Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-054

Proposal Title: Why are Minnesota's Floods Larger and More Frequent?

Project Manager Information

Name: Andrew Wickert

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: (1) Assess statewide extent of intensified flooding. (2) Attribute flooding to changes in rainfall and snowfall patterns, land cover, and/or agricultural drainage. (3) Support flood-mitigation strategies.

ENRTF Funds Requested: $299,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Small Projects (G)

Secondary 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.

Minnesota's rivers are flooding more frequently and intensely than ever before. These floods threaten wildlife habitat, cause erosion, and impact communities and recreation. To prevent or mitigate damage from these floods, managers must first understand why they became so large and frequent. The goal of this project is to find and quantitatively attribute these causes.

Increased flooding across Minnesota has been attributed to changes in climate, land cover, and land use. Firstly, Minnesota often receives 20% more annual precipitation now than it did around 1990. Warmer winters cause more precipitation to fall as rain, which rapidly flows into rivers, than as snow, which travels more slowly through the watershed as snowmelt or recharges groundwater. Secondly, reduced vegetation cover reduces evapotranspiration rates (that is, the rates at which plants and bare earth return water to the atmosphere), leaving more water in the soil and thus routing more rainfall directly into rivers. Lastly, expanded agricultural drainage, comprising ditches and subsurface ("tile") drains, replaces slower infiltration and groundwater-flow pathways with more direct and rapid conduits for water to reach rivers. Each of these three drivers holds different importance across Minnesota's diverse landscapes and ecosystems.

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 will combine data and models to determine the proportional impacts of precipitation, temperature, land cover, and agricultural drainage efficiency on river flooding across Minnesota. Our deliverables include (1) streamflow and flood-frequency analyses for each of the 958 gauged river catchments across Minnesota and (2) proportional attribution of streamflow changes, if observed, to precipitation, temperature, land cover, and agricultural drainage.

To produce each of these deliverables, we will set up a hydrological model for each watershed. We will provide this model with historical temperature and precipitation data and calibrate its parameters to optimize its predictions of observed streamflow. The parameters represent the impacts of vegetation cover and agricultural drainage. By optimizing them for each decade, we will quantify the relative importance of land-cover and land-drainage change over time.

We will make this statewide set of prepared hydrological models, including input data and simulation outputs, usable by water managers across the state so they can digitally experiment with flooding causes and scenarios. These experiments will reveal which Minnesota watersheds have the most potential for flood mitigation, thereby allowing managers to target resources in those rivers to return flow regimes to those better adjusted for their watersheds and ecosystems.

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?

Ever-increasing floods across Minnesota are damaging infrastructure, destabilizing ecosystems, reshaping river channels into forms that no longer provide habitat needed by native species, and reducing opportunities for recreation and outdoors experiences. We will quantify how much and where these floods are increasing across the state and then identify the main causes of this increased flooding. With this knowledge in hand, alongside the support of our statewide model database, state and regional environmental managers will be better equipped to make targeted restoration decisions that readjust Minnesota's streamflows to reduce flood hazards and support our state's vibrant ecosystems.

Activities and Milestones

Activity 1: Compile and analyze hydrological data from across Minnesota

Activity Budget: $89,579

Activity Description:
We will first build a comprehensive and well-organized data set by:
(1) assembling the extents of all gauged watersheds in Minnesota, accounting for areas that overlap between two or more gauged watersheds;
(2) acquiring and organizing streamflow data for each of these watersheds from federal, state, and local sources;
(3) obtaining time series of hydroclimatic data comprising direct measurements and reanalysis products of precipitation and temperature, and ideally also including snow depth and relative humidity;
(4) overlaying historical land-cover and land-use data atop each watershed; and
(5) placing all of the data in an organized and reusable structure.

With these data in hand, we will statistically analyze time series of precipitation, temperature, and streamflow to detect the direction and significance of any trends through time. This analysis will build upon the recent statewide Evaluation of Hydrologic Change (EHC) project performed by the Minnesota Department of Natural Resources.

We will write, document, and publish reusable and open-source computer code to automatically perform the data acquisition and analysis noted above and to visualize the results. This will enable rapid future hydrological and hydroclimatic assessments across Minnesota.

