Minnesota Ground Water Association
www.mgwa.org

Newsletter

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MGWA President
Eric Mohring

Inside:

President's Letter

Before the following rambling diatribe, I want to say it has been my pleasure serving as MGWA President in 2014. I want to thank all of you who attended the spring and fall conferences in capacity numbers. And especially, many thanks to those who helped plan, organize, and make the conferences happen.

Answer me this: how do we as a state manage and protect our water resources, in all their varied forms and facets, so that they are not contaminated, not overused, so that safe drinking water can be delivered to the tap, and so that ecological functions are preserved? How do we divvy up the state's water protection and management pie? Who does what? These are questions the state (not to mention the country and the world) has been wrestling with throughout its history.

Protecting and managing the state's water resources is a delicate interplay between physical and societal factors:

Physical factors	Societal factors
• geography • climate • location distribution • geology – ("container") • quantity • availability • sustainable use • quality • contamination	• history /culture • disciplines • legal • levels of government • population • land use & human impacts • economics • policy & politics • health protection • value of environmental protection

The resource is vast and varied. Minnesota is "on the edge" in many ways. It is at the intersection of four continental watersheds and the headwaters of three of these. It receives little water from outside its boundaries. It encompasses several distinct ecoregions, including northern coniferous forest, prairie grassland, hardwood forest, and corn belt. It straddles the boundary between the semi-humid and semi-arid climate regimes. It is, depending on your frame of reference, the westernmost eastern state or the easternmost western state.

On the surface water side, Minnesota has many more than 10,000 lakes. We have more than 20,000 protected water bodies alone. Stretched end to end, the shorelines of our natural rivers and streams would circle the Earth more than twice. That doesn't even consider our 23,000 miles of drainage ditches or channelized watercourses. The pressures on these resources are relentless.

The ground water resource is even more vast and varied. The varied geology across the state yields many different types of "containers" for the ground water resources, from thick sedimentary basins to thin surficial sand channels, sand plains, buried drift, and fractured igneous and metamorphic rock. The "Minnesota Ground Water Provinces" concept introduced by DNR and MGS is a useful summary of this variability.

— continued on page 3

DNR Upgrades Rig to add Mud Rotary Capabilities

By Matthew Meyer, Minnesota Department of Natural Resources

The Minnesota Department of Natural Resources recently outfitted our CME-55 auger drill rig with a mud rotary tooling package to increase the machine's versatility. The new tooling includes 175 feet of drill rod, 6-inch diameter rotary bits, a 200-gallon aluminum mud tank, a mini-desanding unit, and other various accessories. We are now able to reach depths of approximately 170 feet. This allows us to install wells in most surficial aquifers and quite a few buried aquifers throughout Minnesota. Previously, we used hollow-stem augers exclusively, which limited our well depths to less than 100 feet. The new drilling method has already proven to be quite useful as the DNR continues to expand and maintain our groundwater observation well network.

The CME-55 drill was purchased new in March of 2012 and has proven to be a very functional, versatile, and efficient drilling machine. The machine is operated throughout Minnesota by a full time, two-person drill crew.

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Newsletter Deadlines

Issue	Due to Editor
March '15	02/06/2015
June '15	05/01/2015
September '15	08/01/2015
December '15	11/06/2015

MGWA LOSS

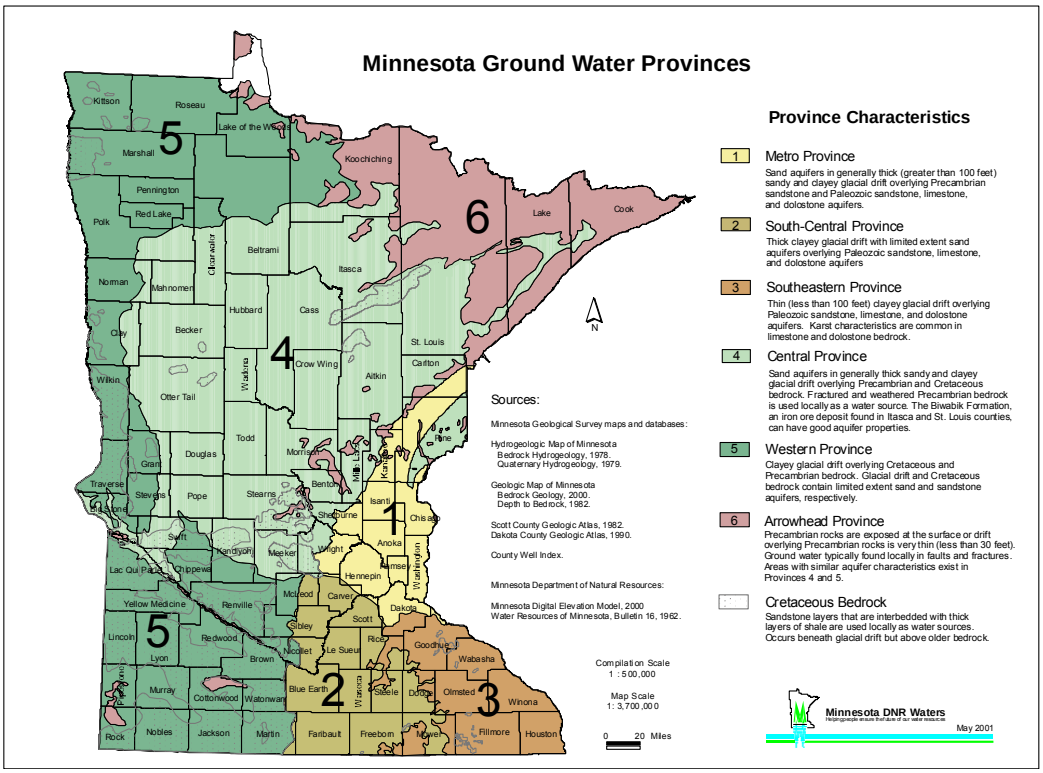
In Memory of Joe Julik

by Andrew Streitz, MGWA Newsletter Team

Joseph Julik, a geologist with the State of Minnesota for over 31 years, died on September 29th in a hang gliding accident. Joe started his career in 1983 at the DNR, working in the new engineering geophysics program. He distinguished himself there as a hard worker, a storyteller, and someone who loved to work outside. He left the Department to work for the MPCA in 1989 where he worked in a variety of programs beginning with Hazardous Waste-RCRA, and eventually settled into the new closed landfill program in 1990, where he stayed the rest of his career. Joe loved the work, especially when he could explore his sites with geophysical tools or track gas migration.

Joe was from the Taylors Falls area and remained a part of that community his entire life. He graduated from the University of St. Thomas in St. Paul, in 1979, with a degree in geology. Joe was also a MGWA member from its inception in the early 1980s and was a fixture at the annual conferences where he was as likely to regale you with stories of working on new landfills as he was to talk about his adventures hunting, fishing, climbing, or hang gliding. He will be remembered as a strong advocate for the environment and a friend with an infectious smile. He is survived by his two children and his grandchildren.

President's Letter, cont.



Minnesota Ground Water Provinces — a simplification of the 'containers' resulting from varied geology across the State.

Combine our surface water, groundwater, and land covers with the variation in climate across the state and you get a resource with huge spatial variability.

(You all know this already, and yes, I am overstating a firm grasp of the obvious, but this variability needs to be emphasized to decision makers who tend to gravitate towards simple, one-size-fits-all solutions).

So, once again, how do we divvy up the job of managing and protecting water resources? By professional discipline (water supply, use management, protect water from people, protect people from water, etc.)? By unit of government (state, regional, county, city)? By surface watershed? Ground water province? By type of water resource? By water utility? Benevolent dictator? Who decides?

Well, we have tried, and are doing, all of the above, to a certain extent. As we have collectively faced the water resource challenges over the last decades, we have jockeyed for position to deal with our perceived roles. There have been conflicts, territorial squabbles, and misunderstandings. Many misunderstandings can be attributed to lack of communication or miscommunication due to players speaking different professional "languages", engaged in one piece of the overall protection and management pie to the exclusion of others.

It shouldn't surprise us that progress has been chaotic. The problems are by definition multi-faceted, and human society is organized at many different levels, so successful solutions to these problems will be by necessity multi-player, inter-disciplinary, and at multiple scales.

Let's take the public sector. Water resource management and protection happens at all levels of government, by different organizations according to their role, as defined by historical tradition and adaptation to evolving circumstances:

It has evolved in bump-and-jerk fashion since its beginnings in 1872, usually in response to public health or environmental crises. The establishment of the State Board of Health paved the way for future water supply protection efforts. State plumbing codes and water supply design standards followed in the 1930s. Until the early 1970s the emphasis was on drinking water – "protecting people from the environment" rather than "protecting the environment from people".

Then, in the 1970s a marked shift occurred. This was the beginning of an era of major legislation at the Federal level, which in turn triggered activities at the state level. The Federal Clean Water Act (CWA) came in 1972 – its

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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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Links at www.mgwa.org

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

MEMBER NEWS

Audrey Van Cleve Retires from MPCA

Audrey Van Cleve has been working as a hydrologist in the MPCA's Petroleum Remediation Program since 2006. Before that, she worked as an environmental consultant for DPRA for 20 years. Audrey is a licensed professional geologist in Minnesota.

Audrey began her working life as a secretary immediately after high school. She began university studies in 1980 and went on to major in Geological Engineering, taking her Bachelor's degree in 1985. She worked on her degree as a single mother and began professional work in a male-dominated field.

As a consultant, Audrey assisted with computer modeling of landfills, conducted investigations and sampling at hazardous waste facilities under the Resource Conservation and Recovery Act, conducted investigations and performed corrective actions at petroleum-release sites, conducted underground storage tank training, and developed water-conservation practices for federal facilities. In addition, she led the successful proposal for one of her company's most significant contracts.

At the MPCA she has been responsible for evaluating contaminant investigations and corrective action at petroleum release sites. In addition, she has participated in various work groups and committees to update PRP guidance documents and to develop policy. She was an active participant in formulating PRP's LNAPL policy and new corrective action guidance documents. She spearheaded the ongoing effort to address water line permeation.

Throughout her career, she has been active in professional organizations including The Forum of Women in the Environmental Field (FWEF), the American Institute of Professional Geologists (AIPG), and the Minnesota Ground Water Association (MGWA). At first, she simply attended meetings and conferences. Later she began volunteering her services and has served on the board of each of these organizations. She is a past board member and co-chair of FWEF. She twice served as vice president of AIPG Minnesota Section and helped plan the 2006 annual meeting in St. Paul. Audrey is now finishing her second two-year term as MGWA's Treasurer. Audrey encourages fellow professionals to serve such organizations as a way to give back to their field and to foster their professional and personal development.

