AMERICAN WATER RESOURCES ASSOCIATION – WISCONSIN SECTION

37th ANNUAL MEETING

Managing Wisconsin's Urban Water Resources

March 7-8, 2013

Sheraton Milwaukee Brookfield Hotel

Brookfield, Wisconsin

Hosts:

American Water Resources Association-Wisconsin Section

University of Wisconsin Water Resources Institute

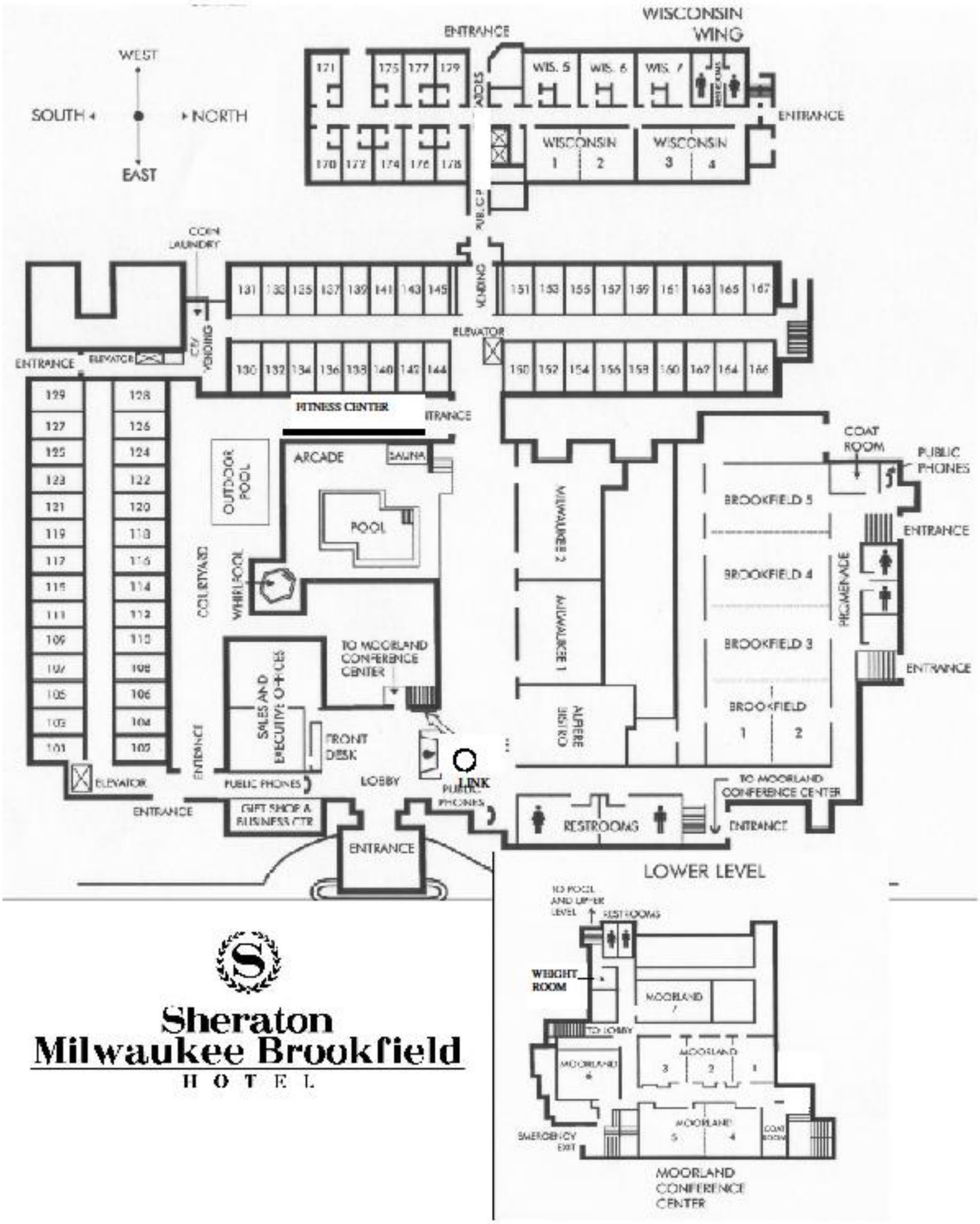
Wisconsin Department of Natural Resources

Center for Watershed Science & Education, UW-Stevens Point

Wisconsin Geological and Natural History Survey

U.S. Geological Survey Wisconsin Water Science Center

Sheraton Milwaukee Brookfield Hotel Conference Facilities



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

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President (1-year term)

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

President-Elect (1-year term)

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

Vice-President (1-year term)

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

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

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

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

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

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

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

BIOGRAPHIES OF CANDIDATES FOR THE AWRA WISCONSIN SECTION BOARD

Andrew Aslesen
Andrew Aslesen has been a Source Water Specialist with the Wisconsin Rural Water Association since March 2010. Mr. Aslesen works with community water systems to solve groundwater quality and quantity issues, including the development and implementation of wellhead protection plans. Previously Mr. Aslesen worked as a project assistant with the Wisconsin Geological and Natural History Survey from 2008 to 2010. Mr. Aslesen has a M.S degree in Water Resources Management with an emphasis in Hydrogeology from UW-Madison's Nelson Institute of Environmental Studies and a B.S in Geography with a Geology emphasis from UW-Whitewater.

Amanda Bell
Amanda Bell has been with the U.S. Geological Survey since the spring of 2001, beginning as an undergraduate student intern for the Snake River NAWQA Basin in Idaho. She then transferred to the Wisconsin Water Science Center so she could complete her Bachelor's Degree from the University of Wisconsin-Stevens Point. Her graduate work, also with UWSP, was closely tied with the NAWQA Mercury Topical Team, where she designed a complimentary periphyton-mercury study to the national food-web mercury accumulation study. Ms. Bell has been intensively involved in studies on the effects of urbanization on stream ecosystems and determination of temporal and nutrient trends in aquatic biological communities. Most recently, she partnered with the Department of Natural Resources to develop a project to evaluate the degraded benthos and plankton community beneficial use impairments in Wisconsin's areas of concern. Over the last 7 years, she has co-authored 18 publications and gained the respect of many senior scientists for her diligence, organization, responsibility, and work ethic.

Brent Brown
Brent Brown is a registered Professional Engineer for CH2M HILL in their Milwaukee office. Mr. Brown practices water resources engineering and works on projects involving ecosystem protection and restoration, habitat and fluvial geomorphic assessments, watershed and stormwater management, low-impact development stormwater controls, sediment dredging and dewatering, and airport deicing fluid control. Mr. Brown has a Bachelor's Degree from the University of Wisconsin at Platteville in Civil/Environmental Engineering and a Master's Degree from the University of Illinois at Urbana-Champaign in Environmental Engineering. Mr. Brown has been employed with CH2M HILL for 12 years.

John Skalbeck
Dr. Skalbeck is an Associate Professor of Geosciences and the Academic Director for the Master of Science in Sustainable Management program. He earned his B.A. in Geology from Gustavus Adolphus College, M.S. in Geology/Geophysics from Western Washington University, and Ph.D. in Hydrogeology from University of Nevada-Reno. He serves on the UW-Parkside Environmental Studies program Steering Committee and is the co-founder of two environmental education community centers in Racine and Kenosha. Dr. Skalbeck spent more than 10 years as a groundwater consultant specializing in soil and groundwater contamination and remediation. His current research includes modeling of gravity and magnetic data for hydrogeologic applications, wetlands characterization, and water quality of beaches.

BIOGRAPHIES OF PLENARY AND EVENING SPEAKERS

Michael G. Hahn

Michael Hahn has 35 years of experience as a Water Resource Engineer. In his current position as Chief Environmental Engineer with the Southeastern Wisconsin Regional Planning Commission, he directs the activities and staff of the Commission's Environmental Planning Division, including the regional water quality management, water supply, and stormwater and floodland management planning programs. He has served as the lead author and/or project manager for numerous SEWRPC watershed-based plans, including the regional water quality management plan update for the greater Milwaukee watersheds (2007); the comprehensive plan for the Des Plaines River watershed (2003); and stormwater management plans for the cities of Brookfield and West Bend and the villages of Elm Grove and Menomonee Falls. He is a registered Professional Engineer and Professional Hydrologist in the state of Wisconsin. Mr. Hahn received a B.S. degree in Civil Engineering from the University of Notre Dame and an M.S. in Civil Engineering from the University of Minnesota, where he was a research assistant at the Saint Anthony Falls Hydraulic Laboratory.

Kevin Shafer

Kevin Shafer became Executive Director at the Milwaukee Metropolitan Sewerage District (MMSD) in 2002. Prior to this, he served as MMSD's Director of Technical Services since 1998. As Executive Director, he is responsible for the overall management, administration, leadership and direction for MMSD in meeting short- and long-term goals and objectives; coordinating the establishment of strategic goals and objectives and their approval by the Commission; overseeing the development of policies and operating plans; and representing MMSD to its customers, bond rating agencies, and the public.

William L. Holahan

William Holahan, Emeritus Professor of Economics at the University of Wisconsin-Milwaukee, received his PhD in Economics from Brown University. Recognized with two university and two business school awards for excellence in teaching, Dr. Holahan has authored numerous articles in academic journals, including the American Economic Review, the Journal of Economic Theory, the Journal of Legal Studies, and the Journal of Economic Education. He has co-authored textbooks on intermediate economics and managerial economics. For twenty years Professor Holahan was the Associate Director of the UWM Center on Economic Education, which is committed to enhancing the economic knowledge and pedagogical practices of high-school teachers of social studies. In that capacity, he has written several articles on the teaching of economics. Professor Holahan also served on the founding executive committee of the UWM School of Freshwater Sciences and has a working paper entitled "Microeconomics of Reliable Urban Water Supply: The Comparative Economic Advantage of Great Lakes Cities."

Bradley Eggold

Brady Eggold has been working on Lake Michigan fisheries issues since he started with the Department of Natural Resources in 1990. For 10 years he was a Fisheries Biologist stationed at the Plymouth Field Station. He has primarily worked on the sport fishing surveys on Lake Michigan. Starting in 2000 to the present, he has been the Fisheries Supervisor for the southern half of Lake Michigan, conducting surveys and assessments on a variety of both sport and commercial fisheries, conducting habitat projects in LM tributaries, and assisting in the operation of our Root River Steelhead Facility located in Lincoln Park in the City of Racine. His talk will focus on the Root River Steelhead Facility.

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PROGRAM SUMMARY

Managing Wisconsin's Urban Water Resources

37^{th} Annual Meeting of the
American Water Resources Association – Wisconsin Section
Brookfield, Wisconsin

Thursday, March 7, 2013

9:00 – 11:30 a.m. Registration

11:30 – 12:15 p.m. Welcome and Lunch - Brookfield 4/5

12:15 – 2:15 p.m. **Plenary Session:** Managing Wisconsin's Urban Water Resources

Michael G. Hahn
Chief Environmental Engineer
Southeastern Wisconsin Regional Planning Commission

Kevin Shafer
Milwaukee Metropolitan Sewerage District

William L. Holahan
Professor of Economics Emeritus, UW-Milwaukee

2:15 – 2:30 p.m. **Break**

2:30 – 3:50 p.m. **Concurrent Sessions 1A and 1B**

Session 1A – Urban Water Resources I

Brookfield 1/2
Moderator: Kevin Masarik, UW-Stevens Point

2:30 Stormwater Green Infrastructure - Changing the Way the City of Milwaukee Implements Street Reconstruction, Erick Shambarger

2:50 Contaminant Transport Pathways between Urban Sewer Networks and Water Supply Wells, Madeline B. Gotkowitz

3:10 The Cost of Bias: Redefining Urban Sediment through Improved Sampling Technology, William R. Selbig

3:30 Soil Stability and Water Quality within Constructed Wetland Treatment Swales, Stephanie G. Prellwitz *

Session 1B – **Lakes Great and Small**

Brookfield 3
Moderator: Earl Spangenberg, Editor-in-Chief, Water Resources IMPACT

2:30 Using Spatial Narrative Geotools to Foster Stewardship in Coastal Communities, Matthew T. Axler *

2:50 An Integrated Nowcasting and Forecasting Observation System (INFOS) for the Water Environment of the Apostle Islands, Lake Superior, Joshua D. Anderson *

3:10 Dissolved Oxygen Stress of a Dimictic Lake in Response to Changing Climate, Madeline Magee *

3:30 Seasonal Responses of Lake Evaporation to Climate Change in Wisconsin, Nathan Gerdts *

3:50 – 4:10 p.m. **Break**

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

Session 2A – **Urban Water Resources II**

Brookfield 1/2
Moderator: Bill Selbig, USGS Wisconsin Water Science Center

4:10 Is “Zero Runoff” a Realistic Goal in Urban Areas?, Brett H. Emmons

4:30 Development and Application of Soil and Water Assessment Tool (SWAT) for an Urban Watershed in Wisconsin, Chaohe (Gary) Guo *

4:50 Water Reuse – Retrofitting Last Century Technology for the Future, Brett H. Emmons

5:10 The Relative Significance of Environmental and Anthropogenic Factors Affecting Zooplankton Community Structure in Southeast Wisconsin Till Plain Lakes, Scott J. Van Egeren

Session 2B – **Water Quality**

Brookfield 3
Moderator: Theresa Nelson, Wisconsin Department of Natural Resources

4:10 Evaluating the Effect of Soil Composition and Depth in Bioretention Systems as a Way to Remove Pollutants in Stormwater Runoff, Judy Horwatich

4:30 Monitoring Groundwater Nitrogen Concentration in Sandy Soils under Vegetable Production, Nicholas J. Bero

4:50 What We've Learned from over 20 Years of Voluntary Private Well Water Testing, Kevin Masarik

5:10 Water Renewal Time Scales in a Lake-River Chain System, John R. Reimer*

5:30 p.m. Refreshments

6:00 p.m. **Dinner** - Brookfield 4/5

Speaker: Bradley Eggold, Southern Lake Michigan Fisheries Supervisor, Wisconsin DNR

Title: *Root River Steelhead Facility*

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

Moorland Suite

1. Transport of Tetracycline-Resistant and Tetracycline-Susceptible *Escherichia coli* within Unsaturated Porous Media, Lucia Feriancikova *
2. Biodiversity of Gastropoda in the Mukwonago River, Wisconsin along a Spatial Gradient, Kristie L. Hansen *
3. Stream Ecosystems Change with Urban Development, Amanda H. Bell
4. Hydrological Effects of Subsurface Heterogeneity Reveal Ecosystem Service Tradeoffs in a Compartmentalized Wetland Stormwater Treatment System, Steven P. Loheide
5. Spatial Distribution of Dissolved Strontium in Eastern Wisconsin's Aquifers, Joseph B. Baeten *
6. Interactions between Cationic Drugs and Zeolite, Christie L. Stockwell *
7. Assessing Different Aquifer Material in WI as Possible Natural Sources of Chromium (VI), Patrick Gorski
8. Export of Heavy Metals and Nutrient Species by Two Urban Rivers in Milwaukee, Michele L. Huppert
9. Simulating the Seasonal Variations in Phosphorus Concentrations in Lakes—Linking Watershed and Lake Models for Upper St. Croix Lake, Paul McGinley

