

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

Project Title:

ENRTF ID: 078-B

Enhanced Nitrogen Removal in Minnesota's Watersheds

Category: B. Water Resources

Sub-Category:

Total Project Budget: \$ 408,277

Proposed Project Time Period for the Funding Requested: June 30, 2022 (3 yrs)

Summary:

We will use GIS and satellite data to develop tools to enhance nitrogen removal in Minnesota watersheds

Name: Miki Hondzo

Sponsoring Organization: U of MN

Title: Professor

Department: St. Anthony Falls Laboratory

Address: 2 Third Ave SE

Minneapolis MN 55414

Telephone Number: (612) 625-0053

Email mhondzo@umn.edu

Web Address

Location

Region: Central

County Name: Nicollet

City / Township: Minneapolis, St. Peter

Alternate Text for Visual:

Enhanced Nitrogen Removal in Minnesota's Watersheds

_____ 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?			



Environment and Natural Resources Trust Fund (ENRTF)
2019 Main Proposal
Project Title: Enhanced Nitrogen Removal in Minnesota's Watersheds

I. PROJECT STATEMENT

Supporting the expansion of crop production requires efforts toward sustainable removal of excess nitrogen fertilizer from Minnesota aquatic ecosystems. High nitrogen concentrations lead to loss of stream biodiversity, eutrophication, toxic algal blooms and more importantly drinking water contamination that is expensive to treat. Areas of enhanced nitrogen-nitrate removal, termed **denitrification hot spots**, frequently account for a high percentage of nitrate removal in streams, riparian areas, flood plains, and wetlands. If managed appropriately, wetlands and flood plains can significantly remove excess nitrogen from water before it reaches larger water bodies where it is difficult to treat. Our research aims to answer the following fundamental question:

- What combination of soil characteristics, hydrological conditions, and land use determine the formation and operation of nitrogen-nitrate **hot spots** and **hot moments** in Minnesota watersheds?

We propose to use geographic information system (GIS) and satellite data to develop tools to enhance nitrogen removal in Minnesota watersheds. The proposed tools will guide watershed best management practices (BMPs) towards sustainable enhancement of nitrogen removal in Minnesota watersheds. Guiding BMPs include (but are not limited to) developing new practices that alter the timing and duration of nitrogen laden water delivery to floodplains, wetlands, ponds, and channels through:

- (1) Identifying the distribution of denitrification hot spots and hot moments across all Minnesota watersheds.
- (2) Developing a practitioner tool to quantify site specific nitrogen removal by individual and combinations of BMPs to promote clean water conditions across the landscape of Minnesota.

The proposed tool will be developed by exploring controlled laboratory measurements, field investigations, and readily available spatial airborne and satellite data about soil characteristics, hydrologic pathways, and land use.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Quantify Microbial Nitrate Removal in Riparian Areas

ENRTF BUDGET: \$129,364

At the Outdoor Stream-Lab (OSL) of St. Anthony Falls Laboratory (SAFL), we will quantify the removal of nitrate by microbes in stream and floodplain sediment. The OSL is home to four basins designed to simulate streams, wetlands, and floodplains in agricultural watersheds. The experimental variables will include organic material content in the soil, flooding duration and frequency, and soil moisture. The dependent variables will include the removal of nitrate, denitrification rates, and activity of denitrifying bacteria. The OSL is a unique experimental facility to answer these questions because of the high level of control (i.e. repeat flood events) and its field scale outdoor setting.

Outcome	Completion Date
1. Quantify nitrogen-nitrate removal to controlled soil moisture	December 2019
2. Quantify nitrogen-nitrate removal to controlled organic material concentration in the soil	December 2019
3. Specify functional relationship to quantify nitrogen-nitrate removal	December 2019

Activity 2: Quantify Denitrification Dynamics to Flooding in the Field

ENRTF BUDGET: \$135,564

We will verify the results of the OSL experiments with measurements from an example watershed, Seven Mile Creek, MN. Measurements will consist of soil properties, soil water content, soil organic matter, sediment microbiota, microorganism DNA and mRNA analysis, and nitrogen transformation. The field outcomes and integration with the outcomes of Activity 1 will lead to the development of mechanistic and predictive functional relationships describing nitrogen-nitrate removal on floodplains, wetlands, channels, and riparian areas.

