

## FROM THE INTERIM DIRECTOR

I extend my sincere gratitude to Dr. Dane Mataic, Associate Professor of Sociology and Anthropology at North Dakota State University (NDSU), for his outstanding leadership over the last year at the North Dakota Water Resources Research Institute (NDWRRRI). Dr. Mataic's dedication and professionalism have been invaluable. In January 2026, I assumed the role of Interim Director with strong support from the NDSU Office of Research and Creative Activity.

This newsletter, for the 2024-2025 period, introduces the eight NDWRRRI Fellows for 2025-2026, and highlights the eight graduate fellowship research projects from 2024-2025, along with the related findings and achievements of the Fellows and their advisors.

Over the past few years, we have welcomed several new junior faculty members with expertise in water-related issues, who have joined the two research universities in the state. They are recognized as Institute-affiliated faculty, and two of them are introduced in the "Meet Our Faculty" section: Dr. Kang Liang, Assistant Professor of Soil Physics and Hydrology in the School of Natural Resources Sciences at North Dakota State University (NDSU) and Dr. Mahmut Selim Ersan, Assistant Professor in the Department of Civil Engineering at the University of North Dakota (UND).



The Institute has consistently benefited from the guidance and assistance of the State Advisory Committee, comprised of Brent Hanson from the United States Geological Survey (USGS) ND Water Science Center, Andrew Nygren from North Dakota Department of Water Resources, Karen Ryberg from Barr Engineering, Aaron Larsen from the North Dakota Game and Fish Department, and Tate Libunao from North Dakota Department of Environmental Quality. Their insightful direction, especially in determining research priorities, allocating Fellowship funding, and aiding in securing support from North Dakota Department of Water Resources, has been instrumental in the Institute's success. Furthermore, you will find lists of recent water-related publications from the USGS, DWR, and the Institute.

*Continued on Page 2*

## » INSIDE

Page 2 NDWRRRI Faculty Fellows  
Page 3 NDWRRRI State Advisory Board  
Pages 4-5 Meet new NDWRRRI Faculty

Pages 6-16 2025-26 NDWRRRI Fellowships/  
Reports  
Pages 17-22 2024-25 NDWRRRI Fellow  
Publications  
Pages 23-24 USGS Publications

In FY 2024-25, the Institute received full base grant funding from USGS, along with supplementary support from the ND DWR. The latter demonstrates the strong commitment to supporting research on water resources in the State. The entire supplementary grant has been allocated to support Graduate Fellowships. The Institute extends its appreciation to ND DWR for this invaluable support.

The research activities in 2025 are primarily driven by this Graduate Research Fellowship program and a series of technical NDWRRI seminars, which cover a range of water resources issues, including contaminant leaching, innovative water treatment, and advanced hydrologic modeling.

Water stands as a vital resource for the growth and prosperity of North Dakota. It is indispensable for the state’s thriving agricultural and industrial sectors, as well as for municipal and domestic consumption. The Institute remains steadfast in its commitment to supporting research, education, training, and outreach that benefit water resources across the state.

The Institute has met mandates required by Section 104 of the Water Resources Research Act of 1984 through a range of research, education, training, and outreach activities addressing water issues in the state. This newsletter is a testament to these efforts. Thank you for your interest in the Institute, and to those of you who have been a part of it. I hope you find this newsletter informative and enjoyable.

With warm regards,  
Trung Le, Ph.D.,  
Associate Professor (Department of Civil, Construction, and Environmental Engineering)  
North Dakota State University

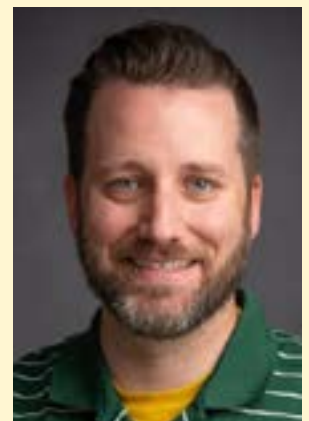
## NDWRRI FACULTY FELLOWS



**Zhulu Lin**  
Associate Professor,  
Department of  
Agricultural and Bio-  
systems Engineering,  
North Dakota State  
University



**Travis Seaborn**  
Assistant Professor,  
Applied Ecology,  
School of Natural  
Resource Sciences,  
North Dakota State  
University



**NDWRRI STATE ADVISORY BOARD**



**Brent Hanson**

*Supervisory Hydrologist  
ND Water Science Center*

Since joining the US Geological Survey in 2003, Hanson has held various roles with the agency including QA/QC coordinator, Supervisory Hydrologist, and Surface Water Specialist.



**Karen Ryberg**

*Senior Water Resources Consultant  
Barr Engineering*

Ryberg work bridges rigorous science, team development, and public mission, revitalizing teams, mentoring emerging scientists, and delivering actionable research that shapes policy and protects public safety.



**Andrew Nygren**

*Director of Appropriation  
ND Department of Water Resources*

Nygren worked for the ND DWR initially as a Water Resource Engineer with the NDSWC Development Division Investigations Section and as a Hydrologist with the NDSWC Water Appropriation Division.

**Tate Libunao**

*Environmental Scientist  
ND Department of Environmental Quality*

Prior to joining the Division of Water at the North Dakota Department of Environmental Quality in 2024, where he manages the Special Project and Water Quality Standards Program, Libunao was an affiliate researcher at IWRI.



**Aaron Larsen**

*Conservation Biologist  
with North Dakota Game & Fish Department*

Larsen focuses on incorporating aquatic species of interest into the State Wildlife Action Plan, as well as providing environmental project review. Prior to that, he worked with the North Dakota Department of Environmental Quality (NDDEQ).

## MEET THE NEW FACULTY

**Dr. Kang Liang** is an Assistant Professor in soil physics and hydrology at the School of Natural Resource Sciences at North Dakota State University. Before joining NDSU in July 2025, he worked as a research hydrologist with USDA-ARS and postdoctoral researcher at the University of Maryland. Liang’s research focuses on understanding how agricultural management practices interact with hydrological and biogeochemical processes to influence soil health, water quality, and ecosystem sustainability. His work integrates field observations, remote sensing, and process-based watershed modeling to investigate nutrient transport, soil carbon dynamics, and greenhouse gas emissions in agricultural landscapes. A major component of his research involves improving and applying agroecosystem and watershed models to better understand nutrient cycling and environmental responses to agricultural management and climate variability. His research addresses critical challenges related to sustainable crop production, conservation practices, and nutrient loss from intensively managed agroecosystems. Liang received a Ph.D. in Environmental Science from the University of New Brunswick, Canada.



