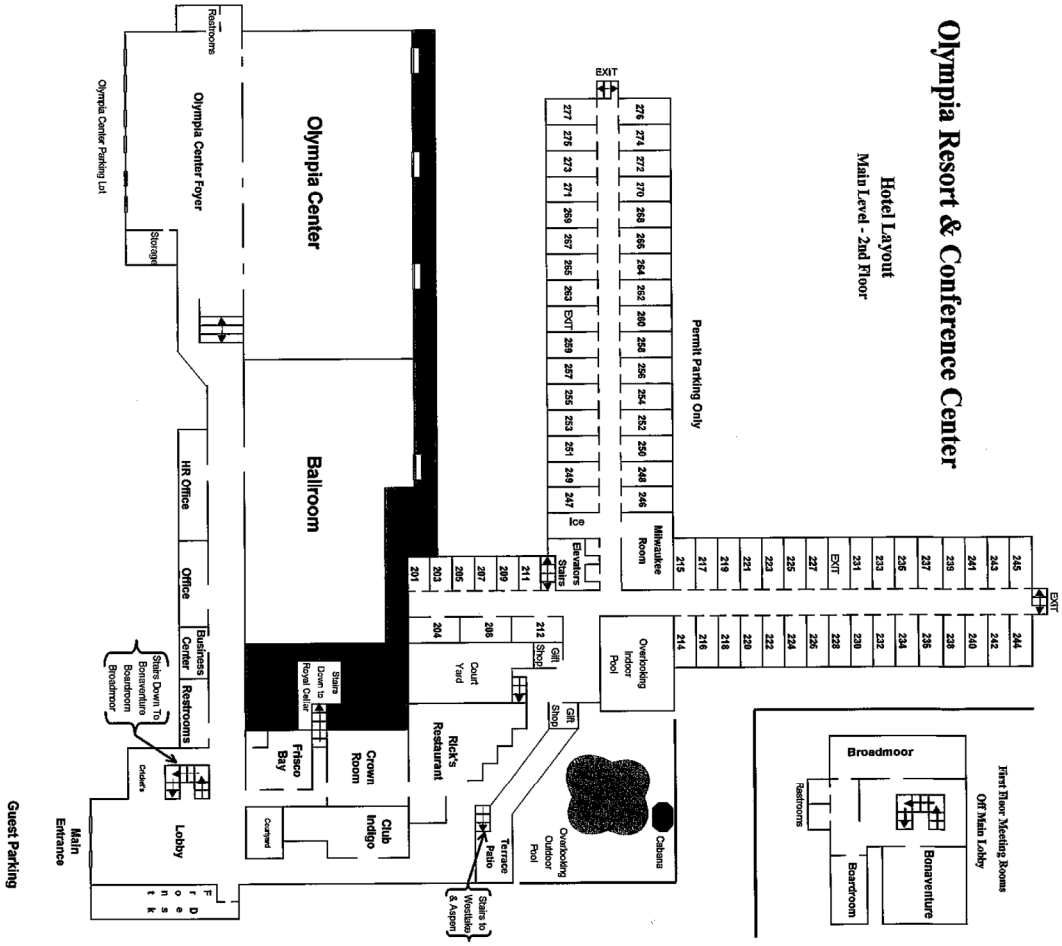
AMERICAN WATER RESOURCES ASSOCIATION – WISCONSIN SECTION
39th ANNUAL MEETING

Wisconsin Water Resources and Agriculture

March 5 & 6, 2015
Olympia Resort and Conference Center
Oconomowoc, Wisconsin

Hosts:
American Water Resources—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

Olympia Resort and Conference Center Facilities



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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 ensure an ongoing dialogue among those committed to water resources research and management in the state of Wisconsin.

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President (1-year term)

Shall preside at meetings, shall, in consultation with the Board of Directors, appoint all committees, and shall perform all other duties incident to the office. The President shall prepare, in collaboration with the Secretary and Treasurer, an annual report of the Section's activities to be presented to the annual meeting of the Section and to be forwarded by the Secretary to the President of the American Water Resources Association.

President-Elect (1-year term)

Shall perform the duties of the President when the latter is absent and shall succeed to the office of President in the following year. Historically has helped to recruit plenary and keynote speakers, has helped coordinate the nomination and election of officers, and performed other responsibilities related to the annual conference.

Vice-President (1-year term)

Shall perform the duties of the President-Elect when the latter is absent. Some of the duties that the vice-president has helped with in the past include recruiting moderators for the general sessions, assisting with the technical program review, and performing other miscellaneous duties as assigned.

Secretary (2-year term, elected in odd years)

Shall keep the minutes of the Section's meetings, shall issue notices of meetings, and shall perform all other duties incident to the office.

Treasurer (2-year term, elected in even years)

Shall be responsible for all funds of the Section and the dues of the American Water Resources Association as agreed to between the Board of Directors and the American Water Resources Association. The Treasurer's accounts shall be audited at the close of each year as directed by the President. The Treasurer shall prepare an annual report and financial statement for presentation at the annual meeting.

Director-at-Large (2 positions, 2-year term, staggered appointments)

Shall serve on the Board of Directors to help manage the affairs of the Section including administration, program development and supervision of financial affairs.

BIOGRAPHIES OF CANDIDATES FOR THE AWRA WISCONSIN SECTION BOARD

Amanda Bell

Amanda Bell has been with the U.S. Geological Survey since the spring of 2001, beginning as an undergraduate student intern for the Snake River NAWQA Basin in Idaho. She then transferred to the Wisconsin Water Science Center so she could complete her Bachelor‘s and Master's Degree from the University of Wisconsin-Stevens Point. Ms. Bell has been intensively involved in studies on the effects of urbanization on stream ecosystems and determination of temporal and nutrient trends in aquatic biological communities. She is currently the National Water-Quality Assessment Program's Ecological Sampling Coordinator overseeing the sampling of 200 streams annually across the US. She has served as the Director-at-Large for the Wisconsin AWRA Chapter for the last two years.

Brent Brown

Brent Brown is a registered Professional Engineer for CH2M HILL in their Milwaukee office. Mr. Brown practices water resources engineering and works on projects involving ecosystem protection and restoration, habitat and fluvial geomorphic assessments, watershed and stormwater management, low-impact development stormwater controls, sediment dredging and dewatering, and airport deicing fluid control. Mr. Brown has a Bachelor’s Degree from the University of Wisconsin at Platteville in Civil/Environmental Engineering and a Master’s Degree from the University of Illinois at Urbana-Champaign in Environmental Engineering. Mr. Brown has been employed with CH2M HILL for 14 years.

Pat Jurcek

Pat Jurcek is a senior hydrogeologist with Layne Christensen in their Pewaukee, Wisconsin office. He has a B.S. and M.S. in Geology and Hydrogeology, respectively from UW-Milwaukee. He has over 20 years of experience in water supply resource development with emphasis in aquifer test analysis, groundwater modeling, and geophysical surveys. He is a licensed professional geologist in Wisconsin, Illinois, Minnesota, and Texas.

Andrew Leaf

Andrew Leaf is a hydrologist at the Wisconsin Water Science Center. He received his bachelor’s from Gustavus Adolphus College, and M.S. degrees in Hydrogeology and Water Resources Management from UW-Madison. He worked in the environmental consulting field in Seattle and now does groundwater flow modeling at the USGS.

Chin Wu

Chin Wu is a Professor in the Civil & Environmental Engineering Department at the University of Wisconsin-Madison. He holds a B.S. & M.S. from National Taiwan University and a Ph.D. from Massachusetts Institute of Technology. Dr. Wu is the director of Environmental Fluid Mechanics & Coastal Sustainability Program at the Civil and Environmental Engineering Department at UW-Madison. His research focuses on sustainability themes including coastal processes and sustainable coastal development, physical-chemical-biological interactions in lakes related to sustainable remediation of contaminates sediments, integrated monitoring/modeling technology development and sustainable water resources management; and sustainable lake and wetland restoration. Dr. Wu has advised 9 PhD students and 20 Master's students that have gone onto graduation and is currently advising 6 PhD students and 10 Master's students. Professor Wu has a strong commitment to the education and welfare of his students, He has won twenty teaching awards including national, university, and college awards. He is the author of over 75 publications advancing knowledge in water resources. He also serves as management council for national Cooperative Institute for Limnology and Ecosystems Research (CILER), advisory committee for national American Society of Civil Engineers-Estuarine and Coastal Modeling and Fluid Mechanics, and advisory board member for Wisconsin Coastal Management. He was awarded for Citizen of the Year, Yahara Lakes Association, in 2012, and also received the Long-term Fellowship Award, CILER, NOAA, 2012-2014.

BIOGRAPHIES OF PLENARY AND EVENING SPEAKERS

Tom Cox

Tom has been a professor at the UW-Madison for nearly 30 years. He teaches classes in Ag Sustainability as well as the required AAE Capstone course. Tom's research interests have included: applied demand analysis; measurement of productivity and technical change; and US, EU, Canadian and international dairy marketing/trade policy. Tom has provided dairy market analyses for many US (USDA, USITC, CFTC, and GAO) and foreign (EU-DG AGRI, AG Canada) governments, NGO's (OECD, FAO, World Bank), multinational agribusinesses and regional dairy organizations.

Dennis Roehrborn

Dennis has been farming in Sheboygan County for over 5 decades. He has seen conservation efforts evolve over this time including no-till planting, strip cropping, rotational grazing, manure storage, grass waterways, and all of the other modes to reduce water, nutrient, and soil runoff. He has actively participated in testing several of these methods and continues to encourage new ideas such as the use of drones, as he works with the local NRCS and County Conservation office. He was one of the first farmers in the area to plant radishes as a covercrop. Radishes are useful in aerating the soil to depths up to 1 foot, providing a large amount of soil coverage with their foliage, and nutrient uptake and storage over winter. He now manages rotational cropping on nearly 1,000 areas in Sheboygan county. His boot-on-the-ground experience provide an insight into how the science that we do affects the farmers in the field.

Bill Schaumberg

Bill is an Independent Crop Consultant at Tilth Agronomy Group in De Pere, WI. Bill's responsibilities include writing nutrient and pest management plans, CNMP planning, GPS soil sampling, variable rate technology maps, fertility management and crop scouting for his farm clientele. Bill is originally from a Diary Farm in Seymour, WI. He earned his BS degrees in Agronomy and Dairy Science from UW- Madison. He is a CCA- Certified Crop Advisor and current President of the Wisconsin Association of Professional Agricultural Consultants.

Ryan Schone

Ryan grew up on a small farm in west-central Illinois, a product of small town America, 4-H, and the great outdoors. He attended *Augustana College* in Rock Island, Illinois with a focus in geography and urban planning. It was also during this time that he developed a deeper passion for local and sustainable food systems, serving as a steering committee member of the Quad Cities Food Hub. Since May of 2013 Ryan has worked for the *University of Wisconsin-Extension* in Milwaukee County as the Local Food Systems Educator. In the summer of 2014, he developed an initiative known as the Milwaukee Urban Discovery Farm which provides emerging farmers with land access and resources for selling product while researching the economic viability and social capital of urban agriculture. Since 2013 he has helped facilitate 80 acres of farmland access and secure over $250k in urban agriculture investments. Milwaukee.uwex.edu/agriculture/microfarming

CONTENTS

PROGRAM SUMMARY

Wisconsin Water Resources and Agriculture

39th Annual Meeting of the American Water Resources Association—Wisconsin Section Oconomowoc, Wisconsin

Thursday, March 5, 2015

9:00 – 11:00 a.m. Registration

11:00 – 11:45 a.m. Welcome and Lunch –Wisconsin Room

11:45 – 1:45 p.m. **Plenary Session**

Tom Cox
Department of Agriculture and Applied Economics, UW-Madison
"Economic/Environmental Optimization in the Wisconsin Dairy Sector: Creating Win-Win Best Management Practices"

Bill Schaumberg
Independent crop consultant, Tilth Agronomy Group
"A Private Agronomist's Perspective on Phosphorus, Agricultural Land Management, and Water Quality"

Dennis Roehrborn
Roehrborn Farms, LLC.
"Evolution of Farming Practices Over a Quarter Century"

1:45 – 2:00 p.m. **Break**

2:00 – 3:40 p.m. **Concurrent Sessions 1A, 1B and 1C**

Session 1A – **Agriculture and Water Quality 1**
Crown Room
Moderator: Kirsten Jurcek

2:00	Factors affecting phosphorus loads to surface waters: comparing the roles of precipitation and land management practices, Melissa Motew*
2:20	Using satellite imagery to determine crop residue cover for improving erosion estimates on agricultural lands, Theresa Nelson
2:40	Design and Implementation of an Agricultural Based Adaptive Management Pilot Study in the Silver Creek Watershed, Brent Brown
3:00	Agriculture's Link to the Water Quality of Green Bay: What does a decade of watershed monitoring tell us? Kevin Fermanich
3:20	Estimating data requirements necessary for quantification of water-quality improvements due to implementation of agricultural best management practices in the GLRI priority watersheds, Jessica Thompson

Session 1B – Groundwater Modeling
Bonaventure Room
Moderator: Andrew Aslesen

2:00 Preliminary Modeling and Monitoring Results from District-Scale Geothermal Exchange Fields, Matthew Harper*

2:20 The value of surface- and borehole-geophysical data to the development of a groundwater-flow model for resource assessment at Les Voigt Fish Hatchery, Bayfield, WI, Leah Kammel

2:40 A tool to generate initial hydraulic conductivity estimates for MODFLOW using a lithology database and maps of glacial categories, Paul Juckem

3:00 A program for rapidly building groundwater flow models, Andrew T. Leaf

3:20 Characterization of Groundwater Flow Processes in the Cedar Creek Watershed and the Cedarburg Bog in Southeastern Wisconsin, Jackson Graham*

Session 1C – Surface Water Quality
Broadmoor A-B Room
Moderator: Steve Corsi

2:00 Use of continuous monitoring data to estimate nutrient and sediment loads from Great Lakes tributaries, Laura Hubbard

2:20 An Innovative Water Exclosure Treatment System (WETs) to Minimize Beach Closures, John Reimer*

2:40 Real-Time Water Imaging System (RTWIS): A Ground-based Water Quality Monitoring Tool, Adam Bechle

3:00 Quantitative Microbial Risk Assessment for Recreational Waters at Three Lake Michigan Beaches in Wisconsin, Tucker Burch

3:20 Development of an Integrated Nowcast -Forecast Operational System (INFOS) for Rip Current Forecasting in Lake Michigan, Prashansa Shrivastava*

3:40 – 4:00 p.m. **Break**

4:00 – 5:40 p.m. **Concurrent Sessions 2A, 2B and 2C**

Session 2A – Agriculture and Water Quality 2
Crown Room
Moderator: Mark Borchardt

4:00 Long-Term Agro-ecosystem Research Network, Dennis Busch

4:20 Evaluating the effectiveness of targeted conservation in an agricultural watershed two years post-implementation: Pleasant Valley Creek, Upper Pecatonica River, Wisconsin, Rebecca Carvin

4:40 Targeted control of agricultural sources of phosphorus and lessons learned, John Nelson

5:00 Water Quality Monitoring in the Jersey Valley Watershed, Callie Herron

Session 2B – Central Sands
Bonaventure Room
Moderator: John Skalbeck

4:00	The Pleasant Lake contested case hearing: one step toward managing cumulative groundwater impacts in Wisconsin's Central Sands, Stephen Gaffield
4:20	The Little Plover River Revisited: Making a Groundwater Management Tool with Community Support, Michael Fienen
4:40	Historical Reconstruction (1948-2007) of evaporative demand in the Wisconsin Central Sands and implications for irrigated agriculture, Mallika Nocco*
5:00	Evaluating the effects of agricultural drainage ditches on water levels in Wisconsin's central sands, Steve Sellwood*
5:20	Groundwater Impacts Associated with Pine Forest Conversion to Irrigated Agriculture and Dairy Manure Waste Application in the Central Sands of Wisconsin, Kenneth Wade

Session 2C – Surface Water and Habitat
Broadmoor A-B Room
Moderator: Catherine Hein

4:00	Lakeshore Habitat Condition in Wisconsin, Catherine Hein
4:20	Long-term Assessments of Aquatic Communities and Habitat for 14 Streams in the Milwaukee Area, Barbara Scudder Eikenberry
4:40	Airport benthic biofilms: taxonomic variability and response to environmental factors, Michelle Lutz
5:00	An Assessment of Barriers to Fish Passage in Streams and Rivers in the Driftless Area Ecoregion Caused by Roadway Culverts and Bridges, Michael Miller
5:20	Development of Geo-Indicators for Regional Integrated Bluff Management on Lake Michigan from a Coastal Bluff Ecosystem Perspective, Nick Jordan*

5:40 – 6:00 p.m. **Social**

6:00 – 7:30 p.m. **Dinner – Wisconsin Room**
Speaker: Ryan Schone, UW-Extension, Milwaukee County
Title: Milwaukee's Local Food Environment: Capacity Built and Lessons Learned

7:30 – 10:00 p.m. **Poster Session and Social – Illinois A, B and C**

1. Monitoring Chloride Concentrations in the Pike River and Pike Creek in Southeastern Wisconsin, Elizabeth Allen*

2. Got Corn? A Large-Scale Stream-Quality Assessment in the Midwest Finds Record High Nitrate Concentrations, Amanda Bell

3. Simulating Winter Dissolved Oxygen Depletion in the Big Eau Pleine Reservoir, James Brodzeller

4. Affordable Edge-of-field Monitoring: A Three-State Project to Promote and Evaluate a Simple, Inexpensive, and Reliable Gauge, Dennis Busch

5. Optimum Phosphorus Concentration for Growth of Catharanthus roseus (L.) G. Don 'Pacifica White' in a Subirrigation and Top Watering System, Donita Cartmill

6. Simulating Changing Water and Nutrient Transport in the Yahara River Watershed Using a Coupled Modeling Approach, Xi Chen

7. Spatiotemporal Measurements of Soil Tension Along an Actively Heated Fiber Optic Cable: A Numerical Modeling and Analytical Solution Approach, Dominick Ciruzzi *

8. Selection and Evaluation of Chemical Indicators for Waste Stream Identification, William DeVita

9. Infiltration and Soil Quality Properties of Cropland Soils in Northeastern Wisconsin, Andrew Docter*

10. Estimating Groundwater Recharge and Solute Loading in Agricultural Systems using Passive Capillary Lysimeters, Chris Ester*

11. Adsorption of Atenolol on Kaolinite, Nicole Fitzgerald*

12. Natural Release Rates and Speciation of Chromium from Solids in Wisconsin Aquifers, Patrick Gorski

13. Exploring the Significance of Faults and Fractures in the Confined Aquifer in Northeastern Wisconsin (Brown and Outagamie Counties): Insights From Stable Isotope Patterns, Amanda (Amy) Hamby*

14. Hydrogeologic Characterization of an Aquitard Using Poroelastic Responses and Near Surface Geophysics, David Hart

15. The Feasibility of Using Volunteers to Monitor Baseflow in the Wisconsin Central Sands, Jessica Haucke

16. Nutrient and Sediment Runoff Losses from Dairy Manure Applied with Low-Disturbance Methods, William Jokela

17. Drawdown of the Potentiometric Surface in the Cambrian-Ordovician Aquifer in Marinette County, Wisconsin, Christa Kananen*

18. Hydrogeology Explains Dramatic Variations in Crop Yields Across a Single Field, Pipestone County, Minnesota, Kerry Keen

19. Predicting Impacts from Anticipated Irrigation Development in the Wisconsin Central Sands, George J. Kraft

20. A Method for Cost Effective Monitoring of Lateral and Vertical Variability in Groundwater Quality at an Agricultural Field Edge, Jacob J. Krause*

21. Aquifer Pumping Tests Demonstrate the Noordbergum Effect (Reverse Drawdown) at the University of Wisconsin-Parkside Campus, Kenosha, WI, Shannon Kurth*

22. Using Multiple Conceptual Models to Understand Transboundary Groundwater Flows in Red Cliff Reservation, WI, Yang Li*

23. Effects from Unsaturated Zone Flow: Parameter Estimation & Oscillatory Pumping Tests, David Lim*

24. A Cost-Effective Discharge Measurement Device Near Hydraulic Structures: Unified Wide-Angle Oblique Automated Streamflow Imaging System (UW-OASIS), Yuli Liu*

25. Temperature Dosage: A Novel Method for Quantifying Oxythermal Stress in Coldwater Fish Species, Madeline Magee*

26. Evaluating Chemical Tracers in Suburban Groundwater as Indicators of Nitrate-Nitrogen Sources, Amy Nitka

27. Evaluating Groundwater Flow near a Municipal Pumping Well with Alternative Conceptual Models, Frances Sayler*

28. Sediment Transport Characteristics of Undisturbed and Degraded Wetlands, Andrew Skog*

29. Predicting Blooms: Can Cyanobacteria Forecasts Improve Lake Management? Caitlin Soley*

30. Beyond the Sandbox: A Geologic Approach to Characterizing Hydrostratigraphic Variability in the Central Sands of Wisconsin, Esther Stewart

31. A New Springs Inventory for the State of Wisconsin, Susan Swanson*

32. Sewage Contamination under Different Storm and Hydrologic Conditions in Three Urban Waterways, Hayley Templar*

33. EflowStats: An R Package to Compute Ecologically-Relevant Streamflow Statistics, Jessica Thompson

34. Soil Moisture and Evapotranspiration as a Function of Distance from Impervious Features in Residential Parcels, Carolyn B.Voter*

35. Characters of Extreme Runoff of Naoli River in Northeast of China and Implications for Flood Management, Yunlong Yao

36. Field-Scale Phosphorus Loading Assessment: Development and Application of TIN-Based SWAT Model, Yan Zhu*

37. Passive Stormwater Agriculture Runoff Sampling, Philip J. Parker

Friday, March 6, 2015

7:00 – 8:30 a.m. AWRA – Wisconsin Section Board of Directors' Breakfast Meeting (Boardroom)