Outcome	Completion Date
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Environment and Natural Resources Trust Fund (ENRTF)

2019 Main Proposal

Project Title: Enhanced Nitrogen Removal in Minnesota's Watersheds

1. Quantify nitrate removal to flooding frequency	September 2020
2. Document linkages between flooding and microbial response	September 2021
3. Develop functional relationship to quantify nitrogen-nitrate removal	December 2021

Activity 3: Watershed-scale Prediction of Nitrogen-Nitrate Hot Spots

ENRTF BUDGET: \$143,349

The proposed geographic information predictive tool will be integrated with the WRF-Hydro modeling system (NCAR) which will integrate digital elevation, land use, and soil type data to predict watershed hydrology, flow pathways, soil moisture, and inundation maps that can incorporate water inundation maps from the MODIS satellite data. The outcomes of Activity 1 and Activity 2 in conjunction with the WRF-Hydro modeling results will provide spatially distributed maps for denitrification hot spots and hot moments of nitrogen-nitrate removal over all Minnesota watersheds. The satellite-based geographic information tool will be presented at the proposed workshop to watershed managers (Minnesota state agencies including DNR, MPCA, and MDA) and other water resources practitioners.

Outcome	Completion Date
1. GIS prediction tool development and integration with the satellite data and WRF model	March 2021
2. Satellite-based geographic information model verification	December 2021
3. Practitioner Workshop at the Upper Midwest Stream Restoration Symposium	April 2022
4. Workshop at SAFL: GIS tools for nitrogen-nitrate removal in Minnesota watersheds	June 2022

III. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
Dr. Miki Hondzo	Professor	University of Minnesota: St. Anthony Falls Lab.	modelling efforts, mentor students (field data collection)
Dr. Ardeshtir Ebtahaj	Assistant Professor	University of Minnesota: St. Anthony Falls Lab.	satellite-based GIS development and verification
Dr. Jessica Kozarek	Research Associate	University of Minnesota: St. Anthony Falls Lab.	experimental effort in Outdoor StreamLab
Dr. Michael Sadowsky	Professor	University of Minnesota: Soil Water and Climate; Biotech. Inst.	microbiological measurements, mentor graduate student

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:

This project is a continuation of research collaboration between SAFL and Dr. Sadowsky focused on predicting and understanding microbial denitrification hot spots and hot moments. Two previous projects, funded by the Minnesota Department of Agriculture (MDA) and the United States Department of Agriculture (USDA) have focused on fundamental research of denitrification hot spots in agricultural landscapes. This project will build of previous research efforts in order to develop a practitioner implementation tool to quantify nitrogen removal by hot spots and BMPs and to facilitate clean water conditions in the Minnesota watersheds.

V. TIME LINE REQUIREMENTS:

This project requires two full summer seasons (2020 and 2021) for field scale experiments and field data collection. Work will begin July 2019 and the final report will be completed by June 2022.

2019 Detailed Project Budget

Project Title:A Satellite-Based Geographic Information Tool for Sustainable Acceleration of Nitrogen Removal in Minnesota Watersheds

