



## Environment and Natural Resources Trust Fund

### 2022 Request for Proposal

#### General Information

**Proposal ID:** 2022-152

**Proposal Title:** Water and Climate Information to Enhance Community Resilience

#### Project Manager Information

**Name:** Tracy Twine

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

**Office Telephone:** (612) 625-7278

**Email:** twine@umn.edu

#### Project Basic Information

**Project Summary:** To support Minnesota's climate resiliency investments, we will generate critical water resources information and share it with impacted communities and individuals to guide adaptation planning and water resources management.

**Funds Requested:** \$564,000

**Proposed Project Completion:** June 30 2025

**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 and In the Future

## Narrative

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

Water in Minnesota is a critical cultural and natural resource, vital to our state's recreation and tourism, industry, agriculture, and Indigenous culture and lifeways. Warmer and wetter conditions, combined with more intense and frequent precipitation events, challenge our ability to effectively manage our water resources for people, plants, and animals. While precipitation is increasing on average across the state, the larger events may also cause more water to runoff and make less available to recharge groundwater. This can reduce water availability, a trend observed in some regions of the state already. Climate projections and hydrologic models are needed to take these observations and provide scenarios of possible Minnesota groundwater futures so communities can prepare for, and respond to, potential changes in groundwater reserves.

**What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.**

Two recent developments have created an opportunity to produce improved information about water fluxes under changing climatic conditions: (1) the University of Minnesota (UMN) has produced climate projection data sets optimized for Minnesota, and (2) the USGS has improved their Soil-Water-Balance (SWB) model code. UMN produced this climate dataset not only to examine what the climate of Minnesota might look like by the end of the century, but also to be used as input into models of other variables relevant to various sectors (i.e., economic, hydrologic, etc.). In this proposed collaboration, we have the unique opportunity to simulate the partitioning of precipitation as it reaches the surface of Minnesota under potential changes in climate. Here we propose to (1) understand how major fluxes of water including runoff, evapotranspiration, and groundwater recharge respond to climate forcings of precipitation and temperature under various future scenarios, (2) develop scenarios of the future impacts to replenishment of groundwater reserves, (3) create a data interface to engage stakeholders with these scenarios, and (4) develop a training module to connect users to the interface.

**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 produce publicly available information about interactions between Minnesota's changing climate and groundwater recharge, evapotranspiration, runoff, and crop water demand. The information can be used to help communities and individuals address issues that intersect both groundwater and surface water. Potential applications of the products from this project include evaluating future irrigation needs due to long-term precipitation changes, assessing the risk of drinking water shortages for communities that rely on groundwater, and reducing impacts to Minnesota's lakes and rivers that have connections to groundwater systems.

## Activities and Milestones

### Activity 1: Produce statewide, long-term simulations of groundwater recharge, runoff, crop water demand, and evapotranspiration

**Activity Budget:** \$290,009

#### Activity Description:

We aim to use state of the art past, present, and future climate data sets with a newly updated USGS Soil-Water-Balance (SWB) model code to translate the climate data into statewide information about groundwater recharge, runoff, crop water demand, and evapotranspiration for the periods 1980 - 2020, 2040-2059, and 2080-2099.

A statewide application of the USGS SWB model already exists and is widely used; however, it has a number of limitations we will address through this project. First, the existing SWB application only covers the years 1996 to 2010; we will extend this range to 1981 through 2020 for a larger baseline. Second, the existing SWB application did not evaluate water budget changes in response to changing climate conditions; we will evaluate water budget changes for two emissions scenarios and two future time periods using newly developed climate datasets. Third, the existing SWB application focused on groundwater recharge; we will add plant evapotranspiration, runoff, and crop water demand to the list of simulated values. The resulting set of model projections will provide a range of values for possible future hydrologic water budget components.

