# Environment and Natural Resources Trust Fund
# 2019 Request for Proposals (RFP)

**Project Title:** **ENRTF ID: 052-B**

Outstate Wastewater: Improving Nitrogen Removal in Treatment Ponds

**Category:** B. Water Resources

**Sub-Category:**

**Total Project Budget: $** 402,033

**Proposed Project Time Period for the Funding Requested:** June 30, 2022 (3 yrs)

**Summary:**

This research will help the State of Minnesota understand how to improve the nitrogen removal of wastewater treatment ponds when needed, protecting outstate surface water quality and groundwater safety.

**Name:** Paige Novak

**Sponsoring Organization:** U of MN

**Title:** Professor

**Department:** Department of Civil, Environmental, and Geo- Engineering

**Address:** 122 Civil Engineering Building, 500 Pillsbury Drive SE
Minneapolis MN 55455

**Telephone Number:** (612) 626-9846

**Email** novak010@umn.edu

**Web Address** http://personal.cege.umn.edu/%7Enovak/

**Location**

**Region:** Statewide

**County Name:** Statewide

**City / Township:**

**Alternate Text for Visual:**

The visual shows a map of oxidation ponds in Minnesota and their effluent nitrogen and how we plan to work with a partner to make this simple treatment technology more predictable.

| | | | |
|---|---|---|---|
| _____ Funding Priorities | _____ Multiple Benefits | _____ Outcomes | _____ Knowledge Base |
| _____ Extent of Impact | _____ Innovation | _____ Scientific/Tech Basis | _____ Urgency |
| _____ Capacity Readiness | _____ Leverage | _____ TOTAL | _____% |
| ____ If under $200,000, waive presentation? | | | |

**PROJECT TITLE: Outstate Wastewater: Improving Nitrogen Removal in Treatment Ponds**

## I. PROJECT STATEMENT

*In this project we will perform laboratory and field research to **understand how nitrogen is removed** in wastewater treatment ponds during winter and spring months. We will also **study how interventions, such as simple paddle mixing and aeration can improve nitrogen removal in pond systems**. This research will help the State of Minnesota understand the right way to improve nitrogen removal by wastewater treatment ponds when needed, protecting outstate surface water quality and groundwater safety.*

In Minnesota:

- There are **over 1000 small communities with unmet wastewater management needs**, ranging from no treatment to inadequate treatment.
- Treatment ponds are a simple but common method of treating wastewater in rural areas.
- There are currently **more than 300 wastewater treatment pond systems** that help serve the needs of Minnesota's small communities.
- Unfortunately, **23% of Minnesota's ponds under-perform** with respect to total nitrogen removal.
- Excess nitrogen loading to surface waters can cause **harmful algal blooms and negatively impact fisheries**.
- Excess nitrogen loading to Minnesota's groundwater can result in **water that is unsafe to drink**.

Ponds are simple to operate and can perform exceptionally well with respect to total nitrogen removal, though they do not always do so. If nitrogen cycling in pond systems was well understood, simple interventions, such as adding oxygen and mixing the sediment of the pond when needed, could be used to stimulate total nitrogen removal during times of poor performance, such as the winter and spring months. **Pond systems, if better understood from a nitrogen-cycling perspective, could serve as an excellent solution for some of Minnesota's 1000 small communities that need wastewater management.**

## II. PROJECT ACTIVITIES AND OUTCOMES

### Activity 1: Laboratory assessment of how nitrogen cycles during winter/spring months

Model pond reactors (22-liter) will be set up in the laboratory, containing sediment and water obtained from two wastewater treatment ponds: a well performing and poorly performing pond. Reactors will be operated to model pond conditions when the temperature is low and ice cover decreases the amount of oxygen that can reach the deeper regions of the pond. It is during these months that the nitrogenous compounds that can cause surface water and groundwater damage are thought to build up. Nitrogen removal and the bacteria that perform various nitrogen cycling steps will be measured to understand how cold temperatures and low oxygen impact these processes.

**ENRTF BUDGET: $186,142**

| Outcome | Completion Date |
|---|---|
| *1. Experiments performed at a variety of oxygen levels at low (4°C) temperature* | *7/31/19* |
| *2. Experiments repeated at 8°C* | *1/31/20* |
| *3. Experiments repeated at 12°C* | *6/31/20* |

**Activity 2: Full-scale pond assessment of nitrogen cycling during winter/spring**

We will work with our project partner, the Minnesota Rural Water Association, to obtain samples from the same two ponds over time. Water-column samples will be taken for analysis of nitrogen species; temperature and oxygen concentrations will be measured with a hand-held sonde. Samples will be taken over time after wastewater loading during the winter and spring months when temperatures are expected to range from 4°C to 12°C and the ponds range from free-surface to ice-covered. Samples of the water column and pond sediment will be taken to measure the nitrogen-cycling bacteria present in the samples.

