# Environment and Natural Resources Trust Fund

2027 Request for Proposal

## General Information

**Proposal ID:** 2027-513

**Proposal Title:** Predicting Microplastic Hotspots in Minnesota Rivers

## Project Manager Information

**Name:** Han Liu

**Organization:** U of MN - St. Anthony Falls Laboratory

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## Project Basic Information

**Project Summary:** This project will develop a predictive tool identifying microplastic accumulation hotspots in Minnesota rivers, converting years of statewide sampling data into actionable guidance for watershed managers

**ENRTF Funds Requested:** $350,000

**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?**

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.**

A 2025 statewide survey by the Environment Minnesota Research & Policy Center found microplastics in all 40 Minnesota waterways tested. Synthetic fibers were present at every site, with fragments at 25 percent and films at 12.5 percent. Since 2020, the Legislature through LCCMR has funded multiple projects investing approximately $3 million to measure, detect, and characterize microplastics in Minnesota waters. These projects confirmed that contamination is pervasive: microplastics are present in rivers, lakes, stormwater ponds, and groundwater across every region of the state.

Yet Minnesota still cannot answer two questions water managers need answered: where do microplastics accumulate, and why do they concentrate in certain locations? Without prediction capability, managers must rely on site-by-site sampling — testing one location at a time while microplastics move unseen through 92,000 miles of rivers and streams. Every funded LCCMR microplastics project measures where microplastics are found; none predicts where they will go next. A prediction tool that identifies accumulation hotspots would allow managers to target monitoring, prioritize cleanup, and protect communities and ecosystems facing the greatest exposure.

**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 a physics-based prediction model that tracks how microplastic particles move through Minnesota's rivers — where currents carry them, where turbulence traps them, and where river geometry causes them to accumulate. The approach uses Lagrangian particle tracking: virtual particles are released into simulated river flow and tracked as currents carry them downstream, turbulence disperses them, and low-velocity zones at bends, backwaters, and obstacles cause deposition. Because fibers, fragments, and films differ in shape, density, and settling speed, the model tracks each type separately. This approach builds on the PI's published methods for particle tracking in turbulent flows.

The project will produce three deliverables: (1) a predictive risk-assessment tool that ranks river segments by predicted microplastic accumulation, (2) an interactive decision-support interface for watershed managers to identify priority sampling locations, and (3) a validated modeling framework updatable as new data become available. The model will be validated against existing concentration data from LCCMR-funded projects — including the citizen science sampling study (2025-191) and the urban ecosystem study (2025-112) — to ensure predictions match observations before the tool is released.

**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 advances the public purpose of protecting Minnesota's water resources by converting measurement data into a statewide prediction system. Outcomes include:

- Statewide predictive tool identifying river segments where microplastics are likely to accumulate
- Interactive decision-support tool for watershed managers to prioritize monitoring and cleanup
- Validated predictions checked against measured data
- Publicly accessible data archive of model inputs, outputs, validation datasets, and source code
- Policy brief and training workshops translating findings into management recommendations

## Activities and Milestones

### Activity 1: Compile River Flow and Microplastic Source Data for Minnesota Waterways

**Activity Budget:** $87,500

**Activity Description:**
This activity assembles the data foundation for predicting microplastic transport across Minnesota. River flow data — discharge rates, velocity profiles, channel geometry, and seasonal variations — will be compiled from the U.S. Geological Survey (USGS) stream gauge network and Minnesota DNR hydrological databases. Microplastic source data — including particle types, measured concentrations, and entry points such as wastewater treatment plant outfalls, stormwater discharge points, and urban runoff corridors — will be gathered from the existing LCCMR-funded microplastics projects. Key data sources include the citizen science statewide sampling study (2025-191), the urban ecosystem study (2025-112), and the wastewater treatment study (2025-265). Particle characteristics (fiber length, fragment size, film area, and density) will be cataloged from published Minnesota-specific data to ensure the model represents the actual microplastics found in state waters. Three priority river systems — the Mississippi, Minnesota, and St. Croix Rivers — will be selected as initial modeling domains based on population exposure, existing data density, and ecological significance.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Compilation of river flow and channel geometry data from USGS and DNR databases | September 30, 2027 |
| Assembly of microplastic source and concentration data from existing LCCMR-funded projects | December 31, 2027 |
| Characterization of particle types and selection of three priority river systems | March 31, 2028 |

