Climate Change Task Force

January 8, 2020
9:00 a.m.
Monroe County Board Assembly Room
(South Side/Oak Street Entrance)
112 S. Court Street
Sparta, WI 54656

1. Call to Order/Introductions

2. Monroe County Task Force Update
   - January 22nd, 2020 – 10am meeting for comprehensive planning
   - Land Conservation Dept. Website is posting info & notes from meetings at:
     - http://www.co.monroe.wi.us/departments/land-conservation/
   - Precipitation monitoring and flood warning system implementation is focused on the Little La Crosse and upper Kickapoo watersheds in 2020, because these two watershed have received the most damage over the past 10 years.

3. Watershed precipitation monitoring/flood warning system – Proposal
   - Updated Cost Estimate for the Water Detection Warning and Alerting Systems:
     - ELTEC: $10,000 – TAPCO: $15,000
   - Project Cost Scenarios: Include startup costs, but not maintenance.
     - Project 1 - $5,000-$10,000
     - Project 2 – $20,000-$25,000
     - Project 3 – $25,000-$50,000
   - The National Weather Service can pull the data from our stations if they have a route into our system network.
   - Nate Young is putting together a proposal for us, and we should have those numbers for next month's meeting.

4. Funding mechanisms for implementing CCTF efforts
   - The goal is to implement these systems for two watersheds in 2020.
   - Bob has landowners interested in sharing costs & or hosting systems on their property.
     - Businesses, townships, farmers, landowners etc. are all potential funding sources.
     - Private Sourcing: need to create accounts more specific to where the funding is coming from, but could still be a part of the CCTF account under the LCD. Segregation of donation would be necessary.
   - Grant opportunities for this project.
     - Roxie – Discussed Federal Emergency Management Funds for mitigation, and integrating into our comprehensive planning

- Highway Dept. could be a part of the funding as well, as the flooding affects the county highways and infra-structure.
- Potential Capital funding for startup costs from the WI County's Association
  - Governor's Budget Meetings are happening now, and we may be able to reach out for funding. It is a problem statewide and the topic is being talked about.
- Wisconsin Towns Association – another potential lobbyist for funding and building local support.

5. Stream crossings, designs etc... (Bobbi Jo Fischer – WDNR)
- Road Stream Crossings & Flood Resiliency Presentation:
  - "Mysteries of the Driftless" is a 28 min video that explains our area.
  - We need to make sure we are performing regular maintenance and inspections/inventories of our culverts/bridges.
    - Highway Dept. has been inventorying and inspecting County culverts/bridges
    - Townships are inventorying and inspecting bridges.
  - Traditional Hydraulic Design:
    - Design for 100 year storm event
    - In the summer when water levels are down, you may cut off the flow and impact aquatic life
    - Debris gets caught in front of these pipes as they are not very wide, which causes more function & maintenance issues
    - Pipe should be installed below ground to be effective and meet full bank width, which eliminates space for water and debris coming through.
    - Creates a plunge pool at the outlet
  - Ecological Design Culverts "bottomless pipes":
    - Sometimes bottomless
    - Bank full width, spans the width of the banks of the stream/water flow
    - This allows water to still flow through during low flow
    - This allows the water to raise and enter the floodplain
    - Higher upfront costs, longer life span, and reduced maintenance.
    - Shallow placement into the streambed.
  - It is important to document the failures of our structures with reports and photos.
  - Volunteers to survey watersheds and crossings and then prioritize which ones should be addressed first vs. the low priority sites. This is based off the "Prioritization Model".
    - Inspecting waterways are categorized by less than 20 feet wide vs. more than 20 feet.
      - The WIDOT states that spans greater than or equal to 20 feet must be inspected every 2 years and the county must have a designated person to provide inspections. Structures deemed emergent have a more frequent inspection time line to follow.
    - The WDNR is available for training for counties, towns, etc. on how to inventory and fill out the paperwork. They could provide equipment, and training.

- Structures must be municipally owned to receive help from the WDNR. Privately owned structures fall under another program.
- In northern WI they hold bus tours (open to the public) to highlight problematic areas and discuss what needs to be done with them.
- TU-DARE fish habitat group could be a potential sponsor.

- FEMA funding is becoming more flexible to allow for larger structures to handle larger storm events to avoid consecutive failures.
- DNR estimates 7% of culverts/bridges are complete barriers, 51% partial barriers in the Driftless area.
- Design Considerations for road culverts for streams 1% gradient or less:
  - Spans bank full width or greater
  - Set below the vertical adjustment potential of the streambed using the stream profile survey to avoid the plunge pools. (ensure the culverts are deep enough)

6. Open discussion/questions
   - Does the DNR study the cumulative impact of stacking stream crossings though-out a stream or river system? Example: 11 stream crossings in 4 miles on Brush Creek. D. Bauman responded, DNR doesn't have statutory authority to review application assessing cumulative impact. There maybe potential for the County Zoning department to address this issues under their review process.

7. Set next meeting date - February 12th 2020 in assembly room, 9am

Monroe County Climate Change Task Force Meeting

Date: 1/8/2020

Monroe County Climate Change Task Force Members

Name	Title	Agency
Tina Osterberg	County Administrator	Monroe County
Bob Micheel	County Conservationist	Monroe County
Alison Elliott	Zoning Administrator	Monroe County
Roxie Anderson	Land Use Planner	Monroe County
David Ohnstad	Highway Commissioner	Monroe County
Wally Habhegger	County Supervisor, District 5	Monroe County
Al McCoy	County Supervisor, District 1	Monroe County
Dave Pierce	County Supervisor, District 2	Monroe County
Jim Schroeder	County Supervisor, District 15	Monroe County
Ron Luethe	Town Supervisor -Ridgeville	Town of Ridgeville
Jack Herricks	Town Chair - Jefferson	Town of Jefferson
Bill Halfman	Agricultural Agent	UW-Extension
John Noble	Fisheries Biologist	Fort McCoy
Tonya Townsell	Public Affairs Officer	Fort McCoy
Cindy Koperski	Program and Policy Analyst	WI Dept. of Natural Resources

RED = Absent

Additional Attendees

Name	Title	Agency
John Wetenkamp	Hydrologist	National Weather Service
Michelle Komiskey	District Conservationist	Natural Resources Conservation Service
Ned Gatzke	Resident	Town of Wells
Ann Smith	Resident	Town of Wells
Tim Welch	Village President	Village of Wilton
Marcy West	Executive Director	Kickapoo Valley Reserve
Gregg Wavrunek	Regional Representative	U.S. Senator Tammy Baldwin
Tim Hundt	Representative	U.S. Representative Ron Kind
Mary Von Ruden	County Supervisor, District 7	Monroe County
Cedric Schnitzler	County Supervisor, District 4	Monroe County
Bobbi Jo Fischer	Environmental Analysis Supervisor	WI Dept. of Natural Resources
Dan Baumann	Secretary's Director	WI Dept. of Natural Resources
Mark Van Wormer	Public Works Director	City of Sparta

Funding Sources to Help Fix Road Stream Crossings (May 2018)

This document summarizes funding sources to help improve municipal road crossings with flooding, water quality, and stream connectivity problems.

Tips for Success

- ✓ A road crossing inventory is an important first step to find the highest priorities.
- ✓ Cooperative efforts that align the priorities and expertise of municipalities and conservation stakeholders are often the most competitive.
- ✓ Emphasize the public benefit of the improved road crossing from a broad range of perspectives including: flood resiliency, public safety, reduced maintenance, longer culvert lifespan, reduced stream impacts, long-term cost savings, etc.
- ✓ Partnerships can often result in assistance with grant application development, project documentation, and timely reimbursement.
- ✓ Projects with a preliminary design and budget prepared at the time of the grant application are more likely to stay on time and budget.

DNR Transportation Liaisons

The **Transportation Liaison** can assist with road stream crossing evaluations, provide training for inventory efforts, and help identify local partners active in road stream crossing improvement projects.
https://dnr.wi.gov/topic/Sectors/documents/transportation/Liaisons.pdf

Culvert Funding

WI DNR Surface Water Grants: http://dnr.wi.gov/aid/surfacewater.html
River Planning Grants are available for watershed inventories of road stream culverts to identify barriers and priorities for replacement. Award maximum is $10,000. A 25% cost share is required and the application deadline for these grants is December 10th. ***River Management Grants*** are awards of up to $50,000 for river restoration activities including the replacement of high priority road crossings that are barriers to stream connectivity. A 25% cost share is required and the application deadline for these grants is February 1st.

U.S. Fish and Wildlife Service, The National Fish Passage Program (NFPP): A cooperative conservation program that provides funding and technical assistance to conduct inventories and/or to replace high priority barriers. Preference is given to projects in watersheds identified as high priority conservation of USFWS priority aquatic species. The funding cycle begins in August with grants awarded the following spring. Applications are accepted year-round. To begin the application process, contact the fish passage biologist for your area. A 1:1 match is strongly encouraged and the average award is $70,000.
https://www.fws.gov/fisheries/fish-passage.html

County Conservation Departments & Dept. of Agricultural, Trade, and Consumer Protection (DATCP): Technical design assistance and cost share of culvert replacements may be available. To be eligible, the project needs to be sponsored and coordinated through the local County Conservation Department. An important eligibility standard is to identify road crossings with negative water quality impacts that can be corrected by erosion control, culvert sizing, and other stabilization methods to reduce sediment loads in streams. A directory of County contacts can be found on the following website.
https://wisconsinlandwater.org/
http://wisconsinlandwater.org/files/pdf/WILandWaterDirectory.pdf
WI DOT Road and bridge assistance programs: There are a number of programs to assist local governments with needed improvements to local roads, highways and bridges.

http://wisconsindot.gov/Pages/doing-bus/local-gov/astnce-pgms/highway/default.aspx

U.S. Forest Service (USFS): Municipal roads that are located within or adjacent to the Chequamegon-Nicolet National Forest may be eligible to receive technical design assistance and cost share for road stream culvert replacements. Contact the Forest Engineering Section for information. https://www.fs.usda.gov/cnnf

National Fish and Wildlife Foundation (NFWF): Provides funding on projects that sustain, restore, and enhance fish, wildlife, and plants and their habitats. NFWF supports over 70 grant programs for federal, state, and local governments. A 1:1 match is required. Two NFWF grant programs that could potentially help fund road stream connectivity projects include: http://www.nfwf.org/whatwedo/grants/applicants/Pages/home.aspx

- ***Five Star and Urban Waters Restoration Grant*** proposals are generally due at the end of January. http://www.nfwf.org/fivestar/Pages/home.aspx
- ***Bring Back the Natives Program*** proposals are generally due at the end of July. http://www.nfwf.org/bbn/Pages/home.aspx

Federal Funding

U.S. Department of Transportation: Funding to address transportation infrastructure needs through the Better Utilizing Investments to Leverage Development (BUILD) Transportation Discretionary Grants program. State, local, and tribal governments are eligible to apply. BUILD Transportation grants are for investments in surface transportation infrastructure and are to be awarded on a competitive basis for projects that will have a significant local or regional impact. Funding can support roads, bridges, transit, rail, ports or intermodal transportation. The minimum construction project grant size for projects located in rural areas is $1 million. A greater share of BUILD Transportation funding will be awarded to projects located in rural areas that align well with the selection criteria. At least 30 percent of funds must be awarded to projects located in rural areas. https://www.transportation.gov/BUILDgrants

Trout Stream Funding

Trout Unlimited (TU): Local TU volunteers may be able to assist with culvert inventories and assessments. Local chapters can also provide cost-share. Grant funding is available to TU chapters through the Embrace-A-Stream program and the Trout and Salmon Foundation. To find a local TU contact: https://wicouncil.tu.org/

