

**33RD ANNUAL MEETING
PROGRAM AND ABSTRACTS**



Wisconsin's Changing Water Resources

March 5 & 6, 2009

**Ramada Stevens Point Hotel
Stevens Point, Wisconsin**



American Water Resources Association –Wisconsin Section

**AMERICAN WATER RESOURCES ASSOCIATION-
WISCONSIN SECTION**

33rd ANNUAL MEETING

Wisconsin's Changing Water Resources

March 5-6, 2009

**Ramada Stevens Point Hotel
Stevens Point, Wisconsin**

Hosts:

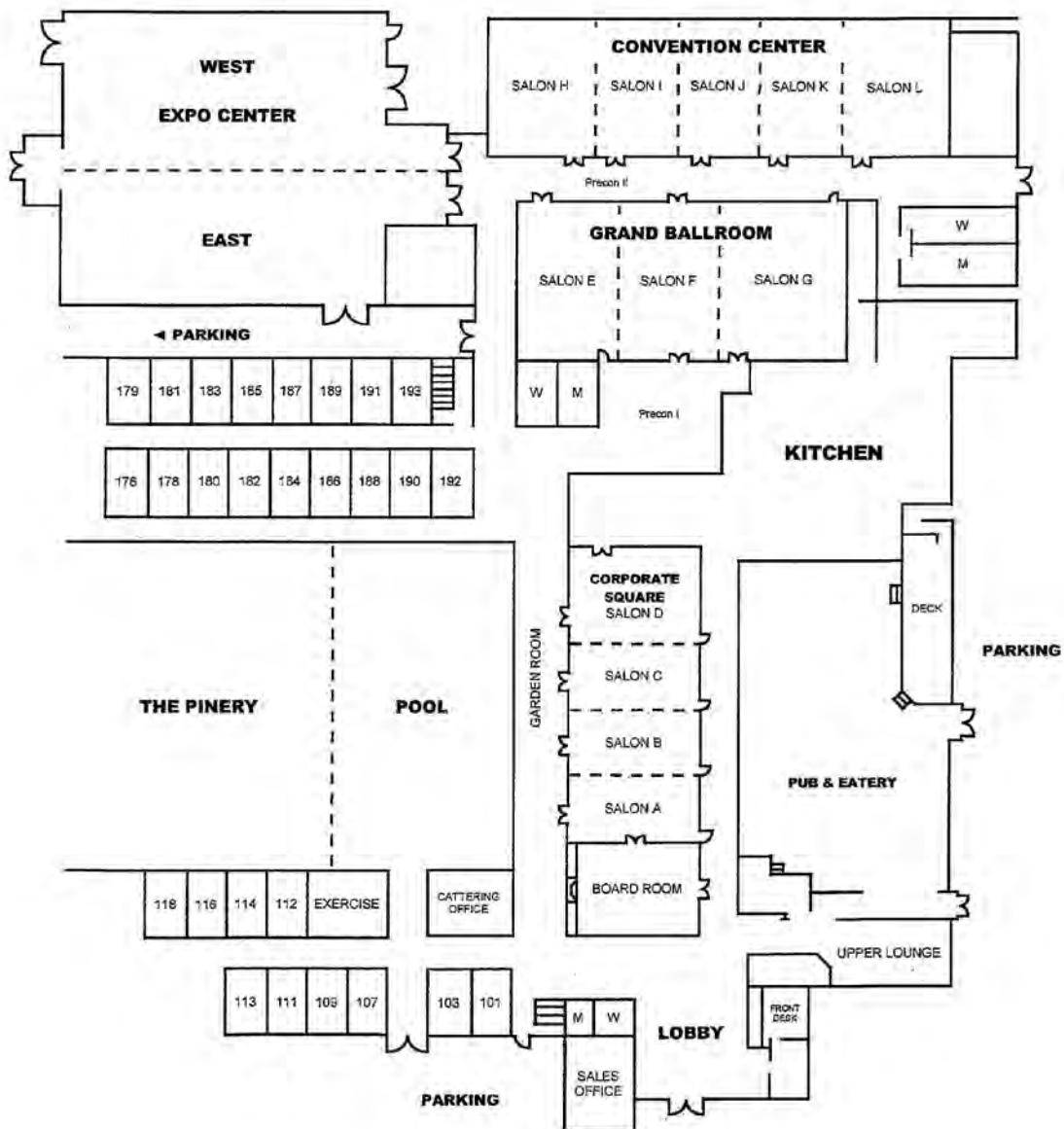
**American Water Resources Association-Wisconsin Section
University of Wisconsin Water Resources Institute
Wisconsin Department of Natural Resources
Center for Watershed Science & Education, UW-Stevens Point
Wisconsin Geological and Natural History Survey
U.S. Geological Survey, Wisconsin Water Science Center**



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OVERVIEW



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The Wisconsin Section of the American Water Resources Association provides an interdisciplinary forum for people involved in all aspects of water resources research and management. The success of the Section is due in part to the dedication of past and current members of our Board of Directors. We heartily acknowledge the following individuals for their service, and we invite others to consider volunteering to insure an ongoing dialogue among those committed to water resources research and management in the state of Wisconsin.

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PROGRAM SUMMARY

Wisconsin's Changing Water Resources

33rd Annual Meeting of the American Water Resources Association – Wisconsin Section Stevens Point, Wisconsin

Thursday, March 5, 2009

- 9:00 a.m. – 2:15 p.m. Registration – Precon B
- 11:20 – 12:00 Welcome and Lunch – Salon H and I
- 12:00 – 12:15 Business Meeting
- 12:15 – 12:30 Professional Hydrologist Licensing Presentation
- 12:30 – 2:00 **Plenary Session:** Wisconsin's Changing Water Resources
- George Stone
Natural Science Instructor
Milwaukee Area Technical College
Global Effects of Climate Change
- John Magnuson
Emeritus Professor of Zoology and Limnology,
University of Wisconsin-Madison
Effects of Climate Change on Wisconsin Lakes
- Chris Kucharik
Senior Scientist
Center for Sustainability and the Global Environment
University of Wisconsin-Madison
Agricultural Response to Climate Change
- 2:00 – 2:20 p.m. **Break**
- 2:20 – 3:20 p.m. **Concurrent Sessions 1A and 1B**

Session 1A – Groundwater Recharge and Resource Planning

Salon J

Moderator: Bill Selbig, USGS

- 2:20 The Role of Science and Uncertainty in Resource-based Planning in Fitchburg, Wisconsin. Stephen J. Gaffield
- 2:40 Assessing Seasonal Variations in Recharge and Water Quality in the Silurian Aquifer in Areas with 10 to 20 ft of Soil Cover. Maureen A. Muldoon
- 3:00 The Influence of Fine-grained Glacial Deposits on Recharge to Cambrian-Ordovician Aquifers in Outagamie County, Wisconsin. Thomas Hooyer

Session 1B – Flooding

Salon K

Moderator: Eric Booth, UW-Madison

- 2:20 Mapping and Documenting the Flood of June 2008 in Southern Wisconsin. Marie C. Peppler
- 2:40 The Wolf River Watershed: Developing a Regional Curve for Bankfull Stage through an Analysis of Landuse Effects. Anna N. Hess**
- 3:00 Floods Are Not Confined to Floodplains: Groundwater-induced Flooding at Spring Green, Wisconsin. Madeline Gotkowitz
- 3:20 – 3:40 p.m. **Break**
- 3:40 – 5:20 p.m. **Concurrent Sessions 2A and 2B**

Session 2A – Methods in Groundwater Investigations

Salon J

Moderator: Paul Juckem, USGS

- 3:40 An Experimental Investigation on Colloid Straining: Implications for the Removal of Biological Colloids in Porous Media. Alexis A. Porubcan**
- 4:00 Imaging Septic Tank Use Using Geophysical Techniques. Alex R. Summit**

- 4:20 Characterization of Groundwater Flux Using Ground-based Thermal Remote Sensing at the Seepage Face. Richard S. Deitchman**
- 4:40 Fluorescence Lifetime Sensing Using Optical Fibers for Remote Measurement in Aqueous Environments. Paul E. Henning**
- 5:00 Distributed Temperature Sensing as a Hydrostratigraphic Characterization Tool for Aquifer Storage Recovery (ASR). Andrew T. Leaf**

Session 2B – Water Quality and Bacterial Contaminants

Salon K

Moderator: Rob Stelzer, UW-Oshkosh

- 3:40 The Connection between Food Choices and Drinking Water Quality. Lynn M. Markham
- 4:00 A 20-Year Analysis of Water Quality, Watershed Condition, and Biotic Integrity in Duck Creek, WI. Daniel A. Cibulka**
- 4:20 Combined Use of Physical/Morphological, Chemical, and Microbial Parameters to Assess Stream Health – Root River, Racine, WI. Julie L. Kinzelman
- 4:40 Characterization of *Escherichia coli* in Beach Sands Relative to Sediment Size Distribution and Hydrologic Factors. John Skalbeck
- 5:00 Transport of Tetracycline Resistant *Escherichia Coli* in Saturated and Unsaturated Porous Media. Jacob J. Walczak**

5:20 – 7:20 p.m. **Poster Session and Social Hour** — Salon L

1. Standard Error Parameter Development for Double-Ringed Infiltrometer Procedure. Veronica M. Alba*
2. Implications of Sustained Low Water Levels for Seepage Lakes in Northern Wisconsin. Timothy R. Asplund
3. Lower Eagle River Chain 2,4-D Residual Monitoring Project. Brian J. Bailey*

4. Estimating GPR Groundwave Penetration Depth in Variably Saturated Soils. Anna C. Baker*
5. A Geophysical Study of the Bradford Beach Shoreline in Milwaukee, Wisconsin. Bonnie J. Bills**
6. Refinement of a Groundwater Model for the Village of Richfield, WI. Bonnie J. Bills**
7. Regional Groundwater Flooding in Southern Wisconsin. Kenneth R. Bradbury
8. Rethinking Nonpoint Source Pollution Management in an Agricultural Watershed: An Application of Wisconsin Buffer Initiative Concepts in Southwest WI. Rebecca B. Carvin**
9. Spatial Patterns of Nitrate Retention in a Central Sand Plains Stream. Damion S. Drover*
10. Hydrostratigraphic and Groundwater Flow Models: Troy Valley Glacial Aquifer, Southeastern Wisconsin. Kallina M Dunkle**
11. Physical Responses of Streams to Urbanization in Nine Metropolitan Areas of the United States. Faith A. Fitzpatrick
12. Identification of Point Source Pollution on an Urbanized River Segment. Adrian J. Koski*
13. Using Environmental Variables to Predict Surface Water Quality. Stephan R. Kurdas*
14. Geochemical Characterization of Sulfide Mineralization in Eastern Wisconsin Carbonate Rocks. John A. Luczaj
15. Groundwater Recovery and Hydrostratigraphy in the Northeastern Groundwater Management Area of Brown, Outagamie, and Calumet Counties, Wisconsin. Julie C. Maas**
16. Influence of Wetland Hydrodynamics on Subsurface Microbial Redox Transformations of Nitrate and Iron. Cassidy A. Miller**

17. Time Resolved, Remote Environmental Sensing along an Optical Fiber, Utilizing a Range-gated, Stroboscopic Detection System for Improved Detection Limits. Robert Olsson
18. Gully Stabilization and Forest Rehabilitation for Brook Trout Habitat, Lake Superior South-Shore Streams, Wisconsin. Marie C. Peppler
19. Plasmonic-Based Optical Fiber Sensor for Real-Time, Remote, and Spatially Resolved Determination of Oxygen. M. Veronica Rigo**
20. Enhancing Reproducibility and Dynamic Range of Luminescent Optical Fiber Sensors for Remote Monitoring in Aqueous Environments. Megan Schultz*
21. Mercury in Fish, Bed Sediment, and Water from Streams across the United States, 1998-2005. Barbara C. Scudder
22. Wisconsin Well Water: Planning Web-based Resources to Promote Safe Drinking Water for Wisconsin Residents. Dolores J. Severtson
23. Impacts of Urban Runoff on Bioretention Basins Planted With Native Vegetation vs. Cool Season Turf Grass. Tiffany Short*
24. Effects of Elevated Nitrate Concentration on Mortality, Growth, and Egestion Rates of Gammarus Pseudolimnaeus Amphipods. Robert S. Stelzer
25. Variation in Spring Water Chemistries within Small Discharging Zones. Sugita Fumi

* Undergraduate student presentation

** Graduate student presentation

7:30 p.m. **Dinner** – Salon H and I

Speakers: Paul Graham and Anello Mollica, Central Waters Brewing Company

Friday, March 7, 2008

7:00 – 8:00 a.m. AWRA–Wisconsin Section Board of Directors' Breakfast Meeting – Board Room

