2010 Fish Passage Culvert Assessments in Gold River Watershed

FIA Project Number: 7008001

Prepared for:

Western Forest Products Inc.
118-1334 Island Hwy
Campbell River, BC, V9W 8C9

Prepared by:

Mac Jedrzejczyk, M.Sc., RPBio.
FINS Consulting Ltd.
4809 Hamer Ave.
Terrace, BC, V8G 2E5

January 2011

Table of Contents

List of Figures

List of Tables

Executive Summary

In November of 2010, part of the of the Gold River watershed on Vancouver Island within Western Forest Products Tree Farm License 19 was assessed using the 2008 fish passage protocol for closed-bottomed culverts by FINS Consulting Ltd. of Terrace. 748 sites were assessed within the project area.

This watershed exhibits a wide range of stream crossing practices and fish habitat. Most of the high value habitat streams are crossed with bridges and wooden box culverts which provide safe fish passage. There were 54 sites with closed bottom structures on known or potential fish streams that were recommended for remediation of fish passage barriers. However, many of these sites do not have a confirmed fish presence and many do not show up on the provided stream layer. An additional 4 sites were recommended for works due to sedimentation or safety concerns.

Recommendations resulting from this project indicate eight fish passage barriers sites with the highest priority for remediation, fish inventory for unconfirmed areas and remediation of sedimentation and safety issues.

This project was funded by the Forest Investment Account Land Base Investment Program (Project #7008001).

Acknowledgements

I would like to thank to all the people who helped make this project possible. Especially to Christine Petrovcic, who promptly provided all shapefiles for mapping and without any hesitation joyfully explained the meaning of some strange abbreviations; Bruce Creelman whose amazing knowledge of "how to get there and how far" made daily trips to sites a walk in the park; and to Annette Van Niejenhuis for giving supportive tips to polish up this report, providing the "Star Trek gun" clinometer when the wrong equipment arrived, and above all, putting up with me throughout the project.

1. Introduction

FINS Consulting Ltd. (FINS) was retained by Western Forest Products Inc. (WFP) to conduct, funded by Forest Investment Account (FIA), Fish Passage Culvert Assessment in the Gold River Watershed - part of the GOLD Sub-basin on Vancouver Island. The Project Area is located within Tree Farm License 19 (TFL 19) and managed by WFP for forest management. The fieldwork was conducted from November 12 – 24, 2010.

GOLD sub-basin is the fifth highest priority sub-basin for assessment of fish passage on Vancouver Island according to scoring system developed in 2007 by the BC Ministry of Environment. Gold River watershed is the highest ranking among 67 units within GOLD Sub-basin.

2. Study Area

The study area includes the main stem of the Gold River basin located west of Strathcona Provincial Park and 10 smaller polygons covering 217.2 km² (Figure 1). Watersheds within the project area are listed in Table 1 below.

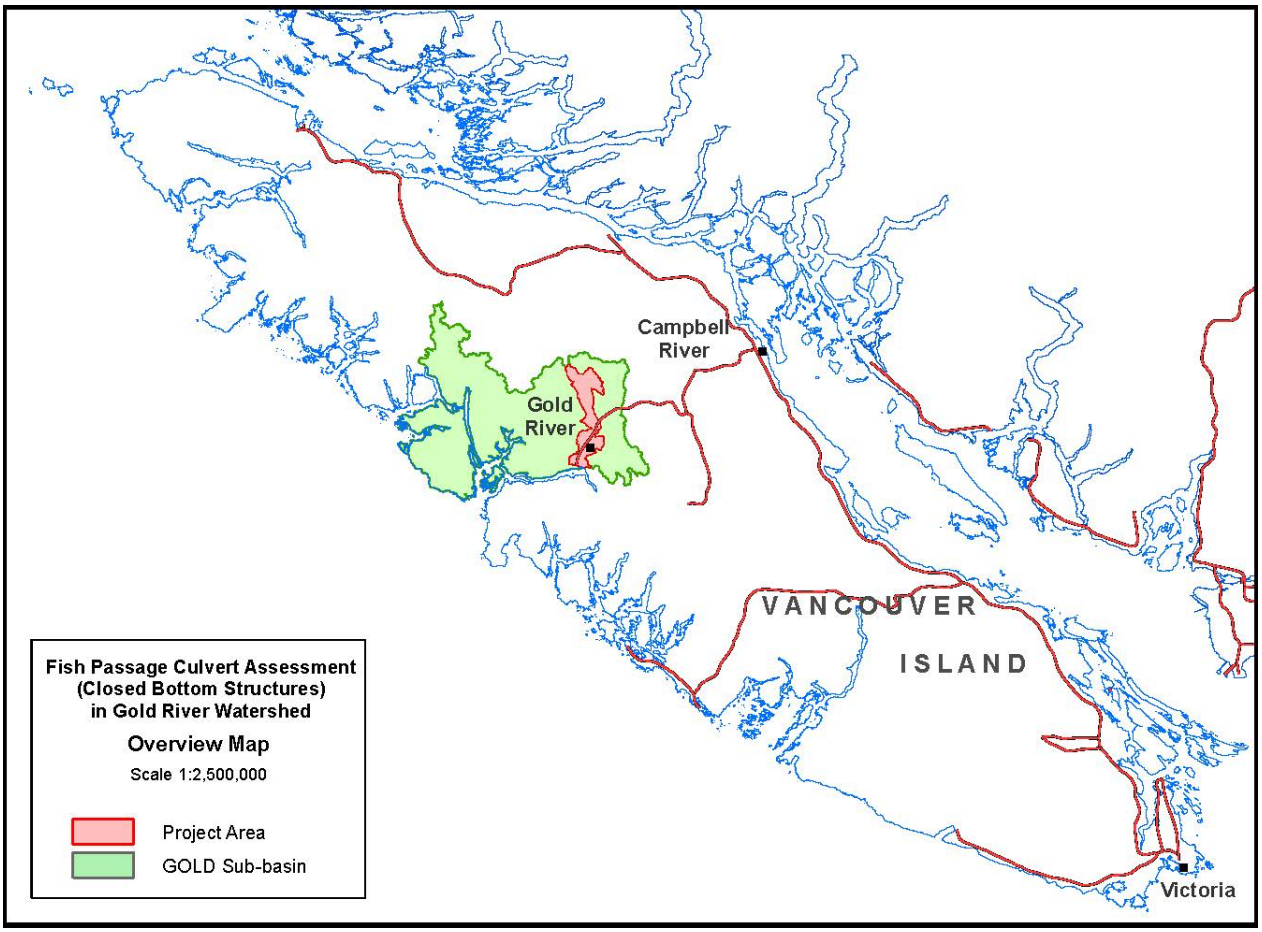

Figure 1. Study Area

Table 1. Watersheds within Project Area.

