AMERICAN WATER RESOURCES ASSOCIATION
WISCONSIN SECTION
28TH ANNUAL MEETING

UNDERSTANDING AND MANAGING WATER RESOURCES FOR THE FUTURE

March 4 & 5, 2004

Hotel Mead and Conference Center
Wisconsin Rapids, Wisconsin

Hosts:
American Water Resources Association – Wisconsin Section
University of Wisconsin Water Resources Institute
Center for Watershed Science and Education, University of Wisconsin - Stevens Point
Wisconsin Department of Natural Resources
U. S. Geological Survey, Wisconsin District

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PROGRAM SUMMARY

Understanding and Managing Water Resources for the Future

28th Annual Meeting of the Wisconsin Section of the American Water Resources Association

Hotel Mead, Wisconsin Rapids, Wisconsin

Thursday, March 4th, 2004

9:00 a.m. –2:30 p.m. **Registration** – *Atrium*

11:30 – Noon **Business meeting and election** – *Riverside Ballroom*

Noon – 1:00 **Lunch** – *Riverside Ballroom*

1:00 – 2:20 **Plenary session on Understanding and Managing Water Resources for the Future** – *Riverside Ballroom*
Moderators: Doug Cherkauer, University of Wisconsin – Milwaukee and Brent Brown, CH2M Hill
Russell Van Herik, Executive Director of the Great Lakes Protection Fund
Val Klump, Senior Scientist at the Great Lakes WATER Institute at UW – Milwaukee
Lon Couillard, Water Quality Manager for City of Milwaukee Water Works
Mary Ellen Bruesch, Environmental Hygienist for the City of Milwaukee Health Department

2:30 – 3:30 **Concurrent Sessions 1 and 2**
Session 1 – Contaminant Treatment – *Grand Ballroom Salon A*
Moderator: Madeline Gotkowitz, Wisconsin Geological and Natural History Survey

2:30 *Diffusion-Controlled Adsorption of Cd^{2+} on Base Treated Juniper Fiber (BTJF) Continuous Fixed Column Study. S. H. Min, J. K. Park, R. M. Rowell and M. Jang.

2:50 *Arsenate Partitioning Among Iron Oxide Nanocrystals. N. L. Aschbrenner, R. L. Penn, A. C. Knudsen and K. J. Nordell.

3:10 *Photoactive Removal of As (III) from Water Using Novel Al_2O_3 /TiO_2 Photoactive Material. T. J. Lee, E. Lee and M. A. Anderson

Session 2 – Runoff – *Grand Ballroom Salon C*
Moderator: Anita Thompson, University of Wisconsin – Madison

2:30 Assessing Infiltration at a Stormwater Basin Serving a Residential Neighborhood, Middleton, Wisconsin. C. P. Dunning, R. T. Bannerman and P. F. Juckem.

2:50 Monitoring and Sampling Design for Water Runoff at UW Platteville Pioneer Farms. D. W. Owens and T. Hunt.

3:10 *Snowmelt Export of Sediment and Nutrients from Agricultural Sub-watersheds in Southwest Wisconsin. R. M. Mentz, M. R. Penn, S. Jonnala and D. W. Owens.

3:30 – 3:50 **Break –** *Atrium*

3:50 – 5:10 **Concurrent Session 3 and 4**

Session 3 – Aquifer Storage and Recovery – *Grand Ballroom Salon A*

Moderator: Maureen Muldoon, University of Wisconsin – Oshkosh

3:50 *Defining Controlling Factors of Aquifer Storage Recovery Using Advection and Dispersion Models. C.S. Lowry and M. P. Anderson.

4:10 Aquifer Storage and Recovery Pilot Testing in Wisconsin. R. T. Roth, D. M. Johnson and W. L. Phelps.

4:30 Geochemical Reactions During Green Bay ASR Pilot Testing. D. M. Johnson, W. L. Phelps and R. T. Roth.

4:50 *An Assessment of Aquifer Storage and Recovery and Mercury Methylation in the South Florida Everglades Ecosystem. R. M. Hodo, D. P. Krabbenhoft and M. P. Anderson.

Session 4 – Groundwater–Surface Water Interaction – *Grand Ballroom Salon C*

Moderator: David Hart, Wisconsin Geological and Natural History Survey

3:50 *Hydrogeologic Controls on Springs in the Mukwonago River Watershed, Southeast Wisconsin. H. E. Gittings and J. M. Bahr.

4:10 Spatial Patterns and Temporal Trends in Groundwater Recharge, Upper Coon Creek Watershed, Southwest Wisconsin. P. F. Juckem, R. J. Hunt, and M. P. Anderson.

4:30 *An Integrated Modeling Approach to Analyze Groundwater – Lake Interactions: Trout Lake Basin, Northern Wisconsin. R. John, M. P. Anderson and R. J. Hunt.

4:50 Measuring Groundwater-Surface Water Interaction and its Effect on Wetland Stream Benthic Productivity, Trout Lake Watershed, Northern Wisconsin. R. J. Hunt, M. Strand and J. F. Walker.

5:30 – 7:00 **Poster Session and Social Hour –** *Grand Ballroom Salon B*

Removal of Arsenate Using Lanthanum Oxide Immobilized Highly Ordered Mesostructured Silicate. M. Jang, J. K. Park, E. W. Shin, S. I. Choi, J. Naser, S. H. Min, S. C. Kim and S. B. Rho.

Initial Evaluation of Hydrologic Response at a 3-Year Old Phytoremediation Site. W. M. DeVita and M. Dawson.

*A Novel Fabrication Method for Large, Diverse Arrays of Optical Fiber Sensors with Potential Applications in Water Security. P. Geissinger, R. Olsson, E. J. Kiefer and A. W. Schwabacher

*Relationships Between Land Use and Water Quality on Lakes Helen and Lions, Portage County, Wisconsin. L. W. Hennigan and K. A. Rasmussen.

*Assessing the Utility of Historical Spring Surveys in Dane County. D. R. Ginder-Vogel and S. K. Swanson.

*The Groundwater and Surface Water Relationship in the Ridge's Sanctuary, Door County, WI. L. R. Evenson, R. D. Stieglitz, P. Sager, and K. Fermanich.

Low-Flow Purging and Sampling of Groundwater at Argonne National Laboratory – East, East Northeast Landfill. R. E. Piorkowski and D. A. Milinko

wiscLITH: A Database of Wisconsin Geological Information. M. B. Gotkowitz, R. M. Peters, T. J. Evans, A. Santipiromkul and B. C. Bristoll.

Evaluating Groundwater Phosphorus Concentrations in Wisconsin Through Private Well Testing. P. M. McGinley and R. Stevens

*Electrical Resistivity Survey of a Site in Vilas County, Wisconsin. L. R. Atkinson and W. Kean

*Important Steps for Processing and Analyzing Biological Samples for Methylmercury. L. E. Pons, P. R. Gorski, R. J. Moore and J. P. Hurley.

*Applying a Health Behavior Theory to Understand Responses to Arsenic Risk from Well Water. D. J. Severtson, L. C. Baumann and R. L. Shepard.

*A Utilization-focused and Theory-based Evaluation of an Arsenic Well Testing Program. D. J. Severtson, L. C. Baumann and R. L. Shepard.

7:00 **Banquet –** *Riverside Ballroom*

Speaker: Tom Lochner, Executive Director, Wisconsin State Cranberry Growers Association

Wisconsin's Cranberry Industry: A description of the history, methods and economics of this unique agricultural industry

Friday, March 5th, 2004

7:00a.m – 8:00 AWRA Board of Directors Breakfast – *Aspen Room*

8:00 – 9:40 **Concurrent Sessions 5 and 6**

Session 5 – Groundwater Contaminants – *Grand Ballroom Salon A*

Moderator: Tim Grundl, University of Wisconsin - Milwaukee

8:00 *Geochemical and Environmental Controls on Arsenic in Groundwater near Lake Geneva, Wisconsin. T. L. Root, J. M. Bahr and M. B. Gotkowitz.

8:20 *Viruses, Hormones, Pharmaceuticals and Other Household Products as Potential Groundwater Contaminants from On-site Wastewater Treatment Systems. J. D. Wilcox, J. M. Bahr and K. R. Bradbury.

8:40 Susceptibility of Municipal Wells in LaCrosse, Wisconsin, to Enteric Virus Contamination from Surface Water Contributions. M. Borchardt, R. J. Hunt, N. Haas, P. Bertz and S. Spencer.

9:00 Groundwater Nitrate and Pesticide Penetration and Trends: The Springfield Corners Profile. G. J. Kraft, W. M. DeVita and B. A.

Browne.

9:20 Groundwater Denitrification: The Springfield Corners Vertical Profile. B. A. Browne, G. J. Kraft and W. M. DeVita.

Session 6 – Surface Water Studies – *Grand Ballroom Salon C*
Moderator: Charles Dunning, U. S. Geological Survey

8:00 *Trends in Boating Use on Geneva Lake. A.R. Bock and T. W. Peters

8:20 *Increased Diatom Colony Size Induced by a Chemical Cue from Daphnia. L. A. Pansch and D. J. Poister.

8:40 *2003 PBDE Levels in Lake Michigan Fish. J. Hahm, J. B. Manchester-Neesvig and W. C. Sonzogni.

9:00 *Speciation Controls on the Fate and Transport of Mercury and Methylmercury Across Biogeochemical Gradients. S. P. Chadwick, C. L. Babiarz, J. P. Hurley and D. E. Armstrong.

9:20 *Role of the Hyporheic Zone in Methylmercury Production and Transport to Allequash Creek. M. H. Meyer

9:40 – 10:00 **Break** – *Atrium*

10:00 – 11:40 **Concurrent Sessions 7 and 8**

Session 7 – Groundwater Studies – *Grand Ballroom Salon A*
Moderator: Kevin Masarik, Center for Watershed Science and Education, University of Wisconsin Extension

10:00 Simulating Impacts of Land Use and Groundwater Flow on the Temperature of Wisconsin Trout Streams. S. J. Gaffield, T. W. Rayne, K. R. Bradbury and L. Wang.

10:20 Groundwater Modeling Investigation of Lockport Prairie Nature Preserve, Lockport, Illinois. G. B. Parish.

10:40 The Influence of Glacial Till, Outwash, and Lacustrine Deposits on Lakes, Streams, and Groundwater in the Menominee Indian Reservation, Wisconsin. G. F. Howlett, Jr. and C. P. Dunning.

11:00 Using Time-Domain Electromagnetics to Map the Transition of an Aquifer to an Aquitard. D. J. Hart and C. L. Thomas.

11:20 Vertical Distribution of Hydraulic Conductivity in Cambrian Sandstones near Madison, Wisconsin. K. R. Bradbury, D. J. Hart and D. L. LePain.

11:40 Announcement of student paper award winners

Session 8 – Water Management – *Grand Ballroom Salon C*
Moderator: Kevin Fermanich, University of Wisconsin – Green Bay

10:00 Chemical Terrorism Preparedness and Environmental Resources – Dual Role for State Laboratories. W. C. Sonzogni and D. D. Degenhardt.

10:20 Using an Ecological Currency Approach to Measure Resource Improvements in Southeastern Wisconsin. B. A. Brown.

10:40 Restoration of Devil's Lake (Sauk County, Wisconsin) by Hypolimnetic Withdrawal. R. C. Lathrop, T. J. Astfalk, J. C. Panuska and D. W. Marshall.

11:00 Factors Affecting Variability in Flow in the Little Plover River. N.

Earl Spangenberg.

11:20 Use of Surface Waters From Lake Mendota for Cogeneration Electric Power Facility. J. M. Jaeckels, J. C. Kucher, K. G. Johnson and S. G. Josheff.

11:40 Announcement of student paper award winners

12:30 – 2:30 **Student Career Workshop** – *Grand Ballroom Salon B*

2004 AWRA AUTHOR INDEX

PLENARY SESSION
Understanding and Managing Water Resources for the Future
Thursday, March 4, 2004
12:45-2:20 pm

Presentation 1

Russell Van Herik, Executive Director
Great Lakes Protection Fund
1550 Sherman Avenue, Suite 800, Evanston, IL 60201
vanherik@glpf.org

I will identify emerging research, management, and governance issues associated with multi-jurisdictional authority over water resource decisions. Using recent work developed by grantees of the Great Lakes Protection Fund, I will discuss the rapidly changing environment within which researchers, agency staff, consultants, and public officials will be operating. Focus will be upon the physical and biological drivers that are changing our perception of water management, and upon how those drivers are affecting the Provinces and States as they negotiate Annex 2001.

Presentation 2

J. Val Klump, Director
Wisconsin Aquatic Technology and Environmental Research (WATER) Institute
University of Wisconsin-Milwaukee
600 E. Greenfield Ave., Milwaukee, WI
vklump@uwm.edu

The Great Lakes: How secure are they?

Despite their size, the Great Lakes and their waters are surprisingly vulnerable to a number of influences that compromise their integrity and security. Included are: pollution, exotic species, global warming, and the accidental or deliberate introduction of chemical or biological agents. Our ability to understand these impacts and to respond to them intelligently will require the development of new sensors and sensor networks designed to monitor variations in both time and space with a higher resolution. To decipher natural environmental variability from subtle, yet important, changes driven by climate or alterations in the chemical and biological composition of these waters is a major analytical challenge.

