Forest Practices Board

Fish Passage at Stream Crossings

Special Investigation

FPB/SIR/25

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Executive Summary

This Forest Practices Board report presents the results of an investigation of fish passage at stream crossings in 19 watersheds in the central and northern interior and on Vancouver Island, British Columbia. In total, 1,110 crossings of fish-bearing streams were examined. Each watershed had a mix of crossings built before the implementation of the 1995 *Forest Practices Code of British Columbia Act* (the Code), after the implementation of the Code, and also after the replacement of the Code with the *Forest and Range Practices Act* (FRPA) in 2004.

The number of stream crossings within British Columbia is constantly increasing due to new road development. Government estimates that there are approximately 370,000 stream crossings in the province, of which about 76,000 are culverts on fish streams (BC Ministry of Environment 2008). For this reason, fish stream crossings may be the single most important habitat impact affecting fish.

There have been numerous studies of stream crossings in the province. Nearly all of these studies have focused on fish passage through closed bottom structures (CBS). However, watersheds also contain a variety of other crossing types, including open bottom structures (OBS) such as bridges, log culverts, arch culverts, and open box structures. This study is the first to examine fish passage in context: on a watershed scale, in a large number of watersheds, reporting on the overall fish passage through road crossings.

This investigation shows that, for the 19 watersheds examined, 42 percent of all stream crossings in fish-bearing habitat have a high likelihood of passing fish, with individual watersheds ranging from 20 to 94 percent. The remainder have a moderate to high risk of causing fish passage problems. For important and critical habitat, 72 percent of crossings have a high likelihood of passing fish; for marginal habitat, the number is only 12 percent.

Open bottom structures were used on 39 percent of all crossings, including 66 and 77 percent of crossings of important and critical habitat, respectively. Open bottom structures account for most of the observation of success in providing for fish passage.

Fish passage is often highly impeded by closed bottom structures, which were used in 61 percent of the stream crossings. They were used in 91 percent of crossings of marginal habitat, where they presented a moderate to high risk to fish passage in 96 percent of cases.

Closed bottom structures were also used in 34 percent of the stream crossings of important habitat and 23 percent of the crossings of critical habitat, where the Board found that they present a moderate to high risk to fish passage in 90 percent of the cases.This study leads the Board to conclude that road crossings constitute a widespread risk to fish passage in these watersheds, especially when closed bottom structures are used.

Introduction

Background

Impeded passage of fish through crossings is a risk for fish of all species and age classes. Fish require access to a variety of habitats to feed, spawn and hide. Movement between these habitats is vital for their survival. The most obvious problem for migrating fish is the loss of access to habitat upstream of crossing structures that impede fish passage. Less obvious are the problems related to habitat fragmentation, isolation of specific fish populations, and species replacement.

Culverts are an economical method of crossing small and medium sized streams when building a road. While most culverts are installed as round closed bottom structures (CBS), some culverts are embedded below the level of the natural stream bed resulting in natural material being retained through the length of the culvert. A natural channel substrate provides a wide variety of widths, depths and water velocities throughout its length and width, thus offering fish a choice of routes suited to a wide range of swimming abilities. In contrast, a non-embedded round bottom culvert is a streamlined, hydraulically efficient channel which has comparatively high water velocities that are relatively constant throughout the culvert length. Other physical factors that may influence fish passage include: outlet drop heights; plunge pool condition; turbulence within the culvert; ice or debris blockage; lack of resting pools downstream or upstream; and culvert alignment relative to the stream channel.

FIGURE 1. Outlet drops at culvert openings can impede or partially impede fish passage.

FIGURE 2. Coho attempting to pass through a round bottom culvert.

The number of stream crossings in British Columbia is constantly increasing due to new road development. The forestry sector is responsible for the majority of the road construction over fish-bearing streams in BC, but other resource industries also contribute to this development. Government estimates that there are currently 550,000 kilometres of resource roads on Crown forest land in BC with approximately 370,000 stream crossings, of which about 76,000 are culverts on fish streams (BC Ministry of Environment 2008). For this reason, fish stream crossings may be the single most important habitat impact affecting fish.

Over the past 30 years, there have been several initiatives in environmental legislation and policy that address the negative impacts that stream crossings can have on fish habitat. Section 20 of the Federal *Fisheries Act* provides discretionary power for the Minister to order a licensee who owns a culvert to provide for the free passage of fish. Section 35(1) of the Act prevents the harmful alteration, disruption, or destruction of fish habitat, which can include culverts, unless authorized by the federal Department of Fisheries and Oceans. In 1987, the *British Columbia Coastal Fisheries/Forestry Guidelines* recommended the use of open bottom wooden culverts, or arch culverts, for fish passage (Ministry of Forests 1987). In 1995, the *Forest Practices Code of British Columbia Act* (the Code) legislated safe fish passage through stream crossings under the *Forest Road Regulation*. In 2002, the *Stream Crossing Guidebook for Fish Streams* provided guidance in designing safe crossing structures on fish-bearing streams.

Since 2004, section 56 of the *Forest Planning and Practices Regulation*, under the *Forest and Range Practices Act* (FRPA), has required licensees to ensure that their forest activity does not have a "material adverse effect on fish passage."[1] It specifies that anyone who maintains a road with a fish stream crossing built after June 15, 1995, must ensure that the crossing does not have a material adverse effect on fish passage. Section 57 of the regulation also requires that primary forest activities be carried out in a manner that is unlikely to harm fish or destroy, damage or harmfully alter fish habitat.

There have been numerous studies of stream crossings in the province. Nearly all of these studies have focused on fish passage through CBS. However, watersheds contain a variety of other crossing types. These include open bottom structures (OBS) such as bridges, log culverts, arch culverts, and open box structures. No previous studies have examined fish passage in context: on a watershed scale, in a large number of watersheds, reporting on the overall fish passage through road crossings.

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[1] Note that the requirement under the Code, to provide "safe fish passage," was changed to "not have a material adverse effect on fish passage." The term "material adverse effect" is not defined in the legislation.

Objectives

This project examines the effectiveness of stream crossings structures in allowing passage of fish. This project differs from other fish passage studies undertaken in BC in the following ways:

- A "whole watershed" approach was used, where all of the accessible active road crossings in the watershed were examined.
- All types of stream crossing structures – OBS, as well as CBS were included.
- The crossing results are stratified by stream habitat class.

