Environment and Natural Resources Trust Fund
2019 Request for Proposals (RFP)

Project Title: **ENRTF ID: 085-B**

The Future of Groundwater Supply

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 280,000

Proposed Project Time Period for the Funding Requested: June 30, 2022 (3 yrs)

Summary:

Future groundwater supply -- crucial for sustaining Minnesota's lakes, streams, and drinking water -- will be forecast for a region of east-central Minnesota sensitive to groundwater inputs.

Name: James Almendinger

Sponsoring Organization: Science Museum of Minnesota

Title: Director, St. Croix Watershed Research Station

Department: St. Croix Watershed Research Station

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Location

Region: Northeast

County Name: Aitkin, Anoka, Carlton, Chisago, Isanti, Kanabec, Pine, Washington

City / Township: Stillwater and others in St. Croix basin

Alternate Text for Visual:

Schematic cross-section of watershed showing that a small reduction in precipitation can cause a large reduction in groundwater supply, causing large drops in water tables, lake levels, and streamflow.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%
____ If under $200,000, waive presentation?			

PROJECT TITLE: The Future of Groundwater Supply

I. PROJECT STATEMENT

• **Summary:** ***Future groundwater supply -- crucial for sustaining Minnesota's lakes, streams, and drinking water -- will be forecast for a region of east-central Minnesota sensitive to groundwater inputs.***

• **Groundwater is the foundation for virtually all water resources in Minnesota.** Without groundwater, we would have no perennial lakes and rivers. We would have almost no drinking water. We would have no irrigation agriculture. *Therefore, the future of groundwater supply is the future of Minnesota.*

• **Groundwater supply (recharge) is difficult to estimate.** It is a complex result of land cover, topography, climate, soils, and geology. *Therefore, we need computational tools that account for these complexities.*

• **Watershed simulations can estimate groundwater supply.** These programs account for geographic complexities and translate climate inputs (principally precipitation and temperature) into hydrologic flows, both surface and sub-surface. *Therefore, these programs are sufficiently complex to calculate groundwater supply.*

• **Future groundwater supplies can be forecast by feeding future climate into these simulations.** Once the simulation is configured for the non-changing components (topography, soils, geography), then the effect of changing components (land cover and climate) can be tested for their effects on groundwater supply. Future climate has been estimated by multiple Global Climate Models (GCMs), and output data from these models can be down-scaled and bias-corrected for use in watershed simulations. *Therefore, these simulations answer the crucial question, how much groundwater will Minnesota have in the future?*

• **The impact of future groundwater supply on water-table and lake-level changes needs to be known.** This outcome requires a more comprehensive tool that integrates watershed and groundwater hydrology. In order to account for aquifer hydraulics, this tool is best applied to a small watersheds with manageable data coverage. The effect of well pumping can also be included in this program. *This new groundwater/surface-water tool will lead to wiser, integrated management of aquifers and the lakes and streams embedded within them.*

II. PROJECT ACTIVITIES AND OUTCOMES

ACTIVITY 1: *Apply future climate to the entire St. Croix basin simulation.*
Description: The St. Croix basin is broadly representative of the Minnesota landscape as a whole with an array of forests, lakes, wetlands, and agricultural land covers. To generate results over this large region, future climate will be input into an existing watershed simulation for the St. Croix basin to estimate changes in groundwater supply (recharge) and streamflow. Output from four GCMs, running under two scenarios of projected greenhouse gas emissions, will drive the model to the year 2100.
ENRTF BUDGET: $100,000

Outcome	Completion Date
1. Future groundwater supply and streamflow for the St. Croix basin	*June 2020*

ACTIVITY 2: *Construct integrated watershed + groundwater simulation for pilot watershed and apply future climate*
Description: To clarify hydrologic mechanism at the local scale, an integrated watershed/groundwater simulation will be constructed for a pilot watershed that is tributary to the St. Croix. Climate data specific to the pilot watershed will be extracted from the same GCM output used to drive the St. Croix simulation. We are targeting Browns Creek, a tributary to the St. Croix, as our pilot watershed. This watershed comprises not only a designated trout stream, which relies on groundwater discharge, but also close-basin lakes whose fluctuating levels have caused property damage in the past.
ENRTF BUDGET: $180,000

Outcome	Completion Date
1. Integrated watershed + groundwater simulation for pilot watershed	*June 2021*
2. Future groundwater supply, lake levels, and streamflow in pilot watershed	*June 2022*

III. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
TBD	Grad student / post-doc	Univ. of Minnesota	Modeling assistant

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
Dr. Xuesong Zhang	Senior Scientist	Pacific Northwest National Labs	Future climate data
Karen Kill	Administrator	Browns Creek Watershed District	Data coordination

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:
This project will provide proof-of-concept for estimating future groundwater supply (recharge) with other watershed simulation models across the state. GCM model results are freely available, and labor expenses to process the input data and run watershed models are modest, once such models have been constructed. Further, the watershed models constructed and updated for this project, combined with the future climate data from GCMs, will allow projections of other impacts from climate change, especially loads of nonpoint-source pollution (sediment, nutrients).

