



# Environment and Natural Resources Trust Fund

## 2024 Request for Proposal

### General Information

**Proposal ID:** 2024-285

**Proposal Title:** Nutrient Recovery and Recycling for Agricultural Lands

### Project Manager Information

**Name:** Matthew Leiphon

**Organization:** Agricultural Utilization Research Institute

**Office Telephone:** (218) 281-7600

**Email:** mleiphon@auri.org

### Project Basic Information

**Project Summary:** Identification, validation, and market assessment of technologies to recover and recycle nitrogen, phosphorus and other nutrients from process waste streams for use in agricultural land applications.

**Funds Requested:** \$700,000

**Proposed Project Completion:** June 30, 2027

**LCCMR Funding Category:** Methods to Protect, Restore, and Enhance Land, Water, and Habitat (F)

### Project Location

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

Statewide

**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

## Narrative

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

Manure was the primary source of nitrogen fertilizer until technological advances made synthetic fertilizers possible. While manure is still widely used, it can be seen as an environmental liability rather than a resource. A 2020 USDA study indicated that recycled nitrogen from manure could satisfy up to 30% of Minnesota's nitrogen needs, but most of the recyclable nitrogen was lost. Inefficient use of manure nitrogen can lead to dispersion in the environment leading to water and air pollution.

Anaerobic digestion provides an excellent platform for nitrogen recovery as the digestate provides a superior feedstock for nitrogen recovery processes as the digestion process converts organic nitrogen into inorganic nitrogen.

Additionally, phosphorus in animal feed is not fully metabolized by the animals. An effective approach to recover phosphorus is to remove it from feed at the facility where it is aggregated in a single large stream rather than at the farm level. The ethanol industry represents an immediate target as the phosphorus in corn ends up in the stillage. Stillage contains more than 1% phosphorus, meaning a single ethanol plant could recover hundreds of tons of phosphorus fertilizer annually.

Improving plant recycling in agriculture is an economic, environmental, and food safety imperative.

**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 opportunity exists to investigate agricultural aqueous waste streams rich in minerals and identify the integration of physical and chemical processes to effectively separate or concentrate critical plant nutrients with an emphasis on nitrogen and phosphorus. A critical goal of this activity is to identify opportunities for the economic valorization of these nutrient sources, thus making them real valuable generation opportunities for stakeholders in the agricultural supply chain. And therefore, achieving the intended environmental impacts driven by private markets vs government intervention. Project partners will focus on phosphorus and nitrogen recovery from coproducts produced at ethanol plants and digestate from anaerobic digestion of livestock manures and/or food processing waste.

The project team will then evaluate coproduct streams using new technologies capable of capturing phosphorus or concentrating nitrogen from these aqueous side streams to evaluate performance and efficiency. Part of the evaluation will include a techno-economic analysis of the opportunity focusing on expand the footprint of existing infrastructure such on-farm digesters, wastewater treatment systems, ethanol plants, and other agricultural commodities processing facilities. Business development staff will identify opportunities, bottlenecks and associated supply chain relationships and market development needs necessary to move recovered nutrients to in-field applications at-scale.

**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 recovery and reuse of nitrogen, phosphorus, and other nutrients from industrial and waste streams can provide both economic and environmental benefits. Economically, there is an opportunity to create a new value chain for rural stakeholders and reduce dependency on synthetic fertilizer and its associated market volatility and supply chain risks. Environmentally, the reduced dependency on synthetic fertilizer lowers the carbon intensity of the agricultural sector and the capture and reuse of otherwise dispersed nutrients lowers the risk of negative environmental impacts including eutrophication of water and excessive nitrous oxide release.

## Activities and Milestones

### Activity 1: Source and Analysis of Ethanol Aqueous Streams and Digestate from Anaerobic Digestion

**Activity Budget:** \$133,500

**Activity Description:**

This activity will focus on phosphorus recovery from aqueous streams in corn ethanol plants and phosphorus and nitrogen recovery in digestate streams.

Thin stillage is the most likely stream of interest in ethanol plants, we will inventory and characterize other streams for their nutrient content throughout the state. The work aims to identify phosphorus and characteristics in the wet mash, thin stillage, post-evaporation, and backset water. AURI will collaborate with ethanol companies to collect samples and define a recovery process for existing plants.

