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Overview Assessment of Fish Passage at Stream Crossings in the Hardisty Creek Watershed

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Alberta Conservation Association

Weldwood

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The funds to complete this Foothills Model Forest study were provided by our core partners including Weldwood of Canada Ltd. – Hinton Division, Canadian Forest Service, Alberta Sustainable Resource Development, and Parks Canada – Jasper National Park. Scott Wilson, field leader for this assessment, was employed as a Fish Biologist Intern through the Natural Resources Canada Internship Program. Additional financial support was provided by the Hinton Fish and Game Association.

The methodology used for this assessment was developed with the assistance of Chris Spytz, a Biologist with Weldwood of Canada Ltd. - Hinton Division.

Abstract

A stream crossing is the intersection of any stream with a road, rail line, or other linear feature. They are usually constructed of wood, concrete, or metal pipe and are designed to convey water under the road or rail line. Historically, many crossings were not designed with fish passage as a priority. Therefore, many existing structures do not allow upstream fish passage for migration, spawning, and overwintering habitat.

The Foothills Model Forest had several goals for this overview assessment. We recognized that considerable investment will be required to modify any existing infrastructure, and selected a watershed perspective to establish priorities for future engineering and biological assessments. These more detailed assessments will be required to identify options and establish budgets for remediation.

At the overview level we identified three crossings that currently present a full barrier to upstream fish migration. If these crossings were repaired, access to a total of 12.4 km of upstream habitat would be created. We also identified five crossings that present potential partial barriers to upstream fish migration. Detailed assessments are required to determine the degree to which each of these crossings poses a barrier to upstream fish migration. If these crossings are all found to present some type of barrier and repairs are subsequently made, access to a total of 13.6 km of fish habitat would be created. Two other crossings are located in streams with unknown fish bearing status and additional fish inventory is recommended prior to assessing these crossings for fish passage.

The Foothills Model Forest is willing to assist, where possible, with additional assessments. Ultimately, the crossing owner remains responsible for completing any detailed assessments and completing repairs to improve passage. Our goal is to increase awareness of fish passage issues and to provide practical tools for moving forward with remediation.

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1. 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 rearing habitat, and all life stages as they move towards suitable over-wintering areas (Whyte et. al 1997). Stream crossings occur wherever roads or rail lines intersect streams. Structures designed to convey water under roads and rail lines 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 an impacted area.

Within the Foothills Model Forest (FMF), native fish including Bull Trout (*Salvelinus confluentus*), Rainbow Trout (*Oncorhynchus mykiss*), Mountain Whitefish (*Prosopium williamsoni*), Arctic Grayling (*Thymallus arcticus*) and Long-nosed Sucker (*Catastomus catastomus*) have been observed making the seasonal upstream migration for spawning (FMF 1999 - 2001). In comparison to these spawning adults, juveniles of these species, which have significantly reduced swimming capabilities (Katopodis 1994) are also widely distributed throughout the region. Other species including Spoonhead Sculpin (*Cottus ricei*), Northern Pike (*Esox lucius*) and Burbot (*Lota lota*), which have reduced swimming capabilities in moving water due to their mode of swimming (Katopodis 1994), also inhabit small streams in the region (FMF 1999 - 2002).

Barriers typically occur when upstream fish migration is not identified as an objective during the stream crossing design and engineering phase. Current standards for stream crossings include maintaining fish passage at man-made structures (Fisheries Act 1985). Fish passage on older roads and crossings may not have been identified as an objective at the time of construction. However, both the federal and provincial governments have more recently established approval processes to ensure that fish passage requirements are addressed in the project design phase (Fisheries and Oceans Canada 1991 and Alberta Government 2001).

