Environment and Natural Resources Trust Fund

2025 Request for Proposal

General Information

Proposal ID: 2025-074

Proposal Title: Design of Zero Effluent Discharge Taconite Concentrators

Project Manager Information

Name: Jestos Taguta

Organization: U of MN - Duluth - NRRI

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Project Basic Information

Project Summary: The project aims to design zero effluent discharge taconite concentrators in Minnesota to maximize water resource utilization, conserve freshwater sources and prevent the pollution of surface freshwater sources.

ENRTF Funds Requested: $984,000

Proposed Project Completion: June 30, 2028

LCCMR Funding Category: Water Resources (B)

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.

Taconite concentrators consume a lot of water and generate huge volumes of tailings which have negative environmental impact associated with tailings disposal, effluent discharge, and release of process water into the water table. The tailings stream is dewatered to recover process water which is then recycled back to the concentrator. This configuration is called short water recycling. The thickener underflow is pumped to tailings pond for storage. Process water is also recycled from tailings ponds, and this configuration is called long water recycling. Although process water recycling reduces freshwater consumption and effluent volume, it may impact the efficiency of various unit processes in taconite processing e.g. grinding, classification, selective flocculation, flotation, and dewatering (thickening and filtration). This is because process water recycling results in the accumulation of residual reagents (collectors, frothers, flocculent, etc), slimes, ions, and organic constituents e.g. microbes whose effects on taconite processing are limited in literature. Discussions with plant metallurgists suggest that seasonal temperature variation may affect process water quality and the metallurgical performance of taconite concentrators. Existing taconite concentrators struggle with process water temperature control because of the long process water retention time associated with long water reticulation from the tailings pond.

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 project seeks to design zero effluent discharge taconite concentrators, which offer the following benefits:
1. Maximize water resource utilization.
2. Conservation of freshwater sources.
3. Prevention of the pollution of freshwater pollution.
4. Improving the environmental footprint of taconite processing by eliminating the need for tailings ponds and facilitating the dry stacking of tailings.
5. Improved control of process water temperature due to shorter process water retention time associated with short water reticulation.

The project will systematically characterize the effects of water quality on the various unit processes in taconite processing e.g. grinding, classification, flotation, thickening, and filtration. Process water recycling will be simulated at laboratory scale by increasing the overall water ionic strength, spiking the concentration of targeted ions and closing the water loop (re-using filtrate for subsequent test work). Detrimental and beneficial water quality aspects as well as their threshold values will be determined. The project will design and evaluate several process water management and treatment strategies to mitigate any detrimental effects of water quality on the various unit processes in taconite processing without compromising metallurgical performance. The project will also demonstrate the zero effluent discharge taconite concentrator concept at pilot scale.

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?

Minnesota is the biggest producer of iron ore in the USA, having produced 2% of the world's iron ore production in 2020. Mining activities are a threat to the environment, especially considering that Minnesota holds 10 percent of the freshwater in the world. Zero effluent discharge in taconite concentrators in Minnesota will conserve freshwater sources and prevent pollution of the surface freshwater sources. Attaining 100% short recirculation rates eliminates the need for tailings ponds which pose safety and occupational challenges to humans and the ecosystem. Overall, the project will improve the environmental footprint of taconite processing plants in Minnesota.

Activities and Milestones

Activity 1: Literature review, data consolidation and plant surveys

Activity Budget: $199,000

Activity Description:
An extensive literature review and consolidation of historical laboratory/plant process water related data will be undertaken to gain an in-depth understanding of the effect of process water chemistry on the various unit processes in taconite beneficiation. Voice of customer will also be conducted with plant metallurgists and operators to understand the technical challenges associated with process water quality at selected taconite plants. This will be followed by 2 plant surveys (winter and summer) at a selected Minnesota taconite concentrator to collect water samples, internal and external plant streams. The objectives of the plant surveys will be to understand the water footprint as well as to determine the water and mass/metallurgical balances. Water samples will be refrigerated immediately after collection, transported, and maintained at −20 °C until analysis and flotation tests. Refrigeration is necessary to preserve, as far as possible, the chemistry of the water samples. Chemical analysis of the samples will be conducted at the analytical laboratory at NRRI and selected external laboratories. Solid samples will be analyzed for total iron and total silica. Water samples will be analyzed for ions (e.g. Ca2+, Na+, Mg2+, SO4 2−) and residual reagents using UV/VIS Spectrophotometry and gas chromatography.