10. Runoff Water and Nutrient Fluxes from Biofuel Cropping Systems, Michael J. Polich *
11. Phosphorus and TSS Trends in Two Streams in Northeastern Wisconsin, Paul D. Baumgart
12. TMDL Goals and Water Quality Realities in a Lower Fox River Watershed, Kevin Fermanich
13. Testing the Effectiveness of Targeted Conservation with a Paired Watershed Approach, Laura Ward Good
14. Sedimentation in the Miljala Channel Watershed: Drained Wetlands, Agriculture and Restoration Potential, Steve G. Neary *
15. Sediment Routing through Ephemeral Grassed Waterways in a Nested Watershed, Harsh Vardhan Singh *
16. Comparison of Sediment Budgets of Nearshore Environment for Two High Bluffs on Lake Michigan, William Roznik *
17. Effects of Inter-annual and Seasonal Variability in Regionalization of Hydrologic Response in the Great Lakes Basin, Jonathan Kult *
18. Spatial and Temporal Variability in Wisconsin's Stream Flow Dynamics, Ron C. Chester *
19. Effects of Slope Length and Soil Moisture Content on Stormwater Runoff from Turfgrass, Damodhara R. Mailapalli
20. Hydrogeology of the Mink River Estuary, Door County, WI: Geologic Controls on Spring Locations, Kylie Larson-Robl *
21. Brine Water Chemistry and Relationship to Bedrock Geology in the Deep Subsurface of Manitowoc County, WI, Patrick McLaughlin
22. Hydrologic and Geochemical Investigation of the Albion Basin, Little Cottonwood Canyon, Alta, Utah, Jennifer Kraus *
23. Simulating Groundwater Recharge of Prairie River Watershed Using the Soil-Water Balance Model: Effects of Sub-annual Precipitation Patterns, Alice M. Egan
24. Groundwater Pumping Impacts in the Wisconsin Central Sands During the 2012 Drought, George J. Kraft
25. The Role of Groundwater in the Flooding History of Clear Lake, Wisconsin, Susan K. Swanson
26. Modeling Groundwater Flooding Recurrence Intervals Using GSFLOW, Russell J. Henning
27. Identification of Shallow Groundwater Flood Risk Areas, Spring Green Area, Wisconsin, Jacqueline R. Marciulionis
28. Analyses of Hydraulic Properties at the Cedarburg Bog with Emphasis on Subsurface Characterization and Groundwater Flow, Owen J. Miller *

29. An Initial Hydrogeophysical Investigation of the Cedarburg Bog, Michael S. Baierlipp*
30. Characterization of Artificial Recharge at the University of Wisconsin–Parkside Campus, Keith Krukowski *
31. Hydrological Investigation of Aquifer Characteristics at the University of Wisconsin-Parkside Campus, Jennifer Kraus *
32. Modeling the Effects of Nuanced Changes in Lot Layout and Impervious Area Connectivity on Urban Recharge in COMSOL, Carolyn B. Voter *
33. Obstacles to Estimating Soil Moisture with Heated Fiber Optics, John J. Sourbeer *

Friday, March 8, 2013

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

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

Session 3A – Agricultural Hydrology and Management

Brookfield 1/2
Moderator: Eric Booth, UW-Madison

8:30 Characterizing the Response of Total Suspended Solids and Total Phosphorus Loading to Rainfall and Snowmelt Runoff in Agricultural Watersheds, Mari E. Danz

8:50 Evaluating Newly Adopted Nitrogen Management Strategies for Irrigated Potato and Vegetable Production in the Golden Sand of Central Wisconsin, Mack R. Naber

9:10 Using Fallout Radionuclides to Track Sediment Movement within an Agricultural Watershed, Jasmeet Lamba *

9:30 Examining the Influence of Shallow Groundwater on Net Primary Productivity and Evapotranspiration in Managed Ecosystems, Mehmet E. Soylu

9:50 Shallow Groundwater Impacts on Corn Biophysics and Yield During a Drought, Yahara River Watershed, Wisconsin, Samuel C. Zipper *

Session 3B – **Advances in Hydrological Techniques**

Brookfield 3
Moderator: Andrew Aslesen, Wisconsin Rural Water Association

8:30	Mapping Flow Path Uncertainty with an Analytic Element Model and Monte Carlo Techniques, Paul F. Juckem
8:50	Hydrologic Modeling of Internally Drained Basins in the Yahara River Watershed Using an Extreme Precipitation Event, Douglas R. Brugger *
9:10	Exploring the Occurrence of Riverbank Inducement into a Shallow Aquifer in Southeastern Wisconsin through Geochemical Analysis, Anna Thorp *
9:30	Borehole Flow Characterization Using Discrete In-well Heat Tracer Tests Monitored by DTS, Stephen M. Sellwood *
9:50	Influence of Enterococcal Surface Protein (esp) on the Transport of *Enterococcus faecium* within Saturated Quartz Sands, Jennifer J. Johanson

10:10 – 10:30 a.m. **Break**

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

Session 4A – **Groundwater Modeling**

Brookfield 1/2
Moderator: Paul Juckem, USGS Wisconsin Water Science Center

10:30	A New Groundwater Flow Model for Dane County, Wisconsin, Kenneth R. Bradbury
10:50	Simulation of Groundwater Flow and Groundwater/Surface-water Interactions in the Bad River Watershed, Wisconsin, Andrew T. Leaf
11:10	Application of a Groundwater/Surface-water Model to Water-supply Management: Upper Fox Basin, Waukesha County, Wisconsin, Daniel T. Feinstein
11:30	Using a Bayesian Decision Network to Emulate a Groundwater Model for Efficient Decision Support, Michael N. Fienen
11:50	Simplified Access to the Power of Parameter Estimation through PEST++ and keyPEST, Randall J. Hunt

Session 4B – Measuring, Monitoring and Managing Wisconsin's Water Resources

Brookfield 3
Moderator: Pat Jurcek, Layne-Christensen

10:30	Issues Pertaining to Developing a High Capacity Water Supply for an Industrial Sand Mine in Wisconsin, Doug Losee
10:50	Integrating Flood Control with Natural Lands Management in the Clark Creek Watershed, Sauk County, Wisconsin, Stephen J. Gaffield
11:10	Using Geophysics to Better Understand Wetland Hydrogeology, Dave Hart
11:30	Wisconsin's Water Withdrawal Inventory and Reporting Program, Robert A. Smail
11:50	Updating Wisconsin’s Statewide Groundwater Monitoring Network, Michael Parsen

* Student Presentation

SESSION 1A:

Urban Water Resources I

Thursday, March 7, 2012

2:30 - 3:50 p.m.

Stormwater Green Infrastructure - Changing the Way the City of Milwaukee Implements Street Reconstruction

Erick Shambarger, City of Milwaukee, Office of Environmental Sustainability, Milwaukee, WI, *eshamb@milwaukee.gov*

Brent Brown, CH2M HILL, Milwaukee, WI, *brent.brown@ch2m.com*

The City of Milwaukee Office of Environmental Sustainability was created by Mayor Tom Barrett to position Milwaukee as a leader in environmental sustainability and performance in the 21st century. The office was created through community support received by the Milwaukee Green Team, a group commissioned by Mayor Barrett in 2004.

The OES promotes cost-effective environmental sustainability practices that meet Milwaukee's urgent environmental, economic and social needs while enhancing long-term economic growth, thus, improving the environment and livability of Milwaukee for all its citizens. For instance, the OES team works with other City departments, the Common Council, area businesses, and academic, community, and workforce organizations, to save taxpayer dollars by reducing energy bills in city buildings and in homes and businesses. OES also promotes cost-effective green infrastructure solutions to the city's stormwater management challenges.

The OES is updating its Sustainability Plan and Green Team report that addresses all aspects for sustainability within the City. Along with this effort, the City has recently completed a comprehensive evaluation of how green infrastructure for stormwater control is implemented on street and alley reconstruction and resurfacing projects. This evaluation included working with multiple units within the Department of Public Works to integrate stormwater green infrastructure into all future street projects. This presentation will summarize these efforts and how this project is changing the way the City of Milwaukee integrates green infrastructure for stormwater management.

Contaminant Transport Pathways between Urban Sewer Networks and Water Supply Wells

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

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

Mark A. Borchardt, USDA–Agricultural Research Service, Marshfield, WI

Water supply wells and sanitary sewers are critical components of urban infrastructure, but sewer leakage threatens the quality of groundwater in sewered areas. Previous work by our group has documented the presence of human enteric viruses in deep public supply wells. Our current research uses such viruses as a waste water tracer to identify contaminant transport pathways between sewer networks and supply wells. Enteric viruses are excellent tracers of sanitary sewage because they are mobile in the subsurface, can be uniquely identified, and can be quantified over a broad concentration range, from millions to a fraction of genomic copies per liter.

Project objectives include quantifying the temporal and spatial distribution of pathogenic viruses in shallow groundwater near urban sewers, and establishing correlations between virus presence in groundwater and sewer characteristics such as age, material, and overall condition. Seven field sites were developed near sewers ranging in age from 10 to 75 years old. The network of 22 monitoring and supply wells will be sampled twice monthly for one year. Samples are analyzed for viruses, coliform bacteria, major ions and environmental isotopes.

Ultimately, development of this urban groundwater monitoring network and these water quality data will contribute to proactive risk assessment, useful monitoring, and maintenance of sewer and water supply infrastructure.

The Cost of Bias: Redefining Urban Sediment through Improved Sampling Technology

William R. Selbig, U.S. Geological Survey, Middleton, WI, *wrselbig@usgs.gov*

Roger T. Bannerman, Wisconsin Department of Natural Resources, Madison, WI, *roger.bannerman@wisconsin.gov*

A new stormwater sample collection device was developed to improve representation of sediment and sediment-associated contaminants entrained in urban stormwater by integrating samples spaced vertically throughout the entire water column. Compared to traditional fixed-point sample collection methods, the depth-integrated sample arm (DISA) was better able to characterize suspended-sediment concentration and particle size distribution in a flowing water column. Use of the DISA resulted in generally lower suspended-sediment concentrations and finer particle size distributions with lower variance when tested in a controlled laboratory environment. These improvements are important to the calibration of urban runoff models as well as evaluating the performance of stormwater control measures. Models calibrated with DISA results may produce lower sediment loads, which could change the load allocations of pollutants in a TMDL. The cost of many stormwater control measures, such as wet ponds, could increase when a finer PSD is required as part of the design.

By significantly lowering the variability in the sediment concentrations, the DISA extends the range of performance levels observable for different types of stormwater control measures with a higher degree of confidence. These higher confidence levels can be achieved while still collecting a reasonable number of samples. In addition, a lower variability has made it easier to detect trends, not only in concentration, but also in particle size distribution. An improved ability to detect trends can aid future efforts to improve the way urban runoff models predict sediment and sediment-associated constituent concentrations.

Soil Stability and Water Quality within Constructed Wetland Treatment Swales

Stephanie G. Prellwitz,* Biological Systems Engineering, UW-Madison, Madison, WI, *s.prellwitz@gmail.com*

Anita M. Thompson, Biological Systems Engineering, UW-Madison, Madison, WI, *amthompson2@wisc.edu*

The use of constructed wetlands to treat urban stormwater can be challenging because of hydrologic inputs that vary in amount, timing and nutrient concentration. The impact of hydroperiod and vegetation on soil stability and water quality was investigated at the Stormwater Management Research Facility within the University of Wisconsin Arboretum in Madison, Wisconsin. Stormwater from a 34 ha urban watershed was directed towards parallel wetland swales totaling 1.1 ha. Despite efforts to create replicate swales, distinct hydrologic and vegetation regimes developed. The combination of hydroperiod (high-, intermediate-, and low-water level recession rate) and vegetation led to (i) differences in soil substrate establishment that ranged in erodibility and (ii) varied responses in nutrient removal.

Critical shear stress (shear stress required to initiate particle detachment) was measured as an indicator of soil stability and was highest in the high-recession swale and lowest in the low-recession swale. These values are a result of various surface substrates that developed within the swales. Biotic substrates (moss and algae) were the most resistant to erosion while abiotic substrates (organic matter, bare soil, and muck) were the least resistant. Total removal of TSS, N, and P for 13 storms was highest in the high-recession swale and lowest in the low-recession swale. The low-recession swale produced the most biomass (and least diversity), yet exported the most nutrients and was the most prone to erosion. The high-recession swale produced the least biomass (and most diversity), yet exported the least nutrients and was the most resistant to erosion.

* Student Presentation

SESSION 1B:

Lakes Great and Small

Thursday, March 7, 2013

2:30 – 3:50 p.m.

Using Spatial Narrative Geotools to Foster Stewardship in Coastal Communities

Matthew T. Axler,* UW-Madison, Madison, WI, axler@wisc.edu

Francis R. Eanes,* UW-Madison, Madison, WI, feanes@wisc.edu

Janet Silbernagel, UW-Madison, Madison, WI, jmsilber@wisc.edu

Patrick Robinson, UW-Extension, Green Bay, WI, robinsop@uwgb.edu

David A. Hart, UW Sea Grant Institute, Madison, WI, dhart@aqua.wisc.edu

Every community has a unique narrative but may lack an effective way to share it. This Wisconsin Sea Grant-funded project attempts to bridge this gap by introducing a series of three spatial narrative "geotools," designed to foster citizen engagement and spatial literacy of socio-environmental complexities in Great Lakes coastal communities. These geotools, consist of 1) an authoring tool to construct places and topics; 2) a surfer tool to support community leader input and moderation in an interactive web map format; and 3) an explorer tool for mobile devices that allows citizens to engage with the narrative on site and submit their own photos, audio, videos, and journal entries based on their experiences. The Bay Renaissance Group of Green Bay, Wisconsin, is working with us to pilot these geotools and design and publish place-based stories generated by community user groups in the Green Bay watershed. Based on feedback from community workshops we will then evaluate the efficacy of geotools in fostering citizen engagement with place, in the hope that the collaborative user experience will generate greater environmental awareness and natural resource stewardship in the watershed.

* Student Presentation

An Integrated Nowcasting and Forecasting Observation System (INFOS) for the Water Environment of the Apostle Islands, Lake Superior.

