Environment and Natural Resources Trust Fund

M.L. 2025 Approved Work Plan

General Information

ID Number: 2025-110

Staff Lead: Tom Dietrich

Date this document submitted to LCCMR: June 11, 2025

Project Title: Predicting Contaminant Movement in Minnesota's Fractured Aquifers

Project Budget: $650,000

Project Manager Information

Name: Peter Kang

Organization: U of MN - St. Anthony Falls Laboratory

Office Telephone: (612) 624-5779

Email: pkkang@umn.edu

Web Address: https://www.safl.umn.edu/

Project Reporting

Date Work Plan Approved by LCCMR: June 24, 2025

Reporting Schedule: March 1 / September 1 of each year.

Project Completion: June 30, 2028

Final Report Due Date: August 14, 2028

Legal Information

Legal Citation: M.L. 2025, First Special Session, Chp. 1, Art. 2, Sec. 2, Subd. 04i

Appropriation Language: $650,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota, St. Anthony Falls Laboratory, to develop a software program that predicts the fate and movement of contaminants, such as PFAS, chloride, nitrate, and pathogens, in Minnesota's fractured aquifers.

Appropriation End Date: June 30, 2028

Narrative

Project Summary: We develop and demonstrate a software program that predicts the fate and movement of contaminants such as PFAS, chloride, nitrate, and pathogens in Minnesota's fractured aquifers.

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Groundwater supplies about 80% of Minnesotans' drinking water and is critically important for irrigation. However, Minnesota is experiencing serious groundwater problems due to a dramatic increase in water demand and pervasive contamination issues. In particular, groundwater contamination due to nitrate, PFAS, and pathogens poses a significant risk to public health and the environment. Conventional groundwater models over-simplify fracture flow, and as a result, often fail to accurately predict contaminant transport. The recent $850 million settlement between the state of Minnesota and the 3M Company over PFAS contamination is a representative example: the recently documented extent of the PFAS contamination plume in the eastern Twin Cities area is far greater than that predicted by conventional models. This was because high permeability fractures allowed contaminants to spread much faster than was expected. Groundwater systems are often composed of fractured rocks (rocks with cracks and other large cavities), and fractured aquifers in the Twin Cities area serve over one-half of the drinking water for its 3 million citizens. Accordingly, there is an urgent need for practical software that can more accurately forecast the movement of contaminants in fractured aquifers.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

Our goal is to develop a practical software program that can predict contaminant transport in Minnesota's fractured aquifers. Using the software, users can predict the travel time of contaminants in aquifers by entering several inputs (e.g., groundwater level, fractured rock type, tracer data). The software will be validated at two field sites and packaged so that state agencies and groundwater consulting companies can use it (see support letters). For example, the software will allow one to better evaluate the efficacy of improved agriculture practices on groundwater quality. The project focuses on two fractured limestone rock formations: the Platteville Formation, which is critical to the Twin Cities, and the Prosser and Cummingsville Formations, which are critical to the southeast Minnesota region. We will conduct field dye tracing and cutting-edge hydraulic testing to gather necessary site-specific data, building upon fracture flow properties accumulated from previous Environmental Trust Fund projects. This information will guide the development of three-dimensional numerical models. Finally, the modeling results will be used to develop the software program that predicts contaminant travel time. Note that the software will be applicable to sites beyond the proposed field sites, but it will still require the identification of site-specific parameters.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

The project will improve the prediction of contaminant migration through fractured aquifers, which is essential for protecting, remediating, and managing the state's water resources. Particularly, the project will generate hydrogeologic information necessary to understand how contaminants move through fractured rock formations. Among the major outcomes of the project will be a software program that can be run on standard computers. The software will enable predictions of the travel time distribution of contaminants, thereby providing water resource managers with critical information and making results more accessible to the public. In addition, the project will strengthen the hydrogeology curriculum at UMN.

Project Location

What is the best scale for describing where your work will take place?

