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

Project Title: **ENRTF ID: 115-BH**

Map and Monitor Turbidity in Minnesota Water Bodies

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

Sub-Category: B. Water Resources

Total Project Budget: $ 197,012

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

Summary:

We will use laboratory experiments and simulations to investigate how water movements spread turbidity to help control and reduce the turbidity pollution in 371 impaired water bodies in Minnesota.

Name: Lian Shen

Sponsoring Organization: U of MN

Title: Director and Professor

Department: St. Anthony Falls Laboratory

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Top: examples of water bodies impaired by turbidity. Middle: illustration of the turbidity pollution spread by water movement. Bottom: description of proposed model to predict the turbidity spreading.

_____ 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: Map and Monitor Turbidity in Minnesota Water Bodies

I. PROJECT STATEMENT

Turbidity is the phenomenon when small particles from soil and organism breakdown make water appear cloudy and murky. In Minnesota, **371 water bodies (rivers and lakes)** are listed as **impaired waters by turbidity** as of 2018. Turbidity can significantly change the aquatic environment because the particles block sunlight from entering the water. Turbid water causes damage to the aesthetic value of the environment, provides shelter to bad bacteria, increases pollutants such as phosphates, and contaminates drinking water. High turbidity may also directly kill aquatic animals and harm their reproduction. **In the proposed research, we will combine field observation, laboratory experiment, and computer simulation to build a model to map and predict the spreading of turbidity**.

In lakes and rivers, the water movements play a key role in the spreading of pollutants (e.g. nitrates, phosphates, and chlorides) that are associated with turbid water. However, the water movement effect on turbidity is often excluded in the present water quality monitoring system of government agencies. For instance, the wave movement cannot be solved by the Hydrological Simulation Program-FORTRAN (HSPF) model used by the Minnesota Pollution Control Agency (MPCA). While MPCA has developed projects to monitor the turbidity impairment, it remains unknown how the water movements spread turbidity and degrade the water quality. **The evaluation of the water movement effect on turbidity is therefore critical to the monitoring and control of turbid water** to reduce the damage caused by turbidity to the environment.

The main objectives of this project include:

- **Assess the water movement effect on the turbidity level in different types of water bodies.** Our result will have the potential to help the monitoring of turbidity.
- **Investigate the movement of turbid water generated in extreme weathers and the mixing between turbid water and clear water.** This will provide valuable information for developing strategies and risk management during natural hazards that generate turbid water.
- **Develop an accurate model on water turbidity for public use.** The new model can serve as an important supplement to the HSPF model.

We plan to provide the outcomes of this project to the state agencies, research institutes, and the public in the form of a free database and software. The proposed research addresses the critically needed research on the turbidity pollution to surface water in Minnesota's impaired water bodies. This project will be beneficial for the monitoring of the movements of contaminants caused by turbidity, and therefore has a broader impact of protecting the surface and ground water and public health.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Field measurement of representative water bodies impaired by turbidity

We will conduct field observation of representative water bodies, including the Nemadji River, Root River, Hawk Creek-Beaver Creek, Red River Basin, Little Fork River, and Credit River. Each candidate in this plan belongs to a major water basin in Minnesota, and is currently impaired by turbidity pollution. By assessing the data collected from the field, we will categorize these water bodies into different types according to their turbidity level and water movement.

ENRTF BUDGET: $49, 698

Outcome	Completion Date
1. Compile datasets of the hydrological properties (e.g. depths, flow rate) of the impaired waters.	*March 1, 2020*

2. Conduct field observation of representative water bodies impaired by turbidity.	*September 1, 2020*

Activity 2: Conduct laboratory experiments to investigate the spreading of turbid water.
We will conduct laboratory experiments that match the hydrological properties of the water bodies in Activity 1. In each experiment, we will release dye along with illumination particles, i.e., man-made turbidity from the surface and bottom in the water tank. The particle velocity and locations will be measured to track the turbidity trajectory. A system will be developed to describe the turbidity, such as its volume and spreading velocity. These quantities will be compiled as a function of the hydrological properties of the water for ease of use.
ENRTF BUDGET: $78, 447

Outcome	Completion Date
1. Conduct experiments on tracking turbid water, and analyze the data.	*May 1, 2021*
2. Conduct experiments on the turbid water and clear water mixing, and analyze the data.	*October 1, 2021*
3. Compile the data into a database, and develop an online interface for data access.	*January 1, 2022*

