34TH ANNUAL MEETING
PROGRAM AND ABSTRACTS

Emerging Challenges for the Waters of Wisconsin

MARCH 4 & 5, 2010

MADISON MARRIOTT WEST

MIDDLETON, WISCONSIN

American Water Resources Association – Wisconsin Section

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.

AMERICAN WATER RESOURCES ASSOCIATION-WISCONSIN SECTION

34th ANNUAL MEETING

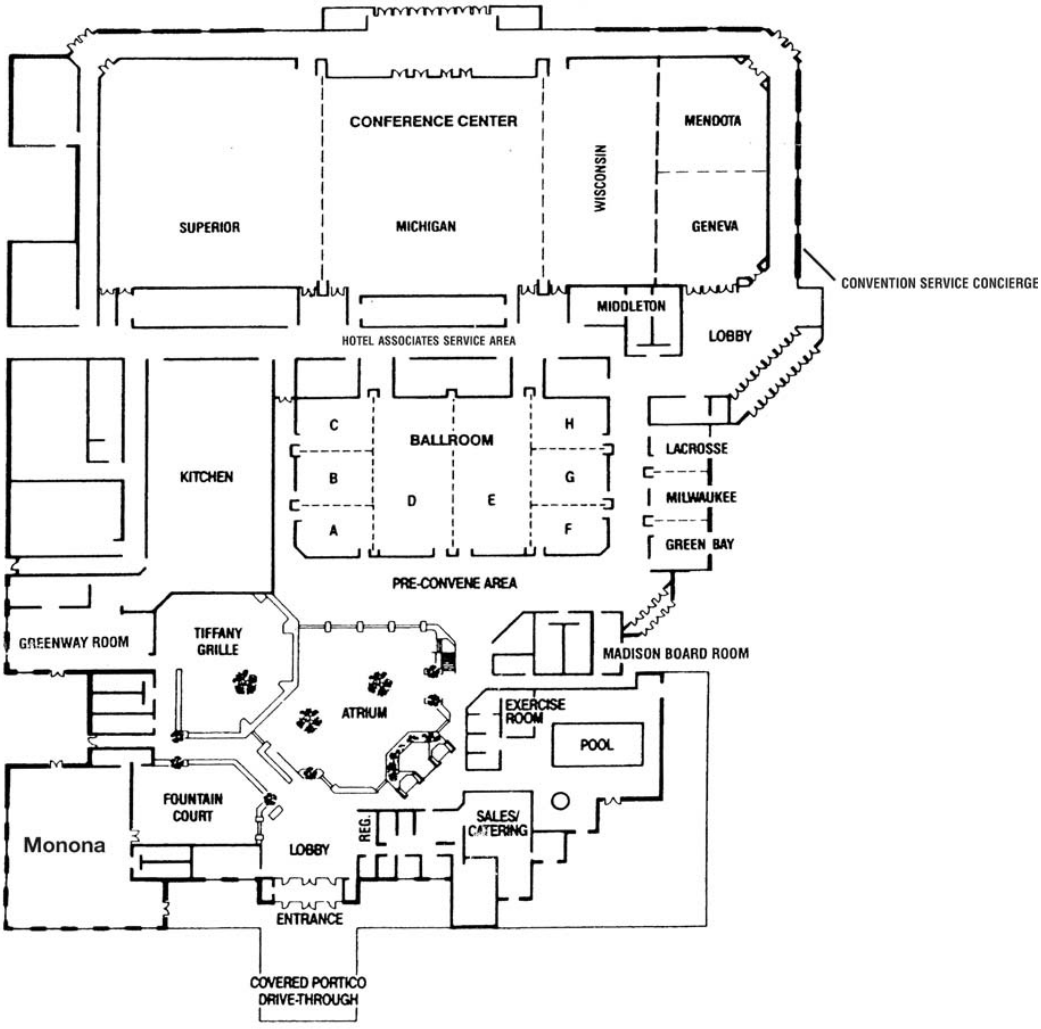
Emerging Challenges for the Waters of Wisconsin

March 4-5, 2010

Madison Marriott West
Middleton, 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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PROGRAM SUMMARY

Emerging Challenges for the Waters of Wisconsin

34th Annual Meeting of the
American Water Resources Association – Wisconsin Section

Middleton, Wisconsin

Thursday, March 4, 2010

9:00 a.m. – 2:15 p.m.	Registration – Conference Center Lobby
11:30 a.m. – 12:15 p.m.	Welcome and Lunch – Michigan
12:15 – 12:30 p.m.	Business Meeting – Michigan
12:30 – 2:00 p.m.	**Plenary Session**: Emerging Challenges for the Waters of Wisconsin Mark Borchardt Research Scientist Marshfield Clinic Research Foundation *[Title of presentation]* Paul Kent Attorney Anderson & Kent, S.C. *[Title of presentation]* Jonathan Patz Professor & Director of Global Environmental Health UW-Madison Center for Sustainability and the Global Environment *[Title of presentation]*
2:00 – 2:15 p.m.	**Break**
2:15 – 3:55 p.m.	**Concurrent Sessions 1A and 1B**

Session 1A – Groundwater and Environmental Tracers

Geneva
Moderator: Ken Bradbury, WGNHS

2:15 Ambient Flow and Heterogeneity in Multi-Aquifer Wells. David J. Hart

2:35 Distributed Temperature Sensing for Characterizing Vertical Aquifer Heterogeneity. Andrew T. Leaf**

2:55 Investigation of Groundwater Nutrient Contribution to Dunes Lake, Door County, Wisconsin. Scott K. Johnson**

3:15 Surface Water/Groundwater Interactions in SE Wisconsin: Can Anthropogenic Influences Be Traced in Groundwater Using Simple Geochemistry? Tim Grundl

3:35 Evaluating the Relative Benefits of Natural Environmental Tracers in a Wetland-Stream Complex, Trout Lake, Wisconsin. Michael N. Fienen

Session 1B – Biology and Biotic Stressors

Mendota
Moderator: Faith Fitzpatrick, USGS

2:15 Secondary Production of Chironomidae in Lake Winnebago. Timothy J. Anderson**

2:35 Age Validation of Walleye, *Sander vitreus*, in the Winnebago System. Ryan P. Koenigs**

2:55 Water Quality Effects on *Pimephales promelas* Spawning Vary Along an Agriculture-to-Urban Land-Use Gradient. Steven R. Corsi

3:15 Interpreting Geomorphic, Biological and Chemical Stream Data to Determine Biotic Stressors for an Impaired Trout Stream in the St. Croix River Watershed. Patrick J. Conrad

3:35 The Increasing Impact of Road Salt: Widespread Aquatic Toxicity and Water Quality Impacts on a Local, Regional, and National Scale. Steven R. Corsi

3:55 – 4:15 p.m. **Break**

4:15 – 5:35 p.m. **Concurrent Sessions 2A and 2B**

Session 2A – Emerging Contaminants

Geneva
Moderator: Tim Grundl, UW-Milwaukee

4:15 Occurrence of Endocrine Active Compounds in Runoff from Dairy and Beef Operations. Jocelyn D.C. Hemming

4:35 A Comparison of Three Techniques for Extracting Hormones from Soils and Their Storage Stability. Sonya M. Havens**

4:55 An Integrated Approach to Microbial Source Tracking. Jeremy M. Olstadt

5:15 Evaluating Municipal Drinking-Well Vulnerability to Wastewater Tracers and Human Enteric Viruses from Sanitary Sewer Sources. Randall J. Hunt

Session 2B – Central Sand Plain Studies

Mendota
Moderator: Sue Swanson, Beloit College

4:15 Land Use Change: Impact of Vegetative Cover on Groundwater Recharge Dynamics in the Central Wisconsin Sand Plain. Mack R. Naber**

4:35 Using Climate Variables to Evaluate Groundwater Levels in Central Wisconsin. Jessica E. Haucke**

4:55 Groundwater Pumping Effects on Wisconsin Central Sands Surface Waters. George J. Kraft

5:15 Nitrate Processing Below the Hyporheic Zone in a Sand Plains Stream. Robert S. Stelzer

5:35 p.m. Refreshments – Michigan
6:00 p.m. **Dinner** – Michigan

Speaker: State Senator Mark Miller
"Wisconsin's Buried Treasure… The Sequel"
Groundwater Legislation in Wisconsin

7:45 p.m. **Poster Session and Dessert Social** — Michigan

1. Interactions between Tetracycline and Kaolinite in Aqueous Solution. Caren J. Ackley*

2. Using an Analytic Element Model to Map the Regional Water Table in Columbia County Wisconsin. Andrew D. Aslesen**

3. Hydrogeophysical Study of the Bradford Beach Shoreline, Milwaukee Wisconsin. Bonnie J. Bills**

4. Upper St. Croix-Eau Claire Rivers Watershed: State of the Lakes 2009. James R. Brodzeller*

5. Depth-discrete Groundwater Monitoring Near a Water-Supply Well. Madeline B. Gotkowitz

6. The Determination of Bankfull Discharge and the Development of Regional Curves for the Southwestern Region of Wisconsin. Jessica E. Haucke**

7. A Sediment Phosphorus Inventory and Preliminary Phosphorus Budget for the Fever River at Pioneer Farm. Jon T. Immel*

8. Evaluating the Effects of Increased Precipitation Due to Climate Change on Wisconsin's Groundwater Levels. Douglas R. Joachim**

9. Drawdown, Recovery, and Hydrostratigraphy in the Northeast Groundwater Management Area (Brown, Outagamie, and Calumet Counties, WI). Julie C. Maas**

10. Using a GIS-Based Model to Identify Internally Drained Areas in a North-West Wisconsin Watershed. Jacob A. Macholl

11. Incorporating Shoreline Development in a Lake Impact Model. Paul M. McGinley

12. Assessment of Major Stressors and Threats to Great Lakes Waters in National Parks and Lakeshores of Wisconsin and Michigan. Christine Mechenich

13. Cattle Crossings in Riparian Pastures: Costs, Benefits, and Performance. Randy S. Mentz

14. Initiating a Long-term Monitoring Program of Aquatic and Terrestrial Invasive Species in Kenosha County, Wisconsin. Samantha N. Miller*

15. Adaptation of Survey Equipment for Robotic Vehicle Tracking in an Aquatic Environment. Matthew T. Peterson*

16. Seeing and Believing: Exploring Public Understanding of Maps Depicting Private Well Water Test Results. Dolores J. Severtson

17. The Geology and Ecohydrology of Springs in the Driftless Area of Southwest Wisconsin. Susan K. Swanson.

* Undergraduate student presentation
** Graduate student presentation

Friday, March 5, 2010

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

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

Session 3A – Remediation and Stormwater Management
Geneva
Moderator: Ken Quinn, RMT, Inc.