**ENRTF BUDGET: $120,000**

| Outcome | Completion Date |
|---|---|
| *1. Sampling the oxidation ponds during winter and spring* | *6/30/19* |
| *2. Analysis of the bacteria present in pond samples* | *6/30/19* |

**Activity 3: Evaluation of simple methods (mixing and aeration) to stimulate total nitrogen removal during winter/spring**

Laboratory and field experiments will be performed to evaluate the effect of oxygen addition, via the solid and easily deployed "oxygen-release compound" (ORC®, Regenesis), and the effect of gentle pond sediment mixing via a paddle mixer. The effect of such simple stimulation methods on the transformation patterns of nitrogen species under conditions least favorable to nitrogen removal in the winter and spring will be determined.

**ENRTF BUDGET: $95,891**

| Outcome | Completion Date |
|---|---|
| *1. Evaluation of effect of ORC addition and mixing on nitrogen removal in the laboratory* | *9/30/20* |
| *2. Evaluation of effect of ORC addition on nitrogen removal in the field* | *3/30/21* |
| *3. Evaluation of the effect of mixing on nitrogen removal in the field* | *4/30/21* |

**III. PROJECT PARTNERS:**

**A. Partners receiving ENRTF funding**

| Name | Title | Affiliation | Role |
|---|---|---|---|
| Minnesota Rural Water Association | | | Responsible for sampling in activity 2 and assisting with activity 3 |

**IV. LONG-TERM- IMPLEMENTATION AND FUNDING:**

The proposed work fits into a larger research agenda at UMN on the development and evaluation of treatment technologies for water and wastewater. The proposed research expands the focus to outstate and rural infrastructure support, coordinating with several other proposals. **This research will also be coordinated with the Minnesota Pollution Control Agency's (MPCA's) work on the optimization of rural wastewater systems. The MPCA does not have the capacity to perform longer-term and well controlled experiments and this research will complement their work well.**

**V. TIME LINE REQUIREMENTS:**

The proposed project will be completed in the allotted three-year period.

# 2019 Proposal Budget Spreadsheet

**Project Title:** Outstate Wastewater: Improving Nitrogen Removal in Treatment Ponds

**IV. TOTAL ENRTF REQUEST BUDGET:** 3 years

| BUDGET ITEM | AMOUNT |
|---|---|
| **Personnel:** | $ 231,033 |
| Novak (PI, 4% time per year for three years, salary 75% of cost, fringe benefits 25% of cost). Project supervision, provide guidance on the reactor construction and operation. Total estimated cost is $33,161. | $ 33,161 |
| LaPara (PI, 4% time per year for three years, salary 75% of cost, fringe benefits 25% of cost). Project supervision, guidance on microbial analysis aspects of the project. Total estimated cost is $25,349. | $ 25,349 |
| Graduate student (50% time per year for three years, 57% salary, 32% tuition, 11% fringe benefits). Conducting laboratory experiments and analyzing samples collected from oxidation ponds by the Minnesota Rural Water Association. Total estimated cost is $142,523. | $ 142,523 |
| Undergraduate student (13 weeks (i.e., summer), full time per year for three years). Assisting with routine wastewater analyses (nitrogen measurements) and laboratory experiments. Total estimated cost is $30,000. | $ 30,000 |
| **Professional/Technical/Service Contracts:** Minnesota Rural Water Association will work with us to take treatment pond samples, do chemical analysis in the field (dissolved oxygen, temperature, and some nitrogen species), and assist with in-pond interventions (paddle mixing and oxygen addition). A 25% engineer will be paid to perform this work. They will also help with disseminating findings through their outreach programs using staff time (25% FTE/year). | $ 100,000 |
| **Equipment/Tools/Supplies:** Laboratory supplies are budgeted ($14,800) including, but not limited to: kits for in-field nitrogen species analysis, chemicals for synthetic wastewater generation, materials to construct wastewater reactors, chillers to maintain low reactor temperatures, analysis needs such as standards, sample vials, columns and guard columns, supplies for culture-independent bacterial enumeration and identification; consumables such as gloves and solvents ($18,333/yr). Funds are also budgeted for three sondes for multi-location real-time analysis of treatment pond chemistry ($3,600/each, so $10,800 total). Additional funds budgeted for equipment repair and maintenance ($6,000), and laboratory services (sequencing for confirmation of organism identity, $8,000). | $ 69,200 |
| **Travel:** Mileage charges to oxidation pond sites for sample collection, and pond water, wastewater, and pond sediment collection. Mileage will be reimbursed $0.55 per mile or current U of M compensation plan. | $ 1,800 |
| **TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =** | $ 402,033 |