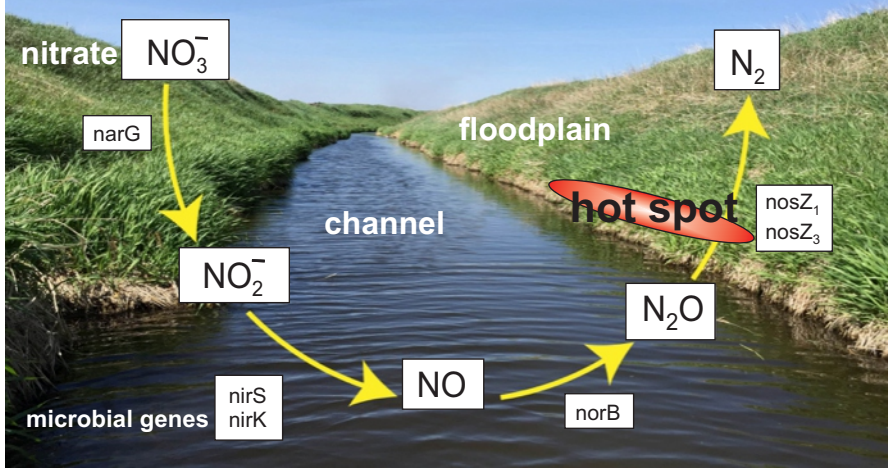
IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel:	\$ 388,777
Professor: Miki Hondzo, PI, (75% salary, 25% benefits), 8% time, (\$61,514)	
Assistant Professor: Ardeshir Ebtehaj, Co-PI, (75% salary, 25% benefits), 4% time, (\$19,469)	
Research Associate: Jessica Kozarek, Co-PI, (75% salary, 25% benefits), 17% time, (\$48,673)	
Engineering Technician, (79% salary, 21% benefits), 17% time, (\$39,723)	
SAFL Graduate Student, (58% salary, 42% benefits), 50% time, (\$94,017)	
Biotech Graduate Student, (58% salary, 42% benefits), 50% time, (\$94,017)	
Undergraduate Research Team (3 students for 12.5 weeks yrs 1-2), (\$31,364)	
Professional/Technical/Service Contracts: (N/A)	
Equipment/Tools/Supplies:	\$ 15,500
OSL Supplies (soil, carbon, chemicals, sediment, vegetation, etc.) (\$5,000)	
General Laboratory Supplies (safety, glassware, etc.) (\$1,000)	
LaChat Supplies (Nitrogen Analyzer) (\$2,000)	
Microbial Lab Supplies (\$7,500)	
Acquisition (Fee Title or Permanent Easements): (N/A)	
Travel:	\$ 4,000
Travel to in-state conferences (\$2,000)	
Travel to field sites (\$2,000)	
Additional Budget Items: (N/A)	
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND \$ REQUEST	\$ 408,277

V. OTHER FUNDS

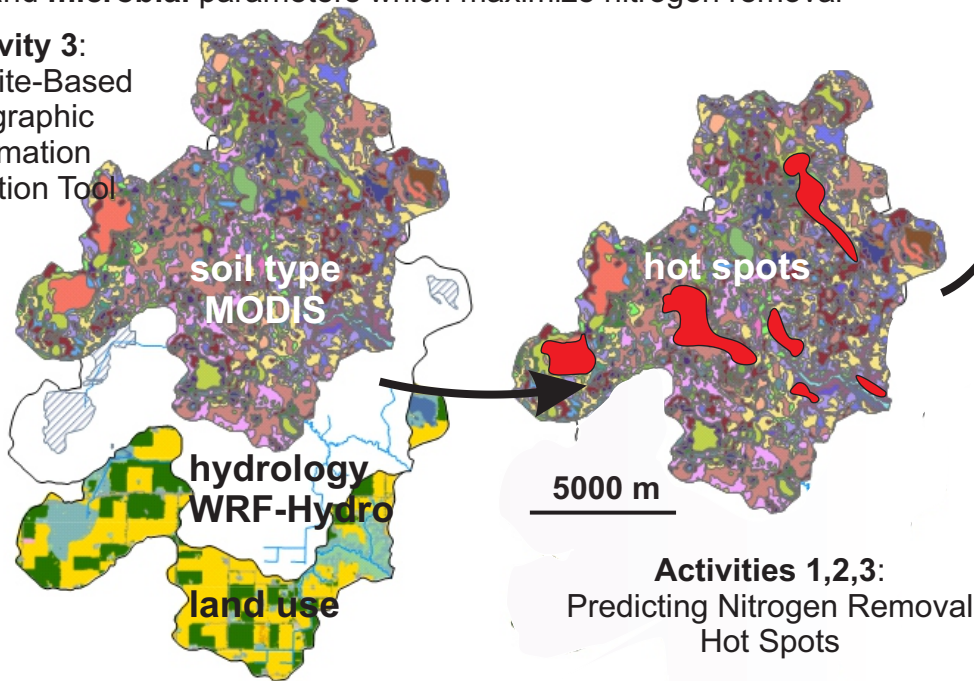
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State \$ To Be Applied To Project During Project Period: N/A	\$ -	
Other State \$ To Be Applied To Project During Project Period: N/A	\$ -	
In-kind Services To Be Applied To Project During Project Period: Unrecovered UMN overhead (54% MTDC)	\$ 187,106	
Past and Current ENRTF Appropriation: N/A	\$ -	
Other Funding History:	\$ -	

