Creating Useful Scour Documentation

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What is scour

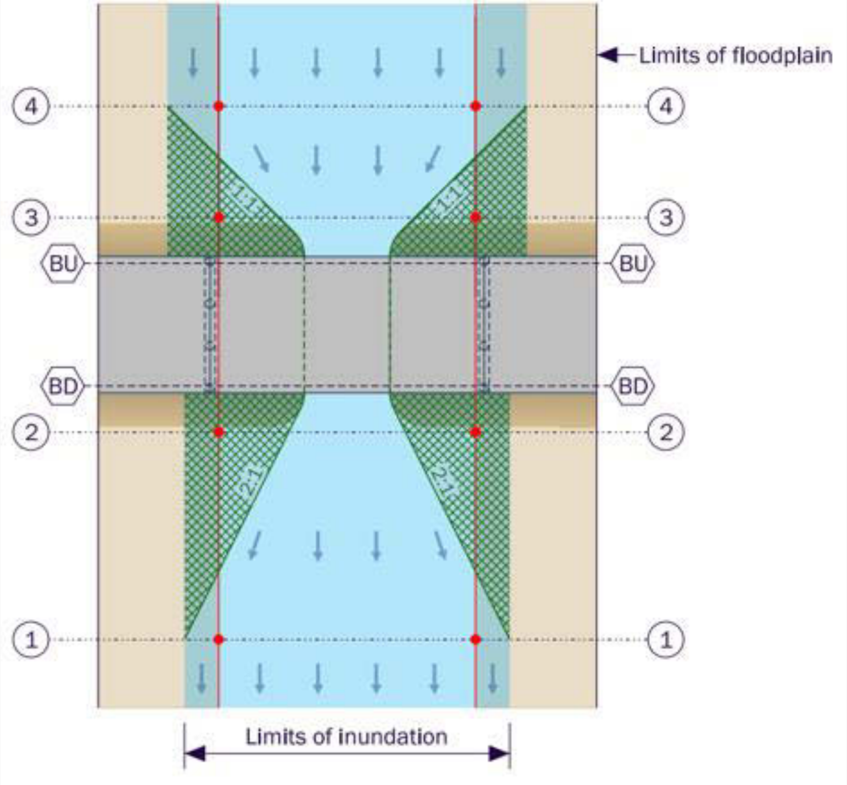
FHWA "Scour is the result of the erosive action of flowing water, excavating and carrying away material from the bed and banks of streams and from around the piers and abutments of bridges."

More things to consider

- Different materials scour at different rates, however ultimate scour depth can be similar across soil types.
- Maximum scour often occurs during peak floods and may take several floods.
- Scour holes can refill, hiding damage.

Scour at Bridges

- Erosion of streambed or bank material due to flowing water
  - Contraction scour
    - Constricting the channel at a bridge opening
  - Pier Scour
    - Obstructions to flow in the channel



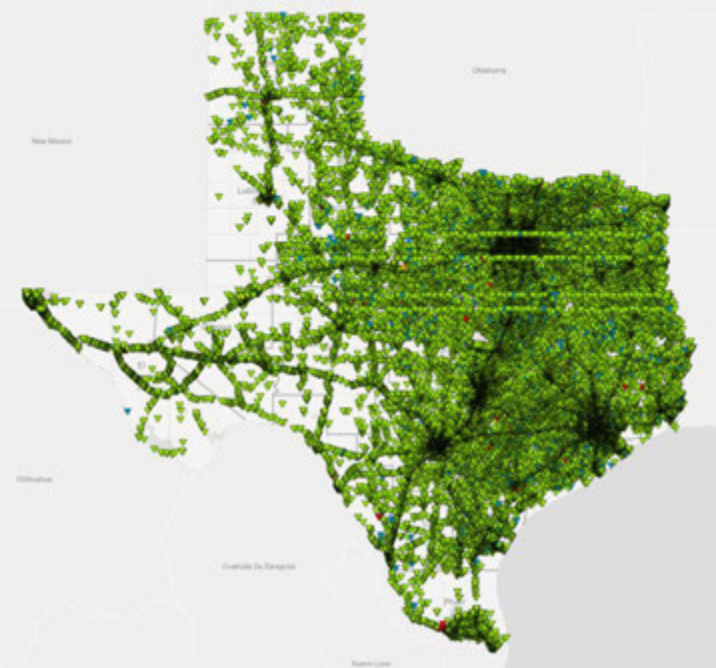
The Leading Cause of Bridge Failures

Scour is the primary cause of bridge collapses during floods.