Activity 3: Conduct simulations and develop a model for the water movement effect on turbidity.
We will develop a computer software system based on the observation of representative water bodies (Activity 1). The data obtained from computer simulation will be used for cross-validation with the lab experimental data (Activity 2). By synthesizing the simulation and measurement data, we will establish a model that is accessible to the public for evaluating the water movement effect on turbidity. This model will serve as a tool for the real-time mapping and monitoring of the turbidity in water bodies. We will distribute the software for practical use, and will provide the media resources (e.g. videos and recordings) generated during the process of this project for training and educational purposes.
ENRTF BUDGET: $68, 867

Outcome	Completion Date
1. Conduct simulations of the representative water bodies impaired by turbidity.	*December 1, 2021*
2. Analyze data, develop an operational model, and validate the model.	*March 31, 2022*
3. Publish the data online, develop a user-friendly software interface, edit user tutorials, and distribute media resources.	*June 30, 2022*

III. PROJECT PARTNERS:

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:

The primary outcomes of this project, i.e. the experimental data measured in the field and laboratory, database built from the computer simulations, the operational model, and the computer software to predict and map the turbidity, will be disseminated to the state agencies, research institutes, and the public to use. The data will be published online. The videos and recordings of the experiments and simulations will also be published online for educational outreach. Because all these outcomes will be available on the internet, no extra ENRTF funding will be needed for the dissemination of the project outcomes, and the project can directly benefit the control of the statewide turbidity pollution.

V. TIME LINE REQUIREMENTS:

This project is planned for 3 years beginning on July 1, 2019 and ending on June 30, 2022. The initial field observation will be completed in the first year to cover different seasons to monitor turbidity features under different hydrological conditions. The lab experiment procedure requires one year for the system calibration, device setup, measurement, and repetition. The development of the computer software, the simulations, model development, and the data distribution will take one year to finish.

2019 Proposal Budget Spreadsheet

Project Title: Map and monitor turbility in Minnesota water bodies

IV. TOTAL ENRTF REQUEST BUDGET: 3 years

BUDGET ITEM	AMOUNT
Personnel:	$ 180,512
Prof. Lian Shen, project manager (75% salary, 25% benefit); 4.2% FTE (i.e., 0.5 month of summer salary) for each of 3 years. ($32,464)	
Postdoctoral Associate, experiment and modeling research (82% salary, 18% benefit); 58% FTE for each of 3 years. ($111,630)	
IT Research Staff, data analysis and model development (75% salary, 25% benefit); 10% FTE for each of 3 years. ($26,818)	
Undergraduate Assistant, measurement and data analysis (100% salary); 2 months for each of 3 years. ($9,600)	
Professional/Technical/Service Contracts: N/A	$ -
Equipment/Tools/Supplies: Silicon oil for water tank experiment $4,269; side view high-speed camera $2,700; top view high-speed camera $2,700; laser $4,800; tracer particles $531.	$ 15,000
Acquisition (Fee Title or Permanent Easements): N/A	$ -
Travel: Tranportation within Minnesota state for data collection and research meetings with other researchers in the state. Estimation of cost for 3 years: Mileage $0.545/mile x 1000 miles =$545; Incidental expense during travel $200; Lodging $755.	$ 1,500
Additional Budget Items: N/A	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 197,012

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

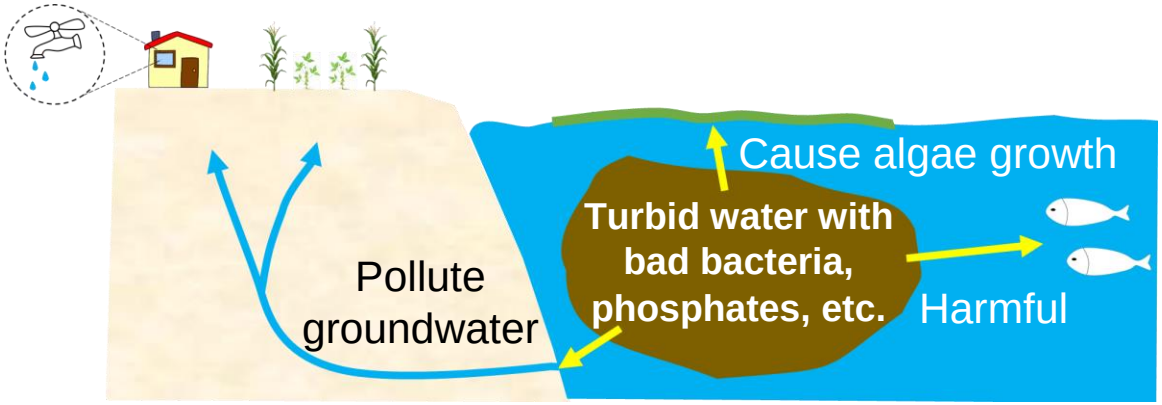
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	$ -	N/A
Other State $ To Be Applied To Project During Project Period: N/A	$ -	N/A
In-kind Services To Be Applied To Project During Project Period: The University of Minnesota does not charge the State of Minnesota its typical overhead rate of 54% of the total modified direct costs (graduate tuition and equipment are excluded).	$ 106,386	Secured
Past and Current ENRTF Appropriation:	$ -	N/A
Other Funding History: N/A	$ -	N/A