Following recognition of the amount of productive fish habitat that was not accessible, many jurisdictions have initiated programs to restore fish passage. Such efforts include the British Columbia Watershed Restoration Program (Parker 2000), US Forest Service restoration programs (Love & Firor 2001) and the Weldwood Stream

Crossing Remediation Program (R. Bonar, Weldwood Chief Biologist, pers. comm. 2002). The Weldwood program for stream crossing remediation involves all crossings that the company is responsible for within their FMA, as well as other crossings they may have encountered. Their program is based on a comprehensive assessment that includes safety and sedimentation, as well as fish passage concerns. Our study is intended to augment their ongoing program by providing a watershed perspective that may assist the company in determining priority sites for fish passage remediation.

The first objective of this preliminary assessment was to identify crossings that may require one of the three more detailed assessments. First, we identified crossings that presented a fish migration barrier within a known fish-bearing stream in the Hardisty watershed. These crossings would be suited to a remediation design assessment. Second, we identified potential fish migration barriers that are present in known fish-bearing streams. These crossings would be candidates for a more detailed crossing assessment to determine the severity of the barrier and the priority for remediation. Third, we identified barriers and potential barriers in streams with unknown fish-bearing status. These crossings would be candidates for future assessment in the ongoing FMF Fish and Fish Habitat Inventory Program. The reader should be aware that our preliminary assessment was not intended to be definite in all cases but to serve as a tool to establish priorities for further work in an ongoing remediation program.

A second objective was to develop a methodology that could be useful to guide other remediation efforts outside of the project study area. Our project may also provide some of the background for terms of reference in the development of a more detailed fish passage assessment as part of Weldwood's remediation program.

A third objective was to determine the extent of upstream habitat that may have been isolated due to migration barriers within each of the monitoring watersheds.

The final objective was to increase awareness and encourage the companies and government agencies responsible for stream crossings to develop and implement plans to upgrade existing structures in order to satisfy fish passage requirements.

The study area for this project includes the Hardisty Creek watershed, located directly south of the town of Hinton, Alberta (Figure 1). The stream crossings within the study area are managed by a number of agencies including:

- Weldwood of Canada Ltd., Hinton Division

- Government of Alberta, Ministry of Transportation
- CN Rail
- Alberta Sustainable Resource Development
- Other License of Occupation holders including oil and gas companies

