AMERICAN WATER RESOURCES ASSOCIATION-WISCONSIN SECTION

29th ANNUAL MEETING

WISCONSIN'S WATERS: A CONFLUENCE OF PERSPECTIVES

March 3 & 4, 2005

Lake Lawn Resort
Delavan, 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 District

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29th Annual Meeting of the American Water Resources Association – Wisconsin Section

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7:00 **Dinner** – *Lake Lawn/Queens Room*

Banquet Speaker – **Dale Robertson,** Research Hydrologist, U.S. Geological Survey

Friday, March 4, 2005

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Moderator: Chris Carlson, WI Department of Natural Resources

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8:50 Investigation of Three Flowpaths of Different Lengths, Allequash Basin, Vilas County, Wisconsin. M.D. Masbruch*

9:10 An Assessment of Wisconsin's Natural Attenuation Closure Protocol. N.R. Keller*

9:30 Has Acid Deposition Affected the pH of Wisconsin's Groundwater? D.L. Ozsvath

9:50 A Comparison of Enzyme-Based Total Coliform/E. coli Tests for Groundwater Monitoring. J.M. Olstadt

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9:30 Quantification of the Export of Sediment and Nutrients in Snowmelt at Pioneer Farm. R.M. Mentz

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10:10 – 10:30 **Break**

10:30 – 11:50 **Concurrent Session 4A and 4B**

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Moderator: Chris Carlson, WI Department of Natural Resources

10:30 Lithostratigraphic Controls on Groundwater Flow through the Tunnel City Group Sandstones, Southern Wisconsin. S.K. Swanson

10:50 Field Comparison of Methods for Collecting Hydraulic Head Profiles Across an Aquitard. K.R. Bradbury

11:10 A Quick Method for Estimating the Vertical Hydraulic Conductivity of a Regional Aquitard. D.J. Hart

11:30 Stagnation Points: Results of Sr Isotope and Modeling Investigations, Allequash Creek, Northern Wisconsin. R.J. Hunt

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Moderator: Chris Carlson, WI Department of Natural Resources

10:30 From Monitoring to Policy: Assessing the Effects of Agricultural Management Practices on Phosphorus Delivery through the Wisconsin Phosphorus Index. L.W. Good

10:50 Computer Tools for Watershed Management: Digital Watershed and Long-Term Hydrologic Impact Assessment. D.C. Lucero

11:10 Groundwater Impacts from Coal Ash Disposal Sites in Wisconsin: Using WDNR Databases as a Research Tool. P.N. Fauble

11:30 Web Sites as Instructional Sources for Water Resources Courses. N.E. Spangenberg

11:50-12:00 **Announcement of Student Paper Award Winners and Closing Remarks –** *Geneva 1/Geneva 3*

*Denotes student presentation.

PLENARY SESSION
Valuing Wisconsin's Waters
Thursday, March 3, 2005
12:45 – 1:55 p.m.

Abstract

From 2000 to 2003 the Wisconsin Academy of Sciences, Arts and Letters organized a statewide effort to examine the status and the future of water resources in Wisconsin. Out of those efforts have come a valuable collection of essays entitled *Wisconsin's Waters: A Confluence of Perspectives*, with contributions from some of Wisconsin's leading scientists and other water experts. The diversity of topics and expertise help illustrate the important role of water and its profound connection to our lives, economies, and experiences. In this session, two of the contributing authors will present their perspectives on the different ways in which value is assigned to and received from our water resources. Invited speakers for this year's plenary session include Dr. David Marcouiller, UW-Madison, who will address the complexities associated with estimating the economic value of water resources, and Dr. Michael Nelson, University of Idaho, who will voice the need for explicit recognition of water as a component of the land ethic.

Biographies

David Marcouiller is an associate professor of urban and regional planning at the University of Wisconsin-Madison. He holds joint appointments in the UW-Madison's Gaylord Nelson Institute for Environmental Studies, the Department of Urban and Regional Planning and Forest Ecology and Management, and the UW-Extension Center for Community Economic Development.

Michael Nelson is an assistant professor of environmental philosophy at the University of Idaho and a former professor at the University of Wisconsin-Stevens Point. In 2002, Nelson was awarded the Excellence in Teaching Award from UWSP. He is the coeditor of *The Great New Wilderness Debate* and coauthor of *American Indian Environmental Ethics: An Ojibwa Case Study*, both with J. Baird Callicott. Currently he is working on a second volume of *The Great New Wilderness Debate*, a collection of the wilderness papers of Aldo Leopold, and an interdisciplinary collection of commentaries on Leopold's contribution to water resources for the American Fisheries Society.

SESSION 1A:
Evaluating Water Ecosystems
Thursday, March 3, 2005
2:15 – 3:35 p.m.

Hydrologic, Ecological, and Geomorphic Responses of Brewery Creek to Construction of a Residential Subdivision, Dane County, Wisconsin, 1999 - 2002

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Michael J. Sorge, WDNR, 3911 Fish Hatchery Road, Fitchburg WI 53711, sorgem@dnr.state.wi.us

The U.S. Geological Survey (USGS), in cooperation with the Dane County Land Conservation Department (LCD) and the Wisconsin Department of Natural Resources (DNR) investigated the instream effects from construction of a residential subdivision on Brewery Creek, Wisconsin. The purpose of the investigation was to determine whether a variety of storm-runoff and erosion-control best-management practices (BMPs) would effectively control the overall sediment load, as well as minimize any physical, biological, and ecological stresses to Brewery Creek.

Stormwater volumes decreased 60 percent from the preconstruction phase to the land-disturbance phase and slightly increased (9 percent) from the land-disturbance phase to the home-construction phase. The stormwater volumes were applied to total solids and total suspended solids concentrations to compute a solids load for each contaminant. Total and suspended solids load exhibited a similar trend from preconstruction to land-disturbance phases with decreases of 52 and 72 percent, respectively. Both total and suspended solids load continued to decrease in the transition from land-disturbance to home-construction phases, by 22 and 37 percent, respectively. However, because of variability in the data, statistically there was no change in the magnitude of the difference between the upstream and downstream solids load from one phase of construction to the next at the 90 percent confidence level.

Other physical, biological, and ecological surveys including macroinvertebrates, fish, habitat, and geomorphology were done on segments of Brewery Creek influenced by the study area. Macroinvertebrate sampling results (Hilsenhoff Biotic Index value, or HBI), on Brewery Creek ranged from “very good” to “good” water-quality with no significant differences during any phase of construction activity. Results for fish community composition, however, were within the “poor” range (Index of Biotic Integrity value, or IBI) during each year of testing. A general absence of intolerant species, with the exception of brown trout, reflects the low IBI values. Habitat values did not change

significantly from preconstruction to postconstruction phases. Although installation of a double-celled culvert in Brewery Creek most likely altered the width-to-depth ratio in that reach, the overall habitat rating remained "fair." Fluvial geomorphology classifications including channel cross sections, bed and bank erosion surveys, and pebble counts did not indicate that stream geomorphic characteristics were altered by home-construction activity in the study area. Increases in fine-grained sediment at various cross sections were attributed to instream erosion processes, such as bank slumping, rather than increases in sediment delivery from the nearby construction site.

Keywords: stormwater, erosion, water quality, ecology, policy

Geomorphic, Flood, and Ground-Water-Flow Characteristics of Bayfield Peninsula Streams, Wisconsin

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The U.S. Geological Survey studied the geomorphic, flood, and ground-water-flow characteristics of five Bayfield Peninsula streams from 2002 to 2003 to better understand the physical limitations for brook trout rehabilitation. Geomorphic characterization consisted of analysis of historical aerial photographs, maps, and documents; observations of helicopter video footage; and field surveys of valley transects and coring. Flood hydrographs were simulated for three land-cover scenarios--present (1992-93), peak agriculture (1928), and presettlement (before 1870). Geomorphic processes are driven by drainage-network position, texture of glacial deposits, and proximity to post-glacial shorelines. However, past land use activities (logging, log drives, and agriculture) altered geomorphic processes. Simulations indicate that present-day flood peaks are 1.5 to 2 times higher than presettlement flood peaks. Increased flood peaks are caused by a combination of land-use change (less infiltration) and decreases in channel and upland roughness. Increased flood peaks have caused accelerated incision in upper reaches, bluff erosion in reaches with entrenched valleys, overbank deposition and bar formation in middle and lower reaches, and aggradation in mouth areas. A GFLOW model was developed to help determine the sources of base flow and delineate ground-water-contributing areas. The source of base flow is a deep aquifer system recharged through the permeable sands in the center of the peninsula. Base flow is unevenly distributed among the streams depending on amount of channel incision and proximity to ground-water-discharge zones. Available brook trout habitat is dependent on both the location of ground-water-discharge zones and the severity of floods.

Keywords: geomorphology, Lake Superior, ground-water-flow, floods, Wisconsin

Shading and its Impacts on Macroinvertebrate Colonization and Fish Distribution

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A large-scale floodplain modification of the North Branch of the Pike River in Racine County was initiated in 2002. Although the primary motivation for the project was to alleviate flooding problems, engineering designs included the creation of riparian wetlands and the restoration of stream habitat for fish and invertebrates. Prior monitoring data from another restored stream (Lincoln Creek, Milwaukee County) suggested that the lack of vegetative canopy may be an important factor in constraining the recovery of restored streams. By manipulating habitat and shading in a newly created section of the Pike River, we examined the effects of ultraviolet radiation on the colonization and diversity of benthic macroinvertebrates and distribution of fishes in regards to quantity and quality of habitat features. In general, areas with deep pools and shade served as refugia for many fish taxa during summer baseflow conditions. Shading also reduced the amount of UV radiation reaching the stream bottom and was correlated with increased macroinvertebrate diversity and colonization of UVR intolerant species. Our results indicate that the establishment of riparian canopy is one of the most critical factors limiting the recovery of biological integrity in restored systems.

