Environment and Natural Resources Trust Fund

2022 Request for Proposal

General Information

Proposal ID: 2022-102

Proposal Title: Public portal for algae blooms in lakes

Project Manager Information

Name: Pamela Anderson

Organization: Minnesota Pollution Control Agency

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Project Basic Information

Project Summary: Provides a public portal for lake users as well as researchers and resource managers showing and predicting the locations of harmful algae blooms.

Funds Requested: $846,000

Proposed Project Completion: June 30 2025

LCCMR Funding Category: Foundational Natural Resource Data and Information (A)

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?
  In the Future

Narrative

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

Summer in Minnesota means a day at the lake fishing, swimming and recreating. With warming temperatures, longer open water seasons, and more intense storms delivering more nutrients to our lakes, harmful algal blooms (HABs) are projected to increase. In addition to being a public health threat due to their potent toxins, HABs can create low oxygen levels that contribute to fish kills and reduce fish habitat within a lake. Current temperature and water quality data are critical to predicting and addressing HABs and to aid lake and fisheries management. This project will enhance the existing online system to provide additional information for Minnesotans and local public health agencies of when and where HABs are likely to occur on recreation and drinking water source lakes. It will additionally fill a void for high resolution data to inform lake management, including watershed protection and conservation of fish habitat.

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

This project will update the existing LakeBrowser (https://lakes.rs.umn.edu/) to forecast lake temperature and the likelihood of HABs for Minnesota's recreational lakes.

This project will use remote sensing and water temperature modeling informed by lake sampling and in-lake monitoring buoys to predict the risk of HABs for 4,000+ Minnesota lakes. Models will use remotely sensed temperature and water quality data (water clarity, chlorophyll, phycocyanin, color) to inform modeled lake temperature to calculate HAB risk near real-time for each lake.

This project leverages:
•   The Pollution Control Agency and other existing monitoring programs to collect lake water samples to characterize nutrients, cyanobacteria abundance, composition, and toxin concentrations to identify lake conditions that lead to toxin production;
•   an automated water quality monitoring system developed in a 2018 LCCMR project that provides historic and current water quality data;
•   lake temperature models developed by the US Geological Survey for 4000+ Minnesota lakes which will be automatically updated with recent remotely sensed water quality, temperature and real-time and forecast weather data; and
•   a molecular (DNA/RNA) tool being developed for a MN Sea Grant project to rapidly and inexpensively assess toxic HABs.

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?

LakeBrowser, an online interactive map for exploring Minnesota lake water quality data, will be frequently updated with new water quality and temperature data along with HAB risk levels. To assist with natural resources planning, annual summaries will be published to the Minnesota Natural Resources Atlas to help agencies characterize HAB risk. High frequency data provides resource managers and lake associations the information needed to fill gaps between sampling events and helps identify waters for prioritization and implementation actions on the ground and to aid resource managers in understanding lake processes and how they relate to fish populations and aquatic habitat.

Activities and Milestones

Activity 1: Water quality monitoring to measure factors that predict HAB risk to update HAB forecast and temperature models.

Activity Budget: $466,792

Activity Description:

We will collect water samples monthly (May-September) from 200 lakes total during Years 1 and 2 to measure HAB abundance (phycocyanin pigment) and toxin concentrations (microcystin, anatoxin-(a)). In addition to variables measured during routine MPCA lake monitoring (phosphorus, chlorophyll a, water clarity), we will analyze lake color and dissolved organic carbon (DOC) due to their influences on underwater light climate and HABs. Molecular approaches (DNA/RNA) will be used to measure HAB composition and identify presence of toxin genes on a subset of lake samples (200 total samples in each of Years 1 and 2). Sampling events that coincide with cloud-free satellite passes will be prioritized for analyses (see Activity 2). In addition to the 200 lakes, we will deploy monitoring buoys (15-minute interval; temperature, dissolved oxygen, chlorophyll a, turbidity) and frequently sample (10 events in year 1 and 2 for nitrogen, phosphorus, chlorophyll a, phycocyanin, water clarity, color, DOC, molecular samples) 2 Sentinel lakes with known HAB occurrences to provide high resolution data to improve HAB forecast and temperature models. We will utilize additional buoy data from other partners, such as the Science Museum of Minnesota St. Croix Research Station and the United States Forest Service.