- ***Embrace-A-Stream (EAS)*** program awards up to $10,000 with an average of $5,200. 1:1 match required. The deadline for the TU chapter representative to contact the regional EAS representative and notifying her/him of their intent to submit a proposal is April 15. Initial drafts of proposals are due on May 15 and final applications are due July 15. http://www.tu.org/conservation/watershed-restoration-home-rivers-initiative/embrace-a-stream
- ***Trout and Salmon Foundation*** awards up to $4,000 with an average of $3,300. The deadline is August 1. https://www.troutandsalmonfoundation.org/

WI DNR Trout Stamp Funds: Are available for addressing problem road crossings on high priority trout waters. A cost share is often required and the funding focuses on crossings that go above and beyond the minimal permit requirements. Contact the DNR fisheries biologist for more information. https://dnr.wi.gov/topic/fishing/people/fisheriesbiologists.html

Great Lakes Watershed Funding

TU Great Lakes Stream Restoration Program: TU has a Stream Restoration Specialist and Manager on staff that may provide technical design assistance and/or cost-share for road crossings on coldwater ecosystems within the Great Lakes basin. Laura McFarland: lmacfarland@tu.org

The Nature Conservancy (TNC): Supports research and development of assessment and prioritization tools in priority watersheds. In 2017-2018 they are focused on prioritization and ground-truthing of basin-wide Lake Michigan regional barrier priorities and are a resource for eastern WI fish passage. Rachel Van Dam, Regional Connectivity Field Representative: rachel.vandam@tnc.org www.nature.org/wisconsin

Wisconsin Coastal Management Program (WCMP): Approximately $1,300,000 is available to enhance and restore coastal resources within the state's coastal zone (all counties adjacent to Lakes Superior and Michigan, with their 1,000 miles of shoreline). WCMP Grants are available for coastal wetland protection and habitat restoration including road stream connectivity projects. Grant projects totaling $60,000 or less require a 50% match. Applications are due in November. https://doa.wi.gov/Pages/LocalGovtsGrants/CoastalGrants.aspx

Fund for Lake Michigan: Accepts projects that improve the water quality of Lake Michigan through habitat restoration, pollutant reduction, stream restoration, or improvements to coastal areas in Wisconsin. Previously funded projects have included culvert replacements. http://www.fundforlakemichigan.org/

National Fish and Wildlife Foundation - Sustain Our Great Lakes Program: Is a public–private partnership designed to address these threats and improve the ecological health of the Great Lakes basin. Funding priorities for this program include aquatic connectivity (e.g., bridge and culvert replacement). A 1:1 cost share match is required. Grant awards range from $25,000 to $1,500,000. Proposals are due February 21, 2017 ($7.8 million is expected to be available in 2017.) http://www.nfwf.org/greatlakes/Pages/home.aspx

Great Lakes Fish and Wildlife Restoration Act (GLFWRA): The program provides federal grants on a competitive basis to states, tribes and other interested entities to encourage cooperative conservation, restoration and management of fish and wildlife resources and their habitat in the Great Lakes basin. The purpose of the Act is to provide assistance to encourage cooperative conservation, restoration and management of the fish and wildlife resources and their habitats in the Great Lakes Basin. Successful project awards have averaged $112,700. All proposals require a 25% non-federal match. Deadline for proposal submission is in December. http://www.fws.gov/midwest/fisheries/glfwra-grants.html

Healing Our Waters Great Lakes Coalition: There are two funding areas offered. ***The Federal Project Support program*** provides funding to groups that are proposing federally funded projects or that have received project funding, but that need help with the development or implementation of on-the-ground work. Awards for this grant program will be up to $15,000. The ***Community Engagement program*** provides funding to organizations that want to be involved in federally funded restoration activities in their communities. Awards for this grant program will be up to $5,000. There is no deadline for proposals, grants are given on a first come, first serve basis. http://healthylakes.org/category/funding-opportunity/ http://freshwaterfuture.org/grants/healing-our-waters-grant-program/

Great Lakes Restoration Initiative: These funds require partnerships with, and are administered by, federal agencies (i.e. Federal Highway Admin., U.S. Forest Service, Bureau of Indian Affairs, etc.). During FY15 -19, federal agencies will continue to use Great Lakes Restoration Initiative resources to strategically target the biggest threats to the Great Lakes ecosystem and to accelerate progress toward long term goals for this important ecosystem. https://www.glri.us/

Lakes Funding

WI DNR Lake Management Grant: Funding is available if a culvert improvement would have a beneficial impact to fish movement and water quality at lakes. For planning and assessment work, S***mall Scale Planning*** grants of up to $3,000 and ***Large Scale Planning*** grants of up to $25,000 are available. Applications for planning grants must be received by December 10th. For on the ground work, ***Lake Protection*** grants of up to $100,000 are available. Application for management grants are due February 1. A 25% cost share is required. http://dnr.wi.gov/aid/surfacewater.html

Midwest Glacial Lakes Partnership (MGLP): Is for projects that benefit fish habitat in midwestern lakes and the driftless region. Funding is through the National Fish Habitat Partnership & U.S. Fish and Wildlife Service. Previously successful projects include fish passage projects. Grant awards generally range from $10,000 to $25,000. http://midwestglaciallakes.org/

Streambank and Shoreline Protection

Army Corps of Engineers: Funding is available for streambank and shoreline erosion that has the potential to threaten the integrity of public infrastructure such as bridges and roads. A feasibility study up to $100,000 is 100% federally funded. The design and construction costs are 65% Federal and 35% non-Federal. To discuss project applicability, contact the St. Paul District CAP Program Manager, Nathan Campbell at 651-290-5544 or Nathan.J.Campbell@usace.army.mil
http://www.mvp.usace.army.mil/Home/Projects/Article/570901/continuing-authorities-program-cap/

Useful Grant Websites:

WI DNR maintains links to a wide variety of state and federal agency grants: http://dnr.wi.gov/Aid/Links.html

Federal Grants database: http://www.grants.gov/web/grants/home.html

National Oceanic and Atmospheric Admin (NOAA): http://www.habitat.noaa.gov/funding/index.html

RA Smith National provides a monthly grant newsletter. http://www.rasmith.com/grants/

Upper Midwest and Great Lakes Landscape Conservation Cooperative:
https://greatlakeslcc.org/issue/aquatic-habitat-connectivity

Opportunities that are now closed often have a similar timeframe each year. For corrections, additions, or comments, please contact Jon Simonsen at: Jonathan.Simonsen@wisconsin.gov

WDNR EA Liaison Assignments

Liaisons

Northern Region

Bill Clark williamH.clark@wisconsin.gov

- **Amy Cronk** amy.cronk@wisconsin.gov
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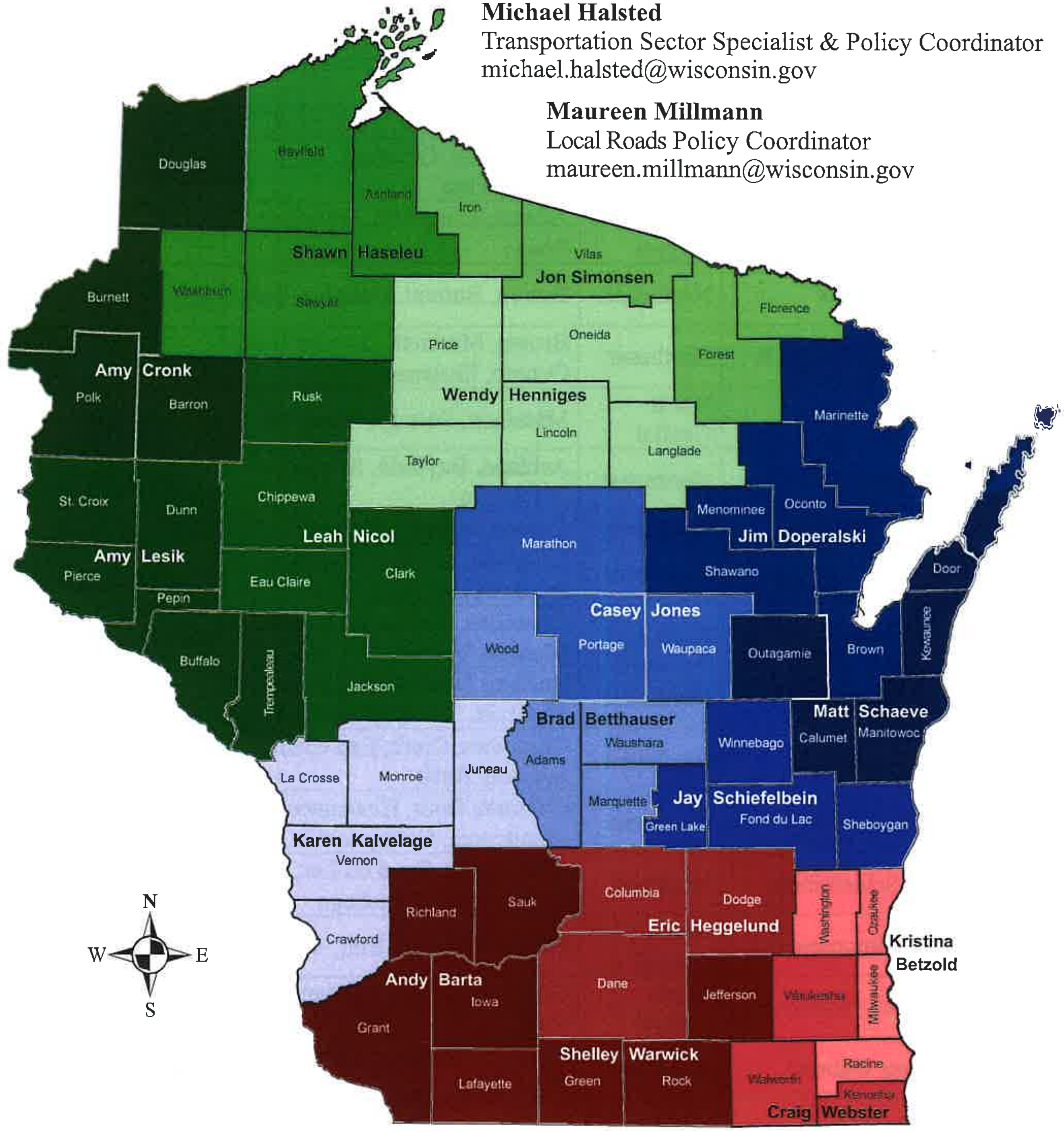

Updated 01-08-2019
by JDR

Transportation Liaison Staff by Last Name

NAME	DOT REGION	COUNTIES	E-MAIL	PHONE #
Andy Barta	Southwest	Grant, Iowa, Richland, Sauk	andrew.barta@wisconsin.gov	(608) 235-2955
Kristina Betzold	Southeast	Milwaukee, Ozaukee, Washington	kristina.betzold@wisconsin.gov	(414) 507-4946
Brad Betthauser	North Central	Adams, Marquette, Waushara, Wood	Bradley.Betthauser@Wisconsin.gov	(715) 421-7851 (715) 213-9064
Amy Cronk	Northwest	Barron, Burnett, Douglas, Polk	amy.cronk@wisconsin.gov	(715) 635-4229 (715) 520-3976
Jim Doperalski Jr.	Northeast	Brown, Marinette, Menominee, Oconto, Shawano	james.doperalski@wisconsin.gov	(920) 412-0165
Casey Jones	North Central	Marathon, Portage, Waupaca	Casey.Jones@wisconsin.gov	(715) 213-6571
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Karen Kalvelage	Northwest	Crawford, Juneau, La Crosse, Monroe, Vernon	karen.kalvelage@wisconsin.gov	(608) 785-9115 (608) 406-7880
Amy Lesik	Northwest	Buffalo, Dunn, Pepin, Pierce, St. Croix, Trempealeau	AmyL.Lesik@Wisconsin.gov	(715) 836-6571 (715) 495-1903
Leah Nicol	Northwest	Chippewa, Clark, Eau Claire, Jackson, Rusk		
Matt Schaeve	Northeast	Calumet, Door, Kewaunee, Manitowoc, Outagamie	matthew.schaeve@wisconsin.gov	(920) 366-1544
Jay Schiefelbein	Northeast	Green Lake, Fond du Lac, Sheboygan, Winnebago	jeremiah.schiefelbein@wisconsin.gov	(920) 360-3784
Jon Simonsen	North Central	Florence, Forest, Iron, Vilas	jonathan.simonsen@wisconsin.gov	(715) 367-1936
Shelley Warwick	South Central	Green, Jefferson, Lafayette, Rock	Shelley.Warwick@wisconsin.gov	(608) 444-2835
Craig Webster	Southeast	Kenosha, Racine, Walworth, Waukesha	craig.webster@wisconsin.gov	(262) 574-2141 (414) 303-3011