In retirement, Audrey is looking forward to having the time to pursue interests, old and new, such as reading, hiking, camping, gardening, traveling with John, relearning the saxophone, spending time with family and friends, and drinking lots of tea. She will miss her professional life and especially her wonderful professional colleagues. But she will remain active in MGWA and AIPG and hopes to see all of you at the 2015 Sinkhole Conference in Rochester, to be co-hosted by MGWA!

White Paper Initiative – CALL FOR TOPICS!

Preparations are underway for undertaking a second white paper. The White Paper Committee (WPC) is again making a **Call for Topics** from MGWA members. The creation of white papers on relevant issues truly begins with you, the members of MGWA. If you have an idea for a white paper, just go to the White Paper website (http://www.mgwa.org/whitepapers_topics.php), fill out the nomination form, and send it to office@mgwa.org. All previously submitted topics will also be actively considered (good ideas never die—they just wait their turn). **Deadline for submittal of white paper topics is January 1, 2015.** We look forward to your ideas!

Meanwhile the Work Group for the first white paper, "Manganese in Minnesota's Groundwaters," is continuing to invite MGWA members to contribute expertise, data, or other information on the topic. Please contact Work Group Chair Mindy Erickson (merickso@usgs.gov) or WPC liaisons Mark Collins (mark.collins.mgwa@gmail.com) or Bruce Olsen (sawdust2013@gmail.com).

——White Paper Committee (Kelton Barr, Mark Collins, Bruce Olsen, Jeff Stoner)

President's Letter, cont.

original focus being protecting surface waters from point source pollution, but came to encompass non-point sources, eventually giving rise to the current "impaired waters" and "Total Maximum Daily Load" efforts. The CWA has also become the primary Federal wetland protection law. Minnesota followed closely behind with the 1973 MN Water Well Construction code. Congress passed the Safe Drinking Water Act (SDWA) in 1974, originally to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water at its sources, including ground water wells (what we know as "wellhead protection"). The 1980s was the era of "Superfund" legislation, at the Federal level and subsequently at the state level. This triggered the rapid evolution of ground water science that jump-started many of our careers.

As programs were put in place to deal with point sources and Superfund sites, some attention became directed towards the widespread "non-point" sources. A 1985 survey by MDH and MDA showed pesticides and nitrate applied to crops showing up in ground water and water-supply wells. MDA began pesticide monitoring in 1987.

After decades of focus on water quality and public health, a major drought in 1988 brought dried-up wells, water use conflicts, well interference, and created havoc for water-dependent industries. Minnesota passed a Ground Water Protection Act 1989, which brought increased regulation of water wells, authorized a state wellhead protection rule, and expanded ground water monitoring among many other things.

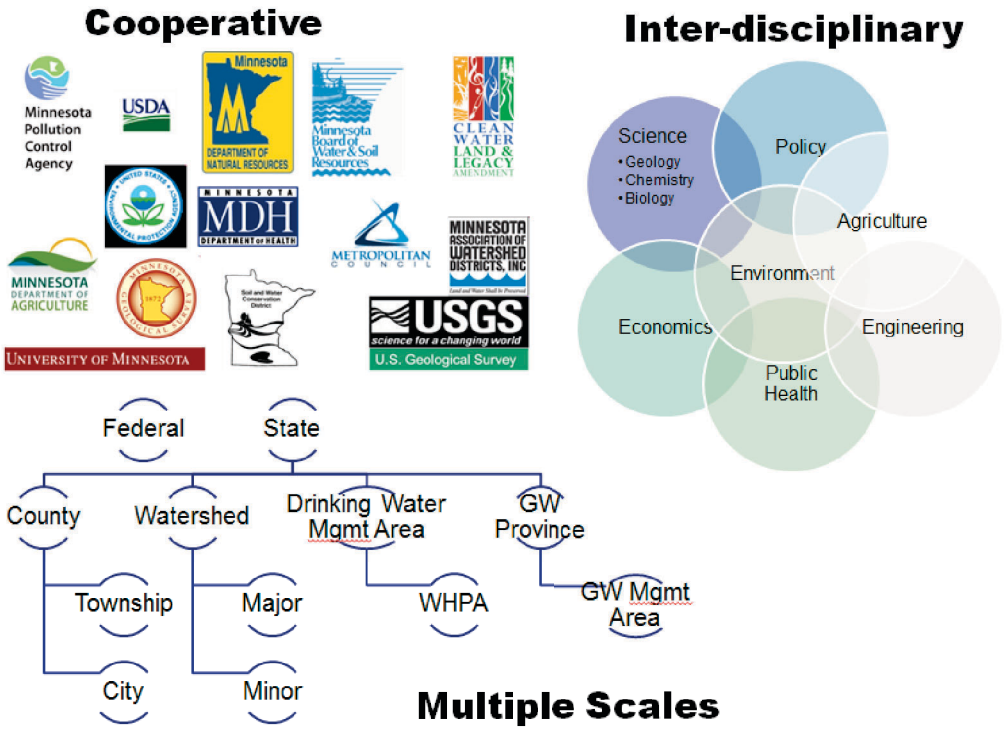
The mid 1980s brought the realization that, while regulation at the state and federal level can be effective up to a point, most of the tools to address non-point pollution, source water protection, and sustainable water use issues were at more local levels. 1985 brought the passage of the Comprehensive Local Water Management Act, which established water planning at the county level outside the Metro area. This led to increased State-local cooperation and capacity building at the local level. The metro area presented its own unique challenges – the region was facing major sewage treatment and disposal problems, transit was inadequate, and development was encroaching on natural areas. In 1967, a unique regional organization was born – the Metropolitan Council. While the 'Met Council' might seem the logical organization to manage water planning in the 7-county metro area, cities were reluctant to cede power to the likes of counties, watershed districts, or the Met Council. Efforts to cover the metro area with watershed districts failed, and the Metropolitan Surface Water Management Act eventually put in place was peculiar hybrid involving both watershed districts and joint-powers agreements between cities called Watershed Management Organizations (WMOs). Metropolitan counties gained the authorization to do County Ground Water Plans in 1987.

Local water planning was going pretty strong in the early 1990s, but efforts began to wane by the late 1990s with increased emphasis on watershed-based planning and management. Local water planning was originally a flagship program of the Board of Water and Soil Resources, formed in 1987, but this effort lost precedence to the Wetland Conservation Act in the 1990s.

As efforts shifted to watershed-based protection and management with the turn of the millennium, many of us in the ground water world wondered how to shoehorn ground water protection efforts in to this paradigm. The Clean Water Land and Legacy Amendment's Clean Water Fund has afforded great new opportunities for water resource protection and management. But how to make sure ground water protection goals are accomplished within a framework largely governed by (surface) watershed–based protection strategies? Aquifers and ground-water flow paths do not necessarily follow surface watersheds. But for that matter, they don't follow county boundaries either.

In some sense, it matters not what geographic area we use to divvy up the job, be it watershed, county, zip-code, or whatever. The point is, we can't treat the state with one-size-fits all solutions, and don't have the resources to work on the whole state at once. The march toward watershed-based protection and management will continue. The effort to convert local water management and planning to a "one-watershed one-plan" approach is a train that has left the station, and ground water protection and management efforts have run alongside the train and hopped on.

The challenge of divvying up the work is complicated even more by our diverse roles as individuals. Each of us wears multiple hats – as watershed managers, geologists, and individual water users. Success will depend on a cooperative, interdisciplinary, and multiple-scales approach. We must be willing to work outside the box of our professional, educational, geographic, or institutional comfort zones. "All the best stuff happens at the edges…."



Ole Olmanson – Shakopee Mdewakanton Sioux Community – Candidate for President-Elect

Ole Olmanson, candidate for President-Elect, has been the water resource scientist for the Shakopee Mdewakanton Sioux Community for the last eight years. His interests are groundwater modeling, green roofs, and using technology to make data collection more automated and reliable. His work focuses on coordinating tribal compliance to federally regulated water issues. He also manages, operates, and occasionally repairs the tribe's 1.5 megawatt wind turbine.

At other times, Ole has taught Earth Science as an adjunct faculty member of Minnesota State University, conducted construction inspection for Braun Intertec, and worked on the business end of a Geoprobe for Bergerson Caswell.

Ole has a B.S. in Earth Science from Minnesota State University (2001), Mankato and a M.S. in Water Resources Science from the University of Minnesota, Twin Cities (2007).

"The MGWA is important to the state of Minnesota because most people take our groundwater resources for granted. Many do not realize that without the work and cooperation of MGWA members, the health and longevity of this very important resource would be far less secure. It is critical that the next generation of scientists, policymakers, and working professionals continue the effort to preserve and enhance the Association and its activities to ensure continued security and prosperity."

Emily Berquist – MDH Well Management – Candidate for Treasurer

Emily Berquist, candidate for Treasurer, is a Hydrologist with the Minnesota Department of Health Well Management Section. Since joining Well Management in 2013, she has been working on a Clean Water Fund research project, testing for arsenic and related geochemical parameters in new private wells to try to understand arsenic occurrence and behavior. In coordinating this project, Ms. Berquist works with well contractors and homeowners to sample wells from initial construction and throughout the upcoming year. She also coordinates sampling efforts with district field staff in northwestern and northeastern Minnesota. She organizes and compiles the field and lab data and geologic information for future data and spatial analysis. She has a Bachelor of Science in Hydrology from St. Cloud State University, with a minor in Geology, and has volunteered with the U.S. Geological Survey performing field work and data analysis.

"After years of attending the MGWA conferences, and getting to know the amazing people that are part of this organization, I am honored and excited to be considered for the treasurer position. I would like to help support the goals and passion of this group by continuing to plan and fund field trips, newsletters and conferences. Education for ground water professionals, and the open public, is essential for effective ground water use, management and policy development, and it begins with a deeper understanding of the science behind our complex groundwater systems and quality."

Carver County Geologic Atlas, Part B County Atlas Series C-21

By Todd Petersen

Part B of the Carver County Geologic Atlas was published in 2014. This report includes four map plates that describe the county's groundwater conditions and pollution sensitivity. This report joins Part A previously published by the Minnesota Geological Survey. Part A contains five map plates describing the county's surficial and bedrock geology and provides the basis to produce the Part B hydrological information.

The groundwater resources of Carver County include one surficial sand and gravel aquifer, six buried sand and gravel aquifers, and eight sedimentary bedrock aquifers. Seventy-three percent of wells in the county are constructed in Quaternary sediments and 25 percent are constructed in sedimentary bedrock aquifers. Bedrock aquifers produce approximately 78 percent of permitted groundwater use because of large-volume users.

