



Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-507

Proposal Title: Fate of Storm-Driven River Sediments in Lake Superior

Project Manager Information

Name: Byron Steinman

Organization: U of MN - Duluth - Large Lakes Observatory

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Project Basic Information

Project Summary: We will map North Shore river plumes and sediment history to determine how storm-driven contaminants impact Lake Superior's nearshore ecosystems and the security of municipal drinking water intakes

ENRTF Funds Requested: \$447,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Water (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?

Region(s): NE

When will the work impact occur?

During the Project

Narrative

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

Sustainable management of freshwater environments requires a strong understanding of how extreme events and land use affect water quality. Lake Superior is a cornerstone of the state's economy, supporting tourism, fisheries, and municipal drinking water. While large river plumes are known drivers of coastal food webs, the role of the ~60 small tributaries along the North Shore remains a critical "blind spot". These streams are highly episodic, discharging massive loads of sediment and nutrients during spring snowmelt and increasingly frequent "mega-storm" events.

Currently, we lack the data to determine if these riverine pulses support productive nearshore ecosystems or degrade them through contaminant delivery. Crucially, these episodic plumes—and the pollutants they carry, such as PFAS—pose a direct, unquantified threat to municipal drinking water intakes for Duluth and other North Shore communities. The mega-storms in 2012, 2016, and 2018 substantially impacted drinking water treatment. Because the rocky coastline makes standard sampling ineffective, water managers cannot currently predict the 3D movement of these plumes during hazardous high-flow events. This project addresses this gap by linking autonomous 3D mapping with historical sediment records to define contaminant capture zones and baselines, ensuring Minnesota's water-quality and infrastructure protection are grounded in comprehensive, ecosystem-scale data.

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 multi-disciplinary study at five strategic North Shore locations to track material transport and its biological impact. We will utilize Jaiabot AUV swarms for high-resolution 3D mapping of storm plumes, providing synoptic data during hazardous high-flow events. This mapping will be coupled with deep-water sediment coring from the R/V Blue Heron; by applying radiometric dating (^{210}Pb and ^{137}Cs) to these cores, we will establish historical baselines for contaminants like PFAS and microplastics. To determine the ecological impact, we will deploy rock basket samplers in paired plume and reference zones for 6–8 weeks, overcoming the challenges of sampling rocky nearshore habitats. Simultaneously, we will anchor drift nets at river mouths to quantify the biomass and taxa actively exported into the lake during storms. This swarm-to-benthos approach allows us to definitively distinguish whether the macroinvertebrates supporting the nearshore food web are resident lake invertebrate taxa responding to plume nutrients or riverine invertebrate taxa washed in during storms. By linking 3D water quality mapping, historical sediment records, and benthic community assessments, we provide the first comprehensive look at how small-stream dynamics dictate the health of Minnesota's Lake Superior fisheries and impact drinking water resilience.

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?

Water Quality Mapping: We will identify how river plumes to Lake Superior impact the distribution of nutrients and sediments and delineate the physical reach of pollutants to help water managers protect municipal drinking water intakes and nearshore infrastructure.

Benthic Biomass and Diversity Assessment: We will quantify how episodic plumes structure macroinvertebrate communities, which form the essential base of the food web supporting North Shore biodiversity and fishery recruitment.

Contaminant & Resiliency Baselines: We will establish a high-fidelity historical record of PFAS/microplastics and current benthic health. This provides a dataset for state agencies to evaluate the long-term resiliency and preservation of

Activities and Milestones

Activity 1: 3D mapping of riverine plumes during storm events

Activity Budget: \$164,048

Activity Description:

To assess river plume inputs during high flow events, we will use Jaiabot AUV swarm technology (4 units). These micro-AUVs work in tandem to capture simultaneous 3D data across the water column, mapping water quality conditions with far greater precision and lower cost than ship-based methods. Our AUVs will collect data on temperature, turbidity, conductivity, and chlorophyll to assess water quality relative to state standards. We will use these data to generate 3D concentration maps for the various water quality parameters. By deploying the Jaiabots multiple times over a multi-day event, we will map the movement of the plumes and develop relationships between storm size, concentrations, and plume development. This will allow us to predict how river inputs might behave in different types of storms and identify risk to drinking water intakes and coastal water quality.