8:00 – 9:40 a.m. **Concurrent Sessions 3A and 3B**

Session 3A – Contaminants in Groundwater

Salon J

Moderator: Paul McGinley, UW-Stevens Point

- 8:00 Interaction between Tetracycline and Rectorite in Aqueous Solution. Zhaohui Li
- 8:20 Assessing Levels and Potential Health Effects of Endocrine Disrupting Chemicals in Groundwater Associated with Karst Areas in Northeast Wisconsin. Sarah E. Wingert**
- 8:40 Modeling Flow and Arsenic Contamination in an Aquifer Storage and Recovery System, Green Bay, WI. Meghan E. Dickoff**
- 9:00 Tracking Shallow Groundwater Anthropogenic Effects in Southeastern Wisconsin. Micah J. Holzbauer**
- 9:20 Human Viruses in Water Supply Wells in Madison, WI. Kenneth R. Bradbury

Session 3B – Hydrologic Trends

Salon K

Moderator: Madeline Gotkowitz, WGNHS

- 8:00 Open
- 8:20 When My Beach Is Really Lakebed: Managing Shorelines and Water Levels in Wisconsin. Martin P. Griffin
- 8:40 Trends in Groundwater Levels in Central Wisconsin. Amber M. Weisenberger**
- 9:00 Historical Perspectives on Groundwater Pumping. Jennifer L. McNelly
- 9:20 A Distributed Approach to Model Calibration – the Model Center Concept. Michael N. Fienen

9:40 – 10:00 a.m. **Break**

10:00 – 11:55 a.m. **Concurrent Sessions 4A and 4B**

Session 4A – Modeling Groundwater and Surface Water Systems

Salon J

Moderator: Steve Gaffield, Montgomery Associates

- 10:00 GIS-based Groundwater Recharge Estimation for Southeastern Wisconsin. David J. Hart
- 10:20 Southeastern Wisconsin Regional Planning Commission Ground Water Model of the Troy Bedrock Valley Aquifer of Southeastern Wisconsin. John Jansen
- 10:40 A New Tool for Inset Modeling: An Example of Local Grid Refinement Methods in Southeastern Wisconsin. Charles P. Dunning
- 11:00 Simulation of the Ground-Water-Flow System in Pierce, Polk, and St. Croix Counties, Wisconsin. Paul F. Juckem
- 11:20 Building Coupled Ground-water/Surface-water Models to Simulate Climate Change. Randall J. Hunt
- 11:40 Closing Remarks and Announcement of Student Award Winners

Session 4B – Runoff

Salon K

Moderator: Todd Stuntenbeck, USGS

- 10:00 Seven Years of Edge-of-Field Agricultural Runoff Monitoring: What We Have Learned. Randy S. Mentz
- 10:20 Snowmelt: The Silent Majority of Runoff. Michael R. Penn
- 10:40 Effects of Riparian Cattle Grazing on Bank Erosion, University of Wisconsin-Platteville Pioneer Farm. Faith A. Fitzpatrick
- 11:00 Comparison of Water Quantity and Quality between Subsurface-Tile and Surface-Water Runoff from a Wisconsin Discovery Farm. Matt J. Komiskey

11:20 Phosphorus Content and Particle Size of Sediments in
Grassed Waterways Draining Corn and Alfalfa Fields in
Southwestern WI. John C. Panuska

11:40 Closing Remarks and Announcement of Student Award
Winners

* Undergraduate student presentation

** Graduate student presentation

**SESSION 1A:
Groundwater Recharge and Resource Planning
Thursday, March 5, 2009
2:20 – 3:20 p.m.**

The Role of Science and Uncertainty in Resource-based Planning in Fitchburg, Wisconsin

Stephen J. Gaffield, Montgomery Associates: Resource Solutions, LLC, Cottage Grove, WI, *steve@ma-rs.org*

Nancy R. Zolidis, Montgomery Associates: Resource Solutions, LLC, Cottage Grove, WI, *nancy@ma-rs.org*

Robert J. Montgomery, Montgomery Associates: Resource Solutions, LLC, Cottage Grove, WI, *rob@ma-rs.org*

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Scott Goldstein, Teska Associates, Inc., Evanston, IL,
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Susan Swanson, Department of Geology, Beloit College, Beloit, WI,
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The City of Fitchburg's North McGaw Park Neighborhood Plan is noteworthy because detailed ecological and hydrologic analyses have been included from the very beginning of the planning process. This future expansion of the City's urban center will occupy approximately 700 acres near sensitive streams and wetlands, and drains eastward to the Waubesa Wetlands State Natural Area and Lake Waubesa. Constraints and opportunities for future development were identified through a data collection effort including upland and wetland habitat assessments, in-stream flow and quality monitoring, and aquatic invertebrates and fish surveys. Maintaining groundwater inputs to these resources was identified as a key planning objective. The soil water balance model RECARGA and an existing MODFLOW groundwater flow model developed for the adjacent Nine Springs Creek watershed were used to evaluate the benefits of stormwater infiltration, and reduced water supply demand through conservation and greywater reuse. This resource analysis produced recommendations for development locations, natural area enhancement, runoff control and recharge standards, and water supply. The Plan considers uncertainty in the groundwater flow system properties, especially the distribution the Eau Claire Shale and the degree of connection between the shallow and deep aquifers, and includes recommendations for ongoing monitoring and adaptive management. This planning process also has had a substantial educational component, with the City and public thoughtfully engaged in the challenges of balancing urban development with resource protection.

Assessing Seasonal Variations in Recharge and Water Quality in the Silurian Aquifer in Areas with 10 to 20 ft of Soil Cover

Maureen A. Muldoon, Department of Geology, University of Wisconsin- Oshkosh, Oshkosh, WI, muldoon@uwosh.edu

Kenneth R. Bradbury, Wisconsin Geological and Natural History Survey, Madison, WI, krbradbu@wisc.edu

Recent well contamination events in the Town of Morrison (winter-spring 2006) in Brown County and Cooperstown in Manitowoc County (winter-spring 2008) have refocused public attention on the aquifer's susceptibility to contamination. In both events, it appears that manure-contaminated recharge impacted several domestic wells completed in the underlying dolomite aquifer. While these events generated media attention, they are not isolated incidents. Historically, "brown-water" events during spring have been noted in several other counties underlain by the Silurian aquifer—specifically in Door, Calumet, Kewaunee and Manitowoc Counties. In response to these events, Kevin Erb of UW-Extension organized a Northeast Wisconsin Karst Task Force that was charged with developing recommendations for best management practices (BMPs) that would help minimize groundwater contamination in areas underlain by shallow carbonate aquifers with specific attention to BMPs relating to the storage and application of animal wastes. As the task force proceeded, it became clear that there was little to no scientific data, for areas other than Door County, on which to base a vulnerability ranking. Specifically, there were no data on the seasonal variability in recharge and the resulting water-quality variations in areas with thicker soil cover.

The objective of this project was to gain an understanding of seasonal variations in recharge and the resulting water-quality variations in the Silurian dolomite aquifer in areas with thicker soil cover. Specifically we identified sites in four counties (Brown, Calumet, Kewaunee, and Manitowoc) where the Silurian aquifer was the uppermost bedrock aquifer, soil was 10 to 20 feet thick, and manure or sewage sludge was being applied. At each site we installed a shallow bedrock well and monitored variations in water levels and water quality for one year.

Water levels in all wells responded rapidly to recharge events in January, March, and June. The overall range in water level variation was least in the Manitowoc well (~ 2.4 ft). The other three wells showed increases on the order of 7 to 8 ft. The response to recharge seems to be a function of the thickness and texture of the unconsolidated material. The surficial sediment in Manitowoc area is red clay till, whereas sandier sediments are found at the other three sites. Additionally, all of the wells showed rapid variations in temperature and conductivity in response to recharge events.

Water quality results were also variable over time. All wells exhibited nitrate values greater than the drinking water standard of 10 mg/L at some point during the year. Three of the four wells exhibited NO₃-N values that varied by 9 to 10 mg/L over the course of the year. The Calumet well had NO₃-N values that varied over 28 mg/L. Generally the lowest nitrate values followed recharge events. Chloride and phosphorous values were also elevated and showed trends similar to nitrate.

The Influence of Fine-grained Glacial Deposits on Recharge to Cambrian-Ordovician Aquifers in Outagamie County, Wisconsin

Thomas S. Hooyer, Wisconsin Geological and Natural History Survey, Madison, WI, tshooyer@wisc.edu

David J. Hart, Wisconsin Geological and Natural History Survey, Madison, WI, djhart@wisc.edu

Carolyn A. Moeller-Eaton, Department of Geology and Geophysics, University of Wisconsin-Madison, Madison, WI, moeller@geology.wisc.edu

William G. Batten, Wisconsin Geological and Natural History Survey, Madison, WI, wgbatten@wisc.edu

Unlithified glacial sediment covers a large part of the landscape along the Fox River valley in east-central Wisconsin. Most of this sediment consists of silt and clay which can limit infiltration of surface water to recharge important bedrock aquifers in the region. The amount of infiltration is thought to be controlled by the thickness of the sediment: a thin layer of sediment (<15 m) will allow greater infiltration compared to a thicker layer of sediment (>30 m).

To test this idea, a set of four multilevel monitoring wells were installed at various locations in Outagamie County where the thickness of fine-grained sediment varies. Data collected from the wells, including hydrogeologic and chemical analyses of groundwater samples, indicate that where the sediment is thick (>30 m) there is virtually no infiltration of surface water to deep bedrock aquifers. However, where the sediment is thin (<15 m), significant recharge does occur to the deeper bedrock aquifers. Using hydraulic conductivity data determined from slug tests and hydraulic gradients determined from water-level data were the sediment is thin, we calculated an average downward vertical flux (recharge) of 163 mma^{-1} (6.4 in yr^{-1}).

Based on geological mapping, we estimated that the bedrock surface is within 15 m of the land surface over approximately 20% (324 km^2) of Outagamie County. A calculation indicates that over $1.45 \times 10^8 \text{ ld}^{-1}$ ($32 \times 10^6 \text{ gal d}^{-1}$) recharges the two major bedrock aquifers underlying the County. Approximately half of this area (162 km^2) is west of the Sinnipee Group subcrop, which indicates that half of this recharge ($16 \times 10^6 \text{ gal d}^{-1}$) would reach the deep Cambrian-Ordovician bedrock aquifer that supplies many municipal and industrial wells along the Fox River valley urban corridor. Recent work in the lower Fox River valley indicates that around $36 \times 10^6 \text{ ld}^{-1}$ ($8 \times 10^6 \text{ gal. d}^{-1}$) was withdrawn by area municipal wells in 2007 indicating that recharge to the deep aquifer could be supplied by flow across the sediment where it is relatively thin. A ground water flow model would be needed to understand what part of the flow moves to the deep bedrock aquifer in the lower Fox River valley.

**SESSION 1B:
Flooding
Thursday, March 5, 2009
2:20 – 3:20 p.m.**

Mapping and Documenting the Flood of June 2008 in Southern Wisconsin

Marie C. Peppler, U.S. Geological Survey – WI Water Science Center, Middleton, WI, mpeppler@usgs.gov

Faith A. Fitzpatrick, U.S. Geological Survey – WI Water Science Center, Middleton, WI, fafitzpa@usgs.gov

In June 2008, heavy rain (up to 10-15 in.) caused severe flooding across southern Wisconsin. The floods were aggravated by saturated soils which persisted from unusually wet antecedent conditions. The flooding caused unprecedented evacuations of residents, road closures and extensive damages and losses. Record gage heights and streamflows occurred at 21 U.S. Geological Survey streamgages; at approximately half of the streamgages, flood probabilities were less than 0.01 (recurrence interval of greater than 100 years). The U.S. Geological Survey flagged and surveyed 377 high-water marks over 40 stream miles in August 2008. Reaches of the Baraboo River, Kickapoo River, Crawfish River, and Rock River were assessed in nine communities: Reedsburg, Rock Springs, La Farge, Gays Mills, Milford, Jefferson, Fort Atkinson, Janesville, and Beloit. Elevation surveys were performed using Real-Time Kinematic Global Positioning System (RTK-GPS) units, and were accurate to within 0.1 ft. Flood-peak inundation maps and water-surface profiles were modeled in a geographic information system by combining high-water-mark elevations with topography based on digital-elevation-model data (ranging from 1-10-meter resolution). The 189 high-water marks used in the modeling were a combination of a subset of USGS high-water marks and those surveyed during the June flood by communities, counties, and Federal agencies. The resulting maps outline the extent and depth of flooding and are being used in flood response and recovery efforts by local, county, state, and federal agencies.

The Wolf River Watershed: Developing a Regional Curve for Bankfull Stage through an Analysis of Landuse Effects

******Anna N. Hess, University of Wisconsin-Stevens Point, *ahess361@uwsp.edu*

Katherine F. Clancy, University of Wisconsin-Stevens Point, Stevens Point, WI, *Katherine.Clancy@uwsp.edu*

Regional hydraulic geometry curves are a graphical plot of discharge and channel geometry that can be used to calculate bankfull, the channel-forming flood. Specifically, a regional curve provides information to estimate bankfull discharge, mean depth, width, and cross-sectional area at ungauged sites within given watersheds. (Mistak and Stille, 2007). Bankfull forms the average or natural stream channel, used for stream restoration. Bankfull is assumed to be associated with the $Q_{1.5}$ year flood, but varies between the 1.0 and 2.5-year flood (Copeland et al., 2000). The geometry of bankfull can be calculated using several methods, including collecting field data, collecting historical gauging station data, and by developing a regional curve.

