Wisconsin Ground Water Association Newsletter

INSIDE THIS ISSUE:

President's Message

Kudos go to President-Elect Brian Hahn and the entire Board of Becky Caudill, Boyd Possin, Marilyn Weiss, and Janis Kesy for putting together a great conference. We all came away learning a great deal. Who knew that the latest water sensor technology is using live fish in its instrument panel?! Steve Elmore of the WDNR shared such cutting edge items that are part of the realm of drinking water security. He also indicated how multi-parameter sensors are now comparing real-time data to past history so that potentially harmful conditions can be separated from rain events and other natural phenomena.

Key-note speaker Robert Karnauskas gave a very thought-provoking talk on sustainable development. Did you know the average American consumes 3.7 millions pounds of minerals, metals, and fuels in their lifetime? It was interesting (and encouraging!) to discover that Dow Jones now has a sustainability index to rank the top companies in terms of economic, environmental, and social criteria—and that such companies outperform their peers by an average of 10%. Long-term thinking really is most productive! You might want to consider such companies in choosing where you invest your money.

Speaking of sustainability, graduate student Marie Johnston shared the interesting fact that developed areas in Dane County went from a density of 8.36 people per acre in 1970 to 5.84 in 1990, quantifying the sprawl we continue to see. Her talk on the potential effects of prairie landscaping in developed areas gave further food for thought.

Sue Trinrud of Eon Products, Inc. presented information on no purge sampling techniques. She discussed how samplers could be filled in the field with deionized water and left in monitoring wells to equilibrate with groundwater until the next sampling event (typically for volatile compounds although other parameters are being evaluated more and more). Profiles can be done in five foot intervals to determine the zones contributing the greatest amount of contamination. Regulators have generally been receptive to trying no purge sampling on a side by side basis with traditional

(Continued on page 2)

The newsletter is published four times per year. If you have any suggestions or submissions, please contact us at: Wisconsin Ground Water Association, c/o Marilyn Weiss, WGWA Treasurer, P.O. Box 8593, Madison, Wisconsin 53708-8593. Email: wgwainfo@wgwa.org; Web site: http://www.wgwa.org. The deadline for submissions to the 3rd quarter of 2005 newsletter is August 15, 2005.

(Continued from page 1)

methods to evaluate their use for ongoing monitoring.

Graduate student Nathaniel Keller spoke on the WDNR study assessing Wisconsin's natural attenuation protocol for sites that achieved regulatory closure in 1999 to 2000. He shared a case study in Dane County that was typical of the petroleum sites studied—the plume extent was similar at the water table and had lower concentrations overall but the piezometer monitoring wells revealed advancement of the plume. No one would seem to have the stomach for reopening closed releases, but this study could impact the monitoring of new and existing sites. The seasonality of plume conditions was also still apparent at many sites.

Switching gears from learning to teaching, the 3rd Annual Wisconsin Groundwater Festival took place on May 6 in Eau Claire and was another tremendous success. Jen Kingsley is to be congratulated for continuing a high standard of excellence with this event. Several WGWA members were present lending their expertise and enthusiasm to the hands-on activities that engaged the interest of hundreds of 5th and 6th graders. I would encourage all of us to keep this event in mind as one of most impacting legacies our career can have is influencing future generations to be the stewards needed to allow man and earth to exist together.

Lastly, it's not too early to be thinking about our annual field trip, which will be held in the fall. If you have some ideas for the trip and would like to lend a hand in helping it be another memorable time, let me know as we will soon be making plans. Keep in the flow!

Dave Nemetz, P.G.
WGWA President

Calendar of Events

What: Minnesota Land Development & Water Law Seminar
When: May 26, 2005 - Registration 8:30 am to 8:55 am - Seminar 8:55 am to 4:30 pm.
Where: Four Points Sheraton Hotel, Saint Paul, MN
More info: "An Exceptional Seminar" Sponsored by Clarion Legal - 6 CLE credits MN (approved), 7 CLE credits WI (approved) Tuition $295. Complete PDF schedule and registration form: www.mgwa.org/mnwaterlaw2005.pdf Or visit http://www.clarionlegal.com/

Second Edition of the 'Karst: Avoid that Sinking Feeling' is now available.

The second edition of the 'Karst: Avoid that Sinking Feeling' brochure is now available. People can request up to 300 brochures by emailing kimb@co.jefferson.wi.us. For questions about the brochure contact Suzanne Wade suzanne.wade@ces.uwex.edu or at 920-674-8972.
A pdf of the original brochure is at http://asineducation.uwex.edu/rockriver. The only changes made in this new edition is to the inside graphic so it is more accurate and a few minor wording adjustments.

