AMERICAN WATER RESOURCES ASSOCIATION-WISCONSIN SECTION

31st ANNUAL MEETING

The Future of Wisconsin's Water Resources: Science and Policy

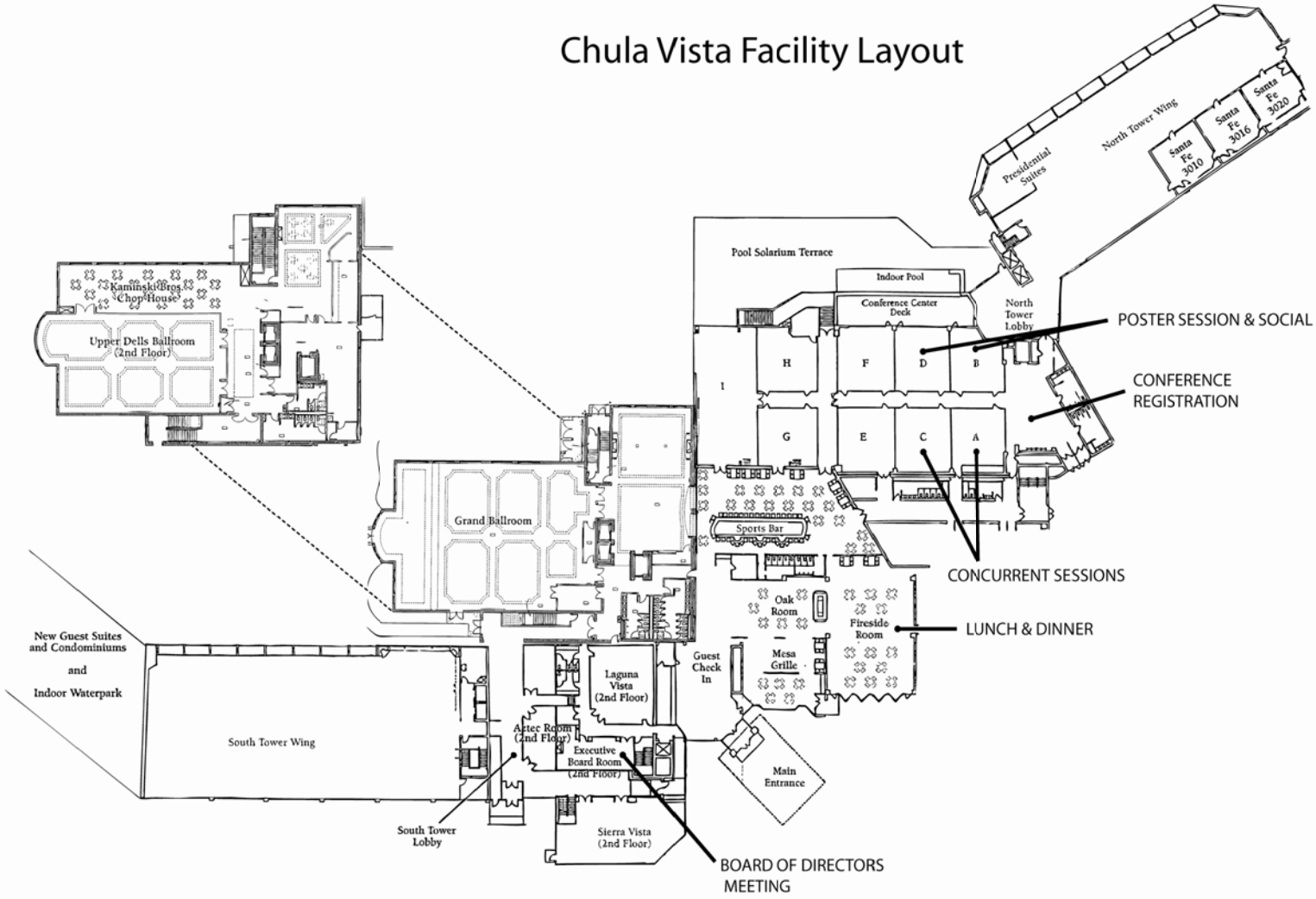
March 1-2, 2007

The Chula Vista Resort
Wisconsin Dells, 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

Chula Vista Facility Layout



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

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CONTENTS

Program Summary	2
Session 1A: Groundwater and Surface Water Interactions	9
Session 1B: Linking Public and Environmental Health	13
Session 2A: Groundwater and Aquifer Recharge	17
Session 2B: Advances in Water Monitoring and Remediation	21
Poster Session	25
Session 3A: Hydrogeologic Investigations	40
Session 3B: Water Quality and Ecological Assessment	45
Session 4A: Sustainability and Use of Groundwater Resources	50
Session 4B: Stream Monitoring, Restoration and BMPs	55
Index	60

PROGRAM SUMMARY

The Future of Wisconsin's Water Resources: Science and Policy

31st Annual Meeting of the American Water Resources Association – Wisconsin Section

The Chula Vista Resort, Wisconsin Dells, Wisconsin

Thursday, March 1, 2007

9:00 a.m. – 2:15 p.m. Registration – Conference Center Lobby

11:30 – 12:15 Welcome and Lunch – Fireside Dining Room

12:15 – 12:30 Board Member Elections and Treasurer's Report

12:30 – 2:00 **Plenary Session:** The Future of Wisconsin's Water Resources: Science and Policy

Todd L. Ambs
Water Division, Wisconsin Department of Natural Resources

Jodi Habush Sinykin
Of Counsel, Midwest Environmental Advocates

M. Carol McCartney
Ayres Associates

2:00 – 2:15 p.m. **Break**

2:15 – 3:55 p.m. **Concurrent Sessions 1A and 1B**

Session 1A – Groundwater and Surface Water Interactions
Conference Center Room A
Moderator: John Skalbeck, UW-Parkside

2:15 The Cook Creek-Mollet Quarry high capacity well connection and how cooperation among private and public interests benefited all. William Furbish and David Hart

2:35 Groundwater interactions in the Vermillion River Headwaters. Jennifer Olson

2:55 Identifying denitrification zones and processes in a riparian floodplain and wetland at Dorn Creek Marsh Nature Preserve, Dane County, WI. Laura Craig**

3:15 Evidence for focused groundwater/surface water interaction using a distributed temperature sensor. Christopher Lowry**

3:35 Toward coupled groundwater-surface water modeling: The importance of simulating unsaturated zone flow in the Trout Lake Basin. Randall Hunt

Session 1B – Linking Public and Environmental Health
Conference Center Room C
Moderator: Lynn Markham, UW-Stevens Point

2:15 Making the connection: Public health and the environment. David Edwards

2:35 Unused medicine disposal: Sources, environmental concerns, and initiatives. Susan Boehme

2:55 Visualizing uncertainty in assessing the vulnerability of groundwater to pesticide contamination. Dolores Severtson

3:15 Feasibility of utilizing treated wastewater to mitigate water supply stresses in southeastern WI. Rachel Wilberding**

3:35 Amery Regional Medical Center: Improving human and ecological health in Northwest Wisconsin. Brett Emmons

3:55 – 4:10 p.m. **Break**

4:10 – 5:30 p.m. **Concurrent Sessions 2A and 2B**

Session 2A – Groundwater and Aquifer Recharge

Conference Center Room A
Moderator: Steve Gaffield, Montgomery and Associates

4:10 Use of streamflow data to estimate baseflow/ground-water recharge for Wisconsin. Warren Gebert

4:30 Evaluation of changes in groundwater recharge under future climate conditions. Robert Servais**

4:50 Investigating recharge to the Cambrian-Ordovician aquifer through fine-grained glacial deposits in east-central Wisconsin. Carolyn Moeller**

5:10 Enhanced groundwater flow between perched and regional aquifers through cross-connecting wells and effects on groundwater quality. Jonathon Carter**

Session 2B – Advances in Water Monitoring and Remediation

Conference Center Room C
Moderator: Steve Loheide, UW-Madison

4:10 Optical sensing of dissolved oxygen and temperature in aqueous environments. M. Veronica Rigo**

4:30 Using dissolved gases to explore biogeochemical relationships of a small baseflow dominated central Wisconsin stream. Samuel Werner*

4:50 A simple, buoy deployable instrument for accurate dissolved carbon dioxide and total inorganic carbon measurements in freshwater and marine ecosystems. Bryant Browne

5:10 Improving recreational navigation in Fond du Lac, Wisconsin, through hydraulic dredging and sediment dewatering using Geotextile tubes. Mark Lentz

5:30 – 7:00 p.m. **Poster Session and Social Hour** –
Conference Center Rooms B and D

Implementing methods to assess the spatial extent and density of *Schoenoplectus acustus* for future management in Clark Lake, Door County, WI.
Justin Barrick*

Geochemical and flow characteristics of two contact springs in Iowa County, WI.
Brandon Bartkowiak*

Hydrogeologic characterization of the Catherine Wolter Nature Conservancy site, Vilas County, WI.
Kristina A. Betzold**

Filter strip attenuation of feedlot runoff contaminants.
Dennis Busch

Leveraging existing data and models for developing a basin-scale groundwater flow model of the Rock River Basin, southeast WI. Charles Dunning

Determination of nitrate retention capacity in a Wisconsin Sand Plains stream. David Flagel*

West Campus Cogeneration Facility compensatory recharge system: Initial operation results.
Stephen Gaffield

A geologic and geophysical investigation of liquid manure transport through the vadose zone.
David Hart

Optical fiber sensors with microsphere-templated, porous fiber claddings for remote measurement in aqueous environments. Paul Henning**

The impact of intensive grazing land management on groundwater phosphorus. Kyle Homan*

Ground-water contamination susceptibility in the St. Croix River Basin, WI and MN. Paul Juckem

Developing an inventory of Wisconsin springs.
Jacob Macholl

Nitrogen export and speciation from edge-of-field runoff from agricultural fields in southwest WI. Randy Mentz

Mapping recharge areas to groundwater dependent resources. Jennifer Olson

Groundwater monitoring at Argonne National Laboratory. Robert E. Piorkowski

Bringing meaning to well water test results: A standard laboratory result versus a visual display result. Dolores Severtson

Plant beds in streams: a biodiversity hotspot? Michael Shupryt**

Delineating seasonal wetlands at Chiwaukee Prairie, Pleasant Prairie, WI. John Skalbeck

Particle size, mobility and phosphorus content of stream deposits in an agriculturally dominated watershed. Bryce VandenBoom* and Erica Stephens*

Use of petroleum exploration techniques in ground water exploration. Mari Vice

Mapping and characterization of springs in Brown and Calumet Counties, WI. Christian Waltman**

7:00 p.m. **Dinner** – Fireside Dining Room

Speaker: Jack Waterman, Builder and Former Operator of Noah's Ark Waterpark, Wisconsin Dells

* Undergraduate student presentation
** Graduate student presentation

Friday, March 2, 2007

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

8:15 – 9:55 a.m. Concurrent Sessions 3A and 3B

Session 3A – Hydrogeologic Investigations

Conference Center Room A
Moderator: Ken Bradbury, Wisconsin Geological and Natural History Survey

8:15 A fresh look at a regional imbalance: Indices of groundwater budget components to denote historical change in southeastern Wisconsin. Kristina A. Betzold**

8:35 Simulating the role of domestic wells in the ground-water system of southeastern Wisconsin. Douglas S. Cherkauer

8:55 Pleistocene hydrology of the deep sandstone aquifer in southeast Wisconsin – Revised Edition. Timothy J. Grundl

9:15 Regularized inversion of a groundwater flow model of the Trout Lake Basin. Christopher Muffels**

9:35 Looking for a silt layer on the Crystal-Big Muskellunge Lake isthmus. Michael N. Fienen

Session 3B – Water Quality and Ecological Assessments

Conference Center Room C
Moderator: Dennis Busch, UW-Platteville

8:15 Ecological assessment and restoration planning for an urbanized kettle pond, Tiedeman Pond, City of Middleton, Dane County. Nicole Kalkbrenner

8:35 Particle size, mobility and phosphorus content of stream deposits in an agriculturally dominated watershed. Bryce VandenBoom* and Erica Stephens*

8:55 a.m. Phosphorus forms along a flow path and application of an area weighted p-index to multi-field watersheds. Nick A. Reckinger**

9:15 Impacts to stormwater quality by past road salt usage at Argonne National Laboratory. Lawrence P. Moos

9:35 Assessing the ecological status and vulnerability of springs in southern Wisconsin. Susan K. Swanson

9:55 – 10:15 a.m. **Break**

10:15 – 11:55 a.m. **Concurrent Sessions 4A and 4B**

Session 4A – Sustainability and Use of Groundwater Resources

Conference Center Room A
Moderator: Randall Hunt, U.S. Geological Survey

10:15 Where is the deep groundwater divide in Southeastern Wisconsin? Kenneth R. Bradbury

10:35 Estimating groundwater use in urban and rural areas of Wisconsin. Madeline B. Gotkowitz

10:55 Is Wisconsin ready for artificial recharge? John R. Jansen

11:15 Getting to know the hydrologic neighborhood: An approach for protecting natural areas. Nancy R. Zolidis

11:35 Aldo Leopold and a groundwater ethic. Mary P. Anderson

11:55 Closing remarks and announcement of student paper award winners

Session 4B – Stream Monitoring, Restoration and BMPs
Conference Center Room C
Moderator: Bryant Browne, UW-Stevens Point

10:15 a.m. Evaluation of probabilistic and targeted sampling designs used to assess wadeable streams in Wisconsin. Michael A. Miller

10:35 Monitoring the effects of riparian grazing on streambank erosion and morphology, Pioneer Farm, Platteville, Wisconsin. Marie C. Peppler

10:55 Restoring the riparian corridor of the East Branch of the Pecatonica River. Robert D. Hansis

11:15 Incorporating record uncertainty into regional flood frequency regressions. John F. Walker

11:35 Restoration and improvements around bridges and culverts for channel stability and fish passage. Dan Salas

11:55 Closing remarks and announcement of student paper award winners

* Undergraduate student presentation
** Graduate student presentation

SESSION 1A:
Groundwater and Surface Water Interactions
Thursday, March 1, 2007
2:15 – 3:55 p.m.

