Environment and Natural Resources Trust Fund
2019 Request for Proposals (RFP)

Project Title: **ENRTF ID: 103-BH**

Using Local Iron Byproducts to Remove Surface-water Phosphorus

Category: H. Proposals seeking $200,000 or less in funding

Sub-Category: B. Water Resources

Total Project Budget: $ 195,216

Proposed Project Time Period for the Funding Requested: June 30, 2021 (2 yrs)

Summary:

We will use local iron byproducts to remove phosphorus from agricultural drainage, lakes, and streams exhibiting eutrophication. Project results will identify cost-effective materials for water treatment applications.

Name: Meijun Cai

Sponsoring Organization: U of MN - Duluth

Title: Research Associate

Department: Natural Resources Research Institute

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Web Address

Location

Region: Metro, Northeast

County Name: Aitkin, Anoka, Carlton, Carver, Chisago, Cook, Dakota, Hennepin, Isanti, Itasca, Koochiching, Lake, Pine, Ramsey, Scott, Sherburne, St. Louis, Washington, Wright

City / Township:

Alternate Text for Visual:

The visual pictures show examples of iron byproducts (tailing) and agricultural drainage to be used in project, experiments to be done, and cost-effective analysis.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%
____ If under $200,000, waive presentation?			

PROJECT TITLE: Using Local Iron Byproducts to Remove Surface-water Phosphorus

I. PROJECT STATEMENT

This project will develop criteria for using **cost-effective** local iron-containing materials in phosphorus removal systems.

Iron-enhanced sand filtration is one of the Best Management Practices effective for removal of phosphorus from stormwater and has started being used in treating agricultural drainage in Minnesota. However, iron-enhanced sand filtration practices in MN typically use higher-cost iron filings purchased from other states. As a mining state, Minnesota has a wide array of abundant iron-bearing minerals in iron ores, iron mining byproduct materials, and other iron industry products. Successful and widespread use of locally available iron for reducing phosphorus levels benefits the environment in Minnesota and has a real economic benefit.

It is **cost-effective and efficient** for our research team to conduct this work since we can apply our experience and data from previous projects. Our existing data include characterization of iron sources and pure iron materials, so research costs are only needed for analyzing iron byproducts.

Our goal is to evaluate locally iron-bearing minerals and produce a cost-effective way for phosphorus removal for the protection of water resources in Minnesota. The specific project objectives are to:

(1) **characterize** mineralogy, chemical composition, and particle size distribution of locally iron byproducts;

(2) **evaluate** their phosphorus removal ability by using different water sources; and

(3) **recommend** the most cost-effective way to use these iron-containing byproduct materials in phosphorus treatment and removal systems.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Characterize mineralogical, physical, and chemical properties of selected iron byproducts.

Iron byproducts will be collected from mining facilities across the Mesabi Range in Northeast Minnesota, and other iron materials from industrial sources such as steel mills across Minnesota. The potential iron byproducts to be tested may include magnetite-rich ore, iron carbonate-rich waste rock, hematite-rich waste rock, fine and coarse tailings, and selected industrial byproducts. To compare the performance of local iron-bearing material, iron filings from commercial products and several pure materials will be used as reference materials. Characterization of iron byproducts will be conducted for both physical and chemical properties through lab experiments following environmental or ASTM standard procedures.

ENRTF BUDGET: $78,210

Outcome	Completion Date
1. Dataset of local iron byproducts sources and properties	08/31/2019
2. Characteristics of selected iron byproducts	02/29/2020

Activity 2: Evaluate phosphorus removal efficiencies of selected iron byproducts through laboratory experiment and statistical models.

Laboratory experiments will be performed to evaluate phosphorus removal efficiency by different iron materials through batch and column experiments. Iron materials will be selected to maximize the variation of their properties delivered from Activity 1. The columns will be constructed with a single material and/or a mixture of media. Statewide water quality data will be compiled from agricultural runoff and lakes/streams exhibiting eutrophication across Minnesota. Water for the column experiments will represent typical phosphorus levels from compromised water bodies and from agricultural drainage effluent.

The removal efficiencies of phosphorus for studied iron materials will be related with their characterization data to develop statistical models to provide information in two aspects: (1) the most important property of iron-bearing materials, which has been related to phosphorus removal efficiencies; and (2) the relationships (such as positive or negative) between the iron materials' properties and phosphorus removal. These models will become a tool to assist the selection of other iron-based materials in the future.

ENRTF BUDGET: $96,817

Outcome	Completion Date
1. Dataset of compiled water quality for agricultural runoff and lakes/streams	07/31/2020
2. Phosphorus removal efficiencies of selected iron byproducts	10/31/2020
3. Relationships between phosphorus removal efficiency and characteristics	12/31/2020

Activity 3: Cost-effective analysis of iron materials to be used in water treatment practice.