8:00 Nanotechnology and Remediation of Ground and Surface Waters. Martin P. Griffin

8:20 Characterization of Tar-Contaminated Sediment for Remediation. Eugene L. McLinn

8:40 Doing the Dirty Work: Making Contaminated Sediment Remediation a Priority in the St. Louis River Area of Concern. Megan C. O'Shea

9:00 The Influence of Root Distribution and Water Stress on Evapotranspiration. Karen E. Cardinal**

9:20 Evaluation of Effects of Middleton's Storm Water Management Activities on Streamflow and Water Quality Characteristics of Pheasant Branch, 1975-2008. Warren A. Gebert

Session 3B – Watershed Management

Mendota
Moderator: Jim Hurley, UW Water Resources Institute

8:00 Evolution and Recent Developments of Web-based Decision Support Systems for Watershed Management. Dreux J. Watermolen

8:20 Statewide Assessment of Wisconsin Streams Using a Sample Survey Design. Michael A. Miller

8:40 Recreational Water Quality Modeling Tools for Local Beach Managers. Adam C. Mednick

9:00 Controls on the Soil Moisture Regime of a Restored Floodplain, East Branch Pecatonica River: A Field and Modeling Investigation. Eric G. Booth**

9:20 Exploring the Role of Channel Processes and Legacy Sediment in Nutrient and Sediment Delivery, Upper Pecatonica River, Wisconsin. Faith A. Fitzpatrick

9:40 – 10:00 a.m. **Break**

10:00 – 11:40 a.m. **Concurrent Sessions 4A and 4B**

Session 4A – Water Policy and Law

Geneva
Moderator: Randy Hunt, USGS

10:00 Livestock, Land Application of Wastes, Groundwater and Sustainability in Brown County. William C. Hafs

10:20 A Perfect Storm: Invasive Species and Climate Change. Martin P. Griffin

10:40 Responding to the Impacts of Climate Change on Wisconsin's Water Resources – WICCI Water Resources Working Group Update. Timothy R. Asplund

11:00 Putting Wisconsin's Aquitards to Work: an Opportunity to Protect Groundwater Quality. Madeline B. Gotkowitz

11:20 Groundwater Science Meets Public Policy in Wisconsin. Kenneth R. Bradbury

11:40 Closing Remarks and Announcement of Student Award Winners

Session 4B – Agricultural Management
Mendota
Moderator: Dennis Busch, UW-Platteville

10:00 Modeling the Effects of Agricultural Management Practices on Hydrologic Processes at the Field Scale. Philip M. Younger

10:20 Runoff Patterns and Water-Quality Characteristics at Edge-of-Field Sites, Discovery Farms and Pioneer Farm, Wisconsin. Todd D. Stuntebeck

10:40 Liquid Manure in Tile Drains: Pathways and Risk Reduction Strategies. John C. Panuska

11:00 Evaluating the effectiveness of fallowing on bank erosion in a grazed riparian paddock. Marie C. Peppler

11:20 Bioavailability, Equilibrium, and Mixing Characteristics of Sediment Bound Phosphorus in the Fever River at Pioneer Farm. Adam R. Hoffman

11:40 Closing Remarks and Announcement of Student Award Winners

* Undergraduate student presentation
** Graduate student presentation

12:15 – 2:00 p.m. **Student Career Workshop**
Salons G and H

12:15 – 4:00 p.m. **WICCI Water Resources Workshop**
Lacrosse/Milwaukee/Green Bay

SESSION 1A:
Groundwater and Environmental Tracers
Thursday, March 4, 2010
2:15 – 3:55 p.m.

Ambient Flow and Heterogeneity in Multi-Aquifer Wells

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

John A. Luczaj, Department of Natural & Applied Sciences, University of Wisconsin-Green Bay, Green Bay, WI, *luczajj@uwgb.edu*

Borehole flowmeter logging gives important hydrogeologic data for relatively little effort. We used a spinner flow meter to show high volumes of flow and identify zones of very high hydraulic conductivity in three multi-aquifer wells in Wisconsin's sandstone aquifers. Multi-aquifer wells provide a connection between aquifers separated by an aquitard. These measurements demonstrated that high flows between aquifers should be expected anytime a multi-aquifer well is drilled, especially where pumping or a difference in aquifer recharge elevations produces a head gradient between the aquifers, across the aquitard. The measurements also showed that narrow zones of high hydraulic conductivity might dominate flows in some wells, even in sandstone aquifers where porous media flows are thought to dominate.

We measured flows by trolling a spinner flow meter in three multi-aquifer wells. The three wells had maximum ambient flows, defined as flows where there was no pumping in the well, from 40 to 140 gallons per minute. In two of the wells, we saw dramatic changes in the flow logs, more than 50 gpm, over intervals of less than 3 feet. These flow changes all corresponded to some type of opening observed in video logs of the wells. These openings might be fractures, dissolution features or weakly cemented zones enlarged by the drilling process.

The spinner flow meter logs provide a means to characterize the variability of Wisconsin's aquifers and the impacts of multi-aquifer well flows. This knowledge can then be applied to statewide groundwater issues such as contaminant transport, well-head protection, and regional water supply.

Distributed Temperature Sensing for Characterizing Vertical Aquifer Heterogeneity

**Andrew T. Leaf, Department of Geoscience, UW-Madison, Madison, WI, *aleaf@geology.wisc.edu*

Jean M. Bahr, Department of Geoscience, UW-Madison, Madison, WI, *jmbahr@geology.wisc.edu*

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

Despite many advantages, the usefulness of heat as a groundwater tracer has been limited by the discrete nature of available measurement technologies. Distributed temperature sensing (DTS), which allows for the nearly continuous measurement of temperature in time and space, is expanding the potential applications of heat to the study of complex phenomena such as aquifer heterogeneity.

At the Oak Creek, WI aquifer storage and recovery site, permeable zones in the deep sandstone aquifer have undergone cooling resulting from the repeated injection of Lake Michigan water. During pumping conditions, consecutive DTS profiles capture the development of temperature inflections marking the locations of these zones.

Additional DTS profiling is being conducted in other multi-aquifer wells near Madison, WI. Borehole geophysical data suggest localized zones of preferential flow produced by bedding plane-parallel fractures and/or lithologic variations. Temperature profiles collected under ambient conditions will be compared to those collected during and after thermal perturbations created by the low-flow circulation of borehole water through an above ground heat exchanger. The resulting temperature contrasts should allow for the detection of flow into and out of the borehole, and provide detailed information on vertical variations in hydraulic conductivity. As the cost of the DTS decreases, this method may complement and serve as an alternative to more costly and labor-intensive packer testing.

**Graduate student presentation

Investigation of Groundwater Nutrient Contribution to Dunes Lake, Door County, Wisconsin

**Scott K. Johnson, Department of Geoscience, UW-Madison, Madison, WI, *skjohnson1@wisc.edu*

Ken Bradbury, Wisconsin Geological and Natural History Survey, Madison, WI, *krbradbu@wisc.edu*

Mary Anderson, Department of Geoscience, UW-Madison, Madison, WI, *andy@geology.wisc.edu*

Dunes Lake is an 80 acre lake/wetland complex near Sturgeon Bay, Wisconsin, that drains into Lake Michigan. The lake is situated in glacial deposits overlying dolomite and receives groundwater discharge from seepage and several discrete springs, as well as flow from a small creek. Significant eutrophication of the lake motivated a study of nutrient loading to the lake and surrounding watershed. A hydrogeologic investigation of the lake includes delineation of the zone of groundwater contribution to the lake, and measurement of nitrate and phosphate concentrations in local groundwater and surface water. A wastewater treatment pond in the upper portion of the Dunes Lake watershed is being investigated as a source of nutrients to the lake using human enteric viruses as a tracer.

A multi-layer, steady-state, groundwater flow model of the Dunes Lake watershed was developed and calibrated to field data. The zone of groundwater contribution to Dunes Lake was delineated via backward particle tracking. A land use inventory for the area surrounding the lake will be conducted, and together with the groundwater flow model, will be used to identify likely significant sources of nutrients to the lake.

Early results indicate that phosphorus is present at concentrations of 15-200 µg/l, with the highest concentrations found in samples taken from minipiezometers installed in and around the lake. Nitrate concentrations range from 0-9 mg/l, with the highest concentrations found in the springs feeding the lake. Measured vertical gradients are consistent with the groundwater model's prediction of greater spring discharge on the west side of the lake.

**Graduate student presentation

Surface Water/Groundwater Interactions in SE Wisconsin: Can Anthropogenic Influences Be Traced in Groundwater Using Simple Geochemistry?

Tim Grundl, Geosciences Department, University of Wisconsin-Milwaukee, Milwaukee, WI, *grundl@uwm.edu*

Micah Holzbauer, Geosciences Department, University of Wisconsin-Milwaukee, Milwaukee, WI, *holzbau2@uwm.edu*

By their very nature, urbanized areas upset the delicate interaction between surface water and the underlying shallow groundwater. The most prominent effects on shallow groundwater systems are a decrease in recharge rate and an increased load of anthropogenic compounds. A network of 3 wastewater treatment plant effluents (WWTP), 6 wells, 1 spring and 7 stream sites has been monitored since the summer of 2007. We find increasing chloride and other halogen concentrations along with a number of emerging contaminants in the streams and shallow aquifer of SE Wisconsin. Several indicators including B/Cl, Br/Cl and Br/δ^{79}Br ratios are used as indicators of WWTP effluent in both the Fox River and the shallow groundwater of Waukesha County. Results are in agreement with mass balance calculations made on the Fox River and indicate the percentage of WWTP effluent that is being pumped from Waukesha County wells.

Evaluating the Relative Benefits of Natural Environmental Tracers in a Wetland-Stream Complex, Trout Lake, Wisconsin

Michael N. Fienen, U.S. Geological Survey Wisconsin Water Science Center, Madison, WI, *mnfienen@usgs.gov*

Randall J. Hunt, U.S. Geological Survey Wisconsin Water Science Center, Madison, WI *rjhunt@usgs.gov*

John F. Walker, U.S. Geological Survey Wisconsin Water Science Center, Madison, WI *jfwalker@usgs.gov*

Natural tracers have great potential for understanding interactions between groundwater and surface water. Residence time and environmental signatures of natural tracers provide information about groundwater flowpaths and provenance; insight valuable to modeling groundwater flow and tracer transport. In this work, we focus on $\delta^{18}O$ and temperature in the Allequash wetland-stream complex at the Trout Lake Water, Energy and Biogeochmical Budgets/ North Temperate Lakes Long Term Ecological Research site. $\delta^{18}O$ provides information on provenance of water flowing through the wetland into the stream due to fractionation signatures differentiating recharge through a nearby lake, wetland or terrestrial sediments. Temperature profiles near the wetland surface and temperature anomalies measured in the stream characterize water exchange between preferential flowpath conduits in soil pipes and slower flowpaths through the peat matrix.

A coupled groundwater flow (using MODFLOW-2005) and $\delta^{18}O$ and heat transport (using MT3DMS) model was constructed with 24 layers using pilot-points to represent spatially variable hydrogeologic and thermal properties. This highly-parameterized approach allows flexibility, facilitating identification of heterogeneity and reduction of structural uncertainty. The coupled model was calibrated to 2005 and 2006 hydrologic and temperature conditions using PEST. Through the parameter estimation process, identifiability of specific parameters was examined using singular value decomposition and associated statistics. The leverage and influence of the three data types (hydraulic data, heat and $\delta^{18}O$), before and after calibration, are examined to indicate the relative value of data for the processes being simulated by the model.

SESSION 1B:
Biology and Biotic Stressors
Thursday, March 4, 2010
2:15 – 3:55 p.m.

Secondary Production of Chironomidae in Lake Winnebago

**Timothy J. Anderson, Department of Biology and Microbiology, University of Wisconsin-Oshkosh, Oshkosh, WI, *Andert54@uwosh.edu*

Robert S. Stelzer, Department of Biology and Microbiology, University of Wisconsin-Oshkosh, Oshkosh, WI, *stelzer@uwosh.edu*

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Susan L. Eggert, USDA Forest Service North Central Research Station, Grand Rapids, MN, *seggert@fs.fed.us*

Secondary production of primary consumers can impact fish production and food web structure in lakes. Previous research has shown that lake sturgeon (*Acipenser fulvescens*) in Lake Winnebago rely heavily on the chironomid community as a food source. We calculated secondary production of chironomids in Lake Winnebago, the first estimate of secondary production in this large, eutrophic system. Benthic samples were collected with an Ekman dredge at four profundal sites on eleven dates from spring 2008 to spring 2009. Instantaneous growth rates for seven chironomid length classes at five thermal regimes were measured in the laboratory during the summers of 2008 and 2009. Mean annual production of Chironomidae using the instantaneous growth rate method was 11.90 g dry mass (DM) m^{-2} yr^{-1}. The sub-family Chironominae accounted for 9.56 g DM m^{-2} yr^{-1} and Tanypodinae production was 2.34 g DM m^{-2} yr^{-1}. Mean annual density of Chironomidae was 3946 m^{-2} and mean biomass was 4.08 g DM m^{-2}. Although Tanypodinae had lower mean annual production than Chironominae, Tanypodinae had a production to biomass ratio (P/B) of 9.5 while Chironominae had a P/B ratio of 2.5. These annual production estimates are higher than many other chironomid production rates from lakes but are similar to chironomid production estimates from lotic ecosystems.