County(s): Olmsted, Hennepin,

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Activities and Milestones

Activity 1: Characterizing fracture flow and contaminant transport properties of the Platteville formation

Activity Budget: $233,976

Activity Description:
The main goal of Activity 1 is to characterize the hydrogeologic properties of the Platteville Formation at a level of detail necessary for the development of the numerical model described in Activity 3. First, existing information on the hydrogeologic properties of the Platteville Formation from previous Environmental Trust Fund projects and other past investigations will be collected and synthesized. Additional field experiments will be conducted at a fractured Platteville site at the UMN campus. For fractured aquifers, recent scientific advances show that it is essential to measure hydrogeologic properties from discrete zones in wells rather than traditional whole-well measurements. Modular hydraulic packer-and-port systems (MHPS) will be utilized to obtain hydrogeologic data from discrete zones in wells using advanced sensors like fiber optics. The developer of the MHPS system (Prof. Warren Barrash) will support the field campaigns and the technology transfer. The site has ideal conditions for both teaching and research: groundwater at the site is contaminated with hydrocarbons, and multiple consulting reports with extensive hydrogeologic information are available, along with many monitoring wells. Fractured rock exposures are not only accessible at a nearby river bluff but also in an underground cavern where contaminated groundwater leaks through fractures in the ceiling.

Activity Milestones:

Description	Approximate Completion Date
Get input from water state agencies and groundwater managers to align research to their needs.	September 30, 2025
Synthesize the existing fracture flow and transport properties of the Platteville formation	December 31, 2025
Publish a map illustrating boreholes and their characteristics (such as water chemistry and hydraulic head)	June 30, 2026
First field campaign to characterize fracture flow and transport properties of the Platteville formation	September 30, 2026
Second field campaign to further characterize fracture flow and transport properties of the Platteville formation	September 30, 2027
Apply geophysical techniques such as surface Electrical resistivity Tomography (ERT) during field campaign	September 30, 2027
Develop a 3D hydrogeologic framework of the Platteville formation	October 31, 2027

Activity 2: Characterizing fracture flow and contaminant transport properties of the Prosser and Cummingsville Formations

Activity Budget: $220,454

Activity Description:
In SE Minnesota, nitrate contamination of karst aquifers is an urgent environmental issue. In 2023, EPA issued a letter urging Minnesota to develop a long-term solution to reduce nitrate concentrations in groundwater. The primary objective of Activity 2 is to characterize the hydrogeologic properties of the karstic Prosser and Cummingsville Formations, which will be used to develop the numerical model described in Activity 3. The Bear Spring area in Olmsted County will be used as a target field site. The Bear Spring area is located within the Zumbro River Watershed, where the Minnesota Geological Survey has completed subsurface geologic mapping that will serve as an important basis for model development. The site already has dye tracing information, and additional field dye tracing will be conducted to determine the flow connectivity between sinkholes and springs and to characterize the travel time distribution of contaminants. By completing this project, we will be able to better understand nitrate fate and transport in the karst aquifers of SE Minnesota. Field dye tracing campaigns will be conducted in collaboration with John Barry, a

hydrogeologist at the Minnesota Department of Natural Resources, and the newly collected data will be added to the Minnesota Groundwater Tracing Database.

Activity Milestones:

Description	Approximate Completion Date
Synthesize the existing fracture flow and transport properties of the Prosser and Cummingsville formations	December 31, 2025
First field campaign to characterize flow and transport properties of the Prosser and Cummingsville formations	September 30, 2026
Second field campaign to further characterize flow and transport properties of the Prosser and Cummingsville	September 30, 2027
Develop a 3D hydrogeologic framework of the Prosser and Cummingsville formations	October 31, 2027

Activity 3: Develop a practical software for predicting contaminant transport in fractured aquifers and incorporate findings into college-level hydrogeology courses

Activity Budget: $195,570

Activity Description:
The hydrogeologic characterization from Activities 1 and 2 will be turned into three-dimensional (3D) numerical models that simulate groundwater flow and contaminant transport. The development of numerical models, which reflect the complexity of fractured rocks, will be guided by field data obtained from dye tracing and hydraulic testing. The next phase involves quantifying contaminant travel time distributions using the developed numerical models. A diverse range of fractured rock scenarios will be modeled, and the produced data set will be used to train a machine learning algorithm, ensuring robust predictions while systematically quantifying the associated uncertainties. Based on modeling and machine learning results, user-friendly software capable of predicting contaminant travel time distributions will be developed. Using this software, users can input basic hydrogeologic information and obtain travel time distribution predictions, simplifying the complex process of modeling contaminant transport in fractured aquifers. The software will be made available to users via a publicly available data repository for UMN. An additional step will be to integrate the outcomes of the project into UMN's hydrogeology courses and online tutorials. This curriculum is designed to equip future hydrogeologists with the knowledge and tools necessary for tackling the challenges of groundwater management and protection.

