BC Ministry of Environment

The Strategic Approach:
Protocol for Planning and Prioritizing Culverted Sites for Fish Passage Assessment and Remediation

3rd edition

March, 2009

1 Introduction

Fish passage failure at road crossings constitutes a major if not the major loss of freshwater habitat for both migratory and resident fish populations in BC (Northcote and Hartman, 2004; GAO 2001). Culverts can be especially problematic to fish passage due to increased velocity, turbulence, outlet drop (perching) and maintenance issues that render the structure impassable to fish. A given culverts may be impassable under all flow conditions or perhaps only at high flow. Similarly, a culvert may present a barrier to all fish during all life stages or only to specific fish life stages (e.g. juvenile vs. adult). For the purpose of this protocol, culverts are defined as closed bottom structures (CBS), usually round in shape and made of corrugated metal.

The exact extent of fish passage problems in BC remains undefined, although recent studies completed by the Department of Fisheries and Oceans and the BC Ministry of Environment have shown that a large number of culverts present barriers to fish migration, particularly in parts of the BC interior. The Forest Practices Board special investigation "Fish Passage at Stream Crossings" (FPB, 2009) highlighted the importance of ensuring fish passage and specifically pointed out that a single poorly constructed or maintained structure could result in significant habitat being isolated.

This report outlines a five phase process (Figure1) for undertaking a systematic, watershed-based approach to assessing and prioritizing fish passage at culverted stream crossings. This process covers project planning through to implementation. It is to be used in conjunction with the companion document **"Field Assessment for Fish Passage Determination of Closed Bottomed Structures "** (Field Protocol), which provides the detail for the field data collection phase (phase two) of the overall process.

The objective of this protocol is to conduct a systematic assessment of closed bottom structures so that the most important fish passage issues can be identified and restored in a cost effective manner. The process, in its design, is watershed-based, systematic and efficient. The approach is also flexible and can be implemented at various scales while still maintaining provincial applicability.

FIA targeted funding eligibility criteria are posted on the FIA fish passage website http://www.for.gov.bc.ca/hcp/fia/landbase/fishpassage.htm**. Licensees should consult these in preparation of funding submissions.**