Keywords: macroinvertebrate, fish habitat, stream restoration, UV radiation

*Note: This is a student presentation.

Concentrations and Congener Profiles of PBDEs in Lake Michigan Forage Fish

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Polybrominated diphenyl ethers (PBDEs) are flame retardants used in polyurethane foam and electronic housings. First reported in 1979, they are now found in most environmental compartments over a wide geographic range. PBDE levels in human breast milk have about doubled every five years over the past 25 years. Production of lesser-brominated PBDEs is being phased out due to the above findings and concerns that the chemicals cause thyroid disruption, developmental defects, and possible carcinogenity.

One part of the PBDE story line in Lake Michigan is the PBDE concentrations and time trends in the forage fish. Consequently, PBDEs were analyzed in forage fish collected in 1995 and recently (2002-2004). Over this time period the congener concentration profiles remain similar for individual species, although the congener profiles remained different among species. The two most commonly found congeners, BDE-47 and BDE-99, dominated the profiles except in the deepwater sculpin. The deepwater sculpin were surprisingly lacking in BDE-99. Lipid-normalized levels in these fish showed a significant increase while the alewife trended upward, and bloater chub levels showed a decreasing trend over time. Combining all the forage fish studied, the difference between 1995 levels and recent levels was not statistically different.

Keywords: polybrominated biphenyls, toxic substances, Great Lakes, water quality

*Note: This is a student presentation.

SESSION 1B:
Arsenic Issues in Wisconsin
Thursday, March 3, 2005
2:15 – 3:35 p.m.

Almost Everywhere: Naturally Occurring Arsenic in Wisconsin's Aquifers

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Trace levels of arsenic are almost ubiquitous in Wisconsin groundwater. Over the past decade, researchers have investigated the sources of arsenic in Wisconsin's aquifers and the distribution of arsenic in groundwater across the state. The most extensive testing has occurred in the Fox River valley, in east-central Wisconsin, where the primary source of arsenic to groundwater is sulfide mineralization in the St. Peter sandstone. Up to 30 percent of wells in some parts of Winnebago County have arsenic concentrations greater than 5 μg/L. Arsenic also impacts groundwater quality in the St. Peter sandstone to the south and west of the Fox River valley, in Fond du Lac, Dodge, and Iowa Counties. Arsenic concentrations exceed 5 μg/L in 3 to 10 percent of the wells in these areas.

In eastern and northern Wisconsin, wells completed in the sand and gravel aquifer and some shallow bedrock formations are susceptible to arsenic contamination. Research at a site near Lake Geneva demonstrated that where groundwater is under sufficiently reducing conditions, low solid-phase concentrations of arsenic in Quaternary sediments are sufficient to cause arsenic concentrations in well water to exceed 10 μg/L. Data from water-sampling programs in Taylor and Sheboygan Counties showed that similar geologic and geochemical conditions likely exist in shallow aquifers in other glaciated areas of Wisconsin and result in similar levels of arsenic in groundwater.

A limited number of water samples from the rest of Wisconsin suggests arsenic sources are also present in those places, but little detailed hydrogeologic information exists as to exact nature of arsenic sources and their location in the stratigraphy.

When implemented in 2006, Wisconsin's regulatory standard for arsenic in drinking water will be consistent with the federal standard of 10 μg/L. People who daily consume water with 10 μg/L have a greater than 3 in 1,000 increased risk of developing bladder or lung cancer. New Jersey recently adopted a stricter standard (5 μg/L) to achieve a level of 1.5 in 1,000 increased risk of cancer. Wisconsin has no requirement to test new or existing private residential wells for arsenic. A statewide strategy is needed to alert homeowners to the need to test for arsenic in groundwater.

Keywords: arsenic, groundwater, Wisconsin

The Arsenic Special Casing Area in the Fox Valley: An Example of Data Integration and Interagency Cooperation from Initial Research to Rule Development

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High concentrations of arsenic and other heavy metals in private water wells present a potentially serious public health problem for much of the Fox Valley region. The metals are naturally occurring, and they are released by a complex variety of chemical processes. Oxidation of sulfide minerals, including sulfide cement in the St. Peter sandstone aquifer, is an important mechanism caused by a decline in the regional water table attributed to heavy groundwater use in this region of rapid development.

Because the minerals containing the arsenic occur throughout the region, the Department of Natural Resources (DNR) determined that scientifically based guidelines were needed to assist well drillers in constructing wells that had the highest probability of avoiding the contaminated waters. Wisconsin Geological and Natural History Survey (WGNHS) and DNR worked together to assemble and integrate existing well construction data, match wells with addresses provided by Winnebago County, interpret the geology and geometry of the aquifer system, and prepare a series of digital primary and derivative maps.

The final set of township-scale maps specify a minimum casing depth required by DNR for completing a well within a specific quarter section. This easy to use set of maps represents integration and manipulation of spatial data sets including elevation and depth below surface of various water-bearing formations, and determination of required depth by subtraction from the DEM.

Wisconsin DNR identified an urgent public health concern, and provided both data and assistance with processing and interpretation that enabled WGNHS to accelerate bedrock mapping studies already underway. The cooperation and sharing of digital topography, address grids, and digital orthophotography by the involved counties was essential to the success of this project. The result will be a valuable tool for water resource management and for addressing water supply and quality issues in the comprehensive planning process.

Keywords: arsenic, sulfides, water quality, well construction

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

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The arsenic concentrations in the groundwater and its migration patterns on a Shawano County site used for a arsenic pesticide storage and disposal site in the 1950s provide a unique opportunity to assess the success of a remediation effort. A small shed on the property was used to store unused liquid formations of arsenic, possibly sodium arsenite. Steel barrels were buried in a shallow 10-foot square pit next to the shed. In 1984, the site was cleaned up with the removal of the hazardous sources from the shed and the burial pit. In addition, two feet of soil surrounding the barrels were removed. Prior to the clean up, arsenic levels in the soils ranged from 8,000-57,000 ug/g. Eight groundwater monitoring wells were installed on the site at that time.

In 2001, the monitoring well near the former storage area was found to contain 38,858 ug/l and a down gradient well 60 ft. to the southeast contained 914 ug/L of arsenic, both exceeding the Wisconsin Department of Natural Resources' enforcement standard of 50 ug/l As. Dissolved arsenic levels in two of the contaminated monitoring wells for the last fourteen years, including monthly results for the years 2001-2004 suggest that some contaminant source remains on the site. In 2004, an additional monitoring well was installed 135 feet southeast of the burial pit at the south property line. Dissolved arsenic concentrations in samples from the new well ranged from 242-325 ug/L. Private drinking water wells to the west and north of the site have arsenic concentrations of 4.0-4.8 ug/L. An interpretation of the groundwater hydrology of the site is also discussed.

Keywords: arsenic, groundwater

*Note: This is a student presentation.

In-Situ Permiable Reactive Barriers Using Adsorptive Media for Remediation of High Level of Organic- and Inorganic Arsenic Contaminated Groundwater

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One of the two largest arsenic contaminated sites in the world exists in the Lower Menominee River, Wisconsin. In order to remediate groundwater contaminated with extremely high level of arsenic [0.6~2,038 mg/L] in this area, there is an urgent demand for a highly effective, reliable, and economical technique. Permeable Reactive Barrier (PRB) technology may be a practical and economical alternative to conventional groundwater remediation systems for treating arsenic contaminated groundwater. In this study, hydrous ferric oxide (HFO) incorporated porous natural-occurring aluminum silicates, diatomite, were prepared to compare arsenic removal efficiencies with ZVI that have been successfully applied for PRB application. The synthesis methods of HFO incorporated porous diatomite studied herein are efficient for arsenic removal process, environmentally acceptable, cost-effective, and simple for synthesis process. Through batch tests, the HFO (40%) impregnated diatomite showed faster initial sorption rates and higher removal capacities than granular activated carbon or zero-valent iron (ZVI) in both groundwater samples that have different arsenic species and concentrations. In addition, the column studies simulated to PRB application showed that HFO (40%) diatomite preloaded with GAC showed much higher removal performances than ZVI/sand (50% w/w). Since less mass is needed and longer treatability time can be obtained, HFO impregnated diatomite is a promising adsorptive media for PRBs application in high level of inorganic- and organic arsenic contaminted groundwater.

Keywords: arsenic, hydrous ferric oxide, impregnation, PRB, groundwater

SESSION 2A:
Runoff and Infiltration Studies
Thursday, March 3, 2005
3:55 – 5:15 p.m.

Rainfall-Runoff Modeling of Small Urban Watersheds in Milwaukee, Wisconsin

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Hydrologic models are used by engineers, scientists and planners to simulate the rainfall-runoff process for small urban watersheds. These rainfall-runoff models are commonly not calibrated, primarily because of a lack of data on observed rainfall and watershed runoff. Despite the lack of calibration, and the resulting model uncertainty, these models are widely used to plan and design extensive public infrastructure for managing the quantity and quality of stormwater.

