Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID: 192-F**

Floating Mini-Gardens for Shoreline Protection and Wetland Restoration

Category: F. Methods to Protect or Restore Land, Water, and Habitat

Total Project Budget: $ 310,753

Proposed Project Time Period for the Funding Requested: 3 years, July 2018 to June 2021

Summary:

Floating mini-gardens are proposed to decrease waves crashing onto shoreline to reduce erosion, to provide habitats, and to facilitate soil accumulation to help vegetation growth for wetland restoration.

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

(1) Motivation: Existing approach for wetland restoration by planting vegetation is costly; we will develop an innovative technology using floating mini-gardens that is effective and has multiple environmental benefits. (2) Advanced research methods: lab experiment, field measurement, and computer simulation. (3) Expected outcomes: optimal design of floating mini-gardens, measurement data, and modeling tool, which will be provided to MN DNR, MPCA, MBWR, and the public.

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

PROJECT TITLE: Floating Mini-gardens for Shoreline Protection and Wetland Restoration

I. PROJECT STATEMENT

This project aims at developing an innovative technology of deploying floating mini-gardens near shore to reduce the crashing of water waves on the shoreline and thus to prevent bank erosion. The mini-gardens have the size of three to five feet, made by wooden rafts filled with soils, floating at water surface, and anchored to the lake bottom to prevent them from drifting away. The soils inside the wooden rafts are seeded with native plants, and the mini-gardens are environmentally friendly. Recent studies on the floating mini-gardens have shown that they can bring multiple environmental benefits, including:

(1) Effectively reducing the wave energy impacting on the soils of the lake bank to stabilize the shoreline.
(2) Divert the water flow so that sediments and soils can accumulate between the floating mini-gardens and shore, which will help the growth of aquatic vegetation for the restoration of wetlands.
(3) Provide habitats for wildlife, such as insects and waterfowl.

While the idea of floating mini-gardens has shown great promise in shoreline protection and wetland restoration (e.g., a recent study at University of Wisconsin showed that sediments and soils can accumulate at the lake bottom between the floating mini-gardens and shoreline rapidly by nearly a foot after three weeks of mini-garden deployment, and the wave energy is greatly reduced) and has received considerable attention in the scientific community and news media, the technology is still at its early stage of development. There exist several engineering and scientific barriers restraining this technology from being widely employed, including:

(a) Lack of guidance for the design of the floating mini-gardens to improve environmental benefits with reduced cost for their production and deployment.
(b) Knowledge gap between the engineering design of mini-gardens and their resilience in high winds, which is critical to their survival in severe weather.
(c) Insufficiency in the scientific data of the performance of floating mini-gardens and their environmental benefits.

This project aims to address the above issues, using the advanced experimental and computational research facilities at the St. Anthony Falls Laboratory (SAFL), to enable this innovative technology to be widely used.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Obtain optimal design for floating mini-gardens to maximize environmental benefits in a cost effective way **Budget:** $139,839

The object of this activity is to obtain optimal design of floating mini-gardens regarding their geometry, size, and deployment location and spacing, for the purpose of efficiently reducing the waves crashing onto the shore and best benefiting the accumulation of sediments to help the growth of aquatic vegetation. Advanced research tools will be employed, including: laboratory experiment in the SAFL water channel for precise measurement, test using scale-down models in the SAFL Outdoor StreamLab for investigation in natural environment, and computer simulation for the motions of floating mini-gardens and ambient wind and lake water flows.

Outcome	Completion Date
1. Use computer simulations to design floating mini-gardens	March 31, 2019
2. Build models in SAFL water channel and Outdoor StreamLab, and test the models	June 30, 2019
3. Use iterations between simulations and model testing to obtain optimal design	Dec. 31, 2019

Activity 2: Quantify benefits of floating mini-gardens on the environment **Budget:** $124,301

We will perform experiments in the SAFL water channel and the Outdoor StreamLab to collect data on the interactions among floating mini-gardens, wind, water flows, vegetation, and sediments and soils, based on which we will develop an advanced computational tool for their modeling. The floating mini-gardens will also be demonstrated through deployment in lakes followed by data collection in the field.