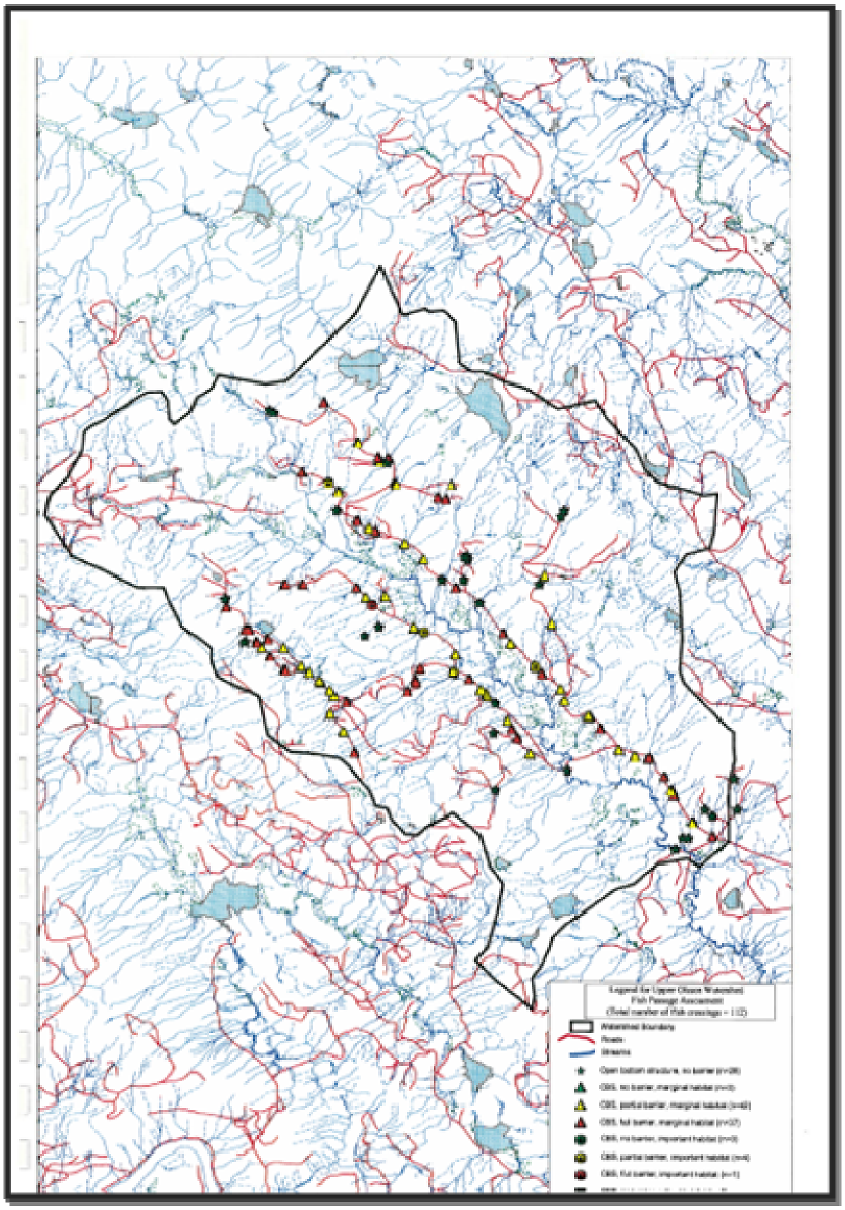

FIGURE 3. Example of a watershed map showing the sample sites.

Methodology

Selection of Watersheds

Nineteen watersheds were selected for this project, based on the availability of fish stream habitat maps and recently collected data about the characteristics of stream crossings. The approximate location of these watersheds is shown in Figure 4. The Board conducted field-based assessments specifically designed to assess fish passage in the Louis Creek and Heffley Creek watersheds (E in Figure 4) and the Campbell/Memekay watershed (F in Figure 4). In the other watersheds, the Board used data previously collected primarily for the purpose of assessing the impacts of stream crossings on water quality. The Board wishes to thank Canfor for allowing us access to this data. Details of the methods used for these two types of assessments are presented in the following section.

FIGURE 4. Map of watershed locations.

A. Babine Corridor, Nichyeskwa
B. Burnt Creek
C. Houston Tommy, Lamprey, McBride
D. Tay Creek, Upper Olsson, Lower Seeback, Horn Creek, Mokus Creek, Basin C, Basin F, Basin #7, Hubble Creek, West Torpy
E. Louis Creek, Heffley Creek
F. Campbell/Memekay

Determining Fish Stream Status

During the course of the Board investigation, the fish-bearing status of stream reaches in the watersheds was determined by reference to fish habitat maps. Some watersheds (such as Louis Creek, Campbell Lakes and Memekay) already had detailed fish inventories. Others had inventories of the main stems, but not of the small tributaries. Some of the streams the Board looked at were "default S4 streams;" that is, a licensee had decided that stream characteristics (gradient, size, etc.) were such that the stream was most likely fish-bearing and so it was treated as fish-bearing without inventory. Streams less than 0.5 metres in bankfull width were considered non-fish-bearing, unless the site conditions suggested otherwise. Only stream crossings over fish-bearing streams were included in the sample. While some individual stream reaches may be incorrectly classified, the inventory is suitable for reasonable inferences about the likelihood of fish passage at these locations and across a watershed generally.

Types of Crossings

All types of fish stream crossings on all roads with vehicular access in each watershed were examined in this study.[2] This included:

- ***Open Bottom Structures (OBS):*** bridges, arch culverts, semi-elliptical culverts, wooden box culverts, accessible deactivated crossings, open bottom rail cars.
- ***Closed Bottom Structures (CBS):*** round bottom steel culverts, round bottom wood stave pipes, steel round pipes (see sketch of a round bottom culvert, Figure 5).

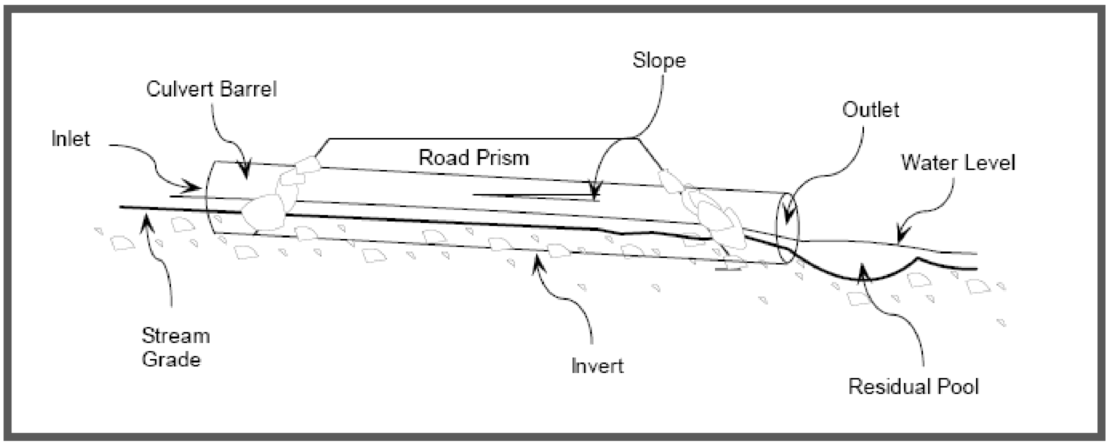

FIGURE 5. Terms used in the descriptions of closed bottom structures.

[2] Many pipe culverts are installed for only a short period of time and are then pulled, restoring the stream to its original state from a fish passage point of view. These deactivated/restored crossings were not included in this investigation.

FIGURE 6. A round bottom culvert (CBS) with no embedded gravel.

