

Final Abstract

Final Report Approved on April 23, 2025

M.L. 2022 Project Abstract

For the Period Ending June 30, 2025

Project Title: PFAS Contaminant Mitigation Using Hybrid Engineered Wetlands

Project Manager: Mark St. Lawrence

Affiliation: St. Louis County

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Website: <https://www.stlouiscountymn.gov/departments-a-z/environmental-services>

Funding Source:

Fiscal Year:

Legal Citation: M.L. 2022, Chp. 94, Sec. 2, Subd. 04m

Appropriation Amount: \$446,000

Amount Spent: \$446,000

Amount Remaining: -

Sound bite of Project Outcomes and Results

An effective alternative landfill leachate PFAS treatment method was developed for the landfill using reverse osmosis. Testing of the hybrid engineered wetland treatment system provided novel data for the scientific community, industry, and regulators. Landfills throughout Minnesota can apply the findings from this project to design advanced leachate treatment systems.

Overall Project Outcome and Results

Landfill leachate poses environmental risks to water resources because of its high pollutant load and must be treated before disposal. Alternative treatment methods are increasingly necessary due to recent PFAS concerns, and the St. Louis County Regional Landfill needed to evaluate alternative leachate PFAS treatment options. Significant progress was made towards accomplishing the overall outcome of designing and developing an effective alternative leachate treatment method. An on-site demonstration-scale hybrid engineered wetland treatment system (EWTS) was designed, constructed, planted, and initiated in 2022. The EWTS was evaluated for a second growing season in 2023. Leachate chemical characterization, and volume and flow rate calculations were completed. Additional EWTS outflow treatment steps (advanced oxidation, filtration, activated carbon, ion exchange) were designed, constructed, and implemented.

Evaluation of two growing seasons of the onsite hybrid EWTS were completed. The hybrid EWTS effectively removed PFAS and other contaminants from the leachate. However, the system was not considered feasible to implement at full scale at the Regional Landfill, primarily because of the energy requirements of the oxidation treatment step. Additional redesign and testing would be necessary before scale up of the hybrid EWTS.

The County added a Vibratory Shear Enhanced Processing (VSEP) reverse osmosis unit to the leachate treatment system in 2023. Three months of VSEP testing were completed and significant data was collected to validate VSEP treatment as an alternative option to the EWTS. Data collected has been used to develop full-scale system design parameters and estimate capital and operational costs.

All activities have been completed and additional dissemination efforts including open forums and scientific journal publication may be pursued. Information collected from the hybrid EWTS and reverse osmosis studies can be used to inform landfill and waste treatment managers of alternative leachate treatment systems that could be implemented at their facilities to address PFAS treatment.

Project Results Use and Dissemination

Project results have been used to develop full-scale system design parameters and estimate capital and operational costs. Results from the project can be extended to landfills throughout Minnesota.

Dissemination efforts include the following: college student tours (four tours), two project summary reports (2022 and 2023), and four open forums (2024 Battelle Chlorinated Conference, 2024 Arrowhead Region Environmental Conference, 2024 MRWA Water & Wastewater Technical Conference, 2025 SWANA Solid Waste Operators Conference). Additional open forums and scientific journal publication may be pursued



Environment and Natural Resources Trust Fund

M.L. 2022 Approved Final Report

General Information

Date: May 1, 2025

ID Number: 2022-286

Staff Lead: Tom Dietrich

Project Title: PFAS Contaminant Mitigation Using Hybrid Engineered Wetlands

Project Budget: \$446,000

Project Manager Information

Name: Mark St. Lawrence

Organization: St. Louis County

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Project Reporting

Final Report Approved: April 23, 2025

Reporting Status: Project Completed & Additional Update Approved

Date of Last Action: April 23, 2025

Project Completion: December 31, 2024

Legal Information

Legal Citation: M.L. 2022, Chp. 94, Sec. 2, Subd. 04m

Appropriation Language: \$446,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with St. Louis County to design, implement, and evaluate an innovative method for protecting water resources through mitigation of per- and polyfluoroalkyl substances (PFAS) from landfill leachate using engineered wetland treatment systems.

Appropriation End Date: June 30, 2025

Narrative

Project Summary: This project will result in the design, implementation, and evaluation of an innovative method for protection of water resources and mitigation of emerging water contaminants in landfill leachate; specifically, PFAS.

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

Landfill leachate poses environmental risks to surface and groundwater because of its high pollutant load and must be decontaminated or remediated before disposal, typically via transport to a municipal wastewater treatment plant (WWTP), or pre-treated prior to spray-irrigation. Alternative treatment methods are increasingly necessary due to capacity challenges and recent PFAS concerns at WWTPs, increased cost-of-transport, and the need for removal of emerging contaminants of concern such as PFAS (per-and polyfluoroalkyl substances). St. Louis County's Regional Landfill is the only Municipal Solid Waste landfill in northeast Minnesota, serving a population of 80,000 increasing seasonally to 110,000 (summer). Leachate is currently irrigated on adjacent fields following pre-treatment. Cost effective transport-for-treatment does not exist. Concerns about PFAS alter the management requirements for spray irrigation and substantially increase pre-treatment costs. An innovative approach to leachate treatment was explored July-Oct 2019 by creating a small-scale Engineered Wetland Treatment System (EWTS) designed to remove and reduce contaminants. A small-scale hybrid EWTS was tested in 2020, resulting in substantial decreases in PFAS, nitrogen, and manganese. The next step is testing larger, demonstration-scale hybrid EWTS to better quantify decreases of PFAS and other contaminants of interest to prevent release into surface and groundwater resources.

