American Water Resources Association – Wisconsin Section

The Wisconsin Section of the American Water Resources Association provides an interdisciplinary forum for people involved in all aspects of water resources research and management.
2020 Wisconsin AWRA Student Award Sponsor

Front cover photo by Megan Haserodt, USGS, the Wisconsin River near the Wisconsin Dells (USGS station 05404000), while making a discharge measurement during 2019 spring flood.
Wisconsin’s Year of Clean Water

March 12-13, 2020
Chula Vista Resort
Wisconsin Dells, WI

Support From:
University of Wisconsin Water Resources Institute
Wisconsin Department of Natural Resources
Center for Watershed Science and Education, UW-Stevens Point
Wisconsin Geological and Natural History Survey
U.S. Geological Survey Upper Midwest Water Science Center
Chula Vista Resort Facilities
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Wisconsin Geological and Natural History Survey

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Milwaukee Metropolitan Sewerage District

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Jacobs Engineering Group (formerly CH2M), Milwaukee

Laurel Braatz           Director-at-Large
Wisconsin Department of Natural Resources

Meg Haserodt           Director-at-Large
USGS Upper Midwest Water Science Center

PROGRAM COMMITTEE

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USGS Upper Midwest Water Science Center

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Wisconsin Department of Natural Resources

John Luczaj              Technical Co-Chair
UW-Green Bay

Elizabeth White         WRI Representative
University of Wisconsin Water Resources Institute

Hayley Olds,           Communications Chair
USGS Upper Midwest Water Science Center
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 and conference planning committee. 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.

Mary Anderson
Max Anderson
Andrew Aslesen
Tim Asplund
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Roger Bannerman
Bill Barnwell
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Carol McCartney
Paul McGinley
Chris Mechenich
Maureen Muldoon
Vern Norman
Vladimir Novotny
Hayley Olds
Mitch Olds
Meredith Ostrom
Dave Ozsvath
John Panuska

Mike Parsen
Dale Patterson
Mike Penn
Marie Peppler
Don Pirrung
Austin Polebitski
Ted Powell
Gary Raasch
Bruce Rheineck
Mike Rupiper
Rada Sandheinrich
Rosalie Schnick
Jo Ellen Seiser
Bill Selbig
Kari Sherman
John Skalbeck
William Sloey
Bill Sonzogni
Earl Spangenberg
Fred Spangler
Bob Stelzer
Jeff Steuer
Ron Stieglitz
Will Stites
Rick Stoll
Todd Stuntebeck
Sue Swanson
Don Theiler
John Tinker
Joan Underwood
Randy Videkovich
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Kathy Webster
Elizabeth White
Don Winter
Tom Wirth
Philip Younger
AWRA BOARD OF DIRECTORS POSITION DUTIES

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

Director-at-Large

Matt Diebel

Matt Diebel is watershed management coordinator for Dane County Land & Water Resources Department, where he develops watershed management tools, programs, and policies and evaluates water quality trends. He previously worked for the Wisconsin Department of Natural Resources in the water quality and research programs. He has a BA in biology from Colorado College, a MS in water resources management and a PhD in limnology from UW-Madison. He has experience with a wide variety of hydrologic and water quality models for streams and lakes, and is particularly interested in translating model results into formats for non-technical audiences. As a candidate for the AWRA-WI board, he is interested in recruiting and engaging student members.

Treasurer

Eric Booth

Eric Booth is an Assistant Research Scientist at UW-Madison in the Departments of Agronomy and Civil & Environmental Engineering. He also collaborates with the North Temperate Lakes Long-Term Ecological Research site, Center for Limnology, UW Arboretum, Great Lakes Bioenergy Research Center, and Wisconsin Energy Institute. He holds a BS in Environmental Engineering from UW-Madison (2004), MS in Hydrologic Science from UC-Davis (2006), and PhD in Limnology from UW-Madison (2011). His research interests cut across many disciplines with water as a centerpiece; these include hydroecology, impacts of climate and land-use change, urban stormwater management, wetland/stream restoration, water quality, groundwater hydrology, fluvial geomorphology, environmental history, agroecology, remote sensing, and numerical modeling.

President-Elect

Mitch Olds

Mitch received his Bachelor’s Degree in Watershed Management and Hydrogeology from the University of Wisconsin-Stevens Point in 2012. While attending UWS, Mitch was an active member of the student chapter of AWRA serving as Treasurer (2009-2010) and chapter president (2010-2012). Mitch is employed at the Milwaukee Metropolitan Sewerage District (MMSD) where he is involved in water quality monitoring in southeastern Wisconsin and is the captain of R/V Pelagos on Lake Michigan. Mitch received his Master’s Degree in Freshwater Sciences and Technology at the University of Wisconsin-Milwaukee. He has continued to attend AWRA Wisconsin Section Annual Meetings, serving as a judge for student presentations, and plans to continue to be involved in AWRA throughout his career.
Vice President

Michael Cardiff

Mike received his Bachelor’s Degree in Mathematics and Geology from Oberlin College (2001). After his undergraduate degree, Mike worked in environmental consulting as a senior project associate at Project Performance Corporation (PPC) near Washington, DC (2001-2004). He then returned to graduate school, completing his MS (2005) and PhD (2010) at Stanford University in Civil and Environmental Engineering, with a focus in Environmental Fluid Mechanics and Hydrology. He joined the faculty of UW-Madison in 2012 in the department of Geoscience, where he is now a tenured Associate Professor. Mike has worked on a variety of hydrogeologic problems including aquifer characterization and imaging, groundwater modeling, and contaminant source identification. He is proud to be part of the vibrant water community in Wisconsin, and looks forward to supporting opportunities for researchers, consultants, and students at AWRA meetings in the future.

Aaron Pruitt

Aaron Pruitt has been a hydrogeologist at the DNR’s Water Use Section since 2018, where he works on groundwater quantity issues throughout the state, including high capacity wells reviews, groundwater flooding issues, and the Central Sands Lake Study. Prior to the DNR, Mr. Pruitt worked for five years as an environmental consultant in Seattle, WA, working on prior appropriation water rights issues and groundwater contamination projects. He earned Bachelor’s Degrees in English and Geology from Appalachian State University in Boone, NC, and earned a Master’s Degree in Hydrogeology from UW-Madison under Jean Bahr and Ken Bradbury, where he worked on potential climate change impacts to groundwater/surface water interactions in the Chequamegon-Nicolet National Forest. Mr. Pruitt would be honored to contribute to AWRA’s work of connecting water researchers across the state and building a community of hydroscientists.
BIOGRAPHIES OF PLENARY SPEAKERS

Plenary speakers

Todd Ambs

Todd Ambs is the Assistant Deputy Secretary for the Wisconsin Department of Natural Resources, appointed in March 2019. Todd has worked in the environmental policy field for nearly four decades. From 2013 to 2019, Ambs was the Director of the Healing Our Waters-Great Lakes Coalition, a nongovernmental coalition advocating for programs and policies at the federal level that benefit the Great Lakes. Prior to that, Todd was President of the national conservation group River Network. Prior to that, he ran the Water Division for the Wisconsin Department of Natural Resources from 2003 through 2010.

His extensive experience in both state government and nonprofit organizations includes serving as Executive Director of two statewide river organizations, Policy Director for the Ohio Attorney General and Senior Policy Analyst for the Wisconsin Department of Justice.

Todd has served on a number of conservation-related boards and commissions including the Great Lakes Protection Fund, Southeast Wisconsin Watershed Trust and the Upper Mississippi River Basin Association. He currently serves on the Great Lakes Commission, the Regional Administrative Council for the North Central Region Water Network and the Wisconsin Sea Grant Advisory Council.

Todd graduated from Eastern Michigan University in 1980 with a BS in Political Science/Speech.

Rep. Todd Novak

Representative Todd Novak is currently serving his third term as a member of the Wisconsin State Assembly representing the 51st Assembly District. The 51st District includes parts of Sauk, Richland, Iowa, Lafayette, and Green Counties. He was born and raised on a farm in Cobb, WI and has been a lifelong resident of Iowa County. Prior to serving in the Assembly, he served as a newspaper editor for the Dodgeville Chronicle for over twenty years. Rep. Novak serves on the committees on Criminal Justice and Public Safety, Environment, Mental Health, and Rural Development. He is the Vice Chair of the Committee on Agriculture, is Chairman of the Committee on Local Government, and is the chairman of the 16 member bipartisan Water Quality Task Force. This session, the Water Quality Task Force held 14 hearings across the state and heard hours of testimony from experts and members of the public. In January, the task force assembled a report to present to the legislature that outlines their findings and legislative recommendations for this session.
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THURSDAY, March 12, 2020

9:00 – 11:00 a.m.  Registration
Riverview Pre-function area

11:00 – 11:45 a.m.  Welcome and Lunch
Riverview North

   Kiana Beaudin
   Executive Director, Ho-Chunk Nation Department of Health
   Opening Remarks

   Randy Poelma
   Environmental Specialist, Ho-Chunk Nation Division of Environmental Health
   Ho-Chunk Nation’s Water Resource Management Initiatives

11:45 – 1:15 p.m.  Plenary Session
Riverview North

   Todd Ambs
   Assistant Deputy Secretary, Wisconsin Department of Natural Resources
   *Moving Beyond the Year of Clean Drinking Water*

   Rep. Todd Novak
   Wisconsin State Legislature
   *Update on the Speaker’s Task Force on Water Quality*

1:15 – 1:30 p.m.  Break: E/F/G/H
1:30 – 2:45 p.m. Concurrent Sessions 1A, 1B, and 1C

Session 1A Agriculture and Water Quality
Room: A/C
Moderator: Patrick Gorski

1:30 Influence of Winter Manure Application on Non-Growing Season Nutrient Losses in Surface Runoff
Laxmi Prasad,* UW – Madison, Dept. of Biological Systems Engineering

1:45 Legacy Phosphorus in Stream Sediments: Removal & Water Quality Response
John Reimer, Dane County Land & Water Resources

2:00 Treatment of Horizontal Silage Bunker Runoff Using Biochar Amended Vegetative Filter Strips
Joseph Sanford, UW – Madison, Dept. of Biological Systems Engineering

2:15 Improving Nitrogen Management Strategies Across Wisconsin
Tracy Campbell,* UW – Madison

2:30 DATCP’s Role and Responsibility for Wisconsin’s Surface Water Quality
Ken Potrykus, WI Dept. of Agriculture, Trade and Consumer Protection

Session 1B Groundwater Quality
Room: B/D
Moderator: Maureen Muldoon

1:30 Incidence and Fecal Sources of Private Well Contamination in the Driftless Area: The Southwest Wisconsin Groundwater and Geology Study
Joel Stokdyk, US Geological Survey

1:45 Multi-year Well Water Quality Study in Trempealeau County
Melissa Kono, UW – Madison

2:00 The Dynamics and Speciation of Arsenic in Drinking Water Wells in Eastern Wisconsin
Shangping Xu, UW – Milwaukee, Dept. of Geosciences

2:15 Hydrogeologic and Geochemical Evidence for a Correlation Between Bedrock Folds and Arsenic Detection in Groundwater, Dodge County, Wisconsin
Eric Stewart, WI Geological and Natural History Survey, UW – Extension

2:30 What Comes After the Groundwater Study? The Need for Practical Responses to Regional Groundwater Contamination
Kenneth Bradbury, WI Geological and Natural History Survey, UW-Madison Division of Extension

* Student presentation
**Session 1C**  
**Climate Change and Flood Risk**  
**Room:** I  
**Moderator:** Mike Rupiper

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<tr>
<th>Time</th>
<th>Title</th>
<th>Presenter(s)</th>
<th>Institution(s)</th>
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<tbody>
<tr>
<td>1:30</td>
<td>Updating Rainfall Statistics for Infrastructure Design in a Warming Climate</td>
<td>Daniel Wright, UW – Madison, Dept. of Civil and Environmental Engineering</td>
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<td>1:45</td>
<td>Restoring Hydrology to Solve Problems and Build Flood Resilience</td>
<td>Kyle Magyera, Wisconsin Wetlands Association</td>
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<td>2:00</td>
<td>Investigating Paths to Increased Flood Resilience in the Coon Creek and Kickapoo River Watersheds</td>
<td>Eric Booth, UW – Madison, Dept. of Agronomy</td>
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<td>2:15</td>
<td>Strategies for Managing Increasing Urban Flood Risk</td>
<td>Kenneth Potter, UW – Madison, Dept. of Civil and Environmental Engineering</td>
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<td>2:30</td>
<td>Scaling Investment in Distributed Green Infrastructure Solutions</td>
<td>Cynthia Koehler, WaterNow Alliance</td>
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<td>2:45 – 3:00 p.m.</td>
<td>Break: E/F/G/H</td>
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<td>3:00 – 4:15 p.m.</td>
<td>Concurrent Sessions 2A, 2B, and 2C</td>
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**Session 2A**  
**Surface Water Quality**  
**Room:** A/C  
**Moderator:** Michael Tiboris

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<tr>
<td>3:00</td>
<td>Low-cost Turbidity Sensors as a Method for Watershed Monitoring</td>
<td>Andrew Schmitz,* UW – Green Bay</td>
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<td>3:15</td>
<td>Modeling Phosphorus and Algae Blooms in Utah Lake Using the Algae Estimator Smartphone Application</td>
<td>Tyler Dietz,* UW – Parkside, Geosciences Department</td>
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<td>3:30</td>
<td>Untapped Data: Utilizing Satellite Remote Sensing to Improve Statistically-Based Water Quality Predictions</td>
<td>Bryan O'Reilly,* UW – Madison, Nelson Institute for Environmental Studies</td>
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<td>4:00</td>
<td>Stream and River Conditions in Wisconsin and the United States</td>
<td>Michael Miller, WI Dept. Natural Resources</td>
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* Student presentation
Session 2B  Hydrogeology
Room: B/D
Moderator: Andrew Aslesen

3:00  High Capacity Well Permitting Study for a Proposed Sand Mine, Jackson County, WI Part 1: Field Aquifer and Stream Characterization Program and Conceptual Model Development
Pat Jurcek, INTERA

Erik Anderson, INTERA

3:30  Characterization of Fluid Flow and Energy Exchange in a Natural Rough-Walled Fracture
Noah Vriese,* UW – Madison

3:45  Wisconsin Karst: Northeast Versus Southwest. What’s the Same and What's Different?
Maureen Muldoon, WI Geological and Natural History Survey, UW-Extension

4:00  Disentangling Flow Processes in Fractured Sedimentary Rock
Michael Cardiff, UW – Madison, Dept. of Geoscience

Session 2C  Climate Change and Water Resources Management
Room: I
Moderator: Steve Corsi

3:00  Concurrent Changes in Winter Precipitation and Ground Freeze-Thaw State and Implications for Streamflow Regimes
Kamila Turczewski,* Marquette University

3:15  Geologic Influence on Stream Temperatures and Implications for Future Trout Habitat in the Marengo Headwaters
Anna Fehling,* WI Geological and Natural History Survey

3:30  Physics to Fish: Lake-Specific Climate Change Adaptation Strategies for Cisco Habitat
Madeline Magee, WI Dept. Natural Resources

3:45  How Will Flood Hazard Change in a Warming Midwest?
Guo Yu,* UW – Madison, Dept. of Civil and Environmental Engineering

4:00  Characterizing the Biogeochemical Factors Impacting Manoomin(Wild Rice) Propagation and Survival in Wisconsin Wetlands Using Culturally-Relevant Practices and Various Spatial Resolutions
Sarah Dance,* UW – Madison, Dept. of Civil and Environmental Engineering

* Student presentation
4:15 – 4:30 p.m.   Break: E/F/G/H
4:30 – 5:30 p.m.   Concurrent Sessions 3A, 3B, and 3C

Session 3A   Empirical Data Challenging Hydrologic Assumptions
Room: A/C
Moderator: Adam Freihoeffer

4:30   Cumulative Deviation from Moving Mean Precipitation as a Proxy for
Groundwater Level Variation in Wisconsin
Robert Smail, WI Dept. Natural Resources

4:45   Insights from Instantaneous Measurements: 15 Years of Streamflow Data in the
Central Sands
Jessica Haucke, UW – Extension & UW – Stevens Point and Aaron Pruitt, Wisconsin
Department of Natural Resources

5:00   Water Use by Crops and Forest and Improving Irrigation Planning and Early
Prediction for Agricultural Drought in Wisconsin
Ammara Talib,* UW – Madison, Civil and Environmental Engineering

5:15   Impact of Agricultural Practices on Evapotranspiration Rates in Wisconsin
Robert Smail, WI Dept. Natural Resources

Session 3B   Emerging Contaminants and Surface Water Quality
Room: B/D
Moderator: Ken Potrykus

4:30   Preliminary Survey of PFAS in Surface Water and Fish Tissue from Select
Wisconsin Waterbodies
Timothy Asplund, WI Dept. Natural Resources

4:45   The Potential Biological Impacts of Pesticides in Great Lakes Tributaries
Samantha Oliver, US Geological Survey, Upper Midwest Water Science Center

5:00   From Rivers to Lakes - the Movement and Distribution of Microplastics from
Tributaries to the Great Lakes
Peter Lenaker, US Geological Survey, Upper Midwest Water Science Center

5:15   Prioritizing Chemicals and Chemical Mixtures of Ecological Concern in Great
Lakes Tributaries
Steven Corsi, US Geological Survey, Upper Midwest Water Science Center

* Student presentation
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<th>Time</th>
<th>Session 3C</th>
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<tr>
<td>4:30</td>
<td>Water Chemistry and Lake Dynamics of Laguna Bacalar, Quitana Roo, Mexico</td>
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<td>Ryan Matzuk,* UW – Milwaukee, Dept. of Geosciences</td>
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<td>4:45</td>
<td>Importance of Childhood Pb Exposure from Food Crops Grown in Contaminated Residential Soils Versus Exposure from Soil/Dust or from Drinking Water</td>
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<td>Tim Grundl, UW – Milwaukee, Dept. of Geosciences</td>
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<td>5:00</td>
<td>USGS Plans for Integrated Model Development – the Gathering of the Clans</td>
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<td>Mike Fienen, US Geological Survey</td>
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<td>5:15</td>
<td>Challenges and Insights from Heat Transport Modeling of a Humid Temperate Watershed</td>
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<td>Randy Hunt, US Geological Survey, Upper Midwest Water Science Center</td>
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<td>5:30 – 6:00 p.m.</td>
<td>Break/Networking</td>
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<td>6:00 – 7:15 p.m.</td>
<td>Dinner and Lightning Talks</td>
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<td>Room: Riverview North</td>
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<td>Evaluating the Condition of Wisconsin's Surface Waters</td>
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<td>Catherine Hein, WI Dept. Natural Resources</td>
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<td>Protecting Water Quality with Prairie Filter Strips</td>
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<td>Craig Ficenec, Sand County Foundation</td>
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<td>Using Hydrograph Separation to Improve a Statistical Water Quality Model</td>
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<td>Matthew Diebel, Dane County Land &amp; Water Resources</td>
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<td>Quantifying Manure Application Methods on Greenhouse Gas Fluxes and Runoff Water Quality in a Dairy Agroecosystem</td>
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<td>Eric Young, USDA, Agricultural Research Service</td>
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<td>Adaptation Strategies for Wisconsin Lakes Facing Climate Change</td>
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<td>Madeline Magee, WI Dept. Natural Resources</td>
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<td>The Groundwater Connection: Implementing the Central Sands Lakes Study</td>
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<td>Jeffrey Helmut, WI Dept. Natural Resources</td>
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<td>Putting the Fun in Fundamentals: Interesting Problems at the Intersection of Fluid Mechanics, Coastal Engineering, and Environmental Processes</td>
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<td>Nimish Pujara, UW – Madison, Dept. of Civil and Environmental Engineering</td>
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<td>Putting Science to Work for Clean Drinking Water</td>
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<td>Andrew Aslesen, Wisconsin Rural Water Association</td>
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* Student presentation
7:15 – 10:00 p.m.  **Poster Session and Social**  
**Room:** Riverview South

| 1. | A Sedimentological Characterization of Huron Mountain Streams for Application to Future Ecological Studies  
   Benjamín Sieren,* UW – Parkside, Geosciences Department |
| 2. | Source Water Contribution in Albion Basin Wetlands Based on Spring and Surface Flow Measurements  
   Kristen Carlson,* UW – Parkside, Geosciences Department |
| 3. | A Seasonal Record of Monthly Mean Discharge in the Upper Midwest  
   Paige Blaha,* UW – Whitewater |
| 4. | Impact of Changing Frozen Ground Regimes on Groundwater Recharge in the Midwest  
   Katrina Rabeler,* UW – Madison, Geological Engineering |
| 5. | Frequency Dependence in Flow Properties of a Fractured Bedrock Aquifer  
   Jeremy Patterson,* UW – Madison, Dept. of Geoscience |
| 6. | Sharing Interactive Water Use Sector Data  
   Joseph Rosnow, WI Dept. Natural Resources |
| 7. | Hydrologic Investigation of the Chiwaukee Prairie Restoration Site (Kenosha County, Wisconsin)  
   Nicholas Potter,* Michigan Technological University |
| 8. | Transport of Microplastic Fibres in Waves: The Effects of Fibre Length and Wave Properties  
   Gabrielle Every,* UW – Madison, Dept. of Civil and Environmental Engineering |
| 9. | Geophysical Models Suggest Precambrian Bedrock Structures Are an Important Control on Precambrian Surface Topography  
   Joseph Rasmussen,* UW – Madison, Dept. of Geoscience |
| 10. | Solitary-wave-induced Boundary Layer Flows Over Permeable Beds  
    Claudio Meza-valle,* UW–Madison, Civil and Environmental Engineering |
| 11. | Are Knowledge Brokers an Undiscovered and Already Endangered Species in the Ecosystem of Environmental Organizations?  
    Francisco Guerrero-Bolaño, WI Dept. Natural Resources |
| 12. | Using Infrared Thermography to Characterize Temperature Over Space and Time in Wisconsin Springs  
    J. Garrett Rachal,* Beloit College |

* Student presentation
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<tr>
<td>13.</td>
<td>Assessment of the Source and Mobility of Phosphorus in the Hydrologic System in Western Wisconsin</td>
<td>Evan Lundeen,* UW – Eau Claire</td>
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<td>14.</td>
<td>An Investigation of Phosphorus Loading Through Lacustrine Groundwater Discharge in Mud Lake, Barron County, WI</td>
<td>Jacob Erickson,* UW – Eau Claire</td>
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<td>15.</td>
<td>New Bedrock Mapping of Dodge County Improves the Geologic Framework for Understanding and Managing Southeast Wisconsin’s Groundwater Resources</td>
<td>Esther Stewart, WI Geological and Natural History Survey, UW – Extension</td>
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<td>17.</td>
<td>Exploring Evidence of Increased Groundwater Nitrogen and Calcium in Lakes</td>
<td>Paul McGinley, UW – Extension &amp; UW - Stevens Point</td>
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<td>18.</td>
<td>Legacy Phosphorus in the Green Lake Watershed</td>
<td>Rachel Johnson,* UW – Madison, Dept. of Biological Systems Engineering</td>
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<td>19.</td>
<td>Effectiveness of Agricultural BMPs Under Future Climate Using SWAT Model</td>
<td>Xi Chen,* UW – Madison, Dept. of Biological Systems Engineering</td>
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<td>21.</td>
<td>Relationships Between Land Use and Stream Temperature in the Yahara River Watershed</td>
<td>Yu Li,* UW – Madison, Dept. of Biological Systems Engineering</td>
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<td>22.</td>
<td>Measuring Stream Baseflow Conditions in West-Central Wisconsin</td>
<td>Katherine Langfield,* UW – Eau Claire</td>
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<td>23.</td>
<td>Characterization and History of the Dead Tree Wetland at University of Wisconsin Parkside</td>
<td>Amy Johnston,* UW – Parkside, Geosciences Department</td>
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<td>24.</td>
<td>Precipitation Throughfall Beneath Urban Tree Canopies: An Investigation of Precipitation Re-Distribution</td>
<td>William Avery,* UW – Madison, Civil and Environmental Engineering</td>
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* Student presentation
26. **Sorption of Monensin to Soil in Agricultural Runoff**  
   Abby Demeyer,* UW – Stevens Point, AWRA Stevens Point Chapter