The Cook Creek-Mollet Quarry High Capacity Well Connection and How Cooperation among Private and Public Interests Benefited All

Furbish, William B. Wisconsin DNR. P.O. Box 7921, Madison, WI 53707, william.furbish@wisconsin.gov
Dave Hart (co-presenter), Wisconsin Geological and Natural History Survey, 3817 Mineral Point Road, Madison, WI 53705, djhart@wisc.edu
Cindy Koperski, Wisconsin DNR, 3550 Coulee Road, LaCrosse, WI 54601, Cindy.koperski@wisconsin.gov

Due to concern that a proposed water bottling plant in Adams County could dewater neighboring trout streams, the Wisconsin groundwater law was updated in 2003 to state that high-capacity wells could not be sited closer than 1,200 feet from a trout stream. However, high capacity wells in place before the law changed were grandfathered in. One such well, located 350 feet away from Cook Creek, a Class I brook trout stream in central Vernon County, was drying up a portion of the stream when the well was in operation. Cooperation from the quarry owners, WGHNS, and DNR allowed information to be gathered about the high capacity well borehole. A solution was proposed to reduce affects to Cook Creek during pumping and implemented by the quarry owner.

Groundwater Interactions in the Vermillion River Headwaters

Olson, Jennifer. Emmons and Olivier Resources, Inc., 651 Hale Avenue North
Oakdale, MN 55128, jolson@reorinc.com

The Vermillion River is one of five high priority trout streams in the Twin Cities Metropolitan Area, Minnesota, and located in a watershed that is rapidly developing. Anticipated development within the watershed and along the banks of the river have the potential to impact the river significantly. This project was initiated by the Dakota County SWCD to determine the current interaction of groundwater in the river, identify key recharge areas, and develop management policies for protecting the river and cold water fisheries.

A comprehensive monitoring program was established to evaluate groundwater interactions within the river. Monitoring components included surface water levels; water levels at private residential wells and within shallow hand driven piezometers within the river; chemistry in the river, its tributaries, and nearby lakes; temperature in the river and river bed; and base flow measurements.

A total of 23 stream reaches were monitored as part of a long-term program which evaluated over 55 miles of river channel. The data were analyzed to determine the significance of groundwater interaction at each reach. Data were then used to develop maps of ground water influence on the river, ground water contours, key recharge areas and infiltration potential.

A model ordinance has been developed to protect ground water recharge quality and quantity and dependent natural resources based on the data collected as part of this study.

Identifying Denitrification Zones and Processes in a Riparian Floodplain and Wetland at Dorn Creek Marsh Nature Preserve, Dane County, Wisconsin

**Craig, Laura. University of Wisconsin-Madison, Department of Geology and Geophysics, 1215 W. Dayton St., Madison, WI 53706, lcraig@geology.wisc.edu
Jean M. Bahr, University of Wisconsin-Madison, Department of Geology and Geophysics, jmbahr@geology.wisc.edu
Eric Roden, University of Wisconsin-Madison, Department of Geology and Geophysics, eroden@geology.wisc.edu
Kenneth W. Potter, University of Wisconsin-Madison, Department of Civil and Environmental Engineering, 1415 Engineering Dr., Madison, WI, 53706, kwpotter@wisc.edu

The Mississippi River drains forty percent of the Continental United States into the Gulf of Mexico, with serious consequences to the coastal-marine environment at the river's outlet. Much of the nation's agricultural activities occur in the Upper Mississippi River Basin, with significant nutrient loading to the surface water. As a result of the increased nutrient output, high levels of nitrate released from Mississippi River discharge have created an extensive coastal hypoxic zone at the interface of the Mississippi River and the Gulf of Mexico. Although northern states such as Wisconsin do not suffer the effects of nitrogen loading seen along the southern coast, it is a relevant water quality concern for the Upper Mississippi Region because the bulk of nitrogen released into the Gulf originates from agricultural land located hundreds of miles up stream.

Several studies have documented significant reduction in nitrate levels within riparian wetlands and floodplains receiving agricultural discharge, suggesting that riparian buffer zones can act as a control mechanism limiting nitrate contamination of water. The location of this project is a riverine floodplain and wetland in Dorn Creek Marsh Nature Preserve, Dane County, Wisconsin. A small stream flows through an agricultural watershed and into Dorn Creek Marsh Nature Preserve before emptying into Six Mile Creek just east of the marsh. Chemical data collected for this study indicate that nitrate levels decrease 90% as the stream flows through the two-mile marsh. The results also indicate that nitrate levels drop from approximately 9.0ppm NO_3-N to 0.1ppm NO_3-N as groundwater moves through the marsh's floodplain and discharges into the creek. Though it is clear from these data that nitrate concentrations drop drastically in the wetland and groundwater, the reasons for this decrease still need to be identified.

The first part of this study is to determine whether denitrification is the primary mechanism driving the observed decrease in nitrate concentrations and to estimate whether dilution and plant uptake contribute to the reduced nitrate levels. The second parallel component is to identify the conditions and processes

that control microbial denitrification in groundwater discharge to depths of ten to twelve feet. Using water chemistry analyses, isotope fractionation of O-18 and N-15 in nitrate, and dissolved nitrogen gas concentrations in groundwater, we hope to locate areas with high denitrification rates and pinpoint the conditions that favor denitrification. Isotope fractionation of deuterium and O-18 in water will also be applied to determine whether mixing and dilution from surface precipitation and deeper regional groundwater contribute to the decreased nitrate levels. The results of the above work are intended to provide insight on denitrification processes in order to improve wetland management techniques and maximize wetland services, with the broader long-term goal of reducing nitrogen loading downstream.

**Graduate student presentation

Evidence for Focused Groundwater/Surface Water Interaction Using a Distributed Temperature Sensor

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

Diffuse flow is typically assumed to be the dominant process of groundwater discharge to streams. Using temperature measurements obtained with a distributed temperature sensor, we found what appear to be zones of focused groundwater discharge in a wetland stream underlain by peat. A one-kilometer long fiber-optic cable was placed just below the stream/sediment interface in Allequash Creek, Vilas County, to measure variations in temperature. The difference in temperature between groundwater and surface water was used to identify gaining and losing reaches along the stream. In addition, temperatures in zones of focused groundwater discharge were relatively constant through time. The focused zones of high groundwater discharge are assumed to be a result of soil pipes within the peat. Seepage-meter measurements conducted in two of the focused discharge zones showed two orders of magnitude more discharge as compared to non-focused discharge zones.

The results demonstrate the utility of fine spatial (1 meter) and temporal (60 seconds) resolution of the distributed temperature sensor for identifying zones of focused discharge. The results also verify that the distributed temperature sensor gave contemporaneous and accurate measurements of streambed temperatures. While temperature measurements provide only indirect estimates of groundwater flux in and out of the stream, distributed temperature sensor measurements appear to have great potential to help characterize groundwater/surface water interactions, especially in conjunction with additional data collection, including seepage meters, stream gaging, thermocouple probes and forward looking infrared (FLIR) images.

**Graduate student presentation

Toward Coupled Groundwater-Surface Water Modeling: The Importance of Simulating Unsaturated Zone Flow in the Trout Lake Basin

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Mary P. Anderson, University of Wisconsin-Madison, 1215 W. Dayton Street, Madison, WI 53706, andy@geology.wisc.edu

Many ecosystems are influenced by groundwater-surface water interactions, but they are often not well quantified. To simulate a coupled system, a mechanism to connect the surface process to the groundwater system is needed. Recently, a computationally efficient one-dimensional, kinematic wave approach was implemented in MODFLOW that maintains conservation of mass in a homogeneous unsaturated zone (UZF package). This code was applied to the Trout Lake watershed in northern Wisconsin where an existing transient simulation was used to evaluate the importance of unsaturated-zone flow. Two cases were compared: 1) the standard approach of adding infiltration directly to the water table using the recharge package (RCH) for MODFLOW; and 2) adding the same infiltration below the root zone and subsequently routing it through the unsaturated zone using the unsaturated zone (UZF) package for MODFLOW. Results show that in areas with thin (<2 m) unsaturated zones, a standard RCH package approach was at times adding more water to the water table than would be expected given the soils present in the watershed. In areas with thicker unsaturated zones (>8 m), the volume of water infiltrated was properly simulated using the standard RCH approach, but timing of recharge was less representative of field conditions. Accounting for unsaturated zone flow provided a more representative simulation of the watershed-scale hydrology, both in a better fit to transient head data as well as stream flows and lake stages.

SESSION 1B:
Linking Public and Environmental Health
Thursday, March 1, 2007
2:15 – 3:55 p.m.

Making the Connection: Public Health and the Environment

Edwards, David S. Environmental Enforcement Coordinator, Wisconsin Department of Natural Resources (WDNR), PO Box 7921, 101 S. Webster St., Madison, WI 53707-7921, david.edwards@wisconsin.gov

This PowerPoint program developed by WDNR's Bureau of Law Enforcement looks at how the health of the environment relates to our health.

The program covers the following issues: 1) The relationship between the health of the environment and our health (historical incidents will be discussed including the burning of coal in London); 2) How mercury in our environment is impacting our health; 3) Why sound science is critical in decision making, and 4) What we as individuals can do to help protect the health of the environment (we will examine why the initial Earth Day movement was so successful).

The purpose of the program is not to tell people what to believe or how to think, but simply to get people interested in the health of our environment. It is designed to speak directly to the individual on how pollution can affect our health. The information in this presentation has been highly researched and all facts are documented by credible sources.

Attendees can modify this presentation and present similar programs promoting environmental health in their own communities.

Unused Medicine Disposal: Sources, Environmental Concerns, and Initiatives

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Proper disposal of unused medicines is a rapidly emerging concern that spans a broad range of issues including human health, water quality, solid waste management, law enforcement, and environmental integrity. Substances of concern include both prescription and non-prescription drugs.

Pharmaceuticals are produced in increasing volumes every year. With this growth comes concern about the fate of these compounds in the environment. Recent studies have identified a wide range of pharmaceuticals in fresh and marine waters nationwide, and several of these compounds are potentially harmful to aquatic organisms, even in small quantities, as they are specifically designed to be bioactive. Additionally, improper medicine disposal poses risks of poisoning to children, the elderly and pets and can lead to drug/identity theft.

Currently, there are no official U.S. federal guidelines for consumers on proper disposal of unused/unwanted medicines. Unused medicines are either accumulated in homes or disposed of by flushing, placing in the trash, or giving to family or friends, all of which have significant disadvantages. This presentation will describe the current situation of unused/unwanted medicines by identifying the various environmental, health and societal concerns related to this issue, the current barriers to improved disposal programs, and case studies of successful take-back programs.
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Visualizing Uncertainty in Assessing the Vulnerability of Groundwater to Pesticide Contamination

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Technological developments in geographic information systems (GIS) have led to an increased use of mapping approaches in depicting health outcome and environmental exposure data. Numerous data modeling approaches have been developed to address spatial gaps in environmental databases. It has been difficult, however, to visually convey geographical distribution of exposure or health risk estimates in a manner that appropriately reflects the magnitude of the problem along with the uncertainty inherent in such modeling approaches. The Environmental Public Health Tracking Program is developing a model to use as a screening-level tool to identify areas of the state where the potential is highest for agricultural pesticides to contaminate drinking water. The tool is being developed as part of an integrated and pro-active environmental public health management program. In validating this model, it has been deemed critical that the visual presentation of model output accurately and intuitively reflect both the information and the level of uncertainty in the results.