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.

To develop, refine, and evaluate an innovative semi-passive form of leachate treatment using an EWTS in combination with post wetland treatments throughout multiple consecutive growing seasons. Small-scale hybrid EWTS testing during 2019 and 2020 provided very encouraging results, prompting Environmental Services to propose upgrading its research to demonstration-scale. Small-scale single-season use of a hybrid EWTS during 2020 resulted in $\geq 90\%$ PFAS with health risk limits (PFOS, PFOA, PFHxS, PFBS, PFBA), $>90\%$ ammonia, and $\sim 90\%$ manganese removals. The proposed system would include five, approximately 6-meter x 2.5-meter reactor cells in series, followed by EWTS-outflow treatment intended for additional organic carbon and PFAS removal. It is well documented that the right combination of plants and soils within a wetland system can act as a natural filter but additional treatment is needed to effectively decrease specific pollutants in leachate such as PFAS. Specifically, with this proposed system, fates, movements, and decreases of contaminants, specifically PFAS, in leachate will be closely studied. This will result in reducing and preventing leachate contaminants from entering critical surface- and ground- water resources. Should this project provide the results we anticipate, its application could be extended to landfills throughout Minnesota.

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?

This proposal addresses 5 of the 10 priority areas of concern identified in the recently released "Minnesota's PFAS Blueprint:" to measure PFAS effectively and consistently, prevent PFAS pollution to surface- and ground-water resources, protect ecosystem health, reduce PFAS exposure from fish and game consumption, and manage PFAS in waste. The overall outcome: design and develop an effective alternative leachate treatment method other than, or prior to, wastewater treatment facility disposal. Additional outcomes include 1) evaluate onsite hybrid EWTS design criteria for effective and cost-efficient PFAS removal throughout multiple consecutive seasons; and 2) evaluate EWTS-outflow treatment efficacy and life expectancy.

Project Location

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

County(s): St. Louis

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: Activity 1: Year One (2022) Design, Permit, and Build Semi-Passive Leachate Treatment System

Activity Budget: \$136,600

Activity Description:

Based on previous small-scale EWTS data, and current published literature, the proposed semi-passive demonstration-scale hybrid EWTS, which includes construction of a wetland pond (30,000 square feet), versus use of containers (900 total square feet) per the Approved Work Plan, will be designed, constructed, planted, and initiated to better replicate a full scale EWTS and ensure more accurate project data. Initial leachate chemical characterization, and volume and flow rate calculations, will be completed. Additional EWTS outflow treatment steps will be designed and constructed. Preparations for growing-season efficacy and efficiency testing during 2023-2024 will be completed. Quarterly and other progress and accomplishment reporting requirements to LCCMR and County personnel will be completed.

The EWTS pond will be built on St. Louis County Regional Landfill land (within their permitted area). Specifically, the EWTS pond will be constructed north of existing onsite leachate holding ponds within the footprint of St. Louis County Environmental Service's / St. Louis County Regional Landfill's existing and permitted leachate spray-irrigation field. Construction of the EWTS pond will not impact any existing wetlands as the land is, and has been for decades, a leachate spray-irrigation field.

Activity Milestones:

Description	Approximate Completion Date
Design and construct a hybrid EWTS wetland pond for landfill leachate treatment.	August 31, 2022
Complete additional EWTS outflow treatment steps construction.	December 31, 2022
Complete maintenance for overwinter storage of hybrid EWTS components.	December 31, 2022
Complete yearly and other reporting throughout 2022 to LCCMR and County personnel.	December 31, 2022
Construct hybrid EWTS.	December 31, 2022

Activity 2: Activity 2: Year Two (2023) Hybrid EWTS Testing and Evaluation

Activity Budget: \$95,800

Activity Description:

Two complete growing seasons will be used to more thoroughly evaluate a hybrid EWTS for this purpose. The initial complete growing season for the demonstration-scale hybrid EWTS evaluation will begin following spring thaw 2023. EWTS status will be assessed; plant growth will be evaluated; and Landfill leachate inflow will begin when appropriate. Information from previous testing will inform any adjustment of system dynamics in an effort to improve overall efficacy. EWTS outflow will be exposed to additional treatment targeting suspended solids, organic carbon, and PFAS. EWTS outflow, and additional-treatment outflow, samples will be used to determine overall system effectiveness throughout 2023, and to guide any adjustments to increase efficacy. EWTS soil and plant samples will be used to determine fate and movement of contaminants of interest within the EWTS. 2023 growing season data will be used to guide decision-making focused on improving intended system function for the 2024 growing season; with the ultimate data quality objective of potential development of a larger, field-scale hybrid EWTS for treatment/removal of leachate contaminants of interest.