371 water bodies in Minnesota are impaired by turbidity.

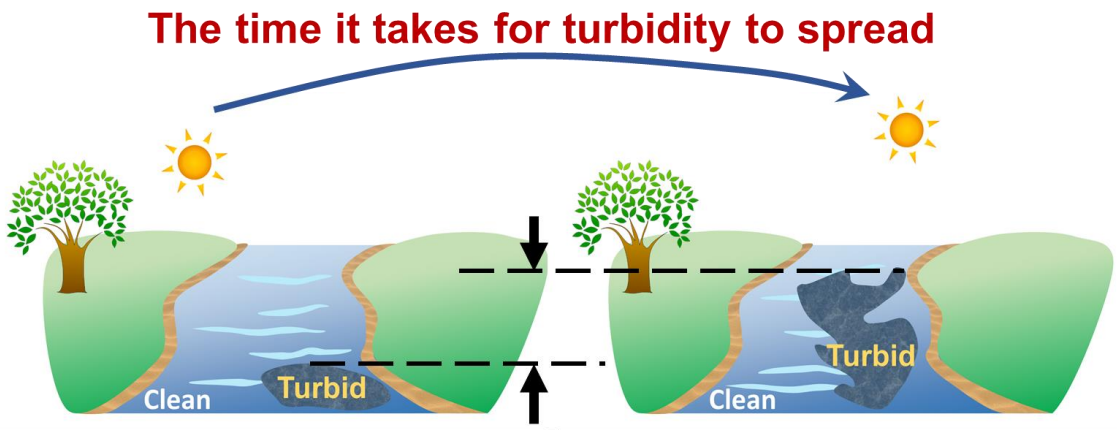
Turbidity caused by algae in Lake Crystal in southern Minnesota (Credit: MPCA)

Confluence of the clean Mississippi River and the turbid Minnesota River (Credit: MPCA)

Water movement spreads turbidity pollution.



We will build a model to predict the spreading of turbidity.



Project Manager Qualifications & Organization Description

PROJECT MANAGER QUALIFICATIONS

Lian Shen

Director of the St. Anthony Falls Laboratory and Professor in the Department of Mechanical Engineering, University of Minnesota, Twin Cities

Dr. Shen earned his Doctor of Science degree from Massachusetts Institute of Technology (MIT) in 2001. After three years of postdoctoral training at MIT, he joined the faculty of Johns Hopkins University (JHU) in 2004. At JHU, he performed extensive research on environmental water and air flows. In 2012, he was recruited by University of Minnesota to join its faculty.

Dr. Shen is a world expert on the study of environmental fluid flows. He is currently serving on the national committee of ASCE Environmental & Water Resources Institute on CFD Applications in Water and Wastewater Treatment. He is also on the editorial boards of the International Journal of Computational Methods and the Ocean Systems Engineering journal. Prof. Shen has also been active in professional societies, including American Geophysical Union, American Society of Civil Engineers, American Society of Mechanical Engineers, and Association of Environmental Engineering and Science Professors. He has organized many national and international conferences and symposiums.

ORGANIZATION DESCRIPTION

This project will be performed at the St. Anthony Falls Laboratory (SAFL, http://www.safl.umn.edu) at University of Minnesota. SAFL is a world-renowned research laboratory specialized in environmental and engineering fluid mechanics. SAFL researchers have been performing many innovative environmental studies for the state of Minnesota. Some of the projects were/are funded by the Minnesota Environment and Natural Resources Trust Fund.