Watershed Code	Name	Area (km²)
930-511600	Gold River	146.6
930-511600-01500	Ahaminqas Creek	10.2
930-511600-26000	De Loriol (Siwash) Creek	5.5
930-511600-31900	Antler Lake Creek (alias)	7.7
930-511600-36800	Unnamed	3.6
930-511600-41500	Unnamed	2.9
930-511600-54300	Unnamed	3.3
930-511600-66500	East Waring Creek	17.5
930-511600-66500-30700	West Waring Creek (alias)	4.0
930-511600-78700	Trio Creek (alias)	14.8
930-511600-78700-03900	West Trio Creek (alias)	5.0

The Project Area is located within the windward part of Vancouver Island in mainly coastal western hemlock biogeoclimatic zone. Mild climate with plentiful rainfall results in an extended growing season and an abundance of watercourses. Because of the terrain ruggedness and precipitation, streams are generally well oxygenated, fast flowing, and have high flow fluctuations due to intense and frequent precipitation. Larger streams often exhibit torrential channel characteristics. Fish habitat in these streams is poor overall due to low nutrient contents and is limited to the narrow valley along Gold River and its larger tributaries.

Since the 1960s, resource roads, hydro maintenance roads, and the highway have been built within the watershed with the purpose of accessing and processing timber and connecting local communities to the urban centres. The road system is generally at the valley bottom running along Gold River and its larger tributaries and therefore affecting stream habitat. Some of the streams have been diverted from their original channels during road construction and their connectivity to fish-bearing waters and fish presence is questionable at present.

3. Methods

3.1 Standards

Work was completed in accordance with the following:

a. General FIA Standards (FS1001);
b. Field Assessment for Fish Passage Determination of Closed Bottom Structures 3rd Edition (May 2009);
c. Protocol for Fish Passage Determination of Closed Bottom Structures (May 2008);

d. The Strategic Approach: Protocol for Planning and Prioritizing Culverted Sites for Fish Passage Assessment and Remediation 3rd Edition March, 2009;
e. Field Data Submission Form (2010);
f. Data Submission Standards for Closed Bottom Culvert Assessment Projects 2009-10;
g. Land Base Investment Program Update (September 2010).

3.2 Phase 1 - Sampling Plan Development

Prior to preparation of sampling plan for the project area, WFP provided pertinent mapping layers containing stream network, 20m contours, road network, and water bodies. Next, all necessary and available fisheries information were collected from EcoCat, FISS database, Habitat Wizard (formerly Fish Wizard), and WFP fisheries data.

Data containing known fish distribution limits, anadromous and/or sport fish use, location of fish barriers, and known fish absence were assembled, compiled and transferred onto stream network. Streams with no fisheries information were split at 25% gradient using GIS software into fish bearing and non-fish bearing sections. Non-fish bearing streams were considered upstream of continued stream gradient greater than 25% and streams with gradients 25% or lower were assumed fish bearing. The inferred type of fish use in these streams was derived after analysis of their location, gradient, connectivity to known fish streams, magnitude and professional judgment. Streams then were divided into six categories depending on the type of fish use and were depicted on field maps by different colours:

1. Documented anadromous and sport fish use – solid orange.
2. Assumed anadromous and sport fish use – dashed orange.
3. Documented sport fish use - solid red.
4. Assumed sport fish use - dashed red.
5. Documented non-fish bearing – solid blue.
6. Assumed non-fish bearing – dashed blue.

In the next step, modeled streams were intersected with the road network and cross points located downstream of 25% slope gradient were marked. Because the provided stream network was discontinuous, supplementary cross points were added after analysis of existing stream sections and contour pattern with an aid of GIS software and available ortophotos. The cross points on the confirmed non-fish streams were then removed and the final crossings' location were established.

The identified crossings on roads longer than 4km were then pre-labeled with sequential and increasing three digit identifiers from the road's "0 KM" mark. Identifiers were spaced every 10 digits (i.e. 210, 220, 230) with the purpose of accommodating crossings on unmapped streams and/or the existing cross drains. This way of labeling was to streamline the field work in order to avoid possible repetition of the same crossing ID in field cards for two different crossing and/or in cases where work would be carried out from two different locations on the same road.

To avoid redundant assessments, road sections located within greater than 25% slopes were excluded from the survey. Assessment of all eligible roads located on hills and paralleling those in valleys were to be commenced after valley roads crossings were assessed to be on fish streams. Deactivated roads were included in the assessment after WFP staff (Christine Petrovcic – pers. comm.) informed that some of the crossing structures may still be in place.

Due to the lateness in season and risk of snowfall the assessment would begin on qualified roads at higher elevations and gradually would proceed towards Gold River mouth.

As per the amendment of Sept 1, 2010 in the Land Base Investment Program Update selected crossings were not prioritized by road age.

In final, crossings on 190km of the roads were identified for assessment.

Prior to field work, the plan was discussed and amended during pre-field meetings in WFP offices in Campbell River and Gold River, incorporating all the most recent information pertinent to this project.

3.3 Phase 2 - Data Collection

Data collection followed the 2008 protocol and amendments from 2009 and 2010, and adhered to the sampling plan. Many crossings were wooden box culverts, bridges, deactivated, or had NCD (non-classified drainage) status. All sites had crossing structures described and UTM coordinates were recorded using professional GPS with differential correction (Ashtech MM100). Full assessment sites and sites with safety issues were photographed.

Out of the closed-bottomed stream crossings assessed for fish passage, some had no fish potential due to steep gradient and/or lack of habitat. Some were above in-field identified barriers and many require further inventory to confirm fish presence.

Crossings requiring works for safety or erosion risks were noted.

For CBS sites with fish potential, the following information was gathered:

- Location and Survey Data
  - Date
  - Crossing ID Number
  - Crew Names
  - UTM coordinates
  - Stream Name if was available
  - Road Name and Kilometer if available
  - MFR District
  - Crossing Type (RC = round culvert; PA = Pipe Arch; EC = Embedded Culvert; EA = Embedded Pipe Arch)

- Fish Passage Criteria
  - Embedded
  - Culvert Dimensions
  - Culvert Slope (%)
  - Downstream Channel Width
  - Outlet drop (cm)

- Site Information
  - Outlet Residual Pool Depth (cm)
  - Downstream Stream Slope (%)
  - Habitat Value
  - Depth of Fill (cm)
  - Valley Fill (indication of amount of bedrock)
  - Beaver Activity
  - Inlet Drop
  - Backwatered
  - Fish Sighted
  - photo documentation (inlet, upstream, outlet, downstream, barrel)
  - Comments

Over the course of field work it was noted that many crossings were over unmapped streams or location of the streams differed from those mapped. This caused uncertainty in some situations and resulted in the assessments of crossings over documented non-fish streams. However, there are only a few of these redundant sites.

