

A STREAM CROSSINGS REMEDIATION PLANNING PROCESS AND EXAMPLE APPLICATION IN THE FOOTHILLS MODEL FOREST, ALBERTA.

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Abstract

Migration barriers at stream crossings have been identified as a fish conservation concern in many areas of North America. While this issue has been raised in Alberta, there is no single agency or standard process to guide remediation. The two objectives of this paper are: to describe a seven step model that can be adapted by any party interested in initiating remediation; and to review an example overview fish passage assessment.

Stream crossing remediation at the watershed scale is typically a multi-year / multi-agency process that can be guided by a seven step model. In the first step, one or more of the stakeholders would conduct an overview assessment of structural integrity, upslope sediment inputs and fish passage at all crossings within one or more watersheds. The findings would then be communicated to the various crossing owners who could then pursue funding to proceed with detailed assessments at priority crossings (Step 2). Engineered designs and construction costs for modifications would then be developed (Step 3). Once funding (Step 4) and permits (Step 5) are secured, construction would follow (Step 6). Post-construction monitoring (Step 7) could include both an engineering (stability) and biological (fish passage) evaluation.

In an example overview fish passage assessment (a component of Step 1), all crossings within a watershed were visited. For each crossing, the fish migration barrier status and upstream fish habitat value were determined. Recommendations included designing remediation structures and assessing upstream fish habitat. The overview fish passage assessment could be improved by development of a GIS-based fish habitat model applied across the landscape. The success of a remediation program will depend upon the commitment and resources of the individual crossing owners. The overview fish passage assessment can serve as a tool to educate crossing owners and stakeholders on the need for fish passage remediation within watersheds of interest.

Key words: fish passage, fish habitat, stream crossing, culvert, stream remediation planning

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Introduction

Fish migrate to different locations in a watershed in order to meet a variety of life history requirements. This includes adult fish returning upstream to spawn, juvenile fish dispersing throughout watersheds to access suitable habitat, and all life stages as they move towards suitable over-wintering areas (Whyte et al. 1997). Stream crossings occur wherever roads or railways intersect streams. Structures designed to convey water under roads and railways have the potential to block upstream fish migration. Over the long-term, stream crossings that block upstream fish migration have the potential to reduce the productivity and distribution of the various fish species that inhabit impacted areas. Many of the crossings occur on small streams that are not used for commercial or sport fishing purposes, but these watercourses may contribute to downstream productivity by providing juvenile rearing or other important habitats.

Within west-central Alberta, native fish including Bull Trout (*Salvelinus confluentus*), Rainbow Trout (*Oncorhynchus mykiss*), Mountain Whitefish (*Prosopium williamsoni*), Arctic Grayling (*Thymallus arcticus*) and Long Nosed Sucker (*Catostomus catostomus*) have been observed making the seasonal upstream migration for spawning (Foothills Model Forest 2003). Juveniles of these species have significantly reduced swimming capabilities than have adults (Katopodis 1994), and have also been observed widely distributed throughout the region. Other species including Spoonhead Sculpin (*Cottus ricei*), Northern Pike (*Esox lucius*) and Burbot (*Lota lota*), all of which have reduced swimming capabilities in moving water because of their mode of swimming (Katopodis 1994), also inhabit small streams in the region (Foothills Model Forest 2003).

Fish passage on older roads or crossings may not have been identified as an objective at the time of construction. In other situations where fish passage was considered, very little information was available on stream discharge to ensure sufficient culvert sizing until recently. As a result, culverts with insufficient capacity may have been installed. Increased water velocity within an undersized culvert frequently results in channel scour at the outlet. Therefore, although these culverts may have been installed at the stream grade, over time they often develop hanging outfalls and fish migration barriers. Hydrologic studies within the study area provide peak flow discharge estimates for small streams that can now be considered during crossing design (Hydroconsult 1997 and Golder 2002). In addition, both the federal and provincial governments have established approval processes to ensure that long-term fish passage requirements are addressed in the project design phase (Fisheries and Oceans Canada 1991; Alberta Government 2001).

