Environment and Natural Resources Trust Fund

2023 Request for Proposal

General Information

Proposal ID: 2023-215

Proposal Title: Removing CECs from Stormwater with Biofiltration

Project Manager Information

Name: Andy Erickson

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: This project will optimize a treatment practice design for removing contaminants of emerging concern (CECs) from stormwater runoff using biofiltration media. Guidance will be developed for stormwater managers statewide.

Funds Requested: $650,000

Proposed Project Completion: June 30, 2026

LCCMR Funding Category: Water Resources (B)

Project Location

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

Region(s): Metro

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

Narrative

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

Several ENRTF funded project have measured the number and concentration of Contaminants of Emerging Concern (CECs) throughout Minnesota, but no research has developed a treatment practice design that can remove a wide spectrum of CECs from stormwater runoff. CECs include hormones, pesticides, herbicides, industrial compounds, pharmaceuticals, personal care product ingredients, "lifestyle" compounds such as caffeine and nicotine, and many other commercial-consumer product-related compounds (Fairbairn et al. 2018). Most of these chemicals are unregulated and pose a hazard to fish and biota such as mussels and insect larvae in receiving waterbodies. For example, phosphate-based flame retardants are estrogenic, which can interfere with organisms' development and ability to reproduce. Stormwater runoff frequently contains CECs and carries them to our surface and groundwaters (Fairbairn et al. 2018). While sanitary wastewater and municipal drinking water have large treatment facilities to remove pollutants, stormwater runoff does not. Cities, counties, and watershed districts and organizations rely on neighborhood stormwater ponds and rain gardens (bioretention) to remove sediment and nutrients from runoff. Little is known about whether CECs are captured in these practices, so stormwater managers need cost-effective shovel-ready treatment practice designs to remove CECs from stormwater.

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.

Biofiltration practices are an urban stormwater treatment practice designed to capture pollutants such as sediment, nutrients, and polycyclic aromatic hydrocarbons (PAHs), among others (LeFevre et al., 2015, Erickson et al., 2021). The mixed media within biofiltration practices have the potential to also capture CECs (e.g., biochar; Ulrich et al., 2015 & 2017), but the effectiveness and best design has yet to be determined. This project proposes to develop new treatment designs that can remove CECs from stormwater runoff. First, we will evaluate biofiltration by determining the best media components (e.g., compost, biochar, peat, iron, spent lime, etc.) and mix ratios for capturing CECs using outdoor experiments (Activity 1). These experiments will optimize the components to balance cost and CEC removal to produce the most cost-effective shovel-ready design. This project will also validate the experiments by monitoring CECs in paired inflow (untreated) and outflow (treated by biofiltration media) stormwater samples at several field locations (Activity 2). Through this combined outdoor experiment-scale and field pilot-scale study, guidance will be developed to empower water resource planners and managers with a treatment practice design to remove harmful CECs from stormwater runoff and protect Minnesota's precious water resources.

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 project proposes to develop a new treatment practice design that can remove CECs from stormwater runoff. By removing CECs from stormwater runoff, the public is protected from direct contact with these pollutants because they are not delivered to our lakes, rivers, streams, and groundwater via stormwater runoff. CECs in stormwater are also a known stressor to fish, affecting their growth and reproduction in Minnesota lakes and streams. Removing CECs from runoff reduces exposure of fish and biota to this stress, helping preserve existing water resources and habitat as well as improving impacted water resources throughout Minnesota.

Activities and Milestones

Activity 1: Outdoor Mesocosm Evaluation of CECs capture by Biofiltration Media

Activity Budget: $369,833

Activity Description:
An existing research project developed thirty outdoor mesocosms for the evaluation of nutrient capture and release and vegetation growth by biofiltration media over four rainy seasons (see Non ENRTF Funds). The mesocosms allow us to measure a wide variety of media components and mix ratios, which is typically not possible in most field studies. Activity 1 will use the existing mesocosm research infrastructure to measure capture of CECs by biofiltration media mixes for both simulated events and natural rainfall. Media components that are readily available in Minnesota and could be tested include: sand, food- or leaf-based compost, reed sedge or sphagnum peat, spent lime, biochar, and iron aggregate. Specific CECs from several classes (e.g., neonicotinoids, herbicides, pharmaceuticals, and phosphate-based flame retardants) will be selected and known concentrations of these CECs will be added to synthetic stormwater runoff. This synthetic runoff will be added to mesocosms to represent natural rainfall runoff and samples will be collected from the inflow and outflow to calculate capture performance. This process will be repeated several times throughout the rainy seasons of the project, as weather permits. Any impacts to vegetation growth will also be evaluated.

