Environment and Natural Resources Trust Fund

M.L. 2025 Approved Work Plan

General Information

ID Number: 2025-181

Staff Lead: Noah Fribley

Date this document submitted to LCCMR: June 11, 2025

Project Title: Highly Efficient Nutrient Removal Technology for Agricultural Drainage

Project Budget: $453,000

Project Manager Information

Name: Satoshi Ishii

Organization: U of MN - College of Biological Sciences

Office Telephone: (612) 624-7902

Email: ishi0040@umn.edu

Web Address: https://cbs.umn.edu/

Project Reporting

Date Work Plan Approved by LCCMR: June 24, 2025

Reporting Schedule: March 1 / September 1 of each year.

Project Completion: June 30, 2028

Final Report Due Date: August 14, 2028

Legal Information

Legal Citation: M.L. 2025, First Special Session, Chp. 1, Art. 2, Sec. 2, Subd. 04o

Appropriation Language: $453,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to conduct lab- and field-scale tests of a novel bioreactor technology for removing nutrients from agricultural drainage and disseminate results to farmers and the public.

Appropriation End Date: June 30, 2028

Narrative

Project Summary: This project will apply our novel highly efficient nutrient removal technology for the treatment of agricultural drainage in the field.

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Nutrient pollution can cause eutrophication in rivers, lakes, and oceans. Nitrate/nitrite contamination in groundwater wells can also cause human diseases such as blue baby syndrome, and is, therefore, a serious public health concern as well. Agricultural drainage is one of the major non-point sources of nutrients to the environment. Efforts have been made to reduce nutrient production from agricultural drainage; however, the nutrient removal efficiency of the existing technologies such as woodchip bioreactors and constructed wetlands is not satisfactory, especially in early spring when water temperature is low and large quantities of water and nitrate are discharged into waterways. The emission of nitrous oxide (N2O), a potent greenhouse gas, from woodchip bioreactors and wetlands is also of concern.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

The overall goal of this project is to improve water quality and mitigate global warming by removing nutrients, especially nitrate, from agricultural drainage with minimal emission of N2O. We will achieve this goal by applying our novel bioreactor technology, which uses corn cobs (a sustainable bioreactor medium), microbial immobilization technology, lignin-degrading microbes, and cold-adapted, nitrate and N2O-removing bacteria, to treat drainage in agricultural ditches.

The specific objectives of this research are to (1) test laboratory-scale bacteria-coated corncob bioreactor with actual agricultural drainage, (2) install and operate field-scale bacteria-coated corncob bioreactors in agricultural drainage ditches, and (3) disseminate the results to farmers and the public.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

The specific outcome of this project is the novel highly efficient bioreactors installed in ditches for the treatment of agricultural drainage. These bioreactors can be used to remove nitrate and other nutrients with minimal emission of N2O, thereby contributing to improving Minnesota's water quality and easing global warming. The same technology can be also applicable for the treatment of other non-point sources such as urban stormwater and septic leakages.

Project Location

What is the best scale for describing where your work will take place?

Region(s): SW

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Activities and Milestones

Activity 1: Test laboratory-scale bacteria-coated corncob bioreactor with actual agricultural drainage

Activity Budget: $139,000

Activity Description:
The objective of this activity is to analyze the nitrate removal efficiency of laboratory-scale bacteria-coated corncob bioreactors fed with actual agricultural drainage.

Task 1: We will design and operate laboratory-scale column reactors filled with bacteria-immobilized corn cobs. These bacteria were previously isolated from soil by the research team and characterized as being able to reduce nitrate and N2O to harmless N2 gas under cold conditions. We will also immobilize lignin-degrading microbes on the surface of corn cobs to provide more readily available carbon to the nitrate/N2O-removing bacteria. The reactors will be fed with agricultural drainage collected from the Southwest Research and Outreach Center (SWROC) and operated under field-simulated conditions. The nitrate and N2O concentrations of the effluent from the reactors will be measured over time. Based on these measurements, we will calculate nitrate removal and N2O emission rates.
Deliverable 1: The laboratory-scale nitrate-removing corncob bioreactors and their nitrate removal and N2O emission rates.

