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

Project Title:

ENRTF ID: 102-B

Protozoan Microbes in Groundwater Used for Drinking Water

Category: B. Water Resources

Sub-Category:

Total Project Budget: \$ 499.699

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

Summary:

This project will determine the ability of a treatment system to destroy Cryptosporidium, Giardia, and other dangerous microbes that were recently detected in groundwater used for drinking water

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Alternate Text for Visual:

A recent study by the Minnesota Department of Health unexpectedly found Cryptosporidium and Giardia in groundwater. These organisms, which cause intestinal illness, are not normally thought to be in groundwater. Research is needed to determine the best solution for these microbes.

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



PROJECT TITLE: Protozoan Microbes in Groundwater Used for Drinking Water

I. PROJECT STATEMENT

This research project will confirm the presence of two protozoan microorganisms (*Cryptosporidium* and *Giardia*) in the groundwater used as the source of drinking water by a City in Minnesota, design and implement a treatment system to solve this problem, and then demonstrate that the problem has been solved. This proposed research project is in direct response to a very recent study by the Minnesota Department of Health (MDH) that detected *Cryptosporidium* and *Giardia* at least once in 40% of tested wells (145 wells) and in 11% of all samples (i.e., 964 samples). This study will be performed at the yet-to-be-named City (pending City Council approval) because it had multiple positive detections for *Cryptosporidium* and *Giardia*.

Groundwater is used as the source for more than 90% of Minnesota's public water supplies, serving about 75% of the State's population. The discovery of *Cryptosporidium* and *Giardia* in groundwater was unexpected, because these organisms are commonly believed to be associated with surface water. *Cryptosporidium* and *Giardia* are worrisome for several reasons: (1) they cause severe diarrhea, dehydration, fever, nausea, and vomiting; (2) the infections caused by these organisms can prove fatal for immunocompromised individuals, and (3) the cyst and especially oocyst forms of these organisms that exist in water supplies are highly resistant to our disinfection gold-standard of chlorination. On April 3, 2019, MDH personnel attended a City Council meeting in the City in north-central Minnesota and informed its residents that *Cryptosporidium* and *Giardia* were detected in their drinking water wells, suggesting potential causes and solutions.

This proposed research study is needed for several reasons. First, although MDH's data are highly suggestive that *Cryptosporidium* and *Giardia* are commonly found in groundwater, the results have not been validated by another research laboratory. Second, the amount of data that MDH generated from a specific public water supply was actually very small. At the City that will be the focus on this study, for example, MDH collected only 12 samples from City's wells, of which 7 were positive for *Cryptosporidium* and/or *Giardia*. At the April 3 City Council meeting, one City Council member was nonplussed that MDH was suggesting expensive changes to the City's water system based on such little documentation; simply put, more data are needed. Third, conventional chlorine disinfection is ineffective against *Cryptosporidium* and moderately effective against *Giardia*. Validation of a viable treatment system for this problem with be invaluable for numerous Minnesota public water supplies. Fourth, the cost of resolving the issue is quite high. For example, MDH recommended that the City re-locate their supply wells, at a cost as high as \$100,000; this City serves approximately 100 people (\$1,000 per person) with a median household income less than \$40,000 per year (according to the 2010 US Census). Finally, the problem is potentially very common across the State of Minnesota. Public water supplies that use groundwater either provide the water to their communities without any form of disinfection or use chlorine to disinfect their water, which is ineffective to moderately effective against protozoan pathogens.

Simply put, the research recent results of the MDH study are very worrisome and almost certainly require substantial changes to how small public water systems in Minnesota are designed and operated. This research will inform the State on the benefits of treating groundwater for *Cryptosporidium* and *Giardia* and provide guidance on the most cost-effective approaches to do so.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Quantify Cryptosporidium, Giardia, and other pathogens in the wells and at the tap prior to the implementation of a drinking water treatment system.

Description: Samples will be collected from each of the supply wells and from 5 residential taps twice per month for the first year of the project (168 samples). We will then characterize the microorganisms in these samples using next-generation DNA sequencing technology. We will use quantitative PCR (qPCR) to quantify the presence of specific pathogenic microorganisms (e.g., *Cryptosporidium, Giardia, Salmonella, rotavirus, E.*



Environment and Natural Resources Trust Fund (ENRTF) 2020 Main Proposal Template

coli) known to cause disease in humans as well as crAssphage, a viral marker of human fecal contamination (i.e., as opposed to animal). Finally, we will collect other water quality data that are commonly used to characterize drinking water quality.

ENRTF BUDGET: \$209,849

Outcome	Completion Date
1. Sample collection and Genomic DNA extractions	June 30, 2021
2. Next-Generation DNA sequencing	December 31, 2021
3. Quantification of specific microorganisms	December 31, 2021
4. Data Analysis	April 30, 2023

Activity 2: Design and implement a water treatment system specifically designed to remove the risk posed by Giardia and Cryptosporidium in groundwater.

Description: We will work with a licensed engineer (chosen by the City) to identify the appropriate technology to solve the water quality problem (likely the installation of a ultraviolet light or UV disinfection system). This technology will then be implemented and operated for the second year of the study.

