



Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-359

Proposal Title: MinLake-IceWatch: Real-Time Minnesota Lake Ice Forecasting Decision Platform

Project Manager Information

Name: Ardeshir Ebtehaj

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: Create a statewide system that forecasts lake ice conditions across Minnesota by integrating modeling, field data, and a public web platform to enhance safety, lake management, and ecological resilience.

ENRTF Funds Requested: \$387,000

Proposed Project Completion: July 31, 2030

LCCMR Funding Category: Water (B)

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.

Lake ice is essential to Minnesota's ecosystems, public safety, and cultural identity, yet real-time statewide measurements of ice thickness remain costly and logistically impractical. Seasonal ice cover insulates lakes, sustains fish and wildlife through winter, and supports recreation and local economies built around ice fishing, skating, curling, and snowmobiling. Long-term records show that lake-ice duration across Minnesota has declined by about two weeks over the past seven decades, while ice thickness has become more variable and less stable.

Reduced ice cover exposes lakes to longer warming periods, raising water temperatures in late fall and early spring, shrinking cold-water habitat for species such as cisco, and disrupting walleye spawning. Shorter ice seasons can increase shoreline erosion, sediment inputs, methane release, evaporation, invasive aquatic plant growth, and harmful algal blooms. Thinner, less reliable ice heightens safety risks and economic losses associated with winter recreation.

We hypothesize that continued warming can further shorten ice seasons and increase variability in ice thickness, making lake conditions less predictable and more hazardous, particularly without improved forecasting tools. These trends underscore the need for a statewide lake-ice prediction system to strengthen lake management, protect public safety, and support ecologically resilient decision-making across Minnesota.

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.

This project will develop MinLake-IceWatch: a state-of-the-art lake-ice predictive system by expanding, adapting, and validating a parsimonious, physically based lake-ice model for Minnesota's climate and diverse lake conditions. The system will require only limited meteorological forcing and basic lake characteristics (e.g., air temperature, wind speed, depth, and fetch length) to simulate water temperature, ice formation, duration, and thickness. By calibrating the model with Minnesota weather records and lake bathymetry data, and by automating the ingestion of meteorological data from nearby stations, public databases, and satellite imagery of lake ice extent; we will generate reliable daily estimates of lake water temperature, ice presence, and thickness within a sub-seasonal to seasonal timeframe (i.e., 2 weeks to 2 months), delivering accessible decision support for residents, lake managers, and winter recreation across Minnesota.

The MinLake-IceWatch will be deployed through an interactive web-based Geographic Information System (GIS) platform, similar to Google Maps, that allows users to select the county and lake of interest and access current and forecast water temperatures and ice conditions, including safety-relevant guidance for recreational activities.

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 project will deliver a statewide, publicly accessible web-based system that provides daily and sub-seasonal forecasts of lake freeze-up, breakup, ice thickness, and water temperature profile. These lake-specific predictions will help reduce ice-related accidents, inform fisheries and habitat management, and monitor climate-driven changes in lake conditions. By automatically integrating weather and satellite images with lake characteristics, the system will enable consistent, statewide tracking of ice phenology to support stewardship and conservation planning. The platform will strengthen public safety, sustain winter recreation and local economies, and serve as a long-term decision-support tool for managing Minnesota's lakes under a changing climate.

Activities and Milestones

Activity 1: Development of a Lake-Ice Model for the MinLake-IceWatch System

Activity Budget: \$143,803

Activity Description:

This activity will tailor a physically based lake model (<https://www.cosmo-model.org/content/model/cosmo/misc/flake/default.htm>) to Minnesota's climate and the wide variety of lakes across the state. The model will use basic information—such as lake depth, water clarity, and local weather conditions—to estimate water temperature profile, the timing of ice formation and melt, and ice thickness. We will gather statewide data on lake characteristics and weather from public sources, including NOAA, LakeFinder, and state monitoring networks. Using historical records of lake temperatures and ice cover, we will refine and validate the model to accurately reflect real conditions across Minnesota.

Based on historical DNR ground-based observations and satellite imagery of lake ice extent, we will evaluate and calibrate the model across thousands of lake types, including shallow prairie lakes, forested lakes, and deeper northern lakes, to ensure it works reliably statewide. Testing will be conducted across multiple regions to confirm the model's ability to predict ice-in and ice-out timing, as well as ice thickness.

