

**Environment and Natural Resources Trust Fund  
2020 Request for Proposals (RFP)**

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**Project Title:**

**ENRTF ID: 004-A**

Minnesota; How much Water? How is it Changing?

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**Category:** A. Foundational Natural Resource Data and Information

**Sub-Category:**

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**Total Project Budget: \$** 529,139

**Proposed Project Time Period for the Funding Requested:** June 30, 2023 (3 yrs)

**Summary:**

Accurate water storage estimates (groundwater, soil moisture, streams, lakes, wetlands) are essential to sustainable water management. We will integrate satellite monitoring with traditional ground-based measurements to improve water storage estimates.

**Name:** John Nieber

**Sponsoring Organization:** U of MN

**Job Title:** Dr.

**Department:** Bioproducts and Biosystems Engineering

**Address:** 1390 Eckles Ave.

St. Paul MN 55108

**Telephone Number:** (612) 625-6724

**Email** nieber@umn.edu

**Web Address**

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**Location:**

**Region:** Statewide

**County Name:** Statewide

**City / Township:**

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**Alternate Text for Visual:**

Illustrations of water storage related to flooding and drought conditions, satellite data display of water storage across Minnesota, and designation of areas for Phase I and Phase II projects.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____ %



**PROJECT TITLE: Minnesota; How much water? How is it changing?**

**I. PROJECT STATEMENT**

Minnesota is known as a land of plentiful water – but up until now nobody has been able to determine how much water there is. This proposed project would complete an ongoing LCCMR-funded project to answer the questions “**How much water is in Minnesota?**” and “**how is it changing over time?**” In phase 1 (presently underway), we are completing an analysis for 17 of major watersheds in the central part of Minnesota. In this proposed phase 2, we will complete the same analysis for the remaining 63 of 81 major Minnesota watersheds, resulting in a consistent statewide assessment of current water storage and development of methods for tracking how that storage is changing with time.

This project will improve our ability to monitor and quantify changes in the amount of water stored in groundwater aquifers, soils, lakes, wetlands, and streams throughout Minnesota. Knowledge of total water storage and how it changes through time is essential for sustainable management and wise use of water resources throughout the state. Water storage affects the availability of the water for human use (industry, irrigation, power production, domestic), and the availability of the water needed to support aquatic ecosystems (streams, lakes, wetlands, springs, etc.) throughout the state.

Currently water storage in aquifers can be estimated using networks of observation wells (MNDNR, MDA, USGS, and other entities), and water storage in lakes and wetlands can be estimated from water level measurements at MNDNR/citizen monitoring sites. The combined phase 1 and phase 2 results will leverage these extensive monitoring data sets to produce the first statewide estimate of total water storage and changes through time. Adding to this capability we will utilize the vast amount of available satellite data for use in remote monitoring of water storage. In the current project we have been using satellite data to estimate storage of groundwater, soil moisture, and water in lakes in the central part of Minnesota. Putting the ground-based data together with the satellite data provides a reliable basis for tracking water storage, and also provide estimates of water storage in locations where ground-based measurements are sparse or missing entirely.

**II. PROJECT ACTIVITIES AND OUTCOMES**

**Activity 1 Title: Acquire archived data and calibration data for HSPF (Hydrologic Simulation Program Fortran) models.**

**Description:** ***Monitoring data:** Used to ground-truth satellite data and models. Available data will be acquired for streamflows, river and lake water levels, wetland water levels, soil moisture, groundwater levels, and meteorological variables. The data will be acquired for the period 2002-2019. **Satellite data:** Used to observe large-scale changes in water storage and thereby extend ground-based monitoring data. Available data will be acquired from NASA and associated database sources. **Models:** Used to conduct water balances to explain storage changes observed by satellites and ground-based data. Through contract the MPCA has calibrated HSPF models for most of the major watersheds in the state.*

**ENRTF BUDGET: \$60,000**

Outcome	Completion Date
1. Complete set of hydrologic, soil, geologic, groundwater level, meteorological, and topographic data, prepared for our use. All data will be archived and available on DVD as well as on our current project website and on the USGS website.	3/31/21

**Activity 2 Title: Develop estimates of groundwater, soil moisture and surface water storage for each of the 81 major watersheds for each year, 2002-2019.**

**Description:** *In our current study we have developed estimates of water storage in groundwater, soil moisture and surface water for the 17 major watersheds for each year of the period 2002-2015. We will use the same*



**Environment and Natural Resources Trust Fund (ENRTF)**

**2020 Main Proposal**

**PROJECT TITLE: Minnesota; How much water? How is it changing?**

*methodologies for estimating water storages of the remaining 81 major watersheds of the state, and for each year 2002-2019. The methodology involves the use of groundwater level data from the MNDNR monitoring well network along with aquifer property information (e.g., available Minnesota County Geologic Maps), river stage data, and lake/wetland water level data along with lake/wetland bathymetry data. Pointwise estimates of water storage are extended with statistical methods to provide areal estimates across whole watersheds.*

