Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-106

Proposal Title: Minnesota Ice: River Ice Dynamics and Resiliency

Project Manager Information

Name: Jessica Kozarek

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: Advance knowledge of Minnesota's river and stream ice dynamics by developing affordable GPS ice trackers, deploying cameras, and combining field data with novel experiments, informing riverbank and community resiliency planning

ENRTF Funds Requested: $431,000

Proposed Project Completion: June 30, 2029

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?

During the Project and In the Future

Narrative

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

Many of Minnesota's rivers and streams are ice-covered during winter months in a typical year with implications for safety and recreation, ecology, habitat, erosion, water quality, flooding and infrastructure that are poorly understood and understudied, especially in smaller rivers. River ice formation, transformation, and break up are complex processes dependent not only on the number of freezing days in a particular winter, but also on local water flow rates and turbulence, river bank and bed characteristics, solar radiation and shading, and groundwater input. In addition, as air temperatures and precipitation patterns change in Minnesota, the timing and duration of river and stream ice and the subsequent break up processes are expected to change.

Understanding the impact of weather and local climate patterns on water resources in Minnesota requires better monitoring data during winter, especially during critical ice processes. For example, during breakup, ice can interact directly with bridge pilings, creating large loading on transportation infrastructure, or ice can contribute to annual sediment loads by scouring river banks, plucking sediment from stream beds, or scouring river beds with pressurized flow conditions under heavy ice cover.

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.

We propose a study to investigate stream and river ice processes in Minnesota to support the development of resiliency and adaptation plans to ice impacts. Specifically, we plan to monitor ice formation, breakup and movement in northern and southern MN over three winter seasons. These efforts will be supported by measurements of ice thickness, water flow, and sediment transport. We will leverage existing flow gaging (MN Cooperative Stream Gaging) and climate data to inform our field monitoring efforts. Timelapse images will provide key information on the timing and mode of ice formation (e.g. frazil ice, anchor ice, or bank ice) and the timing and mode of ice breakup. GPS ice trackers, designed by University of Minnesota - Duluth students, will document ice movement prior to and during breakup. During breakup, ice will be sampled to quantify sediment contained within the mobile ice. Because of the variability in field conditions driving ice processes, field data collection will be supplemented by controlled ice experiments in the Outdoor StreamLab (OSL). In the OSL, flow rate can be carefully controlled to manipulate ice formation and breakup and instrumentation allows for more detailed flow and sediment measurements for insight into stream ice processes.

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?

This project will: 1) develop low-cost GPS ice tracking sensors that will provide key data on the timing of ice and magnitude of ice movement, 2) collect valuable data on ice formation and breakup processes in rivers and streams in MN, 3) link field data and experimental data on ice interactions with flow and sediment processes, and 4) engage undergraduate engineering students in advanced sensing applications and development for marine and harsh environments. Data from these efforts will be examined in the context of long-term climatic data in MN to support the development of local climate resiliency and adaptation plans.

Activities and Milestones

Activity 1: Monitoring river ice formation and transformation

Activity Budget: $128,500

Activity Description:
River ice formation will be monitored at two sites each winter season of the project via georeferenced timelapse images. Images will be georeference by surveying ground control points visible in each image. Paired images one second apart will be collected hourly and transmitted via cellular network. Timelapse images will provide data on the timing and mode of ice formation, while image pairs can be used to quantify the speed of any ice chunk movement. Sites will be visited to directly measure river ice thickness throughout each winter and the crystalline structure of ice will be documented with cross polarized photography. Images and ice measurements will be used to create a timeline of ice formation at each site. Depending on winter characteristics, cameras and sites may be moved between years, but sites will located in both northern and southern Minnesota on small to intermediate sized rivers adjacent to gaging stations with long-term flow data records.

