Environment and Natural Resources Trust Fund

M.L. 2024 Approved Work Plan

General Information

ID Number: 2024-257

Staff Lead: Mike Campana

Date this document submitted to LCCMR: June 12, 2024

Project Title: Breaking the PFAS Cycle with a Full-Scale Demonstration

Project Budget: $1,481,000

Project Manager Information

Name: Andrew McCabe

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Project Reporting

Date Work Plan Approved by LCCMR: June 20, 2024

Reporting Schedule: June 1 / December 1 of each year.

Project Completion: June 30, 2026

Final Report Due Date: August 14, 2026

Legal Information

Legal Citation: M.L. 2024, Chp. 83, Sec. 2, Subd. 04k

Appropriation Language: $1,481,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with Barr Engineering Company, in partnership with the city of St. Cloud and the Minnesota Technical Assistance Program (MnTAP) at the University of Minnesota, to conduct a full-scale pilot to evaluate supercritical water oxidation of biosolids and drinking water treatment residuals to destroy per- and polyfluoroalkyl substances (PFAS) and recover energy in the water treatment process. This appropriation is subject to Minnesota Statutes, section 116P.10.

Appropriation End Date: June 30, 2027

Narrative

Project Summary: This full-scale pilot will evaluate supercritical water oxidation (SCWO) for managing PFAS in biosolids and water treatment residuals. SCWO can destroy PFAS in a variety of wastes and recover energy.

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

PFAS are ubiquitous contaminants, impacting Minnesota's water resources. Efforts are accelerating on the state and federal level to understand the extent of PFAS contamination. Regulatory actions are accelerating with the EPA proposing drinking water MCLs and CERCLA hazardous substance designations. To protect Minnesota's water resources, we will need sustainable ways to manage and destroy PFAS, particularly in residuals from water and wastewater treatment, to break the PFAS cycle.

Water resource recovery facilities (WRRFs) receive industrial and municipal wastewater containing PFAS. PFAS partition into biosolids at WRRFs, and traditional management methods like composting, land application, and sewage sludge incineration do not destroy PFAS and may promote their environmental spread.

Up to 20% of U.S. drinking water systems may need advanced treatment or alternative water sources to meet proposed PFAS MCLs. Granular activated carbon and anion exchange resin, both available technologies, can remove PFAS from drinking water. Once the capacities of these media are exhausted, they are typically disposed of and replaced.

Municipalities throughout Minnesota will likely require PFAS destruction options for these waste streams. The only PFAS destruction technologies currently applied at municipal scales require high temperatures, significant external energy, have no installations in Minnesota, and carry significant regulatory uncertainty.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

Supercritical water oxidation (SCWO) has been applied for waste management and has the potential to mineralize PFAS, produce clean water for beneficial reuse, and recover valuable nutrients and energy from waste. This project is a full-scale demonstration pilot of SCWO to destroy PFAS as an initial step in evaluating this promising PFAS destruction option for future implementation in Minnesota. The goal of our team, which represents a public-private partnership, is to evaluate the ability of SCWO to destroy PFAS in a range of wastes while remaining energy neutral. A long-term outcome could be PFAS destruction facilities using SCWO and accepting residuals from a variety of sources, including wastewater treatment utilities seeking alternative biosolids management options and drinking water treatment utilities upgrading to meet proposed MCLs.

PFAS destruction using SCWO has been tested in academic research and small-scale installations but needs additional, full-scale vetting of the PFAS destruction efficiency and options for disposal or reuse of treated water and solids. Thus, the need to progress toward full-scale implementation falls less to academic research and more in the area of engineering application and logistics. Our team is well positioned to successfully complete this project based on our experience implementing innovative infrastructure projects.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

Sustainable options are needed to manage PFAS, both in biosolids from municipal wastewater treatment and in sorption media from drinking water treatment. Project outcomes will demonstrate the potential benefits of implementing SCWO for PFAS waste management in Minnesota. Implementing PFAS destruction reduces the potential load of PFAS that could be routed back to the environment, preserving the state's natural resources, improving water quality, and reducing potential for human exposure. Applying SCWO at a WRRF takes advantage of existing conventional biological

treatment that already concentrates PFAS into biosolids. SCWO has the potential to recover valuable nutrients from biosolids while mineralizing PFAS.

