Environment and Natural Resources Trust Fund

M.L. 2020 Approved Work Plan

General Information

ID Number: 2020-083

Date this document submitted to LCCMR: August 27, 2021

Project Title: Minerals and Water: Demonstration of Three Sulfate Reduction Technology Applications

Project Budget: $300,000

Project Manager Information

Name: Meijun Cai

Organization: U of MN - Duluth - NRRI

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Project Reporting

Date Work Plan Approved by LCCMR: August 26, 2021

Reporting Schedule: April 1 / October 1 of each year.

Project Completion: June 30, 2023

Final Report Due Date: August 14, 2023

Legal Information

Legal Citation: M.L. 2021, First Special Session, Chp. 6, Art. 5, Sec. 2, Subd. 20a3

Appropriation Language: The appropriation in Laws 2019, First Special Session chapter 4, article 2, section 2, subdivision 8, paragraph (c), Sauk River Dam Removal and Rock Rapids Replacement, in the amount of $2,768,000, no longer needed for its original purpose is transferred as follows:

(3) $750,000 is transferred to the Board of Regents of the University of Minnesota for academic and applied research through the MnDRIVE program at the Natural Resources Research Institute to develop and demonstrate technologies that enhance the long-term health and management of Minnesota's mineral and water resources. Of this amount, $300,000 is to support demonstration of three sulfate reduction technologies for improved water quality, and $450,000

is for continued characterization of Minnesota iron resources and for developing next-generation technologies and iron products. This research must be conducted in consultation with the Mineral Coordinating Committee established under Minnesota Statutes, section 93.0015;

(d) Transfers and Availability
The transfers under this subdivision are effective June 30, 2021, and the transferred amounts are available until June 30, 2023.

Appropriation End Date: June 30, 2023

Narrative

Project Summary: Applied research and demonstration of three sulfate reduction in Minnesota waters

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

Sulfate concentration is a challenge across the state due to a restrictive water quality standard for sulfate of 10mg/L in wild rice waters. Meeting this or a modified water quality standard is a special challenge, especially in systems with relatively low (<300 mg/L) sulfate concentrations. Existing technologies (e.g., reverse osmosis; ultrafiltration) can achieve this standard, but are expensive and generate significant waste products. New tools are required to provide economically viable technologies in support of Minnesota's industries and wastewater treatment facilities. NRRI has tested several technologies for reducing sulfate in water bodies, including chemical precipitation technology via barite precipitation, microbial treatment, and development of novel carbon-based sorption materials. This project will test the effectiveness of sulfate reduction technologies and assess economic costs associated with their deployment.

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

On the basis of this past funding, NRRI is proceeding to pilot three technologies for reducing sulfate in water bodies: chemical precipitation; microbial treatment, and novel carbon-based materials to absorb sulfate ion. Two trailer-based pilot systems have been constructed to deploy the chemical precipitation system and a microbial treatment system. These will be deployed in tandem for demonstration at regional sites to determine effectiveness and quantify costs in real-world applications. The novel carbon sorbent materials will be evaluated first in the laboratory using pit lake water samples and will be piloted when the proper activity is achieved.

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?

Technologies to reduce sulfate in Minnesota's waters that are both effective and affordable for municipal and industrial water treatment challenges offer new tools to manage and remediate impacts on regional water resources. Demonstration of these approaches in different combinations should provide options for a range of sulfate challenges.

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?

In the Future

Activities and Milestones

Activity 1: Minerals and Water: Demonstration of Three Sulfate Reduction Technology Applications

Activity Budget: $300,000

Activity Description:

Two trailer-based pilot systems will be deployed at one mining pit lake to test and refine the chemical treatment system and the biological reactor system on site. The field pilot trial will be performed by biological and chemical processes to reduce sulfate concentrations below 10 mg/L. The run will be conducted for a duration of 4-6 months when temperature is above freezing point. The performance of the treatment systems will be evaluated through water chemistry, operational parameters, and waste management. A series of laboratory tests will be conducted to remove sulfate anions from the same mining pit lake water using the functional carbon materials with introduced anion exchange properties. The performance of the functional carbon materials will be evaluated using equilibrium and column tests. The water chemistry, ability to lower concentration of sulfate anions in the presence of competing anions (selectivity) as well as breakthrough capacity will be measured and reported. Costs associated with each treatment system will be documented to estimate operational costs.