8:30 – 10:10 a.m. **Concurrent Sessions 3A, 3B and 3C**

Session 3A – Agriculture and Groundwater
Bonaventure Room
Moderator: Paul Juckem

8:30	Investigating Intra-annual Variability of Well Water Quality in Shallow Carbonate Rock Aquifers, Kevin Masarik
8:50	Lower Wisconsin State Riverway Floodplain Lakes - A Groundwater Study to Delineate Nutrient Contribution Areas, David Marshall
9:10	Using Enteric Pathogens to Assess Sources of Fecal Contamination in the Silurian Dolomite Aquifer: Preliminary Results, Maureen Muldoon
9:30	Migration of Inorganic Arsenic at a Former Arsenic Pesticide Storage and Disposal Site, Warren Hohn
9:50	Subsurface Transport of cryptosporidium oocysts in soils of Wisconsin's carbonate aquifer region, Zach Zopp

Session 3B — Managing Water Resources
Crown Room
Moderator: Mike Shupryt

8:30	Irrigation Rates in Wisconsin, Robert Smail
8:50	Predicting natural phosphorus concentrations in Wisconsin streams using a Spatial Stream Network geostatistical model, Michael Shupryt
9:10	Results from a decade of groundwater protection in a Wisconsin community, Douglas Cherkauer
9:30	Building the Wisconsin Water-Use Data Exchange, Cheryl Buchwald
9:50	If there is no history to a stream, is it a stream? Martin Griffin

Session 3C — Urban Water Quality
Broadmoor A-B Room
Moderator: Bill Selbig

8:30	Bioretention Studies Searching for an Engineered Soil Mixture that Reduces Phosphorus, Judy Horwatich
8:50	Assessing the effects of riverbank inducement on groundwater quality on a shallow aquifer in southeastern Wisconsin, Laura Fields-Sommers*
9:10	Impacts of a Rural Subdivision on Groundwater Quality: Documenting a Transition from Agriculture to Residential Land Use, Ken Bradbury
9:30	River Chloride Trends in Snow-Affected Urban Watersheds: Increasing Concentrations Outpace Urban Growth Rate and are Common among all Seasons, Steven Corsi
9:50	The Fate of Emerging Contaminants in a Municipal Waste Water Treatment Plant, Tim Grundl

10:10 – 10:30 a.m. **Break**

10:30 – 12:10 p.m. **Concurrent Sessions 4A, 4B and 4C**

Session 4A — Wetlands
Bonaventure Room
Moderator: Martin Griffin

10:30	Floating Bog Interceptors (FBIs): An innovative ecological tool for wetland protection, Michael Busch*
10:50	Role of river backwater wetlands on flood reduction, Biyun Sheng*
11:10	Wetlands and Agriculture - Are Wetland Permits Needed? Cami Peterson

Session 4B — Potpourri
Crown Room
Moderator: Pat Jurcek

10:30	Shallow groundwater and soil texture drive subfield-scale yield patterns, Samuel Zipper*
10:50	A revision to the textbook Applied Groundwater Modeling: Opportunities for online Wisconsin hydrology, Randall Hunt
11:10	Effects of High Frequency Water Level Oscillations on Contaminated Sediment Transport in the Manistique River, Michigan, Alvaro Linares*
11:30	Impacts of Delineation Methods on Modeled Runoff in Watersheds Containing Non-Connected Internally Drained Depressions, Bill Troolin*
11:50	Simulating the Effect of Climate Change on Stream Temperature in Black Earth Creek, Bill Selbig

Session 4C — Water Quality
Broadmoor A-B Room
Moderator: Barb Scudder Eikenberry

10:30	Denitrification removal potential and limitations in small sized reservoirs, Bree Bender*
10:50	Evaluation of Feed Storage Leachate and Runoff Collection System Design and Operation, Aaron Wunderlin
11:10	Pathogens in non-disinfected drinking water from community and non-community wells in Minnesota: Reprising Wisconsin research across the border, Joel Stokdyk
11:30	Quantitative Microbial Risk Assessment for Estimating Setback Distance from Aerial Irrigation of Dairy Manure, Mark Borchardt
11:50	Improving the safety of groundwater-sourced public water supplies, Madeline Gotkowitz

12:10 – 12:30 **Student Awards and 2016 Meeting Announcements**
Crown Room

***** Student Presentation

Session 1A:

Agriculture and Water Quality 1

Thursday, March 5, 2015

2:00 – 3:30 p.m.

Factors affecting phosphorus loads to surface waters: comparing the roles of precipitation and land management practices

Melissa Motew,* University of Wisconsin - Madison, *motew@wisc.edu*
Xi Chen, University of Wisconsin - Madison
Eric Booth, University of Wisconsin - Madison
Steve Carpenter, University of Wisconsin - Madison
Chris Kucharik, University of Wisconsin – Madison

Surface water quality is a major concern in the Yahara watershed (YW) of southern Wisconsin, home to a thriving dairy industry, the city of Madison, and five highly valued lakes that are eutrophic. Despite management interventions to mitigate nutrient runoff, there has been no significant trend in P loading to the lakes since 1975. Increases in manure production and areal density along with the frequency of heavy rainfall events over this time period may have offset any effects of management. We developed a comprehensive, integrated modeling framework that can simulate the effects of multiple drivers on ecosystem services, including surface water quality. The framework includes process-based representation of terrestrial ecosystems (Agro-IBIS), hydrologic routing of water and nutrients across the landscape (THMB), and assessment of lake water quality (YWQM). Biogeochemical cycling and hydrologic transport of P have been added to the framework to enable detailed simulation of P dynamics within the watershed, including interactions with climate and management. The P module features in-soil cycling of organic, inorganic, and labile forms of P; manure application, decomposition, and subsequent loss of dissolved P in runoff; loss of particulate-bound P with erosion; and transport of dissolved and particulate P within waterways. Model results will compare the effects of increased heavy rainfall events, increased manure production and areal density, and implementation of best management practices on P loads to the Yahara lakes. (Student presentation)

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Using satellite imagery to determine crop residue cover for improving erosion estimates on agricultural lands

Theresa Nelson, Wisconsin Department of Natural Resources, *theresa.nelson@wisconsin.gov*
Aaron Ruesch, Wisconsin Department of Natural Resources
David Evans, Wisconsin Department of Natural Resources

The Wisconsin Department of Natural Resources has developed EVAAL – Erosion Vulnerability Assessment for Agricultural Lands to support the prioritization and implementation of agricultural best management practices for improving surface water quality. The GIS-based tool evaluates locations of relative vulnerability to sheet, rill, and gully erosion using readily available information about topography, soils, and land cover. This tool enables watershed managers to prioritize field-scale data collection efforts, thus saving time and money while increasing the probability of locating fields with high sediment and nutrient export. Currently EVAAL uses assumptions regarding tillage types for various crop rotation practices. Since tillage practices and the resulting amount of residue cover can greatly impact erosion and nutrient export, it is advantageous to research methods to refine our assumptions. The Iowa Daily Erosion Project, out of Iowa State University, has demonstrated the use of satellite imagery to determine percent residue coverage as a surrogate for tillage types. Similar methods will be applied and evaluated

for determining tillage types in Wisconsin. This presentation will give an overview of EVAAL, show results of using Landsat imagery to map percent crop residue coverage and the associated tillage types, and demonstrate the associated improvement in the accuracy of EVAAL erosion estimates.

* * *

Design and Implementation of an Agricultural Based Adaptive Management Pilot Study in the Silver Creek Watershed

Brent Brown, CH2M HILL, *brent.brown@ch2m.com*
Jeff Smudde, NEW Water
Bill Hafs, NEW Water

Silver Creek is a small stream located 1 mile west of the Green Bay Austin Straubel Airport and flows into Duck Creek which flows into the bay of Green Bay. The watershed is about 7.5 square miles (4,800 acres). Water testing in Silver Creek shows that it has high levels of phosphorus and sediment that contributes to algae growth, low oxygen and loss of habitat for fish and aquatic life. The Silver Creek watershed has been selected as a demonstration area to partner with agricultural landowners and operators, Outagamie and Brown County Land Conservation, NRCS, and the Oneida Nation to collect soil and water samples and design and install conservation practices to reduce phosphorus and soil erosion. NEW Water (the brand of the Green Bay Metropolitan Sewerage District) is leading the planning of the project and has engaged other stakeholders such as the U.S. Fish and Wildlife Service, The Nature Conservancy, Ducks Unlimited, and the University of Green Bay. Through this project, NEW Water will be evaluating if it is more cost effective to spend $200 million or more on wastewater treatment plant phosphorus improvements or to partner with agricultural efforts to control the amount of phosphorus reaching the bay of Green Bay. NEW Water has hired a team lead by CH2M HILL to design and implement the pilot project. The project includes 124 agricultural fields, 26 landowners, 15 growers and has collected over 1,000 soil sample tests and in-stream biological and water chemistry data. An innovative GIS-based iPad application was developed to allow for the remote data collection and real-time data entry into the project GIS. This presentation will review the results of the project to date, plans for the future, and summarize the decision criteria used on the project to evaluate successful implementation of an Adaptive Management program.

* * *

Agriculture's Link to the Water Quality of Green Bay: What does a decade of watershed monitoring tell us?

Kevin Fermanich, University of Wisconsin-Green Bay, *fermanik@uwgb.edu*
Paul Baumgart

It has been recognized for many decades that excessive nutrient and sediment loads cause major impairments in the Lower Fox River and Lower Green Bay Area of Concern. This recognition has brought about a variety of initiatives to reduce water pollutant loads ranging from point source pollution elimination regulations to more recent efforts through the Great Lakes Restoration Initiative. The Fox River contributes about two-thirds of the phosphorus load to Green Bay. Loads from all industrial and municipal point sources have decreased to about half of what it they were in the 1990's and nonpoint loads now represent about 80% of the total load. Robust, multi-year monitoring of tributaries representing the majority of agriculturally-dominated watersheds within the Lower Fox River (LFR) basin indicate that: 1) more than 65% of the annual load occurs during less than 14 days a year, 2) the majority of these days are when and where croplands are vulnerable to losses, 3) about half of the phosphorus export is in

soluble (available) forms, and 4) the magnitude of the loads consistently exceed water quality targets developed to improve ecological conditions in Green Bay. Our recent monitoring shows that total phosphorus (TP) concentrations in runoff event samples collected from several LFR watersheds in Water Year 2014 were some of the highest measured since monitoring began in 2003. More than 25% of event samples (N=74) collected from Plum Creek in 2014 were greater than 2 mg/L TP and nearly 10% were greater than 4 mg/L TP. In both Plum and Baird Creeks the frequency of high TP concentrations were 2 to 4 times greater than previous years. We hypothesize that the high TP concentrations are a direct result of poor conditions for timely harvest, tillage, and planting of croplands and suboptimum (risky) conditions during annual manure applications. These results suggest that it is critical that watershed managers and stakeholders devise comprehensive programs and implementation strategies that reduce vulnerabilities and minimize risks, not only during high runoff times of the year, but also during years with significant weather constraints for dairy agriculture operations.

* * *

Estimating data requirements necessary for quantification of water-quality improvements due to implementation of agricultural best management practices in the GLRI priority watersheds

Jessica Thompson, USGS, *jlthomps@usgs.gov*
Matthew Komiskey, USGS
Todd Stuntebeck, USGS
Laura DeCicco, USGS

Eutrophication and related water-quality issues in the Great Lakes are an ongoing concern. The focus for improvement of the Great Lakes system often falls on the contributing drainage basin, where agricultural runoff is a large contributor. The Great Lakes Restoration Initiative (GLRI) is piloting the implementation of various agricultural best management practices (BMPs) in several priority watersheds as a strategy to improve overall water-quality. This study addresses how to best gather baseline data for these locations and develop a method for quantifying the effects of BMP implementation. Numerous monitoring locations have been installed to collect data for this effort, including edge-of field sites, sub-surface tile sites and small watershed stream sites. These are selected based on their ability to directly capture the effects of agricultural field treatments. However, it is difficult in these long-term monitoring efforts to verify that necessary data is being collected and appropriate reporting timelines are met. For the GLRI Priority Watershed project the data are used in regression models for each site, with storm characteristics, soil moisture and seasonality available as possible independent variables in the stepwise regression process. The standard error of the chosen regression model for each site is used to approximate the percent change that will be needed at each site to detect statistically significant water-quality improvements. This information is used to determine the timing of BMP implementation, ensuring sufficient pre-implementation data has been collected, and help efficiently assess water-quality change detection likelihood to meet project objectives.

Session 1B:

Groundwater Monitoring

Thursday, March 5, 2015

2:00 – 3:30 p.m.

Preliminary Modeling and Monitoring Results from District-Scale Geothermal Exchange Fields

Matthew Harper,* UW-Madison, *mharper2@wisc.edu*
Christopher Choi, UW-Madison
David Hart, WGNHS

Many buildings and homes are heated and cooled by geothermal systems in Wisconsin, where the geothermal industry has experienced significant growth over the last two decades. Large-scale versions of the system have recently been installed in Dane County, including the largest Geothermal Source Heat Exchanger field in the nation. Clearly, geothermal systems have acquired a potential to conserve a significant amount of energy and reduce the current rate of greenhouse gas emissions immediately. It remains only to be demonstrated that geothermal systems can be environmentally sound and sustainable over the long term; consequently, to partially meet that need, our project aims to address two significant environmental concerns: (i) the potential release of arsenic into groundwater as a result of temperature increases in a geothermal field and (ii) the subsequent increases in the temperature of surface water in trout streams. Using computational tools, we have begun to estimate the effects of a large-scale geothermal field by quantifying the amount of heat transferred from vertical heat exchanger arrays and also to determine both the direction and the rate of groundwater flow. At selected wells, we will monitor groundwater temperature continuously and also groundwater chemistry. The current modeling and field studies will assess the presence, concentration level and spread of the potential thermal and arsenic pollutants produced by ground source heat exchangers. The results of the study should help in any effort to create regulatory guidelines for dealing with the threats these outcomes may pose to humans and environment. In addition, the assessment protocol to be developed using computational tools could also be employed to plan, develop and operate sustainable geothermal energy systems in Wisconsin and elsewhere. (Student presentation)

* * *

The value of surface- and borehole-geophysical data to the development of a groundwater-flow model for resource assessment at Les Voigt Fish Hatchery, Bayfield, WI

Leah Kammel, USGS Wisconsin Water Science Center, *lkammel@usgs.gov*
Peter Chase, Wisconsin Geological and Natural History Survey, University of Wisconsin Extension
Carolyn Streiff, Wisconsin Geological and Natural History Survey, University of Wisconsin Extension
Michael Baiarlipp, University of Wisconsin - Milwaukee
William Kean, University of Wisconsin - Milwaukee

A groundwater-flow model was developed for the area surrounding the State of Wisconsin Les Voigt Fish Hatchery near Bayfield, Wisconsin, to help assess the potential for increasing groundwater supply to the hatchery. Three geophysical survey methods were utilized to obtain hydrogeologic information for the area: surface georesistivity profiles, passive seismic point surveys, and a suite of methods from borehole logs. The seven georesistivity profiles indicate that the shallow unconsolidated material locally consists largely of fine-grained sediments. Flow and video logs of the 800-foot deep hatchery water-supply well suggest intervals of preferential flow exist in the sandstone aquifer near the weathered bedrock surface and also near the bottom of the well where there may be a formation change. However, there do not appear to be areas of concentrated fracture flow that would dominate the flow field. Passive seismic point surveys conducted at 17 locations in and around the fish hatchery property confirm and refine the conceptual model of a bedrock valley that runs under the fish hatchery east toward Lake Superior.

Combined with the ten available driller's logs describing lithology of local bedrock wells, the passive seismic point surveys support a detailed representation of the bedrock surface in the vicinity of the fish hatchery. Taken together, the three geophysical data sets inform crucial aspects of the flow model - including its stratigraphy, model layer structure, and hydraulic conductivity - enabling more accurate simulation of the local flow system. The refined model will be used to design a pumping test in the sandstone aquifer, the results of which will be used to evaluate ways to increase groundwater supply to the Les Voigt Fish Hatchery without adversely affecting nearby wells and surface-water bodies.

* * *

A tool to generate initial hydraulic conductivity estimates for MODFLOW using a lithology database and maps of glacial categories

Paul Juckem, U.S. Geological Survey, Wisconsin Water Science Center, Middleton, WI, *pfjuckem@usgs.gov*

Daniel Feinstein, U.S. Geological Survey, Wisconsin Water Science Center, Milwaukee, WI

Brian Clark, U.S. Geological Survey, Lower Mississippi Gulf Water Science Center, Fayetteville, AR

Both geologic maps and borehole lithologic data provide a foundation for informing hydraulic conductivity patterns in groundwater flow models. Geologic maps produced by trained geologists typically describe homogeneous units of similar depositional environments and lithologies. Lithologic databases can offer insight into spatial heterogeneity of sediments. Previous studies have leveraged these resources to produce heterogeneous hydraulic conductivity fields in which the final values are estimated via calibration. This presentation will describe a generalized tool (in development) designed to facilitate the processing of glacial maps and a recently expanded lithologic database of well construction reports for the glaciated area of the United States (Arihood, 2009) into hydraulic conductivity estimates for MODFLOW models. The tool, incorporating Fortran and Python scripts, uses the Discretization file of a MODFLOW model along with a chosen glacial geology map and the standardized lithologic description database of Arihood (2009). Grain-size descriptors (eg: sandy, silty, clayey) in the lithologic database are used to bin the specified intervals as coarse, mixed, or fine and then matched with the model grid and layer geometry to compute a cell-averaged coarse fraction (0 to 100%) for cells that contain lithologic logs. Three methods are currently available to interpolate coarse-fraction estimates across all model cells per layer. The glacial geology map is then simplified into a subset of glacial categories, or grouped map units, based on an editable look-up table and mapped to the model grid. Initial hydraulic conductivity estimates are computed by pairing the minimum, average, and maximum coarse fractions in each glacial category with a user-supplied minimum, expected, and maximum hydraulic conductivity value. This approach allows for differing relationships between coarse fraction and hydraulic conductivity in each glacial category. This final step of computing hydraulic conductivity estimates on a cell-by-cell basis from glacial categories and coarse fractions is fast, and has been developed for easy integration with parameter estimation tools, such as PEST. References: Arihood, L.D., 2009, Processing, analysis, and general evaluation of well-driller records for estimating hydrogeologic parameters of the glacial sediments in a ground-water flow model of the Lake Michigan Basin: U.S. Geological Survey Scientific Investigations Report, 2008-5184, 26 p.

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A program for rapidly building groundwater flow models

Andrew T. Leaf, U.S. Geological Survey, *aleaf@usgs.gov*

As the availability of datasets required for groundwater modeling has increased, so too has the need for improved methods for rapidly assessing stresses to aquatic systems such as cumulative pumping impacts. Analytic element groundwater flow models such as GFLOW provide an efficient, rapid, and flexible method for evaluating drawdown and surface water depletion at multiple scales. However, the most common approach to constructing analytic element models involves manually digitizing important hydrologic features (e.g. streams, rivers, lakes), using existing hydrographic and topographic layers as guides. Although typically less cumbersome than building finite difference grids, this process can still be prohibitively labor-intensive for many water resources decisions. A computer program has been developed to leverage existing information in the National Hydrography Dataset (NHDPlus v2) for the rapid construction of line-sink elements representing streams, rivers, and lakes. Vector information defining the waterbody geometries is read in and simplified using a line simplification algorithm in the Shapely Python package. The level of simplification is controlled by a distance tolerance, which can be varied by geographic area (allowing for different levels of complexity in the model near- and farfields). Further simplification can be achieved using ancillary information in NHDPlus such as stream order and arbolate sum. Other properties, such as resistance, width and parameter group, can also be specified. A prototyping mode facilitates selection of an optimal distance tolerance to achieve a desired number of line-sink equations. The program produces a line-sink file for import into the GFLOW graphical user interface. The software has been tested successfully on the dense surface water region of the U.S. Forest Service Nicolet Forest Unit, where an analytic element model of the Forest Unit with ~3,000 equations was created and roughly calibrated in a matter of hours.

* * *

Characterization of Groundwater Flow Processes in the Cedar Creek Watershed and the Cedarburg Bog in Southeastern Wisconsin

Jackson Graham,* University of Wisconsin- Milwaukee, *jpgraham@uwm.edu*
Weon Shik Han, University of Wisconsin- Milwaukee, Milwaukee, WI, United States
Daniel Feinstein, United States Geological Survey, Milwaukee, WI, United States
David Hart, Wisconsin Geological and Natural History Survey, Madison, WI, United States
Emily Joint, University of Wisconsin- Milwaukee, Milwaukee, WI, United States

The purpose of this study is to characterize the geology and groundwater flow of the bog as well as the surrounding area, notably the Cedar Creek Watershed, a HUC 12 watershed. This watershed has importance due to the contribution to both the Milwaukee River and Lake Michigan, and is integral in the study of regional groundwater flow of Southeastern Wisconsin. Furthermore, the Cedarburg Bog, located in the northeast corner of the Cedar Creek Watershed preserves diverse ecology and is recognized by the U.S. Department of Interior as a National Landmark. Groundwater is the primary driver for the diverse and unique ecology that is contained within the bog. Within the Cedar Creek Watershed, well data and glacial geology maps were integrated to develop a 3-dimensional subsurface map and watershed-scale groundwater flow model using the LAK3 and the SFR2 package to simulate surface water-aquifer interactions. The model includes 18 zones of the glacial sediments and the weathered and consolidated Silurian Dolomite bedrock. The hydraulic conductivity and storage parameters were calibrated with 200 head targets using universal parameter estimation code (PEST). Then, a series of future climate scenarios, developed by the Wisconsin Initiative on Climate Change Impact, were implemented to the USGS Soil-Water-Balance Code (SWB) to identify variations in recharge. The simulated recharge scenarios were adopted to predict the response of groundwater resources in the watershed and the Cedarburg Bog. Preliminary results produced from the MODFLOW model indicate the bog is acting as a recharge zone under current recharge conditions, approximately 12.7cm/year, with regional groundwater flow from the groundwater divide to Lake Michigan and a mean residual on calibration targets of 4.32m. Knowledge acquired from this investigation can be used to better inform local agencies of potential threats, as well as predict future changes within this groundwater system. (Student presentation)

Session 1C:

Surface Water Quality

Thursday, March 5, 2015

2:00 – 3:30 p.m.