27. **The Future of the DNR Groundwater Retrieval Network (GRN) Database**  
   Jennifer Filbert, WI Dept. Natural Resources

   Lam Duyen Thuy,* Marquette University

29. **Development and Assessment of Season-Ahead Cyanobacteria Abundance Forecasts in Lake Mendota, WI.**  
   Maxwell Beal,* UW – Madison

30. **Impact of Dissolved Organic Sulfur on Metal Distribution in Riverine Sediments**  
   Marissa Kneer,* UW – Madison

31. **Using Calcium Isotopes to Characterize the Surface Water Dynamics of Two Madison Lakes**  
   Gage Hunter,* Edgewood College

32. **Leachable Phosphorus in Street Leaf Litter and Its Impact on Phosphorus in Urban Stormwater Runoff**  
   Yi Wang,* UW – Madison

33. **Blueprint for Salt Sustainability on the UW - Madison Campus**  
   Lydia Salus,* UW – Madison, Nelson Institute for Environmental Studies

34. **Lake Russo: Pond or Lake?**  
   Jessica Baker,* UW – Parkside, Geosciences Department

35. **Seasonal Soil Nutrient Dynamics in Urban Green Spaces**  
   Isabelle Horvath,* Marquette University

36. **Isotopic Examination of Photochemical Demethylation of Mercury in Natural Systems**  
   Grace Armstrong,* UW – Madison

37. **Clear Water Farms: Farmer-Led Market Drivers for Agricultural Water Stewardship**  
   Michael Tiborins, River Alliance of Wisconsin

38. **Application of MeHg Stable Isotopes in the Lower Green Bay and Fox River Area of Concern to Understand Bioaccumulation in a Contaminated Freshwater Estuary**  
   Tylor Rosera,* UW Madison, Environmental Chemistry and Technology

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* Student presentation
FRIDAY, March 13, 2020

7:00 – 8:30 a.m. Board Breakfast Meeting
Room: Executive Board Room

8:30 – 10:00 a.m. Concurrent Sessions 4A, 4B, and 4C

Session 4A High Great Lakes Water Levels
Room: A/C
Moderator: Mitch Olds

8:30 Nature-based Shorelines for Wisconsin’s Great Lakes Coast
Briana Shea,* Wisconsin Sea Grant

8:45 Adapting to a Changing Coast
Adam Bechle, Wisconsin Sea Grant

9:00 Meteo-rips (Meteotsunami Generated Rip Currents) in Lake Michigan
Yuli Liu,* UW – Madison, Dept. of Civil and Environmental Engineering

9:15 Restoring Ecological Health and Aquatic Biodiversity (Rehab) for Eroding Kenosha Dunes, WI
Chin Wu, UW – Madison, Dept. of Civil and Environmental Engineering

9:30 Coastal Bluff Erosion and Groundwater Responses to Elevated Lake Levels
Collin Roland,* UW – Madison, Dept. of Geoscience

9:45 Effects of High Water Levels on Wave Climate and Nearshore Processes in Lower Green Bay, WI
Joshua Anderson, UW – Madison, Dept. of Civil and Environmental Engineering

Session 4B Urban hydrology
Room: B/D
Moderator: Barbara Eikenberry

8:30 Monitoring the Performance of Two Bioswales that Collect Runoff from an Urban Farm
Elizabeth Regier,* Marquette University

8:45 When Traditional Site Restoration Isn’t the Best Option: Recovering Ecological Resiliency Through Adaptive Water Resources Engineering
Kirsten James, Hey and Associates, Inc.

9:00 Impact of Increased Infiltration in Residential Sewersheds on Rainfall Derived Inflow and Infiltration
Spencer Sebo,* Marquette University

* Student presentation
9:15  Characterization of Chloride Concentration in Stormwater Runoff from Commercial Land Use  
Nicolas Buer, US Geological Survey, Upper Midwest Water Science Center

9:30  Potential for a New Interceptometer: Monitoring Tree Sway with Accelerometers as an Indicator of Interception Before, During, and After it Rains  
Dominick Ciruzzi,* UW – Madison, Dept. of Civil and Environmental Engineering

9:45  How’s the Water? Fifteen Years of Fish Community Sampling in the Milwaukee Area  
Amanda Bell, US Geological Survey, Upper Midwest Water Science Center

Session 4C  Using Isotopes for Tracking Water Quality from the Source to Tap  
Room: I  
Moderator: Sean Scott

8:30  Using Stable Isotopes of H, O, S, B, Sr, Pb, Cu and Radiometric Dating to Elucidate Groundwater Flow Paths and Histories in the Cambrian-Ordovician Aquifer of Northeastern Wisconsin  
John Luczaj, UW – Green Bay, Dept. of Natural and Applied Sciences

8:45  Using Isotopes to Investigate Sources of Solutes in the Cambrian-Ordovician Aquifer System of Eastern Wisconsin  
Amy Plechacek,* UW-Madison, Environmental Chemistry and Technology Program, Dept. of Civil and Environmental Engineering

9:00  Examining Radionuclide Mobility in the Midwestern Cambrian-Ordovician Aquifer System  
Madeleine Mathews,* UW – Madison

9:15  Isotopic Assessment of Mercury Transport in the Dissolved and Particulate-Bound Phases of Surface Water  
Sarah Janssen, US Geological Survey

9:30  Using Stable Lead Isotope Composition to Track Lead Exposure in Drinking Water – Are Lead Lateral Lines the Source?  
Patrick Gorski, WI State Lab of Hygiene

9:45  Mercury Contamination at Gruber’s Grover Bay: Application of Mercury Isotopes as Source Tracer  
Michael Tate, US Geological Survey, Upper Midwest Water Science Center

10:00 – 10:15 a.m.  Break: E/F/G/H

* Student presentation
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<tr>
<th>Time</th>
<th>Session 5A</th>
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<tr>
<td>10:15</td>
<td>Concurrent Sessions 5A, 5B, and 5C</td>
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<td>10:15</td>
<td>The Central Sands Lakes Study</td>
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<td>10:15</td>
<td>Room: A/C</td>
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<td>10:15</td>
<td>Moderator: Jeff Helmuth</td>
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<td>10:15</td>
<td>Defining a “Significant Reduction” in Lake Levels in the Central Sands in Terms of Water Quality, Aquatic Life, and Recreation and Navigation</td>
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<td>10:15</td>
<td>Carolyn Voter, UW – Madison, Aquatic Sciences Center</td>
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<td>10:30</td>
<td>Heterogeneity in Context: A Glacial History Perspective on Wisconsin’s Central Sands</td>
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<td>J Elmo Rawling III, WI Geological and Natural History Survey</td>
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<td>10:45</td>
<td>Estimating Groundwater Recharge, Irrigation Demand, and Crop Water Use for the Central Sands</td>
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<td>Stephen Westenbroek, US Geological Survey, Upper Midwest Water Science Center</td>
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<td>11:00</td>
<td>Development of a Regional Groundwater Flow Model of the Central Sands</td>
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<td>11:00</td>
<td>Meg Haserodt, US Geological Survey, Upper Midwest Water Science Center</td>
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<td>11:15</td>
<td>Do We Really Know Anything? Monte Carlo Simulations to Evaluate Potential Outcomes of a Lake Drawdown Test</td>
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<td>11:15</td>
<td>Andrew Leaf, US Geological Survey, Upper Midwest Water Science Center</td>
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<tr>
<th>Time</th>
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<tr>
<td>10:15</td>
<td>Surface Water Quality and Policy</td>
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<td>Room: B/D</td>
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<td>10:15</td>
<td>Moderator: Madeline Magee</td>
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<td>10:15</td>
<td>Instream Water Quality Response to Agricultural Best Management Practice Implementation in the Silver Creek Watershed</td>
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<td>Ben Young, NEW Water, Green Bay Metropolitan Sewerage District</td>
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<td>10:30</td>
<td>Municipal-Agriculture Partnerships for Watershed Management</td>
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<td>Bartlett Durand, Sand County Foundation</td>
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<td>10:45</td>
<td>Long-term Monitoring Sheds Light on Urban Stressors in Milwaukee Area Stream Communities</td>
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<td>Barbara Scudder Eikenberry, US Geological Survey, Upper Midwest Water Science Center</td>
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<td>11:00</td>
<td>Improving Predictions of TSS in Urban Models</td>
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<td>11:00</td>
<td>Judy Horwacht, US Geological Survey, Upper Midwest Water Science Center</td>
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<td>11:15</td>
<td>Water Quality Indicators of Human Impacts to the Wetlands of Door Co., WI</td>
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<td>David Hart, WI Geological and Natural History Survey</td>
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Session 5C  Neonicotinoid Toxicity and Monitoring  
Room: I  
Moderator: Mike Miller

10:15  Widespread Detections of Neonicotinoid Contaminants in Central Wisconsin Groundwater  
Russell Groves, UW – Madison, Dept. of Entomology

10:30  Neonicotinoid Pesticides in Wisconsin Groundwater and Surface Water  
Stanley Senger, WI Dept. of Agriculture, Trade and Consumer Protection

10:45  Use of Polar Organic Chemical Integrative Samplers (Pocis) to Monitor Neonicotinoid Insecticides in Streams and Ditches on the Central Wisconsin Sand Plain  
William Devita, UW – Stevens Point, Water and Environmental Analysis Lab

11:00  Chronic Exposure to Thiamethoxam Causes Neurotoxicity in Larval Fish  
Tisha King-Heiden, UW – La Crosse

11:15  Acute and Chronic Toxicity of the Neonicotinoid Insecticide Thiamethoxam to Select Aquatic Invertebrates  
Elisabeth Harrahy, UW – Whitewater

11:45 – 12:00 p.m.  Student Awards and 2020 Meeting Announcements  
Room: E/F/G/H  
Moderator: Mike Rupiper

12:00 – 2:00 p.m.  Student Career Session Lunch  
Room: Laguna Vista  
Facilitator: Brent Brown
Influence of Winter Manure Application on Non-Growing Season Nutrient Losses in Surface Runoff

Laxmi Prasad,* University of Wisconsin-Madison, Department of Biological Systems Engineering, lprasad@wisc.edu
Anita Thompson, UW-Madison, Department of Biological Systems Engineering
Francisco Arriaga, UW-Madison, Department of Soil Science
Peter Vadas, USDA Agricultural Research Center, Beltsville, Maryland

In Wisconsin, nutrient pollution of freshwater bodies due to agricultural runoff is a longstanding and recurring problem. Research has identified that 60-70% of the annual runoff occurs during the non-growing season (Dec-Apr). Wisconsin is a major dairy production state and the dairy industry is often challenged with manure management. To avoid large capital investments of long-term storage and farm logistics, many farmers dispose of manure on agricultural fields during the non-growing season when soil is frozen and often snow-covered. Snowmelt and rain on snow produces significant manure nutrient losses due to reduced infiltration and no crop nutrient uptake. Nutrient management standards help in choosing appropriate manure application practices but in most cases do not account for soil physical, chemical and biological processes which are important for water quality. In a complete factorial design, surface runoff, nutrient and sediment losses are monitored from two different tillage systems (conventional and no-tillage) each receiving two different types of manure (dairy liquid and solid) as late winter application. Experiments are in progress, however preliminary data showed that no-tillage plots produced significantly more runoff (average = 51.3 mm) compared to conventional tillage (23.8 mm; p < 0.05) and liquid manure application produced higher nutrient loads irrespective of tillage type. Results from this study will inform winter manure application practice recommendations in Wisconsin.

* Student presentation
Legacy Phosphorus in Stream Sediments: Removal & Water Quality Response

John Reimer, Dane County Land & Water Resources, reimer.john@countyofdane.com
Chin Wu, UW-Madison

Legacy phosphorus in stream sediments can complicate and delay the outcome of intended water quality benefits. Specifically, water quality concerns from phosphorus loads measured at the watershed outlet reflect both current and remobilized legacy phosphorus sources from watersheds. Regulations such as the Total Maximum Daily Loads (TMDL) are established to set allowable water quality concentration during base flow conditions which occurs during one time scale. Another time scale from storm conditions can produce high water quality loads that can exceed the regulated allocation level. In this talk, we will present a pioneer project that assesses and implements the removal of legacy phosphorus in stream sediments in Dorn Creek, an agricultural dominated watershed, in Dane County, Wisconsin. Prior to sediment removal, the phosphorus concentration of water column released from the bottom sediments were above the allowable TMDL allocation. After removal of 2.3 miles of legacy stream sediments (equating to over 20,000 tons of sediment and 75,000 pounds of phosphorus), phosphorus concentrations released from stream sediments vary over seasonal and episodic event time scales. We will show the results and discuss the implication. Last but not least, beneficial ecosystem services such as flood attenuation, habitat improvements, and fish/wildlife biodiversity will be shown and discussed.

Treatment of Horizontal Silage Bunker Runoff Using Biochar Amended Vegetative Filter Strips

Joseph Sanford, University of Wisconsin-Madison, Department of Biological Systems Engineering, jrsanford@wisc.edu
Rebecca Larson, UW-Madison, Dept. of Biological Systems Engineering

Horizontal silage bunkers produce leachate that contains contaminants that can be detrimental to the environment if released untreated. Vegetated filter strips are currently used to treat silage bunker runoff to
prevent contamination of surface waters via infiltration, however increased infiltration poses risks to groundwater, particularly for nitrate (NO\textsubscript{3}). A sandy loam vegetated filter strip amended with corn cob biochar was used to treat silage bunker runoff for 20 application events. The subsurface effluent of BOD\textsubscript{5}, COD, and TP were reduced by 42 and 38\%, 50 and 43\%, and 78 and 73\% as compared to the influent for control and biochar amended plots, respectively, but treatments were not statistically different for these parameters. The total nitrogen (TN) was reduced by 49 and 64\% for control and biochar plots, respectively, and biochar significantly reduced the NO\textsubscript{3}-N leaching by 40\% compared to the control. A mass balance of N input suggest that primary mechanisms for reduce NO\textsubscript{3}-N leaching from biochar amended plots was due to enhancement of ORG-N and NO\textsubscript{3}-N retention in the soil. The NO\textsubscript{3}-N concentration in leachate ranged from 0.19 to 191.04 mg NO\textsubscript{3}-N L\textsuperscript{-1} and 0.18 to 108.89 mg NO\textsubscript{3}-N L\textsuperscript{-1} for control and biochar plots, respectively, well above EPA drink water standards for 13 application events, suggesting that further treatment modifications are necessary.

* * *

**Improving Nitrogen Management Strategies Across Wisconsin**

Tracy Campbell,* University of Wisconsin-Madison, tacampbell@wisc.edu  
Kevin Masarik, UW-Stevens Point  
Emily Marrs, UW-Madison  
Chris Kucharik, UW-Madison

Across Wisconsin it has become increasingly clear that nitrogen management strategies must be improved in order to prevent further contamination of groundwater. Using both on-farm fieldwork, as well as ecosystem modeling, we are: 1) assessing the amount of nitrate (N) found in irrigation water and 2) determining the impact of timing and quantity of nitrogen application on nitrate leaching and crop yield. Based on samples of irrigation water collected during the 2018 and 2019 growing season, results indicate a large spatial variability in N concentrations, * Student presentation
while temporal variability is limited. Specifically, some wells only varied between 1 to 2 ppm of N from year to year. Preliminary model runs across multiple counties in Wisconsin have incorporated future climate projections in order to determine nitrogen best management practices moving forward. Through our combined approach of field and modeling research, we hope to provide farmers, researchers, and policy makers with the tools to make management decisions that will improve groundwater quality - which will be of heightened importance as increasing weather variability makes management of water resources and N applications to crops more challenging.

* * *

DATCP's Role and Responsibility for Wisconsin's Surface Water Quality

Ken Potrykus, Wisconsin Department of Agriculture, Trade and Consumer Protection  
kennethj.potrykus@wisconsin.gov

It is estimated that agriculture contributes $88-billion annually to Wisconsin’s economy. Growers use millions of pounds of pesticides, and millions of tons of fertilizers annually, to grow a wide variety of crops. Wisconsin’s Department of Agricultural, Trade and Consumer Protection (DATCP) Surface Water Sampling Program is one form of monitoring the agency performs to meet its statutory obligation to protect human health and the environment. The Program’s goal is to document what impact pesticide use is having on surface water quality in Wisconsin. Surface water samples are collected prior to the traditional pesticide application season (January - April), during the traditional application season (May, June, July) and after the pesticide application season is over (August - December) to provide an indication of how the timing of pesticide application is related to surface water quality. Analytical data is compared to benchmark values and drinking water standards to assess potential risk to human health and the environment.

This presentation will include findings, conclusions and recommendations of DATCP’s Surface Water Program. Historical analytical data trends are indicating seasonal variations and groundwater baseline contributions to
pesticide concentrations in surface water. Discussions of potential risk to human health and the environment (ecological receptors) will be presented. It will also include a discussion of emerging contaminants of concern.

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Incidence and Fecal Sources of Private Well Contamination in the Driftless Area: The Southwest Wisconsin Groundwater and Geology Study

Joel Stokdyk, US Geological Survey, jstokdyk@usgs.gov
Aaron Firnstahl, USGS
Susan Spencer, USDA
Ken Bradbury, WGNHS
Maureen Muldoon, WGNHS
Mark Borchardt, USDA

Rural residents of Wisconsin’s Driftless Area rely on private wells for drinking water. The fractured carbonate bedrock aquifers are overlain with shallow soils, making wells potentially vulnerable to contaminants on or near the land surface, like nitrate and pathogens associated with agricultural practices and septic systems. The objectives of this study are to 1) evaluate private well contamination based on the presence of indicator bacteria or nitrate exceeding the drinking water standard of 10 mg/L and 2) identify the sources of fecal contamination using microbial source tracking. Randomly selected private wells were sampled synoptically in November (n = 301) and April (n = 539) and tested for nitrate, total coliforms, and E. coli. Overall, 42% (November) and 27% (April) of samples tested positive for total coliforms or E. coli or had nitrate >10 mg/L. Wells (n = 35) were randomly selected from those with total coliforms present or nitrate >10 mg/L to identify fecal contamination sources. Samples were analyzed by quantitative polymerase chain reaction for gene markers capable of distinguishing human wastewater and livestock manure. Thirty-two of the 35 wells had fecal contamination, including human, bovine, and porcine fecal markers. Pathogen genes were detected in 13 wells. Results show that a higher percentage of private wells in the study area are contaminated compared to statewide averages and that both human and livestock fecal sources contribute to contamination.
Multi-year Well Water Quality Study in Trempealeau County

Melissa Kono, UW-Madison, melissa.kono@wisc.edu

The University of Wisconsin-Madison Trempealeau County Extension undertook a county-funded well water quality study that tested the well water of 100 private residences for nitrates and arsenic to measure the effects of agricultural and mining along the Trempealeau River in Trempealeau County, Wisconsin. Results of testing as well as discussion on how to partner with counties and other local forms of government to conduct water quality studies.

The Dynamics and Speciation of Arsenic in Drinking Water Wells in Eastern Wisconsin

Shangping Xu, University of Wisconsin-Milwaukee, Department of Geosciences, xus@uwm.edu
Evvan Pkank, UW-Milwaukee, Geosciences
Yin Wang, UW-Milwaukee, Civil and Environmental Engineering
Haiyan Yang, UW-Milwaukee, Geosciences

Arsenic typically develops in Eastern Wisconsin groundwater as a result of oxidation of sulfide bearing minerals in the limestone bedrock (Schreiber et al. 2000). Naturally occurring arsenic exists in groundwater as oxyanions which have two oxidation states, As(III) and As(V). Although many studies exist establishing arsenic concentrations across Wisconsin, there is a lack of investigations into the concentrations of each arsenic species, which is essential for establishing a removal technique. The primary goal of this research was to establish baseline concentrations of each arsenic species, accounting for seasonal variations, and determine how these concentrations could be affected by water usage. Private drinking water wells were selected at 16 locations across Eastern Wisconsin. The wells were screened at various depths, in multiple geologic units, and contained a wide-range of total arsenic concentrations. Analysis of the speciation data indicated that As(III) was the dominant species of arsenic in all of
Data from the 11 pumping tests that were conducted, showed 9 exhibiting a downward trend in As(III) concentration and an upward trend in As(V) concentration as volume purged increased. The pumping tests also showed a substantial increase in total arsenic in many of the wells as volume purged increased. There did not appear to be a seasonal trend in arsenic concentration.

* * *

**Hydrogeologic and Geochemical Evidence for a Correlation Between Bedrock Folds and Arsenic Detection in Groundwater, Dodge County, Wisconsin**

Eric Stewart, Wisconsin Geological and Natural History Survey, University of Wisconsin-Madison Division of Extension, eric.stewart@wisc.edu
Esther Stewart, WI Geological and Natural History Survey, UW-Extension
Kenneth Bradbury, WI Geological and Natural History Survey, UW-Extension

Arsenic in drinking water wells is a significant problem across much of eastern Wisconsin. While most prior work on bedrock arsenic sources has focused on discrete stratigraphic intervals, less work has been done on the potential role of geologic structures. As part of a new bedrock mapping effort in Dodge County we are investigating the relationships between bedrock structures, hydraulic conductivity, geochemistry, and low to moderate levels of arsenic in groundwater.

Recent bedrock mapping in Dodge County, SE Wisconsin, identified the Beaver Dam Anticline, an ESE plunging gentile fold with ~200 feet of structural relief. Rock cores collected near the fold axis show a higher density of vertical fractures than away from the axis. Across northwestern Dodge County, elevated hydraulic conductivity values (~15-200 ft/day) for the St. Peter aquifer are restricted to areas near folds. Geochemical profiles of cores indicate arsenic predominantly resides in red beds near the Beaver Dam Anticline, while off axis arsenic predominantly resides in sulfides. Finally, binary logistic regression of publicly available WDNR water tests show a
statistically significant increase in the probability of detecting arsenic near the Beaver Dam Anticline. We suggest focused flow along vertical fractures near folds facilitated a change in the dominant arsenic source from sulfide to (hydr)oxide. This change in arsenic source appears to increase the probability of detecting arsenic in groundwater wells.

* * *

**What Comes After the Groundwater Study? the Need for Practical Responses to Regional Groundwater Contamination**

Kenneth Bradbury, Wisconsin Geological and Natural History Survey, University of Wisconsin-Madison Division of Extension, ken.bradbury@wisc.edu

Maureen Muldoon, WI Geological and Natural History Survey

Recent and ongoing groundwater-quality studies, along with historic water-quality data, have documented regional-scale groundwater-quality problems in many parts of Wisconsin. Residents and local governments desire improved water quality while simultaneously wishing to maintain Wisconsin’s agricultural heritage and farming lifestyle. Decision makers and regulators not only face difficult choices for improving water quality but often do not even understand what those choices might be.

The path forward will likely require a three-pronged approach of applied research and mapping, public outreach, and regulation. Comprehensive guidelines for groundwater quality planning in Wisconsin (e.g. Born et al, 1987) have not been updated in over 30 years.

Hydrogeologic information is the key to effective groundwater planning, and includes appropriate mapping of bedrock and Quaternary geology, depth to bedrock, water table and potentiometric surfaces, and recharge distributions. Stratigraphic and structural analyses contribute to consolidating this information into understandable conceptual models of aquifers, aquitards, and groundwater flow systems.
Interpretation of these models in the context of aquifer and landscape vulnerability and the communication of these ideas to stakeholders and decision makers will be necessary to support future practical advice and regulatory processes to achieve water quality goals.