Joshua D. Anderson,* Department of Civil and Environmental Engineering, UW–Madison, Madison, WI, *janderson1@wisc.edu*

Chin H. Wu, Department of Civil and Environmental Engineering, UW-Madison, Madison, WI, *chinwu@engr.wisc.edu*

The Apostle Islands National Lakeshore is one of Lake Superior's most popular destinations for sea kayaking, luring paddlers with scenic wilderness, ancient geology and a rich cultural history. The water environment in the Apostle Islands is undoubtedly complex and dynamic due to the interactions of currents and waves caused by rapidly changing weather conditions. For example, strong winds and sudden squalls, common to Lake Superior, can produce dangerous episodic storm surges and extreme waves. The islands that comprise the archipelago strongly alter wave propagation by focusing energy at certain locations, yielding so-called freak waves. To date, observations of the water environment in the Apostle Islands are very sparse and rare. Furthermore, there is no real-time or forecasting model that can resolve the influence of the islands on the water environment (i.e., waves, currents, and temperature).

In this talk, an Integrated Nowcasting and Forecasting Operation System (INFOS) for the Apostle Islands will be presented. The INFOS-Apostles computes the real-time and future water environment with a third generation wave model, SWAN, and a three-dimensional hydrodynamic model, SELFE. Models are calibrated with acoustic Doppler current profiler observations and pressure gauge observations using data assimilation techniques. Results elucidate mysterious patterns of freak waves and circulation in the Apostle Islands. A website (http://infosapostles.cee.wisc.edu/) has been developed to provide forecast model results and local real-time observations. The INFOS-Apostles would be continuously utilized by visitors, National Park personnel, and first responders to improve the safety and management of this natural resource.

* Student Presentation

Dissolved Oxygen Stress of a Dimictic Lake in Response to Changing Climate

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While much research has been devoted to determining how lakes will respond to changing climate, the effects of climate change on dissolved oxygen are still not well understood. Research suggests climate change impacts lake thermal structure, and there is a strong link between the thermal structure of lakes and the corresponding dissolved oxygen levels. For example, oxygen solubility decreases with rising water temperatures. Increases in the period of thermal stratification and changes in the thermocline depth in stratified lakes isolate hypolimnetic water from access to atmospheric oxygen, creating anoxic conditions. The duration of anoxic conditions in hypolimnetic waters is especially detrimental to cold-water fish species, resulting in periods of oxygen stress. Understanding how these periods of oxygen stress will respond to changing climate is essential to prepare for unknown future climates.

Fish Lake, located in Dane County, WI, USA, is a small, deep, dimictic lake. Our previous study shows that as air temperature increases, lake water temperature and stratified periods will increase. In this talk, we aim to investigate how the past changing climate has impacted dissolved oxygen levels during the stratified season. Employing a one-dimensional lake model (DYRESM), we will simulate dissolved oxygen levels over the past 100 years. Specifically, the duration of oxygen stress under the changing climate will be obtained. Furthermore, we will simulate the spatial distribution of oxygen stress in Fish Lake using a state-of-the-art 3D hydrodynamic model. Afterwards, the changing oxygen stress duration under several future scenarios will be modeled and discussed.

* Student Presentation

Seasonal Responses of Lake Evaporation to Climate Change in Wisconsin

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As temperatures increase from climate change, annual lake evaporation increases. However to date the seasonable response of lake evaporation is not yet fully understood. In this study a one-dimensional hydrodynamic lake model (DYRESM-I) with a newly implemented energy method is used to simulate lake evaporation over the one-hundred year period from 1911 to 2010. Seasonable lake evaporation is compared with linear trends of air temperature, solar radiation, vapor pressure, wind speed, and ice cover. Furthermore analysis is conducted on both a deep dimictic lake and a shallow polymictic lake to examine how lake thermal structure and mixing will affect seasonable lake evaporation responses. Results show an increase in the spring and winter evaporation and a decrease in the summer and fall evaporation. The increases in spring and winter evaporation correlate with increasing temperature, leading to decreases in ice-cover duration. These increases in evaporation occur despite decreases in wind speed and short wave radiation. Decreases in summer evaporation correlate with increasing vapor pressure while decreases in fall correlate with decreasing wind speed. Lastly, synthesized future climate scenarios show greater decreases in evaporation in the spring for the shallow polymictic lake and greater decreases in the fall for the deeper dimictic lake.

* Student Presentation

SESSION 2A:

Urban Water Resources II

Thursday, March 7, 2013

4:10 - 5:30 p.m.

Is "Zero Runoff" a Realistic Goal in Urban Areas?

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Stormwater volume control has been an issue in Minnesota for many years. The State of Minnesota has many valuable water resources, including many high-quality lakes and streams. Many areas also include closed depressions that are landlocked that do not commonly outlet. Some local authorities had started pursuing stormwater volume runoff regulations as early as 15 years ago. The City of Inver Grove Heights (IGH), MN, in 2006 was faced with the challenge of planning its infrastructure for a major growth expansion and was comparing conventional pipe and pumping options to the newer, low impact development (LID) approaches. Through a process of system design, cost comparisons, and innovative ordinance development, the city became the first of its kind to adopt a complete LID approach to stormwater and plan for major urban expansion without a surface outlet. The city now has several developments that have gone through the LID ordinances process and the first of those have been built to those standards.

The land use plan that evolved included a standard that allowed development capacities to be calculated based on the overall area, but that 20% open space be left and higher densities allowed. Stormwater standards and ordinances were developed that retained the natural, pre-existing site drainage runoff volumes for the 5-year event and preservation of the natural depressions in the system. The design of the Argenta Hills wove many BMPs in the site as green infrastructure. Can 100-year volume control be accomplished on an urban site? If the natural conditions are appropriate for that level of volume retention, the Argenta Hills site, along with others, demonstrates that it can be accomplished.

Development and Application of Soil and Water Assessment Tool (SWAT) for an Urban Watershed in Wisconsin

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Urbanization and its effects on land use changes have profound impacts on the runoff characteristics of the watershed. The hydrologic changes that are associated with urbanization include more frequent and higher magnitude flows, flashier/less predictable flows, altered duration of low-flow periods, and conversion of subsurface distributed discharge inputs to surface discharges. All of these observed changes can be interrelated. Therefore, best management practices (BMPs) for stormwater runoff are crucial to mitigate these urbanization impacts. As a result models are usually employed to identify the impacts of urbanization and effectiveness of best management practices (BMPs). In the past the Soil and Water Assessment Tool (SWAT) has been widely used in the agriculture setting but has failed to accurately predict within the urban setting. Due to this shortcoming, we further develop SWAT for urban watersheds.

In this study, we implement a so-called two-unit hydrograph to resolve the total runoff hydrograph attributed to the different time scales of non-urban and urban runoff. This feature resolves the previous SWAT model with a single unit hydrograph that is difficult to capture water yields from both urban and non-urban areas. Specifically an urban drainage coefficient is employed to represent an adaptive unit hydrograph for urban water. Furthermore we introduce an exchange coefficient to account for water overflow between non-urban and urban areas. The new SWAT model is applied and validated to an urban watershed in Wisconsin.

* Student Presentation

Water Reuse – Retrofitting Last Century Technology for the Future

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Reuse and harvesting of stormwater is not new and has been used for ages. In urban areas it has not been used recently with commonly available potable water. Our team is using an applied research grant to better understand and define how stormwater can be reused to reduce stormwater impacts and reduce our use of public potable water, and indirectly provide some solutions for wastewater combined sewer overflows. The project will make stormwater reuse a more reliable and common tool for urban stormwater managers and provide guidance on how to quantify the benefits or “credits.”

The Problem - The challenges include: overtaxed potable water sources, increasing costs of both providing potable water and “disposing of” stormwater, and the new paradigm of volume control rules. The latter includes urban challenges of soils (permeability, contamination, bedrock). A “one water paradigm” sustainable approach is in contrast to the status quo of each “silo” trying to dispose of its problems and burdening other facets of our systems in the process.

In our experience, utilizing water reuse for stormwater is good in concept, but defining benefits numerically, especially to meeting regulatory volume control standards, can be a challenge. While the distinctions between arid approaches of hoarding water and using up water to retain runoff may seem like minor distinctions, there are important differences in the design approach. For instance, a reuse tank that is full when a storm occurs provides virtually zero benefit.

The Approach/Solution - To provide a practical solution we developed a spreadsheet model to assess designs and quantify benefits. The model allows us to test the storage needed and green space used for irrigation to optimize the system. With the use of the model we are able to optimize storage needs, which is a costly component. The amount of green space needed to support effective treatment via irrigation was actually found to be a driving parameter in the design of a reuse system in very urban situations. Also examined is the water quality of typical stormwater and limitations and treatment that may be needed when selecting water reuse as a practice.

The Relative Significance of Environmental and Anthropogenic Factors Affecting Zooplankton Community Structure in Southeast Wisconsin Till Plain Lakes

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Zooplankton community composition can be related to natural environmental factors such as lake morphology, lake landscape position, and water chemistry as well as anthropogenic factors such as agricultural and urban land-use. We hypothesized that within-lake factors, such as water chemistry, lake morphology, and human land-use would each be related to zooplankton community structure, but that watershed land-use would be the strongest correlate in southeast Wisconsin lakes. Zooplankton samples, collected every 3 months over a year, from 29 lakes were used to determine how lake and watershed morphology, water quality, and land-use were related to zooplankton community structure in the heavily developed Southeast Wisconsin Till Plain Ecoregion. Forward selection and a variation partitioning procedure were used to determine relative and shared contributions of each suite of variables in predicting zooplankton community structure. Redundancy analysis was used to characterize dominant gradients in pelagic zooplankton communities and related environmental factors and land-use. The major correlates of community structure included summer phosphorus, lake depth and surface area and urban and natural land. Variation partitioning illustrated that phosphorus alone accounts for the greatest part (12%) of community structure. Urban land-uses (residential, commercial and paved land) and lake morphology partially explain zooplankton community variation through combined effects with phosphorus. Small cladocerans and Skistodiaptomus pallidus were associated with higher phosphorus, shallow depth and higher urban land-use, while Daphnia pulicaria dominates in deep lakes with lower phosphorus and less urban land-use. This study contributes to the understanding of factors affecting zooplankton community structure in a largely human-developed region and illustrates the importance of eutrophication in structuring zooplankton community composition.

SESSION 2B:

Water Quality

Thursday, March 7, 2013

4:10 - 5:30 p.m.

Evaluating the Effect of Soil Composition and Depth in Bioretention Systems as a Way to Remove Pollutants in Stormwater Runoff

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Bioretention is a rapidly growing stormwater control measure in Wisconsin. Wisconsin's Department of Natural Resources technical standard for bio-retention systems (technical standard 1004) requires a minimum engineered soil thickness of 3 ft and a mixture of sand and compost. Unfortunately, many places in Wisconsin with shallow bedrock and groundwater tables restrict the use of bioretention systems. For many sites, all that might be needed is another foot or two of separation to keep the bioretention system above the bedrock or groundwater table. Three bioretention systems with soil thicknesses of 1.5, 2.0 and 3.0 feet were monitored in 2010 as a means to evaluate the potential changes in pollutant reduction with different soil depths. Initial soil mixtures were composed of 50% sand and 50% compost. Results from the first year of water-quality samples showed large amounts of phosphorus leached from each system, regardless of depth. In an attempt to find an engineering soil that does not leach phosphorus, the UW Soils and Plant Laboratory evaluated a number of potential mixes. In the fall of 2011 a new mixture of sand, peat moss, and a proprietary product was selected to replace the sand and compost mixture. The three systems with a new soil mix were monitored through the summer of 2012. Results from monitoring the two engineered soil types show how the soil thickness affects the level of pollutant reduction and how the selection of engineered soil impacts the leaching of nutrients.

Monitoring Groundwater Nitrogen Concentration in Sandy Soils under Vegetable Production

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Current nitrogen (N) fertilizer management practices for vegetable farming have led to elevated levels of nitrate-nitrogen in the local groundwater. A study was conducted to determine if controlled release fertilizer, specifically Environmentally Smart Nitrogen (ESN®), could reduce groundwater nitrogen concentration. Field experiments were conducted at the Hancock Agricultural Research Station using Russet Burbank potato and Overland sweet corn, planted in Plainfield sand. Four fertilizer rates were evaluated: 1) 0 N control, 2) 224 kg ha^{-1} of N as ESN®, 3) 280 kg ha^{-1} of N as ESN®, and 4) 280 kg ha^{-1} of N as a split application of ammonium sulfate and ammonium nitrate (AS-AN) for the potato study. Sweet corn fertilizer rates were 1) 0 N control, 2) 168 kg ha^{-1} ESN®, 3) 168 kg ha^{-1} AS-Urea-Urea, and 4) 224 kg ha^{-1} AS-Urea-Urea. Both studies included three replicates to create twelve 14.6 m by 15.2 m field plots. Three groundwater monitoring wells spaced diagonally across plots were installed and sampled weekly during the growing season for assessing nitrate. Bromide tracer was used to evaluate solute flux and spatial distribution among plots. Bromide tracer shows that plot size was sufficiently large with no plot-to-plot contamination from N migration and the time for groundwater to flow to adjacent plots is longer than the growing season. Therefore, in-season contamination is minimal, and thus nitrate measurements were from respective plots. Trends indicate that ESN® reduced the amount of nitrate leaching to groundwater. However, highly variable background nitrate concentration in the groundwater made it difficult to determine statistical significance. The effective use of groundwater monitoring wells requires careful consideration of depth to groundwater, groundwater flow direction, and variability of groundwater nitrogen concentration.

What We’ve Learned from over 20 Tears of Voluntary Private Well Water Testing

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Groundwater is utilized by 95% of Wisconsin communities and virtually all rural residents for their everyday water needs. Surprisingly, many people lack a basic understanding of where their drinking water comes from and know little about the safety of their water supply. Meanwhile, communities looking to address groundwater quality concerns often lack information because of the difficulty and expense of gathering data.

To address these needs, our Center has been organizing community drinking water programs as a convenient way for private well owners to have water tested. Information collected over the past 20 years can be used to help communities identify problems and inform groundwater management decisions. We will demo an on-line mapping tool that allows individuals to view well water data and generate summaries to engage citizens and local communities in learning about local groundwater quality. Maps summarizing well water data are available for 14 different water quality parameters and can be viewed at a county, town or section level of detail. Summaries of data can be generated for any municipal boundary or any user-defined area including watershed.

Using data from the programs we will share other important lessons for moving forward such as: the value of routine testing, the difficulties in using this type of data to detect trends or changes in water quality, the advantage of organized community testing, and targeting future testing efforts with limited resources.