Several jurisdictions have initiated programs to restore fish passage following the recognition of the amount of productive fish habitat that was not accessible. Such efforts include the British Columbia Watershed Restoration Program (Parker 2000), US Forest Service restoration programs (Love and Firor 2001) and small-scale projects, such as industry, government and local stakeholder initiatives. Successful programs have employed a step-by-step process to guide remediation programs. The objectives of this paper are to present a seven-step model, and to illustrate example findings from the first step in the process - an overview fish passage assessment (Wilson and McCleary 2003).

Methods

Stream Crossing Remediation Process

A stream crossing remediation program is an investment that requires careful evaluations, establishment of priorities and budgets, and development of interagency relationships. A seven-step model was developed to guide the process (Table 1).

Table 1. Summary of seven-step model to guide the stream crossing remediation process.

Step	Description	Agencies / Parties Involved
1. Overview Assessments	<ul style="list-style-type: none">• Crossing structural integrity assessment• Sediment input assessment• Overview fish passage assessment	<ul style="list-style-type: none">• Crossing owners• Qualified technicians
2. Communication with Stakeholders	<ul style="list-style-type: none">• Identification of crossing owners• Education of owners based on results from overview assessments• Determination level of interest in a coordinated remediation project	<ul style="list-style-type: none">• Crossing owners
3. Detailed Assessments for Individual Crossings	<ul style="list-style-type: none">• Upstream fish habitat status assessment• Detailed fish passage assessment• Crossing remediation design including cost / benefit analysis	<ul style="list-style-type: none">• Crossing owners• Qualified engineers and aquatic biologists
4. Budget Development	<ul style="list-style-type: none">• Development of a coordinated watershed plan• Allocation of annual budgets	<ul style="list-style-type: none">• Crossing owners
5. Permitting and Approvals	<ul style="list-style-type: none">• Appropriate regulatory approvals	<ul style="list-style-type: none">• Crossing owners• Regulatory agencies
6. Implementation	<ul style="list-style-type: none">• Structures replaced / repaired based on annual budget	<ul style="list-style-type: none">• Crossing owners
7. Evaluation and Reporting of Outcomes	<ul style="list-style-type: none">• Fish passage and other benefits measured / assessed• Gradual improvement in stream crossing performance based on a system of priorities	<ul style="list-style-type: none">• Crossing owners

Overview Assessment of Fish Passage

An overview assessment of fish passage was an important first step in the remediation process. This assessment served to identify crossings suited to more detailed evaluations. Candidate crossings were identified using GIS, and included all road-stream intersections and railroad-stream intersections within the study area watershed. During a field visit, a determination of barrier status was made (Figure 1). The procedure for determining barrier status was based upon Love and Firor (2001) and Parker (2000).




Full Barrier	Potential Partial Barrier	No Barrier
		
<ul style="list-style-type: none"> • Hang height greater than 0.6 m • Outfall pool depth less than 1.25 x hang height • Debris at inlet or outlet 	<ul style="list-style-type: none"> • Outlet hang height less than 0.6 m • Outfall pool depth > 1.25 x hang height • Water velocity in culvert greater than upstream water velocity 	<ul style="list-style-type: none"> • All bridges, fords, or engineered culverts with baffles or a natural stream-bed • Outlet not hanging and culvert backwatered by grade control downstream of outlet • Water velocity in culvert comparable to upstream

Figure 1. Assessment of stream crossing barrier status.

In order to prioritize sites for remediation, the amount of habitat located in upstream areas was assessed based on probability of fish capture in upstream areas (Table 2). Stream reach information that was used for determining fish habitat status was generated through an automated process (Golder 2002). Fish inventory data considered during the habitat evaluation were collected between 1995 and 2002 (Foothills Model Forest 2003).

Table 2. Fish habitat assessment based on probability of fish capture.