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Updating Rainfall Statistics for Infrastructure Design in a Warming Climate

Daniel Wright, University of Wisconsin-Madison, Department of Civil and Environmental Engineering, danielb.wright@wisc.edu
Robert Montgomery, Emmons & Olivier Resources, Inc.; Wisconsin Initiative on Climate Change Impacts

There is overwhelming evidence that rainfall extremes are growing more severe due to human-induced climate warming. This understanding, however, has not translated into actionable information needed by hydrologists and engineers. In this presentation, we show that existing rainfall intensity-duration-frequency (IDF) statistics such as the “100-year storm” are inadequate for current and future needs, leading to serious deficiencies in our hydrologic design standards and infrastructure. We then discuss two solutions to address this challenge in both current and future conditions. We close with a “call to arms,” and show how the Wisconsin Initiative on Climate Change Impacts and the University of Wisconsin-Madison is ready to provide support to the water resources and engineering communities to solve this challenging problem.

* * *

Restoring Hydrology to Solve Problems and Build Flood Resilience

Kyle Magyera, Wisconsin Wetlands Association, kyle.magyera@wisconsinwetlands.org

This presentation will highlight how degraded hydrologic conditions reduce upper watershed storage, disconnect floodplains, and reduce the landscape’s ability to manage runoff during storms. The speaker will highlight a locally-led initiative in the Lake Superior Basin to utilize FEMA-approved methods for: 1) assessing how fluvial erosion hazards such as gulling and channel incision increases peak flow and velocity; and, 2) determining natural flood
management solutions to mimic, restore, or repair hydrologic processes in order to ‘slow the flow’ upstream of vulnerable infrastructure. The presentation will conclude with a brief interactive discussion on how better hydrologic assessment data, decision-support tools, training, and technical support can help Wisconsin communities meet land and water conservation goals.

* * *

Investigating Paths to Increased Flood Resilience in the Coon Creek and Kickapoo River Watersheds

Eric Booth, University of Wisconsin-Madison, Department of Agronomy, egbooth@wisc.edu

Increased frequency of heavy rainfall events associated with a warming climate has impacted many watersheds in Wisconsin in recent decades, but that combined with steep topography has made the Driftless Area particularly susceptible to extreme flooding. Specifically, the Coon Creek and Kickapoo River Watersheds have experienced dramatic flooding in 5 of the last 13 years, with Aug-Sept 2018 setting records across both watersheds including the breaching of five flood control structures. These breaches have led to an increased willingness by county, state, and federal agencies to commit resources to develop a more holistic, systems-level approach to enhancing flood resilience. Several new collaborative and interdisciplinary research projects are contributing to this process. First, students from the Water Resources Management Practicum are exploring ways to promote flood resilience through an analysis of historical rainfall and land-use change, flood policies, and the feasibility and efficacy of enhanced infiltration practices across the landscape. Second, another project is studying the runoff impacts of – as well as the policy, financial, and cultural barriers to – increased adoption of grassland agriculture in the Kickapoo region. Third, ongoing research in the Kickapoo watershed is investigating the relationship between stream-floodplain restoration and extreme flood events to help develop more resilient strategies for managing a multifunctional system.
Strategies for Managing Increasing Urban Flood Risk

Kenneth Potter, University of Wisconsin-Madison, Department of Civil and Environmental Engineering, kwpotter@wisc.edu

Flood risk is increasing throughout Wisconsin as a result of climate and land use change. Current mitigation efforts are clearly insufficient. Recently proposed improvements in stormwater regulations have been prohibited by state legislation. Soils in urban areas are commonly compacted. Infiltration practices are sometimes limited by high water tables. Local solutions to internal urban flooding are commonly increasing downstream flood risk. There are several potentially effective strategies for overcoming these barriers. The recently enacted state prohibition can be repealed, allowing more effective management of runoff volumes. The design of stormwater infrastructure and the mapping of regulatory floodplains can be based on updated rainfall statistics, rather than on the outdated statistics in current use. Methods for enhancing infiltration rates, such as subsoiling, can be widely applied to both new and existing developments. For example, subsoiling can be applied to soils conveying roof-top runoff. And grassed swales with enhanced infiltration capacities can be encouraged in new rural developments. Stormwater ordinances can be modified to consider downstream impacts of local stormwater management improvements. In areas with problematic groundwater levels, evapotranspiration standards can be set for new developments. Finally, the Wisconsin Geological and Natural History Survey can be authorized to determine current water table depths at critical locations.
Scaling Investment in Distributed Green Infrastructure Solutions

Cynthia Koehler, WaterNow Alliance, cak@waternow.org
Caroline Koch, WaterNow Alliance

WaterNow Alliance is a national network of local water leaders supporting sustainable, affordable, and climate resilient water strategies. Distributed green stormwater infrastructure (GSI) is a cost-effective and innovative approach to local water management and a key strategy for building climate resiliency. Bioswales, green roofs, permeable pavement, rain barrels, and more limit flooding from severe storms, capture runoff, and treat pollutants often more affordably and faster than built infrastructure. Municipal water agencies typically fund consumer-facing GSI rebates with operating cash which substantially limits scale and impact. WaterNow launched our Tap into Resilience (TiR) initiative to support cities and water agencies in scaling-up their GSI by financing these programs in the same way that they finance conventional infrastructure – by capitalizing them. WaterNow’s presentation will focus on two key parts of TiR: (1) how water managers can use WaterNow’s TiR Toolkit an online resource with answers to common tax, accounting, legal, and other implementing questions to explore whether and how to scale up consumer GSI programs; and (2) exploring a diverse set of utility case studies across the country that demonstrate the effectiveness of GSI (and other distributed solutions) to address local water challenges as outlined in WaterNow’s new report, “Innovation in Action: 21st Century Water Infrastructure Solutions” published on November 14, 2019.

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36
Low-cost Turbidity Sensors as a Method for Watershed Monitoring

Andrew Schmitz,* University of Wisconsin-Green Bay, schmar20@uwgb.edu
Kevin Fermanich, UW-Green Bay
Paul Baumgart, UW-Green Bay

In-situ continuous turbidity monitoring can be used as a surrogate for tracking total suspended solids (TSS) concentrations in streams and other locations. It can be useful for tracking the possible sources of TSS, and attached constituents, based on timing and multiple deployment schemes. Commercial turbidity sensors may be too costly for extensive deployments. The purpose of our study was to develop and test low-cost alternatives to off-the-shelf instruments. Four types of dishwasher-based turbidity sensors were successfully bench-tested. We found little difference once they were calibrated with dilutions of TSS mixtures composed of stream and field runoff samples (R-sq. > 0.99). 14 sensors were constructed. Pairs of low cost sensors and Campbell Scientific OBS-501 retractable head BS and SS turbidity sensors were deployed in two streams and two edge-of-field sites. All were equipped with automated samplers and Campbell data loggers. Eight sensors were matched with EnviroDIY Mayfly data loggers and deployed in streams and culverts for evaluation and source tracking. Low-cost sensors were combined with commercial loggers at a treatment pond study and a stream. Record precipitation occurred in 2019 at Green Bay, Wisconsin, so numerous runoff events were captured this year. We will report our comparisons between low-cost and commercial sensors, with regards to TSS, phosphorus and turbidity relationships. The utility and limitations of the low-cost system will be discussed.

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* Student presentation

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Modeling Phosphorus and Algae Blooms in Utah Lake Using the Algae Estimator Smartphone Application

Tyler Dietz,* University of Wisconsin-Parkside, Geosciences Department, dietz011@rangers.uwp.edu
Matt George, UW-Parkside, Geosciences Department
Stephanie Rogalinski, UW-Parkside, Geosciences Department
John Skalbeck, UW-Parkside, Geosciences Department

Utah Lake is a shallow (3-4 m depth) desert lake that provides freshwater for surrounding ranches and farms and supports boating, swimming, and fishing. Recent harmful algae blooms (HAB) have interrupted water deliveries and recreational activities. The need for a predictive HAB model has been expressed by public health officials. Water quality and algae data was collected in 2017, 2018, and 2019 using three monitoring buoys at Utah Lake every 15 minutes from May through November; however, phosphorus (PO₄) concentrations critical for predicting HAB is not measured. This study used the Algae Estimator smartphone app to calculated best-fit PO₄ values by modeling peak Chlorophyll (Chl) and Cyanobacteria (Cba) occurrences from the buoy data.

Water depth, temperature, light, and initial Chl and Cba values from 10 days prior to peak occurrences provided the app input data. Trial PO₄ input values iteratively adjusted until model Chl and Cba match buoy measured values. The Algae Estimator modeling yields best-fit PO₄ values ranging from 0.086 to 0.216 mg/L in 2017, 0.125 to 0.403 mg/L in 2018, and 0.090 to 0.155 mg/L in 2019. The highest best-fit PO₄ concentration (0.403 mg/L) was calculated from the highest peak Chl and Cba values measured at the Provo Bay buoy. These high values may be associated with discharge from the nearby Provo Wastewater Treatment Plant. Strong correlations of best-fit PO₄ values versus model Chl and Cba values will be useful for future HAB modeling.

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* Student presentation
Untapped Data: Utilizing Satellite Remote Sensing to Improve Statistically-Based Water Quality Predictions

Bryan O’Reilly,* University of Wisconsin-Madison, Nelson Institute for Environmental Studies, beoreilly@wisc.edu
Paul Block, UW-Madison
Maxwell Beal, UW-Madison
Kaitlynn Hietpas, UW-Madison

As freshwater ecosystems continue to degrade with implications regarding human health, focus on water quality predictions is growing. Lacustrine ecosystems present a unique challenge for physically-based predictive modeling, given the complexity of their dynamics, feedback loops, and interactions all occurring at multiple time-scales. Alternatively, we propose statistically-based models focusing on seasonal cyanobacteria abundance and associated beach closings across the June-August summer season on Lake Mendota in Wisconsin. We seek to use our novel modeling approach to aid local and state government organizations in lake and health management. Statistical approaches, however, are highly dependent on sufficiently long and diverse historical records for model fitting. This is problematic for applications void of rich temporal and spatial observations. Satellite based remote sensing products, such as phycocyanin, and chlorophyll-a can augment the observational records. Satellite images are processed with existing and proposed algorithms to derive cyanobacteria products and compare with observational records using GIS spatial analysis tools and spatial performance metrics. Preliminary assessments indicate that the corrected satellite-derived products reasonably agree with observational records for Lake Mendota and serve to increase the observational dataset potentially improving seasonal prediction performance of expected summertime cyanobacteria abundance and beach closings.

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* Student presentation
A Survey of Cyanotoxins and the Occurrence of Harmful Algal Blooms in the Upper Midwest

Hayley Olds, US Geological Survey, Upper Midwest Water Science Center, hholds@usgs.gov
Victoria Christensen, US Geological Survey, Upper Midwest Water Science Center
Amanda Bell, US Geological Survey, Upper Midwest Water Science Center
Richard Kiesling, US Geological Survey, Upper Midwest Water Science Center

Recent research on harmful algal blooms (HABs) in the Upper Midwest region of the United States has focused on the cyanotoxin microcystin. Ongoing work in Minnesota and surrounding states has shown that the neurotoxins anatoxin-a and saxitoxin are also present in many blooms and have been linked to recent cattle deaths in North Dakota and dog deaths in Minnesota. However, it is unknown whether the prevalence of these neurotoxins instead of microcystin is a regional or localized phenomenon. This study combined the use of solid phase adsorption tracking technology (SPATT) passive samplers and phycocyanin sensors at selected existing lake and stream gaging stations in Minnesota, Wisconsin, and North Dakota. Real-time monitoring was combined with state-of-the-art laboratory analyses, including cyanotoxin analysis with targeted liquid chromatography tandem mass spectrometry (LC-MS/MS) and phytoplankton identification. This enhanced sampling plan not only detected up to 32 cyanotoxins (ranging from hepatotoxins to neurotoxins) and described their geographical extent during typical bloom events, but also sought to establish whether these toxins, or a combination, can be used for future predictions with phycocyanin sensors and other real-time data.

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Stream and River Conditions in Wisconsin and the United States

Michael Miller, Wisconsin Department of Natural Resources, michaela.miller@wisconsin.gov

Wisconsin has an estimated 42,000 miles of perennial streams and rivers, enough to encircle the planet nearly 1.7 times. To adequately sample each of these waterbodies would take decades and be prohibitively expensive. Yet science-based management and an informed public requires accurate and current evaluation of resource conditions. The U.S. Environment Protection Agency’s National Rivers and Streams Assessment (NRSA), is a collaborative effort among states, federal agencies, and tribes, designed to evaluate the ecological conditions of the nation’s flowing waters on a recurring basis. Key findings of the 2013 – 2014 NRSA survey include: nutrient
pollution is widespread; 60% of both WI and U.S. streams and rivers have high concentrations of phosphorus; 67% of WI and 43% of U.S. waters have high nitrogen concentrations. Degraded physical habitat and water quality significantly impact macroinvertebrates and fish both in Wisconsin and across the U.S. Less than 1/2 of WI and 1/3 of U.S. streams and rivers have healthy fish assemblages. Enterococci bacteria an indicator of fecal contamination is widely present in both WI and U.S. waters. Microcystin, toxins produced by cyanobacteria are present in a small proportion of both WI and U.S. streams and rivers, and usually at low concentrations. These findings can promote informed advocacy and documents the need for improved watershed management.

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High Capacity Well Permitting Study for a Proposed Sand Mine, Jackson County, WI Part 1: Field Aquifer and Stream Characterization Program and Conceptual Model Development

Pat Jurcek, INTERA, pjurcek@intera.com

We provide a two-part presentation describing field characterization and hydrologic analysis aimed at permitting a 750 gpm sandstone aquifer groundwater supply for a proposed sand mine in Jackson County, Wisconsin. These presentations describe the hydrogeological study methodology and results, and the difficulties faced by both the DNR and the applicant, from the consultant’s perspective.

Very little detailed data was available on the hydraulic properties of the Cambrian Elk Mound Group sandstone aquifer in Western Jackson County, Wisconsin. Numerous Class I-III trout streams were also present in the study area which were not monitored with permanent gaging stations. A field program was implemented consisting of: the installation of 4 deep test borings (to the top of the Precambrian); the construction and extended pump testing of two sandstone test wells and nested piezometers; borehole geophysical logging of the test wells; and a stream gaging program of the streams and rivers in the study area. The collected field data and analysis results were used to develop a detailed conceptual model of the sandstone aquifer and surface water features in the area, providing the framework for the detailed modeling analysis needed for the high capacity well permit application.

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High-capacity Well Permitting Study for a Proposed Sand Mine, Jackson County, Wisconsin Part 2. Hydrologic Analysis and NR820 Review

Erik Anderson, INTERA, eanderson@intera.com
Pat Jurcek, INTERA

In Part 2 we discuss how the field-testing program was used to address potential concerns of the DNR in the absence of a well-defined review process. The work took place in 2013-14, when the DNR was overhauling the NR 820 review process and attempting to define reasonable use of groundwater. We highlight the difficulties faced by both the applicant and the State as the process evolved from a loose application of Michigan’s rules to a strict application of a new desktop review tool unveiled by the DNR.

Issues that had to be resolved include the definition of an Index Flow for each stream and tributary near the project site, evaluation of the critical fish species present, the definition and assessment of cumulative impacts, defining the ecological limits on stream depletions, and stream depletion modeling.

On the surface, High-capacity well permitting is a groundwater problem, and groundwater modeling would appear to be a critical aspect of the analysis. In contrast, our study focused on collection of field data and standard hydrologic analysis; groundwater modeling, and the confusion commonly generated by it, was purposely minimized in our analysis.

* * *
Quantitative studies of flow in fractured rock are important to engineering, hydrogeological, and geotechnical practices due to the ubiquitous nature of fractures in geothermal, water supply, and petroleum reservoirs. Importantly, fluid flow through fractured systems induces energy and chemical exchange with the host rock. The nature and magnitude of this exchange, however, has been shown to be dependent upon several factors including flow path tortuosity and the geometry of fracture heterogeneities. Due to the difficulty of observing flow fields in a natural fracture system, many studies of single-fracture flow have used geometric simplifications such as the parallel plate model. These models, however, lead to inaccuracies when predicting advection and diffusion in natural systems with complex asperity geometries. Here we present work conducted to quantitatively model the effect of natural fracture roughness on fluid flow and energy exchange processes. The first phase of study involves the replication of natural granite fractures using white light interferometry and digital re-composition. Transient modeling of coupled heat diffusion and advection processes through the host fracture is then conducted using COMSOL Multiphysics 5.3a. Preliminary results from flow modeling focus upon the relationship between fracture surface roughness and conjugate heat transfer efficiency in a series of synthetic and natural apertures of variable displacement and surface roughness.

* Student presentation
Karst is defined as a landscape created when water dissolves carbonate rocks, such as dolomite and limestone. Karst potential in Wisconsin occurs in a U-shaped pattern that extends southeast from St. Croix County along the Mississippi River, across the southern two tiers of counties, and northeast along Lake Michigan up to Marinette County. In eastern Wisconsin, karst develops within the Silurian dolomite aquifer. In western Wisconsin, karst forms within both the Sinnipee Group and Prairie du Chien dolomites. Long-term research in northeastern Wisconsin and the ongoing Southwest Wisconsin Geology and Groundwater (SWIGG) project provide opportunities to compare and contrast these karst aquifers.

Both aquifers have a high percentage of wells not meeting drinking water quality standards for nitrate and/or total coliform bacteria. Flow along bedding-plane fractures appears significant in both aquifers, and both can contain perched flow systems over some portions of the aquifer.

While there are some similarities between these karst aquifers, there are significant differences in the topography, lithostratigraphy, structural geology, and geologic history between the two areas of the state. All of these factors contribute to differences in hydrogeology. Our understanding of Silurian aquifer characteristics and recharge dynamics may not be transferable to the southwestern part of the state. It is likely that these aquifers will require different protection strategies.
Disentangling Flow Processes in Fractured Sedimentary Rock

Michael Cardiff, University of Wisconsin-Madison, Department of Geoscience, cardiff@wisc.edu
Jeremy Patterson, UW-Madison, Dept. of Geoscience

The state of Wisconsin is underlain by several sedimentary rock aquifers that provide a valuable water source across the state. While these aquifers have been traditionally thought of as a porous media, more recent detailed investigations have demonstrated the importance of bedding plane partings and other secondary porosity features (henceforth, “fractures”) in controlling groundwater flow through these units. Protecting our deep water resources will require an understanding of how these fracture features contribute to groundwater flow, as well as the potential, during transport, for water in fractures to interact with relatively more slowly-moving water in the host rock.

This presentation will discuss the evaluation of flow processes in fractured sedimentary rock using multifrequency oscillatory testing, a relatively non-invasive method for assessing fracture hydraulic behavior. In particular, we will present field, laboratory, and numerical results demonstrating how multifrequency oscillating tests can provide important information about fracture and host-rock properties. Since oscillatory pumping tests are less familiar to many field practitioners than standard slug and pumping tests, we will further discuss guidelines for applying these methods in the field.

* * *
Concurrent Changes in Winter Precipitation and Ground Freeze-Thaw State and Implications for Streamflow Regimes

Kamila Turczewski,* Marquette University, kamila.turczewski@marquette.edu
Lam Duyen Thuy, Marquette University
Anthony Parolari, Marquette University

Changes in flood frequency and magnitude remain one of the most uncertain impacts of climate change. Rainfall on frozen ground generates more runoff, potentially increasing the severity of floods and altering catchment water balances. Given recent and projected changes in winter precipitation and ground temperature, understanding how rainfall-runoff regimes respond to ground freeze-thaw state is critical to flood and catchment water balance forecasts. We combined precipitation and runoff data from the MOPEX catchments with satellite observations of ground freeze-thaw state to quantify winter rainfall-runoff dynamics. Winter runoff increased for some sites due to increased precipitation depth, whereas it decreased at other sites because the number of winter precipitation events decreased more than the number of frozen days. When the ground was frozen, precipitation depths were generally lower, whereas the runoff depth and runoff ratio were generally higher. Most sites (76%) showed a decrease in the number of frozen days, while 31% of sites, clustered in the Northeastern U.S., showed a decrease in the number of winter rainfall events. There was a significant increase in precipitation depth in the central plains (18% of sites), no change in runoff depths, and a decrease in runoff ratio in the western Appalachian region (23% of sites). This data will improve the understanding of soil hydrologic and thermal regimes toward forecasting streamflow regimes under climate change.

* Student presentation
Geologic Influence on Stream Temperatures and Implications for Future Trout Habitat in the Marengo Headwaters

Anna Fehling,* Wisconsin Geological and Natural History Survey, anna.fehling@wisc.edu
David Hart, Wisconsin Geological and Natural History Survey
Jean Bahr, UW-Madison

Cold-water trout habitat in Wisconsin is projected to decrease as a result of climate change. The extent of habitat loss depends, in part, on groundwater discharge to streams, which can provide cool water refuges suitable for trout. In this study, we evaluated potential climate change impacts to groundwater discharge, stream temperatures, and trout in a small headwater stream in the Chequamegon-Nicolet National Forest in northern Wisconsin.

We used groundwater flow and stream temperature models to evaluate the sensitivity of stream temperature to climatic changes in baseflow and air temperature, as well as physical characteristics like shade and width. Impacts to baseflow were simulated by modifying recharge in a steady-state groundwater flow model. Thermal impacts from climate change were simulated by modifying baseflow, air temperature, and groundwater temperature in a mechanistic stream temperature model. Results were compared to trout thermal tolerance limits over a range of time periods to evaluate habitat impacts. Persistent higher temperatures over several months were projected to have a greater impact on trout than short-term increases in daily mean temperature. Projected increases in air temperature have the greatest influence on simulated stream temperatures, and overwhelm modest changes to width or shade. This improved understanding of system dynamics will help the U.S. Forest Service manage the watershed for trout.

* Student presentation
Physics to Fish: Lake-Specific Climate Change Adaptation Strategies for Cisco Habitat

Madeline Magee, Wisconsin Department of Natural Resources, madeline.magee@wisconsin.gov
Robert Ladwig, UW-Madison
Hilary Dugan, UW-Madison
Peter McIntyre, Cornell University
Andrew Rypel, University of California - Davis
Jordan Read, U.S. Geological Survey

Climate changes have caused significant loss of biodiversity and changes in species distribution in freshwater lakes. In Wisconsin, habitat of cold- and cool-water fish within a lake is constrained by both water temperature and dissolved oxygen, typically forcing these fish into deep waters during summer. Climate warming has squeezed the available thermal habitat within many lakes and fostered prolonged periods of low oxygen in the bottom waters – sometimes causing complete loss of suitable habitat within a lake. The key to managing such lakes under climate change is understanding how climate drivers alter physical processes in the lake and how these processes in turn affect the chemistry and biology of the lake ecosystem. Particularly important is understanding how differences in morphometry, hydrology, and surrounding land use among lakes impact the effectiveness of climate adaptation strategies. From this, we can develop effective lake-specific approaches to offset changes in climate. Using two lakes as an example, I describe the development of lake-specific climate adaptation strategies for cisco (Coregonus artedi), and work to extend the process regionally to identify management options for all of Wisconsin’s cisco lakes.

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How Will Flood Hazard Change in a Warming Midwest?