The downward recharge rate of water from the land surface to deeper aquifers is very slow in most of Carver County. The vertical hydraulic gradient is very low and the fine-grained till that forms most of the surficial geologic deposits has a low hydraulic conductivity. In most of the county, this fine-grained till does not allow much shallow groundwater to recharge deeper aquifers. However, in some local areas younger (mixed tritium age) groundwater is found hundreds of feet below land surface, such as near Lake Minnetonka in northern Carver County and in the Minnesota River valley in southeastern Carver County. The shortest groundwater residence times occur in the Quaternary sand and gravel and shallow bedrock aquifers in the Minnesota River valley, where sand and gravel aquifers are at the land surface.

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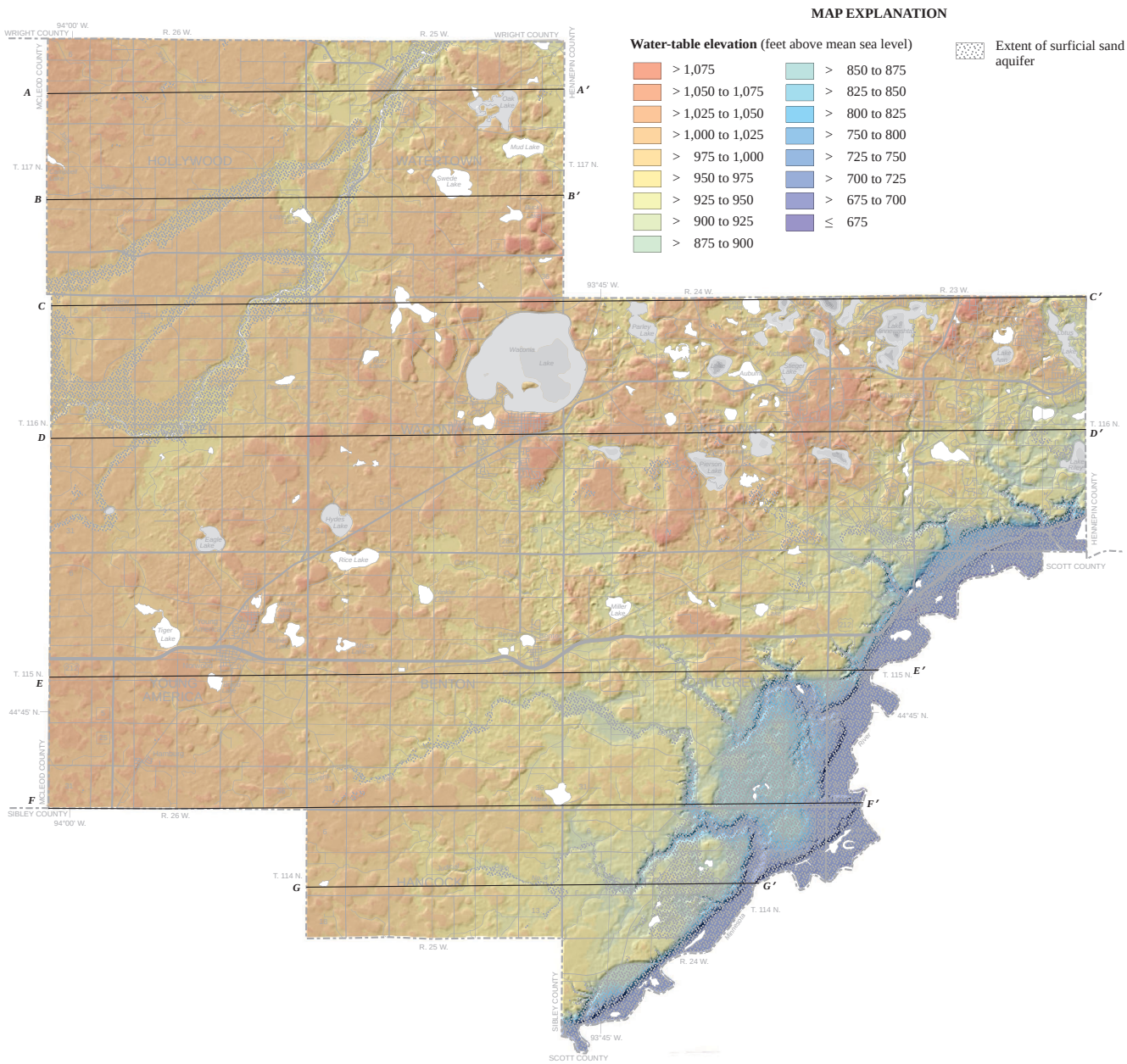

Figure 1. Simplified water-table elevation map with surficial aquifer location (from Plate 6, Figure 1).

Carver County Geologic Atlas Part B, cont.

Water Table

The water table generally occurs in both aquifer and non-aquifer sediments across Carver County (**Figure 1**). Most of the county has fine-grained (non-aquifer) sediments at the land surface. Only 11 percent of Carver County has surficial sand at the surface, which is shown is shown in stipple pattern on **Figure 1.** Only 46 wells are constructed in the surficial sand aquifer. The water table generally follows the surface topography. The elevation of the water table is highest in the northwestern part of the county (brown to yellow colors) and lowest on the east and southeast sides of the county (blue to purple colors).

Quaternary Buried Sand and Gravel Aquifers

Six Quaternary buried sand and gravel aquifers are mapped in Carver County. Some areas have multiple sand and gravel aquifers that overlie each other while other areas have only one or two mapped sand and gravel aquifers. Part of this lateral variation in the distribution of aquifers is the result of non-uniform deposition and part may be due to insufficient data to identify them or determine their extent. The potentiometric surface is a contoured map of the water levels measured in wells constructed in a confined aquifer. For this review article, only one aquifer is shown: the sx buried sand and gravel aquifer. The potentiometric surface elevation is shown in **Figure 2**. Topography appears to have a strong influence on groundwater flow in all buried sand and gravel aquifers. All of the potentiometric surfaces for buried sand and gravel aquifers exhibit large gradients that are related to surface topography. In Carver County aquifers, groundwater generally flows from northwest to southeast and eventually drains to the Minnesota River.

Pollution sensitivity maps were made for each of the six buried sand and gravel aquifers mapped for this atlas. The pollution sensitivity map of the sx aquifer is shown in **Figure 3** with colors that represent pollution sensitivity conditions: very high–hours to months, high–weeks to years, moderate–years to decades, low–decades to a century, and very low–a century or more.

The elevation surfaces of geologic layers created by the Minnesota Geological Survey were used to calculate pollution sensitivity maps for each buried aquifer (Petersen, 2014). In the final step of the sensitivity evaluation, the thickness of the protective till

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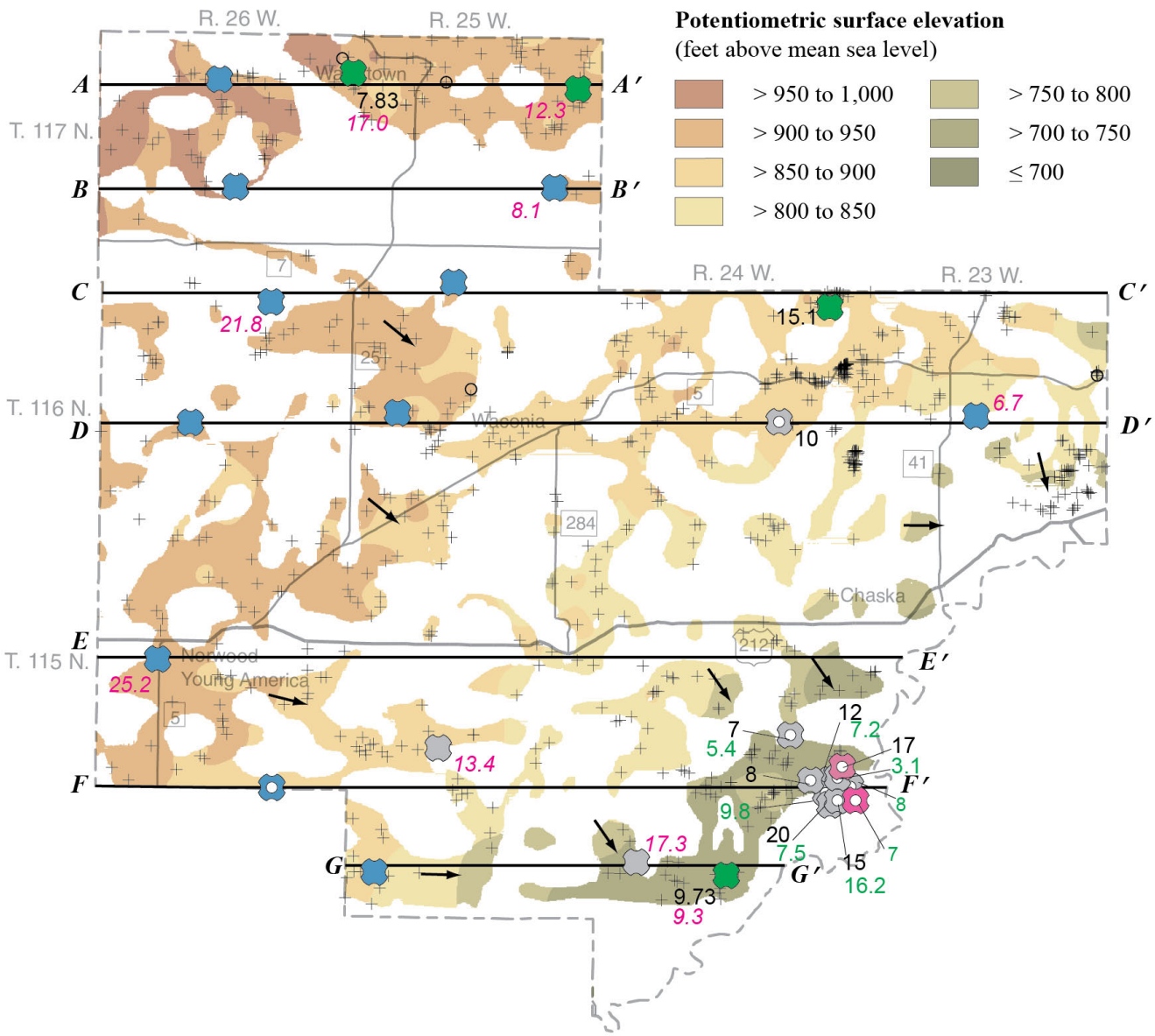

Figure 2. Potentiometric Surface of sx buried sand and gravel aquifer (from Plate 6, Figure 5).