Activity Milestones:

Description	Approximate Completion Date
Initiate leachate inflow to EWTS; prep for outflow treatment processes.	June 30, 2023
Assess spring 2023 status of demonstration-scale hybrid EWTS and complete reporting requirements.	July 31, 2023
Complete initial outflow treatment process life-expectancy evaluations.	December 31, 2023
Complete yearly and other reporting throughout 2023 to LCCMR and County personnel.	December 31, 2023

Activity 3: Activity 3: Year Three (2024) Hybrid EWTS Testing and Evaluation

Activity Budget: \$95,600

Activity Description:

EWTS status will be assessed; plant growth will be evaluated; and leachate inflow will begin when appropriate for the second of two complete growing season evaluations. Information from 2023 testing will inform any adjustment of system dynamics in an effort to improve overall efficacy. EWTS outflow will continue to be exposed to additional treatment targeting removal of suspended materials, organic carbon, and PFAS; and will be adjusted if needed in an effort to improve effectiveness. EWTS outflow samples, and additional-treatment outflow samples, will be used to determine overall system effectiveness throughout 2024 and guide any adjustments to increase efficacy. EWTS soil and plant samples will be used to determine fate and movement of contaminants of interest. Ultimately, 2023-2024 hybrid EWTS data will be used for evaluation of field-scale hybrid EWTS feasibility for treatment/removal of landfill leachate contaminants of interest.

Activity Milestones:

Description	Approximate Completion Date
Assess spring 2024 status of demonstration-scale hybrid EWTS.	May 31, 2024
Initiate leachate inflow to EWTS; prep for outflow treatment processes.	June 30, 2024
Complete yearly and other reporting throughout 2024 to LCCMR and County personnel.	July 31, 2024
Complete maintenance for overwinter storage of hybrid EWTS components.	December 31, 2024
Complete final reporting and hybrid EWTS evaluation.	December 31, 2024

Activity 4: Activity 4: Education and Outreach

Activity Budget: \$1,000

Activity Description:

As an Adjunct Instructor at Vermilion Community College (VCC), Dr. Tedrow will coordinate with other VCC Instructors and involve students in relevant Degree programs throughout the duration of this project. Despite the majority of work being completed during summer months, sufficient time will exist during late-spring and early- / mid- autumn for student involvement. Specifically, students in Water / Wastewater Treatment and Watershed Science Programs will have opportunities to visit, tour, and ask questions about this project. Due to the uniqueness of this project (novel applications of typical water treatment processes to a landfill leachate treatment scenario), opportunities to involve students in relevant Degree Programs from a local Community College are unmatched. This opportunity will not exist without LCCMR financial assistance. Students will learn first-hand (i.e., 'hands-on experience') the importance of preventing PFAS pollution, limiting PFAS from drinking water, protecting overall ecosystem health, and managing PFAS in wastes. The latter is critical - keep PFAS out of landfills, and we can avoid additional energy- and cost- intensive treatment needs. This effort will culminate in pursuit of an open forum to distribute project details, information, results, and other specifics. We anticipate 15-30 students per year (likely more).

Activity Milestones:

Description	Approximate Completion Date
Fall 2022 site visit.	December 31, 2022
Spring 2023 site visit.	May 31, 2023
Fall 2023 site visit.	December 31, 2023
Spring 2024 site visit.	May 31, 2024
Fall 2024 site visit.	December 31, 2024

Activity 5: Reverse Osmosis Pilot Testing and Evaluation

Activity Budget: \$117,000

Activity Description:

One season will be used to pilot test reverse osmosis (RO) leachate treatment. Leachate will be treated through a RO system with additional polishing treatment included if deemed necessary. Treated contaminants will include PFAS, metals, nitrogen species, and organic carbon. Samples will be collected to validate the treatment efficacy, develop full-scale system design parameters, and estimate capital and operational costs.

Activity Milestones:

Description	Approximate Completion Date
Design pilot RO system for landfill leachate treatment.	December 31, 2023
Setup pilot RO system.	December 31, 2023
Operate pilot RO system and collect data.	December 31, 2023
Complete yearly and other reporting throughout 2023 to LCCMR and County personnel.	December 31, 2023

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
O'Niell Tedrow, Ph. D.	Northeast Technical Services, Inc. and Vermilion Community College	As a water resources scientist, Dr. Tedrow's primary role will be functional design and evaluation of the proposed hybrid EWTS. As an Adjunct Instructor, he will involve students with this project to the extent possible individually and in collaboration with other VCC instructors; and will assist with public forum coordination.	Yes
Paul Eger, Ph. D.	Global Minerals Engineering	Dr. Eger will work with Dr. Tedrow on functional design of the proposed hybrid engineered wetland treatment system.	Yes
Rick Crum, P.G.	Northeast Technical Services, Inc.	Mr. Crum will serve as the Project Manager for Northeast Technical Services, Inc., and Global Minerals Engineering personnel associated with roles on this project.	Yes
Jonathan Novak, E.I.T.	Northeast Technical Services, Inc.	Jonathan will primarily be involved with designing, initiating, integrating, and maintaining EWTS-outflow treatment processes. Additional responsibilities will be associated with field and lab report data quality review, and data management in an online-accessible database with GIS integration.	Yes
Jacob Crispo, P.E.	Northeast Technical Services, Inc.	Jacob will primarily be responsible for construction oversight, inspection, and any certification(s) of the EWTS. Specifically, verification of structural integrity, reactor cell liner integrity, and other engineering specifics.	Yes
Jordan Erickson	Northeast Technical Services, Inc.	Jordan's experience is focused on environmental engineering. Her primary responsibility will be working with Jacob during the design, construction, inspection, and certification processes associated with the EWTS. As a field scientist, Jordan will assist with EWTS monitoring and characterization requirements.	Yes
Karissa Vosen	Northeast Technical Services, Inc.	Karissa's primary responsibility will be associated with field and lab report data quality reviews, and data management in an online-accessible database with GIS integration.	Yes
Nick Joelson	Northeast Technical Services, Inc.	Nick holds a MN Class D wastewater operator's license, HAZWOPER certification, MN Type V Basic (spray irrigation) certification, MN Waste Disposal Facility Inspector Certification, and is responsible for seasonal operation/maintenance of existing landfill leachate spray-irrigation system. He will be responsible for periodic EWTS inspections above and beyond current responsibilities.	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.