Guo Yu, * University of Wisconsin-Madison, Department of Civil and Environmental Engineering, gyu29@wisc.edu
Daniel Wright, UW-Madison
Zhe Li, UW-Madison

Predicting changes in overall flood hazard due to climate change is more difficult than predicting the change in the individual factors that cause floods (e.g. rainfall, soil moisture, and vegetation). Regional Climate Model (RCM) simulations hold great promise in weather forecasting, land-atmosphere studies, and projection of climate change impacts including rainfall and flood extremes. The relatively short (~10-year) model runs that are currently feasible, however, inhibit the assessment of the upper tail of flooding (e.g. the 100-year recurrence interval) using conventional statistical methods. Stochastic storm transposition (SST) and process-based Flood Frequency Analysis (FFA) are two approaches that together can help overcome this limitation. We apply our RainyDay SST software and a process-based FFA approach with outputs from high-resolution regional climate simulations to examine current and future extreme flood quantiles in Turkey River watershed in Iowa. We first use a stochastic approach to correct seasonal precipitation biases. These bias-corrected precipitation fields are then be used within RainyDay to create large numbers of extreme rainfall “scenarios.” Finally, we use these scenarios as inputs to process-based FFA to show the potential to understand changes in future flood magnitude and seasonality at various watershed scales.

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* Student presentation
Characterizing the Biogeochemical Factors Impacting Manoomin (Wild Rice) Propagation and Survival in Wisconsin Wetlands Using Culturally-Relevant Practices and Various Spatial Resolutions

Sarah Dance,* University of Wisconsin–Madison, Civil and Environmental Engineering, sdance2@wisc.edu
Marissa Kneer, UW-Madison
Matthew Ginder-Vogel, UW-Madison
Deidre Peroff, UW-Milwaukee

Manoomin, also known as wild rice, is a significant cultural, food, and economic resource for Anishinaabe and other diverse Native Nations and peoples in the Great Lakes Region. As the only natural annual aquatic macrophyte in the region, manoomin occupies a highly specialized niche in the environment. Over the past 100 years we’ve seen dramatic declines in manoomin populations across the state of Wisconsin due to climate change, pollution, overgrazing, and disease. This ongoing work investigates water and sediment quality changes that influence manoomin health and survival. Large scale research is done at Trout Lake Research Station and across the state to support equitable collaborations between Native Nations and university researchers. Fine scale research is done on bucket experiments growing manoomin in water and sediment with conditions changed for current and potential anthropogenic influences. A variety of field and laboratory techniques are used to characterize relevant nutrient and metal concentrations, speciation, and distribution across sediment and root. Ongoing relationship building and consultations with Native Nations and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) will guide research topics, approach, and science communication and outreach. Overall goal of the research is to: 1. Connect large scale processes to fine scale biogeochemical reactions in root environment, and 2. communicate those relationships effectively to diverse stakeholders.

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* Student presentation
Cumulative Deviation from Moving Mean Precipitation as a Proxy for Groundwater Level Variation in Wisconsin

Robert Smail, Wisconsin Department of Natural Resources, robert.smail@wisconsin.gov
Aaron Pruit, WI Dept. Natural Resources

This study introduces a modified method for comparing cumulative precipitation anomalies to groundwater level variation. This method transformed gridded monthly precipitation data from 1895 to 2018 into monthly deviations from different moving mean lengths at 90 USGS groundwater monitoring locations in Wisconsin. The precipitation data was then compared to water level variation at each site and correlations were calculated. The average optimal moving mean window length for all sites was identified. Well depth, aquifer classification and location were tested as potential factors influencing the strength of correlation with groundwater levels and optimal mean length. This presentation will show how this method can help diagnose factors affecting monitoring well response, identify inconsistencies in a monitoring record and generate hypotheses regarding aquifer response to precipitation. Further, this presentation will show how this method can be used to impute historical seepage lake levels when limited data is available. This method leverages easily accessible datasets to serve as a starting point that engineers, groundwater professionals and resources managers can use to generate and test hypotheses about sites without prior knowledge of the geology or aquifer properties, extraction rates, and land cover.

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Insights from Instantaneous Measurements: 15 Years of Streamflow Data in the Central Sands

Jessica Haucke, University of Wisconsin-Extension & University of Wisconsin-Stevens Point, jhaucke@uwsp.edu
Aaron Pruitt, Wisconsin Department of Natural Resources, Aaron.Pruitt@wisconsin.gov
Adam Freihoefer, Wisconsin Department of Natural Resources

The Wisconsin Department of Natural Resources (WDNR) relies on measured streamflow to assess natural flow variability and the impact of nearby groundwater pumping on classified trout streams. In order to assess stream impacts, an established record of measured flows is needed, and more importantly, an established record of groundwater contribution to those streams is needed. With over 13,000 miles of classified trout streams within the state, the existing network of real-time streamflow monitoring is spatially and temporally sparse.

Since 2005, UW-Stevens Point (UWSP), in partnership with the WDNR, has systematically collected over 5000 monthly baseflow measurements on 163 stream segments throughout the Central Sands region of Wisconsin. The development of a reliable, robust 15-year record of streamflow measurements has required consistent methodology, quality control and participation by UWSP staff and citizen volunteers.

The WDNR has incorporated the UWSP dataset into high capacity well reviews, groundwater flow model calibration, and the identification of longitudinal changes in flow regimes within a stream. This retrospective assessment of the UWSP dataset offers insights on our perceived understanding of Central Sands hydrology, the use of the data for water management decision making, and future improvements to the spatiotemporal collection this important water budget component.

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Water Use by Crops and Forest and Improving Irrigation Planning and Early Prediction for Agricultural Drought in Wisconsin

Ammara Talib,* Civil and Environmental Engineering, UW–Madison, talib@wisc.edu
Ankur Desai, UW-Madison

In our ability to sustain food production, it is important to know how much water our crops need. The risks of climate extremes such as heat waves and droughts are increasing and have already threatened the north Central America agricultural system in form of increased drought duration, intensity and reduced crop yield. Agricultural vulnerability can be reduced through advanced monitoring of agricultural water consumptive use and improved drought estimation. The goal, of this research is 1) to calculate the water use efficiency of different potato varieties 2) comparison of water use between potatoes and pines. These goals are achieved by comparing ET and soil moisture data from eddy covariance flux towers and soil moisture sensors installed in irrigated Heartland and pine forest in Tri-county of WI. The data comparison between potatoes and pine ET shows that when there is a big rainfall or irrigation event, the differences between already available ET measurement based on remote sensing models and actual ET measurements are small. However, when soil is dry, ET measurement from Eddy covariance flux tower are more accurate. In addition, the soil moisture and ET comparison provides insight about coupling between soil moisture and ET. New field-scale actual ET measurement will provide deep insights and indicate when plants are under stress and farmers can take actions and use limited water resources efficiently to maintain productivity.

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* Student presentation
Impact of Agricultural Practices on Evapotranspiration Rates in Wisconsin

Robert Smail, Wisconsin Department of Natural Resources, robert.smail@wisconsin.gov

In highly agricultural areas such as the upper Midwest of the United States, agricultural management choices such as crop selection, crop rotation, and irrigation can affect how precipitation is partitioned between infiltration, runoff, evapotranspiration. This partitioning can in-turn affect how agricultural land management impacts surface water and groundwater quality and quantity. Much research has been done in the region measuring and estimating landscape scale runoff and infiltration. However, actual evapotranspiration remains one of the most difficult to measure or estimate at landscape scales despite it being the second largest component of the hydrological budget behind precipitation. In recent years, several remote sensing products have become available that estimate actual evapotranspiration (ETa) based on combinations of remote sensing data and land based meteorological observations. When combined with precipitation observations, a better understanding of ETa can support the design and planning practices or policies that minimize the impact of different land uses. This presentation will first compare ETa estimates from two remote sensing-based products. Second, this presentation will show how different landscape features and agricultural practices affect agricultural ETa rates on Wisconsin agricultural lands. Finally, this presentation will show how differences in ETa rates affect the amount of water available for runoff and infiltration.
Preliminary Survey of PFAS in Surface Water and Fish Tissue from Select Wisconsin Waterbodies

Timothy Asplund, Wisconsin Department of Natural Resources, tim.asplund@wisconsin.gov
Michael Shupryt, WI Dept. of Natural Resources
Meghan Williams, WI Dept. of Natural Resources

Per- and polyfluoroalkyl substances (PFAS) are a group of human-made organic chemicals that have been used in industry and consumer products worldwide since the 1950s. PFAS are highly resistant to degradation, are distributed worldwide, and have documented toxicity to animals and links to adverse health effects in humans. In 2019 Wisconsin DNR conducted an initial survey of PFAS compounds in surface water and fish tissue collected from six waterbodies near known or suspected sources of PFAS contamination. The goals of the survey were two-fold: A) document PFAS concentrations in water and fish tissue at sites with known or suspected contamination and B) collect paired fish tissue and surface water chemistry to aid development of a future water quality standard. Initial water chemistry results revealed that all sites had some detectable PFAS analytes, however, two sites with lower stream flow and proximity to known sources of PFAS contamination showed the highest concentrations. For example, PFOA and PFOS were measured in the range of 20-40 ng/l and 71-360 ng/l, respectively for one waterbody surveyed. Interestingly, one other waterbody near a known source of PFAS did not have any detectable levels of PFOS or PFOA. In this presentation we will present the results of water chemistry and fish tissue monitoring, as well as describe how these data will be used in the development of a future water quality standard and inform future monitoring and source identification efforts.

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Urban and agricultural lands in the Great Lakes basin represent a large potential source of pesticides to surface water. However, it is unclear how the number, mixtures, and concentrations of pesticides relate to corresponding potential biological effects. The USEPA ToxCast database and USEPA Aquatic Life Benchmarks were used to evaluate potential biological relevance of pesticides detected in samples from 16 Great Lakes tributaries collected monthly in 2015-16. A combination of detection frequency, toxicity quotient (TQ), exposure activity ratios (EAR), and mixture metrics were used to characterize the potential biological effects of pesticides. Pesticides were detected at all sites and in 190 of 198 samples. The suite of metrics showed two rivers in row-crop dominated basins, the Maumee and Vermillion in Ohio, were the most impacted sites, followed by three urban rivers that were all similarly ranked. To prioritize chemicals, we combined the effects of each parent compound and associated degradates. Two herbicides stood out for their potential to impact biota; metolachlor and atrazine had threshold exceedances (TQ and EAR) in >70% of samples, at 14 or more sites, and in all months. There was no biologically-relevant data available for seven commonly detected pesticides, six of which were degradates. These results highlight degradates as a large unknown for impact assessment and suggest our understanding of potential effects of pesticides on aquatic organisms is incomplete.
The presence of microplastics has been documented in the Great Lakes and their tributaries. The distribution of particle types (fibers, fragments, beads/pellets, films, foams) have been found to vary in the water surface with a low proportion of fibers (< 14%) in Great Lake water and high proportion (> 70%) in the tributaries. Despite knowledge of microplastic presence, little is understood about the distribution and fate of microplastics in the Great Lakes. Two follow-up studies were conducted to understand the distribution and fate of microplastics in the Great Lakes: (1) evaluate the vertical distribution of microplastics in the water column in rivers, estuaries and nearshore Lake Michigan; (2) quantify microplastics in sediment samples from Lake Michigan and Lake Erie. Microplastics of all types, were observed in every sediment and water sample collected. Microplastic particles were distributed throughout the water column and sediment with increasing particle density from the water surface through the water column to the sediment. Results indicate that the discrepancy between high proportions of fibers in the water surface of the tributaries compared to the Great Lakes is explained by fibers settling through the water column and into the sediments. These studies provide progress towards understanding the distribution and movement of microplastics in the aquatic environment, key information for future assessments of potential effects on aquatic life.
Prioritizing Chemicals and Chemical Mixtures of Ecological Concern in Great Lakes Tributaries

Steven Corsi, US Geological Survey, Upper Midwest Water Science Center, srcorsi@usgs.gov
Laura De Cicco, USGS
Daniel Villeneuve, USEPA
Brett Blackwell, USEPA
Gerald Ankley, USEPA

With thousands of chemicals in production and analytical methods with very low detection levels, identifying which chemicals are most likely to pose an ecological hazard is challenging. Many chemicals are present as complex mixtures for which the potential biological consequences are difficult to predict. For a sequence of Great Lakes tributary surveillance studies from 2010-2018, chemicals and chemical mixtures of ecological relevance were prioritized based on potential for biological effects using a “high-throughput” database from the ToxCast program and established water quality benchmarks using the toxEval R-package. Predictions of cumulative biological effects from chemical mixtures were estimated based on summation of effects from common biological pathways. Collectively, contaminants monitored in these studies included more than 500 chemicals. Chemicals identified to be of potential concern have included PAHs, flame retardants, components of plastic products, pesticides, pharmaceutical compounds, and others. Analysis on molecular-level bio-chemical interactions from ToxCast provided information on potential biological pathways and associated adverse outcomes. With this bio-effect-based approach, the number of chemicals targeted for further consideration were reduced by about 90% from the total number of chemicals analyzed, providing an option for resource managers to focus their attention on chemicals with the greatest potential for adverse ecological effects.

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Water Chemistry and Lake Dynamics of Laguna Bacalar, Quintana Roo, Mexico

Ryan Matzuk,* University of Wisconsin–Milwaukee, Department of Geosciences, rmmatzuk@uwm.edu
Timothy Grundl, UW-Milwaukee, Department of Geosciences

Laguna Bacalar in the Quintana Roo region is the second largest lake in Mexico and contains freshwater derived solely from groundwater. An increasing flux of travelers to the city of Bacalar is threatening the health of this freshwater resource, which is used as a drinking water source and for recreation by locals and tourists alike. Local geology on the Yucatan Peninsula is karstic and the southern shoreline of Laguna Bacalar is spotted with a handful of cenotes that contribute substantial amounts of inflowing groundwater to the lake. This is shown by sonde profile data taken in one of the largest cenotes in the area. Outflow is dominated by a surface water outlet in the southern portion of the lake and an unknown amount of outflowing groundwater. During January of 2016 through 2019, UWM researchers collected data on the physical flow to and from the lake, $\delta^{13}$C, $\delta^{18}$O and D isotopes, and major ion chemistry in order to provide insight into the overall physical hydrology of the lake. The primary hydrochemical processes controlling lake chemistry include influx of high alkalinity groundwater in the southern portion, CO$_2$ evolution and a resultant pH rise and calcite precipitation. Saturation indices modeled using PHREEQC indicate the water in Laguna Bacalar is oversaturated with calcite and gypsum. The northern portion of the lake has no groundwater influx and is dominated by evaporative effects.

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* Student presentation
Importance of Childhood Pb Exposure from Food Crops Grown in Contaminated Residential Soils Versus Exposure from Soil/Dust or from Drinking Water

Tim Grundl, University of Wisconsin-Milwaukee, Department of Geosciences, grundl@uwm.edu
Harris Byers, UW-Milwaukee, Department of Geosciences

Pb exposure causes a multitude of poor health outcomes particularly in children less than 6 years old. There is no safe level of lead exposure. In food-insecure areas, growing fresh produce in residential gardens is one option for parents; however, commonly grown crops accumulate Pb in consumable tissues when grown in metals-rich soils. A variety of produce crops were grown in soils from two metals-contaminated urban vegetable gardens, a former metal foundry, and commercial topsoil. Custom wavelength dispersive X-ray Fluorescence (WD-XRF) and portable energy dispersive X-ray Fluorescence (ED-XRF) quantification routines were developed that allowed detection of Pb at levels relevant to health standards (0.3 ppm). The accumulation of Pb in consumable tissues was the greatest in vegetables with a modified taproot (turnip, beetroot, radish, carrot), with lesser concentrations in fruits (tomato, pepper), and produce grown on modified stems (potato).

Three primary sources of childhood Pb exposure in impoverished urban settings are ingestion of a) contaminated soil/dust; b) food grown in contaminated soil and c) contaminated drinking water. The relative importance of these three sources was evaluated under a variety of scenarios likely to be encountered in an urban setting. Ingestion of contaminated soil/dust was found to be the most important, followed by ingestion of food grown in contaminated soil. No scenario was found in which exposure via Pb contaminated water was a dominant factor. This result calls into question the relative economic benefit of Pb pipe removal as a means of reducing the incidence of Pb poisoning.
USGS Plans for Integrated Model Development – The Gathering of the Clans

Mike Fienen, US Geological Survey, mnfienen@usgs.gov

The US Geological Survey has a long history of developing open-source hydrologic modeling codes that have been staples of the environmental hydrology field and industry. The codes (including MODFLOW, PRMS, GSFLOW~, SWB, and others) have been historically developed in response to specific needs by various programs and groups within USGS. A goal for the next 10 years is to more deeply integrate model capabilities and development.

Integration has two meanings in this context: first is integration of hydrologic processes, and second is integration of the software development team. For processes, it is well-recognized that one and two-way coupling of processes varies depending on scale and the reason for modeling. Integration, then, motivates a flexible framework where the degree of coupling is dependent on the problem. For the team, various groups that have developed modeling codes for USGS have adopted various levels of modern software design principles. Integrating the team with a common vision and approach will result in a more stable environment for robust software.

* * *
Challenges and Insights from Heat Transport Modeling of a Humid Temperate Watershed

Randy Hunt, US Geological Survey, Upper Midwest Water Science Center, rjhunt@usgs.gov
Daniel Feinstein, USGS, Upper Midwest Water Science Center
Eric Morway, USGS, Nevada Water Science Center
Jordan Read, USGS, Water Mission Area
Vivek Bedekar, SSPA

Models of future climate suggest general atmospheric warming; how these changes ripple through to the subsurface and aquatic resources is less understood. To characterize such systems, a multi-process simulation is required, but this can require tradeoffs in how the modeling problem is decomposed. Temporal and spatial scales can be different, and importance of a given simulated process may be influenced by the forecast of interest type. These tradeoffs, and insights attained, are explored with an existing well-calibrated watershed model in the Trout Lake watershed, Wisconsin. The basin is simulated using a coupled GSFLOW-SNTEMP model, that drives a MT3D-USGS transport model that moves changes in air temperature through the unsaturated and saturated zone to streams and lakes. The overall objective is to forecast lags and magnitudes of temperature changes throughout the system. The simulations show reasonable results for stream temperatures. However, some important lake physical processes such as phase changes at ice-in and ice-out cannot be handled in the current version of MT3D-USGS. Moreover, handling such processes requires sophistication in energy balance simulation — sophistication not required for simply simulating solute transport to lakes. The success of modeling is a function of keeping what is needed and omitting what is not. Therefore, decomposing the modeling problem can only help bringing coupled and integrated models to bear on societally relevant questions.

* * *
Evaluating the Condition of Wisconsin's Surface Waters

Catherine Hein, Wisconsin Department of Natural Resources, catherine.hein@wisconsin.gov
Michael Miller, WDNR
Tim Asplund, WDNR
Sally Jarosz, WDNR
Madeline Magee, WDNR

According to EPA National Aquatic Resource Surveys, most of Wisconsin’s lakes, streams, rivers, wetlands, and coasts are in good condition. The prevalence of disturbance varies by resource and stressor. Nutrient pollution is common and most widely observed on rivers and streams. Habitat degradation is prevalent, and fish contamination is the primary stressor in coastal areas of the Great Lakes. These probabilistic surveys allow condition evaluations to be scaled up across all surface waters.

* * * 

Protecting Water Quality with Prairie Filter Strips

Craig Ficenec, Sand County Foundation, cficenec@sandcountyfoundation.org

Greater protections against farm runoff are needed in Wisconsin, especially under extreme weather events. Research from Iowa State University shows that establishing strips of diverse perennial vegetation (i.e. “prairie strips”) on 10% of a farm field can reduce soil and nutrient losses by over 80%, while enhancing biodiversity. Sand
County Foundation and partners are installing prairie strips with Wisconsin farmers and modeling their potential role in watershed adaptive management efforts.

* * *

Using Hydrograph Separation to Improve a Statistical Water Quality Model

Matthew Diebel, Dane County Land & Water Resources, diebel.matthew@countyofdane.com

Weighted Regression on Time, Discharge, and Season (WRTDS) has become a standard method for statistical modeling of river water quality dynamics. We developed an extension of this method, the Flow Separation Model (QSM), which separates discharge into base flow and quick flow. Based on total phosphorus data from 10 rivers in southern Wisconsin, QSM consistently fits better than WRTDS and sometimes indicates different temporal trends in flow-normalized concentrations and fluxes.

* * *
Quantifying Manure Application Methods on Greenhouse Gas Fluxes and Runoff Water Quality in a Dairy Agroecosystem

Eric Young, USDA, Agricultural Research Service, eric.young@usda.gov
Jessica Sherman, USDA-ARS
Eric Young, USDA-ARS
Jason Cavadini, University of Wisconsin, Marshfield Agricultural Research Station

Runoff water quality and greenhouse gas (GHG) emissions are two challenging nutrient management issues in dairy production. During 2018-2019, field runoff water quality and GHG fluxes were measured in a corn silage field after: i) no manure, ii) surface application, iii) chisel plow incorporation, and iv) vertical tillage incorporation (VT). Results indicate that VT reduced both GHG fluxes (nitrous oxide and methane) and runoff nutrient losses (nitrogen and phosphorus) compared to other methods.

* * *

Adaptation Strategies for Wisconsin Lakes Facing Climate Change

Madeline Magee, Wisconsin Department of Natural Resources, madeline.magee@wisconsin.gov

A WICCI workshop identified climate change adaptation strategies for inland lakes. Participants identified a multi-faceted approach that incorporates communication and outreach, policy and regulation changes, traditional resource conservation approaches, and novel engineering designs. This approach focuses on protecting high-quality lakes, building lake resilience, and retaining beneficial ecosystem services while promoting thoughtful, strategic interactions with stakeholders.
The Lake Connection: Implementing the Central Sands Lakes Study

Jeffrey Helmuth, Wisconsin Department of Natural Resources, jeffrey.helmuth@wisconsin.gov

The influence of water budget components, particularly groundwater withdrawals, on Wisconsin’s lakes has been difficult to measure or predict. To that end, the Legislature mandated that the WDNR evaluate and model the impacts of existing and future groundwater withdrawals on three lakes in Waushara County. This talk introduces the Central Sands Lakes Study break-out session which is designed to generate discussion and gather input on the approaches and methods being used in the study.

* * *

Putting the Fun in Fundamentals: Interesting Problems at the Intersection of Fluid Mechanics, Coastal Engineering, and Environmental Processes

Nimish Pujara, University of Wisconsin-Madison, Department of Civil and Environmental Engineering, npujara@wisc.edu

The complex motion of water and air is an important piece of the puzzle in a wide range of problems in environmental and coastal processes. This talk will give a few examples of research projects that bring knowledge from fluid mechanics to bear on such applied problems. Along the way, we will see why brass beats bubbles when it comes to erosion, what water waves have in common with dodgy dams, and why glitter is important to understand whether plankton get dizzy.
Putting Science to Work for Clean Drinking Water

Andrew Aslesen, Wisconsin Rural Water Association, aaslesen@wrwa.org

This talk highlights how the research done by academia, state agencies and others is put to work on a day to day basis. Specifically for the purpose of protecting municipal drinking water supplies through the development of source water protection plans.
1. A Sedimentological Characterization of Huron Mountain Streams for Application to Future Ecological Studies

Benjamin Sieren,* University of Wisconsin-Parkside, Geosciences Department, siere001@rangers.uwp.edu
Rachel Headley, UW-Parkside

The Huron Mountain region of Michigan’s Upper Peninsula provides a pristine environment for interdisciplinary studies across ecology and geology. A preliminary analysis of multiple rivers within two separate watersheds links hydrologic setting to its impact on aquatic plants and dragonflies. Characterizing the diverse fluvial environments was done via Wolman pebble counts using a gravimeter and sieving lithologic bed load samples to determine grain-size frequency. Geomorphic analysis of river dimensions and velocity as well as documentation of obvious aquatic vegetation and emergent rocks within the bed load helped to further study which areas will best suit future efforts. Streams with greater gradients and coarser average grain size appeared to hold more emergent cobble and boulders—such as the Pine River—for potential dragonfly larval hatch to occur on. Depth and velocity of the rivers had an apparent link to prevalence of aquatic plants observed. Bed material of the streams showed linkage to its provenance—either the Jacobsville sandstone or Precambrian metamorphic rock. Overall grain-size ranged from fine sand to small boulders, depending on the river. Sediment load of the river has the potential to affect water chemistry and nutrients available to the biota of this ecological setting. With an expectation to begin biological sampling of insects and aquatic vegetation soon, the familiarity of this riparian environment through this study will prove worthwhile.