Presentation 3

Lon Couillard
Water Quality Manager
Milwaukee Water Works
lcouil@mpw.net

Mary Ellen Bruesch
Environmental and Disease Control
Specialist
City of Milwaukee Health Department

Milwaukee Water Quality Improvements and Continued Watershed Surveillance Monitoring

Milwaukee Water Works (MWW), since 1993, has invested over $89 million in upgrades to both municipal and water treatment plants. The total package included ozone disinfection, source protection via intake relocation, filter bed replacement, instrumentation and SCADA automation, and chemical feed improvements. These water system upgrades were designed to strengthen the multiple barriers approach to water treatment in Milwaukee.

In addition, since the 1993 outbreak, the Disease Control and Prevention Branch of the City of Milwaukee Health Dept. has conducted an on-going Watershed Monitoring Program to enhance our water quality surveillance and monitoring of watersheds contributing to the overall health of Milwaukee's beaches and near shore environment. Assessment of these specific sources is crucial to our understanding of long-term trends in water quality in the region.

Biographies

Russell Van Herik is the Executive Director of the Great Lakes Protection Fund, based in Evanston, Illinois. The Fund was created by the Governors of the eight Great Lakes States in 1989, as a permanent $100 million endowment to help them meet the challenges of governing their shared water resources.

Before joining the Fund in 1995, Van Herik held a series of posts with The Nature Conservancy. In 1978, he became the Conservancy's first Wisconsin State Director. He also served as General Counsel for International Programs, Director of Land Protection for California, and Midwest Regional Director.

Mr. Van Herik practiced law in Madison, Wisconsin, from 1974 to 1978. He received his law degree from the University of Wisconsin and his BA from Beloit College.

Dr. J. Val Klump is a Senior Scientist and biogeochemist at the University of Wisconsin-Milwaukee Great Lakes WATER Institute where he is currently serving as Director. His research on how nutrients and carbon are cycled in lakes has taken him from the deepest sounding in Lake Superior aboard a research submersible, to the largest and oldest lake in the world -- Lake Baikal in eastern Siberia.

Since joining UWM's Center for Great Lakes Studies in 1980, Dr. Klump has been active in bringing more than $6 million in extramural research support to the University and the state. In the course of this research Dr. Klump has participated in over 40 research cruises as both scientist and chief scientist representing over 400 days at sea.

He has a degree in law from Georgetown University (1975), a Ph.D. in chemical oceanography from the University of North Carolina (1980) and a B. S. in zoology from Duke University (1971).

Mary Ellen Bruesch received a BS in Biology from UW-Milwaukee in 1993, and a

MS in Microbiology and Molecular Genetics from the Medical College of Wisconsin in 1997. She has been employed at the City of Milwaukee Health Department as an Environmental Hygienist since 1997, responsible for several water quality-monitoring projects.

Lon Couillard received his B.S. in Environmental Health from UWEC in 1976, and an M.S. in Environmental Health from Univ of Minn in 1984. He has worked in the water industry for 20 years, at Des Moines (IA) Water Works, and for the past 6 years as Water Quality Manager for Milwaukee Water Works.

SESSION 1
Contaminant Treatment
Thursday, March 4, 2004
2:30-3:30 pm

Diffusion-Controlled Adsorption of Cd2+ on Base Treated Juniper Fiber (BTJF): Continuous Fixed Column Study

S. H. Min, University of Wisconsin – Madison
Department of Civil and Environmental Engineering, Forest Products Laboratory, Room 149 Building #33 One Gifford Pinchot Drive Madison, WI 53726-2398, soohongmin@wisc.edu
J. K. Park, University of Wisconsin-Madison
Department of Civil and Environmental Engineering, 3230 Engineering Hall 1415 Engineering Drive Madison, WI 53706, jkpark@wisc.edu
R. M. Rowell, USDA-Forest Service, Forest Products Laboratory
One Gifford Pinchot Drive Madison, WI 53726-2398, rmrowell@facstaff.wisc.edu
M. Jang, University of Wisconsin-Madison
Department of Civil and Environmental Engineering, University of Wisconsin-Madison. 3230 Engineering Hall 1415 Engineering Drive Madison, WI 53706. jang@cae.wisc.edu

Lignocellulosic fibers have been examined for potential use as inexpensive heavy metal removaladsorbents. Toxic heavy metal adsorption processes with lignocelluloses can be used for the removal of contamination from stormwater. They must be evaluated not only using equilibrium data but also with mass-transfer data. In this study, base treated juniper (Juniperus Monosperma) fiber (Min et al. 2004) was tested as an adsorbent to remove Cd2+ with continuous fixed column experiment.

In this study, column experiments were run under different conditions of particle sizes and flow rates. The breakthrough curve analysis showed that transport was most affected by intraparticle diffusion. Non-conventional features were observed, such as the variation of the total adsorption capacity with the flow rate and with the particle size. This was attributed to the complex porous structure of the media.

Column breakthrough curves were fitted to a two parameter model and each of the parameters, σ and t0 were linearly correlated with column operating parameters. Moreover, the model, despite its simplicity, succeeded in predicting the breakthrough points of Cd2+ at different flowrates and for different particle sizes. This modeling approach could be useful for the design of adsorption processes for the removal of heavy metal ions from water.

Keywords: Lignocellulosic, heavy metal removal, column, and diffusion.

*Note: This is a student presentation.

Arsenate Partitioning Among Iron Oxide Nanocrystals

N. L. Aschbrenner, Lawrence University Chemistry Department
723 East John Street, Appleton, WI 54911, aschbren@hotmail.com.
R. L. Penn, University of Minnesota Chemistry Department
207 Pleasant Street, Minneapolis, MN 55455, penn@chem.umn.edu.
A. C. Knudsen, Lawrence University Geology Department
115 South Drew Street, Appleton, WI 54911, andrew.knudsen@lawrence.edu.
K. J. Nordell, Lawrence University Chemistry Department
115 South Drew Street, Appleton, WI 54911, karen.nordell@lawrence.edu.

Iron oxyhydroxides, such as ferrihydrite, goethite and hematite, are ubiquitous in the natural environment and impact the biogeochemical cycle of arsenic at the Earth's surface. Traditionally, studies bridging iron oxide minerals and trace element partitioning have used acicular particles that are significantly larger than the nanoparticles observed in natural waters. This study seeks to examine the formation and transformation of synthetic nanocrystalline iron oxide minerals that mimic those formed in a complex natural system.

In an effort to understand the maturation of ferrihydrite to either goethite or hematite, ferrihydrite was synthesized with and without the presence of arsenic, aged for 400 hours, and sampled periodically. Samples were characterized using x-ray diffraction (XRD), transmission and scanning electron microscopy (TEM, SEM), electron dispersion spectroscopy (EDS), low-temperature magnetometry, Fourier-transform infrared spectroscopy (FTIR), and atomic absorption spectroscopy (AAS).

XRD has revealed that goethite was the primary reaction product without the presence of arsenate, and that hematite was the primary reaction product with the presence of arsenate. Preliminary TEM results indicate that the presence of arsenic retards the maturation of ferrihydrite. SEM-EDS has confirmed that the hematite nanoparticles contain arsenic.

Keywords: arsenic, ferrihydrite, iron oxides

*Note: This is a student presentation.

Photoactive Removal of As (III) from Water using Novel Al2O3/TiO2 Photoactive Material

T. J. Lee, University of Wisconsin – Madison
660 N. Park St., Madison, WI 53706; tjlee1@students.wisc.edu
E. Lee, University of Wisconsin – Madison
660 N. Park St., Madison, WI 53706; elee@cae.wisc.edu
M. A. Anderson, University of Wisconsin – Madison
660 N. Park St. Madison, WI 53706; nanopor@wisc.edu

The oxidation status of arsenic in source waters significantly affects the adsorption capacity of adsorbents. Many arsenic removal processes have been found to be ineffective for arsenite, As(III), which is uncharged at the pH of drinking water. For removal, As(III) is generally oxidized to arsenate, As(V), which can be removed by adsorption or ion-exchange mechanism. Previous researchers have found that the TiO2/UV photo catalytic process effectively converted As(III) to As(V). However, most of the research was performed with TiO2 nano-particle suspensions. These might be required to be separated later in a particle removal process. In addition, the TiO2 did not adsorb a significant amount of arsenic. During our testing, a TiO2/ Al2O3 mixed oxide was developed which has shown to effectively remove As(III) without a separate oxidation process. Our heterogeneous photo¬catalytic adsorbent (Al2O3/TiO2) was synthesized by sol-gel technology. The material acts as a photocatalyst which is capable of oxidizing As(III) to As(V), with the latter species being adsorbed by the catalytic adsorbent. These particles were mixed as a stable suspension (sol) that was used to coat glass beads. The thin-films deposited on the glass beads served as both photocatalyst and adsorbent.

Keywords: arsenite, arsenate, remediation, photooxidation

*Note: This is a student presentation.

SESSION 2
Runoff
Thursday, March 4, 2004
2:30-3:30

Assessing Infiltration at a Stormwater Basin Serving a Residential Neighborhood, Middleton, Wisconsin

C. P. Dunning, US Geological Survey
8505 Research Way, Middleton, WI, 53562, cdunning@usgs.gov
R.T. Bannerman, Wisconsin Department of Natural Resources
101 S. Webster, Madison, WI, 53703, banner@dnr.state.wi.us
P.F. Juckem, US Geological Survey
8505 Research Way, Middleton, WI, 53562, pfjuckem@usgs.gov

The importance of managing urban stormwater runoff in ways that maximize infiltration has been increasingly recognized in recent years. However, it remains a difficult task to choose the most effective means of infiltrating stormwater at any given site, or to quantify how well an infiltration site actually performs. Assessing stormwater infiltration has been a focus of recent work in a residential neighborhood in Middleton, Wisconsin. 55.2 acres of the neighborhood generates stormwater that is directed to a dry infiltration basin. The maximum area of the infiltration basin covered by ponded stormwater during an event is approximately 0.21 acres, or about 0.4% of the area contributing stormwater. Infiltration of stormwater can occur in two ways at this site: through the bottom of the basin, or by flowing into an injection well constructed in the basin. Infiltrometer data suggest that ponded stormwater will infiltrate through the basin bottom at a modest rate (0.1 to 1 inch per hour). Greater volumes of stormwater are believed to infiltrate by means of the injection well. During the period March 25 to July 31, 2003, ponded stormwater overtopped the injection well 10 times, resulting in a measurable rise of the water table. Although a general decline in water-table elevation is observed beginning January of 2003, stormwater flow into the injection well during events in early May reversed that decline. The decline in water level resumed during the drier period of late May and June. Conversely, there is no strong signal of infiltration through the basin bottom on water-table elevation data collected to date.

Keywords: infiltration, stormwater, water-table, injection well

Monitoring and Sampling Design for Water Runoff at UW Platteville Pioneer Farms

D. W. Owens, US Geological Survey
8505 Research Way, Middleton, WI 53562. dwowens@usgs.gov
T. Hunt, University of Wisconsin – Platteville
Director of Research for Pioneer Farm, 207 Pioneer Tower, Platteville, WI, hunt@uwplatt.edu

Quantifying runoff from agricultural fields is a high priority for the State of Wisconsin, but this data is not easily acquired. Pioneer Farm, the systems farm for the Wisconsin Agricultural

Stewardship Initiative (WASI), is charged with intensive collection of baseline information including agricultural runoff. An interdisciplinary team helped devise a plan to monitor runoff data from Pioneer Farm at the University of Wisconsin-Platteville. The USGS has been responsible for implementing the monitoring plan to ensure data quality and consistency. Acquiring high quality agricultural runoff data is difficult due to a plethora of physical and logistical factors such as type, timing, and duration of the runoff event; remoteness of the sites; and timing of collection, processing, and analysis of samples. Effective sampling design, proper equipment, and reliable personnel are essential to collecting good data. The monitoring equipment must function under extreme conditions in all seasons, be easily maintained, be flexible, and affordable. The Pioneer Farm case study is a demonstration of collaborative efforts to overcome these challenges.

Keywords: agricultural field runoff, water-quality sampling

Snowmelt Export of Sediment and Nutrients from Agricultural Sub-watersheds in Southwest Wisconsin

R. M. Mentz, University of Wisconsin-Platteville
Pioneer Farm, Platteville, WI 53818, mentzr@uwplatt.edu
M. R. Penn, University of Wisconsin-Platteville
Department of Civil and Environmental Engineering, Platteville, WI 53818, mrpenn@uwplatt.edu
S. Jonnala, University of Wisconsin-Platteville
Pioneer Farm, Platteville, WI 53818, jonnalas@uwplatt.edu
D. W. Owens, US Geological Survey
8505 Research Way, Middleton, WI 53562, dwowens@USGS.gov

Non-point source pollution of surface water with sediment, nutrients, and other agrichemicals is a growing problem. Export from agricultural fields is often estimated using computer models and simulated runoff experiments, rather than with actual field measurements. Pioneer Farm, a 420-acre farm by University of Wisconsin-Platteville is instrumented with several flumes and automated samplers to sample runoff at intervals throughout individual storm events. With modification, these field devices can quantify snowmelt events, which are rarely reported in scientific literature due to the difficulty in obtaining representative samples. This presentation focuses on results from the 2003 spring snowmelt runoff event at Pioneer Farm. In the spring of 2003, runoff from three snowmelt events was sampled. There were two minor events in February and one major event in March. Snowmelt runoff was sampled at regular intervals from four field-scale sub-watersheds ranging in size from 14 to 72 acres. During the course of a single-day March snowmelt event, 0.05 inches of runoff was observed with concentrations of total phosphorus up to 42 mg•L-1. Export rates of sediment and nutrients for each of the sub-watersheds will be presented.

Keywords: Snowmelt, runoff, agriculture, phosphorus, nutrients
*Note: This is a student presentation.

