Environment and Natural Resources Trust Fund

2023 Request for Proposal

General Information

Proposal ID: 2023-083

Proposal Title: Maintaining Connectivity at Road-Stream Crossings: Floodplains and Fish

Project Manager Information

Name: Jessica Kozarek

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: Road-stream crossings affect roadway safety, fish movement and access to habitat, and water quality. We will investigate the benefits and design of culverts for connectivity, fish passage, and infrastructure resiliency.

Funds Requested: $199,000

Proposed Project Completion: June 30, 2026

LCCMR Funding Category: Small Projects (H)

Secondary Category: Methods to Protect, Restore, and Enhance Land, Water, and Habitat (F)

Project Location

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

Statewide

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.

Minnesota roadways intersect rivers and streams in hundreds of thousands of locations across the state, often in culverts, an economical way to pass water underneath roadways. The flow of water and sediment across Minnesota's landscape is highly altered by road-stream crossing designs that concentrate flow through culverts, disconnecting floodplains and habitats and creating barriers to movement within a stream network that can have dramatic consequences for fish populations. Importantly, these practices can also affect infrastructure resiliency, channel stability, water quality, and maintenance needs. To reduce the impact of transportation infrastructure, improve stream connectivity and thus reduce habitat fragmentation, recent guidance for road-stream crossings is moving toward designs that account for the transport of not only water but also sediment and aquatic organisms through culverts. Much of this guidance focuses on culverts located on the stream channel, but floodplains carry water, sediment, nutrients, and aquatic organisms during high flows. Culverts installed on the floodplain, dry except during high flows, can reconnect floodplain processes, in addition to providing safe crossings for terrestrial animals. The question of when and how to design floodplain culverts is one of critical importance to state agencies and contractors responsible for permitting and design of road stream crossings.

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.

The least expensive designs for road-stream crossings are often culverts; however, for wide floodplains, culverts placed only the channel can disconnect flow across the floodplain, forcing this flow to the main stream channel disrupting sediment transport processes and leading to erosion and sedimentation. The addition of floodplain culverts can help to alleviate these issues and have added benefits of improving fish passage and providing terrestrial crossings under the roadway, but many questions and concerns remain about where and how to best install floodplain culverts. Construction of floodplain culverts adds cost to a project and thus there is a need to prioritize sites where the benefit of floodplain reconnection will be greatest. We propose to address these questions by 1) evaluating existing culvert designs for floodplain connectivity, 2) exploring culvert placement benefits with laboratory experiments, and 3) analyzing existing culvert data to provide practitioners with key guidance for when and where floodplain culverts are the most beneficial and how best to design. We will develop a technical advisory panel comprised of representatives from MN DNR, MnDOT, and other state, local and regional stakeholders who will help inform site selection, experimental parameters, and will provide a direct connection for research dissemination.

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?

When roads cross small streams and rivers, structures allowing for the passage of water underneath roadways are critical for unimpeded and safe roadway travel. However, when viewed from a river's perspective, road crossings, and culverts, in particular, can create disrupt the flow of water, sediment, nutrients and aquatic organisms. The overall outcome of this project will be critical research to inform culvert designs that maintain stream connectivity incorporating floodplains, moving toward road-stream crossing designs that meet multiple goals: infrastructure resiliency to large flow events, fish and wildlife passage, flood protection, and channel stability.

Activities and Milestones

Activity 1: Field and modelling study: Performance of floodplain culverts

Activity Budget: $61,163

Activity Description:
Activity 1 will focus on the evaluation of existing road-stream crossing designs with floodplain culverts. We will use a combination of existing data and plans, field survey and assessments, and hydraulic modelling to develop case studies of culvert performance for resiliency, fish passage, and connectivity (unimpeded movement of water and sediment). Four study sites will be selected in consultation with MN DNR and our technical advisory panel. Watersheds will be selected to represent a range of fish communities and geomorphic characteristics present in Minnesota. Existing fish data present in each watershed (e.g. Fishes of Minnesota database) will be compiled. Each culvert or potential barrier will be surveyed, and habitat characteristics (depth, velocity, substrate) will be quantified upstream and downstream of each culvert to evaluate the impact of the road crossing. These surveys will be used to 1) identify potential issues with on-channel and floodplain culverts, 2) quantify differences between habitat upstream and downstream of road crossing and 3) develop detailed hydraulic models of each site that can be used to model depths and velocities across a range of flows to evaluate fish passage, culvert resiliency, and connectivity (water flow and sediment transport).

