Water Resources Institute
The University of Wisconsin-Madison

Annual Technical Report
2018

General Information

Products

SCIENTIFIC PRODUCTS:
Water Resources Institute Reports

Stewart, E.K., J. Rasmussen, J. Skalbeck, L. Brengman, M. Gotkowitz. 2018. Mapping the base of the Cambrian aquifer through geophysical modeling of Precambrian topography, southern Wisconsin. (University of Wisconsin-Extension). Final Report, University of Wisconsin Water Resources Institute. 15p. WR17R003.

Theses

Hamby, A., 2018. The effects of faults and changing water levels on confined sandstone aquifer water chemistry in northeastern Wisconsin. MS Thesis. University of Wisconsin-Green Bay, Green Bay, WI. WR12R004/2013WI329O.

Michaud, Alex. 2019. Long term performance of radon barrier in limiting radon flux from four uranium mill tailings containment facilities. M.S. Thesis. Geological Engineering, University of Wisconsin-Madison, Madison, WI. WR15R008/2015WI359S.

Other Publications

Fuhrmann, M., C. Benson, J. Waugh, M. Williams, and H. Arlt. 2019. Proceedings of the Radon Barriers Workshop July 25–26, 2018, NRC Headquarters, Rockville, MD. US Nuclear Regulatory Commission, NUREG/CP-0312. WR15R008/2015WI359S.

Hamilton, D.P., Magee, M.R., Wu, C.H., Kratz, T.K. 2018. Ice cover and thermal regime in a dimictic seepage lake under climate change. Inland Waters 8:3, 381-398. DOI: 10.1080/20442041.2018.1505372. WR11R003/2011WI268B.

Holly, M.A., R.A. Larson, E. Cooley, and A. Wunderlin. 2018. Silage storage runoff characterization: Annual nutrient loading rate and first flush analysis of bunker silos. Agriculture, Ecosystems, and Environment 264:85-93. WR11R007/2011WI298O.

Janssen, S.E., R.F. Lepak, M.T. Tate, J.M. Ogorek, J.F. DeWild, C.L. Babiarz, J.P. Hurley, and D.P. Krabbenhoft. 2019. Rapid pre-concentration of mercury in solids and water for isotopic analysis. Analytica Chimica Acta 1054:95-103. https://doi.org/10.1016/j.aca.2018.12.026. WR18R005.

Li, W., C. Wu, and W. Choi. 2018. Predicting future urban impervious surface distribution using cellular automata and regression analysis. Earth Science Informatics 11:19-29. https://doi.org/10.1007/s12145-017-0312-8. WR13R004/2013WI314B.

Luczaj, J., and H. Huang. 2018. Copper and sulfur isotope ratios in Paleozoic-hosted Mississippi Valley-type mineralization in Wisconsin, USA. Applied Geochemistry 89:173-179. https://doi.org/10.1016/j.apgeochem.2017.12.013. WR07R004.

Lv, G., Li, Z., Elliott, L., Schmidt, M.J., MacWilliams, M.P., Zhang, B. 2018. Impact of tetracycline-clay interactions on bacterial growth. Journal of Hazardous Materials in press. http://doi.org/10.1016/j.jhazmat.2017.09.029. WR10R006/2010WI285O.

Magee, M.R., Hein C.L, Walsh J.R., Shannon, P.D, Vander Zanden, M.J., Campbell, T.B., Hansen, G.J.A., Hauxwell, J., LaLiberte, G.D., Parks, T.P., Sass, G.G., Swanston, C.W., Janowiak, M.K., 2019. Scientific advances and adaptation strategies for Wisconsin lakes facing climate change. Lake and Reservoir Management. doi: 10.1080/10402381.2019.1622612. WR16R003/2016WI351B.

Pan, F. and W. Choi. 2018. Effects of urban imperviousness scenarios on simulated storm flow. Environmental

Monitoring and Assessment 190:499. https://doi.org/10.1007/s10661-018-6874-1. WR13R004/2013WI314B.

Parish, A.L., A.D. Kendall, A.M. Thompson, R.S. Stenjem, D.W. Hyndman. 2019. Cellulosic biofuel crops alter evapotranspiration and drainage fluxes: Direct quantification using automated equilibrium tension lysimeters. GCB Bioenergy 11:505-516. https://doi.org/10.1111/gcbb.12585W. R10R003/2010WI282O.

Stenjem, R.S., A.M. Thompson, K.G. Karthikeyan, B.J. Lepore, A.D. Kendall, D.W. Hyndman. 2019. Quantity and quality of water percolating below the root zone of three biofuel feedstock crop systems. Agricultural Water Management 221:109-119. https://doi.org/10.1016/j.agwat.2019.04.008. WR10R003/2010WI282O.