Dissemination efforts will include 1) hosting Vermilion Community College (MN North College campus in Ely, MN) Water Quality Program and Watershed Science students for multiple visits - at least one per year; 2) pursuing scheduling one or more open forums for information dissemination; and 3) pursuing publication of project results in peer-reviewed scientific journal(s). The initial target Journal is Water, Air, and Soil Pollution. Minnesota ENRTF funding support for this project will be acknowledged during any oral and / or poster presentation, press release, peer-reviewed scientific publication, or other project information dissemination method. The following verbiage will be used for such acknowledgement: written – Primary funding for this project was provided by the Minnesota Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources (LCCMR); verbal – Primary funding for this project was provided by the Minnesota Environment and Natural Resources Trust Fund.

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?

Results from this proposed study will be used to develop and refine an innovative field-scale leachate treatment system for protection of water resources, and effective and efficient removal of emerging water contaminants (e.g., PFAS) from leachate prior to spray irrigation. Funding for which will likely be pursued through grants and County enterprise and environmental trust funds. Additionally, results from this proposed study may be used to inform effective and efficient onsite leachate treatment strategies for other landfills throughout Minnesota.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount	\$ Amount Spent	\$ Amount Remaining
Personnel										
							Sub Total	-	-	-
Contracts and Services										
Northeast Technical Services, Inc. (NTS)	Service Contract	NTS maintains a contract with SLCES for landfill leachate management and treatment, and will provide expertise for designing, constructing, managing, and evaluating the hybrid EWTS: \$326,000 includes personnel (collaborator section); electrician contract; sampling; hybrid EWTS consumables; all leachate, substrate, soil, plant testing/characterization, and reporting for 2.5 years.		X		1.25		\$444,000	\$444,000	-
							Sub Total	\$444,000	\$444,000	-
Equipment, Tools, and Supplies										
	Tools and Supplies	Wetland plants.	St. Louis County Env. Svcs. is providing start-up funding, which includes plants. These funds will be used for any replanting required following the first and second growing seasons.					-	-	-
	Equipment	Flow meter(s) (up to 4 flow meters).	To regulate flow between the leachate holding pond, EWTS, and EWTS-outflow treatment process(es) (round to \$3,000).					-	-	-
	Equipment	Level switchgear (up to 10 switches).	The level switchgear will be used during initiation of batch-treatment of EWTS-					-	-	-

			outflow, when needed, between the EWTS and EWTS-outflow treatment processes.							
	Equipment	Pumps (up to 4 pumps).	The pumps will be used to transfer leachate between the leachate holding pond, the EWTS, and EWTS-outflow treatment processes.					-	-	-
	Equipment	Piping and pipe-fittings.	Piping and pipe-fittings will be used in the construction of conveyance / transfer pathways between the leachate holding pond, the EWTS, and EWTS-outflow treatment processes.					-	-	-
	Equipment	Valves	Valves will be used for adjustment and regulation of flow between the leachate holding pond, the EWTS, and EWTS-outflow treatment processes.					-	-	-
							Sub Total	-	-	-
Capital Expenditures										
		Transfer and Holding Tanks.	Contain leachate between treatment process steps (2x5000 gal.: \$7,000; 1x500 gal.: \$500); rounded to \$8,000.	X				-	-	-
		Granular activated carbon containers, with yearly carbon refresh.	This will be a final PFAS removal step in the overall process (2 columns at \$11,000 = \$22,000; 2 carbon refreshes at \$9,000 = \$18,000).	X				-	-	-
		EWTS Outflow Pre-GAC Treatment.	Removal of dissolved organic carbon in EWTS outflow prior to use of granular activated carbon	X				-	-	-

			filtration for final PFAS removal.							
							Sub Total	-	-	-
Acquisitions and Stewardship										
							Sub Total	-	-	-
Travel In Minnesota										
	Miles/ Meals/ Lodging	We anticipate VCC student involvement in this project will be as follows: six (6) trips; 120 miles round trip; two vehicles; at \$0.575 per mile = \$828; round to \$1,000.	These site visits from VCC will be scheduled for each fall and spring throughout the duration of the project, plus one visit for other faculty to become familiar with the project, and the work site for course planning purposes.					\$1,000	\$1,000	-
	Conference Registration Miles/ Meals/ Lodging	Travel to conference location, lodging, meals (per diem): \$500 per person (two total) total for each of two conferences.	We anticipate two personnel to participate in at least two conferences to disseminate available data.					\$1,000	\$1,000	-
							Sub Total	\$2,000	\$2,000	-
Travel Outside Minnesota										
							Sub Total	-	-	-
Printing and Publication										
	Publication	Report distribution	All reports for this proposal are expected to be electronically distributed; therefore, no printing fees are expected for this project.					-	-	-
							Sub Total	-	-	-