Activity Milestones:

Description	Completion Date
Outcome 1: Literature Review and Selection of Media Mixes	December 31, 2023
Outcome 2: Evaluate Performance of Media Mixes to Remove CECs from synthetic runoff.	December 31, 2025
Outcome 3: Prepare Final Activity Report	June 30, 2026

Activity 2: Field Monitoring of CEC Removal by Biofiltration Practices

Activity Budget: $280,167

Activity Description:
Up to four biofiltration practices will be selected within or near the Twin Cities Metropolitan Area to characterize the presence and removal of CECs in stormwater runoff. Sites with media mixtures that align with Activity 1 will be chosen to compare CEC removal between mesocosms and field practices. At each site, paired inflow (stormwater that has not flowed through the biofilter media) and outflow (stormwater that has flowed through the biofilter media) samples will be collected during at least 3 rain events for two rainy seasons, for a total of 6 rain events at each location (overall total of 53 samples, including 5 quality-assurance samples). All samples will be analyzed for 82 pesticides, 110 pharmaceuticals, and 65 wastewater indicator contaminants at the USGS National Water Quality Laboratory. Results will be used to estimate contaminant removal from raw stormwater runoff at each biofiltration location and compare different media mixtures.

Activity Milestones:

Description	Completion Date
Solicit stakeholder feedback for site selection	December 31, 2023
Sample collection and laboratory analyses	December 31, 2025
CEC removal calculations and final report preparation	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Sarah Elliott	U.S. Geological Survey	General project management, data analysis, report preparation	Yes
Richard Kiesling	U.S. Geological Survey	Oversee site selection and field sampling logistics, data analysis, report preparation	Yes
Mike Trojan & Mark Ferrey	Minnesota Pollution Control Agency	Develop guidance and update information in the Minnesota Stormwater Manual, providing review of materials or other tech support, and conducting outreach as needed.	No
Tim Kelly	Coon Creek Watershed District	Discuss the availability of required data and coordinate collection of samples and/or provide access for sample collection.	No

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 project expands on extensive stormwater research that is already being disseminated via presentations (~10 per year), online email newsletters (2000+ email subscribers), webpages (620+ pageviews per month), webinars (~170 registrants per month) and publications, in addition to upcoming workshops and training programs such as the Minnesota Pollution Control Agency (5000+ email subscribers). The results generated by the proposed project will be disseminated by similar means through these established partnerships. Stormwater practitioners will learn about best design practices and begin incorporating those designs in new construction.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Solar Driven Destruction of Pesticides, Pharmaceuticals, Contaminants in Water	M.L. 2014, Chp. 226, Sec. 2, Subd. 03a	$291,000
Antibiotics and Antibiotic Resistance Genes in Minnesota Lakes	M.L. 2014, Chp. 226, Sec. 2, Subd. 03e	$300,000
Biological Consequences of Septic Pollution in Minnesota Lakes	M.L. 2015, Chp. 76, Sec. 2, Subd. 04c	$364,000
Assessing Neonicotinoid Insecticide Effects on Aquatic and Soil Communities	M.L. 2016, Chp. 186, Sec. 2, Subd. 04e	$400,000
Assessment of Surface Water Quality With Satellite Sensors	M.L. 2016, Chp. 186, Sec. 2, Subd. 04i	$345,000
Assessment of Household Chemicals and Herbicides in Rivers and Lakes	M.L. 2017, Chp. 96, Sec. 2, Subd. 04a	$236,000
Water Quality Monitoring in Southeastern Minnesota Trout Streams	M.L. 2017, Chp. 96, Sec. 2, Subd. 04d	$500,000
Protect Water Quality with Efficient Removal of Contaminants in Treatment Ponds for Storm Water	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 04d	$325,000
Mapping Antibiotic Resistance in Minnesota to Help Protect Environmental, Animal, and Human Health	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 04h	$750,000
Determining Influence of Insecticides on Algal Blooms	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04a	$350,000
Benign Design: Environmental Studies Leading to Sustainable Pharmaceuticals	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04b	$415,000