Use of continuous monitoring data to estimate nutrient and sediment loads from Great Lakes tributaries

Laura Hubbard, U.S. Geological Survey, *lhubbard@usgs.gov*

Stream water-quality (QW) and river habitat of many tributaries to the Great Lakes has been degraded in recent decades due to land-use changes in their watersheds. Excessive nutrients and sediment delivered downstream has also impacted estuaries and bays of the Great Lakes, resulting in eutrophication of many of these surface waters. From 2011 to present, nutrients, suspended sediment (SS), continuous QW constituents (turbidity, temperature, specific conductance, pH, and dissolved oxygen) and flow were collected in 30 tributaries to document recent QW conditions as part of the Great Lakes Restoration Initiative. These 30 tributaries drain approximately 46% of the US area to the Great Lakes and represent the spectrum of land use in the basin. The objective of this study is to provide continuous (15-minute) nutrient and SS loading information from these tributaries to the Great Lakes. This information will provide a better understanding of the variability and trends in loading of nonpoint source pollution affecting the environmental health of the Great Lakes. Two sets of multiple linear regression models were developed to estimate continuous nutrient and SS concentrations for each tributary: One set of models was developed using continuous QW constituents and flow and seasonality (sine and cosine of Julian day); a second set of models used only continuous flow and seasonality. The two approaches were compared to determine how much the use of QW constituents improved concentration estimations for each tributary. Final models were developed by selecting a subset of the explanatory variables. If continuous QW data were unavailable for short periods, flow and seasonality models were used to maintain continuity. Continuous loads and 95% confidence intervals for each response variable were calculated using the user-defined model of LOADEST in R to include explanatory variable(s) selected from the regression analysis.

* * *

An Innovative Water Exclosure Treatment System (WETs) to Minimize Beach Closures

John Reimer,* Department of Civil and Environmental Engineering, University of Wisconsin–Madison, *jrreimer@wisc.edu*

Chin Wu, Department of Civil and Environmental Engineering, University of Wisconsin–Madison

Excessive growths or “blooms” of blue-green algae (cyanobacteria) and bacteria such as E. coli (Escherichia coli) are mainly attributed to beach closures in the Yahara River Chain of Lakes near Madison, Wisconsin. While many efforts have been devoted to reduce nutrient loadings that feed the growth of algae in lakes, it may take years for lakes to return to non-eutrophic state. For immediate concerns, there is a great desire to have a system that can provide safe and clean water for swimmers/toddlers on public beaches. In this talk, we will introduce an innovative Water Exclosure Treatment System (WETs). The system consists of an “exclosure” component which is a polypropylene, five-sided barrier that excludes lake water from swimming area water. Inside the swimming area, water is pumped to a portable filtration-ultraviolet treatment component. First, heavy debris such as vegetation are

removed through a strainer. Second, fine particles are removed through a sand filter. Third, destruction of pathogens, algae, bacteria, viruses occur using ultraviolet disinfection. The returning clean water is then sent back to the swimming area. To ensure the swimming area water to be safe and clean, design scenarios are evaluated based on two water renewal time scales (i.e. flushing time and residence time). Conventionally, flushing time is estimated by dividing the volume of the water body by the outlet discharge under a well-mixed water environment. To address possible spatially inhomogeneous concentration hot spots that are caused by short circuiting of the treatment system and re-circulation/dead zones due to the exclosure beach shape, we employ a state-of-the-art hydrodynamic model and particle track model to delineate the time for specific water parcels to leave the swimming area. As a result residence time thereby addresses the fates of introduced substances at different locations within the swimming area. The system was installed in the summer of 2011 and has undergone four seasons of beach testing. Comparison of the treatments using the two time scales are made. To date no beach closures have been posted. (Student presentation)

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Real-Time Water Imaging System (RTWIS): A Ground-based Water Quality Monitoring Tool

Adam Bechle,* UW-Madison, *bechle@wisc.edu*
Chin Wu, UW-Madison

Water quality at Madison area beaches is a growing concern due to high levels of blue-green algae. Routine water quality monitoring has been used to provide warning of toxic algae levels and issue beach closures. Current in situ water sampling procedures are spatially limited and delayed by laboratory analysis. In contrast, image-based spectral remote sensing offers immediate estimates of chlorophyll concentration over a large spatial area. Nevertheless, the temporal resolution of satellite and airborne remote sensing is limited by the frequency of satellite orbit and cloud conditions. To address this issue, we develop a ground-based Real-Time Water Imaging System (RTWIS) that can spatially monitor real-time chlorophyll concentration in inland eutrophic lakes. RTWIS consists of a near-infrared camera and a set of narrowband optical filters to capture the spectral characteristics of the chlorophyll in algae. RWTIS is easily installed at a building to capture images of the water surface. Spectrally-filtered images are calibrated for reflectance and a band-ratio algorithm retrieves chlorophyll concentrations throughout the image. RWTIS was calibrated and validated in the field for chlorophyll concentrations with 10-15 % error. We employed RTWIS to map the spatial distribution of chlorophyll-a concentration in Lake Mendota, WI. Over a series of experiments, RTWIS detected clear contrast between different levels of chlorophyll in the highly eutrophic lake water. Overall, the ground-based RTWIS can be a cost-effective and powerful tool to monitor real-time water quality in inland lakes. (Student presentation)

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Quantitative Microbial Risk Assessment for Recreational Waters at Three Lake Michigan Beaches in Wisconsin

Tucker Burch, USGS, Wisconsin Water Science Center, *tburch@usgs.gov*

Susan K. Spencer, USDA - Agricultural Research Service, Environmentally Integrated Dairy Management Research Unit

Rebecca Carvin, USGS, Wisconsin Water Science Center

Steven R. Corsi, USGS, Wisconsin Water Science Center

Mark A. Borchardt, USDA - Agricultural Research Service, Environmentally Integrated Dairy Management Research Unit

We performed a quantitative microbial risk assessment (QMRA) at three Lake Michigan beaches in Wisconsin to 1) estimate the distributions of one-time infection and illness risks for swimmers and 2)

investigate the factors that most influence those estimates. We focused on the three most prevalent human pathogens (Campylobacter jejuni, Salmonella spp., and enteroviruses) from among 22 human and/or bovine pathogens measured in recreational water at Clay Banks Beach (Sturgeon Bay), Point Beach State Park (Two Rivers), and Red Arrow Park Beach (Manitowoc) during the 2010 swimming season. Pathogen concentrations were measured using quantitative polymerase chain reaction (qPCR) and culture methods. These 2010 data were then used to develop regression models to predict pathogen concentrations from several environmental variables. A two-dimensional Monte Carlo simulation was used to assess the effects of variability in exposure factors and uncertainty in model parameters on the estimated risk distributions. Pathogen concentrations were input either by drawing values directly from the distributions of 2010 sampling data or by utilizing model-predicted concentrations. Swimming time and ingestion rate distributions were used together with pathogen concentrations to calculate dose distributions, which were in turn input into pathogen-specific dose-response models. Median infection risks for one-time swimming events during a swimming season were approximately 3×10-5, 7×10-9, and 6×10-7 for C. jejuni, Salmonella spp., and enteroviruses, respectively, with even lower median illness risks for each pathogen. For model inputs representing controllable risk factors, risk estimates tended to be most influenced by beach location, swimming time, and mean 10-day water temperature for C. jejuni, Salmonella spp., and enteroviruses, respectively. These QMRA results can be used by beach managers to inform risk mitigation decisions related to swimmers at these three beaches.

* * *

Development of Integrated Nowcast-Forecast Operational System (INFOS) for Rip Current Forecasting in Lake Michigan

Prashansa Shrivastava,* University of Wisconsin Madison, *prashansa@wisc.edu*
Chin H. Wu, University of Wisconsin Madison

Rip currents are strong, narrow offshore directed flows in a surf zone. They represent a major hazard contributing to hundreds of deaths annually. An outstanding 38 percent of water related deaths in Great Lakes are caused by rip currents. Lake Michigan has a huge number of rip current incidents, which is responsible for 82 percent of the recorded incidents in the Great Lakes. 8 lives were lost due to rip currents in Lake Michigan on July 4, 2003. In this talk, an Integrated Nowcast-Forecast Operational System (INFOS) for rip current forecasting in Lake Michigan will be presented. A mechanistic process-based wave-current interaction hydrodynamic model is developed to resolve fine scale and intermittent rip currents. First a low resolution model of Lake Michigan is taken and NOAA wind fields are used as input to drive the model. Then the wave and current information around the areas of interest is taken from the coarse grid and applied as boundary conditions for the high resolution model to resolve the rip currents at areas of interest. This two-step process enables to capture rip currents while keeping the computational cost relatively low. Video imaging techniques are developed to detect and characterize rip currents at areas of interest. Both modeling and observations improve our understanding of the formation and features of rip currents. INFOS will help improve the risk communication about rips and address beach hazards. Enhanced forecasts will lead to safer beaches. (Student presentation)

Session 2A:

Agriculture and Water Quality 2

Thursday, March 5, 2015

4:00 – 5:00 p.m.

Long-Term Agro-ecosystem Research Network

Dennis Busch, University of Wisconsin-Platteville, *buschd@uwplatt.edu*
Andrew D Cartmill, University of Wisconsin-Platteville

The over-arching challenge facing agricultural production is one of demand for increased production framed within long-term resilience and sustainability. Understanding the long-term fluxes of water, nutrients, and carbon within an agro-ecosystem is fundamental in ensuring a sustainable future. Here we outline an ongoing strategy to reduce scientific uncertainty and understand how an agro-ecosystem will respond to change in land use, management practice, and climate change drivers. Our goal is to develop meaningful, integrated, economic, social, and institutional instruments for the implementation of long term improved land and water resource use at the catchment, regional, and continental scale. This goal will be accomplished through our participation in the United States Department of Agriculture (USDA) Agricultural Research Service (ARS) Long Term Agro-ecosystem Research (LTAR) network. This network now includes 18 nodes strategically located across the USA, one of which is the Upper Mississippi River Basin (UMRB). The UMRB is a collaboration of four sites which include the University of Wisconsin-Platteville Pioneer Farm and three USDA-ARS groups: the National Laboratory for Agriculture and the Environment in Ames, Iowa; the Soil and Water Management Research Unit in St. Paul, Minnesota; and the North Central Soil Conservation Research Laboratory in Morris, Minnesota.

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Evaluating the effectiveness of targeted conservation in an agricultural watershed two years post-implementation: Pleasant Valley Creek, Upper Pecatonica River, Wisconsin.

Rebecca Carvin, U.S. Geological Survey, *rbcarvin@usgs.gov*
Faith Fitzpatrick, U.S. Geological Survey, Middleton, WI fafitzpa@usgs.gov
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Targeted placement of agricultural conservation practices in small watersheds is becoming an increasingly popular approach for decreasing sediment and nutrients in streams. A pilot study of Pleasant Valley in the Upper Pecatonica River Basin, Wisconsin Driftless Area tested the targeting strategy with a paired watershed approach. Baseline assessment and monitoring began in 2006 and included inventories of agricultural land management and phosphorus soil tests, a sediment budget, sediment-source fingerprinting, and stream monitoring for suspended sediment and total phosphorus loads. From 2010-13, farmers implemented targeted erosion and runoff reduction practices on uplands and along stream corridors in the treatment watershed to reduce sediment and phosphorus contributions from high loss areas. Sediment fingerprinting and geomorphic assessment data indicate that, during periods of high sediment loading, agriculture was the primary source of suspended sediment at the majority of sites. The exception was during snowmelt runoff, when stream banks became the dominant source of suspended sediment at the watershed outlet. Stream monitoring results from 2013 indicate statistically significant reductions in total phosphorus loads compared to the control watershed. While there has been a small reduction in suspended sediment it is not statistically significant. On-going agricultural practice inventory

in the watershed indicates that although the extent of targeted practice implementation to date is substantial, activity in non-targeted areas has been counteractive as approximately 10% of the agricultural land that was grassland during baseline assessment has been converted to row crops. Storage of sediment and phosphorus in the stream channel may also mask decreases in suspended sediment and phosphorus loads.

* * *

Targeted control of agricultural sources of phosphorus and lessons learned

John Nelson, The Nature Conservancy, *jnelson@tnc.org*

The Nature Conservancy, through a grant from the Kohler Trust for Preservation, is testing the "targeted" approach to reducing phosphorus (P) loss from agricultural sources in the Sheboygan River basin, Sheboygan County, Wisconsin. The Conservancy is using the 2590 hectare Otter Creek watershed as the test watershed and the nearby 2850 hectare Fisher Creek as the control watershed. A total of 223 fields were sampled in the test watershed with an average soil P level of 28.4 mg/l P. 180 fields were sampled in the control watershed with an average soil P value of 25.0 mg/l P. The SNAP-Plus model developed by the UW-Madison Soil Sciences Department was used to estimate a Phosphorus Index (PI) value of phosphorus loss from individual fields in each watershed. The average PI values were 2.84 and 2.87 for the Otter and Fisher Creek watersheds, respectively. The pre-action average PI values in the Otter Creek watershed were used to target the highest PI fields where best management practices were proposed to farmers. Several significant practices have been applied. Farmer participation is voluntary and cooperation has varied from immediate acceptance to total rejection. Estimated P savings will be discussed for the various practices installed. The targeting approach could be a useful tool in developing adaptive management strategies.

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Water Quality Monitoring in the Jersey Valley Watershed

Callie Herron, UW-Discovery Farms, *callie.herron@ces.uwex.edu*

In 2005 a community debate about the cause of poor lake water quality arose in Monroe and Vernon Counties after a fish kill occurred in the Jersey Valley Lake, a 52-acre impoundment that receives water from the 5,000 acre Jersey Valley Watershed. Local land use is primarily agricultural, with the majority of land being used to supply farms with corn, hay, and other forages for dairy cattle. UW-Discovery Farms has worked with local producers and community members for the past four years in an effort to identify and mitigate critical nonpoint-source contribution areas. Runoff water samples have been collected from five edge-of-field sites, one city site, and two in-stream sites. In the past four years a total of 33 lake samples have also been taken during summer months. On-site tests are conducted to identify color and clarity, and to measure dissolved oxygen levels and Secchi disk depth. This year, additional stream samples were conducted to assess phosphorus, temperature, flow, dissolved oxygen, habitat, and biotic index. Samples have created a robust dataset that helps identify both critical contribution areas and the relationship between stream and lake water quality. Edge-of-field results show that farmers' nutrient management and conservation practices have resulted in rather low phosphorus and sediment losses from farm fields. Data indicates that the stream above the lake is of excellent water quality. However, average phosphorus levels at the lake's surface exceed the recreational use threshold (40 ug/l) but meet the fish and aquatic threshold (100 ug/l), ranging from 52 ug/L in 2012 to 63 ug/L in 2013 (2014 results are still being analyzed). What additional steps can be taken to improve the lake's water quality? Is it possible that impoundment lakes in the Southwest georegion of Wisconsin will have difficulty meeting water quality standards necessary for recreational use even if all controllable factors, such as runoff and erosion, are reduced?

Session 2B:

Central Sands

Thursday, March 5, 2015

4:00 – 5:00 p.m.

The Pleasant Lake Contested Case Hearing: One Step Toward Managing Cumulative Groundwater Impacts in Wisconsin's Central Sands

Stephen Gaffield, Montgomery Associates: Resource Solutions, LLC, *steve@ma-rs.org*
David Marshall, Underwater Habitat Investigations LLC
George Kraft, University of Wisconsin - Stevens Point
Francis Rowe, Edgewood College

The cumulative impact of groundwater pumping on lakes and streams in the Central Sands has garnered considerable attention, but statewide policy has lacked direction to address this issue. In a contested case hearing challenging the Department of Natural Resources' approval of high capacity dairy wells in Adams County, the Pleasant Lake Management District, Family Farm Defenders, Friends of the Central Sands and individual petitioners argued that the impacts of the proposed wells – including cumulative impacts – were not adequately considered. A large dairy proposed approximately 2.5 miles from Pleasant Lake received approval from DNR for two high capacity wells with a total pumping rate of 72.5 MGD. The incremental groundwater drawdown near Pleasant Lake due to the proposed wells was estimated to be about 2 – 6 inches, depending on which groundwater flow model and assumptions were used. Although seemingly small, the impact on Banded Killifish and other environmentally sensitive fish species would be significant due to loss of connectivity with littoral wetlands. These ecological impacts are especially concerning in the context of the cumulative impact of hundreds of high capacity irrigation wells which have already drawn down Pleasant Lake by two to three feet and reduced baseflow in nearby creeks by up to 22%, and future high capacity wells that can be reasonably expected in the area. The administrative law judge ruled that DNR must consider the cumulative impacts to protect public surface water and groundwater. He directed DNR to reduce the approved pumping rate to 52.5 MGD to balance private and public rights under the modified reasonable use doctrine. This ruling is one small step in addressing cumulative groundwater impacts, however many technical and policy challenges remain.

* * *

The Little Plover River Revisited: Making a Groundwater Management Tool with Community Support

Michael Fienen, U.S. Geological Survey, Wisconsin Water Science Center, *mnfienen@usgs.gov*
Kenneth Bradbury, Wisconsin Geological and Natural History Survey, University of Wisconsin Extension
Maribeth Kniffin, Wisconsin Geological and Natural History Survey, University of Wisconsin Extension
Jacob Krause, Wisconsin Geological and Natural History Survey, University of Wisconsin Extension

The Little Plover River basin in Portage County has a long history of groundwater/surface water interaction studies. Declines in river flow, and subsequent establishment of legally-mandated public rights flows motivated the Wisconsin DNR to commission a project using updated modeling to explore possible management options for all water users, including municipal, industrial, agricultural, and ecological. Previous groundwater models of the basin have been criticized for lack of detail and lack of explicit pumping wells. This project has developed a new transient MODFLOW model with updated geology based on new borings and geophysics; explicit simulation of groundwater pumping; an updated calibration to new and historic data; and application of a groundwater management tool to evaluate

scenarios for optimal water use (maximize withdrawal while minimizing stream and water table declines). Outreach is a key aspect of the project, with the goal of reducing public controversy regarding the relationships between groundwater extraction, river flows, and water-table declines. Our team has engaged stakeholders with various viewpoints to address their concerns and theories of how the groundwater system is connected to surface water. We have also participated in formal and informal discussions about various aspects of the modeling techniques, data, and assumptions. The end result—we hope—will be a model that all parties agree is an accurate representation of the system. From that common starting point, solutions to river depletion can be evaluated and similar management strategies can be developed that may then be used in other water-stressed areas of Wisconsin.

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Historical Reconstruction (1948-2007) of evaporative demand in the Wisconsin Central Sands and implications for irrigated agriculture

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Christopher Kucharik, University of Wisconsin-Madison, the Nelson Institute for Environmental Studies, Center for Sustainability and the Global Environment

Historical reconstructions of evaporative demand are essential to understand how irrigated agriculture and greenhouse gases act synergistically or antagonistically to drive regional water cycling. Potential evapotranspiration (PET) models are integrated assessments of evaporative demand that require varying degrees of meteorological and land cover data. The simplest PET models, such as Hargreaves-Samani (1985), only require surface temperature data, while more complex PET models such as Priestley-Taylor (1972) incorporate solar radiation, relative humidity, and surface albedo into estimates, which typically leads to increased accuracy. Surface albedo is a crucial energetic driver of evaporative demand that responds to the changes in phenology, soil moisture, and crop residue management associated with irrigated agricultural practices. Modeling PET in the response to different irrigated agricultural practices may provide insight as to how the dynamic determinants of surface albedo alter evaporative demand at historical timescales. We are reconstructing evaporative demand in the Wisconsin Central Sands over the past 60 years to examine its sensitivity to realistic agricultural scenarios that alter surface albedo (crop type, soil moisture, and residue management). To this end, we are implementing key PET models of varying complexity into the greater Agro-IBIS dynamic ecosystem modeling framework. Agro-IBIS calculates surface albedo at an hourly-time step based on the fractional coverage of crops, soil, and snow. PET simulations are driven by gridded meteorological data from 1948-2007 with approximately 8 km x 8 km spatial resolution in the Wisconsin Central Sands. Preliminary results show a 60-year average evaporative demand of 486 ± 28 mm and 536 ± 27 mm in C3 and C4 crops without shoulder season residue, respectively. Continued analyses will compare these results to simulations incorporating residue and irrigation water temperature into PET estimates. (Student presentation)

* * *

Evaluating the effects of agricultural drainage ditches on water levels in Wisconsin's central sands

Steve Sellwood,* Wisconsin Geological and Natural History Survey, *sellwood@wisc.edu*

Lake levels in parts of Wisconsin's central sands region have declined in recent years raising questions about causes and potential water-level management strategies. This study evaluates the magnitude of water-level declines in the vicinity of central sands lakes caused by the construction of drainage ditches

downgradient from the lakes. A network of drainage ditches was constructed in a portion of the central sands region of Wisconsin in the early 1900s to drain the land so that it could be farmed. Prior to ditch construction groundwater levels in the ditched region were at or near the land surface. Ditches were dug to depths of 2 to 3 meters and lowered the water table sufficiently to make agriculture possible on land within the ditch network. Two steady-state groundwater flow models were developed to evaluate the impact of the drainage ditches on water levels near two central sands lakes, located several kilometers upgradient from the ditch network. The first model represents groundwater conditions in the ditched region of the central sands prior to drainage ditch construction while the second model represents groundwater conditions after installation of the ditch network. Ditches are simulated using the MODFLOW stream package (STR). Comparison of water levels simulated by the two models provides an estimate of the magnitude of groundwater-level change caused by the ditches. The lakes are not explicitly simulated in the models and simulated changes to groundwater levels at the lake locations are assumed to represent lake level changes. The modeling results show the magnitude of drawdown at the two lakes resulting from ditch installation is approximately 1 meter or less under steady-state conditions. Simulated drawdown at the two lake locations is relatively insensitive to variations in recharge and hydraulic conductivity, with all simulated scenarios producing water-level drawdown at the lake locations ranging from 0.3 meters to 0.9 meters. These results suggest that changes to water levels within the ditch network can effect lake levels. Future work is needed to investigate the time required for water-level changes to propagate through the system. (Student presentation)

* * *

Groundwater Impacts Associated with Pine Forest Conversion to Irrigated Agriculture and Dairy Manure Waste Application in the Central Sands of Wisconsin

Kenneth Wade, Kenneth Wade Consulting LLC, *kenneth.wade@tds.net*

The results of five years of groundwater monitoring associated with a concentrated animal feeding operation (CAFO) in the Town of Armenia, Juneau County, Wisconsin was evaluated. Land use history in the site area where the groundwater was monitored included: conversion of pine forest to irrigated commercial agriculture; conversion of commercial irrigated agriculture lands to a large dairy facility; and conversion of commercial irrigated agricultural lands to manure waste application fields where nutrient management planning (NMP) was required as part of the dairy WPDES permit. The evaluation showed the variations in groundwater quality observed over the five year groundwater monitoring period reflected the three different land use areas monitored. The timing of the land use changes and related groundwater impacts conformed to the hydrogeological data associated with the site. The results showed similar significant impacts of nutrient applications at both conventional commercial irrigated agriculture areas and at the site of waste manure application where an approved nutrient management plan was required. The results provide greater understanding of the flow systems typical of the Central Sands and similar hydrogeological environments and allow for improved strategies for groundwater monitoring. The results indicate that the evaluation of the background groundwater quality and establishment of alternate concentration limits (ACLs), as provided for in compliance monitoring under NR 140.28(4)(a), Wis. Adm. Code, must include evaluation of the anticipated groundwater flow lines in the area of monitoring and carefully consider the depth of penetration of recharging water at the site in relation to the screen depths of the monitoring wells.