Activity Milestones:

Description	Approximate Completion Date
Construct 2 new ice monitoring camera systems	December 31, 2026
YR 1: Monitoring - timeline and timelapse video of ice formation, ice thickness measurements	March 31, 2027
YR 2: Monitoring - timeframe and timelapse video of ice formation, ice thickness measurements	March 31, 2028
YR 3: Monitoring - timeframe and timelapse of ice formation, ice thickness measurements	March 31, 2029
Develop relationships between river characteristics, air temperature and ice formation.	June 30, 2029

Activity 2: Linking field data and experimental data on ice interactions with flow and sediment processes

Activity Budget: $128,500

Activity Description:
River and stream ice interacts directly and indirectly with flowing water and sediment in rivers and streams. Ice cover can alter water flow rates under ice leading to pressurized flow and in turn leading to enhanced erosion. In addition, ice can interact directly with sediment through plucking or scouring. Researchers will document these interactions in the field by (1) measuring flows under the ice near the peak of annual ice thickness and (2) measuring sediment content in mobile ice.

Due to the complexity of these flow/ice/sediment interactions, experiments will be conducted in Outdoor StreamLab (OSL) at St. Anthony Falls Laboratory. This facility is an experimental stream fed year-round by Mississippi River water that allows for control over flowrates and for detailed channel bathymetry, flow and turbulence, and sediment transport measurements with and without ice. We will manipulate stream ice formation and breakup in the OSL by controlling the water flow rate and will measure under ice flows using an acoustic Doppler velocimeter. Topography and scour will be measured by surveying, or with an instrumentation carriage specially designed for the OSL with sonar and laser instrumentation. Depending on temperature, OSL experiments may extend for two years.

Activity Milestones:

Description	Approximate Completion Date
OSL ice experiments: ice, flow, and sediment	March 31, 2029
Measure water flow under ice using field accoustic Doppler velocimeter (ADV)	March 31, 2029

Measure ice/sediment interactions by quantifying sediment trasported in mobile ice	March 31, 2029

Activity 3: Tracking River Ice: Breakup and Movement

Activity Budget: $152,000

Activity Description:
The development and testing of low-cost GPS ice trackers will be led by co-PI Dr. Hill. The development of these trackers will be integrated into two courses at UMD: ENGR 1210 Introduction to Engineering's active learning research program, and ME 4495 - Marine Engineering, providing students with a hands-on experience in design, computer aided drafting (CAD), 3D printing for harsh outdoor environments, data acquisition, and real-time data telemetry. YR 1 (winter 2026-2027) 10 fabricated ice trackers will be tested at UMD, in the Outdoor StreamLab at SAFL, and potentially at another local field site. YR 2 (winter 2027-2028) 20 additional fabricated ice trackers will be deployed at select field sites in both northern and southern MN. YR 3 (winter 2028-2029) 20 additional sensors will be fabricated an used to enable swarm deployment of GPS ice trackers, enhancing coverage and dynamic tracking of ice breakup.

Activity Milestones:

Description	Approximate Completion Date
Design and build ice trackers: Test in Outdoor StreamLab	March 31, 2027
Ice tracking: YR 1	March 31, 2028
Ice tracking: YR 2	March 31, 2029

Activity 4: Minnesota Ice: Knowledge dissemination

Activity Budget: $22,000

Activity Description:
The research team will strive actively disseminate results to Minnesota agencies and practitioners via presentations at conferences (MN Water Resources Conference/ Upper Midwest Stream Restoration Symposium) and a seminar/webinar hosted at SAFL. All data from this project will be published with open access and all data will be compiled and made publicly available in the Data Repository for the University of Minnesota (DRUM). Timelapse videos of ice formation and breakup will also be shared. seminar/webinar hosted at SAFL. Detailed plans and coding for the GPS ice trackers will be shared via GitHUB.

