Environment and Natural Resources Trust Fund
2024 Request for Proposal

General Information

Proposal ID: 2024-213

Proposal Title: Flood and Drought Prediction for Minnesota

Project Manager Information

Name: Wendy Moylan

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

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Project Basic Information

Project Summary: This project will analyze existing and projected data to develop simple tools to predict the effect of land use and climate change on extreme floods and droughts.

Funds Requested: $499,000

Proposed Project Completion: June 30, 2026

LCCMR Funding Category: Water Resources (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

Narrative

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

The world's environment is changing fast, and we need adaptable tools to plan for and manage extreme water events in the future. Future weather is expected to be more variable and extreme because of climate change. For this study, we focus on extreme high and low flows as surrogates for floods and droughts. For high flows, we know that extreme storms and more urban impervious areas aggravate high streamflow and increase flooding. We also know that water withdrawals, irrigation, and field drainage can lower baseflows and exacerbate droughts. How do we plan for and manage water resources in the future?

High- and low- streamflow prediction has been used by the USGS for decades. The approach uses simple regression equations to estimate extreme flows, but these equations included mostly static variables (e.g., soils). No variables accounted for changing conditions due to development (e.g., urban sprawl) or extreme weather conditions (e.g., 100-year 24-hour storm), In addition, few variables were included to represent management options. The opportunity we see is to upgrade the USGS approach to include both changing land use, weather, and management variables, thereby providing a powerful and simple planning tool to estimate future floods and droughts.

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 develop this planning tool for Minnesota by teaming with USGS and Geosyntec. The tool will be designed to accommodate newer information as it becomes available.

We will focus on watersheds with downstream long-term USGS streamflow gauges. We will start with a smaller area to flesh out ideas and limit data processing before expanding to the state. USGS will perform a gap analysis of available geographic (GIS) data for the selected watersheds. We envision developing some new data and GIS layers.

We will review past regression approaches to identify regions, approaches, and timesteps that should be used for high- and low flow analysis. We will identify crucial land use, weather, and management variables that influence both high- and low streamflow. We plan to use the downscaled CMIP5/CMIP6 data depending on what's available at project initiation. We will use the best five models that mimic Minnesota's historical weather and two climate change scenarios (RCP4.5 and RCP8.5). The gridded downscaled CMIP data will averaged over the watershed area.

The tool will be hosted online by Geosyntec and likely be included in USGS's online StreamStats package. Project outcomes will be detailed in a final report and summarized in webinar.

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 provide a quantitative analysis of floods and droughts in a changing environment, providing cities and watershed districts with more accurate estimates of extreme water events. The quantitative nature of the approach will clearly identify the most important factors that affect these extreme events. Water suppliers, planners and resiliency managers will be better equipped to plan and/or manage for extreme water events in the future. Because of the way the tool will be designed, it will be adaptable to new information so it will have a useful life beyond this project, and it will be readily available.

Activities and Milestones

Activity 1: Collection of Data

Activity Budget: $125,000

Activity Description:
The research team will collect GIS and time series data for the project using data from existing tools, publications, and past work. We will use at least five hydrologic regions that might be different for high and low flow estimation. This targeted effort will prioritize relevant factors in prior USGS reports on extreme flow prediction. Known spatial factors that could affect extreme flows are drainage area and slope, soil types, net precipitation or mean runoff, and water, forest, cropland, drained, flat, and impervious areas. In addition, water withdrawals, wastewater discharges, and irrigation patterns affect low flows.

We will begin with 15-20 pilot watersheds and ultimately expand to about 200 watersheds statewide. Watersheds will be selected by geographic distribution, streamflow record, and quality of data. We will leverage our partnerships and the TAC to establish the best data sources for GIS data and time series data. In contrast to previous USGS reports on extreme flows, we will not discard data with trends, instead we will work to capture the effect of the trend (e.g., climate change data) in our approach. Data extraction, transformation, and loading scripts will be developed in R or Python to streamline data collection and minimize duplication.

Activity Milestones:

Description	Approximate Completion Date
Database format for available data	August 31, 2024
Scripts used to populate the database	December 31, 2024
Database populated with available data	April 30, 2025

Activity 2: Development of Simple Prediction Tools

Activity Budget: $299,000

Activity Description:
The research team will first develop the analysis framework for this project. Regression analysis will be guided by past USGS approaches and other publications. The goals of the regression are accuracy (fits the observed) and efficiency (less correlated parameters) without losing meaningful management variables. We will use common procedures for selecting regression models (like stepwise selection) that can be automated to streamline the process.

Regression scripts will be developed in R or Python to help with the analysis of this large dataset based on both physical and trend factors. For our pilot phase, we will investigate supplementary approaches (e.g., principal componentanalysis, machine learning) to help identify meaningful relationships to guide the regressions. We will also consider a few sub-models to predict variables that directly affect flow (e.g., actual evapotranspiration).

The outcome of this project will be a summary table of regionally based equations that predict extreme streamflow using both physical and anthropogenic factors. To facilitate the use of these complex equations at the local level, we will develop a user-friendly spreadsheet for extreme flow estimation. This spreadsheet will enable planners and climate resiliency managers to keep track of the risk of extreme flow events as the environment continues.