Activity Milestones:

Description	Completion Date
Milestone 1: Deploy the trailer based pilot systems on the site	June 30, 2022
Milestone 2: Completion of the field pilot trial of the chemical treatment process	June 30, 2023
Milestone 3: Performance evaluation of biological treatment system to reduce sulfate concentration from a minepit	June 30, 2023
Milestone 4: Performance evaluation of the functional carbon materials with anion exchange properties to remove	June 30, 2023

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Rolf Weberg	Natural Resources Research Institute, UMD	NRRI Executive Director, Dr. Rolf Weberg, who is on the Minerals Coordinating Committee, will review project progress for comment and potential collaboration at regularly scheduled Minerals Coordinating Committee meetings	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.
We anticipate building partnerships with the agencies and industrial partners during our field pilot trial and lab tests. The results will be shared with the partners to seek suggestions and recommendations for the applications of the treatment systems in the real world. The research findings will be disseminated to the public, agencies and industry through reports, workshops and conference presentations that will acknowledge the ENRTF funding of the project.

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 be funded?
With funds from 2016 and 2019 Minnesota Legislative investment, Industry, and internal funding, NRRI sulfate team has successfully demonstrated three sulfate reduction technologies in the laboratory; one trailer based system has been deployed for field pilot trials. Lessons learned from the past and ongoing tests will refine the system process and material development for wide applications in industrial and natural environments. Application of the permanent university trust fund is another potential source to bridge any funding gaps.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
George Hudak		Principal Investigator			25.09%	0.02		$3,612
Meijun Cai		Project manager and lead of chemical treatment project			25.09%	0.3		$28,284
Chan Lan Chun		Lead of biological treatment project			25.09%	0.1		$14,590
Lucinda Johnson		Part of the project management team			25.09%	0.02		$4,557
Adrian Hanson		Technical advisor			25.09%	0.3		$7,013
Shashi Rao		Co-lead of chemical treatment project			25.09%	0.08		$9,456
Igor Kolomitsyn		Lead of material modification project			25.09%	0.2		$25,216
Erik Hendrickson		Lab technician for material modification project			22.3%	0.22		$15,074
Sara Post		Field operation of the chemical treatment project			22.3%	0.8		$5,467
Jeff Kinkel		Mechanical Engineer			25.09%	0.06		$8,167
Jack Grochowski		Mechanical Engineer			25.09%	0.1		$10,963
Jerald Henneck		Lab technician			22.3%	0.2		$16,378
Matthew Mlinar		Mlinar will provide project management support and serve as a part of the project management team for this grant			25.09%	0.04		$5,235
Anthony Masching		Mechanical maintenance			22.3%	0.1		$7,570
TBD Field Tech, temp/casual		Field operation of the chemical treatment project			6.91%	0.2		$7,488
Undergraduate Researcher		Lab and field support			0%	0.32		$7,546
Matthew Berens		Field operation for the biological treatment project			17.28%	0.6		$36,814
Summer Graduate Student		Laboratory support			18.96%	0.02		$128
TBD Researcher 1		Field operation for the biological treatment project			22.3%	0.4		$19,855

