



Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-270

Proposal Title: A Safety Rating System of Mining Waste Storage in Northern Minnesota

Project Manager Information

Name: Joseph Labuz

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: A major public concern related to mining operations is the storage of the waste material. In this work, we will develop safety rating tools for mining waste storage.

Funds Requested: \$390,000

Proposed Project Completion: 2024-06-30

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?

Region(s): NE

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

Region(s): NE

When will the work impact occur?

In the Future

Narrative

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

Northern Minnesota is home to numerous earth dams surrounding storage basins or ponds containing mining waste of iron ore extraction. Some mining waste basins are reclaimed or abandoned, several are in operation, while new mining of non-iron ore deposits are being considered.

The mining and processing of low-grade metallic ores result in large quantities of waste (tailings) in the form of a slurry – a mixture of water and clay-to-sand size particles. The slurry is retained in a basin by a dam, where the solids settle with time and the water is recycled to the processing plant or treated prior to discharge. The dam is typically made of lower water content mining waste, which results in sufficient strength to ensure dam stability. Thus, the main function of a dam is to secure operational safety of a basin, where the solid particles are stored permanently and water temporarily.

Metallic mining waste may contain toxic chemicals (e.g. sulfides) that must be prevented from entering the surface- or ground-water. Contamination can happen when a dam surrounding a basin “fails,” which may also cause mud slides and debris flows that result in the loss of life and devastation of infrastructure.

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.

The mining industry is an important economic contributor to the State of Minnesota. Although the industry is committed to environmentally sound management, a major public concern related to mineral processing plants from mining operations is the storage of the waste material known as tailings. If the earth dam structures built to impound the tailings fail, then serious environmental pollution and even fatalities can occur. Catastrophic events of failure have been reported in Canada (e.g. Mount Polley Dam failure in 2014) and more recently in Brazil (e.g. Brumadinho Dam failure in 2019).

The aims of the project are threefold: (1) to develop an inventory and classification system for active and inactive tailings dams; (2) to measure the material properties of the tailings in the laboratory; and (3) to synthesize, with GIS software, and analyze, with the developed system, selected tailings dams in northern Minnesota. The three objectives are complimentary and will lead to safe operations and stewardship of these critical structures.

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?

1. Development of an inventory and safety rating system for active and inactive tailings dams: The inventory of tailings dams will be based on public maps and aerial imagery, which will allow technical characteristics of the tailing impoundments to be computed and stored.
2. Laboratory testing of mine tailings to determine material properties: The characterization of tailings will assist regulatory agencies in evaluating the design, expansion, and eventual closing of the impoundment structures.
3. Integration of the rating system in a GIS platform.

Activities and Milestones

Activity 1: Development of an inventory and safety rating system for active and inactive tailings dams

Activity Budget: \$120,000

Activity Description:

The inventory of tailings dams will be based on public maps and aerial imagery, and will be integrated into a geographical information system (GIS), which will allow technical characteristics of the tailing impoundments to be computed and stored. Some of these include, for example, storage volumes, depths, and extents of tailings ponds. The classification will focus on the characterization of tailings dam materials, with the objective of assisting regulatory agencies in evaluating the design, expansion, and eventual closing of the impoundment structures.

Activity Milestones:

Description	Completion Date
Acquire public maps and aerial imagery of existing impoundment facilities	2021-09-30
Integrate inventory of tailings dams into a geographical information system (GIS)	2022-04-30
Classify tailings dam materials and geometrical features of mining waste storage facilities	2022-06-30

Activity 2: Laboratory testing of mine tailings to determine material properties

Activity Budget: \$135,000

Activity Description:

Triaxial compression tests will be performed with ultrasonic probing on specimens of reconstituted tailings material from one site, which is representative of the some of the materials found in northern Minnesota. To simulate field conditions, specimens will be saturated and consolidated under four different pressures. In essence, each compression test will involve ultrasonic probing throughout the testing process and stress path, with measurements of travel time recorded. The specimens, each with ultrasound records and corresponding displacement and loading conditions, will result in a wealth of data for a “machine learning” approach in determining material behavior.

Activity Milestones:

Description	Completion Date
Acquire tailings material from a northern Minnesota site	2022-09-30
Develop specimen preparation procedures, including saturation and consolidation.	2022-12-31
Analyze ultrasonic data using a machine learning approach	2023-09-30
Perform triaxial compression tests with ultrasonic probing to characterize the tailings	2023-12-31

Activity 3: Integration of the rating system in a GIS platform and evaluation of selected storage sites in northern Minnesota

Activity Budget: \$135,000

Activity Description:

Representative cases of tailing dams in the Iron Range will be selected and analyzed using the proposed rating safety system. The evaluation will be based on information gathered in activities 1 and 2, i.e. surveyed geometrical characteristics of the impoundments and measured characteristics of the materials involved, and will additionally

include application of state-of-the-art techniques used for evaluation of the safety rating of tailing impoundments in northern Minnesota.