Liang’s Soil Hydrology and Physics Lab at NDSU focuses on understanding the physical and hydrological processes that regulate water, nutrient, solute, and carbon cycling in agricultural systems. The lab investigates how soil properties, hydrological pathways, and management practices influence nutrient losses, soil salinity, and soil carbon sequestration across multiple spatial scales, from field experiments to large watersheds (such as the Red River Basin, Upper Mississippi River Basin, Mississippi River Basin, etc). Many environmental challenges in agricultural landscapes arise from the interactions among soil processes, hydrology, and human management, which can lead to complex and sometimes unexpected impacts on the environment and ecosystem health. To address these challenges, the Soil Hydrology and Physics Lab integrate field measurements, process-based modeling, and data-driven approaches to better understand the transport and transformation of nutrients and other biogeochemical constituents in soil-plant-water systems. The Lab will also work on developing and applying advanced modeling tools to evaluate conservation practices such as cover crops, tillage, and nutrient management strategies under variable conditions. Through interdisciplinary collaboration, the lab aims to develop science-based solutions and decision support tools that improve agricultural sustainability while reducing environmental impacts on downstream ecosystems.

## MEET THE NEW FACULTY

**Dr. Mahmut Selim Ersan** is an Assistant Professor in the Department of Civil Engineering at the University of North Dakota. Ersan received his Ph.D. from the Department of Environmental Engineering and Earth Sciences at Clemson University in 2017. From 2017 to 2018, he worked as a Postdoctoral Fellow on a project funded by United States Environmental Protection Agency, focusing on the impact of wildfires on surface water quality and the subsequent formation of disinfection byproducts. From 2018-2020, Dr. Ersan joined Southern Nevada Water Authority as a Postdoctoral Researcher, where his research delved into controlling the occurrence and formation of emerging contaminants in potable water reuse applications.



In 2020, Ersan joined the School of Sustainable Engineering and the Built Environment at Arizona State University as an Assistant Research Professor. His research interests lie in the fundamentals and applications of physico-chemical processes in natural and engineered environmental systems. He has made significant contributions to the scientific understanding and removal of organic contaminants and harmful emerging contaminants (e.g., disinfection by-products, poly- and perfluorinated alkyl substances, pharmaceuticals, and endocrine-disrupting compounds) in water and wastewater treatment, as well as water reuse applications. Ersan's research team at the University of North Dakota focuses on developing novel treatment and regeneration technologies for sustainable futures, as well as sensing technologies for cost-effective, chemical-free, and real-time analysis of emerging compounds in water systems. Dr. Ersan serves as the faculty advisor for the UND Student Chapter of the American Water Works Association. He teaches both undergraduate and graduate courses, including Unit Operations in Water and Wastewater Treatment (CE 437/537), Environmental Chemistry (CE 436/536), and Environmental Engineering Laboratory (CE 431L). In addition to his teaching and research responsibilities, Ersan also leads the organization of summer camps and BrainSTEM programs for K-12 students at UND.

## **NINE GRADUATE FELLOWSHIPS AWARDED FOR 2025-26**

The North Dakota Water Resources Research Institute announced its Graduate Research Fellowship recipients for 2025-26. The fellowships were awarded to nine graduate students who will conduct water resources research at North Dakota State University and the University of North Dakota. These nine graduate research projects are supported with the annual base (104b) United States Geographical Survey federal grant and an additional fund from North Dakota State Water Commission. The 2025-26 NDWRRRI Fellows and their faculty advisors, academic programs, and research projects are:

**Name:** Paige Arsenault (M.S. student)  
**Title:** Wetland Characteristics and Waterfowl Production of Alternative Agricultural Practices  
**Program:** Department of Biology, UND  
**Advisor:** Mark Kaemingk, Ph.D.

**Name:** Debarshi Dasgupta (Ph.D. student)  
**Title:** Through The Looking Glass: Exploring Soil Microbiomes To Mitigate Groundwater Contamination In Agroecosystems  
**Program:** Microbiological Sciences, NDSU  
**Advisor:** Samiran Banerjee, Ph.D.

**Name:** Aditya Goyal (Ph.D. student)  
**Title:** Phosphate Removal from Water Using Calcium Peroxide Nanoparticles  
**Program:** Materials and Nanotechnology, NDSU  
**Advisor:** Achintya Bezbaruah, Ph.D.

**Name:** Hesham Mahmoud (Ph.D. student)  
**Title:** Groundwater Head Response to Seasonal Snowmelt, Rainfall Recharge, and Climate Variability in a Cold Region Unconfined Aquifer (Oakes Aquifer)  
**Program:** Geological Engineering, UND  
**Advisor:** Taufique Mahmood, Ph.D.

**Name:** Matthew Maldonado (Ph.D. student)  
**Title:** Evaluating the influence of temperature and precipitation regimes on angler effort and expenditures  
**Program:** Department of Biology, UND  
**Advisor:** Mark Kaemingk, Ph.D.

**Name:** Shirsa Mazumdar (Ph.D. student)  
**Title:** Bio-Adsorbent-Embedded Ceramic Filters: A Point-of-Use Solution for Phosphate and Sulfate Removal  
**Program:** Materials and Nanotechnology, NDSU  
**Advisor:** Achintya Bezbaruah, Ph.D.

**Name:** Amresh Selukka Nagarajan (Ph.D. student)  
**Title:** Carbon quantum dots from agricultural waste for the removal of heavy metals in produced water  
**Program:** Civil Engineering, NDSU  
**Advisor:** Jiale Xu, Ph.D.

**Name:** Michael Rosati (Ph.D. student)  
**Title:** Assessing Groundwater Dynamics of North Dakota's Alluvial and Glacial Aquifers using InSAR and Subsidence Analysis  
**Program:** Environmental Engineering, UND  
**Advisor:** Howe Lim, Ph.D.

**Name:** Arvin Samadi-Koucheksaraee (Ph.D. student)  
**Title:** Enhancing Daily Streamflow Forecasting: A Coupled GPR-EBBO Hybrid Machine Learning Method  
**Program:** Civil Engineering with the option of Water Resources, Department of Civil, Construction and Environmental Engineering, NDSU  
**Advisor:** Dr. Xuefeng Chu, Ph.D.

In 2024-25, the North Dakota Water Resources Research Institute (NDWRRI) funded a diverse cohort of researchers at North Dakota State University and the University of North Dakota focused on critical regional issues, including emerging contaminants, predictive modeling, and water infrastructure.