Voter, C.B. and S.P. Loheide II. 2018. Urban residential surface and subsurface hydrology: Synergistic effects of low-impact features at the parcel scale. Water Resources Research 54, 8216–8233. https://doi.org/10.1029/2018WR022534. WR12R002/2013WI327O.

COMMUNICATIONS PRODUCTS:
Aquatic Sciences Chronicle Vol 3 2018 - https://www.aqua.wisc.edu/chronicle/Portals/0/PrintEditions/2018_vol3.pdf
Aquatic Sciences Chronicle Vol 4 2018 - https://www.aqua.wisc.edu/chronicle/Portals/0/PrintEditions/2018_vol4.pdf
Aquatic Sciences Chronicle Vol 1 2019 - https://www.aqua.wisc.edu/chronicle/Portals/0/PrintEditions/2019_vol1.pdf
Aquatic Sciences Chronicle Vol 2 2019 - https://www.aqua.wisc.edu/chronicle/Portals/0/PrintEditions/2019_vol2.pdf
Podcasts - https://www.seagrant.wisc.edu/audio/wisconsin-water-news/
Central Sands and Nitrogen
Facebook account - https://www.facebook.com/UWiscSeaGrant/
Twitter feed - https://twitter.com/UWiscSeaGrant
Water blog - https://waterlibrary.aqua.wisc.edu/blog/
News releases - https://www.wri.wisc.edu/news-categories/release/
Water Resources Postdoc Concludes Fellowship by Presenting Key Findings to the City of Waupaca
Combining Approaches Yields Best Results for Urban Stormwater Control
Remucal's Research Furthers Knowledge About Drinking Water Safety, Particularly From Groundwater
ASC Associate Fellow Greb Tracks Wisconsin Water Quality Through High-Tech Approach
Water Runs Through Career of Guerrero-Bolano, Wisconsin Water Resources Science-Policy Fellow
UW-Madison Researches Focus on Efficient Water and Nitrogen Use in the Central Sands of Wisconsin
Environmental Chemistry Graduate Students Win Fellowships
Big Thanks for the Big Lakes, and Other State Waters
New Projects Address Wisconsin Groundwater Resources
Researchers Fill Critical Gaps in Knowledge About Arsenic and Private Well Water
Tap Talks Series Taps Into Community Science Learning
Postdoctoral Fellow Will Look at Role of Nitrate Contamination in Wisconsin Municipal Water Supplies
Fish-O-Pedia K-12 curriculum

Information Transfer Program

The Information Transfer Project ensures information dissemination to relevant audiences in order to inform and leading to action, resulting in enhanced stewardship for the state's waters in the areas of quantity, quality and management.
Various tools are employed, including news releases, audio podcasts, fact sheets, newsletters, social media, curriculum and events. Each is selected to reach audiences effectively. Those audiences are resource managers, students, policymakers, researchers, educators and people who don't fall into any of those categories but are state residents who would benefit from learning more about water issues to deepen their understanding and move toward greater stewardship.
At the end of this reporting period, there were 1,670 followers on Facebook and 4,742 on Twitter. The program produced 12 news releases in this reporting year that went to the state's media outlets. Releases were also distributed through a website, which ended the reporting period with 13,905 visitors. Further, the releases were shared through a listserv of roughly 200 people, many of whom are researchers in the water field. Work is also highlighted in a quarterly newsletter that has about 5,000 subscribers made up all of the primary audiences cited above. Audio podcasts are innovative and in this reporting period, one new episode specific to a WRI-funded

research project was produced and joined another two exiting multi-episode series that continue to be popular. Finally, multiple fact sheets are available through an online site, with the most popular being about rain gardens. This year, it was downloaded more than 100 times.

Student Support

Undergraduates - 8, Master's - 4, PhDs - 1, Postdocs - 2

Notable Achievements and Awards

In 2018, WRI supported a workshop of 48 experts discussing scientific advances and strategies under climate change affecting 15,000 Wisconsin lakes. In 2019, workshop proceedings were published in Lake and Reservoir Management. The paper’s lead author also developed Climate Wisconsin 2050 for a lay audience, broadening understanding and sharing options for actions.

Wisconsin leads the nation in producing cranberries, worth $1 billion according to 2018 figures, and ranks No. 3 in potato cultivation. These crops, along with green beans, cabbage, peas and beets, are important for the state’s agricultural sector and Central Wisconsin’s economy. Yet, that region faces challenges in water quality and availability of groundwater for crop irrigation. A WRI-funded researcher in this reporting period collected data about nitrogen fertilizer use and irrigation practices in the area. The goal is to offer recommendations for optimizing economic returns for vegetable producers by increasing irrigation efficiencies while reducing the amount of nitrogen going into groundwater.