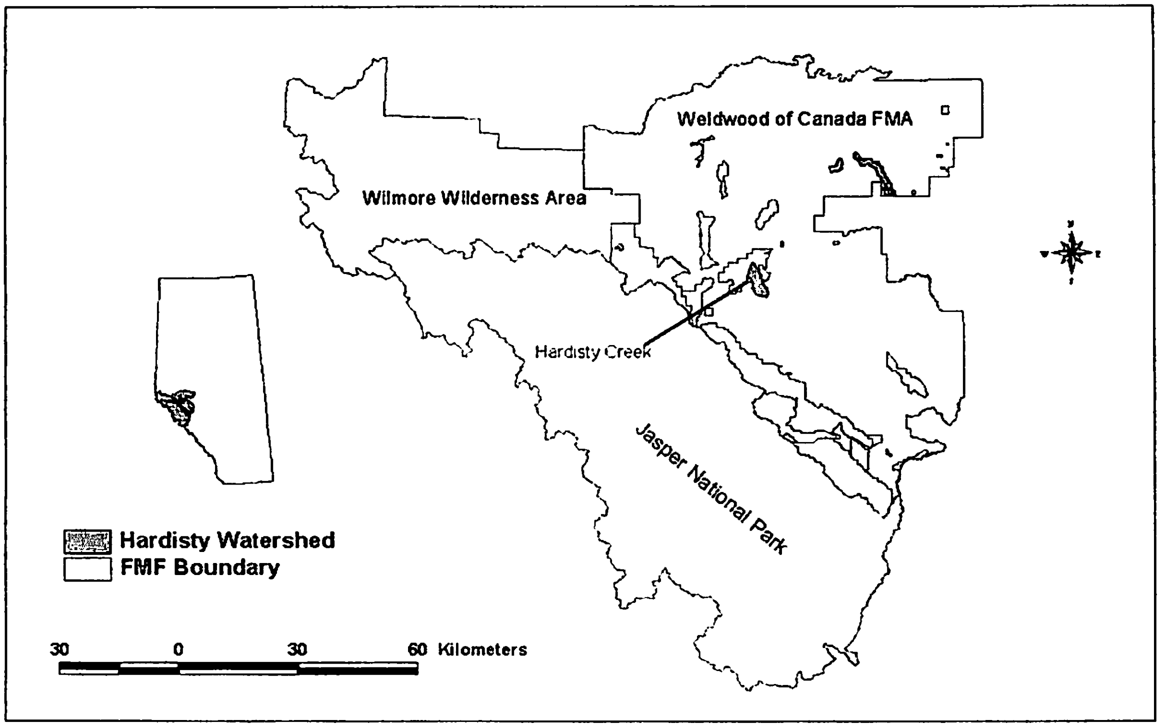

Figure 1. Hardisty Creek watershed, within the Foothills Model Forest

2. Methods

2.1. Site Selection

To identify field survey sites within the watershed, maps were produced showing all streams along with highways, railways, and industrial roads. All road-stream intersections and railroad-stream intersections were numbered and field maps were created.

2.2. Field Methods

All field data were recorded on a crossing data form (Appendix I). This data included location description, structure type, stream channel measurements, and crossing details. Along with a general description of the site location, GPS coordinates were taken at each site. Photographs of each inflow, outflow and any other important features were also taken.

Field assessments were completed during the fall of 2002. Each crossing was identified as a bridge, a culvert, or a ford. At all sites, stream channel measurements were taken at a location upstream of the crossing's influence. Measurements included wetted stream width, rooted/bank-full width, and three representative depths across the channel (Figure 2).

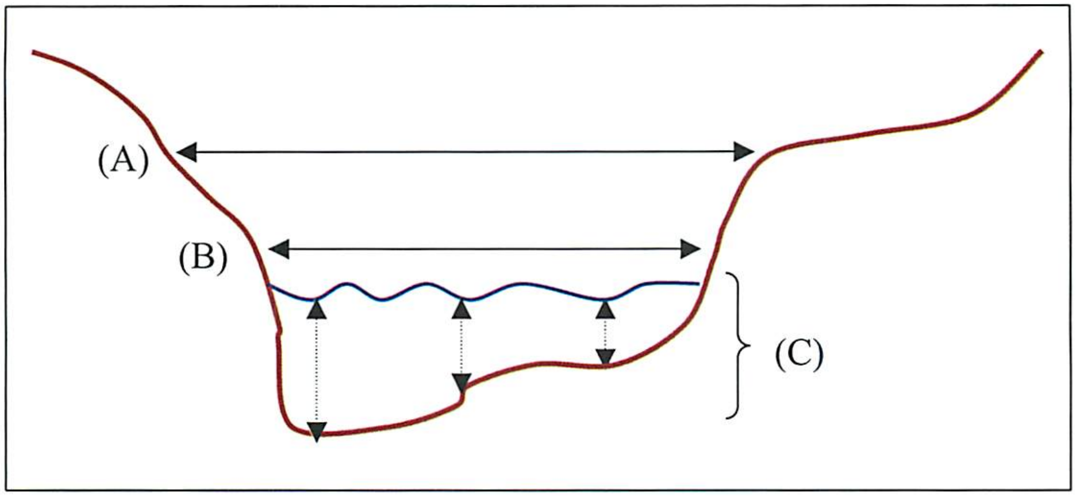

Figure 2. Stream channel measurements taken upstream of each crossing included; rooted width (A), wetted width (B), and three water depths across the channel (C).

For stream crossings with a culvert, field measurements included hang height, culvert diameter, plunge pool presence and depth, and the total length of the culvert (Figure 3). In addition, presence of substrate within the culvert was noted.

