**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**

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| **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** |  |

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| **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* |

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| **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** |  |

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| **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* |

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| **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** |  |

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| **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.