**Graduate student presentation

Age Validation of Walleye, *Sander vitreus*, in the Winnebago System

**Ryan P. Koenigs, University of Wisconsin-Oshkosh and Wisconsin Department of Natural Resources, Oshkosh, WI, *koenir19@uwosh.edu*

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Robert S. Stelzer, Department of Biology and Microbiology, University of Wisconsin-Oshkosh, Oshkosh, WI, *stelzer@uwosh.edu*

Sport fishing on the Lake Winnebago System contributes $234 million dollars to the local economy, and walleye are one of the most important sport fishes in the system. It is essential to obtain and use accurate aging data to estimate rates of somatic growth, mortality, and exploitation, which are required to effectively manage the walleye fishery. We removed otoliths and dorsal spines from 75 known-age walleye, recaptured fish which were initially tagged at small enough lengths (<368mm) for age assignment to ±1 year. We compared the age estimates derived from spines and otoliths to the true age of the fish to determine the accuracy of both aging structures. Otoliths and spines were also collected from tournament mortalities and weekly samples to better determine the relationship between age estimates from the two structures. Age estimates from both dorsal spines and otoliths were in agreement for fish 4-8 years old, although spines underestimated age of fish 9 years of age and older (otolith age estimates were 0.67 to 5.00 years greater for females and 0 to 5.21 years greater for males). Total mortality rates based on spine age estimates were higher (40%) than those based on otoliths (20%). Age distributions within the mortality curve correlated directly with year class strength, suggesting that otoliths, unlike spines, are accurate for all ages of walleye.

**Graduate student presentation

Water Quality Effects on *Pimephales Promelas* Spawning Vary Along an Agriculture-To-Urban Land-Use Gradient

Steven R. Corsi, U.S. Geological Survey, Middleton, WI, *srcorsi@usgs.gov*

Rebecca Klaper, Great Lakes WATER Institute, UW-Milwaukee, Milwaukee, WI, *rklaper@uwm.edu*

Daniel Weber, Great Lakes WATER Institute, UW-Milwaukee, Milwaukee, WI *dweber@uwm.edu*;

Roger Bannerman, Wisconsin Department of Natural Resources, Madison, WI.

Many streams in the U.S. are considered to be “impaired” due to anthropogenic influence. In order for watershed managers to achieve a practical understanding of causes of these impairments, a multitude of factors must be considered, including point and nonpoint-source influence on water quality. A spawning assay was developed and used in this study to evaluate water- and sediment-quality effects that influenced *Pimephales promelas* (fathead minnow*)* egg production over a gradient of urban and agricultural land use in 27 small watersheds. The use of constructed flow-through chambers in this study removed habitat and minimized flow and food source as variables, and effectively focused on water- and sediment- quality as the primary variables influencing egg production. Six pairs of reproducing fathead minnows were contained in separate flow-through cartridges within one larger flow-through chamber at each of 27 streams in Eastern Wisconsin. Water and sediment quality were sampled for an array of chemistry parameters. Egg production was monitored for each pair providing a composite assessment of spawning success throughout the 21 day test periods. Incidences of low dissolved oxygen (DO) in many of these streams negatively impacted spawning success in this study. During the 21-day test periods, nine of 27 streams experienced minimum DO less than 3.1 mg/L and 15 streams experienced minimum DO less than 4.8 mg/L. These results indicate that DO must be a high priority watershed management consideration for this region. Incidences of low DO were observed in urban as well as agricultural watersheds, but the upper threshold of minimum DO decreased with increasing urban development in the watershed. An increase in specific conductance was related to a decrease in spawning success in this study. Specific conductance had a linear relation with chloride in these watersheds, suggesting the possibility that chloride could be a factor in egg production. However, there was positive correlation between specific conductance and numerous water- and sediment-quality parameters, confounding the actual cause of the relation between specific conductance and spawning success. Egg production was also correlated to several land-use parameters including the percentage of urban development.

Interpreting Geomorphic, Biological and Chemical Stream Data to Determine Biotic Stressors for an Impaired Trout Stream in the St. Croix River Watershed

Patrick J. Conrad, Emmons & Olivier Resources, Inc., Oakdale MN, *pconrad@eorinc.com*

Jason Naber, Emmons & Olivier Resources, Oakdale MN, *jnaber@eorinc.com*

Brown's Creek is located in the Brown's Creek Watershed District (BCWD) in the St. Croix River watershed in Central Minnesota. Brown's Creek was listed on the 303(d) list of impaired water bodies in 2002 for aquatic life impairment based on a low Index of Biotic Integrity (IBI) for its classification as a cold water stream. Brown's Creek has an approximate 19,000-acre watershed that includes a small portion of urban land uses and significant portion of rural and agricultural areas.

The first step in addressing impairment was the stressor identification process, an analysis to identify factors causing the impairment. Stressor identification is an important step that guarantees that the solutions correctly target the most important causes. Data gathered between 2000 and 2008 were compiled and analyzed to assess the factors leading to the biological impairments of Brown's Creek. Monitoring data were evaluated against water quality standards, guidelines based on healthy streams, and the physiology of indicator organisms like insects and trout.

Correlations, monitoring data, and models of causal pathways were compared to identify mechanisms that explain the biological impairment. All available evidence was investigated using the CADDIS (Causal Analysis/Diagnosis Decision Information System) system of the EPA. This process formalizes causal reasoning in a quantitative checklist that balances the strength of evidence from a variety of sources and is a record of the reasoning behind the scientific analysis. The stressors identified by the CADDIS process were high suspended sediment, high temperature, low dissolved oxygen, and pulses of high copper concentrations. A P8 model was built to target subwatersheds contributing high sediment loads to the creek and to evaluate implementation practices to reduce future sediment loads.

Geomorphic analyses of the stream found the bed and bank to be relatively stable concluding that sediment was being derived from the watershed. Temperature exceedances were observed primarily after summer thunderstorm events where runoff from paved surfaces entered the stream. Specific reaches of the stream were also identified as lacking adequate tree cover for shading. Copper exceedances were observed more sporadically and likely linked to applications of algaecides and fungicides in the watershed prior to runoff producing precipitation events. This TMDL is in the formal review process and is one of only a few biological TMDLs written in the State of Minnesota.

The Increasing Impact of Road Salt: Widespread Aquatic Toxicity and Water Quality Impacts on a Local, Regional, and National Scale

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While road salt runoff influence on water quality has been documented for at least forty years, a new perspective on the severity of aquatic toxicity impact was gained by a focused research effort directed at winter runoff periods. Dramatic impacts were observed on a local, regional, and national scale. ***Locally***, samples from 7 of 13 Milwaukee area streams during two road salt runoff events exhibited toxicity in *Ceriodaphnia dubia* and *Pimephales promelas* bioassays with chloride concentrations as high as 6,470 mg/L, well exceeding the U.S. Environmental Protection Agency (USEPA) acute and chronic water quality criteria of 860mg/L and 230 mg/L, respectively.. In long term testing, Wilson Park Creek in Milwaukee was sampled 37 times from 1996 to 2008 with resulting chloride concentrations as high as 7,730 mg/L. Toxicity was observed in 72% of these samples in chronic bioassays and 43% in acute bioassays. ***Regionally*** in eastern and southern Wisconsin, continuous specific conductance sensors were deployed as chloride surrogates in 11 watersheds with urban land use ranging from 6% to 100%. Elevated specific conductance was present during cold-weather months at all sites with continuing effects during warm-weather months at sites with the greatest effect. Specific conductance increased with increasing urban intensity and was measured as high as 30,800 µS/cm (Cl = 11,200 mg/L). Estimated chloride concentrations exceeded USEPA acute water quality criteria at 55% and chronic water quality criteria at 100% of these sites. ***Nationally***, U.S. Geological Survey historical chloride data was examined for 13 northern and 4 southern metropolitan areas. Chloride concentrations exceeded USEPA water quality criteria at 25% (acute) and 55% (chronic) of the 168 northern monitoring locations during cold-weather months. Only 1% (acute) and 16% (chronic) of sites exceeded criteria during warm-weather months. At southern sites, 2% and 4% of sites had samples that exceeded chronic water quality criteria during cold- and warm-weather months, respectively; no samples exceeded acute criteria.

SESSION 2A
Emerging Contaminants
Thursday, March 4, 2010
2:15 – 3:55 p.m.

Occurrence of Endocrine Active Compounds in Runoff from Dairy and Beef Operations

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Concerns have emerged regarding the contribution of agricultural activities to the presence of hormones in the environment. Livestock excrete naturally produced hormones. Additionally, use of hormone implants in cattle can also contribute to excreted hormonally active compounds. Manure is a valuable nutrient amendment to farm fields; however under certain environmental conditions field runoff can enter surface waters. A goal in this study is to determine concentrations of a large suite of hormones (twenty-three natural and synthetic compounds including estrogens, androgens and progestogens) in field runoff and subsurface tile drainage from operating farms practicing a variety of tillage and manure application strategies. Most samples have been collected from six sites on three farms, and include steer, dairy and mixed steer and dairy facilities. Runoff samples were immediately preserved with sulfuric acid and split in the lab for: (a) hormone analyses with HPLC-MS/MS (which requires a spike of deuterated internal standards (dISTD)) and (b) in-vitro bioassays, which are incompatible with a dISTD spike. The bioassays applied are transcriptional activation bioassays including E-and A-screen which identify samples that can activate estrogen or androgen receptors. A majority of the runoff events occurred when the fields were frozen. Several of the target hormones were identified and quantified, though the concentrations of most hormones were <100 ng/L. However, the levels of a few compounds (e.g. progesterone, zearalenone) were occasionally above 100 ng/L. Bioassays indicated estrogen and androgen active compounds in many samples.

A Comparison of Three Techniques for Extracting Hormones from Soils and Their Storage Stability

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This study compares the extraction efficiencies of accelerated solvent extraction (ASE), Soxhlet and sonication techniques for a suite of endocrine disrupting compounds (EDCs; naturally occurring estrogens, androgens and progestogens and synthetic hormones, *e.g.,* trenbolone) and their metabolites in three types of soil (silt loam, clay and organic). The stability of hormones spiked into these soils and stored for 30, 90 and 180 days at -20 °C was also investigated. A reference sand matrix (Ottawa Sand; 5 g) and soil subsamples (5 g) were spiked with 50 µL of 10 $\mu g \cdot mL^{-1}$ (in methanol; final conc. 100 $ng \cdot g^{-1}$) of a mix of target and deuterium-labeled hormone and hormone metabolite standards. The spiked standards were mixed into soils and allowed to equilibrate for two hours and then extracted using ASE, Soxhlet and sonication, each in triplicate, and analyzed via HPLC-MS/MS. For the storage stability determination, the spiked standards were extracted from each of the soil types, after 30, 90 and 180 days of storage at -20 °C, by ASE and analyzed via HPLC-MS/MS. The efficacy of these techniques were assessed based on their spike recoveries and precision of extraction. The recovery of each standard was determined by comparing the peak area of the extracted sample, minus the ambient peak area in the unspiked samples, to the peak area of the 500 ng standards in the calibration curve and quality control injections. With the exception of organic soils, the recoveries were consistently better (33.8 – 117%) in the samples extracted by ASE compared with samples extracted by Soxhlet (16.5 – 72.4%). The recoveries in organic soils (13.1 -55.5 %) were generally lower than in the other soil types and did not differ between extraction techniques. The standards spiked into the sand, silt loam and organic soils types were stable over of the storage period. The recovery of standard spiked into the clay soils and stored were significantly lower than the time zero extractions. This result is believed to be due to adsorption as opposed to degradation.