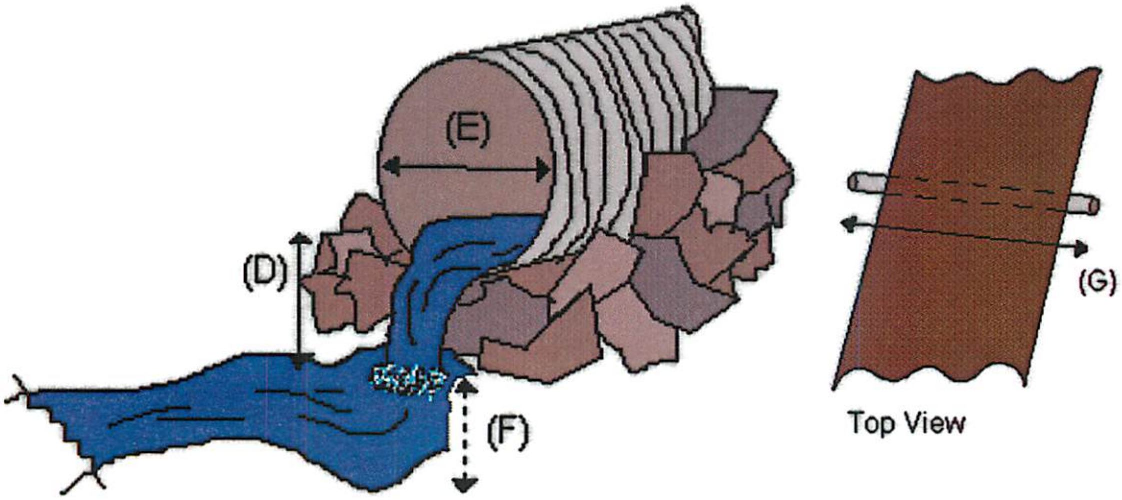

Figure 3. Typical measurements taken from a culvert-type stream crossing, where; (D) hang height, (E) culvert diameter, (F) pool depth, and (G) culvert length.

2.3. Assessment of Fish Passage Status

All field data were entered into a Microsoft Access database. For quality control, all database tables were compared to the original field data sheets. In the office, the status of each crossing as a barrier was determined based on criteria identified in other fish passage studies (Table 1).

Table 1. Stream crossing barrier classification

Barrier Type	Barrier Class	Criteria
Full barrier	3	A culvert was considered a full barrier if any one of the following criteria were met: 1. Hang height greater than 0.6m (Love & Firor 2001). 2. Outfall pool depth less than 1.25 times hang height (Love & Firor 2001). 3. Debris at inlet or outlet.
No barrier	1	A culvert was considered to allow unobstructed passage if either of the following criteria were met: 1. Outlet not hanging and culvert backwatered by grade control downstream of outlet (Love & Firor 2001). 2. Water velocity in culvert comparable to upstream water velocity indicated by retention of substrate of similar composition as the natural streambed inside culvert (Parker 2000).
Potential partial barrier	2	All other culverts not meeting the criteria above were identified as potential partial barriers including: 1. Outlet hang height less than 0.6m (Love & Firor 2001). 2. Outfall pool depth greater than 1.25 times hang height (Love & Firor 2001). 3. Water velocity in culvert greater than upstream water velocity indicated by lack of retention of substrate of similar composition to the natural streambed within culvert (Parker 2000).

All bridges, fords, or engineered culverts with baffles were considered to allow full passage and were classified as non-barriers.

2.4 Determination of Fish-bearing Status

The crossing data presented in this report were collected during the fall of 2002. The fish inventory information used to determine fish distribution within the study area watershed was collected during previous Foothills Model Forest studies (FMF 1999-2001).

Understanding fish distribution can help to establish priorities for further work. Ideally, sites for remediation would be priorized by a number of factors such as the amount of habitat located in upstream areas and the degree to which the culvert presents a barrier. In order to assist with such a priorization exercise, a classification scheme based on probability of fish capture at any individual site was developed (Table 2).

Table 2. Determination of probability of fish capture.