Outcome	Completion Date
1. Acquire and analyze lab measurement data on flow diversion and sediment accumulation	June 30, 2020
2. Deploy floating mini-gardens in lakes and collect field data	Sept. 30, 2020
3. Develop a predictive model for the performance of floating mini-gardens under various weather conditions to provide practice guidance	June 30, 2021

Activity 3: Dissimilate knowledge of mini-garden design and deployment to state agencies and the public **Budget:** $46,613

The optimal design of floating mini-gardens and our measurement data will be provided to state agencies, including MPCA, BWSR, and DNR. They will also be shared with water quality managers, lake management associates, land owners, and the public via a publicly accessible website that will be set up at SAFL. We will produce online tutorials and offer virtual workshops to dissimilate the knowledge of floating mini-gardens. The laboratory experiments and field demonstration will also provide excellent materials for education, for which we will work with high school students and teachers, including Native American students through the gidakiimanaaniwigamig (which stands for "our Earth lodge" in Anishinaabe, the language of the Ojibwe people) youth science immersion program. Moreover, citizen scientists will be enlisted for data collection and analysis.

Outcome	Completion Date
1. Create a user-friendly, publicly accessible web portal to share optimal design and data	June 30, 2019
2. Produce online tutorials and user-friendly instruction materials, and offer five workshops	Dec. 31, 2019
3. Give eight on-site demonstrations to citizen scientists, students, teachers, and the public	June 30, 2020

III. PROJECT STRATEGY

A. Project Team/Partners

This work will be carried out by Prof. Lian Shen as the project manager, with the assistance of a postdoctoral associate, a research associate (partial efforts with 20% FTE), and an undergraduate student assistant (3 months per year) for the design of floating mini-gardens, laboratory and field measurements, and environment benefits assessment. The project will be performed in close collaboration with state agencies and researchers in Minnesota. We will also collaborate with Prof. Chin Wu at University of Wisconsin, Madison, who is supported by Wisconsin side of funding agency and will not be part of the budget in this proposed project.

B. Project Impact and Long-Term Strategy

Minnesota has 11,842 lakes more than 10 acres in size, with more than 90,000 miles of shoreline. It has 10.6 million acres of wetlands, an essential part of the state's natural ecosystem and water resources. In 1991, Minnesota passed the Wetlands Conservation Act, which says that there should be no loss in the quantity, quality, and biological diversity of the existing wetlands. This project aims at assisting the state's conservation programs of shoreline stabilization, wetland restoration, and habitat protection. The impact of this project will be significant. It will overcome the technical barriers to the wide use of floating mini-gardens, and thus substantially improve the technology for shoreline protection and wetland restoration.

The long term strategy of the project is to ensure that the optimal design of the floating mini-gardens and the measurement data will be provided to state agencies including MPCA, BWSR, and DNR. The results will also be shared with water quality and lake/wetland managers, land owners, and concerned citizens. Substantial efforts will be made on education and outreach to students and teachers, including Native American students, as well as the public. We expect that the design, data, and models resulting from the project will greatly benefit the state's wetland restoration and habitat protection programs for long term, by providing an innovative and cost-effective technology for shoreline protection and wetland restoration with multiple environmental benefits.

C. Timeline Requirements

This project will be conducted over a 3-year period from July 1, 2018 to June 30, 2021.

2018 Detailed Project Budget

Project Title: Floating Mini-gardens for Shoreline Protection and Wetland Restoration