Activity Milestones:

Description	Approximate Completion Date
Present Minnesota ice reserach at MN Water Resources Conference, yrs 2 and 3	October 31, 2028
Host seminar/webinar on Minnesota river ice processes at SAFL	June 30, 2029
Submit manuscript detailing ice tracker design, and river ice processes to open access journal	June 30, 2029
Publish CAD files and code for GPS ice trackers	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Craig Hill	University of Minnesota-Duluth Mechanical and Industrial Engineering Department	Co-PI Dr. Craig Hill will supervise project tasks happening at UMN-Duluth and work with the UMN-TC SAFL research team. Dr. Hill will lead the development of ice trackers and plans to integrate several of the project activities into engineering curriculum.	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 proposed project is building off of a current project funded by MnDOT led by PI Kozarek to study ice loading on bridge pilings in MN. While focused on ice/infrastructure interactions, data and images collected from this project highlight the complexity of ice processes in rivers and the need to better understand these processes for resiliency planning, water quality and habitat. Results from the proposed project will be disseminated to the public and state agencies including MnDOT, MPCA, and MN DNR. Ice trackers developed by undergraduate engineering students have other applications in lake and marine ice tracking.

Project Manager and Organization Qualifications

Project Manager Name: Jessica Kozarek

Job Title: Senior Research Associate

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

Dr. Jessica Kozarek is a senior research associate and manager of the Outdoor StreamLab and outdoor research space at the University of Minnesota at St. Anthony Falls Laboratory. She is an adjunct Associate Professor Biological Systems Engineer in Bioproducts and Biosystems Engineering, a Research Fellow with the Minnesota Aquatic Invasive Species Research Center, a Research Scholar with the Center for Transportation Studies, and an Affiliate Member of the Water Resources Science Graduate Program. She received a BS in chemical engineering from Penn State, and MS and PhD degrees in biological systems engineering from Virginia Tech. Dr. Kozarek's primary research interests are in the areas of stream restoration and management; ecohydraulics; interactions between flow, sediment, and aquatic biota and vegetation; use of hydraulic models to develop restoration guidance; and water quality and nutrient dynamics. She designs and leads experiments linking physical (flow and sediment movement), and biological processes (fish, mussels and vegetation) in aquatic environments in the lab, the field, and in the Outdoor StreamLab, a field-scale stream and floodplain experimental facility. Dr. Kozarek is an experienced project manager having led multi-investigator projects for state and federal agencies and will work in conjunction with co-PI Craig Hill at University of Minnesota - Duluth.

Dr. Hill's research interests span the intersection between marine environments and engineered systems with a focus on identifying new technologies to aid in society's transition towards sustainable energy, smart environments, and resilient coastal communities. His research explores new real-time observation platforms for aquatic monitoring. He is particularly interested in connecting students to research and is an affiliate faculty member with the UMD Large Lakes Observatory, UMN Water Resources Science Graduate Degree Program, and the UMN Institute on the Environment.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:
The St. Anthony Falls Laboratory (SAFL) is an interdisciplinary fluid mechanics research laboratory and educational facility under the College of Science and Engineering at the University of Minnesota.

SAFL is comprised of engineers and scientists who collaborate across disciplines to solve fluids-related problems in the Earth-surface environment. Our vision encompasses both science and practice, beginning with basic research and moving through application, decision-making, and management.

Located on Hennepin Island in the Mississippi River in the heart of Minneapolis, SAFL serves as a resource for departments across the Twin Cities campus, the statewide University system, and the broader research community. SAFL partners with local, state and federal agencies; private consulting firms; businesses of many kinds; technical associations; and other educational institutions to expand knowledge and solve problems.