High Probability	Medium Probability	Low Probability
<ul style="list-style-type: none"> • Stream reaches where fish were captured during fish inventory • All reaches located downstream of fish capture sites • All reaches located upstream of fish capture sites with the same gradient class and stream order 	<ul style="list-style-type: none"> • All reaches that did not fall into high or low probability categories 	<ul style="list-style-type: none"> • Any stream reach where fish have not been captured during two different years and two different seasons • Any headwater tributary which has emergent wetland vegetation across entire channel or no flow during a summer field visit • Drainage area of reach is less than 0.23 km² • Slope of reach is greater than 10%

Crossings that presented a full barrier within a known fish-bearing stream were candidates for remediation design assessment. Potential partial barriers in known fish-bearing streams were candidates for a detailed fish passage assessment to determine the severity of the barrier. Full barriers and potential barriers in streams with unknown fish-bearing status were candidates for fish and fish habitat inventory.

Results

Within our sample watershed, all three classes of fish bearing streams were encountered, and stream crossings of three barrier status types were found in these streams (Figure 2). Of the eight crossings that were visited, only one was suitable for a detailed crossing remediation design, while the other seven required additional assessments before they could be considered for remediation design (Table 3). The priority for future assessments could be based upon the upstream length of medium and high value fish habitat. For example, because of the greater upstream length of medium value fish habitat (3.2 km at Crossing 2 versus 2.5 km at Crossing 3), the upstream fish habitat assessment at Crossing 2 would be higher priority.

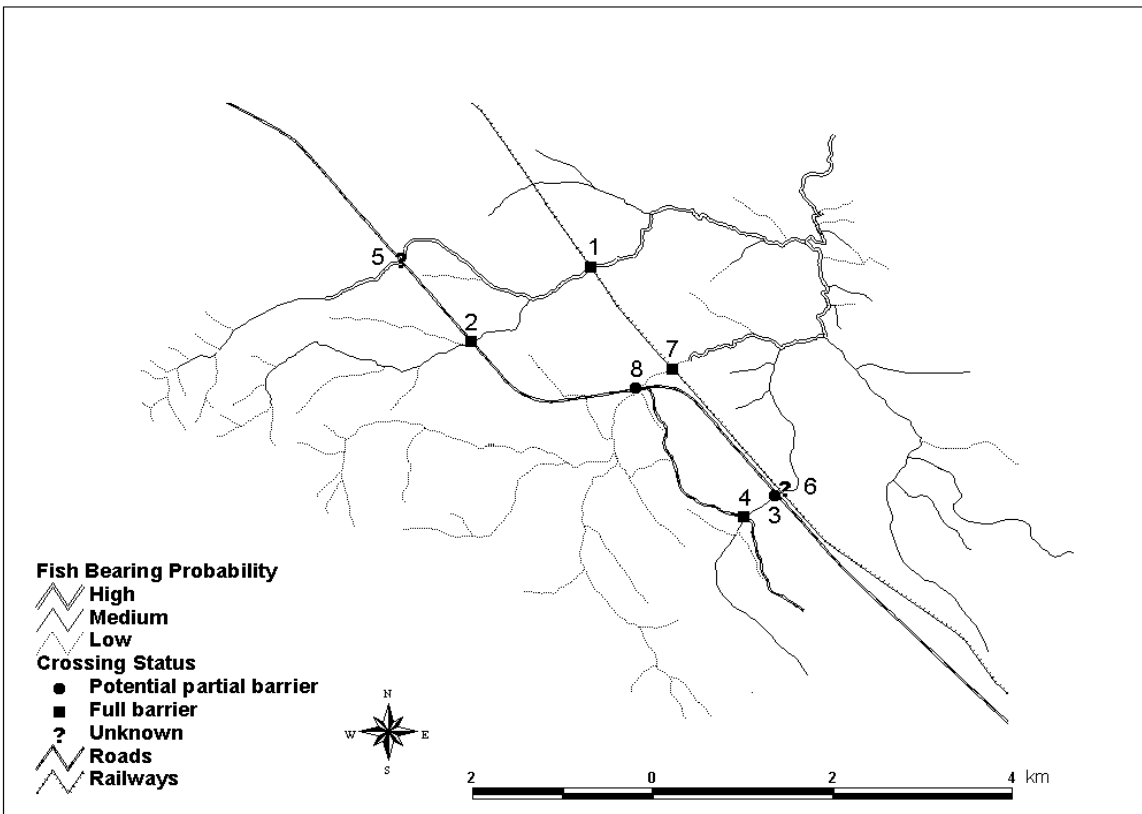


Figure 2. Location and status of stream crossings within a portion of a west-central Alberta watershed.

