Scour Evaluation Guide

Revised July 2023

Chapter 1 OVERVIEW

This guide sets forth the requirements of TxDOT's scour evaluation program and is intended to serve as a stand-alone resource for TxDOT staff and consultants performing and documenting scour evaluations. This revision incorporates the recommendations and principles for transitioning to the new scour coding system in the 2022 Specification for the National Bridge Inventory (SNBI).

Bridge scour is the leading cause of bridge failures. Scour is defined by the Federal Highway Administration (FHWA) as the erosion of streambed or bank material due to flowing water. Scour can become problematic for transportation infrastructure when it:

- exposes bridge foundations,
- undermines drainage structures, and/or
- removes embankment material.

TxDOT mitigates the risks associated with bridge scour by:

- requiring a scour analysis to be conducted during the design phase to determine calculated scour depths for each new span bridge over water, and using that information to make prudent decisions related to span layout, foundation selection, and scour countermeasures;
- estimating the maximum allowable scour depth for all span bridges over water;
- measuring channel cross-section profiles during routine bridge inspections, comparing those measurements to as-built channel profiles, and thereby determining the observed scour depth for all span bridges over water;
- summarizing the calculated, observed, and max allowable scour depths, for each span bridge over water on a Scour Summary Sheet, and requiring inspectors to verify this information during routine bridge inspections for all span bridges over water;
- assessing the scour vulnerability based on current and historic inspection records, for span bridges built before the implementation of scour analyses during the design phase;
- assessing the condition of bridge-class culverts based on observed exposure and undermining;
- identifying bridges most vulnerable to scour ("scour critical") and implementing a Plan of Action (POA) for all such bridges;
- maintaining all required scour documentation in the State's electronic bridge inspection management system; and
- requiring inspectors to review scour documentation, verify conditions, and notify the local District office of any changes or deficiencies, as a part of every routine bridge inspection.

1.1 Scour Evaluation Guide Revision History

July 2020

The first edition of the Scour Evaluation Guide was released in tandem with a virtual scour workshop presented by TxDOT Bridge Division on July 2, 2020.

August 2020

The second edition of the Scour Evaluation Guide was released soon after the initial release in response to issues identified during the virtual scour workshop in July 2020:

- Chapter 1: Clarified that the Scour Summary Sheet for Bridge-Class Culverts (Form 2606) does not need to be completed after each bridge inspection; it only needs to be updated if the bridge inspection identifies a change in conditions.
- Chapter 2: Clarified the context, usage, and definition for the max allowable scour depth for rotation (y_{ar}).

July 2023

The third edition of the Scour Evaluation Guide is the first substantive update to the first edition. Revisions include:

- Chapter 1: Added a new Overview chapter.
- Chapter 2: Added a flowchart (Figure 2-1) to clarify evaluation and documentation requirements.
- Chapter 3: Added a figure (Figure 3-1) to illustrate max allowable scour depth for shallow foundations. Revised the allowable unbraced length (y_u) equation for deep foundations in Figures 3-2 and 3-3 to be consistent in unit of feet.
- Chapter 4: Revised D_{50} table (Table 4-2) to make it more useful for scour analyses.
- Chapter 5: Revised coding guidance table for Item 113 (Table 5-1) with condition of countermeasures and assessment. Added coding guidance (Tables 5-2a and 5-2b) for TxDOT scour coding in compliance with the SNBI.
- Chapter 6: Added new guidance in Sections 6.1, 6.2, and 6.4 for assessing scour vulnerability for bridges with unknown foundations.
- Chapter 7: Clarified the need for scour evaluation for bridges that are not over waterway in Section 7.1.
- Chapter 8: Updated Figure 8-1 for foundation exposures categories; added Figure 8-2 for the spill-through abutment conditions; and update Tables 8-5 and 8-6 that included the SNBI coding guidance.
- Chapter 9: Moved the Chapter of "Detailed Scour Evaluation based on Analyses" to the TxDOT Scour Analysis Guide in Design Division, Hydrology & Hydraulics Section.
- Chapter 10: Addressed the need to avoid trigger elevations within 1 ft. of current channel elevation. Updated Table 10-1 that included SNBI coding.
- Appendix A: Updated to reflect changes in coding guidance. Provide the SNBI coding guide for ease of transition in short future.
- Appendix B: Moved the guide of SRICOS method to the TxDOT Scour Analysis Guide in Hydrology and Hydraulics Section.
- Appendix C: Editorial revisions
- Appendix D: Editorial revisions

Chapter 2 TxDOT Scour Evaluation Program

2.1 Overview of Program Requirements

A scour evaluation is required for every span bridge that crosses a waterway or other significant body of water, and for every bridge-class culvert. For span bridges, a scour summary sheet (Form 2605) is required in addition to the scour evaluation. For bridge-class culverts, the scour summary sheet (Form 2606) *is* the scour evaluation.

In general, use Figure 2-1 to identify the appropriate type of scour evaluation and the associated scour documentation requirements for any bridge or bridge-class culvert in Texas. District bridge inspection staff are responsible for uploading all required scour documentation to AssetWise.

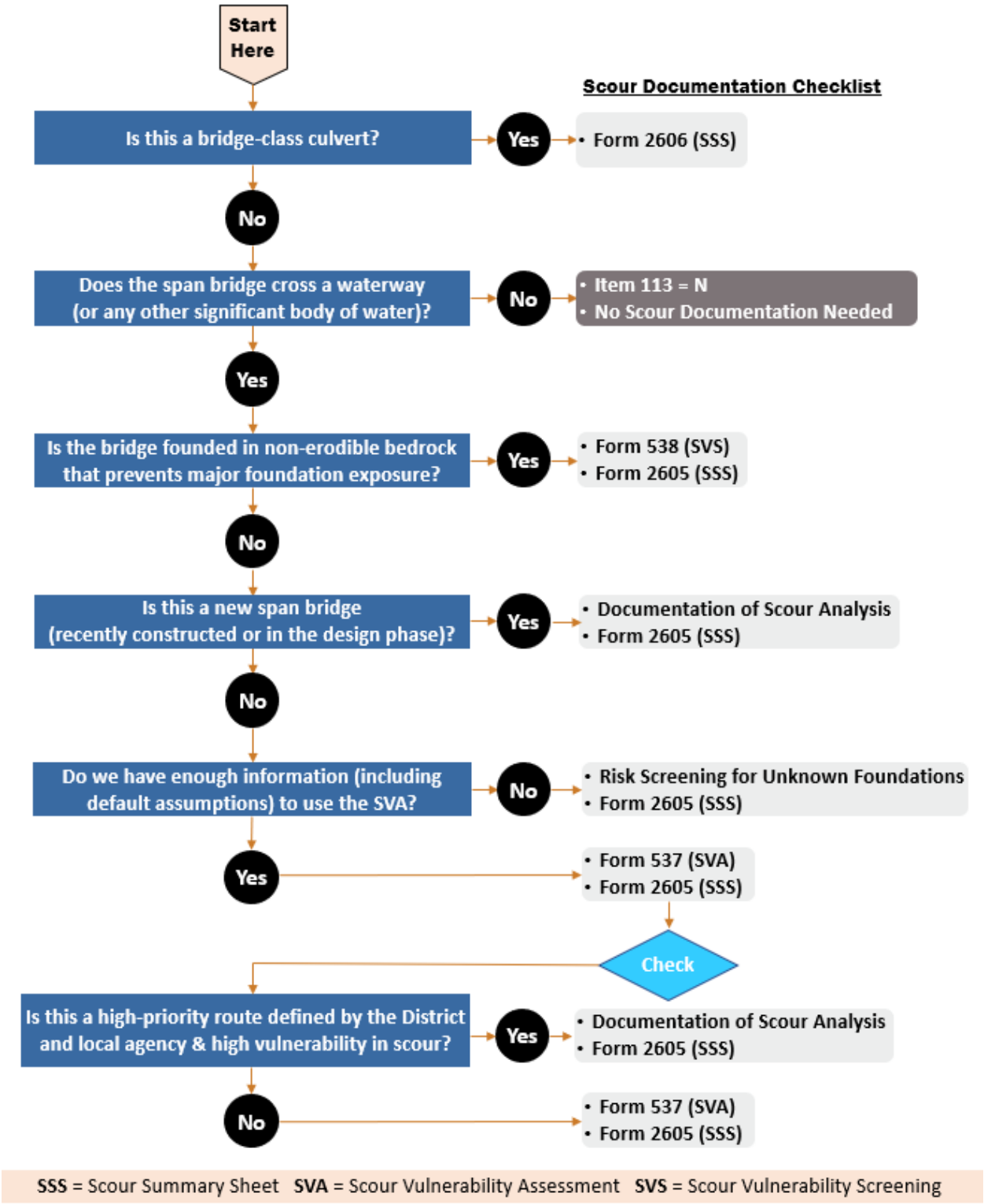


Figure 2-1 – Scour Evaluation and Documentation Flowchart

2.2 Scour Evaluations: Purpose and Methods and Scour Summary Sheets

The Federal Highway Administration (FHWA) began requiring scour evaluations for water crossings in the late 1980s. After the 1987 failure of Schoharie Creek Bridge in New York, and under the direction of the FHWA, Departments of Transportation around the U.S. began performing scour evaluations for new and existing bridges.

For a new bridge, the purpose of a scour evaluation is to predict the scour depth that will be caused by:

- constricting the channel at the bridge opening
- adding obstructions to flow within the channel (*e.g.*, columns, piers, bridge deck, etc.).

A scour analysis, based on hydrologic and hydraulic analyses, is required during the design phase for every new bridge or bridge widening over water. The results of this analysis should be summarized in a professional report and/or a scour data sheet that is signed and sealed by a licensed professional engineer. This report or scour data sheet should be provided to the foundation designer, included in the preliminary bridge layout review (PBLR) package, and uploaded to AssetWise.

All new span bridges must be designed to resist damage resulting from the Scour Design Flood. Scour vulnerability must also be evaluated for all existing bridges. As such, scour evaluations (and documentation thereof) are required for all span bridges over waterways. A scour summary sheet is also required for all span bridges over waterways (Form 2605). Form 2605 does not serve as documentation of a scour evaluation.

Scour evaluations are required for bridge-class culverts, but scour evaluations for culverts are based solely on inspection observations. Therefore, the scour summary sheet for bridge-class culverts (Form 2606) serves as both the scour summary sheet and the documentation of a scour evaluation. Form 2606 must be updated anytime a routine inspection identifies a change in conditions.

Scour summary sheets and documentation of scour evaluations must be uploaded to AssetWise by bridge inspection staff.

2.3 Scour Critical Bridges (NBI Item 113 or SNBI Item B.C.11=3 or less)

The scour summary sheet includes a recommended coding for National Bridge Inventory (NBI) Item 113, "Scour Critical Bridges" or SNBI Item B.C.11, "Scour Condition Rating". Structures most vulnerable to scour (NBI Item 113 or SNBI Item B.C.11=3 or less) are designated scour critical. The SNBI defines Scour Critical Bridges as a bridge with a foundation member that is unstable, or may become unstable, as determined by the scour appraisal, B.AP.03. A coding of "C or D" for B.AP.03 requires a scour plan of action. Bridge scour plans of action must be implemented for all scour critical bridges and bridge-class culverts.

If a bridge or culvert is scour critical, the district or area office must prepare a bridge scour plan of action. Plans of action for off-system bridges must be coordinated with local owners. Bridge

scour plans of action must be prepared using the appropriate form listed in Table 2-1. The completed form must be signed and sealed by a professional engineer. Implementation efforts such as flood monitoring, debris removal, or countermeasure installation must be documented on Form 2607, "Plan of Action Follow-Up" after they are executed. District bridge inspection staff are responsible for uploading the bridge scour plan of action and Form 2607 to AssetWise. Form 2607 does not need to be signed and sealed by a professional engineer.