Activity Milestones:

Description	Completion Date
Collect and analyze water quality samples from 100 lakes in Year 1 (530 total samples)	March 31 2023
Collect and analyze water quality samples from 100 lakes in Year 2 (530 total samples)	March 31 2024
Statistical analyses to identify conditions responsible for toxic harmful algal blooms	December 31 2024

Activity 2: Update automated water quality monitoring system with indicators of HABs and new satellite products.

Activity Budget: $219,208

Activity Description:

We will add Landsat 9 (launch Sep 2021) data to the automated water quality monitoring system and update the code for new Sentinel 2 products. Using the field data collected in Activity 1 we will develop methods for measurement of phycocyanin (pigment indicating HAB abundance) and remotely sensed temperature using Landsat 8 and 9 and add those capabilities to the automated water quality monitoring system.

Activity Milestones:

Description	Completion Date
Add Landsat 9 data and update automated water quality monitoring system for new Sentinel products	June 30 2023
Analysis of field and satellite data to develop predictive relationships to permit monitoring of phycocyanin	June 30 2024
Analysis of field and satellite data to develop predictive relationships to permit monitoring of temperature	June 30 2024
Add temperature and phycocyanin to the automated water quality monitoring system	December 31 2024
Update system with biweekly clarity, algae, color, temperature and phycocyanin from the past 7 years	June 30 2025

Activity 3: Develop near-real time and forecast-modeled temperature and adapt LakeBrowser to display HAB risk

Activity Budget: $160,000

Activity Description:

To fill in temperature between satellite overpasses and when clouds may obscure measurements, we will automate lake temperature models that the USGS has created for 4000+ lakes in Minnesota using historic weather data. We would run those models on UMN supercomputers and link them to real-time and forecast weather data from the National Weather Service to predict and forecast lake temperature for 4000+ lakes in near real-time. Remotely sensed water quality and temperature data (Activity 2) combined with the modeled lake temperature will allow us to apply the criteria determined in Activity 1 to predict and forecast HAB risk for 4000+ lakes on a daily basis.

Underlying computer code will be adapted to include HAB maps and to provide near real-time and forecast information through automated updates based on the most current satellite imagery and weather data. The online HAB tool will be freely available to Minnesotans through the popular UMN LakeBrowser (www.lakes.rs.umn.edu) and through its connection to the Minnesota Department of Natural Resources Lake Finder (https://www.dnr.state.mn.us/lakefind/index.html). We will work with end users to improve data access and the user interface of the LakeBrowser and add annual summaries

Activity Milestones:

Description	Completion Date
System to automatically model lake temperature for 4000+ lakes utilizing real-time and forecasted weather data	June 30 2024
Develop and implement method to calculate HAB probability risk for 4000+ lakes	March 31 2025
System to update LakeBrowser with daily temperature and harmful algal bloom risk predictions	June 30 2025
Create flagging system to highlight with high harmful algal bloom risk	June 30 2025
Add summarized harmful algal bloom risk to Minnesota Natural Resource Atlas	June 30 2025