- 1987 floods: 17 bridges destroyed in NY and New England.
- 1985 floods: 73 bridges failed across PA, VA, and WV.
- 1993 Mississippi flood: 23 bridge failures.
- 1994 Georgia storm: Over 500 bridges damaged

TxDOT bridge inventory

- 58,923 total bridges
  - 46,464 bridges over water (79%)
    - Of these:
      - 21,346 bridge class culverts (36%)
      - ~1% scour critical



Objectives of scour evaluation program

- Minimizing future flood damage requires greater focus on developing and applying improved procedures for designing and inspecting bridges for scour.

Importance of Scour Evaluation

- Scour documentation
  - Rapid evaluation in flood response
  - Prioritization of structures for replacement
  - Identify structures requiring repair
- Supports cost-effective maintenance and rehabilitation strategies.
- Helps prevent bridge collapse and loss of life.
- FHWA mandates evaluation of scour for all bridges over waterways.

TxDOT Scour Evaluation Method

Field Observation Approach

- Ideal for older structures and culverts
- Evaluation based on current and historical performance
- Requires sufficient channel history

Prediction Approach

- Required for new span bridges
- Evaluation based on analysis
- Required for critical structures

Scour Documentation

Scour Summary Sheet supported by

- Scour analysis
- Scour screening evaluation
- Scour vulnerability assessment
- Risk assessment for unknown foundations
- Plan of action for scour critical structures
- In depth capacity analysis
- Plan of action follow up

Scour Summary Sheet Contents

- Bridge information
- Engineer's seal and signature
- Countermeasure condition
- Maximum allowable scour depth
- Observed scour depth
- Trigger elevation (for reevaluation)
- Description for future action

SCOUR DEPTHS

☑ Scour depths are measured from the as-built channel profile.

☐ Scour depths are measured from:

Abutment or Bent #	Bent 2	Abut 1
y_{ab} ☑ or y_{ar} ☐	15	
y_{al}	25	
Max Allowable Scour Depth[1], y_a	15 (Elev. 200)	
Max Possible Scour Depth[2]		See Trigger
Calculated Contraction Scour	5	
Calculated Pier Scour	2.5	
Total Calculated Scour Depth	7.5	
Observed Scour Depth	10 (Elev. 195)	See below

Notes: (1) Min (y_{ar} or y_{ab}, or y_{al}). (2) ONLY applicable if a non-erodible stratum is pres

Abutment Protection Condition: (Describe below)	None or Minor	Moderate	Major	
	☐	☒	☐	B.C.09

Form 2605
(Rev. 03/24)
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TRIGGER ELEVATION & FUTURE ACTION

Refer to Chapter 10 of the Scour Evaluation Guide.

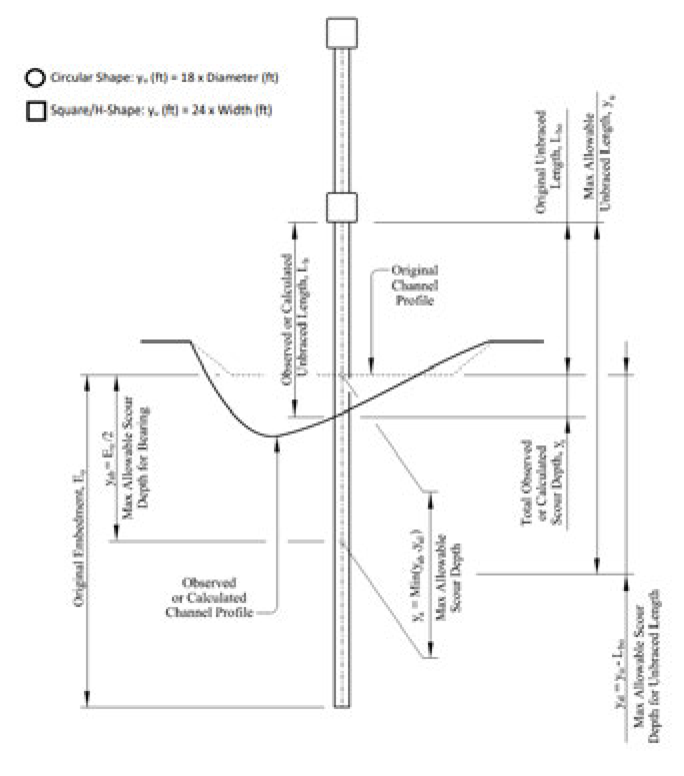
Current scour at abutment exposed toe wall of CRR. Considered moderate exposure condition.
Re-evaluation will be needed:
-When scour exposed the bottom of abutment cap
-When scour at Bent 2 exceeded 13 feet (Elev. 198')