Land use practices within a watershed have been found to affect bankfull discharge, influenced by runoff and mass wasting (Reidel et al., 2005) Areas that are primarily forest cover tend to produce less runoff and consequently less mass wasting, while areas that are primarily agricultural tend to produce more runoff and consequently more mass wasting (Reidel et al., 2005). Channel restoration is a site-specific industry; therefore, regional curves that will be used for restoration must represent the dominant landcover type within a watershed in addition to the dominant bankfull stage.

The purpose of this project is to develop a regional curve for bankfull stage by determining bankfull discharge using field techniques and historical gauging data. We hypothesize that landuse practices within the Wolf River Watershed affects the height and discharge of bankfull such that bankfull sites with more than 33% forest cover will display a different channel geometry than those with less than 33% forest cover.

******Graduate student presentation

Floods Are Not Confined to Floodplains: Groundwater-induced Flooding at Spring Green, Wisconsin

Madeline Gotkowitz, Wisconsin Geological and Natural History Survey, Madison, WI, mbgotkow@wisc.edu

John W. Attig, Wisconsin Geological and Natural History Survey, Madison, WI, jwattig@wisc.edu

In June 2008, overland flow of storm water and a rise in groundwater levels contributed to flooding 4,380 acres in Spring Green, Wisconsin. The affected area, which is located over a mile from the Wisconsin River floodplain, remained flooded for five months.

Spring Green is on the highest of two outwash terraces along the north side of the Wisconsin River in southwest Sauk County. This broad, high terrace lies about 25 feet above the river. Extensive deposits of wind-blown sand create local relief of up to about 20 feet. The terrace is flanked to the north by 200 foot-high bluffs composed of sandstone and dolomite. The lower parts of secondary stream valleys that cut the bluffs are floored with fine-grained sediment deposited in late-glacial outwash-dammed lakes.

We evaluated the role of groundwater in the flooding of this region using conceptual and numerical hydrogeologic models. The geologic setting results in enhanced groundwater recharge from runoff at the base of the fine-grained lake-basin sediments and along the base of the bedrock bluffs. Transient simulations of increased recharge following spring snow melt and June rainfall indicate a 12-foot rise in water table elevation may have occurred within the shallow aquifer on the upper terrace. This is consistent with data from near-by monitoring wells and explains the extensive and long-lasting flooding of topographic depressions far from the floodplain of the river. These results indicate that a shift in climate in the mid-western U.S. towards increased frequency and magnitude of precipitation may cause water table rise sufficient to require adaptations in infrastructure and land use.

**SESSION 2A:
Methods in Groundwater Investigations
Thursday, March 5, 2009
3:40 – 5:20 p.m.**

An Experimental Investigation on Colloid Straining: Implications for the Removal of Biological Colloids in Porous Media

****Alexis A. Porubcan**, Department of Geosciences, University of Wisconsin-Milwaukee, Milwaukee, WI, *porubcan@uwm.edu*

Shangping Xu, Department of Geosciences, University of Wisconsin-Milwaukee, Milwaukee, WI, *xus@uwm.edu*

A thorough understanding of colloid transport in porous media is essential to the assessment of groundwater contamination by pathogenic microorganisms and the removal of biocolloids in engineered systems. Straining, a process that occurs when a pore space is too small to allow for the passage of a particle, is reported to play an important role in colloid immobilization. Previous studies have focused on the straining of spherical particles in uniform sand packs. Natural aquifers and engineered filters, however, are commonly composed of both physically and chemically heterogeneous porous media. This research focuses on the straining of colloids in heterogeneous porous media, a process that is closely related to the movement of important pathogenic parasites, such as *Cryptosporidium* and *Giardia*.

Colloid transport experiments were conducted with four sizes of carboxylated latex microspheres (0.45, 3.1, 5.1, and 6.1 μm) and saturated columns of quartz sand. The sand used in the experiments was thoroughly cleaned with hot, concentrated nitric acid and the strong repulsive forces between the sand and colloids assured minimal physiochemical deposition. Sand packs, with varying degrees of physical heterogeneity, were prepared by mixing sands of various sizes (mesh size 20-25, 35-40, and 60-70). In combination with previous studies, our results indicate that the number of colloids retained in physically heterogeneous porous media is greater than in a uniform media and large quantities of colloids are immobilized through the process of straining.

****Graduate student presentation**

Imaging Septic Tank Use Using Geophysical Techniques

******Alex R. Summit, Geological Engineering Program, University of Wisconsin-Madison, Madison, WI, *summit@wisc.edu*

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Kevin Masarik, University of Wisconsin-Stevens Point and University of Wisconsin-Extension, Stevens Point, WI, *Kevin.Masarik@uwsp.edu*

D. Fratta, Geological Engineering Program, University of Wisconsin-Madison, Madison, WI, *fratta@wisc.edu*

The effluent plume of a septic mound located in a small Portage County park (east of Stevens Point, WI) was monitored using geophysical methods. Ground penetrating radar, electromagnetic induction, self-potential, direct current and capacitive-coupled electrical resistivity were used to monitor septic plume displacements over a four-month period. Surveys at the site were performed before and after high-usage weekends (Memorial Day, Fourth of July, and Labor Day) to identify the influence of high concentration effluent introductions into the plume. Changes in the size and location of the effluent plume were monitored to determine if the effluent was approaching the nearby lake and swimming area of the county park.

The geophysical surveys were supplemented with a Geoprobe investigation at the end of the summer. Soil and water samples were taken as part of this investigation to groundtruth the collected geophysical data. Groundwater samples were taken at several depths at seven locations throughout the site. These water samples were analyzed and qualitatively compared to the geophysical survey results. It is expected that the septic effluent plume will appear as a zone of low electrical resistivity (high conductivity) in the geophysical surveys that can be correlated with higher ionic strengths in the groundwater samples containing septic effluent. Preliminary results suggest that the plume is not moving laterally but increasing in thickness (vertical size). This can tentatively be explained by low horizontal hydraulic gradients at the site that vary seasonally in direction towards and away from the lake.

Another round of geophysical surveys and groundwater sampling along with measurements of water levels is scheduled for Spring of 2009. These results will be used by the Portage County Parks Department to determine if a proposed increase in facility usage will have a significant impact on the lake.

******Graduate student presentation

Characterization of Groundwater Flux Using Ground-based Thermal Remote Sensing at the Seepage Face

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Previously, no method existed to image groundwater flux. However, we report that thermal remote sensing of groundwater at the seepage face provides indirect imaging of groundwater flux at the centimeter scale, providing insight into its heterogeneity and a clear depiction of focused versus diffuse groundwater discharge. The intent of this work is to assess the use of ground-based thermal remote sensing for mapping of groundwater discharge along a stream bank seepage face. Additionally, we present a method for locating the water table position along this boundary using thermal imagery. Seepage faces, external boundaries of the saturated zone, are poorly understood and often neglected in regional hydrologic studies although they likely exert important influence on ecohydrologic processes in riparian zones. Even though the importance of riparian areas is broadly recognized, our ability to quantify hydrologic, ecologic and biogeochemical processes and ecosystem services is hampered by our inability to characterize spatially variable processes such as groundwater discharge. This work employs a new, transferable, non-invasive method that uses heat as a natural tracer to image spatially variable groundwater flow processes and distinguish between focused and diffuse groundwater discharge to the surface. Thermal imaging of groundwater flux has significant implications for research in ecohydrology, the scale dependence of hydraulic conductivity, contaminant transport and groundwater flow modeling.

**Graduate student presentation

Fluorescence Lifetime Sensing Using Optical Fibers for Remote Measurement in Aqueous Environments

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Optical fibers can be employed for remote monitoring in harsh environments. The entire fiber length may be utilized for sensing by placing fluorescent sensor molecules outside of the fiber core. Such fluorosensors may still be excited by the evanescent fields of the light propagating in the fiber core; conversely, light emitted by sensor molecules may be captured by evanescent fields and guided to the fiber ends. Pulsed laser excitation and time-resolved detection allow for pinpointing the location of a sensor along the fiber. Thus, many different parameters may be monitored simultaneously and spatially resolved.

A poly(ethylene) glycol (PEG) based hydrogel was carefully chosen to serve as fiber cladding in a sensor region. This replacement cladding also contains the sensor molecules. PEG was chosen for many reasons, e.g. for its optical properties, for being non-toxic, and for its resistance to biofouling, the latter properties making it suitable for long-term sensing in aqueous environments. A fluorescein based pH sensor was covalently attached to the PEG cladding material to minimize leeching and increase sensor longevity. To ensure fast sensor response in, pores were create in the PEG cladding material by microsphere templating. This allows faster diffusion of analytes to the sensor molecules.

Fluorescence lifetime determination is sensing method that is independent of the signal intensities. This method compensates for signal drift and thus reduces frequent calibration due to sensor degradation, intensity fluctuations, background light present. Moreover, since our sensor arrays already utilize time-resolved measurements, incorporation of fluorescence lifetime techniques, such as time-correlated single photon counting and stroboscopic detection, is possible with relative ease, while offering benefits for real-world sensing. Fluorescein acryl amide was evaluated for based pH sensor using time-resolved fluorescence measurements.

******Graduate student presentation

Distributed Temperature Sensing as a Hydrostratigraphic Characterization Tool for Aquifer Storage Recovery (ASR)

**Andrew T. Leaf, Department of Geology and Geophysics, University of Wisconsin-Madison, Madison, WI, aleaf@geology.wisc.edu

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In 1976, Oak Creek, Wisconsin switched its water supply to Lake Michigan. Since then, population increases have necessitated costly treatment plant expansions to satisfy increases in seasonal water demand. ASR has been sought as an auxiliary water supply, and an economic alternative to plant expansions. An existing municipal well, which is 1800 ft deep and open to 1200 ft of the Cambrian-Ordovician Sandstone Aquifer, was retrofitted for ASR use. From 1999 to 2007, eight pilot injection/recovery cycles were performed. During an ASR cycle, treated Lake Michigan water is injected in early spring (low daily demand), and recovered during summer (high daily demand). Geochemical reactions resulting from the mixing of lake water with ambient groundwater and interactions with aquifer solids have prevented the full-scale implementation of ASR at this site.

The use of ASR has increased substantially over the last decade, and will likely continue to increase as climate change and population issues create additional water management challenges. However, the identification and mitigation of geochemical problems requires a detailed understanding of the flow field, which is often complex due to geologic heterogeneity. Temperature has long been known to be a useful tracer, but its application has been limited by the discrete nature of conventional measurement technologies. Distributed Temperature Sensing (DTS), which allows for the nearly continuous measurement of temperature in both time and space along a standard fiber optic telecommunications cable, has the potential to overcome this problem, both as a logging and monitoring tool. DTS has been used to study other groundwater/surface water interactions, and could prove useful for ASR.

Initial DTS measurements were collected at Oak Creek in an identical monitoring well located 180 feet from the ASR well. Measurements collected under ambient conditions revealed perturbations in the geothermal gradient corresponding to hydrostratigraphically significant lithologies. During a week of continuous pumping in the ASR well, temperature changes were observed over some intervals. Coupled groundwater flow/heat transport modeling is being used to provide insight into the processes behind these temperature anomalies.

**Graduate student presentation

SESSION 2B:
Water Quality and Bacterial Contaminants
Thursday, March 5, 2009
3:40 – 5:20 p.m.

The Connection between Food Choices and Drinking Water Quality

Lynn M. Markham, UW-Extension Center for Land Use Education, Stevens Point, WI, *lmarkham@uwsp.edu*

While many people place a high value on safe drinking water, it can be challenging to figure out how to achieve this goal. A 2007 study by the Wisconsin Department of Agriculture, Trade and Consumer Protection sampled 398 private drinking water wells and estimated that 33.5% of wells in Wisconsin contained a detectable level of a pesticide or pesticide metabolite.

In this session we will explore a number of questions about how our food choices affect the quality of our drinking water including: How is water quality affected when we choose organic vs. conventionally grown fruits and vegetables? What difference does it make to water quality if we choose hamburger from a pasture fed cow vs. one from a feedlot? Which crops grown in Wisconsin are the most and least pesticide-intensive? Which fruits and vegetables contain the highest levels of pesticide residues? Are there drinking water standards for the pesticides used on food crops in Wisconsin?

In addition to these questions related to agriculture and groundwater, we will discuss state and local organizations and resources for finding groundwater-friendly food. Every eater affects drinking water quality and human health through the farming practices they support when they purchase food.

A 20-Year Analysis of Water Quality, Watershed Condition, and Biotic Integrity in Duck Creek, WI

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The Duck Creek watershed has degraded water quality due to non-point source pollution from agricultural lands within the basin. Through federal, state, and local non-point source control programs, Brown County, Outagamie County, and the Oneida Tribe of Indians have implemented various land management changes aimed at improving the water quality within the Duck Creek watershed. In addition, changes in land ownership and related management have occurred. The objectives of our study were to analyze and explore relationships among land use/management, water quality and biotic metrics for the Duck Creek watershed during the period of 1988 to 2008. We collected and analyzed land management, land use, hydrologic, water quality and biotic integrity data available through numerous entities. The dataset included approximately 500 total phosphorous-flow pairs, 300 dissolved phosphorus-flow pairs, 50 benthic community index data values (HBI), 50 fish biotic index (IBI) data values, and data from available records of nutrient management and BMP implementation. Linear regression and other statistical techniques were applied to detect possible trends and relationships between watershed metrics. Preliminary results from regression analysis show a decrease in both total and dissolved phosphorous over the entire period. However, most of the apparent decrease seems to have occurred during a 1988 to 1995 time frame. Possible confounding factors such as climate will be investigated. Potential linkage to land management changes will be discussed.