**ENRTF BUDGET: \$172,000**

<b>Outcome</b>	<b>Completion Date</b>
1. Point estimates of annual baseline water storage for 2002 through 2019.	9/30/2021
2. Maps showing distribution of estimates of annual water storage by surface water and groundwater across the state of Minnesota for 2002 through 2019.	12/31/2021

**Activity 3 Title: Estimate the changes in water storage over the period 2002 through 2019.**

**Description:** *The methodology for tracking the change of water storage across Minnesota will use satellite remote sensing data along with ground-based measurements. The methodology will use the HSPF model to combine and provide consistency among the various satellite and ground-based data. The method will use the data and the model to track changes in water storage for the period 2002 through 2019.*

**ENRTF BUDGET: \$297,139**

<b>Outcome</b>	<b>Completion Date</b>
1. Completed methodology for estimating the change in water storage across the state. User documentation on the methodology and associated software.	6/30/2022
2. Validation of water storage change estimation methodology.	03/31/2022
3. Final completion report.	06/30/2023
4. Publication of reports, data and models	06/30/2023

**III. PROJECT PARTNERS AND COLLABORATORS:**

Jared Trost, USGS hydrologist for estimation of groundwater storage and publication of results; Francisco Lahoud, research associate, University of Minnesota for satellite data analysis; Zhenong Jin, Assistant Professor, University of Minnesota for estimation of evapotranspiration; graduate research assistants, University of Minnesota for data acquisition, analysis, and HSPF modeling; Dr. Bruce Wilson, professor, University of Minnesota for uncertainty analysis.

**IV. LONG-TERM IMPLEMENTATION AND FUNDING:**

A permanent, publicly available, interactive map-based web page will be produced to make the results broadly available to state, national, and international users. Processed data for 2002 through 2019 will be available through the website, and procedures for acquiring data beyond 2019 will be outlined. The methodology will be presented to the Minnesota water community, including resource managers at state and local agencies and scientists at academic institutions, through a workshop and occasional seminars held at the University of Minnesota. Due to the potential of the methods for assisting with flood and drought forecasting we will meet with the National Weather Service, Weather Forecast Office located in Chanhassen. We would like to propose that through this project activity we will be able to assist the MnDNR to develop strategies for placement of additional observation wells that will be beneficial to the interpretation of satellite data.

**Attachment A: Project Budget Spreadsheet**  
**Environment and Natural Resources Trust Fund**  
**M.L. 2020 Budget Spreadsheet**



**Legal Citation:**

**Project Manager:** John Nieber

**Project Title:** Minnesota; How much water? How is it changing?

**Organization:** University of Minnesota

**Project Budget:** \$529,139

**Project Length and Completion Date:** 3 years - June 30, 2023

**Today's Date:** 4/11/19

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET		Budget	Amount Spent	Balance
<b>BUDGET ITEM</b>				
<b>Personnel (Wages and Benefits)</b>		\$ 379,779	\$ -	\$ 379,779
Zhenong Jin, Co-PI, .08 FTE, 3 years, \$42,454, 73.5% salary, 26.5% fringe, Will work with the various satellite projects available for estimating soil moisture and evapotranspiration. He will assist with advising the graduate students involved in the project. (Summer salary)				
Research scientist, 0.43 FTE, \$101,062, 77% salary/23% fringe, Will work on the algorithms for estimation of lake and wetland volumes, and also work on the estimation of soil moisture and evapotranspiration				
Graduate assistants, .75 FTE, \$230,020, 55% salary, 45% fringe, Two graduate students to assist with the research. They will be involved in data collection, data processing, modeling, data analysis, and report writing. One student will be full-time, and the other will be half-time on the project.				
Undergraduate assistant, .06 FTE, \$6,243, 100% salary, One undergraduate student to assist with data collection, data processing, and results presentation				
<b>Professional/Technical/Service Contracts</b>			\$ -	\$ -
Subaward USGS - Jared Trost - will work on the estimate of water storage in the aquifers of the state.		\$ 119,360	\$ -	\$ 119,360
Some satellite products require processing of satellite data to get the data in a format useful for our analysis. While the satellite data is free for download, some of the the processed data is made available only at cost by different vendors. Some processed data is available for free from NASA, JPL, and other government agencies around the world. We propose to purchase the processed data when processed data is not made available for free.		\$ 30,000	\$ -	\$ 30,000
<b>Equipment/Tools/Supplies</b>			\$ -	\$ -
<b>Capital Expenditures Over \$5,000</b>		\$ -	\$ -	\$ -
<b>Fee Title Acquisition</b>		\$ -	\$ -	\$ -
<b>Easement Acquisition</b>		\$ -	\$ -	\$ -
<b>Professional Services for Acquisition</b>		\$ -	\$ -	\$ -
<b>Printing</b>		\$ -	\$ -	\$ -
<b>Travel expenses in Minnesota</b>		\$ -	\$ -	\$ -
<b>Other</b>		\$ -	\$ -	\$ -
		\$ 529,139	\$ -	\$ 529,139
<b>COLUMN TOTAL</b>				
		<b>Budget</b>	<b>Spent</b>	<b>Balance</b>
<b>SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT</b>		<b>Status (secured or pending)</b>		
Non-State: USGS Water Science Center		pending	\$ 51,150	\$ -
State:			\$ -	\$ -
In kind: Unrecovered F&A		Secured	\$ 182,425	\$ 182,425
		<b>Budget</b>	<b>Spent</b>	<b>Balance</b>
Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS		Amount legally obligated but not yet spent	\$ 250,000	\$ 231,000
			\$ 19,000	

