Oregon Department of Transportation

Stage 1 Research Problem Statement

Number*: 25-55*

Proposed Title: Designing Resilient Downstream Flow Control Structures

1. Concisely describe the **transportation issue** (including problems, improvements, or untested solutions) that Oregon needs to research.

Hydraulic control structures are designed to function by reducing the energy of the stream system and provide benefits from stabilization of the reach and banks, preventing headward channel degradation, and providing upstream and downstream passage for native migratory fish. Oregon's fish passage statute directly influences culvert hydraulic design, bridge hydraulic design and stream stabilization projects. These projects include constructing hydraulic control structures downstream of structures that provide a pool or backwater effect during lower flows to help facilitate fish passage. The most common grade control structures installed by ODOT include roughened chutes, concrete weirs, and boulder weirs.

Over the years, many of ODOT's installed hydraulic control structures have not succeeded in meeting the intent of reducing flow energy, preventing scour, protecting structures, and providing backwater for fish passage. Of the structures that have failed, investigation has revealed significant local scour of material immediately at the downstream side of the control structure. These failures indicate a need for an equilibrium scour equation to properly size streambed material in downstream scour zones. A codified design method is needed for determining particle stability and selecting the appropriate material size in scour zones immediately downstream of the control structures. This will provide structure resiliency, minimize repairs and additional cost and is critical for meeting objectives of the Oregon Fish Passage Law and Healthy Watersheds.

2. Document how this **transportation issue** is important to Oregon and will meet the [Oregon Research Advisory Committee Priorities]
Constricted flows from culverts and bridges result in higher flow velocities that scour or erode the streambed materials downstream of the structure. These higher flow velocities and scour often result in the culvert outlet becoming perched (outlet is above the water levels downstream) which threatens roadway embankment failure and prevents upstream passage of fish. Bridges often experience head cutting at the downstream side of the structure. If downstream head cutting and scour is not accounted for in design, bridge footings can fail from undermining and lead to bridge collapse. In addition, fish passage projects that have control weirs constructed to create pool-riffle stream structures, many of the weirs end up moving downstream because the supporting soils are washed away. The failure of these control weirs results in ODOT being out of compliance with OAR 635-412-0001-0065. ODOT must comply with Oregon fish passage statutes when working in a fish-bearing stream. Specifically, Oregon Administrative Rule (OAR) 635-412-0005 requires ODOT to consider fish passage in culvert hydraulic design, bridge hydraulic design and stream stabilization projects. As a part of this requirement, ODOT hydraulic design incorporates hydraulic control structures to provide upstream and downstream passage for native migratory fish.

The goals and benefits of this research proposal include improved design guidance for resilient structures relating to longevity, changing climate/hydrology events, decreased maintenance operational costs, and meeting Oregon's fish passage statute.

3. What **final product or information** needs to be produced to enable this research to be implemented?

To address the limitation of design tools currently available to ODOT Hydraulic Engineers the following objectives will include:

1. Develop design guidance and methodology for properly sizing materials downstream of a grade control structure utilizing the equation from Bormann and Julien (1991). Currently, this method is an iterative process that requires guessing material size, determining the relative roughness, running the hydraulic analysis, and then checking for allowable scour, with iterations as needed until an answer is computed. Part of the final product will be to automate the iterations process, which will save time and ensure a more accurate and quality design. Physical modeling will likely be required to verify the results.

   Bormann, N.E., and Julien, P.Y., 1991. Scour downstream of grade-control structures. Journal of Hydraulic Engineering, 117(5), pp.579-594.

2. Provide manual and documentation for incorporation into ODOT's Hydraulic Manual.
3. Provide workshop and training materials including hands-on demonstration of developed tool and theory behind developed tool.

4. (Optional) Are there any individuals in Oregon who will be instrumental to the success of implementing any solution that is identified by this research? If so, please list them below.

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5. Other comments:

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