Several of the roads planned for a visit were deactivated and the “Deactivation Warning” sign was posted at the start of the road. After inspection of two such roads for leftover structures and not finding any, all other roads with this sign were excluded from field visit. Road E82 was just deactivated with dozens removed culverts stored at the entrance. All these roads are listed below:

- Road E10
- Road E19
- Road E25
- Road E82
- Road W32
- Road W34
- Road W37
- Road W37E
- Road W40
- Road ZJ1

- Road ZMC
- Section of the old Gold River Main
- Water Tower Access

Several of the mapped roads and planned for a visit were completely overgrown by 30-40 year old trees and practically became part of the regenerating forest. Such roads were not inspected and they include:

- Road E77
- Road E85
- Road M21A west section
- Road ZM1A

No need for inspection of some designated roads paralleling the main roads was determined after main road crossings on downhill side were established to be over non-fish bearing streams.

Overall, out of 190km of planned roads for crossing assessment 25km were completely deactivated, 41km became redundant, and 125km were inspected.

3.4 Analysis

According to the standards, once the data gathering has been completed, the analysis phase is used to produce a ranked list for restoration. Ranking is based on the following attributes:

1. Fish presence and habitat value
2. Barrier scoring
3. Habitat Gained Index (HGI)
4. Cost Benefit Analysis
5. Barriers below the crossing

Habitat value / fish presence and barrier scores are the primary values used to rank sites. HGI, cost-benefit and barriers below are used as secondary values to ensure that the recommendations are appropriate. Generally, a high value habitat site will have the highest habitat gained and subsequently a favorable cost-benefit analysis. However, barriers above the crossing can result in a low HGI which would correct the ranking. Barriers below can shuffle priorities as well.

3.5 Implementation Plan

This step of the process involves developing an Implementation Plan that lays out which structures will be identified for restoration of the fish passage. It also identifies the fish inventory requirements and crossing that needs work due to safety or sedimentation risks.

3.6 Mapping

A total of three maps are included for this report. The two project area maps are at 1:20,000 scale and incorporate GIS layers provided by the WFP office. An overview map presents the location of the project area in relation to Vancouver Island and the Gold Sub-basin.

Project maps depict: crossing types, recommended remediation sites, safety concern sites, identified barriers downstream and upstream of crossings, assessed streams, and road network with pre- and post-95 designation. This information is presented using unique symbols which are explained in the map's legend.

4. Results

Table 2 describes the types of sites assessed in each watershed for a total of 748 sites.

Out of the 748 sites, 149 sites were closed bottomed culverts on streams and 47 on NCDs. Of the 149 closed bottomed culverts on streams 95 were assessed to have no fish habitat. For the remaining 54 sites with round culverts barrier scores were calculated. 33 of the 54 sites corresponded with mapped streams and 10 of those are confirmed fish-bearing streams.

Table 2. Site categories after data collection.

Crossing Type	Totals
3xRC on fish streams	2
2xRC on inferred fish streams	6
2xRC on non-fish streams	6
RC on fish streams	8
RC on inferred fish streams	38
RC on non-fish streams	89
RC on NCDs	47
RC - cross drain	272
WBC	68
WBC – cross drain	22
Bridge	11
Pipe Arch	1
Deactivated	169
Ford	4
Washout	1
Other	4
Total Crossings	**748**

RC – Round culvert (corrugated steel), WBC – Wooden box culvert

4.1 Fish Presence and Habitat Value

Known fish presence was the first criteria used to sort and rank the 54 sites.

Habitat value was the second criteria used for the 54 sites. Six crossings were deemed to have high habitat value, 10 crossings had moderate habitat value, and 38 crossings had low habitat value. Low habitat value generally resulted from the lack of in-stream cover, lack of spawning habitat and torrential channel characteristics.

Habitat Value Criteria is taken from the Field Assessment for Fish Passage Determination of Closed Bottomed Structures, 2nd Edition (May 2008) on page 11 as follows:

Table 3. Habitat Value Criteria.

Habitat u/s of the crossing	Fish Habitat Criteria
High	The presence of high-value spawning or rearing habitat (i.e., 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).
Moderate	Important migration corridor. Presence of suitable spawning habitat. Habitat with moderate rearing potential for the fish species present.
Low	The absence of suitable spawning habitat, and habitat with low rearing potential (i.e., 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).

4.2 Barrier Scoring

Barrier scores were calculated for 54 sites – all of the round CMP sites with potential and present fish habitat. Scores ranged from 16 to 42. Only two crossings scored as a potential barrier (scores 15-19) and the remaining were barriers (scores 20 or over). Results are presented in Table 4.

None of the crossings are intentionally embedded, although two were considered partially embedded because of bedload movement, so scored moderately for this attribute. 21 crossings had high-scoring outlet drops. 48 crossings scored high for culvert slope as a barrier. All crossings scored high for constricting the stream (SWR value). Three culverts scored high for culvert length barrier.

Orange highlighting indicates crossings over documented anadromous and sport fish stream, green – over sport fish stream, and no highlighting – over inferred fish-stream. Bold font indicates crossings selected for replacement.

Table 4. Barrier and Habitat Scores.

Crossing ID	Embedded value	Outlet Drop Value	Slope value	SWR value	Length Value	Score	Habitat Value	Result
HWY28-010	10	10	10	6	6	42	Moderate	Barrier
ER-080	10	10	10	6	3	39	Low	Barrier
ER-730	10	10	10	6	3	39	Low	Barrier
GRM-170	10	10	10	6	3	39	Low	Barrier
GRM-210	10	10	10	6	3	39	Low	Barrier
HWY28-040	10	10	10	6	3	39	Low	Barrier
HWY28-060	10	10	10	6	3	39	Low	Barrier
UM-030	10	10	10	6	3	39	Low	Barrier
WR-220	10	10	10	6	3	39	Low	Barrier
E7-050	10	10	10	6	0	36	Moderate	Barrier
ER-190	10	10	10	6	0	36	Low	Barrier
ER-720	10	10	10	6	0	36	Low	Barrier
EWM-002	**10**	**10**	**10**	**6**	**0**	**36**	**High**	**Barrier**
W40-006	10	10	10	6	0	36	Low	Barrier
WR-088	10	10	10	6	0	36	Low	Barrier
WR-200	10	10	10	6	0	36	Low	Barrier
WR-270	10	10	10	6	0	36	Low	Barrier
WR-280	10	10	10	6	0	36	Low	Barrier
WR-310	10	10	10	6	0	36	Low	Barrier
WR-320	10	10	10	6	0	36	Low	Barrier
GRM-020	**10**	**5**	**10**	**6**	**3**	**34**	**High**	**Barrier**
HWY28-260	10	5	10	6	3	34	Moderate	Barrier
M21-002	10	5	10	6	3	34	Low	Barrier
WR-490	10	5	10	6	3	34	Moderate	Barrier
GRM-120	10	0	10	6	6	32	Moderate	Barrier
HWY28-020	**10**	**10**	**0**	**6**	**6**	**32**	**High**	**Barrier**
E20B-020	10	5	10	6	0	31	Low	Barrier
EW3C-002	10	5	10	6	0	31	Low	Barrier
EW3C-003	10	5	10	6	0	31	Moderate	Barrier
M3A-005	10	5	10	6	0	31	Low	Barrier
M3A-006	10	5	10	6	0	31	Low	Barrier
WR-087	10	5	10	6	0	31	Low	Barrier
WR-400	10	5	10	6	0	31	Moderate	Barrier
WR-450	**10**	**5**	**10**	**6**	**0**	**31**	**High**	**Barrier**
ER-850	10	5	5	6	3	29	Low	Barrier
GRM-139	10	5	5	6	3	29	Low	Barrier
HWY28-270	10	0	10	6	3	29	Low	Barrier
HWY28-280	10	0	10	6	3	29	Low	Barrier
WR-100	**10**	**0**	**10**	**6**	**3**	**29**	**Moderate**	**Barrier**

Table 4. Barrier and Habitat Scores.