****Graduate student presentation**

Combined Use of Physical/Morphological, Chemical, and Microbial Parameters to Assess Stream Health – Root River, Racine, WI

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Urbanization has resulted in water quality degradation, impairing beneficial uses. The Root River (Racine, WI) receives significant amounts of pollution. Physical and morphological studies, combined with water quality data, will enable the development of focused remediation efforts. During 2007/2008, sampling was carried out across 33 sites (24 open water, 9 stormwater outfalls), supplemented with visual surveys and a review of previous physical assessments. Samples were tested for a suite of chemical (turbidity, conductivity, pH, detergents, chlorine, dissolved oxygen, phosphorous) and microbial (*E. coli*, *Bacteroides*) parameters to gauge river health and identify contamination sources. In-stream chemical parameters, other than turbidity, rarely exceeded recommended levels. *E. coli* demonstrated variability across sampling sites; in response to rainfall but also during dry weather. Half (50%) of the open water sites were regularly impaired for contact recreation at the 75% confidence interval (> 385 MPN/100 ml: on average 47.5%-dry, 64.5%-wet). *E. coli* was elevated in all stormwater outfalls (34-93%) and detergent, a chemical marker indicating sanitary infiltration, was unilaterally present. Human-specific *Bacteroides* marker was detected at 7/9 outfalls. Decision trees, based on the study results, were developed in order to focus future investigative and remediation efforts. Seasonal sampling indicated that the Root River was in good health from a chemical perspective but improvements are required to reduce bacteria, increasing its recreational value. Priorities should focus on stormwater infrastructure and watershed management techniques to mitigate the impacts of wet weather influences.

Characterization of *Escherichia coli* in Beach Sands Relative to Sediment Size Distribution and Hydrologic Factors

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This study investigated the association between bacteria in beach sands and beach advisories. To better understand the relationship between *Escherichia coli* in sediments, beach hydrology and recreational water quality, ground water and sand samples were collected from three Lake Michigan beaches with varying substrates (fine sand, coarse sand, small pebbles). Sand samples collected within transects perpendicular to and at fixed distances from the shoreline (0 m, 10 m, 20 m) were analyzed for *E. coli* and grain size analysis was performed on duplicate samples to assess the relationship between *E. coli* density and mean sediment size and sediment uniformity.

Relative elevations of beach slope were measured using simple rod and level. Groundwater samples, collected from driven-point piezometers, were analyzed weekly for *E. coli*. The *E. coli* density in beach sediments differed significantly with distance from shore with the highest *E. coli* concentrations occurring at the berm crest (0 m), an area prone to continual wetting. Mean grain size and sediment uniformity accounted for variation in *E. coli* density with fine sand of uniform grain size having the highest *E. coli* content. A comparative analysis of relative elevation indicated that slope changes promoted water retention and increased *E. coli* density at the berm crest. Groundwater samples demonstrate that while beach sand may contain significant amounts of *E. coli* the density in groundwater is generally low to non-detectable, suggesting that sediments may function as a filter for water infiltrating from the surface. Management interventions, including assessments of beach slope, may aid in reducing fecal indicator bacteria in beach sands hence reducing beach advisories.

Transport of Tetracycline Resistant *Escherichia Coli* in Saturated and Unsaturated Porous Media

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The widespread use of antibiotics in the treatment of human patients and in animal farm environments has led to the selection and spread of antibiotic resistant bacteria. Of great concern is the occurrence of the antibiotic resistant bacteria in groundwater, which represents a major source of drinking water supply. Although many studies have documented the existence of antibiotic resistant bacteria in groundwater environments, little is known regarding the transport behavior of antibiotic resistant bacteria in saturated and unsaturated subsurface systems.

The transport characteristics of tetracycline resistant *Escherichia coli* and tetracycline susceptible ones were investigated using saturated and unsaturated flow-through columns packed with silica sands. *E. coli* were isolated from water samples taken from the Lake Michigan shoreline in Milwaukee, Wisconsin using the modified mTEC agar method. The *E. coli* were subsequently verified as *E. coli* with the Simmons Citrate Agar Test. The *E. coli* were then tested for resistance against tetracycline according to methods described by the Clinical and Laboratory Standards Institute. A colony of tetracycline resistant and a colony of tetracycline susceptible *E. coli* were used for multiple packed-bed column experiments under varying conditions of water chemistry and moisture content. In addition to data acquired from packed-bed column experiments, acid-base titration data and electrophoretic mobility data were also collected to further characterize bacterial cell surfaces of both resistant and susceptible bacteria. Differences in the transport behavior of resistant and susceptible *E. coli* in both saturated and unsaturated conditions is related to several controlling factors including, bacterial surface properties, water chemistry, and moisture content.

**Graduate student presentation

POSTER SESSION
Thursday, March 5, 2009
5:20 – 7:20 p.m.

1. Standard Error Parameter Development for Double-Ringed Infiltrometer Procedure

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Hydrologists measure the rate of rainwater infiltration into a soil through the use of a double-ringed infiltrometer. Infiltration rates are critical to hydrologists' understanding of the behavior of a soil during rainfall events, as well as for predictive estimates of runoff potential. However, current infiltration studies fail to account for inherent procedural error associated with this technique. The objective of this study is to establish error parameters for use with double-ringed infiltrometers.

In Fall of 2007 and 2008, infiltration rates of soils determined to be statistically similar on the basis of bulk density, texture (by class), slope, and vegetation were measured and analyzed. The soils' equilibrium infiltration rates (EIRs) were used to develop error parameters for standard use of double-ringed infiltrometers. The EIRs of soils of the same textural class, as well as statistically similar bulk densities were compared, and a 95% confidence interval was established. The hypothesis is that EIRs of soils of like textural class, vegetation cover, slope, and statistically similar bulk densities will fall within two standard deviations of the mean. In the future, additional infiltrations will be completed to assess the viability of using the determined confidence interval as a predictor range of the EIRs of similar soils.

*Undergraduate student presentation

2. Implications of Sustained Low Water Levels for Seepage Lakes in Northern Wisconsin

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Recent drought conditions in northern Wisconsin have caused some lakes to reach historic low water levels. Water level fluctuations are normal for certain types of lakes, depending upon lake morphometry, hydrology, climate, and geography. However, global climate change may be altering these normal cycles, causing some lakes to enter into new hydrologic regimes, with long term implications for water quality and ecosystem services. For example, Anvil Lake in Vilas County may have shifted from an historically mesotrophic, periodically stratified lake to a eutrophic, polymictic, shallow lake due to more internal recycling of nutrients caused by declining water levels. Expansion of native and invasive aquatic plants, changes in shoreline and littoral habitat, and increased human disturbance of shallow or exposed lake beds are some of the other potential consequences of extended periods of low lake levels. Using long term datasets and examples from several lakes in northern Wisconsin, this poster will highlight potential ecological implications of low lake levels to inform sound decision-making about water resource management and adaptation to global climate change in Wisconsin.

3. Lower Eagle River Chain 2,4-D Residual Monitoring Project

*Brian J. Bailey, UW-Stevens Point/Unified Lower Eagle River Chain of Lakes Commission, Stevens Point, WI, bbail804@uwsp.edu

Efforts to manage and control Eurasian watermilfoil (*Myriophyllum spicatum* L.) and other invasive aquatic plant species in Wisconsin's surface waters have been on the rise in recent years. To date there are only a few control method options that are efficient from both a financial and effectiveness standpoint in managing these invasive species. One method used commonly throughout Wisconsin has been to treat with chemical herbicides. This has caused professionals and citizens alike to become increasingly concerned over the potential "overuse" of chemicals in our waterways and how long these chemicals actually remain our lakes. Two years ago, the Unified Lower Eagle River Chain of Lakes Commission sought grant funding to initiate a monitoring program to measure the rate of molecular breakdown of 2,4-D in-situ on a fixed temporal schedule.

In the Spring of 2008, 188 acres of Eurasian watermilfoil was treated with 2,4-D on the Lower Eagle River Chain of Lakes. Water samples were collected the week before chemical treatment, and 1, 4, 7, 14, 21, and 28 days after treatment at 45 predetermined locations on the chain of lakes. These water samples were analyzed by the Wisconsin State Lab of Hygiene for residual 2,4-D concentrations. By 28 days after treatment, the majority of the 2,4-D had broken down with only some locations still reporting measurable concentrations. This project was intended to be the first step in risk assessment and provide managers with baseline information to answer some key questions on the use of chemicals in surface waters.

*Undergraduate student presentation

4. Estimating GPR Groundwave Penetration Depth in Variably Saturated Soils

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Field-scale monitoring of soil moisture at different depths is essential for agricultural and groundwater modeling applications. Ground Penetrating Radar (GPR) groundwaves can be used to estimate soil moisture, but GPR applications are limited by uncertainty of the groundwave penetration depth. This project experimentally determines the penetration depth as a function of GPR frequency, soil moisture conditions, and soil texture. Data were acquired under controlled conditions in a large tank. Sand was uniformly saturated and placed in the tank; the remaining sand was oven-dried. Variable-offset GPR data were collected over the wet sand using four GPR frequencies. Then, the wet sand was sealed, a 3-cm layer of dry sand was placed over it, and GPR surveys were repeated. Additional layers of dry sand were added, with GPR data collection after each layer, until data showed no sensitivity to the wet sand. The depth of dry sand where GPR became insensitive to wet sand was assumed to equal the penetration depth. The experiment was repeated using a basal layer of dry sand overlain by incremental layers of wet sand. Finally, both of these experiments were repeated using an organic-rich soil. Preliminary results show that the penetration depth is a function of frequency, with lowest frequencies having the greatest penetration, and that penetration depth is not highly influenced by soil moisture. Data analysis for the second soil is in progress, but initial results indicate that penetration depth is not strongly dependent upon soil texture.

*Undergraduate student presentation

5. A Geophysical Study of the Bradford Beach Shoreline in Milwaukee, Wisconsin

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Geophysical studies were conducted at the north end of Bradford Beach on Lake Michigan in Milwaukee, Wisconsin to assess the shallow subsurface geology. The location was chosen to supplement current research at the beach relating to bacterial studies, and the construction of water gardens near storm drains that discharge onto the beach. Characterization of the subsurface at this location and its hydrologic interaction with Lake Michigan is a key component in understanding the inflow of storm water runoff and developing environmental solutions to pollution control. Geophysical surveys included electrical resistivity, electromagnetic surveys, and ground penetrating radar. The geophysical data from the three surveys are consistent with each other and with the limited boring data. We interpret the results as 3.5 meters of sand with decreasing resistivity at depth overlaying an impervious subsurface of higher resistivity which is probably till or Antrim Shale. The low conductivity layer dips towards the south showing little to no sedimentary variation, and it lacks distinct natural depositional structures. This layer is probably saturated sand above an impervious base layer of till or shale. This is consistent with the area being a man-made beach dating back to the 1930's.

**Graduate student presentation

6. Refinement of a Groundwater Model for the Village of Richfield, WI

** Bonnie J. Bills, Department of Geosciences, University of Wisconsin-Milwaukee, Milwaukee, WI, *bjbills@uwm.edu*

A groundwater model was developed as part of the Smart Growth Plan for the village of Richfield, WI using the Groundwater Vistas 4.25 and MODFLOW programs. The accuracy of a groundwater model is evaluated by the comparison of the field data to the model's computed data. The original model was not able to adequately replicate groundwater flow through the bedrock valleys or sand & gravel pits. Refinements were made to the model in the areas of stratigraphy, boundary cell classifications and layer alterations.

Additional well construction logs were accessed to better determine the extent of clay and sand located within the bedrock valleys. Drain cells were added to the bottom of the model to simulate windows between the Sinnippee and Silurian dolostone aquifers. The original layer representing the Silurian aquifer was split into two layers. This allowed for a better replication of the different hydraulic conductivity values for the Milwaukee Formation and the underlying Waukesha Formation. These two units make up the bulk of the dolostone aquifer underlying Richfield.

The result of these refinements was a higher correlation between the modeled data and the field data. An effective groundwater model can be an aid to communities in fulfilling their Smart Growth Plan obligations.

**Graduate student presentation

7. Regional Groundwater Flooding in Southern Wisconsin

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Following intense rainfall in June, 2008, severe flooding occurred across southern Wisconsin, resulting in significant property loss, human displacement, and disruption of transportation. While most of the initial flooding occurred as surface water overflow, longer-term groundwater flooding remained for many weeks or months following the rain events. Groundwater flooding occurs when the water table rises above the land surface, and can be long-lasting because water-table decline requires drainage of an entire aquifer. Seepage lakes may also experience flooding of shoreline beaches and developments due to rise in the water table elevation and the related long-term increase in lake stage. Following the rain events, water levels in some wells in southern Wisconsin were nearly 10 feet above historic highs while lake stage increased by about 7 feet at Clear Lake, in Rock County.

