FPInnovations prepared this guide to provide forest and resource workers with information on the planning and design considerations for streambed simulation in closed-bottom structures for fish streams. Other important considerations that are key to the successful implementation of a streambed simulation culvert include structure installation, streambed material, and monitoring. These subjects will be covered in future guides.

FPInnovations worked in close co-operation with British Columbia’s Fish Passage Technical Working Group in the development of this guide.

REFERENCES:
- Cover photo courtesy of the B.C. Fish Passage Technical Working Group.

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A PRACTICAL GUIDE FOR FOREST AND RESOURCE WORKERS

To identify suitable sites and design of appropriate crossing structures, it is critical to understand the site specific processes and characteristics of the natural stream channel by conducting and utilizing a comprehensive site assessment, survey and site plan. High activity streams, with significant debris or bedload movement (e.g., alluvial fans), should be avoided. Steep streams may also have excessive bedload and debris, and should be avoided. Sensitive reaches within streams (e.g., high value spawning and rearing habitat, spawning gravels, deep pools, undercut banks) should be avoided. Sites that have thin soils over bedrock are likely not suitable, as ensuring appropriate levels of embankment may be a challenge. Streambed simulation should be considered where the crossing structure design can maintain the natural stream slope, channel width, and the capacity to move bedload and woody debris downstream. The objective for fish streams is that fish (including juvenile and resident fish) can move through the structure in either direction and access habitat as they would in a natural channel. The crossing will result in a simulated streambed, with characteristics similar to that of a natural stream, including hydraulic diversity.

A closed-bottom structure for fish-stream crossings should provide aquatic habitat and passage through its length. Streambed simulation mimics natural stream channel characteristics, including slope, width, channel bed roughness, and hydraulic diversity. A simulated streambed crossing should be installed with careful consideration of site-specific characteristics. The end result will provide habitat connectivity for aquatic species present in the stream system and will allow safe, efficient vehicle passage over the stream and allow the stream to adjust itself within the culvert for the life of the crossing structure.

Road alignment
Streambed simulation is often well suited for areas of geometric complexity, such as where horizontal and vertical curves in the road are unavoidable and where a linear bridge would not be appropriate. A buried culvert is often more suitable to efficient road alignment.

When designing the position of a new culvert, seek the best fit; evaluate the natural stream alignment and the road alignment to allow the stream to maintain its natural course and to provide for safe, efficient traffic flow.

Stream characteristics and hydrology
The natural stream channel width will not be constricted if the culvert is sized appropriately and the stream width is measured accurately. * Washington State have used a culvert sizing guideline of 1.2 x stream channel width, plus 0.6 m to provide additional width for overbank flow and natural function. Where a natural channel shows signs of bedrock, the feasibility to embed the culvert to the required depth may be impractical.

The culvert should be sized to pass the 100-year event (Q100) without surcharge. Using empirical models to estimate Q100 events provides a greater certainty of the peak flows. The design flood event should also consider climate change.
An elevation profile of the existing streambed (the deepest part of the cross section) is used to establish the design location, depth, and gradient for a culvert. It is critical to establish the vertical placement of the culvert so that it matches that of the existing natural stream slope. To measure the channel gradient and capture the channel characteristics (versus stream processes), a long streambed profile on the order of 100 m is required that includes channel segments both upstream and downstream of the crossing. Existing crossings, particularly undersized culverts, as well as other potential site impacts, will influence the profile both upstream and downstream. Practitioners will need to recognize these influences and consider them when selecting appropriate design crossing depth and grade.

Channel width should be measured at various locations upstream of the crossing to determine required culvert width. Where there is an existing road crossing or other upstream disturbance, stream width measurements should be taken far enough away so that the disturbed portion of the stream does not influence the width measurement.

The stream channel width (normal annual flood level) is determined by averaging between three to six bank to bank measurements. The measurement point on each bank is often defined by a change in or absence of rooted vegetation, and the change in sediment texture. To avoid measurement bias, each channel measurement should be spaced a set distance away from the last measurement (usually a channel width from the previous measurement).

Where an existing structure is present, identify any influences produced by the structure, such as sediment accumulation, scour pool formation or channel widening.

Show any existing structures in General Arrangement (GA) design drawings in plan, profile and cross section.

Take long profile streambed survey points at the main stream channel features, such as pools and riffles, and measure the deepest point of that feature.

The stream channel width influences and consider them when selecting appropriate design crossing depth and grade.

To measure stream channel width, ensure channel measurements are taken along a reference reach that is outside of the influence of the road right of way and any other land disturbance that may have impacted stream channel width.

The streambed profile should be long enough to collect a representative sample of the natural channel characteristics (depth of pools, riffle crests); 100 m upstream and downstream is a typical survey length.

The stable gradient of a stream is determined by a straight line drawn just below the low points plotted from the survey data of the long profile.

The spatial extent of the site survey should be of sufficient scope to provide for simplified field referencing for the construction phase and subsequent long-term monitoring. Provide for the use of a standard construction levelling rod to facilitate establishment of elevations from benchmarks, and place horizontal reference points to allow linear (straight) measurements that limit errors and which can quickly and easily be obtained with a measuring tape. Accurate working point (W.P.) locations can be determined in the field without the use of a total station survey instrument by using straight-line distance measurements as provided on the site specific engineered GA design.

Field referencing should also consider providing for longer term monitoring of streambed elevations, and culvert settlement or shifting. Include the full extent of the site plan with GA design drawings.

The streambed profile should be long enough to collect a representative sample of the natural channel characteristics (depth of pools, riffle crests); 100 m upstream and downstream is a typical survey length.

Include the full extent of the long profile with GA design drawings.