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

Project Title: **ENRTF ID: 092-B**

Assessment of Water Quality for Reuse: Phase II

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 476,000

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

Summary:

This project will maximize the potential of water reuse to conserve Minnesota's groundwater and improve surface water quality by providing the pathogen data needed to eliminate barriers to water reuse.

Name: Satoshi Ishii

Sponsoring Organization: U of MN

Job Title: Assistant Professor

Department: Department of Soil, Water, and Climate

Address: 1479 Gortner Avenue

St. Paul MN 55108

Telephone Number: (612) 624-7902

Email ishi0040@umn.edu

Web Address:

Location:

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

This graphic shows how this project contributes to maximizing the benefit of water reuse in improving surface water quality and reducing demand on groundwater aquifers in Minnesota.

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

PROJECT TITLE: Assessment of Water Quality for Reuse: Phase II

I. PROJECT STATEMENT

To further advance the goal of maximizing the potential of water reuse in Minnesota, we are proposing to implement a second phase (Phase II) of our current water reuse study. Reusing water will reduce demands on groundwater aquifers and improve surface water quality. However, public perception of health risks associated with microbiological contaminants remains a key barrier to the expansion of water reuse. The University of Minnesota (U of M) and the Minnesota Department of Health (MDH) have been collaborating to clarify the potential health risks associated with the water reuse systems in Minnesota. The Phase II project is proposed to (1) better understand water quality characteristics in reuse systems, (2) develop a model to predict occurrences of pathogens, and (3) make recommendations for safe water reuse.

In our Phase I project funded by LCCMR (M.L. 2017, Chp. 96, Sec. 2, Subd. 04f) and the MN Stormwater Research Council, we found that many of the water reuse systems in Minnesota use rainwater or stormwater as their source. Some samples from these systems contained fecal indicator bacteria and pathogens, suggesting a potential health risk to humans. However, the concentration of pathogens in these systems could be reduced to levels acceptable for reuse applications such as toilet flushing and irrigation by using appropriate treatments.

What remains unclear from our Phase I project is the relationships between levels of pathogens and relatively-easy-to-measure water quality parameters. We used a high-throughput gene quantification tool to detect various pathogens in our Phase I project; however, this tool is not widely available and not easy to use. Ideally, water quality guidelines should be set based on easy-to-measure parameters such as temperature, precipitation, turbidity, and fecal indicator bacteria counts. Therefore, there is a clear need to clarify the relationships between levels of pathogens and relatively-easy-to-measure water quality parameters, and to create pathogen-predictive models that are applicable to routine water quality monitoring for safe water reuse. To establish pathogen-predictive models, it is necessary to analyze temporal variation in pathogen abundance. Because precipitation can greatly influence the abundance of pathogens in rainwater and stormwater, we expect large temporal variation in pathogen abundance. Having a better understanding of the temporal variation in pathogen abundance will help us more reliably predict the presence of pathogens.

In the Phase II project, we will focus sampling on a few selected rain/stormwater reuse facilities (3-4 facilities), collect samples more frequently from those systems, and target pathogens, antibiotic resistant bacteria (ARB) and fecal indicators. We will add ARB as the target in our Phase II project because occurrences of ARB in water are of emerging concern for public health. Data collected from Phase I and II projects will be used to develop pathogen/ARB predictive models. These models are expected to be useful for managers of water reuse facilities to assess the quality of their reuse water based on relatively-easy-to-measure chemical parameters and fecal indicators. MDH will also develop water quality and system design recommendations for safe water reuse.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1 Title: Analyze temporal variation in pathogens and ARB abundance in rain/stormwater reuse facilities
Description: We will collect samples from rain/stormwater reuse facilities weekly or every two weeks during the reuse seasons (May-November) for two years (2020-2021). If rain/stormwater is treated (filtration, disinfection, etc.) or stored (stormwater pond) before reuse, both source water and treated water samples will be collected. Water samples will be processed to quantitatively detect various pathogens such as *E. coli* O157, *Salmonella*, *Campylobacter*, *Shigella*, *Clostridium perfringens*, *Legionella pneumophila*, *Listeria monocytogenes*, human adenovirus, Astrovirus, Enterovirus, human Norovirus, Hepatitis A virus, and Rotavirus A as well as dozens of antibiotic resistance genes by using high-throughput quantification tools developed by the U of M team. In addition, basic chemical and biological properties (pH, temperature, fecal indicator levels, etc.) will be also recorded. The data will be used to assess potential health risks associated with the water samples.