Understanding the causes and impacts of groundwater flooding is necessary to advise local residents and officials and for making informed decisions about remediation efforts. Although the hydrogeologic setting varies among affected areas in southern Wisconsin, the widespread occurrences of groundwater flooding and the regional nature of intense precipitation events in 2007 and 2008 show that it is a regional issue. These flooding problems highlight the need to understand relationships between hydrologic systems and climate change so that local flood events can be anticipated and responses are appropriate.

8. Rethinking Nonpoint Source Pollution Management In an Agricultural Watershed: An Application of Wisconsin Buffer Initiative Concepts In Southwest WI

****Rebecca B. Carvin, Gaylord Nelson Institute for Environmental Studies¹,
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****Brandon R. Shelton¹, brshelton@wisc.edu**

The Wisconsin Buffer Initiative (WBI) concluded that water quality improvements in agricultural watersheds could be most efficiently achieved by focusing conservation efforts on fields that have the highest sediment and nutrient yields. The goal of this study is to apply this approach to a small watershed and assess its feasibility for application through the state of Wisconsin.

We used Soil Nutrient Application Planning (SNAP)-Plus software as a tool to quantify phosphorus (P) yields of individual fields in the Pleasant Valley Creek watershed. Data describing crop history, tillage regime, and nutrient application were gathered from land owners and entered into SNAP-Plus, which returned a Phosphorus Index (PI) value for each field. Fields with a PI greater than six were identified as offering the highest potential for conservation practices.

Nutrient, sediment, and habitat data were collected from perennial streams in the watershed in 2008 and compared to a GIS map of the field-scale PI values. Water samples were collected from snowmelt, storm, and baseflow events, and analyzed for dissolved P, total P, and suspended sediment. Channel geometry, soft sediment depth, and habitat surveys were conducted in three stream reaches. Preliminary analysis suggested connectivity between some fields and streams: sampling sites with high nutrient concentrations and thick deposits of soft sediment were found downstream of fields with high PI values.

Application of the WBI concepts resulted in several recommendations for where the Land Conservation Office can focus conservation efforts in the Pleasant Valley Creek watershed to achieve the most efficient improvements.

****Graduate student presentation**

9. Spatial Patterns of Nitrate Retention in a Central Sand Plains Stream

*Damion S. Drover, Department of Biology and Microbiology, University of Wisconsin-Oshkosh, Oshkosh, WI, *droved16@uwosh.edu*

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Previous studies have shown that nitrate is retained and processed in streams. However, less is known about where nitrate processing occurs in streams, particularly those with substantial hyporheic zones. This project was conducted in June and July 2008, and focused on discovering the spatial patterns of nitrate retention in a 300-meter groundwater-fed reach of Emmons Creek, located in the Central Sand Plains of Wisconsin. A push-pull method was used in which nitrate and bromide were injected into minipiezometers, installed at a 50 cm sediment depth, and retrieved at regular intervals. The relative concentrations of nitrate and bromide were monitored over time to determine whether nitrate was lost due to biological or physical means, and in what interval of time this loss was occurring. All appreciable nitrate loss at depth occurred within a 70-meter section of the reach. The largest amount of nitrate loss occurred in the depositional sides of the stream channel, suggesting that these were hotspots of biotic nitrate uptake. Additional research will be conducted to determine if these patterns or others emerge in different streams and in different seasons, and what mechanisms might be causing the patterns.

*Undergraduate student presentation

10. Hydrostratigraphic and Groundwater Flow Models: Troy Valley Glacial Aquifer, Southeastern Wisconsin

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Glacial deposits in the Troy Valley, a pre-glacial valley deepened by subglacial meltwater, could be a possible source of groundwater for municipalities in southeastern Wisconsin. However, municipal pumping could divert significant amounts of water from lakes, streams, and wetlands. Three-dimensional hydrostratigraphic and groundwater flow models were constructed to determine the effects of pumping four recently installed municipal wells near Lake Beulah and Vernon Marsh. The 3D hydrostratigraphic model was produced using Rockworks software and imported into a regional 3D groundwater flow model based on the computer code MODFLOW. Two local scale models encompassing Lake Beulah and Vernon Marsh were created using telescopic mesh refinement and the calibrated regional model. In the local scale models, MODFLOW's Lake and Stream Flow Routing Packages were used so that effects of pumping on surface water levels could be assessed. The groundwater flow modeling included an uncertainty analysis to test the effect of hydraulic conductivity values and pumping rates. Results from the regional and local scale models showed that pumping in the Troy Valley near Vernon Marsh and Lake Beulah will reduce groundwater heads and groundwater flow to surface water features near the pumping wells. Under the fixed flux boundary conditions assumed in the model, the maximum drawdown at depth was predicted to be around 50 ft, while the maximum drawdown of the water table was approximately 7 ft around Lake Beulah and 22 ft near Vernon Marsh.

****Graduate Student Presentation**

11. Physical Responses of Streams to Urbanization in Nine Metropolitan Areas of the United States

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Marie C. Peppler, U.S. Geological Survey – Wisconsin Water Science Center, Middleton, WI, mpeppler@usgs.gov

From 2000–2004, the U.S. Geological Survey conducted a study of urbanization effects on the physical responses of 249 streams in nine metropolitan areas of the U.S. as part of the National Water-Quality Assessment Program. A rural to urban land-cover gradient approach was used. Landscape characteristics and measures of urbanization were examined at multiple spatial scales, including watershed, riparian buffer, and reach. Urban indicators included percent impervious surface, percent urban land, population density, proximity of urban land to the sampled reach, road density, and an index of urbanization. Habitat and geomorphic characteristics were measured at 11 transects during low flow and included channel dimensions, percent of geomorphic channel units, channel-bottom substrate size, and bank conditions (substrate, percent and length of vegetative cover, angle, and percent erosion).

Preliminary results from this study indicate that the main physical alteration from urbanization, on the national level, was channel enlargement (channel widening or downcutting). However, the amount of channel enlargement depended on the climatic and physiographic setting of the watershed and its history. Changes in substrate, channel shape, and geomorphic channel units associated with urbanization depended on local geomorphic and geologic setting and human alterations. Historical watershed and local channel modifications such as interbasin transfers, reservoirs, channelization, bank stabilization, grade control, and dams decreased or masked the potential responsiveness. Results from this study emphasize the importance of including a wide range of landscape variables at multiple scales and knowledge of historical channel modifications in determining stream physical responses to urbanization.

12. Identification of Point Source Pollution on an Urbanized River Segment

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Increased urbanization places stress on water quality inside a watershed. This study investigated the effects of point source pollution on water quality on the Root River in Racine, WI, using chemical and bacterial markers. Nine storm water outfalls were examined for their impact on adjacent open water sites. All samples were tested once weekly for pH, conductivity, turbidity and *Escherichia coli* (*E. coli*). Storm water outfalls were additionally tested for *Bacteroides* (human-specific), detergents, chlorine, phenols, and copper. Detergents, chlorine, *E. coli* and *Bacteroides* are used as indicators of human waste. Presence of these indicators in wet and dry weather storm water discharge may indicate sanitary sewer infrastructure deterioration. Deterioration may result in infiltration to the storm water sewer. Open water sites adjacent to storm water outfalls frequently had elevated *E. coli* levels. Two storm water outfalls were identified as candidates for potential sanitary infiltration: Racine Lutheran Outfall [Average *E. coli*: 44,500MPN/100 mL(dry weather, n=17), 23,400 MPN/100 mL(wet weather, n=11), and χ detergent = 0.15 ppm] and Leudtke and Rupert Street Outfall [Average *E. coli*: 15,700 MPN/100 mL(dry weather, n=14), 14,300 MPN/100 mL (wet weather, n=8), and χ detergent = 0.13 ppm]. No copper or phenols were detected indicating industrial waste as an unlikely contributor. Positive *Bacteroides* tests (both outfalls) indicated a likely sanitary source. Televising confirmed degraded storm and sanitary infrastructure, scheduled for repair in 2009. This study demonstrates the utility of combined chemical and microbial source tracking in pinpointing

*Undergraduate student presentation

13. Using Environmental Variables to Predict Surface Water Quality

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Recreational areas such as beaches generate significant revenue in the Great Lakes. Predictive models, using a suite of environmental variables, could improve monitoring efforts currently hampered by an 18 to 24-hour lag time from sample collection to results. The Racine Health Department created a robust dataset using two years of detailed beach sanitary survey data, in addition to six years of historic monitoring data. From this dataset, six water quality variables were deemed statistically significant for their association to elevated *E. coli* levels. Weak correlation was demonstrated with wave height, turbidity, and in some cases water temperature. A moderate correlation existed between *E. coli* counts and 24-hour precipitation. Using EPA'S *Virtual Beach*, an Excel based modeling program, a multiple linear regression (MLR) equation was generated to predict *E. coli* counts. The model, in its current format, accurately predicted *E. coli* counts 78% of the time ($R^2 = 0.78$) but with a relatively high standard error (~72 MPN/100 ml). Further comparisons of predicted *E. coli* counts to meteorological patterns have demonstrated a better degree of correlation between May and mid-July which then deteriorated in the second half of the beach season (mid-July to early September). This may indicate that alternative sources of contamination and/or other variables, not yet tested, may influence water quality during late summer. Alternatively, the relative infrequency of water quality advisories, given the improved beach management tactics employed by the City of Racine, may skew that dataset in such a way the predictive models are unreliable.

*Undergraduate student presentation

14. Geochemical Characterization of Sulfide Mineralization in Eastern Wisconsin Carbonate Rocks

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We examined the trace metal geochemistry of sedimentary rocks in northeastern Wisconsin in an attempt to better understand their regional, stratigraphic, and petrographic distribution in the different Paleozoic strata. Samples were collected from outcrops, quarries, and drill cores throughout the region, with a principal focus on Brown, Shawano, Oconto, and Marinette counties.

The distribution of sulfide minerals in the host sedimentary rocks of the region is heterogeneous, but stratigraphically predictable. In addition to the well-documented Sulfide Cement Horizon (SCH) below the base of the Platteville Dolomite, other stratigraphic horizons display a predictable occurrence of sulfides, especially the base of the Silurian Mayville Dolomite and the top of the Maquoketa or Neda formations.

This study provides two major conclusions. First, the sulfide mineralization observed in Winnebago and Outagamie counties does indeed extend northward into Brown, Shawano, Oconto, and Marinette counties. Second, abundant quantities of sulfides appear near the contact between the Silurian Mayville Formation and the underlying Maquoketa and/or Neda formations east of the Niagara escarpment. While most water quality concerns in the Silurian hosted wells has focused on bacteria and nitrate contamination, the possibility of metals contamination might exist for wells that reach a total depth near or at this stratigraphic horizon. Future water quality studies should focus on these two mineralized stratigraphic horizons, as it seems likely that groundwater quality problems similar to those in Winnebago and Outagamie counties should continue northward along these outcrop belts.

15. Groundwater Recovery and Hydrostratigraphy in the Northeastern Groundwater Management Area of Brown, Outagamie, and Calumet Counties, Wisconsin

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The northeastern Groundwater Management Area (GMA) experienced more than 300 feet of drawdown in the Green Bay area prior to the switch from groundwater to surface water by eight municipalities during 2006 and 2007. These communities used water from a deep confined aquifer, composed of Cambrian and Ordovician sandstones and carbonates, which are confined by Sinipee Group dolostones and the Maquoketa Shale. After the switch, daily groundwater withdrawal from the regional deep sandstone aquifer decreased by approximately 12 million gallons. We are monitoring the water level recovery and are compiling an estimate of pumping volumes for the deep aquifer.

Water level records from a variety of sources indicate that water levels have recovered more than 100 feet in some wells since the switch to surface water. More than 150 active, high capacity wells penetrate the deep aquifer in the study area. While the collection of these records is ongoing, we have obtained monthly pumping records for 57 of them. From these records we estimate that current pumping varies seasonally from two to four million gallons of groundwater per day. Data collected for additional wells will increase our estimate of daily pumping rates.

Our project also involves developing a refined hydrostratigraphic model for the northeastern GMA. Drill cores, geophysical logs, and other hydrogeologic data obtained in the GMA have allowed a better understanding of the properties of aquifer and confining units.

****Graduate student presentation**

16. Influence of Wetland Hydrodynamics on Subsurface Microbial Redox Transformations of Nitrate and Iron

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The objective of this project is to constrain the mechanisms of nitrate loss and coupled cycling of iron within a riparian wetland aquifer. Although several recent studies have addressed the influence of hydrologic dynamics on subsurface denitrification, the impacts of competing microbial metabolic pathways and redox interactions are not well understood in relation to hydrological dynamics. In particular, interaction between N and Fe redox cycles represents a potentially important but poorly constrained driver of aquifer N dynamics.