Probability of Fish Capture	Class	Criteria
High	1	• Those stream reaches from the automated classification (Golder 2002) where fish were captured during FMF inventories. • All stream reaches located downstream of fish-bearing sites, as well as those stream reaches located upstream with the same gradient class and stream order.
Low	3	• Within the Foothills Model Forest, no fish have been captured in any stream with a gradient exceeding 8.5 % slope (Figure 4). Therefore, all stream reaches with a gradient exceeding 10 % were considered non-fish bearing. • The smallest fish-bearing stream within the Foothills Model Forest had a drainage area of 0.23 km^2. Therefore, all stream reaches with a drainage area of less than 0.23 km^2 were considered non-fish bearing. • Any stream reaches where fish had not been captured in two different years and two different seasons using backpack electrofishing for a 300m long section. • Any stream reaches upstream of a confirmed non-fish bearing reach based on backpack electrofishing. • Any headwater tributary with no stream flow during a summer field visit. • Any headwater stream channel vegetated with emergent wetland type vegetation across the entire channel.
Medium	2	• All other stream reaches.

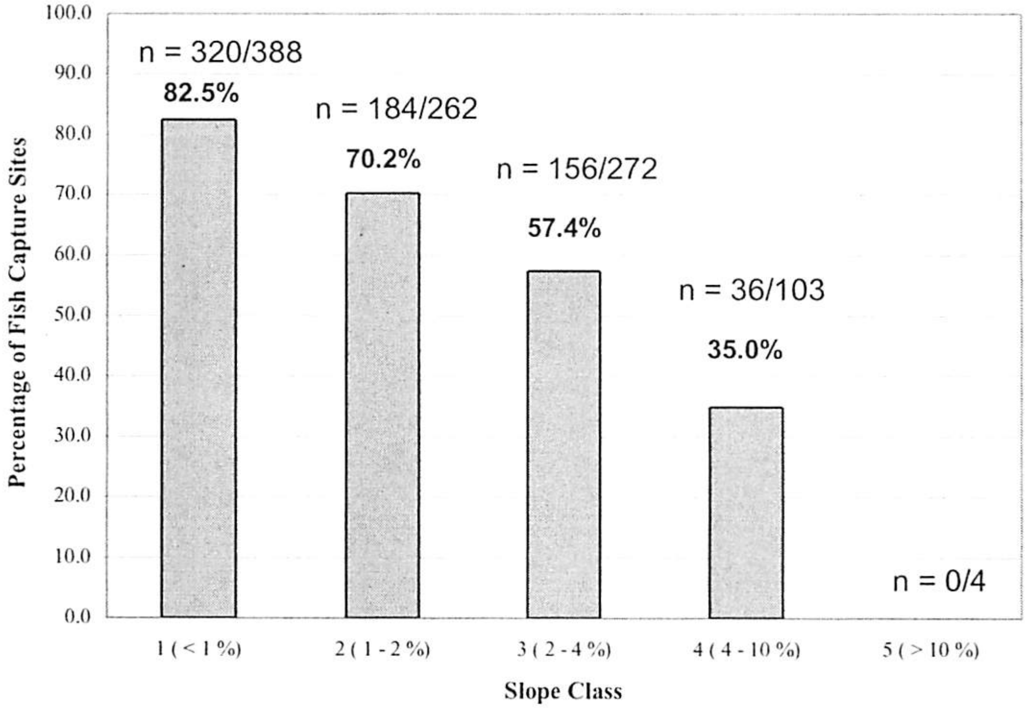

Figure 4. Percentage of sites where fish were captured within the Foothills Model Forest according to stream reach slope class.

3. Results

Results for Hardisty watershed were summarized into one figure and three tables. The figure is a map showing roads, streams and crossings (Figure 5). The status of each crossing was represented by a symbol and the fish capture probability was represented by one of three different colors.