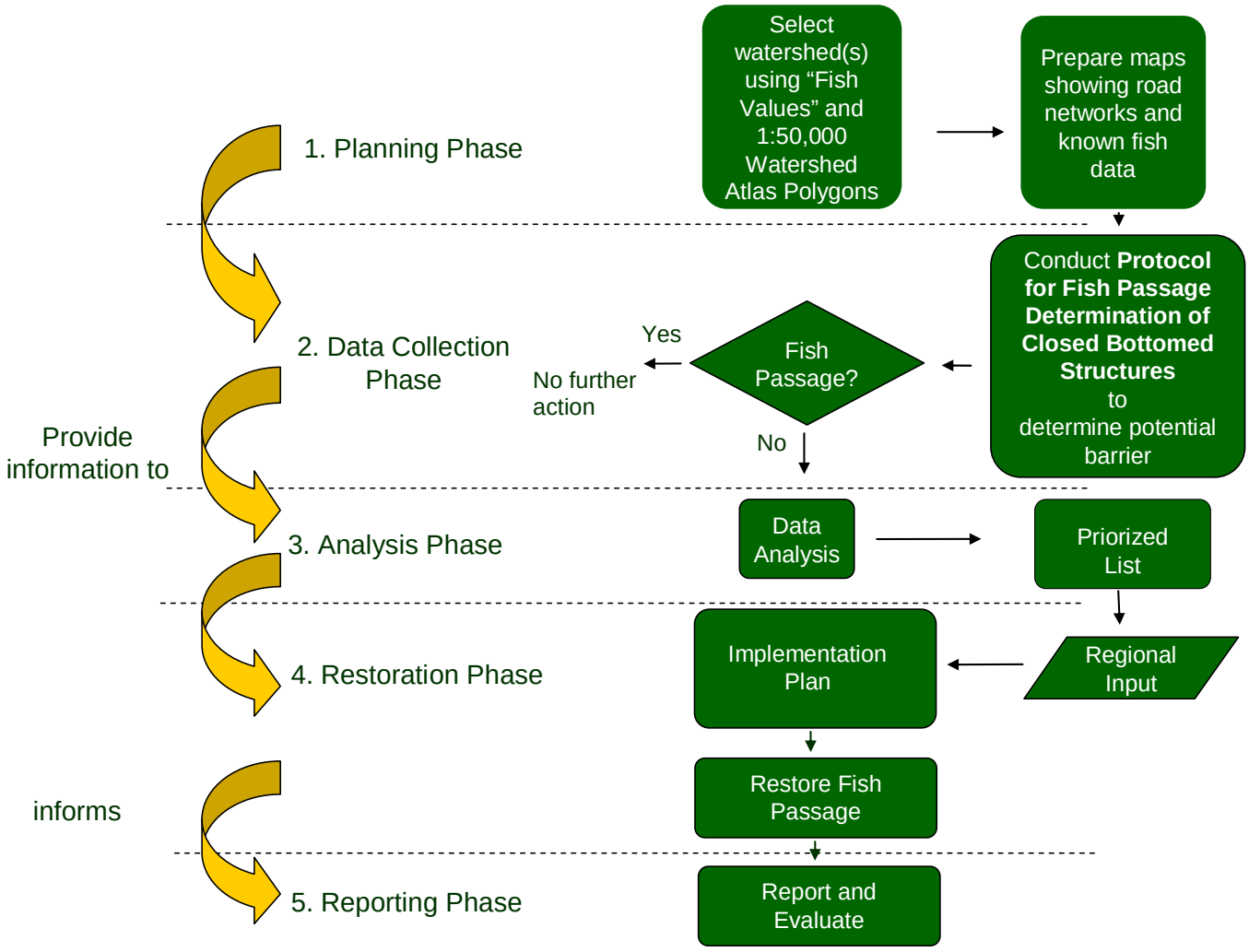


Figure 1: Overview of Provincial Process

2 Strategic Approach

The first phase of the process involves planning and preparation to ensure assessment efforts are focused where fisheries values and stream crossings densities are the highest. (watershed scale) The data collection portion of the process contains a relatively simple, quick and efficient field assessment. The third phase of the process involves analysis of the data collected leading to the development of an implementation plan (restoration phase) with input from local technical experts and users of the subject road network and its associated stream crossings. The final phase is a reporting and evaluation phase.

2.1 Planning Phase

The planning phase of this protocol is intended to do two things. Firstly, it allows the opportunity to select and stratify a study area based on a standard measure of fisheries value that has been derived for all third order watersheds in the Province.
Secondly, this phase is used to develop a set of working field maps that will be of value throughout the project but specifically should be used to guide field assessments.

The process is meant to provide flexibility while still ensuring the work is done within the highest priority fish areas in a given study area. For example, systematic assessments should be targeted for the highest fisheries value watershed or sub-basin within a licensee operating area, division, TSA or BC Ministry of Forests and Range forest district. The size of the area and exact location for the assessments should involve discussion with local experts to confirm the priority and risks identified using the map based fish value and stream crossing information. There are advantages to selecting as large an area as possible with as much cooperation between jurisdictions (highways, oil and gas, hydro etc.) or tenure holders as possible as this will help ensure problem structures on the highest stream order are identified for restoration first.

Establishing Priority Areas

An example of the process that should be followed is outlined here to illustrate how large areas can be stratified to ensure assessment and restoration activity is carried out in the highest fish value areas. It is recommended that assessment work be carried out using this process with the any modification arising from additional work that incorporates better local data and input from technical experts within industry, government or the consulting community
A normalized value called “Fisheries Value” has been derived by the Provincial Ministry of Environment for most of the 1:50,000 BC Watershed Atlas polygons and is used as a strategic planning tool. These polygons, which are the basic unit of the watershed atlas, represent the boundaries of watersheds from third order up to the highest order watershed in the atlas. “Fisheries Value” is derived from scores obtained from two main criteria - biodiversity and socioeconomic. *It is important to note that the model which the “Fisheries Value” is based upon is dynamic and subject to revision as the underlying assumptions behind the model change or are refined.* For this reason, local expertise should be used to review priorities and validate decisions made using the “Fisheries Value” ranks. The “Fisheries Value” dataset Is available through provincial fish passage website http://www.for.gov.bc.ca/hfp/fish/FishPassage.html)

Using data from this “Fisheries Value” model, watersheds are ranked at two different scales. The first model output ranks watershed groups within each provincial sub-basin. It uses the average “Fisheries Value” polygon score for each Watershed Group in the BC Watershed Atlas and then ranks them within provincial sub-basins. This is illustrated in Figure 2.