### Activity 2: Develop Microplastic Transport and Accumulation Model

**Activity Budget:** $105,000

**Activity Description:**
This activity develops the prediction model that tracks microplastic particles through river systems. The model combines flow simulations with Lagrangian particle tracking: river currents are simulated using established computational methods for turbulent open-channel flow, and individual microplastic particles are released and tracked as they are carried downstream. The model accounts for three key physical processes that determine where microplastics end up. First, turbulent mixing near the water surface controls whether particles stay suspended or settle — the PI has published validated methods for tracking how particles of different densities concentrate in turbulent flows (Physics of Fluids, 2016) and for simulating the free-surface dynamics that govern floating particle behavior (Journal of Computational Physics, 2023). Second, interaction with river-bottom sediment determines whether deposited particles are re-suspended during high flows. Third, river geometry — bends, confluences, backwaters, and engineered structures — creates low-velocity zones where particles accumulate. Simulations will be run for each priority river system under low-flow, average, and high-flow conditions to capture seasonal variability in transport patterns.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Flow simulation and baseline particle tracking operational for Mississippi River domain | June 30, 2028 |
| Model extended to Minnesota and St. Croix River systems | August 31, 2028 |
| Sensitivity analysis across flow conditions and particle types completed | October 31, 2028 |

## Activity 3: Validate Predictions Against Existing Measurement Data

**Activity Budget:** $87,500

**Activity Description:**
This activity tests the model's predictions against real-world microplastic measurements collected by other research groups across Minnesota. Predicted hotspot locations will be compared with measured concentration data from existing LCCMR-funded projects. Primary validation sources are the citizen science statewide sampling study (2025-191, Maurer-Jones, UMN Duluth, $419,000), which will provide standardized microplastic concentration data from sampling sites distributed across Minnesota, and the urban ecosystem study (2025-112, Pollack, UMN, $300,000), which provides microplastic concentration and toxicity data from Twin Cities stormwater ponds. Additional validation data will be drawn from the wastewater treatment study (2025-265, $506,000) and, if data become available, from the karst aquifer study (2026-203) and the PFAS co-occurrence study (2026-248), both recommended for ML 2026 funding. For each comparison site, the model's predicted accumulation ranking will be checked against measured concentrations. Discrepancies will be used to identify missing transport processes or inaccurate source estimates, and the model will be refined accordingly. A formal accuracy assessment will be published with the final tool.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Validation dataset assembled from existing LCCMR-funded measurement projects | December 31, 2028 |
| Model predictions compared with measured concentrations at 30+ validation sites | March 31, 2029 |
| Model refinement and formal accuracy assessment completed | September 30, 2029 |

## Activity 4: Build Decision Tool, Data Archive, and Dissemination

**Activity Budget:** $70,000

**Activity Description:**
This activity packages the validated model into usable tools for water managers and makes all project data publicly available. The predictive tool will rank river segments and lake-connected areas by predicted microplastic accumulation risk, presented as an interactive web-based interface. Watershed managers will be able to query specific river reaches, filter by particle type (fiber, fragment, or film), and identify priority monitoring locations. All model inputs, simulation outputs, validation data, and the modeling source code will be archived in a publicly accessible data repository, fulfilling ML 2027 data dissemination requirements. Dissemination activities will include training workshops for watershed district staff and water quality professionals, presentations to relevant watershed management organizations, a policy brief summarizing key findings for legislators, and a technical report documenting the full methodology. The tool and data archive will be designed for long-term use and updating as new measurement data become available.