Activity Milestones:

Description	Approximate Completion Date
Literature review report	November 30, 2025
Plant Survey Data Package & Report - Winter	February 28, 2026
Plant Survey Data Package & Report - Summer	July 31, 2026

Activity 2: Metallurgical Testwork

Activity Budget: $425,000

Activity Description:
Laboratory scale metallurgical testwork will be executed to systematically characterize effects of water quality on the various unit processes involved in taconite processing. The unit processes to be investigated include grinding, classification (fine screening and hydrocycloning), flotation, thickening and filtration. Water quality parameters to be investigated include ionic strength, type and concentrations of ions, pH, slimes concentration, and hardness. Other variables to be investigated include process water aging and temperature (to assess the impact of seasonal variation). 3 water types, namely Coleraine tap water, plant water and synthetic plant water will be investigated as process medium. Detrimental and beneficial water quality aspects will be identified. The acceptable/threshold values of water quality parameters beyond which metallurgical performance decline will also be determined and defined. Process water recycling will be simulated at laboratory scale by increasing the overall water ionic strength, spiking the concentration of targeted ions and closing the water loop by reusing the filtrate obtained from the preceding test as process medium for the subsequent test. Process water management and treatment strategies will be designed and evaluated to mitigate any detrimental effects of water chemistry.

Activity Milestones:

Description	Approximate Completion Date
Establishing the effect of process water chemistry on grinding, classification, flotation and dewatering.	June 30, 2027
Establishing water quality parameters which are beneficial and detrimental to metallurgical performance in taconite processing	November 30, 2027

Developing process water management/treatment strategies to mitigate any detrimental effects of process water chemistry.	February 28, 2028

Activity 3: Pilot demonstration of the zero effluent discharge taconite concentrator concept

Activity Budget: $360,000

Activity Description:

The zero effluent discharge taconite concentrator concept will be demonstrated at pilot scale. Activities will include designing, building, and commissioning of the pilot plant to ensure integration of the pilot mineral processing and dewatering plants. Magnetic taconite will be used as feed. 2 types of circuits will be investigated, i.e., open and closed water circuits. Open water circuit pilot campaign will be conducted to establish a baseline. The water circuit will then be closed to investigate the effect of process water recycling. Samples of the water and process streams will be cut from selected locations after the plant attain steady state. Pilot plant sampling surveys will be conducted during both the baseline and process water recycle test Chemical analysis of the samples will be conducted at the analytical laboratory at NRRI and at selected external laboratories. Solid samples will be analyzed for total iron and total silica. Water samples will be analyzed for ions (e.g. Ca^{2+}, Na^{+}, Mg^{2+}, K^{+}, SO_4^{2-}) and residual reagents using UV/VIS Spectrophotometry and gas chromatography. Mass and water balances of both pilot plant configurations will be calculated. A total of at least 10 mass balances will be targeted for each configuration.

Activity Milestones:

Description	Approximate Completion Date
Development of capabilities to conduct pilot process water recycling studies.	March 31, 2028
Development of procedures and methodologies to conduct pilot plant water recycle studies.	March 31, 2028
Demonstrate water management strategies and appropriate plant-based responses to mitigate detrimental effects of process water	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Sunil Kumar Tripathy	Natural Resources Research Institute, University of Minnesota	Co-PI. Expertise in mineral beneficiation, dewatering and dry beneficiation.	Yes
Mei Cai	Natural Resources Research Institute, University of Minnesota	Co-PI. Expertise in environmental engineering and waste water treatment	Yes
Shashi Rao	Natural Resources Research Institute, University of Minnesota	Co-PI. Expertise in mineral beneficiation and metallurgy	Yes
Matt Mlinar	Natural Resources Research Institute, University of Minnesota	Co-PI: Expertise in mineral beneficiation and beneficiation	Yes
TBD	Natural Resources Research Institute, University of Minnesota	Postdoctoral Research Fellow: Mineral beneficiation and water treatment	Yes

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?

NRRI will partner with selected taconite concentrators in Minnesota to demonstrate and optimize the zero effluent discharge taconite concentrator concept at industrial scale. It is expected that the success and impact of the project will result in other taconite mines onboarding the zero effluent discharge taconite concentrator concept.

Project Manager and Organization Qualifications

Project Manager Name: Jestos Taguta

Job Title: Design of zero effluent discharge taconite concentrators

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

Dr. Jestos Taguta is a Professional Chemical Engineer and Researcher with more than 12 years' international experience in the Mining and Metals industry. He holds a PhD in Chemical Engineering, MSc Chemical Engineering, and B. Eng. (Honors) in Chemical Engineering. Both his PhD and MSc specialized in the field of minerals processing. He is a recipient of the prestigious International Mineral Process Congress (IMPC) Young Author Award at the biannual XXVIII

International Mineral Processing Congress, 2016 in Quebec City, Canada for one of the best ten researchers and technical papers presented by authors younger than 35 years. He has a publication record of 1 book chapter, 24 peer reviewed articles, >40 technical reports and presented at more than 12 international minerals processing conferences.