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Dr. Christopher Filstrup	Natural Resources Research Institute	Filstrup will lead efforts to characterize algae and cyanobacteria composition in lakes, including microscopic quantification of species and total cyanobacteria amount (phycocyanin), as well as dissolved organic carbon (DOC) analyses. He will lead statistical analyses to identify drivers of cyanobacteria toxicity in Minnesota lakes.	Yes
Dr. David Porter	Minnesota Supercomputer Institute, University of Minnesota	Porter will implement the new satellite water quality and temperature model to the existing water quality monitoring system. Will implement USGS lake temperature models with current weather data.	Yes
Marty Rye, P.E.	Superior National Forest, United States Forest Service	Rye will help with collection of additional water samples for this project from Superior National Forest Lakes, and will share concurrent water quality monitoring data collected during routine USFS monitoring.	No
Tracy Lund	Minnesota Department of Health	Lund will provide guidance on user interface for the LakeBrower and how data can be utilized for drinking water protection.	No
Dr. Samantha Oliver	Upper Midwest Water Science Center, United States Geological Survey	Oliver will provide guidance in implementing the lake water temperature models on UMN supercomputers.	No
Dr. Leif Olmanson	Department of Forest Resources, University of Minnesota	Olmanson will lead the remote sensing and temperature modeling and oversee modifications to the LakeBrowser.	Yes
Dr. Cody Sheik	Large Lakes Observatory, University of Minnesota, Duluth	Sheik will lead efforts to characterize algal composition and presence of toxin genes using molecular (DNR/RNA) approaches.	Yes
Dr. Heidi M. Rantala	DNR Fisheries Research Scientist	Rantala will provide guidance and input on how the products of this work will be most useful to fisheries staff in management, habitat, and research.	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 be funded?
Semi-automated computer code will routinely acquire the latest satellite imagery and weather data to quantify HAB risk. Information will be freely available to all through the UMN LakeBrowser. Maintenance to the UMN LakeBrowser and any updates to data processing would be funded through small contracts with state agencies as needed. The MPCA and Minnesota Department of Health will communicate and promote the use of the new risk information to lake users and drinking water professionals. Minnesota Department of Natural Resources will use these data in projects that assess fish habitat and drivers of fish population metrics, and guide lake protection.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Assessment of Surface Water Quality With Satellite Sensors	M.L. 2016, Chp. 186, Sec. 2, Subd. 04i	$345,000
Providing Critical Water-Quality Information for Lake Management	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 03b	$250,000
Forest and Bioeconomy Research	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 03q	$2,200,000
Minerals and Water Research	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 03r	$883,000

Project Manager and Organization Qualifications

Project Manager Name: Pamela Anderson

Job Title: Manager

Provide description of the project manager's qualifications to manage the proposed project.
Pam will oversee the overall management of the project and has had experience managing several LCCMR projects during her tenure at MPCA. She has over 16 years of experience working directly with citizens, river and lake water quality and assessments, and harmful algal blooms. She has responded to hundreds of calls during her tenure from concerned citizens looking for answers on where they can recreate or take their pets without exposure to harmful algal blooms. She has responded to dog deaths, and worked collaboratively with the Minnesota Department of Health to help determine environmental causes of the deaths and worked to prioritize monitoring and assessment of those waters. Pam has managed several projects with the University of Minnesota during that tenure, including the initial work to collect data to calibrate the satellite imagery to develop the initial LakeBrowser. This work included managing budgets, meeting LCCMR reporting requirements, and project oversight. She is well versed in budget oversight and reporting, having developed and managed unit and program budgets for the past 7 years.

Organization: Minnesota Pollution Control Agency

Organization Description:
The Minnesota Pollution Control Agency (MPCA) mission is to protect and improve the environment and human health. The MPCA monitors environmental quality, offers technical and financial assistance, and enforces environmental regulations. The agency finds and cleans up spills or leaks that can affect our health and environment. Staff develop statewide policy, and support environmental education.