SESSION 3
Aquifer Storage and Recovery
Thursday, March 4, 2004
3:50-5:10 pm

Defining Controlling Factors of Aquifer Storage Recovery Using Advection and Dispersion Models

C. S. Lowry, University of Wisconsin-Madison
Department of Geology and Geophysics, 1215 W. Dayton St., Madison, WI 53706, lowry@geology.wisc.edu
M. P. Anderson, University of Wisconsin-Madison
Department of Geology and Geophysics, andy@geology.wisc.edu

As population centers shift and expand in the State of Wisconsin so does the need for managing and sustaining water resources. To help plan for these changes, emerging technologies are being implemented in the State and throughout the country. One such technology is aquifer storage recovery (ASR). In ASR, water is stored in the subsurface when demand is low and then recovered by pumping when demand increases. In this research, a potential ASR system was modeled for a representative hydrogeologic system based on the city of Waukesha, WI. Groundwater flow and transport models were designed to examine potential hydrogeological controlling factors that affect recovery efficiency. These factors include effective porosity, dispersivity, regional hydraulic gradient, storage period, volume of injected water and injection/recovery rates. Advection and advection-dispersion models were run using MODFLOW with MODPATH and MT3DMS, respectively. Results show that porosity, dispersivity and regional hydraulic gradient strongly affect recovery efficiency. General trends in recovery efficiency as computed from results of advection and advection-dispersion models are comparable. Results from this study will be useful in planning for implementing future ASR systems within the State by identifying the likely hydrogeological controls on recovery efficiency.

Keywords: aquifer storage recovery, groundwater, modeling, recovery efficiency, water resources management

*Note: This is a student presentation.

Aquifer Storage and Recovery Pilot Testing in Wisconsin

R. T. Roth, Wisconsin Department of Natural Resources
101 South Webster, Madison WI, rothr@dnr.state.wi.us
D. M. Johnson, Wisconsin DNR
101 South Webster, Madison WI, dave.johnson@dnr.state.wi.us
W. L. Phelps, Wisconsin DNR
101 South Webster, Madison WI, william.phelps@dnr.state.wi.us

Aquifer storage and recovery, or ASR, is a technique for temporarily storing water underground within a groundwater aquifer. Usually ASR systems are designed to inject water during times of abundant supply and/or low demand for later recovery during periods of lower supply and/or high demand. The technique most often involves the injection of treated drinking water; however, more recently, variations involving the injection of untreated surface water or reclaimed wastewater have been discussed.

Artificial recharge practices have been used in various parts of the world for centuries, but the use of the single injection/recovery well method which is typically found in an ASR system has only been in use in the United States since the mid-1960's. There are currently about 55 ASR systems in operation around the country. Three ASR wells have been constructed by water utilities in the upper Midwest. Significant use of ASR wells is also being proposed for the Everglades Restoration Project in the State of Florida.

The development and operation of an ASR system in the State of Wisconsin, including requirements to conduct pilot testing of the technique, is governed by regulations published in chapters NR 811 and NR 140 of the Wisconsin Administrative Code. To date, pilot studies have been conducted in the communities of Oak Creek and Green Bay. In both instances, treated drinking water obtained from Lake Michigan was injected and stored in the Cambrian - Ordovician sandstone aquifer system.

The ASR pilot project at Oak Creek involved six cycles of water storage and recovery. The ASR pilot project at Green Bay was abruptly terminated by the utility during the storage phase of the second test cycle. Water quality analyses conducted during these pilot tests demonstrate the need for careful environmental monitoring and development of a thorough understanding of the local hydrogeological and geochemical systems that are affected by the use of ASR techniques. Monitoring results from both Wisconsin ASR pilot projects have confirmed that geochemical reactions between injected lake water and bedrock aquifer material are occurring and that potential contaminants, such as arsenic and nickel, may be mobilized into the groundwater system.

Keywords: aquifer storage and recovery (ASR), trihalomethanes, arsenic, metals, Wisconsin

Geochemical Reactions during Green Bay ASR Pilot Testing

D. M. Johnson, Wisconsin DNR
101 South Webster, Madison WI, dave.johnson@dnr.state.wi.us
W. L. Phelps, Wisconsin DNR
101 South Webster, Madison WI, william.phelps@dnr.state.wi.us
R. T. Roth, Wisconsin DNR
101 South Webster, Madison WI, richard.roth@dnr.state.wi.us

The injection of surface water into the Cambrio-Ordivician aquifer during Aquifer Storage and Recovery (ASR) pilot testing in Green Bay Wisconsin caused the release of arsenic, nickel and cobalt in excess of drinking water standards. Monitoring of the three discrete hydrostratigraphic

zones into which water was injected revealed different responses and geochemical reactions within each zone.

There were early indications that arsenic and other potential contaminants present in the bedrock aquifer at Green Bay might be mobilized as a result of geochemical reactions between stored lake water and bedrock matrix material. Because of concerns with possible contaminant mobilization the Department limited the initial Green Bay ASR pilot test storage volume to 10 million gallons. Monitoring results from the first pilot test cycle showed that arsenic, nickel, cobalt and other metals had been released into groundwater at levels significantly above state drinking water and groundwater quality standards. Uranium, radium and gross alpha emitting substances also appeared to have been mobilized into groundwater due to ASR water storage. Monitoring of the initial ASR test cycle at Green Bay too, showed that trihalomethane (THM) disinfection byproducts, generated from chlorination of injected lake water, were not degrading in the aquifer as had been predicted.

A number of possible alternatives were considered to reduce mobilization of aquifer constituents during ASR storage. Most of these alternatives were deemed to be too expensive to implement. Green Bay's consultant proposed limiting the extent of stored lake water to the deepest zone of the test aquifer, where arsenic and other metal were believed to be present below levels of concern. To test this theory the Green Bay ASR test well was lined to a depth of 630 feet and a second, smaller volume of treated surface water was injected for storage in July of 2003. Monitoring of this second Green Bay ASR test cycle indicated that injected ASR water was reaching all monitored zones of the storage aquifer, and mobilization of aquifer contaminants, similar to the first test cycle, was observed.

The two ASR pilot test cycles completed at Green Bay appear to demonstrate that ASR, under the operational conditions currently considered economically viable, will not work in the Green Bay area. This talk draws on information from the Green Bay Water Utility, their consultant CH2MHILL, the Central Brown County Water Authority, WGNHS, the DNR technical Advisory Group and the DNR.

Keywords: Green Bay Wisconsin, ASR, trihalomethanes, arsenic, metals

An Assessment of Aquifer Storage and Recovery and Mercury Methylation in the south Florida Everglades Ecosystem

Raycine M. Hodo, Dept. of Geology and Geophysics
Univ. of Wisconsin-Madison, rmhodo@geology.wisc.edu
David P. Krabbenhoft, US Geological Survey
8505 Research Way, Middleton, WI 53562
M. P. Anderson, Univ. of Wisconsin-Madison
Dept. of Geology and Geophysics, andy@geology.wisc.edu

Studies suggest methylmercury is formed in anoxic environments where there is active sulfate reduction; however, no known published studies have considered methylmercury formation in deep subsurface environments. Similarly, few studies evaluate aquifer storage and recovery

(ASR) and water chemistry. In an attempt to restore natural hydroperiods, vital to the Everglades ecosystem, ASR technology is proposed in south Florida. The proposed storage zone is the Upper Floridan Aquifer. There are concerns that the recovered water may contain toxic methylmercury or stimulate mercury methylation in the Everglades.

The objective of this study is to develop a hydrogeochemical model of mercury and methylmercury in the Upper Floridan Aquifer. Though Wisconsin and Florida have different aquifer systems we will compare analytical results of water from the Floridan Aquifer to water recovered from the Green Bay, WI ASR pilot project to assess the transferability of our results to different aquifer systems. Using water samples from Florida municipal wells and cores from preexisting ASR wells to simulate ASR conditions, a series of column studies were set up using Floridan Aquifer materials, native surface water, and mercury isotopes to evaluate the potential for ASR injection to methylate mercury, the time required for stored water to methylate, and the conditions which methylation may occur in ASR stored water. Water samples are analyzed for mercury and methylmercury prior to and after column injection. Preliminary results show the Upper Floridan Aquifer is anoxic and contains H2S, suggesting the potential for methylation during storage periods in the Floridan Aquifer.

Keywords: mercury, methylmercury, aquifer storage and recovery, column studies, sulfate reduction

*Note: This is a student presentation

SESSION 4
Groundwater – Surface Water Interaction
Thursday, March 4, 2004
3:50-5:10

Hydrogeologic Controls on Springs in the Mukwonago River Watershed, SE Wisconsin

H. E. Gittings, Univ. of Wisconsin-Madison
Department of Geology and Geophysics, 1215 W Dayton St. Madison WI 53706, gittings@geology.wisc.edu
J.M. Bahr, Univ. of Wisconsin-Madison
Department of Geology and Geophysics, 1215 W Dayton St. Madison WI 53706, jmbahr@geology.wisc.edu

To allow assessment of impacts of groundwater withdrawals and suburban development on the Mukwonago River watershed in southeastern WI, we are investigating hydrogeologic controls on groundwater discharge to the area's springs and wetlands. Previous studies focused on local scale flow patterns and geochemistry. They produced a conceptual model in which springflow and diffuse discharge to the wetlands are supported by shallow groundwater flow, with minimal contributions bedrock aquifers. An alternative model is that high volume springs are supported by discharge from preferential flow zones in the bedrock, with the springs occurring where these zones intersect the steep wall of the Troy valley, a preglacial buried bedrock valley. The northwest side of this valley underlies many of the wetlands in the northern portion of the watershed as well as a spring complex that contributes approximately 70% of the streamflow in the upstream reaches of river. The southeast side of the buried valley appears to coincide with other wetlands, springs and lakes along the southern margin of the watershed. Major ion and strontium isotope analyses provide additional constraints on sources of water to springs and wetlands in the watershed. A numerical groundwater flow model, developed by telescopic mesh refinement of a regional model, will be used to assess the sensitivity of spring location and fluxes to the geometry of the buried bedrock valley and the hydraulic properties of the glacial and bedrock stratigraphic units.

Keywords: springs, wetlands, hydrostratigraphy, strontium isotopes

*Note: This is a student presentation.

Spatial Patterns and Temporal Trends in Groundwater Recharge, upper Coon Creek Watershed, Southwest Wisconsin

P. F. Juckem, Univ. of Wisconsin-Madison
Dept. of Geology and Geophysics, 1215 W. Dayton St., Madison, WI 53706, pfjuckem@usgs.gov
R. J. Hunt, U.S. Geological Survey
8505 Research Way, Middleton, WI 53562, rjhunt@usgs.gov

M. P. Anderson, Univ. of Wisconsin-Madison
Dept. of Geology and Geophysics, 1215 W. Dayton St., Madison, WI 53706,
andy@ice.geology.wisc.edu

Increased baseflow over the past century in many basins in the Driftless Area of southwestern Wisconsin has been attributed to changes in agricultural land management practices. In the Coon Creek Watershed such practices were introduced during the nation's first watershed-scale soil and water conservation demonstration project, conducted from 1934 to 1940. Research on runoff and infiltration in the Driftless Area suggests that groundwater recharge is likely focused on forested hillslopes, and may account for observed baseflow increases.

Optimization of hillslope and ridge-top recharge rates for a six-layer, steady state, finite difference groundwater flow model produced recharge values on hillslopes that were 2.3 times greater than recharge rates on ridges. Nonetheless, areally uniform recharge was adequate to simulate streamflow in basins larger than about 10 to 30 mi2 in this region of the Driftless Area, partially because rivers that drain large areas were less sensitive to local variations in recharge than streams in headwater basins. The basin-scale threshold also appears to be related to a connection between stream elevation and the hydrostratigraphic units drained by the stream.

Average areal recharge in the upper Coon Creek Watershed increased from 19% of average annual precipitation during the 1934-1940 study period to 28% during two subsequent study periods: 1979-1981 and 2001-2002. Thus, the processes that control apportioning of precipitation into recharge and runoff were modified between the 1934-1940 and 1979-1981 study periods, but have remained stable since the 1979-1981 study period.

Keywords: Driftless Area, hydrogeology, recharge, basin scale

An Integrated Modeling Approach to Analyze Groundwater-Lake Interactions: Trout Lake Basin, Northern Wisconsin

R. John, University of Wisconsin-Madison
Dept. of Geology and Geophysics, 1215 W. Dayton St., Madison, WI 53706,
rahul@geology.wisc.edu
M.P. Anderson, University of Wisconsin-Madison
Dept. of Geology and Geophysics, 1215 W. Dayton St., Madison, WI 53706,
andy@geology.wisc.edu
R.J. Hunt, United States Geologic Survey
8505 Research Way, Middleton, WI 53562, rjhunt@usgs.gov

A comprehensive, terrestrial biosphere model (IBIS) was coupled to a groundwater flow model (MODFLOW) and used to simulate hydrologic processes during 1996-2000 in the Trout Lake watershed in northern Wisconsin. The IBIS (Integrated Biosphere Simulator) model explicitly links land surface and hydrological processes, terrestrial biogeochemical cycles, and vegetation dynamics within a single, physically consistent framework (Foley et al., 1996) and also calculates groundwater recharge rates as a drainage term. MODFLOW, the most widely used code for simulating groundwater flow, is a modular three dimensional, transient, finite-difference model (Harbaugh et al. 2000) with packages that simulate exchange of groundwater with lakes

and rivers. IBIS-calculated recharge rates for 1996-2000 were simulated in MODFLOW as a calibration test. In future work, the linked model will be used to simulate the effects of potential global climate change and land use change. Findings of this project will help elucidate the complex ways in which meteorological parameters (e.g; solar radiation, wind speed and humidity), vegetation dynamics and other terrestrial processes influence groundwater recharge rates, which in turn affect lake levels, lake capture zones, groundwater fluxes to lakes and travel times of flow paths that discharge to lakes and streams. The results will help state regulators understand and address future land use/ land cover changes in northern Wisconsin.