Other Expenses										
							Sub Total	-	-	-
							Grand Total	\$446,000	\$446,000	-

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Contracts and Services - Northeast Technical Services, Inc. (NTS)	Service Contract	NTS maintains a contract with SLCES for landfill leachate management and treatment, and will provide expertise for designing, constructing, managing, and evaluating the hybrid EWTS: \$326,000 includes personnel (collaborator section); electrician contract; sampling; hybrid EWTS consumables; all leachate, substrate, soil, plant testing/characterization, and reporting for 2.5 years.	Northeast Technical Services, Inc. (NTS) is a local Science and Engineering Firm, which has maintained a contract with St. Louis Env. Services (SLCES) for approx. 20 years to manage landfill leachate onsite. NTS' rates to SLCES are typically ~20% less than market, has a history of pro-bono work for SLCES, is within 5 miles of the project site, and is distinctly familiar with the facilities. During summer 2019 and 2020, SLCES contracted with NTS scientists to design, build, and evaluate small-scale EWTSs which were successful at removing PFAS, nitrogen, and manganese. This proposed project would be an addition to this existing contract for NTS scientists to continue development, refinement, and evaluation for multiple consecutive growing seasons of this leachate treatment strategy based on their previous EWTS design; and would ensure critical professional jobs are retained on Minnesota's Iron Range. This is a single source contract.
Capital Expenditures		Transfer and Holding Tanks.	These tanks are required for holding leachate between treatment processes within this system. Additional Explanation : These tanks will continue to be used by SLCES for various leachate holding and experimentation purposes onsite.
Capital Expenditures		Granular activated carbon containers, with yearly carbon refresh.	These are specially designed containers required for the GAC treatment step focused on PFAS removal. Additional Explanation : These GAC containers will continue to be used as a GAC filtration / treatment step for onsite landfill leachate treatment.
Capital Expenditures		EWTS Outflow Pre-GAC Treatment.	This pre-GAC-treatment step is required to extend the GAC medium life expectancy, saving time, money, and overall resources.. Additional Explanation : This EWTS outflow treatment step will continue to be used as a pre-GAC-treatment step in the overall leachate treatment process.

Non ENRTF Funds

Category	Specific Source	Use	Status	\$ Amount	\$ Amount Spent	\$ Amount Remaining
State						
			State Sub Total	-	-	-
Non-State						
In-Kind	St. Louis County Environmental Services (Steve Pellinen) personnel time commitment.	Steve will be an additional County contact, will be available to assist with project needs onsite, and will be a primary contact for onsite project assistance.	Secured	\$10,000	\$10,000	-
In-Kind	St. Louis County Deputy Environmental Services Director (David Fink) personnel time commitment.	David will serve as project coordinator, will be one of two primary County contacts, and will be available to visit the site as required for project updates and briefings.	Secured	\$8,000	\$8,000	-
In-Kind	St. Louis County Auditor's office (Cindy Palm - Financial Analyst)	Cindy will be the County Auditor's primary contact related to fiscal activity.	Secured	\$10,000	\$10,000	-
In-Kind	St. Louis County Environmental Services Director (Mark St. Lawrence)	Mark will be one of two primary County contacts, and will be available for various project requirements, and progress updates and briefings.	Secured	\$12,000	\$12,000	-
In-Kind	St. Louis County Environmental Services (2022, 2023, and 2024)	St. Louis County will provide a maintenance worker to assist with EWTS monitoring on an as-needed basis. This will be accomplished by St. Louis County personnel providing time and effort outside the normal respective position description to monitor and assist with functional maintenance throughout the project duration.	Secured	\$20,000	\$20,000	-
In-Kind	Northeast Technical Services, Inc., will donate an YSI Pro-Plus with Quad Cable field meter for the duration of this project; and a Hach field kit for measuring turbidity.	The field meter will be used to measure the characteristics of leachate at specific locations within the system pathway from inflow to the EWTS to the outflow of the final filtration process: temperature, pH, dissolved oxygen, and conductivity. Oxidation-reduction potential may be added as a sensor capability. The Hach field kit will be used to measure turbidity at the same locations as other field measurements. These data will be critical for verifying EWTS outflow suitability as inflow to micro- and activated carbon- filtration assemblies.	Secured	\$4,750	\$4,750	-
In-Kind	St. Louis County Environmental Services	Funding for start-up of the larger-scale system. Note: Line item in approved budget was \$175,000, actual 2022 expenditures by St. Louis County for larger-scale system start-up were \$657,078. As of August 31, 2023, total expenditures for St. Louis County were \$783,789.	Secured	\$783,789	\$783,789	-

			Non State Sub Total	\$848,539	\$848,539	-
			Funds Total	\$848,539	\$848,539	-

Attachments

Required Attachments

Visual Component

File: [034ef1b6-2c1.pdf](#)

Alternate Text for Visual Component

LEFT: The three charts forming the left column show successful removal of PFAS when compared to MDH Health Based Values (HBVs) during small-scale hybrid engineered wetland treatment system (EWTS) testing in 2020.