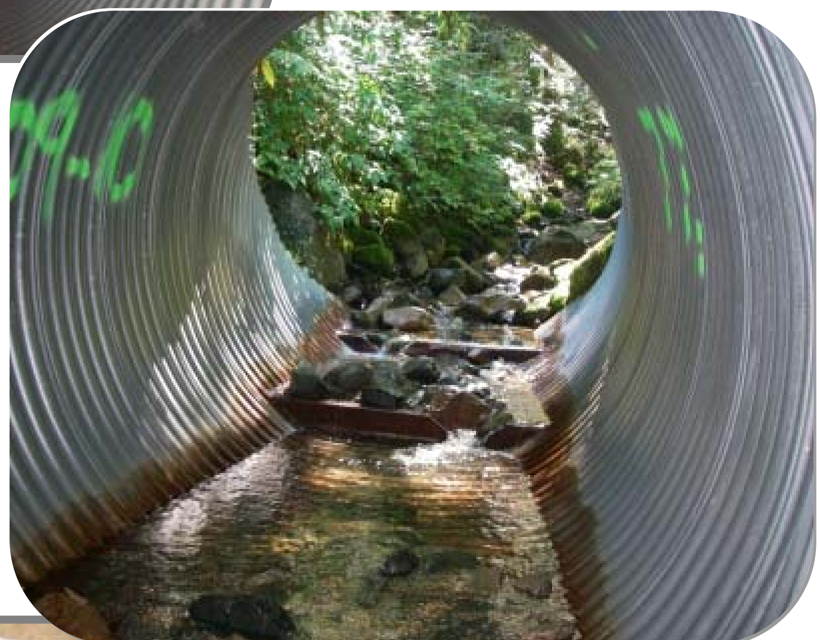

FIGURE 7. A round bottom culvert (CBS) with baffles to retain bed-load and create a more variable velocity profile.

FIGURE 8. An elliptical arch culvert (OBS) retains the natural

Determining Fish Passage

The Board examined fish stream crossings in the Louis, Heffley, and Campbell/Memekay watersheds in August 2007. It also estimated fish passage on streams in north central interior watersheds, using information originally collected at stream crossings for water quality management purposes (Stream Crossing Quality Index – SCQI).

The SCQI method estimates sediment yield at stream crossings, and was not originally developed to evaluate fish passage. However, the site and structure measurements are nearly identical to those used for fish passage assessment. Appendix 1 has a detailed description of how SCQI data were used for assessing fish passage. Investigators cross-checked the two methods to ensure consistency of results.

FIGURE 9. Elevated culvert outlets, with no plunge pool, prevent fish passage. Fish barrier score of 15.

At each crossing with a CBS, the likelihood of a barrier to fish passage was estimated based on the cumulative score of five criteria:

1. degree of embedment
2. outlet drop
3. slope
4. stream width ratio (SWR) (calculated by dividing upstream channel width by culvert diameter)
5. culvert length

The scoring table is provided below. A score of 0 is considered a "low likelihood," a score between 1 and 19 is considered as a "moderate likelihood"and a score of 20 or greater is considered as a "high likelihood" of being a barrier to fish passage.

TABLE 1. Fish Barrier Scoring (Ministry of Environment 2007)[3]

Likelihood of Fish Barrier	Embedded*	Score	Outlet drop (cm)	Score	Slope (%)	Score	SWR	Score	Length (m)	Score
Low	> 30 cm. or 20% of D	0	< 15	0	< 1	0	1.0 or <	0	< 15	0
Mod			15 – 30	5	1 – 3	5	1.0 – 1.3	3	15 – 30	3
High	< 30 cm or 20% of D	10	> 30	10	> 3	10	> 1.3	6	> 30	6

[3] BC Ministry of Environment, *Protocol for Fish Passage Determination of Closed Bottomed Structures*, 2nd edition, June 19, 2007.

OBS are mainly bridges and arch culverts. Properly constructed open bottom stream crossing structures normally are not a barrier to fish passage. On rare occasions, these structures form a partial barrier because they narrow the stream channel by, for example, placing bridge abutments within the stream channel.[4] For our purposes—a landscape scale assessment of fish passage issues—we assumed that all OBS have a low likelihood of being a barrier to fish passage.

The investigation used the method[5] recommended by the Ministry of Environment[6] for operationally assessing the likelihood of fish passage based on crossing characteristics. The investigation did not involve actual observed fish passage through the structures. To conclusively prove fish passage, the Board would need to gather much more detailed data on water velocity at different flow stages, along with fish sampling (minnow traps and electro-fishing), both above and below culverts at these different flow stages. However, the assessments conducted allowed the Board to make reasonable inferences regarding the likelihood of fish passage at these locations.

Also, this investigation does not assess whether there is a material adverse effect on fish passage, as stipulated in FRPA. Therefore, the results of this investigation document the relative risk of all crossings to fish, but cannot be used to conclude that there is non-compliance on any specific site or sites.

Fish passage is more complicated than many people realize. The importance of fish being able to move upstream, through a crossing, can vary by time of year (with fluctuating water levels) and by life stage of the fish (small fry vs. fully grown adults). All stages and conditions need to be kept in mind when assessing fish passage. This also relates to the likelihood of a barrier—a crossing may be fine at certain times of the year, but not others. Or it may pass larger fish, with smaller fry not able to maneuver through the culvert flow.

Assessing Habitat Value

The habitat value of the stream reach immediately above the crossing is a subjective classification based on the physical characteristics of the stream that make the stream suitable for spawning or rearing (see Table 2). The Board assessed habitat value using the criteria below in the Louis, Heffley, Memekay, and Campbell Lakes watersheds. Appendix 1 has a detailed description of how SCQI data was used for assessing habitat value.

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[4] We estimate that issues of this kind may have occurred in as little as three percent of the open bottom structures in the sample.

[5] Since the field work was done, the Ministry of Environment has made some improvements to the methodology. With the revised method, the overall result is unlikely to change but there may be some difference at individual sites.

[6] The revised (2008) method has been adopted by the provincial fish passage assessment working group as the official method for assessing fish passage in BC. See www.for.gov.bc.ca/hcp/fia/landbase/fishpassage.htm.

TABLE 2. Habitat Value Criteria (Forest Practices Code, Fish Stream Crossing Guidebook, 2002).

Habitat Classification Upstream of Crossing Site	Fish Habitat Criteria
Critical	• The presence of high-value spawning or rearing habitat (e.g., locations with abundance of suitably sized gravels, deep pools, undercut banks, or stable debris, which are critical to the fish population downstream of the subject crossing).
Important	• Important migration corridor. • Presence of suitable spawning habitat • Habitat with moderate rearing potential for the fish species present.
Marginal	• The absence of suitable spawning habitat, and habitat with low rearing potential (e.g., locations with distinct absence of deep pools, undercut banks, or stable debris, and with little or no suitably sized spawning gravels for the fish species present).

FIGURE 10. An example of a concrete pipe culvert on a marginal habitat stream.

FIGURE 11. An example of a CBS culvert on an important habitat fish stream. The outlet drop and the length of the culvert, with no velocity refuge, is a partial impediment to fish passage.