We will target five strategic watersheds representing a gradient of land use. Lester/Amity Creek is urbanized and near a Duluth water intake. Knife River has experienced fisheries decline and is at Duluth's water source boundary. Beaver River is near Silver Bay drinking water intake. Poplar River has undergone some restoration from historic erosion. Cascade River serves as a pristine baseline comparison.

Activity Milestones:

Description	Approximate Completion Date
Purchase, sensor integration, and field-calibration of the new Jaiabot AUV unit	September 30, 2027
Completion of Year 1 high-flow plume mapping deployments at all locations	November 30, 2028
Completion of multi-seasonal 3D mapping (spring snowmelt and summer storms) across all five target sites	November 30, 2029
Final processing of synoptic 3D models and calculation of sediment transport volume/velocity	May 31, 2030
Public release of 3D data visualizations and archival in the UMN Data Repository (DRUM)	June 30, 2030

Activity 2: Benthic habitat and biological export assessment

Activity Budget: \$94,309

Activity Description:

To determine how nearshore macroinvertebrate communities respond to low-flow conditions and episodic tributary inputs along Minnesota's North Shore, we will quantify stream exports and resident littoral macroinvertebrate communities across five target tributaries relative to reference communities distant from tributaries.

To capture event-driven changes, we will deploy stream drift nets for 24 hours during low- and high-flow events. This will allow us to quantify the taxonomic diversity and total biomass of stream invertebrates entering the lake system. Concurrently, we will sample the rocky littoral zone (10–20 meters deep) using rock baskets as artificial colonization substrata. Samples will reach equilibrium within this period. We will position these replicate arrays directly within established tributary plumes and in paired, non-influenced reference habitats.

By integrating these paired datasets, we will determine whether the invertebrates aggregating in plume areas are simply transient stream taxa washed offshore, or if terrestrial carbon and nutrient inputs actively support an enriched, resident benthic community. Ultimately, we will compare community composition, density, and biomass metrics between the plume and reference habitats to directly assess whether tributary inputs significantly increase benthic forage availability for nearshore fish populations, particularly coastal brook trout.

Activity Milestones:

Description	Approximate Completion Date
Deployment and recovery of Year 1 seasonal rock basket samplers	September 30, 2027
Completion of riverine drift biomass quantification for spring/summer events	October 31, 2028
Taxonomic identification and community analysis of all benthic samples	February 28, 2029
Final assessment report on plume-driven benthic productivity and habitat quality	June 30, 2030

Activity 3: Identifying historic baselines using analysis of off-shore sediment**Activity Budget:** \$188,643**Activity Description:**

We will use sediment core records to assess how urbanization and climate change have impacted contaminant inputs, including PFAS and microplastics, over the last century. The LLO is uniquely positioned to execute this campaign using the R/V Blue Heron, the only U.S. Academic Research Fleet vessel on the Great Lakes equipped for deep-water recovery.

Offshore of the Minnesota North Shore, depths drop rapidly to 100m–200m, creating ideal zones for sediment deposition from plume inputs. Using a specialized multi-corer system, we will recover undisturbed surface sediments to preserve a high-fidelity record of recent depositional layers from at least 5 sites. This coring system captures the water-sediment interface without disruption—critical for identifying recent episodic flood events. By applying radiometric dating (210-Pb and 137-Cs) and geochemical analyses, we will reconstruct a timeline of sediment and pollutant accumulation. This historical record will allow us to quantify how the frequency and magnitude of storm-driven inputs have evolved. Linking this long-term context with modern data provides the necessary validation to assess current and future risks to Minnesota’s coastal resources.

