Environment and Natural Resources Trust Fund
2016 Request for Proposals (RFP)

Project Title: **ENRTF ID: 039-B**

Is Minnesotas Groundwater Safe to Drink?

Category: B. Water Resources

Total Project Budget: $ 299,829

Proposed Project Time Period for the Funding Requested: 3 years, July 2016 to June 2019

Summary:

Groundwater is used by more than 90% of Minnesotas public water systems, serving more than 75% of the population. This project will determine the microbiological quality of Minnesotas groundwater resources.

Name: Raymond Hozalski

Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Minnesotas groundwater resources are under attack by human waste from septic systems and other sources, agricultural activities, and urban and suburban stormwater runoff. Potential pollutants are numerous and include nitrate, pesticides, and pathogenic microorganisms. Is the groundwater safe to drink as is? Will it make us sick? Which supplies should we chlorinate, if any, to ensure that all Minnesotans have access to water that is free of pathogens?

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

PROJECT TITLE: *Is Minnesota's groundwater safe to drink?*

I. PROJECT STATEMENT

The goal of the proposed project is to characterize the microorganisms of Minnesota's groundwater resources. Until recently, the ability of microbiologists to characterize the microbes in drinking water has been extremely limited. The microbiological safety of drinking water has been primarily assessed by measuring "fecal coliforms," which merely indicate that the presence of fecal material is likely. The connection between fecal coliforms and genuine disease-causing organisms, however, is tenuous. The microbiological standards of drinking water, therefore, are probably very conservative because these standards are based on a surrogate parameter (fecal coliforms) rather any direct measure of microbiological safety. Indeed, we know virtually nothing about the microbiological quality of Minnesota's groundwater. This is particularly problematic because groundwater is used as the source for more than 90% of Minnesota's public water supplies serving about 75% of the state's population; often that water is provided without any disinfection.

This study would be unique because it would characterize and quantify all of the bacteria in Minnesota's groundwater, including the direct quantification of several disease-causing organisms. We predict that the majority of Minnesota's water supplies are free of bacterial pathogens but that numerous supplies (e.g., impacted by agriculture, septic systems, etc.) will contain unsafe levels of pathogens. Our secondary hypothesis is that the microbiological safety of Minnesota's groundwater will correlate to other chemical measures of drinking water quality, such as nitrate levels (an indication of nutrient pollution) and elevated tritium levels (tritium is measured to assess groundwater vulnerability). The specific goals of this work are to:

1. Quantify and characterize the microorganisms in groundwaters around the state
2. Attempt to link the microbiological data to conventional or chemical water quality indicators, including nitrate and tritium
3. Disseminate the information gained from this work to stakeholders by working with the Minnesota Department of Health, Minnesota Rural Water Association, and by presenting at the Minnesota section of the American Water Works Association Annual Conference.

This research would compliment on-going efforts by the Minnesota Department of Health to evaluate the safety of Minnesota's public water supplies with respect to pathogenic viruses and a recent state report showing increased nitrate contamination of water supplies.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: *Characterize the bacterial communities in Minnesota's groundwaters that are used as drinking water supplies.* **Budget: $144,636**

Samples will be collected from groundwater supplies at numerous public water systems around the state. We will work with the Minnesota Rural Water Association and the Minnesota Department of Health to identify possible participants and to solicit their involvement. We anticipate collecting samples from each water supply on at least three different occasions to investigate temporal variability.

We will then make detailed characterizations of the microorganisms in these samples using state-of-the-art, next-generation DNA sequencing technology to generate between 50,000 and 100,000 sequences per sample. We will also directly (as opposed to indirectly, like the fecal coliform assay) quantify the presence of two-dozen organisms (e.g., *Salmonella*, *Legionella,* etc.) known to cause disease in humans. Finally, we will use software that is freely available to University researchers at the Minnesota Supercomputing Institute to statistically analyze the data and correlate our microbiological data to other water quality data (see Activity 2).

Outcome	Completion Date
1. Sample collection and Genomic DNA extractions	December 31, 2017
2. Next-Generation DNA sequencing	December 31, 2018

3. Quantification of specific microorganisms	December 31, 2018
4. Data Analysis	April 30, 2019

Activity 2: *Analyze conventional water quality parameters from the groundwaters and correlate with the microbiological data.* **Budget: $144,635**

At the same time that we collect samples for microbiological analysis, we will also collect samples for analysis of conventional water quality parameters. Of these conventional parameters, we will measure temperature, pH, chloride, sulfate, nitrate, and carbemazepine (a conservative chemical tracer for sewage). We will also measure tritium (a radioactive form of hydrogen), as this is used to assess aquifer vulnerability during the development of wellhead protection plans. We will also quantify fecal coliforms, *E. coli*, and *Enterococcus* spp. using cultivation-based methods.