Results

A total of 1,110 crossings, located on fish-bearing streams, were reviewed for this project. These crossings include all stream crossings on active roads in each of the watersheds. The Board conducted field-based assessments specifically designed to assess fish passage in the Louis Creek, Heffley Creek, and Campbell/Memekay watersheds. In the other watersheds, data previously collected primarily for the purpose of assessing the impacts of stream crossings on water quality was used.

Types of Crossings Used

Table 3 and Figure 14 show the distribution of crossing types (open bottom and closed bottom) in the three habitat types (marginal, important and critical). Six hundred and eighty-two (61 percent) were closed bottom structures (CBS) and 428 (39 percent) were open bottom structures (OBS). Half of the stream crossings (557) were on marginal fish habitat and half were on important or critical habitat. OBS, which are highly likely to provide fish passage, were used on 66 and 77 percent of important and critical habitat crossings, respectively, but only on 9 percent of marginal habitat crossings. There was significant variation among watersheds (Figure 15).

TABLE 3. Summary of the use of open bottom structures and closed bottom structures by habitat type.

		Habitat Type		
	Total Crossings	Marginal	Important	Critical
CBS	682	509	142	31
OBS	428	48	277	103
TOTAL	**1110**	**557**	**419**	**134**

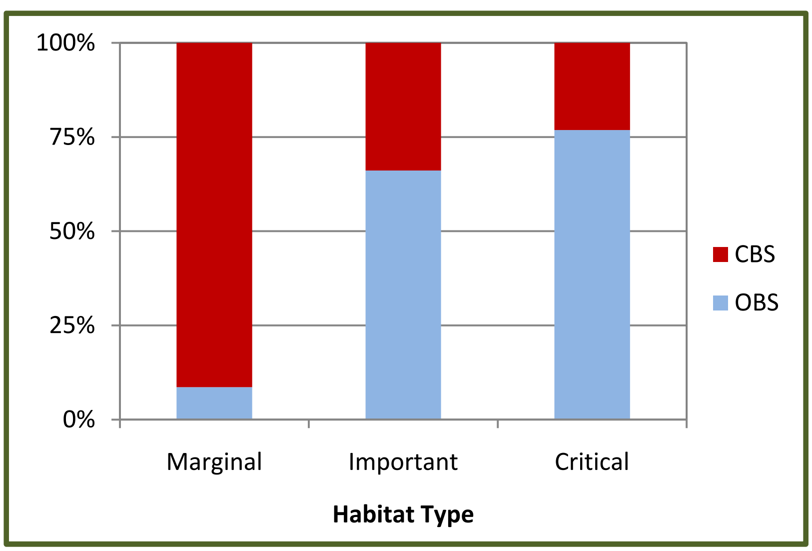


FIGURE 12. Percentage of habitat type that has CBS or OBS crossings.

About 91 percent of the stream crossings on marginal habitat used CBS (Figure 12, Table 3). The use of CBS on both important and critical habitat was far less common (Figure 12, Table 3). Because the proportional use of the two types of structures on important and critical habitat was similar and the number of crossings, in the sample, on important and critical habitat was similar to the number of crossings on marginal habitat, the Board collapsed the important and critical habitat types into a single category for the remainder of the discussion.

Fish Passage

Table 4 shows, for each individual watershed and for the study area as a whole, the likelihood of success in fish passage by habitat type.

TABLE 4: Proportion of crossings with low likelihood of being a barrier, by habitat type and overall.

Watershed	Percent of crossings passing fish ok (low likelihood of barrier)[7]		
	Marginal	Important or critical	Overall
Campbell –Memekay	41	69	59
Heffley Creek	17	50	30
Louis Creek	10	56	31
West Torpy	3	75	20
Hubble Creek	8	73	32
Basin #7	50	80	71
Basin F	100[8]	94	94
Basin C	9	53	23
Mokus Creek	29	83	54
Horn Creek	20	96	72
Lower Seeback	14	78	33
Upper Olsson	2	84	25
Tay Creek	15	84	56
Burnt Creek	18	86	50
Babine Corridor	11	56	36
Nichyeskwa	4	39	23
Houston Tommy	7	56	38
McBride	11	65	48
Lamprey	3	49	29
Total over all watersheds	**12**	**72**	**42**

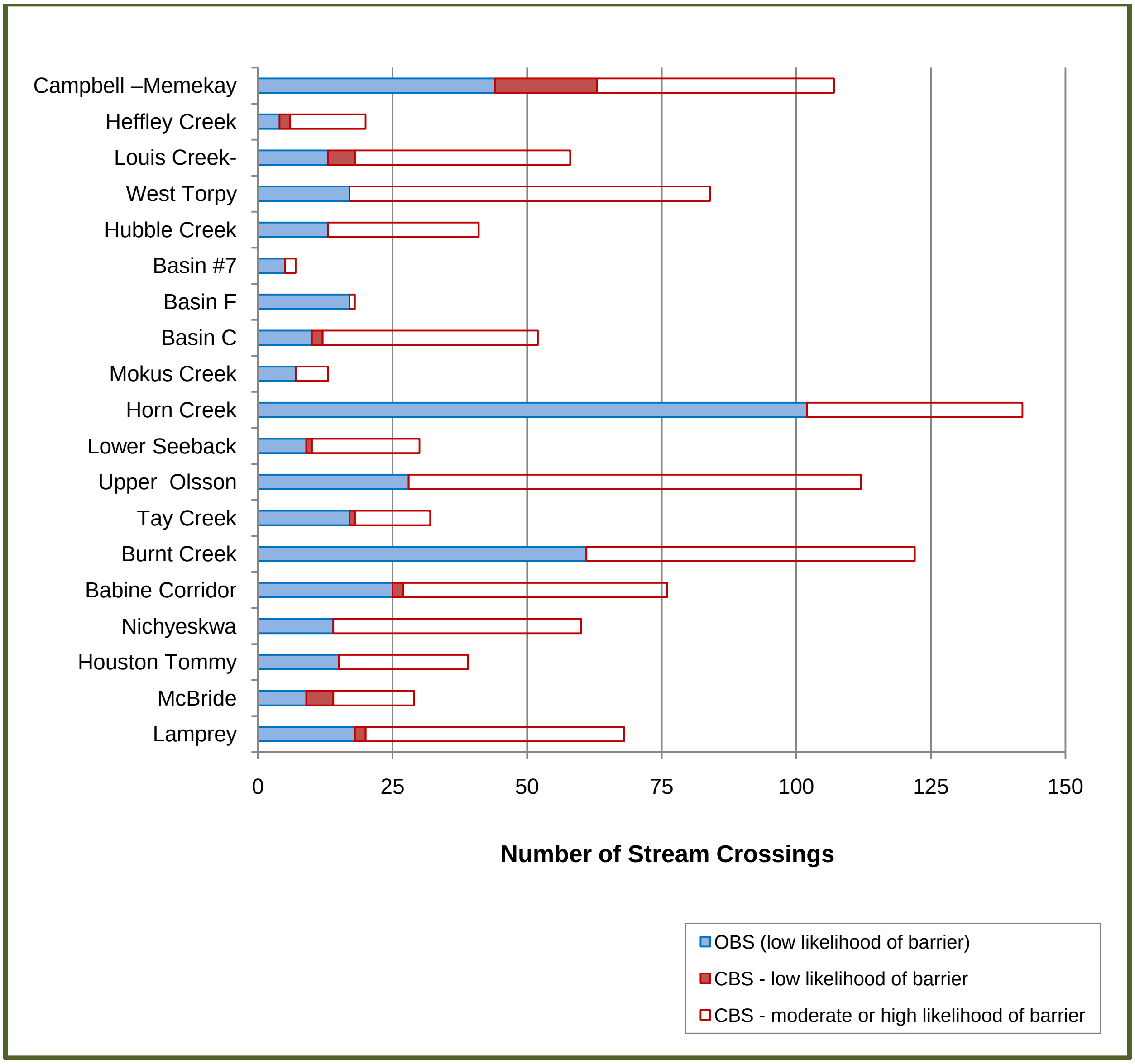
[7] The data used to calculate these percentages is found in Table A-3 on page 24.

