OFFICE OF STRUCTURAL ENGINEERING
Channel Cross Section Requirement and Procedure

DATE: Effective 1/26/2017

TO: Bridge Inspection Program Managers

CC: Bridge Staff

FROM: Tim Keller, Office of Structural Engineering (OSE)

SUBJECT: Channel Cross Section Requirement and Procedure for NBIS Bridges

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I. Background:

FHWA notified ODOT on October 31, 2016 that the State's practice for bridge files does not meet the requirements of the National Bridge Inspection Program 23 CFR 650.313(d), specifically Metric 15 – Bridge Files. An Intermediate Assessment found that the majority of bridge files (sample) did not have documented scour evaluations and channel cross sections. A systematic process is required to identify and address bridges that are vulnerable to scour. The procedure contained in this document is intended to meet this goal and must be completed by October 31, 2018.

II. Requirement for Channel Cross Sections:

The first step to inspect waterways is through visual observation. After a visual inspection of the bridge site, the next step is to probe for any scour or undermining. Extra effort should be taken to probe through soft silt layers that are filling in local scour holes. Structures that cannot be inspected by wading and/or probing at low water within a 60 month interval require dive techniques.

At regular intervals, measurements to obtain the cross section should be taken. These measurements are used to determine change due to general channel scour, channel migration, aggradation or degradation. The measurements should capture scour, degradation or other channel properties that may cause distress to the foundation. Certain types of bridges will require channel cross sections:

a) **Dive Inspections**: Bridges that are coded "Y-Yes" for item 93B Underwater Dive Inspection (Appendix A) **shall** have a Channel Cross Section performed and on file. Channel Cross Sections can be done separately from the dive inspection or made part of the dive inspection scope. The dive inspection includes accessing and probing in a grid pattern around each abutment or pier in water. The channel section is in addition to the dive inspection. Due to access and simplicity, it is recommended that the language in current and future diving contracts is updated to include Channel Cross Sections as part of the scope of work. The dive inspector should be able to easily perform these measurements as part of the dive inspection. In the event the next dive inspection will be performed after October 31, 2018 and there is not a channel cross section on file within 60 months then the baseline channel cross section must be performed using one of the methods described in the policy prior to October 2018.

b) **Scour Critical:** Bridges that are coded "Scour Critical" Item 113 = 3, 2, 1, 0 (Appendix B) **shall** have a Channel Cross Section on file. Channel Cross Sections shall be updated every 60 months or at any obvious change or worsening of the channel condition. It is required that the Channel Cross Section file is in the bridge file for future reference. It is recommended that the Channel Cross Section file is uploaded to SMS for future reference and FHWA sampling.

Channel Cross Sections shall be updated every 60 months. More frequent measurements should be taken when, for example, channel condition worsens or changes abruptly. Along with the above requirements, it is recommended that Channel Cross Sections be performed when the Item 60 Channel Summary is rated 5-Fair or worse or Item 113 Scour Critical Susceptibility is 5 or 4.

Baseline Channel Cross Sections must be complete and on file no later than October 31, 2018.

III. Procedure for Performing Channel Cross Sections:

The goal of a Channel Cross Section is to monitor the channel's horizontal and vertical movement over time, identify size and depth of scour holes and monitor flow line. They must be compared with past measurements in order to monitor change. Priority for choosing a side should follow the precedent:

a) Choose the side that exhibits the most scour, degradation or other channel properties that may cause distress to the foundation units or
b) Choose the same side as the last cross section or
c) Choose the upstream side of the channel or
d) Do both sides.

Flowline characteristics that could directly affect the substructure stability must be entered into the bridge file. Also, channel cross sections may lead to more dive inspections, soil sampling, robust channel profiles and/or LIDAR scanning in order to perform scour analysis.