WDNR-GP2-2017 GENERAL PERMIT APPLICATION INSTRUCTIONS

In compliance with the provision(s) of Wis. Stat. § 281.36 (3b)(b), no person may discharge/place dredged or fill material into a wetland unless the discharge is authorized by a wetland general permit or individual permit issued by the Department of Natural Resources (department or DNR) or the discharge is exempt by statute. In compliance with the provision(s) of Wis. Stat. § 30.123(2), unless an individual or a general permit has been issued by the department or authorization has been granted by the legislature, no person may construct or maintain a public highway, bridge or construct, place, or maintain a culvert in, on, or over navigable waters. To qualify for this general permit, your project must meet all eligibility standards, permit conditions and all other terms and conditions outlined in WDNR-GP2-2017. Projects that do not meet all standards are not eligible for this general permit and will need to apply for state waterway and wetland individual permits as outlined in Wisconsin Statutes § 281.36(3g)(i) and 30.206(3r).

STEP 1: Determine Project Eligibility by carefully reviewing all terms and conditions of **WDNR-GP2-2017** to verify the proposed project meets the eligibility standards and permit conditions. Eligibility standards are listed on pages three and four as an optional checklist that can be used by the applicant and WDNR. **Please contact the local** DNR Transportation Liaison **for a pre-application discussion.**

STEP 2: Prepare DNR Application Package by completing the Water Resources Application for Project Permits (WRAPP)" (Form#3500-053) OR an Information Worksheet and compiling all the required information as outlined on page 2 of this package. Eligibility standards are listed on pages three and four as an optional checklist that can be used by the applicant and WDNR.

STEP 3: Submit a Completed Application Package to the local DNR Transportation Liaison a minimum of 30 calendar days prior to the desired project construction start date.

STEP 4: Receive Notice of Coverage within 30 days after the DNR receives your **complete** application package. You will receive a notification of coverage letter under WDNR-GP2-2017 or you may be requested to provide additional information to verify the proposed project meets all the terms and conditions of this permit. In some cases, you may be notified that your project requires an Individual Permit.

WHAT YOU NEED TO INCLUDE WITH YOUR APPLICATION:
Note: To avoid delays, supply the information listed below in an organized format. **LOCATION**

☐ **Completed and signed** Water Resources Application for Project Permits (WRAPP) OR Information Worksheet — **Form**

☐ **Project plans or schematic drawings showing:** — **Plan sheet/ drawing**
- The existing roadway and/ or structure, including dimensions
- The proposed roadway and/or structure, including dimensions and structure type.
- Proposed site specific erosion control measures
- Details for any stream diversion during construction, if needed, as well as temporary and permanent stabilization
- Temporary and permanent disposal location for excavated materials
- Location of waterway and wetlands, including dimensions and area of impact and wetland type as well as description of the type, composition and quality of material proposed to be used for fill in wetlands.
- Names and addresses of adjoining property owners

☐ A list and status of any local, state, federal authorizations needed. Check all that are applicable. Please indicate if the permit has been Approved (A), Denied (D) or Pending (P): — **GP Attachment**

Local Zoning Permit		List other permits:	
US Army Corps of Engineers Permit			
WDNR Construction Site Stormwater Permit (for total impacts > 1 acre)			

☐ **Photographs** that represent existing site conditions where project will occur. — **Attachment**

☐ **Municipal Highway, Bridges, Arches and Culverts Alternatives Analysis:**
If the project is impacting wetlands, the following information is required:

➢ **Background / Description of the Project – Purpose and Need (Check all that apply)**

Deteriorated Road / Structure		Emergency structure replacement	
Flooding problems on the road			
Safety Problems		Other (Please identify):	
Widening to accommodate traffic increase			

➢ **Alternatives:** Identify ways that wetland impacts were avoided and minimized during design (Check all that apply)

Reduced width of the road		Erosion control BMPs	
Reduced side slopes of the road			
No sidewalks or altered location of sidewalks or terrace		Other (Please identify):	
Chose shorter or more appropriate stream structure type			

➢ **Alternatives analysis:** Explain why alternatives that had less wetland impact were eliminated from consideration, including cost comparisons, logistics, technology and any other reasons

Use separate sheet to describe why the impact to the wetland cannot be avoided and how the impact to the wetland will be minimized.

CERTIFIED ELIGIBILITY STANDARDS	
1. The applicant has contacted the local WDNR Transportation Liaison during the development of the project to have a pre-application discussion. Go to dnr.wi.gov, key word "transportation" for more information.	
2. A municipality is the applicant and the project purpose is a public transportation project to construct, reconstruct or maintain a highway, bridge, arch or culvert associated with a single and complete project. Projects that are administered (or "let") by WisDOT are not eligible for this general permit.	
3. If the project includes a bridge, arch or culvert that is greater than 36" in diameter, the applicant has made a reasonable effort to coordinate with the County Highway Commissioner or a professional engineer that is a designated agent for the municipality.	
4. Structures over lake outlets and lake systems are not eligible for this permit.	
5. A structure that is regulated under Chapter 31 is not eligible for this permit.	
6. A structure installed with the intent to back up water is not eligible for a general permit.	
7. The proposed road stream crossing has water passing characteristics at least as effective as the existing road grade and structure.	
8. Projects that include a new crossing of a navigable waterway where there previously was no structure are not eligible for this general permit.	
9. Projects that may impact tribal lands or rights, including potential impacts to water systems supporting wild rice, may require additional coordination. Please contact the DNR Transportation Liaison as soon as possible to begin coordination.	
10. This general permit does not authorize any permanent change in the course of a navigable stream, or removal of material from the bed of any waterway, except for what is necessary to place the structure.	
11. Minor dredging (less than 25 cubic yards) within the right-of-way (ROW) for road maintenance may be approvable under this general permit, provided best management practices (BMPs) are used to comply with water quality standards.	
12. The proposed project avoids and minimizes wetland impacts to the greatest extent practicable, in accordance with Wis. Admin. Code NR 103.	
13. The project shall not impact more than 10,000 square feet (0.23 acre) of wetland or waterway for a single and complete project.	
14. The discharge will cause only minimal adverse environmental impacts.	
15. Project will not result in a deleterious impact to any publicly owned trails or property.	
16. Project activities will not take place in or result in adverse impacts to Great Lakes ridge and swale complexes, interdunal wetlands, coastal plain marshes, southern sphagnum bogs that are located in the area located south of a horizontal line drawn across the state based on the routes of STH 16 and STH 21 west of Lake Winnebago and on USH 151 east of Lake Winnebago, boreal rich fens, or calcareous fens.	
17. The top surface elevation of the road will not be raised higher than pre-flood conditions without sufficient analysis and shall conform to the requirements of Wis. Admin. Code chapter NR 116 Wisconsin's Floodplain Management Program and local floodplain ordinance.	
18. Rip rap used to stabilize a road will comply with best management practices and technical	

erosion control standards.	

CERTIFIED ELIGILIBLITY STANDARDS (CONTINUED)	
19. Minor stormsewer outfalls within the road right-of-way may be permitted under this general permit, provided that the structure will have minimal impacts to the waterway or wetland and BMPs are used in design and placement of the structure.	
20. Ditch maintenance may be permitted under this general permit provided that the dimensions of the ditch are not being altered and best management practices (BMPs) are used to comply with water quality standards.	
21. Flood Resiliency – Structures over navigable waterways must be sized and set at an elevation so that water depths, widths and velocities at the inlet and outlet match the natural stream channel. Invert elevations of culverts will be determined by surveying the stream upstream and downstream and setting the culvert below the natural flow line.	
22. The project shall not result in a material obstruction to navigation, and must allow for portage to anyone legally navigating the waterway. All bridges shall either maintain a clearance of not less than 5 feet above the ordinary high water mark (OHWM), or comply with requirements of Wis. Admin. Code NR 320.04(3).	
23. To minimize adverse impacts on fish movement, fish spawning, and egg incubation periods, work in the waterway may not take place during the following periods, unless modified by the Transportation Liaison, who will coordinate with the DNR Fisheries Biologist: • September 15th through May 15th for all trout streams and upstream to the first dam or barrier on the Root River (Racine County), the Kewaunee River (Kewaunee County), and Strawberry Creek (Door County). To determine if a waterway is a trout stream, you may use the WDNR website trout maps which can be found at http://dnr.wi.gov/topic/fishing/trout/streammaps.html. • March 1st through June 15th for ALL other waters.	
24. For projects located in an area that is known for wildlife movement or migration, the applicant has coordinated with the Transportation Liaison to use BMP's to provide habitat connectivity in the design and construction of the project.	

Signature of municipal representative certifying that the project meets the eligibility standards as outlined in the optional attached checklist and WDNR-GP2-2017:

Signature of County Highway Commissioner or PE representing the municipality, if structure is >36" in diameter (optional):

INFORMATION WORKSHEET for Municipal Transportation Projects (Sept. 2015)

Contact your DNR Transportation Liaison BEFORE filling out this information. For more information and to find your DNR Transportation Liaison, go to http://dnr.wi.gov (search keyword "transportation").

WISCONSIN DEPT. OF NATURAL RESOURCES

Applicant/ Road Owner (Town, Village, City or County):	**Road Name:**
Municipal Representative's Name:	**Stream Name:**
Address, City, State, Zip Code:	**County:**
	Legal Description: ________1/4, ________1/4, Section__________ Township________ North, Range__________ East West
Telephone Number:	**Project Start Date:** **Project End Date:**
E-mail Address:	**Project Start and End Location (attach map if necessary):**
Contractor / Consultant Contact Information (if available):	

General Project Information (check all that apply)

	Wetlands present
	Streams/ Lakes present
	Stream culvert(s) replacement
	Bridge replacement
	New culvert or bridge *(currently no crossing present)*
	Riprap placement
	Road surface / mill & overlay

	Road reconstruction
	Road widening/ fill outside toe of slope
	New road layout *(currently no road present)*
	Road /hill / curve realignment
	Clearing & Grubbing
	Storm sewer replacement
	Ditch work

1. Briefly describe the current situation and why corrective actions are needed including any safety concerns.

2. Will wetlands be impacted? If so, provide an estimate of potential wetland fill (square feet).

REPLACEMENT OF EXISTING NAVIGABLE STREAM CULVERT— EXEMPTION INFORMATION / RECORDS

This worksheet can be used to request an exemption from DNR permits under chapter 30.123(6)(r)(a) Wis. Stats. DNR staff can often meet onsite to help identify if a culvert may be vulnerable to flood failure, maintenance problems, and/or adversely impacts the stream.