[8] There were only two crossings of marginal habitat, and both were open bottom structures.

Overall

The Board examined the total performance for fish passage in each of the watersheds, with their mix of habitat types and OBS and CBS crossings. The proportion of crossings that had a low likelihood of being a barrier to fish ranges from 20 to 94 percent (Table 4) among individual watersheds. The proportion for all 19 watersheds is 42 percent. This wide range among watersheds was primarily due to differences in the relative use of OBS and CBS crossings (Figure 13).

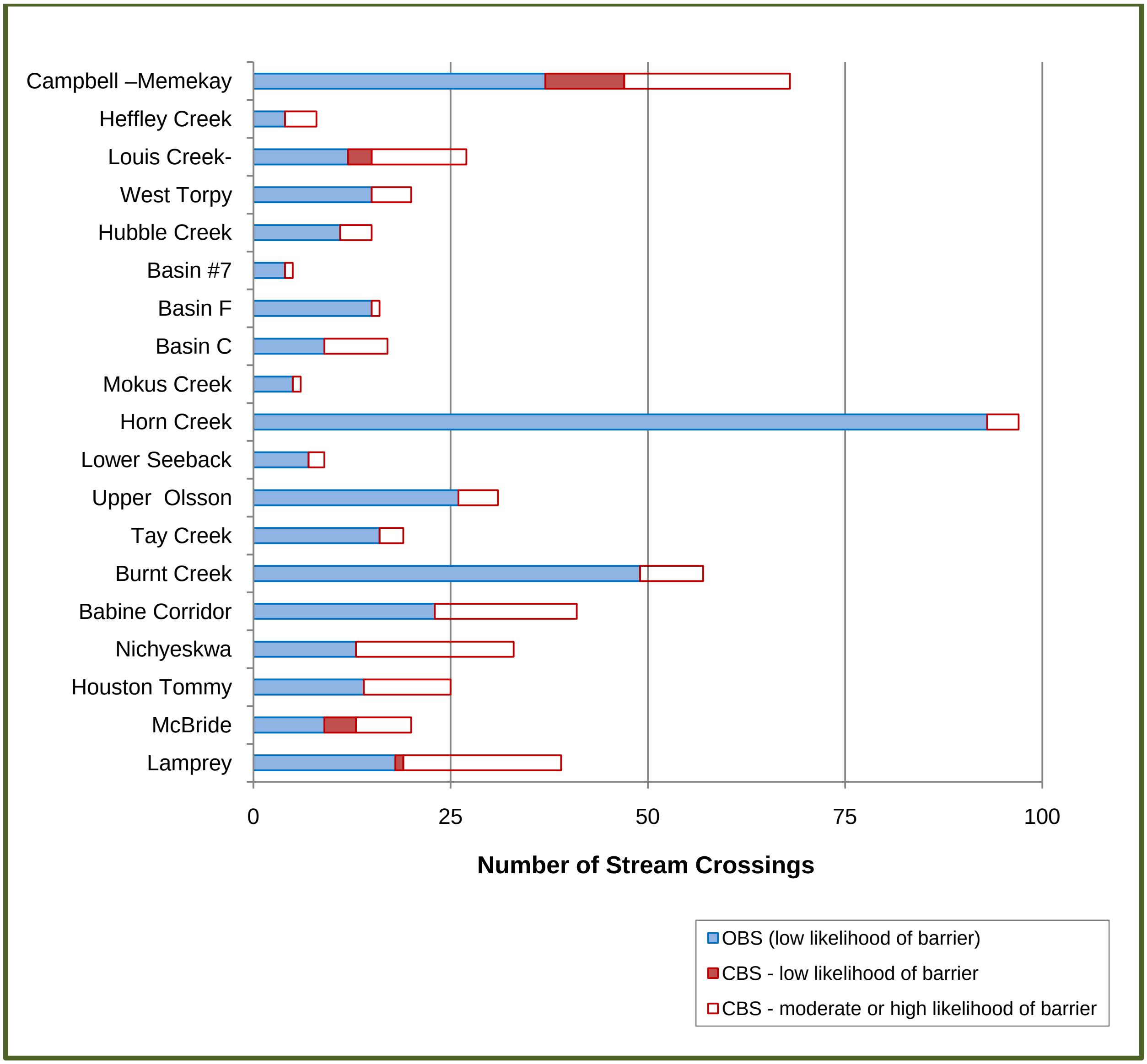
FIGURE 13. The total number of crossings by crossing type and by fish passage likelihood.