A network of multilevel samplers and piezometers has been installed in the wetland, with two transects perpendicular to the creek and single multilevels have been installed near County Highway Q and Oncken Road (Figure 1). From this network, a variety of geochemical parameters (temperature, conductivity, dissolved O₂, dissolved organic carbon, Fe²⁺, Fe³⁺, NO₃⁻, SO₄²⁻, and Cl⁻) will be determined on a monthly basis. Also, three times per year (September, December, and March), the abundance of culturable organotrophic NO₃⁻-reducing, organotrophic Fe(III)-oxide reducing, and Fe²⁺-oxidizing NO₃⁻-reducing microorganisms will be determined in groundwater across the transects. In parallel with these measurements, the relative abundance of genes associated with NO₃⁻ removal processes will be quantified using real-time PCR.

**Graduate student presentation

17. Time Resolved, Remote Environmental Sensing along an Optical Fiber, Utilizing a Range-gated, Stroboscopic Detection System for Improved Detection Limits

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We investigate Fiber Optic Chemical Sensors (FOCS) in which excitation light traverses an optical fiber, interacting with environmental sensors located at points along ~1 km of fiber. These sensors are located within the cladding of the fiber resulting in a chemically-modified, fluorescent cladding. The fluorescence response of each region depends on the local environment (in this case pH) at each sensor. A portion of the fluorescent light travels back down the fiber; the position of each sensor gives rise to a time delay of the fluorescent signal to the light detector, located at the front face of the fiber.

Previous work showed that the detection system is initially saturated by the excitation light, which was reflected back to the detector at the front face as well as scattered back as the light traversed through the fiber (Rayleigh scattering), obscuring the signals originating at the sensor regions. To circumvent these problems, we employ a range-gated detection method, where only those signal pulses originating at the selected sensor region (at any point on the fiber) are registered by the detector, a standard photomultiplier tube. Thus, all light arriving at the detector outside of the selected time-window (i.e. from all points other than the selected sensor region) is rejected. We report on the performance of this detection method with particular emphasis on application for pH-sensing in aqueous environments. For this pH-sensor, we present calibration curves and detection limit estimates.

18. Gully Stabilization and Forest Rehabilitation for Brook Trout Habitat, Lake Superior South-Shore Streams, Wisconsin

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The Bark River is a forested tributary to Lake Superior in Wisconsin. In 2005, we began an integrated multi-agency study of brook trout habitat rehabilitation, erosion and sedimentation control, stream hydrologic and geomorphic conditions, and runoff and infiltration characteristics from upland forests. Previous studies in the vicinity of the Bark River indicated that available brook trout spawning habitat is dependent on the location of ground-water discharge zones, the severity of floods, and erosion/sedimentation processes. Rehabilitation techniques tested on gullies as part of this study included grade control (mainly natural, onsite materials), addition of large woody debris for increasing roughness, slowing and infiltrating flow and trapping sediment, and native plant restoration. Rehabilitation of perennial reaches has involved removal of alder, which tend to trap sand, widen the channel, and bury gravel spawning areas. Snowpack moisture variability under different tree species canopies is being measured to assess forest type contributions to spring snow melt magnitude, and to model landscape effects of forest changes. Headcutting, incision, bank erosion, and sediment deposition along ephemeral gullies are monitored through semi-annual measurements of gully cross sections and erosion pins. In perennial reaches upstream and downstream of the gullies, streamflow is monitored with continuous stage recorders and suspended sediment samples are collected after floods from single-stage samplers. Habitat and brook trout populations are surveyed annually. Results from this integrated study will be used to evaluate the applicability of the gully stabilization techniques and forestry practices for other steep tributaries along the south shore of Lake Superior.

19. Plasmonic-Based Optical Fiber Sensor for Real-Time, Remote, and Spatially Resolved Determination of Oxygen

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We report a novel oxygen sensor comprised of a nanoscale system of silver nanoparticles, which were covalently attached to the core of an optical fiber and labelled with luminescent sensor molecules. The particular combination of metallic nanostructures, providing large enhancement of luminescence via localized plasmon resonance, and optical fiber technology, providing fast, remote and real time detection capabilities, allows for the fabrication of versatile sensor.

Sensing is based on luminescence quenching of a ruthenium complex in presence of molecular oxygen. To take advantage of the metal-enhancement effects in our sensor arrays, the ruthenium complex was kept at an appropriate distance from the silver nanoparticles by spacer layers assembled using the well-established Layer-by-Layer (LbL) technique. Varying the number of non-luminescent polyelectrolyte spacer layers allow for placing luminophores at varying distances from the metal nanoparticles and, thus, for optimizing the metal enhancement effect.

The plasmonic-based sensor was tested using a two-crossed-fiber sensor array with two regions excited with a dye laser (465 nm) pumped by a nitrogen laser. The second region was used as intensity reference. The sensor was mounted in a home-built flow chamber where both oxygen and nitrogen were pumped into the chamber at different partial pressures. The luminescence emitted by the sensor molecules was captured by a second fiber at right angle to the fiber carrying the excitation light. We measured calibration curves for this sensor system and determined detection limits.

**Graduate student presentation

20. Enhancing Reproducibility and Dynamic Range of Luminescent Optical Fiber Sensors for Remote Monitoring in Aqueous Environments

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Water quality testing is commonly done by collecting water samples in the field to determine composition, including heavy metal contaminants, toxins, pH, and dissolved oxygen concentration. This method is time-consuming and does not account for fluctuating conditions of the natural environment. These water systems can be monitored in-situ using optical fiber sensors, which give remote, real-time measurements. Luminescent dyes provide strong signals for oxygen and pH monitoring, and, thus, may be used in optical fiber sensors: Fluorescein molecules have a characteristic pH-range with a pH-dependent emission intensity (which provides the “signal” in the optical fiber array). Likewise, the luminescence intensity of ruthenium phenanthroline changes inversely with oxygen concentration. Materials containing sensor molecules must be applied uniformly (and reproducibly) as a cladding for optical fibers to achieve consistent sensor performance.

To optimize deposition procedures, a reliable way of measuring the thickness of sensor layers attached to optical fiber cores is needed. We are using the Beer-Lambert Law to measure thickness of the cladding through measurement of its absorbance (using known concentrations and extinction coefficients of the absorbing species). We will present calibration procedures and thickness measurements as well as fluorescence quantum yields for ruthenium sensor layers that were deposited under varying conditions.

We are also working on extending the dynamic range of sensors. For pH-sensing, we will mix several derivatives of fluorescein (with side groups containing various halides and/or hydrocarbon chains), all of which have different pKa values. By mixing these derivatives in appropriate proportions (considering extinction coefficients and fluorescence quantum yields), the pH-range that can be measured will be extended significantly. We will present results on the fluorescence of dye mixtures and their pH-dependence.

*Undergraduate student presentation

21. Mercury in Fish, Bed Sediment, and Water from Streams across the United States, 1998-2005

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Mercury (Hg) was examined in top predator fish (primarily largemouth bass), bed sediment, and water from streams that spanned regional and national gradients of Hg source strength and other factors thought to influence methylmercury (MeHg) bioaccumulation. The highest total Hg (THg) concentrations in fish were from blackwater coastal-plain streams draining forests or wetlands in the eastern and southeastern US, as well as from streams draining gold or Hg mined basins in the western US (1.80 and 1.95 $\mu\text{g/g}$ THg wet weight, respectively). For non-mined basins, length-normalized Hg concentrations in largemouth bass were significantly higher in fish from predominantly undeveloped or mixed-land-use basins compared to urban basins. Hg concentrations in largemouth bass from non-mined basins also were correlated positively to basin percentages of evergreen forest and woody wetland, especially with increasing proximity of these two land cover types to the sampling site; this underscores the greater likelihood for Hg bioaccumulation to occur in these types of settings. Increasing concentrations of MeHg in unfiltered stream water, sediment MeHg normalized by loss-on-ignition (LOI, a measure of organic matter content), and decreasing pH and dissolved sulfate were also important in explaining Hg concentrations in largemouth bass. MeHg concentrations in sediment correlated positively with THg, LOI, and acid-volatile sulfide in sediment. Concentrations of MeHg in water correlated positively with DOC, UV absorbance, and THg in water, and with the percentage of MeHg in sediment, and percentage of wetland in the basin.

22. Wisconsin Well Water: Planning Web-based Resources to Promote Safe Drinking Water for Wisconsin Residents

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The purpose of this collaborative stakeholder project is to develop a plan toward a goal of making accurate and user-centered private well water information more easily accessible for Wisconsin residents. Projects objectives include: (1) identify and prioritize system needs, (2) identify technology-based solutions toward addressing these needs, (3) select the most appropriate and feasible solutions. Objectives will be accomplished via a series of 3 iterative planning meetings. We will present methods and results from the first planning meeting.

Thirty-two meeting attendees represented state and local agencies, and private businesses at this meeting. Morning presentations provided an overview of the project goals, current information resources, results from several internet surveys designed to understand how this work occurs among local agencies and commercial laboratories, and a summary of several research projects among WI private well owners. Gaps in information access were noted for: well water testing, understanding water test results, and local water quality. An afternoon discussion centered on 3 questions: What are the biggest communication challenges? Ideal functions your job would include? What technology-based solutions could help? Comments pertaining to the first 2 questions were solicited in open discussion. Ideas for the last question were solicited using nominal group process. Each participant stated one idea that was recorded. Each participant used 7 colored dots (different colors for different stakeholder categories) to vote for (prioritize) the solutions. The top 3 priorities were: interactivity related to promoting corrective action, resources toward annual maintenance and reminders, and maps with testing information and needs. These and other stakeholder priorities will drive the agenda for the following 2 meetings.

23. Impacts of Urban Runoff on Bioretention Basins Planted with Native Vegetation vs. Cool Season Turf Grass

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A large amount of the area occupied by the University of Wisconsin-Stevens Point campus is covered with impervious surfaces. The volume of stormwater runoff into surface waters through stormwater discharge is positively related to the percentage of land area covered with impervious surfaces. Bioretention basins which incorporate a variety of plants are thought to be effective bio-filters to increase infiltration associated with storm water. To evaluate the effectiveness of bioretention to increase infiltration, two bioretention basins were constructed on the UW – Stevens Point campus. One basin was planted with cool season turf grasses and the other planted with native vegetation. The basins are 15 cm (6 in) deep and collect runoff from two source areas of 70.3 m² (757 ft²).

The objective is to compare vegetation effects on the surplus water at different depths in the soil profile. We hypothesize that the native prairie vegetation will exhibit a greater infiltration rate than the turf grass. Results from this study will advance our understanding of the composition of plants required to create effective storm water collection basins.

*Undergraduate student presentation

24. Effects of Elevated Nitrate Concentration on Mortality, Growth, and Egestion Rates of *Gammarus pseudolimnaeus* Amphipods

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Elevated nitrate concentration can cause acute and chronic toxicity in a variety of aquatic animal species at environmental concentrations. Most of the studies of nitrate toxicity in aquatic invertebrates have centered on taxa that primarily inhabit surface waters. Much less is known about the acute and chronic toxicity of nitrate in invertebrates inhabiting shallow sediments, where nitrate concentrations in the pore water can greatly exceed those in the surface water, particularly in regions with high nitrate inputs. Our target species was *Gammarus pseudolimnaeus*, a sediment-dwelling amphipod that is widely distributed in streams throughout Wisconsin. The objectives were: 1) to determine if *Gammarus* experiences acute nitrate toxicity at environmentally realistic nitrate concentrations. 2) to assess the effects of elevated nitrate concentration on somatic growth, molting, and egestion rates of *Gammarus*. Organisms were exposed in the laboratory to seven nitrate concentration treatments (target concentrations were 0.2, 4, 8, 16, 32, 64, and 128 mg NO₃-N/L) for three weeks in microcosms. There were no effects of nitrate concentration on amphipod mortality, molting frequency or egestion rate. Elevated nitrate concentration had weak negative effects on *Gammarus* growth rate. Our results suggest that elevated nitrate concentrations up to 128 mg NO₃-N/L have no lethal effect and weak nonlethal effects on *Gammarus pseudolimnaeus*.

25. Variation in Spring Water Chemistries within Small Discharging Zones

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High flow springs were sampled at discharging “boils” and analyzed for pH, EC, DO, NO₃-N, Cl and alkalinity within three spring complexes located near Madison Wisconsin. The dimensions of the sampling areas in this study were 5m×20m for the Nine Springs discharge zone, 4m×10m for Pheasant Branch and 1.5m×2m for Token Creek.

An elevated average Cl concentration (88mg/l) with a wide range of variation (45-135mg/l) was found in Nine Springs for which the watershed consists of mainly urban land use. The average NO₃-N concentration (12mg/l) in Pheasant Branch Creek exceeds the drinking water standard, reflecting dominating agricultural land use in the watershed. A fairly wide range (4-20mg/l) in NO₃-N concentrations was also found. Token Creek spring waters have lower NO₃-N concentrations but very similar anion compositions to those of Pheasant Branch springs, except several samples which exhibited compositions similar to those of Nine Springs.

Despite of the small sampling area, the large variations in chemical concentrations and compositions found in each discharging zone suggest existence of independent non-mixing flow paths for the spring waters discharging into the same area.

Relatively high DO and NO₃-N concentrations in the spring waters indicate lack of denitrification during groundwater transport. In the absence of denitrification, the lack of correlation between Cl and NO₃-N, which come mainly from various anthropogenic sources, indicates that these springs have different sources for Cl and NO₃-N. The findings support the idea that water from distinct recharge areas with different NO₃ and Cl sources are converging to small discharge area without mixing.

