

## UNIVERSITIES OF WISCONSIN

The Universities of Wisconsin undertake groundwater-related research, teaching, and outreach responsibilities. These three missions are integrated through cooperation and joint appointments of research, education, and outreach and extension personnel, along with postgraduate fellows, who address groundwater issues. Staff members work with state and federal agencies and other partners to solve groundwater resources issues. Research is coordinated through the University of Wisconsin Water Resources Institute, which conducts annual calls for proposals followed by rigorous peer and panel review of the proposed projects. Typically, four to seven projects are funded through the Institute each year. Citizen outreach is accomplished through publications, video and audio podcasts, social media, media relations, public meetings and presentations, teleconferences, and water testing and satellite programs. The following sections describe the activities of several university programs, including the [University of Wisconsin Water Resources Institute](#) based at the University of Wisconsin-Madison; the [Central Wisconsin Groundwater Center](#), affiliated with University of Wisconsin-Madison's Division of Extension and the University of Wisconsin-Stevens Point; the [Natural Resources Institute's Land and Water Programs](#) at the University of Wisconsin-Madison's Division of Extension; the [University of Wisconsin Nutrient and Pest Management Program](#); and the [Wisconsin State Laboratory of Hygiene](#).

### Details of Ongoing Activities:

#### University of Wisconsin Water Resources Institute (WRI)

The University of Wisconsin Water Resources Institute (WRI) is one of 54 water resources institutes located on universities across the nation with core funding provided and administered by the U.S. Department of the Interior through the U.S. Geological Survey. The Institute promotes research, training, and information dissemination focused on **Wisconsin's and the nation's water resources problems. WRI is a** Universities of Wisconsin program administratively housed at UW-Madison's **Aquatic Sciences Center**, along with the University of Wisconsin Sea Grant College Program.

### FY 2024 Highlights

- In support of the Wisconsin Groundwater Research and Monitoring Program, provided Universities of Wisconsin funding to five research projects focused on groundwater contaminants, including per- and polyfluoroalkyl substances (PFAS), pathogens, and geogenic contaminants; challenges associated with groundwater flooding; and understanding public perspectives and values; and supported graduate and undergraduate students at UW-Milwaukee, UW-Madison, and UW-Green Bay.



Per- and polyfluoroalkyl substances (PFAS) are chemicals used in everyday items like clothing and cookware. They can cause health problems for people. Here, graduate students explain to lab visitors how they test water samples for the contaminant. *Photo: Bonnie Willison.*

- Coordinated the Request for Proposals and the review process for the FY25 Joint Solicitation for the Wisconsin Groundwater Research and Monitoring Program.
- Supported four Water Resources Science-Policy post-graduate fellows in partnership with the Wisconsin Department of Health Services (DHS), Wisconsin Department of Agriculture, Trade & Consumer Protection (DATCP), and the Wisconsin Department of Natural Resources (DNR) to work on state priority groundwater and surface water challenges, including groundwater toxicology focused on PFAS and atrazine, and fish habitat in lakes. WRI also leveraged Aquatic Sciences Center funding to support eight additional post-graduate fellows working on community flood resiliency, coastal hazards, coastal wetlands, and Great Lakes and Mississippi River Basin water policy.
- Launched a successful 2023 undergraduate research opportunities program for 31 summer interns placed across the University of Wisconsin System, resulting in several students applying for graduate water-related studies. The program is continuing for summer 2024. It is funded by the Freshwater Collaborative of Wisconsin, WRI, the Sea Grant College Program and Water@UW-Madison.
- Completed its 5-year reporting requirement to its federal funding agency, the US Geological Survey, and received the highest rating possible, **“performing at an outstanding level and is eligible for continued support under the Water Resources Research Act.”**
- In late October, Christy Remucal was named as interim WRI director. Remucal is an emerging contaminants scientist and faculty member in civil and environmental engineering at UW-Madison. In November, former WRI director Jim Hurley, who spent 11 years on the Wisconsin Groundwater Coordinating Council, was honored with a resolution thanking him for his contributions on the occasion of his retirement.
- Anne Moser, a senior special librarian who manages the Wisconsin Water Library, was named volunteer of the year by the Wisconsin Library Association. In announcing the award, the **association referred to Moser as “well known and well-loved among public librarians all around Wisconsin, and their patrons, for the cheerful, fun and educational programs she presents on STEM and water-related topics.”**



Several of the undergraduates participating in the 2023 summer research opportunity program. *Photo: Jim Hurley.*



Anne Moser was named the **Wisconsin Library Association’s** volunteer of the year for her tireless water-education programs across the state, such as this demonstration of how microplastics move through a wastewater treatment facility using a teaching tool she and partners developed. *Photo: Marie Zhuikov.*

- Supported the annual Wisconsin Chapter of the American Water Resources Association meeting. The Wisconsin Water Library and the Wisconsin Geological and Natural History Survey continue **to post digital copies of the meetings' proceedings** from 1978 to the present on a University of Wisconsin-Madison library [website](#) to make the water science material widely available.
- Supported the production of 15 final project reports, 8 theses, and 59 peer-reviewed publications over the past five years.

## Research

The WRI research portfolio is supported by Universities of Wisconsin funding for the Wisconsin Groundwater Research and Monitoring Program and includes interdisciplinary projects in four areas: groundwater, surface water, groundwater-surface water interactions, and drinking water. Groundwater is a top priority and an area of particular strength at the WRI.

During FY24, the WRI directed a wide-ranging program of priority groundwater research consisting of three new projects and two continued projects. These included short- and long-term studies both applied and fundamental in nature. They provide a balanced program of laboratory, field, and computer-modeling studies and applications aimed at preserving or improving groundwater quality and quantity. Key areas of emphasis in FY24 included research projects focused on groundwater contaminants, including per- and polyfluoroalkyl substances (PFAS), pathogens, and geogenic contaminants; challenges associated with groundwater flooding; and understanding public perspectives and values; and supported graduate and undergraduate students at UW-Milwaukee, UW-Madison, and UW-Green Bay.

Groundwater issues investigated during the past year included:

- Aligning the Wisconsin Idea on water: Interpreting public perspectives and values. Michael Cardiff, Ken Genskow, and Bret Shaw, UW-Madison. (continuing)
- Biomanipulation of groundwater flooding. Steven Loheide and Kenneth Potter, UW-Madison. (continuing)
- Long-term threat of geogenic contaminants to water quality and quantity in the Midwestern Cambrian Ordovician Aquifer System. Matthew Ginder-Vogel, UW-Madison. (new)
- An experimental investigation on the leaching of per- and polyfluoroalkyl substances (PFAS) from contaminated soil. Shangping Xu and Yin Wang, UW-Milwaukee, and Erin Berns-Herrboldt, UW-Green Bay. (new)
- Risk from pathogens and exposure to antibiotic resistance genes in private wells in southwest Wisconsin. Maureen Muldoon, UW-Madison. (new)



A WRI research project is looking at how land-use changes might be influencing groundwater flooding. Photo: *Bonnie Willison.*

For FY25, the Universities of Wisconsin selected two new groundwater research projects from proposals submitted in response to the Joint Solicitation for Wisconsin Groundwater Research and Monitoring Program and will continue the three projects selected from the **previous years' solicitations**. The new projects are based at UW-Madison and include:

- Effects of Great Lake water level fluctuations on groundwater and forests in ridge and swale ecosystems. Steven Loheide, UW-Madison. (new)
- Biogeochemical processes controlling contaminant transport and transformation in a hydrocarbon contaminated aquifer. Matthew Ginder-Vogel, UW-Madison. (new)

Additionally, the WRI receives an annual federal 104(B) allocation that can be used to advance groundwater and other water resources research and initiatives. This allocation is often used to fully support or augment a project selected through the state groundwater competition, freeing up state resources to invest in additional strong proposals submitted to the groundwater competition. In FY24, this allocation supported:

- Aligning the Wisconsin Idea on water: Interpreting public perspectives and values. Michael Cardiff, Ken Genskow, and Bret Shaw, UW-Madison. (continuing)
- Biomanipulation of groundwater flooding. Steven Loheide and Kenneth Potter, UW-Madison. (continuing)

In addition, this federal allocation was matched by state agency partners and used to:

- Support a Water Resources Science-Policy postdoctoral fellow in partnership with **DNR's** Fisheries Management Program to build understanding of habitat needs to support statewide fisheries in inland lakes (Dr. Ellen Albright, 2022-23).
- Recruit and support two Water Resources Science-Policy fellows in partnership with DHS to work on public health aspects of groundwater toxicology (Sarah Gravlee, 2023-24 and AJ Jeninga, 2022-23).
- Recruit a Water Resources Science-Policy fellow in partnership with DATCP to address atrazine contamination of groundwater (2024-25).