Activity Milestones:

Description	Completion Date
Develop the safety rating system based geoengineering analysis	2023-06-30
Integrate the rating system in a GIS platform	2023-09-30
Evaluate selected storage sites in northern Minnesota	2024-03-31

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
David Saftner	Department of Civil Engineering, University of Minnesota Duluth	Saftner is co-investigator and will lead the effort on the analysis of structures used for mining waste storage.	Yes
Carlos Carranza-Torres	Department of Civil Engineering, University of Minnesota Duluth	Carranza-Torres is co-investigator and will lead the effort on geographical information systems and the development of safety ratings.	Yes
Bojan Guzina	Department of Civil, Environmental, and Geo-Engineering, University of Minnesota	Guzina is co-principal investigator and will lead the investigation in seismic imaging and machine learning.	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 be funded?

Representative cases of tailing dams in the Iron Range will be selected and analyzed using the proposed rating safety system. The evaluation will be based on information gathered in the project outcomes, i.e. surveyed geometrical characteristics of the impoundments and measured characteristics of the materials involved, and will additionally include application of state-of-the-art techniques used for evaluation of the safety rating of mining waste storage in northern Minnesota.

Project Manager and Organization Qualifications

Project Manager Name: Joseph Labuz

Job Title: Professor and Head

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

Labuz has been at UMN since 1987 and he is a world leader in experimental investigation of strength and deformation of fluid-saturated materials. He will act as Project Manager / Principal Investigator, and he will be responsible for management and reporting. Labuz has considerable experience in managing research projects, having served as PI on over 30 grants worth over \$8M. Labuz is an experimentalist, with two patents, and he studies fluid-saturated geomaterials. Guzina has been at UMN since 1998, and he is leading expert in seismic imaging and machine learning. Carranza-Torres has been at UMN-Duluth since 2008, and his research is focused on engineering geology and geomechanical aspects of design and analysis of surface and underground excavations. Saftner has been at UMN-Duluth since 2011 and has developed multiple design guides currently in use by MnDOT and FHWA to integrate state-of-the-art approaches and current geotechnical design practice.

The geomechanics laboratories at UMN are well equipped for determining strength and seismic properties of tailings,

including triaxial compression testing. Basic instrumentation associated with an experimental mechanics laboratory is also available. Maintenance of hydraulic systems is performed annually by a certified technician. Supporting equipment to monitor seismic velocities include a high speed data acquisition system.

The UMN-Duluth civil engineering program began in 2007 and has developed an outstanding reputation for practical research solving regional and national engineering problems. Past projects include improving computational tools in geotechnical engineering practice and development of design guides to integrate state-of-the-art and state-of-the-practice. The geotechnical laboratories are equipped with new equipment to characterize soil and determine strength, settlement, and stiffness parameters, as well as accompanying state-of-the-art software.

Organization: U of MN - College of Science and Engineering

Organization Description:

The Department of Civil, Environmental, and Geo- Engineering (CEGE) at the University of Minnesota (UMN) is known for its pioneering work in analytical, computational, and experimental methods. The culture of our department is one of research excellence using rigorous fundamentals for wide-ranging applications. Our research can be described generally as (i) covering a broad spectrum of areas, (ii) interdisciplinary, and (iii) having an emphasis on science and fundamentals. Our vision, inspired and innovative engineering for society, is directly related to recent contributions stemming from basic research:

- investigation of pollutant fate and transport led to Minnesota banning the use of triclosan in consumer products
- analyses of the fluid-driven fracture problem provided scaling laws and the development of novel numerical algorithms
- studies of stream hydraulics and bed topography predicted macro-invertebrate spatial distribution in aquatic ecosystems for improved stream restoration projects
- developments in isogeometric and embedded domain finite element methods (FEM) allowed interaction between structural design through trimmed CAD surfaces and FEM analysis

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Joseph Labuz		Principle Investigator			27%	0.09		\$36,855
Bojan Guzina		Co-Principal Investigator			27%	0.12		\$36,855
Carlos Carranza-Torres		Co-Investigator			27%	0.15		\$32,760
David Saftner		Co-Investigator			27%	0.18		\$32,760
Mugur Turos		Research Scientist 1			24%	0.09		\$7,908
TBD		Research Scientist 2			24%	0.48		\$31,500
TBD		Graduate Student 1			44%	1.26		\$126,285
TBD		Graduate Student 2			44%	0.75		\$76,077
							Sub Total	\$381,000
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	Replacement sensors, signal conditioners	Measurement of force, displacement, and time histories					\$6,000
							Sub Total	\$6,000
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-

Travel In Minnesota								
	Miles/ Meals/ Lodging	Visit mining waste storage facilities in northern Minnesota	Acquire maps and aerial imagery					\$3,000
							Sub Total	\$3,000
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$390,000

Classified Staff or Generally Ineligible Expenses

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

Category	Specific Source	Use	Status	Amount
State				
In-Kind	1% academic year cost share for PI Labuz and Co-PI Guzina.	Working on project during academic year.	Pending	\$14,925
In-Kind	F&A costs are provided as in-kind.	UMN's federally negotiated F&A rate is 55.0% beginning fiscal year 2022 (07/01/21).	Pending	\$178,433
			State Sub Total	\$193,358
Non-State				
			Non State Sub Total	-
			Funds Total	\$193,358

Attachments

Required Attachments

Visual Component

File: [b261af59-05d.pdf](#)

Alternate Text for Visual Component

Process by which mining waste is produced and stored. Map showing mining waste storage facilities in northern Minnesota.