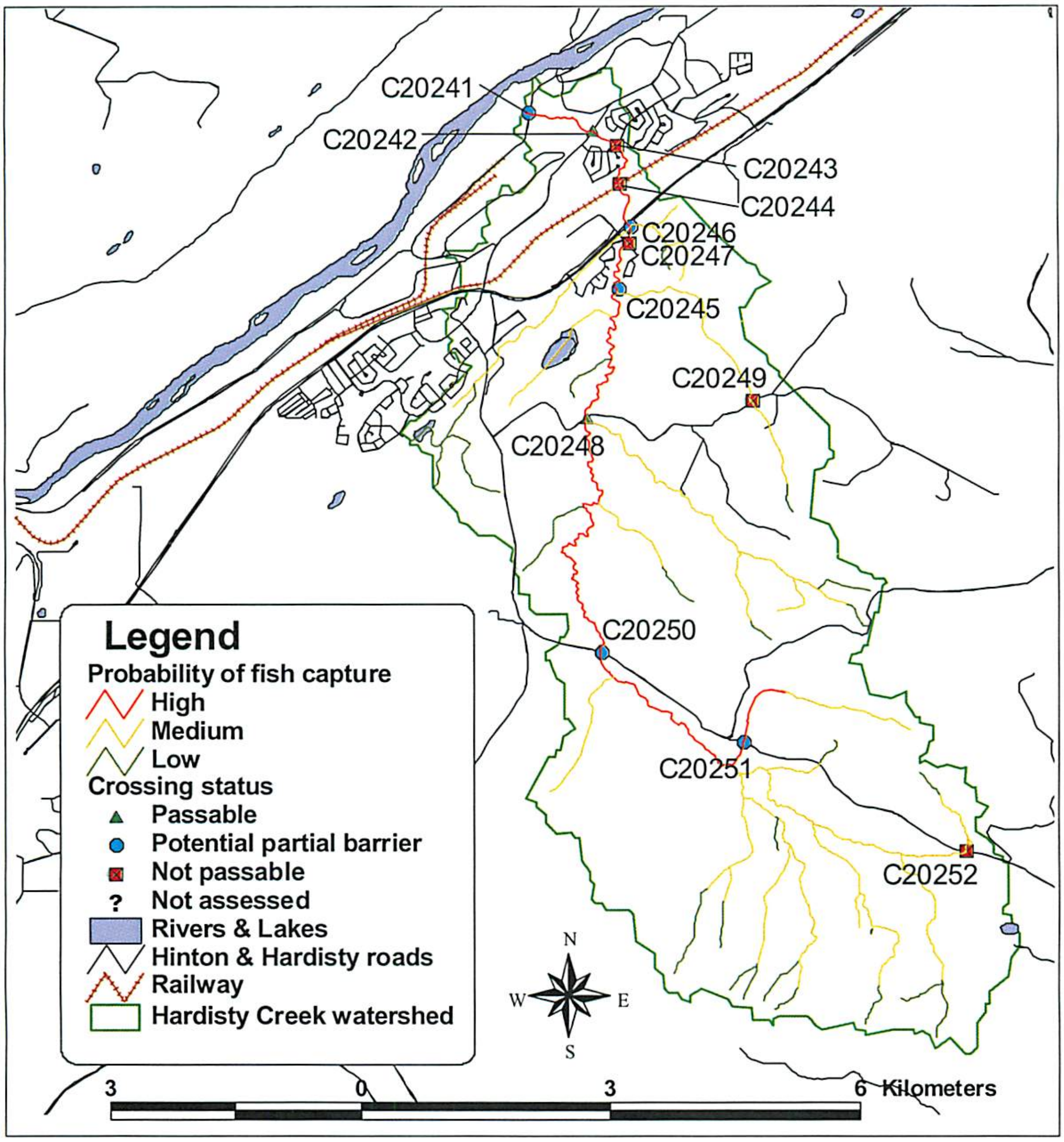

Figure 5. Stream crossings in Hardisty watershed.

Three crossings that were located in high probability of fish capture streams presented full barriers to fish migration (Table 3). These sites would be candidates for detailed restoration prescriptions.

Table 3. Full barriers in high probability of fish capture streams (remediation candidate sites).

Crossing #	Km of High Probability of Fish Capture Stream Upstream
C20243	12.4
C20244	11.8
C20247	10.9

Five crossings that were located within high probability streams were found to present a potential partial barrier to fish migration (Table 4). These sites would be candidates for more detailed crossing assessments.

