Environment and Natural Resources Trust Fund

2025 Request for Proposal

General Information

Proposal ID: 2025-076

Proposal Title: Assessing Cyanobacteria Threats at Lake Superior Beaches

Project Manager Information

Name: Christopher Filstrup

Organization: U of MN - Duluth - NRRI

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Project Basic Information

Project Summary: Because cyanobacteria blooms are becoming more severe in Lake Superior and the St. Louis River Estuary, cyanobacteria toxin detection will be integrated into beach monitoring programs to keep beachgoers safe.

ENRTF Funds Requested: $197,000

Proposed Project Completion: June 30, 2028

LCCMR Funding Category: Small Projects (H)

Secondary Category: Water Resources (B)

Project Location

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

Region(s): NE

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.

Largely attributed to its large size and pristine waters, Lake Superior is a critical natural resource for Minnesota and an important driver of regional economies. While cyanobacteria harmful algal blooms (cHABs) are a new phenomenon in Lake Superior and the inflowing St. Louis River Estuary, cHABs have occurred regularly in both ecosystems since 2018 and are anticipated to increase in severity and duration under climate change. Despite toxic cyanobacteria blooms being reported in the estuary, no programs are routinely testing for cyanobacteria toxins at Lake Superior beaches, such as those along Park Point. Public beach advisory warnings are based on harmful E. coli levels, but the known public health threats associated with cyanobacteria toxins are not considered. Further, cutting-edge portable DNA / RNA sequencing technologies that can quantify cyanobacteria toxin genes before toxins are actively being produced (i.e., potentially toxic blooms) are still being developed, yet offer a promising approach for warning the public of impending hazardous conditions. We feel that we are at a critical juncture to establish procedures and recreational guidelines for cyanobacteria toxin monitoring at Lake Superior beaches before the problem gets worse.

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.

To protect the public and regional economies from cHABs, this proposal aims to develop cost-efficient strategies for integrating cyanobacteria toxin quantification into existing beach monitoring programs, and to work with local and state agencies to determine how to include cyanobacteria toxins to guide beach advisories. Water samples for cyanobacteria toxins and toxin-producing genes (DNA / RNA) will be collected twice a week from Labor Day through October for two years at five beaches on Park Point during routine beach monitoring by the Minnesota Department of Health. Park Point beaches are strongly influenced by St. Louis River Estuary inflow, and therefore are likely to experience toxic cHABs. Microcystin concentrations will be quantified using Enzyme-Linked Immunosorbent Assay (ELISA) kits. The presence and activity of microcystin-production genes will be quantified using a cutting-edge, portable sequencer for rapidly quantifying genes on-site in near real-time. While portable sequencing technologies require some refinement, the platform is inexpensive, portable, and does not require specialized equipment, making it suitable for use by natural resource managers and public agencies. While recreational guidelines for microcystin concentrations are established for Minnesota, the application of molecular data to inform public warnings and beach advisories needs to be refined with project partners.

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?

Although several programs are interested in monitoring cyanobacteria toxins at Lake Superior beaches, there is not currently a plan in place, despite predictions that these regularly occurring cHABs will become more severe under climate change. Our proposal takes a proactive approach to resolving these issues by using gold-standard and cutting-edge approaches to quantify toxic cHABs for two years, and subsequently using this information to develop beach advisory guidelines. Conversations with project partners will help determine best approaches for integrating cyanobacteria toxin analysis into long-term beach monitoring programs, as well as determining how these programs should be funded going forward.

Activities and Milestones

Activity 1: Quantify microcystin concentrations at Park Point beaches to inform beach advisories and keep people safe

Activity Budget: $71,393

Activity Description:
For two years, we will measure microcystin concentrations in water samples collected by the Minnesota Department of Health at five beaches on Park Point. Samples will coincide with collection of E. coli samples, which are collected twice per week from Memorial Day through Labor Day. We will extend sampling for cHABs through October (~200 samples per year) because cyanobacteria blooms frequently occur after Labor Day. Microcystin concentrations will be quantified using Abraxis Enzyme-Linked Immunosorbent Assay (ELISA) plates analyzed on an automated Gold Standard Diagnostics CAAS Cube instrument, the most advanced cyanobacteria toxin monitoring instrument in Minnesota. Before analysis, samples will be prepared by either undergoing three freeze-thaw cycles or using a commercially available QuikLyse kit to measure total toxin concentrations (i.e., dissolved and intracellular toxins). The QuikLyse kit allows for quicker reporting of microcystin concentrations (within 24 hours of collection) compared to the longer freeze-thaw cycles. To better predict future cHABs and guide recommendations for monitoring strategies, we will perform timeseries analysis on the dataset to better understand interannual variability in cyanobacteria seasonality, and perform correlation analyses to identify environmental conditions (e.g., temperature, precipitation, wind speed and direction) that could be contributing to cHABs.