Project Location

What is the best scale for describing where your work will take place?

Region(s): Central

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Activities and Milestones

Activity 1: Work plan development, equipment procurement, and pilot system installation

Activity Budget: $623,800

Activity Description:
Our project partners will collaborate to design and procure the pilot equipment and install it onsite at the St. Cloud Nutrient, Energy and Water Recovery Facility (NEW RF). The team will develop plans for pilot operation, sampling and data quality, data management, and waste management.

The driving hypothesis for this project is that SCWO can mineralize PFAS while recovering energy from biosolids and other wastes. The specific objectives are to:

1. Evaluate the operability of SCWO and ongoing maintenance costs.
2. Evaluate the efficiency of PFAS mineralization.
3. Evaluate the efficiency of energy recovery and viable use options.
4. Evaluate the potential value of the nutrient content of residual solids and potential for beneficial reuse as a soil amendment.
5. Evaluate the quality of the condensate water and identify options for beneficial reuse.

Barr Engineering will manage the project and subcontracts. A project principal from Barr Engineering will also be responsible for the delivery of this project and project quality control. 374Water will provide equipment and labor for commissioning and later operations. St. Cloud will facilitate logistics associated with equipment and labor for commissioning and later operations. St. Cloud will facilitate logistics associated with equipment installation.

Activity Milestones:

Description	Approximate Completion Date
Pilot study work plan completion	September 30, 2024
Equipment Procurement (delivery of all pilot equipment to demonstration site)	December 31, 2024
Installation of pilot equipment	March 31, 2025
Pilot system commissioning	April 30, 2025

Activity 2: Operation of SCWO demonstration pilot to evaluate PFAS mineralization, energy recovery, and nutrient recovery

Activity Budget: $792,200

Activity Description:
Pilot operation will occur in a series of phases over four months to evaluate SCWO operation and performance relative to PFAS fate and destruction, energy efficiency, and beneficial reuse of the effluents. Phases will include operation using St. Cloud NEW RF biosolids and sorption media from Minnesota water treatment plants as individual feedstocks and phases with mixed feedstock. Data collection will include sampling for targeted PFAS, organic fluorine and total fluoride, and general characteristics (e.g., nutrient contents) in feedstocks and treated effluents (including the exhaust air, condensate water, residual solids, and effluent water). Operational data, energy use and recovery, and potential for beneficial reuse of the condensate water and solid residuals will be evaluated as well.

Pilot operation will be a collaborative effort among all project partners. Day-to-day operation of pilot equipment will be conducted by 374Water, with support from St. Cloud NEW RF staff, who will be trained on basic operations as well as

emergency procedures. Students or interns with MnTAP and the University of St. Thomas will conduct routine sampling and analysis, with Barr leading data quality reviews and data management. Data analyses will be completed by certified external laboratories. Barr will also lead air quality sampling.

Activity Milestones:

Description	Approximate Completion Date
Pilot system startup	May 31, 2025
Pilot operation and testing	September 30, 2025
Completion of data reporting	December 31, 2025

Activity 3: Communication and outreach to the water and wastewater communities of Minnesota

Activity Budget: $65,000

Activity Description:
We will communicate pilot impact and results and PFAS destruction context through three primary activities:

1. Pre-pilot promotion will include communications with the MPCA, local chapters of the American Water Works Association (drinking water professional organization), and the Water Environment Federation (wastewater professional organization), with a goal of sharing planned pilot activities with utilities and listening for recommended improvements.
2. Post-pilot outreach may include guest lectures at area universities and industry events and discussions with water and wastewater utilities in the state, with a goal of sharing knowledge about PFAS destruction and piloting outcomes and listening to stakeholder needs and limitations.
3. Technical reporting and manuscript preparation will be critical to making the pilot outcomes useful for future implementation of PFAS destruction projects. This will include writing a peer-reviewed journal article that can be referenced by others as well as presenting at local conferences (e.g., Central States Water Environment Association and Minnesota Wastewater Operators Association) about results and implications for PFAS management in Minnesota.