Improving Drinking Water for Minnesotans through Pollution Prevention	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04f	$345,000
Protecting Minnesota Waters by Removing Contaminants from Wastewater	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04g	$250,000
Managed Aquifer Recharge	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04t	$350,000

Project Manager and Organization Qualifications

Project Manager Name: Andy Erickson

Job Title: Research Manager

Provide description of the project manager's qualifications to manage the proposed project.
Andy Erickson, PhD, PE, is a Research Manager at St. Anthony Falls Laboratory and the University of Minnesota and registered professional engineer in Minnesota. Dr. Erickson's research pursues an understanding of water quality in urban and agricultural watersheds, assessment and maintenance of stormwater treatment practices, and developing new stormwater treatment technologies such as the Iron-Enhanced Sand Filter. Dr. Erickson is lead author for the book, "Optimizing Stormwater Treatment Practices: A Handbook of Assessment and Maintenance," and the editor of the University of Minnesota stormwater newsletter, UPDATES to approximately 1900 email subscribers, and leads the Minnesota Stormwater Seminar Series for approximately 170 stormwater practitioners per month. Dr. Erickson has given over 210 presentations, over 30 invited guest lectures, and 30 one- and two-day professional trainings and workshops. Dr. Erickson is the Vice Chair of the ASTM international E64 Committee on Stormwater Control Measures and a member of the Water Environment Federation Stormwater Institute Advisory Board. Dr. Erickson also serves the University of Minnesota as the Chair-Elect of the Water Council, a member of the Civil, Environmental, and Geo-Engineering Graduate Faculty, an affiliate member of the Water Resources Science Graduate Program, and a member of the Environment and Energy in Transportation Research Council.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:
The St. Anthony Falls Laboratory (SAFL), an interdisciplinary fluids research and educational facility, is focused at the intersection of fluid dynamics with major societal challenges in energy, environment, and health. SAFL serves as a resource for departments across the Twin Cities campus, the statewide University system, and the broader research community. The connections and collaborations between the University, St. Anthony Falls Laboratory, and the USGS reach across the country and all over the world, and our laboratories partner with local, state and federal agencies, and other educational institutions to expand knowledge and solve problems.

The U.S. Geological Survey's mission is to provide unbiased science about the natural hazards that threaten lives and livelihoods, the water, energy, minerals, and other natural resources we rely on, the health of our ecosystems and environment, and the impacts of climate and land-use change. With respect to water resources, USGS scientists work with local partners to monitor, assess, and conduct targeted research on the wide range of water resources and conditions, including streamflow, groundwater, water quality, and water use and availability.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Andy Erickson		Manager and PI			26.9%	0.45		$66,598
John Gulliver		Research Support			7.7%	0.06		$13,991
Bill Arnold		Research Support			26.9%	0.06		$13,472
Jess Kozarek		Research Support			26.9%	0.3		$30,995
Post-Doctoral Fellow		Research Support			20.4%	2.01		$150,458
Chris Milliren		Research Support			26.9%	0.06		$4,606
Undergraduate Staff		Research Support			0%	0.57		$16,619
							Sub Total	**$296,739**
Contracts and Services								
US Geological Survey	Professional or Technical Service Contract	Stormwater sampling and analysis coordinated by the US Geological Survey (Activity 2) including analytical services from the USGS National Water Quality Laboratory for the analysis of 53 samples (48 environmental, 5 QA/QC) for three analytical schedules of approximately 250 chemicals ($103,880), expendable supplies ($3,264), sample shipment to laboratory ($900), contingency for unanticipated costs (2% of total project cost = $5,000), and travel to collection sites and project meetings ($400). Subcontract includes salary and benefits for project staff: (Kiesling – 0.27 FTE at 79% salary, 21% benefits = $63,512; Elliott – 0.31 FTE at 72% salary, 28% benefits = $58,418; GS-11 Hydrologic Technician – 0.15 FTE at 72% salary, 28% benefits = $18,094; Water quality database manager – 0.19 FTE at 71% salary, 29% benefits = $1,664; Administrative Assistance – 0.16 FTE at 69% salary, 31% benefits = $25,035)				3.24		$280,167
							Sub Total	**$280,167**