**Name:** Tiansong Qi, NDSU

**Research topic/project title:** Incorporating wet-land characteristics in watershed-scale hydrologic modeling.

**Name:** Michael Rosati, UND

**Research topic/project title:** Enhancing water quality monitoring through regional machine learning models.

**Name:** Biraj Saha, NDSU

**Research topic/project title:** PFAS leaching from yard waste compost and landfill leachate management.

**Name:** Odunola Latifah Odofin, UND

**Research topic/project title:** Biodegradation of Per- and Polyfluoroalkyl Substances (PFAS) in water.

**Name:** Shirsa Mazumdar, NDSU

**Research topic/project title:** Metal/Metal oxide-modified bio-based adsorbents for phosphate removal.

**Name:** Mousa Almousa, UND

**Research topic/project title:** Lithium adsorption from Bakken oilfield-produced water using Metal-Organic Frameworks.

**Name:** Arvin Samadi Koucheksaraee, NDSU

**Research topic/project title:** Hybrid machine learning methods for streamflow forecasting in cold regions.

**Name:** Javad Souri, NDSU

**Research topic/project title:** Turbulent characteristics in locations with potential ice jams.

**Name:** Mohsin Uddin, NDSU

**Research topic/project title:** Formation and decay of disinfection byproducts (DBP) in water distribution systems.

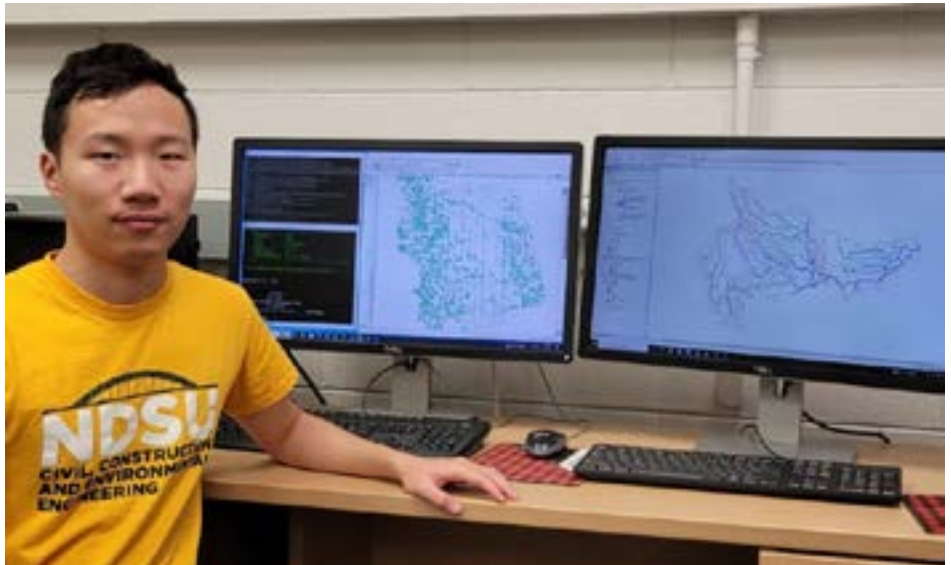
## 2024-25 NDWRRI FELLOWSHIP RESEARCH HIGHLIGHTS

**Project:** Incorporating wetland characteristics in watershed-scale hydrologic modeling in depression-dominated areas

**Fellow:** Tiansong Qi, North Dakota State University

**Advisors:** Xuefeng Chu, Ph.D., and Marinus Otte, Ph.D.

Depressional wetlands are important components of watersheds and play a significant role in watershed hydrologic cycles by affecting surface runoff generation, overland flow routing, and other processes. The threshold-controlled, filling-spilling processes over individual wetlands result in dynamic ponding storage and varying partial contributing areas of surface runoff to a watershed outlet. However, such complex hydrologic processes are usually oversimplified in conventional watershed models by assuming a lumped, constant contributing area. This project aimed to improve watershed-scale hydrologic modeling, especially for depression-dominated regions, by quantifying the influence of individual depressional wetlands. In this project, a four-factor hydrologic response unit (HRU) redefinition technique was proposed to characterize the variations of topographic features, soil properties, and land covers in depressional areas and a novel HRU-level wetland modeling approach was developed to account for the influence of dynamic ponding storages of individual depressional wetlands on surface runoff generation and overland flow routing. The new modeling approach was applied to the Upper Forest River watershed in North Dakota, demonstrating its improved modeling performance and enhanced capability in simulating the spatially and temporally varying characteristics of ponded water across individual depressional wetlands, as well as the stepwise expansion and contraction of dynamic partial contributing areas. This project provides a novel modeling framework for evaluating and elucidating the influences of depressional wetlands on watershed hydrologic processes, which can further help address the relevant water resources management issues.



## 2024-25 NDWRRI FELLOWSHIP RESEARCH HIGHLIGHTS

**Project:** Enhancing water quality monitoring through regional machine learning models

**Fellow:** Michael Rosati, University of North Dakota

**Advisor:** Yeo Howe Lim, Ph.D.

This project evaluated how sequence-based neural networks can be used to improve hydrologic and water-quality prediction in data-limited watersheds. Originally designed to incorporate hyperspectral datasets across a broad region, the study was refined to a four-basin regional modeling framework due to data availability constraints. Using daily climate forcings, hydrologic variables, and USGS nutrient observations, both basin-specific and regional Long Short-Term Memory (LSTM) models were developed and tested.

Despite the reduced spatial scope, results demonstrated strong predictive performance. Regional models showed high agreement with observed nutrient concentrations (correlation values generally between 0.8 and 0.9 for phosphorus and up to 0.97 for nitrate) and performed comparably to, and in some cases slightly better than, site-specific models. These findings indicate that regional LSTM frameworks can effectively “borrow strength” across watersheds while maintaining accuracy, offering a scalable tool for improving water-quality prediction where monitoring data are limited.

Beyond predictive skill, the primary impact of this work lies in advancing interpretable neural network design for hydrologic science. Comparative testing of regional and site-specific architectures clarified how watershed characteristics, model conditioning strategies, and training data limitations influence generalization and physical consistency. These methodological insights informed the modeling framework used in a recent peer-reviewed publication on groundwater and baseflow dynamics and now serve as the foundation for an ongoing doctoral dissertation focused on testing flow-path partitioning theory using interpretable neural networks. Collectively, this fellowship-supported work strengthens the integration of machine learning and process-based understanding in water resources research.

## 2024-25 NDWRRI FELLOWSHIP RESEARCH HIGHLIGHTS

**Project:** Per and polyfluoroalkyl substances (PFAS) leaching from yard waste compost

**Fellow:** Biraj Saha, North Dakota State University

**Advisors:** Syeed Md Iskander, Ph.D.

This study identified substantial per- and polyfluoroalkyl substances (PFAS) contamination in yard waste compost and demonstrated a clear vertical distribution pattern that indicates leaching potential. Total PFAS concentrations were  $18.53 \pm 1.5 \text{ mg kg}^{-1}$ , with seventeen compounds detected across six classes, dominated by perfluoroalkyl carboxylic acids (PFCAs; 72.5%) and perfluoroalkyl sulfonic acids (PFSA; 22.1%). Short-chain compounds, perfluorobutanoic acid (PFBA;  $11.15 \pm 1.5 \text{ mg kg}^{-1}$ ), were dominant among the detected PFAS and contributed substantially to the total concentration. In an idle compost pile, total PFAS concentrations at two-foot depth were approximately 2.1–2.5 times higher than surface concentrations.