Cora Sutherland (left), a fellow researching water resources and policy, appears with mentors at a summer 2023 event highlighting the experiences she, and other fellows and undergraduate scholars, have had thanks to WRI support. Photo: *Eron Laber*.

Lastly, the Aquatic Sciences Center (home to WRI) successfully completed a project funded by the U.S. Environmental Protection Agency (EPA) to support two UW-U.S. EPA Human Health and the Environment Postdoctoral Research Fellows (Drs. Sally Mayasich, 2019-23, and Bryan Maitland, 2023-24). And, through a variety of partnerships, the Aquatic Sciences Center was also able to support post-graduate fellows to work on community flood resiliency (Jackson Parr, DHS, 2021-24), coastal hazards (Hannah Paulson and Dr. Helena Tiedmann, Wisconsin Department of Administration, 2022-24), coastal wetlands (Mike Smale, DNR, 2023-24), and water policy (Cora Sutherland and Rajpreet Grewal, UW-Milwaukee Center for Water Policy, 2023-24).

## Teaching

The Universities of Wisconsin continue to offer undergraduate- and graduate-level courses and opportunities focusing on diverse issues regarding groundwater resources. Additionally, several campuses offer for-credit, field-oriented water curriculum courses for middle and high school teachers during summer sessions. The WRI also views continuing education for P-12 teachers as an important component of its outreach and training effort.

The Wisconsin Water Library, housed on the UW-Madison campus and funded by the WRI, maintains an extensive collection of curricula with innovative approaches and other educational materials for teaching water-related science in P-12 classrooms. Through the **librarian's outreach to teachers last year, more than 51,000 students were exposed to** water-science learning. The **library's** curricula are available for checkout by all teachers and residents in Wisconsin. The librarian also has deep experience in working with children. She put that experience to use in developing kits based on field-tested science, technology, engineering, art, and math. New this year were additional teaching materials about marine debris and wastewater treatment. Other education kits will eventually number 27 on topics such as the water cycle, art and water, and pond science. The kits contain several books, directions for a guided science experiment and other themed activities. Finally, the library provides checkout of an aquatic invasive species elementary and middle school curriculum collection known as an "Attack Pack." The packs have been used to educate people about aquatic invasive species in the waters of Wisconsin and are being updated to include additional information about fish.

### Grants Administration

The WRI conducts the annual outside peer review of all proposals submitted to the state of Wisconsin Joint Solicitation for Groundwater Research and Monitoring. In FY24, WRI continued to use a web-based proposal submission, review, and reporting system [eDrop](#). The website enables seamless online submission and review of proposals. At the site, prospective investigators submit a proposal by filling out a series of forms and uploading their full proposal and budget. Assigned reviewers then complete their reviews through eDrop by answering a series of questions online. Once all the reviews are completed, the UW Groundwater Research Advisory Council is granted access to anonymous reviews and original proposals to help decide which proposals to recommend for funding. Agency partners also have access to the reviews to inform their selection processes. The website provides a framework for consistently capturing the same information from all the prospective investigators and reviewers, ensuring all proposals are treated equally.

### Information-Sharing and Outreach Activities

The [University of Wisconsin Water Resources Institute website](#) offers research projects and **publications. One of the site's main audiences is researchers. To that end, the site** provides a clear navigational path to the WRI project listings, project reports, a groundwater research database, funding opportunities, and conference information. All of these areas are updated on a regular basis to ensure currency of information transfer. Additionally, WRI has a presence on X, LinkedIn, Facebook, Instagram, and Flickr.

Video is a compelling way to share water-**science information. The Institute's video** catalog includes eight titles. The most popular one is "A new measure of groundwater **flow.**" To date it has more than 17,000 views, which is a large number for a scientific topic.

The Pew Research Center, in a spring 2023 report, noted that about half of U.S. adults have listened to a podcast in the past year. One in five of those responding to the Pew survey say they listen a few times a week. About 66% of survey respondents say podcasts appeal to them for learning, diversion, and entertainment. Satisfying this desire for learning through podcasts is an important reason why WRI offers podcasts. It provides

five multi-part [podcast](#) series on topics such as groundwater, mercury in aquatic environments, and aquifers and watersheds. **WRI's sister program, the Sea Grant College Program**, also produced a new four-part series about PFAS in groundwater and shared it **with WRI's audiences**, <https://www.seagrant.wisc.edu/audio/the-water-we-swim-in/>.

During this reporting period, WRI staff were integral to the leadership and content population of Water@UW-Madison - <https://water.wisc.edu>. The site is a portal to the breadth and depth of water-related work on the state's flagship campus, UW-Madison, and serves as the first stop for anyone interested in water research. Graduate students can search for departments offering courses and degrees that fit their interests. Prospective graduate students can use the site to investigate potential faculty advisors. Finally, staff and faculty can search for colleagues working on topics complementary to their own to facilitate greater interdisciplinary collaboration and efficiencies. This year, Institute Associate Director Dr. Jennifer Hauxwell advised the Water@UW-Madison executive committee. The group hosted a spring symposium featuring lightning talks, longer presentations, an art-science installation, and plenty of opportunities for the 100 people in attendance to network with fellow researchers, students, and agency staff. Additionally, the WRI director serves on the Steering Committee for the Freshwater Collaborative of Wisconsin, another entity promoting collaboration, this time among the Universities of Wisconsin.

### Water Resources Publications

The program offers easily accessible publications through an [online site](#), with free information. Topics include nitrates in groundwater, siting rain gardens, and arsenic in groundwater. The program also produces the [Aquatic Sciences Chronicle](#) on a quarterly basis. It circulates to roughly 5,800 electronic and print subscribers with an interest in WRI projects and related water topics. The newsletters are also posted online.

### **Wisconsin's Water Library**

**Wisconsin's Water Library is a unique resource for Wisconsin citizens. It contains more than 30,000 volumes of water-related information about the Great Lakes and the other waters of Wisconsin.** The library includes a curriculum collection, dozens of educational videos, a children's collection, and more than five journals and 30 newsletters.

In addition to archival benefits, the library provides outreach by answering many in-depth reference questions on a wide range of water-related topics. In partnership with the Wisconsin Department of Natural Resources and the Wisconsin Wastewater Operator's Association (WWOA), the library offers assistance to current and future wastewater and drinking water operators of Wisconsin. The library catalogs the essential technical manuals and loans them to WWOA members around the state in support of required state license examinations.

**Wisconsin's Water Library continues to catalog all groundwater research reports from projects funded by the WRI into WorldCat and MadCat, two library indexing tools that provide both worldwide and statewide access to WRI research.** By having this information permanently indexed, the research results are easily available to other scientists throughout the University of Wisconsin System as well as across the nation and the world.

The library also maintains a digital archive of the entire collection of [Groundwater Research and Monitoring Program reports](#). The archive was created in partnership with the UW Digital Collections Center and ensures a permanent and accessible electronic record of Wisconsin groundwater-related activities since 1984. Paper copies of the reports continue to be a part of the Wisconsin Water Library.

The library offers a book club to raise awareness of Ojibwe culture and teach children, parents, librarians, and educators about water resources, with a focus on the Great Lakes. Each month, the virtual book club reached about a dozen people. Participants expressed that the experience made them proud of their culture. Library staff also created a guide for librarians and information professionals about Traditional Ecological Knowledge, and added Ojibwe word keys to existing teaching kits about fish and freshwater ponds.

In spring 2024, and in partnership with the Wisconsin Library Association, the library launched a one-book, one-read initiative called Great Lakes, Great Reads to foster greater understanding of water resources not just in Wisconsin but throughout the region. **A children's book and a title for adults were selected. Until the end of 2024**, there will be community-based book discussions, presentations, and web-based resources available for reference and download.