Activity Milestones:

Description	Approximate Completion Date
Assemble geospatial extents of watersheds associated with each stream gauge across Minnesota	November 30, 2026
Compile hydrological data (streamflow, temperature, precipitation) and generate time series across each gauged watershed	May 31, 2027
Analyze precipitation, temperature, and streamflow trends for each gauged watershed, building on EHC project results	September 30, 2027
Assemble historical land-use and land-cover data and associate them within each gauged watershed	December 31, 2027
Publish documented, reusable, open-source code to automate data acquisition, analysis, and visualization	February 28, 2028

Activity 2: Generate hydrological models for each watershed to assess climatic and land-management drivers of streamflow

Activity Budget: $107,800

Activity Description:
To attribute changing (or unchanging) river flow to climate, land use, and/or land cover, we will run and calibrate the reduced-complexity hydrological model "HydroRaVENS" for each gauged watershed across Minnesota. HydroRaVENS, developed by Wickert, takes precipitation and temperature data as inputs and simulates the streamflow that best matches data by calibrating parameters associated with (a) snowmelt, (b) evapotranspiration, (c) runoff, and (d) subsurface water storage and release.

The HydroRaVENS model design is intentionally straightforward and minimalistic to support large-scale assessments of streamflow changes and their drivers. Precipitation and temperature inputs provide climate impacts directly. Temperature also predicts (a) snowmelt, and data on snow depth and relative humidity can improve these estimates.

Parameters driving (b) evapotranspiration reflect vegetation cover and will be validated against available land-cover data. Parameters for (c) runoff and (d) subsurface water storage relate to impervious surfaces, surface drainage, and subsurface (tile) drainage.

We will run and recalibrate best-fitting parameters for HydroRaVENS for each decade of record. By tracking trends in climate inputs, as well as those associated with land-cover and agricultural drainage efficiency, we will investigate how changes in climate, land use, and land management have reshaped the hydrology of Minnesota's rivers.

Activity Milestones:

Description	Approximate Completion Date
Configure HydroRaVENS to automatically import data for all watersheds compiled in Activity 1	March 31, 2028
Apply a Markov chain Monte Carlo approach to calibrate HydroRaVENS parameters for each decade	June 30, 2028
Assess model outputs against known changes in land use and land cover	August 31, 2028
Analyze and visualize trends in best-fitting parameters; relate these to climate and land management	September 30, 2028
Publish reusable code to drive the HydroRaVENS model with the Activity 1 data from Minnesota	December 31, 2028

Activity 3: Quantitatively attribute streamflow changes to altered climate and/or land management, and communicate these findings

Activity Budget: $101,621

Activity Description:
We will analyze trends between streamflow and (a) precipitation, (b) evapotranspiration efficiency, (c) runoff generation, and (d) subsurface water storage and release, with particular attention to high-magnitude flows that may generate floods. The statistical significance and practical importance of drivers (a–d) on streamflow and flooding will quantify their relative importance in each gauged watershed across Minnesota.

To communicate these findings, we will translate these four parameters into their relationships to on-the-ground changes. Evapotranspiration efficiency relates to land cover. Runoff generation corresponds to impervious surfaces and surface (or near-surface) drainage. Subsurface water storage and release times decrease with tile drainage. These factors, in addition to precipitation, will be used to generate statewide maps depicting (1) the changes in streamflow statistics and (2) the relative contribution of drivers (a–d) to observed streamflow change. Published products will be hosted by the University of Minnesota and made available online.

To support local land and water managers, we will provide a documented code to run HydroRaVENS simulations and test how changes in management practices could impact flood frequencies and magnitudes. Accompanying this will be information on how local actions to manage and restore vegetation cover, wetlands, and drainage systems can impact streamflow dynamics.

Activity Milestones:

Description	Approximate Completion Date
Publish compiled statewide data sets on watersheds and hydroclimate	December 31, 2027
Publish statewide maps of observed changes in precipitation and streamflow statistics	February 28, 2028
Quantify the relative importance of precipitation, land cover, and surface/subsurface drainage on streamflow statistics	April 30, 2029
Publish statewide attribution maps online and in a submission to HESS, an open-access hydrology journal	June 30, 2029
Publish reusable, open-source code developed to perform analyses and generate maps	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Xue Feng	University of Minnesota	Associate Professor of Hydrology	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 key deliverables—statewide streamflow and flooding assessment, flood attribution, and model database—will be generated during the course of the project. These will be published in open-access scientific journals, made available via University of Minnesota web servers, and presented at water-focused conferences. These results will inform the work of others with diverse funding sources (e.g., watershed districts, county, state, national) for on-the-ground implementation to mitigate flooding. All code used to develop this work will be made reusable, accessible, and open-source for future hydrological research across the state of Minnesota.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Land-Use and Climate Impacts on Minnesota's Whitewater River	M.L. 2022, , Chp. 94, Art. , Sec. 2, Subd. 03h	$199,000
Ditching Delinquent Ditches: Optimizing Wetland Restoration	M.L. 2023, , Chp. 60, Art. 2, Sec. 2, Subd. 04a	$199,000