Short-chain PFCAs such as PFBA and perfluoropentanoic acid (PFPeA) were enriched by approximately 5.9–9.3 times at two feet compared to the surface. Linear regression analysis showed a positive relationship between the PFAS concentration ratio (two feet to surface) and PFAS water solubility, indicating preferential downward transport of more soluble compounds. Dissolved organic matter (DOM) was significantly associated with total PFAS distribution across depths, suggesting that DOM-facilitated transport contributes to PFAS migration within the compost matrix. Semi-volatile precursor compounds, including 6:2 fluorotelomer sulfonic acid (6:2 FTS) and N-ethyl perfluorooctane sulfonamido acetic acid (EtFOSAA), were 25–80% lower at the surface relative to deeper layers, which is likely due to transformation of PFAS precursors into short- and long-chain PFAS within the compost profile. These findings indicate that yard waste compost permits downward movement of soluble and DOM-associated PFAS fractions, which can facilitate PFAS leaching to underlying soils and potentially groundwater following land application.



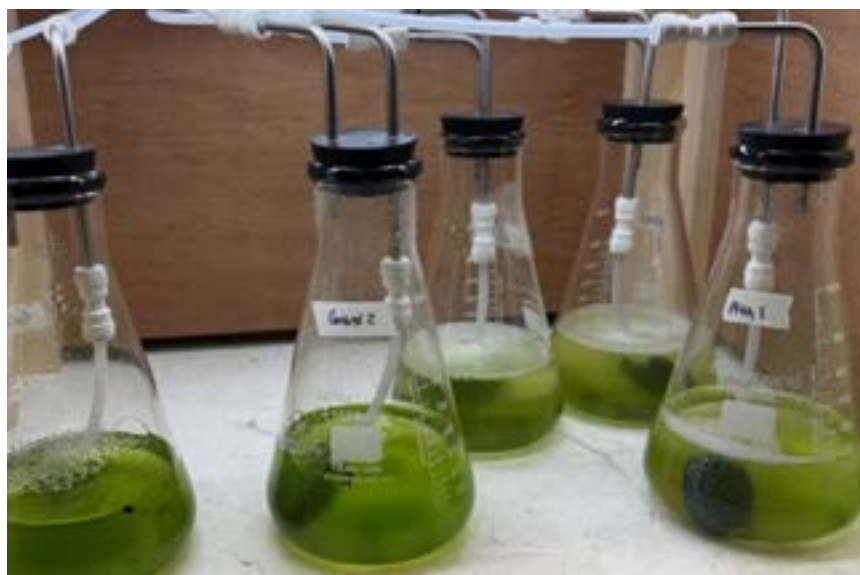
## 2024-25 NDWRRI FELLOWSHIP RESEARCH HIGHLIGHTS

**Project:** Biodegradation of Per- and Polyfluoroalkyl Substances (PFAS) in water

**Fellow:** Odunola Latifah Odofin, University of North Dakota

**Advisors:** Yun Ji, Ph.D.

Per- and polyfluoroalkyl substances (PFAS), commonly known as “forever chemicals”, are widely used in products such as non-stick cookware, firefighting foams, and water-resistant materials. Their strong carbon-fluorine bonds make them highly resistant to degradation, allowing them to persist in water and accumulate in the environment. Exposure to PFAS has been linked to health concerns including thyroid disease, impaired fertility, cancer, and liver damage. Current treatment methods are often costly, energy-intensive, and may generate secondary waste. These concerns highlight the urgent need for more sustainable solutions.



This project investigates the potential of biological approaches, particularly microalgae, for PFAS remediation in water. Experiments were conducted using a freshwater microalga to examine its interaction with perfluorooctanoic acid (PFOA), a commonly detected PFAS compound. Algal growth was monitored throughout, and changes in PFAS concentrations were evaluated using liquid chromatography-mass spectrometry (LC-MS).

The results show that the microalgae can tolerate PFAS exposure while continuing to grow, and observations suggest some degree of PFAS transformation may be occurring. However, further research is needed to confirm the mechanisms involved and validate the findings. The study also identified key analytical challenges, including low concentration detection, matrix effects and difficulties in interpreting LC-MS signals, which can influence data reliability. Current work focuses on expanding the range of PFAS compounds studied, improving experimental methods, and exploring additional treatment strategies including enzymatic and heat-assisted approaches. This research contributes to the development of sustainable solutions for PFAS contamination and supports efforts to protect water quality in North Dakota and beyond.

## 2024-25 NDWRRI FELLOWSHIP RESEARCH HIGHLIGHTS

**Project:** Metal/metal oxide-modified bio-based adsorbent for phosphate removal and recovery

**Fellow:** Shirsa Mazumdar, North Dakota State University

**Advisors:** Achintya N. Bezbaruah, Ph.D.

Excessive phosphate levels in water bodies, primarily from agricultural activities, fuel algal blooms and disrupt the natural balance of aquatic environments. The efficient and cost-effective elimination of phosphates from aqueous solutions has become an urgent priority to protect our lakes and rivers. In response, we reported a bio-based adsorbent for phosphates derived from agricultural waste (wheat straw). Nanocellulose was extracted from wheat straws (waste byproduct) using chemical treatments and then modified with an iron (Fe) salt to enhance the adsorption capacity. Material characterization techniques confirmed successful iron loading in the adsorbent. Batch experiments demonstrated effective phosphate recovery by the material (>90% within one hour), and the maximum phosphorus (P) adsorption capacity was 1.42 mg/g. Kinetic studies revealed a dominant role of chemisorption in aqueous P removal.



This confirms that the adsorption is not just physical (van der Waals forces) but involves chemical bonding (formation of stable binuclear complexes between phosphate ions and the iron oxides/hydroxides on the surface). There were negligible interferences from co-existing ions, pH, temperature, and organic matter on phosphate removal efficiency at environmentally relevant levels. The results demonstrate that wheat straw could be an inexpensive and promising raw material for developing a bio-based adsorbent for P removal. Beyond these findings, the study also highlights a way forward towards a green and circular economy by integrating waste valorization, nutrient recovery, and resource reuse.

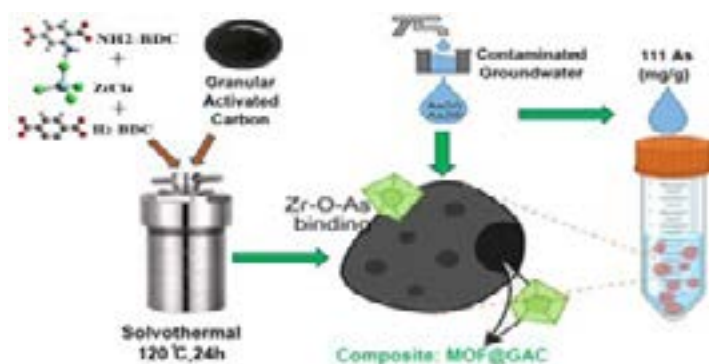
**2024-25 NDWRRI FELLOWSHIP RESEARCH HIGHLIGHTS**

**Project:** Development of Fe-Doped MOF and MOF-GAC Composite Materials for Arsenic Removal from Water

**Fellow:** Mousa Almousa, University of North Dakota

**Advisors:** Yeo Howe Kim, Ph.D.

This project, funded by the North Dakota Water Resources Research Institute (NDWRRI), investigates advanced adsorbent materials for improving arsenic removal from water. The study focuses on the development of composite materials combining metal-organic frameworks (MOFs) with granular activated carbon (GAC), as well as iron-doped MOFs, to enhance adsorption performance and stability.