Specifically related to this project, the MPCA operates statewide lake and stream water quality monitoring programs. Historically, MPCA has partnered with the University of Minnesota to utilize agency collected water quality data to calibrate remote sensed imagery to show clarity on lakes across Minnesota. MPCA also maintains, in partnership with the Minnesota Department of Health, web pages devoted to harmful algal blooms to help inform the public of ways to reduce exposure and risk, operates phone and email reporting of blooms, human illness, and animal illness and/or death, and coordinates an interagency team devoted to coordinating work and efforts surrounding harmful algal blooms.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Student workers, Minnesota Pollution Control Agency		field staff to assist agency staff with water monitoring			7%	0.46		$18,000
Christopher Filstrup, UMD NRRI		Project Coordinator			26.7%	0.18		$19,223
Jerry Henneck, UMD NRRI		Researcher 4			24.1%	0.24		$21,349
Beth Bernhardt, UMD NRRI		Researcher 3			24.1%	0.24		$17,631
Leif Olmanson, UMN		Researcher			26.7%	1.2		$111,198
David Porter, UMN		Consultant			26.7%	0.6		$100,283
Peter Wiringa, UMN		Geospatial Analyst			26.7%	0.39		$40,563
Research Fellow TBD, UMN		Remote sensing coding, database development and Lake Browser coding			26.7%	1.5		$112,164
Cody Sheik, UMD LLO		LLO Molecular Lead			26.7%	0.12		$17,895
Zachary Wagner		Researcher 2			24%	0.12		$7,223
Graduate Student		sampling and data processing			32.6%	0.56		$42,844
Undergraduate Student		Data collection			0%	0.74		$18,720
							Sub Total	**$527,093**
Contracts and Services								
Univerity of Minnesota Remote Sensing Laboratory	Internal services or fees (uncommon)	Access to remote sensing/GIS software and computers for model development at the University of Minnesota.				-		$3,000

University of Minnesota Supercomputing Institute	Internal services or fees (uncommon)	Access to supercomputer servers to process and store data.					-	$9,000
Minnesota Department of Health	Professional or Technical Service Contract	Lab analysis for 1060 water quality samples and 460 algal toxin samples from 200 lakes. The results will calibrate the satellite imagery. Minnesota Pollution Control Agency is doing the sampling; they use the Minnesota Department of Health to analyze samples through an interagency agreement.					0	$152,039
University of Minnesota Duluth	Internal services or fees (uncommon)	Water quality analytical fees: fees to analyze DOC and phycocyanin in all lakes, and water chemistries in buoy lakes					0	$16,920
University of Minnesota DNA sequencing	Internal services or fees (uncommon)	Sequence molecular data for phytoplankton					-	$35,196
							Sub Total	**$216,155**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lake buoy construction materials	To build buoys and temperature strings needed for housing sensors; data needed to build temperature models and HAB forecasts					$8,838
	Tools and Supplies	Field filtration and phytoplankton sampling	bottles, filters, and reagents for phytoplankton analysis					$25,756
	Tools and Supplies	Lab supplies	Reagents and lab supplies for molecular sample and water quality analyses					$26,456
							Sub Total	**$61,050**
Capital Expenditures								
		Hydrolab DS5 sonde with sensors for temperature, conductivity, pH, DO, turbidity and chloropyll-a (2 units)	To collect high frequency data to build temperature models and HAB forecasts					$27,164

							Sub Total	$27,164
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	Meals for student workers (70 daily per diems over 2 field seasons), MPCA	Student workers will accompany agency staff to collect water quality samples. This will include funds to cover their meals.					$2,538
	Conference Registration Miles/ Meals/ Lodging	1 conference (in state) per year, UMN/UMD	Present results of LCCMR funded work.					$2,100
	Miles/ Meals/ Lodging	Mileage for field work, UMN/UMD	Field work to perform in situ spectroradiometer measurements with water quality samples for model development					$5,900
							Sub Total	$10,538
Travel Outside Minnesota								
-							Sub Total	-
Printing and Publication								
-							Sub Total	-
Other Expenses								
		Shipping of samples from MPCA to NRRI; 20 weekly shipments for 5 months in years 1 and 2, estimated at $100 per shipment	MPCA is collecting the water quality samples based out of St. Paul. NRRI is conducting the DOC and algal composition work out of its Duluth lab. MPCA will need to ship samples to Duluth for analysis.					$4,000
							Sub Total	$4,000