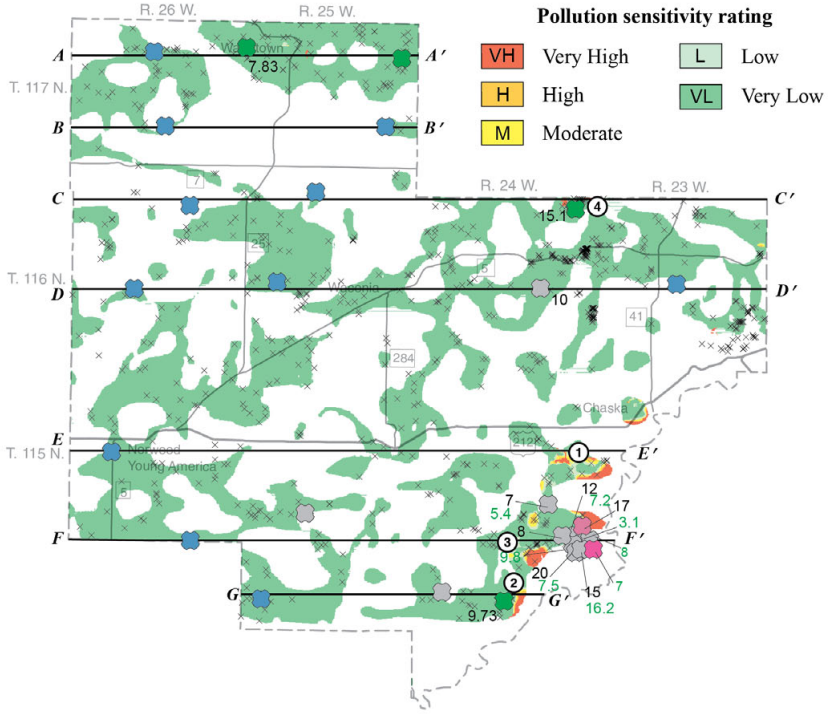

Figure 3. Sensitivity to pollution of sx buried sand and gravel aquifer (from Plate 9, Figure 10).

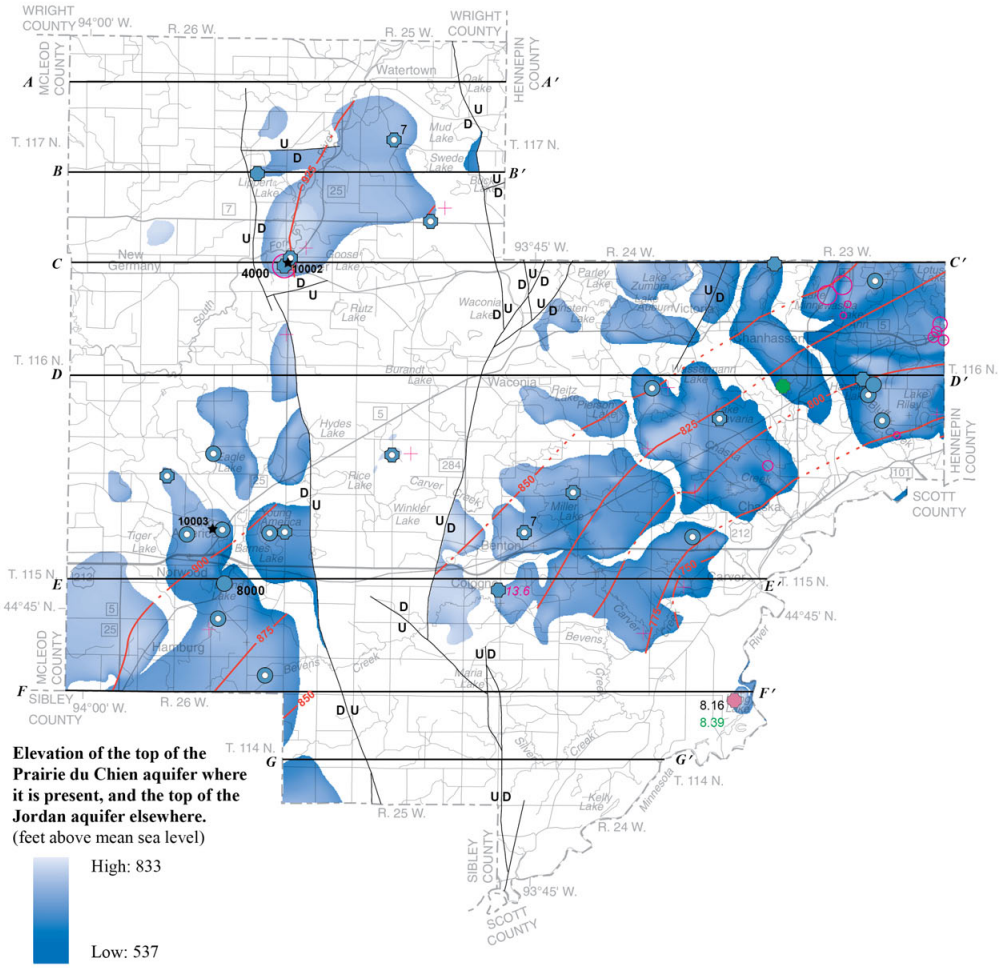

Figure 4. Potentiometric surface elevation contours of the combined Prairie du Chien and Jordan aquifers (from Plate 8, Figure 2).

Carver County Geologic Atlas Part B, cont.

layer that directly overlies the aquifer is calculated and a sensitivity rating is made. The sensitivity of the aquifer is inversely proportional to the thickness of this overlying till layer.

Bedrock Aquifers

Two of the bedrock aquifers in Carver County are shown in **Figures 4 and 5**. The bedrock formations in Carver County are heavily faulted. The relatively shallow Prairie du Chien and Jordan aquifers are heavily eroded and are only present in limited areas. The deep Mt. Simon aquifer is present over almost all of the county. The potentiometric surface contours of both aquifers indicate that groundwater flows from northwest to southeast and drains to the Minnesota River.

Cross Sections

Seven hydrogeologic cross sections are shown in the Carver County Geologic Atlas, Part B. Portions of two cross sections are shown in this article. The eastern third of cross section C-C' shows the Quaternary section overlying bedrock aquifers near Lake Minnetonka (**Figure 6**). The eastern half of cross section F-F' shows the Quaternary section overlying bedrock aquifers near and in the Minnesota River valley (**Figure 7**).

The sand and gravel aquifers are shown by pattern on the cross sections. The Quaternary till units have limited permeability and are considered to be non-aquifer units; these units are shown in shades of gray. The sand percentage is used to estimate the relative hydraulic conductivity of the non-aquifer units. It is assumed that as sand content of the till increases, hydraulic conductivity also increases, and with greater hydraulic conductivity there is more potential for water movement through the till units. Lighter grays represent relatively higher hydraulic conductivities; darker grays represent relatively lower hydraulic conductivities.

The pink, green, and blue areas shown on these cross sections represent the groundwater residence time. This is the approximate length of time that has elapsed since the water infiltrated the land surface to the time it was pumped from the aquifer. Groundwater residence time can be estimated by the amount of tritium (^3H) that is present in the groundwater. Because tritium decays at a known rate, the proportion of recently recharged water in a sample can be estimated by its tritium content. Water samples are classified by the tritium unit (TU) concentrations as follows:

- Recent: 8 or more TU, water that entered the ground since the early 1950s
- Vintage: 1 TU or less, water that entered the ground before approximately 1953
- Mixed: greater than 1 TU and less than 8 TU, a mixture of vintage and recent waters.

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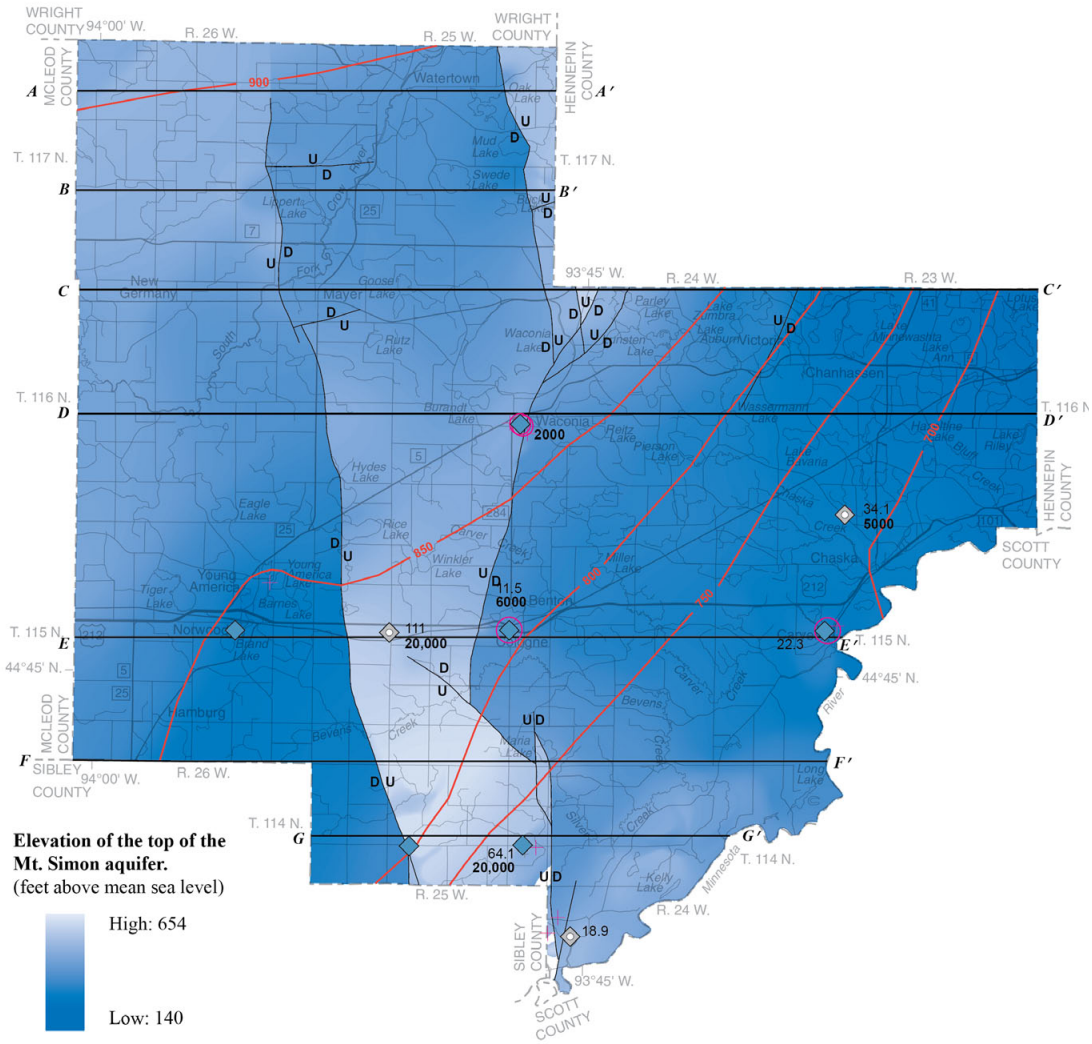
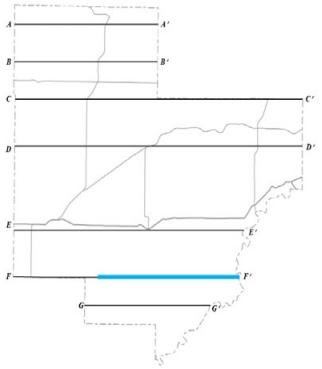


Figure 5. Potentiometric surface elevation contours of the Mt. Simon aquifer (from Plate 8, Figure 4).