Activity Milestones:

Description	Approximate Completion Date
Analysis framework for extreme flow prediction	May 31, 2025
Scripts used to perform regression analysis	December 31, 2025
Final table of extreme flow equations	March 31, 2026
User-based spreadsheet for extreme flow estimation	April 30, 2026

Activity 3: Project Management and Reporting

Activity Budget: $75,000

Activity Description:

The team will establish a Technical Advisory Committee (TAC) with experts from Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources, watershed districts, municipal planners and resiliency managers. The TAC will meet every three months while the full project team will meet monthly.

A draft and final report will provide documentation of the project and the user page in the spreadsheet model will clearly explain the tools. Following the completion of the final report, Geosyntec will develop draft and final training slides, then conduct a one-hour workshop (recorded) on the newly developed tool for Minnesota.

Our team will provide brief progress updates to the LCCMR as contracted. The updates will include documentation of the TAC meetings, status of the tasks, discussion of unexpected issues and resolutions, and any results to date.

Activity Milestones:

Description	Approximate Completion Date
Proposed TAC members to LCCMR	August 31, 2024
Monthly team meetings and three-monthly TAC meetings	June 30, 2026
Brief progress updates as contracted	June 30, 2026
Final Report	June 30, 2026
One-hour training webinar	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Nigel Pickering	Geosyntec	Partner, research, developer, host of tool	Yes
Sara Levin	USGS	Partner, Research, developer	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?

Geosyntec will initially host the download of the spreadsheet tool as part of the project but seek assistance from the DNR or MPCA for hosting and training. The tool's equations will ultimately be included in USGS's online StreamStats package. The LCCMR could provide funds for the development of enhancements to the tool, if necessary, as more data (e.g., CMIP6) become available.

The results of this project will be disseminated by 1) interacting closely with practitioners in our TAC; presenting the results at conferences including the: Minnesota Water Resources Conference, Minnesota Watersheds Conference, Central States Water Environment Association (CSWEA) Conference,

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Setting Realistic Nitrate Reduction Goals in Southeast Minnesota	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04m	$350,000

Project Manager and Organization Qualifications

Project Manager Name: Wendy Moylan

Job Title: Professor

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

John Nieber has 43 years conducting research and teaching at major research universities (38 years at the University of Minnesota). He has conducted research in hydrology and water quality problems during that time. He has published over 100 refereed journal manuscripts and is a license professional engineering and certified professional hydrologist.

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

Organization Description:

In the College of Food, Agricultural and Natural Resources Sciences (CFANS) at the University of Minnesota, we look at the bigger picture. When we envision a better tomorrow, it includes disease-resistant crops, products that protect our health, lakes free from invasive species, and so much more. We use science to find answers to Minnesota's and the world's grand challenges and solve tomorrow's problems. Almost 93 percent of students who earn CFANS undergraduate degrees find jobs in their career field or enter graduate school within six months of graduation.
The Department of Bioproducts and Biosystems Engineering, in CFANS, discovers and teaches solutions for the sustainable use of renewable resources and the enhancement of the environment. We discover innovative solutions to address challenges in the sustainable production and consumption of food, feed, fiber, materials, and chemicals by integrating engineering, science, technology, and management into all degree programs.
We have a public impact through community engagement and extension efforts. We develop and deliver high quality,

regionally and nationally-recognized research-based programs to meet current and emerging needs of industry and communities. We also have a long-standing tradition of close partnerships with alumni, industry professionals, organizations, government agencies, donors, and community members.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Lead Principal Investigator		Lead research, oversee all aspects of project			36.8%	0.08		$23,722
Co-Principal Investigator		Supervise student, advice on machine learning and statistical methods			36.8%	0.12		$28,884
Graduate student		Computer Science Researcher applying machine learning methods, education			39.22%	2		$152,809
							Sub Total	$205,415
Contracts and Services								
Geosyntec	Sub award	Geosyntec's highly technical staff will support all aspects of the project including the GIS and scripting tasks.				0		$200,000
USGS (United States Geological Society)	Sub award	USGS will provide access to prior similar projects and support the data aggregation and analysis tasks.				0		$85,440
University of Minnesota College of Science and Engineering	Internal services or fees (uncommon)	This College has a special charge for networking and computing costs				0		$8,145
							Sub Total	$293,585
Equipment, Tools, and Supplies								
							Sub Total	-
Capital Expenditures								
							Sub Total	-

Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
							Sub Total	-
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	**$499,000**

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	-

Attachments

Required Attachments

Visual Component

File: 6b51280f-486.pdf

Alternate Text for Visual Component

The steps involved in creating a system of prediction equations and the dissemination of the methods to practitioners....

Optional Attachments

Support Letter, Photos, Media, Other

Title	File
UMN authorization	6ae966fd-2ea.pdf
Geosyntec agreement to collaborate	efe9b728-645.pdf
2022 Audit	25380caf-bcd.pdf
Geosyntec audited financials document	febc67b7-e31.pdf
USGS letter of agreement to collaborate	3880119f-df2.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

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 design, construction, or renovation of a building, trail, campground, or other capital asset costing $10,000 or more?

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?

No