RIGHT: Proposed demonstration-scale hybrid EWTS testing to verify and validate PFAS removal efficiency and efficacy. This demonstration-scale hybrid (EWTS) is specifically designed to promote transfers and transformations of contaminants of interest based on published data and 2020...

Board Resolution or Letter

Title	File
St. Louis County Board Resolution Authorizing Proposal Submittal to LCCMR	16480725-7af.pdf

Supplemental Attachments

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

Title	File
Letter of Support - MPCA	0a7bf844-2b1.pdf
Letter of Support - Vermilion Community College	fec71bbe-0c2.pdf
Background Check Form	e7f20acb-73a.pdf
PFAS Contaminant Mitigation Using Hybrid Engineered Wetlands	f549d6cc-3be.pdf
2023-02-28_Leachate_Treatment_Pilot_Study_2022_Summary_Report	7819f564-c3f.pdf
2023 Leachate Treatment Demonstration Project Summary Report	cf927004-14f.pdf
2024 Battelle Chlorinated Conference Presentation	dbbe17cd-17c.pdf
2024 Arrowhead Environmental Conference Presentation	be52107e-fbc.pdf

Media Links

Title	Link
2023-02-28_Leachate_Treatment_Pilot_Study_2022_Summary_Report	https://ntsgis.netechnical.com/files/2023-02-28_Leachate_Treatment_Pilot_Study_2022_Summary_Report.zip

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

This project required an increase in scale and an earlier than anticipated initiation, both of which will be funded by St. Louis County Environmental Services (approx. \$175,000). With the exceptions of project scale increase and early initiation, this project will proceed as planned. Additionally, with the exception of removing some items intended to be purchased using LCCMR funds (e.g., wetland plants; 40-yard containers) instead purchased using funds provided by St. Louis County Environmental Services, and likely request to re-allocate some existing funds, LCCMR funds will be used as intended.

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?

Yes

Do you understand that travel expenses are only approved if they 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 understand the Commissioner's Plan applies.

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?

No

Does the organization have a fiscal agent for this project?

No

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

Yes, I understand

Work Plan Amendments

Amendment ID	Request Type	Changes made on the following pages	Explanation & justification for Amendment Request (word limit 75)	Date Submitted	Approved	Date of LCCMR Action
1	Amendment Request	<ul style="list-style-type: none"> • Narrative • Activities and Milestones • Budget - Professional / Technical Contracts • Budget - Capital, Equipment, Tools, and Supplies • Budget - Non-ENRTF Funds Contributed 	<p>The project work plan will incorporate an additional evaluation of a reverse osmosis leachate treatment system. Initial results from hybrid EWTS testing indicate that reverse osmosis may be a more feasible long-term on site treatment strategy. Request project budget amendment reallocating \$117,000 from Capital Expenditures and Equipment/Tools/Supplies (both categories covered by County local match) to Professional/Technical Contracts for additional project engineering/management, monitoring, and testing costs associated with reverse osmosis component.</p>	March 1, 2023	Yes	March 1, 2023
2	Amendment Request	<ul style="list-style-type: none"> • Budget - Non-ENRTF Funds Contributed 	<p>St. Louis County's Budget - Non-ENRTF Funds Contributed expenditures for 2022 were \$657,078. The County is updating the Budget - Non-ENRTF Funds Contributed section to reflect actual county expenditures through 8-31-2023.</p>	August 31, 2023	Yes	October 5, 2023
3	Amendment Request	<ul style="list-style-type: none"> • Budget - Professional / Technical Contracts • Budget - Travel and Conferences 	<p>Request \$1,000 transfer from Budget - Travel and Conferences to Budget - Professional / Technical Contracts. St. Louis County requested Contractor perform additional grant eligible work resulting in costs exceeding the Professional/Technical Contracts budget by \$1,000. This amendment is for expenses incurred before the project end date.</p>	March 20, 2025	Yes	March 24, 2025

Additional Status Update Reporting

Additional Status Update March 12, 2025

Date Submitted: March 20, 2025

Date Approved: March 24, 2025

Overall Update

Additional Update submitted in error. Disregard per LCCMR staff.

Activity 1

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Activity 2

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Activity 3

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Activity 4

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Activity 5

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Dissemination

No additional Dissemination Update since last submittal.

Status Update Reporting

Final Status Update February 14, 2025

Date Submitted: February 10, 2025

Date Approved: February 18, 2025

Overall Update

Significant progress was made towards accomplishing the overall outcome of designing and developing an effective alternative leachate treatment method. An onsite demonstration-scale hybrid engineered wetland treatment system (EWTS) was designed, constructed, planted, and initiated in 2022. The EWTS was evaluated for a second growing season in 2023. Leachate chemical characterization, and volume and flow rate calculations, were completed. Additional EWTS outflow treatment steps were designed, constructed, and implemented. Evaluation of two growing seasons of the onsite hybrid EWTS were completed.