Task 2: We will operate the laboratory-scale bioreactors for >2 months to examine the longer-term stability of the reactors. Corn cob samples will be periodically collected to analyze the amount of bacteria remaining on the corn cobs.
Deliverable 2: The long-term bioreactor operation data

Activity Milestones:

Description	Approximate Completion Date
Demonstrate high nutrient removal efficiency of the laboratory-scale nitrate-removing corncob bioreactors	December 31, 2025
Long-term (>2 months) stable operation of the bioreactors	June 30, 2026

Activity 2: Install and operate field-scale bacteria-coated corncob bioreactors in agricultural drainage ditches

Activity Budget: $230,000

Activity Description:
This activity aims to examine the performance of our bacteria-coated corncob bioreactors in the field.

Task 1: We will install bacteria-coated corncob bioreactors (n=6) in the agricultural ditches at the SWROC. The bioreactor influent and effluent samples will be collected over time for the analysis of nitrate. Various environmental parameters such as temperature, pH, redox potential, flow rate, chemical oxygen demand, etc., will be also measured. Corn cob samples will be periodically collected to analyze the amount of bacteria remaining on the corn cobs. The field testing will be done in spring and fall (2 months each) over two years (2026 and 2027).
Deliverable 1: Nitrate removal data of the bioreactors installed in the field

Task 2: We will statistically analyze the data collected in the field to identify the factors influencing nitrate removal. We will also try to construct a model to predict nitrate removal based on environmental parameters. This information is important and useful for designing and implementing field-scale bioreactors in other locations.
Deliverable 2: Summary of statistics

Activity Milestones:

Description	Approximate Completion Date
Demonstrate high nutrient removal of the field-scale corncob bioreactors	December 31, 2027
Identify the factors influencing nutrient removal efficiency of the field-scale bioreactors	June 30, 2028

Activity 3: Disseminate the results to farmers and the public

Activity Budget: $84,000

Activity Description:
This activity aims to disseminate the results to farmers and the public.

Task 1: We will reach out to farmers to disseminate our bioreactor technology and receive their feedback through U of M's extension activities, such as webinars, blog posts, and field days. We will also conduct outreach activities to introduce our bioreactor technology to the public, including K-12 students, at various venues such as the Minnesota State Fair.
Deliverable 1: Webinars, blog posts, field days, and other outreach events

Task 2: We will present our results at the Minnesota Water Resources Conference. We will also produce scientific manuscripts in open-access journals.
Deliverable 2: Presentations and publications

Activity Milestones:

Description	Approximate Completion Date
Conduct outreach activities	June 30, 2028
Publications and presentations	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Paige Novak	University of Minnesota	Co-Investigator	Yes
Jeffery Strock	University of Minnesota	Co-Investigator	Yes
Nigel Pickering	Geosyntec Consultants	Co-Investigator	Yes
Laura Christianson	University of Illinois	Collaborator	No

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
We will reach out to farmers to disseminate our bioreactor technology and receive their feedback through U of M's extension activities, such as webinars, blog posts, and field days. We will also conduct outreach activities to introduce our bioreactor technology to the public, including K-12 students, at various venues such as the Minnesota State Fair.

In addition, we will present our results at the Minnesota Water Resources Conference and produce scientific manuscripts in open-access journals. Environment and Natural Resources Trust Fund will be acknowledged in the publications, presentations, and other media per the ENTRF Acknowledgment Guidelines. The ENTRF logos and signage will appear on the bioreactors in the lab and field settings.