Session 2C:

Surface Water and Habitat

Thursday, March 5, 2015

4:00 – 5:00 p.m.

Lakeshore Habitat Condition in Wisconsin

Catherine Hein, Department of Natural Resources, *catherine.hein@wisconsin.gov*
Caitlin Carlson, Department of Natural Resources
Paul Garrison, Department of Natural Resources
Tim Asplund, Department of Natural Resources

Nearshore lake habitat degradation has resulted in lower species diversity and altered species composition of macrophytes, macroinvertebrates, and fish in lakes across the nation. Although the biological impacts of habitat loss on lakes have been well-documented, state-level monitoring efforts still focus on trophic status indicators (e.g., Secchi depth, total phosphorus, and chlorophyll). Poor lakeshore habitat can be predicted in part by high levels of agricultural and urban land use in the watershed, but these correlations leave much of the variance in habitat condition unexplained, indicating that lakeshore habitat monitoring is needed to assess local, within-lake habitat. The state of Wisconsin aims to initiate a lakeshore habitat monitoring program to improve its assessment of the state's ~15,000 lakes. As part of the National Lake Assessment, 39 randomly selected lakes were monitored for lakeshore habitat condition in 2007 and 50 additional lakes in 2012. In 2013, the Wisconsin Department of Natural Resources (DNR) monitored 100 randomly selected lakes stratified by lake area and land use. Metrics of habitat health (good, fair, and poor) were calculated to characterize riparian habitat, littoral habitat, and the level of human influence. The latter metric counts the presence of man-made structures, such as buildings, walls, roads, and lawns. Seventy percent of lakes are in good health in terms of riparian and littoral habitat despite the fact that 75% of lakes ranked fair in terms of human influence. Although urban and agricultural development is more prevalent in southern Wisconsin, there was not a latitudinal gradient in lakeshore habitat condition. Lakes that ranked fair and poor in terms of habitat were evenly distributed statewide. These results underscore the need to monitor lakeshore habitat statewide and invest in restoration and protection activities.

* * *

Long-term Assessments of Aquatic Communities and Habitat for 14 Streams in the Milwaukee Area

Barbara Scudder Eikenberry, US Geological Survey, WI Water Science Center, *beikenberry@usgs.gov*
Michelle A. Lutz, US Geological Survey, WI Water Science Center
Daniel J. Sullivan, US Geological Survey, WI Water Science Center

As part of the Watercourse Corridor Study in the Milwaukee area, fourteen streams have been sampled annually in 2004, 2007, 2010, and 2013 for aquatic community data (fish, benthic invertebrates and algae) by the U.S. Geological Survey with nationally-consistent methods for water-quality assessment and ecological status. Biological metrics computed include species relative abundance, diversity and richness, percentages of intolerant and tolerant taxa, and indexes of biotic integrity for fish and invertebrates. Selected physical and chemical environmental data were also collected. Biological metrics are being compared across sampling years and with environmental data to evaluate the ecological status of these streams, to determine primary stressors on the aquatic communities, and to help resource

managers understand and improve the ecological health of these and other urban and urbanizing rivers in the study area. Most of the streams are located in primarily urban land or agricultural land that is urbanizing, with potential adverse effects from physical and chemical changes common to urbanizing streams. Such changes may include increases in temperature and the rate and volume of streamflow due to increased impervious surfaces in the watershed, decreases in riparian cover, or declines in water quality. Preliminary results suggest that all sites show some level of diminished ecological status compared to benchmark metrics for streams in less urbanized areas of eastern Wisconsin. Results of multiple years of data collection will be presented in context of watershed conditions and other factors.

* * *

Airport Benthic Biofilms: Taxonomic Variability and Response to Environmental Factors

Michelle Lutz, U.S. Geological Survey, Wisconsin Water Science Center, Middleton, WI, *malutz@usgs.gov*

Scott Tighe, University of Vermont, Vermont Cancer Center Bioinformatics Core, Burlington, VT

Mahesh Vangala, Vermont Genetics Network, Burlington, VT

Heather Driscoll, Norwich University, Department of Biology, Northfield, VT

Steven Corsi, U.S. Geological Survey, Wisconsin Water Science Center, Middleton, WI

Timothy Hunter, University of Vermont, Vermont Cancer Center Bioinformatics Core, Burlington, VT

Airports utilize deicer and anti-icer compounds on aircraft and pavement during freezing conditions to ensure safety and compliance with established guidelines. However, runoff from deicer and anti-icer application frequently results in elevated chemical oxygen demand (COD) in airport receiving streams. Thriving populations of nuisance benthic biofilms have been observed in a number of such organic-rich streams; they blanket the stream bottom, thereby crowding out diverse benthic communities and degrading the aesthetic quality of the stream. A study investigating biofilms growing upstream and downstream of General Mitchell International Airport in Milwaukee, Wisconsin, was performed during (and surrounding) the 2009-2010 and 2010-2011 deicing seasons. Objectives were to characterize the spatial and temporal variability of biofilm growth as well as the genetic variability and responses to prevailing environmental factors in an effort to inform potential biofilm mitigation efforts. Various types of data were collected including water quality data, biofilm surveys, and genetic analyses (microarray, PhyloChip, and next-gen sequencing techniques). Throughout both deicing seasons, water quality results consistently showed the highest COD concentrations immediately downstream of the airport, with progressively lower concentrations as water flowed downstream (median values of 310, 51 and 25 mg/L, respectively). Nuisance biofilms dominated benthic communities at these sites throughout both deicing seasons (89% cover) and attained thicknesses as large as 8.5 cm. Genetic data showed that biofilm communities growing upstream of the airport and downstream of the airport (prior to the deicing season) differed strongly from each other, and also differed strongly from biofilms growing downstream of the airport during the deicing season. Differences between biofilm communities growing at downstream sites during the deicing season reflected the influence of water temperature and COD.

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An Assessment of Barriers to Fish Passage in Streams and Rivers in the Driftless Area Ecoregion Caused by Roadway Culverts and Bridges

Michael Miller, WI Dept. of Natural Resources, *michaela.miller@wisconsin.gov*

Continuity is vital to the physical and biological integrity of streams and rivers. While it has long been recognized that dams affect river continuity, the extent to which roadway culverts and bridges fragment streams and rivers is a relatively recent concern and is poorly understood. The Wisconsin Department of Natural Resources with support from the U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency, and Trout Unlimited used a random sample of 100 roadway stream crossings in the Driftless Area ecoregion to estimate the extent to which bridges and culverts fragment streams and rivers. Survey results were used to estimate the frequency of occurrence of various barrier types and the total number of crossings that were barriers to fish passage in the entire ecoregion. Study results indicate 8% of all crossings in the Driftless Area were complete barriers to fish passage, 25% were barriers to specific species or sizes of fish, 23% were barriers during high flows, and 44% of crossings were not barriers to fish passage. Using crossing structures with open bottoms that expose natural stream beds and structures with sufficient width to accommodate greater stream flow volumes would significantly reduce the number of barriers to fish passage in the Driftless Area ecoregion.

* * *

Development of Geo-Indicators for Regional Integrated Bluff Management on Lake Michigan from a Coastal Bluff Ecosystem Perspective

Nick Jordan,* UW-Madison Department of Civil and Environmental Engineering, *nbjordan@wisc.edu*
Brent Teske, UW-Madison Department of Civil and Environmental Engineering
Chin Wu, UW-Madison Department of Civil and Environmental Engineering

Coastal bluffs on the Great Lakes are sensitive landscape features that provide vital habitat while facing stress from increased urban development. Sediment is a major component of coastal bluff ecosystems (CBE), which are characterized by rapidly changing morphology. Natural climate factors and land use change play major roles in the movement of sediment in the CBE, which includes periodic bluff recession and erosion, changes in subaerial beach width, sediment transport within the nearshore zone, and lakebed downcutting. Management of a dynamic CBE requires sound, science-based knowledge of physical coastal processes and their relationships to both CBE health and coastal development. Three tiers of geo-indicators are used to assess CBEs, quantify coastal processes with a regional-scale sediment budget, and characterize habitat health and hazards to coastal development. The first tier is derived from field measurements, geospatial data, and anthropogenic impacts at developed and undeveloped sites along the Wisconsin shore of Lake Michigan. The second tier is developed using a comprehensive hydro-morphological model to predict sediment transport, deposition, and erosion at the study sites. The model uses data from the first tier of geo-indicators with known bluff recession and sediment transportation rates, wave climate data, and bathymetric measurements to predict both longshore and cross-shore sediment transport, beach erosion and accretion. The overall balance between sediment sources and sinks are thereby predicted. The last tier assesses overall CBE health based on results from the other tiers. Ultimately, geo-indicators will help coastal managers effectively assess CBE health with respect to coastal land use changes for regional integrated bluff management along Lake Michigan. (Student presentation)

Poster Session

Thursday, March 5, 2015

7:30 – 10:00 p.m.

1. Monitoring Chloride Concentrations in the Pike River and Pike Creek in Southeastern Wisconsin

Elizabeth Allen,* *eallen1@carthage.edu*
Mitchell Ducett
Christine Blaine

The use of road salt to deice roadways during winter and the subsequent runoff during spring months have shown negative effects on aquatic ecosystems. 1 Since the Fall of 2007, the chloride ion concentration of the Pike River that flows through Racine, Kenosha and into Lake Michigan has been quantified. In 2012, sampling sites on the Pike Creek, which flows through the northern portion of Kenosha, were added and monitored. Data from 2014 showed that two dates in late February and early March exceeded 500 ppm chloride in the river, while the mean chloride concentration from late February to early May was 368 ppm, with a range of 205 to 622 ppm. Of the 13 sampling dates in this time period, 12 of the dates measured a chloride concentration above the chronic level of 230 ppm set by the EPA. During the same time period, the chloride values of the Pike Creek measured 50 to 70 ppm higher than the river. Baseline chloride concentrations of the Pike River measured in the fall have shown an increase from 101 ±22 ppm in 2011 to 153 ±5 ppm in 2014. This data suggests chloride retention in the river over time. Since Fall 2012, Carthage College has partnered with Root-Pike-WIN on the Pike River Watershed-Based Plan. As a research institution in the watershed contributing chloride data, this research will directly aid in setting outcomes to improve the water quality of the Pike River Watershed in the future. 1 Corsi, Steven R., David J. Graczyk, Steven W. Geis, Nathaniel L. Booth, and Kevin D. Richards. "A Fresh Look at Road Salt: Aquatic Toxicity and Water-Quality Impacts on Local, Regional, and National Scales." Environmental Science and Technology, 2010, 44, 7376-7382. (Student presentation)

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2. Got Corn? A Large-Scale Stream-Quality Assessment in the Midwest Finds Record High Nitrate Concentrations

Amanda Bell, *ahbell@usgs.gov*
Jeffery Frey, US Geological Survey IN-WSC

The 2012 growing season was difficult for many farmers in the Midwest due to historic drought conditions. This lack of rain reduced corn production in most of the Cornbelt states. A fewer number of spring and summer rains resulted in reduced runoff and residual nitrogen and phosphorus retention in fields. In contrast, during the spring and summer of 2013, flooding across the Midwest allowed for extreme amounts of sediment and nutrients to flush out of the fields into waterways. In 2013 the US Environmental Protection Agency and US Geological Survey cooperatively sampled 100 streams in the Midwest for 12 weeks during the growing season. Weekly water chemistry samples were collected at each site from May to July followed by an aquatic ecological assessment. Record high levels of nitrate were found in several streams mostly in the western part of the study area, more specifically Iowa and Minnesota; historical data shows these areas have higher nitrate concentrations than the rest of the Cornbelt region. In some streams used for public water supply, nitrate concentrations were well above USEPA's maximum

contaminant level of 10 mg/L. Preliminary analyses found that high nitrate concentrations were related to fall drought conditions followed by high spring streamflow. The percent of corn row crop was also highly correlated to the median concentrations of nitrate, especially in basins that were in continuous corn production. Additional analysis is necessary to determine if these high nitrogen concentrations affected the ecology in these streams and if other water quality parameters were affected by the unusual weather patterns.

* * *

3. Simulating Winter Dissolved Oxygen Depletion in the Big Eau Pleine Reservoir

James Brodzeller, *jbrodzel@uwsp.edu*
Paul McGinley, UW Stevens Point

The Big Eau Pleine reservoir is a 6000 acre impoundment in the Wisconsin River system that has experienced periodic winter fish kills since it was constructed. Previous research has suggested the cause is low dissolved oxygen in the reservoir from either winter runoff of animal waste in this agricultural watershed or reduction in reservoir water levels to accommodate storage of spring runoff for the Wisconsin River flow management. To better understand the causes and possible solutions of winter fish kills, a two dimensional dissolved oxygen model was developed using CE-QUAL-W2. This is a laterally averaged hydrodynamic model that can be used to simulate the temporal and spatial variation in dissolved oxygen throughout the reservoir. A long historical record of dissolved oxygen measurements made by the Wisconsin Valley Improvement Corporation provided a set of calibration data. Model output was modified to allow the development of time series of oxygen concentrations at different locations in the reservoir for comparison with measured data and to develop indices of fish habitat quality in the reservoir. The results were used to understand the sensitivity of dissolved oxygen with the reservoir to incoming biochemical oxygen demand and to reservoir level management.

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4. Affordable Edge-of-field Monitoring: A Three-State Project to Promote and Evaluate a Simple, Inexpensive, and Reliable Gauge

Dennis Busch, *buschd@uwplatt.edu*
Randy S. Mentz, University of Wisconsin-Platteville
Mark D. Tomer, USDA ARS, Ames, IA
Bill Van Ryswyk, Minnesota Department of Agriculture

Edge-of-field monitoring results can be used for on-farm adaptive management, management practice evaluation, and model validation, all of which enhance water quality improvement efforts. However, monitoring efforts are often hindered by the expense and technical nature of equipment used. Here we outline a three state (Wisconsin, Iowa, and Minnesota) field test (24 sites) of a prototype edge-of-field runoff monitoring gauge designed for reduced installation costs, simpler operation, better reliability, and improved data quality. Our objectives were to: 1) Evaluate and field test a prototype edge-of-field runoff monitoring gauge; 2) Promote edge of field monitoring; and 3) Provide training for project partners, and coordinate the development of standard methods, technical guides, and data handling techniques.

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5. Optimum Phosphorus Concentration for Growth of Catharanthus roseus (L.) G. Don 'Pacifica White' in a Subirrigation and Top Watering System

Donita Cartmill, *cartmilld@uwplatt.edu*
Danielle L. Ballweg, University of Wisconsin-Platteville
Luis A. Valdez-Aguilar, Universidad Autónoma Agraria Antonio Narro
Andrew D. Cartmill, University of Wisconsin-Platteville

The objective of this study was to quantify the optimum rates of water-soluble phosphorus (P) on the growth of Catharanthus roseus (L.) G. Don 'Pacifica White' in soilless media in a recirculating subirrigation and top watering system. The experiment was designed so that only P varied between treatments; nitrogen (N), ammoniacal N to nitrate N ratio, and potassium (K) content were held constant. Media pH decreased with increasing P concentration in the nutrient solution in both the subirrigated and top watered plants. Shoot N, P, K, magnesium, manganese, zinc, and copper were in general higher in the subirrigated plants when compared to top watered plants. Shoot calcium, sulfur, iron, aluminum, and boron were higher in top watered plants when compared to subirrigated plants. Optimal plant growth was achieved at ≥0.5 mM P in the subirrigated and top watered plants, which is lower than what is usually commercially applied. Subirrigated plants were of higher quality and dry mass regardless of P concentration in the nutrient solution, when compared to top watered plants.

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6. Simulating Changing Water and Nutrient Transport in the Yahara River Watershed Using a Coupled Modeling Approach

Xi Chen, *xichen0904@gmail.com*
Melissa M. Motew, University of Wisconsin - Madison
Eric G. Booth, University of Wisconsin - Madison
Stephen R. Carpenter, University of Wisconsin - Madison
Steven P. Loheide II, University of Wisconsin - Madison
Christopher J. Kucharik, University of Wisconsin - Madison

The Yahara River basin located in southern Wisconsin is a watershed with long-term eutrophication issues due largely to a thriving dairy industry upstream of the Madison chain of lakes. The increase in phosphorus (P) loading from manure production and other sources has contributed directly to a decline in water quality of the lakes and river system, and is often viewed as the most important environmental problem to solve in the region. In this study, the daily water and P transport in the Yahara River basin is simulated using a physically-based hydrologic routing model: the Terrestrial Hydrology Model with Biogeochemistry (THMB), whereby the original model includes representation of water and nitrogen transport. As part of this work, P transport was added based on a P mass balance equation, which includes both dissolved and particulate P. The modified THMB model is coupled with the Agro-IBIS agroecosystem model to represent dynamic coupling between agricultural management in the watershed, and N, P and sediment transport to lakes and streams. Agro-IBIS simulates surface and subsurface runoff, sediment, N and P leaving the landscape, while THMB takes this information and simulates the water and nutrient transport through the river, stream and lake network. We will present model calibration and validation that demonstrates the hydrologic routing simulation capability of THMB at the watershed scale at a spatial resolution of 220m that is several orders of magnitude finer than attempted previously with THMB. The calibrated modeling system is being used to simulate the impacts of climate change and land management on biogeochemistry in the Yahara watershed under four different pathways of change to the year 2070 (Yahara 2070). These scenarios are used to better understand how future decision-making influences the provisioning and trade-offs of ecosystem services.

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7. Spatiotemporal Measurements of Soil Tension Along an Actively Heated Fiber Optic Cable: A Numerical Modeling and Analytical Solution Approach

Dominick Ciruzzi,* *ciruzzi@wisc.edu*
Steven P. Loheide II, University of Wisconsin-Madison

Soil tension varies spatially and temporally and is a primary factor in monitoring ecosystem sustainability and soil-plant interactions. Traditionally, multiple devices at the field scale identify spatial and temporal patterning of soil tension from point measurements. Within the past decade, fiber optic distributed temperature sensing technology (FODTS) coupled with actively heated wires is able to quantify high resolution spatial and temporal soil-water characteristics along buried transects. Using recent advances in this technology, it is possible to measure soil tension at different depths, several times per hour, and at 0.25 m spacing along cables of multiple kilometers in length. Recent research has indicated that this technology is more sensitive to measuring soil-water characteristics in dryer soils and is less sensitive in more saturated soils. We propose to improve sensitivity by surrounding the cable with a material a few centimeters in radius during installation. Ideally this material will readily equilibrate hydraulically with the surrounding soil and will have thermal characteristics that change substantially over a range of conditions form soil saturation to the wilting point. However, identifying a geotechnical material or mix of materials that fits these parameters remains elusive. Preliminary results indicate that the material may need to be engineered from multiple low thermally conductive materials with varying grain and pore size distributions. Here, numerical models and analytical solutions of an actively heated FODTS, which considers surrounding fill materials, at a field site along the East Branch Pecatonica River in southwest Wisconsin are presented. These numerical models and analytical solutions suggest that measurement sensitivity changes in both dry and wet regimes when considering a low thermally conductive material immediately surrounding the cable. (Student presentation)

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8. Selection and Evaluation of Chemical Indicators for Waste Stream Identification

William DeVita, *wdevita@uwsp.edu*
Justin Hall, Wisconsin Institute for Sustainable Technologies, UW-Stevens Point

Human and animal waste pose a threat to the quality of groundwater, surface water and sources of drinking water. This is especially of concern for private and public water supplies in agricultural areas of Wisconsin where land spreading of livestock waste occurs on thin soils overlaying fractured bedrock. Current microbial source tracking methods for reliable source identification requires the use of polymerase chain reaction (PCR) techniques. Due to cost, these tests are often not an option for homeowners, municipalities or state agencies with limited resources. The Water and Environmental Analysis Laboratory sought to develop methods to provide lower cost analytical processes to determine a source of fecal waste using fecal sterols, pharmaceuticals (human and veterinary) and human care/use products in ground and surface waters using solid phase extraction techniques combined with triple quadrupole mass spectrometry (LC/MS/MS). The two separate techniques allow the detection of fecal sterols and other chemical markers in the sub part per billion levels. Fecal samples were analyzed from known point sources to establish a baseline sterol profile for each species of interest. Pharmaceuticals and personal care products indicative of human waste include: acetaminophen, caffeine, paraxanthine, cotinine, sulfamethoxazole, carbamazepine and the artificial sweeteners; acesulfame, sucralose and saccharin. The bovine antibiotic sulfamethazine was also a target analyte. Well water samples where suspected contamination was present were analyzed for fecal sterols and PPCPs. These results were compared to traditional microbiological source tracking results from the Wisconsin State Laboratory of Hygiene. Chemical indicators were found in 6 of 11 groundwater samples, and 5 of 11 were in support of MST results. Lack of detection of chemical indicators in samples contaminated with bovine or human Bacteroides supports the need for confirmatory methods and advancement of chemical indicator detection technologies.