Crossing ID	Embedded value	Outlet Drop Value	Slope value	SWR value	Length Value	Score	Habitat Value	Result
ER-220	10	0	10	6	0	26	Moderate	Barrier
GRM-140	10	0	10	6	0	26	Low	Barrier
GRM-158	**10**	**0**	**10**	**6**	**0**	**26**	**High**	**Barrier**
U3-001	10	0	10	6	0	26	Low	Barrier
U3-002	10	0	10	6	0	26	Low	Barrier
W40-003	5	5	10	6	0	26	Low	Barrier
WR-120	10	0	10	6	0	26	Low	Barrier
WR-340	10	0	10	6	0	26	Low	Barrier
WR-398	10	0	10	6	0	26	Low	Barrier
WR-480	10	0	10	6	0	26	Low	Barrier
WWM-002	10	0	10	6	0	26	Low	Barrier
ER-870	5	0	10	6	3	24	Low	Barrier
T-002	10	0	5	6	3	24	Low	Barrier
WR-460	**10**	**0**	**5**	**3**	**0**	**18**	**High**	**Potential barrier**
ER-740	10	0	0	6	0	16	Moderate	Potential barrier

There are 6 crossings with high habitat value that scored as barriers or potential barriers:

1. Crossing EWM-002 scored 36.
2. Crossing GRM-020 scored 34.
3. Crossing HWY28-020 scored 32.
4. Crossing WR-450 scored 31.
5. Crossing GRM-158 scored 26.
6. Crossing WR-460 scored 18.

4.3 Habitat Gained Index

Habitat Gained Index is the amount of accessible habitat upstream of the subject crossing. For many of the assessed streams, HGI is purely speculative because fish presence is inferred in and the fish distribution limits are unknown. However, it gives a relative value to other crossings and is used in the Cost Benefit Analysis as a useful ranking tool.

HGI was measured using GIS software on all continuous stream segments. However many streams provided are fragmented or are not mapped and in such cases the HGI was estimated based on the contour pattern interpretation.

The results (See Table 6) of the HGI yielded small numbers, with the highest being 3,335m (crossing HWY28-020) and 7 sites had less than 100m of habitat gain.

4.4 Cost Benefit Analysis

Cost benefit analysis is a ratio of HGI to the cost of proposed remediation for CBS barriers. As these two factors are usually imprecise that ratio can only be an indicative tool to how costly the solution could be in terms of recovered length of habitat by dollars spent to improve access to this habitat. It depends on the results of the fish inventory and determined fish habitat value as well as on structure type and cost involved with design, production, transportation and replacement of the barrier.

In order to provide a satisfactory price of the proposed solution to the culvert barrier, the Replacement Structure Cost Matrix table was derived by comparing and extrapolating the costs of crossings restoration projects already completed in the province during the last two years. The table below gives the bulk part figures for the replacement costs with pipe arch, bridge, backwater or structure removal. However, the real costs of work depend on the barrier CBS location, terrain, access, distance to fill material, all transportation and material costs, material used, engineering, newer crossing designs, road traffic, environmental monitoring, and labour. Many of these partial costs fluctuate monthly and may significantly differ within a span of several months from presenting a recommendation to the actual replacement work.

Table 5. Replacement Structure Cost Matrix in $1,000.

Type	Road Fill							
	1m	3m	5m	7m	9m	11m	13m	15m
< 3m arch	30	60	110	130	190	220	260	295
3-5m arch	55	115	145	165	225	260	300	340
≤ 6m bridge	45	65	120	150	190	225	260	300
9m bridge	65	110	150	220	270	320	370	410
12m bridge	85	135	195	245	300	355	410	460
15m bridge	100	150	215	270	325	385	445	500
18m bridge	120	170	240	295	355	415	480	540
21m bridge	137	190	265	320	385	445	510	575
24m bridge	155	210	295	345	410	480	555	635
28m bridge	175	230	335	370	435	510	590	680
31m bridge	200	250	380	395	465	540	630	720
Backwater	5	5	5	5	5	5	5	5
Deactivation	2	4	6	8	10	12	14	16

4.5 Remediation proposals

Proposed work greatly affects the cost benefit analysis score (See Table 6). Adding substrate to a pipe (EM), backwatering (BW) or removing a pipe (RM) are much cheaper options than replacing a CBS with an open-bottomed structure (OBS). However, because all of the crossings constrict streams, embedding or backwatering were not options in any of the sites. Deactivating sites was proposed on some of the secondary roads.

For all sites recommended for OBS, wooden boxes are also an option and are approximately half the cost but they may not be eligible for FIA funding.

Orange highlighting indicate crossings over documented anadromous and sport fish stream, green – over sport fish stream, and no highlighting – over inferred fish-stream. Bold font indicates crossings selected for replacement.

Table 6. HGI, Proposed Solution and Cost Benefit Analysis.