Geovisualization guidelines have been developed to provide some guidance for selecting visual features that facilitate the ease and accuracy of map comprehension. For example, quantitative trends from low to high are optimally conveyed with color gradients from light to dark. Uncertainty is also a focus of GIS research. Findings suggest that visually conveying uncertainty improves the speed and accuracy of decision-making. We will share some visualization guidelines for creating maps that merge environmental and public health information, and review methods that have been proposed for visualizing uncertainty.

Feasibility of Utilizing Treated Wastewater to Mitigate Water Supply Stresses in Southeastern Wisconsin

**Wilberding, Rachel M. University of Wisconsin-Milwaukee, Department of Geosciences, P.O. Box 413, Milwaukee, WI 53201, rachelw6@uwm.edu
Tim Grundl, University of Wisconsin-Milwaukee, Department of Geosciences, P.O. Box 413, Milwaukee, WI 53201, grundl@uwm.edu

The traditional drinking water source for Waukesha County, the Cambrian Ordovician aquifer, is continuing to experience drawdown of the potenitometric surface and high levels of radium and TDS. The city of Waukesha is under a regulatory mandate to reduce radium levels to comply with EPA standards by the end of 2006. Efforts are therefore underway to explore alternative water supply options for this region, including shifting pumping to the shallow aquifer system and using water from Lake Michigan. Each of these alternatives has significant drawbacks. Pumping of the shallow aquifer would require increased recharge to prevent water table drawdown, and international agreements require that water diverted from the Great Lakes be returned to the watershed of origin.

This research will analyze surface water, treated wastewater, and groundwater from the shallow aquifer: both the sand and gravel and the shallow dolomite aquifers. Using a network of sentinel wells, changes in groundwater chemistry will be tracked into the future. In addition to major ion chemistry, sentinel wells will be analyzed for emerging contaminants. Geochemical modeling will be performed using the chemistry of treated wastewater, three major southeastern Wisconsin rivers, and sentinel wells, along with historical geochemical data from the shallow aquifer system to determine what effects, if any, would result from recycling treated wastewater – either as artificial surface recharge or as input to the Great Lakes watershed for diversion mitigation.

**Graduate student presentation

Amery Regional Medical Center: Improving Human and Ecological Health in Northwest Wisconsin

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Low-impact development design and Wisconsin stormwater management requirements harmonize in the design and construction of the Amery Regional Medical Center, a 28-acre development adjacent to the Apple River, in Amery, Wisconsin. Construction is underway and will be completed in Fall 2007. The Amery Regional Medical Center includes numerous bioretention areas, also known as raingardens, distributed throughout the parking lot and planted with native vegetation as well as a trail system along the river to promote an ecologically enhancing environment while also encouraging human health and wellness.

An initial site plan included a traditional wet pond located on clayey soils. When EOR was brought into the project, soils and geology were used to redesign the parking layout and stormwater system with infiltration as the focus. Using soil boring data and infiltration rates consistent with WDNR NR-151 technical standards, the site was found to be highly suitable for bioretention as a method of stormwater control and water quality treatment. This facility, located on the site of a former farm field, was designed to include an effective treatment train to filter runoff from impervious surfaces, including the roof and parking lot areas. A series of vegetated buffers, small inner parking lot bioretention areas and larger site perimeter bioretention areas make up a distributed treatment approach. Key elements included the treatment train, site construction schedule, erosion control methods, and plant species to provide extensive water quality and quantity management and exceed both Polk County and the Wisconsin Department of Natural Resources (WDNR) NR-151 requirements. Minimal impact will occur on the existing landscape, the Apple River, and city storm sewer infrastructure since peak discharge rates and total runoff volumes in post-developed conditions will not exceed pre-development peak discharge rates and total runoff volumes for the 2-year and 100-year storm events. A 95% reduction in total suspended solids is estimated for post-developed conditions.

Site design techniques were also used in the parking and sidewalk design, trails, and landscaping plan to reduce tree loss, minimize impervious surfaces, avoid wetland impacts, and provide a synergy between the Amery Regional Medical Center building and the scenic setting along the Apple River. The goal of the facility is to serve the entire Amery community by providing an environmentally-conscious, healing surrounding for hospital residents, visitors, and employees.

SESSION 2A:
Groundwater and Aquifer Recharge
Thursday, March 1, 2007
4:10 – 5:30 p.m.

Use of Streamflow Data to Estimate Baseflow/Ground-Water Recharge for Wisconsin

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Average annual baseflow/recharge was determined for streamflow gaging stations throughout Wisconsin by baseflow separation. A map of the State was prepared that shows average annual baseflow for the period 1970-99 for watersheds at 118 gaging stations. Trend analysis was performed on 22 of the 118 streamflow-gaging stations that had long-term records, unregulated flow, and provided aerial coverage of the State. Trend The analysis found that a statistically significant increasing trend was occurring for watersheds where the primary land use was agriculture. Most gaging stations where the land cover was forest had no significant trend. A method to estimate average annual baseflow at ungaged sites was developed by multiple- regression analysis using basin characteristics. The equation with the lowest standard error of estimate, 9.5 percent, has drainage area, soil infiltration and baseflow factor as independent variables. To determine average annual baseflow for smaller watersheds, estimates were made at about 900 low-flow partial-record stations in Wisconsin. Estimates of average annual baseflow were also made about 3000 miscellaneous measurement sites using the multiple regression equation. The estimates for the gaging stations, low flow partial record stations and miscellaneous measurement station are shown on three separate statewide maps.

Regression equations were developed for each of the three of the twelve major river basins using basin characteristics. Drainage area, soil infiltration, basin storage and baseflow factor were the independent variables in the regression equations with the lowest standard error of estimate. The standard error of estimate ranged from 17 percent to 52 percent for the three river basins. Error analysis was made on the various methods to provide an indication of the accuracy of the three methods. The error analysis included using estimates from the three methods to estimate recharge for areas that had calibrated groundwater models.

Evaluation of Changes in Groundwater Recharge Under Future Climate Conditions

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Possible management of water resources in the future requires an accurate understanding of the response of groundwater recharge to future climate conditions. As global climate changes, people are concerned about the effects these changes will have on water supplies. To evaluate the effect of potential future climate scenarios on groundwater recharge, calibrated Precipitation Runoff Modeling System (PRMS) models of several watersheds in the southeast Wisconsin area are manipulated to simulate the hydrological effects of a number of possible future climate scenarios. Several temperature and precipitation combinations are simulated to address the range of climate projections suggested from different computational methods. The change in total monthly recharge, evapotranspiration (ET), and runoff between a given climate scenario and the calibrated base condition is evaluated on a total basin as well as an individual hydrologic response unit (HRU) basis for each watershed.

The response of recharge, ET, and runoff to changes in precipitation and temperature is shown to be temporally dependent, as the activation and extent of ET and infiltration within PRMS is determined by temperature and water availability. The sensitivity of recharge, ET, and runoff to changes in temperature and precipitation is also shown to be dependent on topographic, hydrogeologic, and land use characteristics of the HRUs that make up each basin. Comparison of the hydrologic response to climate change between individual HRUs can allow for relationships to be established between groundwater recharge and basin topographic, hydrogeologic, and land use characteristics.PRMS can only be calibrated in gaged watersheds, however, the relationships established will allow the prediction of changes in groundwater recharge due to climate variation in ungaged basins.

**Graduate student presentation

Investigating Recharge to the Cambrian-Ordovician Aquifer through Fine-Grained Glacial Deposits in East-Central Wisconsin

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Cambrian-Ordovician sandstone and dolomite formations make up the primary aquifers in east-central Wisconsin, and are frequently confined by overlying dolomite of the Sinnipee Group and the Maquoketa shale. These important aquifers may also be confined by another, more shallow, aquitard—fine-grained glacial sediment originating from a proglacial lake that existed during the most recent glaciation. Regions previously thought to be potential areas of recharge to the deeper aquifers are covered by thick sequences of this low-permeability sediment that limits vertical flow. A total of eighteen boreholes have been drilled to better characterize the extent and thickness of the Pleistocene-age deposits, and samples have been taken from seven of these boreholes to collect sediment pore-water for stable isotope analyses. Multi-level well systems have been installed across the aquitard in two deep boreholes to measure head distributions and to collect water samples for stable isotopes and major ions. Preliminary results of oxygen-isotope analyses from sediment pore-water where the aquitard is 275 feet thick show a bow-shaped curve typical of modern oxygen isotope values (-9 $\delta^{18}O$) diffusing downward from the surface and upward from a lower aquifer into the clay aquitard, with a decrease in oxygen isotope values (-15 $\delta^{18}O$) toward the middle of the sequence. This curve is typical of chemical diffusion with limited advection. In areas where the aquitard is thinner, results show predominantly modern oxygen isotope values across the aquitard's thickness. This suggests that recharge to the bedrock aquifer is limited where the sediment is thicker. Water may move through the aquitard where it is thinner or contains more conductive sediment. Recharge to the bedrock aquifers may simply be a function of the conductivity and thickness of the Pleistocene deposits present in this region.

**Graduate student presentation

Enhanced Groundwater Flow between Perched and Regional Aquifers through Cross-Connecting Wells and Effects on Groundwater Quality

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Common well construction techniques enhance groundwater flow between perched and regionally extensive aquifers that are separated by an aquitard. At a study site in southwestern Wisconsin, an aquifer in dolomite of the Galena Formation is perched above a regionally extensive aquifer in the St. Peter Sandstone. They are separated by an aquitard composed of the Decorah Shale and dolomite of the Platteville Formation. Unsaturated conditions exist in the upper 100 feet of the St. Peter Sandstone. Hydraulic conductivity (K), estimated from specific capacity tests, is 2.0 ft/day for the dolomite aquifer and 1.4 ft/day for the sandstone aquifer. Permeability tests on core samples from the aquitard yielded estimates of K eight orders of magnitude lower. The vertical hydraulic gradient within the aquitard is greater than one.

A test well was completed in the sandstone aquifer to specifications similar to those of residential wells in the area; specifically, it was not cased into or through the aquitard. Consequently, the well facilitated enhanced interaquifer flow from the perched aquifer to the regional aquifer; flow through the well was measured at 0.5 gpm. Results from a numerical model of groundwater flow and contaminant transport illustrate the potential for cross-connecting wells to enhance transport of contaminated water from the perched aquifer to the uncontaminated regional aquifer.

**Graduate student presentation

SESSION 2B:
Advances in Water Monitoring and Remediation
Thursday, March 1, 2007
4:10 – 5:30 p.m.

Optical Sensing of Dissolved Oxygen and Temperature in Aqueous Environments

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Dissolved oxygen (DO) is essential for the health of many organisms in aquatic environments. Thus, spatially resolved, real-time remote measurement of the DO-concentration (and of parameters such as temperature and pH) is of great interest for monitoring the dynamics of an aquatic system and may also give clues to sources of pollution.

We developed a novel optical-fiber oxygen/temperature sensor using the effect of metal-enhanced fluorescence to improve signal intensities. Oxygen-sensing is based on the fluorescence quenching of dichlorotris (1,10-phenanthroline) ruthenium(II). To employ metal-enhancement effects, a thin silver film was deposited by vacuum evaporation onto optical fiber cores. Subsequently, SiO_2 was deposited as an optically transparent spacer layer between the metal and the fluorosensor and to protect the metal film as well as the optical fiber from degradation. A photo-polymerized hydrogel matrix containing the fluorosensor was covalently attached to the spacer layer. Other sensor regions contained the luminophore Kiton Red – encapsulated in polyacrylonitrile nanospheres – for temperature-measurement and the dye Rhodamine 110 as intensity reference

This optical fiber sensor array was tested in a flow chamber where both oxygen and nitrogen were pumped into the chamber at different partial pressures. Excitation with Nd:YAG laser pulses (532.1 nm) allowed for spatially resolved readout, with the fluorescence emitted by the sensor molecules captured by a second fiber at right angle to the fiber carrying the excitation light. We will present results on the sensor performance including temperature and intensity referencing.

**Graduate student presentation

Using Dissolved Gases to Explore Biogeochemical Relationships of a Small Baseflow Dominated Central Wisconsin Stream

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Traditional water quality studies focus primarily on dissolved solids. However, much less attention is generally given to the many dissolved gases present in surface and ground waters. Together, dissolved gases and solids can enhance our understanding of the biogeochemical processes affecting stream water quality. In this study, we investigated the Little Plover River- a baseflow dominated stream in a predominantly agricultural sand plain watershed. We measured a suite of dissolved gases (oxygen, carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, and noble gases) in conjunction with major and minor ions. Measurements were obtained at from 350 meter intervals along the thalweg of a meandering 8 km stretch of stream into headwater tributaries.