References:

Foley, J.A., I.C. Prentice, N. Ramunkutty, S. Levis, D. Pollard, S. Sitch, and A. Haxeltine. (1996). An integrated biosphere model of land surface processes, terrestrial carbon balance and vegetation dynamics, Global Biogeochemical Cycles, 10, 603-628.

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, the U.S. Geological Survey modular ground-water model -- User guide to modularization concepts and the Ground-Water Flow Process: U.S. Geological Survey Open-File Report 00-92, 121 p.

Keywords: terrestrial biosphere model, groundwater flow model, groundwater recharge, climate change, lakes

*Note: This is a student presentation

Measuring Groundwater-Surface Water Interaction and its Effect on Wetland Stream Benthic Productivity, Trout Lake Watershed, northern Wisconsin

R. J. Hunt, US Geological Survey
8505 Research Lane, Middleton, WI, rjhunt@usgs.gov
M. Strand, Northern Michigan University
Marquette, MI, rostrand@nmu.edu
J.F. Walker, US Geological Survey
8505 Research Lane, Middleton, WI, jfwalker@usgs.gov

Measurements of groundwater-surface water interaction at three wetland stream sites were related to patterns in benthic productivity as part of the USGS NTL-WEBB project. The sites included one high groundwater discharge (HGD) site, one weak groundwater discharge (WGD) site, and one groundwater recharge (GR) site. Large upward vertical gradients were associated with smallest variation in head below the stream and fewest gradient reversals between the stream and the groundwater beneath the stream, and the stream and the adjacent streambank. The WGD site had the highest number of gradient reversals reflecting the average condition being closest to zero gradient. Groundwater discharge duration was also related to discharge magnitude, where the HGD site had the longest strong-gradient durations for both horizontal and vertical groundwater flow. Strong groundwater discharge also controlled transient temperature and chemical hyporheic conditions by limiting the infiltration of surface water. Finally, high groundwater discharge was related to higher benthic invertebrate abundance, taxonomic richness,

and periphyton respiration. This work suggests groundwater-surface interaction can affect the biology of a stream-wetland system, and evaluations of this interaction within a watershed may be required to accurately assess and manage the wetland habitat function.

Keywords: groundwater, surface water, benthic invertebrates

POSTER SESSION
Thursday, March 4, 2004
5:30-7:00 pm

Removal of Arsenate Using Lanthanum Oxide Immobilized Highly Ordered Mesostructured Silicate

M. Jang, University of Wisconsin-Madison
Department of Civil and Environmental Engineering, 1415 Engineering Drive, Madison, WI 53706, jang@cae.wisc.edu
J. K. Park, University of Wisconsin-Madison
Department of Civil and Environmental Engineering, 1415 Engineering Drive, Madison, WI 53706; jkpark@wisc.edu
E. W. Shin, University of Wisconsin-Madison
Department of Biological Systems Engineering, 460 Henry Mall, Madison, WI 53706, ewshin@wisc.edu
S. I. Choi, Kwangwoon University
Department of Environmental Engineering, 447-1 Wolgye-Dong, Nowon-Gu, Seoul, South Korea, sichoi@kw.ac.kr
J. Naser, Tuskegee University
Chemical Engineering Department, Tuskegee, AL 36088, naserj@tuskegee.edu
S. H. Min, University of Wisconsin-Madison
Department of Civil and Environmental Engineering, 1415 Engineering Drive, Madison, WI 53706, soohongmin@wisc.edu
S. C. Kim, Mokpo National University
Department of Environmental Education, 61, Dorim-Ri, Cheonggye-Myun, Muan-Gun, Chonnam 534-729, South Korea, gikim@mokpo.ac.kr
S. B. Rho, Keimyung University
Department of Chemical Engineering, 1000 Shindang-Dong, Dalseo-Gu, Daegu 704-701, South Korea, rhosb@kmu.ac.kr

A highly-ordered mesoporous silica SBA-15 was synthesized and incorporated with various amounts of lanthanum oxide. Several fine characterization techniques such as x-ray diffraction (XRD), nitrogen gas isotherm, and Fourier transform infrared (FTIR) were used to study the physicochemical properties of the media and elucidate their arsenate adsorption behavior. XRD and N2 isotherm results showed that immoderate substitution of lanthanum in the silica networks occurred at 80% lanthanum impregnation even though the lanthanum was highly dispersed inside the mesopore structures of SBA-15 and lanthanum oxide particles did not form on the outside of the solid. However, it was found from FTIR analyses that there was no structural collapse of the silica framework at 80% lanthanum impregnation since partial substitution of lanthanum precursors with silicon occurred and this may play an important role in structural stabilization as other studies have shown. Although the arsenate adsorption densities increased with increasing lanthanum impregnation up to 50% (the most efficient percentage of lanthanum impregnation), it abruptly decreased at 80% due to the substitution of lanthanum with silicon, leading to an overall reduction in arsenate adsorption capacity. At the arsenate concentration of 0.667 mmolAs/L, the

adsorption capacity of 50% lanthanum-impregnated SBA-15 by weight (designated as La50SBA-15) was 1.651 mmolAs/g (123.7 mgAs/g). The nano-scale impregnation of lanthanum onto SBA-15 has many advantages in terms of not only adsorption velocity and capacity but also cost benefits for POU/POE application of arsenate removal since a small amount of lanthanum precursor is needed for impregnation.

Keywords: arsenate, mesoporous, lanthanum, impregnation, POU/POE

Initial Evaluation of Hydrologic Response at a 3-Year Old Phytoremediation Site

W. M. DeVita, University of Wisconsin – Stevens Point
College of Natural Resources, wdevita@uwsp.edu
M. Dawson, Hyde Environmental, Inc.
Amherst, WI hydeenv2@triver.com

Phytoremediation offers the prospect of using a biotechnology to degrade or sequester contaminants from soil and groundwater, and/or slow the movement of shallow groundwater. Sequestration of heavy metals and degradation of petroleum hydrocarbons and volatile organic compounds is well documented; however, the fate of many pesticides is unclear. If groundwater movement can be slowed, so will the movement of contaminants off-site, and therefore, a greater likelihood they will be degraded by biotic or abiotic processes, or be sequestered by plants.

The study site, located near Bancroft, Wisconsin, has a history of soil and groundwater degradation. Sandy soil, shallow groundwater, and other factors make this a prime site to study the effects of phytoremediation. In June 2000, a mixture of 834 hybrid poplars, willows, and cottonwoods were planted in an effort to degrade and/or retard the movement of pesticides.

Following four growing seasons, approximately 20% mortality has been observed in the hybrid poplar clones (DN-34 and NM-6), with most mortality inflicted in the known contaminant source area. Estimated biomass measured as a function of tree diameter and height varies widely throughout the site, with greater biomass reported downgradient of the source area. Groundwater fluctuations of up to 9 mm were observed on a diurnal basis through the use of groundwater elevation data loggers within the plantation. Thermal dissipation probes were installed in late summer of 2003 to determine sap flow within 12 of the larger trees (due to size restrictions on the probes). Preliminary evidence suggests some of these 3-year old trees used between 7 and 28 liters of water per day during this period of reduced photosynthesis. Sap flow is correlated with estimated biomass and local weather data. Groundwater chemistry at this point in the study seems unchanged with no observed degradation of known contaminants.

Keywords: phytoremediation, groundwater, pesticides

A Novel Fabrication Method for Large, Diverse Arrays of Optical Fiber Sensors with Potential Applications in Water Security

P. Geissinger, University of Wisconsin-Milwaukee
Dept. of Chemistry, geissing@uwm.edu
R. Olsson, Milwaukee School of Engineering
Department of Physics and Chemistry, olsson@msoe.edu
E. J. Kiefer, University of Wisconsin-Milwaukee

Department of Chemistry, ejkiefer@uwm.edu
A. W. Schwabacher, A.W., University of Wisconsin-Milwaukee
Dept. of Chemistry, awschwab@uwm.edu

Distributed optical fiber sensing allows for the measurement of desired parameters spatially resolved along a continuous section of an optical fiber or on a number of discrete regions along a fiber. This permits multi-parameter sensing on a single fiber. For the readout of many sensor regions, it is advantageous to place fluorescent sensor molecules in the cladding of the fiber. Light pulses coupled into the fiber core excite the fluorosensors, which subsequently emit light and couple a fluorescence pulse back into the fiber core. The time delay between the exciting pulse and the returning pulse allows for the calculation of the position of the emitting fluorosensor along the fiber, providing spatially resolved sensing.

We have developed a combinatorial synthetic method that allows for the chemical synthesis of libraries of compounds with thousands of members on linear support materials, i.e. the compounds systematically synthesized by this method are arrayed in a linear format. Optical fibers constitute ideal linear support materials for our technique, putting us in a position of building diverse libraries of chemical compounds on optical fibers for many different purposes, ranging from the design of new drugs to the fabrication of linear optical fiber sensor arrays for a multitude of sensing tasks, from the screening of medical analytes to the monitoring of pollutants in the environment. Potential applications for water security will be described.

Keywords: water security, environmental monitoring, optical fiber sensors, linear combinatorial synthesis

*Note: This is a student presentation

Relationships Between Land Use and Water Quality on Lakes Helen and Lions, Portage County, Wisconsin

L. W. Hennigan, University of Wisconsin - Stevens Point
Center for Watershed Science and Education, Stevens Point WI 54481,
lhenn304@uwps.edu
K. A. Rasmussen, University of Wisconsin - Stevens Point
Center for Watershed Science and Education, Stevens Point, WI 54481;
krasm815@uwsp.edu

Two groundwater seepage lakes in northern Portage County Wisconsin were assessed using land use in the groundwater and surface watersheds and water quality measurements. Each lake had both historic and current water chemistry (1974-1981, 2002-2003) and land use data (1948, 1968, 1990, 2002). Comparison of water quality was accomplished using water clarity data (May-September), total nitrogen (TN) and total phosphorus (TP) loading from overturn, and annual chloride concentrations.

Lake Helen encompasses 87 surface acres and has a volume of 600 acre-feet with a mean depth of 8 feet. Historically agriculture and forests were the dominant land use in the groundwater and

surface watersheds. Analysis of recent land use shows that agriculture has decreased, but remains the dominant land use and residential uses have increased. Historic Secchi measurements averaged 9.1 ±4.0 feet, chloride concentrations averaged 10.0 ±3.7 mg/L, and average concentrations of TN and TP were 1.0 ±0.3 mg/L and 21.4 ±5.1 ug/L, respectively. Recent water quality data have average Secchi measurements 10.3 ±3.3 feet, average chloride 19.3 ±2.0 mg/L, and average concentrations of TN and TP were 1.25 ±0.3 ug/L and 17.0 ±7 mg/L.

Lions Lake is 44 surface acres and has a volume of 188 acre-feet with a mean depth of 5 feet. Historic and current land uses in Lions Lake's groundwater and surface watersheds are dominated by forests and agriculture. Historic Secchi measurements averaged 8.65 ±2.2 feet, chloride concentrations averaged 3.5 ±0.6 mg/L, and TN and TP concentrations averaged 1.1 ±0.3 mg/L and 15.9 +/-5.2 ug/L, respectively. Recent Secchi measurements averaged 9.0 ±1.1 feet, chloride concentration averaged 0.8 ±0.6 mg/L, and TN and TP concentrations averaged 0.9 ±0.3 ug/L and 14.0 ±10.4 ug/L.
Elevated chloride concentrations in Lake Helen can likely be attributed to the additional development around the lake and within its watersheds and the land practices associated with development. Lake to lake differences in total phosphorus and TN were evident when loading was compared.

Keywords: land use, water quality, lakes

*Note: This is a student presentation.

Assessing the Utility of Historical Spring Surveys in Dane County

D. R. Ginder-Vogel, Beloit College
Department of Geology, 700 College Street, Beloit WI 53511, gindervo@stu.beloit.edu
S. K. Swanson, Beloit College
Department of Geology, 700 College Street, Beloit WI 53511, swansons@beloit.edu

In 1958-59, the Wisconsin Conservation Department conducted spring surveys across the State to document spring locations and discharge. In some regions of Wisconsin pumping rates since the 1950's have increased and land use changes may have decreased ground water recharge. These changes may be reducing spring discharge to wetlands and fragile aquatic ecosystems. The purpose of my research is to see if urbanization in the past 50 years has affected springs in Dane County. Because the spring surveys are so extensive, I thought I could test whether pumping and land use changes are affecting springs by directly comparing spring flow rates from 1958-59 to those measured in 2003.
The springs in this study are located in three townships, Dunn, Fitchburg, and Madison. These townships represent both rural and urban settings. At each location, spring discharge was measured, UTM coordinates were recorded, and the springs were photographed. This information has been incorporated into a geographic information system, and hopefully it will provide a foundation for further studies on springs in Dane County. I found that the 1958-59 spring locations are accurate, but that the discharge measurements are not. Therefore, a direct comparison of flow could not be completed. However, I could still determine if a spring

completely dried up and evaluate if urbanization is responsible; 24% of the springs appear to be impacted in some way by urbanization.