V. TIME LINE REQUIREMENTS:
The time line is simple, generating a deliverable product at the end of each of three years. We are also allowing some extra time for training a graduate student or post-doc in methods of watershed simulation.

2019 Proposal Budget Spreadsheet

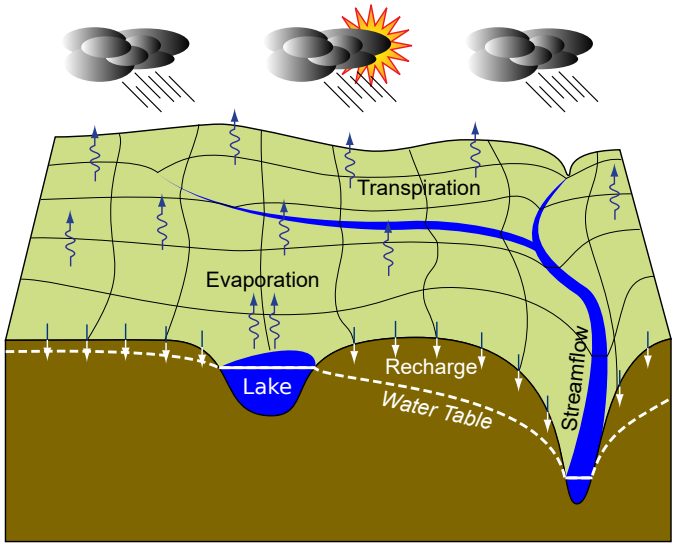
Project Title: The Future of Groundwater Supply

IV. TOTAL ENRTF REQUEST BUDGET -- 3 years

BUDGET ITEM (See "Guidance on Allowable Expenses")	**AMOUNT**
Personnel:	$ 155,500
Senior Scientist: Simulation development, both for St. Croix and tributary watershed; $155,000 for 50% FTE for 3 yrs (70% salary + 30% benefits).	
Professional/Technical/Service Contracts:	$ 120,000
Grad student: Simulation development and application; $120,000 for 50% FTE for 3 yrs (70% salary + 30% benefits).	
Equipment/Tools/Supplies:	$ 3,000
Software; data acquisition	
Acquisition (Fee Title or Permanent Easements):	$ -
Travel:	$ 1,500
Conference fees; local in-state travel	
Additional Budget Items:	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 280,000

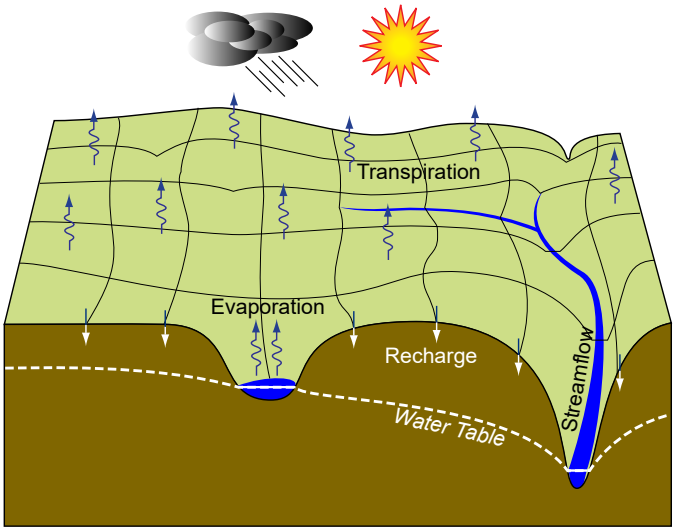
V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $ To Be Applied To Project During Project Period:	$ -	
Other State $ To Be Applied To Project During Project Period:	$ -	
In-kind Services To Be Applied To Project During Project Period:	$ -	
Past and Current ENRTF Appropriation:	$ -	
Other Funding History:	$ -	



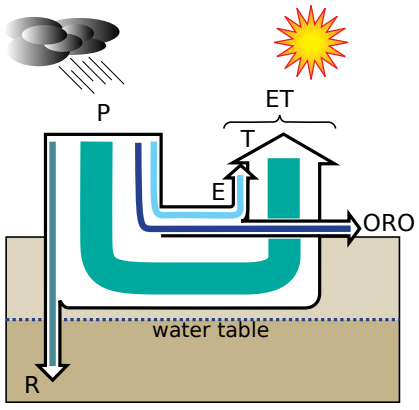
Under humid conditions, groundwater recharge is large.