Activity Milestones:

Description	Approximate Completion Date
Successful recovery of undisturbed deep-water sediment cores from five offshore focusing zones	September 30, 2027
Completion of radiometric dating (210-Pb and 137-Cs) to establish sediment chronologies	October 31, 2028
Completion of geochemical analysis for historical PFAS and microplastic profiles	June 30, 2029
Final assessment report on sediment and contaminant history	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Catherine O'Reilly	University of Minnesota Duluth - Large Lakes Observatory	Director and Project Collaborator	Yes
William Perry	University of Minnesota Duluth - Department of Biology	Professor and Project Collaborator	Yes

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.

Target Entities & Resource Management

We will actively share our findings with entities directly responsible for Minnesota's coastal resources. Technical reports detailing plume dynamics and contaminant baselines will be provided to the Minnesota Department of Natural Resources (DNR) Fisheries, the Minnesota Pollution Control Agency (MPCA), and municipal water managers in Duluth and other North Shore communities. By defining contaminant capture zones, this project provides actionable data for infrastructure protection and water-quality standard assessments.

Public Awareness

To engage the broader public, we will present our results at the St. Louis River Summit and through LLO's public outreach channels. This awareness aims to promote better land-stewardship practices in North Shore watersheds.

Data Longevity & Physical Collections

Digital Data: All mapping data and technical reports will be archived in the Data Repository for the University of Minnesota (DRUM). This provides a persistent DOI and ensures the data remains findable and reusable for decades.

Samples: Any physical sediment core sections or macroinvertebrate collections will be cataloged and housed at the Large Lakes Observatory, available for future comparative research.

ENRTF Acknowledgment

We will strictly adhere to the ENRTF Acknowledgment Guidelines and will display the logo accordingly.

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?

Findings will be shared with the MN DNR Fisheries and MPCA and will be disseminated via peer-review publications and technical reports to inform infrastructure planning. Data will be archived in the University of Minnesota's Digital Conservancy for public access. The project leverages existing UMN infrastructure and Jaiabot hardware; follow-up monitoring or expanded watershed studies will be funded through subsequent UMN research initiatives. This

foundational data set is designed to be a one-time baseline investment that state agencies can utilize to inform coastal resiliency strategies.

Project Manager and Organization Qualifications

Project Manager Name: Byron Steinman

Job Title: Professor

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

The project manager is an experienced paleolimnologist with more than 20 years of research focused on lake sediment records, watershed–lake interactions, and environmental change. Their expertise includes sediment core collection and the application of geochemical and biogeochemical analyses to reconstruct past environmental conditions. They have extensive experience conducting field campaigns in large lakes and remote environments, including planning logistics, coordinating field teams, and implementing sampling protocols. The project manager has particular expertise in sediment core dating and chronology development, including radiometric methods used to establish recent sedimentation rates and historical timelines. Their research integrates sediment records with watershed processes, hydrology, and climate change. They have successfully led international, multidisciplinary research projects, managed project budgets and timelines, supervised students and staff, and collaborated with state and federal partners. This experience ensures effective coordination of fieldwork, laboratory analyses, data interpretation, and reporting required for the proposed project.

Select publications by the project manager:

Vall, K. A., Murphy, C., Pompeani*, D. P., Steinman*, B. A., Schreiner, K. M., Bain, D. J., DePasqual, S., & Wagner, Z. (2022).

Ancient mining pollution in early to middle Holocene lake sediments from the Lake Superior region, USA. *Anthropocene*, 39, 100348.

<https://doi.org/10.1016/j.ancene.2022.100348>

*Project Leaders

Steinman, B.A., Nelson, D.B., Abbott, M.B., Stansell, N.D., Finkenbinder, M.S., & Finney, B.P. (2019).

Lake sediment records of Holocene hydroclimate and impacts of the Mount Mazama eruption, north-central Washington, USA. *Quaternary Science Reviews*, 204, 17–36.

<https://doi.org/10.1016/j.quascirev.2018.09.018>

Stansell, N. D., Steinman, B. A., Lachniet, et al. (2020).