Equipment, Tools, and Supplies								
	Tools and Supplies	Lab supplies for water sampling	Sampling Supplies					$2,513
	Tools and Supplies	Lumber, buckets, hoses, etc.	Mesocosm supplies					$1,516
	Tools and Supplies	Parts and supplies for flow rate monitoring, datalogger, etc.	Data recording system supplies					$1,015
	Tools and Supplies	Analytical supplies: Vials, standards, isotopic standards, cartridges, etc.	Supplies to support CEGE-lab analysis of CEC samples.					$67,500
							Sub Total	**$72,544**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	2 conference registrations ($275 per person x 2 people)	Attending and presenting research results at the Minnesota Water Resources Conference.					$550
							Sub Total	**$550**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**

							Grand Total	**$650,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
In-Kind	Minnesota Stormwater Research and Technology Transfer Program administered by the University of Minnesota Water Resources Center through an appropriation from the Clean Water Fund established by Minnesota Clean Water Land and Legacy Amendment and from the Minnesota Stormwater Research Council.	Research Project titled: "Biofiltration Media Optimization"	Secured	$295,926
In-Kind	University of Minnesota	Unrecovered F&A at Federally Negotiated Rate (55%)	Pending	$217,158
In-Kind	Minnesota Stormwater Research and Technology Transfer Program administered by the University of Minnesota Water Resources Center through an appropriation from the Clean Water Fund established by Minnesota Clean Water Land and Legacy Amendment and from the Minnesota Stormwater Research Council.	Capturing Contaminants of Emerging Concern (CECs) with Biofiltration	Secured	$210,258
			State Sub Total	**$723,342**
Non-State				
In-Kind	Coon Creek Watershed District	Salary for field monitoring coordination and planning, sample collection from field sites, and coordination of sample delivery to USGS staff for shipment to the USGS laboratory. Justin Dauphinais (20 hours at $76.02) - $1,520 and Chase Vanderbilt (25 hours at $56.14)	Pending	$1,403
In-Kind	U.S. Geological Survey Cooperative Matching Funds	Cover U.S. Geological Survey overhead and other indirect charges accrued by the project, open-access for a journal article, and conference registration and travel to disseminate results	Pending	$120,000
			Non State Sub Total	**$121,403**
			Funds Total	**$844,745**

Attachments

Required Attachments

Visual Component

File: 30449479-896.pdf

Alternate Text for Visual Component

Image 1: outdoor gray cylindrical containers labeled mesocosm 1, mesocosm 2, mesocosm 3, and so on with 5-gallon buckets above and below for inflow and outflow. Image 2: outdoor bowl-shaped vegetated basin within a parking lot with two individuals collecting scientific measurements and samples with caption: Typical biofiltration practice. Image 3: a cross-section of a biofiltration practice with arrows depicting stormwater movement through the system and where CECs will be measured....