This study evaluates the performance of uncalibrated and calibrated rainfall-runoff models. Three commonly used rainfall-runoff models were applied to two small urban watersheds in Milwaukee, Wisconsin – the Lyons Park Creek watershed and the Eighteenth Street Storm Sewer watershed. The United States Geological Survey measured rainfall and runoff in each of these watersheds during 2002 and 2003. The three models applied to the watersheds were the Rational Method, the Storm Water Management Model (SWMM), and the Soil Conservation Service (SCS) model. First, uncalibrated models were constructed using default model parameters or parameters estimated from literature review. The uncalibrated models were used to simulate ten recorded rainfall events in each watershed. The peak flows and runoff volumes simulated by the uncalibrated models were compared to observed data, and the error associated with each model assessed. The models were then calibrated to the observed runoff data. SWMM appeared to perform the best, while the SCS models were generally the poorest performers.

Keywords: stormwater, runoff, urban, modeling, calibration

Design and Use of Small-scale Infiltration Practices

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Urbanization increases the rate and volume of stormwater runoff, degrades water quality, and reduces groundwater recharge. Traditional approaches, which rely heavily on storage, control peak runoff rates and reduce water quality impacts, but do not address increases in runoff volume or decreases in groundwater recharge. Infiltration practices offer a means of addressing these deficiencies.

We have developed a numerical model that can be used for designing and evaluating the performance of small-scale infiltration practices, such as bioretention facilities. The model, called RECARGA, continuously simulates the water budget of an infiltration practice, accounting for infiltration, percolation to groundwater, underdrain flow, surface spill, and evaporation. Based on simulations with RECARGA we have made the following generalizations: (1) it is ineffective to leave some impervious surfaces untreated and attempt to compensate by constructing a larger facility for the areas treated; (2) treating runoff from pervious surfaces is much less effective than treating runoff from impervious surfaces; (3) the performance of multiple bioretention facilities with the same facility area ratios is the same as the performance as of a single facility; (4) the ponding zone provides the greatest increase in stayon per inch zone compared to the root and storage zone.

Keywords: infiltration, bioretention facility, design

*Note: This is a student presentation.

West Campus Cogeneration Facility Compensatory Recharge Design I: Integrated Modeling Approach

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The Water Loss Approval for the West Campus Cogeneration Facility being constructed by Madison Gas & Electric calls for compensatory groundwater recharge of 80.4 MGY. We used an integrated modeling approach to develop a conceptual design and choose between two potential sites (Wexford Park and Odana Hills Golf Course) where pumping will be from existing ponds. First, annual runoff volume available at each site was predicted with rainfall-runoff models. Second, we simulated the pumping effect on the stage fluctuation of the ponds. Third, we used finite difference and analytical element groundwater models to evaluate water table mounding impacts of the estimated groundwater recharge rate and to predict travel times to local water supply wells. Additionally, field investigations at both sites and analytical modeling provided data for decision making and design.

Although both sites are feasible, approximately one half as much runoff is available at the Wexford site. Impacts from the proposed groundwater recharge will be significant at the Wexford site during periods of low flow when extensive mudflats are exposed resulting in a change from an open pond to wetland ecosystem. Simulated groundwater travel times at both sites indicate that the downgradient supply wells will not pump infiltrated water for at least 100 years, and a minimum distance of 30 feet will exist between the trench bottom and mounded water table. Based upon these results, we are proceeding with detailed design at Odana Hills Golf Course.

Keywords: modeling, recharge, infiltration, runoff, mounding

West Campus Cogeneration Facility Compensatory Recharge Design II: Predicting Unsaturated Zone Behavior

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The challenge of predicting long-term infiltration rates for an enhanced groundwater recharge system is made more difficult by the potential development of a clogging layer on the infiltration surface. Clogging layers can develop due to deposition of suspended solids in the source water or biofilm growth. Soil infiltration rate is a key design parameter dictating the area required for an infiltration basin or trenches to achieve the recharge required for the West Campus Cogeneration Facility. In the absence of soil clogging, the long-term infiltration rate for a flooded basin or trench can be estimated as the hydraulic conductivity of the wetted soil below the infiltration surface (10^{-3} cm/s for Wexford Park and 10^{-4} cm/s for Odana Hills). Infiltration rates through a clogging layer a few millimeters thick can be an order of magnitude or more lower, causing ponding above and unsaturated conditions below. With clogging, these sites would have very similar infiltration rates in spite of their geological differences. At the target recharge rate of 80.4 MGY, suspended sediment loading rates will likely be high enough to reduce design life, even with pretreatment of stormwater by settling in ponds and sand filtration. This may necessitate use of microfiltration capable of removing sub-micron particles. Until more detailed information is available on the make up of sediment in stormwater and the development of clogging layers, a conservative approach will be necessary to design successful enhanced recharge systems.

Keywords: enhanced groundwater recharge; unsaturated hydraulic conductivity; infiltration rate; soil clogging

SESSION 2B:
Groundwater Policy and Planning
Thursday, March 3, 2005
3:55 – 5:15 p.m.

Wisconsin's New Groundwater Protection Act - A first step towards regional groundwater management and completing the water cycle

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Groundwater pumping in Wisconsin has become a significant concern to scientists, water supply managers, and citizens, despite the fact that the state receives over 30 inches of rainfall per year, has abundant lakes, streams, and wetlands, and two of the Great Lakes touching its borders. In the last century, pumping caused by a rapidly growing population and associated demands for water has reduced groundwater levels by 450 feet in the suburban Milwaukee area, and by more than 300 feet in the Lower Fox River Valley near Green Bay. In addition, public attention bubbled to the surface in 1999-2000 when a proposed water bottling plant showed that state laws didn't prevent impacts to nearby springs, wetlands, or trout streams if wells were constructed to provide the water.

In the spring of 2004, Wisconsin enacted a new groundwater protection law that expands the State's authority to protect critical water resources from over-pumping and takes the first step in addressing water quantity management on a regional scale. Specifically, 2003 Wisconsin Act 310 sets new standards and conditions for approval of high capacity wells that may affect critical surface water resources, such as springs and trout streams. It also creates Groundwater Management Areas (GMA's) to address regional drawdowns in the deep sandstone aquifer underlying large portions of Southeastern Wisconsin and the Green Bay area. The law also establishes a Groundwater Advisory Committee to make recommendations about (1) management strategies in the designated GMA's; (2) other areas of the state where regional groundwater management is warranted, and (3) further legislation to minimize the adverse impacts of high capacity wells.

This presentation will summarize the key features and limitations of the Groundwater Protection Act, as well as illustrate how science and policy interacted in crafting legislation that addresses a complex water resource management issue.

Keywords: groundwater pumping, high capacity wells, water policy, regional water management

Wisconsin's 2004 Groundwater Quantity Management Law: What do we need? What did we get?

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Wisconsin 2003 Act 310 was passed to address the impacts of groundwater pumping on surface waters and to manage the large drawdown region in the eastern part of the state. Some provisions of the Act include:

- Creating groundwater protection areas (GPAs) within 1200 feet of trout streams, outstanding resource waters (ORWs), and exceptional resource waters (ERWs).
- Requiring that new high capacity well approvals, subject to certain exemptions, may not allow significant adverse environmental impacts to water bodies within GPAs nor to large springs (greater than 1 cubic foot per second).
- Creating groundwater management areas (GMAs) in parts of the large drawdown region, and setting processes for developing management tools.

The legislation was described by its two main sponsors as a "good first step," who also recognized that substantial gaps still exist in groundwater quantity management. The gaps include:

- The law offers no protection for any wetlands, 99% of lakes, 92% of streams, and 99% springs.
- A 1200 foot buffer still does not shield trout streams, ORWs, and ERWs from impact.
- Processes are not in place to manage the surface water impacts of multiple pumpers.
- Procedures for developing processes to manage eastern Wisconsin drawdowns are vague.

These and other gaps are the result of a give-and-take among interest groups and reflected the limits of the political envelope of the time. Though environmental interests pressed for stronger protections; business, farm, and municipal interests pressed for a more limited approach. The more limited approach was advocated from fears of being excluded from the groundwater resource and of a burdensome regulatory process. Science could play an important role in achieving political acceptance of the next generation of groundwater quantity legislation, especially by identifying measures for significant adverse environmental impact risk and streamlining high capacity well approval processes.

Keywords: groundwater quantity, high capacity wells, legislation

Comprehensive Planning in Wisconsin: Are Communities Planning to Protect Their Groundwater?

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Legislation adopted in 1999 (*s. 66.1001 Wis. Stats.*) requires that by January 1, 2010 all communities that make land use decisions do so consistent with their comprehensive plan. The legislation outlines nine elements that must be included in each comprehensive plan. Though one of the nine elements specifically addresses agricultural, natural, and cultural resources, groundwater information or issues may be a factor in all nine elements.

To understand the extent to which groundwater is being addressed in Wisconsin's comprehensive plans thus far, and identify how government agencies and educational institutions could better assist communities in this aspect, we evaluated comprehensive plans that have been adopted and filed with the Wisconsin Department of Administration. We examined the presence of issues, goals and policies relating to several aspects of groundwater protection, including: water supply, wellhead protection, agricultural practices, waste management, remediation and more. These plans were also surveyed for the types of groundwater data/information they provided (e.g., soils, geology, groundwater susceptibility, existing or potential contaminants). Based on this information, a scoring system was designed to rate communities according to the extent they were planning to protect groundwater.