Crossing ID	Habitat Value	Barrier Score	HGI (m)	Fill (m)	Option	Proposed Solution	Diameter (mm) or span (m)	Cost Estimate ($1K)	Cost Benefit
U3-001	Low	26	700	0.4		RM		2	350.0
U3-002	Low	26	700	1		RM		2	350.0
EW3C-003	Moderate	31	461	0.8		RM		2	230.5
EW3C-002	Low	31	470	0.7		RM		4	117.5
GRM-020	**Moderate**	**34**	**1601**	**0.5**		**OBS**	**6**	**45**	**35.6**
WR-460	**High**	**18**	**1025**	**0.7**		**OBS**	**2700x9**	**30**	**34.2**
WR-088	Low	36	1361	0.5	Option 1	OBS	5	45	30.2
					Option 2	OBS	3600x10	55	24.7
WR-280	Low	36	741	0.5		OBS	2700x10	30	24.7
EWM-002	**High**	**36**	**1066**	**2**	**Option 1**	**OBS**	**2700x10**	**45**	**23.7**
					Option 2	**OBS**	**6**	**45**	**23.7**
E7-050	**Moderate**	**36**	**632**	**0.6**		**OBS**	**2200x10**	**30**	**21.1**
W40-006	Low	36	40	0.4		RM		2	20.0
WR-100	**Moderate**	**29**	**2046**	**3**	**Option 1**	**OBS**	**9**	**110**	**18.6**
					Option 2	**OBS**	**4600x15**	**115**	**17.8**
WR-200	Low	36	838	0.9	Option 1	OBS	6	45	18.6
					Option 2	OBS	4600x12	55	15.2
WR-398	Low	26	543	1.5		OBS	1800x9	30	18.1
GRM-158	**High**	**26**	**521**	**0.5**		**OBS**	**2200x11**	**30**	**17.4**
WR-450	**High**	**31**	**1195**	**2**	**Option 1**	**OBS**	**7**	**70**	**17.1**
					Option 2	**OBS**	**3600x10**	**75**	**15.9**
GRM-170	Low	39	829	2		OBS	6	50	16.6
W40-003	Low	26	60	0.8		RM		4	15.0
GRM-140	Low	26	428	0.4		OBS	2200x10	30	14.3
HWY28-280	Low	29	707	0.5		OBS	7	50	14.1
HWY28-270	Low	29	547	1	Option 1	OBS	5	45	12.2
					Option 2	OBS	3600x19	55	9.9
M3A-006	Low	31	350	0.8		OBS	2200x13	30	11.7
HWY28-040	Low	39	1088	0.6		OBS	15	100	10.9

Table 6. HGI, Proposed Solution and Cost Benefit Analysis.

Crossing ID	Habitat Value	Barrier Score	HGI (m)	Fill (m)	Option	Proposed Solution	Diameter (mm) or span (m)	Cost Estimate ($1K)	Cost Benefit
WR-400	Moderate	31	543	1.5	Option 1	OBS	5	55	9.9
					Option 2	OBS	3600x10	60	9.1
WR-220	Low	39	296	0.5		OBS	2700x15	30	9.9
WR-087	Low	31	440	0.5	Option 1	OBS	5	45	9.8
					Option 2	OBS	3200x12	55	8.0
WR-120	Low	26	273	0.5		OBS	2000x11	30	9.1
UM-030	Low	39	784	4		OBS	2000x21	95	8.3
E20B-020	Low	31	241	0.4		OBS	2200x10	30	8.0
GRM-139	Low	29	348	0.5	Option 1	OBS	5	45	7.7
					Option 2	OBS	4000x15	55	6.3
WR-340	Low	26	207	1.5		OBS	2000x10	30	6.9
ER-190	Low	36	539	2	Option 1	OBS	7	80	6.7
					Option 2	OBS	4600x10	85	6.3
ER-220	Moderate	26	373	1.5	Option 1	OBS	6	55	6.8
					Option 2	OBS	3200x10	60	6.2
GRM-120	Moderate	32	1114	7		OBS	4000x32	165	6.8
M3A-005	Low	31	300	1	Option 1	OBS	6	45	6.7
					Option 2	OBS	4800x14	55	5.5
WWM-002	Low	26	260	1.5		OBS	2700x12	40	6.5
GRM-210	Low	39	287	0.5	Option 1	OBS	5	45	6.4
					Option 2	OBS	3600x15	55	5.2
ER-850	Low	29	673	3	Option 1	OBS	9	110	6.1
					Option 2	OBS	4600x22	115	5.9
ER-720	Low	36	271	1.5	Option 1	OBS	6	45	6.0
					Option 2	OBS	3600x10	55	4.9
ER-740	Moderate	16	287	2		OBS	6	50	5.7
HWY28-020	**High**	**32**	**3335**	**15**		**OBS**	**31**	**720**	**4.6**
WR-490	Moderate	34	146	1.5	Option 1	OBS	2700x22	40	3.7
					Option 2	OBS	5	45	3.2
WR-480	Low	26	153	2.5	Option 1	OBS	2200x10	50	3.1
					Option 2	OBS	6	55	2.8
ER-870	Low	24	554	8		OBS	4300x20	195	2.8
WR-320	Low	36	85	0.5		OBS	2700x10	30	2.8
WR-270	Low	36	73	0.7		OBS	1600x10	30	2.4
ER-080	Low	39	833	10		OBS	22	400	2.1
WR-310	Low	36	98	2		OBS	6	50	2.0

Table 6. HGI, Proposed Solution and Cost Benefit Analysis.

Crossing ID	Habitat Value	Barrier Score	HGI (m)	Fill (m)	Option	Proposed Solution	Diameter (mm) or span (m)	Cost Estimate ($1K)	Cost Benefit
HWY28-060	Low	39	70	1	Option 1	OBS	6	45	1.6
					Option 2	OBS	4600x24	55	1.3
HWY28-010	Moderate	42	918	8		OBS	20	660	1.4
M21-002	Low	34	318	6		OBS	15	240	1.3
ER-730	Low	39	478	6		OBS	14	450	1.1
HWY28-260	Moderate	29	100	2.5		OBS	14	120	0.8
T-002	Low	24	25	4		OBS	2700x24	90	0.3

4.6 Barriers Below

Impassable falls and cascades were one of the reasons to determine no fish habitat in streams crossed by roads. Streams upstream of the permanent barriers were lacking perennial habitat needed to support any isolated population, so the available seasonal habitat became inaccessible.

Dispersions and velocity barriers were not so conclusive and in most cases they would require more thorough investigation for fish passage to an available habitat prior to the crossing replacement.

Debris jams are only temporary barriers to upstream fish movement and over time they will rot away or the stream will flow around them and fish will move in.

Due to the scope of the project, fish habitat assessment was only cursory. Without adequate habitat inventory, it shouldn't be considered as definitive and valid.

Table 7. Barriers below Crossings.

Crossing ID	Barrier Type	Zone	Easting	Northing	Comment
ER-040	Cascade	9	711135	5520841	No fish habitat - impassable cascade 20m long at 45% slope 10m d/s from crossing, no perennial habitat u/s.
ER-057	Falls	9	710755	5522555	No fish habitat - impassable 1.5m bedrock falls 100m d/s from crossing, no perennial habitat u/s.
ER-113	Cascade	9	709183	5525909	No fish habitat - impassable cascade 100m d/s from crossing, no perennial habitat u/s.

Table 7. Barriers below Crossings.