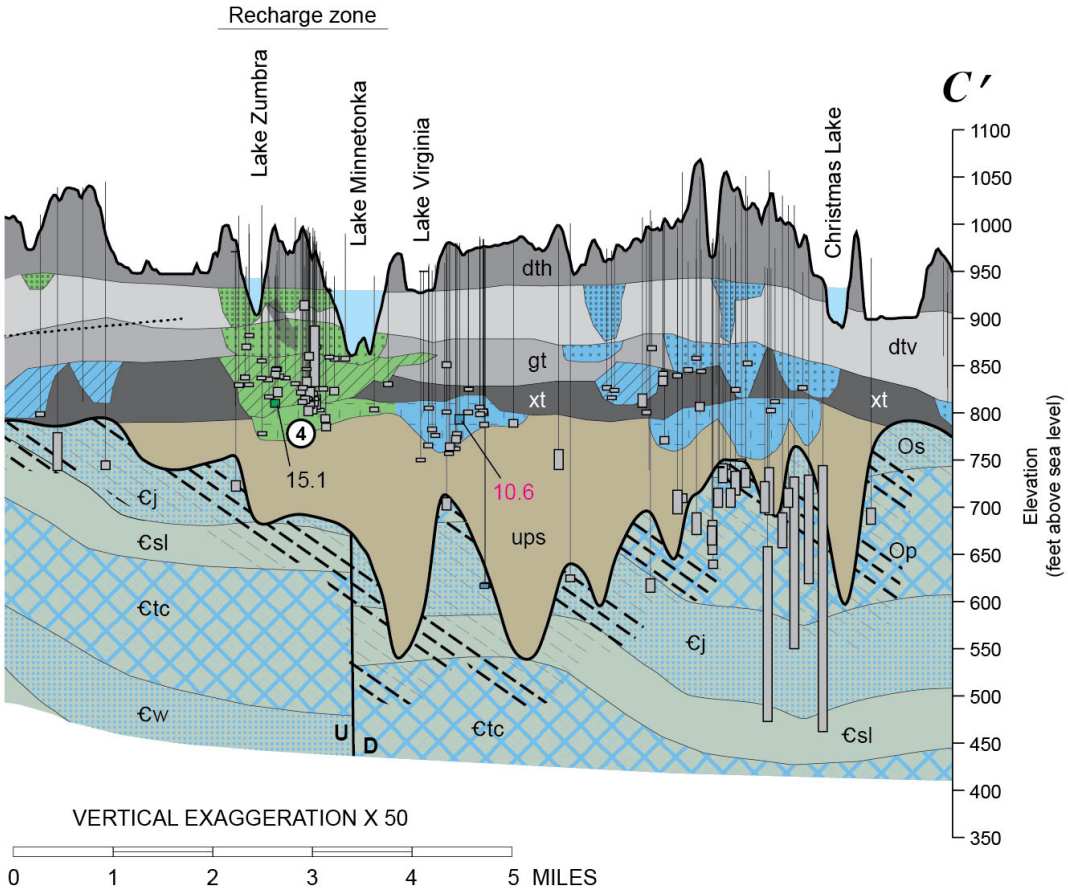


Figure 6. Eastern portion of cross-section C-C' (from Plate 7)

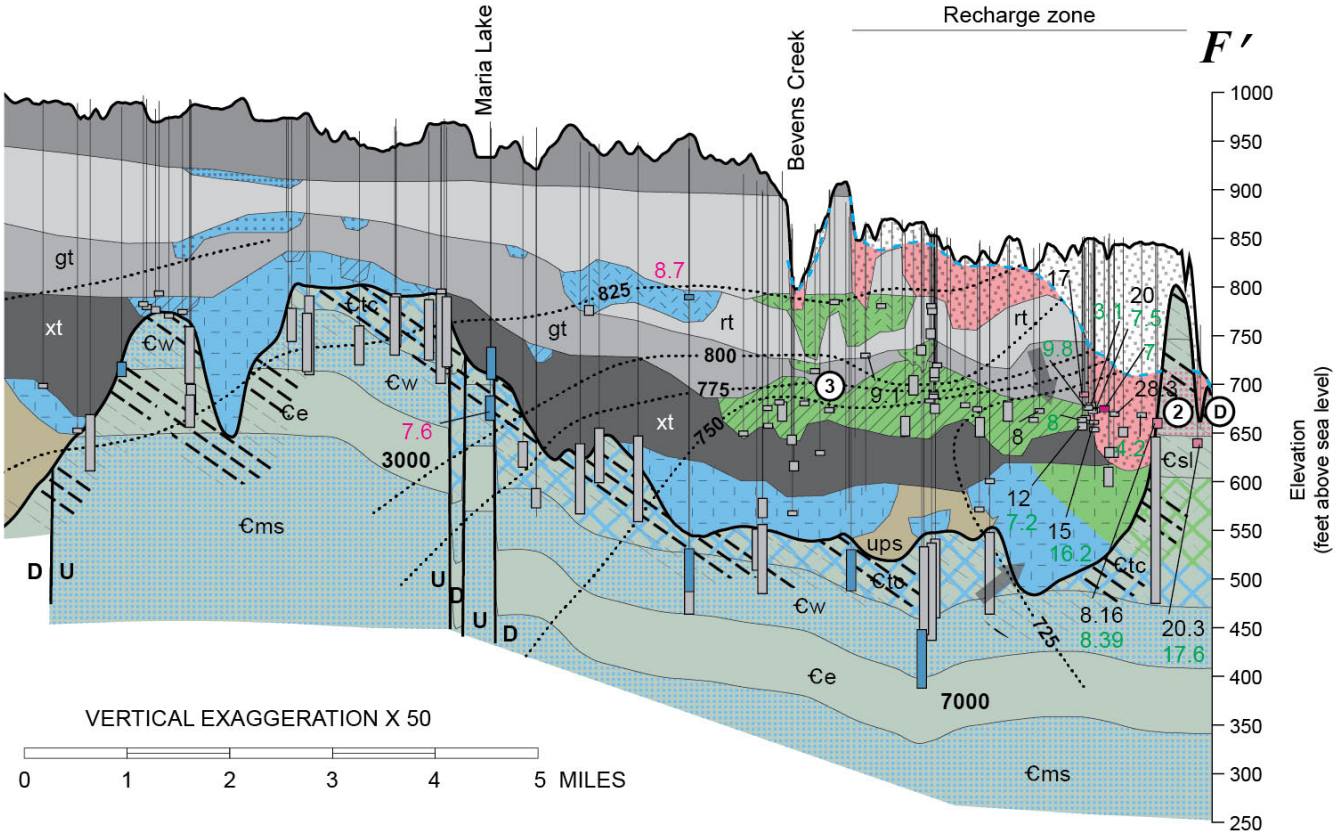


Figure 7. Eastern half of cross-section F-F' (from Plate 7)

Carver County Geologic Atlas Part B, cont.

In the Minnesota River valley, mixed tritium age groundwater was found in samples from the su aquifer to a depth of 300 feet. Near Lake Minnetonka, mixed tritium age groundwater was found as deep as 200 feet. Samples from shallow wells in other areas of Carver County had a vintage tritium age, indicating very slow groundwater recharge. Groundwater infiltrates slowly from the surface into the shallow buried sand and gravel aquifers. Outside the Minnesota River valley and a few other local anomalous areas, groundwater movement into deeper aquifers is very slow. The groundwater residence time for deep aquifers, as estimated by carbon-14 isotope analysis, ranges from 900 to 20,000 years.

Arsenic

Arsenic was found in 26 of the 96 sampled wells in concentrations greater than or equal to 10 parts per billion (ppb), the EPA standard in drinking water (U.S. Environmental Protection Agency, 2001). These wells are distributed widely across the county and were constructed to varying depths in several different aquifers. Twenty-three of these wells are constructed in Quaternary buried sand and gravel aquifers, and three wells are constructed in the bedrock aquifers. Arsenic concentrations does not exceed 10 ppb in all wells constructed in Quaternary sand and gravel aquifers , but all wells constructed in these aquifers in Carver County should be tested because the arsenic concentration cannot be predicted from stratigraphic correlation alone.

References Cited

Alexander, S.C., and Alexander, E.C. Jr., 1989, Residence times of Minnesota groundwaters: Minnesota Academy of Sciences Journal, v. 55, no. 1, p. 48-52.

Petersen, T.A., 2014, Geologic atlas of Carver County, Minnesota: St. Paul, Minnesota Department of Natural Resources, County Atlas Series C-21, Part B, 4 pls., scale 1:100,000.

Symbols and labels

- 30.6 — Arsenic concentration ≥ 5 ppb
- 9.73 — Chloride concentration ≥ 5 ppm
- 8.39 — Nitrate-nitrogen concentration ≥ 3 ppm
- 7000 — Groundwater residence time in years
- General direction of groundwater flow
- 800 — Approximate equipotential contour
- Geologic contact
- Land or bedrock surface
- Water table
- Lake
- U|D — Relative direction of fault movement

Aquifers - grouped by stratigraphy

Surficial sand aquifer
- sdo

Buried sand and gravel aquifers
- sdv
- sr
- sb
- sg
- sx
- su
- Unnamed

Sedimentary bedrock aquifers
- Ka — Ka (probably low yielding)
- Os — St. Peter*
- Op — Prairie du Chien**
- Ꞓj — Jordan***
- Ꞓtc — Upper Tunnel City**
- Ꞓw — Wonewoc*
- Ꞓms — Mt. Simon*
- Ꝑhn / Ꝑf — Hinckley*/ Fond du Lac
- Enhanced-permeability zone
- * — Primarily intergranular flow
- ** — Primarily fracture flow
- *** — Combination of intergranular and fracture flow

Tritium age

- Cold war era
- Recent
- Mixed
- Vintage
- Not sampled for tritium

Quaternary nonaquifer units

Geologic unit	Percent sand
dtv, rt	> 50 and ≤ 60
gt	> 40 and ≤ 50
dth, bt	> 30 and ≤ 40
xt	< 30
ups	Texture unknown

Bedrock nonaquifer units

- Ꞓsl — St. Lawrence Formation
- Ꞓe — Eau Claire Formation
- Ꝑu — Proterozoic undifferentated

Groundwater conditions

- (2) Groundwater recharge from overlying surficial aquifer to buried aquifer
- (3) Groundwater leakage from an overlying buried aquifer to an underlying buried aquifer
- (4) Groundwater leakage through multiple aquifers and fine-grained layers
- (D) Groundwater discharge from a buried aquifer to surface-water body

Legend for Figures 6 and 7

2010-2012 Groundwater Plume and Source Investigation in Capped MSW Landfill and Chlorinated Solvent Deep Vertical Profiling

BY Terry Kaiser, PE, PG, CGWP, Principal Engineer/Scientist - ECAD Engineering

Introduction

Additional investigative and possible corrective action measures appeared warranted to remediate volatile organic compound (VOC) contamination in the groundwater at the property lines of a municipal solid waste landfill in West Central Minnesota (Figure 1). This work was required by the Minnesota Pollution Control Agency (MPCA) in 2010. The landfill owner had to develop and implement a plan that would define the extent of the plume and establish an effective long term groundwater monitoring system.