Suzanne Wade, Rock River Basin Educator for Natural Resources
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Jefferson, WI 53549
920/674-8972
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http://clean-water.uwex.edu/rockriver

Ruth LePoidivan Nominated for 2005 National Wetlands Awards

Ruth LePoidivan has served as an inspiration to over 1300 middle school children, their families, and the local community for 10 years. Mrs. Le-Poidivan founded the Pewaukee River Restoration Project (PRRP) in 1994 as a means to introduce children to environmental issues, with a focus on active involvement through hands-on restoration of their local river. Through her efforts the Pewaukee School District has made participation in the PRRP a mandatory part of the middle school curriculum for all 6th, 7th, and 8th grade students, approximately 130 per grade year. Sixth graders begin the three-year program with an in-depth study of the Pewaukee River followed by actual restoration projects. Seventh-graders learn to collect and identify aquatic macro-organisms while eighth-graders collect and analyze water samples for chemical quality parameters. Students engage directly in restoration efforts on and along the Pewaukee River, developing a strong sense of ownership in the health of the river and its watershed. Many students continue their participation in subsequent years, becoming active members of the River Keepers, another organization Mrs. LePoidivan founded to nurture continued involvement in the Pewaukee River and the environment in general.

Ruth was nominated for the 2005 National Wetlands Award this year by the Pewaukee River Partnership. The WGWA congratulates Ruth on her nomination. Would any of our members make good candidates for the 2006 award? See nomination information available at http://www.epa.gov/owow/wetlands/about/awards.html.

"Groundwater Guardian"
Wisconsin Act 310

Starting on Sunday May 1, the high capacity well application fee of $500 and the private well notification fee of $50 will be implemented. Documents have already been mailed to licensed well drillers, licensed pump installers and selected engineering consultants that frequently submit plans to the Drinking Water and Groundwater program. The fees also apply to applications for a high capacity well that will be a municipal well and to construction dewatering projects that use high capacity wells.

We do not require that contractors that implement construction dewatering projects to be licensed drillers and we do not maintain a list of such contractors, thus this group has not yet received any organized notice from our program. That may be an issue if any of your members are working on construction projects that require dewatering from a high capacity well system, thus your members may consider advising your contractors when they bid on projects about the new fee. This also applies to any projects that have already been bid or awarded to a contractor but have not yet been implemented. There will be a lot of questions and we anticipate preparing a guidance to answer the frequently asked questions in the near future.

George Mickelson
Private Water Systems Section
Bureau of Drinking Water and Groundwater
Wisconsin DNR
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Wisconsin Act 310
Groundwater Quantity Law

- The limitations of Wisconsin's Groundwater Law came to public attention during the Perrier bottled water application.
- The new law was developed through an open and transparent process.
- Many interested groups had a seat at the discussion table, representing industry, agriculture, well drilling, local government, and the environment.
- The Wisconsin Water Well Association represented the well drilling and pump installing community at the discussion table.
- Act 310 passed the legislature with broad bipartisan support.
- The law recognizes the interconnection between surface water and groundwater, and contains provisions intended to protect both.
- The law establishes requirements to improve existing information and data about water level, water use, pumpage, well construction and location.
- The law recognizes the importance of proper location and construction for all wells.
- In order to increase the number of private well inspections the law requires advanced notice before any new private well is constructed.

"Every Drop Counts" program to help reduce sewer overflows and protect Lake Michigan

(Milwaukee, WI) – It's no magic fix. However, a new regional water conservation program that kicked off today is one of the many tools needed to help reduce sewer overflows and basement backups.

This morning a broad coalition of business, civic, and environmental organizations as well as elected officials and schools joined together at the Milwaukee Art Museum on the shores of Lake Michigan to support the "Every Drop Counts" campaign. "Every Drop Counts" offers simple ways for people to help out at home or work by using less water when there is heavy rain.

"If all of our 1.1 million customers cut their water use by 10 gallons when it rains, we could reduce the risk of a sewer overflow by 11-million gallons," said Milwaukee Metropolitan Sewerage District (MMSD) Commission Chairman Tim Seider, Greenfield Mayor. "We all use about 65 gallons of water a day, and there are many ways to keep some of that water out of the sewer system."

Some tips for saving water:

- Fix leaks. Nationally, 14% of the water we pay for drips down the drain, thanks to leaky plumbing.
- Cut water use by 1/3 or more by installing low-flow faucets, showerheads, and toilets.
- Wait to do laundry until the storm passes. Always wash full loads.
- Take a short shower instead of a bath.
- Turn off the water while brushing your teeth or shaving and save 5 gallons of water or more every morning.

The "Every Drop Counts" program includes many partners. As more and more people find out about the program, it's expected that the list of partners below will continue to grow.