Project Name:

	Existing Road	Proposed Road
Culvert size		
Culvert length		
Road top width *(surface + shoulders)*		
Road shoulder side slopes *(i.e. 2:1 or 3:1 slopes)*		
Describe changes to culvert elevation or slope.	NA	
Will the road surface elevation over the culverts be raised?	NA	Yes No

Mark the appropriate box below if any of the following problems exist at the current culvert	
☐	The culvert is perched above the streambed *(i.e. waterfall at the outlet)*
☐	There is a scour pool at the outlet
☐	There is water pooling on the upstream side of the road
☐	Water can overtop the road during flood events
☐	The culvert can get blocked with debris or there are beaver problems

Completion of this Information Worksheet will provide the WDNR with information to evaluate the proposed project. The Department will review the project proposal and site specific conditions to determine if the project is exempt from DNR culvert replacement permits. Depending on specific site conditions, your liaison may request further information. It is the applicant's responsibility to obtain all necessary local, state and federal permits and approvals from the appropriate entities prior to construction. By signing below you are acknowledging that you have read this information and understand that further reviews may be needed to proceed with your project. The signer of this document is acknowledging they have the authority to represent the constructing municipality.

Signature & Title________________________________ Date________________

Field Indicators of Flood Prone Road Stream Crossings

Stream Crossing Location: **Field Date:** **Culvert ID #:**

Culvert dimensions:

Natural channel bankfull width (defined on page 2):

Stream flow: [Lower than normal] [Normal flow] [Channel close to overtopping] [Water out of banks]

High-risk watersheds*

- ☐ High gradient (>1%)
- ☐ Forested area with a high potential for woody debris transport
- ☐ Soil type with limited water infiltration (silt, clay, or shallow depth to bedrock)
- ☐ Limited watershed storage in wetlands, lakes, & floodplains
- ☐ Watershed changes resulting in increased runoff (urbanization, development, land clearing, etc.)

Culvert risk indicators

- ☐ Current culvert had a short service life (in place 30 years or less) Age of culvert: ____________
- ☐ Signs of road overtopping **(Table 1)**
- ☐ Proposals to raise the grade of the road at the culvert or an overtopping area
- ☐ Road core in poor condition **(Table 2)**
- ☐ Deep road fill (>5 feet) over the top of the culvert* Ft. of fill over culvert:_______
- ☐ Culvert material poor condition (corrosion, abrasion, and/or deformation)
- ☐ Total width of the culvert(s) opening is significantly narrower than the natural channel bankfull width
- ☐ Large woody debris in the channel and/or blocking the culvert inlet **(Figure 1)**
- ☐ Stream bottom downstream is significantly lower (>2 ft.) compared to upstream **(Figure 2)***
- ☐ Entrenched channel **(Figure 3)***
- ☐ Perched culvert outlet **(Figure 4)***
- ☐ Significant outlet scouring **(Figure 5)***
- ☐ Speed of water at the culvert is much faster compared to the natural channel
- ☐ Water surface upstream is significantly higher (impounded) compared to downstream*
- ☐ Culvert aligns poorly with the stream channel **(Figure 6)***
- ☐ Significant road gravel in the channel & floodplain downstream **(Figure 7)**

Number of Risk Factors Identified →

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

**Items marked with an asterix (*) can be field checked, or assistance may be available to evaluate these factors region wide using LiDAR and GIS data.*

There are many factors that need to be evaluated on road stream crossing projects. Road issues may include ADT, dead end roads, emergency services, utilities, available cover, impact of downstream structures, etc. Water resource issues may include fisheries, water quality, wild rice, endangered resources, mapped floodplains, etc.

The DNR Transportation Liaison may be able to assist with evaluation of road stream crossing risk factors for culvert replacement projects or to help to set up culvert inventory efforts to identify high priority sites.

Definition of natural channel bankfull width: The width of the channel when the water is at the top of its banks and any further water rise would result in water moving into the floodplain. A site where the stream is significantly wider than the culvert(s) span generally has a much higher risk of flood failure due to the limited ability of the culvert(s) to pass water, sediment, and woody debris. To evaluate flood risk based on the amount of stream constriction, the stream bankfull width should be measured in an area of the stream away from the influence of the culvert.

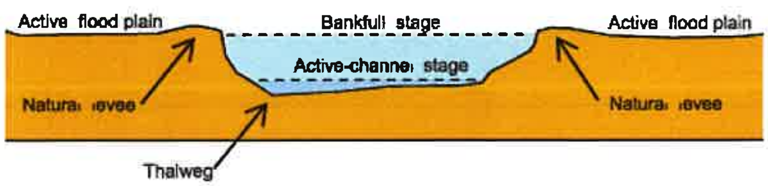


Table 1: Signs of road overtopping.

Road shoulder erosion on outlet side	Pattern of flattened vegetation after a heavy rainfall	Pattern of erosion on the surface of gravel roads
Gravel deposits in the channel and floodplain downstream of the culvert	Elevation of debris lines compared to road elevation	Asphalt covering the entire road shoulder slopes to protect the road during overtopping

Table 2: Signs of poor road core condition. *These factors indicate reduced road core integrity and reduced ability to withstand the forces of flood water and debris.*

Piping of water around culvert	Undermining of the culvert inlet or outlet	Very steep road shoulder slopes
Road shoulder erosion	Sink holes in the road surface or shoulders	Unsuitable road core material
Lack of vegetation and/or riprap to stabilize shoulders	Shifting of the road surface or shoulders	

Figure 1: Large woody debris issues. *Woody debris blocking the culvert is a common cause of culvert failure. Most of the woody material transported during flood events is shorter than the natural streambank width. Risk of culvert failure is greatly reduced by structures that do not constrict the natural stream width and allow woody debris passage.*

Figure 2: Significant change in stream bottom elevation. *Where there the stream bottom is much higher upstream of the road compared to downstream, this can indicate an unstable stream channel condition that may continue to change dramatically during a flood. This has the potential to destabilize the road/ culvert. Care must also be taken if a new culvert is larger or set lower due to the risk of creating additional channel and streambank changes upstream.*

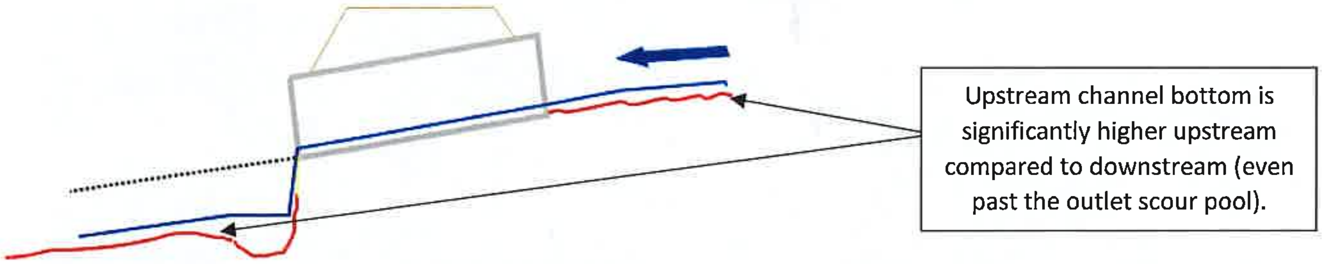


Figure 3: Entrenched channels. *Flood prone areas include entrenched streams where the floodplain width is close to the bankfull width of the stream channel. Since entrenched streams are not well connected to a wider floodplain (and have no room for water to spread out and slow down), flood waters rise quickly and move fast. During a flood event, the water moving in entrenched streams carries a lot of energy to erode streambanks, uproot trees, and washout roadways.*

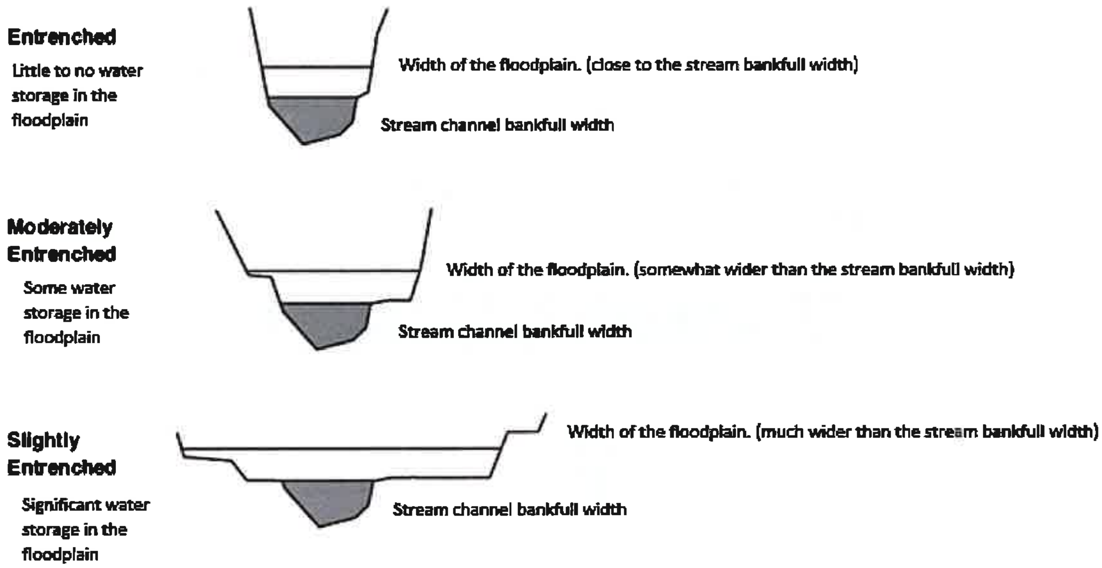


Figure 4: Perched culvert outlets. *This indicates that the culvert has limited ability to convey a wide range of flows and/or backs up water even during non-flood flows to make the crossing more susceptible to failure.*

<u>Figure 5: Outlet scouring.</u> *Large pool that has formed at the outlet that is much wider than the natural stream channel width. This indicates that the culvert has limited ability to convey a wide range of flows.*

<u>Figure 6: Poor culvert alignment.</u> *Poor alignment can significantly decrease the ability of the crossing to convey flows downstream of the road. A significant "angle of attack", as shown below, can greatly increase the flood and debris energy acting to destabilize the road core.*

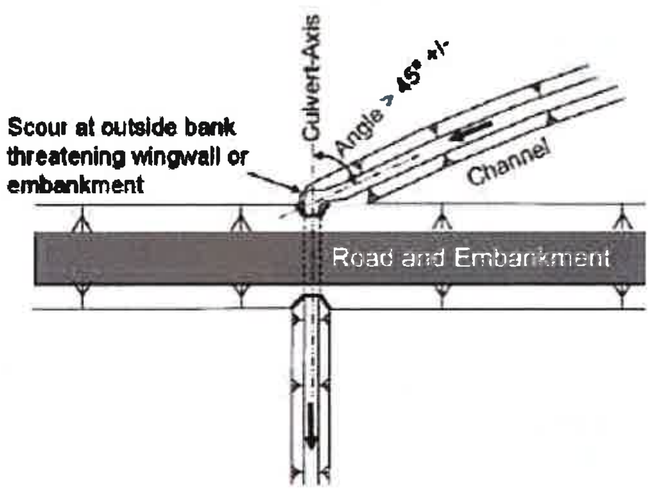


Figure 3.3.1. Poor culvert to channel alignment. (From Hunt et al. (FHWA) 2010)

<u>Figure 7: Road gravel in channel and floodplain downstream of culvert.</u> *Heavy sediment loading can decrease the ability of the channel and floodplain to convey flows downstream making future flooding issues more frequent.*

Building Stronger with Culvert Inventory Data

Inventory Benefits

- Look system-wide to identify the most flood prone, high cost, & high impact sites
- Document the service life of each culvert
- Have time to develop a plan to upgrade the highest priority sites
- Track and share information over time with changing staff
- Increase the chances of cost share assistance
- Inventory maps can be overlapped with flood prone watershed "hot spots"
- Improve coordination with the multiple agencies involved during flood response and reimbursement
- Use data to inform and build broad support for transportation infrastructure spending decisions.