The source area of the VOCs appeared to be a 23 acre unlined section of the landfill, called the Old Phase I Disposal Area. Preliminary corrective action discussions included total excavation and relocation of the waste material within the Old Phase I Disposal Area to a new lined space on site. Initial cost estimates ranged from 3 to 4 million dollars to complete the relocation of the waste in this area.

Background Information

Landfill records indicated that a significant volume of paint waste had been disposed in the Old Phase I Disposal Area between 1970 and 1980. As a corrective action measure, this area was capped from 1989 to 1995 to reduce leachate generation. It was unknown, prior to this investigation, if this area continued to significantly contribute to the groundwater contamination on-site.

The impacted aquifer is a semi confined water table aquifer in outwash sand and gravel with discontinuous clay units. The saturated thickness is 90 feet in some areas, and reaches depths of 120 feet to a thick and regionally continuous aquitard bottom.

Groundwater monitoring on-site indicated that elevated concentrations of vinyl chloride and other VOCs typical of landfills had migrated more than 600 feet beyond the facility's compliance boundary to the property boundary (Figure 1). The data from nested monitoring wells indicated that the vertical profile of the plume was not clearly defined. The horizontal limits of the plume also were unknown because routine monitoring of landfill contaminants at private wells adjacent to the site did not reveal VOC contamination.

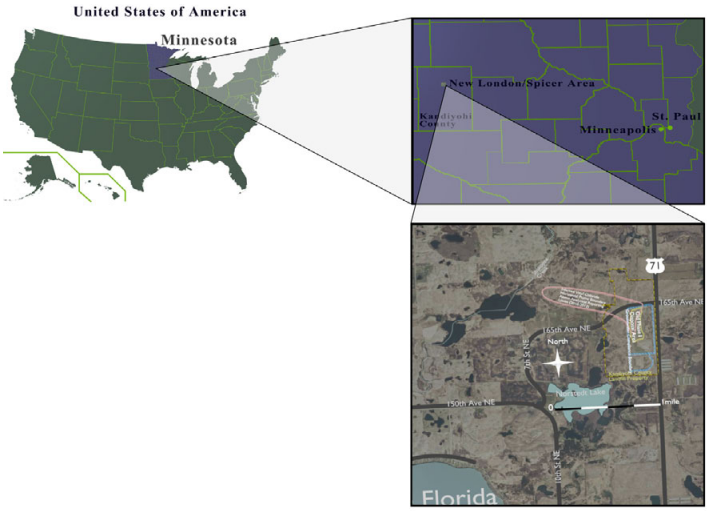


Figure 1 - Kandiyohi County Sanitary Landfill, New London, Minnesota, USA

Future development plans for the landfill required building lined space on top of the existing Old Phase I Disposal Area and knowing whether groundwater remediation plans should include contaminated waste excavation in the source area.

Work Scope

The investigation was tailored to help the facility owner determine the long term needs for additional lined space and delineate groundwater plume to meet environmental regulatory requirements.

A source investigation was completed to determine if any VOC "hot spots" present within the unlined area of the landfill warranted excavation, based on review of available project information and the costs associated with the potential need to relocate waste from the Old Phase I Disposal Area. The groundwater plume delineation was performed on a parallel track to define the horizontal and vertical extent of the contamination.

A description of the vertical profiling techniques required for this study was described in a request for proposals sent to drillers. Following some preliminary testing of experimental techniques, a unique method of sampling groundwater at discrete 5-foot intervals was developed that could meet the real-time reporting requirements for this site

Methods and Procedures

Source Investigation

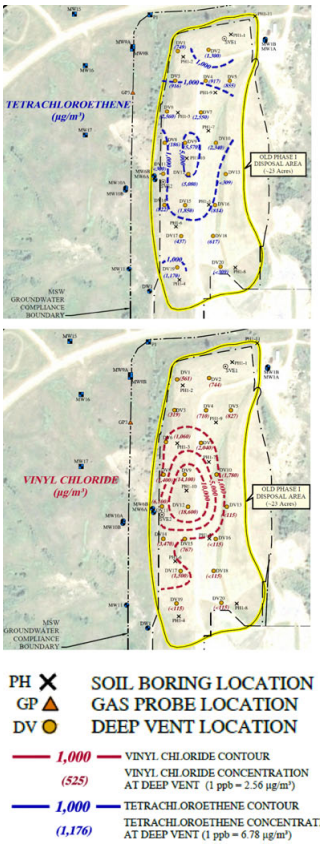


Figure 2 - Soil Vapor Extraction Results, Vinyl Chloride & Tetrachloroethene Contours

Standard procedures approved by the MPCA and Minnesota Department of Health (MDH) were used to evaluate in-place landfill waste material, soil below the old scale house/paint storage area, soil between the bottom of the landfill and top of the water table, and groundwater at the water table directly beneath the landfill waste material. Standard hollow-stem auger, mud rotary, and geo-probe sampling techniques were used. Completed borings were sealed and surveyed as necessary.

Landfill vapor samples from 20 existing deep vertical landfill gas vents (DV1-DV20) within the source area were collected with a portable blower (Figure 2). The deep vents are generally screened in the middle of the waste fill areas, 20-45 feet deep. Standard soil vapor extraction (SVE) sampling equipment and procedures used included the following:

— *continued on page 8*

- Evacuation Flow Rates of 75-90 Standard Cubic Feet/ Minute
- Evacuation Periods of 30 minutes
- Evacuated Borehole Volume Ratios of 7:1 to 19:1
- Suma Canisters, EPA Method TO-15

Two rounds of SVE sampling were completed in April and May of 2010. The samples were tested for VOCs found at the landfill.

Borings (PH1-11) were drilled in the source area. Materials encountered from borings were classified according to ASTM D2488, Visual and Manual Procedure. Representative samples collected from clean split spoon samples were screened for head-space concentrations using a photoionization detector.

Representative groundwater samples at the water table, below the bottom of the landfill, were collected by pounding a drive-point assembly ahead of the auger into the undisturbed material. The drive point screen was constructed of stainless steel and was two inches in diameter and 36 inches long. A 1.5 inch diameter disposable bailer was lowered into the drive point assembly to collect the groundwater sample.

Groundwater Plume Delineation

This study required vertical profile sampling every five feet. Proposals for this work were received from qualified drillers. The technical merits of each proposal were considered. Roto-sonic drilling, proposed by Traut Companies, according to *ASTM D6914 - Standard Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices* was chosen due to the clear ability of the technique to collect representative ground water samples. Figure 3 illustrates the boring locations (RS1-20) selected from 2010-2011. Each boring location was selected based on real-time results received in the field and consultation with MPCA staff.

At each rotosonic boring site, the initial groundwater sample was collected at the water table surface using a temporary PVC well with a 5-foot PVC screen and a disposable bailer. This was done to reduce the use of drill water and the purging time to obtain a representative groundwater sample.

The remaining samples were collected by driving a 6-inch diameter liner to each 5-foot sampling interval. Large potable drill water volumes, typically ranging from 50 gallons to 300 gallons, were needed to set the liner casing for each groundwater sampling interval. A 3-inch x 4-foot .007-slot stainless steel screen was then dropped to the sample interval with a K packer. The 6-inch liner was then pulled back to expose the screened sample interval. In the photo, workers with Traut Companies prepare to attach the inner casing for the drilling.

Photo - Workers set up casing for Rotosonic drilling

Samples were not collected at locations where low and/or insufficient recharge of groundwater was expected based on soil conditions (fine sand/silt/clay) observed in continuous 10-foot soil cores.

Prior to groundwater sample collection, a minimum of three times the potable drill water volume used for drilling was purged using a 2-inch or 3-inch diameter stainless steel pump. Field readings of temperature, specific conductance, dissolved oxygen, and pH also were allowed to stabilize before sample collection.

Groundwater Analysis

Groundwater sample analysis was performed by a mobile lab on-site using gas chromatography-mass spectrometry. Samples were analyzed for the VOCs approved for the facility's routine and corrective action sampling and analysis plan. Replicate samples and field blank samples were also collected and tested at each borehole.

For additional QA/QC analyses, duplicate groundwater samples were collected from monitoring wells adjacent to several of the rotosonic boring locations. These samples were analyzed by the contract lab used for quarterly permit monitoring and the on-site mobile lab used for the study. The results were then compared to the groundwater samples collected from the screen interval of an adjacent soil boring that most closely represented the monitoring well screen interval.

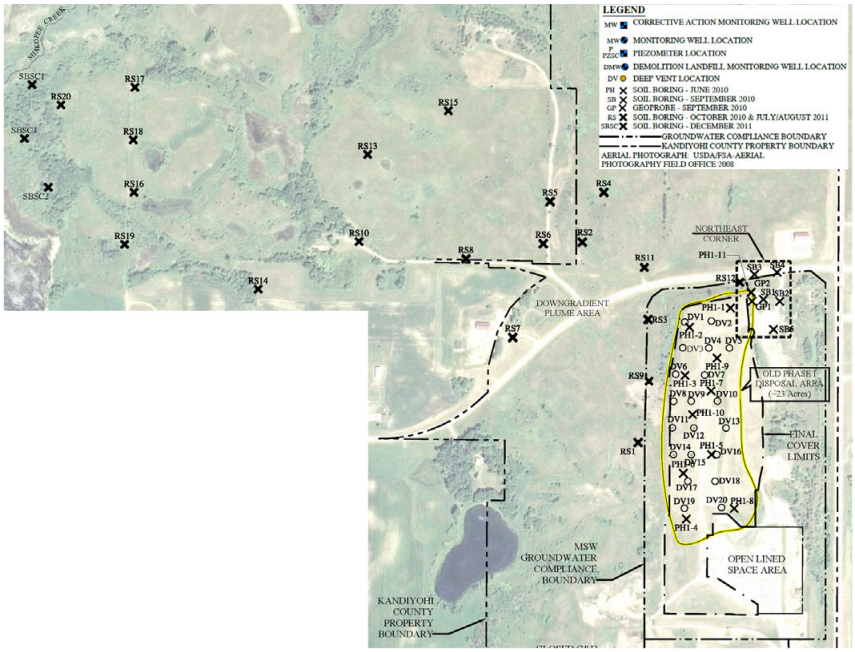


Figure 3 – Boring and Testing Locations

— continued on page 10

Groundwater Plume and Source Investigation, cont.