[#]currently at Department of Geology and Geophysics, University of Wisconsin-Madison (until March 30, 2009)

SESSION 3A
Contaminants in Groundwater
Friday, March 6, 2009
8:00 – 9:40 a.m.

Interaction between Tetracycline and Rectorite in Aqueous Solution

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The use of antibiotics and hormones in human and veterinary has resulted in frequent detection of these pharmaceuticals in ground water and waste water. Thus, it is of great interest to study the interaction between common pharmaceuticals and clay minerals. The sorption and intercalation of tetracycline (TC) from water onto rectorite, a regular interstratified clay mineral made of 1:1 ratio of a nonexpandable illite component and an expandable montmorillonite component, was investigated under different pH and initial concentration conditions. The TC sorption capacity on rectorite reached at 140 mg/g at pH 4–5 and decreased to 54 mg/g at pH 11. Under acidic condition, the intercalated TC produced an interlayer gallery height of 10 Å. On the contrary, at pH 11, the interlayer gallery height is 17Å after TC intercalation, although the amount of TC intercalated is much less than that under acidic condition. Thermogravimetric analyses showed a peak decomposition temperature (T_{peak}) of 230°C for crystalline TC. However, this T_{peak} increased to 410–420°C, suggesting that the intercalated TC in rectorite is thermally more stable than its crystalline form. Both XRD and FTIR spectra showed different interlayer configurations of TC at low and higher amounts of intercalation. The results from this study indicate that rectorite could be a good candidate as sorbents to remove TC from water on one hand, and could be an environmental sink for TC on the other hand. These dual properties deem further study on interactions between a broad spectrum of antibiotics and different types of clays.

Assessing Levels and Potential Health Effects of Endocrine Disrupting Chemicals in Groundwater Associated with Karst Areas in Northeast Wisconsin

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In recent years, concern has risen over the presence of various nonpoint source pollutants in drinking water, including a subset of pharmaceuticals, personal care products, and other synthetic organic chemicals that are considered endocrine disrupting chemicals (EDCs). The growing prevalence of EDCs in environmental systems has been linked to the disruption of aquatic endocrine systems and increased incidence of certain human cancers. Groundwater in northeastern Wisconsin may be particularly susceptible to nonpoint source contamination due to the existence of shallow soils, dolomite bedrock, and karst features, which combine to facilitate the transport of surface run-off to groundwater. Land application of manure containing synthetic and endogenous hormones may be a significant source of non-point source pollutants, including EDCs, to groundwater in the heavily farmed regions of northeast Wisconsin. This study will quantify a specific EDC, 17β estradiol, in groundwater samples collected from four counties in northeast Wisconsin, including Brown, Calumet, Fond du Lac, and Kewaunee. The MCF-7 breast cancer cell proliferation assay will be used to determine whether the groundwater samples exhibit estrogenic behavior. Also, possible sources of EDC contamination will be analyzed by correlating results with nearby farming operations and other indicators of contamination, including nitrates, fecal coliform bacteria, enterococci, and *E. coli*. Samples will be collected four times between summer 2008 and spring 2009 to determine if EDC levels vary with seasonality and in response to major recharge events.

**Graduate student presentation

Modeling Flow and Arsenic Contamination in an Aquifer Storage and Recovery System, Green Bay, WI

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Aquifer Storage and Recovery (ASR) was investigated early in this decade as an option to enhance municipal water supply capacity in Green Bay, WI. The project was ultimately determined to be unfeasible due to high levels of arsenic in the recovered water. Prior to 1957, Green Bay used water from the local Cambrian-Ordovician aquifer, but heavy use created such a large cone of depression that the municipal supply source was switched to Lake Michigan water. During the ASR testing period an old municipal well, open to approximately 550 ft of the aquifer system, including an upper aquifer, a lower aquifer, and a middle unit assumed to be confining, was used as the ASR injection and recovery well. Packers installed in a nearby monitoring well allowed for sampling from three intervals, roughly coinciding with these units. Arsenic concentration histories in these three intervals indicate that the middle unit is the source of most of the arsenic. Previous studies have investigated the presence of preferential flow paths in the units making up this middle interval, and breakthrough curves for specific conductivity indicate that in Green Bay this interval is horizontally highly conductive, allowing for the mobilization and transport of significant quantities of arsenic. This study incorporates this revised conceptual model into computer models for the local flow system and the mobilization and transport of arsenic.

******Graduate student presentation

Tracking Shallow Groundwater Anthropogenic Effects in Southeastern Wisconsin

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The impact humans have on groundwater is always a matter of concern. This research examines the anthropogenic effect in the shallow aquifer of southeastern Wisconsin. In order to measure this effect, a monitoring network of wells, streams, and treated wastewater were sampled and analyzed for a suite of properties including major ion chemistry, pH, temperature, electrical conductivity, dissolved oxygen, concentrations of bromine, iodine, lithium, boron, pharmaceuticals and personal care products (PPCPs) and isotopic ratios of lithium and boron. This sampling was repeated on a regular basis to study temporal changes of these properties. The chemical signatures of the collected samples from the monitoring network were then compared with end members to determine anthropogenic influence. Preliminary results showed surface waters tested positive for 8 of 10 PPCP compounds. In groundwater, caffeine, paraxanthine, and warfarin were found in 100% of wells tested. Also, erythromycin was found in 86% of wells and atrazine in 29% of wells.

Human Viruses in Water Supply Wells in Madison, WI

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Among the many waterborne pathogens of humans, enteric viruses, because of their small size, have the greatest potential to move deeply through the subsurface environment, penetrate aquitards, and reach confined aquifers. During 2007 and 2008 we sampled six deep municipal wells in Madison, WI, for viruses on an approximately monthly basis. Three of these wells had shallow casings, and three were cased through a regional aquitard. We also collected samples from local lakes and from untreated sewage.

Viruses were detected at least twice in each well, but no well was virus-positive in every sampling round. Overall, 43 percent of the samples were virus-positive. Samples from three wells were positive for virus infectivity. Lake samples were positive 78 percent of the time. Sewage samples were extremely high in viruses, with all samples positive. Virus results varied significantly with time, and there is apparent temporal correlation between virus levels in sewage, lakes, and groundwater.

Correlation between viral serotypes found in sewage, lakes, and groundwater suggests very rapid transport from the source(s) to wells. Water isotope analyses showed surface water to be an unlikely source of viruses; thus, the most likely source of the viruses in the wells is leakage of untreated sewage from the Madison sewer system. Given the high concentrations of viruses in sewage, it would take very small volumes of sewage to produce the virus concentrations observed in the wells.

Human enteric viruses might be excellent tracers of recently recharged groundwater in urban settings if virus sources exist.

SESSION 3B
Hydrologic Trends
Friday, March 6, 2009
8:00 – 9:40 a.m.

When My Beach Is Really Lakebed: Managing Shorelines and Water Levels in Wisconsin

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Water levels can fluctuate naturally or be managed through water controls structures. When water levels change, the landscape changes and it is important for the public to know what they can and cannot do when there shoreline changes. In this time of climate change, droughts, and floods, flexible policies and management frameworks are needed in order to manage these dynamic systems and at the same time protecting the public trust and the natural resources we depend on. For example, lakefront property owners on seepage lakes may have a need to manage rising water levels whereas lakefront property owners on other lakes may have a need to manage low water levels.

Landowners are on the front lines when confronted with changing water levels on their property, and now more than ever it is important that they be educated on the proper way to conduct shoreline activities. This presentation aims to outline the state's jurisdiction when it comes to managing water levels, and also take a step by step approach to inform citizens on what options they have to manage their property under different water level scenarios. These may include erosion control, vegetation management, etc.

Trends in Groundwater Levels in Central Wisconsin

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For the past 10 years the Central Sand Plain of Wisconsin, especially Portage and Waushara counties, has experienced an alarming decrease in groundwater elevation, lake levels, and stream flows, with significant impacts on aquatic ecosystems, recreational uses of streams and lakes, and property values of riparian lands. Since 2002, water table levels have dropped over 30 cm per year. It is clear that reduced stream flows and lake levels are associated with reduced groundwater elevations. However, it is unclear the degree to which these groundwater fluctuations are driven by climate changes or increasing irrigated agriculture. After collecting over six months of continuous water table elevation data under several vegetation types, we can see effects of vegetation cover and irrigation practices on fluctuation patterns in the water table. The first year of growing season data show clear differences in recharge and discharge behavior of the water table under irrigated crops and natural vegetations. On sites where data have been collected since February 2008, the impact of seasonal changes on the water table is also apparent. We will continue to expand our current database of groundwater elevations through the winter and over the 2009 growing season to further understand vegetation and irrigation impacts on groundwater levels.

****Graduate student presentation**

Historical Perspectives on Groundwater Pumping

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Talks concerning groundwater withdrawal in Wisconsin are becoming a topic of concern as levels of groundwater, lakes, and streamflows in central Wisconsin have decreased in recent years. The Wisconsin League of Conservation Voters recently stated that that “providing greater protection of groundwater resources and the lakes, rivers, and wetlands dependent on groundwater” as one of the issues most critical for action by the Wisconsin Legislature.

Concerns about groundwater pumping and its impacts have been expressed since groundwater extraction began in the 1950's, when some professionals warned of impending environmental harms if pumping was not managed. However, some 3,000 high capacity wells currently exist in central Wisconsin and large increases in their numbers were documented in 2008. Growth in high capacity well numbers and groundwater pumping has been rapid, minimally controlled, and mainly without regard for impacts in resources.

For us to fully understand the current groundwater situation in central Wisconsin we must first understand what brought us here. The object of this presentation is to examine past attempts at groundwater legislation, as well as identifying major players involved and their motivations for supporting or opposing proposed legislation. It was the ideas touted during these times that went on to form popular opinion regarding groundwater resources for years to come and even today still have influence.

A Distributed Approach to Model Calibration – the Model Center Concept

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Sophisticated and powerful tools for model calibration and uncertainty analysis are now available in hydrogeology—particularly with the release of the JUPITER and PEST software suites. The availability of these tools has been accompanied by an increased awareness by decision-makers and regulators of the value of uncertainty quantification in even routine modeling studies. Together, these factors are forcing practitioners to move beyond trial-and-error calibration and rudimentary sensitivity evaluations. Thomas Friedman, in the book “The World is Flat” argues that today’s problems and best-suited tools have become sophisticated enough that no one person can be expected to do the best job. Is it fair to expect all modelers to become proficient in the regression and statistical techniques used in parameter estimation in addition to the inherent requirements necessary for model construction and conceptualization?

In this work, we propose a collaborative approach to model construction, calibration, and uncertainty analysis being implemented at a prototype Modeling Center at the USGS Wisconsin Water Science Center. In two examples—a mining study and a large regional water-use model—the most central modeling tasks of conceptualization, design and model construction are tackled by a team of modelers most knowledgeable about the site, while the application of state-of-the-art model calibration and uncertainty analysis are handled by the Modeling Center. The benefits and challenges of such a Modeling Center approach are discussed in addition to an outline of the general approach and philosophy of the concept.

SESSION 4A
Modeling Groundwater and Surface Water Systems
Friday, March 6, 2009
10:00 – 11:55 a.m.

GIS-based Groundwater Recharge Estimation for Southeastern Wisconsin

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Groundwater recharge is defined as water that crosses the water table and is added to the groundwater system; recharge is the ultimate source of all groundwater. Understanding recharge and its distribution is important in making informed land-use decisions so that the groundwater needs of society and the environment can continue to be met. Recharge replenishes groundwater needed for human use and natural systems such as rivers, lakes, springs, and wetlands. Informed land-use and water management require information about the spatial and temporal distributions of recharge. A new recharge analysis of southeastern Wisconsin uses a soil-water balance model (SWB) to map annual recharge rates over the entire region. This presentation describes the inputs, operation, and application of the SWB model.

The model results show how groundwater recharge varies spatially and temporally. The spatial variation is due primarily to spatial differences in land-use, soils, and topography with a variation across the region of less than 1 inch/year to more than 20 inches/year. Recharge also varies temporally with climate and precipitation with an estimated variation of less than 1 inch/year to more than 10 inches/year for a selected township in Waukesha County over the last 50 years. Local planning decisions cannot significantly alter the weather or geology, but can impact land-use. This recharge model provides a groundwater management tool to guide land-use decisions and increase understanding of recharge in southeastern Wisconsin.

Southeastern Wisconsin Regional Planning Commission Ground Water Model of the Troy Bedrock Valley Aquifer of Southeastern Wisconsin

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The Southeastern Regional Planning Commission (SEWRPC) has completed a ground water model of the Troy Bedrock Valley aquifer in southeastern Wisconsin. The model is a six layer MODFLOW model that simulates three dimensional groundwater flow from the water table to the base of the Silurian dolomite aquifer. The model covers portions of Milwaukee, Waukesha, and Walworth counties with a near field area focused on the bedrock valley.