Many dissolved solids act fairly conservatively in streams. However, dissolved gases do not act conservatively for several reasons (e.g., evasive losses to the general atmosphere, atmospheric inputs, and temperature changes). We exploited these behavioral differences to draw inferences about the biogeochemical connection of the stream with the landscape. Losing sections of stream had dissolved gas concentrations near atmospheric equilibrium (CFCs, nitrous oxide, and methane). Gaining sections had dissolved gas concentrations both supersaturated (nitrous oxide, methane, and carbon dioxide) and undersaturated (CFCs and oxygen) with respect to atmospheric equilibrium. Entrance of nitrate into the stream was accompanied by high concentrations of nitrous oxide. We will describe these findings and present a further analysis of the biogeochemical footprints and movement of dissolved gases as they relate to the stream's water chemistry and its physical connection to the landscape.

*Undergraduate student presentation

A Simple, Buoy Deployable Instrument for Accurate Dissolved Carbon Dioxide and Total Inorganic Carbon Measurements in Freshwater and Marine Ecosystems

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Knowledge of the patterns and behavior of P_{CO2} are fundamentally important in freshwater (groundwater, streams, rivers, lakes, wetlands) and seawater ecosystems. In freshwater systems, for example, the efflux of CO_2 is now thought to constitute a significant component of the carbon balance in tropical and boreal forest systems. In ocean systems, there is mounting evidence that atmospheric CO_2 driven acidification is affecting fundamental biological and geochemical processes (e.g., calcification and carbonate dissolution rates associated with coral reefs and other marine calcifiers). Despite its biogeochemical importance, carbon dioxide is infrequently measured by direct methods in environmental studies due to relatively challenging logistical constraints.

In this presentation we will introduce a new infrared based instrument for discrete or datalogged measurements of both CO_2 and TIC in natural waters. We will illustrate some recent data from several lakes and streams in Wisconsin. The device requires little maintenance and upkeep and can be operated with minimal training. We will discuss the suitability for the instrument for remote unattended deployments (e.g., buoys and vessels).

Improving Recreational Navigation in Fond du Lac, Wisconsin through Hydraulic Dredging and Sediment Dewatering Using Geotextile Tubes

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Lake Winnebago and the Fond du Lac River are at the downstream reaches of large watersheds that have a mostly agricultural land use. Over many years of erosion and sediment transport, access to Lake Winnebago has decreased for recreational boaters because sediment has deposited in portions of the Fond du Lac River and Lighthouse Harbor restricting safe navigation in these areas.

The City of Fond du Lac has recently completed hydraulic dredging in Lighthouse Harbor and in the Fond du Lac River to improve recreational boating safety and access to Lake Winnebago. Dredging was also completed to prepare for a new boat dock currently under construction within the Harbor.

The dredging was completed with a hydraulic dredge and pipeline to convey the dredged sediments to a dewatering pad where the dredged sediments were dewatered using geotextile tubes. The dredged sediments where mixed with a polymer to enhance the filtering efficiency of the geotextile tubes. The sediments were allowed to dewater and the City will beneficially reuse the sediments instead of disposing of the sediments in a landfill.

A grant was received from the Wisconsin Waterways Commission to assist the City with a cost-share program totaling approximately $564,000. The dredging volume totaled approximately 15,000 cubic yards and included 50 foot channel widths dredged 6 feet below the navigational low water datum.

This presentation will discuss the design, permitting, dredging, and dewatering activities that were completed during this project. The presentation will also present lessons learned and additional information helpful for similar projects or sediment management applications.

POSTER SESSION
Thursday, March 1, 2007
5:30 – 7:00 p.m.

Implementing Methods to Assess the Spatial Extent and Density of *Schoenoplectus Acutus* for Future Management in Clark Lake, Door County, WI

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Large beds of bulrush (*Schoenoplectus acutus*) are absent or receding in Clark Lake, Door County WI. This phenomenon is occurring in a number of Wisconsin lakes and is of concern because of potential impacts to the fishery and shifts in the aquatic ecosystem. This study assessed the prevalence of bulrush in Clark Lake both quantitatively and qualitatively. Objectives of this study included the investigation of bulrush density and its relationship to anthropogenic uses of the lake and shoreline, providing a framework for long-term monitoring of the health and remediation of bulrush by Lake Association volunteers. Implications of the lake's impoundment on the health of bulrush and possible impacts on the lake's ecology were also investigated. Methodology was established in September, 2006 to collect baseline data of bulrush densities for use in evaluating long-term changes in bulrush beds. The entire lake's bulrush was GPS mapped and compared to historical observations in addition to providing a framework for quantitative comparison in the future.

*Undergraduate student presentation

Geochemical and Flow Characteristics of Two Contact Springs in Iowa County, WI

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Two contact springs in Iowa County, Highland Big Spring and Otter Creek Big Spring, were monitored from January 2006 to January 2007 to better understand groundwater flow paths to the springs. The springs are representative of those in Iowa County and the entire Driftless Area in that they occur near major stratigraphic contacts. Highland Big Spring discharges near the contact of the Prairie du Chien Group with the St. Peter Formation. Otter Creek Big Spring discharges near the contact of the Jordan Formation with the Prairie du Chien Group.

Discharge was measured monthly using a current meter or a cutthroat flume, and geochemical sampling occurred on a bi-monthly basis. Alkalinity, conductivity, temperature, dissolved oxygen and pH were measured in the field using a multiparameter sonde, and grab samples were analyzed for major ion concentrations and stable isotopes of oxygen and hydrogen. The average monthly discharge is 0.9 cfs at Highland Big Spring and 0.3 cfs at Otter Creek Big Spring. Flow is more variable at the Highland Big Spring. Major ion concentrations are similar, but calcium and magnesium concentrations are slightly higher at the Highland Big Spring. The differences in flow variability and geochemistry may be due to a more direct groundwater flow path to the Highland Big Spring.

*Undergraduate student presentation

Hydrogeologic Characterization of the Catherine Wolter Nature Conservancy site, Vilas County, Wisconsin

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The Catherine Wolter Wilderness Area encompasses 2,189 acres of primary-growth forest with 15 wild lakes and ponds. The site is part of the larger Border Lakes area of Vilas County, Wisconsin. The land has experienced minimal human impact over the last 60 years, both under private and Nature Conservancy ownership. The purpose of this study is to characterize the site's hydrogeology and groundwater flow, including both groundwater leaving the site and recharge. The work was completed as part of a hydrogeology class project in October 2006.

The site contains a network of 32 shallow piezometers and sandpoints, installed over the past several years. Primary methods utilized for flow characterization included: water level mapping, slug testing, major-ion chemical analyses, historical and yearly water level data, and electrical resistivity. The groundwater system consists of silty glacial tills and sandy, gravely outwash overlying crystalline bedrock, which functions as a no flow boundary. Using field data, depth to bedrock and aquifer thickness were calculated, and Darcian Flow calculations performed. All groundwater originates on-site as precipitation, and exits the site as stream baseflow and groundwater throughflow. Total groundwater flow leaving the site was calculated as 2.81×10^{-4} m^3/sec. Total stream flow leaving the site was calculated as 3.36×10^{-3} m^3/sec. Total discharge from the site was calculated as 3.64×10^{-3} m^3/sec. The range of minimum precipitation required to support this recharge rate is 6.37 cm/yr to 22.3 cm/yr, assuming a porosity range of 10% to 35%.

Previous investigators found a groundwater anomaly located close to the middle of the site near Bug Lake. Soil boring cross-sections on the site suggest the

presence of a sub-terranean glacial outwash channel trending east to west across the site, which functions as a groundwater conduit. This interpretation is further substantiated by water table configuration data and water sample chemical analysis. Data supports the interpretation of a flow system including recharge near Bug Lake, flow through at Knife Lake, and discharge west of the site.

**Graduate student presentation

Filter Strip Attenuation of Feedlot Runoff Contaminants

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Feedlots are a common component of Midwestern animal agriculture, providing an economical option for the feeding and raising of livestock. However, feedlot runoff, if not properly treated, can contribute to environmental pollution. Filter strips are designed to treat runoff by reducing concentrations of nutrients and sediment, mitigating potential environmental impacts. The goal of this study is to determine the ability of a filterstrip to attenuate pollutants.

Research was conducted in southwest Wisconsin at the University of Wisconsin-Platteville's Pioneer Farm. The filter strip was constructed in the 1970's according to Natural Resource Conservation standards and treats effluent from a feedlot containing dairy young stock.

Filter strip treatment performance was determined by comparing water samples entering and exiting the filter strip. Water samples were collected and water volume determined using United States Geological Survey gauging stations. Samples were analyzed for the following: total solids, suspended solids, nitrate-N, ammonium-N, total-N, organic-N, dissolved reactive phosphorus, and total phosphorus. Treatment performance was based on percent removal for each of the above constituents.

Leveraging Existing Data and Models for Developing a Basin-Scale Ground-Water Flow Model of the Rock River Basin, Southeast Wisconsin

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Communities in the Rock River Basin, particularly those with municipal water supply systems, make decisions that affect their ground-water resources every day. To assist with resource management an analytic element ground-water-flow model of the 3,800-square-mile Rock River Basin is being developed by the U.S. Geological Survey in cooperation with The Rock River Coalition and many of the communities within the basin. The initial development of this model leverages existing data and ground-water flow models in Dane County, Rock County, and the South East Wisconsin Regional Planning Commission region. These existing models are of different types (analytic element and finite difference), vintage, and scales, and were constructed with various different objectives. However, through a step-wise approach, in which previous simulation results are used to guide contemporary model design and data collection, the information supporting these existing models is incorporated to develop a unified hydrogeologic framework for the Rock River Basin. The basin-scale model will provide water suppliers and users with an important tool to understand the regional flow of ground water in the basin, its interaction with rivers, lakes, and wetlands, and its sensitivity to historical and future land-use. In addition, the hydrogeologic framework developed through this step-wise approach will provide a foundation for future simulations of detailed local-scale ground-water issues in the Rock River Basin

Determination of Nitrate Retention Capacity in a Wisconsin Sand Plains Stream

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Nitrogen is an essential element for all forms of life, but excess amounts of nitrogen can cause several water-quality problems in aquatic ecosystems. The amount of nitrogen that enters streams is largely a function of the type of land-use in their watersheds. Increasing evidence suggests that in-stream processes, such as denitrification, can also influence the concentrations and flux of nitrogen in these systems. We used a mass balance approach to assess the nitrogen-retention capacity of Emmons Creek in the Wisconsin Central Sand Plains. Water samples were collected from surface water and from seven riparian wells along a 700-m stream reach three times per week for one month in summer 2006. Nitrate and chloride concentrations were determined using ion chromatography. Preliminary results suggest that net nitrate uptake in the reach is negligible. Emmons Creek surface water has consistently high nitrate concentrations (2 to 2.5 mg NO_3-N/L) while groundwater is more variable (0.1 to 4.0 mg NO_3-N/L). Nitrate concentrations in the groundwater gradually increased for most of the wells during the course of the study. Very low nitrate concentration in one of the wells suggests the presence of a local hotspot for denitrification or other nitrate removal process. Regardless, such large nitrate inputs by the groundwater may be overwhelming the system's ability to retain nitrate.

*Undergraduate student presentation

West Campus Cogeneration Facility Compensatory Recharge System: Initial Operation Results

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A compensatory groundwater recharge system to mitigate water use by the Madison Gas & Electric / University of Wisconsin West Campus Cogeneration Facility has been constructed at the Odana Hills Golf Course and began operation in May 2006. The recharge rate required by the Water Loss Approval is currently 34.4 MGY and will increase to 80.4 MGY as plant capacity expands. The design is based on computer models, field investigation and laboratory testing conducted in 2004 and 2005. Water is withdrawn from Odana pond, which receives substantial stormwater inflows that ultimately drain to Lake Wingra. The pond water is treated by microfiltration and pumped to subsurface infiltration beds in the Horicon till. From June through October 2006, approximately 17 million gallons of water (68 gpm average) have been infiltrated. The observed infiltration rate is similar to the predicted rate of 1 ft/d. Groundwater levels and quality have been monitored since 2004, as required by a Wisconsin Pollutant Discharge Elimination System permit. The observed water table mound is somewhat higher than predicted by computer modeling, however the depth to the water table is greater than twenty feet. Background water quality monitoring before the system began operation, as well as ongoing monitoring at wells below the infiltration bed, upgradient and downgradient will be used to assess groundwater quality impacts. Benefits of this system include reduced stormwater discharge to Lake Wingra and an expected increase in groundwater supply to the lake.