A lake sediment stable isotope record of late-middle to late Holocene hydroclimate variability in the western Guatemala highlands. *Earth and Planetary Science Letters*, 543, 116327.

<https://doi.org/10.1016/j.epsl.2020.116327>

Organization: U of MN - Duluth - Large Lakes Observatory

Organization Description:

The Large Lakes Observatory (LLO) at the University of Minnesota Duluth is the only institute in the world dedicated specifically to the study of large lakes. Since its inception in 1994, LLO has established itself as a global leader in limnological research, focusing on the physical, chemical, biological, and geological processes that govern the world's vital freshwater resources. Strategically located on the shores of Lake Superior, LLO operates a suite of sophisticated analytical laboratories and the Research Vessel Blue Heron, the largest university-owned research vessel on the Great Lakes. Our mission is to understand how large lakes function and how they respond to environmental changes. By combining high-tech instrumentation with multidisciplinary expertise, LLO provides the critical data and scientific

insights necessary to understand and manage Lake Superior and Minnesota's inland waters. Our work bridges the gap between fundamental discovery and applied resource management, ensuring that Minnesota remains at the forefront of aquatic science and freshwater stewardship.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
PI - Dr. Byron Steinman		Project Manager. Dr. Steinman, UMD Large Lakes Observatory, will be responsible for sediment core collection and processing, development of the sediment age models, and overseeing geochemical and pollutant analyses of the sediments. Steinman will coordinate with co-PI Perry on Jaiabot operations and sediment plume observation. Steinman will serve as advisor for a graduate student who will work on the sediment/contaminant history components of the project.			26.8%	0.24		\$51,534
2 Graduate Research Assistants		2 MS students will work with PIs Steinman and Perry to develop the sediment/contaminant and biological datasets as part of their theses. 1 MS student will be assigned to each Investigator.			44%	1.64		\$184,174
1 Lab Tech		The LLO technician will work on Jaiabot maintenance and coordinate sediment geochemical analyses at LLO.			24.4%	0.12		\$12,939
Undergraduate Research Assistant		The UG assistant will work with col Perry on processing biological samples.			0%	0.3		\$9,150
Dr. William Perry, Co-I		Dr. Perry, UMD Biology Department, will be responsible for all biological aspects of the project. Perry will coordinate with PI Steinman on Jaiabot operations and sediment plume observation. Perry will serve as advisor for a graduate student who will work on biological aspects of the project.			26.8%	0.16		\$34,321
							Sub Total	\$292,118
Contracts and Services								
UMD	Internal services or fees (uncommon)	Website for project updates and dissemination of results. Accessible to the general public. The PIs will develop the website with the LLO outreach coordinator.				0		\$1,000
UMN Large Lakes	Internal services or	Geochemistry and biogeochemistry analysis of water and sediment core samples. 60 sediment samples /				0		\$30,000

Observatory and Chemistry Department	fees (uncommon)	year. \$150 / sample for microplastics, PFAS, and basic geochemistry. \$9,000 total for sediment work / year. \$1,000 for water chemistry measurements / year.						
UMD R/V Blue Heron	Internal services or fees (uncommon)	3 days of ship time during the first year of the project to collect sediment core transects at 5 off-shore locations. This vessel provides deep-water capability and high-fidelity sampling in deep-water focusing zones, as it is equipped with the winches and A-frame necessary to deploy specialized multi-corer systems.				0		\$52,065
Science Museum of Minnesota	Service Contract	Radiometric dating for sediment cores needed for historical contaminant analysis. Pb-210 measurements for sediment cores at \$2,084/profile, 6 total profiles will be done at the Science Museum of Minnesota's St. Croix Watershed Research Station, a UMN affiliate.				0		\$12,501
							Sub Total	\$95,566
Equipment, Tools, and Supplies								
	Equipment	Data Storage and Backup Hardware	Data storage for Jaiabot Autonomous Underwater Vehicles					\$3,000
	Tools and Supplies	Jaiabot Maintenance and other Misc Supplies	Batteries, sensor replacement and/or calibration needed for the Jaiabot. Supplies for sediment sample collection and processing					\$5,196
							Sub Total	\$8,196
Capital Equipment								
		One additional Jaiabot AUV BIO and a second controller	Needed for expanding 3D plume mapping capabilities.	X				\$30,000
							Sub Total	\$30,000
Acquisitions and Stewardship								
							Sub Total	-