The project team will conduct sourcing and analysis on the liquid fraction of post-anaerobic digestion of livestock or food processing waste from industrial digesters and AURI's Pilot Digester.

Other streams to investigate include, soapstock, dissolved air flotation (DAF), plant food waste, and others. This activity will assess nutrient recovery opportunities and how streams could be integrated into strategies aimed at manures and other aqueous streams.

Sourcing and analysis will be carried out from other streams identified after discussions with agricultural stakeholders. The characterization aims to quantify the amount of nutrients, type (organic vs. inorganic) and physical nature (e.g. aqueous phase or b suspended solids). Such characterization is critical to inform the selection of promising recovery processes.

**Activity Milestones:**

Description	Approximate Completion Date
Analysis of phosphorus and nitrogen samples from ethanol plants	February 28, 2026
Create inventory of nutrient streams in Minnesota for most promising approaches to recovery	December 31, 2026
Explore opportunities for supply chain and market development for nutrient recovery streams and digestate	June 30, 2027

### Activity 2: Identification, Assessment and Demonstration of Nutrient Recovery Technologies

**Activity Budget:** \$182,250

**Activity Description:**

We will inventory existing nutrient recovery technologies that may be suitable for the streams of interest identified in Activity 1. The focus is on technology that is either commercial or close to commercialization, where partnerships with third parties can play a role in development and deployment. We will review the existing literature broadly. We may elect to research technology at an earlier stage of development if deemed exceptionally meritorious and with a high potential impact. This review will consider economics (cost of implementation, operation, and value of nutrient), compatibility of recovered nutrient with the existing fertilizer supply chain, commercial readiness, and complexity of performance at scale. A critical outcome of this activity is a gap analysis identifying critical obstacles and challenges in the widespread adoption of nutrient recovery and recycling processes. Another essential outcome is a realistic assessment of the reasonable amount of recoverable nutrients vs. the theoretical available under different conditions, such as the economic value of nutrients, policy incentives, and technology performance. Finally, as appropriate, the

project team will test the most promising approaches at the bench or pilot scale. The result of these tests will inform detailed techno-economic analysis on which to propose if appropriate next steps.

**Activity Milestones:**

Description	Approximate Completion Date
Identify technology providers for separation of mineral and/or concentration of nitrogen.	February 28, 2026
Provide samples to mineral and nitrogen providers for demonstration and validation of technology.	October 31, 2026
Analysis of separated fractions to determine separation efficiency.	February 28, 2027
Identify and engage supply chain stakeholders to identify adoption barriers and demonstrate and deploy technologies.	June 30, 2027

**Activity 3: Design and Proof of Concept of Phosphorus Recovery from Thin Stillage from Ethanol Plants**

**Activity Budget:** \$82,250

**Activity Description:**

Given the potential scale of phosphorus recovery from the ethanol plant, which may require the addition of a novel process line, we plan - if the results of Activity 2 warrant it - to carry out a pre-FEED engineering analysis of this process to provide a more accurate techno-economic assessment. This will include a detailed process model with mass and energy balance, process flow diagram, and preliminary unit operation identifications to provide a Class 5 or Class 4 capital and operating cost estimate. An important outcome of this activity is a better understanding of any issues arising from integrating this recovery process in existing ethanol plants both technically (space, energy demand, emissions, etc., impact DDGS product) and operationally (possible new revenue but also the possible changed value of DDGS, impact on ethanol carbon intensity both directly and indirectly).

**Activity Milestones:**

Description	Approximate Completion Date
Testing of chemistry at the bench scale	June 30, 2026
Identification of approaches to separate phosphorus from stillage and recover it as phosphorus rich material	December 31, 2026
Design of processes to implement the extraction and recovery inside an ethanol plant	December 31, 2026

**Activity 4: Techno-economic Analysis of Nutrient Recovery from Corn Stillage and Digestate to Producers, Ethanol, and the Biogas Industries**

**Activity Budget:** \$47,250

**Activity Description:**

Individual techno-economic and feasibility analyses of the process technologies identified in Activities 2 and 3 are summarized to determine the best opportunities, resource requirements, and possible deployment timeline, along with any critical gaps or obstacles - technical or otherwise - to deployment. The primary outcome of this activity is to provide an overview of a possible nutrient recovery industry, its feasibility, and the leading technical, economic, and policy enablers. This activity parallels Activity 5, where the opportunity to exploit existing infrastructure is explored in detail.