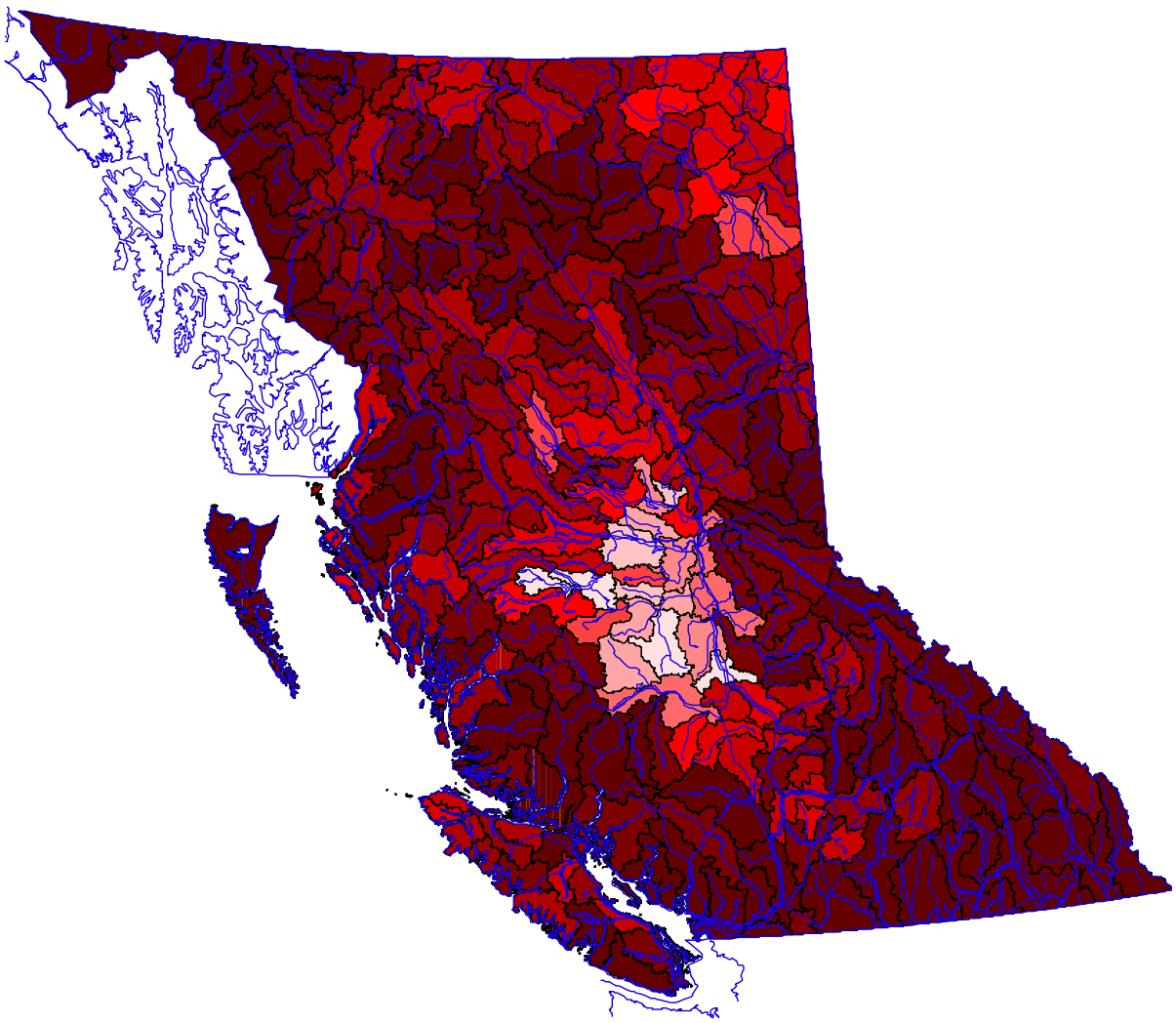


Figure 2: Average Polygon Fisheries Value Score for BC Watershed Groups (darker areas have higher average polygon scores)

This information can be used to identify priority areas within an area of interest to a licensee. Assessment activity should be directed towards the watershed group that have the **highest average "Fisheries Value" within each provincial sub-basin**.