Keywords: springs, urbanization, GIS

*Note: This is a student presentation

The Groundwater and Surface Water Relationship in the Ridge's Sanctuary, Door County WI

L. R. Evenson, University of Wisconsin – Green Bay
2420 Nicolet Avenue, Green Bay, WI, evenlr10@uwgb.edu
R. D. Stieglitz, University of Wisconsin – Green Bay
stieglir@uwgb.edu
P. Sager, University of Wisconsin – Green Bay
sagerp@uwgb.edu
K. Fermanich, University of Wisconsin – Green Bay
fermanik@uwgb.edu

The Ridge's Sanctuary in Door County, Wisconsin is one of the most pristine areas in the state. The Sanctuary is a botanical reserve with a unique landscape of beaches, dunes and swales. The Sanctuary also offers an abundant plant and wildlife, including two endangered species the Pink Lady Slipper Orchid and Hein's Emerald Dragon Fly. To better protect and maintain this area for future generations, the University of Wisconsin – Green Bay has started research on how the surface and groundwater interact within the vast network of swales and natural springs. The study included installing a total of nine piezometers at 1, 2 and 4 meter depths at three swale locations ranging from oldest to youngest. Five surface water sampling sites were chosen which include a stream, two springs and two swales. Water quality tests were conducted on the groundwater obtained from the nine piezometers and surface water obtained from the five surface water sites. Water quality results thus far have identified that groundwater is a contributing source to the surface water. The data was analyzed through a series of cation and anion tests and displayed as piper diagrams and line graphs. The intent of this study to (1) determine the present groundwater and surface water quality, (2) determine the importance of the surface and groundwater interaction, and (3) establish a database for future studies to continue monitoring the water quality while adjusting to the continuous landuse changes in and around the Ridge's Sanctuary.

Keywords: groundwater, surface water, Ridge's Sanctuary, swales

*Note: This is a student presentation

Low-Flow Purging and Sampling of Groundwater at Argonne National Laboratory-East, East Northeast Landfill

R. E. Piorkowski, Argonne National Laboratory
9700 S. Cass Ave, Argonne, Il, 60439, rpiorkowski@anl.gov

D. A. Milinko, Argonne National Laboratory
9700 S. Cass Ave, Argonne, Il, 60439, dmilinko@anl.gov

Low-flow sampling involves minimizing drawdown in a groundwater monitoring well during sample purging and sample removal, by removing water at a rate such that inflow through the well screen equals the pumpage rate. By following this prescribed pumpage (flow) rate, turbidity will be reduced in the water and a higher quality sample will be produced vs. traditional sampling techniques. For specific turbidity sensitive parameters such as metals and VOC, low-flow sampling is the preferred method of collection by regulatory agencies. ANL uses a low-flow sampling technique, which is based on information contained in the EPA publication titled Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, EPA 542-S-02-001, May 2002. In 2001, The Illinois EPA (IEPA) approved this method of sample purging and collection for the ENE Landfill and several other sites on the ANL property.

Samples with low turbidity better represent true conditions of the groundwater than samples that contain silt or clay particles which cause turbidity. The total metals analysis involves digestion which dissolves analytes in water and solids. Because of this, solids in the sample will cause a bias in the actual groundwater result. Long-term monitoring utilizing low-flow purging is a proactive approach to accurately measure groundwater quality based upon turbidity conditions at collection, and EPA approved sample methods.

Keywords: low-flow sampling, groundwater exceedances

wiscLITH: A Database of Wisconsin Geologic Information

M. B. Gotkowitz, Wisconsin Geological and Natural History Survey
3817 Mineral Point Rd. Madison, WI 53705, mbgotkow@facstaff.wisc.edu
R. M. Peters, Wisconsin Geological and Natural History Survey
3817 Mineral Point Rd. Madison, WI 53705
T. J. Evans, Wisconsin Geological and Natural History Survey
3817 Mineral Point Rd. Madison, WI 53705
A. Santipiromkul, Wisconsin Geological and Natural History Survey
3817 Mineral Point Rd. Madison, WI 53705
B. C. Bristoll, Wisconsin Geological and Natural History Survey
3817 Mineral Point Rd. Madison, WI 53705

wiscLITH is a collection of geologic records maintained by the Wisconsin Geological and Natural History Survey (WGNHS) and available through a database in Microsoft® Access. The databse includes information about approximately 44,000 wells and borings in wiscLITH, including 3,400 records of wells and borings for which lithologic descriptions are available and 43,900 records for which stratigraphic interpretations have been made. The database also contains records of groundwater levels measured at approximately 10,000 of these wells. Locations of the wells and borings are provided for a majority of the records in the database. These geologic records, primarily WGNHS geologists' descriptions of rock and sediment samples, are organized in wiscLITH in a set of related tables. Forms and queries supplied with wiscLITH allow a user with rudimentary database skills to sort and view the information.

Database users may perform searches on these records, and select and export records from wiscLITH to other software programs for further analysis. An ESRI® ArcViewTM extension developed by the Indiana Geological Survey is included with wiscLITH, and can be used to facilitate analysis of these subsurface records in an ESRI ArcGISTM environment.
Due to limited resources, not all of the geologic logs and other records developed by WGNHS geologists have been added to this database. For example, stratigraphic information for some records is in wiscLITH, but lithologic descriptions found on the original paper records have not been entered. The user may surmise from wiscLITH entries that additional information related to a specific record is maintained at the WGNHS and request it from the WGNHS.

Keywords: database, lithology, stratigraphy

Evaluating Groundwater Phosphorus Concentrations in Wisconsin Through Private Well Testing

Paul M. McGinley, University of Wisconsin - Stevens Point
College of Natural Resources, pmcginle@uwsp.edu
Richard Stephens, University of Wisconsin - Stevens Point
College of Natural Resources, rstephen@uwsp.edu

Understanding the quantities of phosphorus transferred from terrestrial to aquatic systems is important to surface water management. Attempts to estimate the external phosphorus load to lakes must include groundwater contributions. While groundwater can be a substantial source of water to lakes and streams, little is usually known about groundwater phosphorus concentrations. In this study, we measured the phosphorus concentrations in more than six hundred private water supplies in Wisconsin. The data collected were used to explore variations in phosphorus concentrations in several regions of the State and then relate them to differences in geology, water geochemistry and anthropogenic influence.
Phosphorus concentrations in the water supplies ranged from less than 0.01 mg/l to more than 1 mg/l. Geographic variations in phosphorus concentration were significant. Water collected in some areas of north central and northwest Wisconsin often had higher concentrations of phosphorus than most of the water collected in southern or eastern Wisconsin. Substantial variations in phosphorus concentrations were also found within the different regions. The data demonstrate that relatively high concentrations of phosphorus can be found in Wisconsin groundwater and that regional characteristics may offer opportunities to estimate the likely concentration range.

Keywords: Phosphorus, groundwater, drinking water, geochemistry

Electrical Resistivity Survey of a site in Vilas County, Wisconsin

L. R. Atkinson, University of Wisconsin-Milwaukee
P O Box 413, Milwaukee, WI, 53201, leeann@uwm.edu
W. Kean, University of Wisconsin-Milwaukee
P O Box 413, Milwaukee, WI, 53201, wkean@uwm.edu

A hydrogeologic study is in progress on a site owned by the Nature Conservancy in Vilas County, Wisconsin. It is part of an ongoing collaborative effort to evaluate the environmental conditions of the site for the Nature Conservancy. The site consists of over 3.7 km2 of relatively pristine land with the only development consisting of approximately 20 km of dirt roads, a few primitive shelters, and several culverts that allow the roads to be continuous. The near surface geology is primarily a sequences of till and glacial outwash.

In the summer of 2003, over 20 Wenner electrical resistivity soundings were conducted at and near the site to aid in interpreting the subsurface geology. The electrical sounding locations were selected based on interest in the underlying geology, and availability of well logs and water table data. The results were modeled using standard 2-D inversion program. The soundings are interpreted over large parts of the site as representing continuous layers of silty and clayey till. However, a large central location is dominated by more resistive material, which seems to correlate with sand and gravel outwash. These results are useful in determining the underlying geology and hydrogeology of the site.

Keywords: electrical resistivity, Vilas County, Nature Conservancy

*Note: This is a student presentation.

Important Steps for Processing and Analyzing Biological Samples for Methylmercury

L. E. Pons, University of Wisconsin-Madison
660 N. Park St. Madison, WI 53706, lepons@wisc.edu
P. R. Gorski, University of Wisconsin-Madison
Dissertator, Environmental Chemistry and Technology, 660 N. Park St., Madison, WI 53706, prgorski@wisc.edu
R. J. Moore, University of Wisconsin-Madison
Environmental Chemistry and Technology, 660 N. Park St., Madison, WI 53706
J. P. Hurley, University of Wisconsin-Madison
Environmental Chemistry and Technology, 660 N. Park St., Madison, WI 53706, hurley@aqua.wisc.edu

There are a few key steps required to ensure full recovery of methylmercury (MeHg) from samples. They occur both during sample processing and analysis. During processing, full recovery of MeHg can be inhibited from matrix interference or "nonreactive" MeHg, and analysis is strongly dependent on controlled pH. We compared recoveries of two different biological standard reference materials (TORT-2 and DOLT-2) using four different processing procedures. Several methods designed to optimize MeHg recovery have been developed (Bloom et al., 1992, Horvat et al., 1993, Liang et al., 1996, and Hammerschmidt and Fitzgerald 2001). For processing samples, two major subgroups exist: extraction with methylene chloride and digestion by KOH in methanol. Extractions involving methylene chloride had poor results; recoveries ranged from 2% (for Horvat et al., 1993) to 45% (for Liang et al., 1996). Digestions by KOH in methanol were better: 70% (for Bloom et al. 1992) and 30-55% (for Hammerschmidt and Fitzgerald 2001). We then added a neutralization step prior to analysis, to ensure proper ethylation with sodium tetraethylborate during analysis, and this gave recoveries as high as 82%

for the Hammerschmidt procedure. Adding a pre-neutralization step to the Bloom procedure gave more consistent, although lower, recoveries around 75%. This illustrates that important details in processing and analysis can affect MeHg recovery.

Keywords: methylmercury, extraction

*Note: This is a student presentation

A Utilization-focused and Theory-based Evaluation of an Arsenic Well Testing Program

D. J. Severtson, University of Wisconsin-Madison
School of Nursing, Gaylord Nelson Institute of Environmental Studies,
K6/380 CSC, 600 Highland Ave., Madison, WI 53792-2455, djsevert@wisc.edu
L. C. Baumann, University of Wisconsin-Madison
School of Nursing, ljbauman@wisc.edu
R. L. Shepard, University of Wisconsin-Madison
Life Sciences Communication & UW-Extension, robin.shepard@ces.uwex.edu

The purpose of this study is to understand how people responded to an arsenic well testing program offered to rural Wisconsin residents in an area of the state where 20% of private wells have arsenic levels over the current drinking water standard of 10 ug/L. The evaluation study design incorporated utilization-focused and theory-based elements to collect data useful to program stakeholders and contribute to our theoretical understanding of relationships between risk information and protective behavior. The common sense model (CSM) has shown that people process health threat information to formulate representations that guide behavioral and emotional responses to threats. The CSM was applied to measure sources of risk information, risk representations, the emotional representation and, outcomes of water safety judgments and protective behavior. A survey was developed, piloted and mailed to participants that tested their wells through the program had an arsenic level: a) > 5 ug/L (N = 1154); and random samples of households with wells from b) 1 – 4 ug/L (N = 100) and c) who didn't test their well through the program (N = 259). 1233 (85.4%) of delivered surveys were returned. Descriptive results will be shared for study constructs across study subgroups. The common sense model provided data that can specify risk message content and delivery strategies.

Keywords: arsenic well testing, program evaluation, risk communication

*Note: This is a student presentation.

Applying a Health Behavior Theory to Understand Responses to Arsenic Risk from Well Water

D. J. Severtson, University of Wisconsin-Madison
School of Nursing, Gaylord Nelson Institute of Environmental Studies,
K6/380 CSC, 600 Highland Ave., Madison, WI 53792-2455, djsevert@wisc.edu
L. C. Baumann, University of Wisconsin-Madison
School of Nursing, ljbauman@wisc.edu

R. L. Shepard, University of Wisconsin-Madison
Life Sciences Communication & UW-Extension, robin.shepard@ces.uwex.edu

The purpose of this study is to understand whether the common sense model (CSM) has utility for explaining how people responded to arsenic risk information. The CSM has shown that people process health threat information to formulate representations that guide behavioral and emotional responses to threats. Representational dimensions were evident in a content analysis of public arsenic risk information. The CSM was applied to measure external and experiential sources of risk information, risk representations, the emotional representation, and, outcomes of water safety judgments and protective behavior. A survey was developed to measure study constructs and mailed to all households that tested their well through a government sponsored well test program and had an arsenic level > 10 ug/L. Of 649 surveys mailed, 545 (84%) were suitable for analysis. Exploratory and then confirmatory factor analyses were used to identify representational constructs. Structural equation modeling quantified CSM relationships between information sources, representational constructs and outcomes and fit the data well ($X2/df = 1.89$, RMSEA = .041). External sources of information had a standardized total effect of .64 and experiential sources of .40 on protective behavior. The CSM illustrated how information sources were integrated to influence representations and outcomes, and explained 81% and 52% of the variance in water safety judgments and protective behavior respectively.

Keywords: arsenic well testing, program evaluation, risk communication

*Note: This is a student presentation.

