Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 049-B**

Agricultural Water Remediation Using Novel Woodchip Bioreactor Technology

Category: B. Water Resources

Total Project Budget: $ 567,000

Proposed Project Time Period for the Funding Requested: 3 years, July 2017 - June 2020

Summary:

We will evaluate the effectiveness of nutrient reduction strategies from drainage water using microbiologically-optimized woodchip bioreactors, which will alleviate the adverse effects associated with eutrophication, hypoxia and harmful algal blooms.

Name: Carl Rosen

Sponsoring Organization: U of MN

Address: 1991 Upper Buford Cir

St. Paul MN 55108

Telephone Number: (612) 625-8114

Email crosen@umn.edu

Web Address http://www.swac.umn.edu/

Location

Region: Central, Southwest, Southeast

County Name: Kandiyohi

City / Township: Willmar/Willmar

Alternate Text for Visual:

A woodchip bioreactor improves surface water by removing excess nitrate in drainage water.

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

PROJECT TITLE: Agricultural water remediation using novel woodchip bioreactor technology

I. PROJECT STATEMENT

Farmers in humid and semi-humid regions install perforated drains to remove excess water from farmland. This practice is generally referred to as subsurface (tile) drainage, which enhances agricultural productivity in the Midwest by providing better conditions for root growth and improving soil trafficability for timely planting and harvesting. However, one tradeoff is that with the removal of excess water through subsurface drainage, portions of soluble nitrogen and phosphorus are leached from the soil profile and make their way into surrounding waterways. Consequently, excess nutrients in downstream water bodies can cause adverse effects of eutrophication, harmful algal blooms and hypoxia (oxygen depletion). Harmful algal blooms in streams, rivers and lakes of Minnesota during warmer months are prompting concern on the deleterious effects on tourism, fisheries, and ecosystem function. Therefore, the United States Environmental Protection Agency and the Minnesota Pollution Control Agency have called for a minimum of 45% reduction in total nutrient loads in the Mississippi River. Our proposed research will contribute to the MPCA goal by optimizing the edge-of-field, nutrient removal, best management practice of woodchip bioreactors (also known as denitrification beds).
Therefore, our goal is to evaluate the effectiveness of N and P reduction from drainage water using microbiologically-optimized woodchip bioreactors, and thus, alleviating the adverse effects associated with eutrophication, hypoxia and harmful algal blooms.
A woodchip bioreactor is a trench filled with woodchips through which subsurface drainage water is routed. This practice can remove excess nitrate in drainage water by transformation into nitrogen gas. While a number of bioreactors have been installed in Minnesota, their performance is often erratic due to cold temperatures and poor reactor design. Because of poor performance at low temperatures, we will investigate ways to optimize nutrient mitigation at cold temperatures by adding carbon (biostimulation) and adding denitrifying bacteria (bioaugmentation) to the system. This will result in enhanced nutrient removal at cold temperatures, which will lead to the treatment larger portion of the drainage water.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Determine the effectiveness of adding carbon and bacteria in removing excess nutrients from drainage water. **Budget: $329,000**

We redesigned a woodchip bioreactor near Willmar, Minnesota, into eight replicated bioreactor beds. We will use these beds to conduct a controlled and replicated experiment to evaluate strategies for enhancing nutrient removal throughout the three growing season. The strategies that will be tested include: 1) control (no additions), 2) bioaugmentation (bacteria addition), and 3) biostimulation (carbon addition) using acetate and lactate. Once all the bioreactor beds are exposed to tile-water flow conditions, we will add the bacteria to beds and add carbon to the inlet pipe to initiate the experiment. The bacteria addition includes adding cold-adapted and metabolically-active denitrifying bacteria, and the carbon addition includes acetate and lactate injection into the inlet of the system to boost nutrient removal.