Water Renewal Time Scales in a Lake-River Chain System

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Three water renewal time scales, including flushing time, residence time, and age for a lake-river system are examined. First, flushing time, a good indicator of water quality, is often used to describe the average time water remains within the boundary of a water body. Conventionally, flushing time is a bulk or integrated parameter that is calculated by dividing the volume of the water body by the outflow discharge. However, this approach assumes water in the system is well-mixed, which is not valid for dimictic lakes. To address this issue, we incorporate complex lake hydrodynamics which accounts for thermal stratification, short circuiting, and re-circulation/dead zones. We then obtain residence time that spatially delineates the time for specific water parcels to leave the lake-river system. At last, the third time scale, age, is determined to describe the mean time elapsed since nutrients or particles have traveled to a specific area of concern for water quality deterioration. In this study, we calculate these three time scales for the Yahara lakes-river chain system using a state-of-the-art hydrodynamic model and particle track model. These time scales are often used to help explain biological or chemical constituents in aquatic ecosystems in order to identify the dominant processes underlying variability in water quality. Results from these evaluations of time scales will be used to evaluate water quality management and ongoing nutrient reduction efforts.

* Student Presentation

POSTER SESSION

Thursday, March 7, 2013

7:45 p.m.

1. Transport of Tetracycline-Resistant and Tetracycline-Susceptible *Escherichia coli* within Unsaturated Porous Media.

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In two previous studies, we reported that the tetracycline-resistant *Escherichia coli* isolated from manure and Lake Michigan displayed higher mobility than tetracycline-susceptible *E. coli* within saturated sands. The focus of this research is the transport of tetracycline-resistant and tetracycline –susceptible *E. coli* within unsaturated porous media. Particularly, we examined the effects of soil moisture content and aqueous ionic strengths on their transport behavior. We also examined the potential release and remobilization of previously retained *E. coli* cells under transient flow conditions (e.g., when soil moisture content increased).

Our experimental results showed that under both high and low soil moisture content conditions, the tetracycline-resistant *E.coli* displayed higher mobility than the tetracycline-susceptible *E. coli* under higher ionic strength conditions. When the ionic strength was low, their mobility was comparable. An increase in soil moisture content from 30% to 70% led to minimal release of previously retained *E. coli* cells. A transport model was fitted to the experimental results using the computer program HYDRUS-1D.

Keywords: Groundwater microbial contamination, Bacterial transport in unsaturated soil

* Student Presentation

2. Biodiversity of Gastropoda in the Mukwonago River, Wisconsin along a Spatial Gradient.

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Benthic macroinvertebrate taxa were sampled using Hess and coring samplers in three locations of the Mukwonago River in Waukesha County–encompassing gravel substrates immediately downstream from the Phantom Lake dam, and sand substrates further downstream including a locality within Wisconsin State Natural Area #417. Gastropods of the family Pleuroceridae were the target organisms of the study, although all gastropoda were collected, sorted, identified to species level possible, counted and curated.

Throughout our three sampling sites *Pleurocera acuta* was consistently ranked as the first or second most abundant species, and *Elimia livescens* was ranked as the first or second most abundant species in sites 1 and 1a, but dropped to fifth for site 2. Diversity levels including dominance, diversity, and evenness bootstrapped to the 95% confidence level do not overlap between sites, and diversity comparisons performed using PAST indicate that diversity at all three sites are significantly different from one another (at a 95% confidence level). Further work will include devising secondary production measures for our target species (*Elimia livescens* and *Pleurocera acuta)*. Data from 2012 season is expected to be finalized in spring of 2013 and will allow for additional analysis and understanding of the environmental and biotic interactions of the Mukwonago River gastropoda.

*Student Presentation

3. Stream Ecosystems Change with Urban Development

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In 2003, eighty-three percent of Americans lived in metropolitan areas, and considerable population increases are predicted within the next 50 years. Nowhere are the environmental changes associated with urban development more evident than in urban streams.

Contaminants, habitat destruction, and increasing streamflow flashiness resulting from urban development have been associated with the disruption of biological communities, particularly the loss of sensitive aquatic biota. Every stream is connected downstream to other water bodies, and inputs of contaminants and (or) sediments to streams can cause degradation downstream with adverse effects on biological communities and on economically valuable resources, such as fisheries and tourism. Understanding how algal, invertebrate, and fish communities respond to physical and chemical stressors associated with urban development can provide important clues on how multiple stressors may be managed to protect stream health as a watershed becomes increasingly urbanized.

This poster highlights selected findings of a comprehensive assessment by the National Water-Quality Assessment Program of the U.S. Geological Survey (USGS) of the effects of urban development on stream ecosystems in nine metropolitan study areas.

4. Hydrological Effects of Subsurface Heterogeneity Reveal Ecosystem Service Tradeoffs in a Compartmentalized Wetland Stormwater Treatment System

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Stormwater treatment wetlands are a promising alternative to conventional treatment ponds in urban systems because they can provide enhanced stormwater treatment capabilities and additional ecosystem services, such as biodiversity and productivity. In a wetland stormwater treatment system in the University of Wisconsin-Madison Arboretum, significantly different inundation regimes among what were designed to be three identically functioning, neighboring wetland treatment swales indicate subsurface heterogeneity exerts a strong control on system hydrology.

To determine the extent to which the ecosystem services provided by the swale systems depend on the hydrological effects of the subsurface, we quantified six different services by monitoring hydrology, vegetation structure, water quality, and erosion resistance in the three swales from spring 2010 to autumn 2012. We found that five services – stormflow attenuation, stormwater retention, vegetation diversity, nutrient removal, and erosion resistance – were all positively correlated with each other and highest in the fastest draining swale. Contrarily, plant productivity was negatively correlated with the other five services and highest in the slowest draining swale. This tradeoff suggests that designing to maximize a wide variety of stormwater treatment-related ecosystem services may be difficult when space constrains system design. This result also stands contrary to the general notion that robust-looking vegetation indicates a well-functioning treatment wetland. Our results demonstrate that levels of stormwater treatment-related services are sensitive to difficult-to-characterize subsurface properties.

5. Spatial Distribution of Dissolved Strontium in Eastern Wisconsin's Aquifers

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In northeastern Wisconsin over 75 groundwater samples have been collected and analyzed to better determine the hydrogeochemistry of the aquifers in the region. Dissolved strontium in parts of the Cambro-Ordovician aquifers of eastern Wisconsin exceeds the lifetime and short-term EPA Health Advisory Limit of 4 mg/L and 25 mg/L, respectively. These elevated strontium levels occur along the western rim of the ancestral Michigan Basin. Over 60% of the samples we collected in northeastern Wisconsin had strontium values over the lifetime Health Advisory Limit. For our study, the highest recorded strontium value was 28.6 mg/L. Earlier datasets collected show strontium as high 41.2 mg/L in the region with an exceedance similar to ours!

The high strontium concentrations are contained within the Cambrian and Ordovician aquifers (Sinnipee Group, St. Peter Sandstone, Prairie du Chien Group, and Cambrian Sandstones). Strontium-bearing minerals are present in the region, including celestine ($SrSO_4$) and strontianite ($SrCO_3$), which are possible sources. There does not seem to be a strong correlation between the dissolved strontium concentrations and the position of the western edge of the Maquoketa Shale. Piper plots also reveal significant subregional variation in the general hydrochemistry, even within the same aquifer, suggesting the possibility of compartmentalization or distinct hydrochemical processes operating in different areas. Initial Sr-isotopic results for groundwater show $^{87}Sr/^{86}Sr$ ratios of 0.70992-0.71005, which indicates a radiogenetic source. This suggests that the original source of strontium was likely to be either the Precambrian crystalline rocks or sandstone aquifers.

*Student Presentation

6. Interactions between Cationic Drugs and Zeolite

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Remnants of many pharmaceutical products such as antibiotics and antihistamines are major contributors to the contamination of water and soils. The pharmaceutical products that we may be analyzing are tetracycline, ciprofloxacin, diphenhydramine, and chlorpheniramine. All these drugs are ingested and are only partially metabolized, and consequently, are excreted in high concentrations into the environment.

Zeolite has been widely used in remediation processes. It has negatively charged surfaces that are able to attract dissociated cations from water, reducing contamination.
The purpose of this study is to investigate the interactions between zeolite and one of the aforementioned cationic drugs under different physical and chemical conditions, such as contact time, temperature, pH, ionic strength, and initial concentration. In addition, the desorption of exchangeable cations will be determined by IC.

It is anticipated that a higher removal rate of cationic drugs could be achieved with a natural zeolite. The strong interactions between the cationic drugs and zeolite will enable zeolite as a substrate to remove cationic drugs from water.

* Student Presentation

7. Assessing Different Aquifer Material in WI as Possible Natural Sources of Chromium (VI)

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James Hurley, UW-Madison Aquatic Sciences Center and UW-Madison Environmental Chemistry and Technology Program, Madison, WI, *hurley@aqua.wisc.edu*

Detectable concentrations of hexavalent chromium (Cr(VI)) have been measured in drinking water sourced from Wisconsin groundwater. Although chromium (Cr) is naturally occurring in groundwater, Cr(VI) - Cr in the +6 oxidation state - is a known carcinogen. Biogeochemical cycling of Cr between the +6 oxidation state and the more benign +3 oxidation state (Cr(III)), as well as interaction with aquifer material at ambient groundwater conditions, needs to be fully assessed to determine potential human health concerns within certain aquifers of Wisconsin. We hypothesize that mineralized edges of major geological basins provide conditions favorable to the formation of Cr(VI).

Fresh well cuttings have been collected from new wells drilled in the Fox Valley, Monroe and Dane Counties. We will present total metal concentrations of aquifer material from each well. In cases where replacement wells were drilled due to high metal concentrations (especially arsenic), metal concentrations in well water will be contrasted against total metal concentrations of fresh aquifer material. We plan to further measure release rates of total Cr and Cr(VI) in controlled laboratory experiments on aquifer cuttings inside small volume reactors. Reactor studies will evaluate oxidation state specific release and dissolution rates from aquifer material and will provide a mechanistic understanding of Cr(VI) cycling. By integrating data from detailed chemical and oxidation measurements and reactor studies, we will develop a mechanistic model of Cr release from contrasting aquifers to better assess health concerns regarding exposure to Cr(VI).

8. Export of Heavy Metals and Nutrient Species by Two Urban Rivers in Milwaukee

Michele L. Huppert, Spring Valley Middle-High School, Spring Valley, WI

Samuel Ellis Graber Sr., Department of Geosciences, UW-Milwaukee, Milwaukee, WI

Shangping Xu, Department of Geosciences, UW-Milwaukee, Milwaukee, WI

In this research, we examined the dynamics of the transport of representative inorganic contaminants and nutrient species by urban rivers and streams to Lake Michigan. Water samples were collected from Milwaukee River and Kinnickinnic River on a daily basis for 30 days. The collected water samples were either filtered using 0.45 µm cellulose filter or digested using a Corning dry bath heater following protocols that are detailed in "Standard methods for the examination of water and wastewater." The concentration of Cu, Cr(VI), nitrate, ammonium and phosphate in the filtered water samples were determined using a Hach DR/890 Spectrophotometer. Additionally, the concentrations of Cu and Cr(VI) in the digested samples were similarly quantified. The difference in Cu and Cr(VI) concentrations between the filtered and digested samples was calculated as the fraction of Cu and Cr(VI) that was associated with suspended solids. Furthermore, the water turbidity was measured to reflect the concentrations of total suspended solid (TSS).

Our results showed that for Kinnickinnic River, which is an urban stream, the water turbidity was generally higher than 5 NTU and was only weakly influenced by precipitation events. In contrast, the turbidity of Milwaukee River, the drainage area of which contains a mixture of urban and agricultural areas, remained above 15 NTU for most of time, and in general, precipitation events and high flow conditions led to elevated water turbidity.

Interestingly, the concentrations of the heavy metals and nutrient species showed little variation over time, and precipitation and runoff events seemed to have insignificant impacts. The fluxes of the heavy metals and the nutrient species, however, did increase substantially during and immediately following the precipitation events. As the flux data suggested that precipitation and urban surface runoff could mobilize pollutants from soil to rivers, the potential rise in the concentrations of heavy metals and nutrient species was limited by the diluting effects when river discharge rose during a storm.

9. Simulating the Seasonal Variations in Phosphorus Concentrations in Lakes—Linking Watershed and Lake Models for Upper St. Croix Lake

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It is often important to understand the growing season variations in phosphorus concentrations that occur in lakes. These variations can lead to summer algal blooms that impair recreational uses and may confound monitoring to characterize a water body's trophic status. Simulation modeling may be a useful way to understand this concentration variability, but historically, most lake modeling has used long-term, average annual modeling tools. Increasingly, watershed modeling uses short time-step models that incorporate rainfall and runoff relationships with nutrient transport. While these watershed models may permit more appropriate evaluation of management practices on hydrology and nutrient transport, it may be necessary that they be linked with more dynamic surface water models. This study examined the linkage between a lake and watershed model using Upper St. Croix Lake in Douglas County. The watershed model SWAT was used to simulate the hydrology of the watershed and the transport of phosphorus to the lake. A dynamic, although still relatively simple, lake phosphorus model was developed that incorporated settling and sediment release within short time steps.

The results show the utility of a dynamic seasonal phosphorus model for linking with a watershed model but also demonstrate the challenges of parameter estimation. We show how the model can be used to simulate the three-fold increase in total phosphorus concentration during the summer and its advantages in developing a lake phosphorus budget. Parameter estimation software, PEST, was used to evaluate relationships between parameters. Those results demonstrate the challenges to and importance of constraining the in-lake reaction terms to accurately characterize the internal dynamics of phosphorus in the lake.

10. Runoff Water and Nutrient Fluxes from Biofuel Cropping Systems

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Demand for renewable alternatives to fossil fuels has steadily grown in response to concerns over energy independence, security, and availability. Feedstocks for biofuel have traditionally been in the form of food crops (e.g., corn-grain), which have been grown on a large scale for many years. Large scale production of corn for biofuel can strain the environment and potentially divert food grain. Recently there has been a push to use other high yielding, nontraditional cropping systems, like perennial grasses (e.g., switchgrass, miscanthus) as cellulosic biofuel feedstocks for the potential to maximize fuel yields. The environmental impact of introducing nontraditional cropping systems at scales needed to economically produce biofuels is not fully understood. Both quantity and quality of runoff can have major impacts on local and regional water bodies. The goal of this study is to better understand surface runoff generation and associated nutrient losses for both traditional and nontraditional cropping systems intended as cellulosic biofuel feedstocks.

Three surface runoff plots (1 m^2) were installed within three biofuel cropping systems (9 plots total), established at the Arlington Agricultural Research Station, Arlington, WI. The treatments include continuous corn, monoculture Miscanthus, and monoculture switchgrass. Surface runoff from natural rainfall was collected from June to Sep. 2011, and from Mar. to Aug. 2012, and a rainfall simulation (75 mm/hr for 1 h) was conducted after harvest in Nov. 2012. Samples were analyzed for volume, EC, pH, total nitrogen, total phosphorus (P), total dissolved P, and carbon (organic and inorganic).

Results from the two growing seasons indicate differences in runoff volume between the perennial grasses and corn cropping systems. With a few exceptions, runoff volumes from corn were 2-10x greater than from Miscanthus, and 5-400x greater than from switchgrass. During simulated rainfall, runoff from corn was 3.5 times greater than from switchgrass, and 6.4 times greater than from Miscanthus. Results of nutrient losses for these cropping systems will also be presented and discussed.