Technical Research Publications Resulting From Recent WRI Groundwater Research and Monitoring Program-Sponsored and Other WRI -Supported Projects (Past Five Years):

*Water Resources Institute Reports*

- Booth, E. G., S. P. Loheide II, D. Bart, P. A. Townsend, and A. C. Ryzak. 2019. Linking groundwater and nutrients to monitor fen ecosystems using airborne imaging spectroscopy. (University of Wisconsin-Madison). Final Report, University of Wisconsin Water Resources Institute. 20p. WR17R001/2018WI372B.
- Grundl, T., R. Newton, N. Gayner, and M.J. Salo. 2020. Anthropogenically driven changes to shallow groundwater in southeastern Wisconsin and its effects on the aquifer microbial communities. (University of Wisconsin-Milwaukee). Final Report, University of Wisconsin Water Resources Institute. 36p. WR16R001.
- Huang, J., A. Desai, A. Talib. 2023. Data-driven groundwater depth and risk forecasting in the Central Sands region of WI for sustainable management. (University of Wisconsin-Madison). Final Report, University of Wisconsin Water Resources Institute. 17 pp. WR21R003.
- Kucharik, C.J., T. Campbell. 2020. Improving water and nitrogen use efficiency under changing weather variability in the Central Sands. (University of Wisconsin-Madison). Final Report, University of Wisconsin Water Resources Institute. 18p. WR18R001.
- Lark, T., and Y. Xie. 2020. Mapping annual irrigation extent at 30-m resolution across the United States, 1997-2017. (University of Wisconsin-Madison). Final Report, UW-USGS Irrigation Mapping Project. 60 pp. G19AC00080/2016WI354G.
- Loheide, S. 2022. Impacts of Changing Frozen Ground Regimes on Groundwater Recharge. (University of Wisconsin-Madison). Final Report, University of Wisconsin Water Resources Institute. 17 pp. WR19R005/2020WI308B.
- Loheide, S., and D. M. Ciruzzi. 2019. Historic changes in groundwater use by trees in Wisconsin due to high-capacity groundwater pumping and climate variability.

- (University of Wisconsin-Madison). Final Report, University of Wisconsin Water Resources Institute. WR17R002.
- McLellan, S. 2021. Detection of Sewage Contamination in Urban Areas of the Great Lakes. (University of Wisconsin-Milwaukee). Final Report, University of Wisconsin Water Resources Institute. 3 pp. WR16R005/2016WI354G.
- Paradis, C.J. and L.E. Dechant. 2023. Mass discharge of road salt via groundwater to surface water in southeastern Wisconsin. (University of Wisconsin-Milwaukee). Final Report, University of Wisconsin Water Resources Institute. 16 pp. WR21R002.
- Plank, E., H. Yang, X. Min, Y. Wang, S. Xu. 2020. Dynamics of arsenic concentration and speciation in Wisconsin private drinking water wells. (University of Wisconsin-Milwaukee). Final Report, University of Wisconsin Water Resources Institute. 32p. WR18R002.
- Price, J. 2022. Valuing groundwater quality: A cost function analysis of Wisconsin water utilities. (University of Wisconsin-Milwaukee). Final Report, University of Wisconsin Water Resources Institute. 16 pp. WR20R002.
- Remucal, C. 2020. The impact of dissolved organic matter composition on the formation of disinfection byproducts in groundwater. (University of Wisconsin-Madison). Final Report, University of Wisconsin Water Resources Institute. 18p. WR18R003.
- Stewart, E.D., W. Fitzpatrick, E.K. Stewart. 2021. Correlating bedrock folds and fractures to arsenic detection in drinking water, southeast Wisconsin. WR20R004.
- Vitale, S., J.B. Mahoney, A. Baker. 2020. Assessment of the source and mobility of phosphorus in the hydrologic system in western Wisconsin. (University of Wisconsin-Eau Claire). Final Report, University of Wisconsin Water Resources Institute. 19p. WR19R002.
- Vitale, S., J.B. Mahoney, A. Baker. 2021. Source to sink evaluation of phosphorus in the hydrologic system in Wisconsin: Implications for lake eutrophication. Final Report, University of Wisconsin Water Resources Institute. 17 pp. WR20R003.

### *Theses*

- Dechant, Leah Elizabeth. 2023. Elucidating unique sources and persistent hydrologic pathways of chloride to perennial freshwater streams: Root River analog in a cold-weather environment. MS Thesis. Geosciences. University of Wisconsin-Milwaukee. <https://dc.uwm.edu/etd/3133>. WR21R002.
- Haas, Lisa. 2021. Microbially-mediated oxidation of trace element-bearing sulfide minerals in sandstones of Trempealeau County, WI. MS Thesis. Geosciences. University of Wisconsin-Madison. WR19R001.
- Hyman-Rabeler, Katrina. 2021. Impacts of changing frozen ground regimes on groundwater recharge. MS Thesis. 160 pp. Geological Engineering, University of Wisconsin-Madison. WR19R005/2020WI308B.
- Peterson, Benjamin. 2021. Ecophysiology of mercury-methylating microorganisms in freshwater ecosystems. Ph.D. Thesis. 218 pp. Environmental Chemistry and Technology, University of Wisconsin-Madison. WR19R006/2019WI001G.
- Plank, Evvan. 2019. The dynamics and speciation of arsenic in drinking water wells in eastern Wisconsin. M.S. Thesis. Geosciences. University of Wisconsin - Milwaukee. <https://dc.uwm.edu/etd/2328>. WR18R002.
- Salo, Madeline Jean. 2019. Anthropogenically driven changes to shallow groundwater in southeastern Wisconsin and its effects on the aquifer microbial communities. M.S. Thesis. Geosciences. University of Wisconsin - Milwaukee. <https://dc.uwm.edu/etd/2116>. WR16R001.



- Talib, Ammara. 2023. Prediction and forecasting of Evapotranspiration (ET) and Groundwater (GW) anomalies, along with improved parameterization of ET in agricultural lands. PhD Thesis. Civil & Environmental Engineering. University of Wisconsin-Madison. WR21R003.
- Voter, Carolyn. 2019. Hydroecologic Effects of urban development decisions in residential areas. Doctoral dissertation. University of Wisconsin-Madison, Madison, WI. WR12R002/2013WI3270.

#### *Other Publications*

- Armstrong, G.J., S.E. Janssen, M.T. Tate. 2022. Measurements of mercury stable isotopes during photochemical demethylation of methylmercury: U.S. Geological Survey Data Release. <https://doi.org/10.5066/P93LDG5B>. WR18R005.
- Armstrong, G.J.; S.E. Janssen, B. A. Poulin, M. Tate, D.P. Krabbenhoft, J. P. Hurley. 2023. Competition between dissolved organic matter and freshwater plankton control methylmercury isotope fractionation during uptake and photochemical demethylation. *ASC Earth and Space Chemistry* 7, 12, 2382-2392. <https://doi.org/10.1021/acsearthspacechem.3c00154>. WR18R005 (USGS).
- Barker, D., A. DeMaria, D. Caraco, S. Corsi, J. Kinzelman, B. Liner, S. McLellan, L. McFadden, C. Nenn. 2019. Detection of Wastewater Contamination - Knowledge Development Forum. Water Environment Federation, Water Science & Engineering Center, WSEC-2019-KDF\_TR-001. WR16R005/2016WI354G.
- Bradbury, K., J.A. Hauxwell, M. Zhuikov. 2021. The Wisconsin Groundwater Coordinating Council: 37 years of state agency cooperation. *Groundwater*. Guest Editorial. <https://doi.org/10.1111/gwat.13141>.
- Bradbury, K.R., J. Hauxwell, M. Zhuikov. 2022. The Wisconsin Groundwater Coordinating Council: 37 years of state agency cooperation. *Groundwater* 60. <https://doi.org/10.1111/gwat.13141>.
- Byrnes, T. K. Genskow, M. Husain, A. Meyer, Z. Raff, M. Scanlan, Z. Wu. 2022. Exploring **Wisconsin's innovative water quality nutrient trading options**. *Nelson Issue Brief, April 2022*, Volume 3, Number 2, p. 5. WR19R007/2020WI294B.
- Ciruzzi, D.M., S.P. Loheide II. 2021. Groundwater subsidizes tree growth and transpiration in sandy humid forests. *Ecohydrology*. <https://doi.org/10.1002/eco.2294>. WR17R002.
- Corsi, S.R., L.A. De Cicco, A.M. Hansen, P.L. Lenaker, B.A. Bergamaschi, B.A. Pellerin, D.K. Dila, M.J. Bootsma, S.K. Spencer, M.A. Borchardt, and S.L. McLellan. 2021. Optical properties of water for prediction of wastewater contamination, human-associated bacteria, and fecal indicator bacteria in surface water at three watershed scales. *Environmental Science & Technology* 55: 13770-13782. <https://doi.org/10.1021/acs.est.1c02644>. WR16R005/2016WI354G.
- Dematatis, M., A. Plechacek, M. Mathews, D.B. Wright, F. Udenby, M.B. Gotkowitz, M. Ginder-Vogel. 2020. Spatial and temporal variability of radium in the Wisconsin Cambrian-Ordovician aquifer system. *AWWA Water Science*. <https://doi.org/10.1002/aws2.1171>.
- Federman, T., et al. 2019. Temperature-sensitive redcedar chronologies from the Driftless Area enable a new suite of climate reconstructions for the Great Lakes region. Conference proceedings of the annual meeting of the American Association of Geographers, Washington, D.C. 2018WI373B.
- Feiner, Z.S., A.D. Shulz, G.G. Sass, A. Trudeau, M.G. Mitro, C.J. Dasso, A.W. Latzka, D.A. Isermann, B.M. Maitland, J.J. Homola, H.S. Embke, M. Preul. 2022. Resist-accept-

