Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 056-B**

Continuous Data to Guide Nitrate Reduction Strategy

Category: B. Water Resources

Total Project Budget: $ 385,241

Proposed Project Time Period for the Funding Requested: 3 years, July 2017 - June 2020

Summary:

Inform Minnesota's strategy to reduce nitrate with analysis of continuously captured data in the Minnesota River Basin so that the strategy can utilize most cost-effective management options.

Name: Amy Hansen

Sponsoring Organization: U of MN - St. Anthony Falls Laboratory

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Web Address

Location

Region: Southwest, Southeast

County Name: Statewide

City / Township:

Alternate Text for Visual:

Map of proposed nitrate sensor locations, graph contrasting continuous data with grab samples

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Continuous data to guide nitrate reduction strategy

I. PROJECT STATEMENT

Excess nitrate in Minnesota streams and rivers is harmful to human and aquatic life. High nitrate levels in drinking water have been linked with blue baby syndrome and increased risk of some cancers, birth defects, and spontaneous abortions. High nitrate is toxic to many species of freshwater mussels, frogs and aquatic insects. Elevated levels of nitrate can also cause reduced water clarity, algal blooms and reduce recreational use. Degraded water quality due to excess nitrate extends from Minnesota all the way to the Dead Zone in the Northern Gulf of Mexico.

The State of Minnesota has committed to reducing nitrate loads to the Mississippi River by 45% by 2045 but lacks sufficient understanding of nitrate source, movement and fate to achieve this without compromising agricultural productivity. This project builds on the foundation provided by the 2013 MPCA Nitrate Report but focuses on improving our understanding of nitrate sources and uptake within the **Minnesota River Basin**, which contributes ~67% of the Mississippi River nitrate load originating in Minnesota. Effective BMPs depend on identifying and intercepting the primary source – either current fertilizer applications or legacy stores of nitrate in the groundwater or the soil. In order to develop cost effective strategies to reduce nitrate loads with a high likelihood of success we need to:

- accurately quantify nitrate loads and timing
- identify primary nitrate sources and storage
- assess existing nitrate removal efficiencies

Nitrate concentrations vary at an hourly to daily time scale but current sampling occurs every 4-6 weeks. From data collected with continuous nitrate sensors in other states, we know that nitrate, an important nutrient for biological processes, fluctuates daily and seasonally as plant photosynthesis fluctuates with sunlight and temperature. Nitrate can also vary at shorter intervals with storm events, being either diluted or concentrated depending on the pathways and timing for rainwater to make its way to the river network. Current and historical sampling efforts, which occur on weekly to monthly sampling frequency, has been invaluable towards understanding long term loading and concentration trends but does not capture the highly dynamic nature of nitrate concentrations or the information about nitrate sources, "age" and fate that is contained in the higher frequency data (as illustrated in the visual handout).

We will capture continuous nitrate, streamflow, sediment and dissolved oxygen measurements at four sites within the Minnesota River Basin **and use our knowledge of biogeochemistry and higher-order statistical tools** to unravel:

- The contribution of historical stores of nitrate to current surface water loads
- The magnitude and mechanism of in-steam nitrate removal

Streamflow gages, suspended sediment gages (maintained by USGS) and one continuous nitrate sensor (maintained by Metropolitan Council) are currently actively collecting data at the sites. USGS owns another continuous nitrate sensor which will be deployed in this network. We will also:

- Quantify loads and compare these to load calculations from grab samples
- Validate the results of the statistical analysis with stable isotope data and independent water chemistry measurements

In itself, the data we propose to collect and make publicly available is inherently valuable to Minnesota and will improve Minnesota's ability to target conservation measures to the times and places where it will be most beneficial.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Collect real-time continuous nitrate data at four USGS stations **Budget: $268,879**

Install four continuous nitrate sensors at USGS streamflow monitoring stations. Nitrate sensors will be co-located with high frequency sediment sensors on Minnesota River funded previously by LCCMR.

Outcome	Completion Date
1. Purchase, calibrate, program and install four sensors	November 2017
2. Measure nitrate concentrations every 15 minutes from mid-March to mid-November for two years at four locations within the Minnesota River Basin. Release data to public in real-time via telemetry.	November 2019
3. Collect grab samples every two weeks at all monitoring sites and analyze in laboratory for O^{18}, chlorophyll, and all forms of carbon, nitrogen and phosphorous	November 2019

Activity 2: Use collected data to determine nitrate loads, source and uptake **Budget: $112,872**

High frequency data (nitrate, streamflow and suspended sediment) will be used together with periodic grab samples and dissolved oxygen data to assess nitrate loads, source and uptake.