By Stream Habitat Type

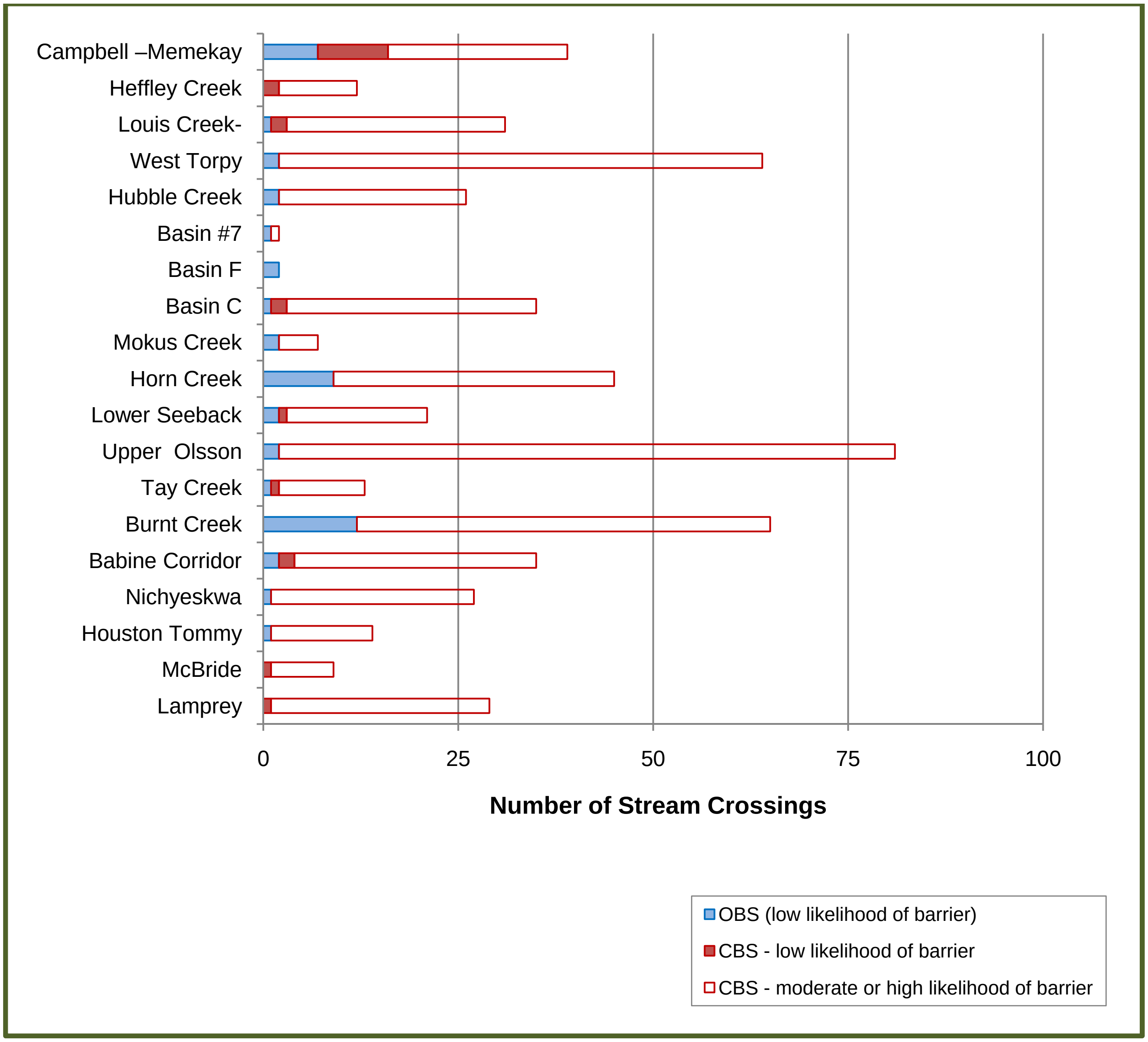
On important and critical habitat streams, 72 percent of crossings had a low likelihood of being a barrier to fish passage (Table 4). On individual watersheds, 39 percent to 96 percent of crossings on important and critical habitat had a low likelihood of being a barrier (Table 4). OBS are used much more frequently on these fish streams (Figure 12), which accounts for most of the success in crossings of this habitat (Figure 14). However, 28 percent of crossings on important and critical fish habitat pose a risk to fish passage.

FIGURE 14. The number and type of crossings and fish passage likelihood on important and critical habitat streams.



Conversely, on marginal habitat, only 12 percent of crossings had a low likelihood of being a barrier to fish passage (Table 4). This is much lower than the overall total of 42 percent because the vast majority of crossings on marginal habitat were CBS (Figure 14), and almost all of those crossings presented a moderate or high likelihood of a barrier to fish passage (Figure 15). While an individual crossing on marginal fish habitat may not produce a significant fish habitat loss, the cumulative amount of lost habitat across a watershed could be significant.

FIGURE 15. The number and type of crossings and fish passage likelihood on marginal habitat streams.



By CBS Crossings Only

CBS crossings almost always represent a moderate or high likelihood of a barrier to fish passage (Table 5). CBS crossings on marginal habitat were likely to be a barrier to fish passage 96 percent of the time; on important and critical habitat, they were likely to be a barrier 90 percent of the time (Table 5). Twenty-five percent of the CBS structures were used in crossings of important and critical habitat (Table 5).

TABLE 5. Summary of fish passage likelihood on closed bottom structures by habitat type.

	Marginal Habitat			Important or Critical Habitat		
Likelihood of Barrier	Low	Moderate	High	Low	Moderate	High
Number of Crossings	21	233	255	18	70	85
% of all CBS crossings	3%	34%	37%	3%	10%	12%
% of CBS with a moderate or high likelihood of a barrier	96%			90%		

Cumulative Impacts

The Louis Creek Watershed is an interesting example of the cumulative effect of forestry, agriculture, highways and residential development on fish passage. The watershed is 15,000 square kilometres in size and is located 50 kilometres north of Kamloops, where it flows into the North Thompson River, near Barriere. There are extensive areas of forestry on the hillslopes, and most of the valley bottom land is under cultivation in forage production. The Sun Peaks ski resort, with residential development, occupies part of the watershed around one tributary, and there is highway access to the resort that has been built through it. Historically, Louis Creek was the largest Coho run in the North Thompson system.

Fifty eight fish-bearing stream crossings were examined in the Louis Creek Watershed. Eighty-nine percent (40 of 45) of CBS crossings had a moderate to high likelihood of being a fish passage barrier. There may be still resident fish populations above these potential barriers. The investigation team estimates that CBS may be restricting fish access to over 20 percent of the 150 kilometres of fish habitat in the watershed. The team also observed that, on average, CBS crossings on important or critical habitat potentially alienated 10 times the length of stream as those on marginal habitat.

The impact is the cumulative result of four land-use footprints—forestry, agriculture, highways and residential development. The forestry crossings are the most numerous, but affect mostly marginal fish habitat. The crossings associated with agriculture, highways and residences are fewer in total, but a larger percentage of them are on stream reaches with important or critical habitat. Additionally, each of these crossings affect far more habitat, on average, than each crossing associated with forestry.

A second example is provided by Heffley Creek, adjacent to Louis Creek. Here, a steep four-metre culvert plunges for 250 metres beneath two railway lines and a twinned highway before a waterfall drop of five metres to the North Thompson River, completely cutting off anadromous fish access to the watershed, which has over 40 kilometres of fish habitat.

These examples demonstrate that, in some watersheds, there are multiple land use footprints that may be associated with stream crossings affecting fish habitat and that a cumulative impact analysis is needed to fully describe the risks to fish in a watershed.

Discussion

The results show that fish passage may be a significant issue in many of the watersheds examined. Where there is a risk to fish passage, it is most likely the result of a CBS – a culvert. These conclusions, especially for CBS, are consistent with those of other studies. This report adds some insight into the overall situation, taking into account the use of OBS crossings in these watersheds.

The Board did not examine the cause of fish passage problems. In some cases, it may have been due to poor culvert installation, while in others it could be a maintenance issue. There are inevitable problems that come with time, such as sediment and debris blocking culverts, or plunge pools and outlet drops forming over time and making it impossible for fish to access the culvert and move upstream. Such problems need to be addressed through maintenance.

Amount of Habitat at Risk

All of the stream crossings examined were on fish-bearing streams (or streams presumed to be fish bearing by forest licensees). Many of the problem structures were on marginal habitat, but the cumulative effect of lost habitat above so many crossings may be significant. Further, many of the CBS were on important or critical habitat.