2. Source Water Contribution in Albion Basin Wetlands Based on Spring and Surface Flow Measurements

Kristen Carlson,* University of Wisconsin-Parkside, Geosciences Department, carls066@rangers.uwp.edu
Dan Kerstan, UW-Parkside
Ben Sieren, UW-Parkside
John Skalbeck, UW-Parkside

The Albion Basin of Alta, Utah is an alpine watershed and headwater for Little Cottonwood Creek which is a source of drinking water for Salt Lake City. Three wetland study sites—Catherine’s Pass, Collin’s Sugarloaf, and Albion Fen—have been characterized using water-level, water chemistry, spring flow, and surface water flow data. Groundwater contribution at each wetland study site was calculated from flow data using a simple water balance approach. Calculated groundwater contributions at Catherine’s Pass for five sampling events show strong correlation relative to peak water levels. Correlation curves comparing groundwater and surface water contribution to the total discharge from the wetland study sites show that Catherine’s Pass is groundwater dominant, and Albion Fen is surface water dominant. Results for Collin’s Sugarloaf suggest a mix between surface and groundwater contribution. These findings are consistent with water chemistry data and hydrographs from thirteen sampling seasons. Redirecting spring flow for anthropogenic purposes looks to have an impact on the wetland water balance. This was examined using a quantitative analysis of residential water usage in the Catherine’s Pass wetland study site. With the expected effects of climate change, precipitation and snowmelt events are becoming increasingly less predictable. The findings of our analysis could potentially influence future watershed management decisions.

* Student presentation
3. A Seasonal Record of Monthly Mean Discharge in the Upper Midwest

Paige Blaha,* University of Wisconsin-Whitewater, blahape18@uww.edu
Dale Splinter, UW-Whitewater
John Frye, UW-Whitewater
Jillian Stephens, UW-Whitewater

The duration, frequency, timing, and type of precipitation received in the upper Midwest has changed over the last 60 years. As an example, much of northern Wisconsin underwent a period of decreased precipitation during the 2000s. Whereas, much of the southern portion of the state saw an increase in precipitation during this same period. For this reason, a study was designed to align monthly mean precipitation with monthly mean discharge for three states in the upper Midwest. A minimum of 60 years of data was required in the selection of weather stations and stream gages. Precipitation data from weather stations is being aggregated and aligned to stream gages in Wisconsin (42 gages), Minnesota (38 gages), and Michigan (52 gages). Preliminary results show that mean annual precipitation has decreased in parts of northern Wisconsin and the Upper Peninsula of Michigan between 1950 and 2017. It is expected that monthly mean discharge will also have decreased. This is based on data highlighting a decrease in days of precipitation across much of the northern latitudes of Wisconsin, Minnesota, and Michigan. Understanding the relationship among precipitation and streamflow across the upper Midwest is critical for making informed management decisions at multiple spatial scales.

4. Impact of Changing Frozen Ground Regimes on Groundwater Recharge in the Midwest

Katrina Rabeler,* University of Wisconsin-Madison, Geological Engineering, rabeler@wisc.edu
Steven Loheide, UW-Madison, Civil and Environmental Engineering

Development of seasonal snowpack leads to groundwater recharge associated with spring snowmelt, which often accounts for a large percentage of annual groundwater recharge in the Midwest. In a warming climate, mid-winter snowmelts are expected to become more common, which may shift a portion of this groundwater recharge to earlier in the year. However, loss of snow cover can also change the soil thermal regime because snow acts as an insulating layer. Understanding the multifaceted feedbacks between frozen ground, infiltration, snow cover, and groundwater recharge are critical for predicting the ways in which groundwater resources will be affected by climate variability in the future. The objective of this study is to determine the extent to which freeze and thaw cycles alter groundwater recharge. Using historical groundwater levels, precipitation, and soil temperature records, we investigate relationships between winter precipitation, the soil thermal regime, and groundwater recharge.

5. Frequency Dependence in Flow Properties of a Fractured Bedrock Aquifer

Jeremy Patterson,* University of Wisconsin-Madison, Department of Geoscience, jpatterson7@wisc.edu
Michael Cardiff, UW-Madison, Dept. of Geoscience

Secondary porosity features such as fractures act as conduits of enhanced flow and transport in bedrock aquifers, which are found extensively throughout the bedrock of Wisconsin. As such, understanding fracture flow and transport through fractured bedrock aquifers is of critical importance to WI groundwater resources. Recent advances in aquifer characterization techniques has seen the development of periodic pumping tests to estimate effective fracture flow properties, with multiple studies observing that estimated flow properties are dependent upon the period of the input signal.

* Student presentation
In this work we present the results of periodic pumping tests conducted in a fractured sedimentary bedrock setting near Madison, WI. Using inflatable packers we isolated and tested individual fractures identified using borehole geophysical logs. We present the results of more than 100 periodic pumping tests conducted across a range of input periods. Consistent with previous studies in fractured bedrock settings, we assess for frequency dependence of fracture flow parameters by conducting parameter estimation with developed analytical solutions.

6. Sharing Interactive Water Use Sector Data

Joseph Rosnow, Wisconsin Department of Natural Resources, Joseph.Rosnow@wisconsin.gov

Wisconsin’s Great Lakes Compact implementing legislation requires water users to annually report their monthly water use to the Wisconsin Department of Natural Resources (WDNR). The implementation of this law allows for spatiotemporal tracking of water use by sectors (agricultural, power, public water supply, etc.). For the past seven years, the WDNR’s Water Use Section has released an annual publication providing an assessment of surface water and groundwater use in Wisconsin. The WDNR continues to look for more effective ways to serve water use data to our customers. In an effort to engage a larger audience with more interactive tools, the Water Use Section has developed an ESRI ARCGIS Online Story Map related to water use in Wisconsin. This Story Map format provides a combination of narrative, graphics, and interactive maps. This provides the public with an opportunity to search and explore water use statewide, by region, by county, per water use sector and more. Additional content will provide insight on water use in Wisconsin and serve as a tool to connect people to local and statewide water use trends.

7. Hydrologic Investigation of the Chiwaukee Prairie Restoration Site (Kenosha County, Wisconsin)

Nicholas Potter,* Michigan Technological University, napotter@mtu.edu
Rodney Chimner, Michigan Technological University
John Gierke, Michigan Technological University

Historically, wetlands were commonly converted to farmland through ditching and tiling. However, a better understanding of the importance of wetland functions has led to restoration efforts. The Nature Conservancy is conducting a restoration project in southeast (Kenosha County) Wisconsin to rewet specific wetlands adjacent to Chiwaukee Prairie. This study’s goal is to evaluate the effectiveness of the restoration activities on the wetland hydrology. The study area (approximately 1.6 km N-S, 1.1 km E-W, 180 ha) is within the Wisconsin-Illinois coastal Lake Plain, which is a 1580-ha wetland complex spanning an area 24-km south of Kenosha, Wisconsin to Waukegan, Illinois. This complex has ridge and swale topography from the ancient shorelines formed from post-glacial fluctuations of Lake Michigan. For this study, 27 piezometers were installed and monitored between late May and early June 2019. Monitoring was also conducted in 18 piezometers operated by the Illinois State Geological Survey and a Wisconsin Department of Natural Resources air quality monitoring station. Measurements were conducted bi-weekly during the summer, and monthly thereafter. Results provide baseline data on groundwater levels and temperatures at selected sites for the wetland restoration that started October 2019. Pre-restoration observations show the restoration site’s water table is lower than Chiwaukee Prairie’s and the sites react similarly to precipitation events but show different drying curves.

* Student presentation
8. Transport of Microplastic Fibres in Waves: The Effects of Fibre Length and Wave Properties

Gabrielle Every,* University of Wisconsin-Madison, Department of Civil and Environmental Engineering, gevery@wisc.edu
Nimish Pujara, UW-Madison, Dept. of Civil and Environmental Engineering

Microplastic fibres that are shed from clothing, fishing lines, and the breakdown of other plastic waste contaminate lakes and oceans. This contamination poses a threat as plastic debris can be ingested by small aquatic organisms and transferred across the food web causing harm to fisheries and humans. Surface waves are one mechanism by which microplastic fibres are spread through the surface waters. We study this phenomenon using mathematical models that apply slender body theory and linear wave theory to predict the motion of fibres in surface waves. We use these models to explore how increasing fibre length and initial position/orientation changes the transport and orientation patterns of fibres under different wave conditions. The results show that the drift velocity decreases exponentially with rod length and is bound by the Stokes drift for extremely small rods. From these results, we further investigate how the rate of decrease relates to wave parameters. This allows us to produce a map of microplastic drift velocity as a function of fibre length and wave properties.

9. Geophysical Models Suggest Precambrian Bedrock Structures Are an Important Control on Precambrian Surface Topography

Joseph Rasmussen,* University of Wisconsin-Madison, Department of Geoscience, jmrasmussen3@wisc.edu
Esther Stewart, Wisconsin Geological and Natural History Survey

Precambrian basement forms the base of southern Wisconsin’s Cambrian sandstone aquifer, and Precambrian surface topography impacts aquifer thickness and perhaps groundwater quality. Existing interpretation of Precambrian elevation is based on outcrops and wells with limited spatial distribution; We use coupled gravity and aeromagnetic models to refine this interpretation, especially in places with little or no well or outcrop control. Initially we hoped to interpolate a Precambrian topographic surface using a grid of topographic profiles modeled from the geophysical data. However, resolution of Precambrian topography is limited by the low resolution of the geophysical data due to the coarse spacing of each data set. Generally, depth-to-Precambrian is less than the data resolution. However, geophysical models do constrain the location of Precambrian bedrock contacts and structures. We modify our approach to first use geophysical data to identify and map Precambrian structures and contacts. We then observe how Precambrian topography known from wells and outcrops changes across these interpreted features. We note that significant changes in the trend and slope of the Precambrian surface coincide with some of the interpreted structures. This observation informs how we hand-contour Precambrian topography: Wells and outcrops are our main input, and we allow breaks and offset in elevation contours across significant Precambrian structures identified in the geophysical data.

10. Solitary-wave-induced Boundary Layer Flows Over Permeable Beds

Claudio Meza-Valle,* University of Wisconsin-Madison, Civil and Environmental Engineering, meza4@wisc.edu
Philip L.-F. Liu, National University of Singapore
Nimish Pujara, University of Wisconsin-Madison

Waves in the nearshore environment are defined by their interactions with the sea bed. Waves can shape the sea bed through sediment transport and, in turn, friction with the sea bed can cause waves to dissipate part of their energy before reaching the shore. We investigate this coupled problem using a combination of theory and laboratory experiments for the case of a solitary wave travelling over a permeable bed. Solitary waves are a useful model since their wavelength to water depth ratios and amplitude to water depth ratios fall within the range of

* Student presentation
nearshore coastal waves. This work focuses on the boundary layers induced by solitary waves over permeable beds, which influence processes such as sediment transport and wave damping. Extending previous work in this area, we calculate the velocity profiles and bed shear stresses using a formulation that includes the effects of fluid viscosity near the sea bed and the flow through the permeable sea bed driven by wave-induced pressure gradients. Using this formulation, we test how the boundary layer is influenced by the hydraulic conductivity of the sea bed and by the properties of the wave. We also investigate the influence of a slip velocity at the interface between the fluid and sea bed.

11. Are Knowledge Brokers an Undiscovered and Already Endangered Species in the Ecosystem of Environmental Organizations?

Francisco Guerrero-Bolaño, Wisconsin Department of Natural Resources, guerrero.francisco.jose@gmail.com
Alison Mikulyuk, Wisconsin Dept. Natural Resources
Matt Diebel, Dane County Land and Water Resources
Alex Latzka, Wisconsin Dept. Natural Resources
Jennifer Hauxwell, Aquatic Sciences Center, UW-Madison

Ecosystems of environmental organizations are clusters of interconnected science-based institutions involved in understanding and regulating the interactions between humans and their environment. Such ecosystems comprise a wide array of “species” dealing with heterogeneous sources of information (e.g., data, paradigms, and stories). Articulating these information sources is essential for understanding and supporting policy formulation. Yet, such articulation involves a “key species” that has remained largely unrecognized within these organizational ecosystems: knowledge brokers. We borrow concepts from (eco)systems biology, business management, and science communication to describe the relationship between the knowledge broker and their organizational context, which includes aspects such as efficiency, robustness, and evolvability. These are key attributes for science-based agencies dealing with changes in the planetary and political climate. We offer a definition for the knowledge broker that figuratively engages the concept of “organisms as ecosystem engineers” (Jones, 1994). “Knowledge brokers are species that modulate the availability of information to other species by transforming and communicating data, paradigms, and stories. In so doing they modify, maintain and create knowledge”. We explore this metaphor to better understand the emergence, functioning and potential future of knowledge brokers within agencies that operate at the interface of science and policy.

12. Using Infrared Thermography to Characterize Temperature Over Space and Time in Wisconsin Springs

J. Garrett Rachal,* Beloit College, rachaljg@beloit.edu
Susan Swanson, Beloit College

Springs are known to create cold refuges for aquatic biota during the summer, but little quantitative information is available on how temperature conditions vary among different spring types. Temperature differences between rheocrene fracture and seepage filtration springs can be spatially and temporally characterized to fill gaps in knowledge about their thermal heterogeneity. In this study, a FLIR Vue Pro R Thermal Camera captured thermal images of the top 0.1 µm of water in a fracture spring and a seepage filtration spring in late summer and early winter of 2019. The camera was mounted at a 90° angle directly above the springs to limit the effects of reflectivity and water disturbance on the thermal images. Emissivity is considered negligible due to the short observational distance (< 2 m). At each site, four static thermal images were taken, in addition to a 10-second sequence of images at one frame per second. The thermal images use a consistent color palette assigned in the FLIR Tools software and have temperature ranges limited to highlight variation in temperature. Initial results suggest greater thermal heterogeneity in seepage filtration springs when compared to fracture springs.

* Student presentation
13. Assessment of the Source and Mobility of Phosphorus in the Hydrologic System in Western Wisconsin

Evan Lundeen,* University of Wisconsin-Eau Claire, Lundeeew4871@uwec.edu
Emily Finger, UW-Eau Claire
Jacob Erickson, UW-Eau Claire
J. Brian Mahoney, UW-Eau Claire
Sarah Vitale, UW-Eau Claire

Lake eutrophication due to nutrient loading from phosphorus and nitrogen is a growing problem across the upper Midwest, causing a loss of recreational tourism and aquatic biodiversity, damage to fisheries, and adverse impacts on human health. Although eutrophication is often blamed on anthropogenic sources, preliminary results suggest a notable amount of nutrient loading may be petrogenic. The objective of this investigation is to distinguish the source of phosphorus contamination in surface and groundwater systems in western Wisconsin, and to understand the mechanisms behind phosphorus mobility in the regional hydrologic system. The project includes a regional analysis of surface (n=45) and municipal well groundwater (n=15) samples in western WI, measured for phosphorus, iron, manganese, nitrate and basic water quality parameters, to obtain a baseline spatial phosphorus distribution and an understanding of the geochemical environment. Sequential extraction analyses of phosphorus-bearing geologic units help determine the natural conditions under which phosphorus may be mobilized. Results demonstrate groundwater phosphorus concentrations frequently exceed WI surface water regulatory limit (max 100 ppb), and that phosphorus is highly mobile along flow pathways into lakes and streams. This research is important in developing a comprehensive understanding of phosphorus migration in Wisconsin’s regional hydrologic systems to implement effective lake and waterway management.

14. An Investigation of Phosphorus Loading Through Lacustrine Groundwater Discharge in Mud Lake, Barron County, WI

Jacob Erickson,* University of Wisconsin-Eau Claire, ericksjp8719@uwec.edu
Maddie Palubicki, UW-Eau Claire
Austen Fairbanks, UW-Eau Claire
Sarah Vitale, UW-Eau Claire
Brian Mahoney, UW-Eau Claire

Mud Lake experiences severe lake eutrophication throughout the summer months. Although anthropogenic nutrient sources have been identified as a contributing factor, an ongoing investigation at UW-Eau Claire has demonstrated that the regional bedrock geology may also be a source of phosphorus (P) to the hydrologic system. Furthermore, despite historic assumptions that P is immobile in groundwater systems, the study provides evidence that P is highly mobile in the subsurface. The objective of this study is to understand the mobility of P in groundwater and its impact on Mud Lake. This entails the collection of groundwater, surface water, and sediment samples at nine different sites around the perimeter of Mud Lake. At each location, hydraulic head measurements were collected inside and outside of each monitoring well to determine vertical gradients. Measured water quality parameters include temperature, pH, nitrate, specific conductivity, oxidation-reduction potential, and dissolved oxygen. After field collection, water samples underwent filtration with .45-micron filters and were preserved with nitric acid. A .20-micron filtering process was also conducted on groundwater samples to test for colloidal (0.20-0.45 micron) P transport. Water samples were analyzed for dissolved phosphorus, iron, and manganese. Preliminary results report an average P flux of 43.6 kg/day with groundwater P concentrations up to 790 ppb.

* Student presentation
15. New Bedrock Mapping of Dodge County Improves the Geologic Framework for Understanding and Managing Southeast Wisconsin’s Groundwater Resources

Esther Stewart, Wisconsin Geological and Natural History Survey, UW-Extension, esther.stewart@wisc.edu
Eric Stewart, Wisconsin Geological and Natural History Survey
Ken Bradbury, Wisconsin Geological and Natural History Survey

Recently completed 1:100,000-scale bedrock and depth-to-bedrock mapping of Dodge County provide an improved geologic framework that adds to our understanding of southeast Wisconsin’s groundwater resources. These maps offer significant refinement over existing, 1:1,000,000-scale maps including (1) detailed interpretation of the elevation and depth-to mostly buried bedrock surface; (2) refined bedrock contacts (i.e., the intersection of buried bedrock units with the buried bedrock surface); (3) identification of low-amplitude folds in the Paleozoic units; (4) several geologic cross-sections; and (5) a map of the elevation of the base Sinnipee Group dolostone. Mapping informs our understanding of the geologic history of the area, which in turn allows us to predict and identify patterns in the physical properties of the rocks that comprise the area’s aquifer system. For example, depth-to-bedrock information of the area underlain by dolostone bedrock units helps identify those places that are most susceptible to groundwater contamination from land application of nutrients and pesticides. Delineation of fold axes may also help predict local changes in the physical properties of the rocks. In northwestern Dodge County, elevated hydraulic conductivity estimates (15-218 feet/day) are restricted to within 2 km of fold axes, suggesting vertical fracturing from folding can alter the hydrogeologic properties of bedrock.

16. Lake-groundwater Interactions of Plainfield, Long, and Pleasant Lakes in the Central Sands of Wisconsin

Michael Parsen, Wisconsin Geological and Natural History Survey, University of Wisconsin-Madison Division of Extension, mike.parsen@wisc.edu
Catherine Hein, Wisconsin Department of Natural Resources
Carolyn Voter, Wisconsin Department of Natural Resources
Aaron Pruitt, Wisconsin Department of Natural Resources

The Wisconsin Department of Natural Resources (WDNR) is conducting a groundwater and lake level evaluation for Pleasant, Long, and Plainfield Lakes in Waushara County, referred to as the Central Sands Lakes Study (CSLS). The overarching goal is to create a hydrologic model to aid WDNR staff in determining whether groundwater withdrawals from high-capacity wells may significantly reduce average seasonal lake levels. An important component includes fieldwork designed to track water levels and water chemistry of the three study lakes and an accompanying network of lake-proximate monitoring wells. This hydrogeochemical dataset provides a means to test hypotheses about lake-groundwater flow regimes and improve our understanding of localized groundwater-surface water interactions. Lake-water budgets for each lake are calculated by combining lake and groundwater-level fluctuation data with water chemistry and stable isotope data as a means of using mass flux budgets to complement the water balance approach. Early results from this analysis indicate that lake-groundwater fluctuations and gradients are largely consistent with lake water-budget calculations, which incorporate water chemistry and stable isotope data. These findings confirm the hypothesis that groundwater is a key component of the water balance at each of these dynamic lake systems and will ultimately inform the hydrologic model, as well as DNR’s decision-making process in regards to lake-level impacts.
17. Exploring Evidence of Increased Groundwater Nitrogen and Calcium in Lakes

Paul McGinley, University of Wisconsin-Extension & University of Wisconsin-Stevens Point, paul.mcginley@uwsp.edu
Ryan Haney, UW-Stevens Point

Groundwater is a major source of nitrogen and calcium to many Wisconsin lakes. These essential elements play critical roles in a lake’s biological productivity and water chemistry. Groundwater nitrogen and calcium concentrations have increased dramatically over the last fifty years, yet little is known about how this increase is transferred to and affects lakes. Because groundwater contributing areas to lakes can be large, some lakes may still be experiencing increasing loads of nitrogen and calcium.

This project seeks to understand how nitrogen and calcium loading from groundwater has changed over time and how it may be impacting lakes in central Wisconsin. Concentrations of both nitrogen and calcium were compared to projected groundwater loading using groundwater flow modeling and land-use in the contributing areas. Both elements are subject to extensive in-lake processing and quantifying the impacts to in-lake concentrations examined both spring overturn and growing season concentrations. In many lakes, nitrate concentrations decrease rapidly from spring to summer and lakes with high rates of groundwater inflow have the highest in-lake summer nitrate concentrations. Similarly, calcium concentrations are highest in lakes with high rates of groundwater inflow but they decrease during the summer consistent with the formation of calcium carbonate.

18. Legacy Phosphorus in the Green Lake Watershed

Rachel Johnson,* University of Wisconsin-Madison, Department of Biological Systems Engineering, rejohnson9@wisc.edu
Anita Thompson, UW-Madison, Dept. of Biological Systems Engineering

Big Green Lake has experienced rising phosphorus (P) concentrations, despite decades of widespread watershed best management practice implementation. Phosphorous in the watershed, accumulated over the past century, may be acting as a long-term and diffuse source of P to the lake. While this “legacy phosphorus” is well documented in other watersheds, where and how it accumulates depends on location-specific factors such as land use history, hydroclimate, and socio-ecological characteristics. Quantifying legacy P is important for developing effective watershed P control measures. We quantified legacy P in the Green Lake watershed through modeling agricultural and urban P flows using a mass-balance approach. The watershed’s size allowed us to utilize publicly available data, as well as spatially explicit data from municipal and county governments, and local nonprofits. Our analysis quantifies current and historical watershed P inputs (e.g. fertilizer, sewage, atmospheric deposition, manure) and outputs (e.g. harvested crops, animal products, stream export) and the magnitude of legacy P stored within the watershed. We further estimate legacy P storage in uplands, marshes, and lake sediments through using soil test P data and paleolimnological analysis. This information can aid Green Lake watershed managers in better targeting best management practices, and communicating reasonable timelines for improving lake water quality.