Project Manager and Organization Qualifications

Project Manager Name: Andrew Wickert

Job Title: Associate Professor

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

Dr. Andrew Wickert, Associate Professor in Geomorphology at the University of Minnesota, has broad expertise in understanding Earth's surface environments and how they change. He obtained his S.B. in Earth, Atmospheric, and Planetary Science from MIT (2008), where his research on river systems and geophysics earned him the highest honors in his department, the Goetze Prize and Crosby Award. For his Ph.D. in Geology from the University of Colorado Boulder (2014), he demonstrated how global glaciation deformed the solid Earth and its gravity field and reshaped rivers across North America. Alongside this research, Wickert developed and built open-source electronic instrumentation for environmental monitoring and gained experience working in environmentally focused projects in rivers and watersheds. He added field and computational experience in river response to changing climate and flooding during his 2014–2015 postdoc at the Universität Potsdam before arriving at the University of Minnesota in Fall 2015, where he joined the Department of Earth & Environmental Sciences and the St. Anthony Falls Laboratory.

At the University of Minnesota, Wickert built a research program with three broad focus areas: (1) the mechanics of rivers and their watersheds and how they reshape themselves in response to environmental change, (2) regional to global patterns of climate-induced hydrologic and sea-level change, and (3) design of innovative open-source instrumentation to support environmental monitoring in the field. He and his group have developed the equations to describe how rivers reshape their slopes and valleys in response to changing water and sediment inputs; constructed field-based data sets on river dynamics and catchment-scale erosion; built computationally efficient tools to map and

simulate lakes and wetlands; designed software to remotely map glacier and land-surface velocities; and invented and installed hundreds of inexpensive low-power sensors to monitor rivers, glaciers, snowpack, and watershed-scale hydrology.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:
The Saint Anthony Falls Laboratory (SAFL) is a world-renowned research facility for environmental fluid mechanics and related fields. This 4,880-square-meter facility is built into the side of St. Anthony Falls in downtown Minneapolis, whose water it uses to run some of the largest hydraulics experiments in the world. In addition to direct experimentation with flowing water, SAFL hosts a diverse group of scientists and engineers who work on environmental fluid mechanics as it applies to the atmosphere, climate, land surface, sediments, and biological processes. The faculty, staff, and students at SAFL spread their efforts across both basic scientific advances and work with immediate applications to infrastructure, the environment, and societal needs. The current SAFL director is Prof. Lian Shen, with Jeff Marr as the associate director for engineering and facilities.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project manager		Coordinate project; support code development; manage reporting; aid in publications			26.8%	0.24		$52,667
Hydrologist		Scientific support for model design			26.8%	0.12		$27,615
IT Professional		Computing and software support; digital data management; dissemination via UMN web resources			24.4%	0.39		$43,907
PhD Student		Develop the model; assemble the data; apply the model across every gauged sub-watershed in Minnesota			44.6%	3		$170,881
							Sub Total	**$295,070**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
							Sub Total	**-**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	2 years with 3 people per year at the Water Resources conference in St. Paul. Funds supplied for registration and per diem meals & incidental expenses	Present data sets, computational resources, and hydrologic attributions of streamflow and flood changes					$2,184
							Sub Total	**$2,184**

Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Publication charges for one open-access paper on the modeling approach and results for Minnesota	Make the model code, data, and results freely available					$1,746
							Sub Total	**$1,746**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$299,000**

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				
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $299,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 5c9d71ce-ce2.pdf

Alternate Text for Visual Component

Possible drivers of increased flooding in Minnesota. At top: clouds with snow shifting to more rain. Middle: trees and grasslands shifting to crops and stubble on barren soil with a pipe coming from drain tile. Bottom: river and a question about the cause of increased streamflows....

Supplemental Attachments

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

Title	File
SPA endorsement letter	9d7f78e6-cf5.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?

No

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:

Prof. Xue Feng, St. Anthony Falls Laboratory, University of Minnesota
Ms. Angela Boutch, St. Anthony Falls Laboratory, University of Minnesota

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