IV. TOTAL ENRTF REQUEST BUDGET: 3 years

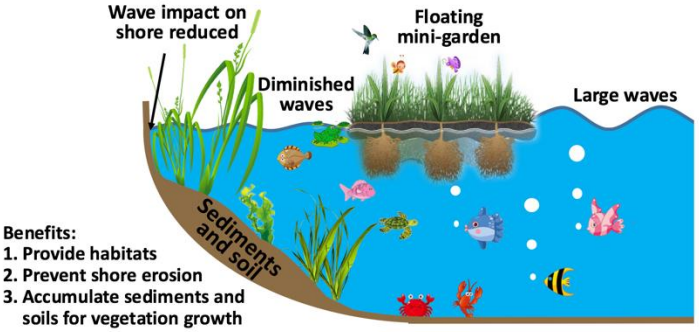
BUDGET ITEM	AMOUNT
Personnel:	$ 281,253
Prof. Lian Shen, project manager (75% salary, 25% benefit); 6.25% FTE (i.e., 0.75 months of salary) for each of 3 years. ($38,595)	
Postdoctoral Associate, experiment and modeling research (82% salary, 18% benefit); 100% FTE for each of 3 years. ($187,617)	
Research Staff, data analysis and model development (75% salary, 25% benefit); 20% FTE for each of 3 years. ($40,641)	
Undergraduate Assistant, measurement and data analysis (100% salary); 3 months for each of 3 years. ($14,400)	
Professional/Technical/Service Contracts: N/A	$ -
Equipment/Tools/Supplies: Cost of setting up floating mini-garden models to test in the lab and to deploy in the field ($9,000), setup of water wave model in the lab water channel ($7,000), and the purchasing of velocimetry ($7,000) and wave sensors ($5,000) for the water flow measurement in this project.	$ 28,000
Acquisition (Fee Title or Permanent Easements): N/A	$ -
Travel: Tranportation within Minnesota state for field data collection and research meetings with other researchers in the state. Estimation of cost for 3 years: Mileage $0.535/mile x 1000 miles =$535; Incidental expense during travel $200; Lodging $765.	$ 1,500
Additional Budget Items: N/A	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$ 310,753**

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: This project will be performed in collaboration with Professor Chin Wu at University of Wisconsin, Madison, who is supported by Wisconsin side of funding agency and will not be part of the budget of our project. Prof. Wu's research is funded by Wisconsin Department of Natural Resources and Dane County Land and Water Resources Department.	$ 300,000	Secured
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).	$ 152,687	Secured
Funding History: N/A	$ -	N/A
Remaining $ From Current ENRTF Appropriation: N/A	$ -	N/A

Motivation:

Wetland restoration by planting vegetation is inefficient and costly, especially with severe weather. The deployment of floating mini-gardens near shore is a novel idea with multiple benefits.



How?

Main Channel at St. Anthony Falls Lab

Supercomputers

Laboratory Experiment

Field Measurement

Computer Simulation

Test in lakes

Outcomes

We can develop more effective tools for shoreline protection and wetland restoration

Optimal design and measurement data

Minnesota Pollution Control Agency

Minnesota Department of Natural Resources

Minnesota Board of Water & Soil Resources

Accurate and user-friendly design and model tools

Publically-accessible data online

Guidance for shoreline stabilization and wetland restoration

PROJECT MANAGER QUALIFICATIONS

This project will be led by Professor Lian Shen as program manager. Prof. Shen is on the faculty of the St. Anthony Falls Laboratory and the Department of Mechanical Engineering at University of Minnesota, Twin Cities. He 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.

Prof. 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 an interdisciplinary fluid mechanics research and educational institution. It has 20 faculty members, 37 research and administrative staff members, and about 50 graduate students. Prof. Shen is the lab's Associate Director for Research overseeing its research and academic activities. 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.

The proposed research leverages on the unique and advanced capability of measuring environmental flows at SAFL, which has 16,000 ft^2 of research space dedicated to physical modeling and experimentation. The facility, which has recently been upgraded with a $16M renovation, has 15 general purpose flumes, tanks, and channels readily configurable to the needs of projects. The primary water source is the Mississippi River. SAFL's maximum flow capacity is 300 ft^3/s (8.5 m^3/s), which can be sustained indefinitely, allowing long-duration experiments. This project will utilize the main channel, SAFL's largest research channel, which is a straight, concrete channel capable of 300 ft^3/s (8.5 m^3/s) flow rates of river water. The channel is equipped with a wave generator, sediment flux monitoring and recirculation system, and a data acquisition carriage. The channel can be run in flow-through mode or as a ponded system.

The proposed project will also use the Outdoor StreamLab (OSL), which is a premier research facility developed at SAFL. The OSL is an experimental stream channel system designed to host experiments on the interactions between physical, chemical, and biological processes with water diverted from the Mississippi River. The OSL is equipped to: a) quantify environmental fluid flow processes from microscopic to reach scales with high-resolution laboratory-quality measurements; b) conduct hydrological and ecological field-scale experiments under controlled conditions; and c) impose and repeat steady and unsteady inlet hydrographs, including floods. Located across the Mississippi River from downtown Minneapolis, OSL is frequently visited by the public. The proposed project will provide an excellent opportunity for public education and outreach.