19. Effectiveness of Agricultural BMPs Under Future Climate Using Swat Model

Xi Chen,* University of Wisconsin-Madison, Department of Biological Systems Engineering, xchen776@wisc.edu

Increasing nutrients and sediment cause water quality degradation, such as eutrophication, in receiving water bodies. Climate changes affect the hydrologic cycle and further increase the vulnerability of freshwater bodies to nonpoint-source pollution. Best management practices (BMPs) are often implemented to mitigate nonpoint-source pollution impacts. However, BMP effectiveness under future climate remains unclear. The goal of this study

* Student presentation
is to assess the performance of three types of BMPs (cover crops, grass waterways and retention ponds) on reducing runoff, phosphorus and sediment using the Soil and Water Assessment Tool (SWAT) model. We developed the SWAT model using current land use and BMPs in a sub-watershed of the Big Green Lake watershed, WI. We calibrated and evaluated the model using USGS data from 2012 to 2018. Our preliminary calibration indicates good model performance. We will use the University of Wisconsin Probabilistic Downscaling Version3 (UWPD3) data product to drive the climate scenarios (2020 – 2050) in the calibrated SWAT model. Our study aims to evaluate the effects of changing climate on the performance of existing BMPs in the watershed and to guide BMP installation planning.

20. Impact of Land Use Change on Water Quality Trends in the United States
Charitha Gunawardana,* Marquette University, charitha.gunawardana@marquette.edu
Walter McDonald, Marquette University

Surface water quality in a watershed is impacted by several factors including climate, soil conditions, and land use; however, the comparative influence of land use changes on changes in surface water quality remains unclear. This study seeks to fill this gap by evaluating the relationship between changes in land use and turbidity at USGS stream gages over the period of 2008 to 2016. To do so, land use and impervious data from the Multi-Resolution Land Characteristics Consortium for the years of 2008, 2011, 2013 and 2016 were analyzed within ArcGIS to obtain the trends in land use. Continuous water quality data from a set of 78 USGS gages were used to analyze the changes in turbidity over the same time period. Taken together, these datasets were statistically analyzed to evaluate how changes in land use compare with changes in turbidity at the selected stream gages. The greatest changes in land use in the watersheds are found in conversions from grasslands to developed land (0.61% average) over the period 2008 to 2016. Preliminary evaluation of the turbidity data indicates high variability in trends over different watersheds and a significant influence from seasonality. Final outcomes will be a comparison of these trends versus land use changes. Overall, this study seeks to improve our understanding of the impact that large-scale land use changes have on surface water quality.

21. Relationships Between Land Use and Stream Temperature in the Yahara River Watershed
Yu Li,* University of Wisconsin-Madison, Department of Biological Systems Engineering, li728@wisc.edu
Anita Thompson, UW-Madison, Dept. of Biological Systems Engineering

Understanding the relationships between land use and stream temperature in the Yahara River Watershed (YRW) is important for urban planning and protecting water quality. We utilized stream temperature data collected monthly by the Rock River Coalition at the outlet of 17 independent sub-watersheds. At each site, we compared stream temperature from 2015 to 2017 with watershed characteristics including urban area, water area, woodland area, watershed size and Base Flow Index (BFI). Land use data for 2015 were obtained from the Capital Area Regional Planning Commission. We evaluated the urban and water area using three metrics: (1) area percentage in the entire watershed and in riparian zones with widths from 20-ft to 700-ft, (2) area factor, the ratio of woodland area in the riparian zone over urban area in the rest of watershed, and (3) inverse-distance-weighted (IDW) area percentage with proximity to watershed outlet and to stream. Water and urban area were better indicators of stream temperature compared to woodland, watershed size and BFI in the YRW. Water area percentage in the entire watershed was positively correlated with stream temperature from June to September, and IDW urban area percentage with proximity to watershed outlet was positively correlated with stream temperature from May to October. Results from this study can guide future urban planning in temperature-sensitive watersheds.

* Student presentation
22. Measuring Stream Baseflow Conditions in West-Central Wisconsin

Katherine Langfield,* University of Wisconsin-Eau Claire, langfikm3250@uwec.edu
Gwen Kieffer, UW-Eau Claire
Jacob Erickson, UW-Eau Claire
Sarah Vitale, UW-Eau Claire
Nicole Clayton, WI Dept. Natural Resources

This study seeks to measure baseflow conditions in West-Central Wisconsin to aid in determining the impacts of groundwater withdrawals on local streams. Streamflow is measured monthly at fifteen (15) sites across eleven (11) streams during baseflow conditions using an OTT MF ProWater Flow Meter. Baseflow conditions are determined by referencing recent rainfall totals and the USGS streamflow gage records. Streams with two or more sites are used to determine if streams are gaining or losing water. A stream gage and seasonal pressure transducer has been installed at one site to establish a relationship between the stream's stage and discharge. This study is conducted by the University of Wisconsin-Eau Claire in partnership with the Water Use Section at the Wisconsin Department of Natural Resources.

23. Characterization and History of the Dead Tree Wetland at University of Wisconsin Parkside

Amy Johnston,* University of Wisconsin-Parkside, Geosciences Department, johns262@rangers.uwp.edu
Maddison Te Stroete,* UW-Parkside
Conor LaRoche,* UW-Parkside
John Skalbeck, UW-Parkside

A standard wetland delineation was conducted for the Dead Tree Wetland located east of Talent Hall on the UW-Parkside campus. The study was conducted for the Environmental Sampling, Monitoring, and Assessment course during the Fall 2019 semester. A series of test holes were dug using a hand auger to delineate the wetland boundary. Test hole transects were established based on where vegetation visibly changed from upland to wetland. Upland vegetation included goldenrod, milkweed, and little bluestem while wetland vegetation consisted of cattail, dogwood, and lake sedge. Each site included test holes in wetland, upland, and transitional locations. Soil samples from test holes were identified using a Wisconsin soil indicator. Wetland soils were a loamy muck mineral. Upland soils were sandier and clayey, while transitional soils were a sandy muck or loamy gleyed matrix. Static depth to water ranged from 4 to 5 inches deep in wetland test holes, 10 to 13 inches in the transitional area, and 17 to 28 inches in the upland. A drainage canal along the Facilities Maintenance parking lot provides water to the western edge of the wetland. A review of historical aerial photographs was conducted to assess wetland development. Photos from 1930 to 1960 show agricultural fields. The 1960 photo indicates saturated soil coincident with the delineation of the wetland. The 1967 photo shows the canal.

24. Precipitation Throughfall Beneath Urban Tree Canopies: An Investigation of Precipitation Re-Distribution

William Avery,* University of Wisconsin-Madison, Civil and Environmental Engineering, waavery@wisc.edu
Steven Loheide, UW-Madison
William Selbig, USGS
William Schuster, US EPA
Harold Barker, UW-Madison
Dominick Ciruzzi, UW-Madison

* Student presentation
Trees in urban environments represent a dominant form of vegetation within many neighborhoods and substantially affect the hydrologic cycle through transpiration. While the role of trees in the water budget is likely significant, the role of the canopy via interception loss is less well understood. In particular, the characteristics of the urban tree canopy may result in a re-distribution of precipitation onto impervious surfaces of the understory. The spatial variability of throughfall must be understood to help quantify the role of urban trees in precipitation/runoff patterns. An experimental design during the summer of 2019 was structured around two street trees located in Fond du Lac Wisconsin. Throughfall was measured using a grid of plastic buckets beneath each study tree placed prior to each storm. Canopy closure was estimated via photographs taken directly above each bucket. Results show high variability of throughfall as well as increased average depths on impervious surfaces of the understory suggesting an effect of regular placement of street trees relative to surface infrastructure. Additionally, “hot spots” of intense throughfall relative to precipitation were found to exist during larger storm events signaling a re-distribution exerted on throughfall via the canopies themselves. Canopy closure was found to have no significant relationship to throughfall for any storm analyzed suggesting that another mechanism is responsible for observed throughfall patterns.

25. High-Frequency Monitoring of Water-Quality in Groundwater: What was Learned in the Glacial Aquifer of Central Wisconsin

Krista Hood, US Geological Survey, Upper Midwest Water Science Center, khood@usgs.gov

An innovative system for high-frequency groundwater water-quality monitoring was used to determine short-term trends and variability within the glacial aquifer of Central Wisconsin. This site was part of the USGS National Water-Quality Assessment’s (NAWQA) Enhanced Trends Network (ETN) where in-situ and above-ground sensors collected high-frequency data along with annual and sub annual discrete samples at eight groundwater sites across the country. The NAWQA program has found significant long-term and land-use driven trends in the glacial aquifer from well networks that have typically been sampled at ten-year intervals. High-frequency data collected from the ETN suggest that water-quality parameters in deeper parts of the glacial aquifer do not have enough variability to be of hydrologic interest in the short term. However, variability of water-quality parameters in shallow parts can be linked to both seasonality and antecedent hydrologic conditions. Discrete water-quality data show potential short-term cation/ion trends in addition to showing strong relationships with high-frequency water-quality data. These types of relationships can have implications for the use of high-frequency monitoring in groundwater management. Understanding long-term trends are critical to interpreting the overall health of an aquifer but additional information can be learned about the factors driving groundwater quality through short-term or seasonal variability within the aquifer.

26. Sorption of Monensin to Soil in Agricultural Runoff

Abby Demeyer,* University of Wisconsin-Stevens Point, AWRA Stevens Point Chapter, ademe218@uwsp.edu

Monensin is an ionophore antibiotic that is widely used in livestock industries as an antiprotozoal additive. It does not digest well in animals and therefore, could be present in manure. Monensin could be a useful indicator to help us track manure contaminations and determine the path of runoff from farm fields. The main objective of this study is to determine how much monensin stays sorbed to soil and how much goes into solution. Only several previous studies have examined monensin sorption by natural solids. We used those results to design our experimental soil to solution ratios. To determine the extent of monensin sorption to soil we mixed different masses of soil with solutions of known concentrations of monensin. Previous research suggested that the sorption reaction is rapid and after a day, the water was separated from the soil. Methanol, cyclohexane, and a citrate-phosphate buffer were all added to both the water and soil containing centrifuge tubes and sonicated. The cyclohexane layer was removed, dried down, reconstituted and run on an Agilent 6430 Triple Quad LC/MS using

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nigericin (a similar antibiotic although, not used in agriculture) as an internal standard and benzyleconine-D3 as a surrogate standard. The results are used to create sorption isotherms describing the relationship between monensin in solution and monensin sorbed to the solid. These isotherms can be used to identify the conditions where monensin is likely to be present in runoff from manure.

27. The Future of the DNR Groundwater Retrieval Network (GRN) Database

Jennifer Filbert, Wisconsin Department of Natural Resources, jennifer.filbert@wisconsin.gov
Amy Ihlenfeldt, Wisconsin DNR

The Groundwater Retrieval Network (GRN) is a database and interface for well sample results from several DNR databases. GRN can help users find information about an individual well or analyze regional or statewide groundwater conditions. GRN was first designed around 1995, and while a large amount of data are available, many samples have been excluded due to lack of a Wisconsin Unique Well Number. Improvements are being made to GRN to accept samples with an address that can be geocoded. This should vastly increase the amount of data through GRN. In 2020, DNR plans to add GRN data to the DNR Open Data Portal to make it more accessible for bulk downloads.


Lam duyen Thuy,* Marquette University, thuy.lam@marquette.edu
Anthony Parolari, Marquette University

In cold climates, deicer salt is applied to sidewalks and roadways to improve traffic safety for pedestrians and drivers. Once applied, these deicers dissolve and are washed into green stormwater infrastructure (GSI) via runoff, which has the potential to mobilize into groundwater as chloride. In addition, excess accumulation of salt-derived cations can negatively impact the GSI soil structure by reducing infiltration capacity, soil water retention, and root uptake. Due to the potential risks of deicer salt on GSI performance and the absence of relevant data, we collected baseline data on the spatial and temporal variability of cation accumulation in urban soils. This data was utilized to inform a simulation model of water and salt balances in GSI soils. The model was then used to quantify the sensitivity of GSI performance to design, land use, and climate parameters. If spring inflow events are not sufficient to completely flush salt from the soil profile, salt will accumulate slowly over time and reduce the performance of the GSI. The model provides a probabilistic estimate of the lifetime of GSI soils for given performance criteria. This research will advance understanding of ecohydrological systems in engineered, urban environments and will develop a methodology that can be applied to evaluate GSI planning, design, and operations and maintenance.


Maxwell Beal,* University of Wisconsin-Madison, mrbeal@wisc.edu
Bryan O'Reilly, UW-Madison
Kaitlynn Hietpas, UW-Madison
Paul Block, UW-Madison

In recent decades, cultural eutrophication of coastal waters and inland lakes around the world has contributed to a rapid expansion of harmful cyanobacteria. Potential outbreaks of toxin-producing cyanobacteria species have drawn concern from health officials and water managers given their negative ecological, aesthetic, and socioeconomic impacts. Currently, little information regarding expected summertime cyanobacteria abundance is

* Student presentation
available prior to the season. With sufficient lead time, communicating the likelihood of elevated cyanobacteria abundance may be informative for proactively managing potential threats to lake and beach safety. Selecting Lake Mendota as a case study, a summertime cyanobacteria abundance model conditioned on season-ahead (spring) local-scale (e.g. discharge, precipitation, etc.) and global scale (e.g. sea-surface temperatures) predictors is constructed. The prediction model demonstrates moderate to good skill and an ability to accurately predict summers with above normal cyanobacteria abundance expected. This latter feature is particularly promising. Associated beach closure predictions show promise but are highly sensitive to the short observational record. The notable forecast model skill warrants further investigation into additional potential predictors as well as exploration of intra-seasonal forecast capabilities.

30. Impact of Dissolved Organic Sulfur on Metal Distribution in Riverine Sediments

Marissa Kneer,* University of Wisconsin-Madison, mkneer@wisc.edu
Matthew Ginder-Vogel, UW-Madison

Sulfur is a common constituent of most natural waters, often found in elevated concentrations in surface waters impacted by specific geology, mining activities, and other industrial discharges. Its oxidized form, sulfate, is an essential nutrient to plants and relatively non-toxic in environmentally relevant concentrations; however, in low oxygen conditions found in riverine sediments, microbial sulfate reduction results in the formation of sulfide, a more toxic form of sulfur. The direct toxicity of sulfide to plants and animals is well documented; however, the indirect impact of sulfide on plants and animals remains poorly understood. In sediment porewater, the accumulation of sulfide leads to an increase in the amount of dissolved organic matter compounds that contain sulfur. Here, in a combination of field and laboratory studies, we show that these dissolved organic sulfur (DOS) compounds enhance the release of metals from the solid phase to the porewater. Most of the metals released to the porewater through interaction with DOS are also toxic to plant and animals. The release of these metals to the porewater makes them more available for uptake by plants and diffusion to the surface water, thus the findings of this study emphasize the indirect negative impact of porewater sulfide accumulation on plants and animals.

31. Using Calcium Isotopes to Characterize the Surface Water Dynamics of Two Madison Lakes

Gage Hunter,* Edgewood College, ghunter@edgewood.edu
Sean Scott, WI State Lab of Hygiene

The four major Madison lakes in the Yahara River chain as well as Lake Wingra have struggled with eutrophic conditions dating as far back as the mid 1800’s. The lake systems, especially Lake Mendota, are some of the most well-studied on Earth, providing historical context for evaluation of new geochemical perspectives. In this study, we present calcium isotope data for water samples from the Lake Mendota and Lake Wingra systems to constrain the effects of distinct hydrologies on calcium in surface waters. The sampling locations for each lake included a spring, a sample on the surface of the lake where the water was at least 8 feet deep, and a location with significant anthropogenic inputs. We determined the δ44/42Ca and δ43/42Ca using Multiple Collector Inductively Coupled Mass Spectrometry and major and trace elements via Sector Field Inductively Coupled Mass Spectrometry and compared these values between the samples for both lakes. Analysis revealed that δ44/42Ca in Lake Wingra steadily declined over the period spanning from 6/15/2019 to 10/13/2019, while Lake Mendota displayed an overall increase in δ44/42Ca over the same time period. The increase of δ44/42Ca in Lake Mendota was correlated with decreases in P and Ca concentrations. These systematics show that Ca isotopes are an indicator of changing surface water dynamics, and sets the stage for further investigation into the biogeochemical processes occurring in a water body at a given point and time.

* Student presentation
32. Leachable Phosphorus in Street Leaf Litter and Its Impact on Phosphorus in Urban Stormwater Runoff

Yi Wang,* University of Wisconsin-Madison, ywang966@wisc.edu
Anita Thompson, UW-Madison
William Selbig, U.S. Geological Survey

Street leaf litter is a critical biogenic source of phosphorus (P) in urban stormwater runoff. Stormwater extracts P from leaf litter and transports it directly to a receiving waterbody through storm sewer network. The goal of this study is to understand P leaching dynamics of two prevalent tree species (Norway Maple and Green Ash) and its impact on end-of-pipe P concentration (P_{con}) and load (P_{load}) in stormwater runoff. Five urban residential basins in Wisconsin were monitored by the U.S. Geological Survey to evaluate the water-quality benefits of municipal leaf collection during Fall 2017 and 2018. Laboratory experiments showed that total P release from Norway maple (2.10 mg/g) was greater than from Green Ash (1.60 mg/g). Within the same species, increased fragmentation of leaves led to more rapid initial P release, but not greater total P release over a 48-hour period. Increased decomposition of leaves led to a notable decrease in total P release. Incubation temperature and volume of water in contact with leaves may not be critical factors affecting P leaching dynamics. Multiple linear regression analyses were used to relate P_{con} and P_{load} to street leaf litter characteristics and storm event hydrologic variables. The key explanatory parameters that affect P_{con} were street leaf litter mass (M_{leaf}) and antecedent dry days, while M_{leaf} and runoff volume explained P_{load}. Results from our study can be used to evaluate P reduction credits for leaf collection in regulated cities.

33. Blueprint for Salt Sustainability on the Uw-Madison Campus

Lydia Salus,* University of Wisconsin-Madison, Nelson Institute for Environmental Studies, lsalus@wisc.edu
Brittany Cobb, UW-Madison
Michael Webber, UW-Madison
Wei Tang, UW-Madison
Brian Flynn, UW-Madison
Tristyn Forget, UW-Madison

Chloride from deicing practices and water softening enters streams, lakes, and groundwater. Water quality monitoring within Dane County, Wisconsin has shown increasing trends of chloride in area surface water and groundwater. Due to inputs of chloride from sources within the Yahara Watershed, the Madison Metropolitan Sewerage District (MMSD) is periodically exceeding the Wisconsin state chloride criteria of 395 mg/L.

Because of their commitment to public and environmental health, MMSD enlisted the UW-Madison Water Resources Management (WRM) cohort to quantify chloride inputs from UW-Madison and assess possible source reduction opportunities on the UW-Madison campus. Through stakeholder-driven prioritization of reduction opportunities and recommendations, the WRM cohort established a pathway for reduction of chloride use by 25% on UW-Madison’s campus in the form of a Blueprint for Salt Sustainability. A campus-wide inventory was utilized to (1) assess the institutional network for salt management decision-making and (2) establish a quantitative snapshot of where and how much salt is being used on campus. A monitoring program with three distinct projects was used to quantify the impacts of chloride on the water resources around UW-Madison’s campus. Finally, the project used outreach, stakeholder engagement, and catalytic projects to bring community awareness to the impacts of salt overuse and influence salting practices.

* Student presentation
34. Lake Russo: Pond or Lake?

Jessica Baker,* University of Wisconsin-Parkside, Geosciences Department, baker064@rangers.uwp.edu
Mark Hrpcek, UW-Parkside, Geosciences Department
Nick Rivera, UW-Parkside, Geosciences Department
John Skalbeck, UW-Parkside, Geosciences Department

Lake Russo in Pleasant Prairie WI serves as a good test for assessing the general questions for classifying small water bodies as a lake or a pond. The purpose of the study was to compare data from Lake Russo and Greenquist Pond, located on University of Wisconsin–Parkside's campus, to assess the general classification. The three requirements that help determine whether a body of water is a pond are the following: are wave heights less than 1 foot?, does light penetrate to the bottom?, and is the water temperature profile uniform?.

Lake Russo surface and bottom water temperature and light intensity were recorded from June to October 2019 using HOBO sensors. Wave height was estimated from resident observations on windy days in November. Water quality data collected in September from both water bodies includes: pH, electrical conductivity, Secci disk depth, and turbidity. Surface and bottom water samples were analyzed for phosphorus and algae levels.

General criteria for Lake Russo are: waves don’t reach 1 ft. in height, light does penetrate the bottom, and the temperature is uniform in the fall but not during the summer. Water quality data show measurable difference between Greenquist Pond and Lake Russo. Another criteria to be considered is the difference in area and max. depth between Lake Russo (area 22 acres, max. depth 11 ft.) and Greenquist pond (area 0.3 acres, max. depth 6ft.). Additionally, phosphorus concentrations were higher in Greenquist Pond than in Lake Russo.

35. Seasonal Soil Nutrient Dynamics in Urban Green Spaces

Isabelle Horvath,* Marquette University, isabelle.horvath@marquette.edu
Laine Pulvermacher, Marquette University
Gerardo Ornelas-Rodriguez, Marquette University
Anthony Parolari, Marquette University

Humans dominate urban nutrient cycles – adding nitrogen (N) and phosphorus (P) through car exhaust, fertilizer over-use, and pet waste. N and P are transported to streams via stormwater runoff, where they create eutrophic conditions and reduced water quality. Nutrient retention is accomplished in urban green spaces through filtration, plant uptake, and biogeochemical processes. These processes are highly variable, due to the influence of varying environmental conditions and rainfall duration and frequency. This work studies seasonal variation in nutrient mobility and corresponding hydrologic and biogeochemical conditions in urban soils. Ion exchange resins were used to capture the seasonality of soil nutrient availability; soil and air temperature, soil moisture, soil oxygen, and precipitation were also monitored. Sites included a green roof, upland and lowland plots in a constructed wetland, and an urban garden in Milwaukee. Increased precipitation and soil moisture were associated with increased mobility of N species. Phosphate mobilization was strongly correlated with air and soil temperature. These patterns indicate varying roles of hydrologic and biogeochemical drivers for N and P mobility in urban green spaces. The observed relationships between environmental drivers and the mobility of nutrients can be used to better understand nutrient retention thresholds in urban green spaces as biogeochemical conditions change with the impacts of land use and climate change.

* Student presentation
36. Isotopic Examination of Photochemical Demethylation of Mercury in Natural Systems

Grace Armstrong,* University of Wisconsin-Madison, gjarmstrong@wisc.edu
Mike Tate, U.S. Geological Survey
Sarah Janssen, U.S. Geological Survey
Tylor Rosera, UW-Madison
James Hurley, UW-Madison
David Krabbenhoft, U.S. Geological Survey

Photochemical processes play an important role in the fate and transport of inorganic mercury (Hg) and methylmercury (MeHg) in aquatic systems. Isotopic tracers have been applied to understand this process in previous studies and the shifts in isotope values during photochemical transformation have been used to estimate Hg sources to aquatic biota. During photochemical demethylation, Hg undergoes both mass-dependent (MDF) and mass-independent fractionation (MIF). However, previous experiments examining these processes utilize elevated levels of MeHg and synthetic DOM at unrealistic Hg/DOM ratios which is not readily applicable to natural systems and may result in unreliable results. In order to make appropriate estimations of the loss of methylmercury (MeHg) in natural systems as well as utilize these isotope tracers to determine Hg sources, we need to understand how photochemically driven MDF and MIF relate to varying types of dissolved organic matter (DOM). We conducted rooftop photochemical (natural sunlight exposure) experiments with both synthetic and natural waters of varying DOM content and Hg/DOM ratios based on real aquatic systems. It was found that photodemethylation in the presence of differing DOM waters yielded variable MIF and MDF slopes. This indicates photochemical fractionation of MeHg is system-specific, especially considering the broad range of DOM content and type in the environment.


Michael Tiboris, River Alliance of Wisconsin, mtiboris@wisconsinrivers.org

Meeting the pressing need for better on-farm water stewardship is especially challenging right now, as farmers face an extraordinarily difficult financial landscape for agricultural products. Existing regulatory and incentive programming has been largely ineffective at encouraging lasting behavioral change. This session presents the work of the Clear Water Farms program, which certifies individual farm operations on the Alliance for Water Stewardship International Standard and aims to create a farmer-led, and empirically credible, credential for water stewardship achievements. The program is designed to link practice changes to existing regulatory and resource structures, and to build intra-supply-chain market advantages for producers and processors that improve water stewardship practices.