Table 2-1 – Bridge Scour Plan of Action Forms

Form Number	NBI Item 113	SNBI Item B.C.11 (Item B.AP.03 = C or D)
2604	3	4 or greater
2624	2	2 or 3
2609	1	1

2.4 Scour Evaluation Methods

Scour evaluation methods generally fall into one of three categories:

Screening | identification of low-risk structures which are not vulnerable to damage from scour

Assessment | detailed scour evaluation based on current & previous bridge inspection records

Analysis | detailed analytical scour evaluation based on hydrologic and hydraulic analyses

Screening criteria should always be checked before proceeding with a more rigorous scour evaluation. A detailed scour evaluation is required for any span bridge designated high-risk during screening. For new span bridges, the detailed scour evaluation must be based on analysis as part of the bridge design phase. However, for existing span bridges, the detailed scour evaluation can be based on assessment and/or analysis. When observed scour conditions are not consistent with the scour design calculation or the assumptions used in the scour analysis, a reevaluation through a scour vulnerability assessment is appropriate. The District and local agencies are responsible to identify the risk of a span bridge based on both of its scour vulnerability and the criticality of the routes (e.g. span bridges on interstate highways, principal arterials, evacuation routes, local emergency services). For interstate structures identified with high risk of scour vulnerability, a more rigorous scour evaluation based on analysis is appropriate.

2.5 Scour Documentation

All required scour documentation must be uploaded to AssetWise by the district bridge inspection staff. Documentation of a scour evaluations and the corresponding scour summary sheets must each be signed and sealed by a professional engineer. For scour critical bridges, a bridge scour plan of action is also required, and must also be signed and sealed by a professional engineer.

Item 113 will be coded "6" or SNBI Item B.AP.03 will be coded either "0" or "E" for any bridge over waterway lacking documentation of a scour evaluation. The following documents may serve as documentation of a scour evaluation (also refer to Figure 2-1):

- Scour Evaluation based on Screening
  - Scour Vulnerability Screening (Form 538)
  - Risk Screening for Unknown Foundations (Only applicable to NBI Item 113)
  - TxDOT Secondary Screening Report*
- Scour Evaluation based on Assessment
  - Scour Vulnerability Assessment Form (Form 537)
  - TxDOT Secondary Scour Evaluation Report*
- Scour Evaluation based on Analysis
  - Detailed Report for Scour Evaluations based on Analysis
  - Bridge Hydraulic Data Sheet with Scour Calculations
  - TxDOT Simplified Scour Method Summary*
  - TxDOT Concise Analysis Report*
  - Bridge Layout Showing Calculated Scour Depths*

Methods marked with an asterisk (*) are no longer permitted for new scour evaluations, but remain valid for scour evaluations conducted prior to June 1, 2020. In general, scour evaluations remain valid for as long as the conditions assumed for the evaluation remain accurate.

Chapter 3 MAXIMUM ALLOWABLE SCOUR DEPTH

The maximum allowable scour depth (y_a) refers to the amount of scour that can occur before a bridge foundation becomes unstable. Instability may be caused by a reduction in bearing capacity, lateral support, rotational stiffness, and/or other factors. Sections 3.1 through 3.3 provide a general guideline for shallow footings and deep foundations in both the erodible and non-erodible soil condition. Additional types of foundations (*e.g.*, large diameter caissons, bell shafts, etc) may be considered in some degree of a hybrid of both shallow and deep foundations. Therefore, the engineer should use appropriate judgement when determining the maximum allowable scour depth. Consult with Bridge Division's Geotechnical Branch for questions related to the calculation of maximum allowable scour depth.

3.1 Maximum Allowable Scour Depth for Shallow Footing Foundations

Figure 3-1 illustrates how to determine y_a and foundation exposure category for shallow foundations (*e.g.,* spread or strip footings). Figure 3-1(a) applies when the footing is founded in erodible soil. For footings founded on non-erodible rock, refer to Figure 3-1(b).

3.2 Maximum Allowable Scour Depth for Deep Foundations in Soil or Soft Rock

For deep foundations (e.g. piles or drilled shafts) founded in soil or soft/weathered rock, use the formulation in Figure 3-1 to determine y_a. This approach considers the maximum allowable scour depth for bearing (y_{ab}) and the maximum allowable scour depth for unbraced length (y_{al}). y_a is the minimum of y_{ab} and y_{al}.

3.3 Maximum Allowable Scour Depth for Deep Foundations in Hard Rock

If deep foundation is tipped in a hard founding layer (*e.g.*, hard rock), it may derive enough strength from point bearing to support the entire design load. If the allowable point bearing capacity is greater than the design load, then skin friction is not required for stability. This condition can typically be verified if resistance or strength measurements (*e.g.*, Texas Cone Penetration blow counts, laboratory strength measurements, etc.) are available for the bearing stratum.

The total allowable point bearing capacity may be calculated by multiplying the cross-sectional area of the pile or shaft by the unit value for allowable point bearing. Refer to Chapter 5, Section 2 of the TxDOT Geotechnical Manual for more information about obtaining the unit value for allowable point bearing. Note: if a softer layer exists within 2 pile or shaft diameters of the tip elevation, allowable point bearing must be based on the allowable point bearing of the softer layer.

If skin friction is not required for bearing capacity, use the formulation in Figure 3-3 to determine y_a. In these cases, there is no need to consider the maximum allowable scour depth for bearing (y_{ab}). However, the foundation must maintain a minimum embedment one pile or shaft diameter (i.e. 1D rock socket). This "rock socket" criterion is intended to assess rotational stiffness. y_a is the minimum of y_{ar} (in the Scour Summary Sheet, y_{ar} should be input as y_{ab} in this case) and y_{al}.

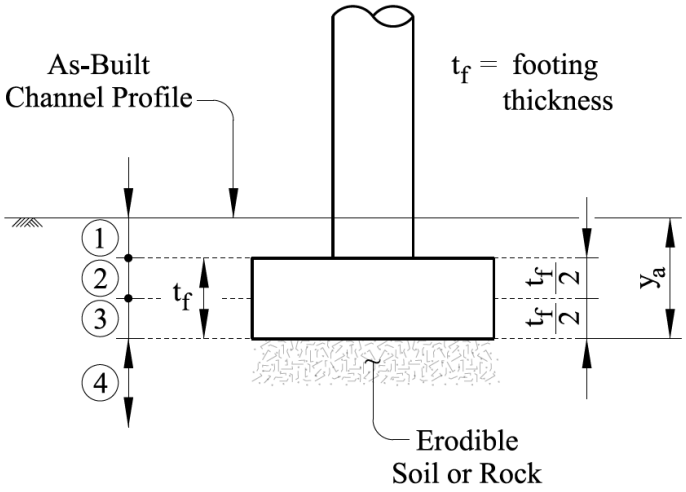
3.4 Backcalculation by Structural Analysis

The formulations for maximum allowable scour depth shown in Figures 3-1, 3-2, and 3-3 are appropriate for scour coding. However, if major foundation exposure is observed (*i.e.*, Item 113 = 2 or SNBI Item B.C.11 = 2), the remaining capacity must be back-calculated using advanced methods. This requires a structural analysis based on subsurface, foundation, and channel properties. Please contact the Geotechnical Branch for assistance with back-calculation by structural analysis.

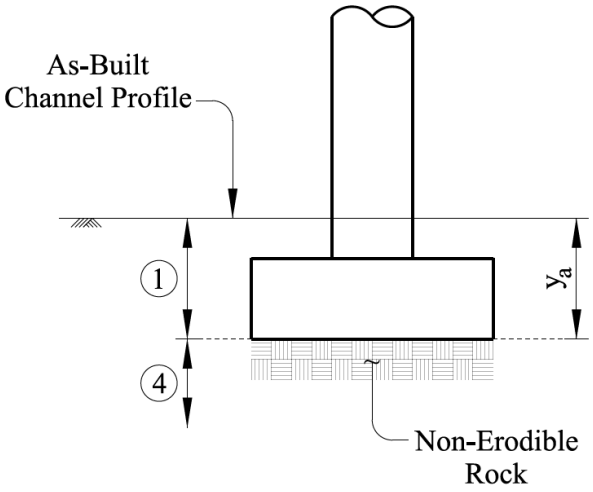
① Minor Foundation Exposure ③ Major Foundation Exposure

② Moderate Foundation Exposure ④ Extreme Foundation Exposure

y_a = Max Allowable Scour Depth



(a) Spread Footing in Erodible Soil or Soft Rock



(b) Spread Footing Founded on Non-Erodible Rock

Figure 3-1 –Maximum Allowable Scour Depth for Shallow Foundations Founded on (a) Erodible Soils or (b) Non-Erodible Rock

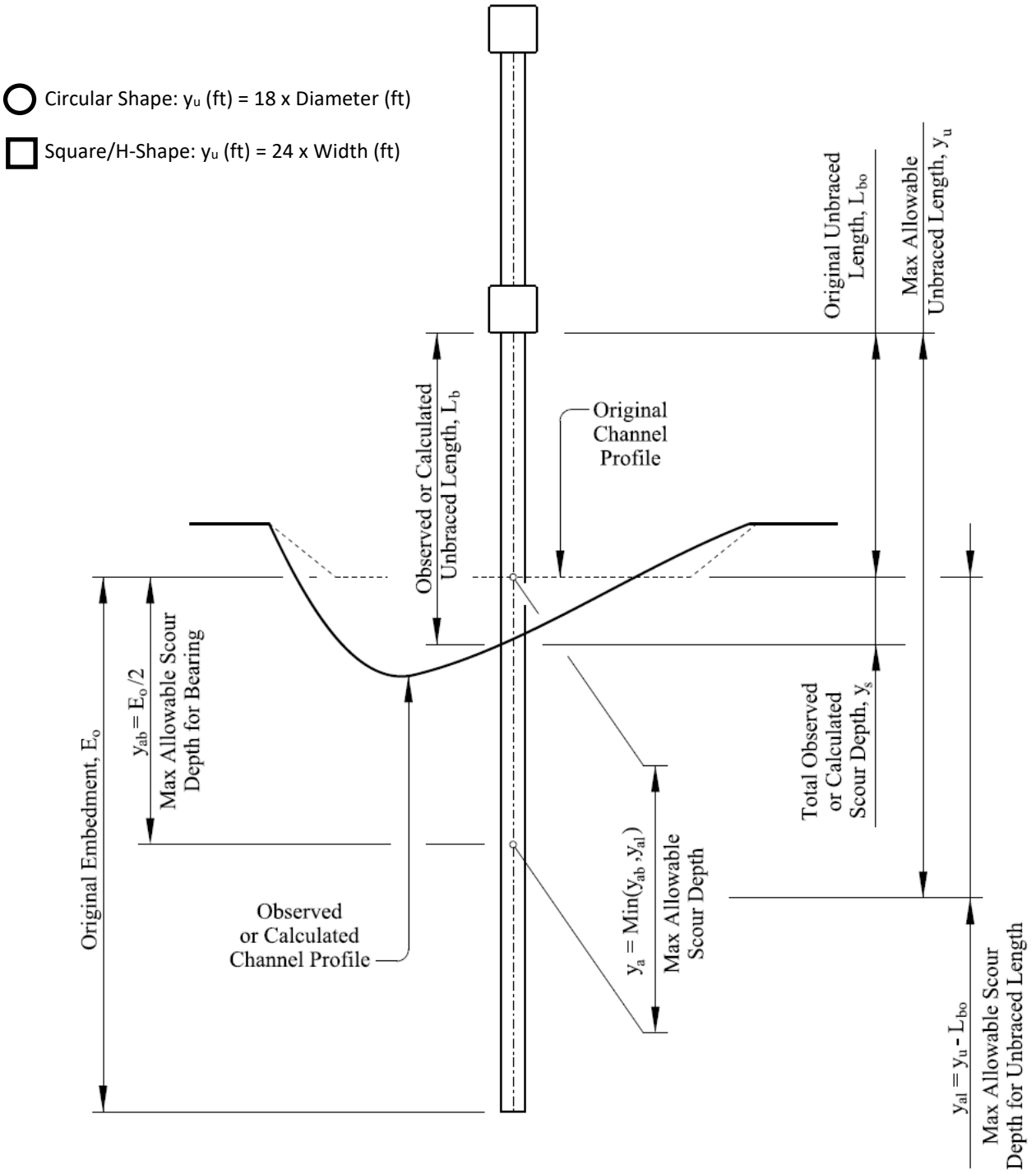


Figure 3-2 –Maximum Allowable Scour Depth for Deep Foundations Tipped in Soil or Soft Rock