Activity Milestones:

Description	Completion Date
Identify field sites and compile information on culvert characteristics, fish communities, etc.	January 31, 2024
Field data collection: surveys and field assessments	December 31, 2024
Hydraulic modelling across a range of flows	June 30, 2025
Case study report on observations on performance of floodplain culverts in MN	June 30, 2026

Activity 2: Flume experiments: Benefits of floodplain culverts

Activity Budget: $88,933

Activity Description:
We will use scaled models of Minnesota streams to investigate the benefits of various culvert placements including floodplain culverts on stream connectivity. Experiments will be conducted in a specially modified flume at St. Anthony Falls Laboratory (SAFL) at the University of Minnesota to allow researchers to test culvert configurations, rapidly adjust, and retest. With input from the culvert surveys and hydraulic models in Activity 1 and the help of an advisory panel and data compilation in Activity 3, we will select several floodplain culvert configurations and flow depths etc. based on the conditions most applicable to Minnesota streams. The scaled model will consist of a stream channel, overbank floodplain area, and roadway embankment in which channel culverts and floodplain culverts will be placed. Velocity and flow patterns in the channel and floodplain areas will be measured with state-of-the-art equipment available at SAFL including an acoustic Doppler velocimeter (ADV) or surface particle image velocimetry (PIV) as the model is subjected to inflow conditions and culvert combinations indicated in the test matrix. Sediment transport in the channel, floodplain, and culverts will be observed qualitatively for scour and deposition. Experiments will be well documented with video that will be published online.

Activity Milestones:

Description	Completion Date
Finalize test matrix based on Activities 1 and 3 and with input from advisory panel	May 31, 2025
Flume Experiments: quantify overtopping potential, areas of scour and deposition, water flow, and fish passage	June 30, 2026
Compile and publish educational videos from experiments	June 30, 2026

Activity 3: Outreach and Engagement: Improving connectivity at road-stream crossings with floodplain culvert design

Activity Budget: $48,904

Activity Description:

Successful road-stream crossing designs are ones that meet multiple goals: safe roadway passage, infrastructure resiliency to large flow events, fish and wildlife passage, flood protection, and channel stability. These benefits are of interest to multiple state agencies including MN DNR, MnDOT, BWSR, as well as federal agencies including USFS, USFWS, USDA, and other stakeholders such as the Nature Conservancy, etc. At the start of this project, we will develop a technical advisory panel to connect to stakeholders and practitioners to: 1) help guide the project details including site selection and experimental parameters and 2) ensure efficient transfer of research results to state agencies and other groups. Activity 3 focuses on connections with ongoing efforts in Minnesota to improve road-stream crossing design. To place our field and laboratory results within context, we will mine existing data on culvert performance in Minnesota including MN DNR's Culvert Inventory Application Suite, and MnDOT's bridge inspection data. Both databases provide data on culvert dimensions and type as well as maintenance needs and structural integrity. In addition to working with our technical advisory panel, we will present our results at the Minnesota Water Resources Conference, a workshop, and through a peer-reviewed publication.

Activity Milestones:

Description	Completion Date
Meet with project advisory panel at project kickoff, and mid-project	June 30, 2025
Compilation and analysis of culvert performance data from existing databases	June 30, 2026
Publish results through a 1 page summary and peer-reviewed publication	June 30, 2026
Workshop to share research results with advisory panel, state agencies and interested stakeholders	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Matthew Hernick	University of Minnesota - St. Anthony Falls Laboratory	co-PI	Yes

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?

Previous research by Kozarek has focused on individual culvert design, hydraulics and sediment transport to mitigate the impact of culverts on fish movement; Kozarek and co-PI Hernick served as part of a research team funded by MnDOT to develop a guidance document for culvert design in Minnesota to maintain stream connectivity. However, this guidance did not take into account floodplain processes. The current proposal represents the first dedicated effort to evaluate the benefits of floodplain culverts on water resources and complements efforts by MN DNR and MnDOT to design more sustainable roadway infrastructure.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
MAISRC Subproject 21.2: Field Validation of Mulitbeam Sonar Zebra Mussel Detection	M.L. 2017, Chp. 96, Sec. 2, Subd. 06a	$0

Project Manager and Organization Qualifications

Project Manager Name: Jessica Kozarek

Job Title: Research Associate

Provide description of the project manager's qualifications to manage the proposed project.