Located adjacent to SAFL, the Outdoor StreamLab (OSL) and affiliated outdoor research space offers laboratory-quality measurements and control in a field-scale setting with access to natural sunlight and climatic conditions. This facility can be used for a variety of hydrological, ecological, and biological research opportunities. Equipment in the OSL includes flow sensors, water chemistry sensors, and a data collection carriage.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Jessica Kozarek		Project Manager			36.6%	0.51		$81,328
Chis Milliren		Instrumentation Engineer			36.6%	0.18		$20,057
John Chapman		Collaborator			36.6%	0.03		$5,557
SAFL Engineer		Assist with field and OSL work			32.3%	0.18		$18,225
Graduate Student		lead OSL and field work			43%	1		$116,749
Craig Hill		Co-investigator			26.8%	0.6		$87,843
Undergraduates-SAFL		assist with reserach			0%	0.18		$12,920
Undergrad-UMD		design and build Ice Trackers			0%	0.93		$30,062
							Sub Total	**$372,741**
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	Supplies include consumable resin used for 3D printing enclosures each year. Funds are requested to purchase supplies needed to build 50 GPS trackers over the course of the project, providing enough units to properly cover regions needed to document ice motion. This includes GPS sensors, microcontrollers, antennas, etc.). Additionally supplies are needed for the prototyping process (circuit boards, wiring, filament for normal 3D printers to test early phase enclosure concepts, etc.)	Supplies needed to build ice trackers					$10,585
	Tools and Supplies	field supplies (safety, ice coring, sediment processing)	supplies for ice safety, ice augers, ice thickness measurements					$3,200
	Equipment	cameras and datalogging system	Funds requested for cameras and datalogging systems (x 2) to capture					$13,417

			ice formation, movement and breakup					
							Sub Total	**$27,202**
Capital Expenditures								
		Resin 3D printer	Funds are requested to purchase a Form 4L resin 3D printer complete package with UV curing capabilities. Normal filament-based 3D printers are incapable of printing waterproof enclosures for marine/ice environments. This printer will be used for prototyping and printing ice tracking enclosures throughout the project.	X				$20,000
							Sub Total	**$20,000**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	travel within MN includes 628 miles per year for travel to field sites (yrs 1-3) @ $0.70 per mile, 3 nights lodging for 2 people at $110 / night for yrs 1 and 2 per diem for travel days yrs 1 and 2 (4 days x 2 people @ $51/day).	travel to field sites to install camera systems, measure ice and install/retreive ice trackers					$3,047
	Conference Registration Miles/ Meals/ Lodging	conference registration to MN WRC	conference registration to present at MN Water Resouces Conference					$500
	Conference Registration Miles/ Meals/ Lodging	conference registstration for 2 people to MN WRC for yrs 2 and 3	registration to Water Resources Confernce for 2 researchers from UMD					$2,000
	Miles/ Meals/ Lodging	Travel funds are requested each year to reimburse mileage from UMN Duluth to UMN St. Anthony Falls Laboratory (1 per year) and field site location (TBD, 1 per year) to carry out project collaboration work.Per diem is requested for travel days and	Travel to field sites and St. Anthony Falls Lab from UMN Duluth					$3,510

		work days at SAFL and/or field site each year, and lodging for one night for two people when visiting SAFL.						
							Sub Total	**$9,057**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	cost for publication fees for peer reviewed journal article (average cost $2,000)	publication fees for peer reviewed journal article					$2,000
							Sub Total	**$2,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$431,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Expenditures		Resin 3D printer	Equipment is needed to manufacture waterproof ice tracker housing **Additional Explanation :** This printer will be used for prototyping and printing ice tracking enclosures throughout the project and will continue to be used to manufacture environmental sensors throughout its useful life at UMD.

Non ENRTF Funds

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

Total Project Cost: $431,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 19d572be-09d.pdf

Alternate Text for Visual Component

Outcomes: low-cost ice trackers, field and experimental ice dynamics data, engage students in environmental sensing. Visual show images of methods to complete project: an ice covered Outdoor StreamLab, a person measuring ice thickness, and a sketch of ice trackers....

Supplemental Attachments

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

Title	File
UMN LoI	fe231978-afb.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?

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 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, UMN St. Anthony Falls Laboratory

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