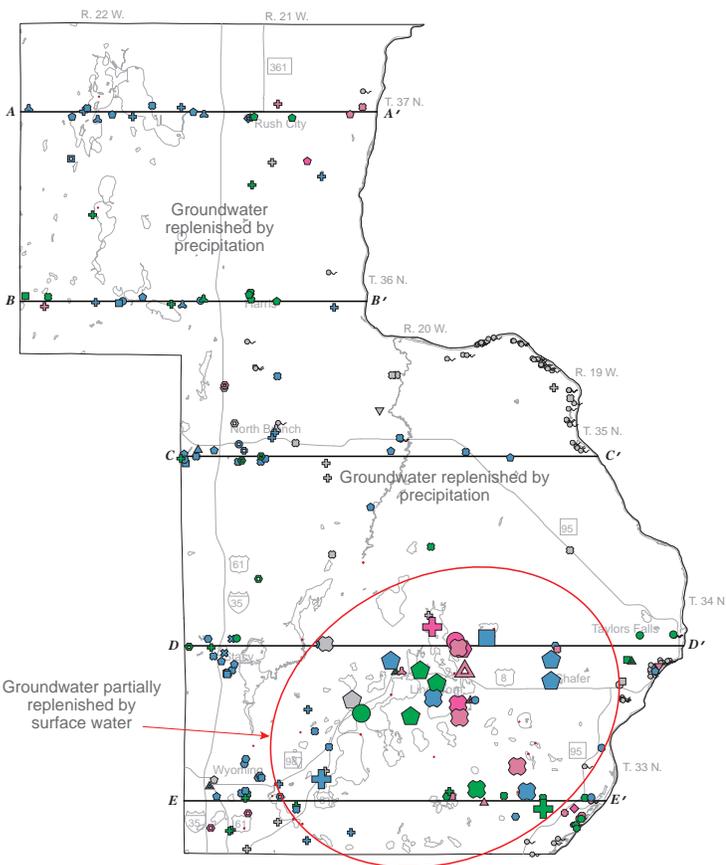


Figure 8: Stable isotopic signatures of the Chisago Lakes area. Groundwater samples with at least 50 percent of the maximum evaporative signature are denoted by a larger symbol size and are clustered in the Chisago Lakes area (Part B, Plate 7, Figure 5).

groundwater residence times, as determined by the presence of tritium, in excess of 60 years. The groundwater residence time for the Mt. Simon, as estimated by carbon-14 isotope analysis, is approximately 1,000 years.

The eastern third of cross section E-E' shows the Quaternary section overlying bedrock aquifers near the St. Croix River valley in southeastern Chisago County (Figure 6). Tills in this area of the county (shown as light gray hues) are leakier than the tills present in the northwestern portion of the county. Buried sand and gravel aquifers in this setting have connectivity to the land surface and have modern or mixed groundwater residence times.

The Chisago County Cross Section Supplement offers 43 additional cross sections depicting aquifer distribution and select chemistry for Chisago County. It can be found with the plates and GIS data on the Department of Natural Resources County Atlas page for Chisago County at:

www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/chiscga.html.

Surface Water-Groundwater Interaction

Isotopes of oxygen and hydrogen are commonly used in hydrologic studies for determining groundwater and surface-water interaction (Kendall and McDonnell, 1998). Mass differences between ^{18}O and ^{16}O and ^2H and ^1H cause them to evaporate or condense at differing rates. Precipitation that fell as rain has an isotopic signature different than precipitation that fell as snow. Precipitation that infiltrates rapidly has an isotopic signature different than water subjected to evaporation. Figure 7 is a graph of stable isotope values of groundwater, lakes, springs, and rivers sampled in Chisago County. Precipitation values for $\delta^{18}\text{O}$ and $\delta^2\text{H}$ generally plot along a line that is referred to as the meteoric water line. Water samples that plot near this line indicate water that has an isotopic signature consistent with rapidly infiltrated precipitation. Lakes and open-water wetlands are subjected to evaporation that changes the isotopic signature of the water over time. Waters that have been subjected to evaporation have ratios of $^{18}\text{O}/^{16}\text{O}$ and

— continued on page 11

Chisago Atlas Part B, cont.

$^2\text{H}/^1\text{H}$ that plot along an evaporative water line, indicated by the bold dashed line in **Figure 7**. Water samples that are enriched in the heavier isotopes (^{18}O and ^2H) plot along the right side of the evaporative water line and represent the maximum evaporative isotopic signature. Water samples that plot at the intersection of the meteoric water line and the evaporative water line represent groundwater directly recharged by precipitation.