Outcome	Completion Date
1. Sample collection, water quality analyses	December 31, 2017
2. Statistical Analysis	April 30, 2019

Activity 3: *Disseminate research results to stakeholders.* **Budget: $10,558**

The first two activities will significantly improve our knowledge of the microbiological safety of Minnesota's groundwater used for drinking water supplies. The final activity will be to disseminate these results at local conferences (e.g., MN Section of the American Water Works Association Annual Conference) and to the stakeholders (e.g., rural water suppliers) by working with the Minnesota Department of Health and the Minnesota Rural Water Association. This information could be used by the small water systems to make changes, if necessary, to protect public health. Such changes could include: (1) install or change disinfection practices, (2) change water source (e.g., drill new wells), or (3) add a new treatment system (e.g., membranes).

Outcome	Completion Date
1. Presentations at in-state scientific conferences (on-going/continuous)	June 30, 2019
2. Meetings with stakeholders to disseminate results (on-going/continuous)	June 30, 2019

III. PROJECT STRATEGY

A. Project Team/Partners:

The project will be led by Raymond Hozalski and Timothy LaPara (University of Minnesota, Department of Civil, Environmental, and Geo- Engineering). The team will also consist of one graduate student researcher, Michael Waak, who is experienced in analyzing bacterial communities from drinking water. Drs. Hozalski and LaPara are experts in drinking water and in analyzing complex microbial communities.

B. Project Impact and Long-Term Strategy:

The long-term goal of the proposed research is to gain a better understanding of the microbiological quality of groundwater in Minnesota. This research is especially important because more than 90% of Minnesota's public water supplies use groundwater as their source, often providing this water without disinfection. Numerous new laboratory techniques have been developed over the last decade to enable microbiologists to analyze the microbes in drinking water with astounding detail and precision. The proposed study, therefore, will generate novel and critically important knowledge on the microbiological quality of Minnesota's public water supplies and will provide sound guidance for protecting the public health of Minnesotans.

C. Timeline Requirements:

The proposed project will be completed in a three-year period. Samples will be collected for the first 18 months of the project followed by microbiological and data analyses for the final 18 months of the project.

2016 Detailed Project Budget

Project Title: *Is Minnesota's groundwater safe to drink?*

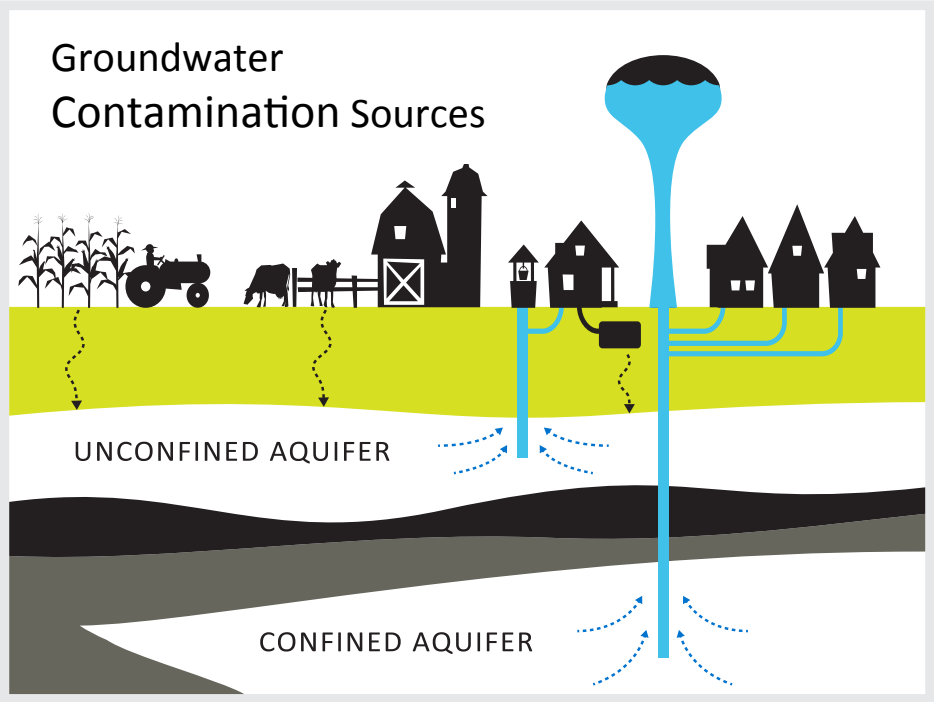
IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel:	
Raymond M. Hozalski, Project Manager (75% salary, 25% benefits); 8% FTE; Project supervision, supervision of post-doctoral and graduate student, project reporting, dissemination and outreach.	$ 52,899
Timothy LaPara, co-Project Manager (75% salary, 25% benefits); 8% FTE; Project supervision, supervision of post-doctoral and graduate student, project reporting, dissemination and outreach.	$ 48,809
Michael Waak, graduate researcher (100% salary, 41% benefits); 50% FTE; Collect samples, perform next-generation DNA sequencing, and quantify pathogens	$ 139,494
Undergraduate researcher, to be hired (100% salary, 0% benefits); 25% FTE during academic year, sample collection and processing	$ 11,127
Professional/Technical/Service Contracts:	$ -
University of Minnesota Genomics Center: next generation DNA sequencing (1000 samples; 210 samples per run = 5 runs x $1500 per run) and microarray qPCR (1000 samples, 84 samples per run = 12 runs x $1050 per run)	$ 20,000
Equipment/Tools/Supplies:	
DNA extraction kits (1000 samples, $3 per sample)	$ 3,000
Reagents for qPCR (1000 samples, $5 per sample)	$ 5,000
PCR purification kits (1000 samples, $2 per sample)	$ 2,000
General laboratory supplies (conventional filters, membrane filters ($20 each x 250 needed), chemicals, reagents, etc)	$ 12,500
Travel:	
In-state travel to collect samples and disseminate results to stakeholders	$ 5,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 299,829

