Environment and Natural Resources Trust Fund

2023 Request for Proposal

General Information

Proposal ID: 2023-079

Proposal Title: Groundwater Pollution of Surface Waters: Chloride and Phosphate

Project Manager Information

Name: John Gulliver

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: We propose identifying two hot spots of groundwater to surface water pollution: chloride which is a long term source increasing impairment and phosphate pollution from groundwater is a substantial unknown.

Funds Requested: $602,000

Proposed Project Completion: June 30, 2026

LCCMR Funding Category: Methods to Protect, Restore, and Enhance Land, Water, and Habitat (F)

Project Location

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

Statewide

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

Narrative

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

This project will investigate groundwater pollution of rivers and streams by chloride and phosphate. It will identify the sources, assess the risk, determine hot spots, and thus improve the water quality of our lakes and streams. Most surface water regulations do not consider groundwater as a pollution source for surface water, but a 2020 court case in Hawaii, has changed that. The pollution of surface water by groundwater is therefore an important research topic. Groundwater media has the ability to filter particulates and adsorb dissolved chemicals but there are exceptions. Chloride is a highly-mobile chemical that is not adsorbed by soil and passes through the groundwater into our lakes and streams. Chloride-based salts, placed onto roads and parking lots during winter, are plowed to the side and infiltrate to groundwater. Another less known groundwater pollutant is phosphate. Added as an anti-corrosive agent for water supply pipes, it can percolate from leaky or broken water mains, or it can percolate from stormwater infiltration. A 2012 survey estimated that one million gallons of water annually leak from each mile of water pipe. Thus, groundwater-to-surface water pollution by phosphates is largely unknown.

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.

This proposal is about finding solutions to the chloride and phosphate groundwater-to-surface water pollution. There are varying amounts of groundwater to surface water pollution of chlorides and phosphates, depending upon the source loading, makeup of the soil and the predominant groundwater flow. A tight soil, for example, will typically have a lower groundwater discharge, and correspondingly less pollution of surface water. A tight soil will also retain more pollutant in capillary spaces. A sandy soil, on the other hand, will have correspondingly greater groundwater recharge and more groundwater pollution. Phosphate can be adsorbed by aluminum oxides or iron oxides in the soil, but in many soils these chemicals do not exist. The combination of all of these considerations requires research to determine where phosphate and chloride groundwater pollution of surface water is more likely and less likely, so that it is possible to focus source reduction on the the potential hot spots within the State.

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?

Chloride and phosphate are powerful pollutants of our lakes and rivers. Chlorides can directly impact aquatic species while phosphorus can cause eutrophication and algae blooms. This project will identify how groundwater exacerbates the contamination of surface water–largely ignored for current surface water pollution management. The result will clarify the potential connections between groundwater and surface water, where this interaction is most likely to occur, allow us to suggest ways of minimizing this source of contamination to surface waters, and allow us to respond to the new legal regulation of groundwater that is significantly connected to surface water.

Activities and Milestones

Activity 1: Project Management and Quality Assurance

Activity Budget: $27,970

Activity Description:
Project management will include initiating agreements, tracking deliverables, preparing invoices, and reporting to the LCCMR. Our team will develop a Technical Advisory Committee (TAC) which will meet every six months while the project team will meet internally every two weeks. The TAC will advise the project team on technical issues and concerns throughout the project. The TAC will be comprised of one to two representatives from state entities (e.g., Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (DNR) and one to two local public entities (cities or watershed districts).
A Quality Assurance Project Plan (QAPP) will be created before any field activity starts. The plan will list the sites to be investigated, the number of surface and groundwater sites, the type of data that will be needed, how often data are collected, maintenance protocols, how data will be managed, and lastly how data will be analyzed. The research team will develop the QAPP from an approved template for monitoring studies. We will use accessible river site and groundwater wells to sample for surface and groundwater. We will follow the general guidelines of prior groundwater sampling protocols and analyze the samples ourselves or identify a qualified local laboratory for the study.