The second model output is used to further focus assessment activity in the highest value part of the selected watershed group, using the individual polygon scores for "Fisheries Value". Figure 3 shows this ranking for the Mid-Fraser sub-basin. Prior to beginning assessment work, a check should be made with DFO and MOE agency staff with good local knowledge of the fisheries resource to confirm the model output is consistent with local knowledge. Individual polygon scores can be obtained through the provincial fish passage website. http://www.for.gov.bc.ca/hcp/fia/landbase/fishpassage.htm

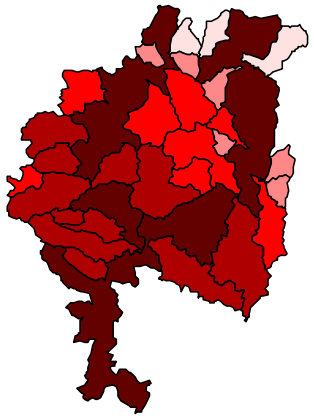


Figure 3: Average Polygon Fisheries Value Score for Watershed Groups in Middle Fraser Basin (darker areas have higher average polygon scores)

2.1.1 Road and fish information

The second part of the planning process is helpful in further directing assessment efforts.

A GIS model developed by the BC Ministry of Environment which intersects modeled fish habitat with road data can be used to provide a snapshot of potential culvert locations on fish streams. This information is useful in directing field efforts to areas where the density of potential culverted fish stream crossings is highest, thereby making assessment efforts more efficient. It will also help eliminate sections of roads where the stream crossing(s) are not thought to be fish-bearing. A brief explanation of the model follows.

The GIS analysis modeled potential fish bearing stream reaches by combining historical spatial data on known fish observations and natural obstructions to fish passage (i.e : dams, waterfalls) with modeled stream gradient. In simple terms, everything downstream of a known fish observation point was considered fish bearing. Moving upstream from a known fish observation site, stream segments were considered fish bearing until they encountered either an obstruction such as a waterfall or dam or a sustained channel gradient of more than 25%.

The resulting network of modeled fish bearing and non-fish bearing streams was then intersected with road data taken from the Digital Road Atlas (DRA) and Forest Tenure Roads (FTEN) spatial coverages. Every intersection of a single line stream with a road

can be considered a potential culvert location. While many of the identified crossing sites will have a closed-bottom structure of some type in place, some sites will have open bottom structures (such as pipe arches, wooden box culverts or small bridges) which are less likely to represent a barrier to fish passage.

As generated, the road-stream crossing dataset is a useful tool for quantifying the magnitude and location of potential barriers to fish passage in a given watershed. However, with further analysis it is possible to build on the utility of this mapping and generate a rough index for prioritizing crossings for assessment and remediation. The index has also been generated by MoE and is an attempt to identify specific crossings where the greatest amount of fish habitat will be gained for the least amount of restoration funds invested.

To generate this index, the position of each road-stream crossings was referenced linearly along the stream network. Given the relative position of all of the crossings on the stream network, it is possible to use the attributes within the stream network (watershed code, blue line key, downstream route measure) to determine what is upstream or downstream of any given crossing. This in turn allowed for the calculation of number of culverts both up and downstream of any crossing site as well as the amount of potential fish habitat upstream of that site but below any other crossing. This is the amount of habitat that would theoretically be freed up if that site is repaired, otherwise known as the Habitat Gained Index (HGI). When used in conjunction with the number of downstream culverts that would have to be repaired in order to realize these gains, this index is most valuable in establishing priorities for both assessments and actual works.