Outcome	Completion Date
1. Calculate nitrate loads, compare loads with estimates from grab samples	March 2020
2. Separate groundwater and surface water contributions to total nitrate using hydrograph separation analysis and spectral analysis. Validate with stable isotope tracers	March 2020
2. Apply higher order statistical methods to entire high frequency data set (nitrate, streamflow, suspended sediment) to determine source and in-stream removal	March 2020

Activity 3: Communicate results with policy makers and scientists **Budget: $3490**

This project will provide much needed information regarding the contribution of long term nitrate accumulation in ground water stores to loads and more accurate load estimates. We expect to inform policy decisions.

Outcome	Completion Date
1. Present results at the Minnesota Water Resource Conference during the final year	October 2019
2. Communicate results to scientific community through two peer-reviewed journal articles	June 2020

III. PROJECT STRATEGY

A. Project Team/Partners

Project Partners Receiving Funds:

- Dr. Amy Hansen (Project Manager; University of Minnesota).
- Dr. Arvind Singh (Collaborator; University of Central Florida)
- Chris Ellison/Joel Groten (Collaborator; USGS)

Project Partners Not Receiving Funds:

- Dr. Jacques Finlay (Collaborator; University of Minnesota)
- Kent Johnson (Collaborator; Metropolitan Council)
- Lee Ganske (Collaborator; Minnesota Pollution Control Agency)

B. Project Impact and Long-Term Strategy

This project will fill gaps in our knowledge of nitrate source, load and in-stream removal rates. This information is critical to our ability to meet Minnesota's commitment to reduce nitrate loads by 45% in the Mississippi River in a cost-effective manner, by allowing us to first target the largest sources and timing with the highest impacts. Long-term, the sensors themselves will be an important asset for the state and can be deployed in other basins at the end of this project.

C. Timeline Requirements

Three years duration is required to successfully implement this project. This will allow for sensor calibration and installation, sufficiently long data sets for spectral analysis and time to analyze and disseminate results.

2017 Detailed Project Budget

Project Title: Continuous data to guide nitrate reduction strategy

IV. TOTAL ENRTF REQUEST BUDGET: 3 years

BUDGET ITEM	AMOUNT
Personnel:	$ 156,461
Dr. Amy T. Hansen, Research Associate (100% soft-funded) Project Manager (50% FTE for 2.5 years, 82.8% salary, 17.2 % fringe) ($124,949)	
Undergraduate students, University of Minnesota: 2 students per summer for 2 summers at 100% FTE, 2 students at 25% 6 mos for 2 years ($31,512)	
Professional/Technical/Service Contracts:	$ 138,530
Contract with University of Central Florida: Dr. Arvind Singh, (8 % FTE for 3 years, 82.8% salary, 17.2% fringe) ($50,642)	
Contract with USGS for nitrate sensor installation and maintenance ($87,888)	
Capital expenditures over $5000	$ 75,761
Three Satlantic SUNA continuous nitrate samplers ($25,253.50 each)	
Equipment/Tools/Supplies:	$ 6,163
Bottles, sampling equipment, batteries, waders. ($500)	
Four Onset HOBO data loggers for dissolved oxygen and temperature, $1250 each. ($5,000)	
Nitrate calibration standards and replacement wipers for nitrate sensors ($663)	
Travel:	$ 3,006
Vehicle costs for 36 day trips to four sites - MN R - Judson, Jordan, Le Sueur R-Rapidan, Blue Earth R at Hwy 169 (2 single day field sampling trips per month, 9 months per year, 2 years). $41/day rental + mileage (~250 miles per trip, $0.17/mile). ($3006)	
Additional Budget Items:	$ 5,320
Laboratory analysis: Full water chemistry analysis of samples for groundtruthing (NO3/2, NH4, TDN/DOC, DIC, O18, TP, SRP, chl a) 2 samples per site per month for 9 months per year for 2 years plus 2 end members per month (rainwater and ground water) (108 samples total at $19.21/sample). ($2075)	
Publication fee for two peer-reviewed publications (approx $1,500 ea)	
Registration for one person to attend and present results at the Minnesota Water Resource Conference in last year of project. ($245)	
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 385,241