The Wisconsin Section of the American Water Resources Association is a premier opportunity for graduate scholars to interact with and present to other students, professionals in the field and leading academics. The 2019 meeting attracted about 200 people. It’s important to offer this enrichment for up-and-coming water leaders. WRI develops and funds production of conference materials.

WRI partnered with the Wisconsin Geological and Natural History Survey to support a fellow who provided a Wisconsin city with options to address nitrate contamination in two of seven municipal wells following her development of a 3D groundwater flow model.

Projects

Evaluating the Effectiveness of Surface Covers for Controlling Fluxes of Water and Radon at Disposal Facilities for Uranium Mill Tailings

Project Type: National Competitive Grant **Project ID:** WR15R008 / G15AP00040

Project Impact: Objectives: Disposal facilities for uranium mill tailings generated by current and historic uranium beneficiation operations have been constructed at locations throughout the United States as required by the Uranium Mine Tailings Radiation Control Act (UMTRCA). Nearly all UMTRCA facilities rely on a surface cover to control the rate at which contaminants migrate in the gas and water phases from the tailings and into the surrounding environment. This study is evaluating the effects of soil structure formation on the hydraulic conductivity and gaseous diffusivity of Rn barriers, how structural development varies with depth and thickness of the Rn barrier, and how structure influences transmission of radon and seepage carrying ground water contaminants. Field Investigation: Field work was conducted at two UMTRCA surface barriers under surveillance by Department of Energy Legacy Management (LM): the Shirley Basin, WY site (primary field work conducted September 2017) and the Lakeview, OR site (primary field work conducted October 2017). Field work was similar to that conducted at two additional sites (Falls City, TX and Bluewater, NM) during the previous reporting period for this project. Combined, the four sites were selected to represent a wide range of climatic conditions (dry, humid, warm, frigid). Goals of the field work were to (1) characterize the morphology of disposal cell cover soils to understand the natural processes that are changing engineering properties and to project the degree of change over decades and millennia, (2) measure the effects of soil-forming processes on gas diffusivity and soil hydraulic properties, (3) determine how changes in engineering properties vary with soil depth in cover profiles, and (4) measure and model how these changes influence radon flux rates and rainwater percolation. The field data demonstrate structure at some locations has developed in the radon barrier due to factors such as biota intrusion (roots, insect burrowing) and wet-dry cycling. Nevertheless, the radon barriers remain effective in controlling radon fluxes below regulatory limits. The field data also illustrate that radon fluxes are not particularly sensitive to measurement scale, with larger scale chambers yielding similar fluxes as smaller chambers, although the variability in the flux is greater for measurements made with smaller chambers. Higher fluxes are measured using the RAD7 device relative to activated carbon in part because the activated carbon measurement misses the early part of the radon build up curve. These observations are being disseminated in the form of recommendations for effective measurement of Rn flux in the future. Pb-210 Analysis: Field sampling and analysis was conducted to compare observed Pb-210 concentration profiles in the barrier material to Pb-210 concentrations estimated to be deposited in the barrier by the decay of Rn-222, based on modeled fluxes of Rn-222 within the barrier. Pb-210 measurements taken at the four field sites were evaluated for their ability to provide an alternative method that can be used to quantify the long-term average Rn-222 flux at different depths within the barrier, such that the Rn flux over the lifetime of the barrier can be calculated. Preliminary results demonstrate feasibility of the approach. Recommendations are currently being formulated. Summit Meeting: A summit meeting including all participating personnel was held to summarize data, findings, draw preliminary conclusions, and outline plans for project dissemination, including journal publications and a NUREG report to NRC. Recommendations for long term maintenance, monitoring, management, and future design of uranium disposal facilities are being developed for reporting and dissemination.

Funding for Water Resources Research Institute Internship at USGS Wisconsin Water Science Center - Rosera

Project Type: Student Internship **Project ID:** WR18R006 / G18AC00354

Project Impact: Please see student internship survey (Tyler Rosera) emailed to Earl Greene.

Importance of bioavailability of multiple mercury sources for environmental applications of stable isotopes

Project Type: National Competitive Grant **Project ID:** WR18R005 / G19AP00003

Project Impact: Our research investigates the use of natural stable isotopes of mercury (Hg) for source identification,

and a novel approach of forensic fingerprinting to define differences in reactivity and bioaccumulation potential for various Hg sources. Our initial work on methods development has allowed us to pre-concentrate and reach lower detection limits for aquatic samples and to directly measure source signatures of methyl-Hg, the bioaccumulative and potentially toxic form, in the aquatic food web.