Table 4. Potential partial barriers in high probability of fish capture streams (detailed assessment sites).

Crossing #	Km of High Probability of Fish Capture Stream Upstream
C20241	13.6
C20246	11.2
C20245	10.1
C20250	3.6
C20251	0.9

Two crossings that were located within medium probability of fish capture streams were found to present either a full or potential partial barrier to fish migration (Table 5). These sites would be candidates for additional inventory of fish and fish habitat to confirm the fish habitat status.

Table 5. Full barriers and potential partial barriers in medium probability of fish capture streams (future inventory sites).

Crossing #	Km of Medium Probability of Fish Capture Stream Upstream	Barrier Status[1]
C20249	1.1	3
C20252	0.8	3

[1] (See Table 1)

4. Discussion

This overview assessment separated those crossings that were likely to pass most fish species and life stages from those crossings that may inhibit the passage of various species or life stages. Over the long-term, the Foothills Model Forest hopes to facilitate the restoration of fish passage at all crossings. However, the greatest benefit in the short term may be to focus remediation efforts on the sites that will restore habitat to the greatest upstream area for the most species and life stages. Therefore, to move forward with remediation, the next step would be to conduct a more detailed assessment that addresses the following questions:

1. What are the options and costs for restoring fish passage at the crossings that present a full barrier?

2. For those culverts identified as potential partial barriers, what is the extent of the barrier and what are the options and costs for remediation?
3. What is the fish bearing status at the crossing and upstream areas for those crossings identified in Table 5?

Other options for proceeding may be identified during the review of this document by the agencies responsible for the management of the crossings who are interested in supporting additional work by the Foothills Model Forest.

5. Glossary

Baffles – structures installed within a culvert, designed to reduce water velocity and aid fish passage upstream; typically concrete blocks or metal plates.

Bankfull width – width of a stream channel at the slope break, or a typical 1.5-year flood occurrence (Rosgen 1996).

Culvert – corrugated metal pipe, or concrete slab structure used to convey water across/underneath a road.

Electrofishing – method of fish capture that uses electricity to stun fish so they can be sampled and returned to the stream.

Ford – no structure present at a crossing; vehicles pass directly through the stream itself.

Geographic Information System – GIS is a system of hardware and software used for storage, retrieval, mapping, and analysis of spatial geographic data (Mayhew 1997).

Global Positioning System – GPS is a radio navigation system that allows users to determine their exact location 24 hours a day anywhere in the world (Isaacs 2000).

Hang height – distance from the bottom of the culvert to the top of the water surface; sometimes called outfall drop (Parker 2000).

Inlet – point where water enters a culvert or other water conveyance structure.

Left upstream bank (LUB) – used to denote the left side of the stream, looking upstream.

Outlet – point at which water returns to the natural stream channel after passing through a structure.

Right upstream bank (RUB) – used to denote the right side of the stream, looking upstream.

Rooted width – See bankfull width.

Stream order – Hierarchical ordering of streams based on the degree of branching. A first-order stream is an unforked/unbranched stream. Two first-order streams flow together to form a second-order, two second-orders combine to make a third-order stream, etc. (Armantrout 1998).

Substrate – bed material in a stream channel.

Wetted width – representative width of water in a stream channel.

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Appendix I

FOOTHILLS MODEL FOREST

ROAD CROSSING DATA FORM -Monitoring/CEA projects

R:\FMF Fish\Field Forms\culvert dataform.xls

foothills model forest

Culvert ID:____________________

Site ID: ____________________

Road Name: ____________________ Km (approx.): __________

Stream Name: ____________________ Tributary to: __________

Monitoring Watershed: ____________________ Date: __________2002

Crew: Day/Month

	Easting	Northing
Crossing locaton UTM:		
Mouth location UTM (if unnamed):		