**Graduate student presentation

An Integrated Approach to Microbial Source Tracking

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Protection, monitoring, and remediation are facets of a holistic approach to protecting drinking water. Access to clean drinking water is essential to maintaining a high quality of life. A toolbox of methods, termed microbial source tracking (MST), is emerging as a component of monitoring that can support targeted remediation and protection efforts. Reports on more than 20 MST methods can be found in the scientific literature. Many of the MST methods have been reported to be limited temporally and geographically. A suite of MST methods have been applied to Wisconsin drinking waters. This MST toolbox includes: *Bacteroides* spp. by qPCR as a forensic fecal indicator as well as to discriminate between human and bovine *Bacteroides* spp.; sorbitol-fermenting Bifidobacteria by membrane filtration as a human-specific indicator; male-specific coliphage genotypes to discriminate between human and non-human wastes; *Rhodococcus coprophilus* by qPCR as a grazing animal-specific indicator; fecal sterol quantification to discriminate between human and non-human wastes; and targeted pharmaceutical and personal care product components to discriminate between human and non-human wastes. This paper reports on the MST methodologies and examples of their use for monitoring ground water contamination incidents in Wisconsin.

Evaluating Municipal Drinking-Well Vulnerability to Wastewater Tracers and Human Enteric Viruses from Sanitary Sewer Sources

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Human enteric pathogens are now recognized as potential contaminants of municipal drinking water wells, but sources and subsurface transport of pathogens such as viruses are poorly understood. This study investigated the source, transport, and occurrence, of human enteric viruses in municipal well water in municipalities in Wisconsin, with a primary focus on sanitary sewer sources. Thirty-three public water-supply wells from 14 communities were each sampled once for wastewater tracers and viruses. Tracers of wastewater were detected in 4 of these wells while 5 wells were positive for human enteric viruses by qRT-PCR. These results, along with analyses for stable water isotopes to exclude wells with surface water infiltration, were used to select three well sites for additional investigation.

Viruses and wastewater tracer were found in the groundwater at all three sites. Study results show that sampling at any one time may not show concurrent virus and trace presence due to differences in analytical precision, seasonality of the sources in the waste stream, and seasonal changes in recharge and pumping. However, given sufficient sampling over time, a strong positive relation between waste-water tracers and virus occurrence was identified. Moreover, estimated groundwater velocities and the presence of infectious viruses at the wellhead demonstrate that high-capacity pumping can induce travel times that permit subsurface transport of infectious viruses. Sanitary sewers are commonly located near municipal wells and can carry very high numbers of infectious viruses, and very small numbers of infectious viruses in water can constitute a health risk. Therefore, drinking water wells are vulnerable to fast groundwater flowpaths even if these flowpaths contribute a small amount of virus-laden water to a well. Thus, study results suggest that vulnerability assessments should include characterization of ‘low yield-fast transport’ pathways in addition to traditional ‘high yield-slow transport’ pathways. Consideration of virus transport in well vulnerability assessments is important because many communities, such as the 14 included in this study, do not routinely chlorinate or otherwise disinfect pumped water.

SESSION 2B:
Central Sand Plain Studies
Thursday, March 4, 2010
4:15 – 5:35 p.m.

Land Use Change: Impact of Vegetative Cover on Groundwater Recharge Dynamics in the Central Wisconsin Sand Plain

**Mack R. Naber, Department of Soil Science, University of Wisconsin–Madison, Madison, WI, *mrnaber@wisc.edu*

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The Central Wisconsin Sand Plain vegetative cover has changed significantly over the last 150 years. White pine forests were logged and cleared land used for agriculture. Initial agriculture in the sandy soil failed from lack of water and the land was reforested to prevent erosion. Center pivot irrigation has allowed the conversion of reforested land to agricultural crops. During the past decade, the water quantity in area lakes and rivers decreased significantly in the Sand Plains despite normal precipitation (75-90 cm yr^{-1}). Groundwater recharge rates are influenced by a variety of factors specific to vegetative cover which obscure the impact of irrigation on groundwater levels. Irrigated lands evapotranspire more water than perennial vegetation during the growing season. However, compared to standing forests capable of year-round precipitation interception, greater recharge to groundwater is possible on irrigated lands during bare soil periods of late fall and early spring. To investigate these phenomena for perennial vegetation and cropped lands we used the Integrated Biosphere Simulator (IBIS) model. This model incorporates a wide range of physical properties including land surface physics, canopy physiology, plant phenology, vegetation dynamics and competition, and carbon and nutrient cycling. Results of computer simulation indicate irrigated crops recharge less water to groundwater than forests but the difference vary widely as a function of precipitation from year to year. Quantifying the impact of irrigated fields on water balance will provide more information to better manage water resources of the Central Wisconsin Sand Plain.

**Graduate student presentation

Using Climate Variables to Evaluate Groundwater Levels in Central Wisconsin

**Jessica E. Haucke, Center for Watershed Science and Education, University of Wisconsin–Stevens Point, Stevens Point, WI, *jhauc@uwsp.edu*

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Precipitation, temperature, and evaporation were used to determine whether changes in groundwater levels were due to changes in climate or due to anthropogenic processes. Precipitation and temperature measurements were obtained from five NOAA weather stations, and groundwater data were obtained from eight USGS monitoring wells. All weather stations and monitoring wells were located in the central sands region of Wisconsin. Four monitoring wells were located in areas where groundwater extraction was high, and four monitoring wells were located in areas with little groundwater withdrawal. Univariate and multivariate statistical models were used to evaluate differences in groundwater levels based on time periods. Additionally, statistical models were used to examine differences in precipitation and temperature throughout the region. Stepwise multiple regression used climate variables to predict groundwater levels for different time periods and landscape positions. Results indicated that climate variables were the main driver of water levels in regions with less groundwater withdrawal. In areas where there was a greater amount of groundwater pumping, well observations were split into two time periods. The period from 1956-1973, represents a time when climate was the main influence on groundwater levels. The period from 1991-2008, a time when groundwater pumping increased substantially, showed that well levels were influenced by groundwater withdrawals more than climate changes. This approach provides a way to estimate long term variability in groundwater levels, and allows for better management of groundwater resources.

**Graduate student presentation

Groundwater Pumping Effects on Wisconsin Central Sands Surface Waters

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The Wisconsin Central Sands is rich in water resources, including about 100 lakes (> 5 ha), over 1000 km of headwater streams (many supporting coldwater ecosystems), and a highly productive aquifer. The area also contains the greatest density of high capacity wells in Wisconsin (about 3000), and the greatest amount of groundwater pumping. Most high capacity wells and most pumping (86%) are for irrigation purposes.

Concerns about groundwater pumping and impacts on surface water resources have been expressed since groundwater extraction began in the 1950s. Since 2000, concerns have hit a crescendo as the levels of lakes, groundwater, and streamflows have become greatly depressed. Particularly depressed conditions have notably included Long Lake near Plainfield, which has been dry or nearly dry for 3 years, and the Little Plover River, which has dried in each of the last four years. Though depressed conditions have been blamed on both drought and groundwater pumping, locations with relatively little groundwater pumping are not as severely depressed (only at 10-15 year lows) as locations with large amounts of pumping (all time lows).

We have used statistical and modeling approaches to investigate potential connections between pumping and depressed hydrologic conditions. Water level declines of 4-5 feet due to pumping are indicated in parts of the Central Sands. Streamflow depletions due to pumping in headwaters areas may approach 50%.

Nitrate Processing Below the Hyporheic Zone in a Sand Plains Stream

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It is well known that processes in riparian zones, in hyporheic zones, and in the surface water of lotic ecosystems can retain substantial amounts of available nitrogen. Much less is known about nitrogen processing in groundwater associated with deep sediments in the stream channel below the hyporheic zone. Our main objective was to determine how nitrate processing changed with depth in stream sediments. We measured denitrification rates and assessed variation in groundwater nitrate concentration in sediments from upwelling locations of Emmons Creek, a third-order stream in the Central Sand Ridges Ecoregion. Sediment cores to 30 cm depth were collected from Emmons Creek and the acetylene block method was used to measure denitrification rates of core sections. Peeper samplers and instream wells were used to measure vertical gradients in groundwater nitrate concentration to a sediment depth of 70 cm. Mean areal denitrification rate was 6.5 μg N_2O-N cm^{-2} hr^{-1}. Core sections deeper than 5 cm accounted for 71 percent of the areal denitrification rates. The nitrate profiles suggested that nitrate retention or loss occurred along upwelling flow paths. Groundwater nitrate concentrations began to decline at sediments depths ranging from 15 to 35 cm. Our results suggest than nitrate processing can be substantial at depth in groundwater-fed streams. Denitrification estimates based only on shallow sediment cores may underestimate denitrification rates in lotic ecosystems.

POSTER SESSION
Thursday, March 4, 2010
7:45 p.m.

1. Interactions between Tetracycline and Kaolinite in Aqueous Solution

*Caren J. Ackley, Geosciences Department, University of Wisconsin–Parkside, Kenosha, WI, *ackle005@uwp.edu*

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Tetracycline (TC) is an antibiotic used for the treatment of bacterial infections in humans and animals, such as urinary tract infections and acne. When ingested, TC is not completely metabolized by the digestive tract, thus, it is excreted in high concentrations. This threatens to contaminate soil and water systems. It is known that clays have a high sorption capacity and can potentially remove contaminants from ground water. This study aimed to determine the reaction rate of kaolinite (KGA 1b) and sorption of TC in waters under specific conditions including varying concentration, pH, ionic strength, and temperature.

The results of this study indicate that the TC adsorption capacity was reached at 9 mmol/g on kaolinite, with the adsorption being instantaneous and primarily on the external surfaces of kaolinite. An increase in pH decreased the adsorption of TC slightly before pH reached the pK_{a2} and drastically at pH values above the pK_{a2} value of TC. Higher ionic strength also reduced TC adsorption. The balance between TC adsorbed and metal cations desorbed suggests that cation exchange is responsible for TC adsorption. Results from this study will provide a better understanding of TC transport in subsurface soils predominated by kaolinite.

*Undergraduate student presentation

2. Using an Analytic Element Model to Map the Regional Water Table in Columbia County Wisconsin.

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This project is part of a comprehensive inventory and assessment of Columbia County's groundwater resources. Groundwater is currently used to meet all public and private water supply needs in the county. Information gained through this study will allow us to judge the susceptibility of water supplies to over-use and contamination. The first step in this study is the development of a 1:100,000-scale water table map of shallow groundwater with the GFLOW analytical element model. One advantage of using GFLOW is that model results reflect a mass balance of flow into and out of the shallow groundwater system. Mapping the water table by contouring observed surface water and groundwater elevations does not insure that resulting contours honor mass balance.

The GFLOW model is calibrated to water level measurements from 1788 well construction records and stream flow from 42 locations. In the near-field, the model simulates the county's streams and groundwater in great detail, while the far-field is a generalization of streams from Dane, Dodge and other surrounding counties. The groundwater divide between the Wisconsin and Fox River Basins runs through the northern part of the county. Model results help identify the location of this divide, which is a significant hydrologic feature that delineates two major watersheds. The model and map will help county and local officials along with local citizens consider groundwater resources in discussions and decisions about planning and land-use issues.

**Graduate student presentation

3. Hydrogeophysical Study of the Bradford Beach Shoreline, Milwaukee Wisconsin

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Geoelectrical studies and groundwater studies were conducted at the north end of Bradford Beach on Lake Michigan in Milwaukee, Wisconsin to assess the shallow hydrogeology. The location was chosen to supplement current research at the beach relating to bacterial studies, and an apparent high water table that keeps the beach sand wet, prolonging fecal indicator bacterial survival. Potential contributions to the wet sand could include lake level influences, or groundwater flow from rain gardens at the top of 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.

