

TO: All Design Section Staff  
FROM: Bijan Khaleghi  
DATE: September 30, 2017  
SUBJECT: Scour Requirements for Bridges, Walls, & Culverts

This design memorandum defines WSDOT policy on scour consideration for bridges, walls, and culverts. Policy on the scour of walls attached or associated with bridges or culverts is also defined. The scour consideration for walls along streams away from bridge and culvert limits shall be determined by the Regions.

### **Bridge Scour:**

All bridge foundations shall be protected from scour regardless of bridge type, location, and usage. Scour at bridge foundations shall be designed by the bridge designers for two conditions:

1. At service and strength limit states: For the design flood for scour, the streambed material in the scour prism above the total scour line shall be assumed to have been removed for design conditions. The design flood storm surge, tide, or mixed population flood shall be the more severe of the 100-year events or from an overtopping flood of lesser recurrence interval.
2. At Extreme Limit State (Earthquake or Scour): For the check flood for scour, the stability of bridge foundation shall be designed for scour conditions resulting from a designated flood storm surge, tide, or mixed population flood not to exceed the 500-year event or from an overtopping flood of lesser recurrence interval. Excess reserve beyond that required for stability under this condition is not necessary.

Unless otherwise specified, bridges shall be designed for the 100-year scour. Unless otherwise specified, bridges shall have a risk assessment for the potential for stream migration for the 500-year scour.

If the site conditions due to ice or debris near stream confluences dictate the use of a more severe flood event for either the design or check flood for scour, the State Hydraulics Engineer may recommend the use of such a flood event.

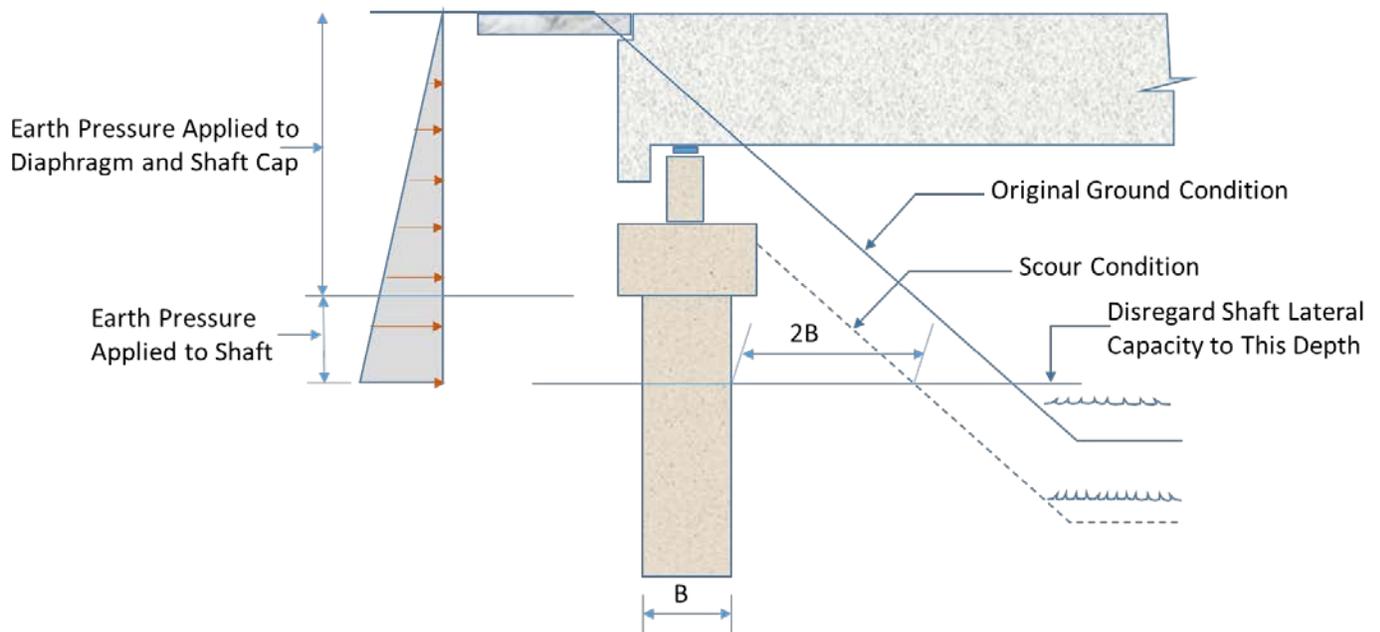
Where conditions dictate a need to construct the top of a footing or cap at an elevation above the streambed, the bridge designers shall address the scour potential of the design, based on HQ Hydraulics Office analysis of the scour potential of the proposed geometry of the foundation element.

Spread footings on soil or erodible rock shall be located by the bridge designers so that the bottom of footing is below scour depths. Spread footings on scour-resistant rock shall be constructed such that the integrity of the supporting rock is maintained.

Deep foundation such as piles or shafts may be selected by the bridge designers to protect bridges from scour. Lower elevations should be considered for pile-supported footings where the piles could be damaged by erosion or corrosion from exposure due to scour.

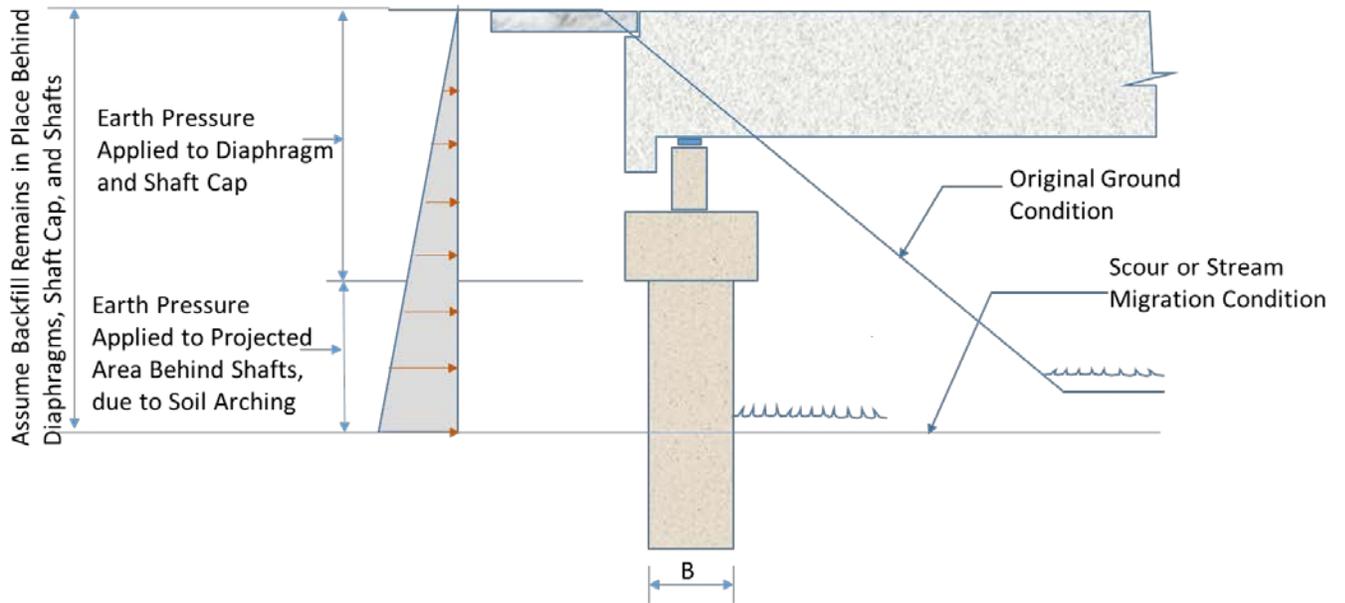
When fenders or other pier protection systems are used, the bridge designers shall address the effects of such systems on pier scour and collection of debris, based on HQ Hydraulics Office analysis of the hydraulic scour side-effects of the proposed systems.

When scour condition expose all or a portion of the shaft cap, drilled shaft lateral capacity shall be disregarded down to the depth of which the remaining soil in front of the shaft reached two shaft diameters in width as shown in Figure 1.



**Figure 1**

When scour or stream conditions could uncover the shaft cap and expose the supporting shafts below, soil arching conditions behind the shafts shall be assumed, requiring the full-depth earth pressures to be applied from behind the shafts and shaft cap as shown in Figure 2.



**Figure 2**

### **Wall and Culvert Scour:**

In situations where scour (e.g., due to wave or stream erosion) can occur in front of the wall, the bottom of the wall foundation (e.g., structural earth or Geosynthetic wall leveling pad, concrete wall spread footing, the cap for pile or shaft supported walls), and the bottom of fascia panel or lagging for soldier pile type walls, shall meet the minimum embedment requirements relative to the scour elevation in front of the wall. A minimum embedment below scour of 2.0 feet shall be used.

At any location where a retaining wall or reinforced slope can be in contact with water (such as a culvert outfall, ditch, wetland, lake, river, or floodplain), there is a risk of scour at the toe. The wall designers shall address this risk, based on HQ Hydraulics Office assessment of the scour potential at the wall site.

The risk for channel migration, low or high, will be identified in the Preliminary Hydraulics Design Report or other documentation prepared by the HQ Hydraulics Office. For low stream migration risk, and if wall foundation is outside of the scour prism, the wall designers may design the wall for 100-year design flood and not for the 500 year check flood.

### **Background:**

Scour is the leading cause of bridge failures in Washington State and nationwide. Of the 70 documented bridge failures in Washington State history, 43 were due to scour. A majority of bridge failures in the United States and elsewhere are the result of scour.

The added cost of making a bridge less vulnerable to damage from scour is small in comparison to the total cost of a bridge failure.

The design flood for scour shall be determined on the basis of the Engineer's judgment of the hydrologic and hydraulic flow conditions at the site. The recommended procedure is to evaluate scour due to the specified flood flows and to design the foundation for the event expected to cause the deepest total scour.

Present and anticipated future flow patterns in the channel and its floodplain and the effects of these flow patterns on the bridge shall be addressed. The bridge design shall be modified as necessary to satisfy concerns raised by the scour analysis and the evaluation of the channel plan form.

Foundation designs shall be based on the total scour depths estimated in the Hydraulic Design Report. Where necessary, bridge modifications for scour mitigation may include:

- Relocation or redesign of piers or abutments to avoid areas of deep scour or overlapping scour holes from adjacent foundation elements,
- Enlargement of the waterway area, or
- Relocation of the crossing to avoid an undesirable location.

Implementation by the bridge designers of any of the individual bridge modifications identified above, or a combination of the above, will be based on a collaborative discussion between the HQ Geotechnical Division, the HQ Hydraulics Office, the Bridge and Structures Office, and Regions Project Office.

Foundations shall be designed to withstand the conditions of scour for the design flood and the check flood. In general, this will result in deep foundations. The design of the foundations of existing bridges that are being rehabilitated shall consider underpinning if scour indicates the need. Riprap and other scour countermeasures may be appropriate if underpinning is not cost effective.

Foundation conditions resulting from the design flood for scour shall be considered at strength and service limit states. Foundation conditions due to scour resulting from the check flood or bridge scour shall be considered of the Extreme Limit State.

Reliance on riprap or other scour protection and mitigation strategies is usually not considered for WSDOT bridges and structures unless it is recommended by the State Hydraulics Engineer.

The HQ Hydraulics Office will indicate the anticipated depth of scour at the bridge piers. They will analyze bridge piers for flow disturbance based on the pier shapes and orientations provided by the Bridge and Structures Office, and will collaborate with the Bridge and Structures Office to establish a final pier shape and orientation. They will also recommend measures to protect the piers from scour activity or accumulation of drift (use of deep foundations, minimum cover to top of footing, riprap, pier alignment to stream flow, closure walls between pier columns, etc.).

If required, bridges and walls can be made resistant to scour. Contained fill material, however, may not be protectable. If associated retaining walls are outside of the scour prism, and if the risk of stream migration is low, the wall may be designed to resist only the 100-year design flood event.

The foundation for all walls constructed along rivers and streams will be evaluated during design by the State Hydraulics Engineer for scour in accordance with AASHTO LRFD Bridge Design Specifications Section 2.6.4.4.2. The wall foundation shall be located by the wall designers at least 2.0 feet below the scour depth in accordance with the Geotechnical Design Manual.

If you have any questions regarding this policy memorandum, please contact [Richard Zeldenrust@wsdot.wa.gov](mailto:Richard.Zeldenrust@wsdot.wa.gov) at 360-705-7196 or [Bijan.Khaleghi@wsdot.wa.gov](mailto:Bijan.Khaleghi@wsdot.wa.gov) at 360-.705-7181 or.

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