# Chapter 2: Stream Characteristics  and Hydrology

## Objective and Purpose

Describe the stream conditions that affect the design of stream road crossings.

## Characteristics in the  Steam that affect a design

1. Stream Bed Materials: type, depth at the site
2. Channel type: Confined, incised, broad wide, etc.
3. Relationship to other streams
4. Gradient of Stream
5. Incision History of channel and the value of the culvert as nick point
6. Watershed size and streams location within the watershed.
7. A profile of Existing Streambed
8. Active Stream width
9. Width of Stream bed in area
10. Geology of a stream

## Stream Bed Materials

The size and type of bed material that is in the pre-existing streambed or in the streambed upstream is required for designing the new structure and monitoring effectiveness.
The various size classes are roughly quantified in the chart below.  This is a reprint of one developed by Oregon Dept. of Fish and Wildlife.

| Type of Substrate | size | relative size |
|---|---|---|
| Bedrock | 13 ft diameter | Bigger than a car, continuous Underlayment. |
| Boulders | 10" to Bedrock | Basketball to Car Size |
| Large Cobbles | 6"    to 10" | Cantaloupe to Basketball |
| Small Cobbles | 2.5" to 6" | tennis ball to cantaloupe |
| Coarse Gravel | 0.6" to 2.5" | Marble to tennis ball |
| Fine Gravel | 0.1" to 0.6" | Ladybug to marble |
| Sand | 0.1" | Smaller than ladybug but visible as particle |
| Fines | Not visible as particles | Silt clay muck not gritty |

## Geology of Site

Geology features that are often necessary for design:

1. Depth to bedrock: It is important to estimate the depth of valley fill material. Valley fills refer to layers of gravel, sand cobbles another sediment that lie over the top of the bedrock. If a little fill is present then culvert sinking/embedding strategies become impractical because of the difficulty of sinking into bedrock. On the other hand placing an open arch in a place where there is excessive depth to bedrock may make an arch impractical.

2. Size and availability of Rock for embedment and ripraping of slope: The width of culverts and arches are dependent on the size of material used for protection of the foundations and used for embedment.

3. Bearing Capacity of soil and estimate of consolidation of soil if footings are not placed on solid rock.

## Assessment of the Adjacent Stream Reach

“The characteristics of the adjacent stream reach determine the size, slope and degree of embedment of the pipe. New culverts will generally be installed at the natural channel gradient. Replacement culverts, in situations where the downstream channel has degraded, will be installed at a steeper gradient than the adjacent channel. The composition and pattern of the adjacent channel (outside the influence of the structure) will suggest what the bed in the culvert should look like. The exceptions are channels dominated by large pieces of wood.”

# Width of Active Channel and Stream Bed

The minimum culvert width, when designing for stream simulation and avoiding contraction at the culvert inlets is a function of the width of the existing stream. That width is estimated in the field and used during the design for developing alternatives.

The minimum width of the culvert bed is still a matter debate accordingly. I will provide excerpts from several sources for comparison.

1. Per WDFW design guide the minimum width for stream simulation of the bed in the culvert (Culvert bed) should be determined by the formula

Wch= Width of the channel Bed

| Formula | Condition |
|---|---|
| W= 1.2 Wch +2 | No Slope culvert option |
| W= Width corresponding to two year interval floods: Bank Full | When Wch is poorly defined |
| W= Width of channel + 2' | In confined valley channels where the stream width does not change substantially with the stage. |

2. George Robison in his manual “Oregon Road/Stream Crossing Restoration Guide” recommends that a culvert be wider than the “Active Channel width “ to prevent an inlet drop and possible bed scour. He defined an active channel as the stream width when larger stream flow events occur. The recurrence of these larger stream flow events associated with active flow is about once every one or two years. George then provides the following help in selecting that width.

| | |
|---|---|
| Alluvial Stream (low gradient streams in Wide valleys) | Active Channel Width: Where the bank slopes moderately from being steep to being more gently or even flat |
| Incised streams | Active Channel Width: At abrupt changes in vegetation, bank texture |

George Recommended that the active channel width be determined from no less than 10 cross sections in the reach that fish passage restoration work is being done. He provided the following a diagram to help in defining the active channel width. See diagram page 5.