MOFs are highly porous materials with tunable structures and large surface areas, making them promising candidates for water treatment applications. In this work, UiO-66 based MOFs were synthesized and modified through iron (Fe) doping and composite formation with GAC. The introduction of Fe into the MOF structure was intended to create additional active sites and improve affinity toward arsenic species, particularly As(III) and As(V), which are common groundwater contaminants. Meanwhile, the incorporation of GAC provided improved structural stability, enhanced mass transfer, and additional adsorption pathways.

The synthesized materials were characterized using several analytical techniques, including Fourier Transform Infrared Spectroscopy (FTIR), X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and nitrogen adsorption-desorption analysis to evaluate their structural, chemical, and textural properties. These analyses confirmed successful MOF formation, structural modifications due to Fe doping, and the formation of MOF-GAC composites. Adsorption experiments demonstrated that the modified materials exhibited improved arsenic removal performance compared to the pristine materials.

Overall, the results highlight the potential of Fe-doped MOF and MOF-GAC composite materials as promising adsorbents for arsenic remediation in water treatment applications. These findings contribute to the development of more efficient and sustainable technologies for addressing groundwater contamination challenges.

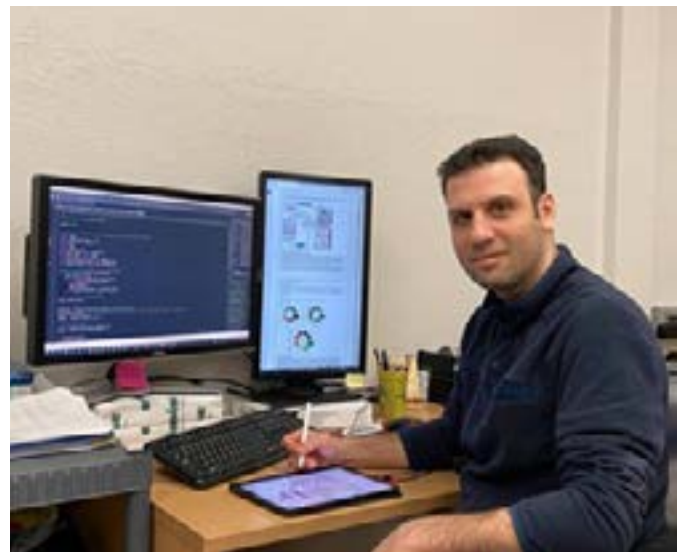
**2024-25 NDWRRI FELLOWSHIP RESEARCH HIGHLIGHTS**

**Project:** A Novel Hybrid Machine Learning Method for Streamflow Forecasting in Cold Regions

**Fellow:** Arvin Samadi Koucheksaraee, North Dakota State University

**Advisors:** Xuefeng Chu, Ph.D.

Machine learning (ML) methods have been widely used for forecasting hydrologic processes in recent years. However, in addition to some notable drawbacks including the need for high-quality input data, challenges in selecting optimal predictors, and difficulties in generalizing models across diverse temporal and spatial horizons, their overall efficacy remains insufficiently understood especially for hydrologic prediction in snow-dominated watersheds. This project aimed to develop a novel intelligent framework for daily streamflow prediction in cold regions across various time horizons by utilizing both satellite and ground-based hydroclimatic data. Specifically, a hybrid ML model, coupled with a multi-step data preprocessing technique, was developed to forecast daily streamflow.



The hybrid ML model (KRR-EN-EINFO) integrated kernel ridge regression (KRR), elastic net (EN), and the enhanced weighted mean of vectors (EINFO) algorithm for multi-step-ahead predictions while considering both linear and nonlinear trends. The multi-step data preprocessing technique combined multivariate variational mode decomposition (MVMD) for decomposing non-stationary and complex signals with Boruta-SHAP feature selection for identifying optimal inputs and reducing dimensionality, thereby simultaneously addressing non-stationarity and selecting relevant predictors. The modeling framework was applied to the Forest River watershed in North Dakota to forecast daily streamflow at different horizons (1-day, 3-day, and 7-day) based on snow cover areas derived from MODIS products processed in the Google Earth Engine platform, river discharge, and other hydroclimatic datasets. The findings demonstrated that KRR-EN-EINFO overperformed other existing ML models particularly for 3-day and 7-day streamflow forecasting horizons.

## 2024-25 NDWRRI FELLOWSHIP RESEARCH HIGHLIGHTS

**Project:** Turbulent Characteristics and cross-stream Shear Stress Distribution in Ice Covered Rivers

**Fellow:** Javad Soury, North Dakota State University

**Advisors:** Trung Le, Ph.D.

River ice occurs yearly across the northern hemisphere, and its presence substantially modifies hydrodynamics of natural rivers. By introducing additional surface roughness, ice cover influences the redistribution of momentum and alters bed shear stress, thereby affecting overall channel dynamics. In this study, we proposed three new analytical frameworks by applying a quartic distribution of turbulent viscosity and velocity into the Reynolds-Averaged Navier-Stokes (RANS) equations. The resulting momentum flux models establish a relationship between depth-averaged velocity and water depth under ice cover, and secondary flow coefficient to describe lateral momentum flux in ice-covered rivers.



To assess model validity, extensive field campaigns were carried out during the winter of 2025 on a meandering reach of the Red River of the North (Fargo, N.D.). Using the Acoustic Doppler Current Profiler (ADCP) and Acoustics Doppler Velocimeter (ADV), time-averaged vertical and also near bed velocities were obtained. Our results demonstrate that these models successfully obtain the lateral distribution of depth-averaged velocity. Also, measurements reveal the secondary flow contributes to lateral momentum flux at magnitudes comparable to Reynolds stresses, while field observations confirm that ice cover significantly modifies the development of coherent secondary flow cells. Shear stress distribution was derived using the logarithmic fitting of the measured velocity profiles. Our novel models are able to replicate the maximum bed shear stress in a cross-section and it is at a distance of 6-10m off the outer bank. Our novel models offer practical tools for monitoring velocity profiles, discharges, and predicting bank erosion in ice-covered rivers.