The large symbols in **Figures 7** and **Figures 8** represent wells having greater than 50 percent of the maximum evaporative signature for area lakes. Wells with this signature were mostly located in the Chisago Lakes area, although some wells with evaporative signature were noted east and southeast of the area. Lakes in this area are primarily in closed-basin settings with no perennial surface water outflow. These data demonstrate the connectivity of surface water bodies in the Chisago Lakes area to the groundwater system, and highlight their importance in providing groundwater recharge to aquifers in this area, including deep bedrock aquifers.

References Cited

- Barry, J.D., 2014, Geologic atlas of Chisago County, Minnesota: St. Paul, Minnesota Department of Natural Resources, County Atlas Series C-22, Part B, 4 pls., scale 1:100,000.
- Fetter, C.W., 2000, Applied hydrogeology, 4th Edition: Prentice-Hall, New Jersey.
- Kendall, C., and McDonnell, J.J., 1998, Isotope tracers in catchment hydrology: Elsevier Science, Amsterdam, The Netherlands.

Introducing the Minnesota Hydrogeology Atlas

By Roberta Adams

The Minnesota Hydrogeology Atlas series (MHA) was created to provide a statewide format for groundwater information, building on maps and data originally published in the County Geologic Atlas (CGA) series. The MHA series provides reports, maps, and digital data for selected information describing Minnesota groundwater, such as pollution sensitivity, water-table elevation, and other groundwater maps or data commonly published in the CGA reports. The digital data for use in geographic information systems (GIS) are provided in a statewide form that can be used by county, by watershed, or a specific area as defined by users.

The MHA series uses current data and methods and, where possible, incorporates information from reports in the CGA series. MHA reports that contain older published county data may not be completely consistent with the current standards for the CGA series. However, both the original published CGA series data and the MHA series data are useful to the public.

The Minnesota Hydrogeology Atlas will help users of the atlas manage and protect groundwater resources by providing more accessible, statewide groundwater data to citizens and all levels of government. This effort is part of the County Geologic Atlas program of the Minnesota Department of Natural Resources (DNR), Ecological and Water Resources Division.

You can find the MHA homepage here: www.dnr.state.mn.us/waters/groundwater_section/mapping/status_mha.html

Available and In-Progress Atlases

The following atlases are either available or in the final stages of production. More atlases are planned for 2016.

Pollution Sensitivity of the Bedrock Surface, HG-01 (see article on page 15 of this issue)

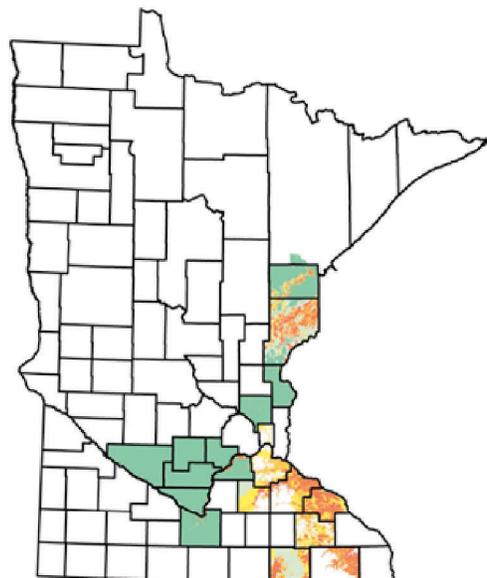


Figure 1: HG-01: Pollution Sensitivity of the Bedrock Surface

This report of the pollution sensitivity of the bedrock surface describes the compilation of county maps from previously published maps and plates in the CGA series. The pollution sensitivity of the bedrock surface is portrayed by a map that characterizes the relative rate of vertical travel of a contaminant that moves conservatively with water from the land surface to the shallowest bedrock surface. Currently there are 19 counties with pollution sensitivity maps for the bedrock.

www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/mha_ps-bs.html

Pollution Sensitivity of the Near Surface Materials

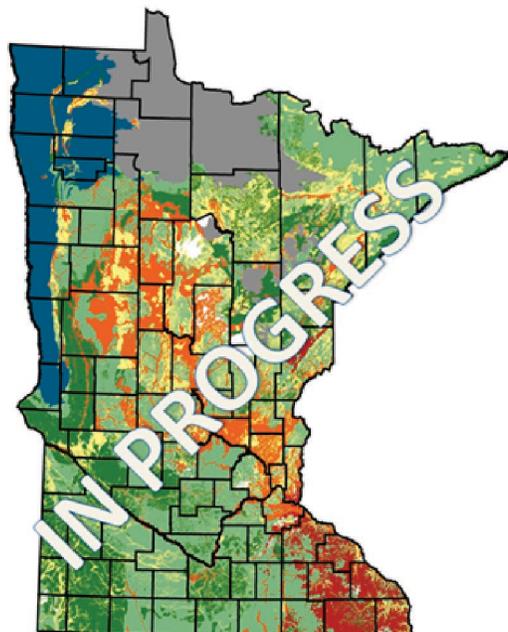


Figure 2: Pollution Sensitivity of Near-Surface Materials

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Minnesota Hydrogeology Atlas, cont.