11. Phosphorus and TSS Trends in Two Streams in Northeastern Wisconsin

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Land management changes have been implemented within the Duck and Baird Creek watersheds to improve water quality. We examined phosphorus and TSS water concentrations to determine if commensurate temporal changes have occurred. Statistical procedures were applied to the Duck Creek dataset (1989-2008) to test for changes in total and dissolved phosphorus concentrations. A 20-year multiple linear regression trend analysis found that phosphorus declined in a non-linear fashion, primarily during the first period. Therefore, regression was conducted separately on Period 1 (1989-1995) and Period 3 (2004-2008). Phosphorus concentrations decreased 10% per year in Period 1. Unusual climate or sampling problems in 2008 were associated with Period 3, so results were inconclusive. A Wilcoxon Rank sum test was applied to phosphorus concentrations between Periods 1 and 3 under a variety of data censoring and flow scenarios. In all cases, phosphorus concentrations were significantly lower in Period 3 than in Period 1 ($p < 0.05$). A Wilcoxon Rank sum test was performed on subsets of data that were based on one sample per month or week to reduce potential serial correlation bias. Again, phosphorus concentrations were significantly lower in Period 3. Multiple regression analysis was performed on monthly and weekly sub-sampled data sets. Time was not a significant explanatory variable. However, the weight of evidence is sufficient to conclude that phosphorus concentrations in Duck Creek have likely decreased during the 20-year record. We will also present the results of statistical procedures applied to over 800 samples collected from Baird Creek (2004-2012).

12. TMDL Goals and Water Quality Realities in a Lower Fox River Watershed

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Recently a TMDL and watershed plan was approved for the Lower Fox River, associated tributaries and Lower Green Bay. Under modeled baseline conditions, the Plum Creek watershed had the greatest sediment and phosphorus yield of all watersheds within the sub-basin. To better characterize sediment and phosphorus losses and driving factors we initiated a three-year study of Plum Creek. Sediment and phosphorus concentrations and loads at the watershed scale have been determined for two water years. In addition, event grab samples were collected at 17 multi-field catchments during four runoff events. Across all flow conditions (226 samples), median TP concentration was 0.66 mg/L. For low flow conditions, the median TP concentration (0.34 mg/L) was four times the goal of 0.075 mg/L. Plum Creek concentrations and water year 2011 yields (kg/ha/yr) were higher than those from Baird Creek (2011) and five other agricultural watersheds in the Lower Fox River Basin (2004-2006). Particulate P was ~70% of TP export. Relatively few storm events (14 days) accounted for 77% of WY2011 annual load. These loads exceed TMDL targets by about seven fold.

Greater than 98% of inventoried areas within catchments had nutrient management plan-based Wisconsin P-Index values that met 590 standards (PI≤6). However, more than half of all samples (N=67) collected from multi-field catchments had TP concentrations >1.03 mg/L. Area-weighted SnapPlus sediment loss and P-Index values were poorly correlated with measured sediment and P concentration rankings. As they are currently applied, SnapPlus and P-Index policy tools will not result in meeting water quality goals in Plum Creek or the Lower Fox River sub-basin. An area weighted P-Index of <2 would be needed to meet TMDL allocated P export rates from croplands in Plum Creek.

13. Testing the Effectiveness of Targeted Conservation with a Paired Watershed Approach

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Two 19 mi^2 agricultural watersheds in SW Wisconsin have been continuously monitored for sediment, phosphorus and flow for six years. Field management and soil phosphorus were inventoried in both watersheds to provide an assessment of runoff phosphorus loss risk for each field and pasture. Following a three-year baseline period, conservation practices were implemented in one of the watersheds using a strategy that focused on the fields and farms that were estimated to contribute the highest amounts of phosphorus to the stream. Management changes implemented over three years are estimated to result in a greater than 25% reduction in phosphorus and sediment delivery from agricultural land to the stream. Although changes implemented at the field level may take some time to result in changes at the watershed outlet, there appears to be a trend of suspended sediment and total phosphorus load reduction in the monitoring data. Analysis of the baseline paired watershed monitoring event data indicates that reductions of 36% in sediment and 28% in phosphorus are needed to be statistically significant and attributable to the implementation of conservation practices.

14. Sedimentation in the Miljala Channel Watershed: Drained Wetlands, Agriculture and Restoration Potential

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Sedimentation, excessive phosphorus loading and bacterial contamination have created cause for concern in the Miljala Channel, a small inlet on the southwest corner of Rock Lake in Lake Mills, Wisconsin. The source of this problem is a drainage ditch created for agricultural purposes in the mid 1950’s. This groundwater-fed ditch drains a significant portion of the subwatershed along its flow path through a former wetland and into the channel.
The UW Madison Water Resources Management (WRM) practicum worked in conjunction with the Jefferson County Land and Water Conservation Department LWCD, Montgomery Associates: Resource Solutions, and the Rock Lake Improvement Association to survey the hydrology, hydrogeology and ecology of the landscape in order to devise a comprehensive solution to three core issues plaguing the Miljala Channel. Final recommendations include buffer strip maintenance, nutrient management plan re-evaluation and a shallow marsh wetland restoration.

* Student Presentation

15. Sediment Routing through Ephemeral Grassed Waterways in a Nested Watershed

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Ephemeral gully erosion may contribute to high sediment loss in erosion-prone areas. Constructing grassed waterways (GWW) is one management practice that can effectively prevent gully formation by providing a stable conveyance for surface runoff. Grassed waterways reduce runoff velocity, allowing sediment to settle before exiting the field. They also represent an important sediment delivery pathway from upland source areas to downstream receiving waters. Review of existing literature suggests that information on the sensitivity of sediment delivery via GWW to storm and landscape characteristics in complex nested watersheds with varied management practices is lacking. This study will improve our understanding of the impact of various storm and landscape characteristics on sediment delivery via GWW in agricultural watersheds. A nested watershed located at the University of Wisconsin-Platteville Pioneer Farm near Platteville, WI, was used for the study. The test watershed contained both terraced and non-terraced fields drained by ephemeral grassed waterways. Land management included corn grain, corn silage and alfalfa cropping systems with chisel plow tillage. Upland and channel slopes in the watershed ranged between 1.5 and 5.6% with silt loam soils. Runoff and sediment data were collected for storm events occurring between 2002 and 2009. The process-based Water Erosion Prediction Project (WEPP) model was set up to represent the nested watershed. The model was calibrated and validated on an event basis using observed water and sediment data. A sensitivity analysis was conducted using WEPP to determine the main factors impacting sediment delivery through the GWW. The process-based model will subsequently be used to parameterize simple empirical relationships for sediment delivery.

* Student Presentation

16. Comparison of Sediment Budgets of Nearshore Environment for Two High Bluffs on Lake Michigan

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The sediment budget concept is valuable in revealing the dynamic evolution of coastal bluff and nearshore environments. In this study, a sediment budget analysis was performed at two high-bluff (30-45 m) sites along Lake Michigan in Ozaukee County, WI. Specifically, we compared sediment budgets of the recently stabilized coast of Concordia University and that of the equilibrium coast surrounding Port Washington. Historical aerial photos and topographic surveys of bluffs and beaches were conducted to obtain the recession rate of bluff crest and toe, shoreline position, and beach width. Successive surveys of nearshore sediment substrates were performed to obtain bottom sediment erosion and deposition. Several sediment traps were deployed to characterize sediment properties and longshore sediment transport rate.

At the equilibrium coast, the bluff crest recession ranged from 0.05 to 0.6 m/yr. In contrast, the bluff toe experienced a net deposition up to 1.1 m/yr. Field observations of beach width and sediment availability agreed with calculated trends of sediment accretion, which in turn protected bluff. At the Concordia University site, no beaches existed in front of the newly-built coastal structures, suggesting that natural sediment pathways may be disrupted. Over the six-year study period, distinct spatial variation of bluff slumping occurred, and it was most severe on the south bluffs, average on the north bluffs, and nonexistant within the structured area. The occurrence of severe bluff recession on the south bluff can be explained by the unbalanced longshore sediment transport. Comparison of sediment budgets for the two high-bluff sites may aid in understanding the impacts of shore protection structures on the nearshore environment.

* Student Presentation

17. Effects of Inter-annual and Seasonal Variability in Regionalization of Hydrologic Response in the Great Lakes Basin

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Methods for predicting streamflow in areas with limited or nonexistent measurements typically invoke the concept of regionalization, whereby knowledge pertaining to gauged catchments is transferred to ungauged ones. Hydrologic response indices have frequently been employed in contemporary regionalization research related to predictions in ungauged basins. In this study, we developed a suite of regionalization models using multiple linear regression and regression tree analysis to derive relationships between hydrologic response and catchment physical characteristics for 163 catchments in the Great Lakes basin. Relevant data were extracted from Version II of the Geospatial Attributes of Gauges for Evaluating Streamflow dataset for the water year 1981-2010. Runoff ratios at different temporal scales were used as the dependent variables in the regression analyses. Our study resulted in a means for predicting runoff in ungauged basins at a monthly time step. Our results show that accounting for inter-annual and seasonal variability of hydrologic response can result in substantially different model-predicted runoff compared to using long-term averages. These results indicate that predictions based on long-term characterizations of hydrologic response can produce misleading conclusions when applied at shorter time steps.

18. Spatial and Temporal Variability in Wisconsin's Stream Flow Dynamics

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This study investigates discharge trends for rivers in Wisconsin. Using data provided from the USGS Real-Time flow data showed that 37 rivers had at least 50 years (to the present) of consecutive stream flow data. Statistical analyses (standard deviation, mean, median, and regression lines) were used to decipher trends in month of peak discharge, peak flow, monthly mean flow, and annual mean discharge. Precursory results show changes in all facets of study with little consistency between rivers. Of the 37 gauges, 87% show peak flow events trending to warmer months by a mean of two-and-a-half weeks over the past 50+ years. Summation of peak annual events between two 25 year intervals (1962-1986 and 1987-2011) reveal a significant decrease in the number of peak events occurring in the month of March by 7.9% (73 events). However, mean discharge values are mixed with 47% of streams still showing positive trends in mean discharge values in the month of March. Linear regression data for peak discharge, as well as annual mean discharge, show adverse trends. Of the streams studied, 58% show a decrease in the value of peak discharge while also illustrating a 56% increase in annual discharge. This study is ongoing with precipitation, stream regulation, and land cover variables soon to be analyzed with flow hydrology changes.

* Student Presentation

19. Effects of Slope Length and Soil Moisture Content on Stormwater Runoff from Turfgrass

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Estimating stormwater pollutant loads and developing stormwater mitigation plans require reasonable estimates of runoff volume from different urban sources such as streets, parking lots, and lawns. Urban runoff models do a reasonable job of predicting runoff from impervious areas, but more uncertainty exists when predicting runoff from lawns. Understanding how and which key variables control lawn runoff will facilitate improved prediction of stormwater runoff volumes and associated pollutant transport from urban sources to receiving waters.

The goal of this study was to evaluate the effect of turfgrass slope length and antecedent soil moisture content on stormwater runoff. Six turfgrass plots located at the University of Wisconsin O.J. Noer Turfgrass Research and Education Facility in west Madison were used to measure stormwater runoff. Each plot was 2.4 m wide with slopes of approximately three percent. Three of the plots were 4.9 m in length, while the other three were 7.8 m. Each plot was equipped with a tipping-bucket apparatus at the downslope end to measure timing, magnitude, and intensity of runoff generated from rainfall and snowmelt events. All plots were instrumented with soil moisture and soil temperature probes at varying depths, and a tipping-bucket rain gage was used to measure rainfall. Data collected by the U.S. Geological Survey for the three-year period from 2008 to 2011 will be used to assess the influence of slope length, antecedent moisture content, and precipitation on the runoff response during both frozen- and unfrozen-ground conditions.

20. Hydrogeology of the Mink River Estuary, Door County, WI: Geologic Controls on Spring Locations

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Located near the tip of the Door Peninsula, the Mink River Estuary (MRE) is one of the most pristine freshwater estuaries in the United States and it provides habitat to many endangered and threatened species, including the Hine's emerald dragonfly. The MRE is dominated by groundwater discharge through springs and seeps thus making groundwater quality and quantity critical to the long-term health of the estuary. The importance of springs to the MRE has long been recognized, however, there has been little detailed characterization of the springs themselves or the underlying flow system.

We hypothesize that spring locations are controlled by two factors: depth to bedrock and the location of high-permeability bedding plane fractures in the underlying carbonate bedrock aquifer. Spring locations were identified in the winter of 2012 when much of the estuary was iced over. Detailed spring inventory data were collected during the summer of 2012. Depth to bedrock was determined using a combination of surface geophysical methods and hand coring using a Russian peat corer. While some springs are located in areas of shallow bedrock, other springs are located where there is >25 ft of low-permeability marl sediments. Geophysical data collected from four bedrock wells that surround the estuary were used to identify high-permeability bedding plane fractures within the carbonate bedrock aquifer. Well-to-well correlations based on these borehole geophysical data suggest that hydraulically important bedding-plane fractures are important conduits for groundwater discharging at the springs, especially the springs located in areas with thick accumulations of marl.

* Student Presentation

21. Brine Water Chemistry and Relationship to Bedrock Geology in the Deep Subsurface of Manitowoc County, WI

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Although the occurrence of high-dissolved solids in deep groundwater in eastern Wisconsin has long been recognized, these deep waters are rarely sampled or studied. New drilling in eastern Wisconsin (WGNHS and USGS-funded STATEMAP project) provides insights into unusual groundwater chemistry and water-rock interactions there. These holes penetrate a brine zone that contains elevated concentrations of many major and minor elements and is unsuitable for most human uses.

Geophysical logs showing high conductivity indicate the presence of high salinity fluids at multiple sites in eastern Manitowoc County. Water sampling shows chemistry indicative of brine (e.g., chloride > 50,000 ppm). Brine waters occur in the lower Silurian downward (>600' below land surface). Aqueous phase trace element concentrations are highest near Ordovician-Silurian boundary. Though XRF scans of sulfide-bearing rocks at this level show arsenic concentrations at the highest level recorded in the state (>7000 ppm), arsenic in the brine is below detection level. By contrast, chromium levels are unusually high (>400 ppb). Additional drilling and sampling are ongoing at this time with the goal of a more comprehensive analysis of rock and water chemistry. Isotopic studies are aimed at identifying the source of the brine. Water analyses are pointed at identifying spatial variation in the brine chemistry. XRF analysis of core and cuttings samples will help establish the stratigraphic variation in bedrock composition. Through this type of comprehensive analysis we will begin to understand the distribution and characteristics of deep brines in eastern Wisconsin and their implications for water supply and management.