BANQUET SPEAKER
Tom Lochner, Executive Director
Wisconsin State Cranberry Growers Association
Thursday, March 4, 2004
8 pm

Title: Wisconsin's Cranberry Industry: A description of the history, methods and economics of this unique agricultural industry

Tom Lochner serves as the Executive Director for the Wisconsin State Cranberry Growers Association. He has held that position since July of 1989. The WSCGA was formed in 1887 to provide educational programs for Wisconsin cranberry growers and to represent their interests. Today the association coordinates research and education programs for growers, policy makers and members of the general public. He also serves as the Executive Director of the Wisconsin Cranberry Board, Inc. which administers the state's Cranberry Marketing Order. WCB funds research, education, and promotion programs on behalf of Wisconsin's cranberry growers. Lochner is also Executive Director of the Cranberry Museum, Inc., a non-profit organization that operates a museum dedicated to the historical and contemporary aspects of cranberry growing in Wisconsin. Prior to joining the WSCGA Mr. Lochner held a variety of positions on the staff of the Wisconsin Farm Bureau Federation from 1978 through 1989, the last of which was Director of Governmental Relations.

Lochner is a native of Prairie du Chien, Wisconsin, and a life resident of the state. He received a Bachelor of Science Degree from UW Madison in 1977 with a major in Agriculture Economics. He is a life member in WALSAA, a member of the UW Madison Horticulture Advisory Committee, Natural Resources Foundation of Wisconsin Board of Directors, a member of the American Society of Association Executives and was the recipient of a McCloy Fellowship from the American Council on Germany in 1988.

SESSION 5
Groundwater Contaminants
Friday, March 5, 2004
8:00-9:40 am

Geochemical and Environmental Controls on Arsenic in Groundwater Near Lake Geneva, Wisconsin

T. L. Root, University of Wisconsin – Madison
Dept. of Geology and Geophysics, 1215 W. Dayton St., Madison, WI 53706, tara@geology.wisc.edu
J.M. Bahr, UW – Madison
Dept. of Geology and Geophysics, 1215 W. Dayton St., Madison, WI 53706, jmbahr@geology.wisc.edu
M.B. Gotkowitz, Wisconsin Geological and Natural History Survey
3817 Mineral Point Road, Madison, Wisconsin 53705, mbgotkow@facstaff.wisc.edu

Water from approximately 15% of wells open to glacial and upper bedrock aquifers near the town of Lake Geneva in southeastern Wisconsin has arsenic concentrations above the U.S. Environmental Protection Agency standard of 10 ppb. Maximum arsenic concentrations are approximately 100 ppb. This paper discusses efforts to characterize natural arsenic sources and geochemical and environmental controls on arsenic mobility in the impacted aquifers.

Geochemical analyses of core samples suggest that the primary source(s) of arsenic is 1) arsenic associated with organic matter in sand and gravel deposits, 2) arsenic associated with clays in dissolution openings at the bedrock surface, and/or 3) low levels of arsenic dispersed throughout clay and silt units in the glacial deposits. We are conducting selective extractions to further characterize the solid phase associations of arsenic in these core samples. Initial results of the extractions indicate that the majority of the arsenic is associated with oxide minerals.

There are no arsenic-impacted wells completed at shallow depths, and the chemical signatures of groundwater samples from shallow wells are distinctly different than those from deeper wells. These chemical signatures and the results of a pumping test suggest that there is minimal groundwater movement between the deeper, arsenic-impacted groundwater system and the shallower non-impacted system. Reducing conditions occur in the deeper flow system, and the combined core chemistry and water chemistry data suggest that arsenic is being mobilized via the reductive dissolution of oxides or reductive desorption of arsenic from clay minerals or oxides.

Keywords: arsenic, groundwater, geochemistry, Southeastern Wisconsin

*Note: This is a student presentation.

Viruses, Hormones, Pharmaceuticals, and other Household Products as Potential Groundwater Contaminants from On-site Wastewater Treatment Systems

J. D. Wilcox, University of Wisconsin-Madison
Department of Geology and Geophysics, 1215 W. Dayton St., Madison, WI 53706, jwilcox@geology.wisc.edu
J.M. Bahr, University of Wisconsin-Madison
Department of Geology and Geophysics, jmbahr@geology.wisc.edu
K.R. Bradbury, Wisconsin Geological and Natural History Survey
3817 Mineral Point Rd., Madison, WI 53705, krbradbu@facstaff.wisc.edu

Population growth and urban expansion in many areas have resulted in residential development on formerly agricultural land. To document the effects of this land-use conversion on groundwater quality, we initiated a monitoring program to collect water-quality data before, during, and after construction of a new, unsewered subdivision on agricultural land several miles outside of Madison, Wisconsin.

Pre-construction groundwater quality varies in space and time and shows the effects of agricultural land use and nearby highway salting. High background nitrate and chloride concentrations may make it difficult to detect any future release of these contaminants from septic systems, lawn fertilization, or storm runoff once homes are built. However, septic systems can also release viruses, hormones, pharmaceuticals, and other household products to the environment. These contaminants may not only be better indicators of human waste in groundwater than nitrate or chloride, but they may also pose larger threats to groundwater quality and public health.

This talk will include background information regarding pharmaceuticals and other personal care products (PPCPs) in the environment, discuss the potential release of these compounds from on-site wastewater treatment systems, and share preliminary results.

Keywords: pharmaceuticals, hormones, land use, nitrate, septic systems

*Note: This is a student presentation.

Susceptibility of Municipal Wells in La Crosse, Wisconsin to Enteric Virus Contamination from Surface Water Contributions

Mark Borchardt, Marshfield Clinic Research Foundation
Marshfield, WI, borchardt.mark@mcrf.mfldclin.edu
Randall Hunt, United States Geological Survey
8505 Research Way, Middleton, WI, rjhunt@usgs.gov
Nathaniel Haas, Marshfield Clinic Research Foundation
Marshfield, WI and the University of Wisconsin-La Crosse, La Crosse, WI
Phillip Bertz, Marshfield Clinic Research Foundation
Marshfield, WI
Susan Spencer, Marshfield Clinic Research Foundation
Marshfield, WI

One-half of groundwater related disease outbreaks are attributed to viruses, but few studies have examined viral occurrence in groundwater in relation to routes of contamination. The objective of this study was to relate the occurrence of enteric viruses in the municipal well water from sand-gravel aquifers in La Crosse, WI, to surface water contributions from the Mississippi River.

One river site and four municipal wells predicted from previous hydrogeological modeling to receive low (one well), high (one well), and intermediate (two wells) levels of surface water contributions were sampled monthly from March 2001 to February 2002. Samples were analyzed for four groups of human enteric viruses and microbial indicators of sanitary quality. Surface water contributions were determined from O18/O16 and 2H/1H ratios. All samples were taken prior to chlorination at the wellhead.

Of 48 well samples analyzed by reverse-transcription PCR for enteric viruses, 24 (50%) were positive. Viruses identified included rotavirus, enteroviruses, hepatitis A virus (HAV), and noroviruses. Enterovirus cell cultures were negative, suggesting that they were non-viable. Three samples were positive, however, for infectious HAV as determined by cell culture. None of the well samples were positive for indicators of sanitary quality.

Viruses were found in all wells, regardless of the amount of surface water contributions, suggesting there were other unidentified sources, in addition to surface water, responsible for the virus contamination. The public health ramifications of these results are uncertain as the research objective called for sampling before chlorination, which may have inactivated any viruses not degraded during transport in the groundwater system.

Keywords: bank filtration, drinking water, enteric viruses, groundwater, water isotopes

Groundwater Nitrate and Pesticide Penetration and Trends: The Springfield Corners Profile

G. J. Kraft, University of Wisconsin - Stevens Point
College of Natural Resources, Stevens Point, WI 54481, gkraft@uwsp.edu
W. M. DeVita, University of Wisconsin - Stevens Point
College of Natural Resources, Stevens Point, WI 54481. wdevita@uwsp.edu
B.A. Browne, University of Wisconsin - Stevens Point
College of Natural Resources, Stevens Point, WI 54481, bbrowne@uwsp.edu

Nitrate and pesticide residues are the major pollutants of Wisconsin's groundwater. An estimated 14% of Wisconsin's wells exceed the nitrate drinking water standard and 38% contain the residues of at least on pesticide. Agriculture is by far the largest source of these pollutants. The rise of nitrate and pesticide groundwater pollution coincides with the increase in commercial fertilizer and pesticide use that began in about 1960 and leveled off in the 1980s.

A key need is to determine long-term nitrate and pesticide future for Wisconsin aquifers. Are aquifers becoming more highly polluted as older, cleaner groundwater leaves the aquifer and is replaced by younger, pollutant-laden recharge? Or do denitrification and degradation processes

limit the penetration of agrichemicals into aquifers? We previously investigated these questions by monitoring along a flowpath in an agricultural groundwater basin near the Town of Stockton on the Wisconsin Central Sand Plain (WCSP). There, we determined that nitrate and pesticide residues generally penetrated the entire saturated thickness, with the exception of a few pockets of older water, and that nitrate was conserved.

We wish to contrast the results of the WCSP study with other agricultural locales in Wisconsin. The present study examines nitrate and pesticide conditions in the groundwater of the Six Mile and Pheasant Branch Creeks Watershed near Springfield Corners, 11 miles northwest of Madison. The Springfield Corners site consists of 30 m of sandy clay glacial till overlying a 90m thick upper bedrock aquifer (Tunnel City and Wonewoc Formations). Below the upper bedrock aquifer is a 10m-thick confining unit (Eau Claire Formation) and a lower bedrock aquifer (Mt. Simon Sandstone).

We obtained groundwater samples from an open borehole in the upper bedrock aquifer using a packer assembly to isolate 3m intervals. These were subject to analysis for general geochemistry, major ions, nutrients, metals, pesticides, nitrate 15N and 18O, and CFCs for determining groundwater age. In this study, we examine how groundwater age varies with depth along with nitrate and pesticide contamination. Groundwater age dates ranged from 1985 (top of unit) to 1962 (bottom). Nitrate and pesticide concentrations were greatest in shallower, younger groundwater. Denitrification averaged 3 mg L-1 NO3-N, or 38% of the nitrate load.

Keywords: nitrate, pesticides, groundwater, age-dating.

Groundwater Denitrification: The Springfield Corners Vertical Profile

B. A. Browne, B.A. University of Wisconsin – Stevens Point
Water & Soil Resources, CNR Dissolved Gas Laboratory, bbrowne@uwsp.edu
G.J. Kraft, University of Wisconsin – Stevens Point
Center for Watershed Science and Education, Stevens Point, gkraft@uwsp.edu
W. M. DeVita, University of Wisconsin – Stevens Point
Water and Environmental Analysis Laboratory, College of Natural Resources, Stevens Point, WI 54481, wdevita@uwsp.edu

The import of fixed N into agricultural landscapes over the last four decades has inadvertently harmed groundwater, surface water and atmospheric quality. Groundwater denitrification generally lessens the severity of harm because the transformation of nitrate to nitrogenous gases (N2, N2O) lowers the nitrate concentration in groundwater and coincidently reduces the amount discharged to rivers and streams. However, the excess burden of nitrogenous gases produced in groundwater by denitrification is not without impact. Although dissolved N2 gas is under most conditions relatively harmless, the groundwater burden of nitrous oxide carried into rivers and streams potentially contributes to global warming when it evades surface water and escapes to the atmosphere.

In this paper we present patterns of nitrate and other dissolved constituents, dissolved gases (N2, N2O, O2, CH4, CO2, others) and apparent CFC-age-dates in a detailed vertical ground water profile in the Six Mile and Pheasant Branch Creeks Watershed near Springfield Corners, 11

miles northwest of Madison. The Springfield Corners site consists of 30 m of sandy clay glacial till overlying a 90m thick upper bedrock aquifer (Tunnel City and Wonewoc Formations). Below the upper bedrock aquifer is a 10m-thick confining unit (Eau Claire Formation) and a lower bedrock aquifer (Mt. Simon Sandstone).

The burden of excess N2 and the progress of denitrification (defined as the percent of nitrate transformed to nitrogenous gases) were largely independent of depth, apparent CFC age-date, and the concentration of nitrate. In addition, the production of excess N2 was negatively correlated with dissolved oxygen. In contrast, the excess burden of N2O decreased systematically with increasing depth and apparent groundwater age. Moreover, N2O was largely independent of dissolved oxygen and was strongly and positively correlated with the nitrate concentration (a pattern more consistent with nitrification than denitrification). We consider our findings in relation to historical fertilizer N records and discuss them in relation to the results of other groundwater denitrification studies.

Keywords: excess N2 gas, nitrous oxide, nitrate, apparent CFC age-dates

SESSION 6
Surface Water Studies
Friday, March 5, 2004
8:00-9:40 am

Trends in Boating Use on Geneva Lake

A. R. Bock, University of Wisconsin – Stevens Point
2532 Stanley Street, Stevens Point, abock010@uwsp.edu
T. W. Peters, Geneva Lake Environmental Agency
Director, P. O. Box 306, Lake Geneva, Wisconsin 53147, glea@genevaonline.com

Geneva Lake is one of the most popular spots in the Midwest for many types of recreational activities due to its size, aesthetics, and driving distance from several large metropolitan areas. The physical characteristics of the lake make it one of the most suitable for boating. As development around the lake and the area has increased, so has the number of boats and boating use. One of the most important issues facing Geneva Lake is recreational use and how to best manage those uses to minimize user conflict. Since the lake is such a highly valued resource in the region, management for minimal user conflict should be a high priority goal. The purpose of this project is to evaluate the boating use patterns and densities on Geneva Lake. The study found that the number of boats in operation on the lake during peak use was within range of the recommended boating densities for optimal boating capacity, but the range has the potential to be exceeded. In addition to quantifying boat access through municipal launches, better information regarding access to the lake, especially with an increase in the number of private launching services will have to be considered into future lake management plans regarding recreational use.

