7-1 Introduction

Most rivers and creeks in Washington State contain one or more species of fish during all or part of the year. These fish must be allowed to freely migrate up and down the streams they occupy. If roadways are constructed across the stream without thought given to fish passage, the roadway could create a migration barrier. However, a stream crossing designed with consideration of fish will not hinder migration. The Washington State Department of Transportation (WSDOT) and the Washington State Department of Fish and Wildlife (WDFW) have been evaluating existing stream crossings through a cooperative Fish Passage Barrier Removal Program since 1991. Some of the fish barriers have been identified for repair and a few of those have been retrofitted and/or replaced. Prior to starting a project, designers should consult the following Web link to determine if their project contains a known fish barrier: www.wsdot.wa.gov/NR/rdonlyres/F9743AD2-B4DB-439E-91C5-B973CBF17506/0/FishPassageRpt08.pdf.

WDFW developed guidelines for permanent road crossing culverts to facilitate upstream fish migration titled "Design of Road Culvert for Fish Passage." The guideline provides direction for projects involving new culvert construction as well as retrofitting or replacing existing culverts.

The purpose of this chapter is to summarize the WDFW design approaches, note the type of structures recommended, and reference grade control. For guidance, designers should consult the WDFW "Design of Road Culverts for Fish Passage" guideline at the following web page: www.wdfw.wa.gov/hab/engineer/cm/. Questions should be directed to the Region Hydraulics Engineer.

7-2 Designing for Fish Passage

7-2.1 General

The basic concept used to ensure continued fish passage is to design the stream crossing to match the natural river or creek channel as much as practical. The idea being if fish migration occurred in the crossing prior to construction, then migration should continue after construction (in other words post construction flow conditions should be similar to preconstruction or natural flow conditions). For some types of crossing structures, it is easy to create flow conditions exactly like the natural flow conditions. But for other types of crossing structures, a detailed analysis is necessary to accomplish an acceptable design. The first step in designing for fish passage is to determine which, if any, species of fish are in the stream. WSDOT

Regional Environmental staff is the primary contact for this information and will contact the WDFW when necessary. The design criterion varies depending on the species of fish since the swimming and leaping ability of fish varies from species to species. Additionally, different species migrate through the stream during different times of the year and, as a result, the design flow used for the analysis must correlate with the time of year that the fish are migrating.

7-2.2 Types of Structures

For fish passage purposes, there are three basic types of stream crossing structures:

1. **Bridges** – Structures that have piers or abutments supporting some type of girder system. Bridges do not have a significant impact on fish migration and are the preferred method of spanning a body of water. HQ Hydraulics is responsible for all water elements concerning bridge design.

2. **Open Bottom Culverts** – Metal and concrete arches or three-sided concrete frame structures that have no floor and are supported by footings.

3. **Full Culverts** – Metal, concrete, and plastic round, pipe arch, elliptical, and box-shaped culverts that are completely enclosed self-supporting structures.

7-2.3 Culvert Design Approach

Adequate fish passage for open bottom or full culverts can be determined using one of the three different design options described below. Independant of which option is selected, designers will also need to evaluate the culvert design using the guidelines described in Chapter 3 of this manual. Figures 3-2.3 and 3-2.4 provide a list of field data and other information that is required for a culvert analysis and hydraulic report.

1. **No-Slope Design Option** – Results in reasonably-sized culverts without requiring much in the way of calculations. It is most effective for relatively short culverts at low-gradient sites. Culverts are typically larger than the hydraulic option; however, the design avoids the additional cost of surveying and engineering.

2. **Stream Simulation Design Option** – A design method used to create or maintain natural stream processes in a culvert. This method is usually the preferred alternative for steep channels and long crossings.

   The streambed mix placed inside the culvert should emulate that found in the natural channel. The guidelines in the "Culvert-Bed Design" section of Chapter 6 in the WFDW "Design of Road Culverts for Fish Passage (2003)" document, describe how to size the streambed gravel.

3. **The Hydraulic Design Option** – A design method that is based on swimming abilities of a target fish species and age class. This method requires hydrologic, open-channel hydraulic calculations and specific site data. The hydraulic design option typically results in smaller culverts than the no-slope option. The analysis is based on velocity, depth, and maximum turbulence requirements for a target species and age class. When this option is selected, designers should not use MGSFlood to determine fish passage flow rates.

   In eastern Washington when the hydraulic option is selected, WDFW recommends the research approach developed by E. R. Rowland. This approach defines fish passage design per unit drainage area and is further discussed in the WDFW "Design of Road Culverts for Fish Passage Guidelines (2003)" under the hydraulic design option section. Fish passage flow rates for eastern Washington can also be found in ArcMap under the WSDOT GIS Environmental Workbench Fish and Wildlife – Fish section.

   For additional guidance, designers can also consult the following WSDOT research documents developed for the hydraulic design option:

   a. Modeling Hydrology for Design of Fish Passage (WA-RD 545.1).

   b. Culvert Design Flows for Fish Passage and Structural Safety in East Cascade and Blue Mountain Streams (WA-RD 545.2).

7-2.4 River Training Devices

River training devices can also be used for fish passage as well as to protect streambanks by redirecting the flow away from the bank towards the center of the channel. The most common types of devices are made of rock, timber, or concrete and reach from bank to bank. Designers should consult Chapter 4 for further design guidance.

WDFW has also developed guidelines for managing streambanks titled "Integrated Streambank Protection Guidelines," located at the following web link: www.wdfw.wa.gov/hab/ahg/ispgdoc.htm. Designers should direct questions to the Region Hydraulics Engineer.