22. Hydrologic and Geochemical Investigation of the Albion Basin, Little Cottonwood Canyon, Alta, Utah

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The Albion Basin watershed is the primary focus of an annual hydrologic and geochemical investigation. This study site, located at the headwaters of Little Cottonwood Canyon in the Wasatch Range, Utah, was chosen to characterize the interrelationship between ground water, surface water, and precipitation of an alpine watershed for future land use considerations. The 2012 sampling season marks the 7th year of data collection consisting of water level monitoring, barometric pressure and temperature measurements, and water and snow sampling for laboratory chemical quality analysis of general ions.

The Albion Basin site consists of three focal points. In the eastern margin, Catherine's Pass remains predictably consistent with water level and water chemistry data suggesting groundwater as the source of recharge. Albion Basin Fen, centrally located, is variable in water level data and ground water sampling, signifying a need for ongoing data collection. The results for Collins Sugarloaf, in the western margin, now aligns with 2012 outcomes as a primary groundwater recharge area, after selecting an artesian well location at Piezometer CS-8. Considerations of previous sampling location were determined to be at an elevation that was possibly exposed to wetland leakage. Continuing data collection will serve to explore and further support the characterization of one nature's most valuable resources, the Albion Basin watershed.

* Student Presentation

23. Simulating Groundwater Recharge of Prairie River Watershed Using the Soil-Water Balance Model: Effects of Sub-annual Precipitation Patterns

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Precipitation is the driving force behind recharging an aquifer. Being able to predict the recharge rate knowing the annual precipitation would be beneficial for water budgeting, but the same annual precipitation rate does not always produce similar annual recharge rates. To understand why this occurs a small watershed of 184 square miles in central Wisconsin, the Prairie River near Merrill, was chosen to study the relation between similar annual precipitation and dissimilar recharge rates. This watershed had decent climate records as well as extensive river discharge records. Two methods to measure recharge were used: PART, a USGS method to determine baseflow using daily streamflow records and the USGS soil water balance (SWB) model. The SWB model requires inputs of daily precipitation, t_{max} and t_{min} values, gridded files with soil groups, land-use, available soil-water capacity and surface water flow direction. For the years 1953-2009, the average recharge using PART was 9.96 inches/year and using SWB was 11.1 inches/year. For an average annual precipitation of 32 inches for the Prairie River watershed, the range of annual recharge rates from the SWB model was 8.5 inches to 13.2 inches for five different years while the PART recharge values for these years ranged from 8.2 inches to 11.94 inches. To provide for a much larger sample size, a weather generator was used, SDSM, a statistical downscaling model. The output from SDSM was multiple files with the same annual precipitation but different storm patterns. Running this precipitation data through the SWB model while keeping all other inputs the same produced a positive correlation(r=.46) between recharge and snowfall. This was repeated using precipitation data with 28 inches annual precipitation giving a moderate positive correlation(r=.3) between recharge and snowfall.

24. Groundwater Pumping Impacts in the Wisconsin Central Sands During the 2012 Drought

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The central sands region of Wisconsin has the greatest amount of groundwater pumping in the state, with the three counties of Portage, Waushara, and Adams accounting for some 20% of the state's total. This pumping has greatly reduced the water levels of the aquifer, wetlands, and lakes as well as the discharge of streams.

The dry summer of 2012 that affected much of the US also affected the central sands, where it has been characterized as a "25 year drought." Combined June, July, and August precipitation amounted to only 6.3 inches (preliminary for Stevens Point) compared to the average 11.6 inches.

We postulate that groundwater pumping during summer 2012 was the historical greatest. Factors that contribute to the large pumping amount include not only the large amount of water applied to individual fields in response to drought, but also to (1) an increase in new irrigation wells, (2) an expanded service area for pre-existing irrigation wells to larger fields and new adjacent fields, and (3) more irrigation of field corn, a full season crop.

Preliminary information indicates that irrigated areas saw substantial pumping effects during the 2012 irrigation season. Irrigated area stream discharges declined markedly, 12 cfs to 4 cfs for the Little Plover River, and by 50-100% in other streams. By comparison, nonirrigated area streamflows generally declined by 25% or less. Water levels in the pumping-impacted Hancock monitoring well declined by 3.5 inches per week during the irrigation season, compared with less than one-half inch per week during the nonirrigation season. Additional work is being done to better define effects of drought alone compared with pumping in response to drought.

25. The Role of Groundwater in the Flooding History of Clear Lake, Wisconsin

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Record precipitation in 2007 and early 2008 contributed to widespread flooding across southern Wisconsin in June 2008. Yet months after surface waters drained, some areas outside of delineated floodplains remained inundated with water. Residents of Clear Lake, Wisconsin, reported about 7 feet of lake level rise, peaking in summer 2009 and remaining elevated until fall 2011. In addition to flooded homes and cabins, local residents contended with flooded septic systems, a potential source of pathogens and other contaminants to Clear Lake and to the many shallow wells that supply nearby residences. These economic losses and detrimental health impacts attest to the need for an improved understanding of the hydrogeologic and climatic conditions that lead to groundwater flooding. This Keck Geology Consortium project seeks to refine a hydrogeologic conceptual model for Clear Lake, a kettle lake in the glaciated portion of Wisconsin, and the significant components of the lake's water budget. We are also exploring long-term climate proxies to better understand the context within which the groundwater flooding event occurred. As part of the project, six undergraduate students and two faculty members spent four weeks collecting field data during the summer of 2012. Student projects include developing a hydrostratigraphic framework for groundwater flow in the vicinity of the lake using descriptions of subsurface materials from wells that were installed last summer and existing well constructor's reports; measuring and mapping lake seepage conditions for Clear Lake and nearby Duck Lake for use in water budget calculations; and collecting and analyzing lakes cores to infer past climate conditions.

26. Modeling Groundwater Flooding Recurrence Intervals Using GSFLOW

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The Spring Green, Wisconsin, area has been susceptible to flooding in the recent past in areas located outside the Federal Emergency Management Agency *Digital Flood Insurance Rate Mapped* areas for the Wisconsin River. The flooding has not been the result of the Wisconsin River overflowing its banks, but rather has resulted from saturated soils, groundwater inundation, and overland flow runoff during periods of heavy snowpack melt and rainfall. On June 7 and 8, 2008, heavy rains fell on snowmelt-saturated soils in Southern Wisconsin, causing historic flooding that inundated almost 7 square miles of the Spring Green area with standing water for five months and caused contamination to water supply wells, agricultural crop loss, and damage to homes, buildings, and infrastructure.

Surface water-groundwater interactions were modeled using GSFLOW, a coupled model developed by the United States Geological Survey, to recreate the June 2008 groundwater inundation flood event for the purpose of calculating recurrence intervals for this and other historical flood events. The coupled model used historical precipitation, land use, soils, vegetative canopy, and other climate data to predict surface water runoff and groundwater elevations. Measured climatic data spanning forty years were used to model precipitation, infiltration and runoff using the PRMS portion of GSFLOW. Groundwater was modeled using a modified version of the Wisconsin Geological and Natural History Survey Sauk County MODFLOW model. Modeled groundwater heads at observation points typically predicted the 2008 flood event as the largest magnitude groundwater event during the 40-year model period and the magnitude of head change was similar to regional groundwater observation well records. Predicted areas of shallow groundwater also generally coincided to the field-mapped areas of shallow groundwater indicators. This approach could be used to assess other large areas susceptible to groundwater inundation flooding.

27. Identification of Shallow Groundwater Flood Risk Areas, Spring Green Area, Wisconsin

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The Spring Green, Wisconsin, area has been susceptible to groundwater inundation flooding in the recent past in areas located outside the Federal Emergency Management Agency (FEMA) *Digital Flood Insurance Rate Mapped* (DFIRM) Special Flood Hazard Areas (SFHA) for the Wisconsin River. Historic flooding during June 2008 inundated nearly 7 square miles of the Spring Green area with standing water for 5 months and caused contamination to water supply wells, agricultural crop loss, and damage to homes, buildings, and infrastructure. The project objectives were to identify areas in portions of southern Richland and Sauk Counties, Wisconsin, that are at risk of groundwater flooding, calculate the frequency of return, and identify mitigation measures that may be feasible. This paper focuses on identifying areas that may be at future risk of groundwater flooding. The approach involved the analysis of existing regional and local data sets and the field mapping of shallow groundwater indicators. Field mapping was conducted June 21 through 25, 2010, following heavy spring rains. Multiple lines of evidence were compiled from historical aerial photographs, terrain model analysis, regional geologic and hydrogeologic setting information, the June 2008 flood extent (mapped by Fred Iausly, Sauk County GIS Analyst), and field-mapped indicators such as standing water, soil types, and wetland vegetation to identify areas at potential risk of groundwater inundation flooding. The areas identified as having potential inundation flooding risk were ranked into four qualitative risk classes based on frequency potential. The qualitative risk classes are higher frequency, moderately higher frequency, moderately lower frequency, and lower frequency. The risk map that was generated was used to calibrate a GSFLOW model built to calculate the frequency of return, and it was used to assist with an evaluation of potential mitigation measures.

28. Analyses of Hydraulic Properties at the Cedarburg Bog with Emphasis on Subsurface Characterization and Groundwater Flow

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The Cedarburg Bog has long been identified as a groundwater recharge zone for surrounding counties. Despite its importance on local water resources, an extensive assessment of aquifer properties and subsurface geology has not been undertaken in decades. The purpose of this study is to characterize the subsurface geology of the UWM-Field Station as well as the bog. Integration of well data and geophysical survey data from electromagnetic and electrical resistivity tomography resulted in a 3-dimensional subsurface map for the development of a groundwater flow model in the bog area. Additionally, we analyzed 20-year trends of the potentiometric surface to identify differences throughout previous years and determined hydraulic conductivity by conducting slug and infiltrometer tests at multiple locations. Through on-going effort, the vertical and horizontal hydraulic gradients at the UWM-Field Station were identified and the associated groundwater velocity was calculated. The results show present day groundwater flow velocity as 1.26E-05 meters/day. Finally, a series of long-term monitoring data of groundwater level, temperature, EC, pH, and dissolved oxygen at several piezometers was analyzed to reveal the role of this peatland on the local groundwater flow system. Knowledge acquired from this investigation can be used to better inform local agencies, as well as predict future changes within this groundwater system.

29. An Initial Hydrogeophysical Investigation of the Cedarburg Bog

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The Cedarburg Bog, located in western Ozaukee County, Wisconsin, is the southernmost bog of its type in North America. The bog consists of a wide range of ecosystems and provides important wildlife habitats, including areas for endangered species. However, the controlling geology and hydrogeology of the area that is important for maintaining this ecosystem is poorly understood. For this reason geophysical studies were initiated to gain a better understanding of the subsurface lithologies. Electrical conductivity (EM) and electrical resistivity tomography (ERT) surveys were completed at the north, south and center sections of the bog, while one seismic refraction survey was performed along the south side of the bog. The depths of investigation vary from 3 meters to 20 meters depending on the method. The results indicate variations in the geological environments among the three sections. The results from the northern area along Highway 33 show irregular lithologies consistent with hummocky topography and possibly paleochannels of coarse grain sediments. The two islands in the center section accessible from the boardwalk appear to be one feature and may have extended to the upland area to the west, partially dividing the bog and creating different ecosystems to the north and south. Based on the seismic studies and the ERT results, bedrock (presumably of Silurian dolomite) is within 2 meters of the surface along sections of Cedar Sauk Rd. The presence of this bedrock high along the south side of the bog may have limited drainage to the south and help promote the formation of the bog.

* Student Presentation

30. Characterization of Artificial Recharge at the University of Wisconsin–Parkside Campus

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Water level data collected in fall 2012 from the shallow aquifer underlying the University of Wisconsin-Parkside campus suggests the presence of a groundwater mound caused by artificial recharge from the campus buildings. Hydrogeologic cross sections of the campus constructed from logs of monitoring wells suggest the building foundations may intersect the sand water-bearing zone within the glacial till.

Pressure transducers were placed in a monitoring well (UWP-9) adjacent to campus buildings and another monitoring well (UWP-7) away from campus buildings to assess the artificial recharge hypothesis. Hourly water level measurements recorded in the two wells were plotted relative to precipitation data from September 12 through November 7, 2012. Water levels in well UWP-9 appear to fluctuate with precipitation while water levels in well UWP-7 remained relatively constant. Water levels in a new piezometer near Greenquist Pond suggest a hydraulic connection of the pond to the water-bearing zone.

A simple spreadsheet model was constructed using hydraulic conductivity data from campus aquifer testing and an annual recharge rate based on average annual precipitation and applied to campus roof areas, athletic fields, and wetland areas. Model recharge was calibrated to minimize error (R^2 = 0.82) between model and observed groundwater elevations. The best-fit model recharge rate from the buildings was estimated at 1.2 feet of annual rainfall. The model annual recharge rate for other areas is 1.8 feet for the athletic fields and 2.4 feet for wetlands.

* Student Presentation

31. Hydrological Investigation of Aquifer Characteristics at the University of Wisconsin-Parkside Campus

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A hydrologic investigation was conducted from September 6th, 2012, through November 7th, 2012, on the University of Wisconsin-Parkside campus to assess hydrological aquifer characteristics. This study was performed as part of the GEOS 465: Applied Hydrogeology course utilizing the existing groundwater monitoring wells network and hydrological features of the campus.

A conceptual hydrologic model of the campus was formulated from cross-sections developed using boring logs of monitoring wells and weekly water level measurements. Beneath the National Cross Country Track on campus a water-bearing zone of silty sand exists within clay till at depths of about 15 to 25 feet. The focus of this study was to evaluate aquifer hydraulic conductivity (K) of this zone from the following flow tests: a peristaltic pump test, at a flow rate of 0.56 gallons per minute; a submersible pump test, at 1.66 gpm; and a series of manual slug (bail down) tests.

Data from each test were analyzed separately, by eight undergraduate course students, using several methods including: Bouwer & Rice (1976)/ Bouwer (1989); Horslev (1951); Copper Jacob (1946); Theis (1946); and the Modified Jacob Method for distance/drawdown. The peristaltic (lower flow) pump test produced a mean K value of 2.0×10^{-3} cm/s while the submersible (higher flow) pump test yielded a mean K of 3.4×10^{-4} cm/s. Slug tests from four wells resulted in a mean K of 3.4×10^{-4} cm/s using the Horslev method and 1.5×10^{-3} cm/s using the Bouwer & Rice method.

* Student Presentation

32. Modeling the Effects of Nuanced Changes in Lot Layout and Impervious Area Connectivity on Urban Recharge in COMSOL

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It is well known that the hydrology of urban watersheds is altered by urbanization, especially by the introduction of impervious areas such as roads, roofs, and parking lots, but it is difficult to predict the effect this has on groundwater recharge, particularly at a small, single-lot scale. This project aims to describe the extent to which the amount, arrangement, and connectivity of impervious area in urban residential lots impacts recharge in urban areas. To explore this, a COMSOL model was developed that fully couples surface and subsurface water movement. Results will be presented from tests of several lot configuration scenarios.