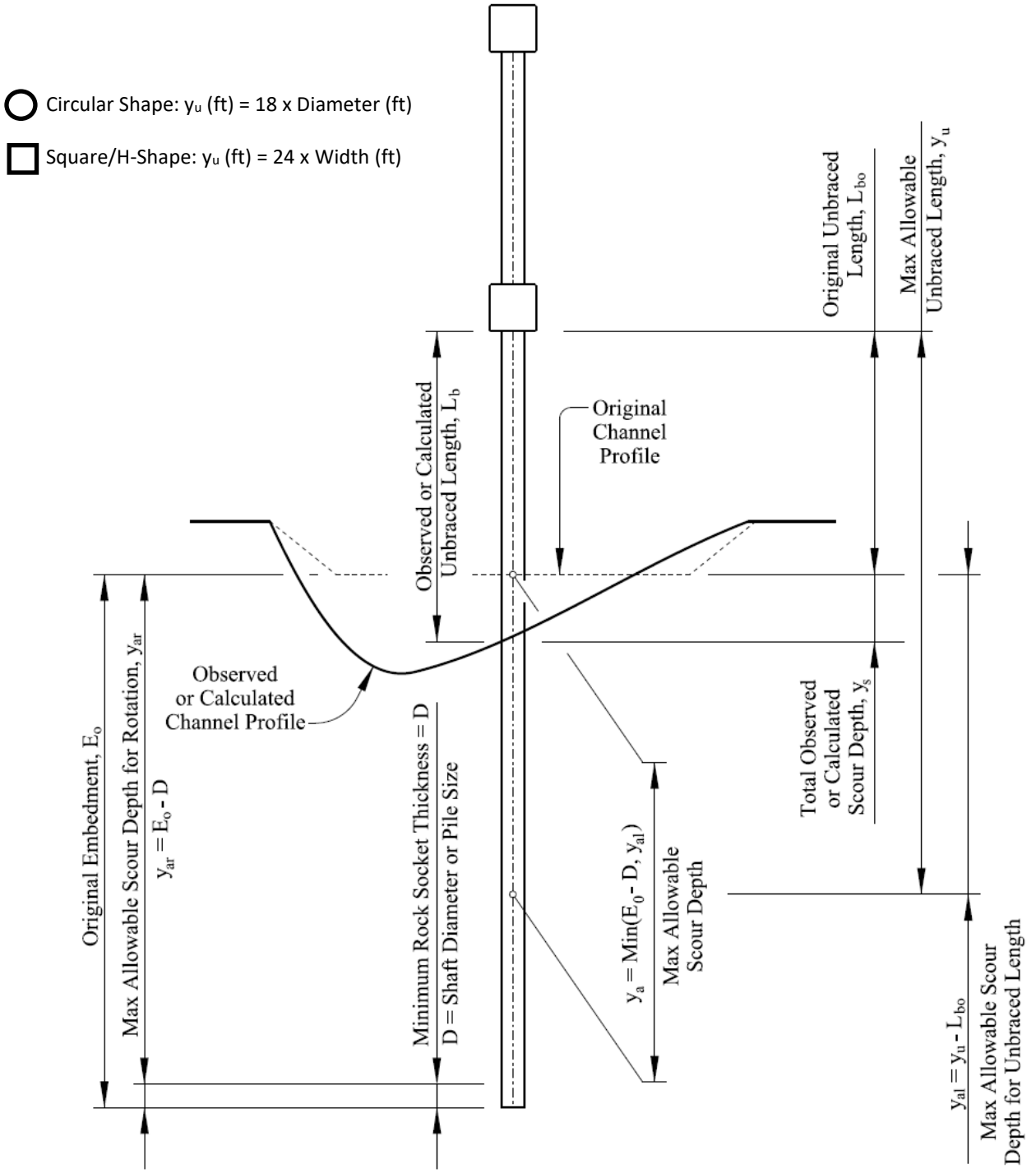


Figure 3-3 – Maximum Allowable Scour Depth for Deep Foundations Socketed in Hard Rock

Chapter 4 MATERIAL CHARACTERIZATION

At a minimum, all scour evaluations and screenings require a basic characterization of the channel material. Table 4-1 categorizes the scour vulnerability of common channel materials.

Sand is especially vulnerable to scour, even over the course of a single flood event. Mildly erodible materials may erode gradually over a long period of time, but those layers are not expected to experience significant erosion during a single flood event. Shales and stiff clays should be monitored for long-term degradations, especially where they are exposed to repeated wetting and drying cycles (*e.g.*, Sulphur River basin in northeast Texas).

Table 4-1 – Channel Materials and Scour Vulnerability

Material	Sub-Category	TCP Values or Equivalent Strength Data	Scour Vulnerability
Rock	Hard (granite, limestone, shale)	< 4 in./100 blows	Non-Erodible
	Soft (shale, sandstone)	< 12 in./100 blows	Mildly Erodible
Clay	Hard (redbed, shaley clays, very stiff clays)	< 12 in./100 blows	Mildly Erodible
	Soft to Medium	> 12 in./100 blows	Erodible
Sand	All	All	Very Erodible

The erodibility of channel material is not solely characterized by TCP testing. Erodibility of channel material is influenced by the channel material shear strength, degree of cementation, joint orientation, and other material properties. Stream characteristics such as channel planform, discharge, and velocity can also influence erodibility. Certain scour evaluation methods require additional input parameters to characterize the channel material. These parameters are geotechnical index properties that can be obtained through laboratory testing. The required inputs for each scour evaluation method are summarized below:

► **Scour Vulnerability Screening**
- Subsurface Profile (Boring Logs)
- Texas Cone Penetrometer Blow Count (Tex-132-E), or equivalent Shear Strength Data
- Rock Quality Designation (RQD) (Optional)

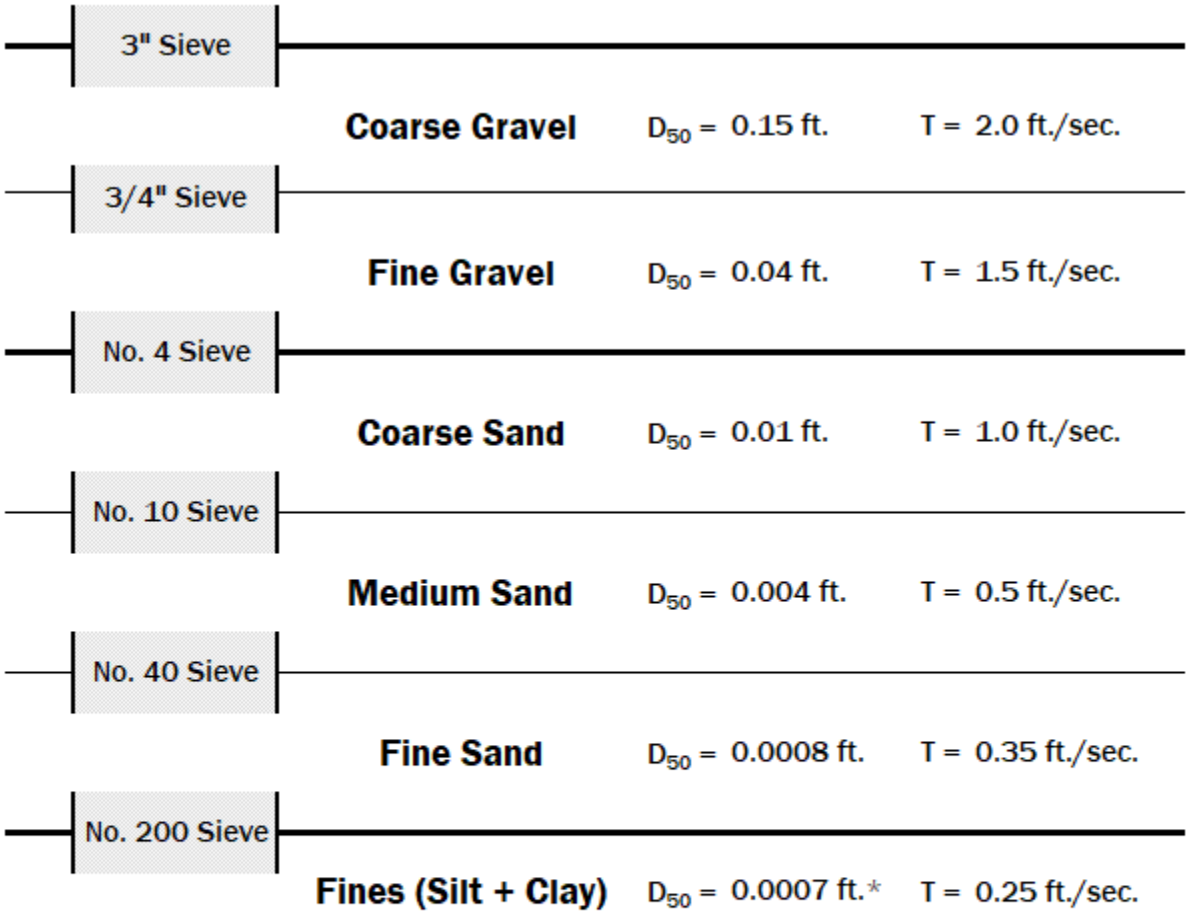
► **Scour Vulnerability Assessment**
- Subsurface Profile (Boring Logs)
- Texas Cone Penetrometer Blow Count (Tex-132-E), or equivalent Shear Strength Data

► **Detailed Scour Evaluation based on Analysis**
- Subsurface Profile (Boring Logs), with the following information for each layer:
  - Particle Size Analysis (Tex-110-E)

- Median Grain Size (D_{50}) & Percent Clay (percent passing No. 200 sieve)
- Common grain dimensions are summarized in Table 4-2

- Liquid Limit (Tex-104-E) [only for clayey soils]
- Plastic Limit (Tex-105-E) [only for clayey soils]
- Plasticity Index (Tex-106-E) [only for clayey soils]
- USCS Soil Classification (Tex-142-E)

Table 4-2 – Grain Dimensions of Cohesionless Materials



*Even if measured D_{50} values are smaller, do not use D_{50} values less than 0.0007 ft. (0.2 mm) in the equations for determining critical velocity or clear-water contraction scour.

D_{50} = median grain size

T = median fall velocity (for use with Laursen's modified live-bed contraction scour equation; refer to HEC-18)

Chapter 5 SCOUR CODING

5.1 2020 TxDOT Coding

National Bridge Inventory (NBI) bridge inspection Item 113 describes a structure's vulnerability to scour damage.

NBI Item 113 | Scour Critical Bridges

TxDOT Item 113.1 | Scour Plans of Action

TxDOT Item 113.2 | Unknown Foundations

The TxDOT Coding Guide includes detailed coding instructions for all three scour items. The same guidance is also provided in Appendix A of this document for ease of reference. **With properly designed and functioning scour countermeasures, Item 113 is assigned an 8.**

Table 5-1, is the basis of Item 113 coding for span bridges without designed and functioning scour countermeasures.