9. Infiltration and Soil Quality Properties of Cropland Soils in Northeastern Wisconsin

Andrew Docter,* *doctar13@uwgb.edu*
Kevin Fermanich, University of Wisconsin-Green Bay
Mathew Dornbush, University of Wisconsin-Green Bay

Agriculture is the dominant land use in Northeastern Wisconsin, contributing about half of the phosphorus and two-thirds of the sediment exported annually to the bay of Green Bay from the Lower Fox River watershed. Water quality impairments in the bay are linked to these agricultural activities. Efforts to improve water quality require the development and analysis of agricultural best management practices to reduce pollutant loads to surface waters, a process that requires a robust understanding of current field conditions. We used replicated ponded infiltration measurements in five agricultural fields located on the clay-heavy soils typical across Brown and Outagamie Counties to provide an estimate of current infiltration potential in the region. Complimentary data on surface soil bulk density, moisture content at field capacity, pH, OM, K, Bray-P, water extractable-P, and microbial respiration were also collected. The five fields represent a wide spectrum of current land uses, including a 25+ year old tall grass prairie established on former cropland, long term no-till (>7 years), shorter term no-till, and conventional row crop practices typical of Northeastern Wisconsin. Preliminary results suggest that infiltration rates in current row crop fields were only one sixth that observed in restored grasslands, mirroring observed differences in surface bulk density and other dynamic soil characteristics. (Student presentation)

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10. Estimating Groundwater Recharge and Solute Loading in Agricultural Systems using Passive Capillary Lysimeters

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Mallika Nocco, University of Wisconsin-Madison, Department of Agronomy
Amy Sandel, University of Wisconsin-Stevens Point
Dr. Chris Kucharik, UW-Madison, Center for Sustainability and the Global Environment
Dr. George Kraft, UW-Stevens Point, Center for Watershed Science and Education

Groundwater recharge and solute loads under agricultural systems are important to groundwater management but notoriously difficult to quantify. A need exists for methodologies that measure recharge and solute loads at field scales to inform modeling at scales of groundwater basins. Approaches for measuring recharge and loads have included pan and monolith lysimeters, pore water collection and analysis, and drain tile monitoring. These have generally proved less than satisfactory. Recharge and loads would ideally be measured directly in the aquifer, but this is practical for only a small subset of cases. Passive capillary lysimeters are a relatively new technology with potential promise for measuring recharge and solute loads. They are unique among lysimeters because of inbuilt fiberglass wicks engineered to match the matric suction of sandy soils (a constant 11 kPa), which allows them to be installed below cultivation to capture percolation in the vadose zone. We installed 24 lysimeters below the effective crop rooting zone in 6 irrigated fields typical of a Wisconsin central sands rotation (sweet corn, field corn, peas, potatoes, and various cover crops). These were sampled intermittently from spring thaw through June 9 2014, and then weekly through November 17 2014. Leachate volume, nitrate-N, and Cl were measured. Preliminary results indicate a tremendous range of values, even within a single field. Across all fields and crops, recharge estimated from deep percolation averaged 567 (376.53) [mean (sd)] mm. Nitrate-N and Cl loads were 269 (203) and 285 (386) kg ha-1, respectively. Within single fields, recharge varied by factors up to 4.8, while nitrate-N and Cl loads varied by up 34 and 92. More evaluation will be done to assess potential sources of variability and whether the variability can be constrained. (Student presentation)

11. Adsorption of Atenolol on Kaolinite

Nicole Fitzgerald,* *FITZG015@rangers.uwp.edu*
Zachary Albert, University of Wisconsin-Parkside

The prescription drug Atenolol (AT) is a beta-blocker that has been widely used for the treatment of hypertension, a cardiovascular disease. AT is a common contaminant in drinking water, and its environmental impacts are of growing concern. Kaolinite is a common clay mineral in soils that formed in warm humid climates. Due to kaolinites abundance in these soils, and its sorption properties, it is important to study its interaction with AT. In this study, the interaction of AT on kaolinite in aqueous solution was investigated under different isotherm, kinetic, ionic strength, pH, and temperature conditions. The isotherms of kaolinite follow the Langmuir adsorption isotherm model, and the maximum adsorption was determined to be 40mmol/kg. Increasing the ionic strength of the aqueous solution decreases the amount of AT adsorbed. Kinetic batch tests determined that AT adsorption on kaolinite reaches equilibrium in less than 30 minutes. The temperature batch study determined that adsorption of AT on kaolinite is exothermic, and the free energy of adsorption was small and negative. The results of the experiment suggest that surface adsorption occurs between AT and kaolinite. (Student presentation)

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12. Natural Release Rates and Speciation of Chromium from Solids in Wisconsin Aquifers

Patrick Gorski, *patrick.gorski@slh.wisc.edu*
Zana Sijan, UW - Madison, Env. Chemistry & Technology
Martin Shafer, UW - Madison, Env. Chemistry & Technology
James Hurley, UW-Madison, Aquatic Sciences Center

Chromium in ground water resulting from natural sources has been detected in Wisconsin and elevated concentrations of Cr (VI) in the drinking water supplies (> 10 µg L-1) are a concern for human health. Chromium is naturally present in minerals as Cr (III) but can be oxidized to the more mobile and toxic form, Cr (VI). Understanding geologic composition of the aquifer material and hydrochemical conditions at the rock-water interface is crucial in predicting chromium release rates, concentration and speciation in ground water. Concentrations and release rates of Cr (VI) were determined using laboratory controlled batch reactors containing well cuttings of aquifer material kept under anoxic conditions (dissolved oxygen < 1 mg/L) and at pH 7 over 21 days. Dissolved Cr (VI) concentrations ranged from 0.22 to 1.23 µg/L across all sites with over 77% of total chromium (CrTot) present as Cr (VI). We found that dissolved Cr (VI) concentrations were not directly related to Cr concentration in the aquifer solid, thus making it difficult to predict which aquifers would contain elevated Cr (VI) simply based on the chromium content of the aquifer solid. The Cr (VI) release rates most similarly resembled a pseudo zero-order with respect to chromium in the solid and ranged from 8.0x10-5 to 2.9x10-3 µg Cr/µg Cr(s) · day or 2.1x10-3 to 1.1x10-2 µg Cr (VI)/g · day. The variability in Cr (VI) release rates decreased upon normalization to the mass of Cr in the solid, indicating that the chromium content of the solid plays a large role in the Cr (VI) release rates, but Cr (VI) release rates were highest for samples which had low solid phase Fe to Cr molar ratios. Furthermore, a non-linear inverse relationship was observed between Cr (VI) release rates and concentrations of Fe and Al in the solid, perhaps indicating that when chromium is present in minerals and clays with high concentrations of Al and Fe, it is more likely to be immobile and not as readily released.

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13. Exploring the Significance of Faults and Fractures in the Confined Aquifer in Northeastern Wisconsin (Brown and Outagamie Counties): Insights From Stable Isotope Patterns

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The Cambrian-Ordovician confined aquifer in northeastern Wisconsin is a complex regional groundwater system impacted by dilution, water-rock interaction, fault compartmentalization, and glacial recharge. Recent geochemical and stable isotopic data suggest a regional flow pattern that is more complex than was previously known. Over 100 groundwater samples were analyzed for stable isotopes of hydrogen and oxygen from throughout the deep aquifer of northeastern Wisconsin. Regionally, ∂D values range between –44.4 and -134.5‰, with ∂18O values between -6.14 and -18.68‰ (SMOW). Local and regional geochemical and isotopic variability appears to correlate with two mapped west- to northwest-trending regional fault zones, and with the northeast-trending Fox River Valley. Variations in isotopic and geochemical parameters are consistent with the concept of "compartmentalization" along mapped fault zones. There does not appear to be significant modern recharge near the west-trending fault in southern Brown County, which suggests that the fault is not presently a conduit for recharge, and Pleistocene sediments are a good confining layer in this area. The Green Bay fault zone in central Brown County, however, shows limited signs of preferential recharge, particularly in areas where unusual fracturing has occurred during well completion or where wells intersect the fault zone. An unexpected result is that the isotopically lightest water (interpreted as Late Pleistocene glacial recharge) occurs along a northeast trend parallel to the Fox River, with isotopically heavier water on both sides of this trend. Two working hypotheses could explain this regional isotopic distribution: eastward flow within the aquifer, or preferential recharge, during the Late Pleistocene, along a bedrock fracture zone paralleling the valley. In either hypothesis, the results are consistent with heavier, possibly interglacial water in the easternmost portion of the study area. (Student presentation)

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14. Hydrogeologic Characterization of an Aquitard Using Poroelastic Responses and Near Surface Geophysics

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Carolyn Streiff, Wisconsin Geological and Natural History Survey
Esther Stewart, Wisconsin Geological and Natural History Survey

In central Wisconsin, irrigation use has dramatically increased over the last several decades. This increase has given rise to concerns over impacts to surface waters from groundwater pumping. We instrumented an irrigated field and a nearby prairie to assess those impacts and compare hydrogeologic responses. The hydrogeology of the two sites is similar, a layered system of 10 meters of sand over 2 to 3 meters of clay and silt over 30 meters of sand. The clay and silt is a recognized geologic unit, the New Rome Formation. Although the New Rome Formation is found over an area of 160 km2, little is known about its hydrogeologic properties. We used poroelastic responses and near-surface geophysics, in addition to traditional hydrogeologic tools such as pumping tests and sediment characterization, to assess the hydrogeologic parameters of the New Rome and the upper and lower sands. The instrumentation consisted of piezometers in all three layers and pumping wells above and below the New Rome. We observed a head decrease of 1.1 meters across the New Rome. We conducted pumping tests using the wells above and below the New Rome. When pumping from below the New Rome, we observed the Noordbergum effect, a small transitory head increase of 4 cm meters 1.5 cm in the New

Rome and 1.5 cm in the shallow piezometer above. The piezometer in the deep sand aquifer showed around 30 cm of drawdown during this pumping. We also conducted a loading test on the New Rome. We backed a truck mounted drill rig over the piezometer and monitored the response. We saw a head increase of 1.3 cm that dissipated in around 3 minutes. These responses were modeling using a coupled poroelastic model. We also collected ground penetrating radar data that can be used to identify the depositional model for the New Rome and the overlying sand aquifer. These results all suggest that the New Rome is behaving like an aquitard at this site with a vertical hydraulic conductivity that varies with depth and location. This new understanding of the hydrogeologic characteristics of a regional aquitard in an area of increased water use is essential for estimating and communicating the impacts of the increased water use. We can better estimate the impacts to surface waters from groundwater pumping for irrigation if we know the role that the New Rome aquitard plays in the regional flow system.

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15. The Feasibility of Using Volunteers to Monitor Baseflow in the Wisconsin Central Sands

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Volunteer monitors could be potential sources of much needed, high quality streamflow data if appropriately recruited, trained, and deployed. In 2013 and 2014, conservation departments from five central Wisconsin counties recruited volunteers to measure stream baseflow. Center for Watershed Science and Education (CWSE) staff trained volunteers through hands-on sessions to use professional grade OTT MF Pro flow meters. Seventy-three sites were monitored monthly by volunteers and county staff. Data were entered into the DNR database SWIMS. For quality control/quality assurance purposes, CWSE staff replicated 10% of volunteer measurements on a monthly basis. Between August 2013 and October 2014, 43 replicate sets of baseflow measurements were collected. Replicate measurements made by CWSE staff were within hours to 21 days of the volunteers' measurements. Measurements taken by volunteers and CWSE staff generally agreed. Signs of systematic error and mistakes in the volunteer monitoring data were absent. Of the 43 sets of replicate measurements, 24 had differences less than 10% and 33 had differences less than 20%. Replicate sets with higher differences in percentage had plausible explanations, such as small discharges (<3.0 cfs) with small absolute differences (<0.3 cfs) or substantial time (up to 21 days) between replicate measurements. Some challenges for sustaining volunteer baseflow monitoring over the long term include: 1) retaining, recruiting, and training volunteers that can handle the technical aspects of flow meters, 2) reimbursing volunteers for mileage traveled to sites, and 3) keeping volunteers engaged and motivated by showing how the data is used.

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16. Nutrient and Sediment Runoff Losses from Dairy Manure Applied with Low-Disturbance Methods

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Jessica Sherman, USDA-Agricultural Research Service
Tony Sternweis, USDA-Agricultural Research Service

Manure applied to cropland is a source of phosphorus and nitrogen in surface runoff and can contribute to impairment of surface waters. Immediate tillage incorporates manure into the soil, thus reducing nutrient loss in runoff, as well as nitrogen loss via ammonia volatilization. But tillage also incorporates crop residue, which may increase erosion potential. We applied liquid dairy manure in a silage corn-rye cover crop system in late October using methods designed to incorporate manure with minimal soil and residue

disturbance. These include low-disturbance sweep injection with paired disks that create a ridge for planting in the spring (strip-till) and tine aerator-band manure application, which applies bands of manure over aerator slots to encourage manure infiltration. These were compared to standard broadcast application, either incorporated with a disk or left on the surface. Runoff generated from a portable rainfall simulator two or more days after manure application was collected from 2 x 2 m subplots bordered by a steel frame with a PVC gutter at the lower end to collect runoff. Preliminary results show the highest runoff losses of total and dissolved P from surface-applied manure, as would be expected. Total P loss was reduced by approximately 35% by the aerator band method, 70% by disk incorporation, and almost 90% by strip-till injection, which was not statistically different from the control treatment that received no manure. Results for dissolved P losses followed a similar pattern, but with even greater reductions from injected or incorporated manure. Overall, preliminary results from this study show that the low-disturbance manure application methods can greatly reduce nutrient runoff losses (and ammonia emission) compared to surface application; and that they maintain residue cover better than disk incorporation of manure.

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17. Drawdown of the Potentiometric Surface in the Cambrian-Ordovician Aquifer in Marinette County, Wisconsin

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Abstract In 2003, the Wisconsin State Assembly passed legislative Act 310, designating regions with at least 150 feet of deep aquifer drawdown from pre-development levels as “Groundwater Management Areas.” In this study, GIS software and well construction reports were used to construct a contour map of the potentiometric surface for the confined Cambrian-Ordovician aquifer in Marinette County, to determine if the region ought to be deemed a Groundwater Management Area. The study area is located north of the existing Groundwater Management Areas and is not likely to have been affected by recent pumping changes near Green Bay. Although limited data are available, the predevelopment potentiometric surface produced flowing artesian wells, with a likely potentiometric surface at least 30-50 feet above the level of Green Bay (elevation 580 feet). Of the wells examined in the study, seven were found to have water level elevations of less than 580 feet at the time of installation. Data from the from the drilling of the Peshtigo City Water Utility well indicates a water level elevation of 496 feet, indicating drawdown of at least 84 feet since pre-development levels, producing a broad, shallow cone of depression, with greatest drawdown near the city of Peshtigo in southeast Marinette County. The region does not appear to qualify as a Groundwater Management Area. However, flowing wells, which were once common in the region, are now rare, and the amount of drawdown in the region should be monitored, particularly if water demands increase. (Student presentation)

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18. Hydrogeology Explains Dramatic Variations in Crop Yields Across a Single Field, Pipestone County, Minnesota

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Ryan Anderson, Summit Envirosolutions, Inc., St. Paul, MN

The link between agronomy and soils is well established and widely understood by the agricultural community. As part of a field-scale project identifying groundwater resources for a specific grower in southwestern Minnesota, evidence accumulated that agronomic production, specifically crop yield, was controlled as much by hydrogeologic factors as by soil factors. This project was performed by Summit

Envirosolutions, Inc. of St. Paul, MN under contract with the grower on his land in Pipestone County, MN. It began as a groundwater resource exploration project – with test borings and wells, but expanded into an investigation of why crop yields varied so dramatically in bands across the nearly-level field. To evaluate the cause of this pattern, numerous pits, trenches, and auger holes provided substantial exposure of the shallow subsurface geologic and hydrologic conditions underlying the field. On the basis of field observations, we identify distinct factors that appear to improve crop yield: 1) increased thickness of surficial, organic-rich, fine-grained alluvium or loess, 2) decreased sorting and grain size of sand and gravel, 3) decreased depth to clay till (beneath the gravel), 4) increased abundance of krotovina, and 5) decreased depth to the water table. These factors act singly, or more typically in combination, especially during dry summers, to create NNE-SSW oriented high-yield and low-yield bands within cropped areas. Both alfalfa and field corn, grown without irrigation, displayed this striking pattern in 2013. In bands where subsurface materials include a thicker loess deposit that overlies more poorly-sorted (ice-contact) silt, sand, and gravel, and where water table is at shallow depth above the till surface, crops appear well-watered and robust. In contrast, where thin loess overlies well-sorted, coarser sandy gravels, with a deeper till surface and deeper water table, crops appear stunted and drought-damaged.

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19. Predicting Impacts from Anticipated Irrigation Development in the Wisconsin Central Sands

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David J. Mechenich, UW-Stevens Point & UW-Extension
Jessica Haucke, UW-Stevens Point & UW-Extension

The lakes, wetlands, and streams in much of the Wisconsin Central Sands have been substantially impacted by the pumping of 2200 high capacity wells, mostly for crop irrigation. Though the impacts of current groundwater pumping have been estimated, little attention has been given to what future impacts will accrue as irrigation continues its expansion. We piloted a procedure for forecasting impacts from anticipated pumping expansion in the "Tomorrow-Waupaca Headwaters Area," a 515 km2 region in eastern Portage County. The procedure has two components; evaluating the suitability of land parcels for conversion to irrigation, and then using groundwater flow modeling to assess the drawdowns and streamflow impacts of irrigating these lands. Parcel suitability classified land based into tiers from "little apparent limitation" (Tier 1) through "not convertible to irrigation" (Tier 4) based on physical characteristics and present use. Currently, irrigated land covers 9.2% of the TWHA. Irrigating all Tier 1 lands would increase that amount to 49.8%; adding Tier 2 lands would cause an increase to 69%. Irrigation impacts were evaluated by modeling four scenarios encompassing two levels of irrigation development and two of irrigation consumption. Irrigation development levels were the current 9.2% and a moderate increase to 38% of the TWHA. Irrigation consumption scenarios were 2 and 4 inches of consumed groundwater. Under moderate increase scenarios, irrigation development causes substantial drawdowns (2-8 ft) in the vicinity of many lakes, nearly dries numerous stream headwaters, and diverts 9.2 to 28% of main stream Tomorrow-Waupaca River baseflow. Assumptions of greater increases in irrigated land lead to more drastic hydrologic effects.

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20. A Method for Cost Effective Monitoring of Lateral and Vertical Variability in Groundwater Quality at an Agricultural Field Edge

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Repeated monitoring of variations in groundwater quality near agricultural fields can help to constrain how nutrient loading at the land surface impacts groundwater quality. However, repeated sampling at several lateral locations and depths can be cost-prohibitive if laboratory analysis of the samples is required to determine the relevant groundwater quality parameters. At our research site in Southern WI, two multi-level piezometers were installed on two down- gradient edges of an actively farmed field. These inexpensive multi-level monitoring systems, consisting of HDPE tubing with mesh screens at different depths, provide more detailed depth profiles of water quality parameters than traditional monitoring wells with longer screen lengths. In order to assemble a full water quality profile, water samples must be obtained and analyzed from each depth interval, which would normally result in high laboratory costs. As an alternative to laboratory analysis, we are using a water quality multiprobe (HydroLab MiniSonde4a) outfitted for the measurement of nitrate ion activity, specific conductance, pH and dissolved oxygen. A peristaltic pump intake line is attached directly to one of the multi-level tubes and the multiprobe is configured as a flow-through cell attached directly to the pump tube outlet. The nitrate ion specific electrode is subject to interference from other ions, and although it has a wide range of sensitivity, the accuracy of the method may limit its utility in field screening samples at this site. This type of monitoring system is particularly well suited for this hydrogeologic setting. The aquifer is highly permeable with a shallow water table, and the small diameter, short-screened mini-peizometers can be sampled with a peristaltic pump. (Student presentation)

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21. Aquifer Pumping Tests Demonstrate the Noordbergum Effect (Reverse Drawdown) at the University of Wisconsin-Parkside Campus, Kenosha, WI

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James Longo, University of Wisconsin-Parkside
John Skalbeck, University of Wisconsin-Parkside

Two pumping tests were conducted at the University of Wisconsin-Parkside on a deep confined aquifer with observation wells located in a shallower confined aquifer. Reverse drawdown in shallow wells during drawdown from pumping a deep well documents the Noordbergum effect at this site. The Noordbergum effect is a response to the decrease in pressure in the layered aquifer system from the drawdown of the water level in the pumping well screened in the deeper aquifer. The pressure decline is transferred quickly to the shallow aquifer which squeezes the aquifer and results in an observable rise in water level in the shallow aquifer. The campus is located on a Holocene glacial moraine overlaying Silurian dolomite of the Racine Formation. The 100-foot thick moraine is composed of the Oak Creek Formation and the New Berlin Formation deposited in two separate advances. These two formations consist primarily of clay separated by a sand lens forms a shallow confined aquifer. Clay separated the shallow confined aquifer from the deep confined aquifer consisting of a sand/gravel layer above the dolomite. Well UWP-1 is screened in the deep confined aquifer from 80 to 100 feet below ground surface (bgs). Wells UWP-2,-3,-4 are screened in the shallow aquifer from 15-30 feet bgs. For the July 14, 2014 test, the pumping rate was stepped from 0.3 gallons per minute (gpm) to 1.2 gpm. The pumping rate was 1.0 gpm for the September 25, 2014 test. During both pumping tests, waters levels in Wells UWP-1 and UWP-3 were measured using an electronic sounder while water levels in Wells UWP-2 and UWP-4 were measured with pressure transducers. During both pumping test waters levels in observation wells UWP-2, UWP-3

and UWP-4 increased (reverse drawdown) while the water level in pumping well UWP-1 decreased (drawdown). The test results suggest that the Noordbergum effect was responsible for the reverse drawdown in the shallow confined aquifer during drawdown of the deep aquifer.