Maximum Allowable Scour – Span Bridges

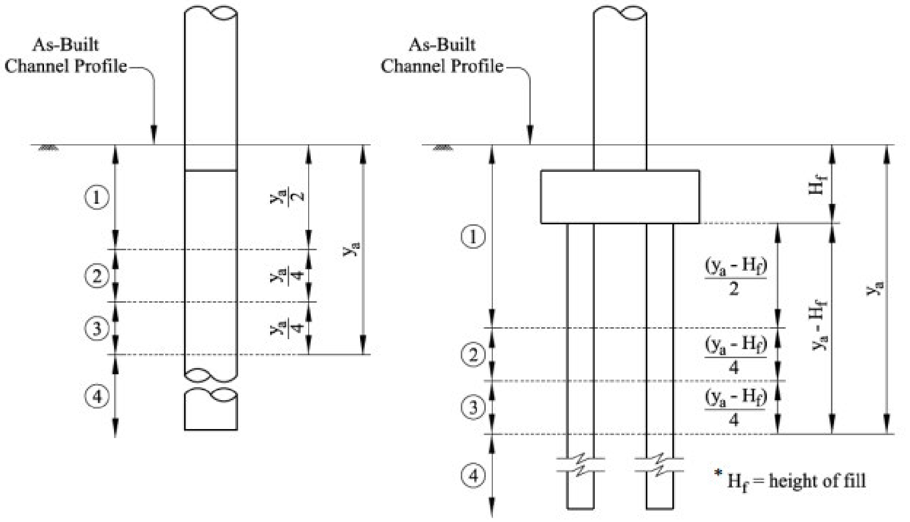
- Amount of scour that can occur before a bridge foundation becomes unstable due to:
  - Bearing capacity
  - Lateral support
  - Rotational stiffness
  - Other applicable failure modes

Maximum Allowable Scour – Deep Foundations

- Geotechnical capacity assumptions
  - Factor of safety of 2 from original embedment
  - Uniform material along full length of element
  - End-bearing neglected
  - No disregard depth from original channel profile



Exposure Categories - Deep Foundations



*Note: When as-built Channel Profile is below the bottom of footing, $H_f=0$

① Minor Foundation Exposure

② Moderate Foundation Exposure

③ Major Foundation Exposure

④ Extreme Foundation Exposure

y_a = Max Allowable Scour Depth (Refer to Ch. 2 in the Scour Evaluation Guide)