2-D electrical profiles collected parallel to the shoreline over an 18 month period show consistent subsurface characteristics to the depth of investigation (3.5 meters) with some seasonal variations noted. A total of 15 piezometers emplaced to a depth of 0.5-1.5 meters in a grid pattern on the beach were monitored from Sept 2009- Dec 2009 on a weekly basis. Fluctuations in the water table are about 0.25 meters and are dominated by changes in lake level produced by wind driven wave action. The water table tends to increase from the lake toward the beach. Large rainfall events did produce groundwater flow toward the lake, but the variations where short lived. A comparison of the electrical profiles with the piezometer studies indicates that there is very little change in the hydrogeologic regime of the beach below the top 1.5 meters. The piezometer results suggest that lake level change is the primary contributor to the change in the water table levels over short time periods of several weeks.

**Graduate student presentation

4. Upper St. Croix-Eau Claire Rivers Watershed: State of the Lakes 2009

*James R. Brodzeller, Center for Watershed Science and Education, University of Wisconsin–Stevens Point, Stevens Point, WI, *jbrod030@uwsp.edu*

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Lentic surface water quality trends are a substantial contributor in developing a thorough hydrologic understanding of a watershed. Measures of water clarity, nutrient levels, and dissolved minerals provide a wealth of knowledge that can be used as a framework for land use planning, and, when connected with local surface and subsurface flow systems, allows for the modeling of nutrient transport and loading. To illustrate the current state of the lakes throughout the Upper St. Croix-Eau Claire River watershed, a study on 97 lakes was done using data compiled from the WDNR Surface Water Integrated Monitoring System (SWIMS) and from spring turnover samples collected in May 2009. Data included in analyses were dissolved mineral concentrations collected from 1979-2009, and nutrient and water clarity data collected from 1999-2009. Turnover periods were selected to ensure data came from homogeneous samples, using vertical temperature and dissolved oxygen profiles as a check for stratification. In addition, water clarity estimates based on LakeSat satellite imagery were compared to traditional field measures, to evaluate the effectiveness of using satellite data as a supplemental monitoring tool. Findings indicated little variability in dissolved mineral concentrations, where the absence of carbonate-rich geology accounts for the areas dominant soft water lakes. Nutrient levels are of concentrations that present a minor risk for accelerated eutrophication based on WDNR criteria values. LakeSat was shown to provide accurate measures of water clarity as defined by average Secchi depth, yielding a less than one foot difference on 27 of 68 lakes.

*Undergraduate student presentation

5. Depth-discrete Groundwater Monitoring Near a Water-Supply Well

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Managing and protecting groundwater in urban areas requires a comprehensive understanding of the local groundwater flow system. The Madison Water Utility operates production wells completed in a deep sandstone aquifer, which is separated from a shallow aquifer by the Eau Claire shale aquitard. The Utility conducted field investigations to characterize the flow system and groundwater quality near a new production well, Unit Well 29, which is located less than 2,000 feet from a closed landfill and has elevated manganese concentrations.

The project included drilling and testing aquifer materials from an 820 foot-deep “sentry well” located between the landfill and Well 29. Borehole geophysical logs were collected prior to installation of a depth–discrete FLUTe ™ monitoring system. This system provides a continuous record of hydraulic head measurements at three shallow and three deep monitoring ports. Gas displacement pumps are used to sample groundwater from the six ports.

Based on data from the sentry well, the potentiometric surface in the deep aquifer is 39 feet lower than the shallow water table, with a downward vertical gradient of 1.2 across the aquitard. Initial tests show elevated chloride and nitrate concentrations (86 and 10 mg/L, respectively) in the shallow aquifer and lower concentrations at the top of the deep aquifer (2.7 mg/L chloride and <0.2 mg/L nitrate). These results indicate that the Eau Claire aquitard limits flow from the shallow to deep aquifers and protects the deep aquifer from dissolved contaminants. These data enable the Utility to better manage and protect Unit Well 29.

6. The Determination of Bankfull Discharge and the Development of Regional Curves for the Southwestern Region of Wisconsin

**Jessica Haucke, University of Wisconsin–Stevens Point, Stevens Point, WI, *jhauc@uwsp.edu*

Katherine Clancy, University of Wisconsin–Stevens Point, Stevens Point, WI, *kclancy@uwsp.edu*

Bankfull discharge is important for stream channel creation and maintenance, and is a parameter used in stream restoration. Bankfull discharge is assumed to be equal to the discharge of the 1.5-year flood. This number is based on a nationwide average which can potentially overestimate or underestimate local bankfull discharges. The statistical determination of bankfull from field surveys has been conducted in the eastern and western United States. This study was done to determine the flood recurrence interval associated with bankfull flows and to develop regional curves for the Midwest. We compared annual maximum recurrence intervals from current and historic USGS gauged streams to bankfull discharge values determined from field surveys. We found that the southwest region of Wisconsin has a lower flood recurrence interval than the assumed 1.5 year return period. We also found that land use affects both the volume and the recurrence interval of bankfull discharge and was included as a factor in the development of regional curves. The regional curves will help restoration efforts become more efficient and proceed with more accuracy.

**Graduate student presentation

7. A Sediment Phosphorus Inventory and Preliminary Phosphorus Budget for the Fever River at Pioneer Farm

*Jon T. Immel, Department of Civil and Environmental Engineering, University of Wisconsin–Platteville, Platteville, WI, *immelj@uwplatt.edu*

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Agricultural phosphorus (P) runoff is of growing regulatory and public concern. The estimation of P export from agricultural land use is possible by either computer modeling or runoff monitoring. Phosphorus dynamics in streams are complex; involving deposition, resuspension, sorption/desorption, etc. In order to perform a P budget for a stream, internal processes must be quantified in addition to external inputs. The United States Geological Survey conducted a stream sediment survey and inventory from 2004 to 2007. Using this and more recent data, a sediment P inventory and preliminary budget was performed. Sediment cores were collected at 30 locations along 11 transects over the 1.3 km reach of the Fever River which bisects the Pioneer Farm of the University of Wisconsin-Platteville. Phosphorus profiles in stream bottom sediments and streambanks were combined with sediment inventories and monitoring data to develop a phosphorus inventory and preliminary P budget for the stream. This sediment P inventory provides a basis for comparison to future inventories, and a basic quantification of P in the stream to guide further research on in-stream P dynamics. Vertical and longitudinal variations in sediment and streambank P will be discussed.

*Undergraduate student presentation

8. Evaluating the Effects of Increased Precipitation Due to Climate Change on Wisconsin's Groundwater Levels

**Douglas R. Joachim, Nelson Institute for Environmental Studies, University of Wisconsin–Madison, Madison, WI, *djoachim@wisc.edu*

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This project addresses water table rise and the likelihood of groundwater inundation of low-lying areas under forecasts of increased precipitation for late in this century. We have developed a transient three-dimensional groundwater flow model of Spring Green, Wisconsin which experienced extensive groundwater flooding in 2008. The model will simulate the water table elevation under various recharge scenarios based on statistically downscaled regional climate forecasts from the Coupled Model Intercomparison Project (CMIP3), which are derived from North American Regional Climate Change Assessment Program (NARCCAP) simulations. Infiltration of precipitation to the water table will be quantified with a grid-based soil water balance model.

Early project efforts include characterization of the Spring Green field site. Data from a groundwater monitoring network show water table decline of several feet since 2008. A direct-push drilling program documented a surficial aquitard in the valley north of the flooded area, but found no evidence of low permeability deposits within the sand aquifer where flooding occurred.

Initial analysis of climate forecasts for 2046-2065 shows average annual precipitation increasing more than 2 inches per year compared to 1961-2000, primarily in spring rainfall. In this set of simulations, the recurrence interval of calendar-day precipitation exceeding 4 inches drops from 8 to 5 years. The recurrence interval of calendar-day precipitation greater than 3 inches declines from 3 to 1.5 years. Next we will evaluate recharge rates under these climate patterns. Ultimately, this work will provide a method to evaluate regional changes in hydrology and groundwater recharge using downscaled NARCCAP climate forecasts.

**Graduate student presentation

9. Drawdown, Recovery, and Hydrostratigraphy in the Northeast Groundwater Management Area (Brown, Outagamie, and Calumet Counties, WI)

**Julie C. Maas, University of Wisconsin–Green Bay, Green Bay, WI, *maasjc28@uwgb.edu*

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There are two cones of depression in the Northeast GMA. The first major area of drawdown is in central Brown County, and the second is just east of Appleton near the communities of Little Chute, Kaukauna, and Kimberly (Fox Cities cone). Between 2005 and 2007, eight communities in central Brown County stopped pumping groundwater for their municipal supplies and began using surface water instead, reducing daily withdrawals from the regional deep sandstone aquifer by approximately 12.25 million gallons. We studied the recovery of groundwater levels and estimated the volume of water that continues to be withdrawn from the regional aquifer.

Before the switch to surface water in 2005, the potentiometric surface of the deep aquifer was less than 300 feet above sea level in the central Brown County cone of depression. Between 2005 and mid 2009, groundwater levels recovered by more than 150 feet in some locations near the center of drawdown. Water levels continue to recover at a slow rate. Rising water levels in central Brown County have resulted in flowing artesian wells northwest of Green Bay, in Howard and Suamico. Flowing conditions could cause property damage and habitat alteration, creating new wetlands that may require monitoring and regulatory attention.

Current deep aquifer withdrawals in central Brown County are estimated to be 4.2 million gallons per day. In contrast, daily withdrawals from the pumping center around the Fox Cities cone have not changed considerably, and water levels do not seem affected by the reduced pumping in central Brown County.

We provide several policy recommendations for the northeast GMA, including increased water level monitoring capabilities, attention to flowing wells, and continuance of the GMA.

**Graduate student presentation

10. Using a GIS-Based Model to Identify Internally Drained Areas in a North-West Wisconsin Watershed

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Hydrologic and water quality modeling requires the delineation of areas from which runoff is physically capable of reaching a drainage network. The later requirement is particularly important in regions with poorly developed drainage networks such as the Midwest, where glaciations have left discontinuous areas of internal drainage, often included within watershed boundaries. The PCSA model provides an efficient method for locating the potential contributing areas, those areas with an uninterrupted slope to a drainage network, and the internally drained areas of watersheds in glaciated landscapes. An investigation was conducted using the model to define the potential contributing areas of Upper St. Croix Lake in north-west Wisconsin. The study evaluated the Curve Number (CN) method of predicting runoff volumes and the extent of potential contributing areas in relation to the minimum contributing area required to generate measured runoff. The PCSA model identified areas of internal drainage comprising up to 70% of the total catchment area of tributaries to Upper St. Croix Lake. Although numerous runoff producing events occurred during the study period, the rainfall was of insufficient depth for estimating runoff using the CN method. The extent of the minimum contributing area, estimated for a range of precipitation events, was found to be substantially less than the potential contributing areas, suggesting the PCSA model successfully delimits the maximum boundary of areas providing runoff to tributaries of Upper St. Croix Lake.

11. Incorporating Shoreline Development in a Lake Impact Model

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A primary goal of many restrictions on construction around lakes is reducing the impact on water quality. These efforts are increasingly challenged as development pressure increases. One of the difficulties to establishing scientifically-based restrictions is the absence of easily applied model systems. This project studied the potential for accelerated transfer of nutrients from land to water resulting from riparian development and designed an impervious surface runoff model to estimate nutrient transfer rates. The impervious surface model was linked with lake eutrophication in a lake impact model to examine the relative importance of impervious surface size, setback distance, site properties and lake characteristics on water quality. While the model was useful in examining the importance of individual modifications to the shore, it also demonstrated the importance of viewing the developed shore and the lake as a system where the introduction of impervious surfaces should be evaluated together with modifications to soils and hydrologic pathways.