The active channel width as used by the Coos Bay District is selected similarly to that of WDFW and George Robison approach. Measurements are taken of the stream bed width upstream and downstream of the culvert in areas of similar reaches. That width is than used a minimum starting point for selecting the culvert or structure width. Initially we selected widths that were close to the graveled or portion of the stream that had no grass or growth. This is slightly smaller than the widths as described above.

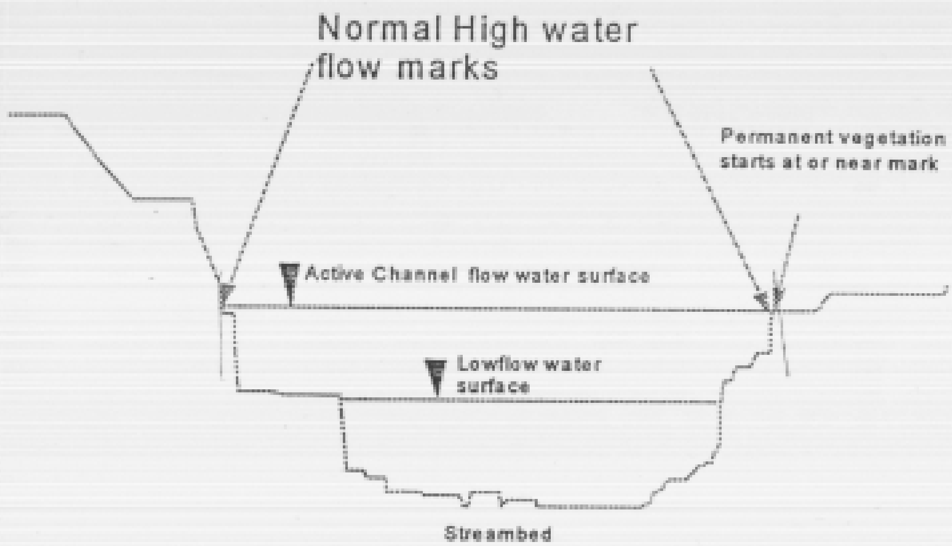

Figure 10. Highwater flow marks and
active channel width schematic.

# Hydrology

Hydrology refers to the study of water. When people use this term in relationship to fish passage, they are usually referring to the quantity of water that can be expected at culverts during different situations. Good discussions on the hydrology of fish passage, delay times and criterion for design are available in the references.

The minimum size of a structure such as a culvert or a bridge should be large enough to carry a design peak flow plus the debris associated with that flow. In bridges we use the Q100 flow with 4 to 5 feet of freeboard. With culverts the Q 100 flow is used and the sites are often hardened to resolve debris flow. If a culvert was designed only to pass water, the size of the structure may be significantly smaller than that necessary to pass fish and aquatic organisms. The hydrology of the sites gives a starting point for the final design.

**Design Flood Q 100**

Q100 = This is the 100-year design flow. In 0regon we predict this flow using a minimum of three methods.

USGS method
WRRI method
Comparison to at least three gauging stations.
Robisons Peak Flow Map for 50 interval

A program that makes these calculations is available upon request and will give a good range of values for predicting peak flows.

**High Flow Fish flow Qhfj, Qlfj**

This is the estimated highest flow when juvenile fish (Qhfj) and the lowest flow (Qlfj) flows when juvenile fish are expected to be moving through the culvert. The objective is to design culverts or structures such that fish movement is never delayed. In particular such that juvenile movement is never delayed. That flow value is very difficult to predict and one that is currently being debated and studied. The following is this authors opinion only on an acceptable methodology for selecting the design range.

For culverts designed for stream simulation such as open bottom structures and pipes that trap gravels this value is not needed as juvenile movement is expected to occur between the roughness elements in the substrate. For culverts that are designed for hydraulic pool and weir flow this value is a primary design value. Using a gaging station record book the monthly flows for gaged stations can be selected. By using the adjustments recommended in the USGS method those flows can than be proportioned to the design un-gauged drainage. This author uses the high mean monthly flow value as a good estimate for Qhfj and Q lfj flows. A program that does this comparison is available with a database of gauging stations for Oregon.

The state of Washington has formulas for high and low fish passage flow adjusted for the various regions within the state. Those formulas can be downloaded off their web site.