In addition, case studies on several groundwater protection tools that Wisconsin communities have implemented were conducted and documented. The goal of these case studies is to demonstrate how some communities have planned for and implemented groundwater protection in their community so that others with the intention to replicate the effort would be better prepared.

Keywords: comprehensive planning, groundwater, groundwater protection, case studies, plan evaluation

Incorporating Ground Water Sustainability into the Comprehensive Planning Process

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Sustainable development in ground-water using communities requires an understanding of the dynamics and quantity of the water supply available. Too many communities in Wisconsin haven't factored water supply into their development plans. As a result, there are many whose population density exceeds the ability of the ground-water system to support it.

The Town of Richfield, Washington County, is serving as a test case for incorporating analysis of ground water resources into the planning process. In a two-year study, the magnitude of the Town's supply has been assessed, and both the Town's leaders and populace have been apprised about the supply's limits. The Town began its comprehensive planning process shortly after the ground-water study began. It simultaneously adopted a moratorium on development to allow the plan and water study to proceed without the pressure from development decisions.

A number of intriguing scientific results have occurred in the water study. The hydrogeology consists of a complex sequence of glacial sediments over discontinuous dolomite. As a result, residents draw water from multiple aquifers which have spatially varied interconnections. A well water level and streamflow monitoring program coupled with GIS-based mapping have revealed the spatial and temporal variations of recharge. A Modflow model of the ground-water system allows testing of different development scenarios and the effects of sand and gravel pits on the water supply.

The policy results are particularly important. Protection of ground-water resources has become a significant component of the Town's plan. They have adopted a land use plan designed to minimize heavy demand and maximize water recycling. The Town Board is now drafting ordinances which will ensure continued resource protection in the future.

Keywords: ground-water resources, sustainability, comprehensive planning

POSTER SESSION
Thursday, March 3, 2005
5:15 – 7:00 p.m.

Insights from a Ground Water Model of a Rural Township: Richfield, Washington County, Wisconsin

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A detailed numerical ground water model of the rural township of Richfield, Wisconsin was developed in MODFLOW to aid officials in planning future development. Two major concerns were addressed: the change in the ground water table due to increased pumping and effects on surface water bodies. Detailed glacial stratigraphy and the underlying dolomite bedrock were integrated into the model and used in calibrating heads and fluxes to measured values. During model development and calibration, it was determined that integrating vertical anisotropy of the bedrock is critical to successful calibration. Further, in a ground water system dominated by glacial sediment with a wide range of hydraulic conductivities, the effects on the ground water table are limited, but the effect on stream and lake levels can be dramatic.

Keywords: MODFLOW, model, calibration, stratigraphy

*Note: This is a student presentation.

Design, Planning and Deployment of a Continuous Water-Quality Monitoring System on the UW-River Falls Campus – Student/Faculty Collaboration

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A state-of-the-art water-quality monitoring system is being developed on the UWRF campus. Students and faculty have collaborated to install three continuous monitoring stations along the South Fork of the Kinnickinnic River. In addition to the goal of improving the scientific understanding of this stream, a key goal is to involve undergraduate students in the process of designing, installing, operating, and analyzing hydrologic data. This project was funded through a UW-River Falls Foundation grant, with additional support from the City of River Falls.

As the project developed and instrumentation was obtained, a core group of students worked on the subsequent steps. A UW-River Falls student/faculty undergraduate collaborative grant was written and awarded to the first author, who also secured additional scholarship funding from the Kinnickinnic River Land Trust. Initially, the team leader (first author) worked closely with the second author to design, purchase, prepare, and participate in the installation of the field instrument shelters/piping.

The next phase involved learning how to operate each probe and sonde. Probes were then calibrated, and sondes deployed. The team leader then began training undergraduate assistants to participate in field maintenance, data collection, compilation, and analysis; field forms were developed to standardize these processes. A website is being developed to allow students and stakeholders access to real-time and archived data, and to a photochronology of the installation and data collection process.

Keywords: water quality, continuous monitoring, coldwater stream, hydrologic instrumentation, hydrology education

*Note: This is a student presentation.

Water Extractable Phosphorus (P) in a Silt Loam Soil and its Relationship to Bray-1 P, Total P and Runoff P

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Excessive phosphorus transfer from land to water can pose a significant threat to aquatic ecological systems. Understanding the mechanisms by which phosphorus is acquired by runoff and transported is important to improving land management and reducing phosphorus transfer. In this project, a series of digestions and extractions were performed to measure total phosphorus and extractable phosphorus in silt loam soils collected in southwestern Wisconsin. Total P was determined using a microwave digestion method. Water soluble phosphorus was determined in short-term experiments at various soil/solution ratios. All samples were then analyzed for phosphorus by inductively coupled plasma optical emission spectrometry. The results of these analyses were used to develop relationships between soil phosphorus concentrations and the water extractable phosphorus at different soil/solution ratios and in field runoff.

Keywords: total phosphorus, dissolved reactive phosphorus

*Note: This is a student presentation.

Local Capacity Building for Healthy Watersheds

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Everyone has heard about capacity building, but what is it really all about? How is capacity building achieved and sustained successfully at the local level? In this paper we will present results of pilot projects in Wisconsin and abroad that implemented a local capacity building model for healthy watersheds. Working with local stakeholders, the UWSP Global Environmental Management Education Center (GEM) and its partners are helping local leaders and citizens make informed decisions in watershed management.

We will feature three watershed projects near completion in Wisconsin and a new initiative in South Africa in the Kat River watershed involving GEM staff and students. Each of these unique projects has different geographic conditions, biophysical and socio-economic expectations and goals, stakeholders, and diverse sources of funding. However, they share the same goal—healthy watersheds and better managed water resources by building local capacity.

Through the Long Lake Project in Washburn County the UWSP Center for Watershed Science and Education (CWSE), the UWSP Center for Land Use Education (CLUE), and GEM partnered with the Long Lake Preservation Association to improve and augment the water quality aspects of land use planning (Smart Growth) underway at the township and county levels. The GEM Wisconsin Rivers Educator Network (WREN) is a citizen water monitoring initiative for secondary science teachers and their students to help improve the teaching of science and knowledge of water resources in the state. The Little Wolf Project joins CWSE and GEM in partnership with the Fox Valley Trout Unlimited Chapter and the Northeast Wisconsin Land Trust to bring about better understanding of water quality conditions in the Little Wolf watershed and to protect unique land resources in the watershed. The Kat River Project in South Africa is collaboration between Rhodes University, other South African agencies and GEM in a rural watershed initiative to create a locally managed river authority under the innovative 1998 South African Water Law.

Keywords: capacity building, watershed management, stakeholders,1998 South African Water Law, GEM Student Ambassadors

A New Quaternary Geologic Map of Walworth County, Wisconsin (with applications for regional and site-specific surface water and groundwater studies)

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The Wisconsin Geological and Natural History Survey began a program of systematic mapping of the Quaternary geology of the State (mostly by county) about 25 years ago. Mapping is compiled on 1:24,000-scale topographic maps; however, final maps are typically published at a scale of 1:100,000 along with a comprehensive report. Geologic mapping is based on standard field methods to including drilling. Field work is supplemented with the study of topographic maps, digital elevation models, and aerial photography. To date, maps and reports for about 35 counties have been published, are in press, or are currently being prepared. These publications have many uses, and a few applied examples related to groundwater include (a) determining hydrostratigraphic units in unconsolidated materials, (b) determining the role that Quaternary deposits play in groundwater contamination susceptibility, and (c) potentially locating some sources of naturally-occurring groundwater contaminants.

We present a new map (in preparation) of the Quaternary geology of Walworth County, Wisconsin. Our work updates some of the earliest detailed mapping done in this part of Wisconsin by W. C. Alden (U.S.G.S. Professional Papers 34 & 106, published 1904 & 1918, respectively), as well as a more recent map compiled by D. H. Hadley (1974, WGNHS open-file map, 1:62,500). Among many things, in our work we have (a) refined the sequence of deglaciation between the Green Bay and Lake Michigan Lobes, (b) mapped more extensive outwash deposits in the Kettle Moraine than previously recognized, and (c) considerably developed and refined contacts among map units. Color-infrared aerial photography and digital elevation models have been especially helpful in defining map units and understanding landscape evolution in this region. We will provide examples of our work in Walworth County as they relate to current and potential surface water and groundwater issues in the area.

Keywords: Wisconsin, Quaternary, geologic map, Kettle Moraine, glacial

High-Density Fiber-Optic Sensor Arrays

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Optical fibers can deliver light to chemical sensor regions and collect light modulated at the sensor region as response to a sensing event. One or more sensors can be placed in the regions near the fiber core where sensor molecules can interact with light. Optical fibers are flexible, immune to electronic noise, and allow for the separation of optical components from the sensing environment.

In previous work, sensors were located along a single fiber with spacings of the order of several meters, which was required for spatially resolved readout. Here, we report on an array of 100 optical fiber sensors contained in a square with a length of 6 centimeters employing only 2 optical fibers. By using a pulsed laser, each sensor could be interrogated and spatially resolved in this readout scheme. Fluorescein and rhodamine 6G served as sensor molecules.