Legal Land of Crossing: ____ ____ ____ W__
sec twp rge mer

Working Circle: ____________________ Compartment: __________

Crossing type (bridge, culvert, etc.): __________ Culvert type: __________

Measurements (m)	Height	Width	Length	Type	Hang Ht	Water in pipe	Water depth at: Outfall	Max.
Culvert 1								
Culvert 2								
Culvert 3								
Culvert 4								

Interior water velocity: High☐ Medium☐ Low ☐

Sketch of Culvert (from D/S corresponding to measurement table)

Erosion Potential: High☐ Medium☐ Low ☐

Baffles? Yes ☐No ☐ Substrate in Pipe? Yes ☐No ☐

Is this crossing a barrier to fish? Yes ☐No ☐

Reasoning:

STREAM MEASUREMENTS (upstream of crossing's influence)

Widths (m) rooted: _____ Wetted: _____ Depths (m) left:_____center:_____ right:_____

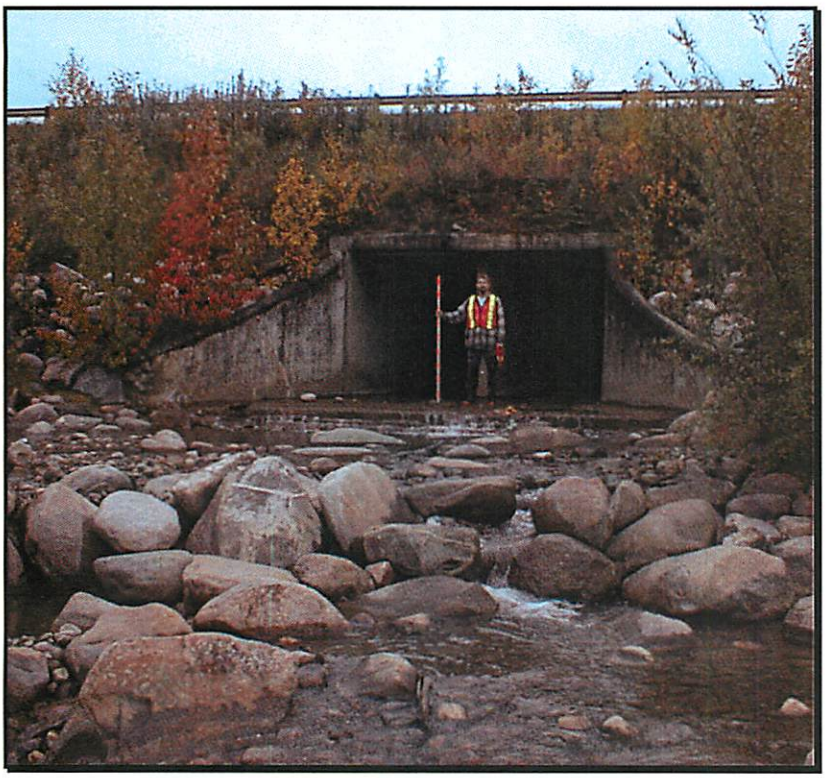
Description of photographs taken:

Comments:

Appendix II

Field Output Reports are included for this managing agency only.

Inlet



Outlet

Crossing Description	
FMF culvert ID	C20246
Weldwood ID	
Date	9/30/2002
Stream	Hardisty Creek
Tributary to	Athabasca River
Watershed	Hardisty
Easting	463 518
Northing	5 917 970
Structure type	Concrete slab
Stream Description	
Wetted width	4.9m
Rooted width	6.4m
Average depth	0.16m
Fish bearing status	Non-fish bearing
Culvert Description	
Culvert 1 diameter	2.4m concrete slab
Hang height	0.28m
Substrate	Yes
Outlet backwatered	No
Pool description	Present
Culvert 2 diameter	2.4m concrete slab
Hang height	0.28m
Substrate	Yes
Outlet backwatered	No
Pool description	Present
Culvert 3 diameter	
Hang height	
Substrate	
Outlet backwatered	
Pool description	
Crossing Obstruction Status	
Barrier class*	3
Reason	Outfall barrier

***1**=No barrier; **2**=Potential partial barrier - detailed assessment recommended; **3**=Full barrier