A Geologic and Geophyisical Investigation of Liquid Manure Transport through the Vadose Zone

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Concerns about the impact of liquid manure on groundwater and surface water have led regulators and the agricultural community to search for methods to safely apply the manure without endangering natural resources. To protect groundwater, it is necessary to understand how liquid manure might be transmitted to the water table through the vadose zone. A geologic and geophysical study of one site in Dodge County impacted by liquid manure showed that the manure flowed downward more than 18 feet through worm burrows and fractures in the glacial deposits and then moved laterally through fractured dolomite to a private domestic well.

We conducted a geophysical survey using an EM-31 electromagnetic profiler to determine the subsurface resistivities. These resistivities were then used to determine the relative depths to bedrock along two parallel transects. On the basis of the geophysical data, we selected two locations for backhoe excavation. One of the locations was on the edge of where the liquid manure ponded during spring melt where bedrock was shallow; the other location was in the center of the liquid manure ponding where the depth to bedrock was deep. The results of the excavations showed no transport of the liquid manure where the bedrock was shallow, but where depth to bedrock was deep (approximately 18 feet) we noticed a definite manure odor. On the basis of this simple study, depth to bedrock is not always sufficient to predict aquifer susceptibility.

Optical Fiber Sensors with Microsphere-Templated, Porous Fiber Claddings for Remote Measurement in Aqueous Environments

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

The sensor density may be increased significantly by adding a second fiber that forms orthogonal fiber-fiber junctions with the first fiber at the sensor regions. The second fiber provides an optical delay, which results in the desired increase in spatial resolution. Small displacements between the fibers, however, can result in large signal changes due to the exponential decay of evanescent fields away from the fiber core/cladding interface. In aqueous environments, the hydrogel resins used in the past as sensor active claddings frequently produced weak and inconsistent results, as the swelling of the resin may change the fiber-fiber spacing.

We used microsphere templating to create pores and channels in non-swelling, hydrophobic polymers that allow analyte passage to the evanescent field regions close to the fiber core. This yields rigid fiber-fiber junctions with significantly enhanced signal repeatability and reproducibility as well as sensor longevity.

**Graduate student presentation

The Impact of Intensive Grazing Land Management on Groundwater Phosphorus

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In areas of high inputs of livestock excrement, phosphorus levels in the soil may exceed those that are strongly adsorbed by soil. This may increase the possibility of phosphorus leaching to groundwater. Groundwater with elevated phosphorus levels are a concern because it could affect water quality after groundwater discharge to lakes and streams.

Our focus is to examine groundwater nutrient levels, concentrating on phosphorus, in management intensive grazing paddocks in an over-wintering location on a farm near Rio, WI. Relatively high concentrations of phosphorus in the soil have been measured in the soil at this site. Goals of this study include identification of correlations between phosphorus and other water quality parameter levels, and changes in spatial and temporal concentrations of nutrients in groundwater. By accomplishing this we hope to gain a better understanding of phosphorus in groundwater in a management intensive grazing setting.

*Undergraduate student presentation

Ground-Water Contamination Susceptibility in the St. Croix River Basin, Wisconsin and Minnesota

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Understanding the susceptibility of ground water to potential contamination is important for managing water resources in the Saint Croix River Basin. In 2005, the U.S. Geological Survey, in cooperation with the National Park Service, developed an analytic-element ground-water screening model (GFLOW) and databases containing hydrogeologic information (for example, well locations with water level and geologic contact altitudes) for the Saint Croix River Basin (Feinstein et al., 2005). Recently, the databases and other state and regional maps were integrated to produce a map of ground-water contamination susceptibility in the St. Croix River Basin. The map is an improvement over similar state-wide maps of Minnesota and Wisconsin in that a single method (Schmidt, 1987) was applied across state boundaries, and local well data from the existing databases were used to construct input maps characterizing the depth to water and depth to bedrock. The result is a map showing relative susceptibility of ground water to possible contamination due to human activities at the land surface. The original GFLOW model was refined for five tributary basins (Kettle, Snake, Sunrise, Apple, and Kinnickinnic River Basins) to evaluate the pathways of potential contaminants that may reach the water table. Maps of simulated results show areas having relatively long or relatively short residence times (compared to the median residence time in each tributary basin). In addition, the GFLOW model was used to identify locations where potential contaminants flowing through a river could move into the ground-water system. Simulated river reaches where surface water (and potential contaminants) moves into the ground-water system are of limited extent and typically occur near areas with steep hydraulic gradients, such as near dams and waterfalls. The results of this work will be of use to resource managers who are charged with protecting water resources in the Saint Croix National Scenic Riverway.

References:

Feinstein, D.T., Buchwald C.A., Dunning C.P., and Hunt R.J., 2005, Development and Application of a Screening Model for Simulating Regional Ground-Water Flow in the St. Croix River Basin, Minnesota and Wisconsin, U.S. Geological Survey Scientific Investigations Report 2005-5283, 41 p.

Schmidt, R.R., 1987, Wisconsin's Groundwater Management Plan, Report no. 5, Groundwater Contamination Susceptibility Map and Evaluation, Wisconsin Department of Natural Resources, 27 p.

Developing an Inventory of Wisconsin Springs

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Wisconsin's groundwater quantity law, WI Act 310, allows the Wisconsin Department of Natural Resources to deny a high capacity well permit if the proposed well "may have a significant environmental impact on a spring." The legislation defines a spring as an area of concentrated discharge occurring at the surface of the land that results in a flow of at least one cubic foot per second 80% of the time. The number of and distribution of springs was unknown at the time of the drafting of Act 310. Because of this lack of knowledge, policy makers were not in the position to make more informed policy decisions for the protection of springs in Wisconsin.

The Wisconsin Wildlife Federation funded a study to compile data on springs in Wisconsin. This project involved the creation of the most up-to-date list of springs in the state, including their location and known physical characteristics, using data from a variety of federal, state, and local surveys and databases. Springs protected by the groundwater quantity law and those afforded no protection were identified using an ArcGIS coverage developed from the list. Discharge measurements were taken and on-site samples were analyzed for dissolved oxygen, total dissolved solids, alkalinity, pH, electrical conductivity, and temperature. Flora and fauna found in the spring area were noted. The ArcGIS coverage was updated with the new data.

This project will provide necessary information to the Groundwater Advisory Committee to assist with developing potential recommendations to the Legislature to create additional protection for Wisconsin's springs and in turn the ecosystems that benefit from springs. The project will also provide a beneficial tool for the WDNR, local planning officials, and other researchers studying springs and spring complexes.

Nitrogen Export and Speciation from Edge-of-Field Runoff from Agricultural Fields in Southwest Wisconsin

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Non-point source pollution of surface water with sediment, nutrients, and other agrichemicals is a growing public and regulatory concern. Pollutants exported from agricultural fields are often estimated using computer models and simulated runoff experiments, rather than with actual field measurements. Pioneer Farm, a 430-acre mixed-livestock farm associated with the University of Wisconsin-Platteville is intensively instrumented with USGS flumes and automated samplers to sample runoff at intervals throughout individual storm events. This presentation will describe the annual nitrogen export and speciation from 2004 and 2005 and relate the results to land use.

Mapping Recharge Areas to Groundwater Dependent Resources

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Understanding the complexity of mapping groundwater recharge areas is critical to managing groundwater dependent resources in an effective manner. Groundwater dependent resources are defined as a natural or water resources that are dependent on groundwater to sustain the hydrology, chemistry, temperature, and ecosystem. Examples include cold water trout streams, rich fens, and hardwood seepage swamps.

Mapping of recharge areas to groundwater dependent resources can vary from very complex using surface and groundwater linked flow models to a more simple approach using available datasets. The methods used to determine recharge areas are dependent on local and regional geology and hydrogeology and the availability of data.

This poster will present an example of mapping recharge areas based on field data collection in the Vermillion River Watershed. The Vermillion River is a designated trout stream in the Twin Cities Metropolitan Area, Minnesota, which maintains a trophy brown trout population.

Recharge areas were mapped based on groundwater contours that were generated using kriging interpolation in a geographic information system. Data points used to generate the contours were obtained from existing well logs and groundwater elevation data collected in the field. Vertical gradients were calculated from these contours to identify which aquifers were contributing groundwater to the River. Recharge areas were delineated by hand for each aquifer supplying groundwater to the River. This method of recharge areas mapping is useful in identifying critical areas for protection in the watershed.

Groundwater Monitoring at Argonne National Laboratory

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Currently at Argonne National Laboratory (ANL), there are over 80 groundwater monitoring wells located in several areas on the site that are sampled for organics, metals and radioactivity. The groundwater at these areas is monitored using traditional methods for sample collection such as bailers, electric submersible pump, and innovative technology such as low-flow sampling.

Areas are currently monitored following approved permits that include: landfills, waste storage and former operations areas. These areas were in operation from the late 1950's to the 1990's. The landfills have ceased operation, and all monitored areas are in post-closure. In addition to quarterly groundwater monitoring, soil gas sampling, leachate sampling and landfill cap inspections are conducted following each areas specific permit.

Permit time frames for the different areas range from 5 year review to 20 year monitoring cycle. Since post closure at the areas was initiated, reviews of analytical data have instituted changes such as additional monitoring wells and decreased analytical requirements. Permits have established dates for data review to further complete corrective action.

Longterm monitoring is a proactive approach to ensuring the protection of our groundwater resource. By following the established permit monitoring, and providing updates for data review, we can ensure the current groundwater monitoring program will provide the necessary information for Argonne and surrounding communities.

Bringing Meaning to Well Water Test Results: A Standard Laboratory Result Versus a Visual Display Result

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People have difficulty understanding and accurately recalling results from well water laboratory tests. Two color-coded visual displays of the test result, with and without shaded gradients to illustrate dose/risk, were developed based on evidence from risk communication research. I explored how these displays influenced beliefs compared to a standard laboratory result via a 3 x 2 randomized control trial (3 test result formats and 2 water test values). A survey measuring beliefs, affect, and intentions to drink their water was administered with the test result and a week later to two different samples. First, the study was conducted among 350 undergraduates; 261 participated. Unexpected format x gender effects prompted a mailed survey replication among 599 private well owners; 362 participated. Principal components analysis resulted in three factors among students and two factors among well owners. For both samples, the three-way ANOVA (format, test value, gender) showed format was related to the factor composed of water problem beliefs, affect, and intentions to stop drinking their water. Among well owners, both visual displays were related to stronger beliefs and were rated as easier to understand than the standard result. The non-graded color display was related to more appropriate safety beliefs than the graded display among participants with high test result values. Format was not related to within-subjects changes in beliefs over time. Applied risk communication research should be conducted among the target population. Visual displays appear to be more effective for communicating well water test results than the standard laboratory result. Further research should be conducted among people who are getting actual well test results to confirm these findings.

Plant Beds in Streams: A Biodiversity Hot Spot?

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There is a growing understanding of the role that plant beds in lotic systems play in nutrient processing and sediment dynamics. Much of our knowledge from macrophyte-invertebrate interactions comes from lentic environments or from large rivers. The importance of aquatic macrophytes to diversity and productivity of macroinvertebrate communities in small streams is largely unknown. We assessed the role of macrophyte beds in shaping invertebrate communities across seasons by measuring the diversity, density, and biomass of macroinvertebrates in plant beds and sand/gravel habitats in a Wisconsin Sand Plain stream. Macrophyte beds were sampled from March to November of 2006 in the West Brach of the White River in Waushara County, WI. We hypothesize that biodiversity, density and biomass of aquatic invertebrates will be greater in plant beds than in sand/gravel habitats. Preliminary results show that plant beds have a 1.5x higher average biodiversity (1.25 to 0.83 Shannon-Weiner index); over 4x higher average invertebrate density (5175 to 1179 individuals/m^2) and a 3.5x higher average invertebrate biomass (2246 to 629 mg dry mass/m^2). These findings suggest that even though macrophytes make up a smaller percentage of a streams habitat than sand/gravel they may hold an equal or larger percentage of macroinvertebrate abundance and biomass compared to inorganic substrates.

**Graduate student presentation

Delineating Seasonal Wetlands at Chiwaukee Prairie, Pleasant Prairie, Wisconsin

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This study characterized two seasonal coastal wetland types (low prairie and sedge meadow) in the Lake Michigan Basin over three growing seasons (2003, 2004, 2005). The six seasonal wetlands are dominated by hydrophytic vegetation based upon percent cover values, subtended by hydric soils, and each site exhibits a positive FAC-neutral test, a secondary hydrology indicator. Water levels from pressure transducers in six water-table wells and hand measurements in three piezometers record large magnitude short-term fluctuations that indicate these wetland sites respond rapidly to precipitation.