Exposure Categories - Abutments

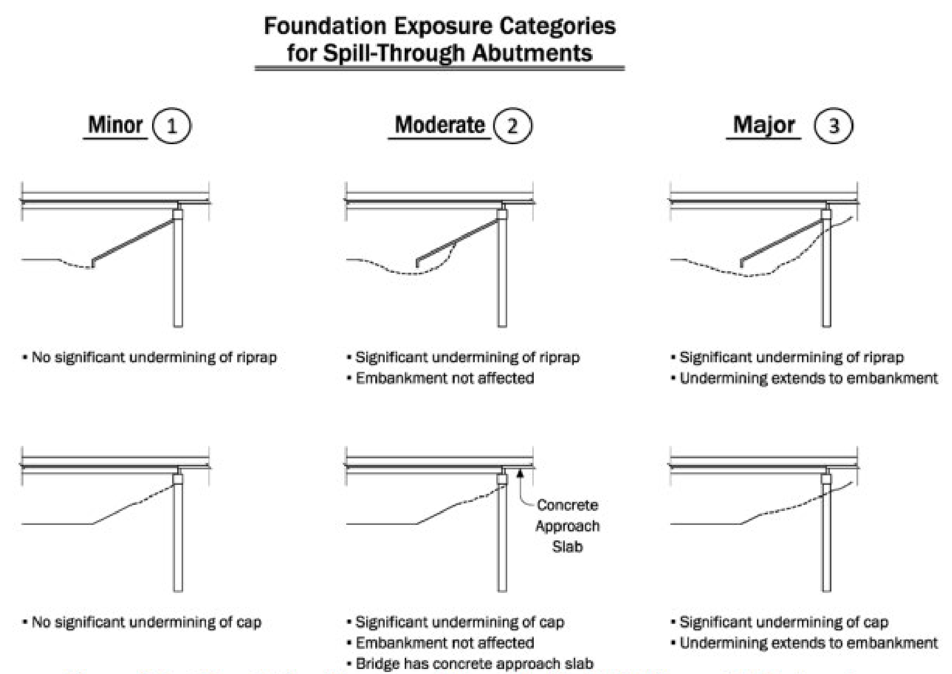


Figure 8-2 – Foundation Exposure Categories for Spill-Through Abutments

Exposure Categories - Abutments

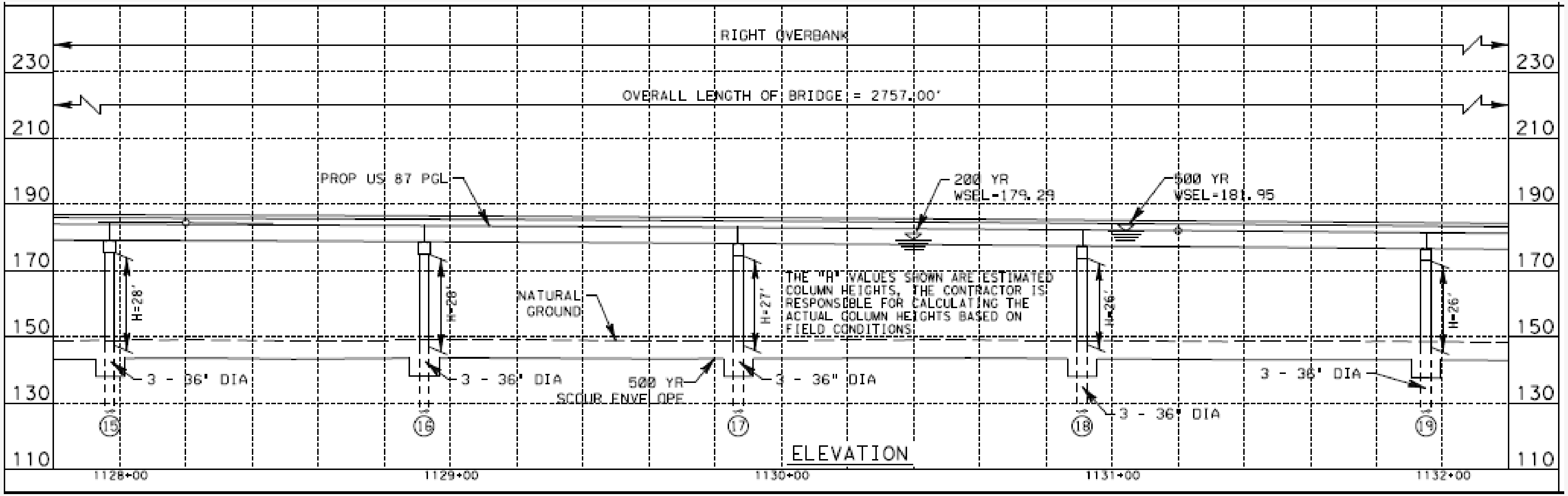
Exposure Categories - Abutments

Scour Analysis Methods

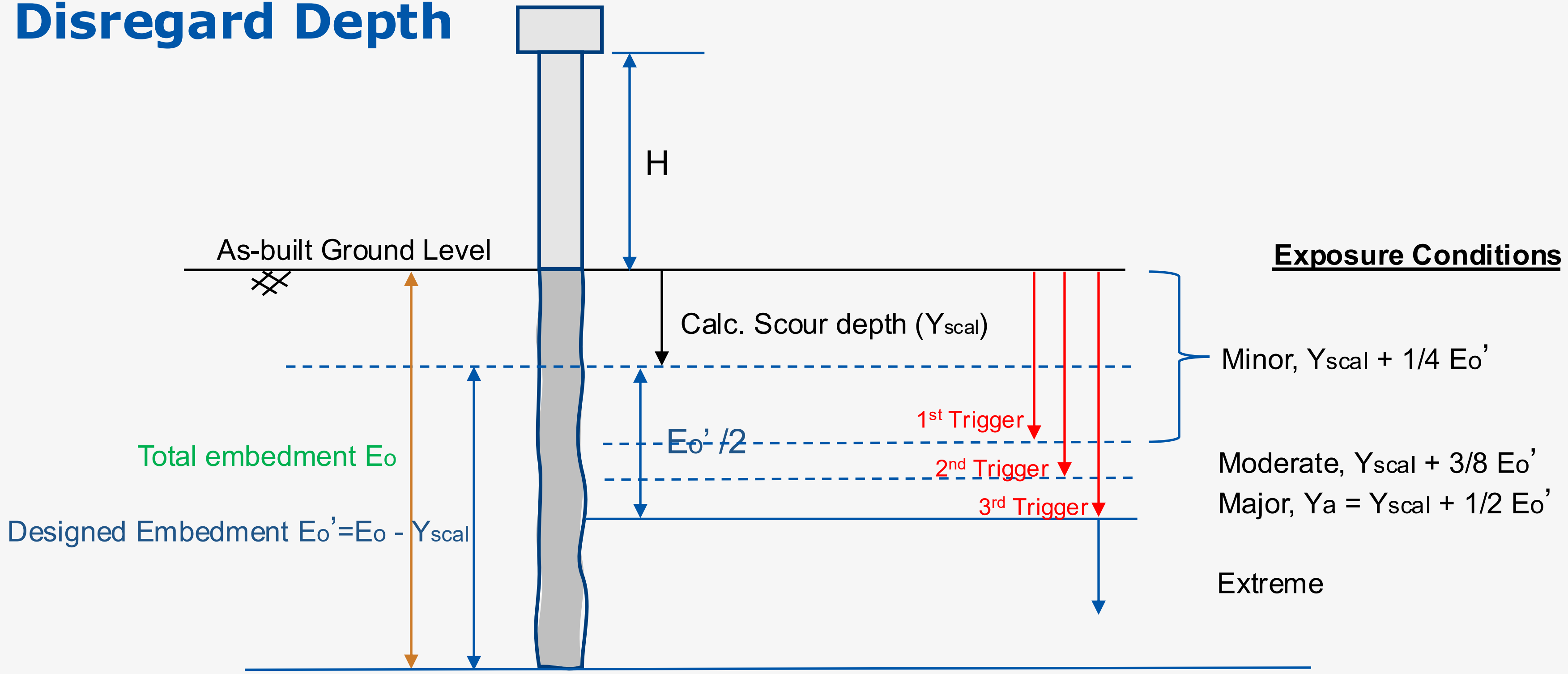
- Contraction Scour
  - Traditional HEC-18 method
    - Sandy Soils
  - SRICOS method
    - Clay and soft rock
  - Pressure method
    - Water above bridge low chord
- Pier Scour
  - Traditional HEC-18 method
    - Sandy Soils