ENRTF BUDGET: $324,000

Outcome	Completion Date
1. Water sample collection and characterization (from 3-4 facilities over 2 years)	*12/31/2021*
2. Potential health risks associated with reuse water samples	*12/31/2021*

Activity 2 Title: Develop and validate pathogen/ARB predictive models
Description: Data generated in Activity 1 as well as in our Phase I project will be used to develop pathogen/ARB predictive models. Statistical models will be developed by using fecal indicators and other easy-to-measure chemical parameters as the input variables. Reliability of the models will be tested by comparing the pathogens/ARG abundance predicted by the models and those measured by experiments in the third year (2022). By this comparison, we will be able to select most reliable pathogen/ARG predictive model.

ENRTF BUDGET: $130,000

Outcome	Completion Date
1. Development of pathogen/ARB predictive models	*12/31/2022*
2. Selection of the most reliable pathogen/ARB predictive model	*12/31/2022*

Activity 3 Title: Disseminate the outcomes for safe water reuse
Description: Pathogen/ARB predictive models will be used by MDH to develop water quality and system design recommendations using best public health and engineering practices and with input from stormwater professionals. In addition to written reports, we will discuss outcomes with managers of local water reuse facilities in various venues, such as conferences, training sessions, workshops or stakeholder meetings. Through these activities, we will contribute to the establishment of safe water reuse in more areas of Minnesota.

ENRTF BUDGET: $22,000

Outcome	Completion Date
1. Water quality recommendations for safe water reuse	*6/30/2023*
2. Events to disseminate the pathogen/ARB predictive models	*6/30/2023*

III. PROJECT PARTNERS AND COLLABORATORS:

University of Minnesota

- Project Manager and Lab Lead: Satoshi Ishii (Department of Soil, Water and Climate)
- Technical support: Timothy LaPara (Department of Civil, Environmental, and Geo- Engineering)
- Sample collection and processing, data analysis, model generation: Postdoctoral researcher and a research technician (to be hired)

Minnesota Department of Health (No ENRTF Funding)

- Technical support: Anita Anderson (Section of Drinking Water Protection)
- Data analysis: Nancy Rice (Health Risk Assessment Unit)

IV. LONG-TERM IMPLEMENTATION AND FUNDING:

This project will maximize the potential of water reuse to conserve Minnesota's groundwater and improve surface water quality by providing the pathogen/ARB data needed to eliminate barriers to water reuse. This research will provide assurances to the public, regulators and system owners that water reuse can become common practice without negative effects on public health and safety and provide design information to provide safety and efficiency.

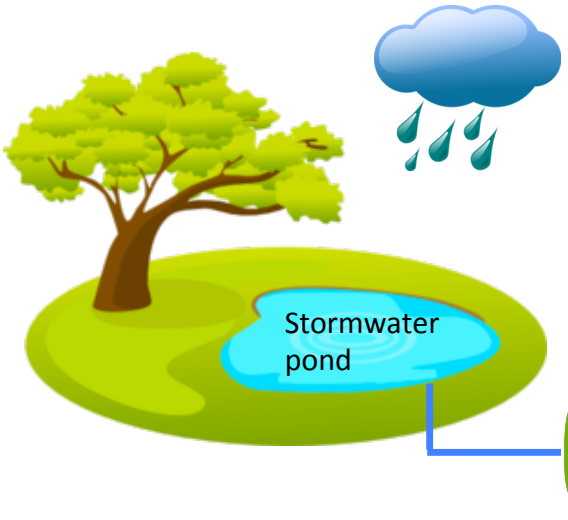
Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Satoshi Ishii
Project Title: Assessment of Water Quality for Reuse: Phase II
Organization: University of Minnesota
Project Budget: $476,000
Project Length and Completion Date: 3 years, June 30th, 2023
Today's Date: April 12th, 2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 402,000	$ -	$ 402,000
Satoshi Ishii, Assistant Professor (74% salary, 26% benefits); 8% FTE for three years; project supervision, supervision of a post-doctoral researcher and a research technician, project reporting.			
Timothy LaPara, Professor (74% salary, 26% benefits); 2% FTE for three years; co-supervision of a post-doctoral researcher and a research technician.			
Postdoctoral research associate (80% salary, 20% benefits); 100% FTE for 36 months; perform microfluidic qPCR and quantify pathogens, perform data analysis			
Research technician (77% salary, 23% benefits); 100% FTE for 36 months; sample collection, DNA/RNA extractions, water quality analysis			
Professional/Technical/Service Contracts			
University of Minnesota Genomics Center: microfluidic qPCRuser fee (Approx $333/run x 12 runs)	$ 4,000	$ -	$ 4,000
Equipment/Tools/Supplies			
Field supplies (a high-performance vacuum pump: $2,000; tubings: $1,000; other reagents: $1,000)	$ 4,000	$ -	$ 4,000
Lab supplies (Membrane filters: 500 samples at $20/sample; DNA/RNA extraction kits: 500 samples at $10/sample; Reagents for microfluidic qPCR pathogen and ARG detections: 500 samples at $60/sample; general water quality analysis: 500 samples at $20/sample; Quanti-Tray sealer for fecal indicator bacteria testing: $4,800; Glassware: $200)	$ 60,000	$ -	$ 60,000
Travel expenses in Minnesota			
In-state travel to collect samples (Approximately 10,345 miles at .58/mile per U of M travel policy)	$ 6,000	$ -	$ 6,000
Other			
	$ -	$ -	$ -
COLUMN TOTAL	$ 476,000	$ -	$ 476,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		N/A	N/A	N/A
State:		N/A	N/A	N/A
In kind:				
The University of Minnesota does not charge the State of Minnesota its typical overhead rate of 54% of the total modified direct costs.	Secured	$ 257,000	$ -	$ 257,000
Minnesota Department of Health provides salary + benefits to its members for this project.	Secured	$ 10,000	$ -	$ 10,000