## 2024-25 NDWRRI FELLOWSHIP RESEARCH HIGHLIGHTS

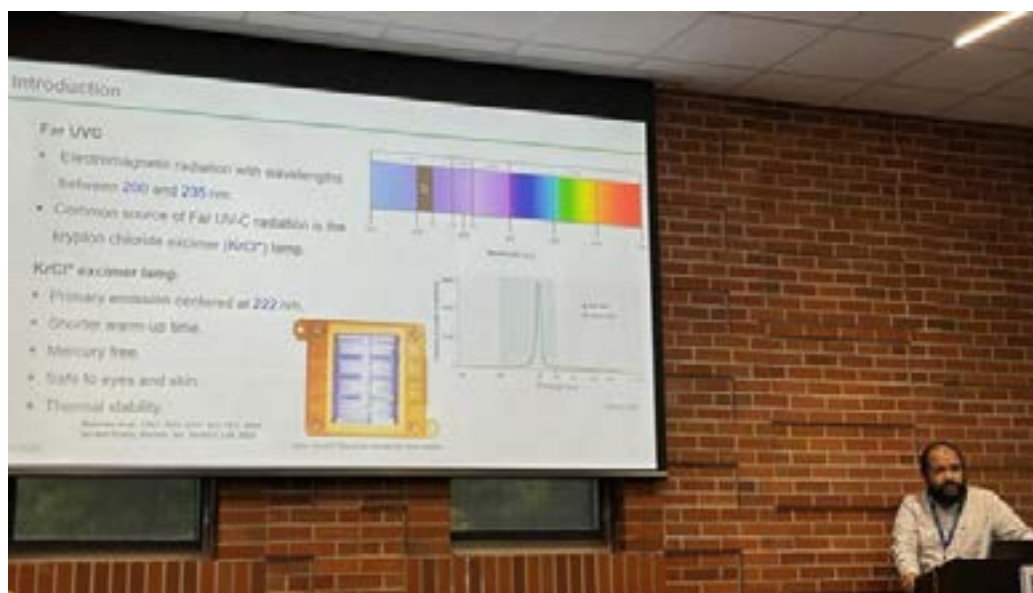
**Project:** Formation and decay of disinfection byproducts (DBP) in water distribution systems

**Fellow:** Mohsin Uddin, North Dakota State University

**Advisors:** Jiale Xu, Ph.D.

Clean drinking water is very important for public health. Water treatment plants add disinfectants to kill harmful germs in water. The disinfectants can react with natural organic matters in water. They can form new chemicals called disinfection byproducts such as trihalomethanes (THMs). Some of these chemicals may affect human health if they are present in high amounts. These chemicals can also form inside water pipes after the water leaves the treatment plant. Conditions inside the pipes can change how these chemicals form or break down. Old pipes can release metals like copper or iron. These metals may

change the way these byproducts form in drinking water. In this study, we tested how water conditions and pipe corrosion affect these chemicals. Water samples were prepared to represent typical drinking water. Chlorine was added to simulate normal water treatment. Small amounts of copper corrosion particles were also added to represent materials that can come from copper pipes. The water was tested at different pH levels and for different times to copy what happens inside water pipes. The results showed clear changes in chemical levels. When the pH increased, THMs increased from about 80  $\mu\text{g/L}$  to 200  $\mu\text{g/L}$ . Over time, the concentration increased to about 150  $\mu\text{g/L}$  after 48 hours in the pipes. Copper corrosion also affected the results. When copper corrosion particles increased from 0 to 0.2 g/L, THMs increased from about 100 nM to 250 nM. These results show that pipes and water conditions can change drinking water quality.



## **RECENT PUBLICATIONS AND PRESENTATIONS BY INSTITUTE FELLOWS AND PIS**

### **Journal Papers and Publications**

Arshad, A., Mazumdar, S., Goswami, J., Quadir, M., Nadagouda, M., Bezbaruah, A.N. and Xia, W., 2026. Ovalbumin as a PFAS carrier protein in aquatic environments. *Cell Reports Physical Science*, 7(2), <https://doi.org/10.1016/j.xcrp.2025.103089>

Khanaum, M. M., Qi, T., and Chu, X. 2025. Dynamic Partial Contributing Area (DPCA) approach: Improved hydrologic modeling for depression-dominated watersheds. *Journal of Hydrology*, 658, 133077, <https://doi.org/10.1016/j.jhydrol.2025.133077>.

Qi, T., and Chu, X. 2025. A depression-oriented four-factor redefinition of hydrological response units. *Hydrological Sciences Journal*, 70(14), 2575-2589, <https://doi.org/10.1080/02626667.2025.2549778>.

Rosati, M., Lim, Y. H., Zemlick, K., & Syed, K. (2026). Decoding LSTM to Reveal Baseflow Contributions in Fractured and Sedimentary Mountain Basins: A Case Study in the Sangre de Cristo Mountains, Southwestern United States. *Hydrology*, 13 (2), 51, <https://doi.org/10.3390/w11050931>.

Rosati, Michael. 2026. Testing Flow-Path Partitioning Theory Using Interpretable Sequence-Based Neural Networks. Ph.D. Dissertation. Environmental Engineering, College of Engineering & Mines, University of North Dakota, Grand Forks, ND (in progress).

Saha, B.; Ateia, M.; Fernando, S.; Xu, J.; DeSutter, T.; Iskander, S. M. PFAS occurrence and distribution in yard waste compost indicate potential volatile loss, downward migration, and transformation. *Environmental Science: Processes & Impacts* 2024, 26 (4), 657-666, <https://doi.org/10.1039/D3EM00538K>

Samadi-Koucheksaraee, A., & Chu, X. (2024). Development of a novel modeling framework based on weighted kernel extreme learning machine and ridge regression for streamflow forecasting. *Scientific Reports*, 14(1), 30910. <https://doi.org/10.1038/s41598-024-81779-z>

Souri, J., Koyuncu, B., Chamorro, L., & Le, T. (2025). Lateral momentum transfer in ice-covered rivers. *Authorea Preprints*. DOI: 10.22541/essoar.176005873.38366158/v1.

Uddin, M., and Xu, J. 2026. Far UVC (222 nm) enhances chloramine-based advanced oxidation in wastewater recycling: 1,4-dioxane removal, radical generation, and DBP formation. *Water Research*, 294, 125541, <https://doi.org/10.1016/j.watres.2026.125541>.

## **Presentations**

Mazumdar, S., Quadir, M., Bezbaruah, A.N. 2024. Nano-Modified Phosphate Fertilizers: For Sustainable Agriculture and Mitigating Eutrophication. South Dakota Student Water Conference, South Dakota Water Resources Institute, Oct. 15, 2024, Brookings, S.D. (Poster Presentation).

Mazumdar, S., Quadir, M., Bezbaruah, A.N. 2025. Sustaining Soil, Nourishing Crops: Layer-by-Layer Engineered Nano-Sized Rock Phosphate for Enhanced P Release. Student Research Days, North Dakota State University, April 9-10, 2025 Fargo, N.D. (Oral Presentation).

Odofin, O., Tudgeu Chendjou, S., Kubatova A., Gupta, S., & Ji, Y. (2026). Can Microalgae Help Remove PFAS from Water? Presented at the UND Graduate Research Achievement Day, March 5, 2026, Grand Forks, N.D.

Odofin, O., Tudgeu Chendjou, S., Kubatova A., Gupta, S., & Ji, Y. (2026). Exploring the Bioremediation Potential of Microalgae for PFAS Removal. Presented at the American Chemical Society Red River Valley Research Conference, Feb. 13-14, 2026, Moorhead, Minn.