Activities 1 & 2:
Quantify nitrogen removal in wetlands, channels and floodplains



Nitrogen removal **hot spot** is optimal combination of **environmental** and **microbial** parameters which maximize nitrogen removal

Activity 3:
A Satellite-Based
Geographic
Information
Prediction Tool



Seven Mile Creek Watershed, MN

Miki Hondzo, Professor

St. Anthony Falls Laboratory, Department of Civil, Environmental, and Geo- Engineering,
University of Minnesota, Minneapolis, MN 55414-2196
mhondzo@umn.edu, voice: +612-625-0053

Professional Preparation

Undergraduate	University of Sarajevo	Civil Engineering	B.Sc. 1983
Graduate	Free University of Brussels	Surface Water Hydrology	M.Sc. 1988
	University of Minnesota	Civil Engineering	Ph.D. 1992
Postdoctoral	Michigan State University	Environmental Engineering	1992-1993
	St. Anthony Falls Lab.	Experimental Fluid Mech.	1993-1995

Appointments

Full Professor	University of Minnesota, Department of Civil Engineering	2007-present
Associate Professor	University of Minnesota, Department of Civil, Environmental, and Geo- Engineering	1999-2006
Assistant Professor	Purdue University, School of Civil Engineering	1995-1999

Awards/Recognitions

2008	Samuel Arnold Greeley Award. Environmental Engineering Division, American Society of Civil Engineers. Award for the best research paper "Modeling heavy metal removal by plant species and sediment."
2006	"Outstanding Limnology and Oceanography Reviewer." Recognized by <i>Limnology and Oceanography</i> journal for reviewing service.
2000	Rudolph Hering Medal. Environmental Engineering Division, American Society of Civil Engineers. Award for most valuable contribution to the increase of knowledge in the environmental branch of the engineering profession for the paper, "Diffusional mass transfer at the sediment-water interface."
1997-2002	CAREER AWARD, National Science Foundation (Division of Chemical and Transport Systems)
1997	Founders Award for the best paper "Long-term lake water quality predictors", appearing in the 1996 year of <i>Water Research</i> . The USA National Committee of International Association on Water Quality.

Research Interests

- Ecological fluid mechanics and environmental restoration
- Water quality and transport processes in lakes, rivers, and watersheds

Journal Publications (selected 5 relevant to the LCCMR proposal out of 80 published papers)

Tomasek, A., C. Staley, P. Wang, T. Kaiser, N. Lurndahl, J.L. Kozarek, M. Hondzo, and M.J. Sadowsky (2017). Increased denitrification rates associated with shifts in prokaryotic community composition caused by varying hydrologic connectivity, *Frontiers in Microbiology*, 8, 2304.

Tomasek, A., J.L. Kozarek, M. Hondzo, N. Lurndahl, M.J. Sadowsky, P. Wang, and C. Staley (2017). Environmental drivers of denitrification rates and denitrifying gene abundances in channels and riparian areas, *Water Resources Research*, 53(8), 6523-6538.

Khosronejad, A., A. T. Hansen, J. L. Kozarek, K. Guentzel, M. **Hondzo**, M. Guala, P. Wilcock, J.C. Finlay, and F. Sotiropoulos (2016). Large eddy simulation of turbulence and solute transport in a forested headwater stream, *Journal of Geophysical Research*, 121 (1), 146-167.

Guentzel, K.S., **Hondzo**, M., Badgley, B.D., Finlay, J.C., Sadowsky, and M.J., and Kozarek J.L. (2014). Measurement and modeling of denitrification in sand-bed streams of varying land use, *Journal of Environmental Quality*, 43: 1013-1023.

O'Connor, B. L., and M. **Hondzo** (2008). Enhancement and inhibition of denitrification by fluid-flow and dissolved oxygen flux to stream sediments, *Environmental Science & Technology*, 42(1), 119-125.

Editorship: Associate Editor: *Environmental Fluid Mechanics* journal, 2016-present.