Travel In Minnesota								
	Miles/ Meals/ Lodging	Car travel to study lakes to perform sampling. Estimate is based on 10 visits to 5 sites for Y1 and Y2 and includes mileage, meals during field work and accommodations near field sites for 4 people. 5,700 total miles of driving at \$0.725/mile. Y1 budget extra 2 trips for scouting. Overnight stays needed during sampling. 2 rooms needed for trip up North (5 sites) x 10 trips, Y1 budget extra 2 trips for scouting. Assuming per diem (\$30) for 4 people per sampling trip; 10 trips/yr, extra 2 trips for Y1 for scouting.	Sampling trips to river mouths for biological investigation and Jaiabot deployment and collection.					\$12,712
	Conference Registration Miles/ Meals/ Lodging	Funds for 2 graduate students and 2 PIs to attend the IAGLR Conference in Duluth in Y2 and the Water Resources Conference in Y3 of the project and present the results of their work. Funds include car travel, accommodations, per diem, and conference registration.	Dissemination of research results and professional development for graduate students.					\$8,408
							Sub Total	\$21,120
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$447,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Equipment		One additional Jaiabot AUV BIO and a second controller	The LLO seeks an exception for the purchase of one Jaiabot Autonomous Underwater Vehicle (AUV). This specialized capital equipment is directly related to and strictly necessary for the successful completion of the Plume Mapping activity for the following reasons: Necessity of 3D Data: Traditional point-sampling (an eligible expense) is insufficient to capture the rapid, three-dimensional dispersion of storm-driven plumes. The Jaiabot is the only cost-effective instrument capable of synoptic, underwater mapping during high-flow events. Safety and Access: These AUVs are necessary to collect data during mega-rain events when conditions are too hazardous for manned boat operations, ensuring the project captures the most critical flashy plume data. Leveraged Investment: This request is for a single unit to complete a four-vehicle swarm. UMN has already provided the foundational investment for three units; this additional AUV is required to ensure that at least three units are operational at any given time to achieve the spatial resolution promised in the deliverables. No Broad Allocation: The cost for this unit is based on a specific vendor quote for the hardware and integrated sensor package (turbidity, temperature, and depth), with no funds allocated for general administrative or indirect costs. Additional Explanation : The Jaiabot AUV has a projected useful life of 7–10 years. LLO has funds to purchase 3 Jaiabot AUVs and will use these funds to purchase a 4th unit. Following this project, the LLO will continue using the AUV for the same program: the long-term monitoring of Lake Superior’s water quality. As a permanent research institution, LLO will provide the technical staff and facilities to maintain, calibrate, and house the vehicle using institutional funds. This ensures the AUV remains a functional state asset for future Minnesota-based research (e.g., MPCA or DNR collaborations) long after the appropriation ends. All subsequent data will be archived at the University of Minnesota for public and agency use.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 54% 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	\$194,854
			State Sub Total	\$194,854
Non-State				
			Non State Sub Total	-
			Funds Total	\$194,854

Total Project Cost: \$641,854

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: [f790df74-bfc.pdf](#)

Alternate Text for Visual Component

A) North Shore rivers for study; red dots are drinking water intakes. B) Two Harbors bathymetry with 100m contour (cyan). Crosses indicate coring locations at 125-175 m depth. Photos show sediment coring on R/V Blue Heron. C) Poplar River plume from 2002. D) Jaiabot being launched from shore....

Supplemental Attachments

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

Title	File
Transmittal Letter 2026 Steinman	32387dcd-b8d.pdf
Letter of Support from Cleveland State University and NASA Ames Research Center	98187bd3-dd7.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:

umdspa@d.umn.edu

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

Yes, I understand