Potentially, each element of such an array could consist of individual, specific chemical sensors, redundant sensors, or combinations of individual and redundant sensors. Also, fiber optic arrays could be used to monitor various parameters in water, such as pH, toxic analytes, and dissolved oxygen.

Keywords: fiber-optic, array, fluorescence, evanescent sensor, multiparameter sensing

*Note: This is a student presentation.

Hydrogeologic Investigation of the University of Wisconsin-Parkside Campus

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A hydrogeologic investigation of the University of Wisconsin-Parkside (UWP) campus was conducted as a class project for the Fall 2004 Applied Hydrogeology course. The UWP campus is located in southeastern Wisconsin, within the Pike River watershed and underlain by the Oak Creek Till and Silurian Niagara Dolomite. A network of 9 shallow (30 ft deep in till) and one deeper (100 ft deep in dolomite) monitoring wells located on campus were used to measure water level fluctuations, conduct aquifer testing (slug and pump tests), perform well development, and collect groundwater samples. Soil samples collected during well installation were examined and well drilling records were reviewed to prepare logs of borings for each well.

Cross sections were constructed to develop a conceptual model of the local hydrogeologic setting that suggests the shallow wells are screened in a thin continuous sand lense, confined above and below by lean clay, which generally follows surface topography. The potentiometric surface of the shallow water zone shows a groundwater mound beneath the topographic high coincident with the central campus complex that indicates radial flow. Additional study is required to determine if the groundwater mound is natural or due to artificial recharge around the subsurface building foundations. Slug test results show considerable scatter suggesting influence from the coarse sand pack of the wells. A pump test provides good drawdown, recovery, and distance versus drawdown data yielding hydraulic conductivity values consistent with sand and storativity values consistent with confined conditions.

Keywords: hydrogeology, pump test, confined aquifer

*Note: This is a student presentation.

An Evaluation of the Water Quality in Relation to Land Classification of Three Drainage Ditches in the Sand Plains of Central Wisconsin

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The Buena Vista Marsh System is located within the sand plains of Central Wisconsin. The area, among other things, is noteworthy as an important habitat for the Prairie Chicken and also as a major area for cranberry production. The majority of the marshland in the area was drained and channelized in the early 1900s for agricultural purposes. The student AWRA chapter of nearby University of Wisconsin-Stevens Point has been monitoring the water quality of the drainage ditches since 1998. There had been a previous presentation about the goals of the project at the AWRA Wisconsin State Conference in 2000, stressing student involvement. The current project looks at the effects of land use/land cover as it affects water quality of the three main channels sampled. Differences in Nitrate, pH, DOC, and other parameters measured in the channels seemed to be related to surrounding land use and sampling site characteristics. As the project continues, differentiating between runoff and groundwater contributions to the channels is a possible direction for future work. The project will continue for many years, giving students first-hand experience in field, laboratory, and analytical procedures. (A version of this presentation was made at the 2004 National AWRA Conference.)

Keywords: water quality, drainage ditches, land-use

*Note: This is a student presentation.

Deposition of Hazardous Airborne Contaminants to the Great Lakes: Operational Forecasts of Unscheduled Atmospheric Releases

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In this presentation I will describe a real-time atmospheric dispersion and deposition modeling system that is freely available for use by civil authorities in the Great Lakes region. This modeling system predicts the movement of airborne material following an unscheduled release, such as an explosion involving toxic, biological and/or radioactive material. Meteorological forecasts from a weather prediction model are used to drive a Lagrangian dispersion and deposition model. Results, including spatial plots of deposition and airborne concentrations, are posted to a web server four times daily.

Predictions of the dispersion and deposition of airborne material resulting from unscheduled hazardous releases can be used to address a variety of important emergency response issues. These issues include the deployment of environmental sensors and hazardous material personnel following a toxic/biological/radioactive material release, evacuation decisions, as well as planning and training exercises corresponding to simulated releases.

Keywords: atmospheric, hazardous, deposition, toxic, dispersion

Determining Macropore Model Parameters with Automated Lysimeter Fluxmeter Data

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Flow through soil macropores such as animal burrows, worm holes, root channels and soil structural voids, are responsible for the rapid movement of water and solutes from the soil surface to the root zone and beyond to the local water table. Numerous models exist for capturing the effect of macropores on the movement of water and solutes in soils. In order to assess the ability of models to simulate preferential flow adequately, field measurements in undisturbed sites with relatively well defined boundary conditions are needed. The Automated Lysimeter Fluxmeter (ALF) was developed to monitor the real-time flux of water and solute flow into an Automated Equilibrium Tension Lysimeter (AETL). The data collected by the ALF will be used to parameterize macropore/matrix models contained in a new version of HYDRUS 1-D, a widely used modeling package that describes water, solute and heat flow in saturated and unsaturated porous media. This new version contains several dual porosity/dual permeability models to accommodate macropore flow. Different model outputs are compared with each other and with ALF data. The complexity of each model and the ease with which they can effectively capture macropore flow are discussed.

Keywords: preferential flow, macropore flow, unsaturated flow, solute transport, lysimetry

*Note: This is a student presentation.

Groundwater Pollutant Transfer and Export from a Northern Mississippi Valley Loess Hills Watershed

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Nitrate and pesticide residues in groundwater have ecological implications when pollutant-bearing groundwater discharges to surface waters. The groundwater contribution of nitrate, pesticides, and phosphorus from agricultural landscapes to surface water systems has received little attention in the Northern Mississippi Valley Loess Hills of Southwestern Wisconsin, where more than 100 water bodies are listed as impaired on state 303(d) lists. In this region, nearly 25% of wells exceed the NO_3-N standard, 11% contain atrazine residues, 32% contain alachlor residues, and 34% contain metolachlor residues.

In order to gain a better understanding of non-point pollution in agricultural landscapes, the contribution of pollutants loading from both surface runoff and groundwater to the Fever River were studied. Baseflow and event flow samples were analyzed for nutrient and pesticides to determine relative contribution from groundwater and surface water runoff, in addition to determining the total pollutant load. An extensive sampling of groundwater discharge features was also performed. Samples were analyzed for nutrients, pesticides, dissolved gases, and age-date. These samples will help determine if there is significant denitrification occurring and whether basin groundwater quality is more or less in equilibrium with the present land-use and management practices.

Keywords: non-point pollution, agriculture, groundwater, nutrients, pesticides

Atrazine Concentrations in Mill Creek, Portage/Wood Counties, Wisconsin

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Atrazine is a commonly used herbicide in corn production that has the potential to contaminate both surface water and groundwater. The impacts of atrazine on aquatic ecosystems are not completely understood, although a variety of possible impacts have been conjectured. Our ability to understand how atrazine impacts streams is limited by our inability to predict likely atrazine concentrations and the duration of those concentrations. Previous research suggests atrazine loss can be greatest near the period of application. In this one-year study, atrazine concentrations were measured in Mill Creek in Wood and Portage Counties. The study watershed is 215 km^2 with approximately 40% of its land in crop production. This study was designed to understand how atrazine concentrations vary during and after the herbicide application period. Grab samples were collected twice per week at the four sample locations in the watershed. Samples were analyzed for atrazine, other triazines, several atrazine metabolites, and chloroacetanilide herbicides. Other water quality parameters and streamflow were also measured. The study showed atrazine concentrations in the stream were closely tied to precipitation events and streamflow, and decreased following the likely period of application. During the spring and summer of 2004, atrazine was found in approximately 60% of the samples. The peak atrazine concentration followed a likely application period, but concentrations persisted in the stream well into the summer at lower concentrations.

Keywords: atrazine, herbicides, nonpoint pollution

*Note: This is a student presentation.

Total Suspended Solids-Turbidity Correlation in Northeastern Wisconsin Streams

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To estimate sediment loading, total suspended solids (TSS) and turbidity are sampled with automated sampling equipment within the Lower Fox River watershed in northeastern Wisconsin. Knowledge of sediment loading is fundamental to assessing non-point source pollution. However, collection and analysis of sediment samples is costly. These costs could be reduced if TSS could be accurately estimated from continuously monitored turbidity.

This poster presents 2003-2004 turbidity and storm event sample data for Apple, Ashwaubenon, Baird, and Duck Creeks. Displayed are comparisons between sites, and within site comparisons for seasonality, rising versus falling stage, and event versus low flow. The water sample collection and analysis adhered to established USGS methods. YSI-6200 multi-parameter sondes were deployed for continuous turbidity measurement.

Linear regression (R^2) ranged from 0.78-0.98 for the different streams. We hypothesize that the weaker relationships are due to variances in hydrologic response and watershed land use. Also, certain sonde data were excluded due to equipment-associated false spikes in turbidity.

In conclusion, continuous monitoring of turbidity appears to offer a viable alternative for TSS estimation in these Lower Fox River watershed locales. Evaluation of pollutant transport under changing land use could be accelerated with this straightforward information alternative.

Keywords: turbidity, total suspended solids

*Note: This is a student presentation.

The Distribution of Phosphorus in Dorn Creek

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Phosphorus is the limiting nutrient in many of Wisconsin's lakes and streams and thus is primarily responsible for water quality degradation caused by excessive algal blooms in surface waters. The primary means through which phosphorus enters surface waters includes urban stormwater, treated municipal (and industrial) wastewaters, and agricultural runoff. After reaching streams, little is documented about the fate of phosphorus within the stream. The purpose of this study is to examine the distribution of phosphorus within Dorn Creek in Dane County, WI.