Crossing ID	Barrier Type	Zone	Easting	Northing	Comment
ER-120	Cascade	9	709192	5525986	No fish habitat - impassable cascade 100m d/s from crossing, no perennial habitat u/s.
ER-130	Cascade	9	709136	5526038	No fish habitat - impassable cascade 100m d/s from crossing, no perennial habitat u/s.
ER-170	Cascade	9	708804	5527713	No fish habitat - 40% cascade 150m d/s, no perennial habitat u/s.
ER-212	Dispersion	9	709330	5528920	No fish habitat - stream dissipates d/s from crossing and becomes NCD, no perennial habitat u/s, no fish access for seasonal use.
ER-642	Cascade	9	707883	5534565	No fish habitat - no perennial habitat u/s of 3m high bedrock cascade located 30m d/s.
GRM-080	Falls	9	710937	5519326	No fish habitat - stream with no perennial habitat and inaccessible due to falls/cascade barrier immediately d/s of crossing and between Gold River.
GRM-139	Dispersion	9	710063	5521704	Stream lacks good cover, but rearing habitat usable; begins to dissipate/disperse 50m d/s from crossing - unknown connectivity to fish-bearing waters.
GRM-140	Dispersion	9	710087	5521767	Usable rearing and spawning habitat for small resident fish u/s from crossing. Stream begins to dissipate/disperse in wetland 80m d/s from crossing - unknown access to fish.
WR-092	Dispersion	9	708695	5529513	No fish habitat - stream disperses 100m d/s from crossing, impassable to fish, no perennial habitat u/s.
WR-180	Dispersion	9	708352	5532566	No fish habitat - stream disperses 25m d/s from crossing, impassable to fish, no perennial habitat u/s.
WR-270	Velocity barrier	9	706851	5535031	Suspect no fish habitat - no perennial habitat present u/s of velocity barrier (14% over glacial till, 8m long) located 50m d/s.
WR-310	Debris jam	9	706588	5535574	Very poor fish habitat due to frequent high scouring flows. 2m high debris jam 50m d/s from crossing is impassable to fish at present.
WR-320	Debris jam	9	706577	5535599	Debris jam 50m d/s of crossing impedes fish passage at present.

5. Recommendations

In order to indicate which of the CBS barriers should be replaced, several factors were analyzed to provide a plausible justification for such a selection and attain a satisfactory benefit for the money to be spent. All considered factors received a specific numeric value that best represented their subjective qualities or quantities. They were combined into five different scoring types which were added in the end to derive a cumulative score to rank the proposed remediation site.

Crossings with a score above 20 received a "High" rank, crossings with a score above 10 and below or equal 20 obtained "Med" rank, and the remaining crossings with a score below or equal 10 received a "Low" rank in priority ranking for the remediation.

5.1. Habitat Quantity Score

To more accurately demonstrate HGI, the measured length of an accessible stream was multiplied by its width to receive the area of the available habitat. In addition, the area of any accessible lake was also added to point out the increased amount of gained habitat. This way, the habitat gained would be reflected more precisely in order to differentiate between streams of similar lengths. The received amount was the first factor incorporated into the Habitat Quantity Score in the Final Rankings Table (Table 9).

Three components of fish habitat: rearing, spawning, and overwintering were examined to offer a relative quantitative score and also to provide an indication of the stream's perennial or seasonal nature. The amount of available habitat in general is related to the stream size and morphology and can further be divided as abundant, fair, low, or none and the quantity would be greater in larger streams than in smaller streams. For example a 5m wide stream with seasonal flows and a good cover would receive 12 points for an abundant seasonal rearing habitat while the same size perennial stream would receive 12 points for rearing and another 12 points for overwintering, doubling the score and therefore indicating a perennial stream as having a greater habitat value. This scoring system is presented in Table 8 and it was applied to quantify each habitat component. The cumulative amount of fish habitat was then used as a second factor to determine the Habitat Quantity in the Final Rankings Table. Based on professional experience, streams were divided at the 2m channel width.

Table 8. Habitat Quantity Score Matrix.

Channel Size	Amount of Habitat			
	Abundant	Fair	Low	None
≥ 2m	12	8	4	0
< 2m	9	6	3	0

The stability of the available habitat was the third and last factor considered in the Habitat Value Score. Any stream exhibiting torrential flows severely affected the amount of habitat

available as well as its use by fish. It was assumed that the amount of available habitat in such channels would be similar to the available habitat in the perennial and stable streams at low flows, which is roughly 15% of the bankfull flow. Therefore, the habitat available in torrential channels was about 6 times smaller than in stable streams and this factor was used in the calculations. Stable streams had a factor of "1".

The Habitat Quantity Score was obtained by a multiplication of the habitat gained area by the total habitat quantity and by the stream stability factor.

5.2 Fish Presence Score

Four values were assigned to the documented fish streams and the inferred fish streams during the survey. These values are only indicative of potential or existing fish diversity and reflect to some degree the habitat types the species are associated with.

The documented anadromous and sport fish streams were given a score of "4", the documented sport fish streams – "3", the inferred anadromous and sport – "2", and the inferred sport fish streams – "1".

5.3 Habitat Value Score

This score was obtained during the habitat quantity evaluation. It indicates that streams with a more diverse habitat and/or that have a potential to provide for more species are more valuable and would bring more benefits if access was restored.

A value of "9" was assigned to streams which had an "Abundant" score at least once in habitat quantity, a value of "6" was given to streams which scored "Fair" at least once, and "3" was assigned to all other streams.

5.4 Habitat Access Score

Streams that were recorded with any temporary barrier impeding fish migration to the available habitat such as beaver dams, debris jams, sediment wedges, dewatering, and excessive post-logging debris were assigned a score of "-2". Streams that were subjected to torrential flows received an additional score of "-2".

These scores indicate the dependency of the fish habitat on stable streams. All impediments cause a reduction of the final scores; further eliminating streams which may have a high HGI but poor habitat, and the real benefits from remediation would be very low.

5.5 Cost Score

The value was derived by averaging all the initial Cost Benefit for the CBS which equaled "10.1". The crossings with an initial evaluation above "10.1" were assigned a score of "10" as an equal preferential value for all sites with a higher cost benefit ratio.

Table 9. Final Rankings.