I will discuss the opportunities and challenges of using this certification to create market driver for agricultural water stewardship, and report on how the certification is being tied to various regulatory mechanisms. I hope to solicit guidance on some tricky aspects of program evaluation in discussion. Speaker: Dr. Michael Tiboris, Clear Water Farms Director, River Alliance of Wisconsin

38. Application of MeHg Stable Isotopes in the Lower Green Bay and Fox River Area of Concern to Understand Bioaccumulation in a Contaminated Freshwater Estuary

Tylor Rosera,* University of Wisconsin-Madison, Environmental Chemistry and Technology, trosera@wisc.edu
Sarah Janssen, U.S. Geological Survey
Mike Tate, U.S. Geological Survey
David Krabbenhoft, U.S. Geological Survey

* Student presentation
James Hurley, UW Aquatic Sciences Center
Ryan Lepak, UW: Environmental Chemistry and Technology

Many beneficial use impairments are listed for the Lower Green Bay and Fox River Area of Concern, including those related to sediment and water quality, and contaminants in sport fish. Our study focuses on the availability of legacy mercury (Hg) in contaminated sediments for bioaccumulation. By tracking the subtle changes in the ratios of naturally occurring Hg isotope ratios in different matrices, we can begin to assess the relative contributions of different sources of Hg in this complex system. Traditional total Hg (HgT) measurements of contaminated sediments have a homogenous isotopic composition ($\delta^{202}$HgT -0.56 ± 0.02 ‰), which complicates source tracking efforts and can mask other potential bioavailable Hg pools. Hg species-specific analyses, focusing on the bioaccumulative methylmercury (MeHg) pool, allow for better assessment of the contribution of legacy Hg to aquatic food webs. Initial results suggest that the MeHg isotopic composition of sediments, invertebrates, and seston are different from their HgT measurements, potentially elucidating other bioaccumulative sources. Better understanding biotic and abiotic processes that govern these Hg isotopic ratios in sediments, biota and in the water column may allow for a more effective prediction of bioaccumulation from source-specific pools of Hg. This information is important for resource managers tasked with the responsibility of identifying and remediating Hg source hotspots that potentially influence bioaccumulation.
Nature-based Shorelines for Wisconsin’s Great Lakes Coast

Briana Shea,* Wisconsin Sea Grant, bshea3@wisc.edu
Adam Bechle, Wisconsin Sea Grant
Gene Clark, Wisconsin Sea Grant

Nature-based shorelines are coastal projects that incorporate vegetation or other natural features into the protection of the shoreline. Compared to traditional “gray” infrastructure approaches to shoreline protection, nature-based shorelines can help maintain natural coastal processes while also enhancing habitat, biodiversity, water quality, air quality, and visual appeal of the shoreline. Long term sustainability goals of Wisconsin’s coast encourage continuing to explore the use of nature-based shorelines. The “Nature-Based Shorelines for Wisconsin’s Great Lakes Coast” guide created for Wisconsin coastal property owners is designed to describe the types of nature-based shorelines, discuss considerations for their implementation on a property, and exhibit case studies in the Great Lakes. The limitations of nature-based shorelines due to high wave energy, water level variability, and cold climate are discussed, as well as what property conditions different methods are suited for. This presentation will discuss the contents of the guide including 6 classifications of nature-based shorelines suitable for the Great Lakes, our method for evaluating site conditions, and Great Lakes example projects with an emphasis on water level impact.

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* Student presentation
Adapting to a Changing Coast

Adam Bechle, Wisconsin Sea Grant, bechle@aqua.wisc.edu

Great Lakes coastal bluffs, beaches, and waterfront infrastructure are impacted by the combined effects of erosion, coastal storms, and fluctuating water levels. With all Great Lakes above or near record high water levels, many of these coastal changes have accelerated and concern among lakeshore communities is growing. A Coastal Resilience Self-Assessment has been developed to help local governments weigh the effects of coastal hazards and begin to consider actions to increase their ability to plan, prepare for, and adapt to coastal hazards. The insights identified in this engagement activity have been used to guide communities as they implement strategies to address high water levels and other coastal hazards. This talk will discuss the current high water conditions on the Great Lakes, the impacts that high water levels have had on Wisconsin’s Great Lakes coasts and the mitigation strategies that can be taken to adapt to a changing coast.

* * *

Meteo-rips (Meteotsunami Generated Rip Currents) in Lake Michigan

Yuli Liu,* University of Wisconsin-Madison, Department of Civil and Environmental Engineering, yliu99@wisc.edu
Chin Wu, UW-Madison, Dept. of Civil and Environmental Engineering

Rip currents are strong, narrow seaward water jets that can sweep unexpected swimmers into deep water, where exhaustion and panic often result in drownings. A recent study reveals that meteo-rips, a new type of rip currents, were the cause of several drownings in the Great Lakes. In this talk, we find that, for the first time, meteo-rips, can be a wide-spread phenomenon in Lake Michigan. Coincident occurrences of rip currents and meteotsunamis at multiple beaches are identified during the same day, based on compiled webcam images, water level and current

* Student presentation
sensor data. Detailed nearshore hazardous conditions at the impacted beaches are reconstructed using the state-of-art integrated atmospheric-hydrodynamic modeling. Results uncover that meteo-rips can be induced by forced or free edge waves of meteotsunamis, with time delays of even hours after the fast-moving storms have passed by. In view of the spatial extents and temporal delays of the rip current risks, avoiding getting into water after storms should be a crucial safety message to coastal communities in the Great Lakes.

* * *

**Restoring Ecological Health and Aquatic Biodiversity (Rehab) for Eroding Kenosha Dunes, WI**

Chin Wu, University of Wisconsin-Madison, Department of Civil and Environmental Engineering, chinwu@engr.wisc.edu

Kenosha Dunes in Wisconsin is a rare Great Lakes dunes ecosystem located within the Chiwaukee Prairie State Natural Area along the Lake Michigan Shoreline. High water levels in Lake Michigan has resulted in failing revetments, yielding severe dune erosion, natural dune habitat loss, and impaired water quality. Recent aerial photo study found the severe dune erosion to be 25 feet loss per year from 2015-2019. Based upon the current erosion rate, shore coastal wetlands at Kenosha Dunes could be completely lost within the next decade, calling for the urgent need to address the severe dune erosion issue. In this talk, we will present a national coastal resilience project, Restoring Ecological Health and Aquatic Biodiversity (REHAB) of degraded dune and beach systems in Lake Michigan, funded by the National Fish and Wildlife Foundation and NOAA. Progress of innovative designs at Kenosha Dunes to create a living shoreline, provide wave mitigation under changing water levels, minimize the interruption of sediment transport, and improve coastal and marine habitats will be shared and discussed. This project builds on community of practice with experts and scientists in fisheries, wildlife, and geology, local government leaders and private property owners, state and federal resource and regulatory agencies to our address challenges and issues of high water levels in Lake Michigan.
Coastal Bluff Erosion and Groundwater Responses to Elevated Lake Levels

Collin Roland,* University of Wisconsin-Madison, Department of Geoscience, cjroland@wisc.edu
Lucas Zoet, UW-Madison, Geoscience
Elmo Rawling, Wisconsin Geological and Natural History Survey
Michael Cardiff, UW-Madison, Geoscience

Elevated water levels in Lake Michigan are causing widespread toe erosion of Wisconsin’s coastal bluffs. This toe erosion steepens the bluff face, increasing the likelihood of slope failure via shallow to intermediate-depth slides and escalating associated inland recession of the bluff crest. Sediment budgets indicate ‘feeder’ bluffs contribute an outsized proportion of sediment to the nearshore system, although differences in lithology and hydrogeologic conditions along these bluffs are poorly constrained. To assess how these impact erosion rates, we evaluate three bluffs with different lithologies and morphologies using a time series of high-resolution digital elevation models along with 3D slope stability models. We also present groundwater level observations for two coastal bluffs and use groundwater models to investigate the sensitivity of bluff groundwater systems to changes in lake level. We find that the site with a higher percentage of coarse-grained sediments is contributing a larger volume of sand to the nearshore than the sites comprised of more cohesive sediments, and that lake level changes contribute minimally to groundwater pore pressure changes, in terms of their impact on slope stability. Additionally, erosion rates and modeled instability are highest in regions of the bluff proximal to groundwater seeps, indicating that the feedback between sediment characteristics and groundwater flow plays an important role in controlling upslope bluff erosion processes.

* Student presentation
Effects of High Water Levels on Wave Climate and Nearshore Processes in Lower Green Bay, WI

Joshua Anderson, University of Wisconsin-Madison, Department of Civil and Environmental Engineering, janderson1@wisc.edu

Water levels on Lake Michigan are currently near all-time record highs. While coastal erosion due to recent high water levels has been evident, it is less clear how nearshore areas are being affected as they are obscured by the water and waves. Since water levels are high, nearshore areas have increased depth, which could allow more wave energy and an increased wave climate. An increased wave climate in the nearshore could have an important impact on sediment transport and nutrient mixing. In this talk we apply a numerical model to assess wave climate variability in the Lower Green Bay AOC under the scenario of increasing water levels. Green Bay is an ideal study site as it has a diverse coastal environment ranging from exposed, high wave energy locations to sheltered, low wave energy locations. As such, the spatial variability of changes to wave climate at Green Bay may be extended to other areas of the Great Lakes. Finally, the variability in wave climate due to high water levels will be applied to examine potential changes in sediment transport and nutrient mixing events that correlate with Harmful Algal Blooms.
Monitoring the Performance of Two Bioswales that Collect Runoff from an Urban Farm

Elizabeth Regier,* Marquette University, elizabeth.regier@marquette.edu
Walter McDonald, Marquette University
Anthony Parolari, Marquette University

Many cities are addressing blighted industrial areas by redeveloping abandoned sites into urban farms. These investments can contribute to economic development and local food production; however, they also present unique challenges for urban runoff systems, such as increased sediment and nutrient runoff, that may be challenging to treat using traditional urban runoff best management practices. This study seeks to improve our understanding of these systems by monitoring the performance of two bioswales that collect runoff from an urban farm in Milwaukee, WI. The influent and effluent of each bioswale were monitored for flow rate, total suspended solids, total phosphorus, and total nitrogen. Influent volumes into the bioswales were estimated using a rain gage and influent water quality samples were collected using a trench drain and 1 L sampling bottles. Effluent flow rate was measured from the underdrains using flumes and bubbler level meters, and water quality samples were collected using automated samplers. Preliminary results from four captured storms the summer of 2019 indicate that significant nutrient reduction occurs within the bioswales of 86% and 72% for total phosphorus and total nitrogen, respectively; however, total suspended solids remained low in both the influent and effluent (< 3 mg/L). Monitoring of these sites is currently ongoing but results to date indicate that bioswales may be an effective stormwater management measure for urban farms.

* * *
When Traditional Site Restoration Isn’t the Best Option: Recovering Ecological Resiliency Through Adaptive Water Resources Engineering

Kirsten James, Hey and Associates, Inc., kjames@heyassoc.com

In this talk, we’ll explore how unique approaches and refined engineering design can replenish resiliency. Join me as we visit Kenosha County’s George Lake to learn how water quality improvement projects were designed: from concept, to securing DNR grant funding, through permitting and implementation. I’ll highlight the resiliency of people, partnerships, and processes when not everything goes according to plan. Next, we’ll venture to Jefferson County to visit a decommissioned industrial pond along the Rock River. Modifications to a DNR grant-funded concept plan realized water quality, flood storage, and habitat benefits. I’ll emphasize the opportunity to jump-start forgotten landscape features into multi-purpose, resilient assets. Learn how the project lifecycle builds and strengthens lasting partnerships, encourages organizational capacity, and contributes to shared experiences. You’ll walk away with a new perspective on the possibilities to enhance and improve ecosystem services, our water resources, and ourselves for the years to come.

* * *

Impact of Increased Infiltration in Residential Sewersheds on Rainfall Derived Inflow and Infiltration

Spencer Sebo, * Marquette University, spencer.sebo@gmail.com
Walter McDonald, Marquette University
Anthony Parolari, Marquette University

Green infrastructure is an effective stormwater management tool for reducing volume and improving water quality of runoff from residential properties. However, the impacts of increased infiltration from green infrastructure on rainfall derived inflow and infiltration is poorly studied and remains a significant concern for sewersheds that experience sanitary sewer overflows. This project investigated the impacts that sewershed-scale infiltration has on rainfall derived inflow and infiltration in an effort to quantify the unintended consequences of increasing infiltration in residential communities. A case study analysis was performed on 24 separate sanitary sewer areas throughout the suburbs of Milwaukee, WI. In each of these sewersheds, residential hydrologic characteristics, such as imperviousness and street drainage type, were quantified using ArcGIS to estimate the infiltration that occurs within a neighborhood. Rainfall derived inflow and infiltration was estimated using EPA SSOAP and precipitation

* Student presentation
and sanitary sewer flow data from 2014 through July 2019. Preliminary results indicate that several neighborhood scale hydrologic characteristics correlate with RDII. A better understanding of the impacts of infiltration and its effects on rainfall derived inflow and infiltration can inform policy decisions in communities to best manage stormwater in light of sanitary sewer overflow concerns.

Characterization of Chloride Concentration in Stormwater Runoff from Commercial Land Use

Nicolas Buer, US Geological Survey, Upper Midwest Water Science Center, n buer@usgs.gov

Freshwater aquifers and surface waters in urban areas across the northern United States have experienced steady and significant increases in chloride concentrations with the widespread use of salt for deicing. More than doubling since the mid-1980s, salt for deicing surpassed use in the industrial production of alkalies and chlorine, previously the largest use of salt in the U.S. Wisconsin water bodies are not immune to this trend. Exceedances of chronic (230 mg/L) and acute (860 mg/L) chloride toxicity levels have been recorded at multiple sites. Although the City of Madison and Dane County have reduced roadway application rates, chloride concentrations in area lakes, shallow aquifers, and municipal wells continue to increase. Reductions in road salt use may be negated by urban sprawl and unabated application rates by individuals and commercial businesses.

To quantify chloride loading from commercial areas, the U.S. Geological Survey and the City of Madison installed a monitoring site to measure chloride surrogates in stormwater runoff coming primarily from a large commercial area. Initial data show stormwater reaching chronic chloride toxicity levels between November and January and acute levels in February. Detention pond runoff from this commercial area remains brackish (>500 mg/L) for up to 4 months. These data will be used to assess whether changes to application rates of deicers by commercial applicators have any effect on chloride concentrations in stormwater runoff.
Potential for a New Interceptometer: Monitoring Tree Sway with Accelerometers as an Indicator of Interception Before, During, and After it Rains

Dominick Ciruzzi,* University of Wisconsin-Madison, Department of Civil and Environmental Engineering, ciruzzi@wisc.edu
William Avery, UW-Madison, Dept. Civil & Environmental Engineering
Harold Barker, UW-Madison, Dept. Civil & Environmental Engineering
William Selbig, United States Geological Survey, Wisconsin Water Science Center
Steven Loheide, UW-Madison, Dept. Civil & Environmental Engineering

Interception is the portion of falling precipitation captured by the foliage of vegetation. Depending on storm intensity, street trees may intercept the majority of precipitation during low intensity storms and attenuate the timing and magnitude of stormwater runoff even in high intensity storms. Traditionally, interception is quantified from two point measurements: subtracting the precipitation between a precipitation gauge inside and outside a canopy, which may over- or underestimate actual interception due to heterogeneity of throughfall rates. We aim to quantify street tree interception by continuously monitoring tree sway period before, during, and after a storm and compare this method with interception quantified using a rain gauge inside and outside the canopy. Tree sway period is related to a tree’s mass, stiffness, height, diameter, and more. During the short time frame of a storm, only the mass of the tree changes that would influence tree sway period. We observed increases in tree sway period as trees intercept and store more water during rainstorms, which suggests that interception rates and total interception can be quantified from monitoring tree sway motion. Further, we observed decreases in tree sway period following the end of a storm, which indicates the rate of the canopy drying. A goal of this research is to provide a new, independent tool and approach to quantify interception in trees, which may be more representative of interception by the whole canopy.

* Student presentation
How’s the Water? Fifteen Years of Fish Community Sampling in the Milwaukee Area

Amanda Bell, US Geological Survey, Upper Midwest Water Science Center, ahbell@usgs.gov
Barbara Eikenberry, US Geological Survey
Hayley Olds, US Geological Survey
Daniel Sullivan, US Geological Survey

One of the most common questions I hear when I’m sampling rivers is, “How’s the water?” The answer to that question is not as simple as a “Good” or “Bad.” The health of the riverine system is based on many characteristics including water chemistry, contaminants, floodplain connectivity, aquatic community dynamics, watershed storage, streambed stability, in-stream habitat, recreation opportunities, and aesthetics, among others. As scientists, we frequently want to provide an analysis overloaded with complex models and multidimensional metrics that are difficult to understand by the general public. However, the general public wants to focus on just one “silver bullet” to determine if the aquatic ecosystem is stable, improving, or getting worse. This presentation seeks to answer this question by looking at changes in several common richness and diversity metrics of the fish communities in streams in the Milwaukee area, over 15 years, using the Wisconsin Warmwater Index of Biotic Integrity (Lyons, 1992).
Using Stable Isotopes of H, O, S, B, Sr, Pb, Cu and Radiometric Dating to Elucidate Groundwater Flow Paths and Histories in the Cambrian-Ordovician Aquifer of Northeastern Wisconsin

John Luczaj, University of Wisconsin-Green Bay, Department of Natural and Applied Sciences, luczajj@uwgb.edu

Early Paleozoic rocks in eastern Wisconsin preserve a complex diagenetic history that strongly influences modern aquifer chemistry. Significant early events were dolomitization and MVT mineralization by Michigan basin brines during the Paleozoic and early Mesozoic Eras. A suite of minerals (sulfides, sulfates, carbonates, and fluorite) has a clear influence on modern aquifer chemistry, which depends upon groundwater sources and flow paths, redox potential, and mineral saturation indices.

The long-term water-rock interaction history was elucidated using whole-rock chemistry, fluid-inclusion microthermometry, groundwater chemistry, stable isotopic analyses, and geospatial (isoscape) mapping. Mineral stable isotopes of Pb, Cu, Sr, and S indicate interaction between early MVT hydrothermal brines and Precambrian basement. Systematic spatial variations of major and minor ion concentrations, H, O, S, and B isotopic compositions, and \(^{14}C\) ages indicate freshwater recharge during and prior to the Wisconsin glaciation. Regional trends in \(\delta^{11}B\) represent a combination of dilution of saline formation waters and mixing with host rock-derived B released by weathering reactions. Sulfide oxidation and associated reactions liberate As, Ni, and Co and produce \(SO_4^{2-}\) near the recharge area for the confined aquifer. Eastward along flow paths, dissolution of celestine and fluorite results in high dissolved Sr and F. Elevated Li, Na, and Cl are related to dilution of residual brines.

* * *
Using Isotopes to Investigate Sources of Solutes in the Cambrian-Ordovician Aquifer System of Eastern Wisconsin

Amy Plechacek,* University of Wisconsin-Madison, Environmental Chemistry and Technology Program, Department of Civil and Environmental Engineering, plechacek@wisc.edu
Sean Scott, Wisconsin State Laboratory of Hygiene
Madeline Gotkowitz, Montana Bureau of Mines and Geology
Matthew Ginder-Vogel, UW-Madison Environmental Chemistry and Technology Program, Dept. of Civil and Environmental Engineering

The Cambrian-Ordovician aquifer system (COAS), an important source of drinking water, contains levels of radium (Ra) and strontium (Sr) greater than the EPA regulatory guidelines at many locations in eastern Wisconsin (WI). Elevated levels often correspond with reducing conditions and relatively old, high-salinity water. However, the sources of salinity (i.e., elevated total dissolved solids) are poorly understood. In this study, we use a suite of isotopes (δ¹⁸O/δD, ⁸⁷Sr/⁸⁶Sr, ²³⁴U/²³⁸U, ³⁴S – SO₄²⁻) to provide new constraints on the sources of dissolved solids in the COAS of Fond du Lac, WI. Samples collected from 19 deep wells open to multiple units of the COAS and 13 shallower wells open to the uppermost units of the COAS were characterized for dissolved constituents including ²²⁶Ra, ²²⁸Ra, and Sr, and field parameters such as conductivity. Groundwater from deep wells ranges between Mg-HCO₃ and Ca-Cl-type, while groundwater from shallow wells is predominantly Mg-HCO₃-type. The δ¹⁸O-δD of most shallow well samples plot on the Global Meteoric Water Line (GMWL), while the δ¹⁸O-δD of most deep well samples plot slightly above the GMWL. The ⁸⁷Sr/⁸⁶Sr ranges from 0.7092-0.7112, and the ²³⁴U/²³⁸U activity ratios range from 2-18. The δ³⁴S of SO₄²⁻ ranges from -2 to +21‰. Conductivity has significant positive correlations with dissolved oxygen, Cl⁻, Br⁻, SO₄²⁻, Ca²⁺, Na⁺, and K⁺. Results will provide a better understanding of the sources of salinity in the COAS of eastern WI.

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* Student presentation
Examining Radionuclide Mobility in the Midwestern Cambrian-Ordovician Aquifer System

Madeleine Mathews,* University of Wisconsin-Madison, mmathews2@wisc.edu
Madeline Gotkowitz, Montana Bureau of Mines and Geology
Sean Scott, Wisconsin State Laboratory of Hygiene
Matthew Ginder-Vogel, UW-Madison

The Midwestern Cambrian-Ordovician aquifer system (MCOAS) covers a large portion of the Midwestern United States, and is a major source for public and domestic water supply. Radium (Ra) is a contaminant frequently exceeding the EPA maximum contaminant level of 5 pCi/L for combined 226Ra and 228Ra in the MCOAS. Radium is formed by the radioactive decay of uranium and thorium (e.g., 238U and 232Th), and Ra mobility in the groundwater system is impacted by aquifer geochemistry. Here, we assess the impact of local geochemistry on Ra release and mobility in the groundwater system, using parent-daughter isotope activity ratios in experimental materials derived from representative aquifer bedrock samples. Inductively coupled plasma mass spectrometry was used for all analyses. Our experiments yielded 1:1 238U and 226Ra activity ratios for each stratigraphic unit examined. Equilibrium between parent and daughter isotopes indicates that Ra is not transported far from the site of parent decay by the groundwater flow system. Additionally, the association of Ra with aquifer solids indicates that potential Ra mobility will vary depending on the distribution of minerals influenced by aqueous geochemistry within each stratigraphic unit. Our new constraints examining the impact of local geochemistry on Ra mobility across bedrock stratigraphy will inform well construction targeted at avoiding high-Ra areas in the MCOAS.

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* Student presentation
Mercury (Hg) is a pervasive contaminant in the environment and is particularly detrimental due to its ability to bioaccumulate in the food web. Surface and groundwater are important vectors for both dissolved and particulate-bound Hg transport. Isotope tracers can be leveraged to further examine the transport of Hg in waters by tracking the original sources as well as additional water column processing of Hg (e.g. photochemical degradation). While Hg stable isotopes have been used extensively for sediments and biological matrices for source identification, the application to waters is highly challenging due to the low ambient concentrations of Hg found in surface, which are too low for typical isotope measurements. Here we present new methods for pre-concentrating Hg in large volume waters (20L) with varying amounts of dissolved organic matter. This method allows for the investigation of isotopic compositions in natural waters across the country including East coast well waters, Midwest and Western surface waters, and aqueous discharges from contaminated regions. Isotopic analysis of these diverse samples has shown that the dissolved and particulate-bound Hg have distinct isotopic signatures ($\delta^{202}$Hg), indicating different sources and cycling dependent on the Hg phase. In addition, the contribution of Hg from rainwater and snowmelt can be tracked using an additional isotope tracer ($\Delta^{200}$Hg) which allows for the designation of local or regional sources of Hg.