**Activity Milestones:**

| Description | Approximate Completion Date |
|---|---|
| Interactive predictive tool and decision-support interface released | November 30, 2029 |
| Public data archive completed with all model inputs, outputs, and code | March 31, 2030 |
| Training workshops and policy brief delivered | June 30, 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.**
All project data, model outputs, validation datasets, and modeling source code will be archived in a publicly accessible data repository hosted by the University of Minnesota, fulfilling ENRTF data availability requirements. The repository will use standard metadata formats and persistent identifiers (DOIs) to ensure long-term discoverability and reuse by other researchers and agencies. All publications, presentations, and the web-based decision tool will acknowledge the Environment and Natural Resources Trust Fund following LCCMR's official acknowledgment requirements and guidelines. Dissemination will target three audiences. For practitioners, the project team will conduct at least two hands-on training workshops for watershed district staff and water quality professionals, demonstrating how to use the predictive tool to prioritize monitoring sites and interpret accumulation risk rankings. These workshops will be coordinated with the Minnesota Board of Water and Soil Resources and relevant watershed management organizations to maximize attendance and practical uptake. For policymakers, a policy brief will translate key findings into management recommendations, summarizing which river segments face the greatest microplastic accumulation risk and what actions can reduce exposure. The brief will be delivered to LCCMR members, relevant legislative committees, and the Minnesota Pollution Control Agency. For the scientific community, results will be submitted for publication in at least two peer-reviewed journals and presented at relevant professional conferences such as the American Geophysical Union Annual Meeting and the Minnesota Water Resources Conference. A technical report documenting the full methodology, model assumptions, validation results, and user guide will also be published through the University of Minnesota Digital Conservancy. The project team will coordinate with existing LCCMR-funded microplastics research groups to share findings and ensure complementary dissemination across related projects.

## 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 predictive tool and public data archive will remain accessible after project completion through web hosting. As new measurement data are collected, the model can be updated to improve predictions with minimal additional resources. The modeling framework extends to other waterborne contaminants (PFAS, nutrients, sediment) using the same river flow simulations, as the particle tracking approach is not specific to microplastics. Funding for continued maintenance could come from EPA water quality grants, state agency budgets, or future LCCMR proposals focused on specific river basins.

## Project Manager and Organization Qualifications

**Project Manager Name:** Han Liu

**Job Title:** Researcher

**Provide description of the project manager's qualifications to manage the proposed project.**
Han Liu is a researcher at the University of Minnesota's St. Anthony Falls Laboratory (SAFL). He holds a Ph.D. in Fluid Mechanics from Peking University (2018) and has served as a postdoctoral associate (2018–2021) and researcher (2021–present) at SAFL, where he develops computational models for environmental and multiphase flows.

Dr. Liu has published 12 peer-reviewed papers in journals including the Journal of Fluid Mechanics, the Journal of Computational Physics, and Physical Review Fluids. His research directly supports this project's technical requirements:

- He co-developed a validated Lagrangian technique for tracking particles in turbulent water flows (International Journal of Multiphase Flow, 2021) — the same approach this project uses to predict microplastic accumulation in rivers.

- He published on the mechanisms of preferential concentration of particles in turbulent flows (Physics of Fluids, 2016), demonstrating expertise in the particle-turbulence interactions that also govern microplastic transport and settling behavior in river systems.

- He developed methods for accurately simulating free-surface dynamics in two-phase flows (Journal of Computational Physics, 2023), governing whether floating microplastic particles remain at the surface or are entrained downward by turbulence.

- He has published on turbulent flow interactions with flexible aquatic vegetation (Journal of Fluid Mechanics, 2022), demonstrating expertise in modeling the complex aquatic environments where microplastics transport occurs.

- His COVID-19 airborne particle transmission simulation (Physics of Fluids, 2021, Featured Article) demonstrates his ability to apply particle transport modeling to urgent public health problems.