- Keep Greater Milwaukee Beautiful
- Sierra Club
- Wisconsin Department of Natural Resources
- Waste Management
- Greater Milwaukee Association of Realtors
- Metropolitan Builders Association
- River Revitalization Foundation
- Milwaukee Metropolitan Sewerage District
- Milwaukee River Basin Partnership
- Milwaukee Community Service Corps
- Kiwanis Club of Milwaukee
- 16th Street Community Health Clinic
- Friends of Milwaukee's Rivers
- Hawley Environmental School
- Jefferson Elementary School

The official "Every Drop Counts" web site can be found at, www.everydrop.org. The site features tips on how to conserve water that can be printed and reproduced for newsletters, mailings, and brochures.

Help Protect the Future of Water Quality

Milwaukee Metropolitan Sewerage District

What is a Rain Barrel?

A rain barrel collects and stores rainwater from your rooftop which you later can use to water your lawn or garden, or to wash your car.

Rain barrels should be used in conjunction with other water management practices, such as rain gardens, green roofs, stormwater trees and porous pavement. But using a rain barrel is a great first step to better water quality.

Why rain barrels?

Well, they…
1. Reduce water pollution.
2. Help lower water bills.
3. Help keep excess water out of the sewer system.
4. Are easy to build & install.

Why should I consider?

1. Rain barrels help slow down rain runoff so it can drain naturally into the ground. That helps us keep excess water out of sewer systems and keeps rain runoff from collecting pollutants on its trip to nearby waterways.
2. Collected rainwater is better for plants because it's not chlorinated although it is mildly acidic, which helps plants take up important minerals from the soil.
3. They can provide water during dry weather, or you can set them to slowly release the water over a 1- 2 day period when the rains have subsided. The slower release of rain will allow the water to seep into the soil and be used by plants.
4. Rain barrel programs are being implemented in communities across North America, including: Portland, Oregon; Toronto, Ontario; Dearborn, Michigan; Fort Wayne, Indiana; Seattle, Washington; and Boston, Massachusetts.

Other MMSD rain barrel information:

Fully screened, it keeps out mosquitoes and other unpleasant insects. An additional safety strip prevents curious little persons or animals from falling in.

55-Gallon Storage. Replenishing its supply every time it rains, this barrel captures the fresh, untreated rainwater for your gardening needs.

Automatic Overflow. The overflow located on the upper part of the barrel diverts excess rain to a nearby garden, additional barrel, or distant area.

Built To Last. These recycled barrels, originally used for cucumber storage, are made of thick durable plastic. They will stand up to all that Wisconsin seasons can bring for years to come.

A 1999 study for the City of Toronto indicates that rain barrels can reduce the volume and peak water discharge for frequent storms.

Things you should know to take care of your rain barrel:

1. Everyone is concerned about mosquitoes and West Nile disease. These rain barrels are fully covered with mosquito screens so you do not need to worry about these pesky insects getting in and laying eggs in your rainwater.
2. During the winter it is important to empty your barrel and turn it upside down
3. Make sure your overflow hose is long enough to divert all the collected water away from your house's foundation.

When possible, empty your barrel within four days following a storm.

To order your rain barrel, go to

www.mmsd.com/rainbarrel/order_form.cfm

Words of Wisdom and Awards from WGWA Conference at Chula Vista Resort April 29, 2005

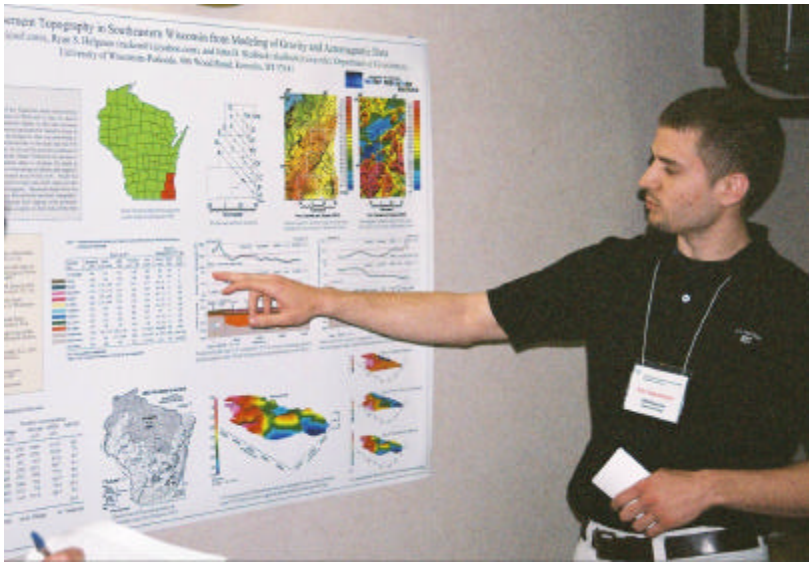
The following "words of wisdom" were gleaned from the many fine presentations at this year's conference.

John Jansen – "You can tell where radium's coming from, but you can't always seal it off".
Sue Trinrud – "The hydrosleeve ($25) gives a grab sample from a 2-ft discrete zone taken after only a day or so of equilibration".
Nathanial Keller – "Our study sample (10% of the 1377 closed remediation sites in Wisconsin) showed that 8% had no down-gradient wells".
Jim Bannantine – "Take hydrogeology back from the engineers!"