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<https://doi.org/10.1111/fme.12549>. WR19R007/2020WI294B
- 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.
- Fuhrmann, M., C.H. Benson, W.J. Likos, N. Stefani, A. Michaud, W.J. Waugh, M.M. Williams. 2021. Radon fluxes at four uranium mill tailings disposal sites after about 20 years of service. Journal of Environmental Radioactivity 237: 106719.  
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- Fuhrmann, M., M. Salay, A. Michaud, C. Benson, W. Albright, W. Likos, N. Stefani, K. Tian, J. Waugh, M. Williams. 2019, "The use of Lead-201 as an indicator of radon transport in UMTRCA covers, 31st Annual Regulatory Information Conference. WR15R008/2015WI359S.
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- Husain, M., M. Scanlan, S. Martinez. 2022. Policy Brief - Keeping the National Flood Insurance Program (NFIP) afloat: Updating maps, premiums, and minimum standards. University of Milwaukee Center for Water Policy.  
<https://uwm.edu/centerforwaterpolicy/wp-content/uploads/sites/170/2022/02/NFIP-Policy-Brief-Final-1.19.22.pdf>. WR19R007/2020WI294B.
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<https://doi.org/10.1016/j.aca.2018.12.026>. WR18R005/USGS G19AP00003.
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For more information on the WRI :

Visit the WRI website [wri.wisc.edu](http://wri.wisc.edu)

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### Central Wisconsin Groundwater Center

The [Central Wisconsin Groundwater Center](#) is an affiliate of the Center for Watershed Science and Education. It is a partnership between the College of Natural Resources at the University of Wisconsin–Stevens Point and the University of Wisconsin–Madison, Division of Extension. The Central Wisconsin Groundwater Center provides groundwater education, research, and technical assistance to the citizens and governments of Wisconsin.

Assistance includes answering citizen questions, helping communities with groundwater protection, describing the extent and causes of groundwater pollution, assessing drinking water quality, and working on groundwater policy. More information can be found at

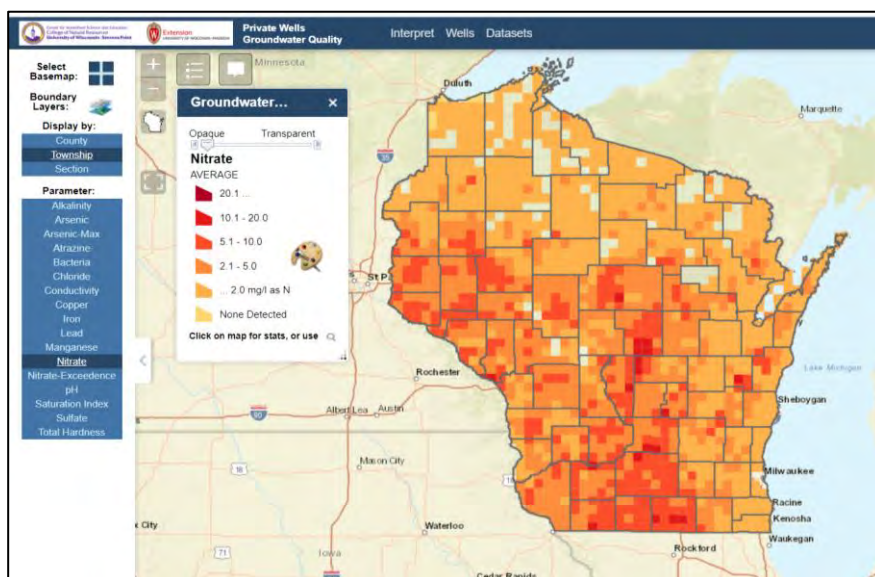
<https://www.uwsp.edu/cnr-ap/watershed/>.

### Well Water Testing and Outreach

In calendar year 2023, the center helped 8,471 households test their water in conjunction with the UW-Stevens Point Water and Environmental Analysis Laboratory (WEAL) along with partners in county Extension offices, county health departments, and county land conservation departments. Well water testing programs were conducted in the following counties: Adams, Barron, Buffalo, Calumet, Chippewa, Dane, Dodge, Douglas, Dunn, Green, Green Lake, Jefferson, Kewaunee, Marathon, Monroe, Portage, Pepin, Polk, Sauk, Sawyer, Sheboygan, St. Croix, Taylor, and Waushara.

## Water Quality Database

The Groundwater Center maintains a database of private well testing data from the Water and Environmental Analysis Regional Laboratory at UW-Stevens Point and conducts drinking water education programs. There are currently 1,048,575 individual test results for approximately 139,387 samples throughout the state. Chemistry data include pH, conductivity, alkalinity, total hardness, nitrate-nitrogen, chloride, saturation index, coliform bacteria, an atrazine screen, various metals, and minerals, including arsenic, lead, and copper. The database primarily covers the period 1985 to the present. The database can be queried, making it an easily accessible source of information for local communities and groundwater managers.



Screen capture of the Wisconsin Well Water Viewer showing average nitrate-nitrogen concentration by town-range. The viewer is accessible online and allows the public to better understand the variability of well water quality in Wisconsin. There is data on 15 different parameters.

## Interactive Wisconsin Well Water Quality Viewer

In July 2012, the Groundwater Center made publicly available an online mapping tool that allows people to search for groundwater quality information. The tool incorporates private well water data from the center's database, the Wisconsin Department of Natural Resources (DNR) Groundwater Retrieval Network and the Department of Agriculture, Trade and Consumer Protection. In 2014, data from the health departments of Eau Claire and La Crosse counties were integrated. In 2024, manganese data from the Lincoln County Health Department were also integrated. [Summary maps](#) are available for 15 different water quality parameters and can be viewed or summarized into a table at a county, town or section level detail. Updated in 2019 to include nitrate/arsenic data from DNR well testing requirements for new wells and/or well pump work, it now includes data for over 290,000 samples: with 134,684 samples from Extension efforts. It allows users to see water quality in their community and other parts of Wisconsin. In 2023, the Viewer was accessed by 7,967 people. The Viewer was recently updated to include data through December 31, 2023. Aggregated datasets (county, town-range, section) are available as [downloadable datafiles](#).