V. OTHER FUNDS

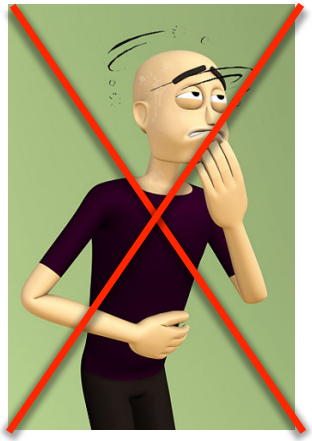
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	N/A	
Other State $ To Be Applied To Project During Project Period:	N/A	
In-kind Services To Be Applied To Project During Project Period: *The University of Minnesota does not charge the State of Minnesota its typical overhead rate of 52% of the total modified direct costs (graduate tuition and academic fringe are excluded).*	$ 127,807	*Secured*
Funding History:	N/A	
Remaining $ From Current ENRTF Appropriation:	N/A	

Is Minnesota's Groundwater Safe to Drink?



Adapted from: www.mn.gov/governor/images/nitrate_sources_infographic.pdf

http://pixshark.com/happy-person.htm



http://pixshark.com/happy-person.htm

Project Manager Qualifications and Organization Description

Raymond M. Hozalski

Professor, Department of Civil, Environmental, and Geo- Engineering, University of Minnesota

B.ChE., Chemical Engineering, 1990, Villanova University, Villanova, PA
M.S., 1992, Environmental Engineering, Johns Hopkins University, Baltimore, MD
Ph.D., 1996, Environmental Engineering, Johns Hopkins University, Baltimore, MD

Dr. Raymond Hozalski will be responsible for overall management of the proposed project. Dr. Hozalski's research focuses on water treatment systems including filtration, biofiltration, sorption, and chemical oxidation as well as water distribution system issues. His research has recently produced some of first detailed characterizations of bacterial communities in biofilms on the inside of water distribution system pipes and in tap water. His investigations span the full spectrum from basic research to applied research done in collaboration with water utilities in Minnesota and beyond. He is well connected in the drinking water community in Minnesota through his involvement with the Minnesota Section of the American Water Works Association.

Timothy M. LaPara

Professor, Department of Civil, Environmental, and Geo- Engineering, University of Minnesota

B.S.C.E., Civil Engineering, 1995, University of Notre Dame, Notre Dame, IN
Ph.D., Civil Engineering, 1999, Purdue University, West Lafayette, IN

Dr. LaPara's research focuses on the microbiology of municipal wastewater treatment and the treatment of public water supplies; the goal of his research is to preserve environmental quality and to protect public health. His research has a strong interdisciplinary nature, stemming from his unique background in both environmental engineering and microbiology.

Organization Description

The University of Minnesota is one of the largest, most comprehensive, and most prestigious public universities in the United States (http://www1.umn.edu/twincities/about/index.html). The laboratories and offices of the PIs contain the necessary fixed and moveable equipment and facilities needed for the proposed studies.