Measurements of stream characteristics including stream and channel width, water depth, sediment thickness, stream gradient, sediment particle size, sediment volatile solids, and sediment water content were made at approximately 50 sites along intermittent and perennial stretches of Dorn Creek. Sediment cores were collected at every site, and analyzed for total phosphorus (TP) concentration in 1 cm or 2.5 cm sub-samples with respect to depth. The vertical and lateral distribution of TP in the stream sediment was then examined. The data indicates that the vertical distribution of TP concentration decreases with depth in the sediment. The lateral distribution of TP is highly variable and the TP concentration appears to be dependent upon sediment characteristics such as the organic content, particle size, and sediment thickness.

Keywords: phosphorus, stream, sediment, distribution

*Note: This is a student presentation.

Potential Applications of Biosensors in Water Monitoring

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The entire length of an optical fiber can be employed to support a large number of diverse sensor regions allowing for distributed sensing of many parameters over a large area. The status of these sensor regions can be interrogated spatially resolved using laser pulses propagating in the core of the fiber.

In this work organically modified sol-gel glasses containing encapsulated proteins were studied as materials for the development of fiber-optic biosensors. Sol-gel glasses were synthesized under mild conditions and deposited onto the surface of unclad multimode optical fibers using a multi-layer coating technique. The porosity of these materials, their chemical stability, and their non-toxic nature, as well as the fact that the protein retains its functionality in these glasses make these systems promising candidates for the remote monitoring of aqueous environments ranging from potable water distribution systems to lakes and rivers for the presence of pollutants.

Keywords: biosensors, sol-gel glasses, optical fibers, encapsulation, distributed sensing

*Note: This is a student presentation.

Monitoring and Modeling of Enteric Pathogen, Microbial Indicator and Real-time Environmental Data at Inland Beaches in Madison, Wisconsin

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A comprehensive beach water quality study was undertaken at three beaches in Madison, WI during the summers of 2002 and 2003. Microbial, physicochemical, and weather-related parameters were monitored. Automated instruments collected real-time rainfall, wind speed and direction, wave height, temperature, turbidity, dissolved oxygen, and solar radiation data. Changes in water quality were communicated to beach users in near real-time via the WEB. Instruments were also programmed to collect microbial samples when specific environmental conditions were met. Using a combination of established and cutting-edge technologies, water samples were analyzed for a battery of fecal indicators (fecal coliform, *E.coli,* enterococci and F+ coliphage) and pathogens (*E. coli* O157:H7*, Salmonella, Cryptosporidium* and *Giardia*).

Statistical analysis was conducted to explore relations between pathogens and microbial indicators, pathogens and real-time environmental parameters, and microbial indicators and real-time environmental parameters. Of these three analyses, only the microbial indicator and real-time environmental analysis resulted in a statistically significant relation. Using this relation, a predictive model was constructed to provide timely and relevant assessment of health risks from pathogenic organisms to help with beach closure decisions.

Conclusions:

- The model developed was able to predict *E. coli* levels above closure limits using real-time environmental data.
- Model parameters included antecedent precipitation, the Universal Soil Loss Equation erosivity index, water temperature, air temperature, wave height, wind speed and direction and specific conductance.
- Neither microbial indicators nor environmental data were useful for prediction of pathogen occurrence.

Keywords: Pathogens, beaches, *E.coli* O157:H7

BANQUET SPEAKER
Dale Robertson
U.S. Geological Survey
Thursday, March 3, 2005
7:00 p.m.

The Rehabilitation of Lake Delavan

Prior to 1980, the water quality in Delavan Lake was ranked one of the worst lakes in the state, with the lake experiencing frequent algal blooms and a fishery dominated by rough fish. To improve the lake's water quality, one of the most comprehensive lake rehabilitation plans ever developed was implemented to shift the lake from a hypereutrophic condition back to a mesotrophic condition. The plan was to treat the sources of the problems (reduce external and internal phosphorus loading and rehabilitate the fishery), rather than treat the individual symptoms observed. Each component of the plan had varying degrees of success. Reduction of external phosphorus loading was not very successful and resulted in phosphorus concentrations in the lake soon returning to near the pretreatment concentrations. The effects of the return of high phosphorus concentrations on water clarity, however, were offset first by a planned biomanipulation and later by the invasion of zebra mussels. With increased clarity, there has been extensive macrophyte growth and abundant filamentous algae. Twenty-five years since original rehabilitative efforts began, the fishery and water clarity in the lake is still much better than it was in 1980. However, without reducing the true sources of the problems to the extent needed, the improved water quality in Delavan Lake is in jeopardy.

Biography

Dale Robertson has been a research hydrologist with the U.S. Geological Survey in Middleton, Wisconsin since 1991. He received a B.S. from St. Norbert College, a M.S. and Ph.D. in Limnology and Oceanography from UW Madison, and spent two years on post-doc at the University of Western Australia. Much of his current research deals with lake eutrophication issues throughout the country and with developing regionalization schemes to describe present and potential water quality in streams.

SESSION 3A
Groundwater Quality Investigations
Friday, March 4, 2005
8:30 – 10:10

Evidence for Denitrification in Wisconsin Cranberry Production

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Does cranberry bed N-cycling have any similarity to N-cycling in undisturbed wetlands? In wetlands, denitrification rates are usually high in poorly drained well-fertilized systems. However, cranberry beds are located in acidic and saturated soil conditions, where nitrification and denitrification rates are expected to be low. We are characterizing groundwater nitrification and denitrification in cranberry beds with contrasting hydrological traits. The upland, seven year old bed, was located on deep, coarse sand with a deep water table, while the 60 year old lowland bed had a peat substrate with a shallow water table. We sampled groundwater and dissolved gases along transects through the bed at three different depths every 15 days from June to September. We analyzed dissolved NO_3^-, NH_4^+, and total N by flow injection, and analyzed dissolved gasses by GC-MS. In the lowland bed, NH_4^+ and organic N were the dominant species at all the depths, while nitrate was present in lower concentrations (less than 1 ppm). In contrast, nitrate dominated mineral N in the upland bed, with NO_3^- concentrations from 1 to 4 ppm and NH_4^+ concentrations below 0.1 ppm. Despite the low pH and prevalent anoxic conditions found in the peat-based lowland bed, we found evidence of nitrification in this bed. All the gas samples showed evidence of denitrification. Cranberry beds appear to retain some wetland functions.

Keywords: denitrification, cranberry, nitrification, groundwater

*Note: This is a student presentation.

Investigation of Three Flowpaths of Different Lengths, Allequash Basin, Vilas County, Wisconsin

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There are numerous lakes, streams, and wetlands in Wisconsin that are well connected to the groundwater system. Consequently, the chemistry of groundwater may appreciably influence the chemistry of surface waters. Tools that identify the source areas of recharge and the geologic controls on groundwater chemistry are therefore crucial to understanding and protecting both groundwater and surface water. In this study, monthly (June-November, 2004) groundwater samples were taken along three transects located within the Allequash basin, a sub-basin within the Trout Lake watershed, Vilas County, Wisconsin. These samples were analyzed for the isotope $\delta^{87}Sr$, as well as major ion concentrations, iron, and dissolved carbon species. Using these data, the effects of transience and the geologic factors controlling the chemistry of groundwater along these paths from point of origin to discharge point were investigated. Initial results indicate that well nests adjacent to lakes show more ion variability than well nests located farther away from the lakes. Well nests located closer to the lakes show that alkalinity concentrations within the nest can differ by as much as a factor of seven, while within the well nests located farther away from the lakes alkalinity concentrations only differ by a factor of two. Cation data also show a similar trend. An existing three-dimensional groundwater flow model of the Trout Lake watershed was modified and refined to delineate lake capture zones and characterize seasonal chemical variability within the Allequash basin.

Keywords: groundwater, water chemistry, isotopes, flow paths, groundwater flow model

*Note: This is a student presentation.

An Assessment of Wisconsin's Natural Attenuation Closure Protocol.

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The State of Wisconsin has had approximately 19,000 leaking underground petroleum storage tank (LUST) sites. In 1996 Wisconsin administrative rule changes allowed site closure on the basis of remediation by natural attenuation. Once the regulatory agencies (WI DNR or WI Dept. of Commerce) judge evidence to be sufficient to assume that natural attenuation processes are controlling the plume, sites are closed and monitoring wells are abandoned. Currently there is no post-closure monitoring to evaluate the assumptions made at the time of closure. To assess the effectiveness of protocols used to make closure decisions for sites with residual contamination we have established a two component study. First we have built a database of information extracted from a subset of closed LUST sites included on the Wisconsin GIS Registry of Closed Remediation Sites. Information from this database is being used to determine if information collected prior to closure was sufficient or appropriate to constrain directions of plume migration and to demonstrate stabilization or decreases in contaminant concentrations within the plume. The second component consists of field studies at a small number of sites selected from the database. Two of the field studies were initiated during the summer of 2004. At these sites we re-established a monitoring system similar to the system at the time of closure, and also added additional monitoring points. We sampled for gasoline contaminants to determine changes in the contaminant distribution since the time of closure.

Preliminary results from the field studies show that the leading edges of the contaminant plumes have advanced relative to the assumed positions at the time of closure, suggesting that the plumes had not stabilized at the time of closure.

Keywords: natural attenuation, petroleum, protocol, LUST

*Note: This is a student presentation

Has Acid Deposition Affected the pH of Wisconsin's Groundwater?