Keywords: Geneva Lake, user conflict, recreational use, recreational carrying capacity

*Note: This is a student presentation.

Increased Diatom Colony Size Induced by a Chemical Cue from Daphnia

L.A. Pansch, St Norbert College
100 Grant St. Suite 1715, De Pere, WI 54115, lori.pansch@snc.edu
D. J. Poister, St. Norbert College
100 Grant St., De Pere, WI 54115, david.poister@snc.edu

Aulacoseira is a centric, colonial diatom common in temperate lakes during spring and early summer. Typically, Aulacoseira forms long, straight colonies of six to eight cells. At the end of May 2002, Aulacoseira growing in Trout Lake (Vilas County, WI) formed colonies with an average length of 14 cells. Results from laboratory experiments suggest that increases in Aulacoseira colony size, such as those observed in Trout Lake, can be induced by an infochemical signal produced by grazing zooplankton. Adult Daphnia were added to cultures of a variety of small phytoplankton. Following a 24-hour grazing period, the infochemical was isolated from the culture media using solid-phase extraction. An aqueous solution of the extract was then added incrementally to newly inoculated Aulacoseira cultures. The total abundance and average size of the diatom colonies was monitored for 20 days. Aulacoseira colony size

showed a significant increase when exposed to the infochemical released by grazing Daphnia, relative to controls.

Keywords: Aulacoseira, phytoplankton, morphological plasticity, diatom

*Note: This is a student presentation.

2003 PBDE Levels in Lake Michigan Fish

J. Hahm, University of Wisconsin-Madison
Environmental Chemistry and Technology Program, 660 N. Park, Madison, 53706, jlhahm@wisc.edu
J. B. Manchester-Neesvig, University of Wisconsin-Madison
Environmental Chemistry and Technology Program, 660 N. Park, Madison, 53706, manchest@engr.wisc.edu
W. C. Sonzogni, University of Wisconsin-Madison
Wisconsin Laboratory of Hygiene, P.O. Box 7996, Madison, 53707, sonzogni@wisc.edu

Polybrominated diphenyl ethers (PBDEs) are flame retardants used in polyurethane foam, textiles and electronic housings. First reported in 1979, they are now found in most environmental compartments over a wide geographic range. PBDE levels in human breast milk have about doubled every five years over the past 25 years. Production of lesser-brominated PBDEs is being phased out due to concerns that the chemicals cause thyroid disruption and developmental defects, and possible carcinogenity. As part of our research on PBDEs in different levels of the Lake Michigan food web, we have studied PBDEs in both planktivorous and piscivorous fish. Bloater chubs (Coregonus hoyi), alewifes (Alosa pseudoharengus) and slimey sculpins (Cottus cognatus) contain the five main PBDE congeners commonly reported. Fourhorn sculpins (Myoxocephalus thompsoni) contained four of the major congeners, but surprisingly, lacked BDE-99. Forage fish harvested from the Sturgeon Bay area (opposite side of the lake from Grand haven) have about the same total PBDE concentration of those taken from Grand Haven, but do show a difference in congener profile. Degradation of highly brominated PBDEs to the more toxic lower brominated ones is of great interest as the completely brominated from of BDE continues in use.

Keywords: polybrominated diphenyl ethers, PBDEs, toxic substances, Lake Michigan

*Note: This is a student paper.

Speciation Controls on the Fate and Transport of Mercury and Methylmercury across Biogeochemical Gradients

S. P. Chadwick, University of Wisconsin – Madison
Environmental Chemistry and Technology Program, 660 N. Park St., Madison, WI 53706, spchadwick@wisc.edu
C. L. Babiarz, University of Wisconsin – Madison
Environmental Chemistry and Technology Program, 660 N. Park St., Madison, WI 53706

J. P. Hurley, University of Wisconsin – Madison
Aquatic Sciences Center, Madison, WI 53706; Environmental Chemistry and Technology Program, 660 N. Park St., Madison, WI, hurley@aqua.wisc.edu
D. E. Armstrong, University of Wisconsin – Madison
Environmental Chemistry and Technology Program, 660 N. Park St., Madison, WI 53706

As part of the "Mercury Experiment to Assess Atmospheric Loading in Canada and the United States" (METAALICUS), the biogeochemical cycling of mercury (Hg) and methylmercury (MeHg) is being investigated to better understand the relationship between atmospheric loading and bioaccumulation. Lake 658, an 8-hectacre first-order boreal lake, was dosed bi-monthly with stable 202Hg during the summers of 2001-2003 at a loading 4-5 times the normal annual wet deposition (4-5 ug/m2/year). Preliminary results from deployed sedimentation traps indicated that both inorganic 202Hg and 202MeHg were being delivered to the sediment-water interface by settling particulate matter and that the newly-deposited Hg and MeHg was being actively recycled in the hypolimnion. The hypolimnetic cycling of Hg and MeHg is hypothesized to be controlled by organic and inorganic aqueous phase speciation (e.g. sulfide, S-containing DOM) and solid-phase partitioning. However, the relative role of iron/manganese oxides, DOM, and sulfide species in controlling the fate and transport of Hg and MeHg in the hypolimnion is poorly understood. Selective resins (e.g. DEAE, Chelex-100) were used to better understand the changes in speciation of Hg and MeHg across critical biogeochemical gradients (e.g. oxic/anoxic, sulfate/sulfide). The use of selective resins and intensive sampling at characterized biogeochemical gradients allows a better understanding of the role of specific ligands controlling the fate and transport of Hg and MeHg near the sediment-water interface.

Keywords: mercury, methylmercury, fate, transport, speciation

*Note: This a student presentation.

Role of the Hyporheic Zone in Methylmercury Production and Transport to Allequash Creek

M. H. Meyer, University of Wisconsin-Madison
Graduate Student and Research Assistant, Environmental Chemistry and Technology Program, 660 North Park Street, Madison, WI 53719; mhmeyer2@wisc.edu

One mechanism for watershed methylmercury (MeHg) production occurs through biological methylation of inorganic mercury by the activity of sulfate-reducing bacteria found in the hyporheic sediment zone of streams and rivers. Subsequent concentrations of MeHg are a function of the balance between production and removal rates as well as transport processes. Previously, rates of methylation were determined using radiotracer methods. Advanced techniques in low-level isotopic mass spectrometry now allow for the determination of coexistent methylation and demethylation rates within single samples.

The area of study includes two distinct and hydrogeologically well-characterized areas of the Allequash Creek watershed located in Vilas County, WI, USA. Levels of MeHg in the ground water are near the level of detection, yet hyporheic pore-water profiles in hydrologically

upwelling zones show significant concentrations of MeHg, greater even than the levels found in the surface water. Differences in ancillary and co-collected samples in the stream, ground water and hyporheic zones reflect the biogeochemical regime changes occurring in these hyporheic sediment profiles.

Methylation and demethylation rates determined by stable 201HgCl2 and 199MeHgCl isotopic additions and incubations show the capacity for MeHg enrichment in this system. The contribution of hyporheic zone methylation to the watershed concentrations of MeHg may impact significantly the amount of mercury rendered bioavailable in the associated aquatic food webs.

Keywords: hyporheic zone, methylation rates, isotopic analysis

*Note: This is a student presentation.

SESSION 7
Groundwater Studies
Friday, March 5, 2004
10:00-11:40 am

Simulating Impacts of Land Use and Groundwater Flow on the Temperature of Wisconsin Trout Streams

S. J. Gaffield, Wisconsin Geological and Natural History Survey
3817 Mineral Point Road, Madison, WI 53705, gaffield@wisc.edu
T.W. Rayne, Hamilton College
Clinton, NY, trayne@hamilton.edu
K.R. Bradbury, Wisconsin Geological and Natural History Survey
3817 Mineral Point Road, Madison, WI, krbradbu@facstaff.wisc.edu
L. Wang, Michigan Department of Natural Resources
Institute for Fisheries Research, Ann Arbor, MI, wangl@michigan.gov

Groundwater discharge to streams is critical for maintaining coldwater fisheries. Currently, a lack of detailed understanding of the controls over summer stream temperature makes habitat management difficult. Using field data from Wisconsin, we evaluated the utility of models of stream temperature, groundwater flow, and groundwater recharge as decision-making tools for stream and watershed management.

Our stream-temperature model is designed to predict water temperature as a function of groundwater inflow, channel shape, weather conditions, and shade from riparian vegetation, and was adapted from existing codes SSTEMP and SNTEMP. We tested model parameters previously calibrated for the Driftless Area to determine their suitability for use in the Northern Lakes and Forests, the North-Central Hardwood Forest, and the Southeast Wisconsin Till Plain Ecoregions of Wisconsin. Model simulations were compared to field data collected from five streams in the summer of 2001. The stream-temperature model matched measured temperatures for three streams reasonably well, but it performed poorly for two streams with extensive wetlands, where model assumptions may not be valid. Our stream-temperature model is well suited for assessment of many small Wisconsin streams; however, more research is needed to determine the best approach for simulating the temperature of streams flowing through large wetlands.

For the Rowan Creek watershed in Columbia County, we linked the stream-temperature model to a groundwater recharge model and a groundwater flow model. By using these three models jointly, we evaluated the impact of future land-use changes on the infiltration of rain and snowmelt into the soil, stream baseflow supplied by the groundwater flow system, and stream temperature. The models predicted changes in stream temperature of up to 0.8□C related to drought, conversion from native vegetation to agricultural land use, and groundwater extraction from a well near the stream. Simulations of increased urban and suburban land covers predicted little change in temperature. Although the linked models indicate that daily mean stream temperature is somewhat insensitive to changes in the groundwater flow system related to human

activities, daily maximum temperature is likely to be more sensitive. Furthermore, human land use can have numerous other impacts on stream habitat that are not represented by our models, including changes in channel width, burial of pools and gravel spawning beds by sediment, and inflows of runoff heated by paved surfaces.

Keywords: Stream temperature, groundwater, recharge, land use, coldwater fisheries, mathematical models

Ground-Water Modeling Investigation Of Lockport Prairie Nature Preserve, Lockport, Illinois

G. B. Parish, Graef, Anhalt, Schloemer & Associates
geoffrey.parish@gasai,com

The primary objective of this modeling investigation was to develop an understanding of the ground-water flow system supplying Lockport Prairie Nature Preserve (LPNP), Lockport, Illinois using ground-water modeling techniques. Effective protection of sensitive natural areas that depend on ground water is difficult if the flow systems supporting them are not defined. This study used interpretive models of the ground water flow system to test system conceptualization and sensitivities of the recharge area to model input parameters. Significant hydrogeologic features include the Des Plaines River to the east, the Du Page River to the west, municipal supply wells, bedrock quarries and ground-water seeps within LPNP. Glacial deposits in the area are generally Wedron Formation tills and Henry Formation outwash. Silurian dolomites cover most of Will County, including recharge area of LPNP.
Modeled ground-water discharge and extent of the recharge area were sensitive to changes in the uppermost rock units and the presence of wells and quarries. Modeled seep discharge was sensitive to changes in the Henry Formation. In certain configurations recharge from east of the Des Plaines River reached LPNP. The modeled recharge area differed in extent from the recharge area interpreted from the published historical potentiometric contours. The differences likely relate to the three dimensional nature of the flow field, impact of surface water features on the flow patterns and the data used to construct regional contour maps.

Keywords: groundwater, modeling, recharge area, ground-water seeps

The Influence of Glacial Till, Outwash, and Lacustrine Deposits on Lakes, Streams, and Groundwater in the Menominee Indian Reservation, Wisconsin

G. F. Howlett Jr., Menominee Indian Tribe of Wisconsin
Environmental Scientist, Box 910, Keshena, WI 54135
C. P. Dunning, U. S. Geological Survey
8505 Research Way, Middleton, WI 59562. cdunning@usgs.gov

Six glacial advances pushed westerly across the Menominee Reservation from the core of the Green Bay Lobe, Wisconsin Age Glacier, during two periods of glacial advance and retreat. Both the Horicon Formation advances (western) and the Kewaunee Formation advances (eastern) deposited Ca(Mg)CO3 in the drift after riding over two dolomite formations, carrying dolostone fragments along with large amounts of sand from intervening sandstone formations and clay

derived from feldspar rich granite in the central path of the Green Bay Lobe. The Kewaunee Formation advance through Upper Michigan cut down to iron and manganese rich deposits that it carried south and then spread west in the drift. Waters originating in the Kewaunee Formation release significant amounts of reduced iron to wells and to surface waters. All waters originating in the deeper tills (the advances), both groundwater and surface water, run high in carbonate hardness. Upper Bass L. in the Upper West Branch of the Wolf River averages 180mg/L CaCO3 equivalent. Water leached through carbonate rich till in the Elderon Phase 1 advance exits from springs to carry very hard water to this lake. Surficial sandy outwash deposits are leached of Ca/MgCO3. Shallow lakes and shallow groundwater sources run lower in hardness. A rainwater dependent lake in sandy outwash runs 2-3 mg/L CaCO3 equivalent.

On the reservation's eastern edge, deep sandy outwash in the Silvercliff Member, Late Mountain Phase, Kewaunee Formation, was covered by a clay confining layer during an early Glacial Lake Oshkosh stage. Later sandy outwash now covers the confining layer. Rainwater, leaching through Mountain Phase upland till in the glacial aquifer is restrained by impermeable bedrock. Rather, it moves down gradient eastward. It flows under the confining layer of the old glacial lake and exits as oxygen deficient hard water to artesian springs. Where deeper glacier formed lakes cut through the confining layer, a flowthrough condition exists. These lakes run high in carbonate hardness and electroconductivity, and are rapidly depleted of dissolved oxygen after turnover due to oxygen deficient groundwater flowthrough. Reduced Fe and Mn builds up in the lake bottoms. The reduced metals appear in wells placed in the Kewaunee Formation drift, and also surface in springs to outlet streams. Eastern reservation wells benefit from iron filters.