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22. Using Multiple Conceptual Models to Understand Transboundary Groundwater Flows in Red Cliff Reservation, WI

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Interactions between surface water and groundwater play a crucial role in water resources management. Understanding recharge dynamics in the vicinity of surface water bodies has important implications for stream ecology. The demand for comprehensive approaches is required to quantify recharge, defined as the entry of water into the saturated zone. A modified Thornthwaite-Mather Soil-Water-Balance code (USGS, 2010) which takes spatially variable factors including climate, land cover and topography into consideration to estimate the spatially- variable recharge rate, is used in this study. The main objective of this study is to understand the probable extent of groundwater recharge areas that contribute to the streams of the Red Cliff Reservation. Stream baseflows and groundwater tables can be estimated through the groundwater flow model developed using the MODFLOW interface (Harbaugh, 2005; Harbaugh et al., 2000). The groundwater models forced by three conceptual models representing different assumptions about estimated recharge and aquifer hydrological properties are calibrated through PEST (Doherty, 2010a, b) to obtain the optimized match between simulated observations (heads and stream flows) with corresponding field observations. Capture zones delineation are then obtained by using backward transport of particles through numerical flow modeling with MODPATH (Pollock, 1994). (Student presentation)

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23. Effects from Unsaturated Zone Flow: Parameter Estimation & Oscillatory Pumping Tests

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Richards' Equation is arguably the most accurate model for predicting flow. However, nonlinearities make it difficult to deal with. In practice, a linear Darcy's Law is used in lieu of Richards' Equation. The purpose of this study is to quantify the errors induced by ignoring the unsaturated zone during oscillatory pumping tests and to test how "certain" estimated parameters are when using multi-frequency oscillatory pumping tests. Data collected from oscillatory pumping tests were then used to estimate both unsaturated flow parameters, i.e. empirical constants α and n and saturated water content (η), and saturated flow parameters, i.e. hydraulic conductivity and specific storage, using Richards-based and Darcy-based COMSOL models. A gradient-based optimization method, specifically a Gauss-Newton algorithm, was implemented in order to obtain an optimal set of parameters. This was accomplished by minimizing the sum of the square of the differences between simulated and observed data. (Student presentation)

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24. A Cost-Effective Discharge Measurement Device Near Hydraulic Structures: Unified Wide-Angle Oblique Automated Streamflow Imaging System (UW-OASIS)

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An efficient method for reliable estimating river discharge at hydraulic structures is in great demand for water resources management such as flood control. The traditional method is infeasible or labor consuming near hydraulic structure. A unified wide-angle oblique automated streamflow imaging system (UW-OASIS) is developed to remotely estimate the river discharge near hydraulic structures. The system contains of wide-angle cameras to capture consecutive images of entire river cross section from an oblique angle. The surface flow velocity is measured from images by using the large-scale particle image velocimetry (LSPIV) technique. The river discharge is then estimated based on the surface-mean velocity relationship derived using an innovative approach, the joint entropy method (JEM), which provides the best possible the 2D velocity distribution in a natural river channel. By coupling those procedures, UW-OASIS is programmed in an automated manner, which allows to monitor river discharge in real-time efficiently. UW-OASIS is validated and deployed at Lafollette Lock, which is the outlet of Kegonsa Lake of Yahara river-lake chain in Wisconsin. The validation benchmark are six sets of ADCP moving-boat measurements obtained at different flow conditions. The results show that discharge estimated using UW-OASIS exhibits an average of 6.2% relative error compared to the ADCP measurement, which indicates that the system is able to estimating flow discharge near hydraulic structures accurately. Furthermore, in cooperation with Dane County, UW-OASIS has been connected to the Integrated Nowcast/Forecast Operation System (INFOS) for Yahara Lakes, which allows discharge information accessible to the public. Overall, UW-OASIS is demonstrated to provide efficient and accurate estimates of the rive discharge near hydraulic structures, and its deployment at Yahara river also fulfills the needs for real-time discharge information from local communities. (Student presentation)

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25. Temperature Dosage: A Novel Method for Quantifying Oxythermal Stress in Coldwater Fish Species

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Survival and growth of fish in lakes is strongly constrained by water temperature and dissolved oxygen. Increasing air temperatures due to global climate warming are projected to significantly alter temperature and dissolved oxygen characteristics in lakes, with these changes leading to significant effects on fish populations and distributions in the USA and Wisconsin in particular. Habitat for coldwater fish may be reduced by both direct warming of water and increased anoxic conditions in the hypolimnion during the stratified season. Understanding how fish habitat and species distribution will change under future climate scenarios is of utmost importance to lake and fish managers throughout the state. However, properly quantifying the oxythermal stress condition is difficult to predict for the future and apply across a large variety of lakes. The common approach in fish niche modeling of defining boundaries and determining layer thickness of useable habitat has not proved accurate in southern Wisconsin lakes. As a result, we have developed a novel metric, temperature dosage, to quantify oxythermal stress of coldwater fish species in Wisconsin lakes. In comparison with conventional methods, this temperature dosage method can reliably quantify oxythermal stress for our study lakes and can be applied across a suite of lakes and for various coldwater fish species of interest. (Student presentation)

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26. Evaluating Chemical Tracers in Suburban Groundwater as Indicators of Nitrate-Nitrogen Sources

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Amy L. Nitka, Water and Environmental Analysis Lab, UW-Stevens Point, Stevens Point, WI anitka@uwsp.edu William M. DeVita, Water and Environmental Analysis Lab, UW-Stevens Point, Stevens Point, WI wdevita@uwsp.edu Paul McGinley, Center for Watershed Science and Education, UW-Stevens Point, Stevens Point, WI pmcginle@uwsp.edu Understanding groundwater quality is increasingly more challenging as human impacts extend to larger portions of aquifers. Increasing anthropogenic impacts to groundwater often elicits difficult questions about other potential contaminants in groundwater and treatment options. The objective of this study was to identify chemical indicators that most reliably determine sources of nitrate contamination in private wells. We developed an analytical method for a suite of septic waste indicators likely to occur in groundwater contaminated by human waste. The suite included artificial sweeteners, pharmaceuticals and personal care products. We also analyzed for the most common pesticide metabolites to identify contamination due to agricultural practices. The study sampled eighteen private water supply wells three times at three month intervals. All of the wells with nitrate concentrations over 3 mg/L had at least one chemical indicator. Of these wells, 70% had two or more human waste contaminants, 40% had pesticide metabolites, and 50% had both over the course of sampling. The most frequently detected chemical tracers were the artificial sweeteners acesulfame and sucralose, and the antibiotic sulfamethoxazole, and they were found in wells with nitrate concentrations ranging from 3 – 20 mg/L. These results show that the best tracers for wastewater are mobile in groundwater and commonly used. The results of this research will help consumers of water understand the sources of contamination, direct land management decisions and select appropriate water treatment options.

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27. Evaluating Groundwater Flow near a Municipal Pumping Well with Alternative Conceptual Models

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MODFLOW groundwater flow models were designed to evaluate the validity of conceptual models in a fractured bedrock environment in southwestern Wisconsin. Modeling efforts were directed towards evaluating the possibility that known horizontal bedrock fractures intersecting municipal well boreholes are hydraulically connected by extensive, intersecting vertical fractures. A high level of vertical hydraulic connectivity within the fracture network is meaningful because it is a possible explanation for the fast vertical transport times of groundwater that have been reported in the Madison area. Several alternative MODFLOW groundwater flow models were designed for a site in Dane County in the vicinity of a municipal well to test the likelihood of two conceptual models. Parameter values and physical dimensions of the models were designed by evaluating and synthesizing available site data from drilling logs, borehole logging data, research findings, and state and USGS MODFLOW models pertaining to the area of interest. The difference between the two conceptual models was the presence/absence of transmissive vertical fracturing. Fractures were simulated with both the MODFLOW2000 multi-node well package, and vertical planes of high hydraulic conductivity. Results of both model runs were calibrated so that drawdowns at given locations matched known pumping response drawdowns, and the likelihood of aquifer parameters required to produce observed drawdowns were evaluated. Results from these model runs will support or negate the hypothesis that horizontal fractures in the region surrounding the Madison municipal well are hydraulically connected due to intersecting transmissive vertical fractures. Future work on this subject will include a multi-frequency oscillating flow aquifer test conducted in the summer of 2015 to determine flow characteristics within and across aquifers. (Student presentation)

28. Sediment Transport Characteristics of Undisturbed and Degraded Wetlands

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Wetlands are complex hydrogeologic land features that affect the transport and quality of surface waters. Environmentally beneficial functions of wetlands include their abilities to reduce the impacts of flooding and remove aquatic pollutants. Unfortunately, not all wetlands perform these environmental services equally. Such is the case of two riparian wetlands located along upper and lower Dorn Creek, a small impaired stream located in Dane County, Wisconsin. The upper Dorn Creek wetland has been considerably affected by agricultural non-point source pollution. Excessive accumulations of sediment and historical construction of drainage ditches have altered the hydraulic interactions between the stream and wetland. Although the wetland is still able to reduce peak flows during large flood events, the wetland has reduced capacity to remove sediment. In contrast, the lower Dorn Creek wetland has remained relatively undisturbed by human activities. Dorn Creek has established a complex meandering flow path through this wetland, and the wetland is believed to have superior capabilities to reduce flood impacts and remove sediment. To test this hypothesis, a coupled flow and sediment model was developed and calibrated. The coupled model was used to characterize and compare hydraulic and sediment transport processes of both wetlands. Results suggest the upper wetland could be improved through restoration activities. (Student presentation)

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29. Predicting Blooms: Can Cyanobacteria Forecasts Improve Lake Management?

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Paul Block, University of Wisconsin-Madison

Cyanobacteria, also commonly referred to as blue-green algae, are photosynthetic bacteria commonly polluting water bodies. Cyanobacteria are unique in their ability to produce toxic compounds called cyanotoxins, posing immediate health risks to the public and a rapid depletion of common nutrients including phosphorus, nitrates, and dissolved oxygen. This bacterium can render the lake insufficient to support a diverse ecological environment and pose serious threats to human health if ingested. Cyanobacteria have long been recorded as polluting Lake Mendota in Madison, WI, prompting extensive research and interest. Presently, however, there is no long-term cyanobacteria outlook that can provide governing bodies, authorities, and recreationalists with advance warning of a potential threat in the upcoming summer season. Season-ahead cyanobacteria forecasts could allow for the advance of management techniques and improved public awareness. Statistical and dynamical modeling approaches are proposed to evaluate the potential for informative cyanobacteria forecasts. A direct statistically based model is developed to predict the likelihood and severity of cyanobacteria bloom formation across the June – August season using season-ahead large-scale (sea-surface temperatures, seas level pressures) and local (water temperature, precipitation) predictors. Complementarily, a dynamic modeling approach is also being developed; in this case, predicted climate and hydrologic conditions for the June - August season are fed into a hydrodynamic-water quality model available through the University of Wisconsin-Madison limnology and microbial sciences departments. Both approaches show promising prospects; preliminary results and ensuing management options will be discussed. (Student presentation)

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30. Beyond the Sandbox: A Geologic Approach to Characterizing Hydrostratigraphic Variability in the Central Sands of Wisconsin

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Carolyn Streiff, Wisconsin Geological and Natural History Survey
Elmo Rawling, Wisconsin Geological and Natural History Survey
Dave Hart, Wisconsin Geological and Natural History Survey

Groundwater use has increased significantly in Wisconsin's central sand plain (CSP) creating growing concerns about the absolute size and sustainability of the resource. Current groundwater models use a simple layer cake stratigraphy of aquifers and aquitards. This is a geologic over-simplification, especially in the eastern CSP, that likely resulted from lithostratigraphic correlation of drill cuttings. We collected new geophysical and geologic data sets that show eastern CSP sediments are organized into a series of stacked sediment packages called clinoforms that are separated by distinct bounding surfaces. We suggest a sequence stratigraphic approach to characterizing CSP sediments will better constrain their physical characteristics and geometry. This will improve our understanding of the hydrostratigraphy, strengthen groundwater models, and help quantify the impacts of pumping. We collected ground-penetrating radar (GPR), sediment core and hydrogeologic measurements in the eastern CSP. The GPR data reveal clinoforms with progradational-aggradational; degradational; and retrogradational stacking patterns separated by bounding surfaces. Individual clinoforms are ~20 feet thick and ~120 feet long. The core shows clinoform bounding surfaces are characterized by interbedded sand and clay. The thickness and frequency of clay interbeds increases towards the clinoform bottomset, which is characterized by about ten feet of clay. The combined data sets indicate clinoforms sole onto a regional, subhorizontal, clay-rich surface that likely represents the New Rome aquitard. Finally, data we collected from two new multilevel groundwater monitoring wells shows a head drop across the New Rome aquitard that varies from several feet to several tenths of a foot across a horizontal length scale of several hundred feet. The depth and thickness of the aquitard changes over the same length scale. Our preliminary observations suggest hydrogeologic variability in the eastern CSP impacts groundwater flow. Our data also indicates CSP sediments may be understood within a sequence stratigraphic framework. This is a new approach in the CSP and has potential to improve our ability to predict the distribution, geometry, and physical characteristics of sediment bodies that comprise the region's groundwater system.

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31. A New Springs Inventory for the State of Wisconsin

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Dave Hart, Wisconsin Geological and Natural History Survey, University of Wisconsin Extension

The goal of a new springs inventory for the State of Wisconsin is to compile updated and accurate spring position and flow information for use in evaluating impacts of high capacity wells on spring flow rates and assessing effects of land use or climate change on groundwater resources. Comprehensive field surveys of springs in Wisconsin were last conducted over 50 years ago by the Wisconsin Conservation Department. These surveys, as well as a few more recent studies, were compiled into a historical springs database by Macholl (2007). The new springs inventory, which is a three-year effort, consists of county-level field surveys of springs with flow rates of approximately 0.25 cfs or more and semiannual surveys of reference springs selected from representative geological, hydrological, and ecological regions of Wisconsin. Field protocols for the new springs inventory are based on those developed for similar purposes by the National Park Service, the U.S. Forest Service, and the Springs Stewardship Institute. Locational, environmental, geological, geomorphic, and hydrologic conditions are recorded for each spring. Surveys of six counties, all in southern Wisconsin, have been conducted since July 2014. The historical database has proven to be an effective resource for identifying springs with flow rates of 0.25 cfs or more, but local experts are also consulted in each county. Over 50 sites were visited in the six

county region, and 36 springs at these sites have flow rates of approximately 0.25 cfs or more. Nearly all of the springs surveyed so far are rheocrenes with multiple orifices. Half are located on private property, and about half have experienced moderate to high levels of disturbance due to agriculture, dredging, or recreation. Once additional surveys are completed, the spatial distribution of springs will be used to inform geological controls on their occurrence. Selection of the reference springs is ongoing and monitoring will begin in spring 2015. (Student presentation)

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32. Sewage Contamination under Different Storm and Hydrologic Conditions in Three Urban Waterways

Hayley Templar,* *htemplar@uwm.edu*
Sandra McLellan, UW-Milwaukee School of Freshwater Sciences
Steven Corsi, United States Geological Survey

Fecal contamination in urban waterways is a major public and environmental health threat. Sanitary sewer and combined sewer overflows are major point sources of fecal pollution. Additionally, stormwater runoff and failing sewer infrastructure contribute fecal contamination and pathogens to urban waterways. Traditionally, fecal indicator bacteria such as E. coli, enterococci, and fecal coliforms are used to gauge fecal contamination in water; however, these general indicators are unable to distinguish fecal sources in the environment. This study used two human-specific fecal indicator bacteria to identify human sewage contamination in Milwaukee, Wisconsin, where three rivers form an estuary that discharges to Lake Michigan. Two-hour composite samples were collected at four sites, one in each of the three rivers and one in the estuary, to represent the entire hydrograph before, during, and after a rain event. Samples were collected throughout a variety of conditions, including dry-weather baseline, light and heavy rain events, and combined sewage overflows (CSOs). These samples were analyzed using quantitative polymerase chain reaction (qPCR) assays to determine human sewage loads in each river during each type of event. Low levels of human indicators were found during dry-weather baseline conditions, and loads increased significantly (one to two orders of magnitude) during rain events. Sampling upstream of the estuary indicated sewage contamination was originating in the heavily urbanized part of the watersheds, likely a result of failing infrastructure. CSO events contributed the highest loads, which were on average ten-fold higher than rainfall events with no CSO. This information will be a useful for directing the efforts of local entities to investigate failing infrastructure, as well as agencies at the state and federal levels to create appropriate goals to address the human health concerns that are posed by sewage contamination in urban waterways. (Student presentation)

* * *

33. EflowStats: An R Package to Compute Ecologically-Relevant Streamflow Statistics

Jessica Thompson, *jlthomps@usgs.gov*
Stacey Archfield, USGS
Jonathan Kennen, USGS
Julie Kiang, USGS

Streamflow processes are critical to understanding the ecological health of rivers. The natural flow regime concept defines five components of streamflow derived from the daily streamflow time series that are strongly linked to the ecological health of river systems: 1) magnitude, 2) frequency, 3) duration, 4) timing and 5) rate of change of streamflow. Statistics representing these five properties have been broadly applied in the literature and the number of ecologically-relevant streamflow statistics (ERSS) available

from various software packages is now in the hundreds. Although useful to compute subsets of the ERSS, some of these software packages have limitations, which include the inability to calculate ERSS for many rivers at once, difficulty integrating with other ecological analysis packages, and proprietary software licensing. To address these limitations, the U.S. Geological Survey National Water Census, in collaboration with the Center for Integrated Data Analytics, has developed EflowStats. The EflowStats package includes the ability to compute a comprehensive set of ERSS using the open-source R software environment and provides batch capabilities that allow a user to calculate ERSS for multiple sites simultaneously. Users also have the ability to compare datasets, for example, before and after land use change, or modeled versus measured streamflow values. EflowStats enables easy, transparent, and repeatable calculation of the most utilized ERSS for any daily streamflow dataset. The EflowStats package is publicly available via GitHub as open-source software, allowing for future modification and development.

* * *

34. Soil Moisture and Evapotranspiration as a Function of Distance from Impervious Features in Residential Parcels

Carolyn B.Voter,* *cvoter@wisc.edu*
Steven P. Loheide II, University of Wisconsin-Madison

The introduction of impervious surfaces is well known to be a major driver of hydrologic change in urban areas. Current understanding in urban hydrology recognizes that the amount of effective impervious area – that is, impervious area which is directly connected to the storm sewer network – is a better indicator of hydrologic behavior than the total amount of impervious area. However, to date most of the work on impervious surface arrangement and connectivity has focused on how it can affect stormwater runoff and surface water flows. The effect of impervious surface arrangement on subsurface flow is not as well described, but field observations demonstrate that differences in soil moisture availability at locations near impervious features and far from impervious features are significant from a root water uptake perspective. This indicates that that parcel-scale subsurface and plant water fluxes may exhibit unique responses to nuanced differences in impervious surface arrangement. Using ParFlow.CLM, a watershed model with variably-saturated subsurface flow and fully-integrated overland flow and land-surface processes, we examine the extent to which soil moisture and evapotranspiration vary under various impervious surface arrangement and connectivity scenarios. Parameters of interest include general lot layout, sidewalk disconnect, downspout disconnect, and direction of driveway/sidewalk slope. We show that soil moisture and evapotranspiration vary as a function of distance from impervious features, which translates to parcel-scale differences in overall hydrologic regime. (Student presentation)

* * *

35. Characters of Extreme Runoff of Naoli River in Northeast of China and Implications for Flood Management

Yunlong Yao, *yl.yao@163.com*

Naoli river basin is the biggest basin of Sanjian plain which is a important food base of China. In this study variations in the frequency of extreme streamflow events (warm season and cold season) available from historical records are analyzed by using parameter and non-parameter methods. This study found that the magnitudes of warm season events of Baoqing Station become the largest in the larger return period, while the magnitudes of Caizuizi Station become the smallest between 25 yr and 100 yr; the frequency of extreme events of Bao'an Station increased during the cold and warm seasons and peaked near 2010, Baoqing Station has them during 1960s and 1970s, while the Caizuizi Staion has them during 1960s and 1990s; the Baoqing Station are the most probably having the extreme events happened than that of other two Stations.