The County added a Vibratory Shear Enhanced Processing (VSEP) reverse osmosis unit to the leachate treatment system for 2023. Three months of VSEP testing were completed and significant data was collected to validate VSEP treatment as an alternative option to the EWTS. Data collected to date has been used to develop full-scale system design parameters and estimate capital and operational costs.

All activities have been completed and additional dissemination efforts including open forums and scientific journal publication are being pursued.

Activity 1

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Activity 2

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Activity 3

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Activity 4

Student tour was conducted in October 2024.

(This activity marked as complete as of this status update)

Activity 5

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Dissemination

Project information and results were presented in an open forum at the 2024 Arrowhead Region Environmental Conference in October 2024. Presentation slides are available on the Attachments page.

Status Update Reporting

Status Update September 1, 2024

Date Submitted: August 30, 2024

Date Approved: September 25, 2024

Overall Update

Significant progress is being made towards accomplishing the overall outcome of designing and developing an effective alternative leachate treatment method. An onsite demonstration-scale hybrid engineered wetland treatment system (EWTS) was designed, constructed, planted, and initiated in 2022. The EWTS was evaluated for a second growing season in 2023. Leachate chemical characterization, and volume and flow rate calculations, were completed. Additional EWTS outflow treatment steps were designed, constructed, and implemented. Evaluation of two growing seasons of the onsite hybrid EWTS was completed.

The County added a Vibratory Shear Enhanced Processing (VSEP) reverse osmosis unit to the leachate treatment system for 2023. Three months of VSEP testing was completed and significant data has been collected to validate VSEP treatment as an alternative option to the EWTS. Data collected to date will be used to develop full-scale system design parameters and estimate capital and operational costs.

All activities have been completed and additional dissemination efforts including open forums and scientific journal publication are being pursued.

Activity 1

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Activity 2

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Activity 3

Initial results from hybrid EWTS testing indicated that reverse osmosis may be a more feasible long-term on-site treatment strategy. The project work plan was amended in January 2023 to incorporate Activity 5, the additional evaluation of a reverse osmosis leachate treatment system. Hybrid EWTS testing was not initiated in 2024.

(This activity marked as complete as of this status update)

Activity 4

No additional student tours were completed since the last status update. Student tours from Vermilion Community College are being planned for Fall 2024.

Activity 5

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Dissemination

Project information and results were presented in an open forum at the 2024 Battelle Chlorinated Conference in June 2024. Presentation slides are available on the Attachments page.

Status Update Reporting

Status Update March 1, 2024

Date Submitted: February 29, 2024

Date Approved: September 25, 2024

Overall Update

Significant progress is being made towards accomplishing the overall outcome of designing and developing an effective alternative leachate treatment method. An onsite demonstration-scale hybrid engineered wetland treatment system (EWTS) was designed, constructed, planted, and initiated in 2022. The EWTS was evaluated for a second growing season in 2023. Leachate chemical characterization, and volume and flow rate calculations, were completed. Additional EWTS outflow treatment steps were designed, constructed, and implemented. Evaluation of two growing seasons of the onsite hybrid EWTS was completed.

The County added a Vibratory Shear Enhanced Processing (VSEP) reverse osmosis unit to the leachate treatment system for 2023. Three months of VSEP testing was completed and significant data has been collected to validate VSEP treatment as an alternative option to the EWTS. Data collected to date will be used to develop full-scale system design parameters, estimate capital and operational costs, and develop the year three workplan.

Activity 1

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Activity 2

The second growing season evaluation of the EWTS has been completed. The EWTS condition was evaluated following spring thaw in 2023, and wetland maintenance activities were conducted in June 2023 to address issues identified in 2022. Leachate flow through the EWTS was reinitiated on June 15, 2023, and operation lasted until September 28, 2023. The additional outflow treatment processes were not restarted in 2023 based on findings from 2022 EWTS operation. Evaluation and reporting of 2023 EWTS data has been completed. A 2023 demonstration project summary report is attached.

(This activity marked as complete as of this status update)

Activity 3

The third growing season will begin in April/May 2024. Leachate treatment will focus on RO methodology with limited EWTS observation and analysis.

Activity 4

One student tour was given during Fall 2022. Two student tours were given in Fall 2023. Additional student tours are anticipated for 2024.

Activity 5

The reverse osmosis (RO) pilot system was designed, setup, and operated in 2023. The RO pilot system was operated June 19 to September 1, 2023. Evaluation and reporting of 2023 RO data has been completed. A 2023 demonstration project summary report is attached.

(This activity marked as complete as of this status update)

Dissemination

The 2023 Leachate Treatment Demonstration Project Summary Report has been submitted to the Minnesota Pollution Control Agency and is available on the Attachments page.