This map is in progress. The map depicts the pollution sensitivity of the near-surface materials in Minnesota. For the purpose of this study, the near-surface is defined as the land surface to a depth of 10 feet. The sensitivity assessment is based on an empirical method that estimates the time of travel for water from infiltration at the land surface to the water table. A rating of high, moderate, low, or very low was applied to units across the county, defined by vertical travel times ranging from hours to a year. A new procedure was developed to allow for the variances encountered across the state as seen in the map above, i.e. karst, loess, glacial lake clays, and peatlands.

Water-Table Elevation

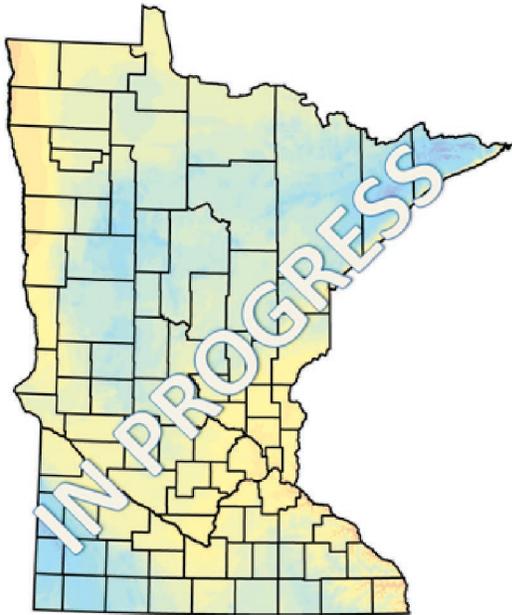


Figure 3: Water Table Elevation

This map is still in progress. It depicts the water-table elevation in Minnesota. The water-table elevation is estimated from several sources of data including water levels in wells constructed in surficial aquifers, the elevation of surface water bodies (rivers, perennial streams, and lakes) from a Light Detection and Ranging (LiDAR) - based digital elevation model (DEM), and estimates of wet soil conditions from the National Resources Conservation Service (NRCS) county soil survey polygon shapefiles and associated tabular data. The water level data in completed wells are obtained from well records in the County Well Index (CWI) database maintained by the Minnesota Geological Survey (MGS) and the Minnesota Department of Health (MDH).

Depth to Water-Table

This map is still in progress. It depicts the depth to water table in Minnesota. The depth-to-water-table model is based on a subtraction of the water-table elevation from the land surface using LiDAR based DEM.

Questions? Email Roberta Adams at roberta.adams@state.mn.us

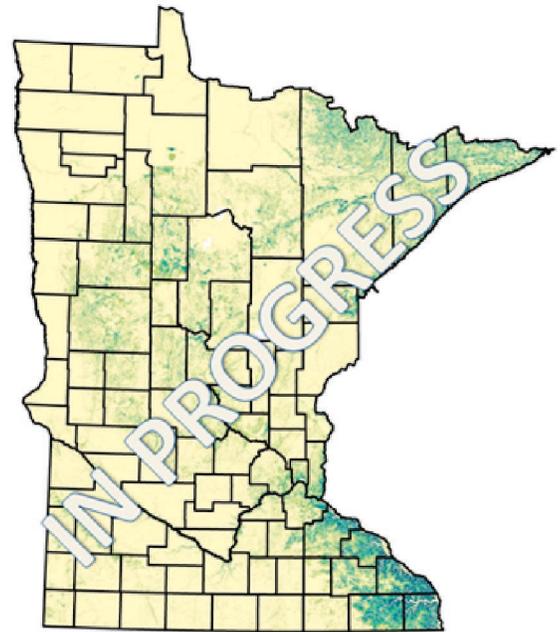


Figure 4: Depth to Water Table

Reference Cited

Adams, R., 2015, Pollution Sensitivity of the Bedrock Surface: St. Paul, Minnesota Department of Natural Resources, Minnesota Hydrogeology Atlas Series HG-01, report and plate, accessible at www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/mha_ps-bs.html.