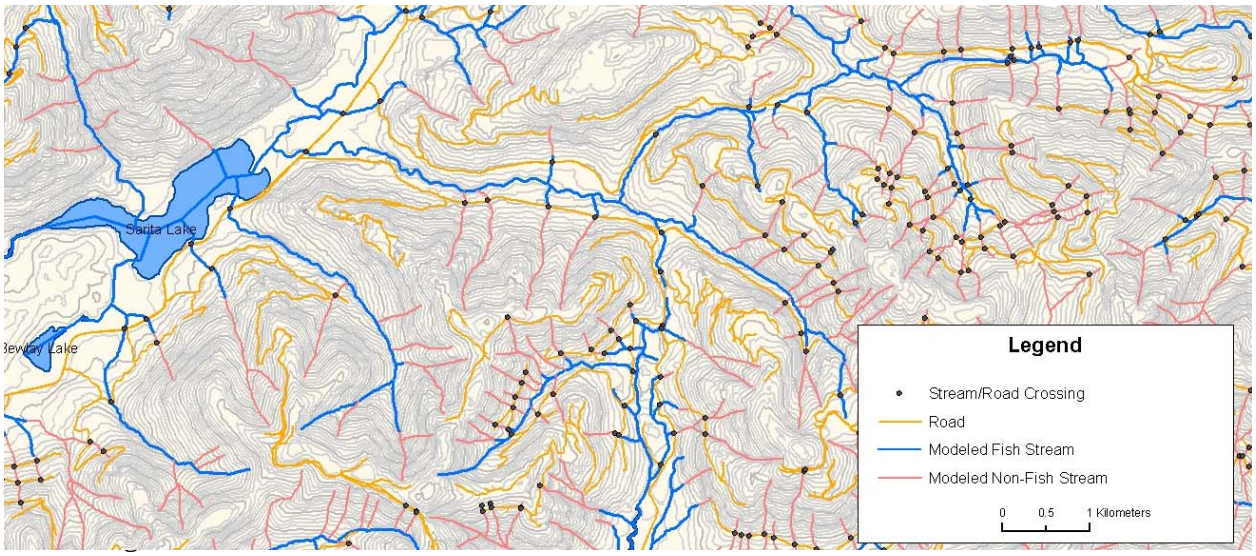
An example of how this information could be used to determine which area to assess first follows. If there are two adjacent valleys filled with road networks in a watershed of interest but only enough time / money in the field season program to focus on one valley, the team could look at a variety of variables to help decide which valley to focus on first:

- Total number of culverts
- Total length of fish habitat
- Overall quality of fish habitat
- Average habitat gained index for all of the culverts in the valley
- Future access plans for the road networks (i.e. deactivation, upgrade, etc.)

By examining and comparing all of these factors for both of the road networks in question, the assessment team should be able to decide where best to focus their efforts. Similarily, once the assessments have been carried out, it will again be these types of factors (along with projected repair cost for each structure) which will determine repair and replacement priorities (See section 2.4.1).

Starting with the 2009/10 FIA season, the Ministry of Environment will provide the modeling and analysis results (including modeled fish habitat, and potential culvert locations with associated attributes) for watershed groups of interest to proponents so that the level of detail and accuracy is uniform and standardized for all proposed projects. Please contact Craig Mount, Aquatic Habitat Geomorphologist with the Ministry of Environment (craig.mount@gov.bc.ca) to request watershed group mapping. Files will be provided in ESRI geodatabase format.

The use of culverts within the province varies regionally and temporally. The exact type of structure in place at any given crossing will not be known until that site has had an assessment performed and that data is reflected in the spatial database of crossings. Likewise, without detailed field inspections, we are not able to classify these structures as being passable to fish or not.



barrier to safe fish passage.

2.3 Analysis Phase

Once the data gathering has been completed, the analysis phase is used to produce a ranked list of sites for restoration. This involves completing a spreadsheet which calculates a cost-benefit for establishing fish passage at a given location based on an examination of potential solutions, the amount of fish habitat upstream of the crossing and local knowledge. This is not an absolute value but rather a rough estimate that will be used to establish a ranking for further consideration during the final phase. Detailed cost estimates can be prepared after restoration plans are determined.

Habitat Gained Index is available as an output from the Ministry of Environment GIS model referred to 2.1.1.