These seasonal wetlands typically are dry for most of the growing season. But even during years with low annual precipitation, they may meet the wetland hydrology criterion of soil saturation for 5% of the growing season. Low (wet) prairie communities had shorter periods of continuous soil saturation than sedge meadow communities. Thus, during droughts that extend multiple years or times of extended lake level lows, these systems might be the first type of community to not exhibit wetland hydrology. Data used in the root zone duration calculations for the ground-water dominated wetland of Hunt et al. (1999) fit a lognormal distribution. The data from the more precipitation dominated wetlands of this study did not fit a lognormal distribution. The 7- and 10-day high water level average of Henszey (2004) was evaluated as a discriminator for these vegetation communities. This approach may be superior to the root zone duration because it is more straight-forward and easier to calculate.

Particle Size, Mobility and Phosphorus Content of Stream Deposits in an Agriculturally Dominated Watershed.

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Export of soil and nutrients from agricultural land uses to surface waters is a primary nonpoint source pollution concern. Many approaches exist to estimate soil and phosphorus (P) loss from agricultural fields, and delivery to streams. However, the fate and transport of P within streams is less understood. This is particularly significant when attempting to manage watershed activities to meet water quality goals for downstream lakes. The residence time of sediment and P in streams can influence biogeochemical transformations that affect the ultimate bioavailability of P delivered to lakes. However, residence times for sediment are very difficult to estimate due to the dynamic nature of streams (deposition and resuspension) and hydrologic variability. Spatial variability in surficial sediment characteristics such as particle size and organic content can be expected, depending on stream reach type (i.e., pool, riffle, etc.), and has been well documented. However, vertical variability in sediment characteristics is less widely studied. To address these vertical variability issues in a stream network context, sediment cores were analyzed for particle size, water and organic content, and P from more than thirty stream sites in the Lake Mendota watershed, north of Madison, Wisconsin. At several sites, a thin surficial layer of fine P-rich particles was present overlying coarser sediment. The implications of these findings will be discussed in context of the sediment and P loadings to the downstream Lake Mendota.

*Undergraduate student presentation

Use of Petroleum Exploration Techniques in Ground Water Exploration

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There is increasing awareness of the importance of utilizing techniques from other geological fields to better characterize our valuable ground water resources. For example, many of the methods used by the petroleum industry for exploration and development of oil and gas fields have now become economically feasible for locating and extracting ground water resources. These synergistic applications make sense as both water and petroleum are produced from the subsurface, commonly occur together, and obey the same laws of fluid dynamics as they move from one location to another.

A good example of this dual application occurs in studies of the Mission Canyon Formation (Madison Group, Mississippian) of the Northern Rocky Mountain region. This formation is not only a significant petroleum reservoir rock, but also an aquifer and source of limestone. In addition, gold deposits are found in the karstic horizons in the mountains of central Montana. Early use of geophysical logs identified prominent evaporite solution-collapse breccias and several papers, including some published in the AAPG Bulletin, examined the petroleum reservoirs in this formation. The diagenetic evolution of carbonate rocks was a major key to identifying zones of significant porosity and permeability. While these studies were initially designed to describe and characterize the formation for its suitability to act as a petroleum reservoir, these same techniques could be used to better define ground water aquifers. Studies about this topic have been available for decades in sedimentary geology publications.

An important source of this research is the American Association of Petroleum Geologists (AAPG). The AAPG began as an organization of petroleum geologists in North America and has expanded to include divisions for Energy, Minerals, and Environmental Geoscientists. Its programs include publications, distinguished lecturers, and continuing education. The continuing education program offers outstanding short and on-line courses in many topics related to geology not just petroleum; these are taught by well known scientists in their disciplines and are available to anyone interested, not just oil company employees. Additional educational opportunities include field seminars, research conferences and education conferences. Publications include the AAPG Bulletin, AAPG Explorer and Environmental Geosciences Bulletin as well as special publications about many technical topics.

In the case of resource extraction, whether it is petroleum or water, researchers should not limit themselves solely to studies in their respective fields. A truly effective research approach should incorporate information from a broad range of specialties.

Mapping and Characterization of Springs in Brown and Calumet Counties, Wisconsin

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2003 Wisconsin Act 310 states that high capacity wells permitted by the Wisconsin Department of Natural Resources (WDNR) must now take into account proximity of natural springs. The permitting process determines whether high capacity wells will impact groundwater or other important water resources and specifies that high capacity wells must not be placed within 1200 feet of natural springs with outflow greater than 1 CFS for more than 80% of the time. Currently, the WDNR does not have a centralized database of spring locations, and no comprehensive natural spring study exists for Brown and Calumet Counties, Wisconsin.

Reconnaissance work was performed in 2005 and the locations of 41 natural springs in Brown and Calumet Counties were determined. After assessing the sites, five were selected for further analysis based on discharge, location and ease of access. Discharge and other basic water quality parameters were measured on a biweekly basis. Spring discharge rates varied spatially and temporally, ranging from a trickle to over 3 CFS. None of the springs in the study area qualified for protection under Act 310. Using ArcGIS, a final map showing the locations of the springs was assembled.

Samples were collected six times during the course of the study to determine the concentrations of major cations and anions in the groundwater. Piper plots of geochemical data indicate that four of the sites studied have similar geochemistry (bicarbonate and Ca+Mg dominated) with the fifth site as an outlier ($Cl+SO_4$ and Ca+Mg dominated)

An apparent age-date for the groundwater was determined using Pumping-Induced Ebullition sampling of dissolved gasses. CFC ultra-trace gas samples collected at the Calumet County sites showed apparent age-dates in the early to mid-1980s, while samples taken at the Brown County sites had apparent age-dates ranging from 1966 to 1977.

**Graduate student presentation

SESSION 3A
Hydrogeologic Investigations
Friday, March 2, 2007
8:15 – 9:55 a.m.

A Fresh Look at a Regional Imbalance: Indices of Groundwater Budget Components to Denote Historical Change in Southeastern Wisconsin

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This proposed presentation would establish the use of groundwater budget indices as fundamental, viable visual aids in relaying groundwater use datum. Using the Southeast Wisconsin Regional Aquifer Model (Feinstein et.al 2002), numerical inflow and outflow data was used for the shallow and deep aquifer systems in southeastern Wisconsin to calculate four primary indices of groundwater use. Contoured datum of historical trends through time will be shown using the indices of Relative Net Demand (RND), Storage Change (SC), and Human Water Balance (HWB) for the shallow and deep aquifers in the five county region. In addition, an index of baseflow reduction (BRI) will be used to show the reduction of lake, wetland, and river levels relative to predevelopment conditions in the shallow aquifer. Focus will center on human effects of municipal pumping on the dual-aquifer system in the region. Several alternative ways of displaying indices will be shown to implicate usefulness and flexibility. Results will not only show the negative effects of pumping on the region, but also how water budget terms can be translated into simple indices that can be displayed in a contoured or graphical format. Contoured percentage maps of inflows and outflows in present day conditions (2000) will be used to illustrate the water imbalance in the region and how we can best plan development of domestic, industrial, and agricultural water use for the future. SEWRPC estimates of population increases and expansion of municipalities for the year 2035 will also be discussed, as research for the project will continue through 2008. This research was funded by the Southeastern Wisconsin Regional Planning Commission in collaboration with UW Milwaukee.

**Graduate student presentation

Simulating the Role of Domestic Wells in the Ground-water System of Southeastern Wisconsin

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In southeastern Wisconsin, over 700,000 people use ground water as their source of water supply. Of those, 52% obtain the water from municipal systems, while the remaining 48% use individual, domestic wells. Most of the domestic well users also have onsite wastewater treatment systems (mostly septic systems), and virtually all draw water from the shallow glacial and dolomite aquifers.

A regional ground-water flow model was developed by the US and Wisconsin Geological Surveys for the local planning agency. Designed to focus primarily on the heavily-utilized deep, sandstone aquifer, the model did not include domestic wells. With the identification of southeastern Wisconsin as a ground-water management area (GMA), the model is now being used to test water management options in both aquifers. Consequently, it has been retrofitted with the best approximation of pumping from domestic wells.

Over 120,000 such wells exist in the region, with limited records on their location and depth and no record of their pumping. Population distribution and estimates of net daily consumption of ground water (20 gal/day/capita (gpdc) for users with onsite wastewater treatment and 100 gpdc for those on sewer) have been used to generate composite domestic rates by section throughout the model's seven county nearfield. The model has been run with this added stress without recalibration.

The additional stress from domestic wells has no effect on the model's calibration within the deep aquifer. In the shallow system, it causes on overall reduction of heads and fluxes at targets, although the changes are deemed tolerable. Comparative runs of the model with and without domestic pumping allow examination of the relative effects of these wells on the overall ground-water budget. Some are striking.

Exclusion of domestic wells in the regional model has underrepresented the total human demand for ground water in the shallow aquifer by 35% on a regional basis. The underrepresentation ranges from 12% to 87% by individual county. Hence the relative net human demand for shallow aquifer water {(Net pumping - Net return)/Natural inflows} increases. This, in turn, causes the simulated ground-water discharge to surface water bodies (baseflow) to decrease 2.4% regionally (ranging from 1% to 6% reduction by county). Spatial distributions of these impacts show that the pumping from domestic wells must be included in regional planning.

Pleistocene Hydrology of the Deep Sandstone Aquifer in Southeast Wisconsin – revised edition

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The deep sandstone aquifer in southeast Wisconsin has been the subject of a rather large amount of study during the past decade by workers at UW-Milwaukee, the Wisconsin Geologic and Natural History Survey and the United States Geologic Survey. As a result, several independent lines of evidence now exist that can be used to deduce the groundwater age and the history of groundwater movement since the last glacial maximum. Information garnered from ground water flow modeling, major ion chemistry, stable isotopic data, noble gas data and ^{14}C dating will be used to develop a hydrologic history of the deep sandstone aquifer over the past 2 millenia and compare the hydrologic history to the glacial record over the same period of time.

Regularized Inversion of a Groundwater Flow Model of the Trout Lake Basin

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The Trout Lake basin model is a three-dimensional general purpose MODFLOW-based watershed model used to address a variety of research questions including flow path delineation, and climate and land use change. The flow system is dominated by groundwater flow that is well connected to the surface water system; thus, a good groundwater model is critically important in determining the movement of water and transport of solutes in the system. The latest versions of the model are quite sophisticated, allowing for dynamic interaction with 30 lakes and 5 streams. The model has been historically calibrated using a small number of parameter values; however, recent calibration using many more parameters has been employed to attempt to capture more of the spatial system heterogeneity. To constrain model calibration with a large number of parameters, a “regularized inversion” approach was used in this research. Regularization can take many forms and is a means of stabilizing large problems by using subjective information about the parameters based on the current hydrogeologic understanding of the system in addition to field measurements. In this paper, the results of using different regularization schemes including Tikhonov, truncation, and damping to calibrate the Trout Lake model are presented. Results show that using a preferred homogeneity Tikhonov scheme improved the model fit to field measurements.

**Graduate student presentation

Looking for a Silt Layer on the Crystal-Big Muskellunge Lake Isthmus

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Randy J. Hunt, U.S. Geological Survey, Wisconsin Water Science Center, 8505 Research Way, Middleton, WI 53562, rjhunt@usgs.gov

The isthmus between Big Muskellunge and Crystal Lakes at the Trout Lake Northern Temperate Lakes Research Station consists of sandy glacial sediments enveloping a thin layer of silt; a pattern typical of ice-block lake formation in continental glaciated terrain. Significant head drop across the silt indicates local hydrogeologic importance. Previous modeling efforts have combined head and isotope transport information to calibrate a groundwater model containing several homogeneous hydraulic conductivity zones specified a priori. In this effort, we use only the available head measurements to attempt to use the model to locate the silt lens using the same discretization and boundary conditions as the previous work. The novelty of our approach is, rather than enforcing the location of homogeneous zones a priori, we allow each model node to be a free and independent parameter. The number of model nodes greatly exceeds the number of head measurements producing a severely underdetermined problem thus regularization is necessary to obtain a meaningful solution. Regularization is accomplished through implementation of the Bayesian geostatistical inverse method. In this approach, an assigned variogram is assumed to adequately characterize the variability of the parameter field of interest. The variogram choice reflects general knowledge of the conductivity fields—e.g. enforcing smoothness. Field data guides selection of specific variables required by the variogram. The goal is to make an objective estimate of the hydraulic conductivity heterogeneity by considering observed data rather than relying solely on preconceived conceptual models.

SESSION 3B
Water Quality and Ecological Assessments
Friday, March 2, 2007
8:15 – 9:55 a.m.