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
M.L. 2017, Chp. 96, Sec. 2, Subd. 04f; Assessment of Water Quality for Reuse		$ 148,000	$ 133,000	$ 15,000

Assessment of Water Quality for Reuse: Phase II



Water Reuse

- Reduces demands on groundwater aquifers
- Improves surface water quality

Image from: https://www.flatlandkc.org/farm-field/water-success-story-kansas/

Irrigation, car washing, etc.

Barrier for to the expansion of water reuse

- Public health concerns
  - Pathogens
  - Antibiotic resistant bacteria (ARB)

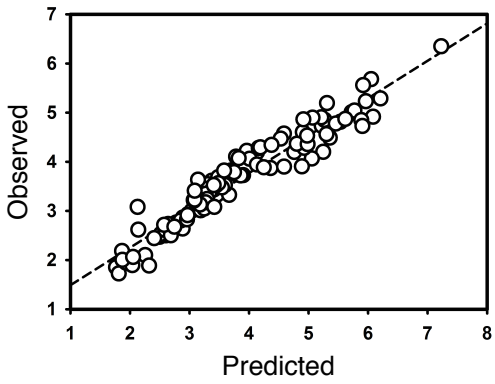
Currently, no water quality standard or recommendation available for reuse

Project Goal

To maximize the potential of water reuse in Minnesota by eliminating barriers to water reuse implementation.

Outcomes

1. Concentrations of pathogens/ARB in reuse water samples and their potential health risks
2. A model to predict pathogen/ARB conc. by easy-to-measure parameters
3. Water quality and system design recommendations for safe water reuse



Aiming to provide a useful tool to assess the quality of reuse water

Project Team

- Satoshi Ishii (U of M)
- Tim LaPara (U of M)
- Anita Anderson (MDH)
- Nancy Rice (MDH)

Project Manager Qualifications and Organization Descriptions

Satoshi Ishii

Satoshi Ishii is Assistant Professor in the BioTechnology Institute (BTI) and the Department of Soil, Water, and Climate (SWC) at the University of Minnesota. Dr. Ishii's research focuses on environmental microbiology and biotechnology, including water quality and public health microbiology. He has developed novel microfluidics tools to simultaneously quantify multiple pathogens and applied these tools to the risk assessment of water samples. The Ishii Lab (located in the St. Paul campus of the University of Minnesota) is equipped with all the necessary items for the proposed research.

Timothy M. LaPara

Tim LaPara is a Professor in the Department of Civil, Environmental, and Geo- Engineering at the University of Minnesota. 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.

Anita Anderson

Anita Anderson, P.E. is a Principal Engineer Supervisor with the Minnesota Department of Health Drinking Water Protection Section. Anita Anderson has 20 years of experience as a water supply engineer with the Minnesota Department of Health. Her primary area of expertise is surface water treatment, specializing in small systems. Currently she is also working on special projects to implement water reuse in Minnesota in a safe and sustainable way and to predict the vulnerability of groundwater drinking water sources to microbial pathogens. She is a registered professional engineer in Minnesota.

Nancy Rice

Nancy Rice is a Research Scientist with the Minnesota Department of Health Environmental Surveillance and Assessment Section. Nancy has been working since 2013 to research, develop, and implement quantitative microbial risk assessment (QMRA) for specific exposure scenarios, particularly water reuse. This work involves coordinating with other health department staff, state interagency staff, and University of Minnesota researchers to gather and analyze data concerning microbial exposure potentials and populations affected and communicating the results of QMRA to staff for use in policy decisions.

Organization Descriptions

The University of Minnesota is the main research and graduate teaching institution in the state of Minnesota. The BioTechnology Institute provides advanced research, training, and university-industry interaction in biological process technology. In the Department of Soil, Water, and Climate, we seek to improve and protect the quality of soil, air, and water resources in natural and managed ecosystems, through research, reaching, and extension.

The mission of the Minnesota Department of Health is to protect, improve, and maintain the health of all Minnesotans.