Optional Attachments

Support Letter or Other

Title	File
Letter of intent	3cc865c9-906.docx
UM_annualreport2019	866b5631-952.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

No

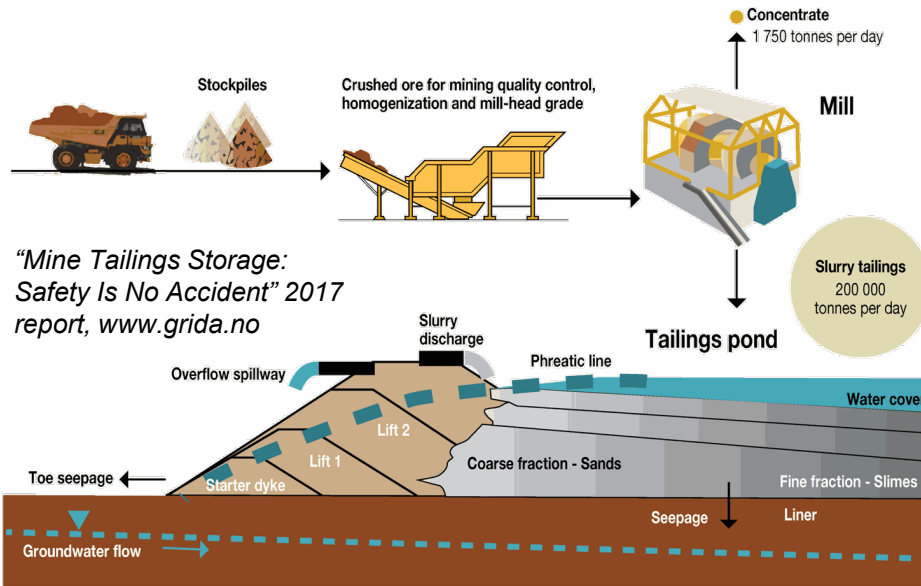
Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

A safety rating system for mining waste storage in northern Minnesota

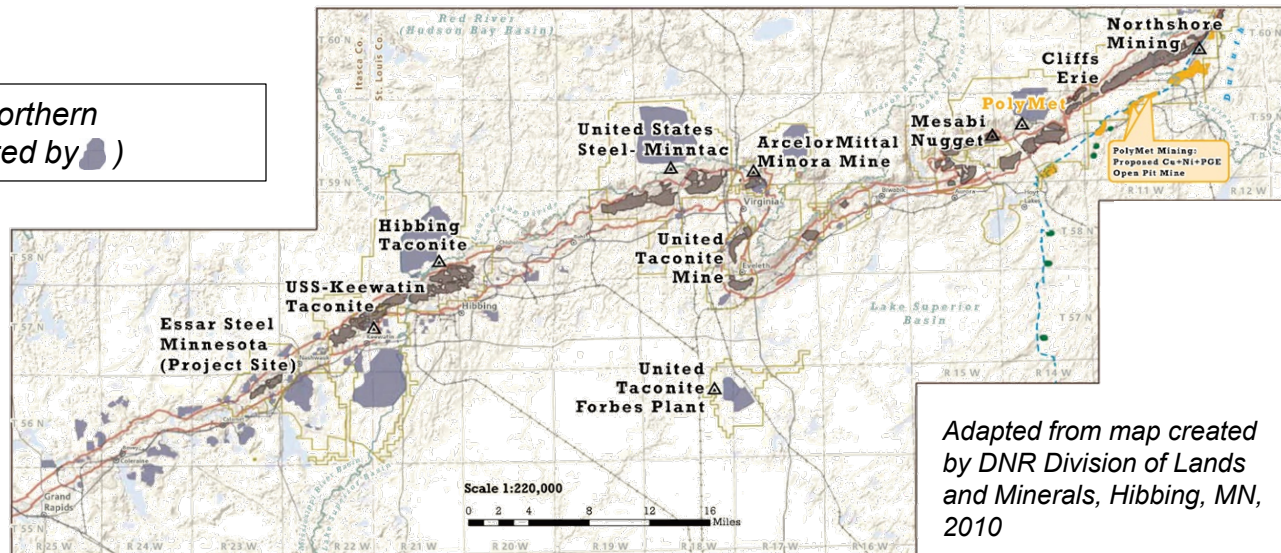


"Mine Tailings Storage: Safety Is No Accident" 2017 report, www.grida.no

Mining is an important contributor to the Minnesota economy but storing mining wastes, called tailings, can have an impact on the environment and community. In this work, we aim to develop safety rating tools for mining waste storage. This will be accomplished by:

1. developing an inventory and safety rating system for active and inactive tailings dams;
2. measuring the material properties of tailings in the laboratory; and
3. integrating the rating system in a GIS platform and evaluating selected storage sites in northern Minnesota.

Tailing basins in northern Minnesota (indicated by)



Adapted from map created by DNR Division of Lands and Minerals, Hibbing, MN, 2010