#### Activity Milestones:

Description	Completion Date
Prepare Soil-Water-Balance (SWB) model for new climate input dataset--format, debug, test	December 31 2022
Assemble observed streamflow, groundwater-level, evapotranspiration, and irrigation data for calibration of model	June 30 2023
Run simulations with observations and historic climate data--evaluate and calibrate	May 31 2024
Run simulations with future climate scenarios, evaluate and engage with visualization in Activity 2	April 30 2025

### Activity 2: Data Delivery and Capacity-Building for Connecting Science to Action

**Activity Budget:** \$273,991

#### Activity Description:

The University of Minnesota Extension (Roop and Larson) is developing a dedicated climate services program to deliver critical climate-related information to a diversity of stakeholders across the state. This work includes the development of a suite of interactive data tools, trainings, convenings and technical support services. We will leverage this program and forthcoming website ([climate.umn.edu](http://climate.umn.edu)) to develop an interface to connect the models, and an interactive data tool to visualize the climate projections and water budgets. This visualization will be supplemented by a series of training modules to help communities, industries, and individuals understand how to best use the data in decision-making, with an emphasis on how to use these data in existing decision-making frameworks. We will also develop a series of narrative-based scenarios using the model output to help illustrate to lake managers, community resilience professionals, public officials, and others the opportunities and potential outcomes and impacts that can result from different changes in climate and groundwater availability and accompanying adaptation interventions or solutions.

#### Activity Milestones:

Description	Completion Date
Develop preliminary data interface and visualization with initial model output	January 31 2023
Conduct user testing; update tools based on user feedback	June 30 2023
Publish visualization and develop toolkit resources	December 31 2024
Finalize visualization and toolkit materials; deliver at least two trainings for target stakeholder groups	May 31 2025



## Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Tracy Twine	University of Minnesota	Project Lead, oversee climate data analysis	Yes
Heidi Roop	University of Minnesota	Co-PI, oversee visualization and data portal activities, coordinate development of Extension training resources, supervise student	Yes
Stefan Liess	University of Minnesota	Co-PI, climate modeler, oversee interface between climate data and SWB model, help supervise student	Yes
Joel Larson	University of Minnesota	Extension program leader for water, assist with connecting the products and results with Water Resources Center audiences and stakeholders	No
Steve Westenbroek	USGS	SWB model developer. Will be involved in all aspects of SWB modeling and incorporate any updates to SWB model code needed to meet the goals of this project	Yes
Jared Trost	USGS	USGS project and data manager, assembly of input data sets, assistance with model calibration and data visualization	Yes
Martha Nielson	USGS	SWB model calibration expert, will provide guidance for model calibration and quantification of uncertainty.	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 be funded?**

Upon project completion, we expect these datasets to be maintained as part of the dedicated climate services program being developed through University Extension. While the datasets evolve as our knowledge is updated, the infrastructure developed will be maintained into the future. Interpretations of the data will be available to the public, and SWB model output will be available as input to users of other models.

## Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
MITPPC #2: Early Detection, Forecasting and Management of Brown Marmorated Stinkbug ( <i>Halymorpha halys</i> )	M.L. 2014, Chp. 312, Sec. 8	-
Understanding Water Scarcity, Threats, and Values to Improve Management	M.L. 2015, Chp. 76, Sec. 2, Subd. 04a	\$234,000
Protection of State's Confined Drinking Water Aquifers - Phase II	M.L. 2016, Chp. 186, Sec. 2, Subd. 04h	\$433,000
Techniques for Water Storage Estimates in Central Minnesota	M.L. 2017, Chp. 96, Sec. 2, Subd. 04h	\$250,000
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:** Tracy Twine

**Job Title:** Associate Professor

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

Professional Preparation

The Pennsylvania State University	University Park, PA Meteorology	B.S., 1994
University of Wisconsin-Madison	Madison, WI Atmospheric and Oceanic Sciences	M.S., 1998
University of Wisconsin-Madison	Madison, WI Atmospheric and Oceanic Sciences	Ph.D., 2004

#### Appointments

Associate Professor, Department of Soil, Water, & Climate, University of Minnesota, 2014-present

Fellow, Institute on the Environment, University of Minnesota, 2017-present

Assistant Professor, Department of Soil, Water, & Climate, University of Minnesota, 2008-2014

Assistant Professor, Department of Atmospheric Sciences, University of Illinois Urbana-Champaign

Graduate Research & Teaching Assistant, University of Wisconsin-Madison, 1996-2004.

Data Analyst on Boreal Ecosystem-Atmosphere Study (BOREAS), Research and Data Systems Corporation, NASA Goddard Space Flight Center, Greenbelt, MD, 1994-1996.

