Department of Fish and Wildlife

DESIGN GUIDELINES APPROVED FOR USE IN DESIGNING WATER CROSSINGS OVER FISH-BEARING WATERS IN WASHINGTON STATE

Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings [1]

Notes for appropriate use to comply with WAC 220-660-190

June 24, 2015

Stream Simulation: An Ecological Approach for Aquatic Organisms at Road-Stream Crossings was written for a national audience and does not address specific state requirements. Additionally, the guidance provided applies well to streams in forested settings and to headwater type streams in the upper end of watersheds. In Washington State, fish passage is required for all water crossings in fish-bearing waters (RCW 55.77.030). WAC 22-660-190(2) further requires that "All water crossings must retain up-stream and downstream connection in order to maintain expected channel processes." We recommend reading the entirety of WAC 220-660-190 to fully understand WDFW's expectations for water crossings. Using the notes below as a guide, the designer can use **Stream Simulation: An Ecological Approach** to design a crossing acceptable under Washington law. Chapters 1-10 have been reviewed.

Stream Simulation: An Ecological Approach was published in two forms – an electronic document in Adobe Acrobat file type (PDF) available through the USFS website, and a printed document in a 3-ring binder. The pagination for these two forms is different and reverences here to specific page and paragraph will apply only to the PDF document. Section numbers have also been included for readers with the printed document, but it is somewhat difficult to understand the meaning of the comments. Since the electronic document is free, we recommend the reader use that form when referring to these notes.

Chapter 1 Ecological Considerations for Crossing Design

> **Page 1-21-¶2 (Section 1.2.4):** While artificial barriers may have some temporary positive benefit, this is not a justification for maintaining or replacing. WAC 220-660-190 requires fish passage on all fish bearing streams and the maintenance or reconstruction of a fish passage barrier must follow the mitigation sequence described in WAC 220-660-080. If, after careful

[1] Forest Service Stream-Simulation Working Group (2008). **STREAM SIMULATION: An Ecological Approach To Providing Passage for Aquatic Organisms at Road-Stream Crossings**, National Technology and Development Program, San Dimas, CA 91773.

scientific study and policy review, a barrier is required to isolate a fish population, the barrier should be constructed as a separate structure and the crossing replaced in compliance with WAC 220-660-190.

Page 1-24-¶1 (Section 1.3.1): The span of Stream Simulation culverts in Washington are larger than the bankfull channel width. Culverts skewed to the channel alignment should be analyzed to assure that bank erosion and upstream aggradation will not cause the development of a fish passage barrier.

Chapter 2 Managing Roads for Connectivity

Page 2-5-¶2 (Section 2.4): All water crossing projects in Washington on fish bearing streams are required to provide fish passage; WAC 220-660-190(2)

Page 2-9-¶2 (2.4): The creation or maintenance of a fish passage barrier is not allowed in fish bearing waters. See comment on **Section 1.2.4** above.

Page 2-11-¶2 (Section 2.4.1): Floodplain culverts are rarely used in Washington State. If floodplain culverts are going to be used, they should be evaluated in a comprehensive way considering scour, debris occlusion, fish stranding, potential avulsion and related issues.

Chapter 3 What Stream Simulation Is and What It Isn't

Page 3-1-¶2 (Section 3.1): This paragraph does not relieve the designer of taking care to minimize the crossing length and provide additional safety factor for unavoidably long culverts (>10*Channel width). See discussion of length in the **WCDG**, Chapter 6.

Chapter 4 Initial Watershed and Reach Review

Page 4-25-¶2 (Section 4.6): The approach discussed in this paragraph regarding utilizing a culvert as a local base level control can be effective; however this method is not a stream simulation approach.

Page 4-27-shaded box #4 (Section 4.6-shaded box #4): Limited Rights of Way and Property are typical constraints on a project; however, they do not justify deviation from stream simulation design principles.

Chapter 5 Site Assessment

Page 5-17-¶2 (Section 5.1.4.1): Note that the use of grade control structures in a stream simulation project should be representative of the natural adjacent/reference reach. These structures should be designed to have similar mobility to reference structures.

Page 5-38-¶11 (Section 5.1.8): Narrow rights of way may limit the applicability of Stream Simulation. A "steeper than ideal" project profile might lead the designer to consider a roughened channel, permitted under WAC 220-660-200.