Activity Milestones:

Description	Approximate Completion Date
Develop and validate 3D flow and transport numerical models at the two field sites	December 31, 2026
Simulate diverse fractured rock scenarios to quantify contaminant travel time distributions	June 30, 2027
Develop an user-friendly software program that predicts contaminant travel time distribution	December 31, 2027
Disseminate project outcomes and the software to state agencies, consulting companies, and other interested parties.	June 30, 2028
Develop teaching curriculum and incorporate into college-level hydrogeology courses	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Anthony Runkel	Minnesota Geological Survey	Dr. Runkel is Lead Geologist of the Minnesota Geological Survey and conducts research that targets geologic controls on groundwater flow. Dr. Runkel will support aquifer characterization and field hydraulic testing.	Yes
Chloé Fandel	Carleton College	Dr. Fandel is a karst hydrogeologist, and Fandel will support activities related to the modeling of a karst spring site in SE Minnesota.	Yes
Warren Barrash	Boise State University	Dr. Barrash will support field activities involving the modular hydraulic packer-and-port system.	Yes
John Barry	Department of Natural Resources	Mr. Barry will support activities related to field dye tracing in SE Minnesota.	No

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
To ensure that our research findings and developed tools reach those who will benefit the most, we will collaborate closely with key stakeholders including state agencies such as the Minnesota Department of Health (MDH) and the Minnesota Pollution Control Agency (MPCA) and groundwater consulting companies. A workshop will be organized to present the software and its applications, emphasizing the practical applications of the software in groundwater contamination scenarios. To promote the longevity and continued development of the software developed through this project, we will establish a plan for ongoing software maintenance and updates to ensure that it remains compatible with evolving technology and user needs. The software will be open-source, enabling the broader scientific community to contribute to its development and improvement.
The results of our research will be made widely accessible, and Environment and Natural Resources Trust Fund will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgment Guidelines. All data, including hydrogeologic characterization data, numerical model outputs, and the software itself, will be made available through a publicly accessible data repository managed by the University of Minnesota (UMN). This ensures long-term accessibility to the research products. We will publish our findings in high-impact peer-reviewed journals and present them at national and international conferences, such as the American Geophysical Union (AGU) Fall Meeting. These publications and presentations will target the broader scientific community. Public outreach efforts will include presentations at local outreach events and participation in the Minnesota Groundwater Association Conference.
This project also aims to enhance environmental protection through education and training. The software and research outcomes will be integrated into UMN's hydrogeology curriculum. By training the next generation of hydrogeologists on cutting-edge tools and methods, we ensure that future professionals are equipped to address groundwater contamination challenges effectively.

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?
As a result of this project, practical software that predicts groundwater contaminant migration will be produced, and a particular focus of the PI will be to continue and expand collaborations with state agencies (MPCA, DNR, and MDH) so that the software can be implemented across the state. Examples of uses by state agencies and consultants include improvement in wellhead protection plans to protect public drinking water supplies and forecasting the transport of

contaminants such as PFAS and nitrate to inform planning and mitigation efforts. Also, the topic is of great interest to federal agencies, which will be potential funding sources.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Managed Aquifer Recharge	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04t	$350,000
Mapping Aquifer Recharge Potential	M.L. 2023, , Chp. 60, Art. 2, Sec. 2, Subd. 04h	$391,000