Rank	Crossing ID	Hab. Value	Barrier Score	HGI (m)	Fill (m)	Option	Prop. Sol.	D (mm) or span (m)	Cost Est. ($1K)	Cost Benefit	Lake Area (ha)	CW (m)	Hab. Gain Area (ha)	Rear. Quant.	Spawn. Quant.	Over Winter Quant.	Hab. Quant. Sum	Chan. Stab. Score	Hab. Quant. Score	Fish Pres. Score	Hab. Value Score	Habitat Access Score	Cost Score	Total Score
High	HWY28-020	High	32	3335	15		OBS	31	720	4.6		5.3	1.77	12	12	4	28	1	49.49	4	9	0	0	62.49
High	EWM-002	High	32	1066	2	Opt 1	OBS	2700x10	45	23.7	1.3	2.1	1.55	12		12	24	1	37.12	2	9	-2	10	56.12
						Opt 2	OBS	6	45	23.7														
High	WR-100	Mod	25	2046	3	Opt 1	OBS	9	110	18.6		4.0	0.82	8	4	8	20	1	16.37	1	6		10	33.37
						Opt 2	OBS	4600x15	115	17.8														
High	GRM-020	High	30	1601	0.5		OBS	6	45	35.6		2.6	0.42	12	4	12	28	1	11.66	1	9		10	31.66
High	E7-050	Mod	32	632	0.6		OBS	2200x10	30	21.1	1.5	1.6	1.61	8			8	1	12.91	1	6	-2	10	27.91
High	WR-450	High	27	1195	2	Opt 1	OBS	7	70	17.1		3.0	0.36	12		12	24	1	8.60	2	9	-2	10	27.60
						Opt 2	OBS	3600x10	75	15.9														
High	WR-460	High	19	1025	0.7		OBS	2700x9	30	34.2		2.1	0.22	12	4	8	24	1	5.17	2	9		10	26.17
High	GRM-158	High	22	521	0.5		OBS	2200x11	30	17.4		1.5	0.08	9	9	9	27	1	2.11	2	9	-2	10	21.11
Mod	EW3C-003	Mod	27	461	0.8		RM		2	230.5		1.5	0.07	6	3	6	15	1	1.04	2	6		10	19.04
Mod	HWY28-040	Low	35	1088	0.6		OBS	15	100	10.9		13.2	1.44	4			4	0.15	0.86	4	3	-2	10	15.86
Mod	WR-200	Low	32	838	0.9	Opt 1	OBS	6	45	18.6		3.9	0.33	4			4	1	1.31	1	3		10	15.31
						Opt 2	OBS	4600x12	55	15.2														
Mod	GRM-170	Low	35	829	2		OBS	6	50	16.6		2.7	0.22	4			4	1	0.90	1	3		10	14.90
Mod	EW3C-002	Low	27	470	0.7		RM		4	117.5		1.2	0.06	3	3		6	1	0.34	1	3		10	14.34
Mod	U3-002	Low	22	700	1		RM		2	350.0		1.6	0.11	3			3	1	0.34	3	3	-2	10	14.34
Mod	U3-001	Low	22	700	0.4		RM		2	350.0		1.3	0.09	3			3	1	0.27	3	3	-2	10	14.27
Mod	WR-398	Low	22	543	1.5		OBS	1800x9	30	18.1		1.2	0.07	3			3	1	0.20	1	3		10	14.20
Mod	M3A-006	Low	27	350	0.8		OBS	2200x13	30	11.7		1.6	0.06	3			3	1	0.17	1	3		10	14.17
Mod	HWY28-280	Low	25	707	0.5		OBS	7	50	14.1		5.0	0.35	4			4	1	1.41	1	3	-2	10	13.41
Mod	GRM-120	Mod	28	1114	7		OBS	4000x32	165	6.8		3.3	0.37	8	4	8	20	1	7.35	2	6	-2	0	13.35
Mod	HWY28-010	Mod	38	918	8		OBS	20	660	1.4		6.9	0.63	8			8	1	5.07	2	6		0	13.07
Mod	HWY28-270	Low	25	547	1	Opt 1	OBS	5	45	12.2		3.10	0.17	4			4	1	0.68	1	3	-2	10	12.68
						Opt 2	OBS	3600x19	55	9.9													0	2.68
Mod	GRM-140	Low	22	428	0.4		OBS	2200x10	30	14.3		1.5	0.06	3	3		6	1	0.39	1	3	-2	10	12.39
Mod	WR-280	Low	32	741	0.5		OBS	2700x10	30	24.7		2.0	0.15	4			4	0.15	0.09	1	3	-2	10	12.09
	W40-006	Low	32	40	0.4		RM		2	20.0		4.2	0.02	4			4	0.15	0.01	1	3	-2	10	12.01

Table 9. Final Rankings.

Rank	Crossing ID	Hab. Value	Barrier Score	HGI (m)	Fill (m)	Option	Prop. Sol.	D (mm) or span (m)	Cost Est. ($1K)	Cost Benefit	Lake Area (ha)	CW (m)	Hab. Gain Area (ha)	Rear. Quant.	Spawn. Quant.	Over Winter Quant.	Hab. Quant. Sum	Chan. Stab. Score	Hab. Quant. Score	Fish Pres. Score	Hab. Value Score	Habitat Access Score	Cost Score	Total Score
Mod	W40-003	Low	22	60	0.8		RM		2	30.0		1.7	0.01	3			3	0.15	0.00	1	3	-2	10	12.00
Mod	WR-088	Low	32	1361	0.5	Opt 1	OBS	5	45	30.2		3.	0.41	4			4	0.15	0.24	1	3	-4	10	10.24
						Opt 2	OBS	3600x10	55	24.7														
Low	ER-740	Mod	16	287	2		OBS	6	50	5.7		2.4	0.07	8		8	16	1	1.10	4	6	-2		9.10
Low	WR-400	Mod	27	543	1.5	Opt 1	OBS	5	55	9.9		3.0	0.16	8	4		12	1	1.95	1	6			8.95
Low	WR-400	Mod	27	543	1.5	Opt 2	OBS	3600x10	60	9.1		3.0	0.16	8	4		12	1	1.95	1	6			8.95
Low	ER-220	Mod	22	373	1.5	Opt 1	OBS	6	55	6.8		2.5	0.09	8	8		16	1	1.49	1	6			8.49
						Opt 2	OBS	3200x10	60	6.2														
Low	HWY28-260	Mod	30	100	2.5		OBS	14	120	0.8		10.2	0.10	8			8	1	0.82	1	6			7.82
Low	WR-490	Mod	30	146	1.5	Opt 1	OBS	2700x22	40	3.7		1.9	0.03	8	8	8	24	1	0.67	1	6			7.67
						Opt 2	OBS	5	45	3.2														
Low	ER-730	Low	35	478	6		OBS	14	450	1.1		4.5	0.22	4			4	0.15	0.13	4	3	-2		5.13
Low	ER-850	Low	27	673	3	Opt 1	OBS	9	110	6.1		4.0	0.27	4			4	1	1.08	1	3			5.08
						Opt 2	OBS	4600x22	115	5.9														
Low	ER-720	Low	32	271	1.5	Opt 1	OBS	6	45	6.0		2.8	0.08	4			4	0.15	0.05	4	3	-2		5.05
						Opt 2	OBS	3600x10	55	4.9														
Low	ER-870	Low	20	554	8		OBS	4300x20	195	2.8		3.7	0.20	4			4	1	0.82	1	3			4.82
Low	M3A-005	Low	27	300	1	Opt 1	OBS	6	45	6.7		4.20	0.13	4			4	1	0.50	1	3			4.50
						Opt 2	OBS	4800x14	55	5.5														
Low	ER-080	Low	35	833	10		OBS	22	400	2.1		5	0.42	4			4	0.15	0.25	3	3	-2		4.25
Low	UM-030	Low	35	784	4		OBS	2000x21	95	8.3		1.4	0.11	3			3	1	0.33	3	3	-2		4.33
Low	GRM-210	Low	35	287	0.5	Opt 1	OBS	5	45	6.4		2.80	0.08	4			4	1	0.32	1	3			4.32
						Opt 2	OBS	3600x15	55	5.2														
Low	WWM-002	Low	22	260	1.5		OBS	2700x12	40	6.5		2.1	0.05	4			4	1	0.22	1	3			4.22
Low	WR-220	Low	35	296	0.5		OBS	2700x15	30	9.9		1.9	0.06	3			3	1	0.17	1	3			4.17
Low	E20B-020	Low	27	241	0.4		OBS	2200x10	30	8.0		1.5	0.04	3			3	1	0.11	3	3	-2		4.11
Low	WR-120	Low	22	273	0.5		OBS	2000x11	30	9.1		1.3	0.04	3			3	1	0.11	1	3			4.11
Low	WR-480	Low	22	153	2.5	Opt 1	OBS	2200x10	50	3.1		1.7	0.03	3			3	1	0.08	1	3			4.08
						Opt 2	OBS	6	55	2.8														