Awards were given for the best student papers and posters. The best paper went to Nathanial Keller. Winners of the poster awards are shown in the following photos:

WGWA President-Elect (Brian Hahn) and 2nd place poster author (Ryan Beachner)

1st Place poster winner (Dan Swosinski)



2005 WGWA Annual Conference Student Winners

Best Graduate Presentation - $500
Nathaniel R. Keller
An Assessment of Wisconsin's Natural Attenuation Closure Protocol
Nathaniel Keller, Rachel M. Greve, and Jean M. Bahr
University of Wisconsin – Madison

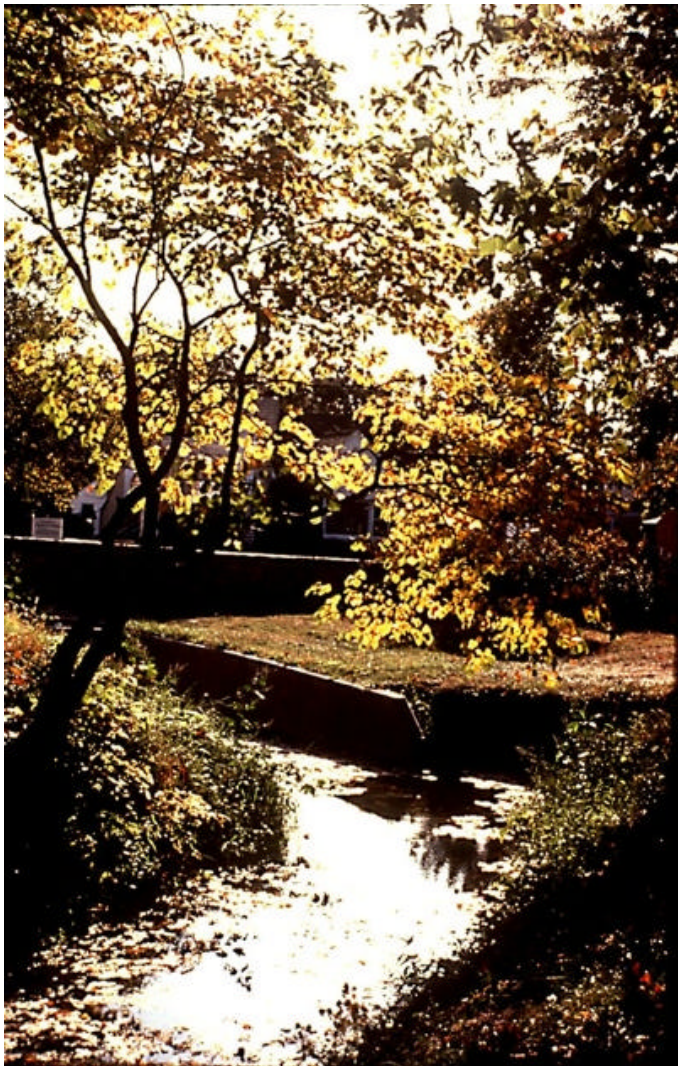
Honorable Mention Graduate Presentation - $250
Warren Hohn
Migration of Inorganic Arsenic at a Former Pesticide Storage and Disposal Site
W.A. Hohn and R.E. Stieglitz
University of Wisconsin – Green Bay

Honorable Mention Graduate Presentation - $250
Marie Johnston
Soil Porosity of Residential Prairie Plantings Relative to Age since Establishment
M.R. Johnston and N.J. Balster
University of Wisconsin – Madison

Best Undergraduate Presentation - $500
Garin Tranberg
Hydrologic Analysis of Ground-Water Conditions Along a Millrace Near the Genesee Roller Mill Dam
Garin Tranberg and Josepth J. Piatt
Carroll College

Best Poster - $500
Dan S. Swosinski
Precambrian Basement Depth in Southeastern Wisconsin from Modeling of Gravity and Aeromagnetic Data
Dan S. Swosinski, Ryan S. Helgesen, and John D. Skalbeck
University of Wisconsin - Parkside

Honorable Mention Poster - $250
Ryan C. Beachner
Hydrologic Characterizing of the University of Wisconsin – Parkside Campus
Ryan C. Beachner, Heather M. Herr, Jamie D. Lambert, Heather M. Olson, and John D. Skalbeck
University of Wisconsin - Parkside



Nationwide, about 11% of pollution in rivers comes from storm sewers and urban runoff.

Wisconsin Groundwater Guardian Program:
3rd annual Wisconsin Groundwater Festival held in Eau Claire

Wisconsin's youth attended the state's third groundwater festival on Friday, May 6, from 9 a.m. to 2 p. m., at the Eau Claire County Exposition Center. This annual event has been rotating around the state for last two years, with past events in Waukesha and Stevens Point.