Activity Milestones:

Description	Approximate Completion Date
Software production of the lake-ice model	August 31, 2027
Historical data collection from weather stations and DNR observations	February 28, 2028
Calibration of the lake-ice model and quantification of uncertainties based on historical data	March 31, 2028
Disseminate the results through peer-reviewed publications	August 31, 2028

Activity 2: Field Validation of the Lake Model for Ice Thickness

Activity Budget: \$100,498

Activity Description:

The DNR does not measure ice thickness on Minnesota lakes, and satellite observations provide only ice extent information on non-cloudy days, not ice thickness. To ensure the proposed modeling system provides reliable information of ice thickness, we will conduct field validation on at least 12 representative lakes across four major ecoregions of the state (i.e., Laurentian Mixed Forest Province, Eastern Broadleaf Forest Province, Tallgrass Aspen Parkland Province, Prairie Parkland Province), spanning three size classes (small, medium, large) and three depth categories (shallow, medium, deep).

The field teams will visit each selected lake three times—during the early freeze, midwinter, and early thaw—to measure ice thickness and the water temperature profile beneath the ice. Ice thickness will be measured using two complementary approaches: mobile ground-penetrating radar (GPR) surveys and targeted drill-hole measurements. GPR enables rapid, safe, and non-destructive mapping of ice thickness over large areas, while a limited number of drilled measurements will be used to verify and calibrate radar results. Observations will be compared with model predictions to quantify errors and uncertainty, allowing us to refine the model and establish appropriate safety margins before sharing results with the public.

Activity Milestones:

Description	Approximate Completion Date
Field measurements of ice thickness and water temperature	September 30, 2028
Field data processing and uncertainty analysis	March 31, 2029
Quantifying safety margins of the lake-ice model to inform decision making	June 30, 2029
Disseminate the results through peer-reviewed publications	July 31, 2029

Activity 3: Development of the Web-GIS Platform and Deployment on AWS

Activity Budget: \$142,699

Activity Description:

We will design and build a public-facing, map-based website that lets Minnesotans and lake managers search for lakes of interest and view forecasts for ice presence, thickness, freeze-up, and breakup dates with relevant uncertainty quantification. Software tools will integrate MinLake-IceWatch with the Minnesota DNR LakeFinder, enabling users to search by county, lake name, location, or ID and view results on interactive maps and simple dashboards. Behind the scenes, we will develop automated data pipelines that retrieve weather observations from nearby stations and public databases, merge them with lake characteristics (e.g., depth, area, and clarity), and run the lake model on a schedule basis. Forecast outputs will be stored in a cloud database and delivered via an application programming interface (API) to ensure fast and reliable access.

We will implement the proposed platform on Amazon Web Services (AWS) using scalable cloud computing, storage, and security services to support statewide access and multiple simultaneous users. We will develop automated workflows to manage data ingestion, model runs, and regular forecast updates. During the final project year, we will conduct statewide testing, refine performance and usability, prepare documentation and maintenance procedures for long-term operation, and develop safety protocols for public sharing and use.

Activity Milestones:

Description	Approximate Completion Date
Web-GIS system user interface design and NOAA, DNR data integration	January 31, 2030
Develop the interactive map, dashboards, and modeling engine	February 28, 2030
Statewide testing and public launch and dissemination through publications	July 31, 2030

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.

Project results will be disseminated through multiple channels to ensure broad participation, transparency, and long-term public benefit. The MinLake-IceWatch web platform will serve as the primary public-facing product, providing free and accessible lake-ice forecasts to residents, lake associations, local governments, and water resource managers statewide. We will present the developed system to the Minnesota Department of Natural Resources (DNR), watershed districts, tribal resource offices, and other state agencies to ensure results inform fisheries management, habitat protection, and winter safety planning.

We anticipate publishing three to four peer-reviewed journal articles documenting model development, field validation, satellite integration, and climate-related trends in Minnesota lake ice. All datasets, model documentation, and technical reports will be archived and publicly accessible through the University of Minnesota and appropriate state repositories to ensure long-term availability. The platform, publications, and outreach materials will acknowledge support from the Environment and Natural Resources Trust Fund in accordance with ENRTF guidelines.