Table 5-1 – Basis of Item 113 Coding for Span Bridges Without Designed and Functioning Scour Countermeasures

Foundation Exposure	Calculated or Assessed Scour Depth (From Scour Analysis)	Observed Scour Depth (From Inspection Record)
Minor	8	8
Moderate	5	4
Major	4	2(1)
Extreme	3(2)	1(1)

Notes: (1) If Major or Extreme foundation exposure is observed, verify the coding with scour assessment (see Section 3.4). Consult Geotechnical Branch at scour@txdot.gov regarding structural scour assessment, recommending repairs and countermeasures, and scour documentation.

(2) When observed scour depths are not consistent with calculated scour depths, this indicates a need to re-evaluate scour vulnerability (e.g., Forms 537 or 538) and /or methods of scour analyses.

5.2 SNBI Coding

The Specification for the National Bridge Inventory (SNBI) supersedes the current Coding Guide. Until the SNBI is fully implemented, bridges may have dual coding (TxDOT Coding Guide and SNBI) for scour.

NBIS Item B.C.11 | Scour Condition Rating – This code only applies to the observed scour condition.

NBIS Item B.AP.03 | Scour Vulnerability – This code reflects the status of scour documentations, conditions of countermeasure, unknown foundation, and calculated/accessed scour.

NBIS Item B.AP.04 | Scour Plan of Action

See Appendix A for detailed definitions and cross walk. Tables 5-2a and 5-2b, are provided here to help explain the basis of Items B.C.11 and B.AP.03 coding for span bridges. **With properly designed and functioning scour countermeasures, Item B.AP.03 is assigned a B.**

Table 5-2a – General Basis for SNBI Coding for Span Bridges With Scour Appraisal

Foundation Exposure	B.C.11 Observed Scour Depth (From Inspection Record)	B.AP.03 Calculated or Assessed Scour on File (From Scour Analyses or Evaluation)
None	9	A, B, C, or D
Minor	6, 7, 8	
Moderate	4, 5, 6	
Major	2 or 3	C or D
Extreme	1	

Table 5-2b – General Basis for SNBI Coding for Span Bridges Without Scour Appraisal

Foundation Exposure	B.C.11 Observed Scour Depth (From Inspection Record)	B.AP.03 Calculated or Assessed Scour NOT on File
None to Extreme	1 to 9	0 (without any countermeasure)
		E (with temporary countermeasure)

5.3 Documentation Requirements

All required scour documentation must be uploaded to AssetWise by district bridge inspection staff before scour coding values are updated. Scour documentation requirements are addressed in Chapter 2 of this guide and in Chapter 9, Section 3 of the TxDOT Bridge Inspection Manual:

- Documentation of scour evaluation
- Inspection Records with Plot of Measured Channel Profile
- Signed and Sealed Scour Summary Sheet
- Signed and Sealed Bridge Scour Plan of Action (for scour critical structures)

NBI Item 113, or SNBI Items B.C.11 and B.AP.03 must be updated for any structure with a change in scour vulnerability within 90 days of the inspection or scour evaluation date. It is the District's responsibility to upload scour documentation to AssetWise and request scour coding updates from Bridge Division. For new structures, District bridge inspection staff should upload scour documentation to AssetWise and request a scour coding update as soon as the structure is added to AssetWise.

Chapter 6 UNKNOWN FOUNDATIONS

Scour vulnerability is a function of hydraulic conditions, subsurface materials, and structural foundation properties. It is difficult to determine foundation properties unless construction plans are available in the bridge record. An "unknown foundation" is any foundation with unknown composition, gross dimensions, or embedment.

6.1 Coding

Item 113.2, Unknown Foundations, should be coded "U" for any span bridge or bottomless culvert with one or more unknown foundations. Item B.AP.03, Scour Vulnerability, should be coded "U" for any span bridges or bottomless culvert with one or more unknown foundations. Note that box or pipe culverts are considered as having known foundations regardless of whether plans are available or not.

6.2 Scour Evaluations

Unknown foundations complicate the determination of maximum allowable scour depth (y_a). This is most problematic for deep foundations, but could also affect shallow foundations if the footing thickness (t_f) or embedment is unknown. Three scour evaluation procedures are currently permitted for structures with unknown foundations:

- Bridge Scour Risk Screening for Unknown Foundation (only applicable to the current Item 113)
- Scour Vulnerability Screening (SVS) (applicable to both NBI Item 113 and SNBI Scour Items)
- Scour Vulnerability Assessment (SVA) (applicable to both NBI Item 113 and SNBI Scour Items)

► Bridge Scour Risk Screening for Unknown Foundations

The risk screening for unknown foundations assigns a structure to one of three risk categories: high, medium, or low. No assumptions about the unknown foundations are required. This method uses condition ratings from the NBI database to estimate the annual probability of failure (P_a) due to bridge scour. P_a is compared with the minimum performance level (MPL), which is assigned based on NBI Item 26 (Functional Classification). Risk categories are assigned as follows:

- P_a / MPL < 1 Risk Category = Low
- P_a / MPL = 1 – 2.5 Risk Category = Medium
- P_a / MPL > 2.5 Risk Category = High

If the risk category is Low, the risk screening serves as documentation of a scour evaluation and NBI Item 113 (Scour Critical Bridges) should be coded "5". If the risk category is Medium or High, the risk screening is not a sufficient scour evaluation. Either the Scour Vulnerability Screening (SVS) or the Scour Vulnerability Assessment (SVA) will be required. In either case, information about unknown foundations will need to be assumed or inferred.

The Bridge Scour Risk Screening for Unknown Foundations is programmed into an Excel spreadsheet which is available from the Bridge Division's Geotechnical Branch. The spreadsheet

should be printed, signed and sealed, and uploaded to AssetWise to serve as documentation of a scour evaluation.

When a bridge's scour evaluation is based solely on the Bridge Scour Risk Screening for Unknown Foundations, it may not be possible to estimate the max allowable scour depth for Form 2605; for this specific case only, the "Scour Depths" table in Form 2605 may be left blank. The risk screening for unknown foundations is not permissible for the following high-priority structures:

- span bridges on the interstate system or principal arterials;
- span bridges on evacuation routes;
- span bridges that provide access to local emergency services such as hospitals; and
- span bridges that are defined as critical in a local emergency plan (*i.e.*, bridges that enable immediate emergency response to disasters).

► **Scour Vulnerability Screening (SVS)**

Information about unknown foundations may need to be assumed or inferred. The SVS is permissible for a structure with unknown foundations if it meets the criteria for Bridges Founded in Non-Erodible Strata (see Chapter 7).

► **Scour Vulnerability Assessment (SVA)**

Information about unknown foundations may need to be assumed or inferred. The SVA is permissible for any structure with unknown foundations. All such assumptions must be listed on the scour summary sheet (Form 2605). When needed, a summary of assumptions and justifications may be attached to Form 2605.

Since foundation embedment depths are likely to be assumed, provide a brief plan of action in the scour summary sheet. As applicable, include the following in the Plan of Action:

- a more frequent inspection or inspection during heavy rain events (e.g., 50 or 100 year flood events);
- arranging Non-Destructive Evaluation to better estimate the foundation depth (refer to Section 6.4 below; and
- requesting original as-built plan from local agencies.

6.3 Assumptions

Deep foundations should not be assumed to exist unless those elements are partially exposed or otherwise verifiable. If deep foundations are verified, assume an as-built embedment of 10 ft. If deep foundations cannot be verified, assume the foundation is a spread footing with 1-ft. embedment and 2-ft. thickness. More liberal assumptions may also be inferred after probing, obtaining test hole data, and/or identifying common practices from similar structures built in the same region and time period.

6.4 Non-Destructive Evaluation

If a more rigorous evaluation is desired, consider employing non-destructive evaluation (NDE) methods to better estimate the depth of the existing foundation(s). Consult with the Bridge Division for more information regarding the use of NDE methods.

6.5 Documentation

Span bridges over waterways with unknown foundations have the same scour documentation and coding requirements as other span bridges over waterways. The following items must be completed, signed and sealed by a professional engineer, and uploaded to AssetWise by District bridge inspection staff:

- Scour Summary Sheet (Form 2605)
- Documentation of Scour Evaluation
- Bridge Scour Plan of Action (only required for scour critical structures)

A risk screening memo serves as documentation of a scour evaluation, but it does not constitute a scour summary sheet or a bridge scour plan of action. Previous risk assessments for unknown foundations performed by the Geotechnical Branch remain valid if both of the following conditions apply:

- the risk assessment is properly documented in AssetWise
- conditions assumed for the risk assessment remain accurate

Chapter 7 SCOUR VULNERABILITY SCREENING

The Scour Vulnerability Screening (SVS) identifies span bridges with a low risk of scour damage. These bridges do not require detailed scour evaluations. Two categories of span bridges are considered low-risk: Bridges Not Over Waterways, and Bridges Founded in Non-Erodible Strata.

7.1 Bridges Not Over Waterways

If a bridge does not cross a waterway, it has a very low risk of incurring damage due to scour. Verify that a bridge does not cross a waterway by reviewing photographic inspection records, bridge layouts, FEMA flood inundation maps, baseline engineering models, and/or other drainage studies. Any span bridge located in a 100-yr floodplain (i.e., FEMA flood zone) requires a scour evaluation. If a bridge's foundations would be inundated by the 100-year flood (in FEMA flood maps, the 100-year flood is called the Base Flood), then the bridge requires a scour evaluation.

For structures in the category of Bridges Not Over Waterways:

- A detailed scour evaluation is not required.
- No scour documentation is required.
- NBI Items 71 (Waterway Adequacy) and 113 should both be coded "N".
- SNBI Item B.AP.02 (Overtopping Likelihood) should be "no value", and Item B.C.09 (Channel Condition Rating) and Item B.C.11 should both be coded "N". Do not report Items B.AP.03 and B.AP.04.

7.2 Bridges Founded in Non-Erodible Strata

A detailed scour evaluation is not required if the foundation would remain stable after all materials above a non-erodible stratum were removed by scour. The maximum possible scour depth (y_{mp}) is the hypothetical scour depth that would remove all erodible materials above the non-erodible stratum. Structures may be assigned to this category if the following conditions apply:

- The stratum in question is determined to be non-erodible by one of the following methods:
  - Classification by Table 4-1. To be considered non-erodible, a stratum must also be free of open joints or other discontinuities in the rock mass.
  - Rock Quality Designation (RQD) is ≥ 75%.
- The maximum possible scour depth (y_{mp}) would cause minimal or moderate foundation exposure, as defined in the TxDOT Coding Guide. In other words, the Bridges founded in Non-Erodible Strata category does not apply if the bridge could become scour critical.

Concrete-lined channels may also be categorized as Bridges Founded in Non-Erodible Strata, but only if all of the following conditions apply:

- The channel is lined by concrete entirely or a considerable distance beyond bridge upstream or downstream; this includes any foundations that would be susceptible to scour from the Scour Design Flood
- The concrete channel is non-erodible (no failed joints, spalling, or major cracks). Figure 3-2 should be applied when determining the Max Allowable Scour Depth regardless of whether the channel is lined with concrete or not.

For structures in the category of Bridges Founded in Non-Erodible Strata:

- The Scour Vulnerability Screening (SVS) form (Form 538) will serve as the documentation of a scour evaluation. It must be completed, signed and sealed by a professional engineer, and uploaded to AssetWise by district bridge inspection staff.
- A Scour Summary Sheet (Form 2605) must be completed, signed and sealed by a professional engineer, and uploaded to AssetWise by district bridge inspection staff.