According to Jen Kingsley, coordinator of the Wisconsin Groundwater Guardian Program located in the Wisconsin Groundwater Center at UWSP, students will had the opportunity to learn about protecting and conserving Wisconsin's groundwater. Festival events throughout the day included hands-on activities, entertainment, and a teacher resource area.

Students using the groundwater model to simulate how rain and runoff can affect our groundwater resources

According to Kingsley, the festival was an overwhelming success with over 500 fifth and sixth graders from across Wisconsin will taking part in the festival with more than 100 volunteers on hand as well. "Education is a large part of protecting one of Wisconsin's most valuable natural resources, groundwater," said Kingsley. "These students are learning that they have the ability to play a powerful role in conservation and protection of groundwater resources."

The four education tracks for Friday's festival included groundwater and you, groundwater-surface water connections, pollution solutions, and taking action. Students that took part in the festival were from Eau Claire, Stanley, LaCrosse, Whitehall, Marshfield, Chippewa Falls, Downsville, and Bloomer.

Those with questions on the festival may call Kingsley at (715) 346-2722 or by e-mail at gwguardian@uwsp.edu. Further festival information can be found on the Web at www.uwsp.edu/cnr/gwguardian/wigg/fest.htm.

Students using the groundwater model to see how groundwater flows, is affected by human uses and what happens when it is contaminated.

A Circuitous Path: Protecting Groundwater in Wisconsin

By Kenneth R. Bradbury

Open most basic groundwater textbooks and you'll find hydrogeology discussed in terms of porous media, with aquifers composed of well-sorted sand, and groundwater moving through pores between sand grains. In the dolomite terrain of northeastern Wisconsin, however, the story is much different. Over much of Wisconsin's Door Peninsula, fractured dolomite is exposed at or near the land surface. Rain or snow falling on this landscape enters the groundwater system through an interconnected network of vertical and horizontal bedrock fractures. Once in the aquifer, the water flows laterally, through horizontal fractures, until it discharges to local lakes, springs or streams or is captured by water-supply wells.

In such systems, rapid groundwater movement and minimal contaminant attenuation are common, and so the land-use practices in the areas where the water originates — often called the capture zones or contributing areas — highly influence the quality of groundwater produced by local wells.

Determining these capture zones and understanding how groundwater moves from recharge to local wells are critical to protecting groundwater in fractured-rock terranes.

The Wisconsin Geological and Natural History Survey (WGNHS) has carried out a series of field-based, hydrogeologic research investigations with the goal of improving our understanding of fluid movement in fractured carbonate rocks throughout Wisconsin. The other aim of this research is to find the best methods for protecting groundwater and making sure contaminants are not carried to the wells that supply drinking water. Undertaking wellhead-protection studies in fractured-rock settings is a challenging endeavor, yet it is in these very vulnerable settings that wellhead-protection programs are most essential.

The focus of our work is the Silurian dolomite aquifer of Door County, in northeastern Wisconsin. A rocky peninsula between Lake Michigan and Green Bay, Door County has rugged shorelines, mild climate, abundant natural resources and a small-town feel that together have made it one of the most popular tourist destinations in the midwestern United States.

The vertical and horizontal fractures in this Silurian dolomite in Door County are typical of the fractures that underlie the county and affect the groundwater. Photos courtesy Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension.

All residents of the county depend on groundwater, but groundwater quality problems have plagued the county for many years. Bacteria and nitrate exceed U.S. Environmental Protection Agency and Wisconsin drinking water standards in about 30 percent of the private wells in the county, and private well owners often report turbid or muddy water in their wells during certain times of the year. Other groundwater contaminants include agricultural chemicals, pesticide residues from cherry and apple orchards, and petroleum and other non-aqueous phase liquids such as gasoline and solvents.

Much of Door County's charm, and its groundwater problems, are directly related to its unique geology — a combination of Paleozoic bedrock and Pleistocene

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modifications. Silurian-age dolomites form the backbone of the peninsula and dip gently eastward into the Michigan Basin. In the Late Pleistocene, continental glaciers covered the area, and, when they retreated, left behind a fascinating landscape.

On the western side of the county the Silurian escarpment forms high cliffs along the Green Bay shoreline; only a few miles to the east the land meets Lake Michigan with sandy beaches and diverse wetlands. In between, in the uplands of the county, the glaciers removed most of the soil, so that in most places the bedrock is less than two meters below the surface and in many places it is exposed at the land surface. The dolomite contains both near-horizontal and vertical fractures. These fractures are extensive, and the vertical fractures are easily visible from the air, particularly under alfalfa fields in dry weather. The combination of thin soils and fractured rock makes groundwater in the county extremely vulnerable to contamination.