Chapter 6 Site Assessment

Page 6-12-¶3 (Section 6.1.2): Permanent grade controls limit natural profile development – a stream process protected in WAC 220-660-190(2). Water crossing projects that require permanent grade control are considered fishways and permitted under WAC 220-660-200, Fish Passage Improvement Structures.

Page 6-20-¶1 (Section 6.1.2.4): See note above concerning grade controls.

Page 6-22-¶4 (Section 6.1.2.5): Right-of-Way constraints may force shortening the design and thus over-steepening of a channel/structure, however, when the slope ratio exceeds 1.25 (see **Water Crossing Design Guidelines**[2] (WCDG) pages 32-33), these crossings will be considered roughened channels and permitted under WAC 220-660-200.

Page 6-26-¶2 (Section 6.1.2.5): The application of slope increases greater than 25% will be considered roughened channels and permitted under WAC 220-660-200.

Page 6-42-Bullet 1 (Section 6.2.2.1): Angular rock does not occur often in streams. The use of angular rock in streams should be limited to locations where angular substrate exists naturally, such as a colluvial reach, or where it is cost prohibitive to import rounded substrate. However, the entire mix cannot be composed entirely of angular material – some portion must be water-rounded. For instance, the size classes smaller than 3 inches would be rounded and the remainder fractured material.

Page 6-43-¶4 (Section 6.2.1.2): Experience in Western Washington has shown that if bedform and structures are not constructed, or at least encouraged, in a culvert, they will not develop over time and the resultant culvert bed will become a simplified, plane bed. If the channel bedform is not installed in a structure at the time of construction, placement of coarse/fine materials in strategic locations to encourage the formation of a natural type bed profile and cross section.

Page 6-45-¶1 (Section 6.2.1.3): Bed materials in this type of structure should be no larger than D100. The use of materials larger than D100 in the reference reach must be justified through proper computational methods.

Page 6-45-¶4 (Section 6.2.1.3): Roughening the concrete stem wall is a technique that has not been tested for application in Washington State. This type of design will be considered an ad hoc method and will be viewed as a pilot study with required monitoring and contingencies.

Page 6-49-¶5 (Section 6.2.2.1): Generally, all culverts are filled with bed material at the time of construction. There might be cases where they could be allowed to naturally fill with bedload, but it would be handled on a case by case basis and should follow the mitigation sequence in WAC 220-660-080 to mitigate for upstream impacts.

Page 6-52-¶2 (Section 6.2.2.1): See notes above regarding the use of angular substrate.

[2] Barnard RJ, Johnson J, Brooks P, Bates KM, Heiner B, Klavas JP, Ponder DC, Smith PD, Powers PD. 2013. Water Crossings Design Guidelines. Washington Department of Fish and Wildlife: Olympia, Washington.

Page 6-61-¶2 (Section 6.3.1): See comments regarding floodplain culverts and unconfined systems above. The use of floodplain culverts has been limited in Washington and new installation should be monitored for proper performance and potential impacts.

Page 6-63-¶1 (Section 6.3.2): The flood headwater depths recommended here (HW/D = 0.8 and 0.67) are in excess of what has been common in stream simulation culverts in Washington. In a recent study of 50 stream simulation culverts[3] we found that "The median 100-year recurrence interval flood stage was 28% (range 10 to 67%) of the culvert clearance." In order to maintain stream-like conditions inside the culvert a lower headwater depth criteria should be used.

Page 6-64-Shaded Box (Section 6.3.2-Shaded Box): The sizing of Stream Simulation structures on small streams should take into account the level of confinement and the potential/quantity of overbank flows.

Page 6-66-¶3 (Section 6.4): The described limitation on bankfull channel width adjustment applies strictly to the bankfull channel width, not the structure span.

Table 6.7-Row 6: Stream Simulation structures shall be sized to prevent submerged inlet conditions. See note above on headwater depth.

Page 6-61-¶2 (Section 6.5.1.1): Over-road flows (road dips) have some of the characteristics of a ford. The designer should read WAC 220-660-190(10) for provisions that might apply. See comments above regarding floodplain culverts.

Appendix B

Note that any hydraulically designed channel must meet WAC 220-660-200 Fish Passage Improvement Structures conditions.

Appendix F

Note that channel grade control structures are considered fishways by the State of Washington and are subject to the provisions of WAC 220-660-200 Fish Passage Improvement Structures.

[3] Barnard, R. J., S. Yokers, A. Nagygyor, T. Quinn (2014). **An Evaluation of the Stream Simulation Culvert Design Method in Washington State.** River Research and Applications, DOI: 10.1002/rra.2837.