Figure 1 – Example Set of Measuring Devices & Tools

The channel cross sections must contain objective and repeatable dimensions. Performing a Channel Cross Section can be done from underneath, or most often, will be performed from on top of the deck. Measurements need two components, the horizontal distance from the rear abutment (X-axis) and the vertical ‘drop’ distance (Y-axis) from a reference point to the ground (Appendix C & D examples). In lieu of an in-depth fathometer sounding, below is a procedure that is repeatable and objective:

1. Obtain tools for measuring from either top or bottom (Figure 1).

2. Measure the vertical distance, vertical offset, between the reference location and the underside of the superstructure. Describe the offset dimension or draw a picture. This measurement is the vertical distance (Figure 2) and is relatively easy to get to and should be accessible during flood or high water.

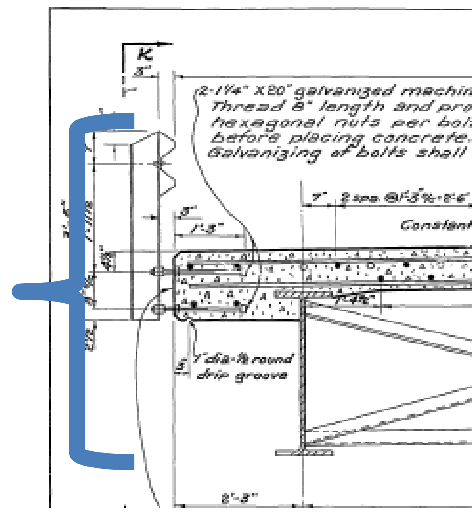


Figure 2 - Offset Distance in this example is not on the plans and needed field measured

3. Mark and document where the vertical measurements will be taken on the bridge and on the form. Use a wheel or fixed objects and walk upstation away from the rear abutment on the appropriate side and mark on the railing or wearing surface where the vertical drop will be taken (Figure 3). For structures longer than 50 feet it must include at a minimum:
   1. Both abutments, and
   2. Every pier, and
   3. Points that are susceptible to change such as:
      a. Top and bottom of a channel cut/slope change
      b. Edge of water (EOW)
      c. Maximum water depth or channel bottom
      d. Scour holes
      e. Edges and highpoints of debris and
   4. 1/2-span points and fields

   On smaller structures less than 50 feet long or structures with active channel misalignment (Channel Summary Condition of 4-Poor or worse), smaller distances between measurements are required such as every guardrail post or every 5 foot increment.

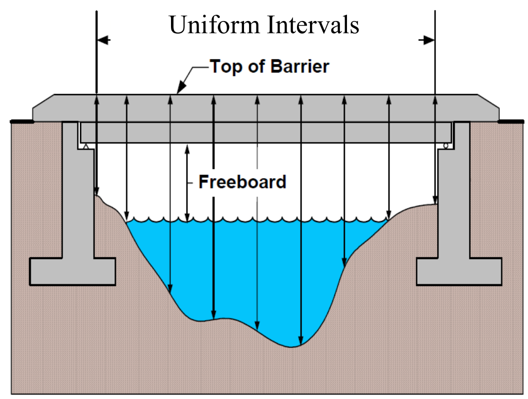


Figure 3 - Channel Cross Section Intervals (NHI)

4. At each drop-point, lower weighted end of a 100’ tape attached to a rope supporting a 5-10 lb weight until the weight touches the ground below.

5. Record the dimension on the tape at the reference point and the horizontal distance. Documentation must be in the bridge file. It is recommended that the measurements are uploaded or typed into SMS (Figure 4).

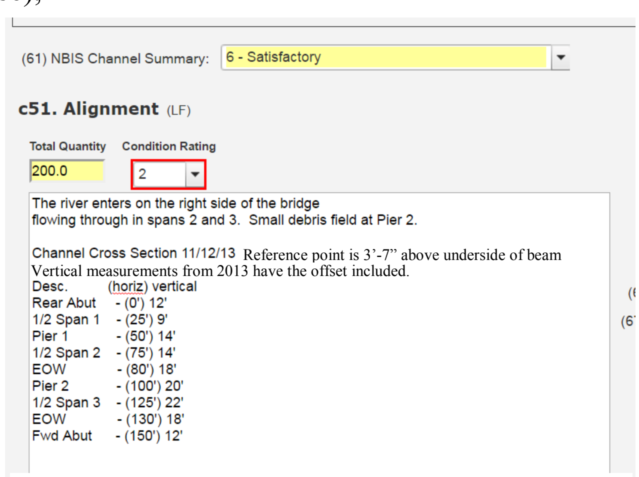


Figure 4 – Comment Fields in SMS can be used for Channel Cross Section Measurements