The Board also mapped all of the crossings in each watershed. Those maps are available on the Board's website at www.fpb.gov.bc.ca. The maps show that crossings at high risk of preventing fish passage are often located in the lower reaches of streams, which then cuts off fish access to large amounts of upstream habitat. The number of at-risk crossings is only one consideration—the location of the crossing in the stream system may be much more important. The Board concludes that, overall, there may be a significant amount of fish habitat at risk as a result of stream crossings that impede fish passage.

Restoration of Fish Passage

Over the past 15 years, there have been a number of government programs to restore fish habitat. This has included fish stream crossing restoration on pre-Code roads under the Forest Renewal BC Watershed Restoration Program (WRP), as well as some Forest Investment Account (FIA) projects. It was evident in our investigation, however, that not all of the pre-Code problems have been fixed. In particular, older stream crossings on mainline forest service roads, which were ineligible for WRP funding, continue to prevent fish passage into the rest of the watershed.

Fish passage is a growing concern because the number of stream crossings within British Columbia is constantly increasing with new road development. The Fish Passage Technical Working Group,[9] as part of a *Strategic Approach to Fish Passage in British Columbia*, recently published new fish passage assessment protocols, and announced that priority watersheds will be identified across the province for restoration of fish passage. The provincial FIA has funded inventories of CBS in priority watersheds, and is currently targeted at pre-Code status roads on Crown forest land. FIA will not fund restoration activities on forestry roads built after 1995, highways or railway crossings.

This investigation shows that CBS continue to be used on fish streams, including some on important and critical habitat, and that they pose a risk to fish passage. These crossings should logically be priorities for restoration of fish habitat.

Enforcement

This investigation showed that many stream crossings established under the Code (or FRPA) are likely barriers to fish passage. That leads to the question of whether government is enforcing the fish passage requirements of the legislation.

The Code regulated the maintenance of fish passage through stream crossings under the 1995 *Forest Road Regulation*, Section (9)(1)(h) [construction] and 13(2)(d) [maintenance]. A brief review of some 500 Ministry of Forests and Range (MFR) administrative determinations, from 2004 to September 2008, found only three cases involving maintenance of fish passage, all under the Code.

The *Forest Planning and Practices Regulation* (FPPR; section 56) under FRPA requires those carrying out forest activities—such as construction and maintenance of fish crossings—to ensure the activity does not have a "material adverse effect" on fish passage. Section 57 requires forestry activities to be carried out so as to be, "unlikely to harm fish or destroy, damage or harmfully alter fish habitat."

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[9] The working group consists of representatives of the provincial Ministries of Environment, Forests and Range, the provincial Integrated Land Management Bureau and the federal Department of Fisheries and Oceans.

During development of this report, it became apparent to the Board that there are differences of opinion among enforcement agencies about what constitutes a material adverse effect on fish passage, and how the assessment methodology for fish passage should be interpreted in the context of enforcement of the legislation.

MFR's Compliance and Enforcement Branch points out that proof of a FRPA contravention of section 56 will require proof of a material adverse effect on fish passage, and this is not directly linked in the legislation to the fish passage scores using the methodology applied in this investigation. However, the federal Department of Fisheries and Oceans (DFO) considers any impairment of fish passage to be a material adverse effect.

The inter-agency fish passage working group (MOE, MFR, DFO) is discussing these issues, and the Board encourages the agencies to come to an agreement on how the fish passage protocol is to be interpreted (i.e., what constitutes a material adverse effect) and how the legislation should be enforced.

The Board is also advised that the fish passage working group has been developing and delivering training on fish passage to field staff. These extension efforts are an important component of addressing this problem.

The Board notes that the concept of "materiality" is common in environmental legislation; it does not appear to be limiting the success of enforcement actions in those enactments.

Conclusions

This study shows that, for the 19 watersheds examined, 42 percent of all stream crossings in fish-bearing habitat have a high likelihood of passing fish, with individual watersheds ranging from 20 to 94 percent. The remainder have a moderate to high risk of causing fish passage problems. For important and critical habitat, 72 percent of crossings have a high likelihood of passing fish; for marginal habitat, the number is only 12 percent.

Open bottom structures were used on 39 percent of all crossings, including 66 and 77 percent of crossings of important and critical habitat, respectively. Open bottom structures account for most of the observation of success in providing for fish passage.

Fish passage is often highly impeded by closed bottom structures, which were used in 61 percent of the stream crossings. They were used in 90 percent of crossings of marginal habitat, where they presented a moderate to high risk to fish passage in 96 percent of cases. Closed bottom structures were also used on 34 percent of the stream crossings of important habitat and 23 percent of the crossings of critical habitat, where we found that they present a risk to fish passage in 90 percent of the cases. These crossings should be a priority for inspection and restoration work.

Stream crossings in the lower reaches of streams can cut off access to large amounts of fish habitat in some cases. Similarly, the cumulative amount of fish habitat lost to many inadequate crossings of marginal habitat can also be substantial.

Stream crossings on forestry roads are not the only source of risk to fish passage. Highways, residential development, agriculture and other developments in watersheds can and do produce crossings that impede fish passage.

This study leads the Board to conclude that road crossings constitute a widespread risk to fish passage in these watersheds, especially when closed bottom structures are used.

Enforcement of legislative requirements to ensure fish passage is an issue and enforcement agencies do not currently agree on what constitutes a material adverse effect on fish passage and how to assess and enforce its maintenance.

Recommendation

This investigation has shown that there is a serious impediment to fish passage in many watersheds in BC. Much of the risk is from forestry road crossings that use closed bottom structures. Other developments, such as highways and railway crossings, also impact fish passage and can cut off access to significant amounts of valuable fish habitat.

Accordingly, the Board makes the following recommendation:

1. The Board recommends that government take the necessary actions to ensure fish access to valuable habitat is maintained and restored.

The Board requests that government advise it of the steps that are taken to address this issue by December 31, 2009.

Appendix 1

Fish Passage and Habitat Quality Determination

This appendix describes in detail how the fish passage determination and the habitat quality determination was made for the watersheds in northern BC.

The passage and habitat quality was determined using data originally collected at stream crossings for water quality management purposes (the Stream Crossing Quality Index – SCQI). This indicator evaluates the size and characteristics of sediment sources in the vicinity of stream crossings and assesses the potential for that sediment to reach the aquatic environment.

Although this indicator was not created to evaluate the effects of the stream crossing on fish passage, the data collection procedure does require that specific information about the stream crossing be collected. Much of these data are very similar to the data collected for a typical fish passage assessment.

The following lists the relevant data that are routinely collected as part of completing an SCQI survey:

1. Site ID
2. GPS coordinates
3. Structure type (bridge, culvert, and fjord, no structure, de-activated)
4. Culvert size (mm)
5. Bankfull width (m)
6. Bankfull depth (m)
7. Stream width class
8. Stream gradient
9. Stream gradient class
10. Percent of culvert plugged
11. Functional condition of structure
12. Culvert outfall drop (cm)
13. Substrate in culvert (Y/N)
14. Constricted flow (Y/N)
15. Numerous photographs of each crossing

Although this information does not provide the perfect database for completing a comprehensive assessment of fish passage, it is adequate to provide a good indication of the extent of fish passage problems at the landscape level (i.e., the percentage of stream crossings that create a fish passage concern) for different fish habitat types.