ENRTF BUDGET: \$80,000

Outcome	Completion Date
1. Select, Design, and Install Treatment System to Resolve Problems with Giardia	June 30, 2021
and Cryptosporidium	
2. Statistical Analysis	June 30, 2023

Activity 3: Quantify Cryptosporidium, Giardia, and other pathogens in the wells and at the tap after the implementation of a drinking water treatment system.

Description: This activity will mimic Activity 1, except that the chosen treatment system will be operating. That is, the City's water supply will likely be disinfected by ultraviolet light during year 2 and we will document whether the system is working adequately. All analyses will be the same as Activity 1. **ENRTE BLIDGET:** \$209 849

Outcome	Completion Date
1. Sample collection and Genomic DNA extractions	June 30, 2022
2. Next-Generation DNA sequencing	December 31, 2022
3. Quantification of specific microorganisms	December 31, 2022
4. Data Analysis	April 30, 2023

III. PROJECT PARTNERS AND COLLABORATORS:

The project team will be led by Drs. Raymond Hozalski and Timothy LaPara (University of Minnesota, Department of Civil, Environmental, & Geo-Engineering) who are experts in water treatment and microbiology. The team also will include one post-doctoral researcher and several undergraduate student researchers, the City engineer, and the City Council and/or Mayor.

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

The long-term goal of the proposed research is to identify the best and most cost-effective approaches to protect the health of Minnesotans served by groundwater resources. This project, specifically, will help resolve a newly-uncovered problem, the presence of *Cryptosporidium* and *Giardia* in groundwater, that likely affects a substantial fraction of Minnesotans, particularly in rural areas where groundwater is commonly used and public water supplies are less likely to be disinfected or disinfected with chlorine.

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Timothy M. LaPara
Project Title: Protozoan Microbes in Groudwater Used for Drinking Water
Organization: University of Minnesota
Project Budget: \$499,699
Project Length and Completion Date: 3 years, June 30, 2023
Today's Date: April 10, 2019



ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	В	udget	Amount Spent	В	alance
BUDGET ITEM					
Personnel (Wages and Benefits)	\$	352,199	\$-	\$	352,199
Timothy LaPara, Professor (74% salary, 26% benefits); 10% FTE for three years; project supervision,					
supervision of a post-doctoral researcher and an undergraduate research assistant, project reporting.	1			1	
(\$67,470)	1			1	
Raymond Hozalski, Professor (74% salary, 26% benefits); 10% FTE for three years; project					
supervision, supervision of a post-doctoral researcher and an undergraduate research assistant,	1			1	
project reporting. (\$74,679)					
Postdoctoral research associate (80% salary, 20% benefits); 100% FTE for 36 months; sample	1			1	
collection, qPCR, DNA sequencing and analysis (\$197,382)	1			1	
Undergraduate Researcher (100% salary, 0% benefits), paid hourly. Sample collection and processing					
(\$12,667)					
Professional/Technical/Service Contracts					
University of Minnesota Genomics Center: droplet digital PCR, DNA sequencing and other tasks	\$	20,000	\$-	\$	20,000
Equipment/Tools/Supplies					
Lab supplies (DNA/RNA extraction kits; Reagents for PCR and DNA sequencing)	\$	30,000	\$-	\$	30,000
Capital Expenditures Over \$5,000					
	\$	-	\$-	\$	-
Fee Title Acquisition					
	\$	-	\$-	\$	-
Easement Acquisition					
	\$	-	\$-	\$	-
Professional Services for Acquisition					
	\$	-	\$-	\$	-
Printing					
	\$	-	\$-	\$	-
Travel expenses in Minnesota					
In-state travel for sample collection and discussions with stakeholders	\$	12,500	\$-	\$	12,500
Other					
Design and construction of water treatment system (\$80,000)					
Open access fees for peer-reviewed journal papers (\$5,000)					
	\$	85,000	\$-	\$	85,000
COLUMN TOTAL	\$	499,699	\$-	\$	499,699

OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance	
Non-State:		\$ -	\$-	\$-	
State: U of MN (In-kind; Indirect costs not charged to project)	Secured	\$ 269,837	\$-	\$ 269,837	
In kind:		\$-	\$ -	\$-	

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but	Budget	Spent	Balance
	not yet spent			



if groundwater is not sufficiently treated

Project Manager Qualifications and Organization Description

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. Timothy LaPara will also be responsible for overall management of the proposed project. Dr. LaPara's research is focused on the role of municipal and industrial wastewater treatment plants in preserving environmental quality and in protecting public health. His research has a strong interdisciplinary nature, stemming from his unique background in both environmental engineering and microbiology.

Raymond M. Hozalski

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

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

Dr. Hozalski will serve as project manager and be responsible for overall project coordination. He is an internationally known expert in water treatment and has been conducting research in that area for over 25 years. He has worked on numerous applied research projects in collaboration with Minnesota drinking water utilities over the past 20 years. He has published more than 70 articles in top environmental engineering and science journals and currently serves on the U.S. Environmental Protection Agency's Science Advisory Board Drinking Water Committee.

Organization Description

The University of Minnesota (UMn) is one of the largest, most comprehensive, and most prestigious public universities in the United States (http://www1.umn.edu/twincities/01_about.php). The laboratories and offices of the PI and co-PI and/or at UMn core facilities contain all of the necessary fixed and moveable equipment needed for the proposed studies.