* Student Presentation

33. Obstacles to Estimating Soil Moisture with Heated Fiber Optics

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Over the past decade, heated fiber optic distributed temperature sensing (DTS) has become a promising method to estimate soil moisture (θ) at high spatial and temporal resolutions. A heat pulse is sent through a cable and the temperature rise is measured by fiber optics within the cable. This project correlates the temperature rise within the cable to the θ of the surrounding soil using co-located, dielectric-based θ measurements at six locations. Field deployment of this technology for over two years has produced some interesting obstacles to correlating temperature rise data to θ.

First, the empirical relationship between the temperature rise and θ seems to change through time and is approaching the theoretical relationship predicted through modeling of the cable. The soil structure surrounding the cable has likely healed after installation, which has led to better contact between the cable and soil. This temporal healing process has led to temporally changing relationships between the temperature rise and θ. Second, there appears to be strong thermal hysteretic behavior in the silt loam soil surrounding the cable, which makes estimating θ from temperature rise data much more difficult. These are important challenges that need to be considered to further the accuracy of this technology under various vadose zone dynamics.

SESSION 3A:

Agricultural Hydrology and Management

Friday, March 8, 2013

8:30 - 10:10 a.m.

Characterizing the Response of Total Suspended Solids and Total Phosphorus Loading to Rainfall and Snowmelt Runoff in Agricultural Watersheds

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Understanding the response of total suspended solids (TSS) and total phosphorus (TP) to influential climate and watershed variables is critical for developing sediment and nutrient reduction plans. In this study, TSS and TP loadings from rainfall and snowmelt events were analyzed from eight predominantly agricultural Wisconsin watersheds with four to ten years of data available. The data showed that a small minority of runoff events accounted for the majority of total loading. The largest 10% of the loading events for each site accounted for 73%-97% of total TSS loading and 64%-88% of total TP loading. Rainfall and snowmelt events were both shown to be influential contributors of TSS and TP loading. Stepwise multivariate regression models for TSS and TP event loadings were developed separately for rainfall and snowmelt events within each watershed as well as all watersheds combined using rainfall, climate, seasonal, and watershed predictors. All individual and combined models for rainfall events resulted in two common predictors as most influential for TSS and TP loading: rainfall depth and antecedent base flow. These two predictors alone resulted in an R^2 greater than 0.7 in most individual models. The combined model yielded an R^2 of 0.66 for TSS and 0.59 for TP. Snowmelt models were statistically significant for all models, but the correlation to predictive variables were weaker than those for rainfall events (R^2 from 0.19-0.87). Unlike the rainfall models, the predictor selection varied between sites, and the common variables were not always selected in the same order.

Evaluating Newly Adopted Nitrogen Management Strategies for Irrigated Potato and Vegetable Production in the Golden Sand of Central Wisconsin

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Nitrogen fixing cover crops and slow-release nitrogen fertilizer have shown potential to improve nitrogen use efficiency and reduce nitrogen leaching in research trials. Best management practices developed from small scale research plots do not always provide the same benefits when applied to field scale production under agronomic conditions. Researchers and growers are working collectively to evaluate nitrogen use and leaching as these practices are adapted to field scale conditions. Results from year one will be presented in terms of complete nitrogen budget compiled using a mass-balance approach. Total amount of nitrogen in the cropping systems is quantified for spring before planting and fall after harvest and includes above ground biomass, fertilizer inputs, crop exports and plant available nitrogen in the top 90 cm of soil. Nitrogen loss is determined by difference. The drought conditions of 2012 may result in optimizing conditions for minimum leaching from irrigated systems, and the lack of summer rainfall may mask the effect of treatment compared to control sections.

Using Fallout Radionuclides to Track Sediment Movement within an Agricultural Watershed

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Agricultural activities play an important role in the offsite transport of productive soil from fields that can lead to significant water quality impairment. The eroded sediments are effective carriers of particulate-bound nutrients, such as phosphorus, from the landscape to downstream water bodies. Excessive transport of sediment-bound nutrients causes eutrophication of streams, rivers and lakes, decreasing their recreational values. The knowledge of sediment origin and in-stream sediment transport parameters (sediment age, percent 'new' sediment, erosion and deposition rates) facilitates gaining a better understanding of sediment transport processes within a watershed and effective targeting of management practices.

Atmospheric fallout radionuclides (cesium (Cs)-137, lead (Pb)-210, and beryllium (Be)-7) are commonly used to identify sediment sources and determine in-stream sediment transport parameters. The $^{7}Be/^{210}Pb$ ratio is commonly used to determine in-stream sediment transport parameters, such as sediment age and percent 'new' sediment on shorter time scales (~ two months). Research was conducted in the Pleasant Valley watershed in South Central Wisconsin to better understand sediment apportionment and transport in agricultural watersheds. The watershed area is approximately 5,025 ha, with average slope of 11% on silt loam soils and is a part of the Sugar Pecatonica River Basin within the Upper Mississippi River Basin. Two runoff generating events (1.2 cm over 4 hrs and 5.9 cm over 2 days) were sampled to study sediment transport processes within the watershed. Soil cores (uplands, stream bed, and stream bank) from the top 1 cm were collected before and after rainfall events. In-stream suspended sediment samples were collected using Phillip's time-integrated tube samplers at six different sites within the watershed. One-time soil cores were also collected from top 20 cm of streambed and an undisturbed (cemetery) reference site to determine long-term sediment fluxes. Results on in-stream suspended sediment sources, sediment age, percent 'new' sediment, erosion and deposition rates will be presented.

* Student Presentation

Examining the Influence of Shallow Groundwater on Net Primary Productivity and Evapotranspiration in Managed Ecosystems

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The feedbacks between water table dynamics and surface/atmosphere energy and water balances have drawn increasing attention during the last decade. In efforts of capturing the influence of water table on plants, groundwater has been represented with varying degrees of complexity in current hydrologic models. Although plant physiology, which plays a key role in understanding the soil-plant-atmosphere continuum, can be simulated with relatively high accuracy, the impacts of groundwater on vegetation is not completely understood mainly due to the limited ability of current models to simulate groundwater – vegetation interactions. In this study, using a modified agroecosystem model (Agro-IBIS), in which the soil physics module is replaced with a widely used variably saturated water flow and heat transfer model (Hydrus-1D), groundwater – plant/crop system interactions were simulated in a physically based fashion. First, we verified the model outputs with observed soil moisture, temperature, leaf area index time series, and annual net primary production from a maize field in south-central Wisconsin. Next, using the same observed climate records, we ran sensitivity simulations to better understand the responses of managed ecosystems to variable water table depth under inter-annual climate forcing conditions. The model results show that as water table nears the surface (1) soil temperature decreases due to the moisture content driven effects on the thermal diffusivity of the soil, and (2) specific humidity at the leaf level increases due to increased rates of evaporation. These changes alter plant productivity as well as phenology depending on seasonal weather and depth to groundwater.

Shallow Groundwater Impacts on Corn Biophysics and Yield during a Drought, Yahara River Watershed, Wisconsin

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Future climate projections for southern Wisconsin include shifting temporal precipitation patterns and increasing temperatures. Non-irrigated cropland, pasture, or natural vegetation covers much of southern Wisconsin; the productivity, distribution, and composition of these ecosystems are dependent upon the availability of water. This highlights the necessity of understanding the influence of subsurface water resources on primary productivity. Excess groundwater in the root zone can cause root waterlogging and oxygen stress in wet years, leading to yield losses; in dry years, however, groundwater can provide a subsidy to growth after soil moisture supplies are exhausted. Here, we quantify the impact of shallow groundwater on corn biophysical processes and overall yield. The Yahara River Watershed in south-central Wisconsin experienced a severe drought during the 2012 growing season, with <8 mm precipitation recorded between June 1 and July 15. This period coincided with the vegetative and reproductive stages of corn growth, which are critical for biomass and grain yield, respectively.

We instrumented a 30 ha cornfield in northern Dane County to characterize the spatial and temporal response of corn to groundwater. The study site has experienced groundwater flooding within the past decade, and water table depths immediately after planting ranged from ~1-6.5 m below the ground surface. We observed a diverse response to drought over the field. All test sites within the field showed a reduction in photosynthetic processes, the magnitude of which was correlated with the depth to groundwater. As soil moisture supplies were depleted during the drought, all sites showed a decrease in stomatal conductance rates and leaf area index, accompanied by an increase in canopy surface temperature. These responses were less severe at sites with shallower groundwater. Similarly, the shallowest groundwater site had a pollination success rate ~400% that of the deepest groundwater site. Kernel counts and kernel mass were higher at shallow groundwater sites due to water subsidy received from shallow groundwater, leading to an increase in grain yield and aboveground biomass. These results demonstrate shallow groundwater's potential as an *in situ* resource to buffer crop responses to drought.

* Student Presentation

SESSION 3B:

Advances in Hydrological Techniques

Friday, March 8, 2013

8:30 – 10:10 a.m.

Mapping Flow Path Uncertainty with an Analytic Element Model and Monte Carlo Techniques

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The Lac du Flambeau Band of Lake Superior Chippewa Indians and the Indian Health Service are concerned about the fate of effluent that infiltrates from wastewater treatment lagoons on the reservation. Of particular concern is the potential for capture of effluent by drinking-water supply wells or short circuiting to a lake given current and possible alternative management scenarios for handling disposal of the wastewater. Groundwater flow and effluent movement from the wastewater treatment lagoons were simulated using the analytic element groundwater flow model, GFLOW, and calibrated using the parameter estimation program, PEST. Uncertainty in the extent of the simulated wastewater plumes as related to calibrated parameter values was evaluated using Monte Carlo techniques and the parameter posterior covariance computed by PEST during model calibration. A grid of particles was simulated with backward tracking from the bottom of the aquifer to the point of recharge. Determining which particles originally recharged as wastewater was done using a novel algorithm based on vector geometry and Voroni Tesselation. A Latin Hypercube algorithm was used to generate 1,000 candidate parameter combinations that each honored the correlation and uncertainty structure of the parameters estimated using PEST. Combining the results of the parameter candidates, the probability that individual particles originated as wastewater was calculated and used for generating maps of plume extent probability. Results were displayed as color-flood maps of probability, allowing the Tribe and Indian Health Services to evaluate risk of plume migration for multiple scenarios.

Hydrologic Modeling of Internally Drained Basins in the Yahara River Watershed Using an Extreme Precipitation Event

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The challenges of large-scale hydrologic watershed modeling are numerous, including uncertainty in heterogeneous spatial inputs. Modeling of the Yahara River Watershed in southern Wisconsin is further complicated by numerous large internally drained basins (IDBs) within the watershed. IDBs are local depressions with no outlet for drainage except during extreme events. IDBs are commonly excluded from hydrologic models of the Yahara River Watershed in order to model surface runoff from typical rain events. However, during periods of high precipitation an IDB may overflow, causing a sudden increase in the drainage area contributing surface runoff. Furthermore, groundwater recharge occurs in IDBs; excluding them results in under-estimation of groundwater discharge in the watershed. These factors have made it difficult to calibrate hydrologic models of the Yahara River Watershed.

We are modeling the Yahara River Watershed with the Soil and Water Assessment Tool (SWAT). The primary goal is to model runoff data from a series of extreme rainfall events in June 2008. We use high-resolution NWS-NEXRAD precipitation data as input for SWAT. In this case, IDBs are explicitly modeled as reservoirs that collect surface runoff until they overflow; the volume of water that an IDB can hold before overflowing is determined using a digital elevation model. The behavior of the IDBs is calibrated so that modeled outflow volumes reasonably agree with gage data. We find that accurate modeling of IDBs improves overall model accuracy in the Yahara River Watershed during high flow periods.

* Student Presentation

Exploring the Occurrence of Riverbank Inducement into a Shallow Aquifer in Southeastern Wisconsin through Geochemical Analysis

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Increased urbanization in Southeastern WI has exacerbated water quantity issues resulting in increased use of the shallow aquifer. One of the alternatives in reducing the impact that pumping has on the water table is riverbank inducement (RBI). This study attempts to provide a comprehensive analysis of surface water and groundwater interaction caused by RBI along a segment of the Fox River in Waukesha County. A prediction of the water's movement through the aquifer will be made based on mixing, chemical evolution and travel time. The extent of anthropogenic influence on the shallow aquifer will also be determined.

In 2007 a network of sampling sites was established to monitor the chemistry of treated waste-water effluent, river water at spatially significant locations and municipal wells located in close proximity to the river. The shallow aquifer is susceptible to sodium chloride inputs from three upstream waste water treatment plants, road salt application, and water softeners. Comparison between these end-member waters over time shows a strong trend in their chemical evolution, further suggesting the occurrence of RBI. Significant increases in groundwater sodium chloride concentrations have been observed over time. Preliminary analysis of the trace elements boron and lithium has been performed to discriminate between road salt and treated effluent. Analysis of oxygen and hydrogen isotope ratios provides a further confirmation of the recharge water. In addition, the results are supported by independent numerical modeling and geophysical data.

* Student Presentation

Borehole Flow Characterization Using Discrete In-well Heat Tracer Tests Monitored by DTS

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Heat tracer tests in open wells provide valuable information about the adjacent formations, including the presence of permeable features such as fractures, the presence of aquitards, and whether flow is upward or downward. We employed a newly developed downhole electric heater to conduct tracer tests in two bedrock boreholes in south-central Wisconsin. Heat movement was monitored with a Distributed Temperature Sensing (DTS) system.

Movement of heat within the borehole as recorded by DTS indicates flow direction, changes in flow velocity, and an approximation of the magnitude of the borehole flow velocity. Our experiments successfully identified both upward and downward flow as well as sharp changes in borehole flow velocity, indicating fracture locations and the influence of the fractures on the borehole flow regime. We also identified regions of the wells in which a lack of change in borehole flow velocity over long distances indicates only limited contribution from the aquifer to the borehole.

Comparison of borehole flow velocities in these experiments to those measured using a spinner flow meter indicates that the heat tracer measurements generally underestimate the borehole flow velocity. However, the results of this research indicate that DTS-monitored in-well heat tracer tests are a useful method of identifying aquifer heterogeneity through determination of vertical flow directions and relative magnitudes. We plan to modify our heater to improve heat exchange with the borehole fluid which may result in a closer match to the spinner flow meter results.

