



Environment and Natural Resources Trust Fund

M.L. 2022 Approved Work Plan

General Information

ID Number: 2022-286

Staff Lead: Becca Nash

Date this document submitted to LCCMR: June 9, 2022

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

Project Reporting

Date Work Plan Approved by LCCMR: June 27, 2022

Reporting Schedule: March 1 / September 1 of each year.

Project Completion: December 31, 2024

Final Report Due Date: February 14, 2025

Legal Information

Legal Citation: M.L. 2022, Chp. 94, Art. , 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 will be designed, constructed, planted, and initiated. 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. EWTS cells will be built on St. Louis County Regional Landfill land (within their permitted area). Specifically, EWTS cells 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 these EWTS cells will not impact any existing wetlands. Land on which they will be constructed is, and has been for decades, a leachate spray irrigation field.

Activity Milestones:

Description	Approximate Completion Date
Design hybrid EWTS 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: \$152,800

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

Activity Budget: \$155,600

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

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 hybrid EWTS 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
Personnel								
							Sub Total	-
Contracts and Services								
Northeast Technical Services, Inc. (NTS)	Professional or Technical 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		\$326,000
							Sub Total	\$326,000
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.					\$4,000
	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).					\$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.					\$1,000
	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.					\$4,000

	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.					\$4,000
	Equipment	Valves	Valves will be used for adjustment and regulation of flow between the leachate holding pond, the EWTS, and EWTS-outflow treatment processes.					\$3,000
							Sub Total	\$19,000
Capital Expenditures								
		Transfer and Holding Tanks.	Contain leachate between treatment process steps (2x5000 gal.: \$7,000; 1x500 gal.: \$500); rounded to \$8,000.	X				\$8,000
		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				\$40,000
		EWTS Outflow Pre-GAC Treatment.	Removal of dissolved organic carbon in EWTS outflow prior to use of granular activated carbon filtration for final PFAS removal.	X				\$50,000
							Sub Total	\$98,000
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

	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.					\$2,000
							Sub Total	\$3,000
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

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)	Professional or Technical 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
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
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
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
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
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
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
In-Kind	St. Louis County Environmental Services	Funding for start-up of the larger-scale system.	Secured	\$175,000
			Non State Sub Total	\$239,750
			Funds Total	\$239,750

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

Optional Attachments

Support Letter or 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

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 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, or sale of products and assets?

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?

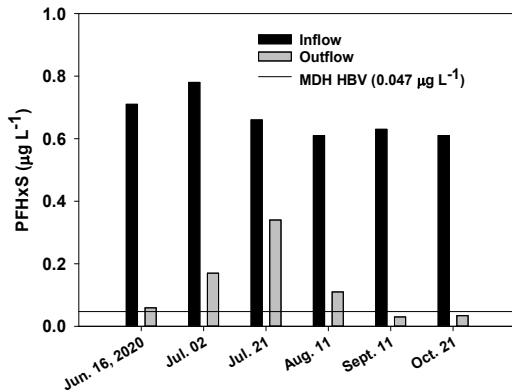
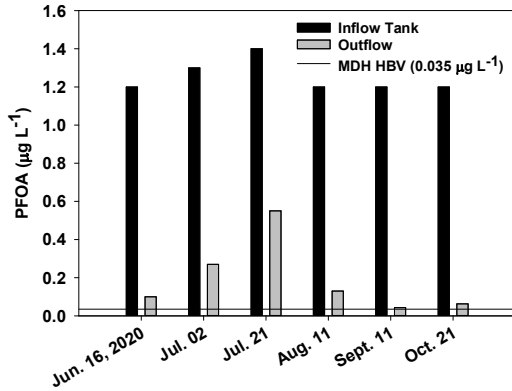
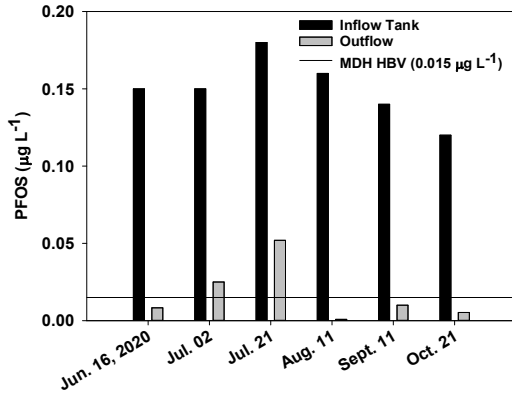
No

Does the organization have a fiscal agent for this project?

No

2020 PFAS Treatment Results

PFAS with MDH Health Based Value (HBV):
PFOS, PFOA, PFHxS, PFBS, PFBA



(Inflow PFBS, PFBA below MDH HBV)

Emerging PFAS Contaminant Mitigation Using Hybrid Engineered Wetlands

- Enhances existing landfill leachate treatment process to remove specific contaminants (PFAS, N)
- Semi-passive treatment – minimal energy/operator input required
- No concentrated waste streams generated