* * *
Using Stable Lead Isotope Composition to Track Lead Exposure in Drinking Water – are Lead Lateral Lines the Source?

Patrick Gorski, Wisconsin State Lab of Hygiene, patrick.gorski@slh.wisc.edu
Sean Scott, WI State Lab of Hygiene
Martin Shafer, WI State Lab of Hygiene
Jonathan Meiman, Wisconsin Department of Health Services

It has been widely established that lead (Pb) has detrimental effects to the cognitive function of children at low blood Pb levels (<5 µg/dL), and adults at higher levels causing anemia, weakness, and kidney and brain damage. The Center for Disease Control (CDC) has more simply stated that no safe level of Pb has been identified. One of the many potential routes of exposure is drinking water, although there may be several sources of Pb that could contribute. One of the potential sources identified is Pb lateral lines that transport drinking water from street water utility pipes to residential houses. In this study we use a multi-collector (MC) ICP-MS, which can precisely quantify the relative ratios of stable lead isotopes (i.e., 204Pb, 206Pb, 207Pb, and 208Pb) in different potential environmental Pb sources, such as lateral line pipes, soil, groundwater, surface water, drinking water, precipitation, paint, house dust, coal, lead ore, and other miscellaneous lead sources. After identifying the isotopic ratios of the sources, we then compare them to isotopic ratios found in blood to directly identify which sources most closely match, and are the likely sources for Pb exposure. Comparison of Pb isotope data in a broad suite of samples and specific case studies should inform policy decisions for reduction of Pb exposure in the general population.

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Mercury Contamination at Gruber's Grover Bay: Application of Mercury Isotopes as Source Tracer

Michael Tate, US Geological Survey, Upper Midwest Water Science Center, mttate@usgs.gov
Sarah Janssen, US Geological Survey
Dave Krabbenhoft, US Geological Survey
John De Wild, US Geological Survey
Mercury (Hg) is a contaminant that has been used in a variety of industrial processes. Once released into the environment, it can be methylated and bioaccumulate in the food web. Elevated Hg levels have been measured at the former Badger Army Ammunition Plant (BAAP) site and Gruber’s Grove Bay (GGB) on the Wisconsin River, which historically received runoff from the plant. In 2019, the USGS Mercury Research Lab initiated a study with two primary objectives: 1) to compare Hg sediment concentrations at GGB to upstream unimpacted sites (Weigand’s Bay and Lake Wisconsin) and 2) utilize Hg isotopes to assess the extent of the contamination. Median surface sediment Hg concentration in GGB was 390 ng g⁻¹ and was not significantly different from the unimpacted sites. However, soil Hg concentrations in the drained settling ponds at the BAAP were found to be much higher (873 ng g⁻¹). Mercury isotopes (δ²⁰²Hg) were used as a fingerprinting tool to identify sources and biogeochemical processing of Hg within the system. Sediments at unimpacted sites displayed negative δ²⁰²Hg (-0.98 to -0.58‰), presumably the background signature of the Wisconsin River. Soils from the former settling pond tended to be more enriched in δ²⁰²Hg (-0.38 to -0.17‰) reflecting the Hg source at BAAP. Sediment δ²⁰²Hg in GGB fall in the range between the contaminated soil Hg and the unimpacted sites. Sediments at depth were closer in δ²⁰²Hg to the soils, suggesting much of the relic Hg is buried at depth.
Defining a “Significant Reduction” in Lake Levels in the Central Sands in Terms of Water Quality, Aquatic Life, and Recreation and Navigation

Carolyn Voter, University of Wisconsin-Madison, Aquatic Sciences Center, carolyn.voter@wisc.edu
Catherine Hein, Wisconsin Department of Natural Resources
Ian Anderson, Wisconsin Department of Natural Resources

2017 Wisconsin Act 10 charged the Wisconsin Department of Natural Resources (WDNR) with determining “whether existing and potential groundwater withdrawals are causing or are likely to cause significant reduction of [the lake’s] water level below its average seasonal levels” for three study lakes in Waushara County: Pleasant Lake, Plainfield Lake and Long Lake. To fulfill this mandate, WDNR and its partners must define a) each lake’s “average seasonal water level”, and b) what a “significant reduction” in levels would be. Our approach to this involved first reconstructing historic lake levels and developing lake-specific lake level exceedance probability curves. Next, we examined the influence of lake levels on 1) water quality (e.g., anion/cation balance, lake stratification, nutrient loading), 2) aquatic life (e.g., aquatic plant diversity, oxygen habitat for fish, littoral habitat), and 3) recreation and navigation (e.g., basin connectivity, waterskiing). For each of these categories, we suggest the lake levels at which major changes would be observed in exceedance of naturally occurring conditions. These lake level thresholds will ultimately be used to determine the likely impacts of groundwater withdrawals on lakes under various pumping scenarios.

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Heterogeneity in Context: A Glacial History Perspective on Wisconsin’s Central Sands

J Elmo Rawling III, Wisconsin Geological and Natural History Survey, elmo.rawling@wisc.edu
Rachel Greve, WI Department of Natural Resources
Dave Hart, WI Geological and Natural History Survey
Steve Mauel, WI Geological and Natural History Survey
Mike Parsen, WI Geological and Natural History Survey

Aquifers in Wisconsin’s Central Sands include ~125 meters of Quaternary age sediments, usually characterized as a homogeneous and isotropic sand for the purposes of modeling groundwater flow and groundwater-surface water interactions. However, significant complexities occur in these sediments resulting from the region’s glacial history that included fine-grained depositional environments. These include proglacial lakes, several prominent north-south moraines, outwash associated with each ice margin, catastrophically formed subglacial drainage features (i.e. tunnel channels), and stagnant ice. Glacial Lake Wisconsin drained catastrophically after ice retreated past the Elderon position, likely sometime around 17,500 years ago, forming the Wisconsin Dells. Permafrost preserved buried ice in the region until sometime around 14,000 years ago. As buried ice melted post-permafrost the collapse of the landscape formed kettles, some of which are occupied by modern lakes, and the hummocky topography typical of the Hancock and Almond Moraines. Finally, evidence of eolian activity until about 12,000 years ago indicates the landscape was unstable until at least that time. This complex Quaternary history results in a hydrostratigraphy that varies across the Central Sands region corresponding to the different depositional environments. Approximately 9000 well construction reports, geologic mapping, and several geologic borings verified this stratigraphic complexity.
Estimating Groundwater Recharge, Irrigation Demand, and Crop Water Use for the Central Sands

Stephen Westenbroek, US Geological Survey, Upper Midwest Water Science Center, smwesten@usgs.gov
Martha Nielsen, US Geological Survey
Michael Fienen, US Geological Survey

Independently derived estimates of recharge calculated from spatially explicit inputs can significantly improve evaluations of groundwater movement. The U.S. Geological Survey’s Soil-Water-Balance (SWB) code is a tool to estimate distribution and timing of net infiltration out of the root zone by means of an approach that uses readily available gridded daily weather, soils, and land-use data. Calculations are completed on a daily time step and gridded results may be summarized on monthly or annual time scales. Version 2.0 of the SWB code includes a crop-water demand method (FAO-56) for estimating irrigation amounts; this method was applied to the Central Sands study area as a way to account for irrigation and crop water use as components of water balance calculations. Output from the Soil-Water-Balance code was used in the development of a transient MODFLOW-NWT model of the Central Sands.

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Development of a Regional Groundwater Flow Model of the Central Sands

Meg Haserodt, US Geological Survey, Upper Midwest Water Science Center, mhaserodt@usgs.gov
Andrew Leaf, USGS
Michael Fienen, USGS
Stephen Westenbroek, USGS
Detailed simulation of groundwater flow in areas with few streams, such as the intermorainal area of the Wisconsin Central Sands, requires consideration of regional groundwater flow at the model boundaries. A transient, MODFLOW-NWT model was constructed for the Central Sands region to provide reasonable boundary conditions as a parent model to lake inset models. The regional model was built upon an existing groundwater flow model developed at University of Wisconsin – Steven Point. Model layering was improved with updated information about glacial and bedrock units from the Wisconsin Geological and Natural History Survey. Updated recharge came from a Soil Water Balance model developed for this study. Model calibration used a series of multipliers on the hydraulic conductivity fields from the existing model to utilize the patterns in previously published parameters fields while still responding to new information in an updated calibration dataset.

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Do We Really Know Anything? Monte Carlo Simulations to Evaluate Potential Outcomes of a Lake Drawdown Test

Andrew Leaf, US Geological Survey, Upper Midwest Water Science Center, aleaf@usgs.gov
Ian Anderson, Wisconsin Dept. of Natural Resources
Megan Haserodt, USGS Upper Midwest Water Science Center
Michael Fienen, USGS Upper Midwest Water Science Center

While the physics of groundwater flow are well understood, the physical properties of aquifers and their boundary condition stresses are complex and defy accurate description at any scale, leading some to argue that groundwater models are at best data processing tools that can assimilate what is known, express what is unknown, and provide a distribution of possible outcomes. 2017 Wisconsin Act 10 mandated the Central Sands Lakes Study, requiring the causal connection between groundwater pumping and lake levels be verified in the field. A pumping test was proposed to achieve measurable drawdown in Plainfield Lake. The WDNR asked the USGS to use a groundwater model to determine an optimal pumping rate, duration, well configuration, and a discharge location that would not influence the test. Ensemble simulations were performed with an uncalibrated 63 km² inset model around the
Plainfield Lakes. Parameter ensembles were conditioned using the Schur complement as implemented in the pyEMU software. A step-wise approach was taken, starting with a simple scheme of global multipliers, progressing to distributed parameterization using pilot points. The pilot point parameterization—which better reflects the true unknowns—produced estimates of lake stage drawdown that were more diffuse and heavily skewed towards lower values. Simple parameterization schemes that neglect important unknowns can lead to unrealistic confidence in model results.

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Instream Water Quality Response to Agricultural Best Management Practice Implementation in the Silver Creek Watershed

Ben Young, NEW Water, Green Bay Metropolitan Sewerage District, byoung@newwater.us

Green Bay has historically been degraded with excessive sediment and nutrients, leading to dangerous algal blooms and zones with depleted oxygen. In 2014, NEW Water, the brand of the Green Bay Metropolitan Sewerage District made an important decision when faced with more stringent phosphorus reductions required by WI DNR. Rather than costly treatment plant upgrades, NEW Water decided to test an alternative compliance option and invested in a five year feasibility study in the Silver Creek watershed to identify and reduce excessive unregulated nonpoint sources of sediment and phosphorus. One of NEW Water’s goals in the pilot study focused on better understanding instream water quality response to the implementation of a variety of agricultural best management practices in the watershed. More frequent and intense precipitation events in Silver Creek have historically played a significant role in soil and nutrient loss from agricultural sources. However, as winter cover in the form of cover crops and inter-seeding acreage has generally increased since 2014, in-stream reductions in TSS and Phosphorus are becoming more evident, both varying spatiotemporally. While in-stream water quality improvements are promising, more time is needed to fully understand the lag time associated with various BMP implementation. Results and experiences of the pilot project will guide NEW Water’s approach to meet new Adaptive Management compliance requirements for a larger watershed in the future.

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Municipal-agriculture Partnerships for Watershed Management

Bartlett Durand, Sand County Foundation, bdurand@sandcountyfoundation.org

Our politics, regulatory environment and often our basic cultural identity are often divided between urban and rural realities. The watershed provides a fundamental geological structure where we all share common water, and the effects of our impact on the land become a common problem for each of us.

As a response, certain areas of the country are exploring partnerships between municipalities, usually municipal wastewater plants, and the common-watershed farmers and landowners. Wisconsin is one of the leaders in this concept, but examples are available throughout the country.

Sand County Foundation’s Director of Watershed Partnerships will present on examples of how these partnerships can work, how the concept is spreading in the upper Midwest, and what the benefits are for everyone involved.

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Long-term Monitoring Sheds Light on Urban Stressors in Milwaukee Area Stream Communities

Barbara Scudder Eikenberry, US Geological Survey, Upper Midwest Water Science Center, beikenberry@usgs.gov
Michelle Nott, US Geological Survey, Upper Midwest Water Science Center
Jana Stewart, US Geological Survey, Upper Midwest Water Science Center
Daniel Sullivan, US Geological Survey, Upper Midwest Water Science Center
David Alvarez, US Geological Survey, Upper Midwest Water Science Center
Faith Fitzpatrick, US Geological Survey, Upper Midwest Water Science Center

Long-term monitoring can yield important insights into streamflow, water quality, and habitat stressors on aquatic communities. Since 2004, the U.S. Geological Survey has been monitoring 14 streams in urban/urbanizing watersheds in the Milwaukee area to assess physical and chemical characteristics of the streams and health of fish, invertebrate, and algal assemblages. Monitoring results showed more frequent flood and scour from high stream flows and higher mean annual chloride concentrations in streams correlated to degraded invertebrate and fish assemblages. Excess nutrients, chloride, and low dissolved oxygen were also stressors for invertebrates and fish and also correlated with algal metrics indicating degradation. Potential toxicity from synthetic organic chemicals
was found at 6 sites tested. Higher percentages of urban land in the stream buffer, impervious surface, developed (urban) land, and developed open space in the watershed all correlated to degraded invertebrate and fish assemblages. These results underscore the effects of frequent high flows that scour stream channels and bring contaminants and excess nutrients into urban streams.

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**Improving Predictions of TSS in Urban Models**

Judy Horwatich, US Geological Survey, Upper Midwest Water Science Center, jahorwat@usgs.gov

Predictions of total suspended solids (TSS) in the urban environment are important for engineers who design stormwater control measures and for predicting pollutant loadings for Total Maximum Daily Loads (TMDL). Urban models often assign an average concentration per land use, which might be modified by washoff or decay coefficients. However, source area TSS concentrations vary considerably within each land use and can be affected seasonally. Recent promotion and adoption of stormwater management practices, advancement in sampling techniques, and newly collected data could enhance model predictions of TSS. A recent study by the USGS, USEPA and WDNR evaluated source areas, such as parking lots, to improve modeling prediction for volume and various pollutant concentrations. The Source Loading and Management Model for Windows (WinSLAMM) uses source area parameter files based on rainfall depth, therefore it can incorporate newly developed equations to simulate event loads. Preliminary results show source area equations based on rainfall depth improve the overall TSS prediction. TSS equation development also showed a seasonal difference in TSS, however WinSLAMM currently does not have the ability to adopt seasonality, thus model enhancements could further improve predictions.
Water Quality Indicators of Human Impacts to the Wetlands of Door Co., WI

David Hart, Wisconsin Geological and Natural History Survey, djhart@wisc.edu
Sarah Gatzke, The Nature Conservancy
Michael Grimm, The Nature Conservancy
Nicole Van Helden, The Nature Conservancy

Poor quality groundwater discharging to a wetland can alter its ecology and negatively affect native plant and animal communities. In Door County there is a concern that groundwater nutrient and contaminant loading to wetlands may support the invasion and spread of aggressive non-native plants and impair habitat that supports species such as the federally endangered Hine’s Emerald Dragonfly.

We selected six representative wetlands in Door County that receive significant groundwater discharge. We sampled springs discharging directly to the wetlands for major ions, nitrate, phosphorus, metals, caffeine, artificial sweeteners, enterococci, and pesticides. The contributing zones to the springs were determined and the residential density and percentage of cropland in the contributing zones were identified. We then calculated the correlations between water quality, human and agriculturally sourced contaminants, residential density, and agricultural land use.

We found that 1) agriculture land use is correlated to higher nitrate concentrations and higher probability of pesticide detects, 2) housing density is correlated to a greater number of detects of caffeine and sweeteners and higher phosphorus concentrations, 3) residential density is not correlated to nitrate, and 4) agriculture land use is not correlated to phosphorus in groundwater. These correlations indicate a role for land use planning within the contributing zones to the groundwater fed wetlands of Door County.
Widespread Detections of Neonicotinoid Contaminants in Central Wisconsin Groundwater

Russell Groves, University of Wisconsin-Madison, Department of Entomology, rgroves@wisc.edu
Benjamin Bradford, UW-Madison, Dept of Entomology
Anders Huseth, NCSU, Department of Entomology

Neonicotinoids are a popular and widely-used class of insecticides whose heavy usage rates and purported negative impacts on arthropods has led to questions about their mobility and accumulation in the environment. In 2008, the Wisconsin Department of Agriculture, Trade and Consumer Protection began testing for neonicotinoids in groundwater test wells, reporting dozens of detections in shallow groundwater test wells. In 2011, similar detection levels were confirmed in several high-capacity overhead center-pivot irrigation systems in central Wisconsin. Here, we investigated the spatial extent and magnitude of neonicotinoid contamination in groundwater in and around areas of irrigated commercial agriculture in central Wisconsin. From 2013-2015 a total of 317 samples were collected from 91 unique high-capacity irrigation wells and tested for the presence of thiamethoxam (TMX) using enzyme-linked immunosorbent assays. 67% of all samples were positive for TMX at a concentration above the analytical limit of quantification (0.05 μg/L) and 78% of all wells tested positive at least once. Mean detection was 0.28 μg/L, with a maximum detection of 1.67 μg/L. Five wells had at least one detection exceeding 1.00 μg/L. Furthermore, an analysis of the spatial structure of these well detects suggests that contamination profiles vary across the landscape, with differences in mean detection levels observed from landscape (25 km), to farm (5 km), to individual well (500 m) scales.

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Neonicotinoid Pesticides in Wisconsin Groundwater and Surface Water

Stanley Senger, Wisconsin Department of Agriculture, Trade and Consumer Protection, stan.senger@wisconsin.gov

DATCP conducts sampling programs to protect State water resources from chemicals used in agriculture. From 2008-2016, DATCP collected samples from 1,048 private wells, 65 field-edge monitoring wells, 22 irrigation wells, and 34 streams. Samples were analyzed by DATCP lab using GC/MS/MS and LC/MS/MS. Three neonicotinoid insecticides were detected, including clothianidin, imidacloprid and thiamethoxam (CIT). These compounds are ingredients in products labeled for use on most crop types and are used extensively in WI agriculture.

Test results show CIT detects mostly in sandy irrigated agricultural areas. About 5.7% of private potable wells, 53% of field-edge, and 82% of irrigation wells had CIT detects. Private well samples were as high as 4 ug/l (clothianidin), monitoring well samples were as high as 9 ug/l (thiamethoxam), and irrigation well samples were as high as 1.87 ug/l (imidacloprid). State groundwater standards do not exist for CIT. DNR recently proposed an NR. 140 ES for imidacloprid at 0.2 ug/l. Fifty-five private well samples exceeded the proposed ES.

Four of 34 streams sampled had detects of imidacloprid and thiamethoxam. Concentrations were present year-round, suggesting contaminated groundwater baseflow as a major cause for in-stream detects. Detections were as high as 0.25 ug/l (thiamethoxam). Imidacloprid exceeded EPA chronic thresholds for freshwater invertebrates (0.01 ug/l) in all samples where detected.

Further study and research is ongoing.

* * *
Use of Polar Organic Chemical Integrative Samplers (POCIS) to Monitor Neonicotinoid Insecticides in Streams and Ditches on the Central Wisconsin Sand Plain

William Devita, University of Wisconsin-Stevens Point, Water and Environmental Analysis Lab, wdevita@uwsp.edu

Polar organic chemical integrative samplers (POCIS) are passive sampling devices that are used to provide a time-weighted average of water quality over the period of deployment. They consist of two porous membranes that encase a polymer acting as the sorbent. In order to derive average water concentrations, POCIS rely on empirically determined effective sampling rates which define rates of accumulation of a specific compound into the sorbent.

In August 2019, these devices were deployed for 30-day periods in baseflow dominated streams and ditches on the Central Wisconsin Sand Plain. Bulk water samples were collected at the time of POCIS deployment and retrieval. Twenty sites were selected on the basis of proximity to headwaters, surrounding land use, baseflow from recent records, and position on the groundwater divide (east or west). Grab samples and POCIS were analyzed for five neonicotinoid insecticides: acetamiprid, clothianidin, dinotefuran, imidacloprid and thiamethoxam. Nine of the 20 sites exceeded chronic US EPA Aquatic Life Benchmarks for invertebrates for imidacloprid and five of the 20 sites exceeded these benchmarks for clothianidin. Neonicotinoid concentrations in the POCIS were consistently lower possibly reflecting dilution effects from heavy rains which occurred during the deployment period.

* * *

Chronic Exposure to Thiamethoxam Causes Neurotoxicity in Larval Fish

Tisha King-Heiden, University of Wisconsin-La Crosse, tking-heiden@uwlax.edu
Elisabeth Harrahy, UW-Whitewater

Neonicotinoid pesticides are the fastest-growing class of pesticides world-wide. These pesticides are designed to activate the nicotinic receptor of invertebrates, leading to neurotoxicity and death of invertebrate pests. In the Central Sands region of WI, the neonicotinoid thiamethoxam (TM) has been detected in waterways at concentrations that exceed ecological thresholds for chronic exposure, raising concern for aquatic organisms.
While TM should pose minimal threat to fish, overstimulation of the nAChR by other neonicotinoids can lead to neurotoxicity in fish. The goal of this work was to determine whether chronic exposure to TM is capable of causing neurotoxicity in larval fish using behavior as a bioindicator. Fathead minnow and zebrafish were exposed to 0.02 – 200 g TM/L for 7 days beginning either just after fertilization (embryonic exposure) or post-hatch (larval exposure). Embryonic exposure decreased hatching success and survival. Increases in embryonic motor activity indicates that TM is capable of activating fish nAChR. Chronic exposure to TM results in non-monotonic dose-response with respect to predator-avoidance behaviors, specifically with respect to latency of response. Following 14 days of depuration, foraging efficiency was reduced, in a non-monotonic manner. While species-specific differences occurred, overall our data suggests that TM is capable of causing neurotoxicity in fish.

* * *

**Acute and Chronic Toxicity of the Neonicotinoid Insecticide Thiamethoxam to Select Aquatic Invertebrates**

Elisabeth Harrahy, University of Wisconsin-Whitewater, harrahye@uww.edu
Austin Draper, UW-Whitewater
Anya Jeninga, UW-Whitewater
Tisha King-Heiden, UW-La Crosse

Neonicotinoid insecticides have been detected in streams and aquatic invertebrates may be at risk from exposure. The goal of this project is to determine the acute and chronic toxicity of thiamethoxam to select aquatic invertebrates. In separate acute tests, water fleas (*Ceriodaphnia dubia*) and amphipods (*Gammarus pseudolimnaeus*) were exposed to nominal concentrations of 0, 28, 47, 78, 130, 216, 360, 600, or 1,000 µg/L thiamethoxam. In the chronic toxicity test, water fleas were exposed to 0, 9, 15, 26, 43, 72, 120, and 200 µg/L thiamethoxam. There were four replicate beakers per treatment in the water flea test, with five water fleas in each beaker. There were 20 replicate beakers per treatment in each amphipod test, with one amphipod in each beaker. There were no significant differences in survival of water fleas among treatments. This test is being repeated with higher concentrations. The calculated LC50 (lethal concentration for 50% of the population) value
for amphipods was 53.69 µg/L thiamethoxam. In the water flea chronic test, there were no significant differences in survival or reproduction among treatments. Additional tests are being conducted to examine the chronic effects of thiamethoxam on growth and feeding activity of the amphipods. Acute and chronic tests are also being conducted with chironomids (*Chironomus dilutus*). Impacts on populations of any of these species could have cascading effects on the structure and function of these aquatic ecosystems.

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