The Ministry of the Environment protocol for determining the likelihood of fish passage barriers of closed bottom structures(CBS)[10] uses data collected at the stream crossing to compute a fish barrier score (FBS) for CBS. The determination of the likelihood of a CBS causing a barrier is based on the cumulative value of five criteria that describe the crossing. These criteria are:

1. Degree of embedment
2. Outlet drop
3. Slope
4. Stream width ratio (SWR) (calculated by dividing upstream channel width by culvert diameter)
5. Culvert length

A cumulative value of 20 or greater has been established as a threshold value that indicates a high likelihood of the CBS being a barrier to fish passage. The protocol document describes in detail the methodology that should be used to measure each of these criteria in the field. The scoring table is provided below, where a score of 0 is considered a "low likelihood" (little or no barrier), a score between 1 and 19 is considered a "moderate likelihood" (or partial barrier), and a score of 20 or greater is considered a "high likelihood" (or full barrier) to fish passage.

TABLE A-1. Fish Barrier Scoring (Ministry of Environment 2007).

Likelihood of Fish Barrier	Embedded*	Score	Outlet drop (cm)	Score	Slope (%)	Score	SWR	Score	Length	Score
Low	> 30 cm. or 20% of D	0	< 15	0	< 1	0	1.0 or <	0	< 15	0
Mod			15 - 30	5	1 - 3	5	1.0 - 1.3	3	15 – 30	3
High	< 30 cm or 20% of D	10	> 30	10	> 3	10	> 1.3	6	> 30	6

For this project, the SCQI data were used, along with the fish barrier scoring protocol (Table A-1), to determine the likelihood of a given crossing of being a fish barrier. The SCQI database provides direct field measurements for three of the five criteria for each crossing surveyed (i.e., outlet drop, slope, and SWR).

However, the SCQI protocol does not require the measurement of culvert length nor the measurement of "embedment" as described in the fish passage protocol, thus estimates needed to be made for these two criteria. For the criterion "culvert length," the Board assumed that for all roads designated as a main line forest service road, the culvert would be longer than 30 metres and that for minor branch roads the culvert length would be less than 15 metres. For all other roads, we assumed a length of between 15 and 30 metres (i.e., a score of 3). For the "embedment" criterion, it was assumed that, by default, the culvert was not embedded unless the stream gradient was less than one percent or the photograph, and/or field notes, indicated that it was embedded. Our experience is that it is very rare that culverts are embedded to any significant degree. Consequently, virtually all culverts reviewed for this project received an

[10] Protocol for Fish Passage Determination of Closed Bottomed Structures, 2nd edition, June 19, 2007.

embedded score of 10 (except for those crossings that had a stream slope of less than one percent).

The Ministry of Environment fish passage protocol provides a methodology to assess habitat value at the stream crossing location. The criteria for this assessment are provided in Table A-2 below (extracted from the Ministry of Environment document).

TABLE A-2. Habitat Value Criteria (extracted from Ministry of Environment, 2007).

Habitat Classification upstream of Crossing Site	Fish Habitat Criteria
Critical	• The presence of high-value spawning or rearing habitat (e.g., locations with abundance of suitably sized gravels deep pools, undercut banks, or stable debris, which are critical to the fish population downstream of the subject crossing.
Important	• Important migration corridor. • Presence of suitable spawning habitat. • Habitat with moderate rearing potential for the fish species present.
Marginal	• The absence of suitable spawning habitat, and habitat with low rearing potential (e.g. locations with distinct absence of deep pools, undercut banks, or stable debris, and with little or no suitably sized spawning gravels for the fish species present.

Each of the crossings reviewed in this project was given a habitat value designation based on the criteria provided in Table A-2 and the following procedure.

1. Available fish inventory data were plotted on each of the watershed maps, thus providing some idea of the species distribution of fish within each of the watersheds.

2. Streams less than 0.5 metres in bankfull width were considered as non-fish-bearing unless the site photographs suggested otherwise.

3. The mainstem of all watersheds and major tributary streams were generally considered "critical" habitat. It is important to note that very few CBS were found on these types of habitat as most of these crossings were bridges. When there was a CBS located on a mainstem or major tributary, the stream description data and site photographs were reviewed as part of the habitat designation procedure.

4. The designation of "important" or "marginal" habitat was based on stream size, stream gradient, the photographs that were available for each of the crossing sites and the fish habitat criteria provided in Table A-2. For almost all cases, this information was adequate to make a reasonable assessment of habitat quality.

Appendix 2

Results of fish passage by watershed

A total of 1,159 crossings of fish streams were reviewed for this project. The summary results for the crossings (Table A-3) are tabulated for each watershed, showing the type of crossing and the results (none, partial, total) for each habitat class (marginal, important, and critical).

TABLE A-3. Watershed summaries of number of crossings by habitat type and rating of likelihood of a barrier to fish passage.

				Ratings of likelihood of a barrier to fish passage											
				Marginal Habitat				Important Habitat				Critical Habitat			
	Total Crossings			OBS	CBS			OBS	CBS			OBS	CBS		
Watershed ID	All	OBS	CBS	(assumed low)	low	moderate	high	(assumed low)	low	moderate	high	(assumed low)	low	moderate	high
Lamprey	68	18	50	0	1	17	11	9	1	13	5	9	0	0	2
McBride	29	9	20	0	1	2	6	4	2	4	2	5	2	0	1
Houston Tommy	39	15	24	1	0	6	7	9	0	7	4	5	0	0	0
Nichyeskwa	60	14	46	1	0	9	17	10	0	4	16	3	0	0	0
Babine Corridor	76	25	51	2	2	23	8	17	0	15	1	6	0	1	1
Burnt Creek	122	61	61	12	0	28	25	42	0	3	5	7	0	0	0
Tay Creek	32	17	15	1	1	5	6	13	0	1	2	3	0	0	0
Upper Olsson	112	28	84	2	0	42	37	21	0	4	1	5	0	0	0
Lower Seeback	30	9	21	2	1	11	7	6	0	1	1	1	0	0	0
Horn Creek	142	102	40	9	0	16	20	80	0	1	3	13	0	0	0
Mokus Creek	13	7	6	2	0	4	1	5	0	1	0	0	0	0	0
Basin C	52	10	42	1	2	21	11	8	0	2	3	1	0	0	3
Basin F	18	17	1	2	0	0	0	13	0	0	0	2	0	1	0
Basin #7	7	5	2	1	0	0	1	4	0	1	0	0	0	0	0
Hubble Creek	41	13	28	2	0	18	6	8	0	3	1	3	0	0	0
West Torpy	84	17	67	2	0	29	33	13	0	1	2	2	0	1	1
Louis Creek-	58	13	45	1	2	2	26	3	1	2	6	9	2	1	3
Heffley Creek	20	4	16	0	2	0	10	2	0	0	4	2	0	0	0
Campbell – Memekay	107	44	63	7	9	0	23	10	8	1	10	27	2	2	8
Total all watersheds	**1110**	**428**	**682**	**48**	**21**	**233**	**255**	**277**	**12**	**64**	**66**	**103**	**6**	**6**	**19**

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