Activity Milestones:

Description	Completion Date
1. Invitations for TAC accepted	September 30, 2023
2. QAPP completed	September 30, 2023

Activity 2: Groundwater Monitoring and Laboratory Studies

Activity Budget: $273,523

Activity Description:
We propose studying up to three areas with different connectivity between surface and groundwater. We will use available groundwater atlases and work closely with state hydrogeologists to identify the study areas. The monitoring sites will be selected in consultation with our TAC and the availability of prior groundwater models. The groundwater sites will be: 1) downgradient from pollutant sources, upgradient from surface water sites, and 3) accessible. The surface water sites will be: 1) downgradient from groundwater sites, 2) accessible from river or bridge, and 3) safe to sample. Each site will have up to three monitoring wells and a surface water station. The aquifer material will be characterized for particle size. We will use a combination of automated sensors and monthly sampling for water quality over two years. Conductivity and water depth will be measured to provide a continuous record. Monthly grab samples will be collected from the wells and river and, in combination with continuous data, used to calibrate and verify the groundwater pollutant transport model. Samples will be analyzed for nitrate/nitrite, phosphate and chloride. Laboratory batch studies on the sampled media will determine phosphate adsorption characteristics.

Activity Milestones:

Description	Completion Date
1. Study sites selected	October 31, 2023
2. Well drilling complete	November 30, 2023
3. Sampling completed (year 1)	November 30, 2024
4. Sampling completed (year 2)	June 30, 2025
5. Summary report on data collection	January 31, 2026

Activity 3: Modeling and Analysis of Groundwater Pollution of Surface Waters

Activity Budget: $300,507

Activity Description:

Numerical models that quantify the groundwater pollution of surface waters will be developed for the selected field sites. Existing data sets will be collected and compiled, and data gaps will be identified which will guide field data collections. Several locations in the southeast karst region, and the north-central sandplains region are currently under detailed study supported by LCCMR, MDH, and the Anishinaabe Agriculture Institute. The research sites at these locations are good candidates for the proposed research. Groundwater flow models either have been or are currently being developed and calibrated for these sites. A surface water model component will be coupled to these groundwater flow models to provide integrated models that quantify the flow connectivity between surface water and groundwater. These integrated models will be used to simulate chloride and phosphorus transport in the groundwater and to quantify the groundwater contribution of chloride and phosphorus pollution of surface waters.

Activity Milestones:

Description	Completion Date
1. Data compilation and identification of data gaps	December 31, 2023
2. Develop surface water - groundwater integrated flow model	December 31, 2024
3. Develop surface water - groundwater integrated chloride and phosphorus transport model	June 30, 2026
4. Couple surface water and groundwater models	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. Nigel Pickering	Geosyntec Consultants	Nigel Pickering will be a Co-PI for this project and the Project Manager for all the Geosyntec tasks. He will manage the overall project, schedule, and budget. He will help pick suitable groundwater monitoring sites, prepare the collected water quality data and interact with the modeling team.	Yes
David Richardson	Geosyntec Consultants	David will be a Co-PI and Senior Engineer for this project. He will help pick suitable groundwater monitoring sites, oversee the well drilling and groundwater monitoring, and analyze the collected water quality data.	Yes
Dr. Neven Kresic	Geosyntec Consultants	Kevin will be the Project Director and Technical Advisor for the Geosyntec portion of this project. He will oversee the project content and obligations and provide technical advice from his groundwater modeling and monitoring experience.	Yes
Dr. Peter T. Weiss	Valparaiso University	Dr. Weiss is a Visiting Professor at the St. Anthony Falls Laboratory, University of Minnesota, every summer. He will be involved in Activities 2 and 3, Laboratory studies to determine adsorption properties of phosphate and application of these results in the computational model.	Yes
Brooke Asleson	Minnesota Pollution Control Agency	Advise on field sites and modeling efforts; collaboration and communication between the research community and state and local government units to improve understanding and outreach; outreach to practitioners and the local community.	No

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?

The proposed project will find hot spots of chloride and phosphate pollution stemming from groundwater flow into surface waters. Follow-on research on mitigating these hot spots will require additional funding. Aside from the LCCMR, there are many potential in-state sources that may fund the mitigation of groundwater to surface water chloride and phosphate pollution, such as the Minnesota Department of Transportation, the Local Road Research board, the Minnesota Stormwater Research Council and the Minnesota Pollution Control Agency.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Reduce Chlorides in Minnesota Waters by Evaluating Road-Salt Alternatives and Pavement Innovations	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 04c	$400,000

Project Manager and Organization Qualifications

Project Manager Name: John Gulliver

Job Title: Professor Emeritus

Provide description of the project manager's qualifications to manage the proposed project.