The Troy Bedrock Valley is a pre-glacial drainage that runs from Milwaukee County, through Waukesha and Walworth Counties, into Illinois where it merges with other bedrock valleys. The Troy Bedrock Valley contains deposits from several glacial advances and retreats. The glacial deposits form a complex sequence of sand and gravel outwash units separated by clay-rich till and lacustrine deposits of varying thickness and continuity. The sand and gravel units are being developed as high capacity aquifers for several municipal water systems. The Troy Bedrock Valley is also host to several lakes, streams, and wetlands which are ecologically important. The development of the aquifer as a water source has raised concerns over the potential impact on the surface water and water dependent habitat. The complex stratigraphy of the glacial units complicates the prediction of the impact of pumping. The SEWRPC Regional Aquifer Model for Southeastern Wisconsin covers a much larger area and has limitations in its ability to simulate flow in the glacial system due to its large grid size. A dedicated model of the Troy Bedrock Valley aquifer was deemed necessary to make reliable predictions of the local flow system.

The model was developed with funding from the City of Muskego, the Waukesha Water Utility, the Village of Mukwonago, and the Village of East Troy. The model was developed as planning tool for local municipal water utilities to allow them to run their own simulations to predict the sustainable yield of the bedrock valley aquifer and determine the surface water impacts from well fields producing from the aquifer. The model is a public domain document and is freely available to the public.

A New Tool for Inset Modeling: An Example of Local Grid Refinement Methods in Southeastern Wisconsin

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Regional ground-water-flow models are increasingly being used as the framework for developing more detailed models designed to answer local or small-scale conjunctive ground-water-and surface-water-resource questions. Traditional one-way, coupled, telescopic-mesh refinement methods are now relatively easy to use, but, if not constructed correctly, can have large, often undetected, inconsistencies related to simulations with the local model and its effect on the regional model calibration. Shared node Local Grid Refinement (LGR) addresses these problems by iteratively coupling two separate MODFLOW-2005 models such that heads and fluxes are always balanced across the shared interface boundary. This capability ensures realistic simulations of the effects of refinements in the inset model, while also enabling sensitivity analysis, parameter estimation, and uncertainty analysis that reflects conditions in both model grids.

LGR is well suited for complex ground-water and surface-water systems such as are present in southeastern Wisconsin. The calibrated southeastern Wisconsin ground-water-flow model was used as the regional model (the parent model) for a LGR of an area in northwestern Waukesha County. The large grid size of the regional model (2,500 ft x 2,500 ft) was too large for accurate representation of, for instance, ground-water flow into and out of surface water bodies. The LGR model inset (the child model) using a smaller grid size (278 ft x 278 ft) was constructed to simulate an area including the chain-of-lakes within and adjacent to the Village of Chenequa. This localized model is being utilized to simulate shallow ground-water flow and evaluate the role of ground water in maintaining levels of Beaver, North, and Pine Lakes. The LGR is also being used to test the effects of future development and ground-water withdrawals (wells) at the regional scale (simulated with the parent model) on lakes, streams, and shallow ground-water flow within the child model.

Simulation of the Ground-Water-Flow System in Pierce, Polk, and St. Croix Counties, Wisconsin

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A regional three-dimensional ground-water-flow model was developed to simulate the ground-water-flow systems in Pierce, Polk, and St. Croix Counties, Wis. The objectives of the model were to improve understanding of the ground-water-flow system and to develop a tool suitable for evaluating the effects of potential water-management programs.

The ground-water-flow model simulates the major hydrogeologic features of the area, including bedrock and surficial aquifers, ground-water/surface-water interactions, and ground-water withdrawals from high-capacity wells. Results from the model indicate that about 82 percent of ground water in the three counties is from recharge within the counties; 15 percent is from surface-water sources, consisting primarily of recirculated ground-water seepage in areas with abrupt surface-water-level changes, such as near waterfalls, dams, and the downgradient side of reservoirs and lakes; and 4 percent is from inflow across the county boundaries. Ground-water flow out of the counties is to streams (85 percent), outflow across county boundaries (14 percent), and pumping wells (1 percent). These results demonstrate that the primary source of ground water withdrawn by pumping wells is water that recharges within the counties and would otherwise discharge to local streams and lakes.

Under current conditions, the St. Croix and Mississippi Rivers are ground-water discharge locations (gaining reaches) and appear to function as “fully penetrating” hydraulic boundaries such that ground water does not cross between Wisconsin and Minnesota beneath them. Being hydraulic boundaries, however, they can change in response to water withdrawals. Tributary rivers act as “partially penetrating” hydraulic boundaries such that ground water can flow underneath them through the deep sandstone aquifers. The model also demonstrates the effects of development on ground water in the study area. Water-level declines since predevelopment (predating withdrawal wells) are most pronounced where pumping is greatest and flow between layered aquifers is impeded by confining units or faults. The maximum simulated water-level decline is about 40 feet in the deep Mount Simon aquifer below the city of Hudson, WI.

Building Coupled Ground-water/Surface-water Models to Simulate Climate Change

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Numerical models are used to investigate potential hydrological effects of climate change. Parameter estimation (PE) has been widely recognized a necessary component for effective modeling, but has had differing degrees of use in hydrologic models. PE of ground-water models has been a focus of research for a relatively long period of time, helped in part by the overlying unsaturated zone which can act as a low-pass filter that dampens surface transience. Surface-water model calibrations are thought to be a more difficult PE problem due to: 1) larger number of parameters, with associated insensitivity and correlation; and 2) large, transient datasets with redundant or correlated information which decreases the signal-to-noise ratio of the data. Coupled ground-water and surface water models are ideally suited for climate change simulations but add some potential modeling-related concerns. First, the run time of a coupled model is appreciable longer than either the uncoupled ground-water or surface water model, which can limit the exploration of optimal parameters and prediction uncertainty. Secondly, artifacts from calibration of parameters that conceptually overlap in the uncoupled models can color the results of the coupled model. Finally, the hydrologic memory of the ground-water system can require longer calibration periods than needed for uncoupled models.

Fortunately, new PE tools have been developed that facilitate the construction of coupled models for climate change, which are applied here to the USGS Trout Lake WEBB site in Wisconsin. Parameter "identifiability" is a quick method to assess what information is, and is not, present in existing or proposed datasets. "Superobservations" provide an automatic mechanism to extract salient information from measured data, including time-series data. Finally, general linear prediction approaches facilitate estimates of prediction uncertainty, both prior to and after calibration. PE tools such as these three help ensure that the maximum amount of information is extracted from the field data. Moreover, they not only help identify what is not known, they allow evaluation of the efficiency of potential future data collection conducted to address the deficiency. Such capabilities will be important as coupled ground-water/surface-water models are used to tackle societally relevant questions such as climate change.

SESSION 4B
Runoff
Friday, March 6, 2009
10:00 – 11:55 a.m.

Seven Years of Edge-of-Field Agricultural Runoff Monitoring: What We Have Learned

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Non-point source pollution of surface water with sediment, nutrients, and other agrichemicals is a growing public and regulatory concern. Pollutants exported from agricultural fields are often estimated using computer models and simulated runoff experiments, rather than with actual field measurements. Pioneer Farm, a 430-acre mixed-livestock farm associated with the University of Wisconsin-Platteville, is intensively instrumented with runoff monitoring stations that are equipped with H-flumes and automated samplers to sample runoff at intervals throughout individual storm events.

When this project began, the primary goal was to determine the quality of water leaving agricultural fields and generate results that are widely accepted by farmers, researchers, and regulatory agencies. To this end, edge-of-field runoff stations were used to monitor runoff from field-scale basins year-round, including snowmelt. Now that seven years of runoff monitoring has been completed covering the full crop rotation, the results have been analyzed in a broad context. This talk will highlight the program's findings and support them with relevant data.

Snowmelt: The Silent Majority of Runoff

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Non-point source pollution of surface waters with sediment, nutrients, and other agrichemicals is a growing public and regulatory concern. Pollutant export from agricultural fields is often estimated using computer models or simulated runoff experiments, rather than with actual field-scale measurements. Pioneer Farm, a 430-acre mixed-livestock farm associated with the University of Wisconsin-Platteville is intensively instrumented with flumes and automated samplers. During storm events the runoff volume is continuously measured, and water quality samples are collected intermittently, from subwatersheds ranging from 3 to 70 acres in size. The field devices were modified to quantify winter runoff events, which are notoriously difficult to monitor and are rarely reported in scientific literature. Our monitoring has shown that winter runoff volumes can be a significant fraction of total annual runoff, particularly during rain events on frozen ground. This presentation will quantify the runoff from several years of monitoring and highlight the relative importance of winter runoff to the annual export of sediment, nitrogen and phosphorus. The impact of the variability in annual snowfall, and the timing of spring season warmer temperatures and rainfall will be demonstrated.

Effects of Riparian Cattle Grazing on Bank Erosion, University of Wisconsin-Platteville Pioneer Farm

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Bank erosion and channel morphology were monitored from 2004-07 by the U.S. Geological Survey along a 0.8 mile reach of the Fever River. This reach runs through a 30-acre beef cattle pasture at the University of Wisconsin-Platteville Pioneer Farm in the Driftless Area of southwestern Wisconsin. Baseline monitoring was done to establish geomorphic conditions prior to future evaluation of riparian grazing management alternatives. Approximately 40 head of beef cattle and 25 calves were rotated through the pasture's seven paddocks. Monitoring included channel cross-section surveys, eroding bank area measurements, longitudinal profiles, erosion-pin measurements, photographs, and an in-channel soft-sediment thickness survey. At 24 of the 35 surveyed channel cross sections, the channel widened, narrowed, down cut, or laterally migrated because of cattle or fluvial processes. Of the 84 eroding banks, 85 percent were caused by cattle and the remaining 15 percent were caused by a combination of cattle and fluvial processes. Trampling at stream crossings accounted for two thirds of the cattle-caused erosion. The remaining one third was caused by longitudinal trampling or scratching. The combination of geomorphic data from multiple sources and time scales were especially useful for determining how cattle behavior related to patterns of erosion and deposition. In-channel storage of soft sediment complicated relations between the amount of bank erosion and downstream sediment transport. Bank erosion and channel morphology monitoring will continue as alternative riparian grazing practices are selected and demonstrated.

Comparison of Water Quantity and Quality between Subsurface-Tile and Surface-Water Runoff from a Wisconsin Discovery Farm

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Four years (Nov. 2004 – Oct. 2008) of precipitation, discharge, and water-quality data were collected by the U.S. Geological Survey and the Discovery Farms Program from pairs of surface-water and subsurface-tile sites within two small (13.2 and 20.5 acres) agricultural basins on a private dairy farm in northeast Wisconsin. Both basins were comprised of single fields in a corn-alfalfa (*Zea mays* L.- *Medicago sativa*) rotation. Discharge was continuously monitored and composite water samples for rainfall and snowmelt-induced runoff events were analyzed.

Subsurface tiles contributed a majority of runoff volume and nitrogen losses in each basin, while surface-water sites accounted for a majority of phosphorus losses. Surface-water runoff was primarily observed during snowmelt and rain-on-snow events (November through March), while subsurface-tile runoff was more persistent, and flow was occasionally observed nearly year-round. Comparison of the timing of surface and subsurface-tile runoff indicated rapid, preferential flow from ground surface to subsurface tiles. Subsurface-tile nitrogen losses ranged between 10 and 100 lb/acre/year and phosphorus losses were generally less than 1 lb/acre/year. Surface-water losses of nitrogen were generally less than 20 lb/acre/year and phosphorus losses consistently exceeded 1 lb/acre/year, with up to 3 lb/acre/year measured. These surface-water losses of phosphorus contributed greater than 50% of the phosphorus losses measured annually in each basin. The highest event-mean concentrations of nitrogen and dissolved phosphorus in both subsurface-tile and surface-water runoff water were observed when events occurred after manure was recently applied.

Phosphorus Content and Particle Size of Sediments in Grassed Waterways Draining Corn and Alfalfa Fields in Southwestern WI.

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Phosphorus movement from land to water occurs in both dissolved and sediment-attached particulate (PP) forms with the latter dominating losses from tilled fields. Sediment characteristics (i.e. particle size, P content) are therefore important for PP delivery. Ephemeral channels (grassed waterways) are a principal runoff conveyor from farm fields to perennial streams. Our poor understanding of sediment characteristics in grassed waterways limits our ability to model the PP transport process. Better defining runoff sediment characteristics will improve management models, such as the WI P index.

A sediment monitoring study of grassed waterways was conducted between May 25 and Jul 12, 2008 at the UW-Platteville Pioneer Farm. Non-automated tube-type samplers were placed in grassed waterways draining tilled corn (PF2) and alfalfa (PF5) fields upstream of existing USGS automated stations. Nine storm-event runoff samples were collected and analyzed for total P and organic matter content in four (> 50 , 10-50, 2-10 and < 2 μm) particle size classes along with continuous particle and aggregate sizes by laser diffraction. The greatest (78%) sediment P mass was in the silt size class, coarse silt (10-50 μm) (43%) and fine silt (2-10 μm) (35%) and the smallest (13%) sediment P mass was in the clay (< 2 μm) size class. The sediment total P concentration in the tube samplers was consistently less (19 % PF2; 49% PF5) than the USGS data. The sediment total P-organic matter content relationship was linear.

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