Linking groundwater and nutrients to monitor fen ecosystems using airborne imaging spectroscopy

Project Type: Annual Base Grant **Project ID:** WR17R001 / 2018WI372B / 144-AAD5419

Project Impact: Our overarching research question is can we use remotely-sensed spectral data to determine the health of fen wetlands - which are groundwater-dependent wetlands of very high conservation value in Wisconsin that are highly susceptible to degradation via local groundwater pumping. We first determined that the health of the fen wetland (expressed by its plant community composition) is strongly predicted by site characteristics related to hydrology, soils, and plant chemistry. Second, we found that spectral characteristics of fen plant material are strongly related to the chemistry of that plant material. Third, connecting the strong predictive relationship between plant chemistry and fen characteristics (result 1) with the strong predictive relationship between plant spectra and plant chemistry (result 2), we determined that fen characteristics (plant community composition/health and hydrology) can be accurately "sensed" remotely. Using these relationships, we can convert airborne spectral data into maps of fen health in a much more efficient way than typical groundbased surveys by plant experts. These maps would then provide crucial and timely information to water and land managers who are charged with monitoring and protecting these important ecosystems.

New proxy-based hydrological reconstructions over the past five centuries in southwest Wisconsin

Project Type: Annual Base Grant **Project ID:** WR17R004 / 2018WI373B / 144-AAD5418

Project Impact: Effective water resource management for the present and future requires a long-term temporal perspective on the variability of past water resources. A better understanding of past conditions allows water managers to make informed decisions regarding present and future groundwater availability and use. Short-term instrumental records, however, are insufficient to provide insight into the occurrence of rare, severe events that have caused pronounced economic, ecological, and social implications over longer time scales. This is problematic in light of numerous predictions that future extreme events will become more frequent and intense due to climate change. Wisconsin benefits from abundant water resources, yet droughts that occurred during the last century illustrate that we are vulnerable to extreme events. The influence of extreme drought has significant implications for the ecology and economy of our state, both of which are intimately connected to the natural environment.

USGS Internship (Middleton)

Project Type: Coordination Grant **Project ID:** WR18R004 / G18AC00221

Project Impact: Please see student internship surveys (Winor Chen and Stanley Kaymen) emailed to Earl Greene.

Wisconsin Inititative on Climate Change Impacts: Water Resources Working Group

Project Type: Annual Base Grant **Project ID:** WR16R003 / 2016WI351B / 144-AAA8795

Project Impact: Climate change threatens inland lakes, which are highly valued for their ecological and economic benefits. Our project aimed to synthesize and present adaptation strategies that could offset climate impacts on Midwestern lakes,. By synthesizing this data for a research and management audience, we are able to provide lake managers with real-world solutions to adapt inland lakes to climate change and to directly connect managers with researchers who can fill research needs. We found that responses to climate change, adaptation options, and societal support are all heterogeneous across the landscape of Wisconsin lakes, so “one-size-fits-all” adaptation strategies will likely be ineffective. Wisconsin’s climate adaptation strategy must take a multifaceted approach that

encompasses traditional conservation practices and new innovations. A holistic approach to climate adaptation for inland lakes includes: protecting intact resources (resistance), improving the capacity of lakes to return to their prior condition (resilience), and accommodating changes while minimizing impacts (response). Communication and outreach, state and municipal level policies, traditional resource conservation, and engineered solutions can all be effective approaches for adapting to climate change. Perhaps most important is the human dimension of climate adaptation. Key to affecting change is ensuring that local communities' values inform adaptation approaches and that communities themselves are the agents of change.

Wisconsin Water Resources Fellowship: Collaborating with Water Managers Education - 104B

Project Type: Annual Base Grant **Project ID:** WR16A001 / 2016WI348B

Project Impact: Unregulated delivery of nutrients and solids by human activities into water bodies is one of the leading causes of water quality impairments worldwide. In Wisconsin, every year thousands to millions of tons of nutrients and suspended solids (respectively) are mobilized across the state by the streams and rivers that drain areas resulting in a variety of ecological, economical and human health impacts . A robust assessment and regulation of water quality in Wisconsin requires realistic predictions of water quality impairments that account not only for the role of land use, but also for the interaction between human impacts and a changing climate. Furthermore, since about 90% of the nutrients and suspended solids are mobilized after short and intense storms, available models must be able to capture the influence of these extreme events. Through a 50:50 partnership between the Water Resources Institute and the Wisconsin Department of Natural Resources, a postdoctoral Water Science-Policy Fellow employed sophisticated statistical models to predict water quality, every hour, across more than 500 sampling locations in Wisconsin by exploiting a large database of samples collected at irregular intervals across the state. These models will allow us to separate the role of land use and climate, and therefore, will guide a more accurate policy formulation in order to regulate the loads of nutrients and solids across the state of Wisconsin.