36. Field-Scale Phosphorus Loading Assessment: Development and Application of TIN-Based SWAT Model

Yan Zhu,* *zhu69@wisc.edu*
John Reimer, University of Wisconsin-Madison
Andrew Skog, University of Wisconsin-Madison
Chin H. Wu, University of Wisconsin-Madison

Excessive nutrient loadings such as phosphorus to surface waters are major concerns in much of the United States. Regulations such as the development of Total Maximum Daily Loads (TMDLs) are established to set pollution limits from nonpoint and point sources that aim to restore and maintain the chemical, physical, and biological integrity of the water body. Based on the water quality criterion in the stream or lake, the TMDL defines load allocations at a watershed level. However, the roadmap to managers on implement practices at a field scale is unclear. Thus, field-scale phosphorus loading assessment tools are in urgent need to assist in identifying locations to implement practices that can provide improvements to overall water quality. In this talk, a new Triangulated Irregular Network (TIN) - based Soil and Water Assessment Tool (SWAT) model is developed to assess the field-scale phosphorus loading to surface waters. Results from TIN-SWAT are compared with those obtained from Soil nutrient application planner (SnapPlus), a field calibrated tool to calculate potential soil and phosphorus runoff losses. Phosphorus from farm fields can thereby be transported to nearby surface waters by runoff. To address phosphorus transport in stream flow hydraulics, we incorporated a spatially a spatially distributed flow routing component into TIN-based SWAT model. The new model is capable of simulating phosphorus transport from farm fields, through streams and rivers, into downstream water bodies to investigate implementing practices and their implications to total load versus stream concentration. Overall, this development of TIN-based SWAT model provides a cost effective tool for prioritizing the implementation of field scale practices to meet TMDL water quality goals. (Student presentation)

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37. Passive Stormwater Agricultural Runoff Sampling

Philip J. Parker, University of Wisconsin-Platteville Environmental Engineering, parkerp@uwplatt.edu
Dennis L. Busch, University of Wisconsin-Platteville Pioneer Farm, Research Manager
John Panuska, University of Wisconsin-Madison Distinguished Facility Assistant
Richard Stephens, University of Wisconsin-Stevens Point Water and Environmental Analysis Lab, Retired
Cassie Elmer, University of Wisconsin-Platteville Environmental Engineering Student

For several years, Pioneer Farms has been monitoring and testing runoff quality and quantity in hopes of having a better understanding of how various storm events or temperature changed effect runoff and snowmelt. The current system in use is automated and costs around $40,000. In order to make this monitoring system more available, a manual system for quantifying and testing water is being designed. When designing a new system, it is important that the system will be able to give you the correct volume of runoff for the event, as well as a representative sample of the runoff water quality. Two types of manual systems were designed to see how they would perform. First, a multi orifice passive sampler (MOPS) was designed and attached to the end of the flume. This was designed to catch a 1:1000 split (i.e. if 1000 gallons passes through the flume, the multi orifice sampler will collect one gallon). Second, a slit-weir passive sampler (SWPS) was designed to have a 1:50 split. These two designs were tested alongside an Isco sampler, the current method for runoff collection, the OEM peristaltic pump sampler, and a grab sample.

Session 3A:

Agriculture and Groundwater

Friday, March 6, 2015

8:30 – 10:10 a.m.

Investigating Intra-annual Variability of Well Water Quality in Shallow Carbonate Rock Aquifers

Kevin Masarik, UW-Extension & UW-Stevens Point, *kmasarik@uwsp.edu*
Davina Bonness, Kewaunee County Land and Water Conservation Dept.

More detailed data are needed in shallow carbonate rock aquifer regions to establish better guidelines for homeowners to reliably assess the safety of their well water system and provide a foundation for monitoring potential changes to groundwater quality over time. The Town of Lincoln has approximately 334 households that rely on private wells and a septic system or holding tank. Nearly 70% of the land base is used for agricultural purposes with the majority of acreage having a current nutrient management plan. Ten wells were tested monthly for 1-year in the Town of Lincoln in Kewaunee County. Specifically we were interested in bacteria and nitrate; however, alkalinity, Cl, hardness and pH were also measured. Coliform bacteria were detected at least once in 6 different wells; 4 wells did not detect bacteria. Levels of coliform bacteria were generally low; the maximum result was 60.2 MPN cfu/100mL. The greatest number of sample periods that any one individual well tested positive was 7. Wells that were positive one month often came back negative the following month, even though no corrective measures took place. None of the wells tested positive for E.coli bacteria. In this geologic setting, a once annual coliform bacteria test is not adequate to assess the year-round bacteriological safety of a private well. Even monthly sampling may not capture the magnitude of bacterial contamination that may result from a rapid recharge event. Nitrate-N was stable in 5 wells (StDev < 0.7 mg/L), while the other 5 showed greater variability (StDev 1.4 – 3.8 mg/L). The greatest difference observed in any one well between the min and max concentration was 13.6 mg/L. Nitrate did fluctuate, but was more stable than expected. Sampling wells bi-annually during non-event flow conditions for nitrate and other chemical constituents over the long-term has potential for illustrating annual fluctuation or detecting widespread changes to groundwater quality.

* * *

Lower Wisconsin State Riverway Floodplain Lakes - A Groundwater Study to Delineate Nutrient Contribution Areas

David Marshall, Underwater Habitat Investigations LLC, *underh2ohab@mhtc.net*
Kenneth Wade, Kenneth Wade Consulting LLC
Kevin Masarik, UW – Stevens Point & UW – Extension

Jones Slough, Norton Slough, Bakken's Pond and Long Lake are four cutoff channel oxbow lakes that lie within the Lower Wisconsin State Riverway in Sauk County Wisconsin. Oxbow lakes are essential features of river ecosystems and represent a class of lakes that are environmentally sensitive and threatened by a environmental degradation. Our four study oxbows are examples of degraded habitats due to groundwater contamination. They lie adjacent to intensively managed agricultural fields located on sandy river terraces with high susceptibility to groundwater contamination associated with agricultural nutrient applications. Recent studies have documented elevated nitrate concentrations and excessive free floating plant growths in the lakes. Secondary effects of these eutrophic conditions include low dissolved oxygen concentrations and habitat degradation that threatens state endangered fish and other species.

Using Enteric Pathogens to Assess Sources of Fecal Contamination in the Silurian Dolomite Aquifer: Preliminary Results

Maureen Muldoon, UW-Oshkosh, *muldoon@uwosh.edu*
Mark Borchardt, USDA-Agricultural Research Service
Susan Spencer, USDA-Agricultural Research Service
Laura Hubbard, USGS Wisconsin Water Science Center
Randy Hunt, USGS Wisconsin Water Science Center

The Silurian aquifer is an important, but vulnerable, source of drinking water in northeastern Wisconsin. In areas where soils are thin, there is a history of "brown water" events that occur in response to groundwater recharge. Sampling programs in Kewaunee County indicate that ~42% of wells in the Town of Lincoln do not meet drinking-water standards due to the presence of bacteria and/or exceedance of the US EPA nitrate standard. As resource managers try to address these water-quality problems, there is no consensus as to whether the main source of fecal contamination is human or bovine waste. Dairy farming and associated crop production comprise the primary land use and manure is commonly applied to crop land. Within the town, there are approximately 13,500 cattle and 334 households. We completed a pilot project to assess whether sampling wells for enteric pathogens could be an effective method of assessing sources of fecal contamination. Sampling was conducted in May 2014 and involved pumping ~800 L of groundwater through hemodialysis filters. Quantitative polymerase chain reaction (qPCR) methods were used to determine genome concentrations for microbial targets divided into three fecal-source groups: 1) human-specific microbes; 2) bovine-specific microbes; and 3) non-specific microbes found in fecal wastes of humans, bovines, and other animals. Results indicate that 7 of the 10 sampled wells were positive for fecal contamination. Two wells contained human-specific viruses, one well contained bovine-specific viruses, one well contained both virus types, and one well was positive for bovine Bacteroides. Salmonella species and Campylobacter jejuni were identified in four wells and one well, respectively, which is a human health concern. Future efforts will 1) determine the timing of fecal contamination in relation to groundwater recharge and meteorological variables and 2) assess the extent of fecal contamination in the Towns of Lincoln, Red River, and Brussels.

* * *

Migration of Inorganic Arsenic at a Former Arsenic Pesticide Storage and Disposal Site

Warren Hohn, Town of Aniwa, Shawano County, *whohntesting@gmail.com*

The arsenic concentrations in the groundwater and soils and its migration patterns at a site in Shawano County used for a arsenic pesticide storage and disposal site in the 1950s provides a unique opportunity to assess the success of a remediation effort. A small shed on the property was used to store unused liquid formulations of arsenic, possibly sodium arsenic. Steel barrels were buried in a shallow 10-foot square pit next to the shed. In 1984, the site was cleaned up with the removal of the hazardous sources from the shed and the burial pit. In addition, two feet of soil surrounding the barrels was removed. Prior to the cleanup, arsenic levels in the soils ranged from 8,000.0-57,000.0 mg/Kg. In 2011, a monitoring well near the former storage shed was found to contain 72,000.0 ug/L As and a down gradient well 60 ft. to the southeast contained 549.0 ug/L As, exceeding the WDNR enforcement standard of 10.0 ug/L. Dissolved arsenic levels in the monitoring wells for the last 24 years suggest that some contaminated source remains on the site. In 2004, an additional monitoring well was installed 135 ft. southeast of the burial pit with dissolved arsenic concentrations gradually decreasing from 444.0-5.7 ug/L. In 2007 elevated levels of soil arsenic were found near the original burial site, 281.0-232.0 ug/L at a depth of 3-6 ft. and just south of the original site, 87.1-465.0 ug/L at 12-18 ft. Additional soil borings in 2012 indicated excessive arsenic concentrations south and west of the old shed foundation at 0-10 ft. of 110.0-8360.0 mg/Kg. Private drinking water wells to the west and north of the site have arsenic concentration of 4.0-9.2 ug/L.

Subsurface Transport of Cryptosporidium Oocysts in Soils of Wisconsin's Carbonate Aquaifer Region

Zach Zopp, UW-Madison: Biological Systems Engineering, *zopp@wisc.edu*
Anita M. Thompson, UW-Madison: Biological Systems Engineering
Sharon C. Long, UW-Madison: Soil Science
K.G. Karthikeyan, UW-Madison: Biological Systems Engineering
Frederick W. Madison, UW-Madison: Soil Science

Much of Northeastern Wisconsin overlies a shallow carbonate aquifer from which private well contamination with microbes normally associated with manure is common place. The soils vary significantly throughout this region, with parent materials associated with diverse glacial tills to clay-rich lake bed sediments and a shallow loess silt cap. The soils overlying the carbonate bedrock are the last possible point to prevent groundwater contamination by land application of manure. Preferential flows through soil macropores have been shown to be the primary route for pathogens to travel from the soil surface to the subsurface, bedrock and groundwater. Cryptosporidium is one pathogen commonly found in manure and known to contaminate groundwater. At a rate of 17.4 cases per 100,000, Wisconsin leads the nation in reported cases of cryptosporidiosis, the human illness caused by Cryptosporidium. Our research has focused on the soils of NE Wisconsin and determining the potential for subsurface transport of Cryptosporidium parvum (C. parvum) oocysts. A screening of 10 soil series has lead to the selection of 3 soils (Lomira, Hochheim, Hortonville) based on a range of physical characteristics for laboratory experimentation. C. parvum transport experiments consisted of simulated rainfall on intact soil cores (15cm W x 50cm L) of the selected soils, which had been surface applied with manure spiked with 10^6 C. parvum oocysts. Results to date have shown C. parvum oocysts transport to be typically governed by the first flush effect. In other words, guided by macropores to migrate downward through the soil column. Furthermore, C. parvum oocysts can penetrate the A and B soil horizons with advective flow, thus reaching the glacial till layer. Once at the till layer, C. parvum can continue its downward migration to groundwater. These findings can be applied toward new best management practices such as landscape position prioritization or manure incorporation techniques.

Session 3B:

Managing Water Resources

Friday, March 6, 2015

8:30 – 10:10 a.m.

Irrigation Rates in Wisconsin

Robert Smail, Wisconsin DNR, *robert.smail@wisconsin.gov*

Starting with 2011 water use data, the Wisconsin DNR estimated and analyzed irrigation rates for various crops across Wisconsin. This presentation will detail methods and results from this work showing variation in irrigation across crop types, locations and soils. These results highlight the impact of the 2012 drought and will also show how Wisconsin compares to other vegetable growing regions in the country. In addition, this presentation will show the growth in construction of irrigation wells over time and highlight where irrigation is most likely to grow in the future.

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Predicting natural phosphorus concentrations in Wisconsin streams using a Spatial Stream Network geostatistical model

Michael Shupryt, WI DNR, *michael.shupryt@wisconsin.gov*
Aaron Ruesch, WI DNR

Recently, some States have begun adopting numeric criteria for in-stream nutrient concentrations. As nutrients are naturally occurring and vary across the landscape there are likely cases where background concentrations may naturally exceed the criterion. To determine natural background phosphorus concentrations we built a geospatial statistical model for Wisconsin's streams using the Spatial Stream Network (SSN) package developed by Ver Hoef and Peterson (2010) that uses a linear model with an autocovariance function based on hydrologic network distances. Using the SSN package, we a fit a model of stream phosphorus concentrations at least-disturbed reference sites using a rich database of landscape-based predictor variables joined with the Wisconsin hydrologic network. At the 178 reference sites, the model performed fairly well with a leave-one-out cross validation correlation r=0.52 and a standard prediction error ± 0.013 mg/l. Predictions were then applied to disturbed streams to predict pre-settlement phosphorus concentrations. We predicted natural background phosphorus concentrations across Wisconsin at 30,000 stream reaches which may be especially important in heavily impacted regions where discerning natural from anthropogenic phosphorus can be difficult with other methods.

* * *

Results from a decade of groundwater protection in a Wisconsin community

Douglas Cherkauer, Emeritus Professor, UW Milwaukee, *aquadoc@uwm.edu*

Richfield, WI, a village of about 12,000, is entirely dependent on private wells in the glacial/Silurian aquifer for its water supply. Concerned about drawdown problems in neighboring communities, adopted a groundwater protection plan in 2004. In short, the plan started with the adoption of good land-use

planning as an attempt to keep water demands within the limits of the available supply. It authorizes bimonthly monitoring of water levels and biannual testing for bacteria. It also requires developers to provide an analysis of the hydrogeology beneath a development, to make a good faith estimate of the quantity of water to be withdrawn, and then to show that the drawdown from the project will not exceed one foot at the property's boundary. Ten years of monitoring or over 40 wells and 20 surface water locations now allows determination of where problems may exist and what's causing them. Several conclusions can be drawn. First, the community remains very supportive of the program and its concept. Second, the data collected from monitoring can be presented in a fashion which allows well owners to easily see what's happening. Third, the expected villains in water level declines (quarries, golf courses) are not having a measureable impact, but a new development may be. Lastly, water levels are declining in one part of the village, but the cause is natural, not human-induced. The results and hydrogeologic background for the protection program are available online at: www.richfieldwi.gov/. From the home page, follow the links to: >Government >Departments >Planning & Zoning >Groundwater Protection.

* * *

Building the Wisconsin Water-Use Data Exchange

Cheryl Buchwald, USGS, *cabuchwa@usgs.gov*
Jim Hudson, WDNR
Kathy Mooney, WDNR
Shaili Pfeiffer, WDNR

Water-use data collected across Wisconsin are essential to understand current supply, project future demands, calculate water budgets and track water-use trends. However, state and federal agencies are not consistent in what water-use data they collect, how they store it, and how they share water-use data. To support the cooperative water-resources programs and investigations of the Wisconsin Department of Natural Resources (WDNR) and U.S. Geological Survey (USGS) Wisconsin Water Science Center, we are developing a process to provide exchange of water-use data and information across agencies. This process, called the Wisconsin Water-Use Data Exchange (WI-WUDE), is currently developing a crosswalk through the Exchange Network between the WDNR's Water Use database and the USGS's Site-specific Water-Use Data System. The WI-WUDE will serve as a one-way web service that will use a common data schema to make data sharing from the WDNR to USGS more streamlined, timely, and sustainable. This work will provide better information about where, how, and by whom water is being used. The WI-WUDE will also provide the necessary data to help to identify trends or existing and emerging problems, to design and implement resource-management programs, and to determine the effect of water use on hydrologic systems including water quantity, flow, and quality. This presentation will provide the background of the WI-WUDE project, how it will function, the types of data it will make available, and why access to the information is important for water resource scientists and managers.

* * *

If there is no history to a stream, is it a stream?

Martin Griffin, State Natural Resources Department, *martinp.griffin@wi.gov*

Agriculture has long been a part of Wisconsin's history. Wisconsin's agricultural exports range from dairy products to ethanol fuel and leads the nation in cranberry exports. This makes it one of Wisconsin's important industries that contribute to the State's economy. But in a water rich state like Wisconsin, what happens when the use of our natural resources for economic gain intersect with the health and quality of the actual natural resources we are trying to use? Under the state's public trust doctrine, laws have been created to preserve the public's interest in navigable waterways. Under these laws the State Department of Natural Resources (DNR) is tasked with balancing the reasonable right of agricultural landowners to undertake activities in and around public waterways while also protecting the public's right to navigate, recreate, and have good fish and wildlife habitat, water quality in public waters. This presentation will examine the jurisdiction the state has over navigable waterways on agricultural lands and outline what agricultural activities need authorization from the state and which do not. The presentation will also attempt to highlight how the laws treat agricultural drainage ditches (do they have stream history or not?) and how they fit into the public's interest.

Session 3C:

Urban Water Quality

Friday, March 6, 2015

8:30 – 10:10 a.m.

Bioretention Studies Searching for an Engineered Soil Mixture that Reduces Phosphorus

Judy Horwatich, USGS, *jahorwatich@usgs.gov*
Roger Bannerman

Wisconsin's Department of Natural Resources technical standard for bio-retention systems (technical standard 1004) requires an engineered soil mixture composed of concrete sand and compost. Unfortunately, previous studies in Wisconsin have determined enough phosphorus is leached from the compost to greatly elevate the concentration in the drain tile effluent. In an attempt to find an engineering soil that does not leach phosphorus two alternative mixes have been tested. In 2011 and 2012 testing of a mixture of sand, peat moss, and a proprietary product proved to be an improvement over a mixture containing compost, since the effluent phosphorus concentrations were not higher than the influent concentrations. In fact, the influent and effluent concentrations were not significantly different, so the media did not produce the desired reduction in phosphorus concentrations. At this point it was decided to use the media developed at North Carolina State University (NCSU) that contains very little organic matter and has proven to reduce phosphorus concentrations. To test the NCSU media, a 500 square foot bioretetion system was constructed at the edge of a parking lot in Middleton, WI. The media was a mixture of 87% concrete sand, 8% fines, and 5% pine bark. Monitoring began in 2012 and sample collection ended in the spring of 2014. Flow and water quality data were collected at the influent, effluent, and overflow structures for the system. All the runoff water was discharged by the drain tile, since an impermeable membrane was installed at the bottom of the media. The most dramatic discovery was high level of fines discharged from the system in the spring. It appears the heavy salting of the parking lot dispersed the clay in the mix due to the sodium absorption ratio effect. The fines could clog a system that is designed for volume control. Results from the 20 sampled runoff events indicate the effluent concentrations of phosphorus tend to be higher than the influent from the parking lot.

* * *

Asessing the Effects of Riverbank Inducement on Groundwater Quality on a Shallow Aquifer in Southeastern Wisconsin

Laura Fields-Sommers,* University of Wisconsin Milwaukee, *fieldss2@uwm.edu*
Timothy Grundl, University of Wisconsin Milwaukee

The state of Wisconsin is heavily reliant upon groundwater resources. In order to induce river water, implementation of shallow wells with close proximity to river systems is being used as a method to augment groundwater supplies in portions of southeastern Wisconsin. However, river bank inducement wells (RBI) are vulnerable to contamination due to their close interaction with the surface water. The vulnerability increases when induced surface waters contain municipally treated waste water. An ideally located, existing monitoring network in Waukesha County, Wisconsin with two RBI wells and a background well are being utilized as the field site for this study. This study intends to determine the recharge mechanisms of the RBI well field, discriminate the source(s) of salt influx seen in the well field, and continue overall geochemistry tracking in order to compile a long-term data base with which to

compare future changes. Stable isotope analysis of δ18O and δ2H ratios will be used to define the dynamics of the river and riverine influx into the well field. Major ion analysis of the well field will furnish a continuation of characteristics of the well field and the breakthrough curve associated with pumping. (Student presentation)

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Impacts of a Rural Subdivision on Groundwater Quality: Documenting a Transition From Agriculture to Residential Land Use

Ken Bradbury, Wisconsin Geological and Natural History Survey, UW-Extension, *krbradbu@wisc.edu*
Todd Rayne, Hamilton College
Jacob Krause, Wisconsin Geological and Natural History Survey, UW-Extension
Jeffrey Wilcox, University of North Carolina at Asheville

This hydrologic study of the lakes and associated floodplain and river terrace areas utilized groundwater well and piezometer clusters along with lake and river staff gages to determine groundwater hydraulic gradients and water quality variation. Lake biological surveys were also conducted. The results indicate the distribution of nutrients in the lake and groundwater in the lake areas is related to adjacent agricultural land uses. Mapping each lake's groundwater recharge area will provide valuable land use planning information and assist in working with landowners to strategically target nutrient reduction practices in those areas with greatest impact on lake water quality.

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River Chloride Trends in Snow-Affected Urban Watersheds: Increasing Concentrations Outpace Urban Growth Rate and are Common among all Seasons

Steven Corsi, U.S. Geological Survey, *srcorsi@usgs.gov*
Laura De Cicco, U.S. Geological Survey
Michelle Lutz, U.S. Geological Survey
Robert Hirsch, U.S. Geological Survey

Chloride concentrations in northern U.S. urban streams where road salt deicers are used during winter months doubled from 1990 to 2011, outpacing the rate of urbanization. Historical chloride and streamflow data were examined for 30 monitoring sites on 19 streams. Data availability at individual sites varied with 18 to 49 years of data ending in 2011 and 151 to 2506 samples. Trend analyses were done using locally weighted regression to distinguish between concentration differences over time and seasons in the context of flow-dependency. Chloride concentrations increased in 13 of the 19 studied streams in all seasons. In winter 16 of 19 streams had increased chloride concentrations; maximum concentrations of chloride were observed during winter coincident with application of road salt deicers. Increasing concentrations at the majority of streams during non-winter periods suggest that runoff with high chloride concentrations is infiltrated to shallow aquifers during the winter and continually released as baseflow to urban streams throughout the year. Chloride concentrations also increased as streamflow decreased, a result of dilution of chloride during rainfall- and snowmelt-induced high-flow periods. The increase in chloride concentrations increased the potential chloride-related effects on aquatic biota; 27% of sites studied exceeded the concentration for the U.S. Environmental Protection Agency chronic water quality criteria of 230 mg/L by an average of more than 100 individual days per year during 2006-2011. Results clearly indicate that chloride concentrations increase with urban land cover, but concentrations are

increasing more rapidly than urbanization. This is likely due to a combination of possible increased road salt application rates, increased shallow groundwater concentrations that discharge to these streams, and more need for deicer because of greater snowfall in the Midwestern U.S. during the latter portion of the study period.