Status Update Reporting

Status Update September 1, 2023

Date Submitted: August 31, 2023

Date Approved: October 4, 2023

Overall Update

Significant progress is being made towards accomplishing the overall outcome of designing and developing an effective alternative leachate treatment method. An onsite demonstration-scale hybrid engineered wetland treatment system (EWTS) was designed, constructed, planted, and initiated in 2022. Initial leachate chemical characterization, and volume and flow rate calculations, were completed. Additional EWTS outflow treatment steps were designed and constructed. Initial evaluation of one partial growing season of the onsite hybrid EWTS was completed.

Inspection of the EWTS in May '23 found the bulrush survived the winter in leachate with green shoots beginning to show. Maintenance to the EWTS prior to spring start-up was completed by mid-June and the wetland has been initiated for a second growing season. The County added a Vibratory Shear Enhanced Processing (VSEP) reverse osmosis unit to the leachate treatment system for 2023, which has operated since June 19. Significant data has been collected to validate VSEP treatment efficacy, develop full-scale system design parameters, and estimate capital and operational costs.

Activity 1

This activity was previously marked complete.

(This activity marked as complete as of this status update)

Activity 2

Milestones:

- 1 Initiate leachate inflow to EWTS; prep for outflow treatment processes. Deadline: 6/30/2023
Leachate inflow to the EWTS for year two was initiated on June 15, 2023. The additional outflow treatment processes were not restarted in 2023 based on findings from 2022 hybrid EWTS operation.
- 2 Assess spring 2023 status of demonstration-scale hybrid EWTS and complete reporting requirements. Deadline: 7/31/2023
Inspection of the EWTS in May 2023 found the bulrush survived the winter in leachate with green shoots beginning to show.
Maintenance to the EWTS prior to spring start-up was completed by mid-June.
- 3 Complete initial outflow treatment process life-expectancy evaluations. Deadline: 12/31/2023
The County is on-track to complete the evaluations by December 31st.
- 4 Complete yearly and other reporting throughout 2023 to LCCMR and County personnel. Deadline: 12/31/2023
The County is on-track to complete all required 2023 reporting by December 31st.

Activity 3

The third growing season was not initiated.

Activity 4

Vermilion Community College student tours are currently being scheduled for fall of 2023.

Activity 5

One season has been initiated to pilot test VSEP reverse osmosis (RO) leachate treatment. Leachate has been treated through a VSEP RO system with additional polishing treatment included. Samples and operational data have been collected to validate the treatment efficacy, develop full-scale system design parameters, and estimate capital and operational costs.

Dissemination

The report: 2023-02-28_Leachate_Treatment_Pilot_Study_2022_Summary_Report can be found on the Attachments page (Tab 7) under Optional Attachments in both the "Support Letter, Photos, Media, Other" or Hyperlink sections.

Status Update Reporting

Status Update March 1, 2023

Date Submitted: March 1, 2023

Date Approved: March 1, 2023

Overall Update

Subsequent to receiving the Approved Work Plan “AWP”, St. Louis County elected to upgrade its project by constructing a wetland pond (30,000 square feet), versus use of containers (900 total square feet) per the AWP, to better replicate a full scale EWTS and ensure more accurate project data. In doing so, project costs increased significantly for start-up, engineering, operations, maintenance, sampling, and laboratory analytical services under the Professional and Technical Contracts category. The County’s In-Kind funding for project start-up, capital expenditures, and equipment, tools and supplies for 2022 also increased significantly (\$657,078 – actual vs. \$175,000 - In-Kind per AWP). Once ENRTF funds are depleted, the County will fully fund this project and its remaining outcomes to fruition.

Significant progress was made towards accomplishing the overall outcome of designing and developing an effective alternative leachate treatment method. An onsite demonstration-scale hybrid EWTS system was designed, constructed, planted, and initiated in 2022. Initial leachate chemical characterization, and volume and flow rate calculations, were completed. Additional EWTS outflow treatment steps were designed and constructed. Initial evaluation of one partial growing season of the onsite hybrid EWTS was completed.

Activity 1

The proposed semi-passive demonstration-scale hybrid EWTS was designed, constructed, planted, and initiated. Initial leachate chemical characterization, and volume and flow rate calculations, were completed. Additional EWTS outflow treatment steps including ozone, UV, media filtration, activated carbon, and ion exchange were designed and constructed. Partial growing-season efficacy and efficiency testing was completed. EWTS outflow was exposed to additional treatment targeting PFAS and other contaminants of concern. EWTS outflow, and additional-treatment outflow, samples were collected and used to determine overall system effectiveness throughout 2022 and to guide adjustments to increase efficacy. EWTS soil and plant samples were collected and used to determine fate and movement of contaminants of interest within the EWTS. The hybrid EWTS was able to meet all target effluent limits at times throughout the 2022 pilot season. However, achieving target effluent limits were very dependent on operating conditions. Further pilot testing during a complete wetland growing season (2023) is needed.

Based on 2022 data, the County will incorporate and evaluate the use of reverse osmosis on the back end of the hybrid EWTS to assist in achieving consistent target effluent limits in 2023.

(This activity marked as complete as of this status update)

Activity 2

The second growing season was not initiated. Activity two is planned for 2023.

Activity 3

The third growing season was not initiated. Activity three is planned for 2024.

Activity 4

One student tour of the project was given during 2022.

Dissemination

One student tour was conducted in 2022. Other dissemination efforts are forthcoming.