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Peter Kang		PI and project manager; will be in charge of overall project management and tasks related to modeling and outreach.			37.1%	0.15		$26,673
Civil Service Employee (Jana Kramer)		Support field work related activites			33.5%	2.25		$100,848
Graduate Student (Benefits include 25.1% health + tuition)		Aquifer characterization and numerical modeling of a karst spring site in SE MN.			55%	1.5		$164,664
Tony Runkel		Support aquifer characterization and hydraulic testing.			33.5%	0.15		$29,164
SAFL engineer		Support field instrumentation			33.5%	0.06		$71,614
Graduate Student		Numerical modeling of the Platteville formation and software development			20%	2		$78,037
							Sub Total	**$471,000**
Contracts and Services								
Carleton College	Subaward	Dr. Chloé Fandel has strong expertise in karst hydrogeology. Dr. Fandel will support activities related to the modeling of a karst spring site in SE Minnesota. Her budget includes out of state travel				0.99		$30,000
Boise State University	Subaward	Subaward to Dr. Warren Barrash at Boise State University for personnel $35K, supplies $5K, travel $10K to provide technical assistance and technology transfer regarding the Modular Hydraulic Packer-and-Port System (MHPS) for discrete zone measurements using fiber optics. Dr. Barrash will make annual trips to the UMN-TC campus to support fieldwork.		X		0.99		$50,000

Research Analytical Laboratory at UMN	Internal services or fees (uncommon)	Water chemistry analysis for quantification of cation and anion concentrations				-		$6,500
							Sub Total	**$86,500**
Equipment, Tools, and Supplies								
	Equipment	Double Valve Pumps (DVPs), including a mini double-valve pump, a 12V compressor, a pump control unit, reel and tubing	To conduct groundwater sampling					$4,652
	Equipment	Regular Pressure Transducers, including van Essen Micro drivers (6) and baro divers (2)	Pressure transducers for measuring hydraulic head					$6,132
	Equipment	Dataloggers (2 CR350-Cell210V-25-Yi and antennas, cable)	For logging field data					$3,404
	Tools and Supplies	2 ferrule cleaners, rack mounting frame for FOXD, misc fiber optic parts, DAQ power cord, case and RJ50 adapter	Fiber Optic Transducer supplies					$1,550
	Tools and Supplies	new tubing, solvent weld, thread compound, packing supplies, Kwik Klamps, well head stability	MHPS Components and Supplies					$8,495
	Tools and Supplies	2 bottles, 2 suction lines and couplers for autosampler	Autosampler Supplies					$920
	Tools and Supplies	3 deep cycle batteries for DVP compressor	Miscellaneous tools for project					$390
	Tools and Supplies	passive carbon detector components	Miscellaneous tools for project					$100
	Tools and Supplies	passive carbon detector supplies (cuvettes, reagents)	Miscellaneous tools for project					$600
	Tools and Supplies	4 solar power panels (10W)	Miscellaneous tools for project					$260
	Tools and Supplies	1 solar power panel (110W)	Miscellaneous tools for project					$385
	Tools and Supplies	solinet 102M mini WL tape (P4)	Miscellaneous tools for project					$385
	Tools and Supplies	consumables - gloves, sampling, tubes	Miscellaneous tools for project					$2,000
							Sub Total	**$29,273**
Capital Expenditures								

		In-line flowmeter (ModMag EM Flow Meter, wireless bridge adaptor, attachment fittings)	Accurate flow rate control during pumping tests	X				$5,390
		ISCO 6712C compact autosamplers (2) and a powerpack/modem	Autosamplers for automatic water sampling	X				$13,326
		Aqua troll 600 multiparameter sonde with anti-fouling wiper and internal logging and backup	Multiparameter sonde for water quality monitoring	X				$13,120
		Fiber Optic Transducer system (Chassis, 2-channel light conditioner FO transducers, fiber optic cables, cDAQ-9178 CompactDAQ Chassis, NI-9205 for FOXDs and NI9933 37-pin DSUB connector kit)	Fiber Optic Transducer system for high accuracy groundwater level monitoring	X				$13,216
		MHPS unit (Ruber Cylinders, Custom Collars, clamps, pipe connectors, 40 pvc pipe, camlocks and push connectors)	Fabrication of new MHPS unit	X				$9,675
							Sub Total	**$54,727**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Other	Travel costs to visit field sites. Four field trips per year per site are planned to conduct field experiments.	To visit field sites for sensor deployment, data collection, and site characterization.					$6,000
							Sub Total	**$6,000**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Domestic conference trip for one person	Conference travel for disseminating project outcomes, networking, and collecting project related information	X				$2,500
							Sub Total	**$2,500**
Printing and Publication								
							Sub Total	**-**
Other Expenses								