Outcome	Completion Date
1. Complete the collection of water quantity and quality dataset for analysis	*October 30, 2019*
2. Quantify the effectiveness of woodchip bioreactors in relation to nitrogen and phosphorus removal from drainage water.	*December 30, 2019*
3. Organize a field day in 2017 for the producer and state agency communities.	*September 30, 2017*
4. The knowledge obtained from this research will be communicated to landowners, farmers, technical agencies, and targeted watershed groups at state meetings.	*December 30, 2019*
5. Enhance nutrient removal at cold temperatures, which will lead to the treatment larger portion of the bioreactor flow capacity.	*December 30, 2019*
6. Write peer-reviewed publications to disseminate our findings.	*December 30, 2019*

Activity 2: Characterize the microbial community that is most efficient in removing excess nutrients from drainage water. **Budget: $238,000**

We will collect woodchip and water samples biweekly from the bioreactor beds along the length and depths of each bioreactor bed, with seasonal sampling thereafter. We will characterize the microbial communities in each bioreactor bed by metagenomic sequencing. We will also quantify the functional genes responsible for denitrification and phosphorus uptake. With these analyses, we can identify the bacteria responsible for N and P removal.

Outcome	Completion Date
1. Identify the most efficient microbial communities responsible for removing soluble nitrogen and phosphorus to enhance bioreactor performance.	*December 30, 2019*
2. Publish a fact sheet about woodchip bioreactors that will help landowners and professionals better understand and manage their systems. This fact sheet will become available on the website of University of Minnesota Extension	*December 30, 2019*
3. Provide farmers optimized bacterial mixtures to add to bioreactors throughout the state.	*December 30, 2019*
4. Experiment performed and final results reported	June 30, 2020

III. PROJECT STRATEGY

A. Project Team/Partners

Project team:

1- Name: Carl J. Rosen
Affiliation: Professor and Head of Department of Soil, Water and Climate, University of Minnesota
Role: Direct research and data collection. Assist with manuscript writing.

2- Name: Gary W. Feyereisen
Affiliation: USDA-Agricultural Research Service, Soil and Water Management Research Unit
Role: Analyze water samples for chemical constituents. Write manuscripts.

3- Name: Ehsan Ghane
Affiliation: Department of Soil, Water, and Climate, University of Minnesota
Role: Collect data and analyze nutrient removal of the system. Write manuscripts.

4- Name: Michael J. Sadowsky
Affiliation: Dept. of Soil, Water, and Climate, and Director of Biotechnology Institute, University of Minnesota
Role: Direct microbial research and analyze microbial data. Write manuscripts.

5- Name: Satoshi Ishii
Affiliation: Biotechnology Institute and Department of Soil, Water, and Climate, University of Minnesota
Role: Laboratory bacteria analyses. Write manuscripts.

B. Project Impact and Long-Term Strategy

The long-term benefit of our work will refine environmental management plans and regulations by government agencies like the U.S. EPA and MDA. With our results, the USDA-NRCS is expected to further promote this system to Minnesota's farming community.

C. Timeline Requirements

We will conduct this project from July 2017 until June 2020 to cover three growing seasons. We will collect water samples for chemical analysis as well as collecting woodchip samples for microbial analysis during this period. Project report will be submitted by June 30, 2020.

