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

Project Title: **ENRTF ID: 065-AH**

Role of Submarine Groundwater Altering Lake Superior's Shore

Category: H. Proposals seeking $200,000 or less in funding

Sub-Category: A. Foundational Natural Resource Data and Information

Total Project Budget: $ 198,643

Proposed Project Time Period for the Funding Requested: June 30, 2022 (2 yrs)

Summary:

We will determine the deep groundwater input to Lake Superior so that forecasts of lake level can be made. This will help protect important North Shore parks and environments.

Name: John Downing

Sponsoring Organization: U of MN -Minnesota Sea Grant

Job Title: Dr.

Department: Minnesota Sea Grant

Address: 31 West College Street

Duluth MN 55812

Telephone Number: (218) 726-8715

Email downing@umn.edu

Web Address: http://www.seagrant.umn.edu/

Location:

Region: Northeast

County Name: Carlton, Cook, Lake, St. Louis

City / Township: All cities in the NE region

Alternate Text for Visual:

Upper is a schematic of the water budget of Lake Superior showing knowledge lacking on deep groundwater. Lower shows high relief on the North Shore that drives deep groundwater there.

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

PROJECT TITLE: Role of submarine groundwater altering Lake Superior's shore

I. PROJECT STATEMENT

How well can you run a household or State without knowing the budget? The purpose of this project is to assess the role of deep groundwater inputs to the water budget of Lake Superior. This will allow better forecasting of lake levels and allow consideration of options for stabilizing them, so we can compensate for rates of change to preserve environmental and recreational quality. Improved predictions of lake levels will help Minnesotans to make better choices about natural resource management along the coast of Lake Superior. Lake Superior is 10% of Earth's surface freshwater and gives Minnesota the most inland seaport in the world yet its water budget (inflows and outflows that determines lake-level) is based only on measures of surface water, evaporation and precipitation (see attached figure). Over the past 60 years, the Lake has seen some of its highest and lowest levels in recorded history while, in spite of very high and damaging water levels now, it is losing 1.5" overall every 3-4 years. Wide swings in water level causes damage to parks and North Shore recreation areas, unpredictably altered fish habitat, and danger to recreationists at the 8 important North Shore parks (including 4 of Minnesota's most popular). High waters drown river mouths and damage shore ecosystems whereas low water can destroy spawning habitat, shore wetlands, and increase distances between recreational resources and water. This project will measure the role of North Shore submarine groundwater in determining future levels of Lake Superior.

Current forecasting models used to design parks, recreation areas, shore installations, and manage fish habitat are inaccurate because they ignore the role of deep, submarine groundwater discharge to the lake. There is ample evidence (e.g., North Shore seeps, springs, ice faces on cliffs, waterfalls from rocks, etc.) that groundwater can be an important water source (or loss) especially along the North Shore of the lake where relief is highest (see figure). In fact, other large water bodies, even seas, have been shown to have important deep groundwater inflows. In the Mediterranean Sea, for example, groundwater inflow is 16-times as large as the water brought in by rivers. Ignoring groundwater inflows and outflows to large water bodies makes it impossible to protect shore environments, especially during a period of changing weather patterns.

This project will use isotopic measures of radon (^{228}Ra) in deep and shallow lake water and groundwater sources to calculate how much water enters Lake Superior along the North Shore and how this compares to surface water inflows and outflows as well as losses or gains via evaporation or precipitation. The reason radon is useful for measuring groundwater input is the same reason it ends up in houses. It is a breakdown product from rocks and soils so will be most concentrated in water that has been in contact with them. This works because ^{228}Ra is much more concentrated in groundwater than in precipitation or surface water inputs. We expect North Shore submarine groundwater to represent the majority of that entering the lake because the topographic relief is very high northwest of the lake and groundwater flow is generally fastest where relief is high (see dark arrows along North Shore in accompanying graphic).

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1 Collect and concentrate isotopes from groundwater, surface water, and deep lake water. **Budget: $135,637**

We will collect 40 sets of lake water samples from Lake Superior's surface and near-bottom. Lake samples will be taken from the R/V Blue Heron. We will also collect 20 samples of deep groundwater from wells along the North

shore. Because ^{228}Ra concentrations are very low, we will take large samples (100-360 liters) and these samples will be filtered through columns loaded with manganese oxide impregnated acrylic fibers that will concentrate ^{228}Ra. These fibers will be combusted to ash, ground up, and sealed in counting vessels. Work will be shared by Downing and a graduate student (yet to be named). Research vessel cruise costs will be discounted because Downing is a member of the Large Lakes Observatory research faculty.