Possible restoration options that should be considered include the following:

1. Removal of the structure and deactivation of the road if access is not required.
2. Replacing the culvert with a bridge or other open bottom structure.
3. Replacing the structure with a streambed simulation design culvert.
4. Adding substrate material to the culvert and a downstream weir to reduce overall velocity and turbulence and provide low velocity areas. *Note: This option should be considered only on sites where there is no Outlet Drop (OD), slope < 1.0 %, Stream Width Ratio (SWR) less than 1.0. Design and installation should not impact flood event design.*
5. Backwatering the structure to reduce velocity and turbulence. *Note: This option should be considered only on sites where OD < 30 cm., slope < 2.0 %, Stream Width Ratio (SWR) less than 1.2 and stream profiling indicates it would be effective. Design of downstream weirs should be given careful consideration and based on a detailed stream profile.*
6. Combination of 4. and 5.

To determine a cost benefit, rough estimates for the first two solutions (bridge and streambed simulation) (see Table 1) can be derived by estimating costs based on measurements taken during the Field Protocol. Confirmation with local authorities on cost inputs should be undertaken to ensure up to date estimates are obtained. Structure removal can only be considered as a solution at the Restoration Phase of the process with input from all affected parties at a regional/sub-regional level.

The result of the Analysis Phase is a spreadsheet outlining a cost benefit for proposed solutions and is shown in Table 1. In most cases, there may be more than one possible solution and this should be noted if applicable.

Table 1: Example Summary of Analysis Phase for Hypothetical Watershed

Site No	Habitat U/S	Proposed Solution	Span (m)	Cost Estimate 1 ($K)	Proposed Solution 2	Cost Estimate ($K)	Cost Benefit 1	Cost Benefit 2
18	32	BW	19	15			2.13	
9	13.4	EM	21	10			1.34	
4	45	SB	36	250			0.18	
17	16	SB	18	120	2000 x 22 SS	65	0.13	0.25
1	16.8	SB	21	140	3000 x 25 SS	85	0.12	0.20
7	2.1	CB	12	80	1600 x 25 SS	70	0.03	0.03
6	2.7	SB	24	135	2000 x 25 SS	75	0.02	0.04
5	1.7	SB	21	120	3200 x 20 SS	80	0.01	0.02

BM	backwatering
EM	embeddment
SB	steel bridge
CB	concrete bridge
SS	streambed simulation

2.4 Restoration Phase

This fourth phase of the process involves making a decision on which structures will be restored using the information from the Analysis Phase. Decisions about which structures to fix and a proposed schedule to fix them are the main components of this plan.

2.4.1 Implementation Plan

The Implementation Plan lays out which structures have been identified for restoration of fish passage. This is done using the results of the Analysis Phase as well as criteria obtained from other sources. The MOE GIS model output is an extremely valuable source of information. Its output details the amount of unobstructed habitat as well as the number of potential culverts upstream of a given crossing. This is illustrated in Figure 6.