Ecological Assessment and Restoration Planning for an Urbanized Kettle Pond, Tiedeman Pond, City of Middleton, Dane County

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In 2006, JFNew undertook the ecological assessment of a 22-acre kettle pond located in Middleton, Wisconsin. This study incorporated historic research, community input, literature review, existing data, and field research to identify the ecological impacts affecting the pond today: changes in surrounding land use, altered hydrology, increased stormwater, increased sedimentation, and colonization of exotic invasive species.

Analysis of these impacts lead to the development of restoration goals and outline of steps taken to improve the ecological health of Tiedeman Pond. These steps incorporate multiple approaches with participation by local government, contractors, and community volunteers. The Tiedeman Pond Ecological Assessment and its restoration recommendations provide an example of a community-based initiative to address ecological improvements on a local level.

Particle Size, Mobility and Phosphorus Content of Stream Deposits in an Agriculturally Dominated Watershed.

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Michael Penn, University of Wisconsin-Platteville, Civil and Environmental Engineering Department, Platteville, WI 53818
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Dave Armstrong, University of Wisconsin-Madison, Environmental Chemistry and Technology Program, Madison, WI 53706
Richard Lathrop, Wisconsin Department of Natural Resources, Madison, WI 53703

Export of soil and nutrients from agricultural land uses to surface waters is a primary nonpoint source pollution concern. Many approaches exist to estimate soil and phosphorus (P) loss from agricultural fields, and delivery to streams. However, the fate and transport of P within streams is less understood. This is particularly significant when attempting to manage watershed activities to meet water quality goals for downstream lakes. The residence time of sediment and P in streams can influence biogeochemical transformations that affect the ultimate bioavailability of P delivered to lakes. However, residence times for sediment are very difficult to estimate due to the dynamic nature of streams (deposition and resuspension) and hydrologic variability. Spatial variability in surficial sediment characteristics such as particle size and organic content can be expected, depending on stream reach type (i.e., pool, riffle, etc.), and has been well documented. However, vertical variability in sediment characteristics is less widely studied. To address these vertical variability issues in a stream network context, sediment cores were analyzed for particle size, water and organic content, and P from more than thirty stream sites in the Lake Mendota watershed, north of Madison, Wisconsin. At several sites, a thin surficial layer of fine P-rich particles was present overlying coarser sediment. The implications of these findings will be discussed in context of the sediment and P loadings to the downstream Lake Mendota.

*Undergraduate student presentation

Phosphorus Forms along a Flow Path and Application of an Area Weighted P-Index to Multi-field Watersheds

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In many settings, particulate phosphorus (PP) has been reported to be the dominant form of P in surface water runoff from agricultural systems. Past monitoring of rural streams in the Lower Fox River basin in Northeastern Wisconsin has shown mean concentrations of dissolved phosphorus representing from 40 to 75% of total P (TP) concentration. The effectiveness of improved management strategies that target PP is dependent on the form of P leaving source areas. Total dissolved phosphorus (TDP) losses may not be reduced with best management practices such as grassed water ways, filter strips, and conservation tillage. This study was conducted to better understand P forms leaving source areas and how the dissolved fraction changes along a flow path at different scales in the Apple Creek watershed, Outagamie County, Wisconsin.

Samples were collected near peak flow at 11 rural source area sites (0.25 to 2.5 km^2) and 4 integrator sites (12 to 85 km^2) during runoff events in 2004-06. A USGS continuous monitoring station also collected event samples on the main stem (117 km^2). For six runoff events in 2004-05, median TP was 0.51 mg/L from source area sites, 0.48 mg/L from integrator sites, and 0.72 mg/L from the main stem. Median TDP percentage was 39% from source areas, 40% from integrator sites, and 27% at the main stem. The median TDP percentage for the six events at each source area site, varied greatly (10% to 82%). The portion of TDP in a snowmelt and a low intensity event in 2006 were twice the median from earlier events.

Area weighted Wisconsin P-Index (SnapPlus) values for eastern red soils were compared to P concentrations from event monitoring at source area watersheds. Farm data, including crop rotation, nutrient applications, and tillage practices were collected from nutrient management plans. Preliminary comparisons show a strong (R^2 = 0.72) relationship between TDP concentration in surface water and area weighted soluble P-Index values. It appears that the factors affecting variability in TDP export between source areas are reasonably described by the Wisconsin P-Index.

**Graduate student presentation

Impacts to Stormwater Quality by Past Road Salt Usage at Argonne National Laboratory

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Argonne National Laboratory in Suburban Chicago discharges process wastewater and stormwater trough a series of outfalls regulated by the National Pollutant Discharge Elimination System (NDPES) administered by the State of Illinois. The latest NPDES permit contains a limit for total dissolved solids (TDS) of 1000 mg/l for five of these outfalls. Monitoring of these outfalls over the last two years has revealed consistent exceedances of the TDS limits for two of these outfalls. These outfalls discharge a combination of clean building drainage and stormwater. An examination of known discharged to these outfalls failed to identify sources that could have caused these exceedances.

An extensive program of continuous monitoring of water quality parameters and soil sampling showed the likely source to be elevated levels of sodium chloride in surface runoff and subsurface drainage seeping into the storm drains during dry weather. The salt contamination was found to be related to the application of road salt during the winter and the storage of snow in unpaved areas adjacent to the paved parking areas.

Continuous monitoring of flow rate, temperature and TDS concentration in the drainage basins for these outfalls enabled Argonne personnel to identify the source of elevated TDS at one outfall and redirect this flow to the process sewer, eliminating this exceedance. The source was found to be a footing drain sump that collected and removed shallow groundwater from one of the research buildings. The groundwater had been impacted by past use of road salt in the parking lot adjacent to the building. At another outfall, the continuous monitoring revealed that, during dry weather, small amount of shallow groundwater, contaminated with residual road salt, seeped into the storm drain resulting in exceedances of the TDS concentration limit. These exceedances continued long after the application of road salt had stopped for the year.

Soil samples reveled that the use of road salt over the 60 years of operation at the Argonne site has resulted in deep penetration of soil by residual road salt, even high clay-content soils. The residual salt concentrations were closely

correlated with snow management practices, where the highest levels of salt were found beneath snow stockpile areas.

In response to these finding, Argonne has begun to modify its snow removal practices and is currently examining ways to reduce the impact of the historic salt contamination of the soil column.

Assessing the Ecological Status and Vulnerability of Springs in Southern Wisconsin

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Wisconsin's springs are generally poorly studied. However, recently conducted surveys reveal the range of geological and biological conditions associated with springs in Iowa and Waukesha Counties and illustrate the utility of baseline information in assessing the ecological significance and vulnerability of spring systems in these regions. The two counties differ in their bedrock geology, surficial geology, and development pressures. In Iowa County, springs are associated with every major stratigraphic unit, but most commonly occur as contact springs that discharge from Ordovician Sinnipee Group rocks, near the upper contact of the Ordovician St. Peter Formation, or near the upper contact of the Cambrian sandstones. Most of the springs that were mapped by the Wisconsin Conservation Department in 1958 still persist, but many springs are impacted by agricultural practices. Spring waters can be distinguished on the basis of major ion geochemistry, and springs discharging from stratigraphically higher units tend to have lower and more variable flow.

Spring systems in Waukesha County have been compromised by urban and residential development; very few historically identified springs remain in pristine condition. Those that do remain are largely found on public lands, in or near wetlands associated with former glacial lakebeds. Major ion geochemistry is less variable among springs, and flow rates are generally low. Preliminary results show that the springs in both settings have a relatively low diversity of aquatic insects, although springs with close biogeographical relationships to receiving waters have more taxa present, including more insects.

SESSION 4A
Sustainability and Use of Groundwater
Friday, March 2, 2007
10:15 – 11:55 a.m.

Where is the Deep Groundwater Divide in Southeastern Wisconsin?

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The groundwater divide for the deep sandstone aquifer in southeastern Wisconsin represents a hydrogeologic boundary between groundwater flowing east toward Lake Michigan and groundwater flowing west toward the Mississippi River drainage basin. This divide does not coincide with regional surface-water or topographic divides. Prior to development, in the region west of Milwaukee, the divide was probably located in western Waukesha County. Today, pumping from the deep aquifer in southeast Wisconsin has caused the divide to migrate westward several miles into Jefferson County, and the pumping centers have become the main discharge points for the regional flow system.

There is currently significant societal interest in the historic and current positions of the deep groundwater divide. During recent legislative deliberations over the international Great Lakes Compact, the divide has gained legal and political significance as a potential regional groundwater boundary. According to some legal interpretations still under debate, groundwater east of the divide might be considered waters of the Great Lakes, giving local communities rights to Lake Michigan water even though they lie outside the Great Lakes surface-water basin. Accordingly, establishing the position of the divide could be important for regional water management.

Our current understanding of the groundwater divide is based on regional groundwater flow models. Modeling shows that the divide is actually a complex three-dimensional surface that varies in position with depth and time. Although current models give a reasonable estimate of the positions of the divide through time, regulators need to understand that the divide is not fixed in space and that different models and different analyses using the same model might yield multiple scientifically defensible estimates of the divide location.

Estimating Groundwater use in Urban and Rural Areas of Wisconsin

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Our study of pumping rates in representative urban (Waukesha County) and rural (Sauk County) areas of Wisconsin illustrates the impact of withdrawals to the water budgets of regional aquifers. Although pumping rates can be measured more accurately than hydrogeologic parameters such as recharge and permeability, Wisconsin has no requirement to meter or report non-municipal groundwater withdrawals. This results in significant uncertainty about total withdrawals from the state's regional aquifers. Groundwater flow models are well-suited to evaluate sustainable use of groundwater resources, but uncertainty in pumping rates increases uncertainty in model calibration and simulation of aquifer response to pumping.

On the basis of well records and land use information, we estimate that municipal wells supply 75% of the groundwater pumped in Waukesha County, where about 30% of the land is in suburban and urban development. In Sauk County, where 8% of the land is similarly developed, municipal systems supply only 25% of the groundwater used in the County. Growth in municipal water use over the last 75 years is highly correlated to population growth in both study areas. Rates of pumping from non-municipal wells in both counties reflect historical trends in agricultural irrigation. Currently, the population of Waukesha County is four times greater than Sauk County, but we estimate that total groundwater use in Waukesha County is only 20% greater than in Sauk County. This suggests that while urbanization accompanied by a reduction in irrigated agriculture reduces overall water use, it concentrates pumping within a smaller geographic region. We found that relatively simple improvements in tracking water use will reduce uncertainty in current pumping rates and improve our understanding of the impacts of groundwater withdrawals.

Is Wisconsin Ready for Artificial Recharge?

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Wisconsin is in the process of formulating new groundwater management practices. Several technologies are under consideration that only a few years ago would have seemed unnecessary in such a water rich state. One of these technologies is artificial recharge. Artificial recharge has a fairly limited track record in the state compared to other parts of the country, but has been proposed as a promising option to offset the effects of pumping from shallow aquifers. We have evaluated the history of artificial recharge in Wisconsin, common practices in other states, and regulatory and cost factors affecting the future use of this technology as part of a regional water plan being conducted by SEWRPC. This presentation summarizes our findings and discusses the viability of expanded use of artificial recharge in Wisconsin.

Wisconsin's limited experience in artificial recharge includes Aquifer Storage and Recovery (ASR), storm water infiltration ponds, wastewater infiltration lagoons, and at least one dedicated groundwater recharge system. Wisconsin has strict regulations covering artificial recharge that are designed to prevent degradation of groundwater quality. These regulations have limited the development of projects in the state. ASR has been tested at two locations. Water quality issues caused the permit application of one system to be withdrawn. The other system has been permitted but is not in operation due to other water quality problems. Many wastewater plants use infiltration lagoons to dispose of effluent. The largest of these systems does not meet groundwater quality standards and operates under a regulatory exemption. Existing regulations require infiltration of storm water for many developments. The state of the practice may not be adequate to protect groundwater quality and these systems may be creating contamination issues that may need to be addressed in the future. A dedicated groundwater recharge system developed to offset water withdrawals for a consumptive use required expensive water treatment to make the water suitable for recharge.

The most commonly discussed sources of recharge water are storm water and wastewater. Both of these sources have significant water quality issues that require treatment prior to recharge to avoid degrading water quality. The design of many existing systems is inadequate to achieve this goal. In most cases, the water would need to be treated to drinking standards and the aquifer would only serves as a storage vessel or a buffer to avoid direct reuse. Under these circumstances, the advantage of artificial recharge over direct use of the water is limited. With the expense of the required treatment, it is unlikely that artificial recharge will represent a significant source of water until water becomes substantially more expensive in the state. It is likely that artificial recharge basins will only be viable in a limited number of special circumstances where high quality recharge water is available or an urgent need for recharge justifies the treatment costs. ASR may become more common due to the availability of high quality recharge water and the cost advantage of underground water storage.