Outcome	Completion Date
1. Seven cruises of the R/V Blue Heron to collect samples from surface and deep water	October 2020
2. Concentration of ^{228}Ra lake water samples	October 2020
3. Collection of groundwater samples from existing wells	June 2021
4. Concentration of ^{228}Ra in groundwater samples	June 2021

Activity 2: Determination of ^{228}Ra activity and calculation of submarine groundwater inflow rates **Budget: $63,006**

Samples collected in activity 1 will be counted in a gamma spectrometer with a well-type, high-purity germanium detector. The spatial distribution of ^{228}Ra in the lake will be interpolated and, by comparison with groundwater reference data, inflow rates of submarine groundwater will be calculated. These will be compared with surface inputs/outputs, precipitation inputs, and evaporative loss. Work will be shared by Downing and a graduate student (yet to be named).

Outcome	Completion Date
1. Complete gamma spectrometry	December 2021
2. Calculate submarine groundwater inputs/outputs	April 2022
3. Compare with traditional budget data.	June 2022

III. PROJECT PARTNERS AND COLLABORATORS:

John A. Downing, Sea Grant College Program, Large Lakes Observatory, and Department of Biology, University of Minnesota (Duluth)

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

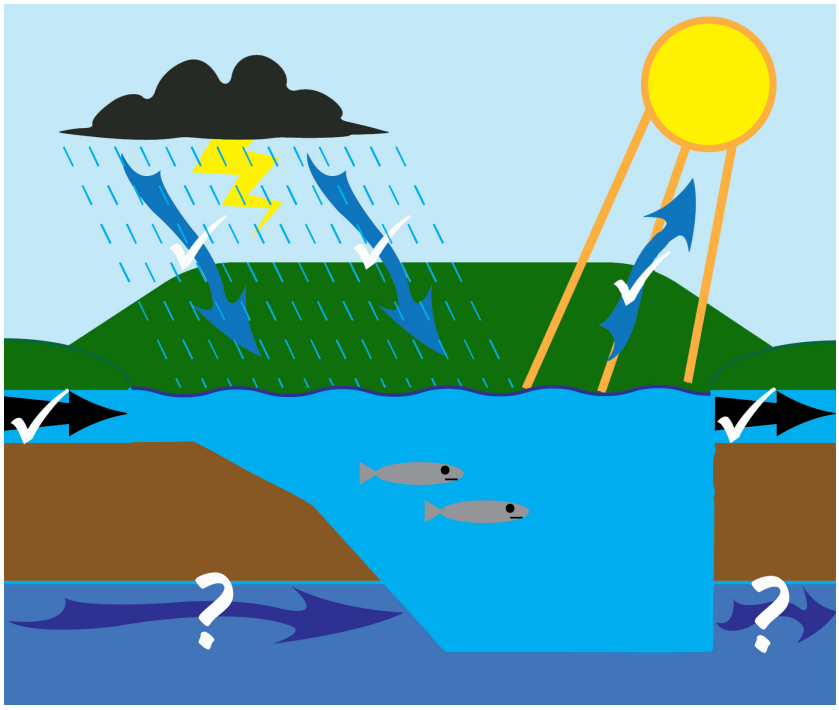
We expect that the results will substantially alter the way we model and predict shore and coastal effects of alterations in lake water level. Therefore, we will work with NOAA offices including the Great Lakes Environmental Research Lab (GLERL) to use the results to leverage federal funds to perform similar analyses across the Great Lakes. We will work with GLERL to use this research on Lake Superior to result in updated models that will allow us to better forecast lake levels and consider options for stabilizing them, so we can compensate for rates of change to preserve environmental and recreational quality on the North Shore of Lake Superior.

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: John A. Downing
Project Title: Role of submarine groundwater altering Lake Superior's shore
Organization: Regents of University of Minnesota (for MN Sea Grant Program)
Project Budget: $198,643
Project Length and Completion Date: June 2022 (2 years)
Today's Date: 4/13/19