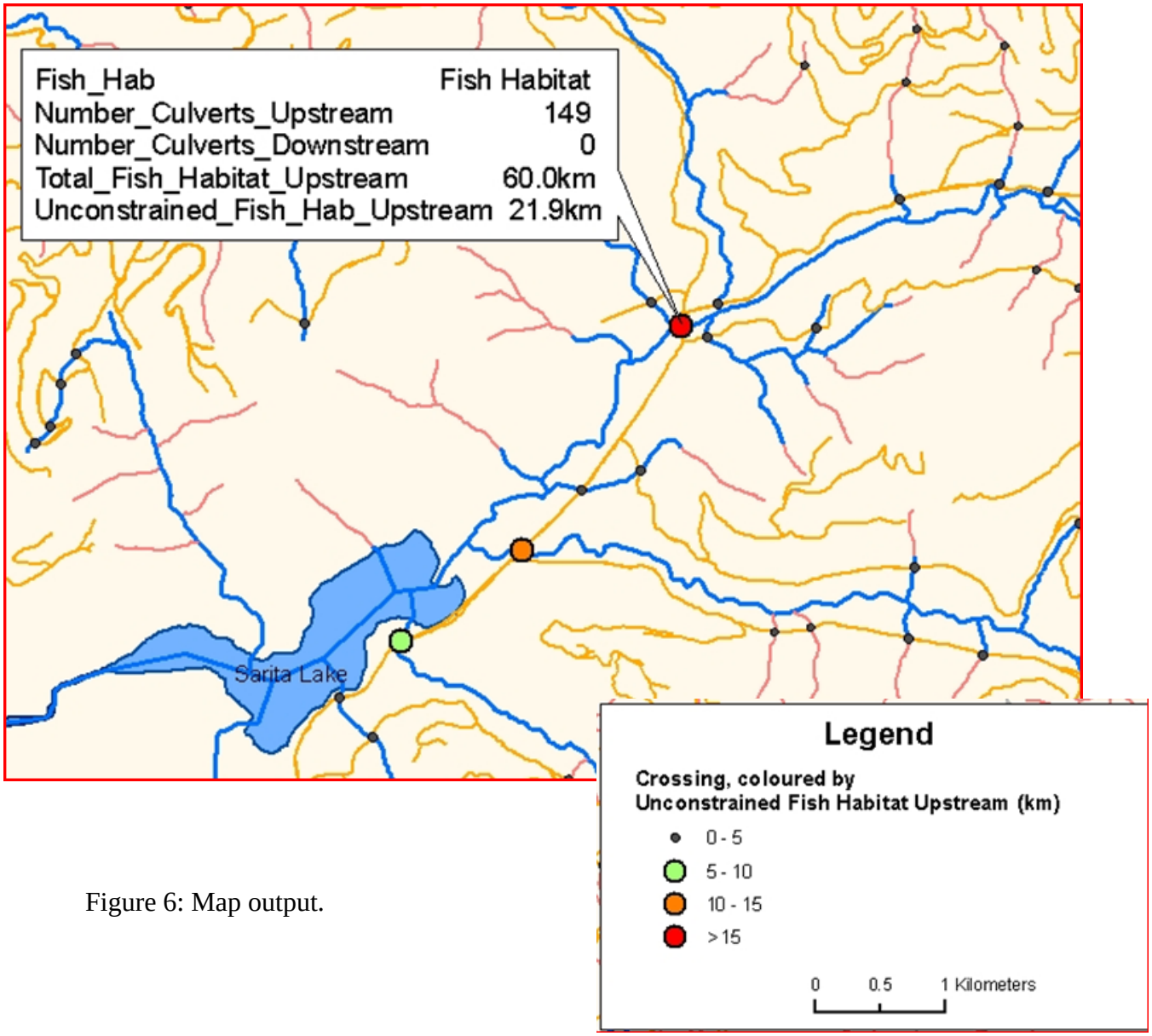


Figure 6: Map output.

This should take place at the regional or sub-regional level and involve all affected parties (and ideally, those having done the assessments) that have an interest in maintaining or using the road. It is at this stage that decisions can be made about which structures should be fixed or removed (along with road deactivation).

It is important that local expertise in fisheries/habitat biology and engineering be used to develop plans which will ensure the greatest return of fish habitat for the dollars spent.

The feasibility associated with backwatering requires further analysis obtained through stream profiling and other sources. This information may have to be obtained to make decisions regarding the potential of backwatering at a given site.

This Implementation Plan should be reviewed annually, updated and endorsed by affected parties as new information is received. Listed here are examples of the kinds of information that will influence the Implementation Plan.

- Habitat value
- Fish life cycles
- Cost/benefit
- Acceptability of embedded culverts
- Scheduled structure replacement date
- Life of structure
- Availability of personnel and equipment
- Longevity of road
- Active hauling
- Access

2.4.2 Detailed Costing

Once the Implementation Plan is complete and sites identified for restoration, more detailed costing will be required for restoration to precede, contracts let, and schedules finalized.

2.5 Report and Evaluation Phase

The final phase of this protocol is the reporting and evaluation phase.

2.5.1 Reporting

Information collected during the Data Collection Phase (Phase 2) should be entered into the Provincial database. Method for data entry can be found on the FIA web site. http://www.for.gov.bc.ca/hcp/fia/landbase/standards/fishpassage.htm

2.5.2 Evaluation

A subset of restored structures should be evaluated using the same field assessment methodology outlined in the field assessment methodology. The evaluation data should be submitted in the same format as requested for new assessment data.