2017 Detailed Project Budget

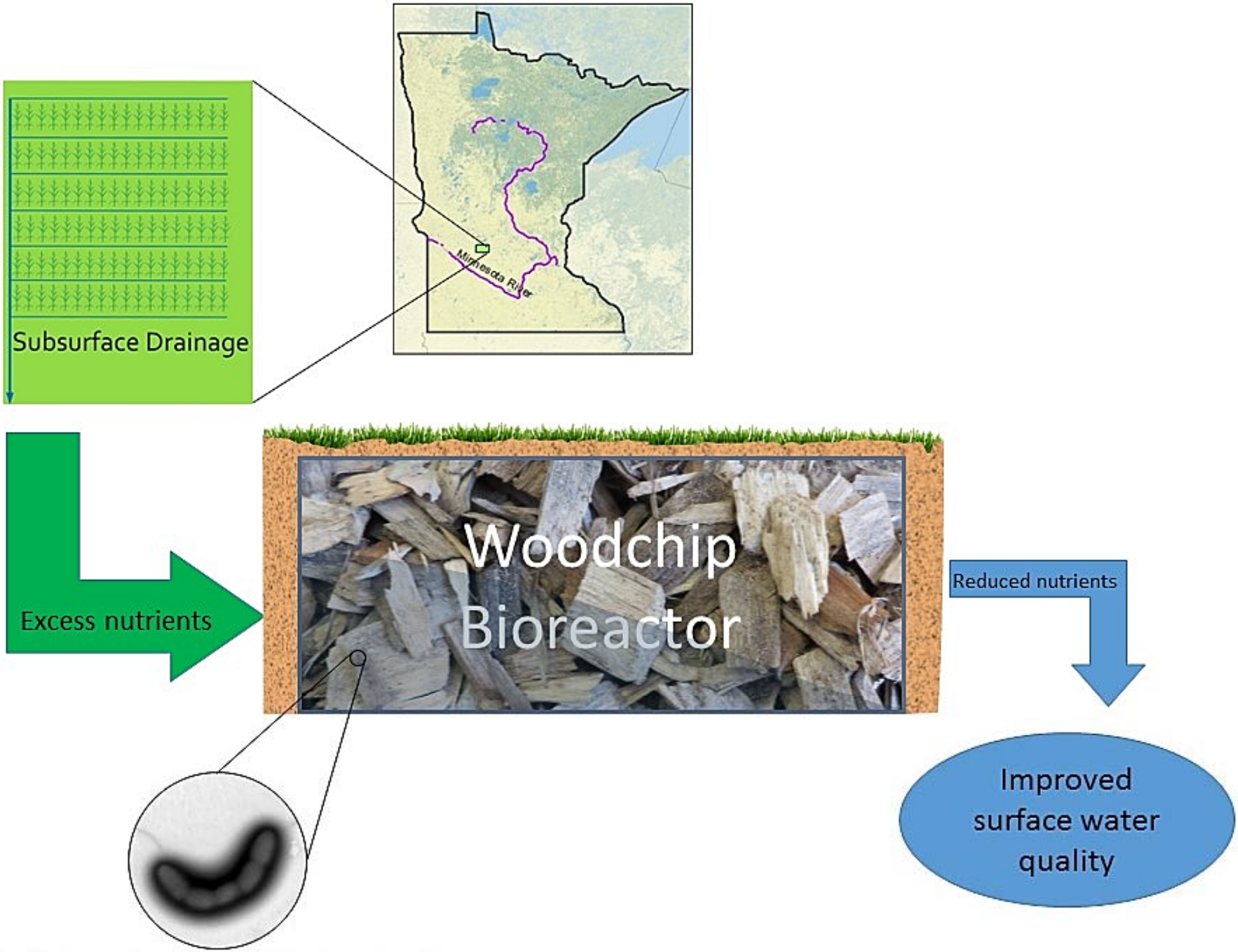
Project Title: Agricultural water remediation using novel woodchip bioreactor technology

IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel: a. Title: Senior Scientist. Role: Sampling and data processing. Annual cost: $43,228. 50% at time. 27.4% benefit and 50% salary. Duration: three years. b. Title: Postdoctoral Associate. Role: Data analysis and writing. Annual cost: $26,974 at 50% time. 22.4% benefit and 50% salary. Duration: three years. c. Title: Researcher 3. Role: Microbial analysis. Annual cost: $35,053 at 50% time. 27.4% benefit and 50% salary. Duration: three years. d. Title: Graduate student. Role: Microbial analysis. Annual cost: $40,000 at 100% time. benefit and 50% salary. Duration: two years.	$ 395,765
Professional/Technical/Service Contracts: N/A	$ -
Equipment/Tools/Supplies: Supplies: Annual cost $5,692 for three years. Needed for maintenance of the bioreactor and sample collection materials. Equipment: one-time total cost $68,000. Need equipment to automated collection of water samples and measurement of water depth.	$ 85,076
Acquisition (Fee Title or Permanent Easements): N/A	$ -
Travel: Annual cost of transportation is $6,008 and for the duration of three years. This fund covers 32 round-trips per year to the site. Need to travel from Saint Paul to the experimental site near Willmar, MN. The round-trip distance is 240.7 miles with a cost of $187.75 per trip at a rate of $0.78/mile for the department van. Annual cost of dinner is $736 (32x$23) for 32 extended day travels per year for the duration of three years. An extended day travel provides dinner only that is $23.	$ 20,232
Additional Budget Items: 1- Education/outreach: $5,000 a- $2,000 for peer-reviewed publication b- $3,000 for organizing field days at sites yet to be determined (i.e., printing handouts, lunch will be provided, transportation to bring U of MN researchers to the field site, etc.) 2- Laboratory Analysis: $60,927 a- $30,957 for DNA analysis and microbial cultures of water and woodchips for approximately 300 samples at $103.19 per sample. b- $29,970 to conduct chemical analysis of water samples including nitrate, ammonium, soluble phosphorus, total phosphorus, and total suspended solids for approximately 540 samples at $55.50	$ 65,927
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 567,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: N/A	$ -	*Indicate: Secured or*
Other State $ To Be Applied To Project During Project Period: *We have aookued for a grant from the Minnesota Department of Agriculture for $299,531 which would provide support until April 2018, if funded.*	$ 299,531	*Indicate: Secured or Pending*
In-kind Services To Be Applied To Project During Project Period: N/A	$ -	*Indicate:*
Funding History: N/A	$ -	
Remaining $ From Current ENRTF Appropriation: N/A	$ -	*Indicate:*


Subsurface Drainage
Minnesota River
Excess nutrients
Woodchip
Bioreactor
Reduced nutrients
Improved surface water quality
Bacteria involved in nutrient reduction

Project Manager Qualifications:

Carl Rosen, Ph.D. - Soil Science

Education and Training

Degree	Major	Institution	Year
Ph.D.	Soil Science	Univ. of California, Davis	1983
M.S.	Horticulture	Penn. State University	1978
B.S.	Horticulture	Penn. State University	1976

Research and Professional Experience

2010-present	Head, Department of Soil, Water & Climate
1995-present	Professor, Univ. of Minn., Dept. of Soil Water, and Climate
1989-95	Associate Professor, Univ. of Minn., Soil Science Dept.
1983-89	Assistant Professor, Univ. of Minn., Soil Science Dept.

Dr. Rosen's current position is Head of the Department of Soil, Water and Climate. As Department Head, he continues to direct an active research program related to nutrient management for crop production. The responsibilities of his research and extension activities include identifying needs and establishing priorities in plant nutrition and improving fertilizer use efficiency for crop production in Minnesota. Primary emphasis is on irrigated crops commercially grown in Minnesota. However, efforts in recent years have also focused water quality issues related to fertilizer use and agricultural use of municipal and industrial by-products as soil amendments. He is an author or co-author on 106 peer-reviewed publications and over 50 extension publications related to nutrient management and crop production.

Organization Description – University of Minnesota

The University of Minnesota (UMN) is Minnesota's research university. UMN changes lives through research, education, and outreach. Faculty and staff at UMN seek new knowledge that can change how we all work and live. At UMN, students do research alongside top professors in all majors. UMN prepares students to meet the great challenges facing our state, our nation, and our world. UMN faculty and staff utilize their expertise to meet the needs of Minnesota, our nation, and the world. UMN partners with communities across Minnesota to engage our students, faculty, and staff in addressing society's most pressing issues.