Results

Source Investigation

An evaluation of the reported results from the source investigation indicates the following:

- The highest levels of tetrachloroethene and vinyl chloride within the source area were discovered at DV9 and DV12.
- Water table samples from below the source area did not contain vinyl chloride; however, low levels of tetrachloroethene were reported.
- The general depth of mixed solid waste ranged from 42 to 69 feet below the top of the landfill cap.

Groundwater Plume Delineation

The results indicate an excellent correlation between the two different analytical laboratories and the samples obtained from the rotosonic groundwater profiling work. Figure 4 identifies the inferred horizontal plume boundary, potentially impacted property, and off-site monitoring wells installed to monitor the plume. An evaluation of the reported results also indicates the following:

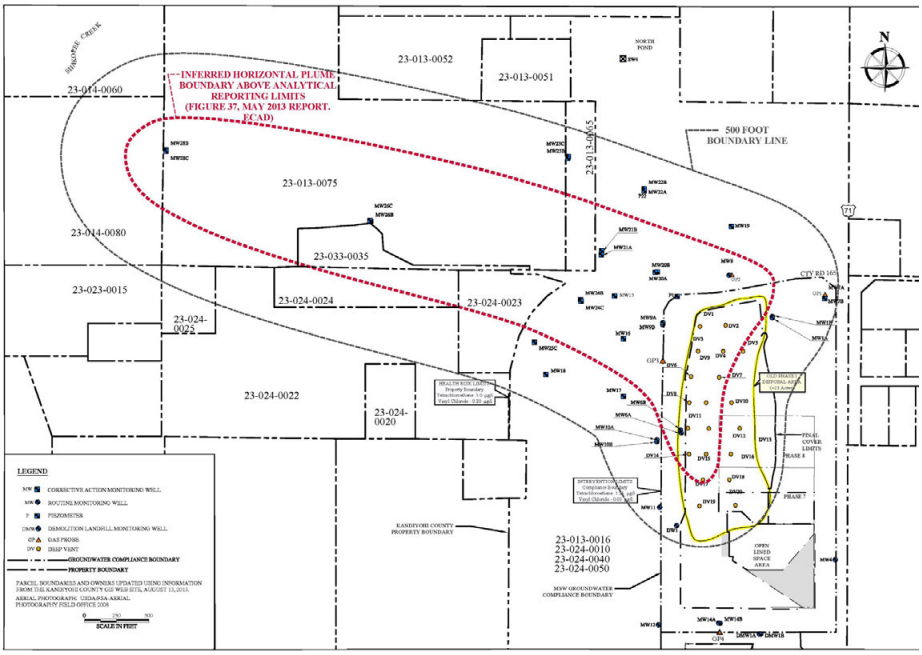


Figure 4 – Inferred Horizontal Plume Boundary for Vinyl Chloride & Tetrachloroethene

- The leading edge of the plume migrated approximately 1 mile to the west-northwest of the landfill.
- The highest VOC concentrations in the groundwater were found approximately 2,000 feet downgradient from the source area.
- The impacted aquifer is approximately 90 feet thick along the northern edge of the unlined source area (RS12) and is approximately 30 feet thick within the southern half of that area (PH1-8).

Figure 5 illustrates a 3D rendering of the water quality results from the rotosonic drilling sites for vinyl chloride and tetrachloroethene, along with cross-sections and borehole soil profiles, highlighting the scope and magnitude of the investigation and results.

A video with 3D illustration of the groundwater plume delineation project is presented online at: http://ECADengineering.com/#video.

Conclusions

The success of the project was driven by a cooperative effort between the regulators, the owner, drilling & laboratory contractors, and the consultant. The project required meticulous planning, data collection, and effective regulatory communications, in dynamic conditions. Cost effective options were considered, and the project was completed in a timely manner, meeting facility permit and future lined space development needs.

The landfill owner was able to obtain a new solid waste permit in 2011. Based on results of the source investigation, the owner was permitted to build a new lined space cell on top of the Old Phase I Disposal Area in 2012 as excavation of waste from this area was not required.

Finally, the facility owner, local drillers, the MDH, and property owners who may be impacted, were notified of the inferred plume limits. They were also informed that drilling in the area may require special considerations with MDH and/or MPCA approval.

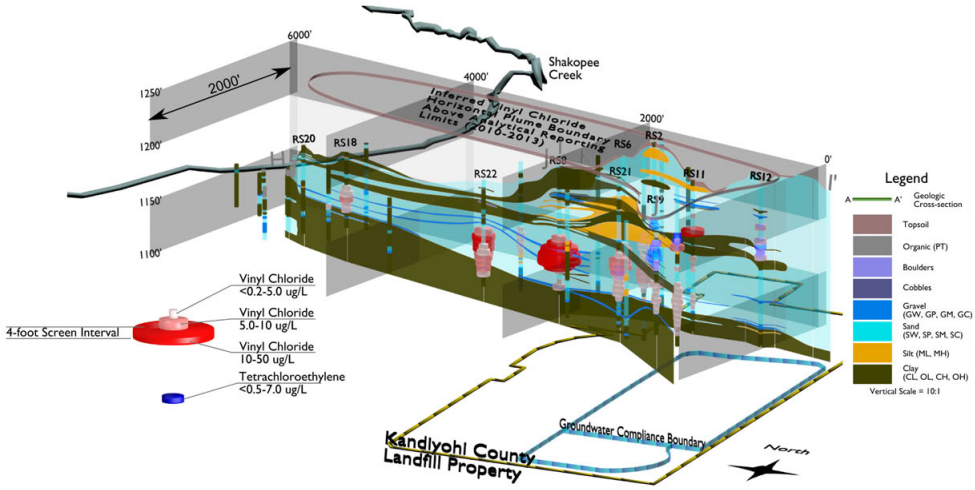


Figure 5 – 3D Illustration of Borings and Sample Results

Featured Photo(s)

Biological Hazards in the Field

Matt from Thein Well Co. gets a thorough equipment inspection from the land owner's lab. Photo taken by Mark Davidson while working on the the Regal Meadows site for the DNR.

Nick Borchardt from the DNR County Geologic Atlas Program gets geo-data advice while sampling wells in Renville County.

Randy Bradt from the DNR County Geologic Atlas program receives assistance while sampling wells in Renville County.

A pre-flight safety check and about 20 minutes of cat herding saved curious kittens from being flattened under the AF-200P Auto-Fire 200 P-Wave Accelerated Weight Drop Energy Source System (aka: the whammer). Thanks to the County Geologic Atlas seismic team working in Becker County.

Heather Emerson, DNR Hydrologist, gets monitoring advice while out stream gaging on the Beaver River near Beaver Bay in July 2014.

Another Successful MGWA Fall Conference!

By Sherri Kroening - MGWA Newsletter Team

The MGWA Fall Conference, "Superfund: Its Legacy and Future", was held on November 12th, 2014 at the University of Minnesota's Continuing Education and Conference Center. John Wilson, Michael Kanner, and Stephen Lee opened the conference by presenting a history of the Superfund Program from both the federal and state perspective. Cathy Villas-Horns discussed other cleanup programs that were created after the state of Minnesota's Superfund Program. Sandeep Burman discussed the Superfund program's accomplishments in Minnesota as well as new issues and challenges that are emerging at these sites. Allan Gebhard, Paul Hyde, and James Payne gave examples and observations of the Superfund Program from the industry's perspective. Anne Morris discussed the approach the MPCA is taking toward re-assessing closed sites, and Mike Bares and Nelson French ended the conference by presenting the Superfund program's role in restoring the St. Louis River Area of Concern.

For those who missed this opportunity or want to see them again, links to the presentations are available at the following:

http://www.mgwa.org/meetings/2014_fall/fall2014.php

Third Annual MGWA/MGWAF Scholarship Announced

The MGWA and MGWA Foundation are excited to announce the Third Annual $1,000 student scholarship for undergraduate or graduate students majoring in hydrogeology, groundwater hydrology, or similar programs at an accredited college or university in Minnesota or an adjoining state or province. The goal of this scholarship is to alleviate a portion of the educational costs of qualified students, while also increasing their interest in the professions of hydrogeology, groundwater geology, and related programs.

There were many qualified candidates who applied for the scholarship last year, and we encourage those who were not successful to reapply this year! The application form and additional information can be found on the MGWA website at:

http://www.mgwa.org/foundation/funding.php

The application deadline is January 31, 2015. Please pass this information on to any students who may be interested in applying for this valuable scholarship!

— MGWA Foundation Board of Directors

The William L. Wilson Scholarship in Karst Science

Administered by the Karst Waters Institute www.karstwaters.org

The William L. Wilson Scholarship in Karst Science was established in 2002 to recognize the significant karst science contributions of the late William (Bill) L. Wilson. Bill Wilson used a variety of techniques, and unusual creativity, to tackle some of the most difficult karst science questions in Florida and elsewhere. He developed a leading karst consulting company in the United States, Subsurface Evaluations, Incorporated. To stimulate the development of new, energetic, motivated, and creative karst scientists, and to remember Bill Wilson and his dedication to karst science, the scholarship has been established in his memory. The value of the scholarship as a one-time award is $1,000.

To apply for the William L. Wilson Scholarship, the following conditions exist:

1) The applicant must be currently enrolled in, or have been accepted into, a master's degree program at an institution of higher education in the United States. PhD students are not eligible.

2) A written proposal of the planned karst study must be submitted. It is limited to 1000 words or less for the narrative, not counting figure captions and references. The research topic should be one concerning karst science, from the field of geochemistry, geology or hydrology. A very simple budget indicating how the funds would be used should also be included (it does not count in the 1000 word limit). Applicants are requested to not recycle master's thesis proposals as applications.

3) Academic transcripts of undergraduate, and any graduate work, should be submitted. Copies issued to the student by their institution are preferred.

4) Two letters of recommendation, with one of them from the student's advisor or mentor, should be submitted. It is requested that these letters be emailed directly to jbmartin@ufl.edu by the letter writers.