## Nitrate in Groundwater

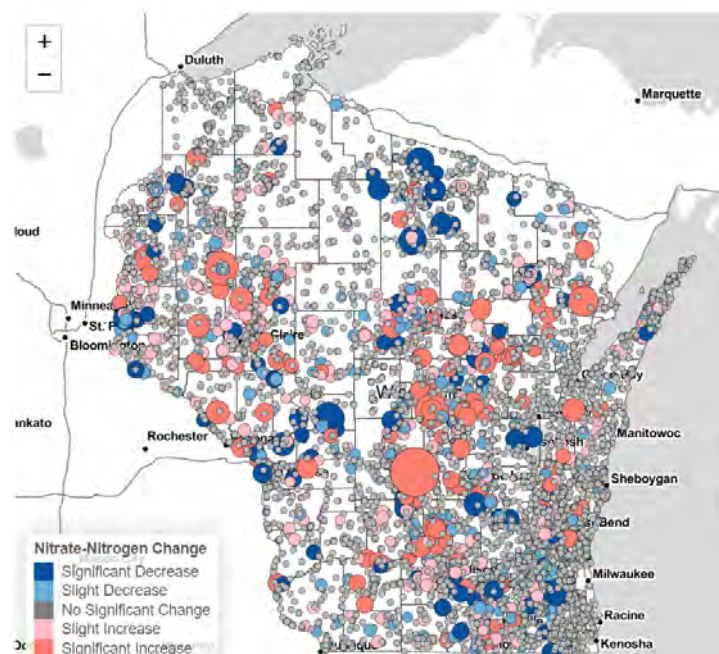
In April 2023, the Center updated a dashboard that investigates nitrate trends in public water supply systems. Using data from public water systems (i.e., municipal, other-than-municipal, transient, non-community, and non-transient, non-community), the app summarizes publicly available data that can be viewed spatially or by Wisconsin Unique Well Number. The data reveal that 90.7% of wells have no trend, 5.4% have an increasing trend, and 3.8% have a decreasing trend. The app can be found online at:

[https://www3.uwsp.edu/cnr-ap/watershed/Pages/nitrate\\_trends.aspx](https://www3.uwsp.edu/cnr-ap/watershed/Pages/nitrate_trends.aspx).

## Five-Year County Well Water Quality Inventories

Starting in 2019, the Center began multi-year projects with Chippewa, Green, and Sauk counties to organize [citizen-based groundwater monitoring networks](#) in each county. Dodge County was added in 2020. Wells are tested annually for the following parameters: nitrate, chloride, alkalinity, pH, hardness, and conductivity. By testing the same wells annually, Center staff are better able to assess where/why groundwater quality changes and what characteristics and/factors can be used to predict changes in well water quality over time.

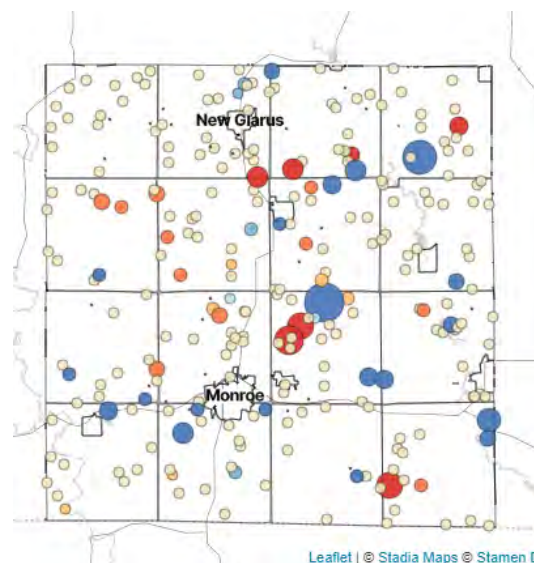
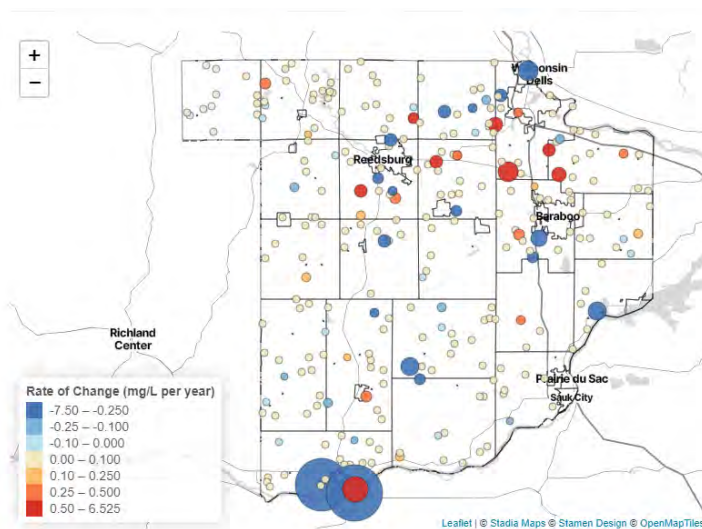
In the summer of 2023, several stretches of trout streams in the Central Sands dried up for the first time in roughly a decade due to moderate to extreme drought conditions statewide. Monthly flow monitoring and photo documentation of these stream sites by Center staff helped to inform the public and the state's Drought Task Force of the extent of drought impacts.



Nitrate trends in Wisconsin's public water supply systems are represented in this rendering. Red dots correspond to wells with increasing trends, while blue dots indicate decreasing trends. The size of the dots corresponds to the rate of change. Additional detail regarding individual wells can be found by visiting the [online dashboard](#).

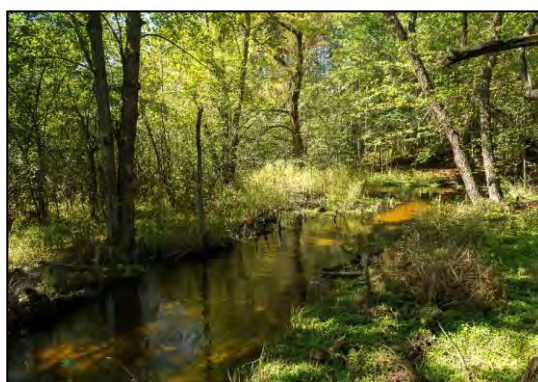


The maps (below) of Sauk County (left) and Green County (right) show wells with nitrate trends based on the five years of data (2019-2014). Blue dots represent wells with decreasing trends, while red dots represent those with increasing trends. The size of the symbol corresponds to the rate of change.



### Central Wisconsin Baseflow Stream Monitoring

For the past decade, the Center has collected monthly baseflow measurements on Central Wisconsin streams. This is part of an effort to better understand water conditions in the Central Sands Region affected by increased pumping. Currently, staff measuring baseflow at 70 sites throughout the Central Sands Region. Measurements are supplemented by measurements collected by county land conservation department staff. These measurements have been invaluable for calibrating groundwater flow models in the region and better understanding the impact of pumping and weather variability on Central Wisconsin streams.



The Little Plover River, one of the many streams in the Central Sands region affected by increased pumping. *Photo: by UW WRI*

### Policy

The center continues to play pivotal roles in a number of state groundwater issues. Working with partners in the private and public sectors on groundwater quantity policy and law has been a continuing priority. Center staff routinely present information on the science of groundwater quality and groundwater pumping and associated impacts to local and state government officials. In the past few years, staff recently participated in the Wisconsin DNR Central Sands Lake Study and the NR151 Nitrate Technical Advisory Committee.

## Recent Publications and Reports (Past Five Years)

- Masarik, K., A. Johnson, L. Lefebvre, & A. Nitka. 2023. Chippewa County nitrate occurrence and source investigation. Center for Watershed Science and Education, University of Wisconsin – Stevens Point & University of Wisconsin-Madison, Division of Extension.
- Masarik, K., J. McNelly, A. Johnson, & L. Lefebvre. 2023. Portage County well water quality - 2022. Center for Watershed Science and Education, University of Wisconsin - Stevens Point & University of Wisconsin – Madison, Division of Extension.
- Nitka, A.L., W. DeVita, P.M. McGinley. 2019. Evaluating a chemical source-tracing suite for septic system nitrate in household wells. *Water Research* 148(1): 438-445  
<http://dx.doi.org/10.1016/j.watres.2018.10.019>

For more information on the Central Wisconsin Groundwater Center:

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University of Wisconsin-Madison Division of Extension: **Natural Resources Institute's (NRI) Land** and Water Programs

The Division of Extension Natural Resources Institute's (NRI) Land and Water Programs include state and local specialists addressing water resources, land and water conservation, forestry, conservation professional training, citizen engagement, and volunteer monitoring. NRI also coordinates a number of regional and national programs addressing water resources and water-education initiatives related to groundwater.

### NRI Regional Water Programs and Conservation Professional Development

NRI coordinates the [North Central Region Water Network \(NCRWN\)](#), a 12-state collaboration among Land Grant universities, including partnerships with state and federal agencies across the Upper Midwest region. Through this network, Extension researchers and educators share programs and coordinate on an array of water resource issues, including groundwater quantity and quality. Currently, multi-state teams are active around soil health, watershed leadership, harmful algal blooms, drought, climate, and green infrastructure.