Activity Milestones:

Description	Approximate Completion Date
Collect and analyze microcystin samples from five beaches in Year 1	October 31, 2026
Collect and analyze microcystin samples from five beaches in Year 2	October 31, 2027
Data analysis and interpretation to develop long-term beach monitoring strategy	June 30, 2028

Activity 2: Develop a rapid on-site cyanobacteria harmful algal bloom detection system using a portable sequencer to reduce warning times

Activity Budget: $111,155

Activity Description:
We will develop procedures to detect toxic cyanobacteria bloom strains more rapidly and inexpensively than traditional approaches in Minnesota waters using environmental genomics (DNA / RNA) and portable Nanopore sequencing platforms. Our framework will include the molecular procedures, data processing pipelines (i.e., alogrithms) for sequencing data, and an instruction module for implementation. DNA / RNA extraction, library preparation, and sequencing protocols for the MinION platform will be validated (e.g., storage time requirements, water sample matrix effects, and sequencing depth) using lake water samples and cyanobacteria cultures before generating monitoring data. During these tests, MinION-derived results will be compared to results from conventional genomic sequencing (Illumina). We will continue to refine procedures during routine beach monitoring, which will follow the sampling schedule described in Activity 1. We will use these results to optimize a detailed library preparation protocol and open-source software packages for computational analysis. Genomics data will be evaluated against cyanobacteria toxin and environmental data to better understand cHAB dynamics and inform monitoring strategies and beach advisory guidelines. In year 3, we will create draft instruction materials for our MinION workflow and solicit feedback from resource managers for the rapid on-site detection of harmful cyanobacteria bloom.

Activity Milestones:

Description	Approximate Completion Date
Develop procedures and framework for MinION platform before monitoring	February 28, 2026
Quantify cyanobacteria toxin genes at beaches while optimizing MinION-based workflow for Minnesota waters	December 31, 2027
Create instructional materials for agencies and community groups to perform the MinION workflow	June 30, 2028

Activity 3: Develop online reporting system and long-term strategy for beach monitoring to protect beachgoers and regional economies

Activity Budget: $14,452

Activity Description:

Microcystin concentration data will be reported with E. coli data on Minnesota Department of Health's Minnesota Lake Superior Beach Monitoring Program website (www.mnbeaches.org). To integrate microcystin data, the website code will be reconfigured to automatically update the underlying data-feed file based on the most recent data submission and to update the website displays to include new data. After initial development, the website will be maintained throughout the project to avoid any delays in data reporting. Additionally, we will host meetings with listed project partners and pertinent state and local agencies (e.g., MPCA, MnDNR, City of Duluth) throughout the project's duration to determine best approaches for integrating cyanobacteria toxin analysis into long-term beach monitoring programs, identifying how cyanobacteria toxin analysis could be funded going forward, and developing guidelines for incorporating cyanobacteria information into beach advisory guidelines. While recreational guidelines for microcystin are established, the application of molecular data to inform public warnings and beach advisories needs to be refined with project partners. We anticipate that partner meetings will consist of an initial project kickoff meeting, annual meetings thereafter to review data and refine approaches, and a final meeting to develop a recommendation report for a comprehensive monitoring program.

Activity Milestones:

Description	Approximate Completion Date
Reconfigure code for auto populating website with most recent cyanobacteria toxin data	January 31, 2026
Maintain website in Years 1 and 2 to advise beachgoers of microcystin concentrations	November 30, 2027
Develop recommendation for long-term monitoring and funding strategy for Minnesota beaches to keep people safe	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Chan Lan Chun	U of MN - Duluth - NRRI	Chun leads NRRI's Environmental Microbiology and Biotechnology Lab and will be responsible for developing a framework for integrating microbial analyses (DNA / RNA) of toxin-producing genes into beach monitoring programs, data analysis and interpretation, project reporting and manuscript development, and mentoring the postdoctoral associate.	Yes
R.C. Boheim	South St. Louis County Soil & Water Conservation District	The South St. Louis County SWCD will work with the project team to provide feedback on monitoring approaches and cyanobacteria toxin criteria development, and work with the public to increase cyanobacteria bloom awareness and visibility of the online reporting system.	No
Dawn Buck	Park Point Community Club	The Park Point Community Club will assist with reporting cyanobacteria blooms along Park Point, as well as helping to increase public awareness of cyanobacteria blooms and the online reporting system. Park Point Community Club meetings will provide a venue for sharing project progress and findings.	No
Pamela Anderson	Minnesota Department of Health	Minnesota Department of Health will be responsible for collecting water samples analyzed for this project, allow reporting of toxin data on the mnbeaches.org website, and provide feedback on future monitoring strategies and beach advisory criteria.	No

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?

Project activities, including data collection, data analysis and interpretation, and online reporting system refinement, will be completed during this project. Institutional funds will be used to fund products that are developed afterwards, such as publications or scientific presentations. As part of this project, we will be developing a long-term strategy for incorporating cyanobacteria toxin monitoring into existing beach monitoring programs, including determining a funding mechanism to support monitoring and sample analysis in future years. If new research directions are developed from LCCMR's investment in this project, partners will seek new funding from other grant opportunities.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Catch and Reveal: Discovering Unknown Fish Contamination Threats	M.L. 2022, , Chp. 94, Art. , Sec. 2, Subd. 04g	$246,000

Project Manager and Organization Qualifications

Project Manager Name: Christopher Filstrup

Job Title: Applied Limnologist

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

Filstrup will be responsible for project management and administration, and has the scientific expertise and project management experience to successfully complete this research. Filstrup leads NRRI's Lake and Stream Ecosystem Ecology Lab along with the Central Analytical Lab, a state-certified water quality laboratory specializing in low-level detection of water quality parameters in the Laurentian Great Lakes and nutrient-poor lakes and streams in the Upper Midwest. He has studied water quality issues, including cyanobacteria harmful algal blooms, in lakes and reservoirs in

the U.S. Central Plains for over 20 years, and excels at engaging natural resources agencies to translate scientific findings to improved management and restoration outcomes. Filstrup currently manages several federal and state funded projects, including serving as PI on a $3M USEPA-funded project investigating contaminants in the Great Lakes and on a 2024 LCCMR project (selected for funding) investigating wildfire impacts of the Greenwood fire on mercury cycling in lakes. Most related to this proposal, Filstrup (PI) was previously lead-PI on a project investigating drivers of cyanobacteria blooms and toxin production across Minnesota lakes, and is co-PI on a current and an upcoming project investigating cyanobacteria bloom dynamics in the St. Louis River Estuary and coastal Lake Superior using molecular approaches.

Organization: U of MN - Duluth - NRRI

Organization Description:
The Natural Resources Research Institute (NRRI) is a part of the University of Minnesota research enterprise and employs over 130 scientists, engineers, and technicians. NRRI's mission is to deliver integrated research solutions that value our resources, environment, and economy for a sustainable and resilient future. NRRI collaborates broadly across the University system, the state, and the region to address the challenges of a natural resource-based economy. NRRI scientists have extensive experience in managing large, interdisciplinary projects, and NRRI has established mechanisms for sharing outcomes through press releases, publications in peer-reviewed journals, technical reports, annual reports, periodicals, and through social media channels.