**Activity Milestones:**

Description	Approximate Completion Date
Capital and operating cost estimates for selected technologies	October 31, 2026
Identification of fertilizer value of recovered nutrients	December 31, 2026

Completed techno-economic analysis of selected technology	March 31, 2027
Environmental impact assessment of nutrient diversion	March 31, 2027
Assess market to identify potential supply chain partners and end-users	June 30, 2027

## Activity 5: Analysis of Opportunities to Integrate Existing Wastewater Treatment Infrastructure into a Statewide Nutrient Recovery and Recycling Strategy

**Activity Budget:** \$137,250

### Activity Description:

The State of Minnesota possesses a vast infrastructure of publicly and privately owned wastewater treatment plants. Nutrient management - if not recovery for recycling - is a critical part of the operations at these facilities. The main goal of this activity is to identify, assess, and pursue opportunities to integrate ag-focused nutrient recovery and recycling technologies that align with existing infrastructure. This will include a focus on nutrient streams where a stand-alone facility may not be appropriate. The goal of this activity is to identify the opportunity while also clearly quantifying any challenges and obstacles which may limit integration of technically feasible nutrient recovery and recycling technologies.

### Activity Milestones:

Description	Approximate Completion Date
Technical analysis of integration with wastewater treatment infrastructure	February 28, 2026
Environmental impact analysis	June 30, 2026
Market transformation plan to identify commercialization pathways with greatest likelihood of success	December 31, 2026

## Activity 6: Outreach, Engagement, and Dissemination

**Activity Budget:** \$117,500

### Activity Description:

AURI and project partners will build connections to the ethanol, livestock, ag commodity processing, biogas, and wastewater industries to highlight research results and support the commercialization of nutrient recovery technologies. AURI and partners will also host and attend events with various industry groups to share the findings and convene industry to propel further investment and adoption. Information and final reports will be made available to any stakeholder or interested party.

Dissemination and engagement efforts will also focus on hosting webinars or in-person meetings and development of informational materials highlighting the project goal and results. Such fact sheets will target specific audiences or stream types. Results will provide the techno-economic data for processors with nutrient-rich side streams to evaluate the opportunity to become also nutrient providers for crop production. The implementation of these efforts will improve nutrient management of aqueous coproducts while protecting the State water from excessive run-offs and adding value to existing operations. Additionally, we plan to engage with public and private stakeholders to discuss strategies to bridge gaps (technical, economic, policy, or regulatory) that may emerge and identify the critical enablers for establishing a nutrient recovery industry with a measurable impact on the State demand for synthetic fertilizers.

### Activity Milestones:

Description	Approximate Completion Date
Engage supply chain participants and stakeholders through facilitated events and targeted outreach	June 30, 2027
Disseminate and communicate research with stakeholders through AURI's Ag Innovation News, website, or podcasts	June 30, 2027

Disseminate findings at AURI hosted webinars and events such as the MN Renewable Energy Roundtable
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June 30, 2027
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## Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Erik Osmon	Bushmills Ethanol, Inc.	General Manager	No
Emma Larson	St. Cloud Public Utilities Department (Nutrient, Energy & Water Recovery Facility)	Assistant Public Utilities Director	Yes
Mike Reiber	Axiom	CEO	Yes

## 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?**

The main goals are:

- Quantify the opportunity.
- Provide an assessment of technology and market risks with practical de-risking strategies.
- Provide individual techno-economic assessments.
- Suggest a framework for implementation in Minnesota's ag sector.

AURI and its partners will continue supporting further work to develop the market. Commercial entities interested will use this work - and our support - to identify the specific project opportunity and needed investments.

We expect these to be mainly implementation projects, which may identify more fundamental or applied research opportunities. This would lead to further scientific investigation and open new opportunities for research partnerships.

## Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Reducing Plastic Pollution With Biodegradable Erosion Control Products	M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 08i	\$200,000

## Project Manager and Organization Qualifications

**Project Manager Name:** Matthew Leiphon

**Job Title:** Project Manager

**Provide description of the project manager's qualifications to manage the proposed project.**

Matthew Leiphon is a Project Manager for the Agricultural Utilization Research Institute (AURI) in Crookston, MN. He has been with AURI for three and a half years. During his time with AURI he has coordinated the organization's activities as a subaward recipient and partner in eight LCCMR-funded projects.

Before joining AURI, Matthew was a field representative with the Office of U.S. Senator Heidi Heitkamp in northeastern North Dakota. His areas of focus included agriculture, rural issues, economic development, small business,

infrastructure, housing, and military and veterans' affairs.

Prior to his time serving on Senator Heitkamp's staff, Matthew spent eight years as a research and development analyst for Praxis Strategy Group- an economic and strategy development firm based in North Dakota. During his time with Praxis, Matthew helped support, develop, and guide a wide variety of projects, working with stakeholders in the private, public, nonprofit, defense, research, and educational sectors.

Matthew graduated from the University of North Dakota in 2007 with a master's degree in public administration. In addition to his graduate degree, Matthew also completed a B.A. with majors in political science and history from the University of North Dakota.

**Organization:** Agricultural Utilization Research Institute

**Organization Description:**

The Agricultural Utilization Research Institute (AURI) helps foster long-term economic benefit for Minnesota through value-added agricultural products. It accomplishes this mission by helping develop new uses for agricultural products through science and technology, while collaborating with businesses and entrepreneurs to bring ideas to reality. AURI provides a broad range of services including hands-on scientific technical assistance and technology transfer, a network of resources, and the applied research necessary to generate ideas for new ag-based products and processes and to help move them to market. With labs specific to analytical chemistry, coproducts, food, meat, and microbiology, as well as staff experienced in science, technology and innovation processes, AURI is a one-of-a-kind resource that aids Minnesota businesses looking to create more value for the state's agricultural products.



## Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
<b>Personnel</b>								
AURI Senior Coproduct Scientist and Coproduct Lab Technician		Primary Operation of AURI Liquid/Solid Separator for digestate. Assist with sourcing samples for analysis and pilot scale trials. Aid with developing project summary report.			27.27%	0.36		\$41,250
AURI Chemist and Associate Scientist		Lead, organize and conduct all analytical analysis for project.			27.27%	0.45		\$51,810
AURI Business Development Directors		Lead business development, market assessment, networking, and project collaboration efforts with industry and other key stakeholders.			27.27%	0.72		\$82,500
AURI Communications Director		Aid in the development of reports and presentation materials for outreach and dissemination. Lead editor and packager of final report			27.27%	0.06		\$6,930
AURI Outreach and AURI Connects Team		Plan, organize and attend field days, events (virtual and in-person), and other outreach and dissemination activities to identify and engage key stakeholders and share information about the processes and prototype products developed during the project.			27.27%	0.51		\$59,070
AURI Project Management		Manage project activities, contracts, budgets, timelines, and ensure project follows grant rules and meets reporting requirements.			27.27%	0.3		\$33,000
AURI Principal Investigator		Principal Investigator- lead and coordinate project technical activities and coordinate with business development and outreach teams and project partners to complete project deliverables.			27.27%	0.63		\$71,940
							<b>Sub Total</b>	<b>\$346,500</b>
<b>Contracts and Services</b>								
TBD	Professional or Technical Service Contract	Conduct pilot scale trials utilizing corn ethanol stillage and anaerobic digestion digestate focused on nutrient removal. Specifically, phosphorus and nitrogen.				0.45		\$50,000