A significant challenge

- Time and money are stretched very thin given the amount of roadwork needed.
- Difficult to justify cost of improvements based on unknown future events & expenses.
- Limited data about total & long term (75+ years) costs.
- Floods will come again and there is every indication they will continue to get worse.

Lacking information to ID the highest priorities in each town/county, decisions are made site by site

Given scarce time and funds, this can lead to a strong preference for in-kind replacements at all sites.

Break the cycle of flood damage using culvert inventory data to identify and strategically improve the highest priorities.

- Where will the most time & money be saved with a larger flood resistant structure (likely to last 75+ yrs. vs. ~20 yrs. or less)?
- Long term cost savings result from reducing repeat construction /maintenance. Especially important at high cost sites (deeper fills, repetitive failures, larger structures, etc.)
- Where are the important sites from a stream or water quality perspective to benefit from various cost share opportunities?

Tips for Successful Cost Share Assistance

- A road crossing inventory is an important first step to find the highest priorities.
- Cooperative efforts that align the priorities and expertise of municipalities and conservation stakeholders are often the most competitive.
- Emphasize the public benefit of the improved road crossing from a broad range of perspectives including: flood resiliency, public safety, reduced maintenance, longer culvert lifespan, reduced stream impacts, long-term cost savings, etc.
- Partnerships can often result in assistance with grant application development, project documentation, and timely reimbursement.
- Projects with a preliminary design and budget prepared at the time of the grant application are more likely to stay on time and budget.

Contact your DNR transportation liaison for a copy of funding sources available. The document summarizes cost share opportunities to help improve municipal road crossings with flooding, water quality, and stream connectivity problems. DNR staff are also knowledgeable about the funding sources and active local groups in your area.

The new culvert has a higher capacity. The old undersized culvert can be seen in the background

Photo: 2017 WI Land & Water Conservation Annual Report.

Woods Creek in Florence County.

Additional information about research evaluating the costs and benefits of upgrading flood prone crossings:

Flood Effects on Road-Stream Crossing Infrastructure: Economic and Ecological Benefits of Stream Simulation Designs. http://fisheries.org/docs/wp/AFS-Fisheries-Magazine-February-2014.pdf

An Economic Analysis of Improved Road-Stream Crossings.
http://www.nature.org/ourinitiatives/regions/northamerica/road-stream-crossing-economic-analysis.pdf

Cost-Benefit Analysis of Stream-Simulation Culverts. (2015)
https://www.lafollette.wisc.edu/images/publications/cba/2014-culvert.pdf

Conservation Leverage: Ecological-Design Culverts also Return Fiscal Benefits
https://fisheries.org/2016/12/conservation-leverage-ecological-design-culverts-also-return-fiscal-benefits/

Stream Crossing Data Sheet

Site ID: ______

General Information

Stream Name: ______ **Road Name:** ______

Name of Observer(s): ______ **Date:** ______

GPS Waypoint: ______ **GPS Lat/Long:** ______

County: ______ **Township:** ______ **Range:** ______ **Sec:** ______

Adjacent Landowner Information: ______ **Additional Comments:** ______

Crossing Information

Crossing Type: Culvert(s) no.: ______ Bridge Ford Dam Other: ______

Structure Shape: Round Square/Rectangle Open Bottom Square/Rectangle Pipe Arch Open Bottom Arch Ellipse

Inlet Type: Projecting Mitered Headwall Apron Wingwall 10-30° or 30-70° Trash Rack Other

Outlet Type: At Stream Grade Cascade over Riprap Freefall into Pool Freefall onto Riprap Outlet Apron Other

Structure Material: Metal Concrete Plastic Wood

Substrate in Structure: None Sand Gravel Rock Mixture

General Condition: New Good Fair Poor

Plugged: ______ % Inlet Outlet In Pipe

Crushed: ______ % Inlet Outlet In Pipe

Rusted Through? Yes No **Structure Interior:** Smooth Corrugated

Multiple Culverts/Spans

Number the culverts/spans left to right, facing downstream.
Include #s in site sketch on back page

Culvert/ Span #	Width (ft)	Length (ft)	Height (ft)	Material

Structure Length (ft):[1] ______ **Structure Width (ft):**[1] ______ **Structure Height (ft):**[1] ______

Structure Water Depth (ft):[1] **inlet** ______ **outlet** ______ **Perch Height (ft):**[1] ______ or NA

Embedded Depth of Structure (ft):[1] **inlet** ______ **outlet** ______

Structure Water Velocity (ft/sec):[1] **inlet** ______ **outlet** ______

Structure Water Velocity Measured: At Surface or ______ **ft Below Surface** **Measured With:** Meter or Float Test

Stream Information

Stream Flow: None < ½ Bankfull < Bankfull = Bankfull > Bankfull

Scour Pool (if present) **Length:** ____ **Width:** ____ **Depth:** ____ **Upstream Pond (if present)** **Length:** ____ **Width:** ____

Riffle Information
(measured in a riffle outside of zone of influence of crossing)

Water Depth (ft): ______ **Bankfull Width (ft):** ______ **Wetted Width (ft):** ______ **Water Velocity (ft/sec):** ______

Dominant Substrate: Cobble Gravel Sand Organics Clay Bedrock Silt **Measured With:** Meter or Float Test

Road Information

Type: Federal State County Town Tribal Private Other:

Road Surface: Paved Gravel Sand Native Surface **Condition:** Good Fair Poor

Road Width at Culvert (ft): ______ **Location of Low Point:** At Stream Other **Runoff Path:** Roadway Ditch

Embankment: **Upstream** **Fill Depth (ft):** ______ **Slope:** Vertical 1:1.5 1:2 >1:2

Downstream **Fill Depth (ft):** ______ **Slope:** Vertical 1:1.5 1:2 >1:2

Left Approach: **Length (ft):** ______ **Slope:** 0% 1-5% 6-10% >10% **Ditch Vegetation:** None Partial Heavy

Right Approach: **Length (ft):** ______ **Slope:** 0% 1-5% 6-10% >10% **Ditch Vegetation:** None Partial Heavy

[1] - Fill out for primary culvert (culvert #1). If multiple culverts are used, number each and use embedded table.

Form Date: February 28, 2011

Erosion Information

Use a new row for each distinct gully/erosion location. Note prominent streambank erosion within 50 feet of crossing.

Location of Erosion Ditch, approach, or streambank Left or right facing downstream	**Erosion Dimensions (ft)**			**Eroded Material Reaching Stream?**		**Material Eroded** Sand, Silt, Clay, Gravel, Loam, Sandy Loam or Gravelly Loam.
	Length	**Width**	**Depth**			
				Yes	**No**	
				Yes	**No**	
				Yes	**No**	
				Yes	**No**	
				Yes	**No**	

If there is erosion occurring, can corrective actions, such as road drainage measures, be installed to address the problem? **Y** **N**

Extent of Erosion: Minor Moderate Severe Stabilized

Erosion Notes:

Photos – enter photo number in blank corresponding to location

❑ Site ID ______ ❑ Upstream Conditions ______ ❑ Downstream Conditions ______

❑ Inlet ______ ❑ Outlet ______ ❑ Road Approach – Left ______ ❑ Road Approach – Right ______

Summary Information

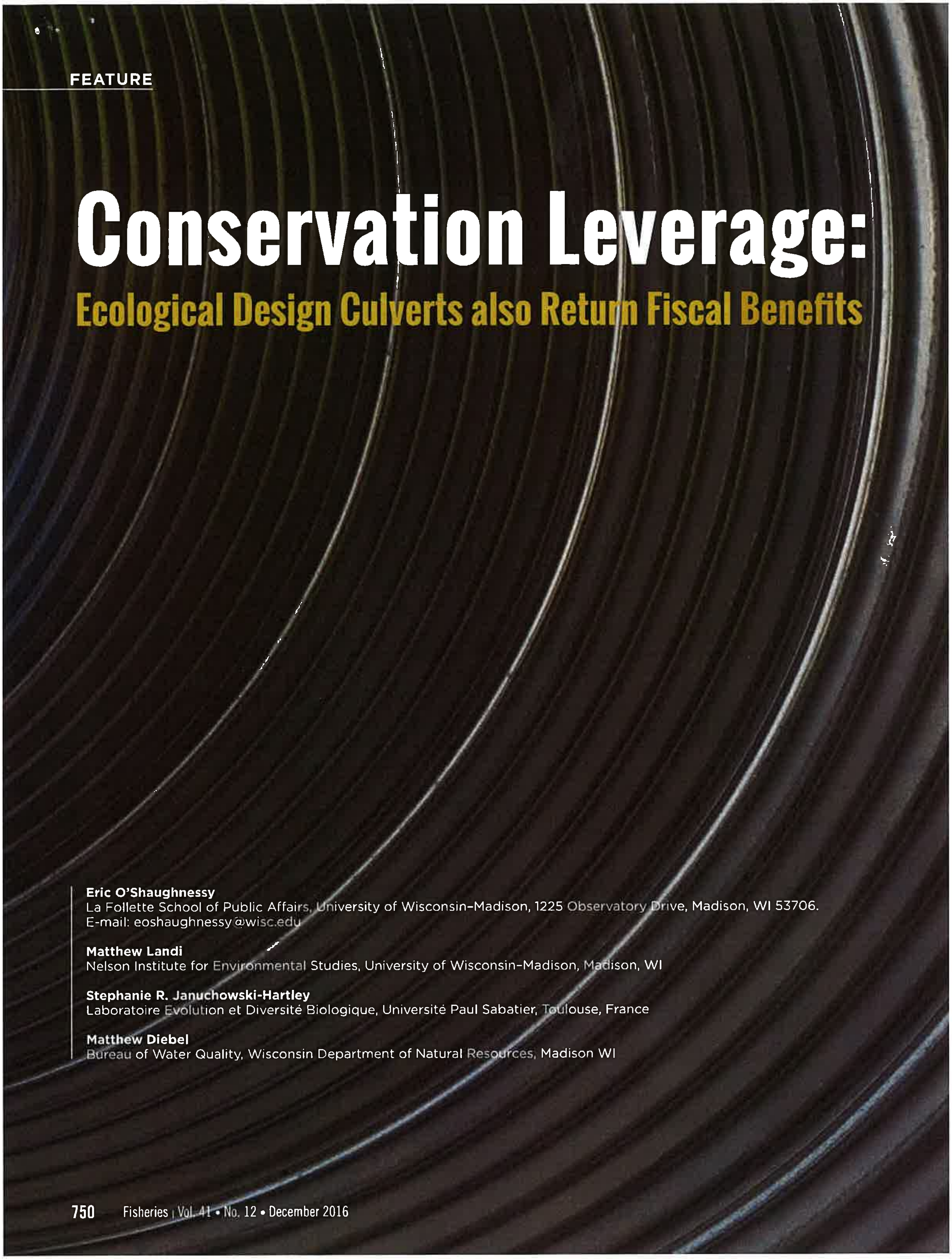
Would you consider this a priority site? Fish Passage Erosion Why?

Would you recommend a future visit to this site? Yes No **Why?**

Were any non-native invasive species observed at the site? Yes No **If yes, what species were observed?**

Site Sketch

Draw an overhead sketch of crossing. Be sure to mark North on the map and to indicate the direction of flow. Include major features documented on form, such as erosion sites, multiple culverts, scour pool, impounded water, etc.