NRI also coordinates the [Conservation Professional Training Program](#), which develops and hosts multi-state professional development for conservation professionals. Wisconsin programs have included issues of conservation lands management such as manure management and fractured bedrock geology, including:

- Classroom and field training for local elected officials (town, county) both on the basic geology of local resources and localized research on groundwater quality and land use impacts in both the northeast and southwest regions of the state.
- Training public- and private-sector professionals to help farmers more effectively manage manure and commercial nitrogen fertilizers that can negatively impact groundwater.

- Training for manure applicators on manure application in karst areas.
- Providing conservation planning training and farmer training that includes karst issues.
- Offering projects that help water resource managers understand farmer awareness of, and capacity to adopt, conservation practices that are most likely to fit into farm management systems.

### NRI Water Outreach and Education

The [Water Action Volunteers](#) stream monitoring program educates both children and adults about stream ecology and stream health. Volunteers continue to monitor more than 500 stream sites statewide for a variety of parameters, including stream flow, which is directly affected by groundwater. Volunteer-collected data helps to characterize water quality and quantity across the state and to identify streams where impairments may exist. This program engages volunteer monitors in partnership with schools, nature centers, and many others to provide educational experiences and important data regarding streams and hydrological systems.



Northland College Professor Tom Fitz teaching Master Naturalist volunteers about artesian wells found in northern Wisconsin.

The [Wisconsin Master Naturalist](#) program, active since 2013, follows a train-the-trainer approach to engage Wisconsin citizens in resource management. The course curriculum covers a variety of natural resources issues specific to Wisconsin, including groundwater quality and use. Certified volunteers are expected to provide 40 hours of natural-resource-related service annually to Wisconsin host organizations, such as nature centers, state parks, or museums. Areas of service include education/interpretation, stewardship, and citizen science. The Wisconsin Master Naturalist Program has resulted in over 290,000 volunteer hours providing nearly \$9.2 million dollars in value to the state since the program began. Sixty host organizations have partnered with the program by having 199 individuals trained as instructors who have trained 1,694 volunteers statewide. There is a presence of Master Naturalists in all of **Wisconsin's 72 counties**. The course provides a broad overview of **Wisconsin's natural resources and the processes that affect them**. This program continues to grow in cooperation with partners across Wisconsin.



Master Naturalist volunteer providing water quality monitoring on a stream in Rock County.

In 2023, NRI hired an Emerging Contaminants Outreach Specialist that is initially focused on PFAS issues in Wisconsin. As more communities and individuals are affected by PFAS contaminated drinking water, it is critical to provide accurate and research-based information to help residents make sound decisions. The outreach specialist serves as a

key convenor of other agency staff and university faculty to promote collaboration, sharing of resources, and common message development.

### Regional Natural Resource Education Program

**Extension's Natural Resources Institute cooperates on community-**focused educational programs with other state agencies involved with water resources and natural resource issues. The [Regional Natural Resources Education Program](#) uses locally based natural resource educators to develop and conduct programs that reach local and statewide audiences by accessing state-level support for educational material development and program evaluation. The educational programs address a broad range of groundwater-related topics, including drinking water, threats to groundwater quality, impacts of land-use changes, and land management decisions on groundwater quantity, information about localized groundwater problems such as karst geology, water conservation, and efficiency, along with a variety of other issues associated with nutrients in surface water and groundwater. Educators have actively engaged with and facilitated the development and growth of farmer-led groups that learn about and implement conservation practices designed to address a host of water quality issues.

For more information on NRI /Land & Water programs related to groundwater: Contact Chad Cook, NRI associate director of outreach  
445 Henry Mall, Room 202  
Madison, WI 53706  
Phone (920) 232-1990, email [chad.cook@wisc.edu](mailto:chad.cook@wisc.edu)

### University of Wisconsin Nutrient and Pest Management (NPM) Program

**The University of Wisconsin's Nutrient and Pest Management (NPM) Program works with** farmers, researchers, agricultural professionals, and citizens to provide research-based agricultural nutrient and pest management education on crop production practices that protect water quality, farm profitability, and resilient landscapes.

In 2023, the NPM Program continued the implementation of their updated strategic plan. The areas of focus include nutrient management, pest management, and resilient agriculture. View the executive summary and/or the entire completed strategic plan [here](#).

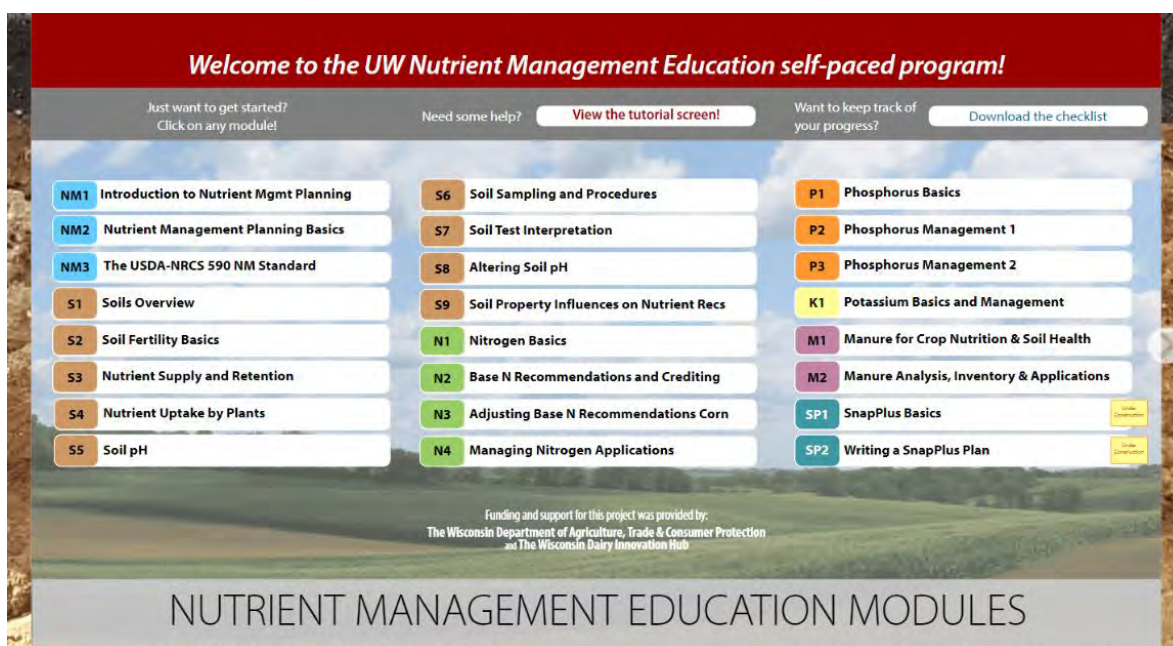
The NPM program staff collectively educated 12,000 people, at 200 events, giving 174 unique (original, first-time) presentations in 2023. In addition, they provided 19,000 individual consultations via email, phone, and in-person contacts. Nutrient management educational products developed in 2023 include 16 videos, 24 outreach publications and newsletter articles, and 167 nutrient management training manuals Online nutrient management training program\was updated.

NPM Program outreach products are available for viewing and downloading at: <https://ipcm.wisc.edu>.

## Nutrient Management

The NPM Program is part of a team that develops, distributes, evaluates, and implements nutrient management education programs. Partners include University of Wisconsin-Madison College of Agriculture and Life Sciences (UW-CALS) faculty/staff; county-based UW-Extension staff; land and water conservation departments; Wisconsin technical colleges; the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP); and the U.S. Department of Agriculture-Natural Resources Conservation Service, along with private-sector agri-businesses and Wisconsin farm producers. Activities include:

- *Nutrient Management Farmer Education Curriculum (NMFEC) development and implementation.* The NMFEC is an essential tool used throughout the state to teach farmers about crop nutrient management practices that improve profitability and reduce adverse impacts of nitrogen and phosphorus pollution. The NPM Program staff maintain, update, produce, distribute, and implement the NMFEC. The curriculum combines classroom instruction, individual consultation, and on-farm field trials to deliver education on the preparation and understanding of farmer-written nutrient management plans. The curriculum is delivered statewide through collaborations with partners identified in the previous paragraph. Participation in a NMFEC project is the only mechanism for Wisconsin farmers to become certified to prepare their own nutrient management plans.



