Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID: 062-B**

Re-Connecting Fish Habitat at Road-Stream Crossings

Category: B. Water Resources

Total Project Budget: $ 474,689

Proposed Project Time Period for the Funding Requested: 3 years, July 2018 to June 2021

Summary:

We will quantify the impact of culverts on fish movement to enable designers and resource managers to preserve fish populations by prioritizing passage at road-stream crossings with the biggest impact.

Name: Jessica Kozarek

Sponsoring Organization: U of MN

Address: St. Anthony Falls Laboratory, University of Minnesota
Minneapolis MN 55414

Telephone Number: (612) 624-4679

Email jkozarek@umn.edu

Web Address www.safl.umn.edu

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Culverts are installed at many road-stream crossings across MN. Culverts can be barriers to fish movement creating fragmented habitat. Multiple culverts along a stream network can have a cumulative effect on fish movment.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Re-connecting Fish Habitat at Road-Stream Crossings

I. PROJECT STATEMENT

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 fish's perspective, road crossings, and culverts in particular, can create barriers to movement within a stream network that can have dramatic consequences for fish populations. This project seeks to quantify the ***cumulative impact of culverts on fish communities and fish movement*** in Minnesota to:

1) Provide information to culvert designers about the impact of various culvert designs on fish movement;
2) Complement ongoing efforts by MN DNR and MnDOT to prioritize and rank culverts for fish passage consideration; and
3) To protect game and non-game fish viability by preserving self-sustaining fish populations (reduce stocking costs).

Culverts can be partial or total barriers to fish movement. The passability of any particular culvert depends on the culvert design, the stream hydrology, and the target fish species and life stages needing to pass through the culvert. The question of when and how resident (non-migratory) stream fish navigate culverts is one of critical importance to state agencies and contractors responsible for permitting and designing of road-stream crossings (MnDOT, MN DNR, local agencies, and consultants). Currently, most fish passage studies conducted in coastal areas of the United States have focused on migratory fish species that need to move to access spawning grounds, but much less is known about resident stream fish movement to respond to seasonally varying stream conditions. For example, fish may need to reach deeper, cooler water when temperatures get too high in the summer, or they made need to vacate certain habitats to avoid predators. Movement also promotes genetic diversity and allows fish species to recolonize areas where populations have been wiped out by disturbance or fishing pressures. In Minnesota, maintaining stream connectivity is also important for endangered or threatened species, such as the Topeka Shiner or mussel species that rely on fish movement for recolonization. When stream habitat becomes fragmented, fish have fewer options to manage stressful conditions, and threatened populations face an increased risk of extinction.

There is growing concern over the effect of habitat fragmentation due to culverts on fish communities including game and non-game species, but the cumulative effects of multiple culverts along a stream network on fish populations are not well understood. In Minnesota, no standard culvert design to facilitate fish passage or stream connectivity currently exists, and the methods and research developed for coastal migratory fish species are likely not appropriate when applied to low-gradient, mid-western streams and stream resident fish. To address these concerns, this project will provide: a) insight into watershed-scale effects of potential fish passage barriers in Minnesota streams, b) information critical to Minnesota resource managers and roadway designers to increase connectivity and reduce fragmentation, and c) the development of a decision-making tool for prioritizing road-stream crossing designs for fish passage.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Watershed Selection, Culvert Mapping, and Passibility Ranking **Budget: $159,509**

A compilation of state-wide spatial databases will be used to identify three key watersheds where fish passage will be monitored. Culverts and other barriers (e.g. dams) will be mapped, visited and ranked for fish passibility. Where feasible, culverts will be investigated using tools such as FishXing that have a database of fish swimming speeds. Data from the Fishes of Minnesota database will be used to determine historic presence of fish species throughout each watershed. Watersheds will be selected to represent a range of stream fish communities present in Minnesota, and will include game and non-game species. Each culvert or potential barrier will be surveyed, and habitat characteristics (depth, velocity, substrate) will be quantified upstream and downstream of each culvert.

Outcome	Completion Date
1. Map and ranking of all potential barriers to fish movement in 3 key watersheds	December 2019

Activity 2: Culvert Barrier Effects on Fishes of Minnesota **Budget: $233,118**

To quantify the impact of culverts on fish movement through a stream network, two years of monitoring will be conducted in three watersheds selected in Activity 1. Fish communities (species richness and relative composition) will be measured using targeted conventional (electrofishing and seining) and eDNA sampling within each watershed. Simultaneously, fish movement (timing, distance moved, and direction) will be monitored across selected reaches using fish tracking methods (PIT tagging with receiver antennae).