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 MinLake-IceWatch will be deployed on Amazon Web Services (AWS) cloud during the final project year for statewide testing and validation. Cloud hosting will be maintained for three additional years after project completion, under a planned multi-year AWS service commitment, to ensure reliable public access and operational stability. The platform will be designed to run at low cost with automated data ingestion and minimal maintenance. During the post-project period, we will work with the Minnesota Department of Natural Resources (DNR) to evaluate performance and negotiate the transition of the system to DNR stewardship, enabling long-term operation as a public decision-support

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Remote Sensing And Super-Resolution Imaging Of Microplastics	M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 08j	\$309,000
Fate of Minnesota's Lakes in the Next Century	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 03d	\$453,000
Hyperspectral Characterization of Toxic Harmful Algal Blooms	M.L. 2024, , Chp. 83, Art. , Sec. 2, Subd. 04a	\$399,000

Project Manager and Organization Qualifications

Project Manager Name: Ardeshir Ebtehaj

Job Title: Associate Professor

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

Ardeshir Ebtehaj will serve as Principal Investigator and will oversee overall project coordination, scientific direction, and stakeholder engagement. He will supervise model development, climate data analysis, and web-based dissemination of results to ensure the system is scientifically robust and publicly accessible. Dr. Ebtehaj has more than 19 years of

experience in hydrology, environmental modeling, and remote sensing. He has led multiple NASA-funded projects and three LCCMR projects, published over 60 peer-reviewed papers, and co-authored a book chapter in the Handbook of Environmental Engineering (2019). He currently serves as an editor of the Journal of Hydrometeorology, is an affiliate member of the University of Minnesota's Institute on the Environment, executive committee member of the UMN data science initiative, and represents the University at the University Corporation for Atmospheric Research (UCAR). His honors include an American Meteorological Society Editor Award, NASA's Earth and Space Science Fellowship (2014), and NASA's Early Career Award (2018).

Miki Hondzo will serve as Co-Principal Investigator and oversee the modeling of lake water temperature and ice thickness. Dr. Hondzo has 30 years of experience in limnology, environmental fluid mechanics, and lake-water-quality modeling. He has led multiple NSF-funded and LCCMR projects and published more than 100 peer-reviewed papers. In 2025, Prof. Hondzo and his students were nominated for the 2025 Jim LaBounty Best Paper Award in the "Lake and Reservoir Management" journal. Dr. Hondzo currently serves as an associate editor of the Frontiers in Environmental Science journal.

The project will be conducted at the Saint Anthony Falls Laboratory (SAFL), an interdisciplinary research facility within the University of Minnesota's College of Science and Engineering. SAFL provides the necessary laboratory space, equipment, and collaborative environment for this work. Advanced computational analyses will be supported by the Minnesota Supercomputing Institute (MSI), which provides high-performance computing resources to University faculty and collaborators.

Organization: U of MN - College of Science and Engineering

Organization Description:

The University of Minnesota is the state's land-grant university and a leading public research institution dedicated to serving Minnesota through education, research, and outreach. With campuses in Minneapolis–Saint Paul and across the state, the University conducts research that directly supports Minnesota's natural resources, economy, and communities. The Association of American Universities (AAU), it brings nationally recognized expertise in climate science, water resources, fisheries, ecology, engineering, and environmental management.

The University has a long history of partnering with Minnesota state agencies, including the Department of Natural Resources, Pollution Control Agency, and Board of Water and Soil Resources, to provide science-based tools that inform policy and resource stewardship. Its researchers routinely translate advanced science into practical, publicly accessible decision-support systems that benefit citizens statewide. Through its land-grant mission and strong public-service commitment, the University is uniquely positioned to develop, implement, and sustain tools that protect Minnesota's lakes, ecosystems, and outdoor heritage for future generations.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Associate Prof. Ardeshir Ebtehaj		Project Manager			28%	0.24		\$66,557
Prof. Miki Hondzo		Colaborator			28%	0.06		\$20,305
Researcher, Dick Christopher		Technical support for field experiments			28%	0.12		\$9,857
Research Assistant		Research Assistant			22%	3		\$133,253
Tuition benefits		Research Assistant			0%	3		\$58,686
							Sub Total	\$288,658
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
							Sub Total	-
Capital Equipment								
		One IceMapper from SPX technologies	This equipment is a ground-penetrating radar (GPR) that enables safe and accurate measurments of lake ice thickness and its spatial variability across multiple large lakes, which is needed for field validation and uncertainty quantification of the proposed MinLake-IceWatch system.	X				\$45,800
							Sub Total	\$45,800

Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	We need to travel to 12 representative lakes three times per season for field measurements of lake ice thickness.	Filed validation of the proposed lake-ice predictive system.					\$1,542
							Sub Total	\$1,542
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
	Publication	3 to 4 publications in reputable journals of the field.	Publication cost					\$6,000
							Sub Total	\$6,000
Other Expenses								
		Hosting cost of the Web-GIS platform on Amazon Web Services (AWS)	The \$45,000 budget supports three years of post-project cloud hosting and maintenance on Amazon Web Services (AWS) to ensure reliable, statewide public access to the MinLake-IceWatch platform. The system requires secure web hosting, scalable computing to run lake-ice simulations, database storage for lake and weather data, automated data pipelines, cybersecurity protections, backups, and technical monitoring. AWS provides government-grade cloud infrastructure with pay-as-you-go pricing and multi-year Savings Plans that reduce long-term costs while ensuring reliability and scalability. This allocation (~\$15,000 per year) reflects typical costs for a secure, publicly					\$45,000

			accessible environmental decision-support system serving statewide users and ensures continuity of service after the project period.					
							Sub Total	\$45,000
							Grand Total	\$387,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Equipment		One IceMapper from SPX technologies	The IceMap ground-penetrating radar (GPR) system is directly necessary for the field validation component of this project and cannot be replaced with lower-cost alternatives. Accurate measurement of lake-ice thickness is essential for calibrating and verifying the statewide prediction system. Satellite data cannot reliably measure freshwater lake-ice thickness, and manual drilling alone is limited to point measurements and poses safety risks to field crews, especially during the thaw season. The IceMap GPR provides rapid, non-destructive, and spatially continuous ice-thickness measurements, significantly improving data quality, safety, and efficiency across 50 representative lakes. The equipment will be used exclusively to support the model validation, uncertainty quantification, and safety-margin development described in this proposal. Without these measurements, the reliability of the public-facing ice prediction system would be substantially reduced. The GPR purchase is therefore directly related to and necessary for achieving the project's objectives of improving lake stewardship and public safety across Minnesota. Additional Explanation : The IceMap ground-penetrating radar (GPR) system will be used throughout the project to conduct non-destructive measurements of lake-ice thickness across representative Minnesota lakes for model validation and safety calibration. Following the initial validation phase, the equipment will continue to support annual monitoring campaigns to refine and update the lake-ice prediction system. The GPR will also be used to verify forecasts during unusual winters, expand validation to additional lakes, and support long-term performance evaluation of the statewide platform. Beyond the funded period, the equipment will remain at the University of Minnesota and will be maintained for continued use in lake-ice monitoring, climate research, and student training. It will support future externally funded projects related to lake management, winter safety, and climate resilience. The system will also be made available for collaboration with the Minnesota Department of Natural Resources and other state agencies to ensure continued public benefit. The equipment's useful life extends well beyond the project period, and its application will remain directly aligned with the program's purpose of improving lake stewardship and public safety.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
			Non State Sub Total	-
			Funds Total	-

Total Project Cost: \$387,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: [ac22abc5-fca.pdf](#)

Alternate Text for Visual Component

The infographic shows visuals of the proposed activities and the outcomes....

Supplemental Attachments

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

Title	File
Sponsored Projects Administration Letter of Endorsement	df3d9cea-394.pdf
Budget justification of 3 years of hosting MinLake-IceWatch on Amazon Web Services Cloud	aeb5936b-6c0.pdf
The price quote of the ground-penetrating radar for lake ice thickness measurments.	36c51625-5c6.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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?

Yes

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 proposal:

Angela Boutch, Administrative Manager, Saint Anthony Falls Lab.

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

N/A