John Gulliver is a professor emeritus in the Department of Civil, Environmental and Geo- Engineering, performing his research at the St. Anthony Falls Laboratory. He is continuing research into the future because it is his advocation. Much of his research, in conjunction with other faculty, involves the development of new technology for stormwater treatment and assessment of field performance of stormwater treatment practices. He has led 108 research projects, most recently on the retention of metals by bioretention media, the infiltration rates of various stormwater treatment

practices, the impact of various types of impervious areas on runoff, and the impact of climate change on stormwater infrastructure. He is a co-author of the book, Optimizing Stormwater Treatment Practices: A Handbook of Assessment and Maintenance, published by Springer. Professor Gulliver is active in outreach to the community, including workshops, the monthly Stormwater Seminar Series and publication of the practitioner-oriented newsletter, Stormwater Updates.

Organization: U of MN - College of Science and Engineering

Organization Description:
The St. Anthony Falls Laboratory (SAFL), an interdisciplinary fluids research and educational facility of the College of Science and Engineering at the University of Minnesota. SAFLs research is focused at the intersection of fluid dynamics with major societal challenges in energy, environment and health. SAFL integrates experiments in the laboratory and field with advanced computational tools and theory to obtain innovative, science-based solutions to real-world fluid-flow problems. SAFL serves as a resource for departments across the Twin Cities campus, the statewide University system, and the broader research community. The connections and collaborations reach across the country and all over the world, and SAFL partners with local, state and federal agencies; private consulting firms; businesses of many kinds; technical associations; and other educational institutions to expand knowledge and solve problems.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
John Gulliver,		PI and project manager; will be in charge of overall project management and tasks required to complete activities			7.5%	0.12		$27,910
John Nieber		Co-PI, Supervision of one graduate research assistant who will be utilizing a large-scale groundwater flow model			33.5%	0.12		$23,934
Peter Kang		Co-PI, Supervision of one graduate research assistant who will be modeling detailed flow and transport around soil particles			33.5%	0.12		$14,892
2 Graduate Research Assistants		One GRA will be modeling flow and transport around particles and the other GRA will be modeling flow and transport at a larger scale.			48%	3		$251,828
Undergraduate Research Assistants		Help in field monitoring and laboratory studies			0%	0.6		$18,001
							Sub Total	**$336,565**
Contracts and Services								
Geosyntec Consultants	Sub award	Groundwater and surface water sampling and analysis and a portion of project management, including: Well installation (9), $49500, Water quality sondes (6), $19800, Instrument enclosures (3), $3300, Travel (4800 mi), $3036, WQ analyses (302 PO4/NO3/Cl), $24948, and Grain size analysis (9 samples), $19800.				1.14		$237,056
Dr. Peter T. Weiss	Professional or Technical Service Contract	Dr. Weiss will be involved in all portions of the project, from field monitoring to verification of groundwater flow modeling. He will lead the laboratory studies.				0.36		$25,085
							Sub Total	**$262,141**
Equipment, Tools, and Supplies								

							Sub Total	**-**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	2 people	Registration for the Minnesota Water Resources Conference					$550
	Miles/ Meals/ Lodging	49 trips of 100 miles at $0.56/mile	Travel to groundwater monitoring sites					$2,744
							Sub Total	**$3,294**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$602,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

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

Attachments

Required Attachments

Visual Component

File: bcee96c2-530.pdf

Alternate Text for Visual Component

Left-truck distributing salt brine. Middle truck plowing snow. Right-map of chloride impairments in the TCMA...

Optional Attachments

Support Letter or Other

Title	File
Geosyntec Letter	ccfae5fe-4a9.pdf
Peter Weiss Letter of Commitment	71d1a80e-71d.docx
MPCA Partnership Letter	fd3ca506-a75.pdf
Authorization Letter	e0c83bb2-536.doc

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

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?

No

Unresolved Challenges of Chloride and Phosphate

- Infiltration and pipe leaks will pollute Groundwater
- Groundwater travels to Lakes and Streams
- ➢ Chloride and Phosphate Pollution of Lakes and Streams
- We will predict this pollution and identify hot spots in Minnesota

Photo: MnDOT

2014 Impaired Streams and Lakes in Metro Area for Chloride
Red = Impaired, Yellow = At Risk