TBD	Professional or Technical Service Contract	Perform additional nutrient and other analysis as required to assess technologies, analyze chemicals, and provide needed data not available with AURI's in-house analytical tools.				0.36		\$40,000
St. Cloud Public Utilities Department (Nutrient, Energy & Water Recovery Facility)	Sub award	(Activity 5) Analyze and assess opportunities to integrate existing wastewater treatment infrastructure into a state-wide nutrient recovery and recycling strategy. Quantify and report on challenges and obstacles which may limit integration (if technically feasible) and identify solutions to enable adoption of new technologies.				0.69		\$90,000
Axiom	Professional or Technical Service Contract	(Activity 2) Identification, assessment and demonstration of nutrient recovery technologies. Inventory and assess existing nutrient recovery technologies that may be suitable for the streams of most interest. Identify, analyze, and report on critical obstacles and challenges in the widespread adoption of nutrient recovery and recycling processes.				0.87		\$100,000
							<b>Sub Total</b>	<b>\$280,000</b>
<b>Equipment, Tools, and Supplies</b>								
	Tools and Supplies	Consumable lab supplies and tools.	Analytical supplies for conducting nutrient analysis of replicated meal, stillage, and digestate samples. Four IBC totes will be purchased for transport and handling of corn stillage and digestate for liquid/solid separation and to provide product to contract service provider. Purchase of small, non-capital lab equipment to enable research (transfer pump for loading and unloading materials).					\$30,000
							<b>Sub Total</b>	<b>\$30,000</b>
<b>Capital Expenditures</b>								
							<b>Sub Total</b>	<b>-</b>

<b>Acquisitions and Stewardship</b>								
							<b>Sub Total</b>	-
<b>Travel In Minnesota</b>								
	Miles/ Meals/ Lodging	In-state travel associated with project activities	In-state travel by the AURI technical, business development, and outreach staff directly involved in project activities including mileage, lodging, and per diem as provided for by Minnesota Management and Budget under the current "Commissioner's Plan."					\$16,000
							<b>Sub Total</b>	<b>\$16,000</b>
<b>Travel Outside Minnesota</b>								
	Miles/ Meals/ Lodging	Travel (3-4 trips) by two AURI staff to pilot scale test sites to coordinate and conduct research with technology partners. Cost to include lodging, meals, incidentals, airfare and mileage.	Oversee technology processes, nutrient separation, and coordinate research with key partners.	X				\$20,000
							<b>Sub Total</b>	<b>\$20,000</b>
<b>Printing and Publication</b>								
							<b>Sub Total</b>	-
<b>Other Expenses</b>								
		Forum and Event Expenses	Field day and event related expenses for stakeholder engagement and dissemination of project findings.					\$7,500
							<b>Sub Total</b>	<b>\$7,500</b>
							<b>Grand Total</b>	<b>\$700,000</b>

## Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
<b>Travel Outside Minnesota</b>	Miles/Meals/Lodging	Travel (3-4 trips) by two AURI staff to pilot scale test sites to coordinate and conduct research with technology partners. Cost to include lodging, meals, incidentals, airfare and mileage.	Potential research partners and technologies of key value to the project may be located outside of Minnesota. This funding will be used to allow AURI staff to assess key technologies, access technical information, and coordinate research at facilities possessing capabilities not available in Minnesota in support of the project.

## Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
<b>State</b>				
			<b>State Sub Total</b>	-
<b>Non-State</b>				
			<b>Non State Sub Total</b>	-
			<b>Funds Total</b>	-

## Attachments

### Required Attachments

#### *Visual Component*

File: [4852b714-a36.pdf](#)

#### *Alternate Text for Visual Component*

Overview of the nutrient recovery cycle and AURI's proposed LCCMR project to recover and recycle nutrients for agricultural lands....

#### *Financial Capacity*

File: [07cd9a30-297.pdf](#)

#### *Board Resolution or Letter*

Title	File
Letter- AURI Executive Director	<a href="#">fe14ef01-43c.pdf</a>

### Optional Attachments

#### *Support Letter, Photos, Media, Other*

Title	File
Letter of Support- Bushmills Ethanol	<a href="#">aa535053-219.pdf</a>

## Administrative Use

**Does your project include restoration or acquisition of land rights?**

No

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

No

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

N/A

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

N/A

**Does your project include original, hypothesis-driven research?**

Yes

**Does the organization have a fiscal agent for this project?**

No

**Does your project include the design, construction, or renovation of a building, trail, campground, or other capital asset costing \$10,000 or more?**

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?**

No