Getting to Know the Hydrologic Neighborhood: An Approach for Protecting Natural Areas

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To support a growing population, development is pressuring communities to make decisions regarding permitting and zoning. Developments pose impacts on the water resources of natural areas that can result in the degradation of these areas directly and/or indirectly. Oftentimes, detailed studies of existing water budgets necessary to understand potential impacts cannot be completed because of limitations of time, money, technology and awareness. A typical reactive scenario unfolds; non-profit agencies and other land owners scramble to make a case to decision makers for the protection of natural areas potentially harmed by water budget alterations.

To generate discussion on water resource management and policy, we propose a proactive, pragmatic approach for the protection of natural areas from changes in land use and existing water budgets illustrated with examples from Goose Lake, Chiwaukee Prairie and Waubesa Marsh. The approach includes the following elements: 1) utilizing known information to identify key characteristics and processes; 2) developing strategies to protect key characteristics and processes; 3) identifying gaps in understanding; 4) working within the regulatory framework; 5) identifying economic and social benefits; 6) developing an education and outreach program; and 7) presenting a protection strategy to decision makers before new development is proposed.

Aldo Leopold and a Groundwater Ethic

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In the final chapter of *The Sand County Almanac*, Aldo Leopold presented the concept of "The Land Ethic," which subsequently became the cornerstone of environmental ethics. The Land Ethic extends the notion of community to include not only humans but also "the land" which Leopold defined to include animals and plants as well as the inanimate components of the environment such as soil, rocks, and water.

In groundwater management we treat water as a resource and seek to develop groundwater resources for beneficial use by human. In imposing limits to use with concepts such as sustainability and safe yield, the goal is to preserve the resource for future generations of humans and to avoid economically and/or esthetically inconvenient consequences of over use such as groundwater depletion and adverse changes in groundwater quality. Sometimes, even these constraints may be overlooked. For example, one interpretation of a groundwater ethic is the beneficial and intensive use of groundwater under well designed and controlled conditions (Lamas 2004, *Water and Ethics: Use of Groundwater*, UNESCO, New York, 33 p).

Defining a groundwater ethic in terms of Leopold's Land Ethic requires preservation of "the integrity, stability, and beauty of the biotic system" and implies "a limitation on freedom of action in the struggle for existence." It further implies that groundwater should exist, at least in some places, in a natural state. In this paper, selected groundwater management decisions and issues in Wisconsin are examined in the context of a groundwater ethic based on Leopold's Land Ethic.

SESSION 4B
Stream Monitoring, Restoration and BMPs
Friday, March 2, 2007
10:15 – 11:55 a.m.

Evaluation of Probabilistic and Targeted Sampling Designs Used to Assess Wadeable Streams in Wisconsin.

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The Wisconsin Department of Natural Resources (WDNR), with support from the U.S. EPA's Regional Environmental Monitoring and Assessment Program conducted an assessment of the physical, chemical, and biological conditions of wadeable streams in the Driftless Area ecoregion in western Wisconsin, using a probabilistic sampling design. For each of the study streams (n = 60), watershed land use, riparian and in-stream habitat, water chemistry, macroinvertebrate, and fish assemblage data were collected at a randomly-selected stream site and an associated "modified-random" sampling site, accessed via a road crossing nearest the random site. Least-disturbed reference stream sites (n = 22) were also sampled to establish reference conditions. Study results show no significant differences between the random and modified-random assessment sites for 7 of 9 physical habitat, 10 of 11 water chemistry, 7 of 7 macroinvertebrate, and 7 of 8 fish metrics. The random sites data were also compared with targeted (non-random) sampling data routinely gathered by the WDNR that was thought to represent the range and modal condition of stream resources in the study area. We provide evidence that targeted sampling data gathered by the WDNR indicate that overall streams are in better condition than indicated by probabilistic sampling. There were significant differences between the random sample population (and by inference the population of all streams in the Driftless Area) and the reference conditions for a number of physical, chemical, and biological measures, suggesting significant environmental degradation of the Driftless Area stream population. While further evaluation of the statistical rigor of using a modified-random sampling is warranted, sampling randomly-selected stream sites accessed via the nearest road crossing may provide a more economical way to apply probabilistic sampling designs in stream sampling programs.

Monitoring the Effects of Riparian Grazing on Streambank Erosion and Morphology, Pioneer Farm, Platteville, Wisconsin

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In 2004, the U.S. Geological Survey began monitoring changes in channel morphology and bank erosion along a 4,350-foot reach of the Fever River through riparian grazing paddocks at the University of Wisconsin (UW)-Platteville Pioneer Farm in southwest Wisconsin. The reach has been monitored four times per year by use of channel cross-section surveys, area measurements and photographs of non-vegetated banks, and erosion pin measurements. In September 2005, experimental photo-electronic erosion pins (PEEPs) were installed in three banks along the study reach. The banks are not fenced.

Preliminary analysis of data collected from June 2004 to September 2006 indicate that, at 20 of the 35 channel cross sections, the channel has widened, narrowed, down cut, or laterally migrated because of cattle trampling and (or) hydraulic processes. Of the possible 8,600 linear feet of banks through the paddocks, approximately 34% is not well vegetated and possibly eroding. Of the 84 bare banks, 67% are caused by cattle activities, 3% from hydraulic or mass wasting processes, and 30% from a combination processes. The numerous exposed banks in the paddocks are potential sources for sediment to the Fever River. However, it is not yet known whether rigorously managed rotational grazing would reduce the amount of bank erosion compared to the conventional or modified continuous grazing, which was practiced during the three-year baseline monitoring period. Channel and bank monitoring are planned to continue as alternative practices, such as a rigorous managed grazing approach, is considered for implementation.

Restoring the Riparian Corridor of the East Branch of the Pecatonica River

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Like many streams in southwestern Wisconsin, the Pecatonica River has high steep banks of beautiful dark soil that crumble easily into the water. Whenever the stream rises, portions of the bank slump down and wash down the river. This beautiful soil becomes water pollution downstream in the Pecatonica, the Mississippi and perhaps as far away as the Gulf of Mexico.

The purpose of this restoration project was to reconnect the stream to its natural floodplain of wetland communities on a quarter-mile stretch. This project goes beyond traditional in-stream habitat improvements in that up to four feet of sediment along the banks of the stream were removed to expose the native soil layer buried by topsoil that eroded from nearby ridges before farmers adopted soil conservation practices. The soil (10,000 cubic yards, or 500 plus truck loads) has proven to be a valuable resource that could be sold to cover the expenses of excavation, tree removal and plantings if the method is replicated.

Scientists from the WDNR and UW-Madison have gathered information on aquatic species and on the levels of nitrogen, phosphorus and sediment in the stream. These researchers hope to learn if the wetlands along a small section of stream can capture and utilize nitrates, sediment and phosphorus when the water spills over the banks, ultimately helping to improve water quality. Monitoring will also assess the wildlife habitat created along the stream in hopes of attracting non-game fish, frogs, toads and birds as this habitat has disappeared along most of the streams in this area of the state.

WDNR and TNC are part of a partnership of conservation organizations working together to sustain important grassland and freshwater habitat in the 50,000-acre Military Ridge Prairie Heritage Area.

Incorporating Record Uncertainty into Regional Flood Frequency Regressions

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The U.S. Geological Survey, in cooperation with the Wisconsin Department of Transportation, maintains a network of non-recording crest-stage gages which are used to estimate annual peak discharge. The annual peak discharges for these non-recording sites are used along with annual peak discharges from the continuous-record stream-gaging network to periodically update regression equations designed to predict floods magnitudes at ungaged sites. This presentation describes a procedure for improving the regression estimates by considering the uncertainty in the data from these two sources.

The annual peak discharge record for a crest-stage gage is potentially more uncertain for two reasons. First, the gage-height record is based on a non-recording device and periodic visits, hence is subject to more uncertainty than a continuous-record stream gage with near-real-time data availability. Second, because the crest-stage gages tend to be installed in smaller basins, the systems are flashy, consequently it is more difficult to obtain the measurements necessary for an accurate stage-discharge rating. Based on a detailed evaluation of the data-collection procedures and established ratings for the crest-stage gages, relative estimates of uncertainty in annual peak discharges were determined. A similar analysis of a limited number of stream gages was used to assess the uncertainty for continuous-record gages. The inverse of the relative uncertainties can then be used as weights in a regional regression to place greater emphasis on sites with less uncertain records.

Restoration and Improvements around Bridges and Culverts for Channel Stability and Fish Passage

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In Wisconsin alone, there are thousands of road and stream crossings. Oftentimes, these road crossings (whether bridges or culverts) inadvertently inhibit fish passage and create local channel instability and erosion. Many of these impacts can be avoided through proper placement and sizing of bridges and culverts. In some cases existing structures can be retrofit or streams can be restored to prevent further erosion. Restoration with use of in-stream structures offer great potential for bridge and stream protection while providing erosion control and improving aquatic habitat.

This session will provide an overview of existing research related to road crossings and their impacts. Guidelines and examples of restoration and stabilization around existing structures and streams will be provided. Considerations for the design of future bridges and culverts will also be reviewed.

AUTHOR INDEX

Anderson, H.A. 17
Anderson, M.P. 13, 14, 23, 53, 65
Armstrong, D. 47, 56
Bahr, J.M. 11
Barrick, J.M. 28
Bartkowiak, B.M. 29
Batten, W.G. 22
Baumgart, P.D. 57
Bekkedal, M.Y.V. 17
Betzold, K. 30, 50
Boehme, S.E. 16
Bowling, J.M. 26
Bradbury, K.R. 61
Brown, B.A. 27
Browne, B.A. 25, 26
Busch, D.L. 32, 41
Carter, J.T. 23, 62
Cherkauer, D.S. 21, 50, 51
Colby, A.C. 66
Considine, E.J. 20
Craig, L. 11
Crunkilton, R.L. 28
Doherty, J. 53
Dorava, J.M. 33
Dunning, C.P. 33, 62
Edwards, S.E. 16
Emmons, B.H. 19
Feinstein, D.T. 61
Fermanich, K.J. 49, 57
Fienen, M.N. 54
Fitzpatrick, F.A. 67
Flagel, D.M. 34
Furbish, W.B. 9
Fracaro, A. 43, 58
Gaffield, S.J. 35, 64
Gebert, W.A. 20
Geissinger, P. 24, 37
Gotkowitz, M.B. 23, 62
Grundl, T.J. 18, 52
Hansis, R.D. 68
Harrower, M.A. 17
Hart, D.J. 9, 22, 36, 61, 62
Henning, P.E. 37
Hinchey Malloy, E. 16
Hoffman, A. 47, 56
Homan, K.J. 38
Hooyer, T.S. 22, 36
Hruby, J.M. 35
Hunt, R.J. 13, 14, 46, 53, 54
Jansen, J.R. 63
Juckem, P.F. 39
Kalkbrenner, N. 55
Kanehl, P.D. 66
Kennedy, J.L. 20
Kiefer, J.O. 27
King, A.N. 38
Koch, Z. 30
Koperski, C. 9
Lange, M.J. 20
Lathrop, R. 47, 56
Lentz, M.O. 27
Lowry, C.S. 13
Macholl, J.A. 40
Malecki, K.M. 17
Mentz, R. 32, 41
Mickelson, D.M. 22
Miller, M.A. 66
Miller, N. 64
Moeller, C.A. 22
Montgomery, R.J. 35
Moos, L.P. 43, 58
Muffels, C. 53
Muldoon, M.A. 34
Olson, J. 10, 42
Olsson, R.J. 24
Owens, D.W. 32, 41
Palasik, J. 43, 58
Penn, M. 47, 56
Peppler, M.C. 67
Piorkowski, R.E. 43
Porubcan, A. 30
Potter, K.W. 11
Reckinger, N.A. 57
Reed, D.M. 46
Richter, S. 68
Rigo, M.V. 24, 37
Roden, E. 11
Sahu, S. 19
Salas, D. 70
Schlotke, M. 30

Schroeder, J. 30
Servais, R.W. 21, 30
Severtson, D.J. 17, 44
Shupryt, M.P. 45
Skalbeck, J.D. 46
Stelzer, R.S. 34, 45
Stephens, E. 47, 56
Stieglitz, R.D. 49
Swanson, S.K. 29, 60
Tucker, J. 48
VandenBoom, B. 47, 56
Vice, M. 48
Walker, J.F. 13, 14, 69
Waltman, C.S. 49
Werner, S.F. 25
Werner, M.A. 17
Wilberding, R.M. 18, 30
Winter, J.L. 16
Wright, M. 30
Wyss, J.R. 26
Zaber, D. 60
Zolidis, N.R. 35, 64
Zorn, M.E. 49