  - SRICOS method
    - Clay and soft rock
  - Annandale's Erodibility Index method
    - Fractured/jointed rock

New Structures

- Scour Analysis based on hydraulic and hydrologic analysis **required** for all bridges
- Bridges designed to resist damage resulting from the scour design flood



Disregard Depth



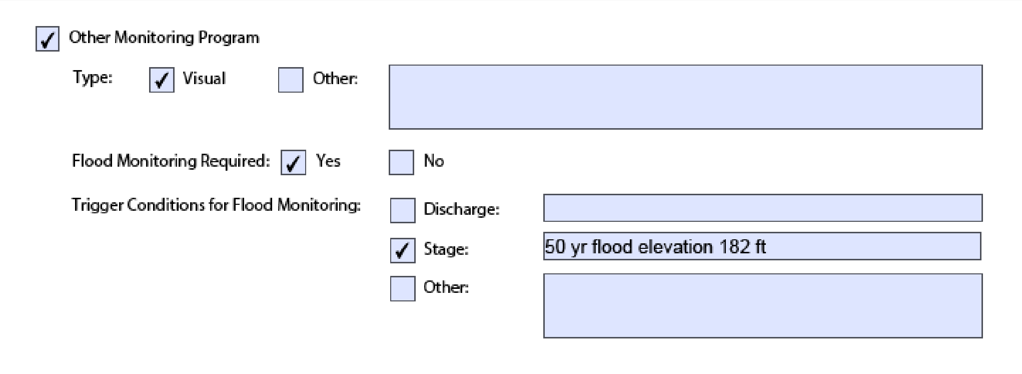
Plan of Action Contents

- Bridge information
- Engineer’s seal and signature
- Current scour and channel coding
- Scour vulnerability rating
- Monitoring plan
- Countermeasure recommendations