							Sub Total	**-**
							Grand Total	**$650,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Contracts and Services - Boise State University	Subaward	Subaward to Dr. Warren Barrash at Boise State University for personnel $35K, supplies $5K, travel $10K to provide technical assistance and technology transfer regarding the Modular Hydraulic Packer-and-Port System (MHPS) for discrete zone measurements using fiber optics. Dr. Barrash will make annual trips to the UMN-TC campus to support fieldwork.	Dr. Barrash's patented borehole installation technology and unique expertise in fiber optic sensing for groundwater monitoring are essential for obtaining high-resolution data critical to the project. No in-state expert possesses his specialized knowledge, making his role irreplaceable for implementing advanced monitoring techniques. Engaging his expertise ensures the project's success by providing accurate data efficiently, avoiding costly delays and additional resource demands.
Capital Expenditures		In-line flowmeter (ModMag EM Flow Meter, wireless bridge adaptor, attachment fittings)	The capital equipment will remain in use at the proposed study sites throughout its lifespan, contributing to an improved hydrogeologic understanding. **Additional Explanation :** The capital equipment will remain in use at the proposed study sites throughout its lifespan, contributing to an improved hydrogeologic understanding.
Capital Expenditures		ISCO 6712C compact autosamplers (2) and a powerpack/modem	The capital equipment will remain in use at the proposed study sites throughout its lifespan, contributing to an improved hydrogeologic understanding. **Additional Explanation :** The capital equipment will remain in use at the proposed study sites throughout its lifespan, contributing to an improved hydrogeologic understanding.
Capital Expenditures		Aqua troll 600 multiparameter sonde with anti-fouling wiper and internal logging and backup	The capital equipment will remain in use at the proposed study sites throughout its lifespan, contributing to an improved hydrogeologic understanding. **Additional Explanation :** The capital equipment will remain in use at the proposed study sites throughout its lifespan, contributing to an improved hydrogeologic understanding.
Capital Expenditures		Fiber Optic Transducer system (Chassis, 2-channel light conditioner FO transducers, fiber optic cables, cDAQ-9178 CompactDAQ Chassis, NI-9205 for FOXDs and NI9933 37-pin DSUB connector kit)	The capital equipment will remain in use at the proposed study sites throughout its lifespan, contributing to an improved hydrogeologic understanding. **Additional Explanation :** The capital equipment will remain in use at the proposed study sites throughout its lifespan, contributing to an improved hydrogeologic understanding.
Capital Expenditures		MHPS unit (Ruber Cylinders, Custom Collars, clamps, pipe connectors, 40 pvc pipe, camlocks and push connectors)	The capital equipment will remain in use at the proposed study sites throughout its lifespan, contributing to an improved hydrogeologic understanding. **Additional Explanation :** The capital equipment will remain in use at the proposed study sites throughout its lifespan, contributing to an improved hydrogeologic understanding.

Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	Domestic conference trip for one person	This travel is to participate in a formal presentation of project findings at the American Geophysical Union (AGU) conference. AGU is a major conference for MAR-related topics. Important information can be acquired, and project outcomes can be disseminated by attending and presenting at the conference.

Non ENRTF Funds

Category	Specific Source	Use	Status	$ Amount
State				
			State Sub Total	**-**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $650,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 6dca2657-647.pdf

Alternate Text for Visual Component

Minnesota urgently needs a practical tool that can predict the movements of contaminants in aquifers. Through this project, we develop and demonstrate a software program that predicts the fate and movement of contaminants such as PFAS, chloride, nitrate, and pathogens in Minnesota's fractured aquifers....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Support letter from Barr	ad18cfd3-6f3.pdf
Support letter from Geosyntec	ce671a09-4ea.pdf
Support letter from Bay West	8860f00d-92c.pdf
Support letter from Freshwater	a15c7b9c-ae3.pdf
Support letter from Minnesota Department of Health	e88d8f39-1d7.pdf
Support letter from Metropolitan Council	b221e3a0-790.pdf
SPA letter UMN	b3b9c24b-24b.pdf
2025-110 Research Addendum revised_final	b55f1278-ba8.docx

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

Edits have been made to address the comments. Milestones have been added to Activity 1, and the requested changes have been made to the Activity 3 description.

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

Yes

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this project:

Victoria Troxler, University of Minnesota, vtroxler@umn.edu

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A