Activity Milestones:

Description	Approximate Completion Date
Promotion of pilot goals	October 31, 2024
Community outreach about PFAS environmental cycle and pilot study results	December 31, 2025
Publication of peer-reviewed journal article reporting pilot results	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Ali Ling	University of St. Thomas	Technical leadership, project planning, data analysis, reporting, information dissemination	Yes
Emma Larson	City of St. Cloud	Utility resource management and onsite logistics	Yes
Jacob Ethen	City of St. Cloud	St. Cloud NEW RF onsite logistics for pilot equipment installation and material handling	Yes
Sudhakar Viswanathan	374Water	Pilot equipment technology lead	Yes
David Garb	374Water	Pilot equipment and operations manager	Yes
Kelsey Klucas	MnTAP at the University of Minnesota	Coordinating onsite monitoring support and leading outreach efforts to Minnesota's Water Resource and Recovery Facility community	Yes
Shanna Czeck	City of St. Cloud	Utility resource management, permitting support, and onsite logistics	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
PFAS are ubiquitous environmental constituents, with wide ranging impacts. Supercritical water oxidation (SCWO) is relatively new technology to the wastewater and water communities, but it has the potential to destroy PFAS while recovering energy and water from waste. By completing this project, our team will make the overall test plan, operations, and performance monitoring data from a full-scale demonstration of a SCWO system accessible to all potential stakeholders and interested parties.

To provide the highest value of this project to the Minnesota water and wastewater communities, we will engage with stakeholders during the work plan development phase to allow the opportunity for input on the test plan and questions about the treatment process.

During pilot operations, we will offer tours to key stakeholders who may be interested in learning about and seeing this technology in action, for example representatives from the Minnesota Pollution Control Agency (MPCA) and wastewater and water operators from other utilities.

A significant portion of the monitoring and outreach effort of this project will be supported by undergraduate researchers from the University of St. Thomas and interns from MnTAP at the University of Minnesota. This study will be an opportunity for these students to get hands-on experience with this emerging technology and give them an opportunity to think about creative ways to tackle the environmental PFAS cycle.

To ensure accessibility of our team's findings, we will publish our final report in an open-access, peer-reviewed journal and make our data publicly available in an online repository.

We plan to present our results at Minnesota-based conferences (e.g., Minnesota Wastewater Operators Association, the Conference on the Environment, the Minnesota chapter of the American Water Works Association [AWWA], and the Minnesota Water Resources Conference) to ensure stakeholders statewide have opportunities to learn about this technology. We will also plan to present the findings at national conferences (e.g., the Water Environment Federation's WEFTEC and the AWWA's Annual Conference and Expo) to highlight Minnesota's leadership in addressing PFAS pollution.

We will engage with relevant university programs in Minnesota (e.g., University of Minnesota, University of St. Thomas, and St. Cloud State University) to present seminars on this project. We will also engage with state agencies, such as MPCA and the Minnesota Department of Health, to offer presentations and public webinars of our project findings.

The Environment and Natural Resources Trust Fund will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENTRF Acknowledgment Guidelines. All sub-awardees will also follow these guidelines.