12. Assessment of Major Stressors and Threats to Great Lakes Waters in National Parks and Lakeshores of Wisconsin and Michigan

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National parks and lakeshores are often perceived as isolated, pristine environments, but they are subject to a variety of stressors and threats at scales varying from local to global. Since 2005, the Center for Watershed Science and Education has conducted Coastal Watershed Assessments for National Parks and Lakeshores along America's "fourth coast" – the Great Lakes shoreline. Assessments have been completed for Pictured Rocks, Apostle Islands, and Sleeping Bear Dunes National Lakeshores, and one is in progress for Isle Royale National Park.

Major threats to the Great Lakes in these lakeshores and parks include deposition of atmospheric contaminants both locally and from as far away as Mexico and Central America and global climate change. Great Lakes shipping also presents major threats, including the possible introduction and transfer of aquatic exotic species, emissions of air pollutants such as oxides of sulfur and nitrogen, accidents that spill cargo or fuel, and discharges of garbage, cargo sweepings, human sewage, dunnage (material placed between cargo during shipping), ballast water, and bilge water.

Sleeping Bear Dunes, located on Lake Michigan, is the most severely affected, and experiences outbreaks of avian botulism in a complex cycle that includes *Cladophora* algae blooms, zebra and quagga mussels, and round gobies. These outbreaks cause shoreline biofouling and have led to the deaths of endangered piping plover (*Charadrius melodus*).

13. Cattle Crossings in Riparian Pastures: Costs, Benefits, and Performance

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Cattle commonly graze riparian areas and have open access to streams. From a management perspective, this practice makes a lot of sense. Riparian areas often cannot be planted with row crops, so making them into pastures maintains the land's productivity. Allowing cattle access to the stream eliminates the need to buy, install, and maintain a watering system. Given the option, cows will spend quite a bit of time near streams, especially during the hot and dry months. They use the stream to drink from and stand in to cool off. Also, grasses near the stream are often more green and lush in late summer, providing better forage.

However, allowing cattle open access to streams can cause environmental problems. When entering and leaving the stream, cows trample the banks and destroy vegetation, resulting in accelerated sedimentation. Cattle crossings are installed in riparian pastures to reduce bank degradation caused by trampling. Four cattle crossings were installed in the riparian pasture at Pioneer Farm in April 2003. Each crossing shares the same general design criteria of width, slope, and limestone gravel cap. However, three different bed stabilization methods were used to compare the performance of each. This presentation will cover the purpose, costs, and benefits of cattle crossings in general and present data and observations from the Pioneer Farm crossings.

14. Initiating a Long-term Monitoring Program of Aquatic and Terrestrial Invasive Species in Kenosha County, Wisconsin

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Approximately 50,000 species have been introduced to the United States, and although the majority of these species remain harmless, others are problematic because they become invasive, outcompeting native species. Riparian areas are particularly vulnerable to invasion due to high natural (e.g. floods) and anthropogenic disturbance (e.g. boats), which promotes the spread of invasives. In Wisconsin, common riparian invaders include aquatic species such as *Myrophyllum spicatum* (Eurasian water milfoil) and *Potamogeton crispus* (curly-leaf pondweed) and terrestrial species such as *Lythrum salicaria* (purple loosestrife). In this study, diversity and abundance of invasive species and native species were measured at two connected pairs of lakes in Kenosha County, Wisconsin. Each pair of lakes was connected by a stream and consisted of one lake with high boat access and one with low boat access. As expected, the lake with the lowest boat access had the highest overall species richness of submerged aquatic vegetation. Contrary to expectations, results showed a slight positive trend with terrestrial species richness marginally increasing as purple loosestrife abundance increased. This suggests that boat access may be more influential in the transport of aquatic invasives compared to terrestrial species. These preliminary results will serve as a baseline for a long-term monitoring program on invasive riparian species, and future work will examine potential links between aquatic and terrestrial invasive species as well as the importance of natural spread of invasive species (e.g. species moving upstream to other lakes). This information will be critical for assessing the problem of invasive species in Kenosha County, Wisconsin and will help improve management strategies.

*Undergraduate student presentation

15. Adaptation of Survey Equipment for Robotic Vehicle Tracking in an Aquatic Environment

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The littoral area is one of the most productive areas of the aquatic environment. Tourism and the natural human attraction to water make a beach valuable for recreation and revenue. Protecting the near shore waters will become more important as we further our understanding of, our dependence on, and our responsibility to the environment.

Understanding the interactions near the shore can be difficult, if not deadly at times. Large waves, strong currents, floating debris and cold water all prevent manual scientific measurement. Robotics offer humans a way to venture into this dangerous environment to monitor it while minimizing the associated risks. A robot, the Lake Michigan Amphibious Robot (LMAR), has been developed to aid scientific exploration of the surf zone. This project focuses on developing a navigation system for LMAR.

Navigating LMAR, as well as collecting scientific data requires highly accurate positioning. Standard GPS, accurate to about 2 meters, while adequate in open water where a few meters are insignificant, is inadequate near shore where a meter could mean the difference of being submerged or not. To accomplish this high accuracy, survey methods and equipment, not usual in the robotic or ocean science community, must be adapted and used in new ways.

*Undergraduate student presentation

16. Seeing and Believing: Exploring Public Understanding of Maps Depicting Private Well Water Test Results

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Maps are used to communicate information about groundwater and/or well water test results to different audiences. Despite the increasing use of maps for environmental risk communication, little evidence is available to suggest how this information is understood and potentially acted on. The purpose of this study was to assess what people "see" and understand for three formats of information (choropleth map, point map, alphanumeric table) that depicted private well water test results for a fictitious substance. "Rhynium" was described as naturally occurring with an MCL of 10 parts per billion based on cancer risk. Cognitive testing interviews with 13 private well users assessed "seeing" and "meaning" for each format. The unit of perception, color, visual salience, and personal relevance influenced what was seen and interpreted as trends. Maps allowed participants to see the spatial distribution of risk. Seeing and meaning were tightly integrated; participants *saw* problem areas on town map, wells on dot map, and well exceeding the MCL on table. Perceived proximity to mapped hazards was a key influence on beliefs. Participant's beliefs were more accurate for the dot map or table than the choropleth map. For the latter, over half did not understand the rate information displayed on the map; numeracy appeared to play a role. Despite this, most understood the gist of the choropleth map – that darker red meant a larger rhynium problem. Most preferred the dot map because it showed the distribution of risk including risks proximal to the estimated location of the viewers' home. The choropleth map was reported as the most "high alert" and likely to promote well water testing. Those who create maps to communicate environmental risk should carefully consider the unit of perception and features that support map orientation. The judicious use of elementary features, symbols, Gestalt Laws, and visual salience can support comprehension. Pretesting with members of audience provide useful insights.

17. The Geology and Ecohydrology of Springs in the Driftless Area of Southwest Wisconsin

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Miles Reed, DePauw University, Greencastle, IN

The Driftless Area of southwest Wisconsin is home to thousands of springs that help support the region's world-class trout streams and sustain critical habitat for endangered and threatened species. Because the region was never ice-covered, some of these springs may have also served as paleorefugia. In other regions, such springs support endemic species and, depending on their size and stability, host high biodiversity of rare species. To better understand the contributions of the springs in the Driftless Area to stream ecology, six undergraduate students and two faculty members are working on a project supported by the Keck Geology Consortium. During the summer of 2009, student researchers spent 3 weeks collecting field data which they are currently analyzing as part of their senior theses.

Springs are associated with every major stratigraphic unit in the Driftless Area; however, most springs are found near the upper contact of the Cambrian sandstones or in close association with the heavily fractured Sinnipee Group (Platteville, Decorah, and Galena Formations). Therefore, field sites were established in Crawford and Grant Counties, where representative examples of springs discharging from the Cambrian sandstones and the Sinnipee Group are located. Students are conducting outcrop analog studies to improve understanding of the geological controls on springs in the region; utilizing spring occurrence, temperature, and geochemistry to better understand modern contributions to trout streams; and studying records of stable isotopes and molar ratios of major and trace elements in spring tufa deposits to explore past climatic variations and to estimate the long-term continuity of spring flow in the region.

SESSION 3A:
Remediation and Stormwater Management
Friday, March 5, 2010
8:00 – 9:40 a.m.

Nanotechnology and Remediation of Ground and Surface Waters

Martin P. Griffin, Martin P; Wisconsin Department of Natural Resources, Madison, WI, *MartinP.Griffin@wi.gov*

Nanotechnologies, among the fastest-growing areas of scientific research and technology development worldwide and have been called the ‘‘Next Industrial Revolution.’’ The science of nanotechnology has great potential to benefit the environment through applications of nanomaterials to prevent, monitor, and remove pollutants in ground and surface waters. At the same time, scientists are raising concerns about the potential environmental risks related to the nano-sized materials used in nanotechnologies.

Nanoparticles have shown enormous promise in the field of environmental remediation. Due to the novel properties exhibited by nanoparticles, it has been discovered that certain particles are able to react with pollutants in various media and either transform them into harmless compounds or enhance removal efforts. With relation to groundwater applications, metal based or composite nanomaterials have been found to be successful for these types of applications.

Uses of nanoparticles in remediation efforts are not just limited to groundwater. In contaminated sediments, initial findings indicate that iron nanoparticles are able to dechlorinate polychlorinated biphenyls (PCBs).

This presentation will give a brief overview of some environmental applications of nanotechnologies and examine the benefits and potential risks of using this emerging technology to help manage our states water resources.

Characterization of Tar-Contaminated Sediment for Remediation

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At many sites where sediments are contaminated with NAPLs such as coal tar, the most important exposure pathway for human health risk assessment is dermal contact with product that migrates from the sediment to surface water. The potential for NAPL migration can be difficult to predict using standard techniques, such as evaluating PAH concentrations in sediment, or visual evidence of separate-phase tar in sediment. We performed laboratory experiments to measure the potential for contaminant flux from sediment in different areas of a tar-contaminated riverbed. By quantifying the potential for NAPL migration from different areas of the body of contaminated sediment, we were able to focus our remedial efforts on the area that posed the most risk.

Doing the Dirty Work: Making Contaminated Sediment Remediation a Priority in the St. Louis River Area of Concern

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The Great Lakes Water Quality Agreement between Canada and the U.S. committed the governments to develop and implement remedial action plans (RAPs) in Areas of Concern (AOCs) around the Great Lakes. AOCs are geographic areas that are severely degraded, often due to water contamination from chemicals such as PCBs and heavy metals or excessive nutrient contributions.

Wisconsin has five AOCs, which includes the St. Louis River System RAP, developed jointly by the states of Minnesota and Wisconsin. Both states share the St. Louis River Area of Concern, and are working to implement actions that are aimed at restoring and protecting designated uses at the AOC.

The St. Louis River, the largest U.S. tributary to Lake Superior, drains 3,634 square miles, entering the southwestern corner of the lake between Duluth, Minnesota and Superior, Wisconsin. As the river approaches Duluth and Superior, it takes on the characteristics of a 12,000-acre freshwater estuary, with the lower portion of the estuary being characterized by urban development, an industrial harbor, and a major port. The lower portion of the river also includes known areas of contaminated sediment, which are the underlying cause of most of the impairments identified for the St. Louis River Area of Concern.

Minnesota and Wisconsin have jointly identified cleaning up contaminated sediment and restoring habitat as the top priority work toward delisting the St. Louis River AOC. In several sites in the AOC, habitat restoration is contingent on remediating contaminated sediment in the estuary. Because of the complexity of the AOC's issues, the states recognize the need to work together to plan and implement projects with a consistent approach to information and cross-jurisdictional decision-making. For several years, the states and other interested parties have been looking to combine information about sites that contain contaminated sediments that are also prime candidates for habitat restoration.

Together, the two states now propose to create a St. Louis River AOC Comprehensive Delisting Framework, which will consolidate information about contaminated sediments and habitat to help decision-makers strategically prioritize project sites that will accomplish removing impairments and ultimately lead to delisting the AOC.