The cost-effectiveness in removing phosphorus will be evaluated for locally available iron materials. Parameters including material costs, transportation costs, removal rate, removal efficiency, and capacity of the materials will be examined. Iron filings from other states will be used as a baseline to create the cost matrix. Performance of iron materials in removing phosphorus from freshwater will be evaluated by either laboratory experiments or models completed in Activity 2. The preliminary cost matrix will aid in selection of iron materials for field water treatment practice.

ENRTF BUDGET: $20,189

Outcome	Completion Date
1. Preliminary cost-effective matrix for local iron materials	03/31/2021
2. Final report	06/30/2021

III. PROJECT PARTNERS:

A. Partners receiving ENRTF funding N/A

B. Partners NOT receiving ENRTF funding N/A

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:

The major outcome of this project is to provide a tool for the users to select **cost-effective** local iron materials in treating phosphorus. The project results will be shared with iron manufacturers, mining industry and government agencies for water treatment application.

With promising results, field-scale experiments will be performed with potential funding from MPCA, MnDOT, and/or USDA.

V. TIME LINE REQUIREMENTS: This project is planned for 2 years beginning on July 1, 2019 and ending on June 30, 2021.

IX. SEE ADDITIONAL PROPOSAL COMPONENTS:

A. Proposal Budget Spreadsheet
B. Visual Component or Map
C. Parcel List Spreadsheet
D. Acquisition, Easements, and Restoration Requirements
E. Research Addendum (not required at proposal stage)
F. Project Manager Qualifications and Organization Description
G. Letter or Resolution
H. Certified Audit or 990 Tax Information

2019 Proposal Budget Spreadsheet

Project Title: Using Local Iron Byproducts to Remove Surface-water Phosphorus

IV. TOTAL ENRTF REQUEST BUDGET 2 years

BUDGET ITEM	AMOUNT
Personnel:	**$ 157,216**
Mei Cai, Principal Investigator: $18,837 (fringe rate 33.5%); 10% FTE each year for 2 years	
Marsha Patelke, Co-Investigator: $16,035 (fringe rate 33.5%); 10% FTE each year for 2 years	
Chanlan Chun, Task Manager: $14,728 (fringe rate 33.5%); 5% FTE each year for 2 years	
Larry Zanko, Task Manager: $12,710 (fringe rate 33.5%); 5% FTE each year for 2 years	
Don Fosnacht, Task Manager: $14,446 (fringe rate 27.2%); 3% FTE each year for 2 years	
John Heine, Lab Scientist: $1,032 (fringe rate 27.2%); 0.5% FTE each year for 2 years	
Rodney Johnson, Lab Scientist: $3,224 (fringe rate 33.5%); 1% FTE each year for 2 years	
Graduate Research Assistant: $61,422 (fringe rate 25%) and tuition reimbursement; 100% FTE in AY (both semesters) in Y1 and 50% FTE in AY (1 semester) in Y2, 100% FTE in SUM in Y1	
Undergraduate Research Assistant: $14,782 (0% fringe); 30% FTE each year for 2 years	
Professional/Technical/Service Contracts:	**$ 10,000**
Scientific/Lab Services ($10,000): sample measurements service from external laboratory. External sample measurements will be used to measure chemical compositions contained in the raw materials, and measure phosphorus from experiment solutions.	
Equipment/Tools/Supplies:	**$ 22,000**
Lab Supplies ($22,000): bottles ($1,500), filtration membrane ($2,500), chemicals ($5,000), glassware ($1,500), filtration funnel ($1,000), plasticware [gloves, pipet tips] ($3,000), columns ($2,000), pumps ($3,500), tubing ($1,500), and other basic supplies ($500). Lab supplies will be used for experiment and also water analysis. Because of this, the chemical cost will be high such as one bottle of eluent solution for IC machine will cost over $1,000.	
Acquisition (Fee Title or Permanent Easements):	**$ -**
Travel:	**$ 6,000**
Fieldwork and experiment travel ($6,000): Travel to collect samples, and do experiments in other campus	
Additional Budget Items:	**$ -**
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$ 195,216**