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

This study will be successful if we can accurately evaluate PFAS destruction and the potential to use captured energy from wastes and reuse condensate water and residual solids. Pending favorable technology outcomes from the demonstration, we will identify and seek opportunities to apply SCWO in Minnesota. We will seek funding, potentially through the Department of Energy, the Department of Defense, state-sponsored grants, or public-private partnerships to assist with future scale-up needs including a potential regional PFAS destruction facility integrating needs of drinking water utilities, wastewater utilities, landfills, and industries. Future efforts could also investigate carbon capture potential for SCWO.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Engineering Project Manager		Project management, team coordination, data management coordination, budget tracking, progress tracking			70%	0.4		$79,000
Engineering Project Principal/Technical Reviewer		Fiscal responsibility for sponsoring organization, project oversight, quality control, and project delivery			70%	0.04		$12,000
Engineering Support		Data management, data quality, and onsite monitoring and commissioning support (split between multiple staff, estimating 3-5 individuals)			70%	0.14		$92,000
							Sub Total	**$183,000**
Contracts and Services								
St. Cloud Nutrient, Energy and Water Recovery Facility	Sub award	Utility resource management, onsite logistics, installation support, operation support, and outreach. Support for approximately 2-4 individuals.				0.14		$36,000
Minnesota Technical Assistance Program (MnTAP)	Sub award	MnTAP will provide intern support to assist with sample collection and pilot monitoring. MnTAP will also take a lead role in outreach to Minnesota's wastewater community. This sub-award will support one MnTAP staff engineer and one intern. This budget includes time and expenses for travel to the project site.				0.14		$43,000
374Water	Professional or Technical Service Contract	374Water will provide the SCWO equipment as well as engineering support. They will provide operations support for 8 hrs/day for the duration of the pilot, plus assistance installing the pilot. The contract amount includes equipment rental for 4 months plus support from two rotating 374Water engineers and onsite operators.				0.24		$600,000
Contract Laboratories (TBD)	Professional or Technical	Commercial laboratory testing fees for general water quality analyses, waste characterization, and PFAS analyses on the wastes, water, and air				0		$300,000

	Service Contract	streams. Commercial laboratories will provide analytical testing, laboratory reports to support data management, and data quality reports.						
Vonco II	Professional or Technical Service Contract	Disposal of solids produced from SCWO unit				-		$30,000
Mechanical and electrical contractor (TBD)	Professional or Technical Service Contract	Electrical and mechanical contractor for installation of equipment, piping, and electrical. Equipment demobilization and demolition.				0		$140,000
University of St. Thomas	Sub award	St. Thomas (Ali Ling) will provide technical leadership, leading data analysis, and reporting. St. Thomas will also support an undergraduate researcher to support system monitoring and data analysis efforts. This budget includes time and expenses for travel to the project site.				0.14		$36,000
							Sub Total	**$1,185,000**
Equipment, Tools, and Supplies								
	Equipment	Tanks for waste receiving and effluent water storage	Tanks to store and prepare feed wastes ahead of the SCWO reactor and tanks to store effluent water. No single piece of equipment is expected to be greater than $5,000.					$40,000
	Equipment	Feed and effluent pumps	Pumps to transfer sludge from St. Cloud's biosolids storage tanks to the SCWO reactor and pumps to transfer effluent water. No single piece of equipment is expected to be greater than $5,000.					$20,000
	Equipment	Solids dewatering equipment	Equipment to separate residual solids and effluent water. No single piece of equipment is expected to be greater than $5,000.					$10,000
	Equipment	Ancillary equipment, piping/hoses, and electrical equipment	Includes process piping, electrical equipment, and instrumentation. No single piece of equipment is expected to be greater than $5,000.					$25,000

	Equipment	Co-fuel (diesel for system start-up) and tank	Start-up fuel for SCWO reactor. Co-fuel is needed to heat and pressurize the system at start-up.					$5,000
							Sub Total	**$100,000**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Amount includes mileage for round trip from the Twin Cities to St. Cloud (140 miles) for Barr staff to visit the demonstration site two times per week during system installation, start-up, and operation. Day trips only. MnTAP interns and St. Thomas undergraduates will also be regularly visiting the site, and budgets have been allocated separately for these individuals in budget requests for MnTAP and St. Thomas.	Barr staff will regularly visit the site to observe and assist with equipment installation. During pilot operation, staff will be collecting samples and assisting with system troubleshooting.					$6,000
	Conference Registration Miles/ Meals/ Lodging	The intent of this budget is to allow the project manager to attend one in-state conference to present the results of this study. The budget includes 8 hours of time and conference registration.	The third activity of this project is to communicate our results to the water and wastewater communities of Minnesota. This budget will directly support this effort.					$600
							Sub Total	**$6,600**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	The intent of this budget is to allow the project manager to travel to and participate in one two-day out-of-state conference). The budget includes 16 hours for conference attendance and travel expenses. Travel time and expenses will be shared with funding provided by Barr Engineering for up to 36 hours of time and $2600 travel expenses.	The third activity of this project is to communicate our results to the water and wastewater communities of Minnesota and beyond. This requested budget will directly support this effort.	X				$1,400