Optional Attachments

Support Letter or Other

Title	File
Letter of Support: USGS Upper Midwest Water Science Center	2b688243-b50.pdf
Letter of Support: Coon Creek Watershed District	f19892cf-791.pdf
Letter of Support: City of Duluth	5da08037-179.pdf
Letter of Support: City of St. Cloud	04817264-33c.pdf
Letter of Support: Shingle Creek Watershed Management Organization	35959d2c-9c2.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Removing CECs from Stormwater with Biofiltration

CECs = Contaminants of Emerging Concern

Activity 1: Outdoor Mesocosm Experiments

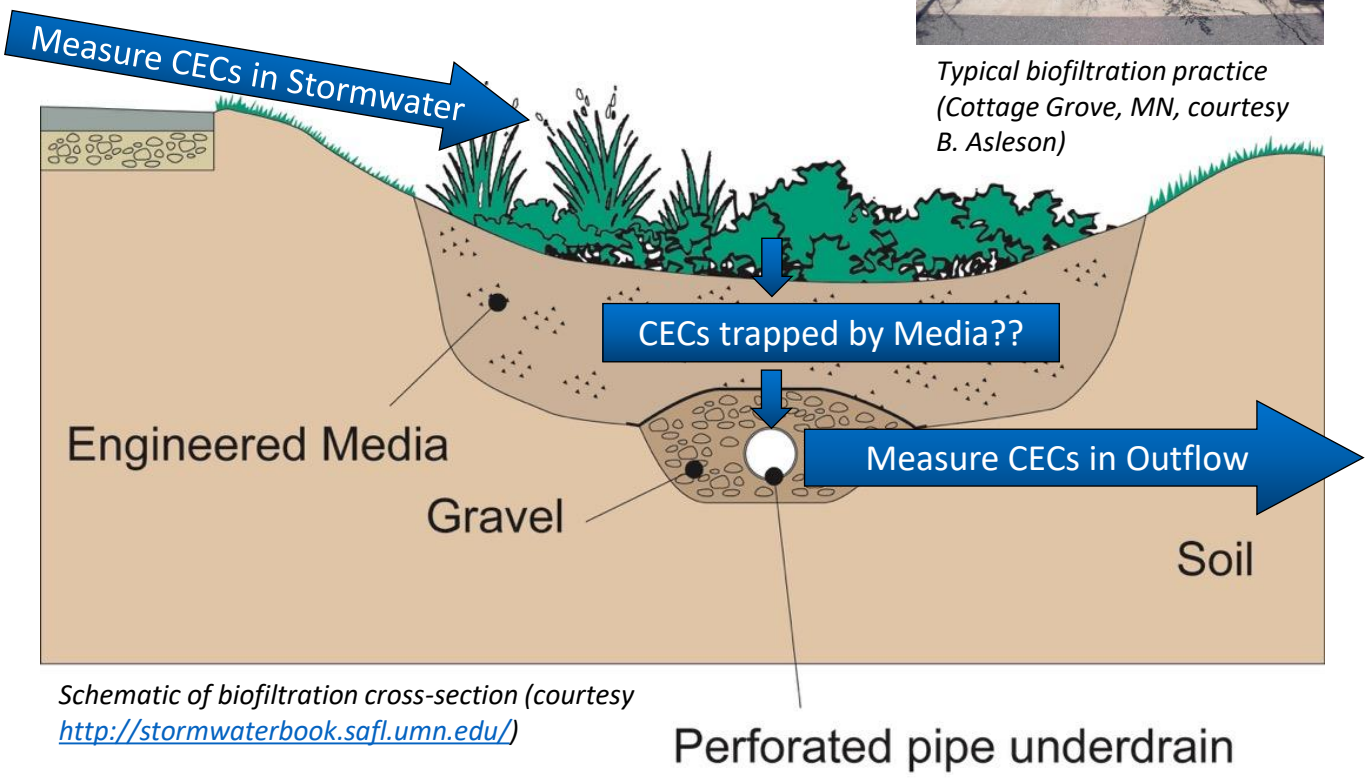
Experimental mesocosm setups to test CEC removal efficiency of different engineered media. Location: St. Anthony Falls laboratory (photo courtesy B. Heitkamp)

Engineered Media:

- Sand + …
  - Biochar?
  - Iron?
  - Spent Lime?
  - Compost?
  - Peat?

Typical biofiltration practice (Cottage Grove, MN, courtesy B. Asleson)

Activity 2: Field Monitoring



Schematic of biofiltration cross-section (courtesy http://stormwaterbook.safl.umn.edu/)