Jestos has fulfilled various senior technical and management roles within Research and Development (R&D), Engineering, and Consulting environments in the mining industry. He has demonstrated experience in supervision/management, research and development, process engineering, flowsheet development, process design, testwork/project management, and commissioning/operational support experience in mineral processing operations. He has experience managing all areas of project development from conceptual to definitive feasibility studies, through to detailed design and commissioning. He possesses specialist expertise in precious, critical, battery and industrial minerals processing as well as iron & steel industry. He has demonstrated experience developing, managing, and executing several strategic research programs aimed at increasing metallurgical, water and energy efficiencies. He has experience in designing zero effluent discharge platinum group minerals (PGM) concentrators in South Africa. He has worked on and supported numerous mineral processing projects in Africa, South America, Australia, Canada, and the USA. He is currently appointed as a Senior Research Engineer within the Minerals Processing & Metallurgy Group at the Natural Resources Research Institute (NRRI), University of Minnesota.

Organization: U of MN - Duluth - NRRI

Organization Description:
The Natural Resources Research Institute (NRRI) has extensive laboratory capabilities to discover and deliver at the bench-to-pilot scales, reducing risk inherent in commercializing innovations. NRRI in Duluth has 19 labs to meeting the needs of land, wildlife, water and minerals research. There's also an additive manufacturing lab and several technology development labs. NRRI's facility in Coleraine is a 27-acre site focused on minerals and bio-based energy research.

The NRRI research informs decisions on natural resource utilization and drives economic opportunities for the State of Minnesota and beyond. The economy of the future will be defined by the natural resource nexus of water, energy and materials within the sustainable development nexus of the environment, economy and society. NRRI seeks to develop a portfolio of opportunities for Minnesota. The NRRI is equipped with massive bench and pilot scale mineral processing capabilities covering the whole mineral beneficiation chain (comminution, gravity separation, magnetic separation, flotation and dewatering). It is also equipped with excellent analytical chemistry, geology and mineralogy capabilities.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Dr. Jestos Taguta, Principal Investigator		Principal Investigator - Expertise in mineral beneficiation, flowsheet development, process/concentrator design, process water recycling and treatment.			27.06%	0.69		$129,256
Sunil Tripathy		Co-Investigator, Expertise in mineral beneficiation, dewatering and dry beneficiation			27.06%	0.09		$46,526
Shashi Rao		Co-Investigator, Expertise in mineral beneficiation and metallurgy			27.06%	0.15		$21,076
Matthew Mlinar		Expertise in mineral beneficiation and beneficiation			27.06%	0.03		$4,731
Meijun Cai		Environmental Engineer, Expertise in environmental engineering and waste water treatment			27.06%	0.12		$16,192
Lysa Chizmadia		Process Mineralogist			27.06%	0.21		$30,327
Tyler Mendonsa		Senior Laboratory Technician, Executing metallurgical testwork and sample analysis			25.09%	0.42		$31,102
Julie Mutchler		Chemical Laboratory Supervisor, Executing metallurgical testwork and sample analysis			25.09%	0.42		$47,916
Michael Swanson		Principal Laboratory Technician, Executing metallurgical testwork and sample analysis			25.09%	1.89		$182,486
Bailey Rohde		Technician, Executing metallurgical testwork and sample analysis			25.09%	1.8		$133,302
TBD Post-Doctoral Research Fellow		Mineral beneficiation and water treatment			21.32%	1.95		$176,086
							Sub Total	**$819,000**
Contracts and Services								
Metcom Technologies	Professional or Technical Service Contract	Providing technical support during plant surveys as well as pilot design and demonstration of the zero effluent discharge taconite concentrator.				3		$50,000
TBD	Professional or Technical	Analysis of water samples				3		$80,000

	Service Contract							
							Sub Total	**$130,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab supplies e.g. filter papers, sample tags, buckets, stop watches, reagents pumps, scales, etc.	These are laboratory consumables.					$20,000
							Sub Total	**$20,000**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	4 trips (winter and summer), from NRRI to mine site and back to NRRI. Standard GSA rates will be applied for mileage, per diem, hotels.	Conducting plant surveys and field work.					$10,000
							Sub Total	**$10,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Shipping costs	Shipping of water samples to an external analytical laboratory					$5,000
							Sub Total	**$5,000**

							Grand Total	**$984,000**

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				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 55% modified total direct costs.	Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs)	Secured	$541,201
			Non State Sub Total	**$541,201**
			Funds Total	**$541,201**

Total Project Cost: $1,525,201

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 01021edd-98d.pdf

Alternate Text for Visual Component

The visual shows the configurations of the existing taconite concentrators and the proposed zero effluent discharge taconite concentrator. The difference between the two is that the later has 100% short water recirculation rates (with and without process water treatment) and therefore eliminates effluent discharge and the need for tailings ponds....

Supplemental Attachments

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

Title	File
UMD SPA Transmittal Letter	c5a821b4-9d7.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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?

No

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 proposal:

University of Minnesota - Duluth