V. OTHER FUNDS

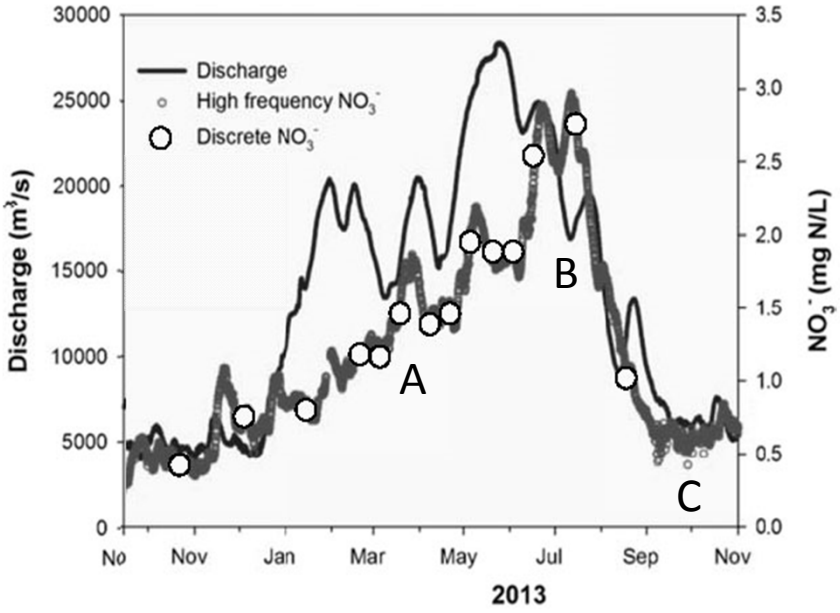
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	N/A	
Other State $ To Be Applied To Project During Project Period:	N/A	
Uncovered U of MN indirect costs:	$ 114,894	
In-kind Services To Be Applied To Project During Project Period:	N/A	
USGS owns one high frequency nitrate sensor that would be installed and used for this project. Metropolitan Council owns and operates one high frequency sensor (Minnesota River at Fort Snelling) - this data will be included in the analysis.		
Funding History:		
Dr. Hansen is currently Principal Investigator on a complementary National Science Foundation (NSF) grant to study optimal wetland placement for watershed scale nitrate reduction. 3 years (2015-2017, $476,039). Note that she will not personally draw funds from the LCCMR grant until the NSF grant has ended, Jan 2018.		
Remaining $ From Current ENRTF Appropriation:	N/A	

Continuous data to guide nitrate reduction strategy

Why we need continuous nitrate data:

A Grab samples can miss nitrate peaks.

B Fluctuations inform us about nitrate removal by plants and microbes within the river. This can be significant.