- *Release of updated content for the NMFE Curriculum.* An online, video-based instruction version was developed in 2021 and released in early 2022. The new NMFE allows for self-paced learning by users. The new curriculum is available at: <https://nmfe.webhosting.cals.wisc.edu>. (Please allow a few minutes for the initial download.) Content of the digital curriculum is displayed in a modular format. Each module deals with a specific component of a nutrient management plan and features multiple, short, instructive videos along with linked resources. This project was in

response to challenges with the traditional delivery of the NMFE curriculum, including COVID-19 restrictions, as well as staff and budget reductions. So far, the website has been viewed 600+ times. This digital remote delivery method will: i) Eliminate or greatly reduce the need for physically close instructor-student contact, ii) Allow for self-paced, self-instruction, and iii) Increase the number of Wisconsin farms possessing and implementing NM plans. Support for this project is provided by DATCP and the UW-Madison Dairy Innovation Hub.

- *SnapPlus nutrient management planning software* assistance and refinement in conjunction with the SnapPlus team (UW-Madison Soil Science). NPM staff assist in developing educational online videos (16), updating the SnapPlus online help system, refining output reports to meet the needs of end users and the creation of a SnapPlus training manual with more than 160 copies requested and delivered in fall of 2023. In addition to creating SnapPlus educational products, NPM staff actively train farmers, agronomists, and others to use SnapPlus. In 2023, NPM staff members continue to assist the SnapPlus team in the development of a new SnapPlus user interface as well as quality control reviews of the software program.
- *Educational support to Wisconsin watershed projects.* Activities include coordination and delivery of individual nutrient management plans, on-farm demonstrations (nutrient crediting, nitrogen rates for corn, soil health, cover crops, soil erosion control, etc.). Support activities include planning, advice, coordination, grant preparation, and reporting. In addition, NPM staff serve on the selection committee for DATCP-sponsored farmer-led watershed projects. NPM Program staff serve as key members of watershed projects (producer-led, federal NRCS, and other) in 22 watershed projects and demonstration farm networks.
- *On-farm demonstrations, field plot research and subsequent educational programs* on various topics, including adaptive nitrogen management for corn, cover crops, conservation tillage, manure applications, etc.

### Pest Management

NPM, in conjunction with numerous partners including UW-CALS faculty, county-based UW-Extension, the UW Integrated Pest Management (IPM) Program, and others, delivers timely educational programming on topics associated with pest management. Activities include:

- *Waterhemp weed control project* involves statewide field trails evaluating control techniques for herbicide-resistant waterhemp. Waterhemp is a very aggressive weed **that is wreaking havoc across the nation's cropland fields.** In 2023, NPM conducted on-farm research waterhemp trials in Grant County.
- *Soil conservation and weed management.* NPM working with the UW-Madison Department of Agronomy conducted on-farm research aimed at managing weeds while improving soil conservation. These trials look at using cover crops, no-till, residual

herbicides, and system-based programs for the management of waterhemp and other troublesome weeds in Wisconsin.

- *Strategies for avoiding herbicide resistance in weeds.* The NPM program delivers educational outreach materials and trainings to Wisconsin producers and agri-businesses on strategies for avoiding the development of herbicide resistance in weeds. Strategies include awareness and diversification of herbicide modes of action used on a given farm/field, equipment sanitation to avoid transport of weed seeds, and identification of weed species likely to be resistant to popular herbicides.

### Cropping Systems

- *Cover crops research, education, and outreach.* NPM partnered with county Extension educators, USDA-NRCS, County Land Conservation Departments, non-governmental organizations, and UW-CALS specialists to deliver cover crop education programs in person and virtually across the state and Midwest. Activities included on-farm field days, on-farm research and demonstration, development of educational videos, fact sheets, publications, and training farmers and agronomists. NPM outreach specialists provided active leadership in the Wisconsin Soil Health Collaborative (SHC) Research and Outreach Project. Cover crop demonstration and research plots were continued at Lancaster and Arlington agriculture research stations.
- *Badger Crop Connect.* NPM staff were part of a team of educators within the Crops and Soils Program of the Division of Extension that organized and delivered a new series of webinars containing timely Wisconsin crop management information from March through October 2023. These webinars were a successful alternative to in-person field days. Three NPM staff delivered four unique presentations at four different sessions.
- *Healthy Grown / Healthy Farms.* NPM, working cooperatively with the Wisconsin Potato and Vegetable Growers Association (WPVGA), has developed a national model of sustainable production systems, exemplifying integrated pest management. In addition, the program includes a nationally recognized ecosystem restoration effort. In 2023, 8 growers were certified and over 8000 acres of fresh market potatoes (about **40% of Wisconsin's fresh market acres**) were verified as "Healthy Grown." **NPM has worked with the WPVGA to expand "Healthy Grown" to carrots and onions.**
- *Water quality and conservation expansion programs.* NPM staff have worked to expand water quality programs with state potato and vegetable growers. The inclusion of water modules into sustainability programs was developed on-farm networks for water quality programs have been established to work on outreach options. NPM staff provide outreach coordination, work with the Central Wis. Farmer Cooperative Producer-Led Watershed, and continued work as a liaison with the Water Task Force.
- *UWEX Agricultural Institute Climate Change Team.* The NPM Program is part of a leadership group guiding the UWEX-Agriculture Institute Climate Change Education **Team. The team's mission is to provide professional development and educational**

resources to enhance the ability of Extension agricultural educators to address current and expected challenges associated with climate change.

### Outreach and Communication

- *Mobile applications.* The NPM Program creates mobile applications (apps) for hand-held devices (Apple and Android). Maintenance and updating of the NPM Program's apps occurred in 2023. Currently available mobile apps include: Tarspotter, Sporebuster, Manure Tracker, Sporecaster, Nitrogen (N) Price Calculator, Corn N Rate Calculator, Potato Virus Predictor, Integrated Pest Management Toolkit, Corn Crop Calculator, Manure and Legume Nutrient Credit Calculator, and BeanCam (<https://ipcm.wisc.edu/apps>). Collectively, these apps have been downloaded by more than 180,000 users from across the world. All apps are created in collaboration with UW-Madison faculty and are promoting agricultural best management practices.
- *YouTube videos.* The NPM Program produced 41 new videos on a range of crop management topics in 2023. Over 300 YouTube educational videos featuring UW-CALS specialists have been prepared and released by the NPM Program over the past 10 years. A complete listing can be found at <https://www.youtube.com/user/uwipm>. A conservative estimate of the number of views is greater than 1,200 worldwide per day with over 2.5 million total views.
- *Wisconsin Crop Manager newsletter and IPCM website.* The NPM and IPM Program website delivers the popular Wisconsin Crop Manager newsletter featuring contributions from faculty and staff across UW-CALS departments. Wisconsin Crop Manager is produced weekly during the growing season with semi-monthly and monthly releases during the winter months. The weekly e-mail distribution list contains 1,250 recipients in 2023. Available online at: <https://ipcm.wisc.edu/wcm>.
- *NPM publications.* The NPM Program has a long history of collaborating with UW-CALS faculty specialists to create timely, pertinent, high-quality publications promoting the adoption of agricultural management practices to improve water quality and farm profitability. NPM staff roles include author, editor, and designer. A listing of NPM's print publications can be found at <https://ipcm.wisc.edu/downloads>.
- *NPM Resource Highlights.* An online, digital newsletter is sent monthly to the UWEX Agricultural Institute (AI) listserv. Its purpose is to inform AI affiliates of new and existing NPM Program resources that are seasonally pertinent. Publications, videos, mobile applications, etc. are featured. The original intent was to inform new county educators of NPM Program educational products; however, feedback from UW/UWEX faculty and staff indicate that they, also, find the information useful in their local programming efforts.

For more information on the NPM program:

Visit the website <https://ipcm.wisc.edu>

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### Wisconsin State Laboratory of Hygiene (WSLH)

At the Wisconsin State Laboratory of Hygiene (WSLH), a great deal of effort is focused on identifying and monitoring chemical and microbial contaminants in groundwater through testing, emergency response, education and outreach, and specialized research. The activities related to groundwater span several departments at WSLH. The mission of the WSLH is to protect the groundwater resources and health of drinking water consumers by providing analytical expertise, research, and educational services to the scientific and regulatory communities and the public.