Dr. Twine's research accomplishments have been in biosphere-atmosphere interactions, primarily the effects of land cover change and climate change on regional water and energy budgets. Her group has developed high resolution projections of Minnesota's future climate, projected changes to crop production and water use with climate change, quantified the potential effects of the large-scale production of perennial grasses as biomass energy crops on the hydrology of the Upper Midwest, and characterized the Twin Cities urban heat island via citizen science with backyard temperature sensors. She has over twenty years' experience with the development, testing, and implementation of dynamic ecosystem modeling. She has used datasets derived from satellite measurements to test these models, and also has experience collecting in situ measurements of biological and micrometeorological variables in grasslands and agroecosystems. She has taught undergraduate and graduate courses including introductory weather and climate, environmental biophysics, and proposal writing for land and atmospheric science. Dr. Twine has advised Mr. Al Gore and Minnesota legislators, and has contributed to Will Steger's Climate Generation, the Bell Museum, and the Science Museum of Minnesota.

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

#### Organization Description:

The mission of the University of Minnesota (UofM) includes Research and Discovery, Teaching and Learning, and Outreach and Public Service. Grand challenges in the College of Food, Agriculture, and Natural Resource Sciences (CFANS) include food security, agricultural productivity, invasive species and biodiversity, pest and disease dynamics, climate change and renewable energy, water resources protection, and educating future leaders in applied science and technology. CFANS includes the Department of Soil, Water, and Climate, whose mission is to advance our understanding of Earth system processes and the interaction among land, atmosphere, and water. Through research, teaching, and extension we seek to improve and protect the quality of soil, air, and water resources in natural and managed ecosystems; enhance agricultural and forest productivity and sustainability; predict and mitigate impacts of environmental and climate change on ecosystems and society; and provide science based knowledge for improved decision making and a better informed citizenry.

## Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
<b>Personnel</b>								
Tracy Twine		Lead PI			36.5%	0.06		\$12,015
Heidi Roop		Co-PI			36.5%	0.12		\$19,609
Stefan Liess		Co-PI			36.5%	0.24		\$24,063
Graduate Student		MS			88%	3		\$155,688
							<b>Sub Total</b>	<b>\$211,375</b>
<b>Contracts and Services</b>								
United States Geological Survey (USGS)	Sub award	Simulate major components of the land surface water cycle (groundwater recharge, runoff, crop water demand, and evapotranspiration) with past, present, and future climate data and soil and land cover data sets in newly updated USGS Soil-Water-Balance model. Costs include project/data management, modeling, IT costs, calibration, reporting, meeting travel.				1.77		\$288,100
University of Minnesota Supercomputing Institute (MSI)	Internal services or fees (uncommon)	MSI charges \$208.95/year per TB of storage. We estimate we will require 10TB of storage for three years of the project.				0		\$6,269
							<b>Sub Total</b>	<b>\$294,369</b>
<b>Equipment, Tools, and Supplies</b>								
	Equipment	one desktop computer	dedicated to project for student to connect to supercomputer and analyze data					\$1,500
	Tools and Supplies	Software	\$5,000 for data portal development, \$50,000 for API development (estimated by CFANS GEMS)					\$55,000
	Tools and Supplies	training supplies	printing materials for training stakeholders on data portal					\$1,000

							<b>Sub Total</b>	<b>\$57,500</b>
<b>Capital Expenditures</b>								
							<b>Sub Total</b>	<b>-</b>
<b>Acquisitions and Stewardship</b>								
							<b>Sub Total</b>	<b>-</b>
<b>Travel In Minnesota</b>								
	Miles/ Meals/ Lodging	two trips, potentially > 100 miles, for car rental & meals for 6 people	engage with stakeholders in region identified as key groundwater resource to train on data visualization, learn their concerns					\$756
							<b>Sub Total</b>	<b>\$756</b>
<b>Travel Outside Minnesota</b>								
							<b>Sub Total</b>	<b>-</b>
<b>Printing and Publication</b>								
							<b>Sub Total</b>	<b>-</b>
<b>Other Expenses</b>								
							<b>Sub Total</b>	<b>-</b>
							<b>Grand Total</b>	<b>\$564,000</b>



Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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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: [65f2f395-2ae.pdf](#)

#### *Alternate Text for Visual Component*

Maps showing 1996-2010 mean potential groundwater recharge, projected change in winter air temperature by 2100 (baseline 1990), and projected change in spring daily precipitation by 2100 (baseline 1990) across the state of Minnesota shown as examples of models to be combined. Photos of a wet crop field, lake, and well shown as example of water resources that will be quantified in the project. Photos of scientists and stakeholders engaged in tours of fields and map examination....