Outcome	Completion Date
1. Cumulative effect of culvert barriers on fish communities (as report)	December 2020
2. Fish movement through culverts and along a stream network (as report)	December 2020

Activity 3: Fish Passage Guidance and Prioritization Tools **Budget: $82,062**

Compiling the results from Activities 1 and 2, we will develop guidance for the design, management, and replacement of culverts to enable fish passage in Minnesota. This will include a prioritization tool for stream networks with multiple barriers. We will equip our student researchers to give talks and present research results to both academic and applied audiences. Researchers will host a workshop with state and local agencies (MN DNR, MPCA, MnDOT and stream practitioners) to present research results and fish passage recommendations.

Outcome	Completion Date
1. Culvert design for fish passage guidance (including prioritization)	March 2021
2. Fish passage workshop: tools and recommendations	June 2021

III. PROJECT STRATEGY

A. Project Team/Partners

University of Minnesota - *Dr. Jessica Kozarek* (Research Associate): Project Manager, spatial data analysis, prioritization tool development, lead fish movement study; *Dr. Jay Hatch* (Associate Professor): Fish identification expert, mentor undergraduate and graduate students; *PhD student*: lead undergraduate team in fish sampling, fish movement evaluation; *MS student*: lead 2nd undergraduate team in fish sampling, fish community analysis; *Undergraduate research team* (2 teams of 3): work with graduate students on fish sampling, field data collection.

Alexandria Technical and Community College – *Dr. Jessica Eichmiller* (Biology Instructor): adviser to project on eDNA methods and analysis

B. Project Impact and Long-Term Strategy

This proposal builds on previous and ongoing collaborations with both MnDOT and MN DNR to develop a statewide picture of the cumulative impact of road crossings on fish community structure and fish movement in Minnesota. Previous research by Kozarek and Hatch has focused on individual culvert design, hydraulics and sediment transport, and light to mitigate the impact of culverts on fish movement. Kozarek is currently serving as part of a research team funded by MnDOT to develop a guidance document for culvert design in Minnesota to maintain stream connectivity. Two key pieces of information are missing in this process: 1) an understanding of the potential effects of culverts (what are the repercussions to the larger fish community if fish cannot pass a barrier or multiple barriers?), and 2) how should culvert design for fish passage be prioritized?

C. Timeline Requirements

This project requires three years of funding including two full summer seasons (2019 and 2020) for field data collection. Work will begin July 2018 and the final report will be completed by June 2021.

2018 Detailed Project Budget

Project Title: *Re-connecting Fish Habitat at Road-Stream Crossings*

IV. TOTAL ENRTF REQUEST BUDGET *3* **years**

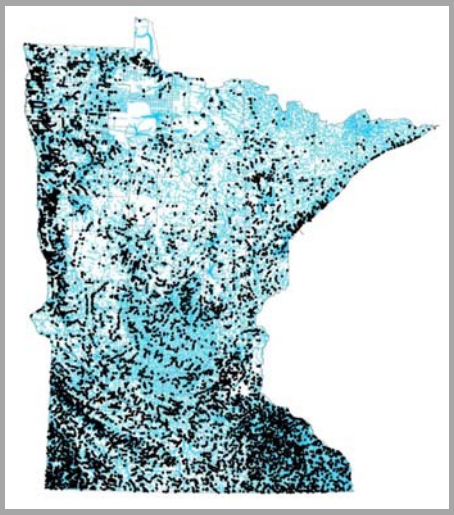
BUDGET ITEM	AMOUNT
Personnel:	$ 383,323
Research Associate: Jessica Kozarek, 25% FTE, (75% salary, 25% benefits), $72,314	
Engineering Technition, 8% FTE, (79% salary, 2% benefits), $19,194	
PhD Graduate Student , 50% FTE, (58% salary, 42% benefits), $139,789	
MS Graduate Student , 50% FTE, (58% salary, 42% benefits), $91,809	
Undergraduate Reasearch Team, 100% salary, 0% benefits, $60,218	
Professional/Technical/Service Contracts: N/A	
Equipment/Tools/Supplies:	$ 25,150
Field Supplies (replacement and repair: nets, waders, safety (high vis), etc.), $2,600	
Field Monitoring Supplies (water level loggers, survey equipment maintenance, etc.), $5,200	
Backpack electofisher, $6,000	
Fish Tracking Supplies (antenna, reader, tags, injector), $10,350	
Fish Handling Supplies (coolers, etc.), $1,000	
Acquisition (Fee Title or Permanent Easements): *(N/A)*	
Travel:	
Travel to field sites (2 field crews, 2 months travel, 2 summers)	$ 46,216
Additional Budget Items: eDNA Laboratory Costs	$ 20,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$ 474,689**