							Sub Total	**$233,413**
Contracts and Services								
David Sersha JR	Professional or Technical Service Contract	~$100/hr, set up the field connection, make any electrical modification and disconnect the electrical connection. Mr. Sersha continued contract has been utilized on multiple NRRI projects. His years working onsite allows for a familiarity of our operations.				0.02		$3,000
Intuitech	Professional or Technical Service Contract	Consulting with Intuitech for any system issue. ~$150/hr, pilot system consulting. Intuitech is the manufacturer of the customized pilot systems. Intuitech provides support consulting for their product				0.02		$1,000
							Sub Total	**$4,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Supplies for the system modification or site connection	Including pumps, pipes, tanks, valves, pressure meters, and any possible changes to be made to the pilot system					$18,000
	Tools and Supplies	Laboratory and chemical supplies	Lab supplies, bottles, vials, chemicals, gloves, filter membrane, pipet, and other supplies that may be needed during laboratory work					$18,287
							Sub Total	**$36,287**
Capital Expenditures								
		Potentiostat	Used for electrochemical analysis to monitor biological sulfate reduction and redox mediator during the biological sulfate treatment.	X				$8,000
							Sub Total	**$8,000**
Acquisitions and Stewardship								

							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Field visit (15 times/month) *5 month* total miles per trip (~154 miles) = $6,462. Additional money for sample dropping to the external lab, travel from Duluth to Coleraine facility	Travel needed between Duluth and Coleraine NRRI sites to perform testing and transporting samples. GSA rates will be used while traveling.					$7,000
							Sub Total	**$7,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Shipping Costs	Sample shipping to external labs	X				$300
		External lab measurement	External lab measurement for samples					$5,000
		Data plan	Data plan for remotely access the control panels, and the data plan for onsite video cameras	X				$3,000
		Electricity	Cost of electricity for the field pilot trial occurring at a remote site off campus					$3,000
							Sub Total	**$11,300**
							Grand Total	**$300,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Expenditures		Potentiostat	The biological treatment used in the project is a biofiltration integrated with electrochemical cells which stimulate and sustain biological sulfate reduction. For the treatment system, the potentiostat is used as an electric instrument that controls the cell potential and measures variable current as an essential component of the system. This will be also used to conduct electrochemical analysis for redox active chemicals in the treatment system through the life of the instrument. **Additional Explanation :** The Potentiostat purchased with the project will continue to be used for the water treatment in relation to sulfate reduction and its associated processes in the lab and field.
Other Expenses		Shipping Costs	Sample shipping to external labs , including labs in the Twin Cities for chemical and physical measurement which are not able to be done locally
Other Expenses		Data plan	The site is located in a remote location (60 miles away) where no Wi-Fi is available. Cellular data will be the only way for remote access. The remote access allows controlling the system remotely, therefore reducing the field visit times and keep the system run smoothly.

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: 8048b91b-692.pdf

Alternate Text for Visual Component

The graphic describes the sulfate remediation, municipal treatment mobile unit, and the minelands treatment...

Optional Attachments

Support Letter or Other

Title	File
Institutional Letter	c85d0358-602.pdf
Background Check	015f5e9e-370.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

Minor editing

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 agree travel expenses must 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 agree to the Commissioner's Plan.

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

Yes

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

Yes

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

No

Does your project include original, hypothesis-driven research?