* * *

The Fate of Emerging Contaminants in a Municipal Waste Water Treatment Plant

Tim Grundl, UW-Milwaukee, *grundl@uwm.edu*
Ben Blair, UW-Milwaukee
Curtis Hedman, State Lab of Hygiene
Rebecca Klaper, UW-Milwaukee

In this study, the fate and occurrence of 57 pharmaceuticals and personal care products (PPCP) and hormones were evaluated in an activated sludge process and the mass balances were determined. The goal of the project was to better understand the overall removal of PPCPs and hormones from an aerobic wastewater treatment process. The samples containing in situ PPCPs were collected from the South Shore Water Reclamation Facility (SSWRF) in Milwaukee, WI. Forty-eight of the PPCPs were detected in the soluble form above the minimum detection limit and 29 were detected sorbed to solids. Intrinsic biodegradation rates were determined for 28 compounds.Two novel results were found. First, a subset of the highly biodegradable PPCPs stop being degraded at low, yet notable, concentrations perhaps due to co-metabolic limits. Second, sorption to bacterial biomass within the aerobic basin was slow with respect to degradation rates. This results in significant transport out of the basin on solids. Overall, the results from this study provide new insights into the fate of PPCPs during wastewater treatment by evaluating the degradation kinetics and sorption to sludge of 57 PPCPs within an activated sludge process.

Session 4A:

Wetlands

Friday, March 6, 2015

10:30 – 12:10 p.m.

Floating Bog Interceptors (FBIs): An Innovative Ecological Tool for Wetland Protection

Michael Busch,* University of Wisconsin-Madison, *mpbusch@wisc.edu*
Chin Wu, University of Wisconsin-Madison

The ecological impacts of wetlands have tremendous importance on surrounding communities, including the retention of nutrients. Over the past century, however, the worldwide wetland coverage has diminished considerably. This trend has occurred in Wisconsin as well, including Dane County's largest wetland: Cherokee Marsh in Madison, WI. In this talk, we will introduce an innovative ecological tool for wetland protection. Specifically, the design, installation, and outcomes of the Floating Bog Interceptors (FBIs) in Cherokee Marsh are presented. It is found that the FBIs function like breakwaters, effectively attenuating 75% of incoming wave energy. The effects of wave attenuation provide sheltered regions, promoting favorable habitat for vegetation growth and wildlife animals. In addition, the decrease of flow field and wave diffraction-induced circulation result in accumulating sediments behind FBIs. Over the course of three summers from 2012 to 2014, after installing FBIs, an average of 3 inches/year sediment accumulation was observed. Overall the results demonstrate that FBIs can be used as a wetland protection tool that can contribute ecological benefits with the physical protection and sediment accumulation of a detached "ecological" breakwater system. (Student presentation)

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Role of River Backwater Wetlands on Flood Reduction

Biyun Sheng,* University of Wisconsin - Madison, *bsheng4@wisc.edu*
Chin H. Wu, University of Wisconsin - Madison

Role of river backwater wetlands on flood reduction Biyung Sheng, Department of Civil and Environmental Engineering-UW Madison, Madison, WI, bsheng4@wisc.edu Chin H. Wu, Department of Civil and Environmental Engineering-UW Madison, Madison, WI, chinwu@engr.wisc.edu ABSTRACT The effectiveness of river wetland function on flood reduction can vary, depending on the size of the area, type and condition of vegetation, slope and location of the wetland in the flood path, and the saturation of wet-land soils before flooding. From the time perspective, when the wetland storage is short-term, flood peaks are delayed and attenuated. In the case of long-term wetland storage, flood volumes are reduced if the stored water in floodplain is retained so that local evapotranspiration increases. In the last century, many dams for controlling lake levels or bridge structures for transportation are built. As a result, backwater effects are significantly alter hydrologic wetland functions, in particular flow connectivity between rivers and floodplains. While many efforts have devoted to assess the ecological impacts, little has been paid to examine the role of backwater wetlands on flood reduction due to lack of fully coupled surface water and groundwater models. In this talk, we will present a case study to assess the backwater effects on wetland flood reduction (peak discharge attenuation and peak time delay). Specifically a coupled surface-groundwater model, HydroGeoSphere, is applied for the subwatershed including the Yahara River, Cherokee Marsh, Cherokee Lake, and downstream Lake Mendota, where the Tenney dam and the Highway 113 bridge constriction are located. The effects with and without backwater on the

hydrological connectivity and wetland storage and drainage are compared. Furthermore we examine the potential benefit of flood reduction for a large scale in-stream wetland restoration at the study site. Results show that the subsurface wetland storage decreases under the backwater effects due to dam and constriction and the in-stream wetland restoration. On the other hand, the surface wetland storage dramatically increases due to the enhanced hydrological connectivity. Overall it is suggested that the backwater wetland provide an optimal flood reduction by keeping the dam and the constriction, and restoring the in-stream wetland. (Student presentation)

* * *

Wetlands and Agriculture - Are Wetland Permits Needed?

Cami Peterson, Waterway and Wetland Protection Section, Bureau of Watershed Management, Wisconsin Dept. of Natural Resources, *cami.peterson@wisconsin.gov*

Have you ever noticed that wet area in the middle of a crop field, or livestock wading around in a low area and wondered if it was wetland? Or have you noticed a ditch being dug or drain tile placed in what looks like a wetland and wondered if that was legal? Recognizing whether a wetland is present on agricultural land is often difficult, and how the agricultural industry and our state's wetland regulations interact can often be complex and confusing. This presentation aims to provide some background on why wetlands are important to the agricultural industry, describe some simple tools to identify wetlands on agricultural land, and clarify when an agricultural activity in a wetland is regulated and when it may not be.

Session 4B:

Potpourri

Friday, March 6, 2015

10:30 – 12:10 p.m.

Shallow Groundwater and Soil Texture Drive Subfield-Scale Yield Patterns

Samuel Zipper,* University of Wisconsin-Madison, *szipper@wisc.edu*
Steven P. Loheide II, University of Wisconsin-Madison

Understanding the influence of shallow groundwater on crop production is critical to maximizing productivity on existing agricultural land. One rarely considered component of groundwater-yield relationships is the role soil texture and weather play in influencing yield within a field. A shallow water table can either increase drought resilience or increase the risk of flood damage, depending on growing season precipitation and the water retention properties of the soil. Focusing on two commercial cornfields in south-central Wisconsin, we identify subfield-scale yield variability that is driven by both the availability of groundwater during the growing season and soil texture within the field. In general, we find that areas with the shallowest water tables have sensitive yield to wet growing seasons, while areas with the deepest groundwater are most sensitive to dry growing season conditions. Using AgroIBIS-VSF, a biophysical agroecosystem model validated at our study site, we perform a series of factorial experiments to identify and separately analyze the roles of groundwater, soil texture, and weather in influencing year-end yield. We find that the optimum water table depth for corn production varies from year-to-year, with increased variability in finer soils and deeper optimum water table depths in wetter years. These findings have important implications for the design of agricultural drainage systems as well as precision agricultural management. (Student presentation)

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A Revision to the Textbook Applied Groundwater Modeling: Opportunities for Online Wisconsin Hydrology

Randall Hunt, USGS WI Water Science Center, *rjhunt@usgs.gov*

The 1st edition of Applied Groundwater Modeling (Anderson and Woessner 1992) was well received for being an essential treatise on the hydrologic application of groundwater flow models, and remains in print even today. This longevity notwithstanding, the authors recognized the need to update their coverage of applied modeling. In 2010 they asked me to coauthor a 2nd edition with the same title. During these last 4 years it has become apparent that applied groundwater modeling has grown exponentially, with projects occurring all over the world. As such, any modern textbook can only be a partial snapshot of a rapidly evolving profession; an online presence can augment, amplify, and extend the best practices and ideas captured in the 2nd edition in an expanded and continually evolving way. In recognition of this potential, I am tasked with maintaining a public website associated with the book after its publication in May 2015. One goal is to facilitate better groundwater modeling worldwide by facilitating public access to teaching and ancillary supporting material – much of it created by Wisconsin hydrologists. The book's website can be used to direct the interested public to teaching materials, example problems, tutorials, and downloadable models hosted by Wisconsin organizations. The book's website provides a portal, and your local hosting and associated credit attribution can serve to increase the profile of Wisconsin

hydrology. Given such a portal approach, a request is to provide these materials using terminology and concepts consistent with the book's presentation. An overview of what is new in the 2nd edition will be presented to facilitate discussion on the topic.

* * *

Effects of High Frequency Water Level Oscillations on Contaminated Sediment Transport in the Manistique River, Michigan

Alvaro Linares,* University of Wisconsin, Madison, *linares2@wisc.edu*
Joshua Anderson, University of Wisconsin, Madison
Chin Wu, University of Wisconsin, Madison

Contaminated sediments is a significant environmental problem that impairs the uses of many water bodies and is often a contributing factor to fish consumption advisories that have been issued nationwide. The Manistique River, located in the north of Lake Michigan, is listed by the US Environmental Protection Agency as an Area of Concern (AOC) due to its high contaminated sediment concentration. Currently remediation actions have to be conducted to mitigate the possible effects of contaminants in nature. The success of remediation actions depend on the understanding of sediment transport processes, such as resuspension, transport and deposition, which are crucial in the cycling of pollutants. In this talk, we will examine contaminated sediment resuspension caused by the so-called High Frequency Water Level Oscillations (HFWLOs), with periods ranging from a few minutes to 2 hours, in the Great Lakes. During two months in 2012, eleven HFWLOs in Lake Michigan were associated with variations of abrupt changes of barometric pressure and wind. Extensive field observations show that HFWLOs with wave height up to 3.5 ft were associated with the cross of traveling atmospheric disturbances over Lake Michigan. HFWLOs are long waves that can effectively disturb the lake bottom in even deep water environment. As a result, the bottom shear stresses induced by HFWLOs may exceed the critical condition to resuspend sediments. Due to their oscillatory nature, HFWLOs can temporarily reverse flow in the Manistique River and transport contaminated sediments upstream to previously cleaned areas. A coupled hydrodynamic and contaminated sediment model for the Manistique River is developed to assess the fate and distribution of contaminated sediment for a series of dredging scenarios under the effects of HFWLOs. Overall the outcomes of this study aid to address the sustainable remediation plan of contaminated sediments in river estuary AOC of the Great Lakes. (Student presentation)

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Impacts of Delineation Methods on Modeled Runoff in Watersheds Containing Non-Connected Internally Drained Depressions

Bill Troolin,* College of Natural Resources, University of Wisconsin, Stevens Point, *wtroo165@uwsp.edu*
Katherine Clancy, College of Natural Resources, University of Wisconsin, Stevens Point

Modeling precipitation-generated runoff in watersheds is an important land-use planning and management tool. In order to accurately model runoff with GIS software, areas that are capable of contributing runoff to surface waters must be correctly identified. This is best accomplished by using watershed delineation methods able to accurately represent unique regional topographical characteristics. Identifying areas contributing runoff to streams is problematic in regions containing many topographically-closed internally-drained depressions and low relief over large distances such as in the Upper Midwest of the United States. Traditional delineation methods fill sinks in the terrain under the assumption that most are results of data errors. This can cause inaccuracies when modeling runoff in extensively internally-drained watersheds. I compared four delineation methods for several northern

Wisconsin and Minnesota watersheds: filled-sink delineation, removing filled sinks from consideration with reclassification, Potential Contributing Source Area, and hydrologic units. Delineated watershed areas were used to model runoff in ArcMap using the curve number method. I modeled the largest rain events based on precipitation data from nearby rain gauges. Model results were compared to hydrographs based on USGS discharge data by separating base flow from direct flow using the local minimum method and calculating runoff for an event. Initial results from four watersheds indicate that model results most closely reflect measured discharge using Potential Contributing Source Area delineations, followed by removal of filled sinks, with filled-sink watershed boundaries and associated hydrologic units generating the highest overestimation at up to ten times observed direct flow. All delineations tend to overestimate runoff, even methods which produce watershed areas less than half of filled sink delineations. Additional modeling in six watersheds is currently under way. (Student presentation)

* * *

Simulating the Effect of Climate Change on Stream Temperature in Black Earth Creek

Bill Selbig, USGS, *wrselbig@usgs.gov*

A one-dimensional SNTEMP (Stream-Network TEMPerature) model was used to simulate daily mean stream temperatures in Black Earth Creek, Dane County, Wisconsin. The calibrated model was used to forecast the potential effects of climate change on stream temperature. Downscaled climate models and emission scenarios from the 2007 Intergovernmental Panel on Climate Change (IPCC) report, covering two 20-year simulation periods of 2046-2065 and 2081-2100 provided the necessary SNTEMP inputs for daily mean air temperature and solar radiation. These same climate models were also used in a GSFLOW (Groundwater/Surface-water FLOW) model to provide simulated streamflows. Other basin characteristics including shading properties, geometry, and climate coefficients were measured in the field or based on published values. Simulated stream temperatures increased appreciably in the latter part of the 21st Century. The upper, high groundwater-inflow reaches of Black Earth Creek remained the coolest of all stream segments but had the largest relative increase in annual average stream temperature, ranging from 3 to 6 degrees Celsius by 2100. Smaller increases in stream temperature occur progressively downstream as relative amounts of groundwater inflow decrease. Cumulative distribution frequencies of mean daily stream temperature representing the last five years of each simulation period (May through September only) suggest optimal temperatures for Brown Trout (Salmo trutta) are exceeded with increasing frequency in the lower reaches of Black Earth Creek. Although all projected future climates showed warming, the climate drivers used for the climate-change scenarios had appreciable variation; however, among the climate models and emission scenarios selected, this uncertainty was reflected in the range of possible temperature model results for all stream segments. Thus, as with all forecasts of this type, the results are best considered to approximate potential outcomes of climate change.

Session 4C:

Water Quality

Friday, March 6, 2015

10:30 – 12:10 a.m.

Denitrification Removal Potential and Limitations in Small Sized Reservoirs

Bree Bender,* University of Wisconsin-Stevens Point, *bbend853@uwsp.edu*
Kyle Herrman

Nitrogen fertilizer being applied to agricultural fields is leaching into groundwater and contaminating adjacent surface waters. Excessive nitrogen consumption can be harmful to human health and causes detrimental effects to the environment (e.g., the dead zone in the Gulf of Mexico). Denitrification is a process mediated by heterotrophic bacteria (i.e., require organic matter to function) and converts nitrate (a mobile form of nitrogen) to dinitrogen gas (a relatively nonreactive gas) under low oxygen conditions. Studies have shown that aquatic ecosystems with higher hydraulic residence times (e.g., wetlands and reservoirs) can be important nitrogen sinks via denitrification. The objective of this study was to identify limitations on denitrifying bacteria and overall nitrogen removal potential of three small to mid-sized reservoirs (Jordan Pond, Springville Pond, and McDill Pond) in central Wisconsin. A correlation analysis of data collected in July revealed that organic matter content was driving microbial abundance ($r^2=0.6028$); however, denitrification rates were poorly correlated with organic matter content ($r^2=0.1019$). Further analysis suggests that Jordan and McDill Pond were nitrate limited in July and this limitation may have inhibited denitrification. Using a steady state mass balance approach, nitrogen removal was 6, 11, and 22% in the three reservoirs. Compared to the literature, our observed removal potentials were consistent with other lotic ecosystems and that an average water depth to hydraulic residence time metric appeared to control removal potential in our study sites. Ultimately, our data suggest that small reservoirs in central Wisconsin become nitrate limited by mid-summer and are not substantial sinks for nitrogen. (Student presentation)

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Evaluation of Feed Storage Leachate and Runoff Collection System Design and Operation

Aaron Wunderlin, UW Discovery Farms, *aaron.wunderlin@ces.uwex.edu*

As farm enterprises have grown and farming systems have changed, an increasing number of Wisconsin livestock producers are using bunker silos, stacking pads, silo bags and commodity storage sheds. These storage facilities can allow for rapid harvest, increased flexibility and improved performance of ensiled materials; but concerns have arisen about the potential of leachate moving from these storage systems to waters of the state. On many farms in Wisconsin, leachate collection systems are required to capture the leachate and runoff perceived to have the most risk and store it for land application, while the rest overflows to a vegetated treatment area. From 2012 through 2014, Discovery Farms evaluated the water quality from feed storage on three Wisconsin farms. Discovery Farms is corroborating its findings with a similar study performed by Becky Larson of the UW Biological Systems Engineering department and PhD candidate, Mike Holly. The goal is to assess current leachate system designs to potentially improve future system designs and/or determine other options for treating leachate and runoff.

* * *

Pathogens in Non-Disinfected Drinking Water from Community and Non-Community Wells in Minnesota: Reprising Wisconsin Research Across the Border

Joel Stokdyk, USGS, *jstokdyk@usgs.gov*
Anita C. Anderson, Minnesota Department of Health
Lih-in W. Rezania, Minnesota Department of Health
Susan K. Spencer, USDA
Aaron D. Firnstahl, USGS
Mark A. Borchardt, USDA

A previous Wisconsin study, Water and Health Trial for Enteric Risk, demonstrated the value of assessing pathogen occurrence in community wells and prompted action by the Minnesota legislature. As a result, the Minnesota Department of Health is collaborating with the Laboratory for Infectious Disease and the Environment in Wisconsin to measure human enteric pathogens in public water supplies. Study Year 1 began May 2014 and involves collecting samples once every 2 months from 82 randomly selected wells that supply non-disinfected drinking water. Samples are analyzed by qPCR for 18 pathogens and markers of fecal contamination, including human and bovine viruses and agricultural zoonotic bacteria. Thus far, 130 samples have been analyzed. Preliminary results show microbial targets detected in 43 (33%) of these samples, including samples from community (40%; n = 55) and non-community (28%; n = 75) water supplies. The most common targets detected were human adenovirus species C, D, and F (12% positive samples), Salmonella (10% positive samples), and bovine polyomavirus (7% positive samples). Other detected targets were pepper mild mottle virus, human polyomavirus, rotavirus A, human enterovirus, and bovine Bacteroides. Target concentrations ranged from 0.01 to 228 genomic copies per liter. Early results indicated that human virus occurrence in these samples (28%) was similar to values reported in non-disinfected community groundwater supplies in Wisconsin (35%). In addition, only 1 well was positive for the same target both times it was sampled. If this trend continues, it may indicate that pathogen presence is transient, suggesting event-based contamination (e.g., groundwater recharge). Year 1 data will be used to evaluate contamination prediction tools (e.g., analysis of well characteristics) and to identify at-risk water supplies. Year 2 will involve an epidemiological study to relate well water virus concentrations to rates of acute gastrointestinal illness.

* * *

Quantitative Microbial Risk Assessment for Estimating Setback Distance from Aerial Irrigation of Dairy Manure

Mark Borchardt, USDA-Agricultural Research Service, *mark.borchardt@ars.usda.gov*
Tucker Burch, USGS Wisconsin Water Science Center
Rebecca Larson, Dept of Biological Engineering, UW-Madison
Susan Spencer, USDA-Agricultural Research Service
Aaron Firnstahl, USGS Wisconsin Water Science Center
Joel Stokdyk, USGS Wisconsin Water Science Center

Application of liquid dairy manure by traveling gun or center pivot irrigation systems is becoming more common in Wisconsin because it offers several potential benefits: reduced road impacts from hauling, optimal timing for crop nutrient uptake, and reduced risks of manure runoff and groundwater contamination. However, irrigation could also increase the risk of airborne pathogen transmission from manure to humans and livestock compared to other application methods. We measured air concentrations of four pathogens and three pathogen surrogates during 23 manure irrigation events on three Wisconsin dairy farms (center pivot, n = 8; traveling gun, n = 15) at multiple distances, typically up to 700 feet, downwind from the irrigation wetted perimeter. We also measured background air concentrations before irrigation and upwind concentrations during irrigation. Air was sampled by two

methods at each distance: button samplers for qPCR analysis of microbial targets and Andersen impactors for culturable bacteria. Meteorological conditions during irrigation were measured with a portable weather station. Early results show that microbial concentrations decline exponentially with distance, but can still be measurable at 650 feet downwind from irrigation depending on wind velocity and solar irradiance. We are currently constructing a two-level hierarchical model to predict downwind pathogen concentrations from meteorological variables. Using Monte Carlo simulations, pathogen concentrations predicted with this model will be input along with random sampling from distributions for inhalation rates and time spent outdoors into dose-response models to estimate the risk of infection during manure irrigation. We will present the results of this comprehensive risk assessment, the first to use measured concentrations of airborne pathogens during manure irrigation.

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Improving the Safety of Groundwater-Sourced Public Water Supplies

Madeline Gotkowitz, Wisconsin Geological and Natural History Survey, University of Wisconsin-Extension, *mbgotkow@wisc.edu*

Recent struggles in Wisconsin surrounding regulation of public water systems identify challenges to improving drinking water safety in developed nations, where drinking water supplies are generally of good quality. In the U.S., the Safe Drinking Water Act and the Ground Water Rule establish a risk-based approach to pathogen safety at systems supplied with groundwater. Following recent studies that identified public health benefits associated with continuous disinfection of municipal groundwater supplies, Wisconsin regulators established a requirement for treatment at these systems. The state legislature subsequently rescinded this rule.

This study explored factors that contributed to the failure to mandate continuous disinfection in Wisconsin. Qualitative interviews were conducted with 33 water system managers, state and federal regulators, public health officials, and water supply engineers. Participants identified impediments to improving water quality, including a lack of awareness or agreement about health risks associated with untreated groundwater, differences in perceptions about current testing requirements, and a lack of community support for improving water quality at public systems.

The conditions and experiences related through these interviews suggest that some improvements in water quality can be achieved through rigorous enforcement of current rules and increasing communication between regulators, public health officials, and local water system governance boards. In the absence of changes to federal rules, a greater responsibility to provide safe water is shifted to local officials and water boards. Village boards and commissions are charged with securing funds to ensure adequate system operation and maintenance, but the results of this study suggest they are not well-informed about risks posed by pathogen contamination of groundwater.

Index