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Human influences on atmospheric chemistry are evident in Wisconsin, where the average pH of rainfall is usually less than 5.0. The effects of acid deposition on surface water quality in this state are well documented, but little attention is given to the study of its potential effects on Wisconsin's groundwater.

Groundwater quality data obtained from the Wisconsin Department Natural Resources for 33 upgradient and side-gradient monitoring wells at nine solid waste disposal sites located in various parts of Wisconsin are used to study pH trends in groundwater. These data sets, which include pH, alkalinity, and total hardness, date back to the early 1980s, spanning a minimum time period of 15 years. Statistically significant ($p < 0.2$) downward trends for pH exist at each of the nine study sites, including three where the geologic substrates have high (>20%) carbonate content; however, most of these trends become less steep or disappear during the 1990s. If acid deposition is the cause of these changes in pH, then stabilizing values during the past decade might reflect the state-mandated reductions in SO_2 emissions that have occurred over the last 20 years.

Keywords: groundwater, pH trends, acid deposition

A Comparison of Enzyme-Based Total Coliform/*E. coli* Tests for Groundwater Monitoring

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Since 2002, the USEPA has approved ten enzyme-based total coliform and *E. coli* detection tests for examination of drinking water. Differences in the ability of some of these methods to detect total coliform and *E. coli* as well as suppress a false positive response from *Aeromonas spp*. have been reported. As a result, this study was undertaken to elucidate the strengths and weaknesses of each method. Water samples were collected from three geographically and chemically diverse groundwaters in Wisconsin (northern Wisconsin site, central Wisconsin site and a southern Wisconsin site). One-hundred milliliter aliquots were individually spiked with low (<10) and high (50-100) amounts of five different total coliform species (*Serratia*, *Citrobacter*, *Enterobacter*, *E. coli* and *Klebsiella*) to test the capacity of each product to both detect and enumerate the spiked organisms. In addition, 100 milliliter samples were independently spiked with two different strains of *Aeromonas spp*. at six different levels to assess the ability of each enzyme-based test to suppress *Aeromonas spp*. Test results for each sampling site indicated that most enzyme-based products were able to detect total coliform and *E. coli* with some exceptions. The results indicated that there were differences in the ability of the enzyme-based methods to quantify total coliform and *E. coli* in the different water samples. Major differences in the ability of the tests to suppress *Aeromonas spp*. and *Aeromonas spp*. strain types were observed. Analysis of the data indicated that wide variability exists among USEPA approved tests to detect and quantify total coliforms as well as their ability to suppress *Aeromonas spp*. Further research with enzyme-based methods is needed to increase the amount of data to better understand their implications.

Keywords: total coliform, E. coli, enzyme-based tests

SESSION 3B
Sediment and Nutrient Issues in Surface Waters
Friday, March 4, 2005
8:30 – 10:10

The Effects of Urbanization on Baird Creek, Green Bay, Wisconsin

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The Baird Creek watershed is rapidly changing from agricultural to urban land use. This project assessed the effects of urbanization on stream quality through real-time monitoring of several water quality parameters, collecting storm event and baseflow samples for sediment and phosphorus analysis, and evaluating fish and macroinvertebrate populations.

In 2004, sampling was conducted at three locations on Baird Creek: an agricultural tributary, a tributary transitioning to urban land use, and the main channel downstream of the confluence. Water samples were analyzed for total suspended solids (TSS), total phosphorus, and dissolved phosphorus. A YSI multi-parameter sonde at each location recorded temperature, pH, dissolved oxygen, turbidity, conductance, and depth.

Storm event concentrations of TSS ranged from 29 to 996 mg/L for the agricultural watershed and from 26 to over 2,000 mg/L for the urban tributary. Analyses related biota and water quality to land use, evaluated the fraction of dissolved phosphorus, and determined a relationship between TSS and turbidity. Overall, this study will assist the City of Green Bay and the Baird Creek Preservation Foundation in making informed land management decisions to protect the unique habitat of the Baird Creek Greenway.

Keywords: stream monitoring, water quality, urbanization

* Note this is a student presentation.

Phosphorus and Sediment Export in streams in the Lower Fox River Watershed

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Previous studies have shown that tributaries in the lower Fox River subbasin disproportionately contribute high sediment and phosphorus loads to the Fox River and lower Green Bay. A better understanding of the phosphorus and sediment yields and forms in which phosphorus is delivered is needed to manage tributary loads and improve our ability to assess basin-wide source areas and estimate future loads. In 2003, a cooperative, multi-year monitoring program designed to quantify sediment (suspended solids, TSS), total phosphorus (TP), and dissolved phosphorus (DP) loads and yields from five key tributaries was started. The tributaries include Apple, Ashwaubenon, Baird, and Duck Creeks, and the East River. Each tributary was sampled during 10-12 events plus periodically during baseflow. The majority of events were associated with above normal spring rains, including the second wettest May on record.

Median event concentrations were greater than 0.34 mg/L for TP, 0.13 mg/L for DP, and 100 mg/L for TSS. TP concentrations equaled or exceeded 2 mg/L at all 5 sites, and exceeded 2 mg/L during 3 separate events at the Baird Creek station. Median DP/TP ratios during events ranged from 0.38 to 0.54 and from 0.42 to 0.79 during low flow conditions. Constituent load estimates and watershed yield comparisons will be presented. Consistent with other studies done in the basin, it appears that DP makes up the majority of phosphorus being transported by streams in this area.

Keywords: phosphorus, stream monitoring, water quality

Predicting Nutrient and Sediment Loading to Streams to Prioritize Riparian Buffer Implementation

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Prediction of stream sediment and nutrient loads using landscape characteristics is useful for identifying problem areas and prioritizing conservation efforts. There is a particular need to build regional models that describe landscape-water quality relationships in different geographic settings. We constructed regression models from a large set of GIS-derived landscape metrics to predict loads of total phosphorus, total nitrogen, nitrate, and suspended sediment in streams across Wisconsin. The landscape metrics included measures of land cover, slope, soils, roads, and stream networks, and were calculated for the entire watershed and for three riparian zone widths. Models were fit to load estimates calculated from stream samples and U.S. Geological Survey flow records.

The best statistical models used few variables (1-4), but consistently explained high amounts (68-86%) of the variation in log-transformed, unit-area loads. For all constituents, there was significantly more variability in loads at sites with small watersheds (<40 km^2) than for larger ones. Metrics representing land cover in stream riparian zones explained most of the variability in sediment and phosphorus loads. Conversely, total nitrogen and nitrate were primarily driven by the percentage of agriculture in the overall watershed. Consistent with previous findings, these results suggest that riparian restoration in agricultural watersheds will likely result in greater reductions in phosphorus and sediment than in nitrogen. The models are then used to predict loads for about 2000 small watersheds in Wisconsin that are being considered for a program of riparian buffer implementation.

Keywords: streams, riparian buffers, nutrient load, sediment load, landscape metrics

*Note: This is a student presentation.

Quantification of the Export of Sediment and Nutrients in Snowmelt at Pioneer Farm

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Non-point source pollution of surface water with sediment and nutrients continues to be an environmental and regulatory concern. Predictions of likely export from agricultural fields are often estimated using computer models or extrapolated from simulated small-plot runoff experiments, rather than with actual field measurements. Little is known about the export of pollutants during snowmelt events and results are rarely reported in scientific literature. To increase our understanding of snowmelt on agricultural non-point source pollution, the monitored fields at Pioneer Farm, a 430-acre University of Wisconsin-Platteville farm, were used to sample snowmelt runoff in the spring of 2004. The farm is instrumented with nine flumes and seven automated samplers to sample runoff at intervals throughout individual storm events. With modification, these field devices can quantify snowmelt events. This presentation compares the results from this event to the total runoff for the 2004 calendar year. Runoff from a single, 11-day snowmelt event was sampled from February 20 to March 1. Snowmelt runoff was sampled at regular intervals from four field-scale sub-watersheds ranging in size from 18 to 69 acres. During the course of the snowmelt event, an average of 0.60 inches of runoff was observed with exports of total phosphorus up to 0.3 $lb \cdot acre^{-1}$. Export rates of sediment and nutrients for each of the sub-watersheds will be presented.

Keywords: snowmelt, runoff, phosphorus, sediment, agriculture

Quantification of Streambed Deposits and Residence Times of Sediment and Phosphorus in an Agricultural Watershed

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Export of soil and nutrients from agricultural activities to surface waters is a primary nonpoint pollution concern. Many approaches exist to estimate soil and nutrient loss from agricultural fields, and delivery to streams. However, the fate and transport of phosphorus (P) within streams is less understood. This is particularly significant when attempting to manage watershed activities to meet water quality goals in stream-fed lakes (i.e., how much of the sediment and P delivered to the stream ultimately enter the lake downstream?) The residence time of sediment and P in streams can influence biogeochemical transformations that affect the ultimate bioavailability of P delivered to lakes. A detailed estimate of the sediment deposits of a first-order stream was performed. Dorn Creek drains 20 km^2 of agricultural land (primarily corn, oats and alfalfa) to Lake Mendota near Madison, WI. The mass of both sediment and phosphorus present as deposits in the stream channel was calculated and compared to estimates of annual soil and nutrient delivery to the stream. Estimated residence times will be presented along with an analysis of the uncertainty of these estimates.