FEATURE

Conservation Leverage:

Ecological Design Culverts also Return Fiscal Benefits

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Traditional hydraulically designed culverts impede ecological connectivity and degrade aquatic ecosystems. This problem is compounded by their ubiquity in the built environment. To overcome these limitations, alternative designs have been created to facilitate natural conditions and restore ecological connectivity. However, these "ecological design" culverts have perceived fiscal limitations that have prevented widespread implementation and consequently hampered conservation and remediation of stream ecosystems important for myriad fish species and aquatic organisms. We addressed these perceived fiscal limitations using cost-benefit analysis to estimate the lifetime fiscal net benefits of ecological design culverts over hydraulic culverts. We found that in nearly half of all cases remediation with ecological design culverts was more cost effective than maintaining hydraulic culverts and that it is most cost effective on small streams compared to larger ones. We also found that higher upfront replacement costs for ecological design culverts are overcome by their lifetime fiscal benefits. This is because of longer life span, reduced maintenance, and improved flood event resiliency of ecological design culverts. Our findings suggest that cost-benefit analysis could help conservation decision makers overcome higher construction costs and guide more cost-effective and sustainable solutions for aquatic conservation and ecological connectivity.

Conservación con ventaja: diseño de alcantarillas ecológicas ofrecen beneficios fiscales

El diseño hidráulico tradicional de alcantarillas impide la conectividad y degrada los ecosistemas acuáticos. Este problema se ve agravado por su ubicuidad en los ambientes afectados. Para superar tales limitaciones, se han creado diseños alternativos que facilitan condiciones naturales y sirven para restaurar la conectividad. No obstante, estas alcantarillas de diseño ecológico han sido sujetas a limitaciones en el terreno fiscal que previenen su implementación en gran escala, lo que en consecuencia ha obstaculizado la conservación y remediación de ecosistemas fluviales que son clave para una miríada de especies de peces y organismos acuáticos. Aquí se abordan estas limitaciones fiscales mediante análisis costo-beneficio para estimar los beneficios fiscales netos de largo plazo de usar alcantarillas ecológicas en vez de alcantarillas hidráulicas. Se encontró que en casi de la mitad de los casos, la remediación utilizando alcantarillas ecológicas, en comparación a las hidráulicas, era más efectiva en términos de costos; y lo mismo aplica a cauces pequeños versus cauces grandes. También se encontró que los beneficios fiscales a lo largo de la vida útil de las alcantarillas ecológicas, sobrepasan sus costos de reemplazo. Esto se debe a que las alcantarillas de diseño ecológico duran más, demandan poco mantenimiento y tienen mayor resiliencia en eventos de inundación. Estos resultados sugieren que un análisis costo-beneficio pudiera ayudar a los tomadores de decisiones a enfrentar los altos gastos de construcción, guiándolos a soluciones sostenibles y más efectivas para la conservación y conectividad ecológica.

Effet de levier de la conservation : Les ponceaux de conception écologique procurent aussi des avantages fiscaux

Les ponceaux traditionnels conçus de manière hydraulique empêchent la connectivité écologique et dégradent les écosystèmes aquatiques. Ce problème est aggravé par leur omniprésence dans l'environnement bâti. Pour surmonter ces limitations, des conceptions alternatives ont été créées pour faciliter les conditions naturelles et restaurer la connectivité écologique. Cependant, ces ponceaux de « conception écologique » se sont heurtés aux limitations fiscales, ce qui a empêché leur mise en œuvre généralisée, ce qui a par conséquent entravé la conservation et la restauration des flux d'écosystèmes importants pour les espèces de poissons innombrables et les organismes aquatiques. Nous avons abordé ces limitations fiscales perçues, en utilisant une analyse coûts-avantages pour estimer la durée de vie des avantages fiscaux nets des ponceaux de conception écologiques par rapport aux ponceaux hydrauliques. Nous avons constaté que, dans près de la moitié de tous les cas, la réhabilitation des ponceaux de conception écologique était plus rentable que le maintien des ponceaux hydrauliques, et qu'ils sont plus rentables sur les petits cours d'eau par rapport aux plus grands. Nous avons également constaté que la hausse des coûts initiaux de remplacement des ponceaux de conception écologique est surmontée par la durée de vie des avantages fiscaux associés. Ceci est dû à une plus grande longévité, une maintenance réduite, et l'amélioration de la résilience des événements d'inondation des ponceaux de conception écologique. Nos résultats suggèrent que l'analyse coûts-avantages pourrait aider les décideurs de la conservation à surmonter les coûts de construction plus élevés et à proposer des solutions plus rentables et durables pour la conservation aquatique et la connectivité écologique.

INTRODUCTION

Despite known impacts of road culverts on aquatic ecosystems and the species that they support, traditional hydraulic design has dominated road culvert design for several decades (USFS 2008). These types of culverts, which we refer to as "hydraulic culverts," are aimed at minimizing structure size and cost by allowing as much water to flow through as is possible for a given flood flow. Historically, the consideration of aquatic ecosystems in culvert design and management has been a low priority relative to construction cost minimization (USGAO 2001). This oversight has resulted in high proportions of hydraulic culverts acting as potential barriers to ecological connectivity, limiting biological and geomorphic processes (e.g., USGAO 2001; Gibson et al. 2005; Burford et al. 2009; Januchowski-Hartley et al. 2014). The consequences of these barriers on ecological connectivity, as well as the identification of cost-effective solutions for remediation, are growing areas of study.

There are several reasons that hydraulic culverts can act as barriers to ecological connectivity, primarily by limiting aquatic organism passage that can have cascading, adverse impacts on stream ecology and aquatic habitat. Undersized or otherwise poorly designed hydraulic culverts have myriad geomorphic effects on streams, including, but not limited to, the modification of the stream's channel and morphology, bank erosion, and channel incision (Furniss et al. 1998). Channel constriction upstream of hydraulic culverts can increase stream flow within the structure to velocities that surpass the swimming abilities of fish species (Gibson et al. 2005; Januchowski-Hartley et al. 2014). In turn, heightened stream velocity can erode the streambed downstream from the structure and result in a vertical gap or "outlet drop" between the stream surface and the mouth

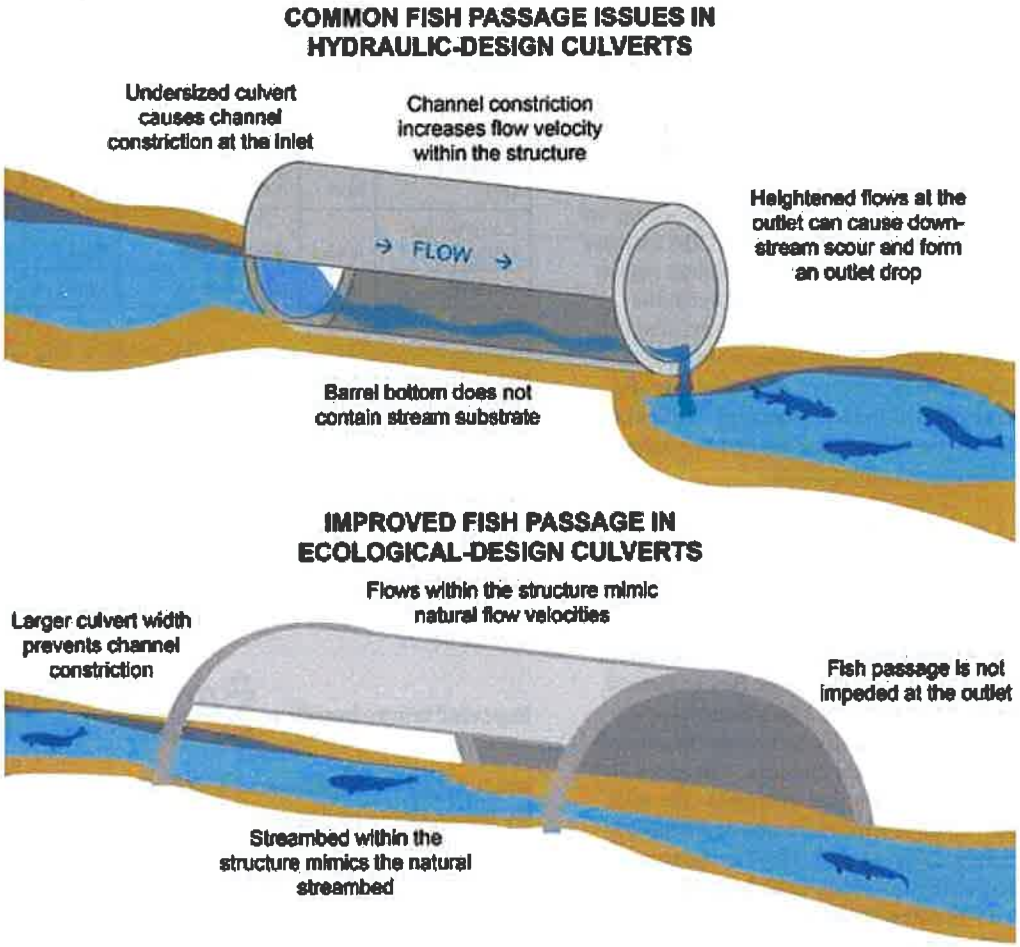

Figure 1. Schematics depicting (a) hydraulic and (b) ecological design culverts.

of structure (Figure 1). Outlet drops act as mini-waterfalls, limiting species' movement upstream (Norman et al. 2009; Poplar-Jeffers et al. 2009). In many cases, hydraulic culverts are also set too high, exacerbating this problem (NCHRP 2002). Hydraulic culverts can also disrupt sediment transport, which can cause culvert structural failure or increase the need for routine maintenance (Furniss et al. 1998; NCHRP 2002). Consequently, road culverts fragment aquatic ecosystems, affecting ecological processes, limiting species' access to spawning habitats, and reducing population connectivity (Fausch et al. 2002; Letcher et al. 2007).

In addition to their ecological benefits, ecological design culverts could have lower fiscal costs than hydraulic culverts, because of increased flood resiliency and reduced debris accumulation, which in turn reduce the need for periodic maintenance and replacement.

The potential ecological benefits gained from remediating hydraulic culverts have prompted the development of "ecological designs" that maintain natural stream conditions upstream, downstream, and within the culvert (Bates et al. 2003; Gillespie et al. 2014). "Ecological design culverts" refers to a variety of proposed structural changes to typical hydraulic culverts (Figure 1) that often employ wider widths, natural slope gradients, and natural streambeds within the structure to reduce the impact of the culvert on natural stream conditions and ecological processes (USGAO 2001; USFS 2008). Stream simulation, one type of ecological design culvert, is based on an artificial stream channel within the structure to encourage more natural fish passage through the structure (Bates et al. 2003; USFS 2008).

In addition to their ecological benefits, ecological design culverts could have lower fiscal costs than hydraulic culverts, because of increased flood resiliency and reduced debris accumulation, which in turn reduce the need for periodic maintenance and replacement (Gillespie et al. 2014). Despite the potential cost savings, the long-term fiscal benefits of ecological design culverts are rarely considered when making decisions about the allocation of resources. Upfront installation costs can make investments in ecological design culverts appear to be cost prohibitive under limited budgets (Gillespie et al. 2014). Given this gap in knowledge, there is a need for cost–benefit analyses (CBAs) to better our understanding of the trade-offs associated with remediating hydraulic culverts with ecological design culverts (Hansen et al. 2009; Diebel 2013; Neeson et al. 2015).

CBAs can monetize and assess decision-making impacts based on the net benefits of proposed alternatives (Boardman et al. 2010). Net benefits are estimated based on all costs accrued over the full lifetime of a project. In this article, we use CBA to quantify and monetize the relative costs and benefits of replacing hydraulic culverts with ecological design culverts. We build upon ideas presented by Gillespie et al. (2014) and predict the relative lifetime costs of ecological design culverts for a large set of road culverts in the midwest United States. Our CBA assesses two strategies: (1) a road culvert infrastructure planning regime that replaces existing hydraulic culverts with new hydraulic culverts and (2) an alternative regime that replaces existing hydraulic culverts with ecological design culverts. We use a sensitivity analysis to explore the effect of uncertainty in cost functions on the relative costs of the two strategies. We discuss the potential utility of CBA to identify fiscally and ecologically responsible solutions for culvert replacement.