Table 9. Final Rankings.

Rank	Crossing ID	Hab. Value	Barrier Score	HGI (m)	Fill (m)	Option	Prop. Sol.	D (mm) or span (m)	Cost Est. ($1K)	Cost Benefit	Lake Area (ha)	CW (m)	Hab. Gain Area (ha)	Rear. Quant.	Spawn. Quant.	Over Winter Quant.	Hab. Quant. Sum	Chan. Stab. Score	Hab. Quant. Score	Fish Pres. Score	Hab. Value Score	Habitat Access Score	Cost Score	Total Score
Low	T-002	Low	22	25	4		OBS	2700x24	90	0.3		1.9	0.00	3			3	1	0.01	1	3			4.01
Low	GRM-139	Low	27	348	0.5	Opt 1	OBS	5	45	7.7		3.4	0.12	4			4	1	0.47	1	3	-2		2.47
						Opt 2	OBS	4000x15	55	6.3														
Low	ER-190	Low	32	539	2	Opt 1	OBS	7	80	6.7		3.8	0.20	4			4	0.15	0.12	1	3	-2		2.12
						Opt 2	OBS	4600x10	85	6.3														
Low	WR-320	Low	32	85	0.5		OBS	2700x10	30	2.8		2.1	0.02	4			4	1	0.07	1	3	-2		2.07
Low	WR-270	Low	32	73	0.7		OBS	1600x10	30	2.4		1.1	0.01	3			3	1	0.02	1	3	-2		2.02
Low	HWY28-060	Low	35	70	1	Opt 1	OBS	6	45	1.6		3.9	0.03	4			4	0.15	0.02	1	3	-2		2.02
						Opt 2	OBS	4600x24	55	1.3														
Low	WR-340	Low	22	207	1.5		OBS	2000x10	30	6.9		1.4	0.03	3			3	0.15	0.01	1	3	-2		2.01
Low	M21-002	Low	30	318	6		OBS	15	240	1.3		5.0	0.16	4			4	0.15	0.10	1	3	-4		0.10
Low	WR-087	Low	27	440	0.5	Opt 1	OBS	5	45	9.8		2.7	0.12	4			4	0.15	0.07	1	3	-4		0.07
						Opt 2	OBS	3200x12	55	8.0														
Low	WR-310	Low	32	98	2		OBS	6	50	2.0		2.4	0.02	4			4	0.15	0.01	1	3	-4		0.01

6. Sites with Safety and Sedimentation Concerns

There are 4 sites with safety and sedimentation issues. They are generally fill failures or plugged culverts. All of the sites are causing erosion of road fill, two are causing sedimentation (2 are only cross drains so sedimentation is not a concern), and one is a safety issue because of a hole in the road and culvert.

Table 10. Sites with Safety and Sedimentation Concerns.

Road	KM	Xing ID	Zone	Easting	Northing	Comments
GRM	12.8	GRM-020	9	711353	5517882	Hole in road and culvert.
GRM	18	GRM-150	9	709973	5522222	Outlet 2/3 plugged, inlet eroding.
GRM	20.7	GRM-219	9	708679	5524235	Down slope side eroded - pipe partially exposed.
WR	34.9	WR-310	9	706553	5535545	Inlet buried - majority of flow washing across road.

7. Further Work Required

Fish inventory and/or Fish Habitat Assessments are recommended in order to establish fish use for all the drainages crossed by the CBS barriers for the following reasons:

1. Several of the streams have been diverted from their original channels and their connectivity to fish bearing streams and therefore fish-bearing status is questionable at present.

2. Many streams are not mapped or only short sections are mapped and their fish status and the extent of fish use are unknown.

3. Stream assessment for determining the fish accessibility from known fish-bearing waters and the extent of fish use in these streams would streamline planning process for restoration works.

8. Conclusions

1. Within the Project Area of the Gold River watershed on Vancouver Island of the Campbell River Forest District, there are 54 crossings that are barriers to fish passage.

2. A fish and fish habitat inventory project should be planned for 44 streams with culvert barriers to determine fish presence or absence.

3. Depending on fish inventory results the number of recommended sites for restoration could be reduced to less than five.

4. An additional four sites have sedimentation and safety issues that should be addressed.

9. References

BC Ministry of Environment, 2008. Fish Passage Protocol for Culverted Sites, 1st Edition. 16 pp.

BC Ministry of Environment, 2008. Field Assessment for Fish Passage Determination of Closed Bottomed Structures, 3rd Edition. 20 pp.

BC Ministry of Environment, 2009. The Strategic Approach: Protocol for Planning and Prioritizing Culverted Sites for Fish Passage Assessment and Remediation, 3rd edition. 12pp.

BC Ministry of Environment. EcoCat: The Ecological Reports Catalogue Website (http://www.env.gov.bc.ca/ecocat)

BC Ministry of Environment. Habitat Wizard Website http://webmaps.gov.bc.ca/imf5/imf.jsp?site=moe_habwiz

BC Ministry of Forests, 2009. FIA Activity Standards Document, Version 4. 21 pp.

Fisheries Information Summary System (FISS). Ministry of Sustainable Resource Management – Fisheries Inventory Data Queries Website (http://srmapps.gov.bc.ca/apps/fidq)

Province of British Columbia. 1998. Fish-stream Identification Guidebook Second Edition. Forest Practices Code Guidebook. B.C. Min. For., Victoria, B.C. 68 pp.

Gold River Village Website http://www.goldriver.ca/history/gold-river.php

10. Appendices

Appendix 1. Site Photos

Appendix 2. Culvert Field Data Submission Form (FIA)

Appendix 3. Overview Project Map

Appendix 4. South Gold River Area Project Map

Appendix 5. North Gold River Area Project Map

Appendix 6. Point Shapefiles for Assessed Crossings