# How much water is there?

## The issues:

Too much water



Too little water

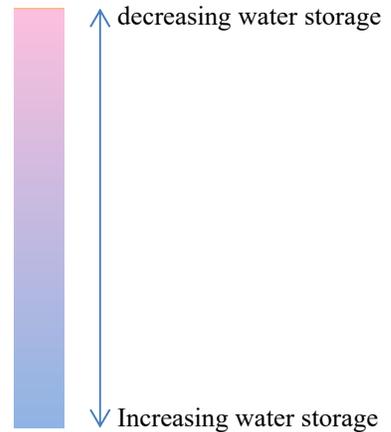


How much water is there? We can quantify this by combining multiple data sources, including data from satellites, observation wells, stream gauges, weather stations, soil maps, geology maps, and land surface topography.

### Satellites:



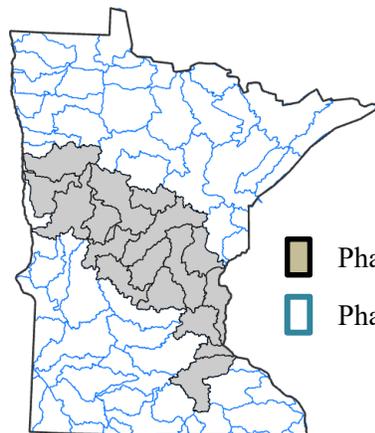
GRACE



GRACE satellite results, 2003-2012. Large parts of Minnesota show decreasing water storage (Source: NOAA)

### Satellite data merged with ground-based measurements, including:

- Observation wells
- Lake levels
- Streamflow
- weather



- Phase 1 (in process)
- Phase 2 (this proposal)

Project study area, as defined by boundaries of 81 major watersheds in Minnesota

## Project Manager Qualifications & Organization Description

### **PI:**

Name: John L. Nieber

Title: Professor

Degrees: 1972, B.S., Forest Engineering, Syracuse University

1974, M.S., Civil and Environmental Engineering, Cornell University

1979, Ph.D., Agricultural Engineering, Cornell University

Licensed Professional Engineer: Minnesota

Certified Professional Hydrologist: American Institute of Hydrology

Affiliation: Department of Bioproducts and Biosystems Engineering, University of Minnesota

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John Nieber has over 36 years of experience working as a professional hydrologist in conducting teaching and research activities related to hydrology and water quality. In the 1980's he collaborated on research involving remote sensing of soil moisture and is currently advising a graduate student on a self-funded project using GRACE satellite data, and meteorological and hydrologic data to characterize changes in water storage within the Minnesota River Basin. He managed a LCCMR project on freshwater sustainability from 2007-2009, from which maps of groundwater recharge were derived. The work resulting in three publications in the scientific literature and has influenced freshwater sustainability planning activities within Minnesota. One student, Dr. Heidi Peterson received her Ph.D. degree as a result of support from this project. In 2014 Dr. Nieber took a 5-month sabbatical leave to the University of Padova in Italy to study the topic of travel time distributions for water in watersheds. The purpose was to learn techniques that could be used to estimate the lag time required for contaminants to be flushed out of watershed surface waters, soils and groundwater. John Nieber has managed numerous other projects as well, including being the manager of a five-year contract with the MPCA for the Impaired Waters Program. He is the author of over 80 refereed articles in the scientific literature.

### **Organization:**

The University of Minnesota Twin Cities campus is one of the Big Ten universities. It ranks very highly in many of its programs including its College of Food, Agriculture and Natural Sciences, and its College of Sciences and Engineering. It has excellent library resources and its resources for supercomputing are exceptional. In addition to all of the high quality features at the University of Minnesota, faculty at the University of Minnesota have developed excellent working collaborative relationships with scientists and engineers at the state and federal agencies within Minnesota.