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?
This project includes a field demonstration of our technology. We will invite farmers, industries, agencies, and other interested parties to the field sites to show our technology. The results will be disseminated to the public through open-access publications and conference presentations. If additional work is needed, funding from federal sources will be sought.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Satoshi Ishii		Lead and manage the project			27%	0.24		$52,803
Paige Novak		Advise/supervise researchers			27%	0.12		$43,475
Jeffery Strock		Manage fieldwork			27%	0.09		$15,130
1 Postdoctoral research associate		Perform experiments and data analysis			21%	3		$225,163
2 Field crews		Collect water samples from the field			7%	0.45		$33,629
2 Undergraduate researchers		Collect water samples and analyze data			0%	0.66		$21,800
							Sub Total	**$392,000**
Contracts and Services								
Nigel Pickering (Geosyntec Consultants)	Service Contract	Technical advice on bioreactor design and operation				0.03		$10,000
University of Minnesota Genomics Center (UMGC)	Internal services or fees (uncommon)	UMGC will provide the DNA sequencing service for the analysis of microbial communities on the corn cob samples				0		$3,000
University of Minnesota Biotechnology Resource Center (BRC)	Internal services or fees (uncommon)	BRC will produce large volumes of bacterial cells to coat corn cobs.				-		$8,000
							Sub Total	**$21,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Materials for reactor construction	Pumps, reactors, and corn cobs necessary to constuct laboratory and field-scale bioreactors					$6,500

	Tools and Supplies	Chemicals for water quality analysis	Necessary to measure nitrate and N2O concentrations					$8,000
	Tools and Supplies	Chemicals and laboratory supplies for microbiological analysis	Necessary to grow bacteria and quantify their abundance (culture media, petri dishes, pipette tips, etc.)					$5,500
	Tools and Supplies	Field supplies and consumables	Various supplies and consumables are needed to collect and process samples (chemicals, glassware, plastic consumables, etc.)					$10,000
							Sub Total	**$30,000**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	A total of 17 trips (~5,100 miles) are planned (~300 miles/trip to visit SWROC from the University of Minnesota St. Paul campus at a rate of $0.67/mile.	Necessary to collect samples from the field site at SWROC					$3,400
	Conference Registration Miles/ Meals/ Lodging	Trips and registration fees to present our research results at a conference in MN ($300/person x 2 researchers)	To disseminate the results					$600
							Sub Total	**$4,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Open access publication fee	Necessary to make our results publicly available					$6,000
							Sub Total	**$6,000**

Other Expenses								
							Sub Total	**-**
							Grand Total	**$453,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	$ Amount
State				
In-Kind	University of Minnesota	The University of Minnesota is not allowed to charge the State of Minnesota its typical overhead rate of 55% of the total modified direct costs. We are listing our unrecoverable indirect cost as in-kind contribution.	Secured	$249,150
			State Sub Total	**$249,150**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$249,150**

Total Project Cost: $702,150

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: d4853bbe-8b5.pdf

Alternate Text for Visual Component

Special bacteria immobilized on the surface of corn cobs break down nitrate into harmless N2 gas under cold conditions....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Authorization letter from the U of M SPA	5d95635b-023.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

- Contact information for the organization's fiscal agent (U of M SPA) has been updated (Project Collaborators section).
- Our 2024 LCCMR project has been added to the Other ENRTF Appropriations Awarded section (General Information section).
- The budget has been revised to meet the approved amount (the FTE of the undergraduate researchers has decreased slightly).
- We have added a description in the Dissemination section.

The following changes were made on 2/4/2025, according to the revision requests from LCCMR
- General information page: "Does your project include original, hypothesis-driven research?" --> "No" was selected.
- Budget page: More detailed information for the expense for "Microbiological analysis" has been added.
- Budget page: The expenses for UMN Genomics Center and the UMN BioTechnology Resource Center have been moved from "others" to "services and subawards."
- Dissemination section: Statements on how the ENRTF will be properly attributed per the acknowledgement guidelines have been added.

The following changes were made on 6/11/2025, according to the revision requests from LCCMR
- The project manager's contact information on the Project Collaborators page (Tab 2) has been reviewed and confirmed correct. The title of the project manager has been updated from "Associate Professor" to "Professor".
- The affiliation of one of the project partners (Laura Christianson) has been updated (from the University of Minnesota to the University of Illinois). She won't receive funds, so this change does not influence the project budget.
- The appropriation language shown at the bottom of Tab 4 (Narrative) was reviewed and confirmed appropriate.
- The project completion date and the appropriation end date shown on Tab 4 (Narrative) have been confirmed correct.

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

N/A

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

Yes

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

Yes

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

No

Does your project include original, hypothesis-driven research?

No

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this project:

NA

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

Yes, I understand