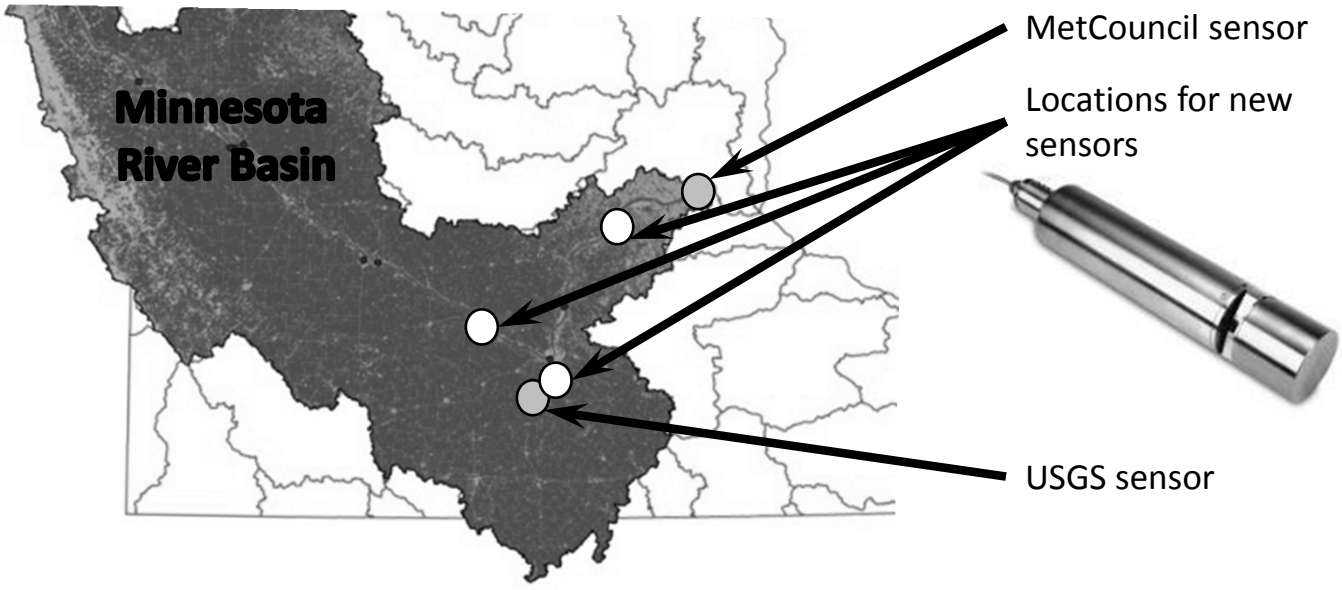


Data from Baton Rouge, LA. Source: Pellerin et al., ES&T 2014

C Nitrate and discharge (streamflow) are not well related because groundwater and surface water have different nitrate concentrations (and age).

Proposed continuous nitrate sensor network

will span ranges in watershed size, land use and in-stream removal.



PROJECT MANAGER QUALIFICATIONS AND ORGANIZATION DESCRIPTION: LCCMR FY 2017

Dr. Amy Hansen is a research associate at St. Anthony Falls Laboratory at the University of Minnesota. She is currently principal investigator on a project funded by the National Science Foundation investigating the potential role of wetlands in mitigating excess nitrate in agricultural landscapes. This includes incorporating nitrate uptake and transport processes into a fluvial network model, and developing an environmental-economic decision analysis tool to assess cost-benefit tradeoffs. Prior to that, she investigated climatic and land use effects on nitrate concentrations, and denitrification rates within the Minnesota River basin. Dr. Hansen has prior project management experience on complex engineering projects both formally at a private company in the semi-conductor industry and informally through her role as a post-doctoral researcher. She reports to the director of St. Anthony Falls Laboratory who supports the proposed effort.

Education

2012 **Ph.D. University of Minnesota**, Civil Engineering, Water Resources, St. Anthony Falls Laboratory, Minor: Ecology, Evolution, & Behavior (EEB)

1995 **M.S. University of Michigan: Ann Arbor**, Mechanical Engineering

1993 **B.S. California Institute of Technology (Caltech)**, Engineering and Applied Science

Experience

01/15 – present **Research Associate**, St. Anthony Falls Laboratory, University of Minnesota

05/12 – 12/14 Postdoctoral Researcher, National Center for Earth-Surface Dynamics, U. of MN

02/03 – 05/05 Peace Corps Volunteer, Engineer; Rural Water and Sanitation, Honduras

10/00 – 01/02 **Project Manager/Engineering Manager**, Veeco Instruments, Santa Barbara, CA

02/98 – 10/00 Lead Project Engineer, Veeco Instruments, Santa Barbara, California

08/95 – 01/98 Design Engineer, Process Engineer, Ford Motor Company, MI

Organization: This project relies on the extensive range in expertise across the team.

Dr. Arvind Singh (Assistant Professor, Dept. of Civil Environmental and Construction Engineering, University of Central Florida). Dr. Singh is uniquely qualified for this project because he has extensive knowledge of the higher order statistical analysis tools which we will employ and has applied this to the fields of hydrology, turbulence and geomorphology. He received his PhD degree in Civil Engineering from University of Minnesota in December 2011. His doctoral thesis focused on the predictive modeling of the coupled hydrologic-sediment transport system with emphasis on environmental applications. His current research, in addition to advancing research on sediment-fluid interaction, focuses on the effect of changing hydrologic regimes on landscapes and material transport.

The USGS team, led by Joel Groten, has experience collecting high quality monitoring data and has protocols in place to assure productive sensor deployment and high quality data. In addition, they own and have actively collected data with the same nitrate sensor we are proposing to purchase. By opting to locate sensors at existing monitoring locations, we leverage the existing sensor infrastructure and maintenance by USGS personnel at minimal additional costs.

Kent Johnson at the Metropolitan Council will collaborate on this project. MetCouncil owns and operates a high frequency nitrate sensor at Fort Snelling. Kent's team will collaborate on load calculations and share data. **Lee Ganske at MPCA** has completed load calculations at two of our proposed sites; Minnesota River at Judson and Le Sueur River at Rapidan. He will collaborate on load analysis and comparison across sensors vs. grab samples. **Dr. Jacques Finlay**, a professor at University of Minnesota in the Ecology, Evolution and Behavior Department, is an expert in aquatic biogeochemistry and will assist the team with ecological interpretation of the analysis as well as provide laboratory chemical analysis.