Glacial fronts run high in clay. Wells drilled into the fronts may need to be drilled into the granitic bedrock (present over the entire reservation), where yield can be as low as 1 gpm. The clay dominated fronts retard eastward movement of groundwater. Some groundwater under the confining layer, restrained by the Athelstane Advance, moves south. The main well in Keshena, under confining head pressure, drilled out artesian at 600 gpm. The fronts also constrain streams, forcing them to run parallel to the front until a break is found. The main Wolf River runs parallel to and then crosses 2 fronts of the Kewaunee Formation.

Keywords: glacial advance, glacial lake, groundwater, surface water, confining layer.

Using Time-domain Electromagnetics to Map the Transition of an Aquifer to an Aquitard

D. J. Hart, Wisconsin Geological and Natural History Survey
3817 Mineral Point Road, Madison, WI, djhart@wisc.edu
C.L. Thomas, Wisconsin Geological and Natural History Survey
3817 Mineral Point Road, Madison, WI, curtisthomas@wisc.edu

The Eau Claire Formation transitions from a sandstone aquifer to a shale aquitard (the Eau Claire shale) in southern Wisconsin. In addition, the thickness of the Eau Claire shale varies considerably in southern and western Wisconsin; it is more than 100 feet in western Dane and eastern Iowa Counties, but is absent in central Sauk and eastern Dane Counties. Understanding the nature of this variation is important for construction and calibration of groundwater flow models.

We examined the well logs on file at the Wisconsin Geological and Natural History Survey that intersect the Eau Claire Formation; the one available well log for Spring Green in Sauk County showed no shale; two well logs for Arena in Iowa County showed the thickness of the shale to be 100 feet. We found no additional logs for wells that intersect the Eau Claire Formation between the two locations. Using well logs alone, we could not determine the nature of the transition between the two areas.

We used a geophysical method, time-domain electromagnetics (TEM), to map the transition on a 10-mile transect from Spring Green in Sauk County east to Arena. Our TEM survey agreed with the well logs in Spring Green and Arena and showed a gradual change from no shale in Spring Green to 100 feet of shale in Arena: We were able to test and reject the possibility of a sharp, perhaps erosional, contact. However, the method was unable to distinguish between a gradual thickening of the shale and a gradual increase in the content of clay minerals over the final 100-foot interval of the shale. We do know that the amount of shale increases gradually over the 10-mile line, resulting in a gradual, not sharp, decrease of hydraulic conductivity. The TEM results can be used to develop better geologic models of the Eau Claire Formation; incorporating the transitional nature of the sandstone to shale in this formation will provide more realistic groundwater flow simulations.

Keywords: aquitard, geophysics, time domain electromagnetics, Eau Claire Formation

Vertical Distribution of Hydraulic Conductivity in Cambrian Sandstones near Madison, Wisconsin

K. R. Bradbury, Wisconsin Geological and Natural History Survey
3817 Mineral Point Road, Madison, WI, krbradbu@facstaff.wisc.edu
D. J. Hart, Wisconsin Geological and Natural History Survey
Madison, WI, djhart@wisc.edu
D. L. LePain, Wisconsin Geological and Natural History Survey
Madison, WI, dllepain@wisc.edu

Cambrian sandstone formations in south-central Wisconsin compose the regionally important "sandstone" aquifer, which is generally assumed to be a classic porous medium having low heterogeneity and anisotropy and high porosity and transmissivity. However, recent lithologic, hydraulic, and geophysical data collected from a deep borehole near Cottage Grove, Wisconsin suggest that the sandstones there, and probably over larger areas, contain much greater vertical heterogeneity than is generally assumed.

In cooperation with scientists from the University of Waterloo, Ontario, we have obtained and described continuous bedrock core from a 500-ft deep borehole penetrating the Jordan, St. Lawrence, Tunnel City, Wonewoc, Eau Claire, and Mount Simon Formations. Lithologies in the core include clean, well sorted, poorly to moderately cemented sandstone with much visible matrix porosity; well cemented sandstone with little or no visible matrix porosity; and moderately to well indurated siltstone and shale. Siltstone and shale are thin, discontinuous drapes within sandstone-dominated successions.

We conducted continuous hydraulic conductivity (K) tests over the entire borehole using short-interval (2.2 ft) straddle packers. The hydraulic test results demonstrate large heterogeneity in K even within the sandstone units. The K values in the Mount Simon and Wonewoc sandstones range over two orders of magnitude, from 0.1 to 30 ft/day; values in the heterogeneous Tunnel City Formation range from less than 0.1 ft/day in unfractured intervals to more than 100 ft/day in bedding-plane fractures.

The large heterogeneity implies that groundwater flow and solute transport through these sandstones are focused in the higher-K intervals. Groundwater velocities through these high-K parts of the sandstones can be orders of magnitude higher than predicted by analyses that lump the sandstones into single homogeneous units.

Keywords: aquifers, heterogeneity, hydraulic conductivity

SESSION 8
Water Management
Friday, March 5, 2004
10:00-11:40 am

Chemical Terrorism Preparedness and Environmental Resources- Dual Role for State Laboratories

W. C. Sonzogni, Wisconsin Laboratory of Hygiene
P.O. Box 7996, University of Wisconsin-Madison, 53707, sonzogni@wisc.edu
D. D. Degenhardt, Wisconsin Laboratory of Hygiene
P.O. Box 7996, University of Wisconsin-Madison, 53707, davidd@mail.slh.wisc.edu

Because of the urgent need to combat terrorism, states have been asked to strengthen their ability to respond to terrorism events. Through federal agencies such as the Center for Disease Control and the Department of Homeland Security, funds have been passed back to the states for this purpose. A basic premise in using this money is that of dual use- namely, that preparing for terrorism also provides opportunity for strengthening the public and environmental health infrastructure. From a laboratory perspective, state facilities have obtained new equipment for use in dealing with biological and chemical terrorism events. At the WI Laboratory of Hygiene, chemical preparedness initiatives resulted in the acquisition of several new instruments, including a microscope equipped Fourier transform infrared analyzer (FTIR), a gas chromatograph- mass spectrometer fashioned for air sample analyses, two gamma radiation spectrophotometers, a liquid chromatograph with tandem mass spectrometer detectors (HPLC-MS-MS), and two inductively coupled plasma mass spectrometers (including a high resolution ICP-MS). These new instruments provide advanced capabilities in dealing with terrorism and other emergencies, but also for analyzing samples necessary for protecting or managing public and environmental health. These samples can be from a variety of matrices, including human blood and tissue, and can cover a wide range of toxic substances, including the here-to-for largely ignored polar organic pollutants.

Keywords: chemical terrorism, emergency response, public health, environment, analytical chemistry

Using an Ecological Currency Approach to Measure Resource Improvements in Southeastern Wisconsin

B. A. Brown, CH2M HILL
135 S. 84th Street, Suite 325, Milwaukee, WI 53214 brent.brown@ch2m.com

The Great Lakes Basin is an important but degraded natural resource. To protect this resource while still allowing for economic development, there must be a fair and defensible process for governing decisions on new/increased water withdrawals. The foundation for this process is established in the Great Lakes Charter Annex of 2001.

The Great Lakes Charter Annex is a blueprint for creating resource management programs over the next several years. This innovative standard is based upon the principles of improving the waters and water-dependent natural resources of the Great Lakes Basin and causing no significant adverse impact to the same.

The objective of this research was to relate the implementation of the resource improvement standard to a case study example of providing resource improvement. The case study, demonstrated in Waukesha Wisconsin, evaluated three candidate resource improvement alternatives that were proposed to satisfy the improvement requirements of the Annex. The values of the resource improvements were quantified using a service-to-service approach, which measures natural resource service gains and losses in ecological units or "currencies". The service-to-service valuation approach for quantifying gains and losses in ecological service flows (i.e., Habitat Equivalency Analysis) supports decisions on the extent of an action needed to go beyond mitigation and to generate a net gain or resource improvement.

Keywords: ecological currency, habitat equivalency analysis, resource improvement, net environmental benefit analysis (NEBA)

Restoration of Devil's Lake (Sauk County, Wisconsin) by Hypolimnetic Withdrawal

R. C. Lathrop, Wis. Dept. of Natural Resources
c/o UW Center for Limnology, 680 N. Park St., Madison, WI, 53706, rlathrop@wisc.edu
T.J. Astfalk, Mead & Hunt, Inc.
6501 Watts Rd., Madison, WI 53719
J.C. Panuska, Wis. Dept. of Natural Resources
P. O. Box 7921, Madison, WI 53707, panusj@dnr.state.wi.us
D.W. Marshall, Wis Dept. of Natural Resources
1350 Femrite Center, Monona, WI 53716, marshd@dnr.state.wi.us

A 5,500-foot siphon (20-inch O.D. HDPE pipe) was installed during 2002 in Devil's Lake, Wisconsin to withdraw P-rich hypolimnetic water from early September until turnover in mid-October over a 15-year period. The purpose of the withdrawals is to reduce internal P recycling from the lake's deep-water sediments, thus leading to a reduction in algae (planktonic, filamentous, and periphyton) with hoped-for reductions in fish mercury concentrations and swimmer's itch. The total project budget was $310,000 ($200,000 State Lake Protection Grant; $100,000 EPA Clean Lakes grant; $10,000 local/state parks grant). The lake portion of the siphon (4,150 ft) has 320-pound concrete weights attached every 12 feet from shore to the lake's deepest spot (~14 m). The intake is a 50-foot pipe section (end capped) with holes drilled along each side. On land the pipe was trenched with manholes located at the pipe's highest point and at the siphon terminus near the main flow valve. A flow meter and air evacuation system for priming the siphon are located at the upper manhole. To replace the withdrawn water, clean runoff water from the intermittent stream is being diverted to the lake using an historic diversion system that was refurbished in October 2003. During the first year of hypolimnetic withdrawals in 2002, the flow rate and P concentration averaged 5.3 cfs and 0.725 mg/L, respectively, resulting in 446 kg of P being removed from the lake. Our presentation will showcase the hypolimnetic withdrawal system along with operational data for 2002 and 2003.

Keywords: hypolimnetic withdrawal, phosphorus, Devil's Lake

Factors Affecting Variability in Flow in the Little Plover River

N. Earl Spangenberg, University of Wisconsin-Stevens Point
College of Natural Resources, Stevens Point, WI 54481, espangen@uwsp.edu

September 2003 flow in the Little Plover River appeared to be lower than it had been in many years. Anecdotal observations indicated that the flow was ". . . lower than it has been in thirty years." Stream flow was measured and compared with data gathered during the 1960 – 1986 period when a recording stream gauge was installed on the river. The measured value was well below the lowest flow recorded on the river during the period of gauging record. Regional climatic and stream flow records were examined and compared to Little Plover flow. These data indicated that while regional values for September 2003 were low, they were not as low as the lowest recorded values for either regional precipitation or stream flow on nearby rivers for the period 1960 – 1986. Stream flow and climatic data for the 1960 – 1986 period of record were used to determine that the measured stream flow measured in September on the Little Plover River was thirty percent of what would have been expected, based on the 1960 – 1986 data. Some possible reasons for the difference are suggested.

Keywords: stream flow, Little Plover River, gauging station, surface water

Use of Surface Waters From Lake Mendota for Cogeneration Electric Power Facility

J. M. Jaeckels, BT 2, Inc.
Principal, 2830 Dairy Drive, Madison, Wisconsin 53718, jjaeckels@bt2inc.com
J. C. Kucher, BT 2, Inc.,
Senior Engineer, 2830 Dairy Drive, Madison, Wisconsin 53718, jkucher@bt2inc.com
K. G. Johnson, Wisconsin Department of Natural Resources
Lower Rock River Water Leader, 3911 Fish Hatchery Road, Fitchburg, Wisconsin 53711, kenneth.johnson@dnr.state.wi.us
S. G. Josheff, Wisconsin Department of Natural Resources
Rock River Basin Engineer, 3911 Fish Hatchery Road, Fitchburg, Wisconsin 53711, susan.josheff@dnr.state.wi.us

The University of Wisconsin - Madison and Madison Gas & Electric (MGE) are constructing a 150 Megawatt West Campus Cogeneration Facility (WCCF). Power is generated both by gas-fired turbine generators and by a heat recovery steam generator.

The permitting issues included the use of surface water from Lake Mendota for the WCCF. Of great interest in this project are the interaction between surface water and groundwater and the decisions that Dane County has made over the last 50 years that made WCCF's proposed use one of great concern for those interested in the Yahara River. Also of great interest is the process this project employed to resolve seemingly un-resolvable resource impacts, in a fashion that was acceptable to all the water resource users of Dane County.

The permitting process involved a unique mitigation plan which was formulated with input from key stake holders including the WDNR, City, USGS, Dane County, WGNHS, and COE. The group looked at a key portion of the Yahara River that needed to be protected and at several options for to mitigation. The solution included makeup water from a high capacity well and several infiltration sites around Madison to restore groundwater taken from the high capacity well. This project exemplifies the creative use of surface waters for a sustainable and cooperative relationship between the need for electrical energy and the protection of surface and groundwater.

Keywords: surface water, groundwater, sustainable, permit, Yahara