Plan of Action

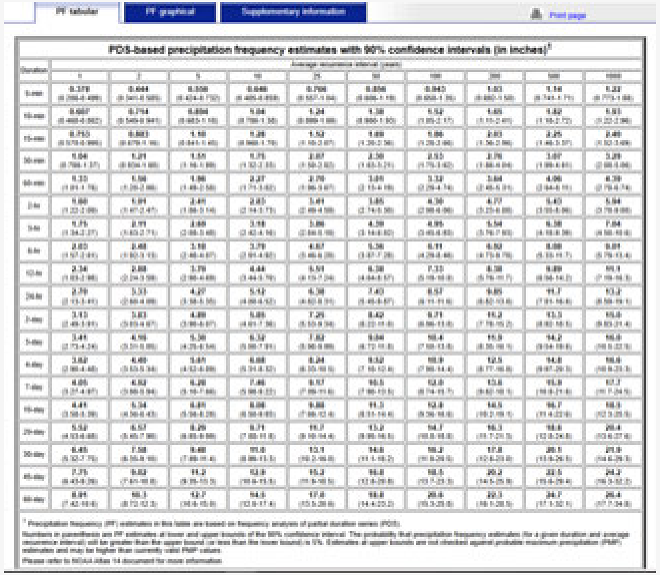
Required for scour critical bridges

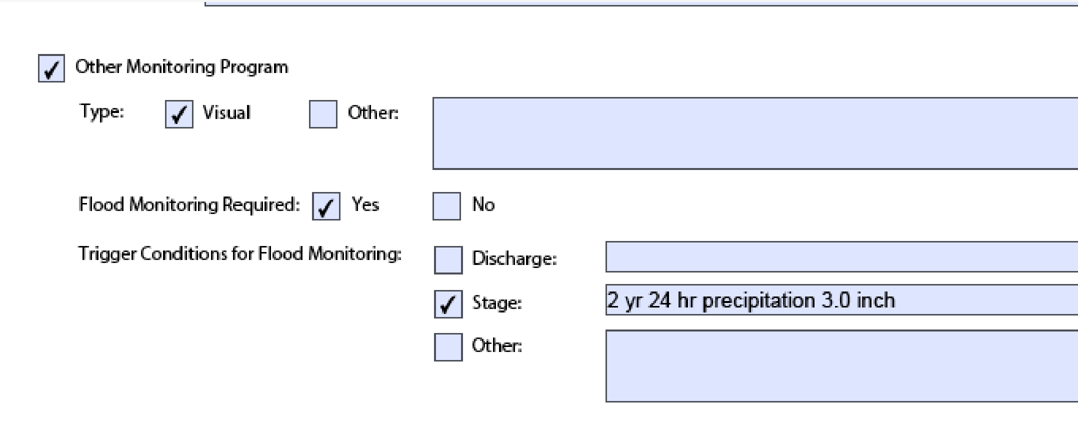
- Monitoring program considered as scour countermeasure only if specific details are provided (e.g., flood elevation or precipitation)


☑ Other Monitoring Program
Type: ☑ Visual ☐ Other:
Flood Monitoring Required: ☑ Yes ☐ No
Trigger Conditions for Flood Monitoring:
☐ Discharge:
☑ Stage: 50 yr flood elevation 182 ft
☐ Other:

NOAA ATLAS 14

NOAA ATLAS 14 data can be used for the precipitation estimate





Example

Example (cont.)

Example (cont.)

FOUNDATION DETAILS

☐ The foundation is protected by a non-erodible stratum. (Describe below.)

Majority of DS is embedded in clays. Drilled-and-underreamed portion embedded in shale (range elev. 288 to 290').

Refer to Chapter 7 of the TxDOT Scour Evaluation Guide.

☐ The foundation is supported by unknown foundations. (List any assumptions below.)

Since drilled-and-underreamed shafts were used and they were founded in shale, assumed end bearing has been considered as a major component of the bearing capacity.

Refer to Chapter 6 of the TxDOT Scour Evaluation Guide.