							Sub Total	**$1,400**
Printing and Publication								
	Publication	Publication of one open access peer-reviewed journal article	Publication of an open access peer-reviewed journal article will allow results from the pilot test to be accessible to a broad community interested in alternative PFAS management options.					$5,000
							Sub Total	**$5,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$1,481,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	The intent of this budget is to allow the project manager to travel to and participate in one two-day out-of-state conference). The budget includes 16 hours for conference attendance and travel expenses. Travel time and expenses will be shared with funding provided by Barr Engineering for up to 36 hours of time and $2600 travel expenses.	This funding will be used to participate in formal presentations of our project findings at an out-of-state conference. The purpose of the presentation will be to demonstrate that the state of Minnesota is a national leader in addressing PFAS contamination using novel, innovative technologies.

Non ENRTF Funds

Category	Specific Source	Use	Status	$ Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	Barr Engineering Co. (Individual Education Account for Andrew McCabe)	Funds will be used to support the project manager (Andrew McCabe) to attend conferences to specifically present results from this project.	Secured	$4,700
			Non State Sub Total	**$4,700**
			Funds Total	**$4,700**

Attachments

Required Attachments

Visual Component

File: 7bbe808c-bcb.pdf

Alternate Text for Visual Component

PFAS are routed from industrial and community uses to wastewater and drinking water facilities, where residuals from these facilities may impact natural resources. Supercritical water oxidation (SCWO) has the potential to aid in breaking the PFAS environmental cycle by destroying PFAS in wastewater facilities and spent sorption media....

Financial Capacity

File: 239bfe53-d98.pdf

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
St. Cloud Letter of Support	bda6db36-092.pdf
MnTAP Letter of Support	34f45fa2-095.pdf
City of Bemidji Letter of Support (drinking water GAC treatment)	a705e9da-58d.pdf
Vonco II Waste Management Letter of Support	2b3ed282-c2f.pdf
Letter of Commitment from Barr Engineering	4335b4ee-494.pdf
374Water Letter of Support	0c26e178-261.pdf
St. Thomas Letter of Support	84628c6d-548.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

The following revisions have been made to this work plan:
1) We have made slight text updates in Section 5, the Activities and Milestones, to highlight that our team is a public-private partnership and that we intend to deliver this project as a collaborative effort between our project partners.
2) We have updated our budget to reflect the recommended funding amount. We decreased the planned duration of the pilot from six months down to four months to decrease equipment rental and service fees. We also updated the amount allocated to Barr for project and data management.
3) We have updated Dr. Ali Ling's affiliation from Barr Engineering to the University of St. Thomas. Ali will maintain her originally intended role on this project. Ali will mentor and support an undergraduate student, through an undergraduate research program at St. Thomas, to assist with this pilot study. We have included a letter of support from Ali, as well.
4) We have added Shanna Czeck to our team. Shanna is with the City of St. Cloud and will support onsite resource management, logistics, and permitting needs.

Changes made on 5/21/24:
1) I updated the descriptions of our ancillary equipment expenditures to state that no individual piece of equipment is expected to be greater than $5,000.
2) I updated the budgets for MnTAP and St. Thomas to be inclusive of their respective travel budgets to and from the site.

3) I updated the language in our dissemination plan in include specific reference to the ENRTF.
4) I updated the allocation of Barr's travel budget for myself (Andy McCabe) to participate in two conferences. I also updated secured non-ENRTF funding I have from Barr Engineering (in the form of an Individual Education Account) to participate in conferences and present our results.

Changes made on 5/29/24:
1) Separated the in-state and out-of-state conference participation budgets, descriptions, and justifications.
2) Updated the descriptions for the budgets for MnTAP and St. Thomas, specifying that the budget includes time and expenses for personnel travel to the project site.

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

N/A

Do you agree travel expenses must follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I agree to the Commissioner's Plan.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No