Over the past 20 years, WGNHS has carried out a number of scientific studies of the hydrogeology of Door County at the request of, and with substantial funding from, local, state and even national regulatory agencies. Each of these studies has involved the collection and analysis of new field data and has included extensive cooperation with local landowners, citizens' groups and decision makers. Each project builds on previous work and has led to a broader understanding of fractured-rock hydrogeology that WGNHS scientists have shared in national and international venues. For example, Maureen Muldoon, now at the University of Wisconsin-Oshkosh, carried out detailed groundwater monitoring and tracer experiments in an active dolomite quarry, producing some of the most detailed data on dolomite hydrogeology ever collected.

A fast trip to the Bay

The City of Sturgeon Bay (population 9,100) lies midway up the Door Peninsula and is the county seat as well as an important industrial and recreational center. Sturgeon Bay's water supply comes entirely from municipal wells drawing water from the fractured dolomite aquifer. In 1998, the Sturgeon Bay Water Utility, with support and funding from the Wisconsin Department of Natural Resources, requested that the WGNHS provide assistance in delineating the capture zones for its municipal wells in support of a wellhead-protection plan. The motivation for this project was twofold: to assist the City of Sturgeon Bay and the county, and to gain a better understanding of how groundwater moves and of techniques for delineating the capture zone. This understanding could be applied to other fractured carbonate aquifers in the state.

Since the turn of the century, the city has installed 12 municipal wells within the city limits; nine of these wells have shown signs of bacterial contamination, and seven of the wells have been shut down and abandoned. Currently the city operates five wells. Water from three of these wells is disinfected on site. Only two wells have remained free of bacterial contamination.

We used our observations and field measurements from the Sturgeon Bay area to create a model showing how rapidly groundwater moves near the city. The existing wellhead protection guidelines are based on a five-year travel time from infiltration at the land surface to capture by the municipal wells. But we found that travel times to municipal wells are so rapid — less than two years — and distances traveled are so large — up to 10 kilometers — that the traditional criteria for wellhead protection are meaningless.

The predicted short travel times of the flow system are consistent with our conceptual model and with numerical modeling results. Additional geochemical and isotopic data collected for this study are consistent with the results of those models. These isotopes can act as effective natural groundwater tracers and should be used routinely in groundwater studies in fractured carbonate rocks.

Armed with the technical understanding that municipal well water is coming from several kilometers away and from outside the city limits, the city, water utility and county officials are working together to develop a wellhead-protection plan that will identify and perhaps reduce potential contaminant sources at the land surface in the contributing areas for the city wells.

How we tracked the groundwater

The Sturgeon Bay work spanned several years and involved numerous investigators, graduate students and local officials.

Field investigations: Extensive field investigations supported the modeling and analyses for this project and had four main objectives: 1) Characterize the hydraulic its temporal variability. We collected water-level measurements during dry and wet seasons and analyzed the historic record of water-level fluctuations at long-term monitoring wells in the area. 2) Evaluation of bulk aqui-

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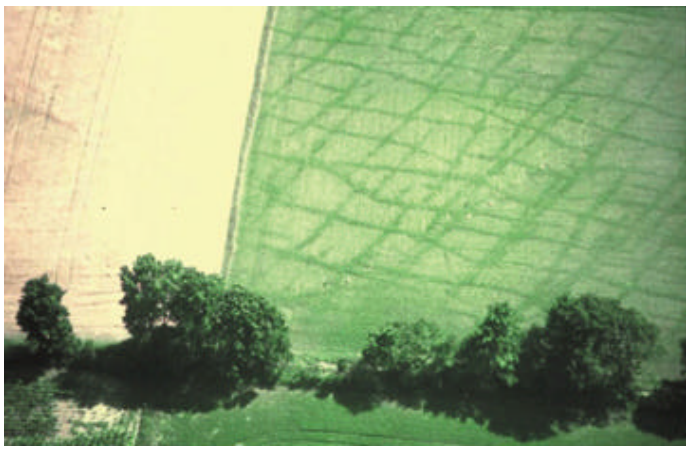

Vertical fractures visible in an alfalfa field, central Door County, reflect fractures below in the carbonate rocks. The alfalfa grows greener and more vigorously above sediment-filled fractures.

fer properties. We conducted a large-scale pumping test using existing municipal wells and also analyzed the results of specific-capacity tests on several hundred domestic wells throughout the study area. 3) Detailed analyses of dolomite hydrostratigraphy. The hydrostratigraphic analyses were a key part of this project and included rock core examination, downhole geophysical logging, straddle-packer experiments and stratigraphic correlation of high-permeability features. 4) Collection of geochemical and isotopic data for model verification.

Hydrostratigraphy and conceptual model: Determining the location and continuity of horizontal flow zones in the dolomite aquifer was essential to simulate groundwater flow accurately in the study area. The basis for the conceptual model of the aquifer was the work of Maureen Muldoon, Toni Simo of the University of Wisconsin at Madison and others, who identified 14 horizontal, high-permeability zones within the dolomite aquifer in the Sturgeon Bay area. All are parallel to bedding and are most highly developed at lithologic contacts.