5) Applications are due by February 2, 2015. They should be submitted electronically as a single pdf file that includes the proposal, budget, and all transcripts to:

Dr. Jonathan B. Martin
Department of Geological Sciences - University of Florida
PO Box 112120
Gainesville, Florida 32611-2120
jbmartin@ufl.edu

Questions regarding the scholarship should be addressed to Dr. Martin. Applicants will be notified in early March of the decision of the Scholarship Committee. Publications derived from supported research should acknowledge the Karst Waters Institute and the William L. Wilson Scholarship.

For more information, go to: http://karstwaters.org/scholarship/

Minnesota Ground Water Association Board Meeting Minutes

Meeting Date: September 3, 2014

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

Attendance: Eric Mohring, President; Lanya Ross, President-Elect; Bob Tipping, Past President; Audrey Van Cleve, Treasurer; Avery Cota-Guertin, Secretary; Sean Hunt, WRI; Jeanette Leete, WRI; Tedd Ronning, Newsletter Editor

Past Minutes: Approved

Treasury: Van Cleve provided the Board with copies of the financial report. Total income for the period of January 1, 2014- September 2, 2014 is $62,585; total assets as of September 2, 2014 are $102, 735. Net income is $ 26,476. Pre-paid dues are starting to show up as negative assets to be applied to next year's finances.

Newsletter: Ronning reported that the newsletter was turned over to Leete last week. Call for technical articles for the upcoming newsletters.

Web Page: MGWA and Foundation taxes were completed and uploaded to the web page.

WRI Report: WRI provided the Board with the Business Manager's report. Unrelated business income is from selling guidebooks and newsletters. Hunt and Mohring are working on finalizing the 2014 Fall Conference Brochure.

Old Business: 2014 Fall Conference. Mohring provided the Board with tentative conference agenda and topic descriptions. Mohring will send the updated conference agenda and descriptions to Hunt to add to the web page. The Board discussed possibly sending notification of the conference to MPR, Legislature, and to target other special interest organizations. Hunt presented to the Board a draft brochure for the conference. Facility costs are the same as it was in Spring and thus, the attendee costs will remain the same for the Fall conference. Tipping and Van Cleve will work to solicit exhibitors for the conference. Poster sessions do not need to be directly related to the conference topic.

2015 Spring Conference. Ross is working on solidifying a theme for the Spring Conference. The Board discussed possible themes and interest. Leete proposed offering an ethics course, possibly a breakout session, to satisfy requirements for professional license renewals in 2016. The Board discussed the feasibility and potential interest in incorporating license renewal requirements in future MGWA conferences.

2015 Sinkhole Conference. Van Cleve relayed that concerns regarding construction at the Civic Center during the conference were addressed. Meeting space will be reconfigured as a result of construction concerns.

White Paper Topics. Mark Collins has been sending updates on the progress of the Manganese white paper. Hunt has been assisting the Manganese work group with access to the google drive.

2014 Fall Field Trip. The Board cancelled plans to host a Fall 2014 Field Trip because of the short timeline and discussed trying for a one day field trip in future years.

Meeting Date: October 01, 2014

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

Attendance: Eric Mohring, President; Lanya Ross, President-Elect; Audrey Van Cleve, Treasurer; Avery Cota-Guertin, Secretary; Sean Hunt, WRI; Jeanette Leete, WRI

Past Minutes: Approved as amended.

Treasury: Van Cleve provided the Board with copies of the financial report. Total income for the period of January 1, 2014- September 30, 2014 is $74,787; total assets as of September 30, 2014 are $111,560. Net income is $26,919.

Newsletter: Hunt reported that the September newsletter was distributed to members. The board discussed issues with the color printer that WRI is currently using to print material for MGWA. Ross motions to authorize, up to $500.00, for the purchase of a replacement color printer, if necessary. A motion was made to authorize the purchase of a new printer to replace the broken printer used by WRI. The motion was approved.

WRI Report WRI reported entry of new conference registrations. To date, the 2014 Fall Conference has 94 attendees. Membership renewals and officer elections are approaching. The due structure has not been updated recently.

Old Business: 2014 Fall Conference. Mohring will solidify the conference agenda, speaker bios, and abstracts with the next week. The Board discussed possible registration fee compensation for speakers who would not otherwise attend the MGWA conference. Tipping and Van Cleve are working on finding exhibitors for the conference.

2015 Spring Conference. The Board discussed the possibility of offering a job fair to bring students and employers together. Ross discussed a few ideas for possible conference topics.

2015 Sinkhole Conference. Field trip costs have yet to be determined; there are concerns that the field trip may be too costly. Abstracts for the conference are due by December 1, 2014. Hunt suggested an internal promotion calling for abstracts; Mohring will make an announcement at the 2014 Fall Conference. .

MGWA 2015 Membership Dues

Professional Rate:	$35
Full-time Student Rate:	$15
Newsletter (printed and mailed)	$20
Directory	$7

Membership dues rates were revised at the October 1, 2010 meeting of the MGWA Board. They remain unchanged.

Minnesota Ground Water Association Board Meeting Minutes, cont.

Meeting Date: November 05, 2014

Location:	Fresh Grounds Café, 1362 West 7th Street, St. Paul, MN
Attendance:	Eric Mohring, President; Lanya Ross, President-Elect; Audrey Van Cleve, Treasurer; Avery Cota-Guertin, Secretary; Sean Hunt, WRI; Jeanette Leete, WRI
Past Minutes:	Approved as amended.
Treasury:	Van Cleve provided the Board with copies of the financial report. Total income for the period of January 1, 2014- November 1, 2014 is $95,911; total assets as of November 1, 2014 are $128,951. Net income is $47,575.
Newsletter:	Call of technical articles and officer candidate biographies for the upcoming newsletter. The purchase of a replacement printer for WRI has not been necessary thus far.
Web Page	Registration for the MGWA 2014 Fall Conference is full; on-line registration is closed. A link to the 2015 Sinkhole Conference registration is posted on the web page.
WRI Report	WRI reported that the MGWA 2014 Fall Conference registration is full. WRI reiterated the desire to move the restricted money out of the Foundation's account to simplify fund management. This will be an item of discussion with the MGWA Foundation Board when a joint meeting is scheduled.
Old Business:	2014 Fall Conference. Mohring provided the Board with a draft conference agenda. The Board discussed ending the conference at 5:00pm instead of 4:30pm. Mohring will touch base with Tipping regarding conference posters. 2015 Sinkhole Conference. Conference abstracts are due by December 1, 2014. The Board discussed including a flyer advertisement with the 2014 Fall Conference materials to remind attendees of this deadline. Mohring will also make an announcement at the 2014 Fall Conference.
New Business	MGWA Foundation. The Board received a letter from Gil Gabanski addressing concerns with pending grant requests. The Board discussed scheduling a joint meeting with the MGWA Board and the MGWA Foundation Board. Mohring suggested the joint meeting be scheduled within the next few months to address concerns. 2015 Officer Candidates. The Board discussed potential officer candidates for Vice-President and Treasurer. Officer candidates will need to send biographies to the Newsletter team. .

New from the USGS:

A new study of contaminants of emerging concern in ambient groundwater in urbanized areas of Minnesota was was released by Erickson, M.L., Langer, S.K., Roth, J.L., and Kroening, S.E. The publication and an interview by the report's authors with Minnesota Public Radio can be found here:.

http://pubs.usgs.gov/sir/2014/5096/

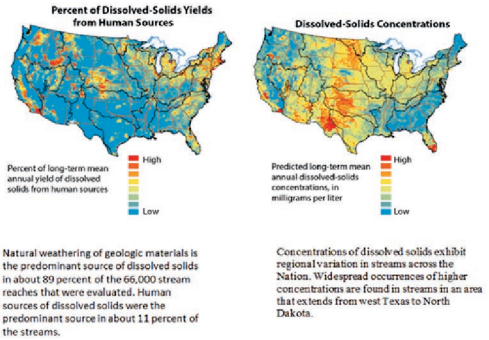
http://www.mprnews.org/story/2014/06/26/ground-level-beneath-the-surface-cec

A new digital map dataset of karst in the United States has been released, by Weary, D.J., and Doctor, D.H., 2014, Karst in the United States: A digital map compilation and database: U.S. Geological Survey Open-File Report 2014–1156, 23 p. The publication and data can be found here: http://pubs.usgs.gov/of/2014/1156/

"Geochemical and Mineralogical Maps for Soils of the Conterminous United States" has been released, by David B. Smith, William F. Cannon, Laurel G. Woodruff, Federico Solano, and Karl J. Ellefsen. The publication can be found here: http://pubs.usgs.gov/of/2014/1082/

A new USGS report provides science-based information on where dissolved solids concentrations are elevated and what are the dominant sources contributing to these conditions. The publication can be found here: http://pubs.usgs.gov/sir/2014/5012/

Maps of concentrations, yields, and loads of dissolved solids in streams are available on the online, interactive decision support tool. The online tool can also be used to evaluate dissolved-solids loads to any user selected watershed outlet or to predict how changes in selected sources of dissolved solids within a selected watershed may change loadings to the watershed outlet.



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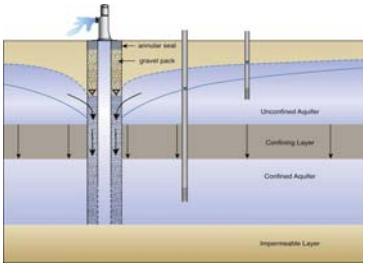
Aquifer Pumping Test Techniques

2015 Special Webinar Series

Jim Butler, PhD Kansas Geological Survey	**Part 1: Practical Guidelines to Get More From Your Test Data**	January 22
Michael Kenrick, PE, LHG GeoEngineers, Inc.	**Part 2: Step Drawdown Testing**	February 12
Keith Halford, PhD Research Hydrologist	**Part 3: Constant Rate Pumping Tests**	March 5
Garth Van der Kamp, PhD Environment Canada	**Part 4: Recovery Testing**	March 16
Molly Mills In-Situ, Inc	**Part 5: From Measuring Water Levels to Exporting Data**	April 9
Shlomo Neuman, PhD University of Arizona	**Part 6: Response from Pumping in Unconfined Aquifers**	April 30

Discover and learn the most up-to-date information about aquifer pumping test techniques from some of the most recognized authorities in ground water.



Aquifer Pumping Tests are a key element to site characterization, water resources assessment and remediation system design. Even when you are confident of the geologic conditions, you may have difficulty designing effective aquifer tests, running field equipment or selecting the best available model to analyze the test data. Where do you turn for help with aquifer testing?

Midwest GeoSciences Group & In-Situ, Inc. can help! We have designed a powerful six-module webinar series about pumping test design, field methods and data analysis techniques. This course will highlight key steps for modernizing your aquifer testing from beginning to end.

Each module is 90-minutes and allows for 1.5 Professional Development Hours (PDH). You receive a copy of the webinar slides, free Record of Attendance Form, and Comprehensive Aquifer Testing References to distribute to webinar registrants at your site.

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