Chapter 8 SCOUR VULNERABILITY ASSESSMENT

The Scour Vulnerability Assessment (SVA) is a detailed scour evaluation based on assessment. The SVA does not require detailed hydrologic or hydraulic analyses. The purpose of the SVA is to rate bridge's vulnerability to scour based on past and present observations. This rating includes two components: (i) Scour Vulnerability Class, and (ii) recommended coding for NBI Item 113, or SNBI Items B.C.11 and B.AP.03.

(i) Scour Vulnerability Class

A bridge will be assigned to one of two scour vulnerability classes: Normal or Enhanced. Bridges with a troublesome scour history and/or multiple risk factors for future scour will be assigned the Enhanced scour vulnerability rating. All remaining bridges will be assigned the Normal scour vulnerability rating. Note that bridges with low scour vulnerability should be identified as such using the Scour Vulnerability Screening (SVS).

(ii) Recommended Coding for NBI Item 113

The SVA includes coding guidance for NBI Item 113. This guidance is consistent with the terms and definitions presented in the TxDOT Coding Guide. The SVA coding guidance is based on scour vulnerability class and current scour conditions. This guidance assumes bridges assigned to the Enhanced scour vulnerability class will experience more future scour than bridges assigned to the Normal scour vulnerability class.

(iii) Recommended Coding for SNBI Items B.C.11 and B.AP.03

The SVA includes coding guidance for SNBI Items B.C.11 and B.AP.03 to ultimately replace NBI Item 113. This guidance is consistent with the terms and definitions presented in the TxDOT Coding Guide. See Appendix A for general mapping of the current NBI Item 113 to SNBI Items B.C.11 and B.AP.03. The SVA coding guidance is based on scour vulnerability class and current scour conditions. This guidance assumes bridges assigned to the Enhanced scour vulnerability class will experience more scour in the future than bridges assigned to the Normal scour vulnerability class.

8.1 SVA Method

Scour vulnerability class should be based on conditions at whichever abutment or bent is most vulnerable to scour. If it is not obvious which abutment or bent is most vulnerable to scour, determine the scour vulnerability class for multiple locations. If any abutment or bent is assigned to the Enhanced scour vulnerability class, then the entire bridge will be assigned to the Enhanced scour vulnerability class.

The scour vulnerability class is assessed based on four risk factors:

- Channel Material
- Channel Condition
- Scour History
- Channel Migration History

Each risk factor is scored based on criteria listed on the next page. Larger scores always indicate greater scour vulnerability. Negative scores indicate scour resistance. The total score for an abutment or bent is the sum of its four risk factor scores. The scour vulnerability class is assessed as follows:

- Total Score < 3 → Scour Vulnerability Class = **Normal**
- Total Score ≥ 3 → Scour Vulnerability Class = **Enhanced**

Record the score for each risk factor and the total score on the Form 537. Use the space provided on Form 537 to provide a brief description for each risk factor.

8.2 SVA Risk Factors

► Channel Material

Use Table 8-1 in conjunction with Table 4-1 to determine the Channel Material score. The subsurface profile will rarely comprise a single, homogeneous layer of material. The actual subsurface profile will likely be interbedded and may contain heterogeneous materials. Therefore, some judgment is required when determining the score for channel material.

Above all else, this score should convey the contribution of channel material to scour vulnerability. For example, sand is highly erodible; however, a thin layer of sand can only contribute to a small amount of scour. A competent layer of hard rock may be non-erodible, but it will only impact scour vulnerability if it intersects bridge's foundations. Thick material layers near the surface will generally have the greatest impact on scour vulnerability, especially for shallow or unknown foundations.

If channel materials are unknown, assume the channel material is sand or use the Natural Resources Conservation Service (NRCS) Web Soil Survey to retrieve soil data.

Table 8-1 – SVA Scoring Criteria for Channel Material

Channel Material	Score
Competent, Hard Rock	-3
Soft Rock or Hard Clay	-1
Fractured or Weathered Rock	1
Soft to Medium Clay	2
Sand	3

► Channel Condition

The score for channel condition is based on the coding of NBI Item 61 (Channel and Channel Protection), or later SNBI Item B.C.09 (Channel Condition Rating), which is available in AssetWise. The item accounts for the condition of the stream bed, banks, and embankments.

Table 8-2 – SVA Scoring Criteria for Channel Condition

NBI Item 61 Coding or SNBI Item B.C.09 Coding	Score
8 – 9	-1
6 – 7	1
5	3
≤ 4	5

► **Scour History**

The Scour History appraisal should be based on a review of the bridge's current and previous measured channel profiles. Each routine inspection report should include a plot of the measured channel cross-section at the end of the report. Routine inspection reports are available in "pdf" format in AssetWise – these documents are identified with "RTInsp_YYYY-MM" at the end of the filename.

Record the maximum historic scour depth (y_{sh}) at whichever abutment or bent has experienced the most severe foundation exposure, past or present. For example, if y_{sh} at one bent caused minimal foundation exposure, but y_{sh} at another bent caused moderate foundation exposure, the latter case would govern. Use Figures 8-1 or 8-2 to determine the category of foundation exposure for a typical interior bent and abutment, respectively. This will require consideration of the maximum allowable scour depth (y_a), which is addressed in Chapter 3. If the critical abutment or bent is supported by an unknown foundation, use assumed foundation dimensions to determine y_a (refer to Chapter 6). Scour depth is always measured from the as-built channel profile.

Scour depth is typically measured from the as-built channel profile shown in the plans. Sometimes there is a slight difference between the as-built channel profile shown in the plans and the as-built channel profile seen in the field. Therefore, it is also acceptable to estimate scour depths by directly measuring the exposed drilled shaft portion of a pier or use the pile driving records to determine the final embedment. For bridges with unknown foundations, it is use the earliest available channel profile to estimate the as-built channel profile and use subsequent channel profiles to estimate the max scour depth.

Table 8-3 – SVA Scoring Criteria for Scour History

Foundation Exposure from y_{sh}	Score
Minimal	-2
Moderate	1
Major	4

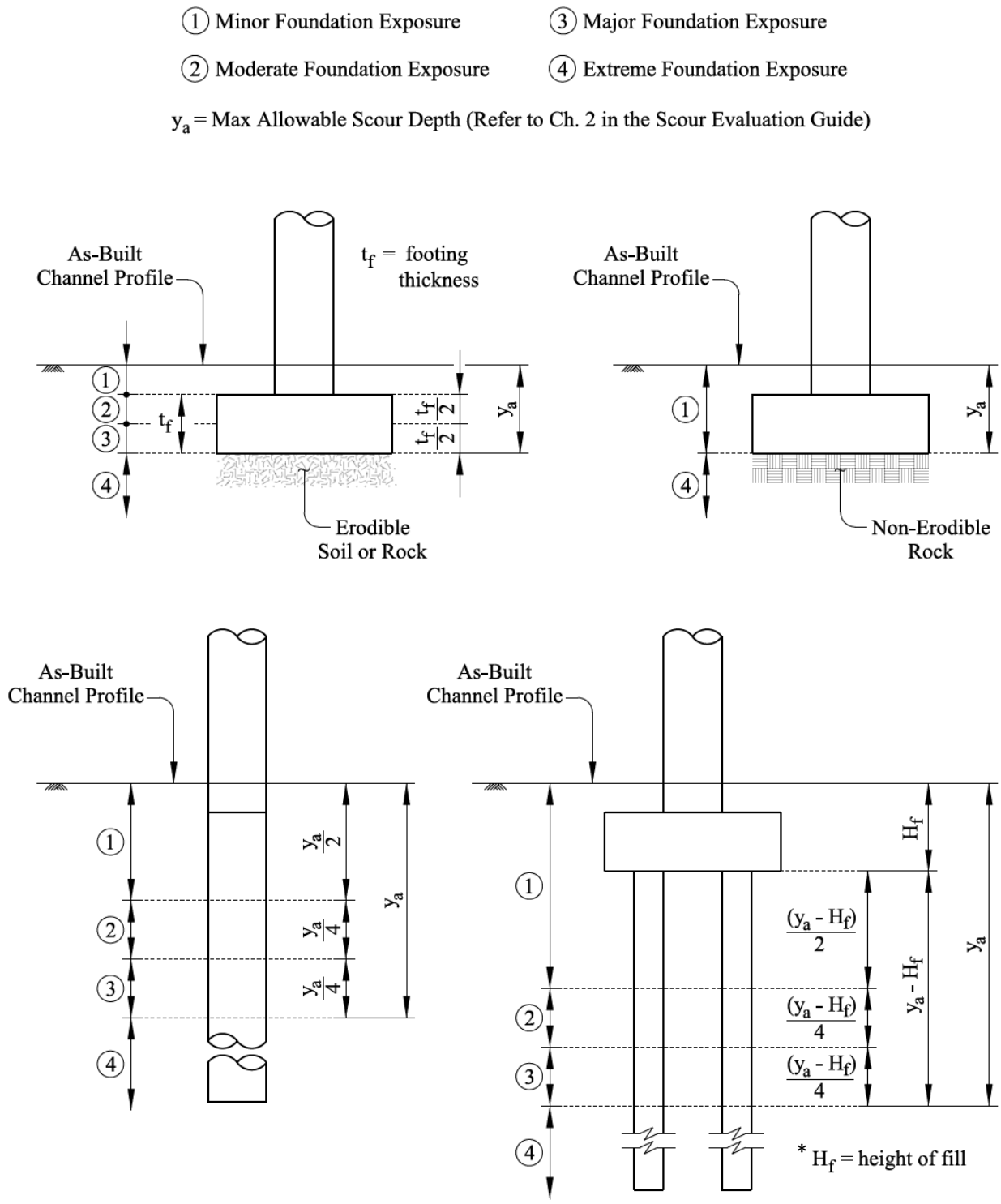
► Channel Migration History

Over time, streams and rivers can migrate laterally to new locations – this is called channel migration. Channel migration can have an adverse impact on bridges because it shifts the deepest part of the channel away from mid-span, toward bents and abutments. Even if the elevation of the channel flowline remains constant, lateral migration of the channel itself can increase the exposure of adjacent foundations.

The Channel Migration History appraisal should be based on a review of the bridge's current and previous measured channel profiles. The score for Channel Migration History is based on what general category of channel migration has been observed.