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Pollution Sensitivity of the Bedrock Surface Minnesota Hydrogeology Atlas HG-01

By Roberta Adams

The Pollution Sensitivity of the Bedrock Surface, MHA HG-01, was completed in November 2015 by the DNR Ecological and Water Resources Division. A digital version is now available for the public. This is the first report in the Minnesota Hydrogeology Atlas (MHA) series (see article in this issue), a statewide format for groundwater information, building on maps and data originally published in the County Geologic Atlas (CGA) series.

The HG-01 report includes one map that describes the state's pollution sensitivity of the bedrock surface. The map in this report combines counties (Table 1) with published bedrock pollution sensitivity information into one statewide map (Figure 1). This compilation respects the legacy of the previous maps with minimal alterations made to the original data. Future county geologic atlases that include mapping of the pollution sensitivity of the bedrock surface will be added to this HG-01 report. Currently there are 19 counties with pollution sensitivity maps for the bedrock (Table 1). These maps were created by various authors using different methods and geologic factors through the years. County atlases created before 2006 used a matrix with author-assigned sensitivity ratings for bedrock surface pollution sensitivity (Legacy Matrix). After 2006 the Recharge Surfaces method was used (Table 1); this is the current method employed by the DNR.

Legacy Matrix Method		Recharge Surfaces Method	
County	Date	County	Date
Olmsted ¹	1988	Scott ¹	2006
Dakota ¹	1990	Carlton ³	2011
Ramsey ²	1992	McLeod ³	2013
Fillmore ³	1996	Carver ³	2014
Rice ³	1997	Chisago ³	2014
Mower ³	2002	Sibley ²	in preparation
Goodhue ³	2003	Nicollet ³	in preparation
Pine ³	2004	Blue Earth ³	in preparation
Wabasha ³	2005	Anoka ³	in preparation
		Renville ³	in preparation

¹ Authored by the Minnesota Geological Survey

² Authored by Minnesota Geological Survey and the Ramsey Soil and Water Conservation District

³ Authored by Minnesota Department of Natural Resources

Table 1. Methods used by 19 county geologic atlases. Highlighted counties depict the pollution sensitivity of a particular bedrock unit or aquifer in their original CGA data. These counties were modified for HG-01 to depict pollution map of the pollution sensitivity of the bedrock surface, the

The pollution sensitivity of the bedrock surface is portrayed by a map that characterizes the relative rate of vertical travel of a contaminant that moves conservatively with water from the land surface to the shallowest bedrock surface. Interpretation of pollution sensitivity of the bedrock surface is based on overlapping estimated time-of-travel ranges (Geologic Sensitivity Workgroup, 1991). The travel time ranges vary: areas with relatively short travel times of less than a few years are rated high or very high, whereas areas with estimated travel times of decades or longer are rated low or very low (Figure 2).

The original CGA reports varied in how bedrock was mapped for pollution sensitivity. In some CGA reports the bedrock pollution sensitivity interpretation is of the bedrock surface, in others it is of the bedrock aquifer. When compiling different atlases for the