						Grand Total	$846,000

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	Game and Fish Fund 97A.055	Dr. Rantala will provide guidance and input on how the products of this work will be most useful to fisheries staff in management, habitat, and research.	Secured	$2,040
			State Sub Total	**$2,040**
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	$168,369
In-Kind	United States Forest Service	Rye will share concurrent water quality monitoring and lake temperature data collected during routine USFS monitoring.	Secured	-
			Non State Sub Total	**$168,369**
			Funds Total	**$170,409**

Attachments

Required Attachments
Visual Component
File: c85e302c-e55.pdf

Alternate Text for Visual Component
Visual contains images of harmful algal blooms on Minnesota lakes. Includes example image of a statewide map of harmful algal bloom risk, with categories ranging from no risk to danger....

Optional Attachments
Support Letter or Other

Title	File
Minnesota Department of Natural Resources Support Letter	b0126e04-6b1.pdf
Metropolitan Council Environmental Services Support Letter	9e6253f9-c63.pdf
United States Forest Service Support Letter	d17e1dc7-39b.pdf
United States Geological Survey Support Letter	70fd3e89-987.pdf
Minnesota Department of Health Support Letter	5eef59f8-dd3.pdf

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

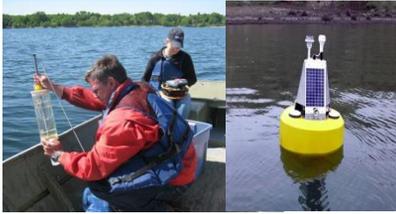**Does your project include original, hypothesis-driven research?**
> Yes

Does the organization have a fiscal agent for this project?
> No

Public portal for algae blooms in lakes

Goal: To provide water temperature and forecast risk of harmful algal blooms (HABs) in Minnesota lakes.
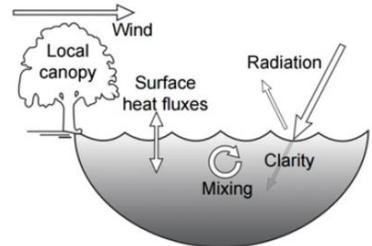
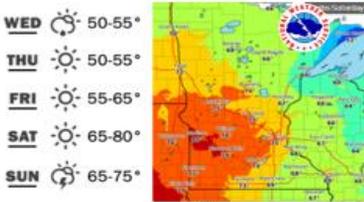**Existing resources** leveraged by this project include:
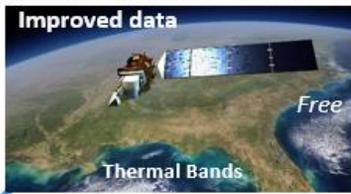

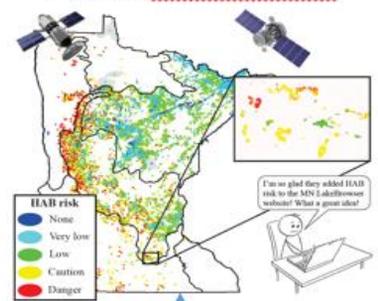**Field monitoring**   **LakeBrowser**   **Water temperature models**

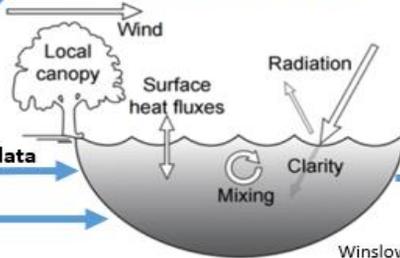## Approach

Real-time and forecast weather data

Recent & upcoming satellites: *Landsat 8 & 9*

Add temperature and HABs risk to LakeBrowser

UMN high performance computing systems

Water Temperature Models

Winslow et al. 2017

weather data

Existing Automated Water Quality Monitoring System + Satellite Derived Temperature

develop models to predict HABs

Applications: Results of this project will provide data for 4,000+ lakes to **help Minnesotan's avoid harmful algal blooms,** assist decision-making for **lake protection, management, and conservation of fish habitat.**