Table 8-4 – SVA Scoring Criteria for Channel Migration History

Foundation Exposure from y_{max}	Score
No History of Channel Migration	0
Channel migration has occurred, but the shift has not impacted adjacent bents or abutments.	1
Channel migration has occurred, and the shift has impacted adjacent bents or abutments.	2



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

Figure 8-1 – Foundation Exposure Categories

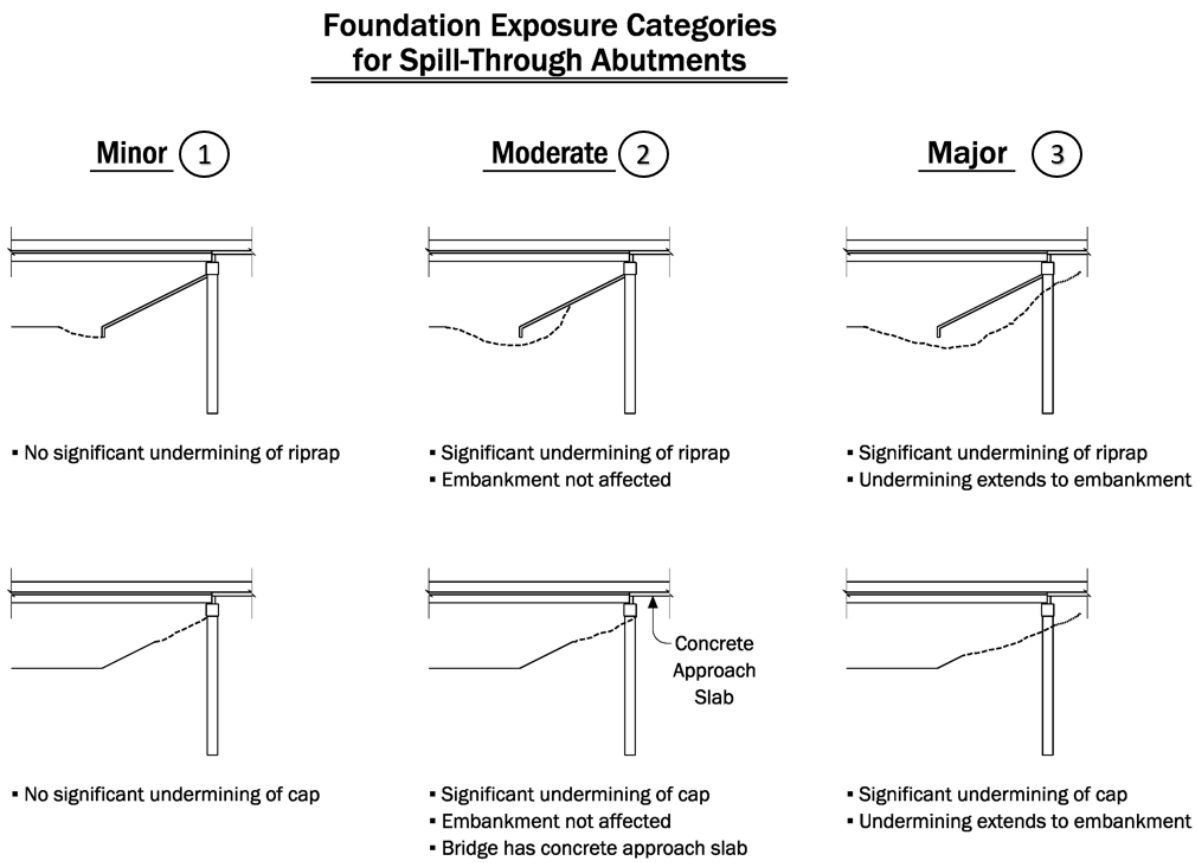


Figure 8-2 – Foundation Exposure Categories for Spill-Through Abutments

8.3 SVA Coding Table for NBI Item 113

After determining the Scour Vulnerability Class, use the Table 8-5 to determine the appropriate coding for NBI Item 113 or SNBI Item B.C.11. Table 8-5 uses the definitions from Figures 8-1 and 8-2 to define foundation exposure categories. Record the recommended scour coding on Form 537.

Table 8-5 – SVA Scour Coding Table

Current Scour Condition Refer to Figures 8-1 and 8-2 for Definitions of Foundation Exposure Categories	**Recommended Scour Coding**			
	Scour Vulnerability Class			
	Normal	Enhanced	Normal	Enhanced
	Item 113		SNBI Item B.C.11 & (Item B.AP.03)	
Countermeasures Installed & Functioning	8	8	4 to 9 (B)	4 to 9 (B)
Minor Foundation Exposure	8	5	6, 7, 8, 9 (A)	6 or 7 (A)
Moderate Foundation Exposure	4	3	4, 5, 6 (A)	4, 5, 6 (C or D)
Major Foundation Exposure	2	2	2 or 3 (C or D)	2 (C or D)
Bridge Closed	1	1	1 (C or D)	1 (C or D)
Bridge Failed	0	0	0	0

8.4 Future Actions

Future actions may be required if the bridge is vulnerable to current or anticipated scour. If the bridge's vulnerability is based on currently observed scour, scour remediation may be required. This could include repairs, or the installation of scour countermeasures. If the bridge is considered vulnerable based on anticipated scour, then a more rigorous scour evaluation may be needed. Table 8-6 provides minimum default recommendations and timelines for each scour coding. These recommendations may be modified when warranted by site-specific conditions.

Table 8-6 – Default Future Action Recommendations for SVA

Recommended Item 113 Scour Coding	Future Action	Timeline for Completion
8	No additional action required.	-
7	No additional action required.	-
5	Continued monitoring and assessment.	Ongoing / Indefinite Monitoring
4	Continued monitoring and assessment. Consider the need of more frequent intervals.	Ongoing / Indefinite Monitoring
3(1)	Plan of Action (Form 2604)	30 days from appraisal to complete the form
2(1)	Plan of Action (Form 2624)	30 days from appraisal to complete the form

Recommended SNBI Scour Coding(2)		Future Action	Timeline for Completion
Item B.C.11	Item B.AP.03		
5 to 9	A or B	No additional action required.	-
4	A or B	Continued monitoring and assessment. Consider the need of more frequent inspection intervals.	Ongoing / Indefinite Monitoring
4(1)	C or D	Plan of Action (Form 2604)	30 days from appraisal to complete the form
2 or 3(1)	C or D	Plan of Action (Form 2624)	30 days from appraisal to complete the form

Notes: (1) Prior to POA (i.e. fill out Form 2604 or 2624), verify the coding with assessment is highly recommended (refer to Section 3.4)
(2) See Table A-1 in Appendix A for mapping the corresponding SNBI Items B.C.11 and B.AP.03.

Upon completion of the SVA method, Form 537 must be completed, signed and sealed by a professional engineer, and uploaded to AssetWise by district bridge inspection staff. Future actions do not need to be described in detail on Form 537; detailed recommendations should be provided on the scour summary sheet and/or bridge scour plan of action.

Chapter 9 DETAILED SCOUR EVALUATIONS BASED ON ANALYSES

See the TxDOT Scour Analysis Guide in the Hydrology & Hydraulics Section.

Chapter 10 TRIGGER ELEVATIONS & CONDITIONS

All span bridges and bridge-class culverts require a scour coding for NBI Item 113 or SNBI Items B.C.11 and B.AP.03 in AssetWise. In most cases, the scour coding will continue to be valid even if additional scour occurs. However, it is possible to identify a threshold elevation or condition, beyond which the structure will be significantly more vulnerable to scour. For example, beyond a certain threshold scour depth, the coding for scour may need to be lowered. Coding thresholds can be determined using coding guidance for scour from the TxDOT Coding Guide. The threshold scour depth could also describe a condition that requires certain scour remediation efforts.

The observation of a "trigger" should serve as an alert that the observed scour is nearing – but has not yet reached – a threshold condition. Therefore, the trigger must represent a condition that would be observed well before the threshold condition could occur. Observation of a trigger elevation or condition does not necessarily require a coding change, but it would automatically warrant a critical assessment of the scour condition. Such an assessment may result in a coding change, installation of countermeasures, load posting, or – in extreme cases – closure of the bridge.

The trigger elevation for a span bridge should generally be set higher than the threshold elevation it represents. If possible, the trigger elevation should also be identified in reference to a permanent physical feature so that it can be readily identified by inspectors. Always specify which abutment(s) and/or bent(s) a trigger elevation applies to. Table 10-1 generally provides trigger elevations for interior bents based on the current scour coding. The trigger elevation for a spill-through abutment can usually be specified near the bottom of the abutment toewall and the rear end bottom of the abutment bent cap (See Figure 8-2). Table 10-1 should be considered in conjunction with Item 113 or SNBI Item B.C.11 in the TxDOT Coding Guide. Both NBI Item 113 and SNBI Item B.C.11 are presented in Appendix A for ease of reference. Trigger elevations must be determined for site-specific conditions on a case-by-case basis.

Table 10-1 – General Trigger Elevations for Interior Bents

Current Item 113 Coding	SNBI Items B.C.11 Coding	Trigger Elevations (Applies to Deep Foundations and Spread Footings)
8	6, 7, 8, 9	Half-way between current channel profile and threshold for moderate foundation exposure.
5	5	
4	4	Half-way between current channel profile and threshold for major foundation exposure.
3	3	
2	2	Half-way between current channel profile and maximum allowable scour depth.

Describe the trigger condition for a culvert as a specific amount of exposure or undermining for a specific element. (Scour coding thresholds for culverts are defined in the same way – refer to Item 113 or Item B.C.11 in the TxDOT Coding Guide.) Exposure and undermining both refer to erosion, regardless of whether it occurs by scour, piping, or another mechanism. Exposure is

measured vertically, measured downward from the as-built ground surface along the face of a toewall. Undermining is measured horizontally, parallel to the culvert barrel(s).

Chapter 11 STONE PROTECTION RIPRAP AT BRIDGES

Stone protection riprap is preferred over concrete riprap. Stone protection riprap is flexible, meaning that it can adjust to distortions and local movements. Concrete riprap and fully grouted stone riprap are rigid – instead of adapting to problem areas, they tend to provoke and mask them. If undetected, erosion under concrete or fully grouted stone riprap can eventually undermine the pavement or approach slab.

Designers who elect to use stone protection riprap are required to determine the appropriate nominal stone size and gradation, thickness, and extents for the specific application and field conditions at the bridge. Refer to Hydraulic Engineering Circular No. 23, Vol. 2, "Bridge Scour and Stream Stability Countermeasures," (HEC-23 Vol. 2) for design guidance.

Stone protection is designed and specified in terms of gradation. Table 1 in Item 432 of the TxDOT Standard Specifications specifies gradation on the basis of weight, but weights are often converted to size for ease of visualization and measurement. Estimated gradations based on size can be read from Table 2 if the bulk specific gravity (G_s) = 2.50, or calculated if G_s > 2.50:

$$D_{50} = 12\left(\frac{W_{50}}{0.85\gamma_w G_s}\right)$$

Where: W_{50} = 50% Size from Item 432, Table 1 (lb.)

γ_w = 62.4 pcf

G_s = bulk specific gravity (Tex-403-A) (-)

The required thickness of stone protection depends on the riprap application, nominal stone size, and the conditions where it is being placed. Minimum recommended stone riprap thicknesses from HEC-23 are summarized in Table 11-1.

Table 11-1 – Minimum Recommended Thickness for Stone Protection Riprap (HEC-23)

Application	Minimum Thickness
Abutment Protection	Greater of $1.5D_{50}$ or $1.0D_{100}$
Pier Protection	$3D_{50}$
Other	Greater of $2.0D_{50}$ or $1.0D_{100}$

Alternatively, for applications other than pier protection, riprap thickness may be specified as 1.5 times the nominal stone size. HEC-23 recommends increasing riprap thickness by 50% if the riprap will be placed under water.

Specify stone protection size (XX) and thickness (YY) in the plans as follows:

Riprap (Stone Protection) XX in.
Thickness = YY in.

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Appendix A TxDOT Coding Guide

Current Coding NBI Item 113 Scour Critical Bridges

Use a single-digit code as indicated below to identify the current status of the bridge regarding its vulnerability to scour based on Figures 8-1 and 8-2 and Table 5-1. A scour critical span bridge is one with major foundation exposure related to observed scour (i.e. Item 113 = 0, 1, 2, or 3) or calculated scour (*i.e.*, Item 113 = 3) depending on the conditions of scour countermeasure and observed scour depths. A scour critical bridge-class culvert is one with major exposure and/or undermining caused by erosion/piping/scour.

If major foundation exposure is observed (*i.e.*, Item 113 = 0, 1, or 2), then Item 60, "Substructure" must receive the same coding as Item 113; major foundation exposure governs the overall condition of the entire substructure.

"Calculated scour depth" is a prediction – it is the result of a scour evaluation based on analysis. "Observed scour depth" refers to current conditions recorded during a physical inspection. "Maximum allowable scour depth" is a structural property of the foundation which indicates how much scour can occur before the foundation becomes unstable. Refer to the TxDOT Scour Evaluation Guide for more information about calculated, observed, and maximum allowable scour depths. FHWA guidance for evaluating scour at bridges is available in Technical Advisory 5140.23 and Hydraulic Engineering Circular No. 18.