INSPECTION DETAILS

Date of Most Recent Inspection:

☐ Scour countermeasures have been installed and are performing well. (Describe below.)

Condition of gabion baskets is still good (with a few baskets broken). Continue to monitor the gabion performance.

SCOUR DEPTHS

☑ Scour depths are measured from the as-built channel profile.

☑ Scour depths are measured from: Yal measured from nearest tie-beam (which vary)

Abutment or Bent #	4	5	6	7	
y_{ab} ☑ or y_{ar} ☐	26' (elev 296')*	20' (elev 296')*	28' (elev 296')*	34' (elev 296')*	
y_{al}	34'	29'	34'	36'	
Max Allowable Scour Depth[1], y_a	26' (elev 296')*	20' (elev 296')*	28' (elev 296')*	34' (elev 296')*	
Max Possible Scour Depth[2]					
Calculated Contraction Scour					
Calculated Pier Scour					
Total Calculated Scour Depth					
Observed Scour Depth	0.0	0.0	9.7	2.0	

Case Study (Cont.)

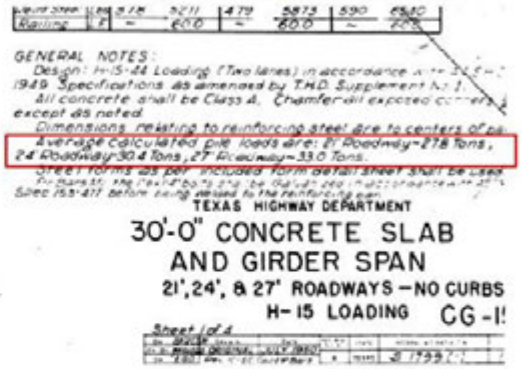
TRIGGER ELEVATION & FUTURE ACTION

Refer to Chapter 10 of the Scour Evaluation Guide.

*See calculation for deepening Yab based on end bearing and the strata of shale.
Channel seems stable at elev 316' (or no vertical scour further), and has sign of later migration southward.
Trigger for Bents 4 to 7: when observed scour reach elev. 296'.

Justification by calculation.

Design load from as-built - For 24' roadway, 30.4 tons per shaft.



Example (cont.)

Conservatively assumed the Shale is softer than 100 blows/12", see below Fig 5-2 in 2020 TxDOT Geotechnical Manual.

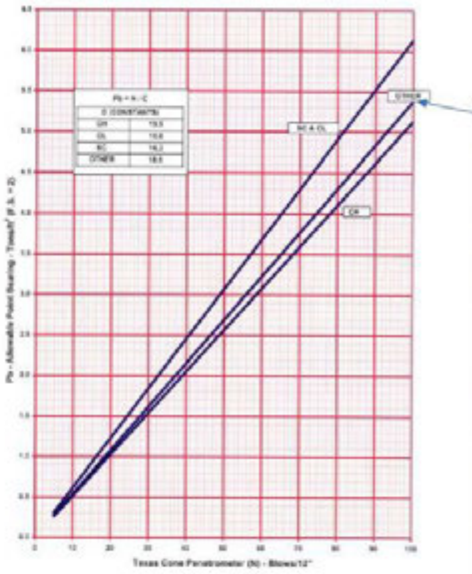


Figure 5-2. Allowable Point Bearing (TCP Values Softer than 100 Blows/12 in.)

Allowable end bearing = 5.37 tsf

Conservatively neglect the contribution of underreamed flares, I take DS diameter = 24" or (2').

End bearing = 5.37 x π x 2^2/4 = 17 tons.

17 tons x 2 (F.S.) = 34 tons

When scour reach elev 292' (about 1 to 2D above the tip) for Bents 4 to 7, F.S. for vertical capacity = 34 tons/30 tons = 1.1.

Therefore, recommended scour rating for Y_{30} ONLY:

Item 113 = 4 for now

Item 113 = 3 when scour reach 296' (the top of shale layer)

Item 113 = 2 when scour reach 292' (re-evaluate scour impact for the bridge).

Item 113 = 1 when scour reach 290' or when the top of underream exposed.

Conclusion

Once again,

- Scour documentation
  - Rapid evaluation in flood response
  - Prioritization of structures for replacement
  - Identify structures requiring repair
- Supports cost-effective maintenance and rehabilitation strategies.

Thank you!

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