The Influence of Root Distribution and Water Stress on Evapotranspiration

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Steven P. Loheide II, Department of Civil and Environmental Engineering, University of Wisconsin–Madison, Madison, WI, *loheide@wisc.edu*

Root distribution and tolerance of different plant species to water and oxygen stress affects root water uptake patterns. These parameters affect one of the largest components of the hydrologic cycle, evapotranspiration. As a result, proper estimation of plant characteristics becomes important in hydrologic models as well as influences species selection for stormwater facility design. Four assemblages of native prairie and wetland species, selected for use in a newly constructed stormwater facility in the University of Wisconsin Arboretum, were grown over approximately 5 months in a temperature controlled greenhouse experiment. Throughout the growth period, flashy hydrologic conditions were simulated by manipulating water application rates. A continuous soil moisture dataset was gathered and critical soil moisture and pressure head values, defining both water stress and oxygen stress, were estimated from measurements of stomatal conductance. This dataset, along with measured plant characteristics and environmental data were used in the creation of a one dimensional ecohydrological model that examines the effects of root distribution and plant characteristics on root water uptake. Our results show that root distribution is an important factor which affects transpiration rates and soil moisture use; therefore, accurate predictive models require improved characterization of root architecture. Results from this research will benefit managers selecting plants for specific functions in stormwater facilities and will enhance the knowledge of plant-water interactions for use in future modeling efforts.

**Graduate student presentation

Evaluation of Effects of Middleton's Storm Water Management Activities on Streamflow and Water Quality Characteristics of Pheasant Branch, 1975-2008

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Few long-term data sets are available to evaluate the effects of urban management practices. Over 30 years of data are available to evaluate the effectiveness of Middleton's storm water management practices by analyzing streamflow and water quality data collected on Pheasant Branch. The data were related to structural and non-structural best management practices put in place during that period.

Urbanization in Pheasant Branch basin seems to be a factor in increasing the peak flows. On the basis of 35 years of streamflow data at the gaging station, the 2-yr flood peak increased 19% and the 100 yr flood peak increased 23%. Average annual runoff also increased due to urbanization and increasing annual precipitation.

The storm water management practices decreased the average annual sediment and phosphorus load even with increasing annual runoff and flood peaks. Since 2002 the annual sediment load has decreased 42% and the phosphorus load 75%. A comparison with other streams that drain into Lake Mendota didn't show the same decrease. The Storm Water Quality Plan done for Middleton shows Middleton met the NR 216/NR151 requirements of reducing TSS by 20 %. In addition the City is close to meeting the 40 % reduction in TSS by 2013.

To evaluate the effect of road deicing, chloride monitoring was conducted during two winter seasons. The maximum concentration of chloride was 931 mg/L, exceeding the USEPA acute criterion of 860 mg/L. Chloride concentrations exceeded the USEPA chronic criterion of 230 mg/L for at least 55 days. These concentrations and loads occurred in spite of being diluted by the Confluence pond and South Pond.

SESSION 3B
Watershed Management
Friday, March 5, 2010
8:00 – 9:40 a.m.

Evolution and Recent Developments of Web-based Decision Support Systems for Watershed Management

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The development of decision support systems (DSS) has drawn on knowledge and theory from disparate disciplines. In the early 1960s, researchers began investigating the use of computerized models to aid planning and decision making. Not long after, business journals began publishing articles on information systems for semi-structured and unstructured decisions and the term “decision support systems” arose. Theoretical studies of organizational decision making and technical work on interactive computer applications provided a foundation, and researchers identified preliminary design criteria for these models and systems: robustness, ease of control/use, simplicity/intuitiveness, and completeness of relevant data. The resulting tools span a continuum ranging from data-oriented query and retrieval tools to model-oriented simulations, and address personal, group, and organizational decisions. Artificial intelligence, expert system, remote sensing, geographic information system (GIS), and global positioning system (GPS) technologies have broadened the applicability of these tools to areas of environmental focus, including watershed management. The Worldwide Web, global Internet, and related network and communications technologies now provide a platform for further extending the capabilities and deployment of DSS. Today DSS include a full range of representation, process, evaluation, change, impact, and decision models. Understanding the history of these developments provides a guide for future activity as concepts and technologies continue evolving. The recent development and release of several knew watershed management tools demonstrates how DSS continue to exploit technological advances and use faster, real-time access to larger and more integrated databases and “open source” applications (like some of those that we will look at in this presentation).

Statewide Assessment of Wisconsin Streams Using a Sample Survey Design

Michael A. Miller, Wisconsin Department of Natural Resources, Madison, WI, *Michaela.miller@wisconsin.gov*

To assess the physical, chemical, and biological conditions of the state's entire wadeable stream population, the Wisconsin Department of Natural Resources conducted a statewide survey of streams in 2007 using a stratified-random sampling design. Within each of the State's four major Omernik Level – III ecoregions, 50 stream sites equally-distributed among Strahler stream orders 1 – 5 were randomly selected (n = 200). Physical, chemical, and biological data were collected at all sites using standardized field and lab methods. Over 200 hand-picked "least-disturbed" reference sites were also sampled to develop objective criteria with which to judge the conditions of the randomly-selected stream sites. Cumulative distribution function plots were used to estimate the proportions of stream sites meeting reference condition thresholds. Depending upon the physical, chemical, or biological parameter being evaluated, between 5% and 30% of the random sample sites (and by inference all of Wisconsin's streams), had some level of degradation. The Southeast Wisconsin Till Plains Ecoregion exhibited the highest degree of overall stream degradation, and the Northern Lakes and Forest Ecoregion the least. Radar plots were used to illustrate the relative quality of various stream habitat, water chemistry, macroinvertebrate, and fish assemblage attributes in each ecoregion. Risk analysis techniques were used to determine which physical or chemical stressors were most strongly associated with degraded stream biota. High total phosphorus concentrations appeared to pose the greatest risk to macroinvertebrates whereas low dissolved oxygen concentrations posed the greatest risk to fish.

Recreational Water Quality Modeling Tools for Local Beach Managers

Adam C. Mednick, Bureau of Science Services, Wisconsin Department of Natural Resources, Madison, WI, *Adam.Mednick@Wisconsin.gov*

Studies at several Great Lakes beaches have demonstrated that multivariate statistical models provide more timely and often more accurate predictions of the pathogen indicator *E. coli* than culture-based monitoring. Multivariate models can additionally assist managers in identifying and evaluating the relative significance of potential contamination sources and contributing environmental factors. Despite its benefits, this method has been adopted at only 11 of the nearly 540 monitored Great Lakes beaches in the U.S. Among the barriers that have prevented more widespread adoption to date has been the lack of free, user-friendly tools for building, evaluating, and implementing such models in an operational context. Faced with limited resources, local managers are unlikely to have the combination of staff time, modeling expertise, and/or commercial software necessary to successfully build and deploy real-time models for "nowcasting" water quality. To help fill this void, the U.S. EPA developed Virtual Beach – free software that enables beach managers to build and refine multivariate models to predict concentrations of pathogen indicators in real-time, based on meteorological, onshore, and near shore conditions. This presentation will introduce Virtual Beach and illustrate its key functionality through recent case-studies in Wisconsin. Operational considerations, including data collection and entry, will be discussed along with current efforts to incorporate non-point source pollution loadings from contributing watersheds using the Long-Term Hydrologic Impact Assessment (L-THIA) tool.

Controls on the Soil Moisture Regime of a Restored Floodplain, East Branch Pecatonica River: A Field and Modeling Investigation

**Eric G. Booth, University of Wisconsin–Madison, Madison, WI, *egbooth@wisc.edu*

Steven P. Loheide, University of Wisconsin–Madison, Madison, WI, *loheide@wisc.edu*

Creation of the hydrologic conditions necessary to establish and sustain wetland vegetation has become a popular goal of wetland restoration activities throughout the U.S. and Wisconsin. Hydrology, and specifically the soil moisture regime, is largely seen as the most critical factor for determining the outcome of a wetland restoration activity with its ability to control vegetation composition and biogeochemical processes. Yet, predicting the hydrologic and ecosystem response following such restoration projects can be challenging due to an inadequate understanding of the dominant controls on the soil moisture regime, especially under recently restored conditions where no natural analog exists.

Quantifying the soil moisture regime requires an understanding of important hydrologic fluxes such as evapotranspiration, infiltration, and groundwater upwelling. Field monitoring of soil moisture, groundwater, and vegetation at two floodplain restoration sites along the East Branch Pecatonica River combined with a numerical hydrologic model reveal several important factors for controlling the soil moisture regime that can vary both spatially and temporally. These factors include leaf-area index (partitioning of evapotranspiration), hydrostratigraphy (presence/absence of a confining layer), plant water stress function, and presence/absence of macropores. Modeling results reveal non-linear interactions among factors and substantial variability in the soil moisture regime under relatively small changes of the controlling factors. In order to accurately predict wetland hydrology and the ecosystem processes that are controlled by the soil moisture regime, consideration and effective characterization of these factors needs to be done.

**Graduate student presentation

Exploring the Role of Channel Processes and Legacy Sediment in Nutrient and Sediment Delivery, Upper Pecatonica River, Wisconsin

Faith A. Fitzpatrick, U.S. Geological Survey, Middleton, WI, *fafitzpa@usgs.gov*

A Wisconsin Buffer Initiative pilot project in the headwaters of the Pecatonica River in the southwest Wisconsin Driftless Area is examining the role of channel processes and legacy sediment in the delivery of nutrients and sediment to Upper Mississippi River. This research is part of a larger study by the University of Wisconsin-Madison, The Nature Conservancy, Dane County, Wisconsin Department of Natural Resources, and the U.S. Geological Survey designed to examine the spatial and temporal pathways of phosphorus and sediment from fields through channel networks and eventual export at a watershed outlet. The Wisconsin Phosphorus Index was used to quantify high-phosphorus and sediment loss areas from fields and pastures. In addition to soil erosion, stored historical sediment in valley bottoms, banks, and on the streambed may contribute a substantial portion of the suspended sediment load. Both sources have episodic delivery mechanisms and post-event time lags of movement that make measurement and quantification difficult. In 2009, a rapid channel assessment was completed at 30 sites in two small watersheds and includes measurements of bank erosion and sediment deposition. Sites were spatially distributed throughout the watershed from ephemeral headwater channels to perennial main stems. Repetitive channel cross section surveys and modified pebble counts that include measurements of fine-grained sediment deposition were begun in 2008. This presentation will cover some of the preliminary results from the channel and sediment surveys.

SESSION 4A
Water Policy and Law
Friday, March 5, 2010
10:00 – 11:40 a.m.

Livestock, Land Application of Wastes, Groundwater and Sustainability in Brown County

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Livestock numbers, number of Confined Animal Feeding Operations (CAFO's), livestock and cropland trends, livestock distribution, and land use are impacting sustainability of dairy industry, groundwater, and water quality in Brown County. Land application of wastes including animal waste is impacting groundwater and surface water quality. The contamination of wells in the Town of Morrison in Brown County as related to density of Karst features and land application of waste has resulted in high nitrate, and bacteria levels has been identified through well testing programs from the University of Wisconsin Stevens Point Center for Watershed studies. Several Factors led to contamination of over 100 wells in Morrison in 2006. A combination of wastes (animal, industrial, municipal) were land applied in winter of 2006 on frozen ground that has shallow soil or Karst features with a direct conduit to groundwater. Significant rainfall events in January and February contributed to the runoff. Current nutrient management plan (590) requirements and other land application requirements are not sufficiently designed or monitored to prevent the pollution of wells in the Karst topography of Morrison Township. Needs and opportunities to help solve future groundwater contamination will be discussed in this presentation.