Code	Descriptions for Span Bridges
N	Bridge is not over waterway.
U	Unknown foundation and lacking scour evaluation and/or documentation.
T	Over tidal waters and lacking scour evaluation and/or documentation.
9	All foundation components, including piles or shafts, are above flood waters.
8	The calculated scour depth (if applicable) would cause minimal foundation exposure. The observed scour depth has caused minimal foundation exposure.
7	Previously observed scour has been remediated: countermeasures have been installed and are performing well.
6	Lacking scour evaluation and/or documentation.
5	The calculated scour depth would cause moderate foundation exposure. The observed scour depth causes minimal foundation exposure.
4	The observed scour has caused moderate foundation exposure. The calculated scour would cause minimal or moderate foundation exposure. Action is required to address the observed scour.
3	The calculated scour depth would cause major foundation exposure. The observed scour has caused minimal or moderate foundation exposure. A Bridge Scour Plan of Action (Form 2604) is required.
2	Observed scour has caused major foundation exposure. Immediate action is required to remediate the observed scour. A Bridge Scour Plan of Action (Form 2624) is required.
1	Observed scour exceeds the max allowable scour depth. Failure is imminent and the bridge is closed to traffic. A Bridge Scour Plan of Action (Form 2609) is required.
0	Failure has occurred, and the bridge is closed to traffic.

Code Descriptions for Bridge-Class Culverts

N Culvert does not span a waterway.

U [not applicable for culverts]

T [not applicable for culverts]

9 [not applicable for culverts]

8 Refer to the table and figures below.

7 Previously observed scour has been remediated: countermeasures have been installed and are performing well.

6 Lacking scour evaluation and/or documentation.

5 [not applicable for culverts]

4 Refer to the table and figures below.

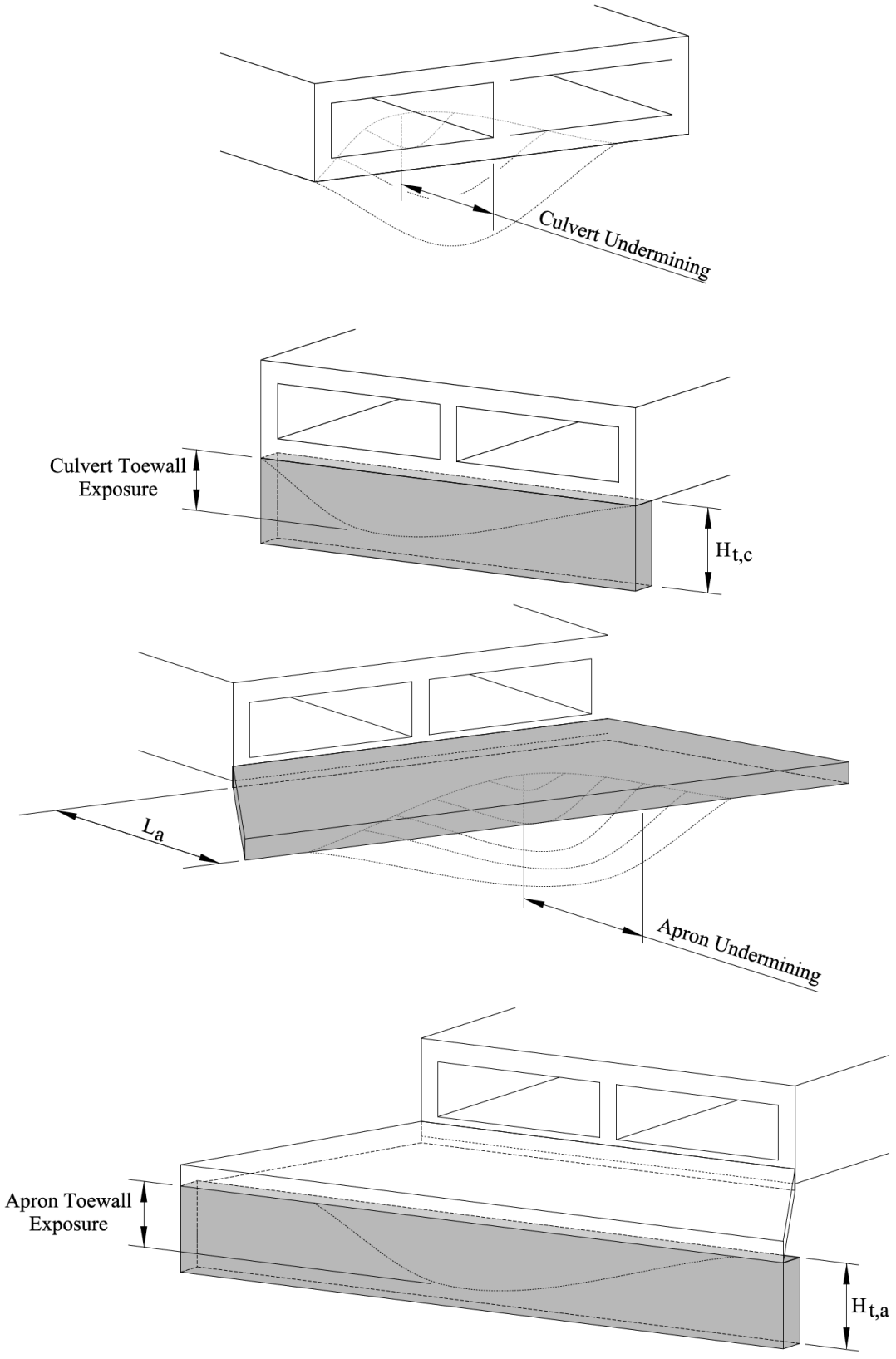
3 [not applicable for culverts]

2 Refer to the table and figures below. A Bridge Scour Plan of Action (Form 2624) is required.

1 Failure is imminent and the bridge-class culvert is closed to traffic. A Bridge Scour Plan of Action (Form 2609) is required.

0 Failure has occurred and the bridge-class culvert is closed to traffic.

Item 113 Coding	Exposure and/or Undermining Category	*Choose the Most Critical Mechanism*			
		Culvert/Pipe Undermining	Culvert/Pipe Toewall Exposure	Apron Undermining	Apron Toewall Exposure
8	Minimal	< 1 ft.	$< {}^{1}/_{3}\ H_{t,c}$	$< {}^{1}/_{5}\ L_a$	$\leq H_{t,a}$
4	Moderate	1 – 3 ft.	$\leq H_{t,c}$	${}^{1}/_{5}\ L_a - {}^{3}/_{5}\ L_a$	$> H_{t,a}$
2	Major	> 3 ft.	$> H_{t,c}$	$> {}^{3}/_{5}\ L_a$	-


Culvert Undermining
Culvert Toewall Exposure
$H_{t,c}$
L_a
Apron Undermining
Apron Toewall Exposure
$H_{t,a}$

SNBI Coding Item B.C.11 Scour Condition Rating for Span Bridge

Use a single-digit code as indicated below to identify the current scour condition of the bridge regarding only the observed scour depth based on Figures 8-1 and 8-2.

"Observed scour depth" refers to current conditions recorded during a physical inspection. "Maximum allowable scour depth" is a structural property of the foundation which indicates how much scour can occur before the foundation becomes unstable. FHWA guidance for evaluating scour at bridges is available in Technical Advisory 5140.23 and Hydraulic Engineering Circular No. 18.

A recommended mapping from current TxDOT coding to the SNBI is presented in Table A-1.

Table A-1 Recommended Mapping for TxDOT Coding to SNBI Coding

TxDOT Coding Guide			New SNBI Coding		
Item 113 Coding Scour Critical Bridges	**Item 113.1 Scour POA**	**Item 113.2 Unknown Foundation**	**Item B.C.11 Scour Condition Rating**	**Item B.AP.03 Scour Vulnerability**	**Item B.AP.04 Scour POA**
N			N		
U		Blank or U		U	
T					
9			9	A	0
8			6, 7, 8, or 9	A or B	0
7			5, 6, 7, 8, or 9	B, C, or E	0, N, or Y
6				0, E	
5			5, 6, 7, 8, or 9	A or B	0
4			4 or 5	A or B	0
3	Blank or P		4, 5, 6, 7, 8, or 9	C or D	N or Y
2	Blank or P		2 or 3	C or D	N or Y
1	Blank or P		1	C or D	N or Y
0			0	C or D	

B.C.11 Code - Descriptions for Span Bridges

N Bridge does not cross over waterway.

9 No scour.

8 Insignificant scour.

7 Some minor scour.

6 Widespread minor scour or isolated moderate scour.

5 Moderate scour; strength and stability of the bridge are not affected.

4 Widespread moderate or isolated major scour; strength and/or stability of the bridge is affected.

3 Major scour; strength and/or stability of the bridge is seriously affected. Condition typically necessitates more frequent monitoring, load restrictions, and/or corrective actions.

2 Major scour; strength and/or stability of the bridge is severely compromised. Condition typically necessitates frequent monitoring, significant load restrictions, and/or corrective actions to keep the bridge open.

1 Bridge is closed to traffic due to scour condition. Channel rehabilitation may return the bridge to service.

0 Bridge is closed due to scour condition and is beyond corrective action. Bridge replacement is needed to restore service.

SNBI Coding Item B.AP.03 – Scour Vulnerability

Use a single-digit code as indicated below to identify the current scour vulnerability of the bridge regarding the calculated scour depth, scour documentations, and the condition of countermeasures.

"Calculated scour depth" is a prediction – it is the result of a scour evaluation based on analysis that is separate from Item B.C.11. Refer to Chapter 2 and Figure 2-1 for scour documentations and evaluations.

Code	Descriptions for Span Bridges and Bridge Class Culvert
0	Scour appraisal has not been completed.
A	Scour appraisal completed. Bridge determined to be stable for scour.
B	Scour appraisal completed. Bridge determined to be stable for scour, dependent upon designed, and functioning countermeasures.
C	Scour appraisal completed. Bridge could become unstable for scour. Temporary (not designed) countermeasure installed to mitigate scour. Bridge is scour critical.
D	Scour appraisal completed. Bridge is, or may become, unstable for scour. Bridge is scour critical.
E	Scour appraisal has not been completed. Temporary (not designed) countermeasure installed to mitigate scour.
U	Scour appraisal has not been completed due to unknown foundations

SNBI Coding Item B.C.11 – Scour Condition Rating for Bridge Class Culverts

Report the scour condition that represents the observed or measured scour only.

N Culvert does not span a waterway.