Dr. Liu builds computational solvers from governing equations to production code, with expertise in parallel computing (MPI, CUDA), GPU-accelerated simulation, and large-eddy simulation of environmental flows. This technical depth enables the statewide-scale predictions this project requires.

**Organization:** U of MN - St. Anthony Falls Laboratory

**Organization Description:**
St. Anthony Falls Laboratory (SAFL, safl.umn.edu) is an interdisciplinary fluid mechanics research and educational center at the University of Minnesota, with 22 faculty members and 27 research and administrative staff. Each year, more than 100 postdocs and students conduct research at SAFL. SAFL specializes in environmental, geophysical, and engineering fluid mechanics and has performed many innovative environmental studies for Minnesota, several funded by the Environment and Natural Resources Trust Fund, including "Novel Piezoelectric Energy Converters for Minnesota Waters" (2026-540, $475,000) and "Modeling Future Mississippi River Gorge" (2025-169, $427,000). The proposed research leverages SAFL's advanced computational infrastructure and 16,000 square feet of dedicated research space.

## Budget Summary

| Category / Name | Subcategory or Type | Description | Purpose | Gen. Ineligible | % Benefits | # FTE | Classified Staff? | $ Amount |
|---|---|---|---|---|---|---|---|---|
| **Personnel** | | | | | | | | |
| Project Manager | | Lead all research activities, develop and validate particle transport model, manage project team, coordinate data compilation and tool development, responsible for project reporting and deliverables. | | | 38.5% | 2.25 | | $318,821 |
| Undergraduate Student Assistant | | Assist with data compilation, quality checking, and data archive preparation | | | 0% | 0.14 | | $4,777 |
| Computer Scientist | | Support computational model setup on Minnesota Supercomputing Institute, develop web-based decision tool, manage data archiving | | | 34.9% | 0.24 | | $26,402 |
| | | | | | | | **Sub Total** | **$350,000** |
| **Contracts and Services** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Equipment, Tools, and Supplies** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Capital Equipment** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Acquisitions and Stewardship** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Travel In Minnesota** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Travel Outside Minnesota** | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | | | | | | | **Sub Total** | **-** |
| **Printing and Publication** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| **Other Expenses** | | | | | | | | |
| | | | | | | | **Sub Total** | **-** |
| | | | | | | | **Grand Total** | **$350,000** |

## Classified Staff or Generally Ineligible Expenses

| Category/Name | Subcategory or Type | Description | Justification Ineligible Expense or Classified Staff Request |
|---|---|---|---|

## Non ENRTF Funds

| Category | Specific Source | Use | Status | Amount |
|---|---|---|---|---|
| **State** | | | | |
| | | | **State Sub Total** | **-** |
| **Non-State** | | | | |
| In-Kind | Unrecovered F&A | Indirect costs including facilities, administrative support, and infrastructure associated with project execution at St. Anthony Falls Laboratory | Pending | $189,000 |
| | | | **Non State Sub Total** | **$189,000** |
| | | | **Funds Total** | **$189,000** |

**Total Project Cost: $539,000**

**This amount accurately reflects total project cost?**

Yes

## Attachments

### Required Attachments

*Visual Component*

File: 2597a721-75c.pdf

*Alternate Text for Visual Component*

Overview of project activities: (1) compiling statewide microplastic sampling data, (2) developing a Lagrangian particle transport model for rivers, (3) validating predicted hotspots against field measurements, and (4) delivering an interactive web-based decision tool for watershed managers....

### Supplemental Attachments

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

| Title | File |
|---|---|
| Cover Letter of Intent – Predicting Microplastic Hotspots in Minnesota Rivers | d73a1b44-8f8.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?**

N/A

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

No

**Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?**

N/A

**Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?**

N/A

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

No

**Does the organization have a fiscal agent for this project?**

No

**Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?**

No

**Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care,**

**treatment, education, training, instruction, or recreation to children")?**

No

**Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:**

Ben Vargas, U of MN - Sponsored Projects Administration

**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