Odofin, O., Tudgeu Chendjou, S., Kubatova A., Gupta, S., & Ji, Y. (2025). Exploring the Biodegradation of PFAS: Current Understanding, Challenges and Early Research Insights. Presented at the NDWRRI Water Research Seminar, North Dakota State University, Aug. 25, 2025, Fargo, N.D.

Odofin, O., Tudgeu Chendjou, S., Kubatova A., Gupta, S., & Ji, Y. (2025). Tiny Organisms, Big Impact: Exploring Sustainable PFAS Remediation with Microalgae. Presented at the American Chemical Society National Conference, Aug. 16-21, 2025, Washington D.C.

Odofin, O., Tudgeu Chendjou, S., Kubatova A., Gupta, S., & Ji, Y. (2025). Evaluating the Potential of Microalgae for the Bioremediation of Per- And Polyfluoroalkyl Substances (PFAS). North Dakota Academy of Science Annual Meeting, April 4-5, 2025, Grand Forks, N.D.

Qi, T. 2025. Improved Watershed-scale Hydrologic Modeling for Characterizing Dynamic Contributing Areas and Threshold-controlled Overland Flow from Depressional Wetlands. Water Seminar Series, North Dakota Water Resources Research Institute, Nov. 3, 2025.

Qi, T., and X. Chu. 2025. Redefinition of Hydrologic Response Units for Capturing Dynamic Partial Contributing Areas in Depression-dominated Watersheds. ND EPSCoR 2025 State Conference, October 21, 2025, Fargo, N.D.

Qi, T., and X. Chu. 2025. Incorporating the Impacts of Individual Surface Depressions in Watershed-scale Hydrologic Model. South Dakota Student Water Conference, October 14, 2025, Brookings, S.D.

Qi, T., and X. Chu. 2024. An Enhanced Modeling Framework for Simulating Hydrologic Processes in a Depression-dominated Watershed. ND EPSCoR 2024 State Conference, November 21, 2024, Grand Forks, N.D.

Qi, T., and X. Chu. 2024. A Four-factor Redefinition Technique of Hydrologic Response Units for Depression-dominated Watersheds. South Dakota Student Water Conference, October 15, 2024, Brookings, S.D.

Rosati, M., and Y. H. Lim. 2025. Enhancing Water Quality Monitoring Through Regional Machine Learning Models. ASCE 2025 World Environmental and Water Resources Congress, May 20-24, 2025, Anchorage, Alaska.

Saha, B.; Ateia, M.; Iskander, S. M. PFAS in Yard Waste Compost: Occurrence and Distribution. 2023 AEESP Research & Education Conference, June 19-23, Boston, Mass.

Samadi-Koucheksaraee, A., & Chu, X. (2025). Hybrid Machine Learning Modeling with an Enhanced Preprocessing Framework for Streamflow Forecasting. AGU25, December 15, 2025, New Orleans, La.

Samadi-Koucheksaraee, A., & Chu, X. (2025). Optimizing Daily Streamflow Forecasting through Tree-Based Feature Selection and Machine Learning in Cold Regions. ND EPSCoR 2025 State Conference, October 21, 2025, Fargo, N.D.

Samadi-Koucheksaraee, A., & Chu, X. (2025). Towards Accurate Streamflow Forecasting: A Hybrid Machine Learning Approach with Optimized Data Input. South Dakota Student Water Conference, Oct. 14, 2025, Brookings, S.D.

Samadi-Koucheksaraee, A., & Chu, X. (2025). Development of a Novel Modeling Framework Based on Weighted Kernel Extreme Learning Machine and Ridge Regression for Streamflow Forecasting. North Dakota Water Resources Research Institute Seminar Series, Nov. 13, 2025, Fargo, N.D.

Samadi-Koucheksaraee, A., & Chu, X. (2024). Leveraging Machine Learning and TVF-EMD for Improved Streamflow Forecasting. ND EPSCoR 2024 State Conference, Nov. 21, 2024, Grand Forks, N.D.

Samadi-Koucheksaraee, A., & Chu, X. (2024). Enhancing Streamflow Prediction through Advanced Preprocessing in Machine Learning Models. South Dakota Student Water Conference, Oct. 15, 2024, Brookings, S.D.

Souri, J., Koyuncu, B., Chamorro, L. P., Le, T. B., 2024. Turbulent Transfer of Momentum in Ice-Covered Rivers, American Geophysical Union 2024, Washington, D.C., Dec. 2024.

Souri, J., Chamorro, L. P., Le, T. B., 2025. Comparison of the Hydrodynamics of Open-Surface and Ice-Covered Rivers, UCOWR/NIWR 2025, Minneapolis, Minn., June 2025.

Souri, J., Le, Anh., Le, T. B., 2025. Advancing Field Measurement Accuracy for Natural Rivers Under Open-Surface and Ice-Covered Conditions, SD Student Water Conf., Brookings, S.D., Oct. 2025.

Souri, J., Chamorro, L. P., Le, T. B., 2025. Influences of Ice Coverage on Secondary Flow Development in Natural Meandering Rivers, ND EPSCoR 2025, Fargo, N.D., Oct. 2025.

Souri, J., Chamorro, L. P., Le, T. B., 2025. Theoretical and field-based analysis of lateral momentum flux in ice-covered streams, Annual Meeting of the APS Division of Fluid Dynamics, Houston, Texas, Oct. 2025.

Uddin, M., and X. Jiale. 2025. Removal of Organic Micropollutants from Wastewater Recycling Concentrate by Far-UVC (222 nm)-based Advanced Oxidation. South Dakota Student Water Conference, Brookings, S.D., Oct. 14-15, 2025,

Uddin, M., and X. Jiale. 2025. Enhanced Removal of N-nitrosamines and 1, 4-Dioxane by Far-UVC (222 nm) in Wastewater Recycling. AEESP 2025 Research and Education Conference, May 20-22, 2025, Durham, N.C.

Uddin, M., and X. Jiale. 2025. Far-UVC (222 nm) for Enhanced Removal of N-Nitrosamines and 1,4-Dioxane in Wastewater Recycling. ACS Red River Valley Conference, February 21-22, 2025, Grand Forks, N.D.

## **Theses and Dissertations**

Qi, T. 2025. Improved Watershed-Scale Hydrologic Modeling for Characterizing Dynamic Contributing Areas and Threshold-Controlled Overland Flow from Depressional Wetlands. Doctoral dissertation. Civil Engineering, College of Graduate and Interdisciplinary Studies, North Dakota State University, Fargo, ND (available at: <https://www.proquest.com/docview/3280829427?pq-origsite=gscholar&fromopenview=true&sourcetype=Dissertations%20&%20Theses>).

## **Awards**

### **Shirsa Mazumdar**

Honorable Mention for Alan R. Bender Poster Presentation. 2024. South Dakota Student Water Conference, South Dakota Water Resources Institute, October 15, 2024, Brookings, SD.

### **Javad Souri**

Session Chair, UCOWR/NIWR Annual Water Resources Conference, 2025.  
Session Chair, APS-DFD Annual Meeting, 2025.