Jessica Kozarek is a research associate and manager of the Outdoor StreamLab at the University of Minnesota at St. Anthony Falls Laboratory and in this position is an experienced project manager. She received a BS in chemical engineering from Penn State, and MS and PhD degrees in biological systems engineering from Virginia Tech. Dr. Kozarek's primary research interests are in the areas of stream restoration and management; ecohydraulics; interactions between flow, sediment, and in-stream biota; use of hydraulic models to develop restoration guidance; and water quality and nutrient dynamics. She is a regional expert on culvert design for fish passage and stream connectivity and along with co-PI Matt Hernick, has worked to develop state guidance and workshops on culvert design for fish passage and stream connectivity.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:

SAFL is an interdisciplinary fluid mechanics research facility of the College of Science and Engineering at the University of Minnesota. SAFL research focuses on environmental, energy, and health challenges. SAFL provides key instrumentation and expertise for the study of turbulence and sediment in rivers and streams, and for understanding interactions between channels, waves, wind driven flows and pollutant dispersion. The experimental portion of this project is centered at SAFL because of the flumes, wave generation facilities, and data collection systems for high accuracy sensor

positioning and sampling (http://www.safl.umn.edu/services/measurements). SAFL also has a sediment laboratory available for grain size analysis.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Jessica Kozarek		Project Manager			33.5%	0.6		$76,524
Matthew Hernick		co-PI			28.7%	0.6		$50,913
Ben Erickson/SAFL tech staff		Experimental Setup			28.7%	0.08		$6,622
Erik Steen/SAFL Technical staff		Instrumentation set up			28.7%	0.04		$3,362
Christopher Milliren/SAFL technical staff		Experiment set up			33.5%	0.04		$3,490
Richard Christpher/SAFL technical staff		Build experimental setup			28.7%	0.08		$7,986
Undergraduate student reseracher		assist in field and experimental work			0%	0.93		$28,753
							Sub Total	**$177,650**
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	supplies for adapting flume set up including lumber, plumbing, paint, plexiglass, equipment mounts, small water proof camera, foam, artificial turf, etc.	Scaled model of a road-stream crossing to test floodplain culvert performance					$13,000
	Tools and Supplies	Sediment grainsize testing supplies including sieves and hydrometer supplies	Laboratory equipment to test sediment grain size from field and laboratory experiments					$2,000
	Tools and Supplies	Field equipment supplies including batteries for survey equipments, safety vests, and sample containers	Safety, maintenance, and expendable supplies for field data collection					$1,000

	Tools and Supplies	Sediment	Sediment for laboratary experiments					$1,500
							Sub Total	**$17,500**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Registration for reserachers (PI and co-PI) to attend and present results at MN Water Resources conference	Minnesota Water Resources Conference					$500
	Miles/ Meals/ Lodging	The requested travel funds cover travel for four trips for field work, broken down as follows: Mileage: 373.5 miles round trip (average mileage for NE, SW, W, and SE MN field sites) x $0.585/mile x 4 trips = $874 Lodging: $96/room for 2 rooms x 4 nights = $768 per Diem (travel days only): $44.25/day for 2 people x 8 days = $709	Travel to 4 field sites in MN to visit case study sites					$2,350
							Sub Total	**$2,850**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Publication costs	Costs for open access publication of reserach results					$1,000
							Sub Total	**$1,000**
Other Expenses								
							Sub Total	**-**

							Grand Total	**$199,000**

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				
			State Sub Total	**-**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**-**

Attachments

Required Attachments

Visual Component

File: e8f1fc96-d42.pdf

Alternate Text for Visual Component

Problem: image of culvert with sedimentation issues, Solution: image of floodplain culverts, Benefits: image of floodplain culverts passing flood flow under roadway...

Optional Attachments

Support Letter or Other

Title	File
UMN Letter of Endorsement	0ad2163f-1c6.doc

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

Floodplain culverts - Maintaining connectivity at road-stream crossings: floodplains and fish

Problem – culverts can disconnect floodplains by confining water flow under a road, leading to detrimental erosion and sedimentation, increased risk to infrastructure and disrupted fish and animal movement.

Solution – road-stream crossings that allow for water and sediment movement both in the stream and across the floodplain with floodplain culverts.

Photos: Salam Murtada, Kevin Zytkovicz

Where are floodplain culverts most beneficial?

- Reduce overtopping
- Improve channel stability
- Enhance fish and other animal passage

Action plan: acquire data from culvert sites -> test physical and computer hydraulic models -> communicate findings to stakeholders