No

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

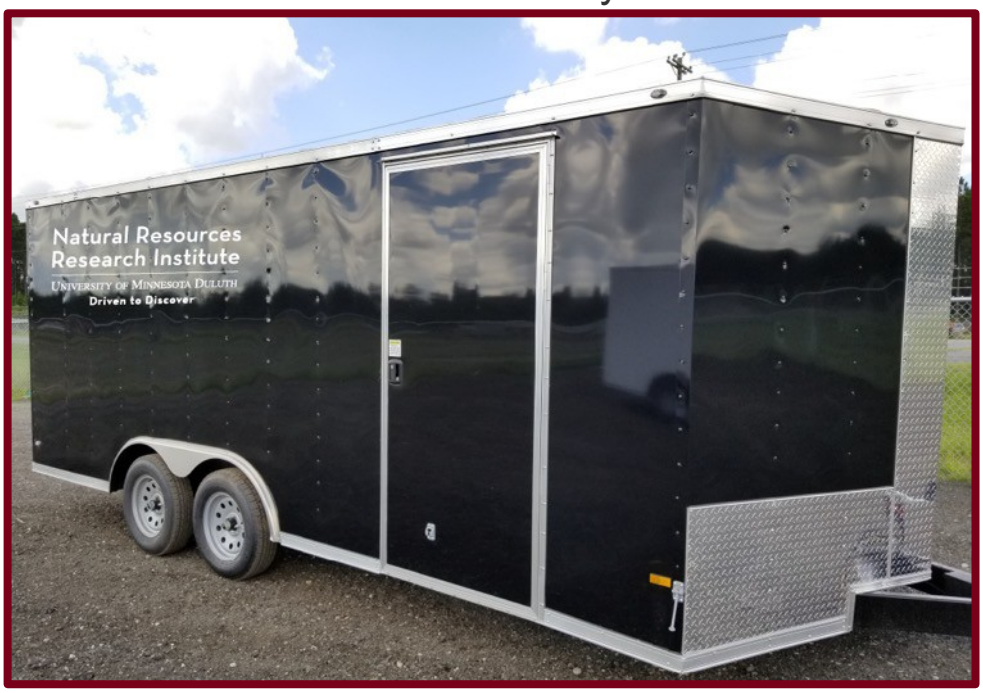
Natural Resources Research Institute
University of Minnesota Duluth
Driven to Discover

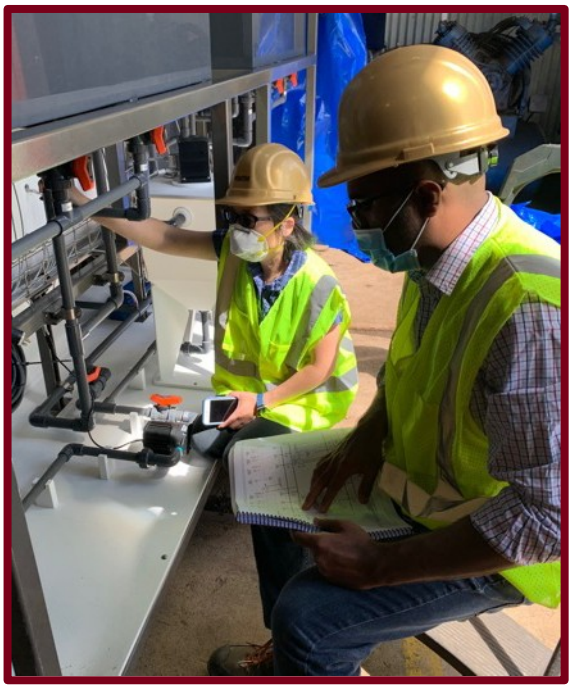
Minnesota Water Quality
Sulfate Remediation Technologies

Sulfate remediation is critical to water quality in Minnesota. NRRI is addressing sulfate in three critical areas:

NRRI Sulfate Remediation Technologies

1. Municipal mobile unit treatment system 50-200 PPM
2. Mineland Treatment system 200-500 PPM
3. Industrial Treatment system 500+ PPM





Municipal Treatment Mobile Unit

Problem: Minnesota's standard for sulfate concentrations in wild rice waters is significantly lower than drinking water standards. Meeting the 10 parts per million goal is very expensive using reverse osmosis.

Research Solution: An inexpensive barium sulfate precipitation process was developed and scaled up to a mobile demonstration system for testing in two Minnesota communities.

Status: NRRI is performing indoor trials to optimize the process, reduce potential risks and demonstrate efficacy. Two wastewater treatment plants have agreed to field pilot tests.

Minelands Treatment

Problem: A municipal drinking water supply that uses mine pit water is threatened by high levels of sulfate. A cost-effective treatment system is needed to address this problem.

Research Solution: New, patented technology introduces a path forward to develop a peat-based media that removes sulfate from industrial and mining impacted waters.

Status: Preliminary testing shows sulfate concentrations can be reduced to as low as 10 parts per million a two-stage process: biofiltration and electrochemical treatment to be followed by the chemical precipitation.