### **Mohsin Uddin**

Research supported by the NDWRRI fellowship contributed to multiple awards. The work was presented at the ACS Red River Valley (RRV) 2025 Conference, where it received the Judges Choice Presentation Award. The research was also presented at the 2025 South Dakota Student Water Conference (Oct. 2025), where it earned the Outstanding Oral Presentation Award.

## **PUBLICATIONS**

### **Dept. Game and Fish:**

<https://gf.nd.gov/magazine/2026/feb>

### **USGS publications:**

Hydrologic budgets and water availability of six bedrock aquifers in the Black Hills area, South Dakota and Wyoming, 1931-2022 | U.S. Geological Survey.

Hydroclimatic and land-use factors affecting peak streamflow in Illinois, Iowa, Michigan, Minnesota, Missouri, Montana, North Dakota, South Dakota, and Wisconsin | U.S. Geological Survey.

A framework for understanding the effects of subsurface agricultural drainage on downstream flows | U.S. Geological Survey.

Evaluating drought risk of the Red River of the North Basin using historical and stochastic streamflow upstream from Emerson, Manitoba | U.S. Geological Survey.

Peak streamflow trends in Minnesota and their relation to changes in climate, water years 1921-2020 | U.S. Geological Survey.

Peak streamflow trends in North Dakota and their relation to changes in climate, water years 1921-2020 | U.S. Geological Survey.

USGS Open-File Report 2026-1066: Floods of June 2024 in Northwestern Iowa  
Suggested citation: Marti, M.K., and O'Shea, P.S., 2026, Floods of June 2024 in northwestern Iowa: U.S. Geological Survey Open-File Report 2026-1066, 16 p., <https://doi.org/10.3133/ofr20261066>. This publication is available online only.

USGS Circular 1557:

Hydroclimatic and Land-Use Factors Affecting Peak Streamflow in Illinois, Iowa, Michigan, Minnesota, Missouri, Montana, North Dakota, South Dakota, and Wisconsin

Suggested citation:

Ryberg, K.R., Marti, M.K., Barth, N.A., Over, T.M., Levin, S.B., Podzorski, H.L., Sando, S.K., Williams-Sether, T., O'Shea, P.S., and Chase, K.J., 2025, Hydroclimatic and land-use factors affecting peak streamflow in Illinois, Iowa, Michigan, Minnesota, Missouri, Montana, North Dakota, South Dakota, and Wisconsin: U.S. Geological Survey Circular 1557, 56 p., <https://doi.org/10.3133/cir1557>. This publication is available online only.

USGS Scientific Investigations Map 3545: Water Use Permits as of July 2024 and Reported Water Use Near the North Unit of Theodore Roosevelt National Park, North Dakota, 1980-2023

Suggested citation:

Anderson, T.M., and Medler, C.J., 2026, Water use permits as of July 2024 and reported water use near the North Unit of Theodore Roosevelt National Park, North Dakota, 1980-2023: U.S. Geological Survey Scientific Investigations Map 3545, 1 p., scale 1:75,000, <https://doi.org/10.3133/sim3545>. This publication is available online only.

USGS Scientific Investigations Report 2025-5067:

Hydrologic Budgets and Water Availability of Six Bedrock Aquifers in the Black Hills Area, South Dakota and Wyoming, 1931-2022

Suggested citation:

Medler, C.J., Anderson, T.M., and Eldridge, W.G., 2025, Hydrologic budgets and water availability of six bedrock aquifers in the Black Hills area, South Dakota and Wyoming, 1931-2022: U.S. Geological Survey Scientific Investigations Report 2025-5067, 87 p., <https://doi.org/10.3133/sir20255067>. This publication is available online only.

USGS Scientific Investigations Report 2025-5002:

Evaluating Drought Risk of the Red River of the North Basin Using Historical and Stochastic Streamflow Upstream from Emerson, Manitoba

Suggested citation:

Redoloza, F.S., Glas, R.L., Nustad, R.A., and Ryberg, K.R., 2025, Evaluating drought risk of the Red River of the North Basin using historical and stochastic streamflow upstream from Emerson, Manitoba: U.S. Geological Survey Scientific Investigations Report 2025-5002, 58 p., <https://doi.org/10.3133/sir20255002>. This publication is available online only.

**Data Releases:**

Williams-Sether, T., Cedar Face, M.A., Sullivan, M.T., Taylor, N.J., and Siefken, S.A., 2025, Data Files for Peak-Flow Frequency Analyses for Selected Streamgages in North Dakota Based on Data Through Water Year 2022 (ver. 2.0, January 2026): U.S. Geological Survey data release, <https://doi.org/10.5066/P14TA8CK>.

Medler, C.J., Eldridge, W.G., and Anderson, T.M., 2025, Electrical resistivity tomography (ERT) data collected near Summerset, South Dakota, July 28-August 4, 2025: U.S. Geological Survey, <https://doi.org/10.5066/P148NEP7>.

Eldridge, W.G., Anderson, T.A., Medler, C.J., and Haueter, J.Z., 2025, MODFLOW-6 model of the Shell Valley aquifer, Belcourt, North Dakota, 1980-2022: U.S. Geological Survey data release, <https://doi.org/10.5066/P13DSAUV>.

**DWR publications:**

2023-25 report: [https://www.dwr.nd.gov/info\\_edu/reports\\_and\\_publications/biennial\\_reports/pdfs/2023-2025.pdf](https://www.dwr.nd.gov/info_edu/reports_and_publications/biennial_reports/pdfs/2023-2025.pdf)

2022 5-year strategic plan: [https://www.swc.nd.gov/info\\_edu/reports\\_and\\_publications/strategic\\_plans/pdfs/2022\\_5\\_year\\_strategic\\_plan.pdf](https://www.swc.nd.gov/info_edu/reports_and_publications/strategic_plans/pdfs/2022_5_year_strategic_plan.pdf)



*Non-Profit Org.  
U.S. Postage Paid  
Permit No. 818  
Fargo, N.D. 58108*

North Dakota Water Resources  
Research Institute  
North Dakota State University  
P.O. Box 6050 Dept. 2890  
Fargo, ND 58108-6050

Phone: (701) 231-6369  
E-mail: [trung.le@ndsu.edu](mailto:trung.le@ndsu.edu)  
Website: [www.ndsu.edu/wrri](http://www.ndsu.edu/wrri)

**About the North Dakota Water Resources Research Institute (NDWRRI)**

*The Institute was founded in 1965 by authority of Congress as one of the 54 Institutes throughout the nation and is administered through the United States Geological Survey. The NDWRRI receives funding through section 104 of the Water Resources Research Act of 1984 and it applies its Federal allotment funds to research that fosters: A) the entry of new research scientists into the water resources field, B) training and education of future water resources scientists, engineers, and technicians; C) the preliminary exploration of new ideas that address water problems or expand understanding of water and water-related phenomena; and D) the dissemination of research results to water managers and the public.*