**V. OTHER FUNDS** *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

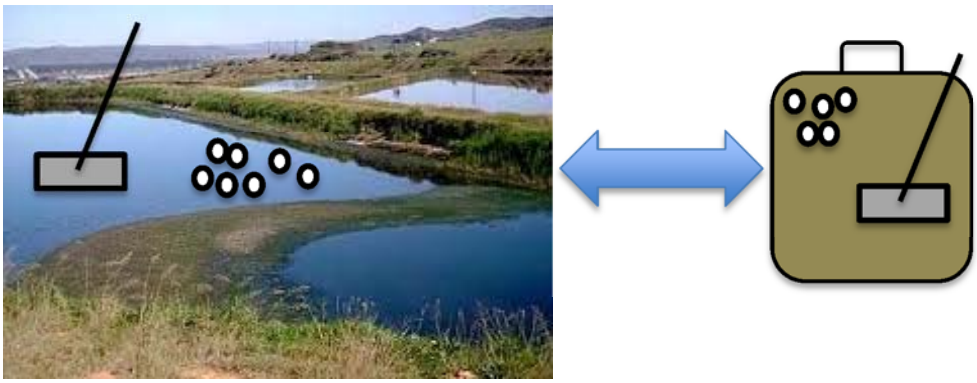
| SOURCE OF FUNDS | AMOUNT | Status |
|---|---|---|
| **Other Non-State $ To Be Applied To Project During Project Period:** | N/A | |
| **Other State $ To Be Applied To Project During Project Period:** | N/A | |
| **In-kind Services To Be Applied To Project During Project Period:** Novak and LaPara will provide unpaid time to the project (including 2% cost-share). Because the project is overhead-free, laboratory space, electricity, and other overhead costs are provided in kind. The University of Minnesota overhead rate is 54%. | $ - | |
| **Past and Current ENRTF Appropriation:** No past projects are related to this proposal; the PI, however, has successfully led or contributed to 6 past LCCMR projects. | N/A | |
| **Other Funding History:** | N/A | |

# Outstate Wastewater: Improving Nitrogen Removal in Treatment Ponds

*With the proposed research, nitrogen removal in treatment ponds is understood and enhanced*

Full-scale pond sampling and experimental intervention (simple paddle mixing and aeration)

Controlled laboratory experiments seeded with pond sediment and water (including interventions)



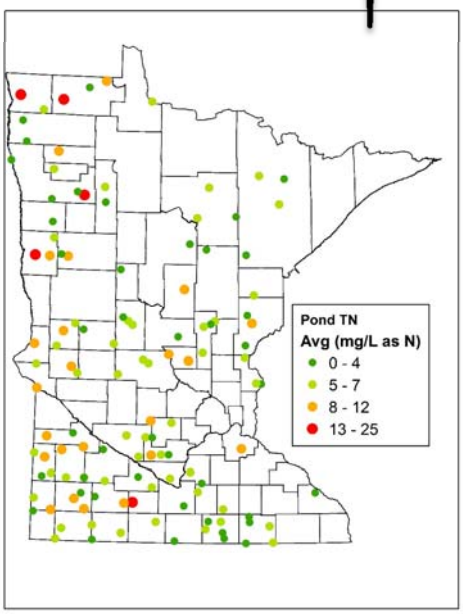



*Figure from the MPCA*

**Result:**
Improve outstate nitrogen removal from wastewater

**Simply put:**
More dark green, less orange and red

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

Partners for water quality solutions

## Project Manager Qualifications and Organization Description

**Dr. Paige J. Novak**
Professor, Department of Civil, Environmental, and Geo- Engineering and Resident Fellow of the Institute on the Environment, University of Minnesota

B.S., Chemical Engineering, 1992, The University of Virginia, Charlottesville, VA.
M.S., Environmental Engineering, 1994, The University of Iowa, Iowa City, IA.
Ph.D., Environmental Engineering, 1997, The University of Iowa, Iowa City, IA.

Dr. Novak will be responsible for overall project coordination. She is an expert in applied environmental microbiology and has been studying biological nitrogen removal and anaerobic biological processes for over 20 years and wastewater treatment for over 12 years. She is currently performing complementary LCCMR-funded research on enhanced nitrogen removal in wastewater.

**Dr. 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/01_about.php). The laboratories and offices of the PI and co-PI contain all of the necessary fixed and moveable equipment and facilities needed for the proposed studies.