### Optional Attachments

#### *Support Letter or Other*

Title	File
USGS Letter of Intent	<a href="#">ebae4cd5-167.pdf</a>

## 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

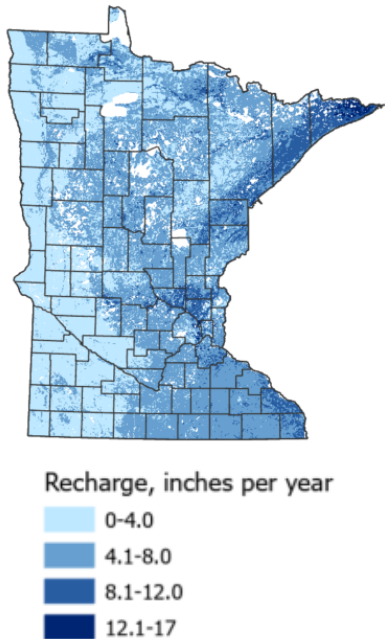
**Does the organization have a fiscal agent for this project?**

Yes, Sponsored Projects Administration

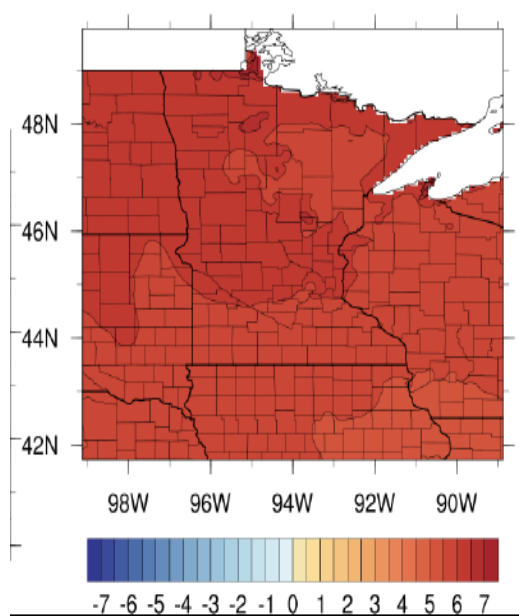
## Water and Climate Information to Enhance Community Resilience

- 1) Combine groundwater models and climate projections to develop scenarios of Minnesota's warmer and wetter future

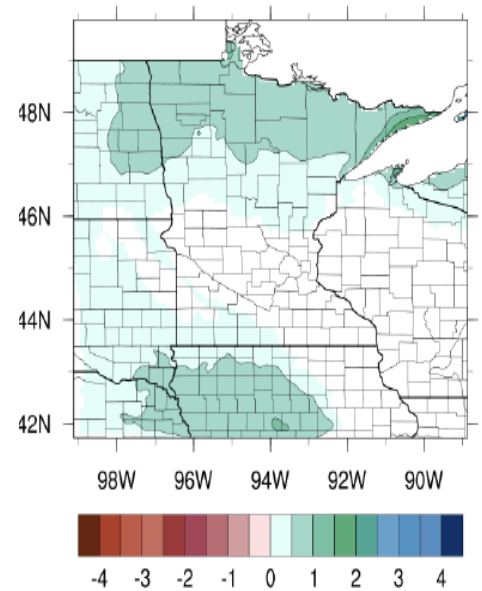
**1996-2010 mean potential groundwater recharge**



**Simulated change in winter air temperature (°C) by 2100**



**Simulated change in spring daily precipitation (mm) by 2100**



- 2) Use combined models to assess impacts on water resources, including irrigation, lakes and rivers, and drinking water



- 3) Collaborate with communities and stakeholders to inform their planning and decision-making