METHODS

Road-Stream Crossing Inventory

We used an inventory of culverts at road–stream crossings collected by the Wisconsin Department of Natural Resources (WI DNR), University of Wisconsin–Madison, and The Nature Conservancy in 2011 and 2012 from the Green Bay watershed, Wisconsin and Michigan (Diebel 2013). The watershed is relatively flat and its streams have flashy hydrology because of low permeability soils and agricultural drainage. The entire data set included 1,615 culverts on Green Bay tributaries. We used stream bank-full width (width at which a stream overflows its channel into its floodplain; Leopold et al. 1964) to determine which existing culverts were most likely to be hydraulic culverts. We identified 998 culverts with widths less than or equal to bank-full width, and 46% of these undersized culverts had sufficient data to populate all inputs for our cost estimation (the installation cost estimator required data on certain structural variables, described further below). We used these 461 culverts for all subsequent CBAs (Table 1).

Culvert Lifetime Costs

We considered four lifetime cost components for culverts: replacement cost, catastrophic failure, routine maintenance, and flood damage maintenance over a 70-year time period. We used a method described by Neeson et al. (2015), which uses structure dimensions and unit costs of materials and labor to estimate culvert replacement cost. In brief, total project cost is equal to the sum of the costs of the culvert structure (market prices in 2009 in Wisconsin and Michigan), excavation (US$20/yard; volume estimated from structure dimensions), road resurfacing ($2,500 per lane for paved roads and $800 for gravel or dirt roads), and miscellaneous costs ($2,500–5,000 depending on structure size), plus 20% for design and construction oversight. The net replacement cost for ecological design culverts relative to a hydraulic culvert was then calculated as

$$\textbf{Net replacement cost} = RC_E - \left(RC_H + \frac{RC_H}{1.035^{35}}\right),$$

where hydraulic culvert replacement cost (RC_H) was based on a structure with the same width as the existing culvert, and ecological design culvert replacement cost (RC_E) was based on a culvert width 20% greater than the bank-full width of the stream, a standard for ecological design culverts (Commonwealth of Massachusetts 2012). We apply the 20% greater than bank-full

Table 1. Summary statistics of the culverts used in the analysis (n = 461). SD = Standard deviation.

Scenario	Mean	SD	Minimum	Median	Maximum
Bank-full width (m)	2.01	0.99	0.91	1.69	5.79
Culvert width (m)	1.08	0.62	0.18	0.91	4.11
Constriction ratio	0.55	0.20	0.14	0.53	1.00
Culvert length	14.19	10.73	2.44	12.80	140.21

width as a conservative approach. It is worth noting that other less stringent standards have been proposed by Bates et al. (2003) and USFS (2008). We assumed that hydraulic culverts required replacement occurring in the 35th year of the analysis based on projected 25- to 50-year lifetimes of hydraulic culverts (see Gillespie et al. 2014). All future costs were discounted at a rate of 3.5%.

Catastrophic culvert failure, especially during flood events, may prompt emergency culvert replacement. We estimated the relative costs of catastrophic failure for the two culvert design approaches as

$$\textbf{Expected failure benefit} = \sum_{0}^{70} \frac{f(t)_C * FC_t}{1.035^t} - \sum_{0}^{70} \frac{f(t)_E * FC_t}{1.035^t},$$

where $f(t)_C$ is the failure rate of hydraulic culverts and $f(t)_E$ is the failure rate of ecological design culverts based on assumed project lifetimes of 35 and 70 years, respectively (for failure rate methodology see Meegoda et al. 2009). Here, the culvert failure rate reflects the risk of failure as the structure approaches the end of its useful life. The failure rate increases over time due to several factors including abrasion from sediment moving through the structure. The wider width of ecological design culverts reduces abrasion by allowing sediment to pass through the culvert without impacting the structure (Gillespie et al. 2014). Reduced abrasion increases the anticipated service life of ecological design culverts (Gillespie et al. 2014); thus, we assume a lower failure rate for ecological design culverts. We assumed that failure cost (FC_t) in any given year (t) equaled the replacement cost adjusted downward to reflect that the culvert would have been replaced after 35 or 70 years in any case for both hydraulic and ecological design culverts, respectively, according to

$$FRC_{i,t} = \frac{L - t}{L} * RC_i,$$

where $FRC_{i,t}$ is the failure replacement cost of culvert i in year t, L is the projected lifetime of the structure (35 or 70 years), and RC_i is the estimated hydraulic culvert replacement cost of the structure.

Culvert maintenance activities include preventative maintenance, clearing the structure of debris, and structural repairs (e.g., patching). Ecological design culverts do not typically require routine maintenance (Gillespie et al. 2014). We assumed that structural obstructions (e.g., debris, crushed culvert barrel), found in about 10% of culverts in Green Bay watershed data, indicated that a culvert required maintenance. We developed a probit model to estimate the probability that a given culvert required maintenance as a function of the constriction ratio (culvert width/bank-full width), given:

$$p(M)_i = \phi(\beta_0 + \beta_1 CR_i),$$

where $p(M)_i$ is the probability of maintenance in a given year for culvert i, Φ is the normal distribution, $ß_0$ and $ß_1$ are coefficients estimated by the model, and CR_i is the constriction ratio of culvert i. The model showed a statistically significant relationship between the probability of required maintenance and the constriction ratio; that is, the probability that a given culvert will require maintenance in a given year decreased as the width of the culvert approached and exceeded the width of the stream (see Supplementary Materials). The model predicted that a culvert sized at half of the bank-full width had a 13% probability of presenting a structural obstruction in any given year, compared to a probability of about 8% for a culvert sized at the bank-full width. In other words, the model suggests that culverts sized at the bank-full width are about 41% less likely to require maintenance than culverts sized at half the bank-full width in any given year. We determined lifetime maintenance costs as the sum of expected values of maintenance costs, given

$$\text{Reduced maintenance benefit} = \sum_{0}^{70} \frac{p(M)_E \cdot 1{,}488}{1.035^t} - \sum_{0}^{70} \frac{p(M)_C \cdot 1{,}488}{1.035^t},$$

where $p(M)_E$ is the modeled probability of maintenance for ecological design culverts (based on a constriction ratio of 1.2), $p(M)_C$ is the modeled probability of maintenance for hydraulic culverts (based on the constriction ratio of the existing culvert), and $1,488 is an assumed maintenance cost based on values determined through a Minnesota Department of Transportation (MNDOT) survey of culvert maintenance costs (MNDOT 2015).

Culvert maintenance costs can also accrue from flood damages. We modeled the 25-year flood as a random event with an annual probability of 0.04 with an estimated repair cost of $2,659 (based on the MNDOT survey data). It is possible that flood damages could accrue during more frequent and lesser flooding events (e.g., 10-year flood). However, we restrict flood damages to 25-year flood events to remain conservative. We assumed that ecological design culverts do not accrue flood damages due to the increased flood resiliency demonstrated by these structures (Barnard et al. 2015; Gillespie et al. 2014). Therefore, the reduced flood damage benefit is given as

$$FDB_i = \sum_{t=1}^{70} \frac{2{,}659}{1.035^t} | u(0,1) < 0.04,$$

where FDB_i is the flood damage benefit of culvert i, and the term $u(0, 1) < 0.04$ indicates that the model generated a random flood event when the value of a uniform distribution bounded by 0 and 1 took on a value less than 0.04.

Scenarios and Monte Carlo Analysis

We used three scenarios and a Monte Carlo analysis to explore the potential range of costs and benefits associated with replacing hydraulic culverts with ecological design culverts. The net benefit in each scenario is the net cost of hydraulic culvert replacement with an ecological design culvert after accounting for longer lifetime, benefits from reduced failure costs, reduced maintenance costs, and reduced flood damage costs of ecological design culverts. Our first scenario determined a point estimate for each of the four cost components outlined above. The point estimate provides a plausible single value for each of the benefit categories. Best- and worst-case scenarios provide reasonable "bookends" for the range of net benefits between the highest and lowest values of the net benefits of ecological design culverts. In the best-case scenario, we assumed that hydraulic culverts required three replacements during the analysis timeframe: in the first, 25th, and 50th years, whereas ecological design culverts only required a first-year replacement. In the worst-case scenario, we assumed that ecological design culverts provided no performance benefits other than increased lifetime and flood damage benefits and that hydraulic culverts would not require replacement until the 50th year of the analysis.

We used a Monte Carlo analysis to assess the sensitivity of our model to uncertain assumptions in our variables. We allowed three of our underlying assumptions to vary. First, we allowed the lifetime of the hydraulic culvert to vary randomly within a uniform distribution from 25 to 50 years according to typical project lifetimes (Gillespie et al. 2014). Second, we allowed our assumption for maintenance costs to vary randomly in a uniform distribution from $36 to $3,869, according to the minimum recorded maintenance cost and a value one standard deviation above the mean for 99 culvert cleanings, ditch cleanings, joint repairs, and hole repairs (MNDOT 2015). Third, we allowed our assumption for flood damage repair costs to vary randomly from $521 to $4,798 based on one standard deviation above and below the mean value of repairs associated with 40 resets (from MNDOT 2015 survey data). Catastrophic culvert failure is a high-cost, low-probability event. To be conservative, we did not include failure benefits in our Monte Carlo analysis. We performed 1,000 iterations to develop Monte Carlo estimates for the percentage of culverts that achieved positive net benefits.

Determinants of Net Benefits

We used ordinary least squares regression to study the primary determinants of the net benefits of culvert replacement with ecological design culverts. Based on the inputs to our costs and benefits, we developed four models:

1. $NB = ß_0 + ß_1 bw$
2. $NB = ß_0 + ß_1 bw + ß_2 cw$
3. $NB = ß_0 + ß_1 bw + ß_2 cw + ß_3 cl$
4. $NB = ß_0 + ß_1 CR$

where NB is net benefits ($/culvert), bw is bank-full width (m), cw is culvert width (m), cl is culvert length (m), and CR is constriction ratio (culvert width/bank-full width). The net difference in lifetime costs between ecological design and hydraulic culverts determines the fiscal net benefit of culvert replacement with ecological design culverts.

RESULTS

Net Benefits of Ecological Design Culverts

The construction costs of ecological design culverts were $40,700 on average, compared to about $22,900 for hydraulic culverts. However, the lifetime costs of ecological design culverts were about $13,300 lower than the lifetime costs of hydraulic culverts: $3,300 compared to $16,500 on average. The savings accrued from reduced lifetime costs exceeded the relatively higher upfront cost of ecological design culverts in 49% of replacements in our point estimate model. Essentially, our result suggests that ecological design culverts would be fiscally net beneficial in about 49% of culvert replacements. The proportion of fiscally net beneficial replacements ranged from 13% in the worst-case scenario to 76% in the best-case scenario (Figure 2). In 1,000 iterations of the Monte Carlo analysis, on average, 43% of culvert replacements were fiscally net beneficial.