V. OTHER FUNDS

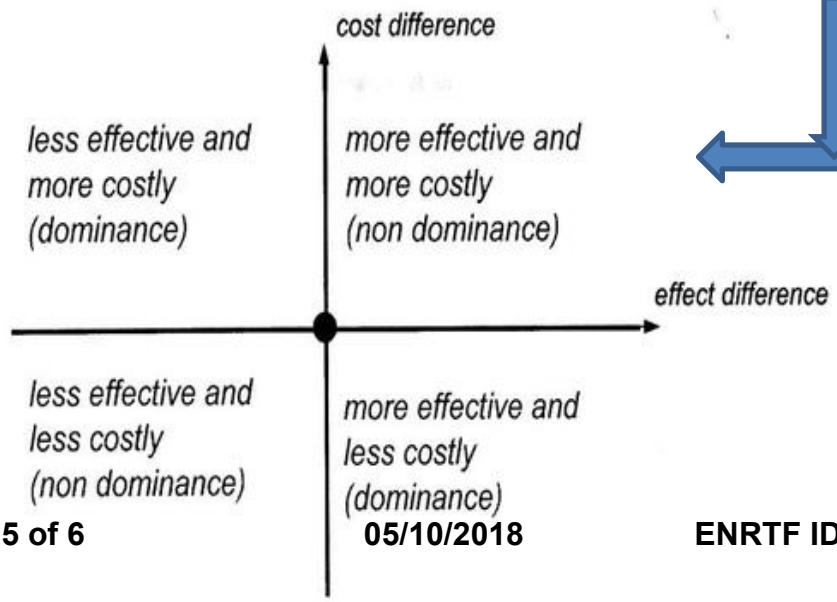
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	$ -	N/A
Other State $ To Be Applied To Project During Project Period:	$ -	N/A
In-kind Services To Be Applied To Project During Project Period:		
Unrecovered indirect: 54% on modified total direct costs ($172,391 base; excludes graduate student tuition reimbursement)	$ 93,091	Secured
Past and Current ENRTF Appropriation:	$ -	N/A
Other Funding History:	$ -	N/A

Using Local Iron Byproducts to Remove Surface-water Phosphorus

Agricultural drainage

Inflow

Materials



PROJECT TITLE: Using Local Iron Byproducts to Remove Surface-water Phosphorus

2019 LCCMR Project Manager Qualifications and Organization Description
Meijun Cai, Natural Resources Research Institute (NRRI), University of Minnesota Duluth

KEY QUALIFICATIONS
Dr. Cai is an environmental engineer with specialties in water quality at NRRI since 2012. Her research focuses on the use of salvage material as filtration materials to treat water in order to improve water quality. She is also an environmental statistician. Cai will be supported by Dr. Gary Feyereisen, an expert in agricultural soil and water sciences; Marsh Patelke, a mineralogist, to characterize mineralogical properties of iron materials; Dr. Chanlan Chun, an environmental engineer, who will identify chemical properties of iron byproducts and is working on a project to use iron liberation methods for sustainable biological sulfate removal from mine water; Mr. Larry Zanko, who has extensive experience in characterizing iron-bearing materials and many years' work experience in mining industry; and Dr. Donald Fosnacht, the associate director specializing in metallurgical engineering, mineral engineering, and applied chemistry.

EDUCATION
May 2010 – Feb. 2012: Postdoctoral (Environmental Engineering), University of Tennessee – Knoxville
Aug. 2006 – April 2010: Ph.D. (Environmental Engineering), University of Tennessee – Knoxville

RELEVANT RESEARCH EXPERIENCE
Dr. Cai is the co-PI of two Minnesota Department of Transportation funded projects (2015-2019) to investigate water quality changes by using alternative materials to treat highway stormwater. Local salvage materials, including taconite tailings, were used to develop filtration materials to evaluate the change of stormwater quality.

PUBLICATIONS
Cai, M. and E.D. Reavie (2018). Pelagic zonation of water quality and phytoplankton in the Great Lakes. *Limnology*, 127-140.

Johnson, K., **M. Cai**, M. Patelke, D. Saftner and J. Swanson (2017). Comparing Properties of Water Absorbing/Filtering Media for Bioslope/ Bioswale Design. http://www.cts.umn.edu/Publications/ResearchReports/reportdetail.html?id=2634

Reavie, E.D., M.B. Edlund, N.A. Andresen, D.R. Engstrom, P.R. Leavitt, S. Schottler and **M. Cai** (2017). Paleolimnology of the Lake of the Woods southern basin: Continued water quality degradation despite lower nutrient influx. *Lake and Reservoir Management*, 1-17.

Kovalenko, K.E., E.D. Reavie, J.D. Allan, **M. Cai**, S.D.P. Smith and L.B. Johnson (2017). Pelagic phytoplankton community change-points across nutrient gradients and in response to invasive mussels. *Freshwater Biology*, 62(2), 366-381.

Reavie, E.D., **M. Cai**, M.R. Twiss, H. Carrick, T.W. Davis, T.H. Johengen, D. Gossiaux, D.E. Smith, D. Palladino, A. Burtner and G.V. Sgro (2016). Winter–spring diatom production in Lake Erie is an important driver of summer hypoxia. *Journal of Great Lakes Research*, 43(3), 608-618.

The Natural Resources Research Institute is a University of Minnesota Duluth applied research organization. NRRI's mission is to deliver research solutions to balance Minnesota's economy, resources and environment for resilient communities.