The Lake and Stream Ecosystem Ecology Lab (PI Filstrup) has the necessary equipment and infrastructure to process and analyze cyanobacteria toxin samples. Most notably, the lab has a Gold Standard Diagnostics CAAS Cube instrument for automated analysis of Enzyme-Linked Immunosorbent Assay (ELISA) kits for toxin analysis, the most sophisticated toxin detection system in Minnesota. The Environmental Microbiology and Biotechnology Lab (PI Chun) has the necessary equipment, computers, and infrastructure to process and quantify molecular samples, including access to the sequencing facilities at the University of Minnesota Genomics Center and bioinformatics computing power at the Minnesota Supercomputing Institute.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Chris Filstrup		Filstrup will serve as Project PI and will be responsible for project administration, project reporting, and coordination with project partners, as well as leading microcystin analyses.			27.06%	0.24		$30,765
Chan Lan Chun		Chun will lead to develop a framework to determine cyanobacteria toxin genes more rapidly and inexpensively in Minnesota beach using eDNA and a nanopore sequencing platform.			27.06%	0.09		$14,731
Eva Hendrickson		Hendrickson will be responsible for analyzing water samples for microcystin concentrations, including sample preparation and analyses, data analyses, and project reporting.			25.09%	0.24		$14,871
Jane Reed		Reed will be responsible for reconfiguring the mnbeaches.org website to report cyanotoxin data and to automatically update the website with recent data, as well as troubleshooting and fixing any website issues.			27.06%	0.09		$9,452
Andrew Wood		Wood will Conduct cyanobacteria toxin gene analysis using a portable Nanopore-based sequencing technologies.			27.06%	0.45		$47,665
Katie Edbald		Edbald will conduct sample processing and molecular analysis for cyanobacteria toxin gene analysis.			25.09%	0.24		$16,693
TBD - Temp Casual		The Temp / Casual employee will be responsible for coordinating sample delivery with MDH staff, pre-processing cyanotoxin samples, and assisting with cyanotoxin analyses. The Temp / Casual employee will be supervised by Dr. Filstrup and Eva Hendrickson. Budgeted as 60 hours @ $20 in each of Years 1, 2.			7.15%	0.06		$2,777
TBD - Undergraduate Student		The Undergraduate Student will be responsible for coordinating sample delivery with MDH staff, pre-processing cyanotoxin samples, and assisting with cyanotoxin analyses. The Undergraduate Student will be mentored by Dr. Filstrup and Eva Hendrickson. Budgeted as 40 hours @ $15 during			0%	0.16		$5,165

		the academic year and120 hours @ $15 during the summer in each of Years 1, 2.						
							Sub Total	**$142,119**
Contracts and Services								
University of Minnesota Genomic Center	Internal services or fees (uncommon)	To compare nanopore sequencing with conventional Illumina sequencing: University of Minnesota Genomic Center: $13.5/sample x 400 samples + MiSeq V3 run $2,624/lane x 2 lanes = $10,648. 3% inflation per year added.				0		$11,009
							Sub Total	**$11,009**
Equipment, Tools, and Supplies								
	Tools and Supplies	Molecular Biological Analysis Supplies	Plasticwares, reagents, genomic extraction kits, biomarkers, and nanopore flow cell for 200 samples per year. 3% inflation per year added.					$20,695
	Tools and Supplies	Cyanotoxin Supplies	Lab supplies needed to collect and process cyanobacteria toxin samples (e.g., bottles, storage vials, filters, standards) and analyze cyanobacteria toxin samples (e.g., ELISA kits). 3% inflation per year added. Y1: $3297 supplies + (8 ELISA kits @ $600) = $8097. Y2: $3297 supplies + (8 ELISA kits @ $600) = $8097. Y3: $1649 supplies + (4 ELISA kits @ $600) = $4049.					$20,731
							Sub Total	**$41,426**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**

Travel In Minnesota								
	Miles/ Meals/ Lodging	Sample Delivery	Field travel in each of Y1 & Y2. Y2 includes 3% inflation. 1000 mi @ $0.31 mileage rate = $310 in each of Y1, Y2 40 days @ $17.92 rental fee = $717 in each of Y1, Y2					$2,084
							Sub Total	**$2,084**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
		Sample Shipping	Shipping DNA/RNA samples to University of Genomic Center					$362
							Sub Total	**$362**
							Grand Total	**$197,000**

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				
			State Sub Total	**-**
Non-State				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 55% modified total direct costs.	Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs)	Secured	$108,350
			Non State Sub Total	**$108,350**
			Funds Total	**$108,350**

Total Project Cost: $305,350

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 02161c71-be2.pdf

Alternate Text for Visual Component

Newspaper headline of first report of cyanobacteria toxins found in Lake Superior tributary with picture of cyanobacteria bloom at beach. Schematic showing microcystin sampling robot and portable DNA sequencer feeding data into the Minnesota Department of Health Beach Monitoring website (mnbeaches.org)....

Supplemental Attachments

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

Title	File
South St. Louis County SWCD letter	cdc61632-449.pdf
Park Point Community Club letter	8eb0f152-2b7.pdf
Minnesota Department of Health letter	7c8523b0-351.pdf
Transmittal Letter	aefce2dd-c57.docx

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

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?

No

Does the organization have a fiscal agent for this project?

No

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 proposal: