

7.1.7 Scour Requirements

Scour can affect the bridge structure, adjacent wall structures, and the bridge embankment. The bridge structure shall be designed for total scour. Total scour for the bridge structure does not take into account any added scour countermeasures as explained in the sections below. If scour countermeasures are designed and constructed following guidance from the most recent version of HEC 23, then walls and embankments benefit as explained in the sections below.

All bridge foundations shall be designed for total scour regardless of bridge type, location, and usage. Bridge foundations shall be designed by the bridge designers for total scour considering the following two conditions:

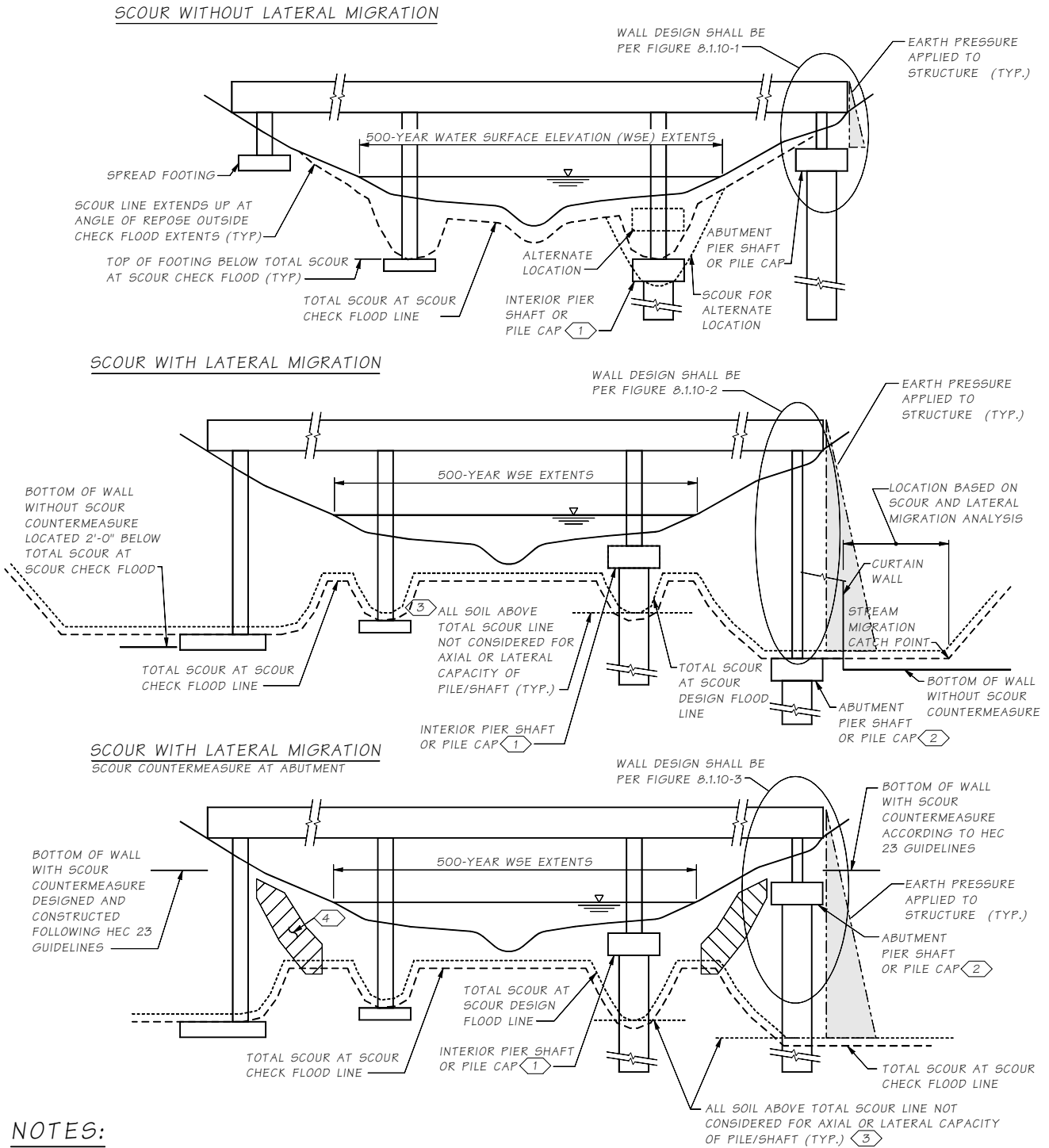
1. At Service and Strength Limit States: For the scour design flood, the streambed material above the total scour line shall be assumed to have been removed for design conditions. The scour design flood is the worst-case scour for all floods up to and including Q100. The Hydraulics Office provides the total scour elevation corresponding to the scour design flood.
2. At Extreme Limit States (Earthquake and Scour): Two separate extreme cases shall be evaluated when verifying the stability of the bridge foundation. The check flood is the worst-case scour for all floods up to and including Q500.
 - Extreme Case I – 50% of the total scour design flood depth plus seismic
 - Extreme Case II – 100% of the scour check flood depth

Unless otherwise specified, the top of footing locations for bridges shall be based on total scour at the scour check flood, and design shall be based on the total scour at the scour design flood or scour check flood depending on the controlling load case. If there is lateral migration, then the determination of total scour during both the scour design flood and the scour check flood shall account for the migrated state.

Total scour is determined by the Hydraulics Office. Figure 7-6 in the *Hydraulics Manual* shows the various contributions on total scour along with lateral migration.

Figure 7.1.7-1 as well as the following subsections provide guidance on top of footing or cap elevations.

Figure 7.1.7-1 Foundation Scour Effects



NOTES:

- ① INTERIOR PIER SHAFT OR CAP MAY BE LOCATED ABOVE THE TOTAL SCOUR AT THE SCOUR CHECK FLOOD LINE AS LONG AS THE FOUNDATION IS DESIGNED FOR THIS CONDITION. BOTH HYDRAULIC AND GEOTECHNICAL RECOMMENDATIONS SHALL ACCOUNT FOR THE EXPOSED FOUNDATION GEOMETRY. THE EFFECT OF THE SCOUR PRISM ON THE CAPACITY OF THE SHAFT MAY FOLLOW FIGURE 10-18 OF THE FHWA GEC10 MANUAL.
- ② ABUTMENT PIER SHAFT CAP OR PILE CAP MAY BE LOCATED ABOVE THE TOTAL SCOUR AT THE SCOUR CHECK FLOOD LINE IF A SCOUR COUNTERMEASURE DESIGNED AND CONSTRUCTED FOLLOWING HEC-23 GUIDELINES HAS BEEN ADDED AT THE BRIDGE END AND THE FOUNDATION IS DESIGNED TO ACCOUNT FOR THE CAP BEING LOCATED AT A HIGHER ELEVATION. BOTH HYDRAULIC AND GEOTECHNICAL RECOMMENDATIONS SHALL ACCOUNT FOR THE EXPOSED FOUNDATION GEOMETRY. EARTH PRESSURE ON ABUTMENT SHALL BE PER FIGURE 7.1.7-2.
- ③ ONLY THE UPPER HALF OF THE TOTAL SCOUR FOR SCOUR DESIGN FLOOD IS IGNORED FOR EXTREME EVENT CASE I.
- ④ COUNTERMEASURES SHALL BE PLACED OUTSIDE THE MINIMUM HYDRAULIC OPENING. LIMITS OF THE COUNTERMEASURE ARE BASED ON SCOUR AND LATERAL MIGRATION ANALYSIS. SCOUR COUNTERMEASURES SHOWN FOR GRAPHICAL PURPOSES ONLY, AND SHALL BE DESIGNED AND CONSTRUCTED BASED ON HEC-23.

7.1.7.A Shallow Foundations

Shallow foundations supporting interior piers and abutments on soil or erodible rock shall be located so that the top of footing is below the total scour at the scour check flood. The presence of scour countermeasures does not change the location of the shallow foundations.

If a bridge abutment footing is reliant on a retaining wall, the wall shall be designed for the total scour depth, regardless of the presence of a scour countermeasure. The retaining wall shall have continuous structural concrete or continuous fascia that extends 2 feet below the total scour at the scour check flood. The length of such a wall shall be determined by performing an assessment to ensure the stability of the wall and structure element through the range of anticipated scour and lateral migration.

Shallow foundations on scour-resistant bedrock shall be designed and constructed to maintain the integrity of the supporting rock and shall be located such that the bottom of footing is at or below the top of the scour resistant material.

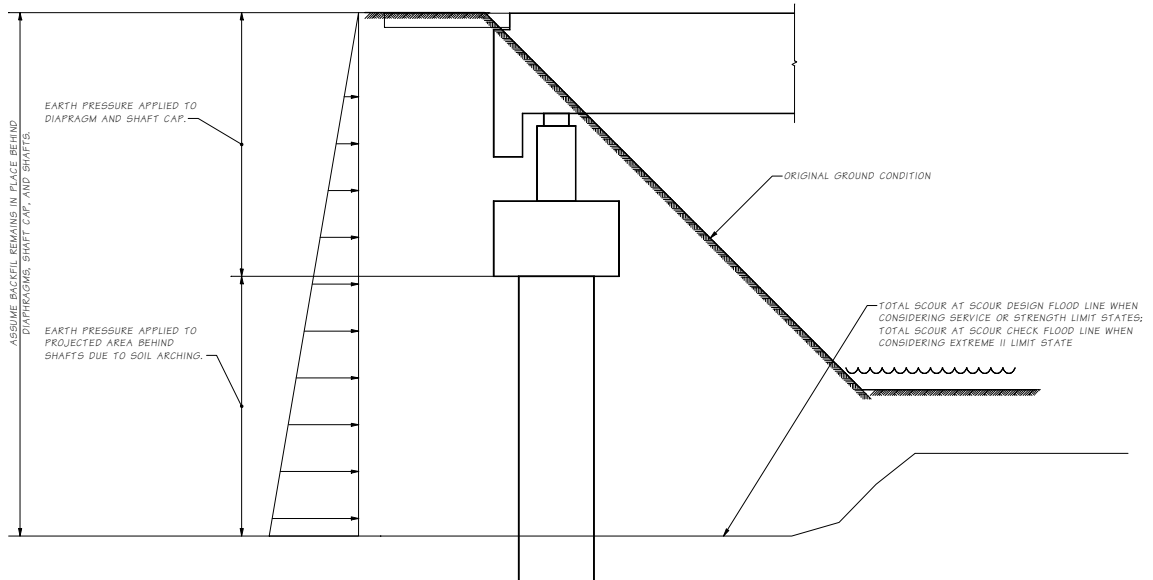
7.1.7.B Deep Foundations

At bridge abutments without scour countermeasures designed and constructed per the most recent HEC 23 guidelines, deep foundations such as drilled shafts or driven piles, with pile or shaft caps, shall be located such that the top of pile or shaft cap is located below the total scour at the scour check flood. **Scour countermeasures shall not be placed at interior piers.** For interior piers, or at bridge abutments with scour countermeasures designed and constructed per the most recent HEC23 guidelines, the top of foundation may be located above the total scour at the scour check flood elevation. There may be select structures where the pile or shaft cap may be located above the total scour at the scour check flood at abutments without scour countermeasures if there is concurrence with the State Hydraulic Engineer, the State Geotechnical Engineer, the State Bridge Design Engineer, and the Region Manager, as well as the structure not being located on a T1 freight route or a lifeline route.

When the top of shaft or pile cap is located above the total scour elevation, the hydraulic and geotechnical recommendations shall account for the exposed foundation geometry. The foundation shall be designed assuming that the soil above the total scour elevation has been removed; or half the depth above the total scour at the scour design flood in Extreme Event Case I.

Soil arching conditions behind the shafts shall be assumed to the total scour elevation at the scour design flood, requiring the full-depth earth pressures to be applied from behind the shafts and shaft cap as shown in [Figure 7.1.7-2](#).

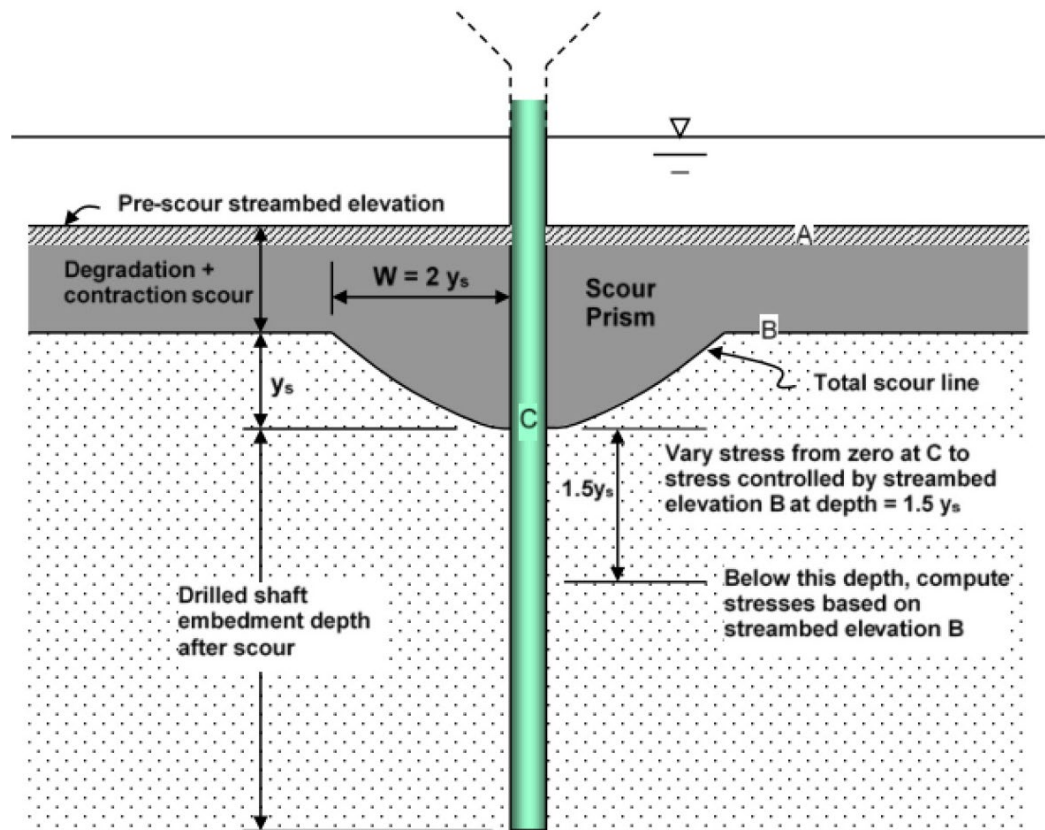
Figure 7.1.7-2 Scour Effects with Lateral Migration



Lateral analysis of the shafts shall be determined using the forces from Figure 7.1.7-2 and ignoring all soil down to the total scour depth (or 50% of the total scour depth) for the particular load case. Axial capacity of the shafts shall be determined by ignoring the soil resistance above the total scour depth (or 50% of the total scour depth) for the particular load case.

The total scour prism on the capacity of the shaft may follow Figure 10-18 of the 2018 FHWA GEC10 Manual, which is shown in Figure 7.1.7-3.

Figure 7.1.7-3 Illustration of Total Scour Prism and Effects on Drilled Shaft



7.1.7.C Walls Adjacent to Structures

The length of walls adjacent to structures that do not have a scour countermeasure designed and constructed per the latest HEC23 guidelines shall be determined by performing an assessment to ensure the stability of the wall and structure element through the range of anticipated scour and lateral migration. See BDM [Figure 8.1.10-2](#) for additional information.

See Section A for retaining walls used to support bridge abutments.

7.1.7.D Existing Structures

When an existing structure is modified due to a widening, retrofit, etc. that would effect scour, the Hydraulics Office and the Bridge Preservation Office shall be contacted to access scour as a repair may be required.

7.1.7.E Buried Structures

Three sided buried structures are supported by shallow or deep foundations, and therefore foundation guidance regarding scour shall follow that in the sections above.

Four sided buried structures shall be positioned such the top of the bottom slab is located a minimum of 2 feet below total scour at the scour design flood.

Wall lengths for buried structures shall be determined by performing an assessment to ensure the stability of the wall and structure element through the range of anticipated scour and lateral migration.