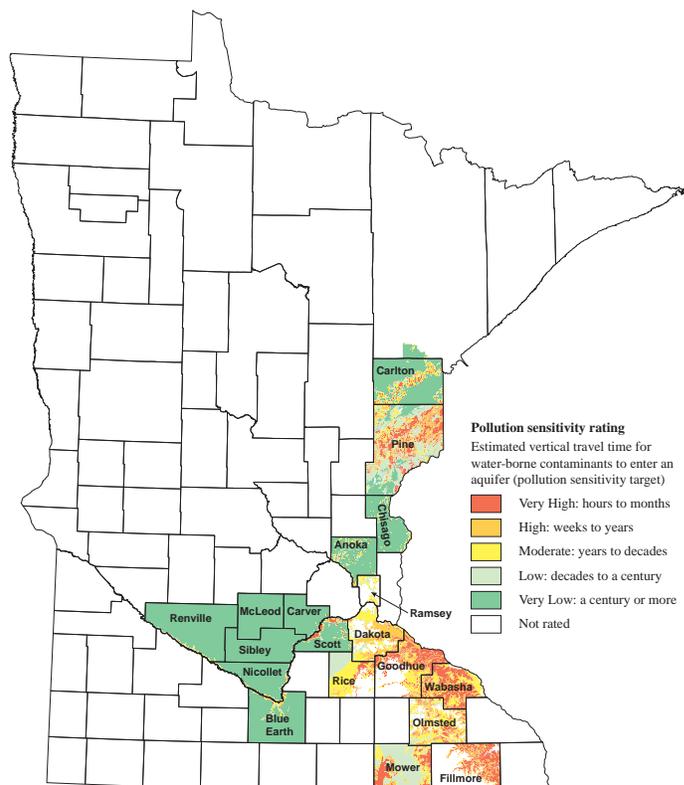


Figure 1. Pollution sensitivity of the bedrock surface in the state of Minnesota. This map depicts the current pollution sensitivity maps for the bedrock surface across Minnesota. Areas that are not rated have either not been completed, not been digitized, are currently being updated, or their pollution sensitivity maps depict particular bedrock units or bedrock aquifers that do not form the top of bedrock surface. Atlases completed in 2006 and later used the Recharge Surfaces method that considers only the effects of focused recharge and the time it takes a waterborne contaminant to reach the top of bedrock surface.

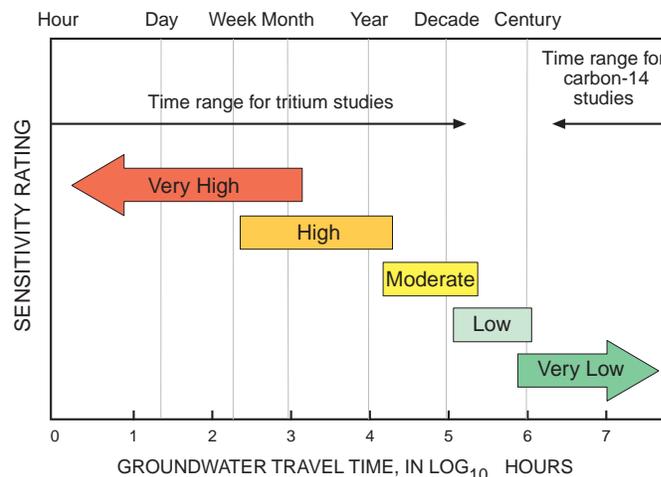


Figure 2. Geologic sensitivity rating for the bedrock surface as defined by vertical travel time. Ratings are based on the time range required for water at or near the surface to travel vertically into the aquifer of interest.

map of the pollution sensitivity of the bedrock surface, the original map product was taken into consideration.

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Minnesota Hydrogeology Atlas HG-01, cont.

Map Creating Methods

Atlases prior to 2006 evaluate a variety of bedrock pollution sensitivity scenarios, from maps showing the sensitivity of the entire top of bedrock surface to maps showing the sensitivity of only the most significant bedrock aquifers, such as the Prairie du Chien and Jordan. This is referred to as the Legacy Matrix method. Starting in 2006 the bedrock pollution sensitivity maps have only shown the pollution sensitivity for the entire top of bedrock surface. The Recharge Surfaces method (Berg, 2006) created a standard approach (Table 1) and is the current method used by the DNR.

The Legacy Matrix method consisted of a matrix of factors that estimated the pollution sensitivity of a target aquifer based on the thickness of the overlying glacial sediment and the relative permeability and texture of those glacial materials. The matrix created for each county was unique to that county and did not necessarily take the same factors into account as surrounding areas. Other geologic and hydrogeologic factors, such as karst, were also considered on a county by county basis. Therefore two counties that may border each other may not be directly comparable, even though the resulting pollution sensitivity rating may be similar.

Starting in 2006, the DNR began calculating pollution sensitivity based on the Recharge Surfaces method (Berg, 2006). This method is a DNR-developed, geographic information systems (GIS) model that attempts to mimic downward focused groundwater recharge from the surface to any of several possible target aquifers, including the top of the bedrock surface, through interconnected sand and gravel layers. This is the method currently being used to determine the pollution sensitivity of the bedrock surface. The maps shown in this compilation show the estimated rate of recharge for the top of the bedrock surface.

Cross Border Discrepancies

The pollution sensitivity ratings of the bedrock surface are not always consistent across county boundaries due to the variability

of data sets used and the varied methods of the authors. Four of the 19 maps were produced by groups other than the DNR, each using different methods and rating matrix structures. Of the 15 DNR-authored maps, the 9 most recent used the Recharge Surfaces method (Table 1).