These zones, predominantly bedding-plane fractures that have been widened by solution, are critical to groundwater flow because they provide pathways for rapid horizontal groundwater movement. Five of the zones are continuous across the study area and can be correlated on both sides of Sturgeon Bay. The flow zones range in thickness from 0.3 to 11 meters and represent boundaries of contrasting lithologies, layers with high primary porosity or lithologies that contain numerous bedding-plane partings at the boundaries of depositional cycles.

Five laterally continuous flow zones are in the vicinity of Sturgeon Bay. We defined the intervals of aquifer between the flow zones as "non-flow" zones. Although some groundwater flow occurs in the non-flow zones, the amount is relatively small in comparison to that in the flow zones.

Numerical modeling: Simulating groundwater flow near Sturgeon Bay required a 3-D transient groundwater flow model with spatial and temporal variability of recharge rates, simulation of near-horizontal flow zones, and representation of flow boundaries. A transient model most accurately reflects aquifer behavior because of the seasonal water level fluctuation seen in wells.

Working with Todd Rayne of Hamilton College in New York, we constructed a porous media porous media groundwater flow model, using the USGS' MODFLOW modeling code model. We simulated the flow zones as thin, continuous, highly permeable layers. The intervals between the flow zones were modeled as thicker layers with lower horizontal and vertical hydraulic conductivities. The 11 bedrock model layers dip approximately 1 degree to the southeast. The top layer, representing glacial deposits and lake sediment, truncates the bedrock layers unconformably and has variable thickness. The thickness of each remaining bedrock layer is uniform throughout the model domain, but thickness varies between layers. Reverse particle tracking through the transient groundwater flow field delineated the land surface area from which water is likely to reach each well.

Model results and verification: The modeling indicated that wells on the north side of the city have contributing areas extending nearly 10 kilometers to the northeast; contributing areas for the wells on the south side of the city extend nearly 7 kilometers to the southwest. Groundwater travel times from the water table to the municipal wells vary with depth in the well, but in all cases are quite short. The average travel time from the water table to the wells is 150 days. The minimum and maximum simulated travel times are, respectively, 14 days and 730 days.

Several of the particles had paths originating in surface water, indicating that some municipal wells may be inducing the flow of surface water from the bay into the aquifer. All particles reached the water table or the bay within the two-year simulation time. The near-horizontal flow zones clearly control groundwater movement to the municipal wells. Groundwater movement is largely vertical from the water table to the first major flow zone. Upon entering a flow zone, groundwater movement is

(Continued on page 13)

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mostly horizontal.

To verify the conceptual and numerical models of the Sturgeon Bay system, we collected temperature, electrical conductivity and oxygen isotope data from groundwater and precipitation samples in one of the contributing areas. Natural precipitation varies seasonally in oxygen isotope ratio and temperature, and the electrical conductivity of recharge water also varies throughout the year. These variations compose a signal that should remain imprinted on groundwater in the study area during its relatively rapid movement from recharge to pumping wells. Rapid and significant changes in water temperature and electrical conductivity occurred in two monitoring wells equipped with continuous recorders. These changes show the discrete nature of recharge events in the study area and demonstrate how rapidly recharge moves into the groundwater flow system. Stable isotopic ratios of oxygen and hydrogen varied significantly with time and location during the sampling period.

Results of particle-tracking simulations agree with the observed behavior of the aquifer. Simulated breakthrough curves for low recharge periods show an average travel time of about 40 days, compared to eight days for particles released from the same location at a time of high recharge. This flow rate compares extremely favorably with the nine-day change in oxygen-18 ratio observed at a city well following a significant recharge event. The rapid transport occurred because of substantially higher hydraulic gradients in the aquifer during times of high recharge.

It doesn't end with a report

At the conclusion of funding for the Sturgeon Bay project, we prepared a report for the funding agencies that summarized our findings. But our commitment to the project did not end there. As a unit of the University of Wisconsin-Extension, WGNHS scientists follow the "Wisconsin Idea": communicating research to the people of the state. The Sturgeon Bay project was no exception.

During and after the project, we have frequently interacted with local officials and citizens; our contributions range from making phone calls and visiting county boards. We prepare copy for articles in the local newspaper and participated in an outdoor environmental fair. We provided advice as the county soil and water conservation staff worked in partnership with the water utility to develop a wellhead-protection plan for the area. Beyond the local scene, we have presented information from the Sturgeon Bay project in professional journal articles and at national and international meetings. We have incorporated this information into professional short courses on fractured-rock hydrogeology.