Keywords: phosphorus, sediment, nonpoint, delivery

SESSION 4A
Water Resource Tools
Friday, March 4, 2005
10:30 – 11:50 am

From Monitoring to Policy: Assessing the Effects of Agricultural Management Practices on Phosphorus Delivery through the Wisconsin Phosphorus Index

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The Wisconsin Phosphorus (P) Index is an agricultural management planning tool for determining the risk of P delivery to surface water from cropland. Although it is not intended to predict actual loads, it uses a quasi-modeling approach to calculate a potential annual total P loads from a given field using readily available information that includes soil test reports, field characteristics, crops, tillage, and fertilizer and manure nutrient applications in the form of manure and/or fertilizer. The potential total P loads are calculated by combining estimated sediment-bound P and dissolved P delivery in rainfall and snowmelt runoff. Calculated P Index values for 17 fields throughout Wisconsin are currently being compared to P loads measured through on-going year-round runoff monitoring stations in those fields. Most of these fields are located on the UW-Platteville Pioneer Farm or on private farms in the Discovery Farm program, and represent a wide range of cropping and manure application practices. The monitoring is being conducted by researchers from the US Geologic Service, UW-Madison, and UW-Platteville. Challenges to making valid comparisons between the field-level P Index and measured annualized P loads include year-to-year climatic variability and soil and management characteristic heterogeneity within the monitored watersheds. Nevertheless, to-date these comparisons demonstrate that the P Index is a useful tool for assessing the relative P loss risks under a range of agricultural management options. The comparisons also indicate that some components of the P Index require further refinement.

Keywords: Phosphorus, runoff, P Index, agriculture

Computer Tools for Watershed Management: Digital Watershed and Long-Term Hydrologic Impact Assessment

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This session will be an opportunity for those interested in marrying traditional environmental and watershed protection with emerging data and technology. Presenters will introduce participants to two computer tools that can be used in effective watershed management and planning. Presenters will take participants through the steps of using both Digital Watershed (developed by Michigan State University) and Long-Term Hydrologic Impact Assessment (L-THIA, developed by Purdue University). Digital Watershed provides users with point-and-click access to watershed delineation and other environmental and land use features. L-THIA allows users to understand the impact of land use change on nonpoint source pollution by estimating the volume and quality of stormwater runoff. Both tools are accessible via the Midwest Spatial Decision Support System partnership's website (www.epa.gov/waterspace), a resource for cost-free decision support tools related to watershed management.

Presenters will provide participants with fact sheets and user guides for the computer tools discussed. They will also highlight upcoming technical assistance workshops for further training opportunities.

Keywords: watershed management, computer tools, decision support, technology

Groundwater Impacts from Coal Ash Disposal Sites in Wisconsin: Using WDNR Databases as a Research Tool

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The Waste Management Program of the Wisconsin Department of Natural Resources (WDNR) also maintains a sizable environmental monitoring database (GEMS) containing over 11 million analytical results from over 18,467 active and 4,259 inactive monitoring points. Data has been collected from numerous solid waste disposal facilities since, in some cases, the late 1970's.

Utilizing some simple statistical methods, the information in this database was analyzed to try to determine trends and patterns associated with groundwater impacts from coal ash disposal sites in Wisconsin. The analysis showed that the compounds boron, sulfate, arsenic and selenium were the best and most consistent indicators of groundwater impacts. Further analysis showed that elevated arsenic was associated with coal ash from older sites, that sluicing coal ash resulted in greater groundwater impacts from arsenic and metals, and that only mean sulfate and mean arsenic levels had a positive correlation.

One of the more impacted sites identified in the initial study could then be selected for a more detailed analysis of the groundwater impacts. Groundwater data showed that the levels of all compounds dropped dramatically after filling ceased at the landfill. However, while selenium levels remained low, boron and sulfate levels began to increase over time until the installation of a geomembrane landfill cover.

The WDNR has large amounts of monitoring and archival data available to the public that could be useful in many different types of studies.

Keywords: groundwater, WDNR, database, ash, disposal

Web Sites as Instructional Sources for Water Resources Courses

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Classroom instruction has always been supported by a variety of resources from film to video to text. The growth of the internet has provided a rich source of material which can supplement a text, and in some cases, can serve as a primary teaching source. This presentation explores the material used in classes in Hydrology, Watershed Management, Water Quality Management, and Wetland Delineation. The nature of the material available ranges from self-teaching modules to basic data. Questions of appropriate content and evaluation of utility are addressed.

Keywords: water resource education, websites

SESSION 4B
Hydrogeologic Investigations
Friday, March 4, 2005
10:30 – 11:50 am

Lithostratigraphic controls on groundwater flow through the Tunnel City Group sandstones, southern Wisconsin

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Several recent studies have demonstrated that in south-central Wisconsin, the Tunnel City Group sandstones have a characteristic and correlatable natural gamma signal. This characteristic signal has been used in association with borehole slug testing and flow modeling to support the lateral continuity of preferential groundwater flow through the Tunnel City Group sandstones. Possible geological explanations for the preferential groundwater flow include bedding plane fractures or porous media flow through interconnected, highly permeable zones; however, sufficient information to test these geological explanations was previously unavailable.

Recent outcrop studies in southwestern Wisconsin suggest that the characteristic natural gamma signal may be related to storm-generated sequences of deposits in the Reno Member of the Lone Rock Formation, which is the dominant unit of the Tunnel City Group throughout much of south-central Wisconsin. The repeating sequences vary in thickness from 10 to 200 cm and are laterally continuous on the scale of an outcrop. They show upward changes in lithology and sedimentary structures. They also generally show upward increases in natural gamma radiation. Fracture densities are highest near the contacts of individual units within and between storm-deposited sequences, although rock strength does not vary considerably within or between sequences. The outcrop studies lend support to the idea that bedding plane fractures may influence groundwater flow through the sandstones of the Tunnel City Group. They also provide a possible explanation for the highly correlatable nature of the characteristic natural gamma signal.

Keywords: aquifer characteristics, natural gamma radiation, Tunnel City Group

Field Comparison of Methods for Collecting Hydraulic Head Profiles Across an Aquitard

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Evaluating the distribution of hydraulic head across and within aquitards is important for assessing aquitard integrity and for understanding the potential for recharge and/or contaminant transport to adjacent aquifers and wells. We are comparing three methods for acquiring head profiles across a buried shale aquitard in south-central Wisconsin: lightweight straddle packers, buried pressure transducers, and a flexible liner multiport (FLUTe) system. The aquitard consists of shale and mudstone within the Cambrian Eau Claire Formation. This aquitard is about 8 ft thick, is about 300 ft below the land surface, and overlies a regional sandstone aquifer. The downward vertical hydraulic gradient across the aquitard exceeds 3 and internally is as high as 9. The gradient is steepest over less than 1 ft at the base of the shale.

The three techniques use 4- or 6-in. diameter boreholes to access the aquitard and adjacent aquifers. A lightweight packer assembly with a 2.2-ft open straddle was used to collect 57 sequential head and hydraulic conductivity measurements over 200 ft of 4-in. borehole, with 11 measurements inside the aquitard itself. Nine vibrating-wire pressure transducers are sealed in a 6-in. borehole using bentonite chips, with two transducers inside the aquitard. The multiport system consists of four and six ports in two adjacent boreholes, with four ports inside the aquitard.

All three systems produce excellent detailed profiles of hydraulic head. Of the three methods, the packer system is probably the most economical and effective system for characterizing an aquitard if sufficient time is available for conducting the tests; an advantage of this method is that it leaves an open borehole for future work. The multiport and buried transducer systems are more useful where longer-term monitoring or water sampling is required. However, the transducer system requires the sacrifice of a borehole, and failed transducers cannot be repaired. The multiport system is relatively expensive, but easy to install. It provides the added advantage of allowing the collection of discrete water samples, is suitable for long-term monitoring, and is removable.

Keywords: aquitards, field techniques, hydraulic head

Stagnation Points: Results of Sr Isotope and Modeling Investigations, Allequash Creek, Northern Wisconsin

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Regional groundwater flow models of the 1960s and subsequent modeling suggested that areas of very low velocity (stagnation points) occur at locations where flow systems meet. While relatively straightforward to describe numerically, stagnation points are difficult to identify in the field using typical head, flow, or geochemical approaches. Isotopic investigation at the USGS NTL-WEBB project site identified elevated (radiogenic) stable isotopes of strontium (Sr) in an area where stagnation points might be expected. Previous work at the site demonstrated that Sr isotope composition can act as a surrogate for groundwater mobility; areas with low groundwater mobility were characterized by more radiogenic values than areas with high groundwater mobility. Thus, elevated Sr isotope compositions may represent a chemical manifestation of the stagnation point. The area of elevated $^{87}Sr/^{86}Sr$ was located off-center under the creek, and formed a small trough less than 2 m in vertical length. The stagnation point is expected in this location due to convergent groundwater discharge from areas north and south of Allequash Creek. A three-dimensional groundwater flow model was extracted from the regional model for the Trout Lake Basin to relate areas of elevated $^{87}Sr/^{86}Sr$ with areas of simulated low groundwater velocity. Model results suggest that the location of the radiogenic Sr is consistent with a simulated stagnation point. In addition, features of the stagnation point, such as off-center location and size of the radiogenic Sr trough, can help describe the spatial and temporal dynamics of groundwater flow. This insight can, in turn, be used for understanding the regional/watershed-scale system.

Keywords: groundwater, stagnation point, strontium isotopes, model

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