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: *N/A*	$ -	
Other State $ To Be Applied To Project During Project Period: *N/A*	$ -	
In-kind Services To Be Applied To Project During Project Period: Unrecovered UMN overhead (54% MTDC)	$ 214,660	
Past and Current ENRTF Appropriation: *N/A*	$ -	
Other Funding History (Previous Minnesota Fish Passage Research):	$ -	
Culvert length and interior lighting impacts to Topeka shiner passage, Minnesota Department of Transportation, PI: J. Kozarek, co-PI: J. Hatch	$ 154,854	*complete by FY 19*
Laboratory based testing of culvert designs for aquatic organism passage, Minnesota Department of Transportation, PI: J. Kozarek, co-PI: J. Marr	$ 105,640	*complete*
Use of mussel spat rope for fish passage in culverts, Minnesota Department of Transportation ($164,816), PI: J. Kozarek	$ 164,816	*complete by FY 19*

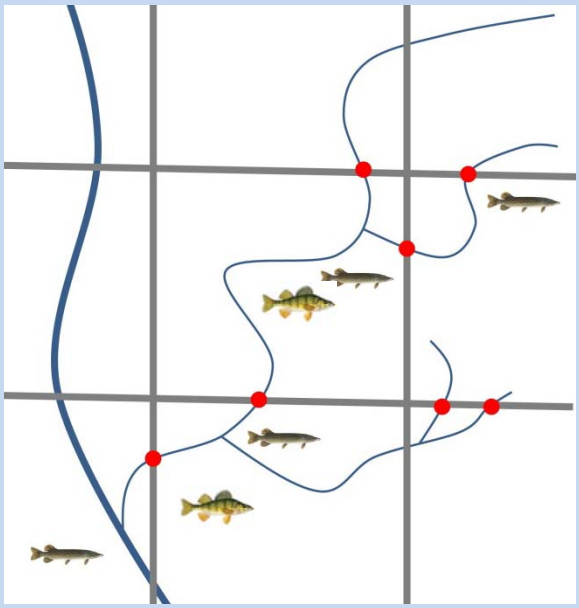
Re-Connecting Fish Habitat at Road-Stream Crossings

Culverts are installed at many road-stream crossings in Minnesota



Culverts can be barriers to fish movement due to excess velocity or turbulence, insufficient depth, or scour that fish cannot navigate.

Fish encounter multiple culverts along a stream network that could block movement



1. **What is the cumulative impact of culverts on MN fishes?**
2. **How do culverts alter fish movement (timing, distance, and direction)**
3. **Which culverts are highest priority for fish passage (which culverts reconnect more stream miles?)**

PROJECT MANAGER QUALIFICATIONS

Jessica L. Kozarek

Current Position: Research Associate and Outdoor StreamLab Research Program Coordinator, St. Anthony Falls Laboratory, University of Minnesota

Education:

The Pennsylvania State University	Chemical Engineering	B.S., 2002
Virginia Tech	Biological Systems Engineering	M.S., 2006
Virginia Tech	Biological Systems Engineering	Ph.D., 2011

Areas of specialization:
Fish and aquatic organism passage; interactions between flow, sediment transport and ecological processes in fluvial systems; stream restoration and management; use of hydraulic models to develop restoration guidance; complexity and structure of in-stream habitat

Select Publications:

Khosronejad, A., Kozarek, J. L., Diplas, P., and Sotiropoulos, F. (2015). Simulation-based optimization of in-stream structures design: J-hook vanes. Journal of Hydraulic Research, 53(5), 588-608.

Khosronejad, A., Kozarek, J. L., and Sotiropoulos, F. (2014). Simulation-based approach for stream restoration structure design: Model development and validation. Journal of Hydraulic Engineering, 140(9).

Plott, J. R., Diplas, P., Kozarek, J., Dancey, C. L., Hill, C., and Sotiropoulos, F. (2013). A generalized log law formulation for a wide range of boundary roughness typically encountered in natural streams. Journal of Geophysical Research-Earth Surface, 118(3), 1419-1431.

Resop, J.P., J.L. Kozarek, and W.C. Hession. (2012). Terrestrial laser scanning for delineating in-stream boulders and quantifying habitat complexity measures. Photogrammetric Engineering and Remote Sensing. 78(4): 363-371.

Kozarek, J.L., W.C. Hession, C.A. Dolloff, and P. Diplas. (2010). Hydraulic complexity metrics for evaluating in-stream Brook Trout (*Salvelinus fontinalis*) habitat. Journal of Hydraulic Engineering. 136(12): 1067-1076.

Book Chapter:

Métivier, F., Paola, C., Kozarek, J. L. and Tal, M. (2016) Experimental studies and practical challenges in fluvial geomorphology, in Tools in Fluvial Geomorphology (eds G. M. Kondolf and H. Piégay), John Wiley & Sons, Ltd, Chichester, UK.

Relevant Technical Report:

Kozarek, J. L., and S. Mielke (2015) Sediment transport through recessed culverts: Laboratory experiments, Final Report 2015-08. Minnesota Department of Transportation, Research Services and Library, Office of Transportation System Management, St. Paul, Minnesota.

ORGANIZATION DESCRIPTION
St. Anthony Falls Laboratory (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.