Most important, our scientific investigations have made subsequent studies of fractured rock in other parts of Wisconsin better. Each project builds on previous work. Working with a variety of students, colleagues and cooperators, WGNHS scientists have carried out nationally recognized research while continuing to stay in touch with local issues and providing advice and assistance to local citizens and officials.

Bradbury has been a research hydrogeologist and professor with the Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension since 1982. His research interests include the hydrogeology of fractured rocks, wellhead protection and regional groundwater modeling. E-mail him at: krbradbu@facstaff.wisc.edu.

Water makes up two-thirds of our bodies and is the main substance found in all living things

News from the Treasurer

Marilyn M. Weiss

For Transactions Between: 1/1/05 to 3/31/05

Account Name	Withdrawals	Deposits	Balance
Beginning Balance			**$13,699.93**
Membership			
Dues	$0.00	$3,935.00	**$3,935.00**
Conference			
Costs	$250.00	$0.00	**($250.00)**
Newsletters			
Production	$400.00	$0.00	**($400.00)**
Ads	$0.00	$100.00	**$100.00**
Board Meeting			
Phone Charges	$121.05	$0.00	**($121.05)**
Donations			
Donations	$3,000.00	$0.00	**($3,000.00)**
General			
P.O. Box	$24.00	$0.00	**($24.00)**
Misc.	$10.00	$0.00	**($10.00)**
TOTALS	**$3,805.05**	**$4,035.00**	**$13,929.88**

The 2004 Board, Committee, and Area Coordinators

President (2005)
Dave Nemetz
Liesch Environmental Services, Inc.
Phone: 608.223.1532 Fax: 608.223.1534
dnemetz@madison.liesch.com

President-Elect
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Secretary (2005-2006)
Janis S. Kesy, P.G., Senior Technical Consultant
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Phone: 920.496-6819; Fax: 920.497.8516
JKesy@foth.com

Treasurer/Membership (2004-2005)
Marilyn M. Weiss
Public Service Commission
Phone: 608.266.1613; Fax: 608.266.3957
marilyn.weiss@psc.state.wi.us

Past President (2004 President)
Boyd Possin
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boydpossin@earthlink.net

At-Large Board Members

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rcaudill@naturalrt.com

Committee Chairpersons

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Phone: 262.641.9341
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jviney@tds.net

Education Committee
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bhahn@bhassoc.com

Groundwater Guardian Committee
Vacant

Area Coordinators

We are looking for coordinators in many of the following areas. If you are interested, please contact Dave Nemetz.

Western Area
(LaCrosse, Black River Falls, Eau Claire, Chippewa Falls, surrounding area)
Position Open.

Southern Area
(Madison and surrounding area)
John Tweddale
BT^2
Phone: 608-224-2830 and 608-224-2839
jtweddale@bt2inc.com

North Central Area
(Stevens Point, Wisconsin Rapids, Wausau, Rhinelander, surrounding area)

Tod Roush
Maxim Technologies
Phone: 715.845.4100; Fax: 715.842.0381
troush@maximusa.com

Northeast Area
(Green Bay, Appleton, Oshkosh, Fond du Lac, surrounding area)
Position Open.

Southeast Area
(Milwaukee, Sheboygan, Racine, Kenosha, surrounding area)

Michael Raimonde
Metcalf & Eddy, Inc.
Phone: 262.909.8316
mike.raimonde@m-e.com

Join the Wisconsin Ground Water Association Today!

WISCONSIN GROUND WATER ASSOCIATION MEMBERSHIP APPLICATION/RENEWAL FORM

Please take a few moments and become a member of, or renew your membership in, WGWA. Annual dues are $15 for students, $30 for individuals, and $25 per person for corporate memberships of six or more. Dues are payable to "WGWA." Complete the following form and send, with check, to:

Wisconsin Ground Water Association
P.O. Box 8593
Madison, WI 53708-8593

Individual Membership: Regular Member:____$30 Student Member:____$15
Name:_____ Title: _____
Firm/Agency: _____
Mailing Address:_____
City, State, ZIP Code: _____
Telephone Number:_____ Fax: _____
E-Mail:_____

Are you interested in participating in any WGWA Committees?

___ Newsletter ___ Membership ____ Web Site ___ Legislation ___ Program & Education
___ Please check if you do not wish to be listed in a WGWA membership directory.
___ Please check if you don't have e-mail access and need to receive the *WGWA Newsletter* via regular mail.

Corporate Membership Discount (six or more individuals): ____$25/individual
Firm:_____
Mailing Address:_____
City, State, ZIP Code: _____
Telephone Number:_____ Fax: _____
Corporate Individuals (include each individual's e-mail address, if available. Attached additional page if necessary):

Name Title E-Mail
1.) _____
2.) _____
3.) _____
4.) _____
5.) _____
6.) _____

___ Check here if your company does not wish to be listed in a WGWA membership directory.
___ Check here if you don't have e-mail, and need to receive the *WGWA Newsletter* via regular mail.