References Cited

- Adams, R., 2015, Pollution Sensitivity of the Bedrock Surface: St. Paul, Minnesota Department of Natural Resources, Minnesota Hydrogeology Atlas Series HG-01, report and plate, accessible at http://www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/mha_ps-bs.html.
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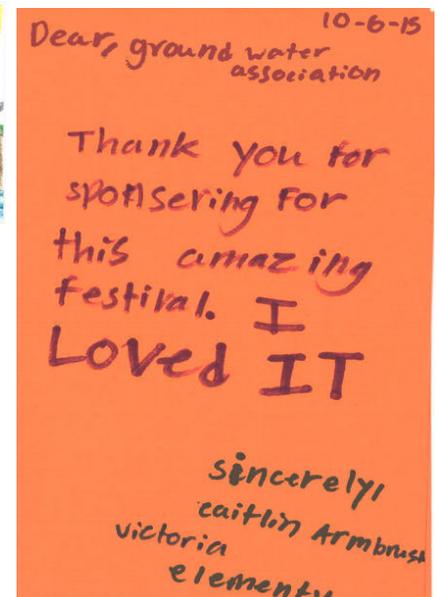
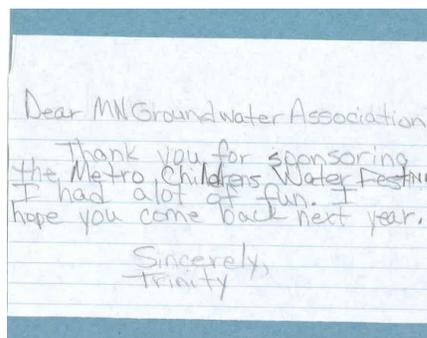
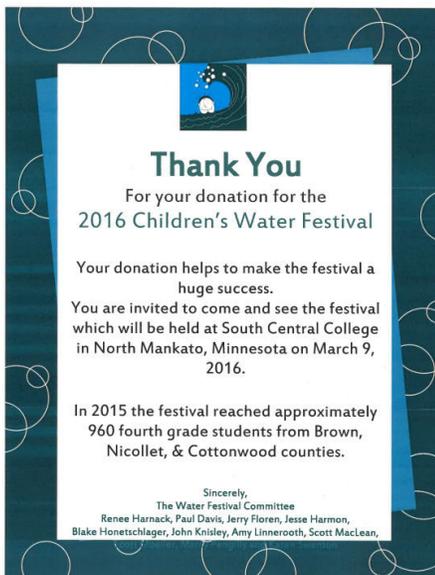
For More Information

To download PDF images and data of the atlas: www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/mha_ps-bs.html

For questions call: Roberta Adams (651) 259-5001 or Jan Falteisek (651) 259-5665.

To see the progress of the County Geologic Atlas - Minnesota Hydrogeology Atlas - Regional Hydrogeologic Assessment Program: www.dnr.state.mn.us/waters/groundwater_section/mapping/atlases.html

Thank You Notes to the MGWA Foundation



MGWAF BOARD MINUTES

MGWA Foundation Minutes

September 11, 2015

Members Present: Scott Alexander, Cathy von Euw, Eric Mohring, Stu Grubb, Cathy Villas-Horns, and Amanda Strommer (via conference call).

MGWA Management Present: Sean Hunt and Jennie Leete

Current Business: **Review Minutes**

Minutes from June 30 meeting approved via email July 28, 2015

Review finances

Jennie discussed IRS charitable organization initial registration and annual report form. Eric made a motion to approve the annual report, Cathy vE seconded; all in favor; motion carries. Total for the MGWAF fund is \$131,574.30 as of 9/10/15. Total for the HOP fund is \$28,624.81. Activity since last meeting was interest accrued; no debits or credits.

Discuss investment possibilities.

Current CD will expire at the end of August 2016. Stu discussed financial advisor options and drafted a request for proposal (RFP). At next meeting the board will have some candidates in for interviews and then select an advisor from there. Cathy vE made a motion to move forward with RFP process, Eric seconded; all in favor; motion carries.

New grant applications.

Pope County requests \$590 for a groundwater model. Motion by Cathy vE to provide \$590 for the purchase and shipping of a groundwater model, and increase costs slightly if costs have increased since the application was received. Eric second; all in favor; motion carries.

Hubbard County SWCD requests \$930 for a groundwater model, Motion by Amanda to provide \$930 for funding of the groundwater model, Cathy VH seconded; all in favor; motion carries.

Northwest Minnesota Water Festival/West Polk SWCD requests \$1000 for water festival. Motion by Eric to provide \$1000 for the Northwest Minnesota Water Festival, Stu seconded; all in favor; motion carries.

Offering a field camp scholarship, growing the Pfannkuch fund awarding scholarships.

Scott making progress on getting fund going. He has a committee set up to assist with development of the scholarship.

Future business:

Discussion of board positions.