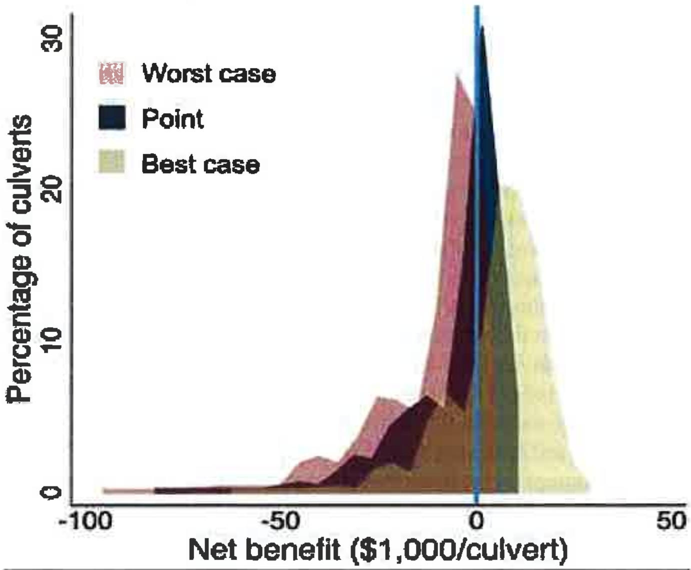

Figure 2. Area plot histograms of fiscal net benefits ($1,000/culvert) for the point estimate, worst-case scenario, and best-case scenario.

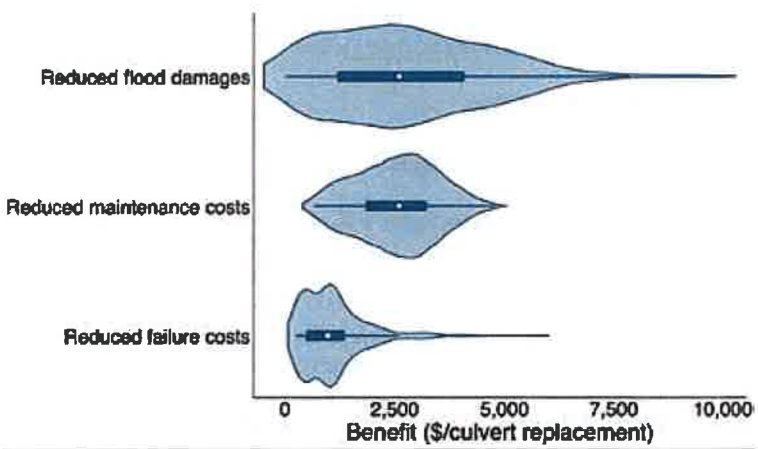

Figure 3. Area plots depicting the distribution of different measured benefits ($/culvert).

Table 2. Mean values for cost components from point estimate and worst-case and best-case scenarios.

Scenario	Lifetime replacement	Flood damage	Reduced maintenance	Expected failure	Net fiscal benefit
Worst case	−13,600	2,800	0	0	−10,800
Point estimate	−10,900	2,800	2,500	1,100	−4,500
Best case	−3,900	2,800	5,000	1,100	4,900

The average fiscal net benefit of hydraulic culvert replacement with ecological design culverts was −$4,500, with a plausible range of −$10,800 to $4,900 based on the worst- and best-case scenarios (Table 2). All benefits displayed considerable variation. Interquartile ranges spanned from −$16,524 to −$2,462 per replacement for net replacement cost, from $1,205 to $4,049 for flood damage benefits, from $1,856 to $3,197 for reduced maintenance benefits, and from $493 to $1,331 for the reduced failure benefit (Figure 3).

Determinants of Net Benefits

The largest determinants of net benefits were stream bank-full width and the width of the existing hydraulic culvert. Together these two factors explained about 80% of the variance in net benefits from our point estimate model (see Supplementary Materials). Fiscal net benefits were negatively correlated with bank-full width (i.e., culverts on larger streams exhibited lower net benefits), whereas net benefits were positively correlated with existing culvert width (Figure 4).

DISCUSSION

We used CBA to quantify and assess the relative lifetime costs and benefits of two strategies to road culvert remediation, namely, a road culvert infrastructure planning regime that replaces existing hydraulic culverts with new hydraulic culverts and an alternative regime that replaces existing hydraulic culverts with ecological design culverts. Our two main findings were that (1) in nearly half of all cases remediation with ecological design culverts is more cost effective over their lifetime than maintaining hydraulic culverts and (2) replacing hydraulic culverts with ecological design culverts may be most cost effective on smaller streams (i.e., those streams with <1.5 m bank-full width).

Our first finding supports our opening argument that CBA can be used over traditional planning emphasis on initial construction costs to give explicit consideration to long-term costs associated with different culvert remediation projects. To date, decision makers responsible for monitoring and replacing road culverts often place greater emphasis on cost minimization than ecological connectivity (Gillespie et al. 2014). However, our findings suggest that ecological considerations do not need to be mutually exclusive of other fiscal concerns related to culvert management. In nearly half of all cases, we found that culvert remediation that could restore ecological connectivity had lower lifetime costs than hydraulic culverts. Our approach allows decision makers to explicitly consider different types of costs and to demonstrate that upfront costs cannot be assumed to be an adequate indicator of long-term costs associated with managing ecologically and socially sustainable road infrastructure.

Our second finding suggests that replacing hydraulic culverts with ecological design culverts could be more cost effective on small streams

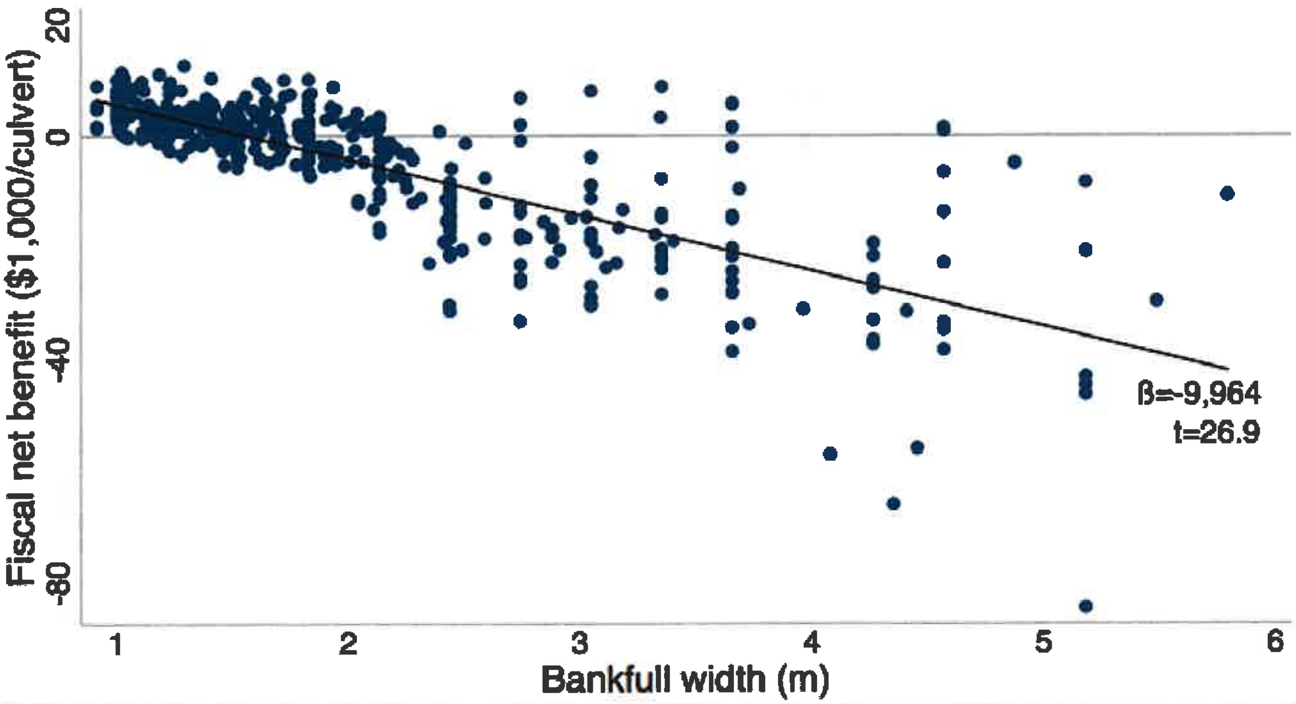

Figure 4. Relationship between fiscal net benefits ($1,000/culvert) and bankfull width (m).

(<1.5 m bank-full width) over larger ones. We found that more than 80% of ecological design replacements on small streams would return positive fiscal net benefits compared to just 30% of replacements on larger streams. This relationship is due, in part, to the fact that the costs of ecological design replacements were positive functions of stream size in our model, whereas the benefits (avoided costs) were less dependent on the stream size. Given our conservative assumption that ecological design culverts are sized at 20% wider than the bank-full width of the stream, our model estimates relatively high construction costs for larger culverts on larger streams that were not ultimately overcome by lower lifetime costs. In regions like the Laurentian Great Lakes, road culverts that act at least as partial barriers to migratory fishes also tend to occur on smaller (<1.5 m bank-full width) streams (Diebel 2013; Januchowski-Hartley et al. 2014). Around the world, small, headwater stream systems often support critical spawning habitat for migratory fishes and invertebrate species (USEPA 2014). Therefore, in addition to the lower cost of ecological design replacements on small streams, there are likely to be greater environmental benefits and potential higher return on investment than we were able to account for in our analyses.

Several underlying assumptions were necessary in our model. First, we made broad assumptions about culvert performance over 35- to 70-year periods based on culvert size and stream characteristics. Though these assumptions simplified the analysis, we acknowledge that culverts will deteriorate at different rates under various site-specific conditions. Further, the applicability of our results is constrained by the underlying culvert data set. However, our results are likely applicable to other regions with similar characteristics and illustrative of the potential benefits of lifetime cost considerations in culvert decision making in all contexts. Last, we assumed that ecological design culverts were sized at 20% greater than the bank-full width of the stream. This assumption resulted in high construction costs for ecological design culverts in our model that may overestimate the true construction costs of ecological design culverts designed under less stringent requirements. For example, relaxing our assumption so that ecological design culverts were sized at 10% over bank-full width would increase the percentage of ecological design culverts that yielded fiscal net benefits to about 58%. We therefore believe that our results represent a conservative estimate of the net benefits of ecological design culverts.

Our framework is the first to quantify the long-term fiscal benefits of ecological design culverts over more commonly used traditional hydraulic culverts and provides a flexible method for evaluating the lifetime costs and benefits associated with such culverts. Our approach can be made more comprehensive as more culvert data become available and methodologies related to monetizing socioecological costs and benefits are further refined. The integration of information on ecological as well as additional societal costs and benefits into CBA will provide a more comprehensive measure of the net benefits of ecological design culverts. A clear next step from our work would be to identify approaches for quantifying and monetizing ecological and societal benefits to be included in CBA. Where data are available, costs associated with travel delays, such as road washouts, damage to private property, maintaining access for emergencies, and threats to human safety could be used to represent societal costs of road culvert remediation (Gillespie et al. 2014). In addition, changes in tourism, recreation, and revenue from fish licenses in restored streams could be used to assign fiscal value to improvements in ecological connectivity.

Our approach complements previous studies that evaluate the ecological limitations of hydraulic culverts (Gibson et al. 2005; Gillespie et al. 2014; Januchowski-Hartley et al. 2014; Diebel et al. 2015), and it can be adapted to prioritize projects for ecological design culvert replacement wherever hydraulic culverts impede fish passage. Importantly, our approach has several advantages: (1) it allows decision makers to allocate public funds more transparently and (2) it can be used to identify fiscal costs of alternative projects, which can be overlooked when the focus is on ecological benefits, but that are equally important when communicating the need for alternative infrastructure to government and funding bodies. Overall, our approach adds to growing literature, and toolsets, aimed at improving the transparency, cost efficiency, and effectiveness of environmental management and conservation decision making (see Januchowski-Hartley et al. 2011; Adams et al. 2015; Neeson et al. 2015). Within this growing literature, we offer a fresh and alternative perspective to how the benefits of alternative infrastructure can be identified and potentially communicated to diverse decision-making groups.

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