9 No observed scour.

8 Refer to the table and figures below.

7 [not applicable for culverts]

6 [not applicable for culverts]

5 [not applicable for culverts]

4 Refer to the table and figures below.

3 Refer to the table and figure below. A Bridge Scour Plan of Action (Form 2604) is required.

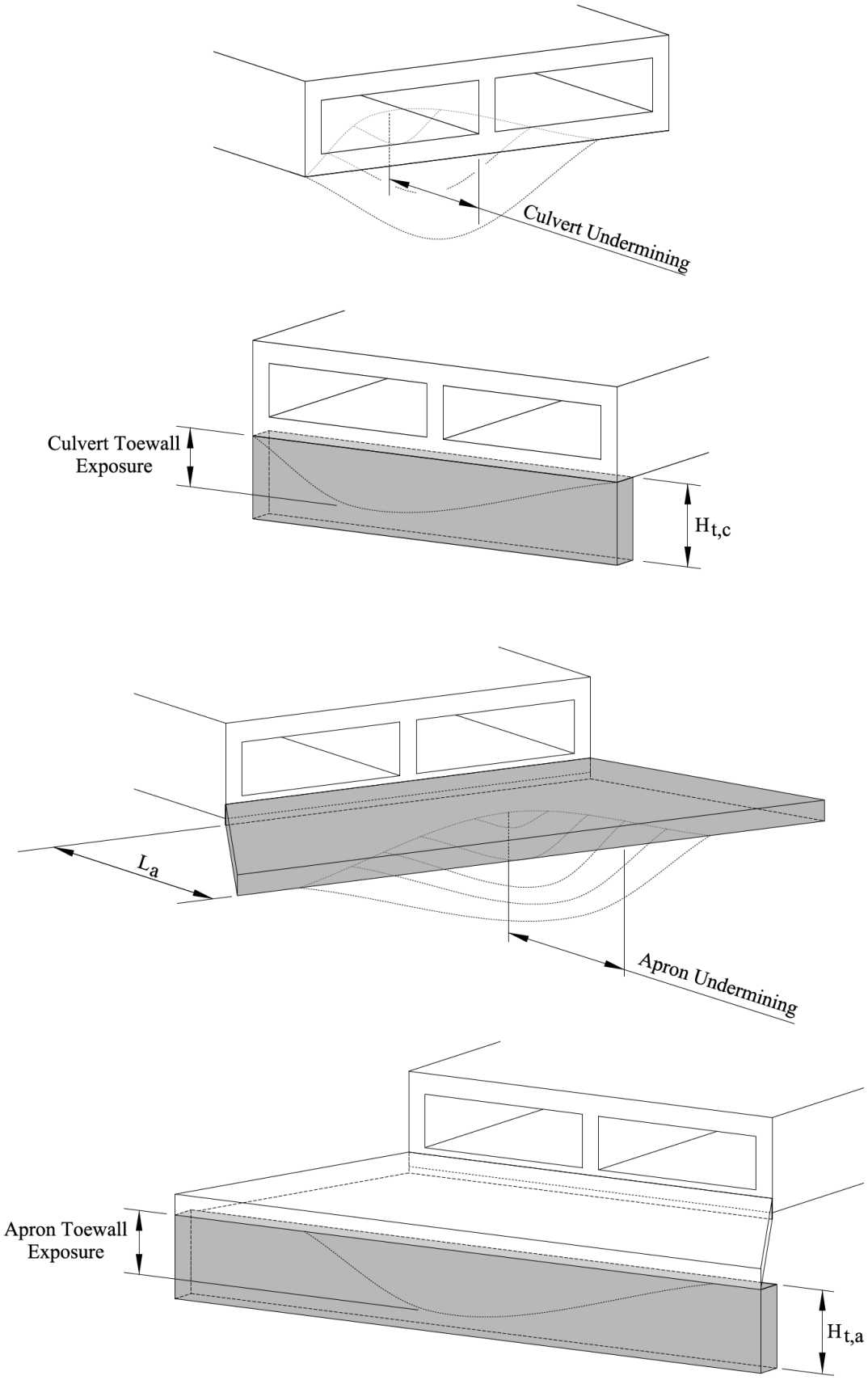
2 Refer to the table and figures below. A Bridge Scour Plan of Action (Form 2624) is required.

1 Failure is imminent, and the bridge-class culvert is closed to traffic. A Bridge Scour Plan of Action (Form 2609) is required.

0 Failure has occurred and the bridge is closed to traffic.

Table A-2 Coding Guide for Bridge Class Culvert

Item B.C.11 Coding	Exposure and/or Undermining Category	*Choose the Most Critical Mechanism*			
		Culvert/Pipe Undermining	Culvert/Pipe Toewall Exposure	Apron Undermining	Apron Toewall Exposure
8	Minimal	< 1 ft.	$< {}^{1}/_{3}\ H_{t,c}$	$< {}^{1}/_{5}\ L_a$	$\leq H_{t,a}$
4	Moderate	1 – 3 ft.	$\leq H_{t,c}$	${}^{1}/_{5}\ L_a - {}^{3}/_{5}\ L_a$	$> H_{t,a}$
3	Major	3 – 5 ft.	$= H_{t,c}$	${}^{3}/_{5}\ L_a - L_a$	-
2	Major & Severely Compromised	> 5 ft.	$> H_{t,c}$	$> L_a$	-


Culvert Undermining
Culvert Toewall Exposure
$H_{t,c}$
L_a
Apron Undermining
Apron Toewall Exposure
$H_{t,a}$

SNBI Coding Item B.AP.04 – Scour Plan of Action

Report whether the bridge has a scour plan of action (POA) on file. Do not report this item if the bridge does not cross on a waterway.

Code	Descriptions
0	A scour POA is not required.
N	A scour POA is required, but not implemented.
Y	A scour POA is required and implemented.

Appendix B SRICOS METHOD FOR CONTRACTION & PIER SCOUR

See the TxDOT Scour Analysis Guide in the Hydrology & Hydraulics Section.

Appendix C SCOUR SUMMARY SHEET FOR SPAN BRIDGES

Use these guidelines to complete Form 2605, "Scour Summary Sheet for Span Bridges".

Title Block
Enter the District, County, NBI Number, Highway, Crossing, and CSJ in the appropriate boxes.

Recommended Scour Coding
Enter the recommended coding for Items 113, 113.1, and 113.2 or later SNBI Items B.C.11, B.AP.03, and B.AP.04. Refer to the TxDOT Coding Guide (or Appendix A) for coding instructions.

Engineer of Record for the Recommended Scour Coding
Enter the name and agency of the engineer who is responsible for the recommended scour coding. This is the engineer who must sign and seal the scour summary sheet.

Date of Recommendation
Enter the date of the coding recommendations.

SCOUR EVALUATION DETAILS

Date – Enter the date of the scour evaluation. This date should be shown on the documentation of the scour evaluation.
Engineer of Record for Scour Evaluation – Enter the name and agency of the engineer who is responsible for the scour evaluation. This individual's seal and signature must be shown on the scour evaluation documentation.
Scour Evaluation Method – Check the box next to the scour evaluation method that was used. If an evaluation method other than those listed was used, check the box next to "Other" and list the method in the space provided.

FOUNDATION DETAILS

Non-Erodible Stratum – Check this box if the foundations are protected by a non-erodible stratum. If this box is checked, describe the non-erodible stratum in the space provided. For example: *Very hard limestone at EL = 535 ft. with TCP < 2 inches per 50 blows.*
Unknown Foundations – Check this box if the bridge is supported by even one unknown foundation (*i.e.*, gross dimensions and embedment not known). If this box is checked, some foundation dimensions may have been assumed to estimate the max allowable scour depths. Use the space provided to document any assumptions that were made. Attach an additional sheet if more space is needed.

INSPECTION DETAILS

Date of Most Recent Inspection – Enter the date of the most recent bridge inspection.
Scour Countermeasures – Check this box if the bridge has a documented history of scour issues which have been corrected by the installation of countermeasures. If this box is checked, provide a brief description of the countermeasures in the space provided. Attach photos if

countermeasures were installed recently and are not documented in the latest inspection report.

SCOUR DEPTHS

All reported scour depths should be measured from the same reference profile or elevation so that maximum allowable, calculated, observed, and/or max possible scour depths at any given bent can be compared "apples to apples".

Scour depths are measured from the as-built channel profile. – Check this box if scour depths are measured from the as-built channel profile. This is always recommended when the as-built channel profile is available (*i.e.*, shown on bridge layout).
Scour depths measured from _____. – Check this box if the as-built channel profile is not known, and indicate the elevation, reference point, or profile from which scour depths are measured.

The recommended scour coding will reflect conditions at whichever abutment or bent is most vulnerable. In some cases, multiple locations will qualify as "most vulnerable". Complete the Scour Depths table only for those abutment(s) and/or bent(s) which are most vulnerable. Enter "N/A" for any fields that are not applicable, and "–" for any values that are not available.

Abutment or Bent # – Identify the abutment or bent using the same nomenclature as the original plans and inspection records.
y_{ab} – Max allowable scour depth for bearing. If the foundation is embedded in rock, this field may be used for y_{ar} (max allowable scour depth for rotation).
y_{al} – Max allowable scour depth for unbraced length. **Not applicable for shallow foundations.**
Max Allowable Scour Depth – The lesser of y_{ab} and y_{al}.
Max Possible Scour Depth – Scour depth that would be required to reach a non-erodible stratum. Only applicable if a non-erodible stratum is present.
Calculated Contraction Scour – One of the calculated scour depths from a detailed scour evaluation based on analysis.
Calculated Pier Scour – One of the calculated scour depths from a detailed scour evaluation based on analysis.
Total Calculated Scour Depth – Equal to sum of calculated contraction and pier scour.
Observed Scour Depth – Scour depth determined from channel profile measured during latest inspection.

TRIGGER ELEVATION & FUTURE ACTION

List a trigger elevation and any actions that should be considered if/when the trigger elevation is observed. Refer to Chapter 10 for more information about selecting a trigger elevation. The trigger elevation must be determined for site-specific conditions on a case-by-case basis.

Appendix D SCOUR SUMMARY SHEET FOR BRIDGE-CLASS CULVERTS

Use these guidelines to complete Form 2606, "Scour Summary Sheet for Bridge Class Culverts".

Title Block
Enter the District, County, NBI Number, Highway, Crossing, and CSJ in the appropriate boxes.

Engineer of Record for the Recommended Scour Coding
Enter the name and agency of the engineer who is responsible for the recommended scour coding. This is the engineer who must sign and seal the scour summary sheet.

Date of Recommendation
Enter the date of the coding recommendations.

Recommended Scour Coding
Enter the recommended coding for Items 113, 113.1, and 113.2 or later SNBI Items B.C.11, B.AP.03, and B.AP.04. Refer to the TxDOT Coding Guide (or Appendix A) for coding instructions.

STRUCTURE DETAILS

Pipe – Check this box if the structure is a pipe culvert.
Box – Check this box if the structure is a box culvert.
Number of Barrels – Enter the number of boxes or pipes.

The following terms are illustrated under Item 113 in the TxDOT Coding Guide:

Culvert/Pipe Toewall Height ($H_{t,c}$) – Enter the height of the culvert toewall. If there is no toewall adjacent to the culvert, check the box for "N/A".
Length of Apron (L_a) – Enter the length of the apron, measured parallel to the barrel(s). If the culvert does not have an apron, check the box for "N/A".
Apron Toewall Height ($H_{t,a}$) – Enter the height of the apron toewall. If the culvert does not have an apron toewall, check the box for "N/A".

INSPECTION DETAILS

Date of Most Recent Inspection – Enter the date of the most recent inspection.

The following terms are illustrated under Item 113 in the TxDOT Coding Guide:

Culvert or Pipe Undermining – Enter the amount of undermining beneath the culvert (not the apron). This is a horizontal length, measured parallel to the barrel(s).
Culvert or Pipe Toewall Exposure – Enter the amount of culvert toewall exposure. This is a vertical length, measured downward from the top of the culvert toewall. If there is no toewall adjacent to the culvert, check the box for "N/A".
Apron Undermining – Enter the amount of undermining beneath the apron. This is a horizontal length, measured parallel to the barrel(s). If the culvert does not have an apron, check the box for "N/A".

Apron Toewall Exposure – Enter the amount of apron toewall exposure. This is a vertical length, measured downward from the top of the apron toewall. If the culvert does not have an apron toewall, check the box for "N/A".

TRIGGER CONDITION & FUTURE ACTION

List a trigger condition and any actions that should be considered if/when the trigger elevation is observed. The trigger condition for a culvert is analogous to the trigger elevation for a span bridge. However, the trigger condition for a culvert should define a specific amount of exposure and/or undermining for a particular element (*e.g.*, apron toewall, apron, culvert toewall, pipe, or culvert). Refer to Chapter 10 for more information about selecting a trigger condition. The trigger condition must be determined for site-specific conditions on a case-by-case basis.