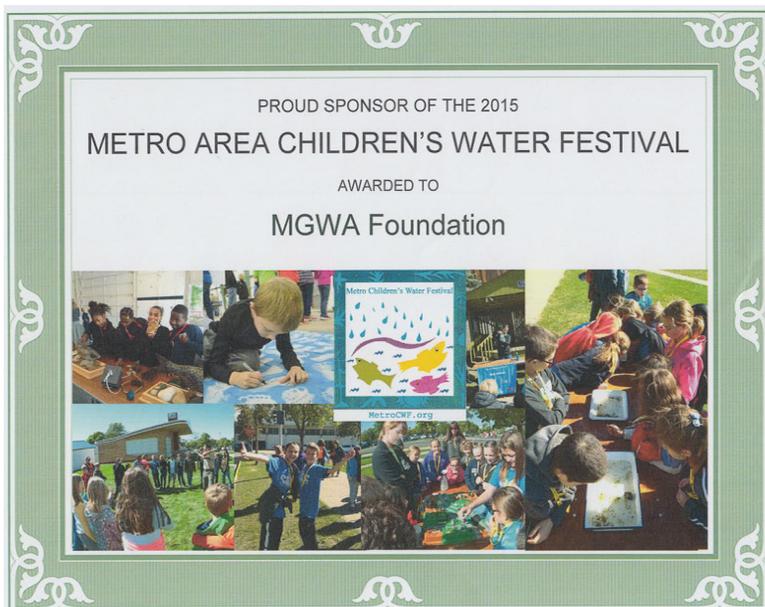
There will be a notice in the newsletter. Eric Mohring is interested in staying on the board.

Give to the Max Day on November 12th.

Amanda will look into Give to the Max Day on November 12th and work with Jennie and Sean to promote.

Next meeting: December 18, 2015

Thank You Notes, cont.



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The MGWA Foundation is a 501(c)3 charitable organization. Donations to the Foundation are deductible on your state and federal income tax returns.

MGWA BOARD MINUTES

Minnesota Ground Water Association Board Meeting Minutes

Meeting Date: September 02, 2015

Location: Fresh Grounds Café 1362 West 7th Street, St. Paul, MN
Attendance: Lanya Ross, President; Eric Mohring, Past President; Ole Olmanson, President-Elect; Emily Berquist, Treasurer; Avery Cota-Guertin, Secretary; Tedd Ronning, Newsletter Editor; Jeanette Leete, WRI; Sean Hunt, WRI; Mindy Erickson, White Paper Work Group; Mark Collins, White Paper Work Group; Kelton Barr, Audrey Van Cleve

Past Minutes: Approved.
Treasury: In order to include some additional 2015 Fall Conference registration information, the financial report is to be shared with the Board via email following the meeting.

Newsletter: Ronning reported that the newsletter will be turned over to WRI on Friday. The Manganese White Paper executive summary will be included in this newsletter with a reference to the full paper.

Web Page: Tax documentation was completed and uploaded to the web page.
WRI Report: WRI is continuing with preparation work for the 2015 Fall Conference. There are approximately 190 registrations for the 2015 Fall Conference; of those registrations, 130 are registered for the full conference.

MGWAF: The MGWAF is scheduled to meet next week. Currently, two funding solicitations are being reviewed by the MGWAF.

Old Business: White Paper Initiative. Barr reported that the Manganese White Paper executive summary was approved by the Board via email. Ross asks the Board what level of review is useful, by the Board, for the White Paper. Erickson suggested that the Board may want to focus more on policy and communication. Collins stated that the White Paper is intended to be a factual paper and not a position paper. The Board discussed the process to conduct a review and edit the White Paper prior to finalization of the document. The Board will review and provide minor 'wordsmithing' edits to the White Paper by September 8th. A technical editor will provide final 'wordsmithing' edits to the document.
2015 Fall Conference. The Board discussed finances for the 2015 Fall Conference. Barr reported that there has been little success in soliciting exhibitors. The Board discussed options to provide drink tickets to attendees for particular events. The 2015 Fall Conference planning committee will meet next week to discuss details of the conference venues, events, short courses, and field trips.
Social Hour. The Social Hour will occur after the 2015 Fall Conference.

New Business: Mohring received an email from the Trout Unlimited Education Coordinator requesting for information to incorporate groundwater in their education program. Mohring requested feedback from the Board.

Meeting Date: September 30, 2015

Location: Fresh Grounds Café, 1362 West 7th Street, St. Paul, MN
Attendance: Eric Mohring, Past President; Ole Olmanson, President-Elect; Emily Berquist, Treasurer; Avery Cota-Guertin, Secretary; Jeanette Leete, WRI; Sean Hunt, WRI; Audrey Van Cleve

Past Minutes: Approved.
Newsletter: WRI reported that comments were sent to the Newsletter team for review. Following comment review, the newsletter will be ready to send to the membership. A call for MGWAF officers will be announced in the next newsletter.