* Student Presentation

Influence of Enterococcal Surface Protein (esp) on the Transport of *Enterococcus faecium* within Saturated Quartz Sands

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Enterococcus was selected by US EPA as a Gram-positive indicator microorganism for groundwater fecal contamination. It was recently reported that enterococcal surface protein (*esp*) was more prevalent in *Enterococcus* from human sources than in *Enterococcus* from non-human sources and *esp* could potentially be used as a source tracking tool for fecal contamination (Scott et al., (2005)). In this research, we performed laboratory column transport experiments to investigate the transport of *Enterococcus faecium* within saturated sands. Particularly, we used a wild type strain (E1162) and a mutant (E1162Δ*esp*) to examine the influence of *esp* on the transport behavior of *E. faecium*. Our results showed that *esp* could significantly enhance the attachment of *E. faecium* cells onto the surface of sands and thus lower the mobility of *E. faecium* within sand packs. Cell surface properties (e.g., zeta potential) were determined and the extended Derjaguin-Landau-Verwey-Overbeek (XDLVO) theory was applied to explain the effects of *esp* on the retention of *E. faecium*. Overall, our results suggested that *E. faecium* strains with *esp* could display lower mobility within saturated sand packs than *E. faecium* strains without *esp*. The disparity in the transport behavior of *E. faecium* with and without *esp* could limit the effectiveness of *esp* as a source tracking tool within the groundwater system.

SESSION 4A:

Groundwater Modeling

Friday, March 8, 2013

10:30 – 12:10 p.m.

A New Groundwater Flow Model for Dane County, Wisconsin

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A new groundwater flow model for Dane County, WI, exemplifies the practical state-of-the-art of model construction and calibration. The model was developed by a team of WGNHS and USGS scientists with support from the Capital Area Regional Planning Commission and Dane County communities, and replaces an earlier model developed in the 1990s. The new model is three-dimensional and transient, and conceptualizes the county's hydrogeology as a 12-layer system including all major hydrostratigraphic units and two high-conductivity fracture zones.

The model uses the newly developed USGS MODFLOW-NWT finite-difference code, with a Newton-Raphson solver to improve the handling of unconfined conditions by smoothing the transition from wet to dry cells. The model explicitly simulates groundwater-surface water interaction with streamflow routing and lake stage fluctuation, redistribution of recharge and evapotranspiration in the unsaturated zone, and overland flow from low-lying variable source areas. Model calibration used the parameter estimation code PEST, and calibration targets included heads, stream and spring flows, lake stages, and borehole flows. Steady-state calibration focused on the period 2006-2010; the transient calibration focused on the 7-week drought period during June and July 2012.

This model represents a significant step forward from previous work because of its finer grid resolution, improved hydrostratigraphic discretization, transient capabilities, and inclusion of surface water features. Potential applications of the model include evaluation of potential sites for and impacts of new high-capacity wells, development of wellhead protection plans, evaluating the effects of changing land use on groundwater and quantifying the relationships between groundwater and surface water.

Simulation of Groundwater Flow and Groundwater/Surface-water Interactions in the Bad River Watershed, Wisconsin

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The groundwater system in the Bad River Watershed drains over 1,000 square miles, extending from shallow glacial and fractured bedrock upland settings near the Geogebic Range to an artesian sandstone aquifer in the lowlands near Lake Superior. Groundwater constitutes the primary water supply for the area and may also be critical to sustaining ecological features including resident trout and lake-run fish habitats, and the largest remaining wild-rice estuary in the Great Lakes Basin. Previously, no quantitative framework existed for understanding the groundwater system in this area and predicting impacts to it from potential future developments such as the proposed Geogebic Taconite Mine. The objectives of this study are to (1) improve our current understanding of the groundwater system in the Bad River Watershed, including groundwater/surface-water interactions, and (2) provide a tool to inform future management of area water resources.

A screening model of the watershed was developed using the analytic element code GFLOW. The model simulates steady-state, two-dimensional groundwater flow and baseflow in streams. Model calibration and parameter estimation was performed with the PEST software suite. Evaluation of the family of possible optimal parameter sets was explored using the newly developed Pareto mode of PEST, which illustrates the trade-off between modelers' "soft" knowledge of reasonable parameter values and best model fit. The calibrated GFLOW model was then used with prediction uncertainty analysis to identify locations where additional data collection would maximize reductions in uncertainty for predictions of interest. The GFLOW model will also form the boundary conditions for a future inset MODFLOW grid. The more detailed MODFLOW model will better capture the complex geometry of the system and will also allow for finer-scale parameterization, enhancing the ability to simulate phenomena at smaller scales within the watershed.

Application of a Groundwater/Surface-water Model to Water-supply Management: Upper Fox Basin, Waukesha County, Wisconsin

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Waukesha County is undergoing urbanization and stresses on water-supply systems, including water-quality degradation. The City of Waukesha is evaluating alternative sources of water such as increased withdrawals from shallow wells or diversions from Lake Michigan. Other communities in the Fox River Basin likely face similar choices.

A USGS study of the Upper Fox River Basin in north-central Waukesha County was undertaken to develop 1) a baseline understanding of shallow groundwater conditions and 2) a tool for evaluating alternative water-supply options. A MODFLOW grid was constructed with thin layers and cells 125 feet per side. The nonlinear, unconfined problem incorporated stream and lake interactions, which yielded unstable solutions sensitive to initial conditions. Application of the recently developed MODFLOW-NWT code overcame numerical problems by smoothing the transition from wet to dry cells. The modeling approach also handled uncertainty arising from heterogeneity in glacial deposits by developing two model versions — one favors the continuity of fine-grained deposits, one the continuity of coarse-grained deposits.

Both geologic representations were used to evaluate interaction of existing shallow riparian wells with the Fox River and also a hypothetical scenario involving 27 riparian wells adjacent to a 10-mile stretch of the river. Results suggest that riparian wells collectively withdrawing about 9 mgd would induce one-third to one-half their total discharge from the river. This riverbank inducement would appreciably limit drawdown around wells, with minimal streamflow depletion if discharge is recycled through upstream wastewater treatment plants.

Using a Bayesian Decision Network to Emulate a Groundwater Model for Efficient Decision Support

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Outside the groundwater community, Bayesian decision networks (BN) have a long history in decision support in systems considering uncertainty. Previous applications range from medical diagnostics to terrorism threat assessment. In the context of groundwater modeling, BNs use the system variability provided by the natural world to synthesize a range of hydrogeologic situations within a single model run. Moreover, BNs explicitly incorporate the uncertainty of the system, thus provide outputs in terms of probabilities – a metric well understood by decision-makers. BNs, therefore, can serve as an efficient alternative to other uncertainty methods such as computationally demanding Monte Carlo analyses and other methods restricted to linear models.

We present an application of the BN to groundwater modeling analyses. A simple spreadsheet of model output realizations is constructed using the variability encompassed by the model domain. In the Lake Michigan Basin (LMB), a regional unstructured-grid MODFLOW-USG model allowed analysis of stream capture and diversion resulting from new pumping. The depletion/diversion can be related to model variables, including well/stream proximity and local stream density; pumping rate; and local recharge and transmissivity. Two models, each with 1,000 synthetic pumping wells scattered throughout the domain, are summarized to build the BN. The BN operates as a transfer function to predict stream depletion conditional upon proposed well location conditions (distance to streams, depth, etc.) and trained by sampling across the Lake Michigan regional model. The goal is to apply this understanding to similar settings encompassed by the Glacial Aquifer System outside the LMB model domain.

The use of MODFLOW-USG with BNs provides decision makers a distilled understanding of the system with the associated uncertainty. This information, in turn, can provide a science-based foundation for water-resource management without the necessity of simulating every potential new situation.

Simplified Access to the Power of Parameter Estimation Through PEST++ and keyPEST

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PEST++, an object oriented adaptation of the parameter estimation code PEST, has been designed to lower the barriers of entry for both users and developers. Initial PEST++ (version 1.X) development focused on implementing the most popular features of PEST using more streamlined user input, and in a manner amenable for extension by other software developers. Two notable differences to PEST are that PEST++1) implements singular value decomposition in an efficient manner that retains the functionality of Marquardt lambda and 2) has the ability to automatically switch between native and super parameters "on the fly." PEST++ retains backward compatibility with PEST, such that the input files are interchangeable. However, backward compatibility was attained by retaining the original relatively complex PEST input structure, which creates a high learning curve for new users. To reduce input requirements, a "keyPEST" translator has been developed to move minimal keyword-oriented input to a full control file suitable for PEST++ and PEST. Input not explicitly provided by the user is supplied by developer-provided defaults that reflect settings suitable for most problems; alternatively, users have the option to override these defaults by simply specifying the associated keyword and value. It is hoped that these efforts will provide a user-friendly entry point that leads to more robust and efficient access to recently developed sophisticated calibration and uncertainty methods. This, in turn, should provide an accessible conduit to interject the insight and transparency afforded by parameter estimation to more environmental models in the future

SESSION 4B:

Measuring, Monitoring and Managing Wisconsin's Water Resources

Friday, March 8, 2013

10:30 – 12:10 p.m.

Issues Pertaining to Developing a High Capacity Water Supply for an Industrial Sand Mine in Wisconsin

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Frac sand mining has become a widely publicized topic within the upper Midwest over the last two years. The State of Wisconsin has more industrial sand mines operating, under construction and proposed than any other state at this point in time. One of the topics of concern has been the amount of water used by a sand processing facility, since water must be acquired to operate the plant. A high capacity well or wells will be required in most cases to supply the water needed to operate the plant. Since the Lake Beulah case, the WDNR has required a much higher level of evaluation to ensure protection of the waters of the state.

Unimin Corporation is currently developing an industrial sand mine in the vicinity of Tunnel City, Wisconsin, which will require a high capacity water supply. Surrounding Unimin's property are several ERW/ORW trout streams with differing DNR classifications. As part of the permitting process, a groundwater flow model was developed to evaluate the operation of the proposed high capacity wells on the sandstone aquifer and surrounding surface water features. Additionally, the groundwater model evaluated the potential impact on nearby domestic and municipal potable supply wells. The model assisted with locating the best sites, number of wells, and withdrawal limits to minimize the potential for impacts.

This presentation will provide information about the water use required for an industrial sand mine (with processing facility), the in-depth review completed for potential affects to natural resources and the neighboring public, regulatory requirements and mitigation for responsible operation.

Issues

Sensitive natural resource issues: Long-term aquifer capacity, springs, trout streams

Neighbors and public: Private and public well interference

Integrating Flood Control with Natural Lands Management in the Clark Creek Watershed, Sauk County, Wisconsin

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Like much of southern Wisconsin, Clark Creek experienced extraordinary floods in June of 2008 due to extended, heavy rainfall. Clark Creek drops steeply from Devil’s Lake State Park in the Baraboo Bluffs to the Baraboo River, and flooding is exacerbated by steep, rocky topography, erodible sandy glacial deposits, and abundant woody debris that creates large log jams that have blocked roadway culverts and diverted flow out of the stream channel. Numerous large floods have occurred in the last two decades, causing severe channel and bluff erosion, destroying boulder stabilization structures, depositing large volumes of sediment in the lower, flatter reaches. In June 2008, significant portions of State Highway 113 and several highway and private driveway culverts were destroyed, several houses were inundated, and approximately 50 acre feet of debris and sediment were deposited on roadways and private property.

Many traditional flood control measures such as dams, detention basins and streambank armoring are not compatible with the Department of Natural Resources (DNR) management requirements and goals for Devil’s Lake State Park. However, significant flood mitigation is possible through more ecologically sensitive actions such as prairie and wetland restoration and managing the riparian forest to reduce entrainment of the woody debris that creates log jams. Sauk County and the DNR are currently working to implement a plan that provides mutual flood relief and natural area management benefits.

Using Geophysics to Better Understand Wetland Hydrogeology

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Conducting field work in wetland settings poses challenges not encountered in routine hydrogeologic investigations. Vehicle, equipment, and even personnel access to the field site are often limited. In this environment alternative methods must sometimes be substituted for the more usual. Geophysics can often provide those alternatives

We used a ground conductivity tool, the EM-31, and ground penetrating radar at a wetland in Door County Wisconsin. These tools were used to determine depth to bedrock beneath the wetland area. The geophysical estimates were confirmed by cores collected with a Russian peat corer and by pushing a steel rod to refusal. In general there is good agreement between the geophysics, assuming a two-layer resistivity model of marl or clay sediment over bedrock, and the push and coring methods. For the several measurements where there was disagreement, the measurements were near one of the small streams found in the wetland. We suspect that the two-layer electrical resistivity/lithology model assumed does not hold for those locations. That implies that there is different and probably more complicated stratigraphy at those locations.

Using geophysics we were able to determine depths to bedrock underneath much of the wetland. These results can be incorporated into the planned groundwater flow model of the wetland to improve the model results. The end result is a better understanding of the hydrogeology of this wetland and improved management of this sensitive habitat.

Wisconsin's Water Withdrawal Inventory and Reporting Program

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In 2008, the Wisconsin DNR undertook an effort to inventory and register high capacity groundwater and surface water withdrawals in the state. Furthermore, it expanded its effort to collect withdrawal reports from owners and operators of these sources. As a result, the state now has withdrawal data available for over 11,000 withdrawals from more than 5,000 properties capable of withdrawing greater than 100,000 gallons per day. This includes a range of users such as public water utilities, electrical power producers, irrigators, paper manufacturers and cranberry growers.

Detailed results will be presented from 2011 in which over 11,000 withdrawal reports were collected over 90% of all sources. Results of these reports will be presented demonstrating seasonal and spatial withdrawal trends as well as differences in withdrawals across water uses. In addition, this presentation will demonstrate tools and methods currently available and in development for sharing withdrawal data with businesses, consultants, NGOs and local governments.

Updating Wisconsin's Statewide Groundwater Monitoring Network

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Wisconsin's statewide groundwater-level monitoring network, jointly operated by the University of Wisconsin–Extension, the Wisconsin Geological and Natural History Survey (WGNHS) and the U.S. Geological Survey (USGS), provides crucial data for understanding the state's groundwater quantity issues. Beginning in the 1940s, Aldo Leopold, then commissioner of the precursor to the modern day Wisconsin Natural Resources Board, worked to formally establish the groundwater monitoring network. The network currently consists of over 160 wells in 50 of Wisconsin's 72 counties.

This monitoring network is critical for establishing benchmarks to monitor short-term and long-term trends in groundwater levels across Wisconsin. Water levels in Wisconsin's aquifers fluctuate in response to weather, climate, water use, land-use changes, and other phenomena. Water-level data are important for designing water supply systems and for documenting the impacts of pumping on water resources. The network also helps scientists understand the response of hydrologic systems to droughts and floods, and provides baseline data for groundwater resource evaluation and research. Planners and engineers commonly use monitoring-network data as a surrogate for site-specific water level trends when developing landfills, highways, and industrial projects.

In 2012, after years of declining funding, the Wisconsin Dept. of Natural Resources (WDNR) allocated water-use-fee revenue for the USGS and WGNHS to install, replace, or upgrade wells and spring monitoring sites in areas of interest in the Lake Michigan Basin. The well-monitoring sites will provide a picture of groundwater movement and quantity in the major aquifers of southeast Wisconsin and within the Maquoketa Shale aquitard.

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