A Perfect Storm: Invasive Species and Climate Change

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Wisconsin lakes and rivers are public resources, owned in common by all Wisconsin citizens and held in trust by the Department of Natural Resources (WDNR). Based on the state constitution, this doctrine has been further defined over the years by case law, statute, and through legal and legislative actions. As a result, the public interest has been broadened to include protected public rights to water quality and quantity.

As we creep nearer to the end of the first decade in this new millennium, greater challenges are emerging that are making it difficult for the state to protect the citizens' natural resources. Invasive species, climate change, and alternative energy, just to name a few, are contributing to difficult challenges facing our state's surface waters today.

Precipitation models for Wisconsin show that our state's surface waters that dependent on water from precipitation, runoff *and* rivers and streams may be affected. For example, if inputs 'dry up' water levels will go down allowing greater exposed shoreline areas that are susceptible to invasion by invasive species. Couple this with the increased populations of invasive species and you have a recipe for the perfect storm. This presentation will examine Wisconsin's current regulatory framework and policies related to these two areas that are available to policy makers to use in order to address some of these challenges surrounding low water levels and invasive species and also determine if there are any regulatory gaps that need examining as we move ahead.

Responding to the Impacts of Climate Change on Wisconsin's Water Resources – WICCI Water Resources Working Group Update

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Climate change has the potential to significantly affect the quality, availability, and functioning of Wisconsin's abundant water resources. While the general implications of a warmer and wetter climate are pretty well understood, there is still a fair amount of uncertainty about the shorter term and local impacts of climate change on wetlands, lakes, streams, and groundwater. Regardless of this uncertainty, it is becoming clear that 1) climate extremes are already occurring in Wisconsin, and 2) climate will continue to change for the foreseeable future regardless of any corrective action taken now. We need to prepare now to deal with the ramifications of climate change in how we manage our water resources over the next 10-20 years.

The Water Resources Working Group of the Wisconsin Initiative on Climate Change Impacts (WICCI) was formed to assess vulnerabilities and begin developing strategies for adapting and responding to the impacts of a changing climate on hydrologic processes and inland water levels and flows, including lakes, rivers, wetlands, stream baseflows, and groundwater. This presentation will provide a brief overview of water resource implications of climate change, and summarize the Working Group's progress to date on vulnerability assessment. It will also serve as an introduction to a focused discussion with water resource professionals later in the conference to help develop and prioritize water resource management adaptation strategies for the state of Wisconsin that can be applied on local, regional and statewide scales.

Putting Wisconsin's Aquitards to Work: an Opportunity to Protect Groundwater Quality

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Aquitards are important components of groundwater flow systems, controlling recharge and limiting transport of dissolved contaminants from shallow to deeper aquifers. Multi-aquifer wells (wells with open intervals that span an aquitard) compromise aquitard integrity by providing a conduit for flow and transport. Wisconsin's well code explicitly recognizes the Maquoketa and requires that deep wells in the eastern portion of the state be cased through shallow formations. There are no restrictions on multi-aquifer wells in other areas of the state where flow systems encompass regionally-extensive aquitards.

Several recent studies describe hydrogeologically significant aquitards in southern Wisconsin. The Eau Claire aquitard consists of a zone of siltstone and shale layers at the base of the Eau Claire Formation. This aquitard is absent in northeast Dane County but ranges up to 70 feet thick to the south and west. Pumping results in a large cone of depression in the potentiometric surface beneath the aquitard, and downward vertical gradients exceed 1. In Iowa County, portions of the Decorah and Platteville Formations constitute an aquitard that restricts flow between the Galena dolomite and the underlying St. Peter sandstone. Although regionally extensive, this aquitard is not coincident with the extent of the Decorah and Platteville Formations.

Aquitards are not homogeneous in their hydrogeologic properties, nor are they always easily identified from geologic maps. The Eau Claire and Decorah – Platteville aquitards are described with geologic and hydrogeologic information. Well construction requirements may now be developed to preserve the protection of natural water quality beneath these aquitards.

Groundwater Science Meets Public Policy in Wisconsin

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Informed management of Wisconsin's water resources should be based on science and technical evaluation. In July, 2009, a legislative work group chaired by Senator Mark Miller and Representative Spencer Black began a series of hearings and meetings with the goal to "…establish a statewide water management policy that protects Wisconsin's water quantity and quality on a sustainable basis for the benefit of Wisconsin's residents and economy." The work group reviewed the findings of a Groundwater Advisory Committee (GAC) that evaluated the current groundwater quantity law (Act 310) and issued reports in 2006 and 2007. The work group also invited testimony and technical assistance from Wisconsin's scientific groundwater community.

Major issues considered by the work group included the designation of groundwater management areas (GMAs) and groundwater attention areas (GAAs), the definition of springs, approval criteria for high-capacity wells, and methods for evaluating the cumulative impacts of groundwater pumping. Ancillary issues included the need for more groundwater monitoring and the statewide availability of and access to hydrogeologic data and groundwater flow models.

Wisconsin has a rich history of hydrogeologic studies and widespread availability of both data and technical expertise for evaluating groundwater issues. Wisconsin's geology and hydrogeology vary in three dimensions across the state, making "one size fits all" regulations difficult to implement. Instead, analytical and numerical groundwater models should be used as state-of-the-practice tools for helping inform and guide decision making.

SESSION 4B
Agricultural Management
Friday, March 5, 2010
10:00 – 11:40 a.m.

Modeling the Effects of Agricultural Management Practices on Hydrologic Processes at the Field Scale

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Agricultural management practices can have a significant impact on runoff, erosion and sediment load as well as crop yield and nutrient loads. The choice of which management practices to use may be influenced by the need to maintain good water quality. Given the potential non-linearity of the nature of the effects of management practices it may be difficult ton determine which practices to use. Precision agricultural modeling can provide great benefits to understand the effects of management practice. The Precision Agricultural Landscape Modeling System (PALMS) was calibrated to a field in south-west Wisconsin and validated to the adjacent field.

PALMS was then used to simulate the effects of changing a number of practices such as conservation practice, tillage, vegetation type and manure and fertilizer application. The effects were indeed non-linear and depended also upon antecedent and meteorological conditions. The full results are given here.

Runoff Patterns and Water-Quality Characteristics at Edge-of-Field Sites, Discovery Farms and Pioneer Farm, Wisconsin

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Runoff, sediment, and nutrients were measured in twenty-three waterways draining small (3-70 acres) agricultural basins on five privately owned Discovery Farms and the University of Wisconsin–Platteville Pioneer Farm from 2003-2008. The farms represented a variety of landscapes, soils, and management systems found on typical livestock farms throughout southern Wisconsin. Annual runoff volumes and sediment and nutrient yields were computed for each basin and averaged for each farm and year, totaling 26 farm-years of data.

Runoff averaged 2.6 inches/year and was nearly equally distributed between frozen and non-frozen ground periods. Runoff was observed in March at every farm during every year, with the highest volumes observed in both February and March. Suspended sediment yields averaged 670 lb/acre/year, ninety percent of which occurred during non-frozen ground periods. Total phosphorus (TP) yields averaged two lb/acre/year, sixty percent which was measured in runoff during non-frozen ground periods. Particulate P was the principal P analyte in runoff during non-frozen ground periods, while dissolved P was the principal P analyte during frozen ground periods. Total nitrogen (TN) yields averaged seven lb/acre/year and were distributed nearly equally between frozen and non-frozen ground periods. Organic nitrogen was the principal N analyte measured during both periods of runoff. Weather, soil condition, and the timing of field activities (most notably manure applications) were important factors affecting runoff volume and water quality. Field activities managed with consideration to critical runoff conditions may help reduce sediment and nutrients in edge-of-field runoff.

Liquid Manure in Tile Drains: Pathways and Risk Reduction Strategies

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Land application is the preferred method of animal waste management throughout Wisconsin. One significant risk of land spreading manure is its entry into streams, lakes and groundwater. Manure can transport nutrients, oxygen demanding organic matter, bacteria and pathogens into surface and groundwater posing significant public health and environmental risks.

The most common and readily apparent transport pathway for surface-applied liquid manure into surface waters is surface runoff. To reduce odors and runoff risk and to capture maximum fertilizer value, many producers also inject liquid manure directly into field soils. For non-tiled fields surface application and injection are appropriate methods of manure application when soil conditions (moisture, slope, frost, etc.) are right and when done at application rates appropriate for soil assimilation. The existence of tile drains, common in parts of Wisconsin's landscape, however, may render these methods inappropriate by providing a direct transport pathway for surface applied and injected liquid manure to surface waters. Manure can enter tile drains via surface inlets, open cavities created by tile blow-outs and via soil macro-pores (earthworm holes, soil cracks and former root holes).

Management action to reduce the risk of manure entry into surface inlets is to avoid surface applications on fields with tile surface inlets, replace surface inlets with closely spaced sub-surface tile laterals or use injection. To reduce risk of manure entering open cavities from tile blow-outs, repair blow-outs properly and/or make the necessary tile system design changes to prevent blow-outs from occurring. The risk of manure leaching through macro-pores can be reduced by tillage timing and equipment type. For both surface and sub-surface application, high soil moisture and tile flow during application significantly increase leaching loss risks. Pre-application tillage over tiles reduces surface application risk, but adds time, cost and requires accurate knowledge of tile line location. Recent research (summer 2009) suggests manure leaching via macro-pores was reduced using ant-leach sweep injector shank with a deeper (~ 6 in) injection depth that simultaneously and aggressively mixes soil and manure. This method showed less leaching at a relatively high (~8,000 gal/ac) rate when compared to shallow injection and surface application. Careful attention to field conditions, application rate and soil moisture along with the use of appropriate manure application equipment can reduce the risk of liquid manure leaching into tile drains and shallow groundwater, thus reducing environmental impacts.

Evaluating the Effectiveness of Fallowing on Bank Erosion in a Grazed Riparian Paddock

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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 and identify active geomorphic processes prior to future evaluation of riparian grazing management alternatives. 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 the conclusion of the baseline monitoring period, a 3-acre area (paddock 7) at the north end of the pasture was removed from the grazing rotation and fenced to exclude the cattle. This area was left fallow for habitat restoration, and small trees were planted to provide bird habitat. The removal of paddock 7 from the riparian rotational beef cattle grazing at Pioneer Farm presented an opportunity to collect and review the cross section and bank erosion data for any changes that have occurred since the permanent fence was installed. In 2009, the six cross sections and 18 eroding bank areas located in the fenced area were remeasured. Erosion-pin measurements, photographs and a soft sediment thickness survey were also completed. Patterns of increased vegetation growth and channel response to the cattle removal will be discussed in the presentation.

Bioavailability, Equilibrium, and Mixing Characteristics of Sediment Bound Phosphorus in the Fever River at Pioneer Farm

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Agricultural lands, as potential sources of non-point source nutrient pollution, are important factors in the health and productivity of streams, rivers, and lakes. Specifically, sediment bound phosphorus (P) is an important parameter that can impact both the receiving water body and also downstream aquatic systems. Sediment samples were collected at 19 stream bed and stream bank sites from an agriculturally impacted stream and were analyzed for bioavailable P (BAP) and equilibrium P concentrations (EPC_0). Stream bed sediments had average BAP concentrations of 360 mg/kg, while the bank samples averaged 224 mg/kg. Stream bed sediments also had a higher proportion of TP that was bioavailable. Over all sites and depths tested, BAP as a percent of total P ranged from 10-73% and the average BAP concentration was 284 mg/kg. Eight of the 19 sites had EPC_0 concentrations above 0.05 mg/L, however only one stream site had an EPC_0 concentration above 0.07 mg/L. During high flow events, most surficial sediments act as sinks to P dissolved in the Fever River's water column. Sediment mixing and transport characteristics were investigated using beryllium isotope (Be-7; half life = 53.3 days) concentrations at two selected sites. Measurable concentrations of Be-7 were detected in only the upper layers of bed sediments. Implications of the sediment bound P characteristics in the Fever River on the source, fate, and influence of sediment bound P in aquatic systems will be discussed.