Table 3. Summary of overview assessment results for individual crossings within example basin.

Crossing Number	Barrier Status	Fish Habitat Value Immediately upstream from Crossing	Length of Stream by Type Immediately Upstream From Crossing (km)	Total Length of Stream Upstream from Crossing (km)	Follow-up Assessment Type
1	Full barrier	High	3.8	21.0	Remediation design
2	Full barrier	Medium	3.2	9.0	Upstream fish habitat assessment
3	Potential partial barrier	Medium	2.9	4.4	Upstream fish habitat assessment
4	Full barrier	Medium	2.5	3.9	Upstream fish habitat assessment
5	Unknown	High	1.0	7.5	Overview assessment
6	Unknown	Medium	3.0	4.5	Overview assessment
7	Full barrier	Low	24.2	24.2	None
8	Potential partial barrier	Low	23.7	23.7	None

Overall, a total of 302 crossings were assessed within 14 watersheds with four full barriers within high probability fish streams and 18 potential partial barriers within high probability streams (Wilson and McCleary 2003). Restoring fish passage at the four crossings with full barriers would restore passage to 6.2 km of high value fish habitat. The length of high value fish habitat upstream from each of the 18 potential partial barriers ranged from 0.2 km to 32.4 km and averaged 5.2 km. The 22 stream crossings of concern are the responsibility of a number of organizations from the railway, highway and industry sectors.

Discussion

Limitations of Fish Habitat Value Assessment

The current method for identification of a stream as non-fish bearing requires backpack electro-fishing surveys. One approach to confirm a stream as non-fish bearing is to sample a reach on three different dates from two different years and two different seasons. Reliance upon this methodology has two major pitfalls. First, this methodology does not consider the historical habitat value prior to the installation of stream crossings that may have limited fish migration for a number of years or decades. Second, for the purposes of stream crossing remediation, a major fish inventory program would be required to provide sufficient information. Even though more than 1000 sites were inventoried within the Foothills Model Forest, information on fish habitat status upstream from many of the existing road crossings is non-existent. To overcome these issues a fish habitat status model based on GIS-based watershed and stream characteristics would be useful for identification of potential fish-bearing streams.

Multiple Crossing Owners

In a number of watersheds where several stream crossings were identified for potential follow-up, the crossings were the responsibility of more than one organization. In such situations, the most timely and efficient restoration of fish passage would likely occur through a coordinated approach involving all crossing owners. In the small example watershed presented here, stream crossings occur at a provincial highway, a railway and on licenced industrial roads. The crossing owners remain responsible for the costs of undertaking additional detailed assessments and repairing any crossings. Current incentives for involvement in such initiatives within Alberta include internal company land stewardship policies, as well as forest certification initiatives. In response to such incentives, several crossing owners have expressed interest in participating. Communication and education relating to the issue of stream crossings remains an important component in the process of ensuring the long-term conservation of all productive fish habitat on the landscape.

Conclusions

Two findings from the overview assessment may prove useful in the stream crossing remediation process within the study area. First, the barrier and fish habitat status of selected crossings were described. Second, the upstream habitat value for each of the crossings of concern may help crossing owners to establish priority crossings for remediation. Our results will be provided to crossing owners for their consideration in any remediation programs that they may have.

Within selected west-central Alberta watersheds, several organizations have taken a lead role in coordinating watershed-level fish passage remediation programs including Athabasca Bioregional Society, the Foothills Model Forest, Jasper National Park and Weldwood of Canada. Establishing standards, providing a mechanism to access stream, road, and fish inventory data, and establishing training programs would be key components of a larger program that could be addressed by potential government, industry and resource stakeholder partnerships.

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