In turn, the water table, lake levels, and streamflow are all high.



Under dry conditions, groundwater recharge is reduced.

In turn, the water table and lake levels drop, streams shorten, and streamflow is reduced.



P = precipitation
R = groundwater recharge
E = evaporation
T = transpiration
ET = evapotranspiration
ORO = overland runoff

Groundwater recharge is especially sensitive to climate and land-use change.

A small change in precipitation (P) or evapotranspiration (ET) means a big change in recharge (R)!

PROJECT MANAGER QUALIFICATIONS

James E. Almendinger, Ph.D.

Education

1988	Ph.D., Ecology. University of Minnesota, Minneapolis, MN 55455
1978	B.A., Botany. Ohio Wesleyan University, Delaware, OH 43015

Positions

2017-	Director, St. Croix Watershed Research Station, Science Museum of Minnesota
1995-2017	Senior Scientist, St. Croix Watershed Research Station, Science Museum of Minnesota
2000-	Adjunct Associate Professor, Univ. of Minn.: Water Resources Science Program; Dept. of Earth Sciences; and Dept. of Fisheries, Wildlife and Conservation Biology
1990-95	Hydrologist, U.S. Geological Survey, Mounds View, MN.

Research Expertise

My research interests focus on land-water interactions, including the hydrology of lakes, streams, and wetlands; the impact of humans on watersheds; and the hydrologic effects of climate change. I have experience with a variety of hydrologic computer models, including groundwater, watershed, and geochemical models. Research projects have included inferring past climate from lake and groundwater levels; quantifying the anthropogenic flux of sediment and nutrients exported from the upper Mississippi Basin; investigating the effects of urbanization on trout streams; and uncovering the way lakes change naturally over time.

Recent Publications

Edlund, M.B., **J.E. Almendinger**, X. Fang, J.M. Ramstack Hobbs, D.D. VanderMeulen, R.L. Key, and D.R. Engstrom. 2017. Effects of climate change on lake thermal structure and biotic response in northern wilderness lakes. Water 9, 678. doi: 10.3390/w9090678.

Almendinger, J.E., and J.S. Ulrich. 2017. Use of SWAT to estimate spatial scaling of phosphorus export coefficients and load reductions due to agricultural BMPs. Journal of the American Water Resources Association (JAWRA). DOI: 10.1111/1752-1688.12523.

Almendinger, J.E., M.S. Murphy, and J.S. Ulrich. 2014. Use of the Soil and Water Assessment Tool to scale sediment delivery from field to watershed in an agricultural landscape with topographic depressions. Journal of Environmental Quality 43: 9-17. DOI: 10.2134/jeq2011.0340.

Schottler, S.P., J. Ulrich, P. Belmont, R. Moore, J. Lauer, D.R. Engstrom, and **J.E. Almendinger**. 2013. Twentieth century agricultural drainage creates more erosive rivers. Hydrological Processes: 1-11.

ORGANIZATION DESCRIPTION

The ***Science Museum of Minnesota*** (SMM) is a private, non-profit 501(c)3 institution dedicated to encouraging public understanding of science through research and education. Its mission is to inspire learners, inform policy, and improve lives through science. The ***St. Croix Watershed Research Station*** (SCWRS) the environmental research center of the SMM with the mission to foster, through research and outreach, "a better understanding of the ecological systems of the St. Croix River basin and watersheds worldwide." The SCWRS supports an active year-round program in environmental research and graduate-student training, guided by a dedicated in-house research staff with direct ties to area universities and colleges. It collaborates closely with federal, state, and local agencies with responsibility for managing the St. Croix and upper Mississippi rivers and is a full partner with the National Park Service for resource management in parks of the western Great Lakes region. Its research has played a central role in setting management policy for the St. Croix and Mississippi rivers, for establishing water-quality standards for Minnesota lakes and for developing long-term monitoring plans for the National Park Service.