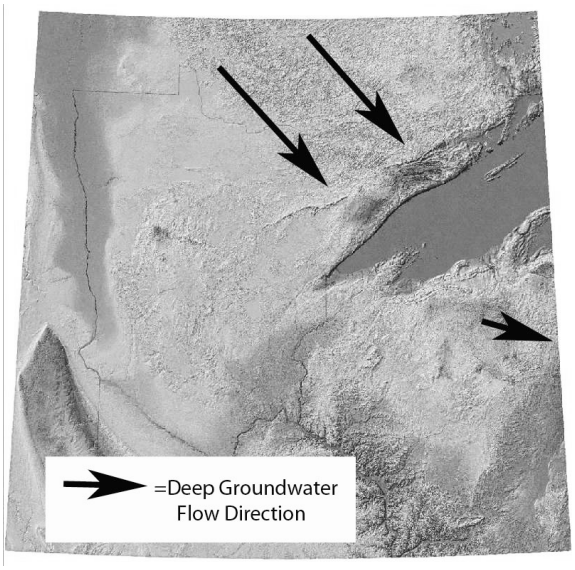
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 103,411	$ -	$ 103,411
John Downing, project manager at 4% time over two years including fringe benefits -$23,471 (74% salary, 26% fringe)			
MS student, 50% FTE graduate research assistant over two years - collect samples, perform analyses, fit 228Ra data contours, calculate rates, write up results -Total $79,940 (52% salary, 48% fringe)			
Professional/Technical/Service Contracts			
	$ -	$ -	$ -
Equipment/Tools/Supplies			
Chemicals and columns (100 @$150 each), ashing furnace ($4000), chemicals & field collection	$ 22,200	$ -	$ 22,200
Capital Expenditures Over $5,000			
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
		$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
travel to collect well water samples (2200 miles @ $0.58, per UMN policy)	$ 1,276	$ -	$ 1,276
Other			
Gamma spectrometer equipment-use charges	$ 11,300		$ 11,300
Ship time on Blue Heron @7 24h days (at discounted Large Lakes Observatory staff rate)	$ 60,456	$ -	$ 60,456
COLUMN TOTAL	$ 198,643	$ -	$ 198,643

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: University of MN unrecovered Indirect Cost @ 54% MTDC		$ 89,998	$ -	$ 89,998

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
		$ -	$ -	$ -



We will find the deep groundwater inputs to Lake Superior (see "?") because they are unknown. Making these estimates will create better forecasting models to predict lake level swings so we can help Minnesotans make better choices about natural resource management along the coast of Lake Superior. Current forecasting models ignore deep groundwater yet in other large water bodies (e.g., the Mediterranean Sea), deep groundwater input, measured by radon concentrations as we plan here, is 16-times bigger than the input via rivers and streams.



Topographic relief map showing elevations of land around the Great Lakes (darkest=highest). Because groundwater inflow rates often are greatest where land relief or "head" is greatest, the majority of groundwater inflow should come in from Minnesota's North Shore (note dark terrain along the northwest shore of Lake Superior). Image after http://mygardenplan.info/wp-content/uploads/2018/03/topographical-map-minnesota-lake-topographic-maps.jpg

Project Manager Description

Project Manager Qualifications and Responsibilities

John A. Downing will manage this project. He has 40 years of experience in aquatic research and community outreach. He is currently the Director of the Minnesota Sea Grant College Program, a research scientist at the Large Lakes Observatory, and a tenured Professor in the Department of Biology at the University of Minnesota Duluth. Although he has life-long roots in Minnesota, he was formerly a Regent's Excellence Professor of Ecology, Evolution, & Organismal Biology and Agricultural & Biosystems Engineering at Iowa State University and ran one of the best-funded and long-standing research operations at that institution. His 150+ peer-reviewed books and journal articles cover diverse topics in limnology, marine science, environmental economics, and terrestrial ecology. His leadership experience has been as the Director of the Laurentian Biological Station (Montreal, Quebec), the co-founder of the Inter-University Limnological Research Group (Montreal, Quebec), Director of the Iowa State University Limnology Laboratory (Ames, Iowa), Chair of the Environmental Science Interdepartmental Graduate Program (Ames, Iowa), President of the Association for the Sciences of Limnology and Oceanography, and Chair of the Council of Scientific Society Presidents (Washington, DC). Recent outreach programs have assisted citizens in agricultural regions to understand and mitigate nutrient pollution and helped citizens and industries in northern Minnesota combat eutrophication and avoid lake degradation from aquatic invasive species.

Organization Description

Minnesota Sea Grant, at the University of Minnesota Duluth, is part of the National Oceanic and Atmospheric Administration's (NOAA) Sea Grant Program, which supports 33 similar programs in coastal states throughout the United States and Puerto Rico. Our mission is to facilitate interaction among the public and scientists to enhance communities, the environment and economies along Lake Superior and Minnesota's inland waters by identifying information needs, fostering research and communicating results. Minnesota Sea Grant concentrates on research, outreach, and education in four focus areas: Healthy coastal ecosystems, sustainable fisheries and aquaculture, resilient communities and economies, environmental literacy and workforce development.

This research will be performed using the facilities of the Large Lakes Observatory (LLO). LLO has a unique mission: to perform scientific study of the largest lakes of Earth. It is one of the largest water-centered research units at the university and its impact has been felt all over the world.