# Environment and Natural Resources Trust Fund

M.L. 2024 Approved Work Plan

## General Information

**ID Number:** 2024-213

**Staff Lead:** Lisa Bigaouette

**Date this document submitted to LCCMR:** June 5, 2024

**Project Title:** Flood and Drought Modeling for Minnesota

**Project Budget:** $499,000

## Project Manager Information

**Name:** John Nieber

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## Project Reporting

**Date Work Plan Approved by LCCMR:** June 20, 2024

**Reporting Schedule:** June 1 / December 1 of each year.

**Project Completion:** June 30, 2026

**Final Report Due Date:** August 14, 2026

## Legal Information

**Legal Citation:** M.L. 2024, Chp. 83, Sec. 2, Subd. 04j

**Appropriation Language:** $499,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to compile new and existing data and develop a tool to provide cities and watershed districts with quantitative estimates of the effects of land use and climate change on floods and droughts.

**Appropriation End Date:** June 30, 2027

## Narrative

**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.

**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.

## 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

## Activities and Milestones

### Activity 1: Collection of Watershed and Climate Data

**Activity Budget:** $125,000

**Activity Description:**
The research team will compile GIS and time series data for the project using data from existing tools, publications, and past work. We will use 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 one hydrologic region and ultimately expand to all regions 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. 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.

Data requirements for ENRTF are understood and will be be complied within the project.

**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 Flood and Drought Prediction Tools

**Activity Budget:** $299,000

**Activity Description:**
First we will develop the analysis framework for this project. Regression analysis will be guided by past USGS approaches and other publications. The goal will be to provide prediction equations that are accurate and efficient (use minimum parameters). 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 component analysis, 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).

This activity will provide a summary table of regionally based equations that predict extreme streamflow using both physical and anthropogenic factors. To facilitate use of these equations at the local level, we will develop a user-friendly spreadsheet to estimate the desired extreme flow statistic. This spreadsheet will enable planners and climate resiliency managers to keep track of the risk of extreme flow events as the environment continues to change.

**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 |
|---|---|---|---|
| TBD | P/T/S/ contract | Partner, research, developer, host of tool | Yes |
| Sara Levin | USGS | Partner, Research, developer | 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.**
The results of this project will be disseminated by 1) interacting closely with practitioners in our TAC; interacting closely with participants in the One Watershed One Plan groups, and 3) presenting the results at conferences including the: Minnesota Water Resources Conference, Minnesota Watersheds Conference, and the Central States Water Environment Association (CSWEA) Conference.

The Minnesota Environment and Natural Resources Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgement Guidelines.

## 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 topic of the project is one of national and international interest. The project manager is currently collaborating with university computer scientists and hydrologists to develop machine learning techniques for hydrologic applications with funding from the National Science Foundation. The ENRTF funding is critical to the formation of the collaboration between the University, the USGS and the environmental industry for development of the specific prediction tools. A successful outcome from this project will provide a platform to compete for funding from agencies including NOAA, NSF, and the USGS for further development of prediction tools.

## 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 |

## 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 | | 1.5 Graduate students applying machine learning methods, education | | | 39.22% | 3 | | $152,809 |
| | | | | | | | **Sub Total** | **$205,415** |
| **Contracts and Services** | | | | | | | | |
| P/T/S contract | Sub award | The contractor 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** | | | | |
| In-Kind | Indirect cost (54%) contributed by the University of Minnesota | NA | Secured | $269,460 |
| Cash | United States Geological Survey, federal funds | support of work by Sara Levin | Pending | $35,000 |
| | | | **Non State Sub Total** | **$304,460** |
| | | | **Funds Total** | **$304,460** |

# 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....

## Supplemental Attachments

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

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

# Difference between Proposal and Work Plan

*Describe changes from Proposal to Work Plan Stage*

We added in the section on the dissemination of project results, and updated the long-term implementation and funding section.

## Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

**Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?**

N/A

**Do you agree travel expenses must 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?**

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