The chemical and microbial groundwater contaminants routinely tested include all contaminants regulated by the federal Safe Drinking Water Act, as well as many emerging contaminants that appear on the USEPA Contaminant Candidate List. Examples include: fecal indicators (total coliform, *E. coli*), *Bacteroides* spp. used for microbial source tracking, pathogens (*E. coli* O157:H7, toxigenic *E. coli*, norovirus, human adenovirus), radioactivity, inorganic compounds (mercury, nitrate, arsenic, lithium and other metals), and organic compounds (VOCs, PAHs, atrazine, PCBs, PBDEs, PFAS). PFAS contamination has garnered significant attention and significant resources are being directed toward testing and outreach to support the many PFAS related efforts.

In addition to routine testing of fecal indicators and emerging contaminants, the WSLH **employs a "toolbox" of microbial and chemical source-tracking** assays. Microbial and chemical source tracking is used to determine sources of fecal contamination in water. The tools provide evidence as to whether contamination is from human or animal sources. The data are then used for making management decisions regarding control of fecal pollution of groundwater.

Another important focus of the WSLH is emergency response to incidents involving groundwater. For example, the WSLH works with the Department of Health Services (DHS) and the Department of Natural Resources (DNR) to investigate outbreaks of illnesses of unknown (possibly food or water) origin. Staff provide background information on the outbreaks for local public health officials and the general public. WSLH responds to spills and incidents and supports state agencies in remediation and emergency cleanup activities.

The WSLH provides educational and outreach activities related to groundwater and drinking water including (1) instructional consultations for well owners and well drillers, (2) assistance and consultation for municipal water supply operators, and (3) tours for a variety of international, educational, regulatory, and governmental groups. Staff members present papers at a variety of conferences and symposia and publish research findings in professional journals.

## Summary of Groundwater-Related Work at WSLH

### *Organic Chemistry Section*

- The WSLH has developed and validated methods for measurement of PFAS chemicals in various matrices, including groundwater and drinking water. Significant coordination with state and federal partners occurs to ensure appropriate certifications are in place, which PFAS compounds to focus on, and matrix-specific challenges such as limits of detection. The WSLH is happy to partner with others and share information as appropriate to collectively advance understanding about these issues. State and federal efforts are ongoing to support drinking water and groundwater testing for PFAS compounds. In 2022, over 450 groundwater samples were tested for PFAS in conjunction with WDNR. In November 2023 this article was published: "Prevalence and Source Tracing of PFAS in Shallow Groundwater Used for Drinking Water in Wisconsin, USA," Matthew Silver, William Phelps, Kevin Masarik, Kyle Burke, Chen Zhang, Alex Schwartz, Miaoyan Wang, Amy L. Nitka, Jordan Schutz, Tom Trainor, John W. Washington, and Bruce D. Rheineck. *Environmental Science & Technology* 2023 57 (45), 17415-17426.
- Analysis of pharmaceuticals, personal care products, and antibiotics as tools to indicate pollution from humans and animals. This analysis can be done in **conjunction with the Microbial Source Tracking "Toolbox" to support various groundwater protection and management projects.**

### *Chemical Emergency Response Section*

- The WSLH serves as the only public health emergency preparedness-supported chemical response laboratory in Wisconsin. The lab has extensive capabilities for testing human exposures to priority chemical agents, provides sampling materials, and guidance for first responders, including hazardous material, drinking water, and natural resource entities, and performs any needed testing of environmental samples related to chemical incidents. One facet of this support has been the development of an emergency response drinking water collection kit, tailored to allow appropriate collection for assessing a wide range of chemical and microbiological contaminants in drinking water. These kits have been provided to all drinking water utilities serving more than 3,000 people, as well as to public health and other appropriate agencies. The emergency kit continues to be deployed to assist in characterizing a possible contamination and the system worked as designed.

### *Water Microbiology Section*

- In 2023 the Wisconsin Wastewater Surveillance Program - a partnership of the Wisconsin State Laboratory of Hygiene, the Wisconsin Department of Health Services, and the UW-Milwaukee School of Freshwater Sciences - was designated a National Center of Excellence by the Centers for Disease Control and Prevention (CDC). The program has been monitoring wastewater influents from wastewater treatment facilities throughout the state since September 2020. Initially implemented as a tool to track SARS-CoV-2, the list of targets has been expanded to include influenza A/B, RSV, norovirus and adenovirus, with many other targets under development. We currently have two public-facing dashboards: one displaying SARS-CoV-2 levels in wastewater from facilities around the state and a second displaying the SARS-CoV-2 variants that are measured by sequencing SARS-CoV-2 in the wastewater. This program has enhanced the molecular testing

capacity in the WSLH Water Microbiology section with respect to both staff expertise and equipment.

- Source assessment requirement under the Revised Total Coliform Rule – the WSLH continues to implement a scientifically based well assessment for wells testing positive for coliforms. The source of contamination is evaluated by collecting large sample volumes using a hollow fiber ultra-filtration system. This allows detection of organisms that are present in low concentrations. Molecular methods are used to evaluate whether the fecal contamination is from human or bovine sources. Other markers such as porcine and waterfowl are also being developed.
- As a part of a larger laboratory-wide preparedness program, WSLH is prepared to offer appropriate microbial water quality testing when needed. WSLH is a member of the Environmental Response Laboratory Network and the Water Laboratory Alliance for both chemical and biological response. This involves participation in nationwide preparedness drills coordinated by the Centers for Disease Control and Prevention in conjunction with the USEPA.
- The WSLH Flow Cytometry Unit coordinates and distributes samples for the only *Cryptosporidium* Proficiency Testing Program available in the United States. This WSLH program supports environmental laboratories testing water samples for the presence of this parasitic protozoan under the Long Term 2 Enhanced Surface Water Treatment Rule. The program is designed to provide water-testing laboratories and accreditation agencies with a means of assessing a laboratory's performance of U.S. EPA Method 1622/1623. The program is accredited under ISO 17043 "general requirements for proficiency testing" and distributes samples twice annually. The program operates with support from the WSLH Water Microbiology **Department, which evaluates the robustness of the parasites' suspensions prior to and following distribution to participant laboratories.**

### *Inorganic Chemistry Section*

- A variety of nutrients are routinely measured in drinking water, surface water, and groundwater. People with health concerns regarding their drinking water, such as nitrates, can submit samples for evaluation. Results are sent to the clients and the DNR for their database. The DHS has worked with WSLH at the county level to provide drinking water kits to families with at-risk individuals to monitor for nitrates, bacteria and metals in well water.
- Most types of metals are also measured. Those of health concern and public interest, such as arsenic and hexavalent chromium, are important in monitoring because they have been associated with specific geological formations and conditions in northeastern Wisconsin.
- DHS and WSLH have been partnering with counties to provide testing of lead in drinking water at daycares across Wisconsin.
- Ancillary inorganic tests are routinely performed to measure chloride, sulfate, pH, alkalinity, and conductivity—properties that are important in controlling the chemical conditions for groundwater systems.
- As with other sections of the WSLH, the Inorganic Section responds to spills that could affect surface water and groundwater. The lab has worked extensively with both DNR and DHS to identify contaminants in well water that may have had surficial origins.
- The WSLH has multi-collector ICPMS instrumentation that can be used to measure isotopic fingerprints of metals to source-track their origin. By measuring isotopic ratios of certain metals (e.g., lead) it is possible to identify primary and secondary

sources of the particular metal, be it the soil, paint, piping, etc. Each case is different, but it is possible to employ this technology to better elucidate the source of a metal in drinking water or other matrices.

- In addition to isotope work, the dedicated trace-level clean lab routinely measures metals or elements in water at the parts per trillion (ppt) ranges for unique applied low-level research questions and monitoring.
- The WSLH works with and receives samples from the U.S. Geological Survey, researchers at UW campuses, and the Wisconsin Geological and Natural History Survey on specialized groundwater projects. The lab also routinely measures samples from drinking water utilities that rely on groundwater.

For more information on the WSLH:

Visit the website <http://www.slh.wisc.edu>

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