Web Page: WRI is working non-web page communications. IRS filings were uploaded to the MGWA webpage.

WRI Report: WRI is managing registrations and other preparations for the 2015 Sinkhole Conference. Dues payments will be solicited after the Give-to-the-Max fundraiser.

MGWAF: Education support requests for a ground-water model and for Children's Water Festivals were approved for Pope, Hubbard and Polk counties at the MGWAF September meeting.

Treasury: Berquist discussed the Treasury report with the Board. The total income from the period of January 1, 2015 – September 28, 2015 is 149,821; total assets as of September 28, 2015 are \$203,305. Net income for the period of January 1, 2015 – September 9, 2015 is \$32,676.

Old Business: White Paper Initiative. The second White Paper group has been meeting to discuss the next paper. Hunt will send the newsletter link for the Manganese White Paper to the Board for review. The Board will work to approve the White Paper via email. Mohring motions to approve Lanya Ross to spend up to \$400 for White Paper group gifts. Motion prevails.
2015 Fall Conference. The Board discussed the details of who is responsible for bringing computers and uploading presentations to session computers. The Presenter's Assistant will help to distribute the microphone in the large conference room for questions. Short courses will not be equipped with microphones. The Board discussed who will assist at registration desk and when additional help is needed.

MGWA 2016 Membership Dues

Sustaining Member	\$65
Professional Member:	\$45
Retired Member	\$25
Full-time Student Member	\$20
Newsletter (printed and mailed)	\$20

Membership dues rates were revised at the July 1, 2015 meeting of the MGWA Board.

MGWA BOARD MINUTES

MGWA Board Meeting Minutes, cont.

Hunt provided the Board with draft drink tickets and badges. Hunt will get the final event numbers to Mindy Erickson.

Social Hour. Berquist suggested October 15th as the next MGWA social hour. The Board will contribute to the refreshment cost for Dr. Cherry's lecture on October 22, 2015.

Trout Unlimited Request Olmanson will follow up with the organization regarding their request to incorporate groundwater in their education program.

New Business:

Dr. Cherry Lecture. An MGWA member will be unable to attend Dr. Cherry's lecture and requested that the lecture be recorded. Hunt will discuss with Kelton Barr and Kelton's University of Minnesota – Twin Cities campus contacts to find out if the lecture can be recorded. A link to the recorded lecture may be available on the MGWA web page

Meeting Date: Thursday, November 12, 2015

Location: Fresh Grounds Café, 1362 West 7th Street, St. Paul, MN

Attendance: Lanya Ross, President; Eric Mohring, Past President; Ole Olmanson, President-Elect; Emily Berquist, Treasurer; Avery Cota-Guertin, Secretary; Jeanette Leete, WRI

Past Minutes: Approved.

Treasury: Berquist discussed the Treasury report with the Board. The total income from the period of January 1, 2015 – November 9, 2015 is 151,308; total assets as of November 9, 2015 are \$138,450. Net income for the period of January 1, 2015 – November 9, 2015 is \$15,539.

Newsletter: The newsletter was completed and sent out to the membership.

Web Page: WRI is working to get the recorded Dr. Cherry lecture files from the University of Minnesota – Twin Cities. These files will be uploaded to the MGWA webpage.

WRI Report: MGWA members should expect to see reminders for membership dues soon.

MGWAF Report: Upcoming scholarships will be discussed at the MGWAF December meeting.

Old Business: 2015 Fall Conference. A debriefing meeting will be scheduled late December or early January to discuss lessons learned and details of the conference.

Dr. Cherry Lecture. The Board discussed the attendance to the Dr. Cherry lecture.

New Business: Election Nominations. The Board discussed potential nominations for the President-Elect position and the Secretary position.

Social Hour. The Board discussed holding another social hour event after the college spring session begins, possibly in early January or February.

White Paper Committee Recognition. The Board discussed options for recognizing and appreciating the hard work and dedication of the Manganese White Paper Committee.

Retiree Recognition. The Board discussed a recognition program for retirees.

The MGWA Board meets once a month, currently over lunch, on the first Wednesday at Fresh Grounds on 7th in St. Paul.

Members are welcome to attend and observe

Thank You Notes, cont.



Save These Dates

2016 and 2017 MGWA Conferences

4/20/2016

11/16/2016

4/26/2017

11/15/2017