If it is easier to record the vertical measurements from underneath, they can be obtained with a survey rod or laser distance measure from the ground-line to the underside of the superstructure. The same horizontal measurements and vertical drop locations described above shall be taken and documented.

IV. <u>Requirement for Baseline Photographs</u>:

All bridges not meeting the requirement for Channel Cross Sections must have baseline channel photographs on file. Channel Cross Sections should be taken when baseline photographs are inadequate or not feasible. Bridges over waterways shall, at a minimum, have baseline Channel Cross Section Photographs that are readily available for monitoring change. Bridge staff shall be able to effectively compare channel conditions with the baseline photos. When Public Entities opt to perform baseline photographs, they are also agreeing to the respective global statement in Appendix E of this document. If the responsibility statements do not best represent the bridges in the entity's jurisdiction, the staff must perform a Channel Cross Section instead of the baseline photographs.

It is required that these photos exist and are on file. It is recommended that the baseline photos are uploaded into the bridge file in SMS as "Channel Inspection Photos" (Figure 5). Under the files tab, choose Channel Inspection Photos from the drop-down selection, and upload the photos.

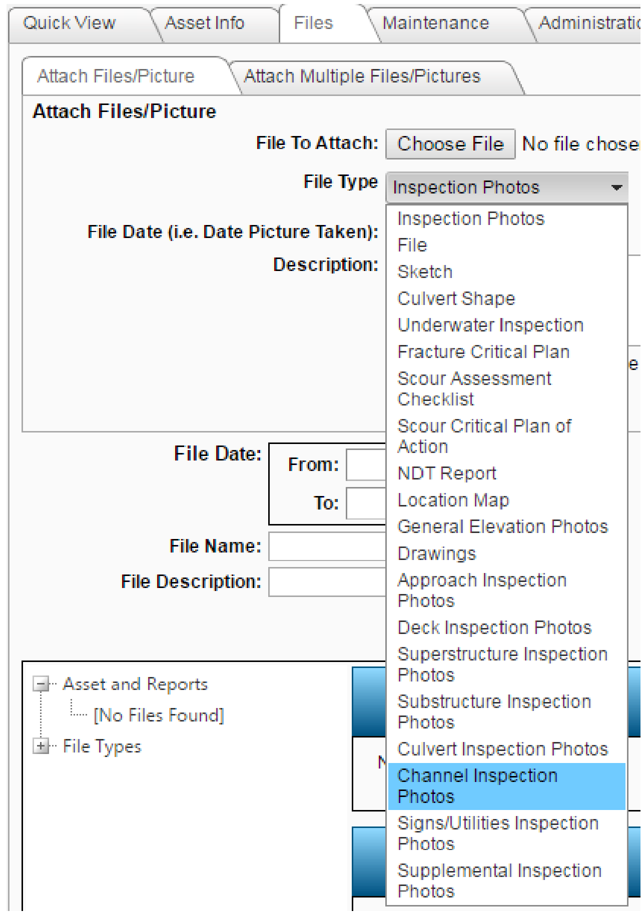


Figure 5 - File Type Photo Upload into SMS

A minimum of two photographs shall be taken. At least one upstream looking toward the bridge and one looking downstream. The photographs shall be taken from a far enough distance as to include all substructure units that are in the channel. Additional photographs are recommended in order to adequately monitor the changes in channel alignment, stream aggradation and stream degradation.

Baseline channel photographs must be complete and on file no later than October 31, 2018.

V. Procedure for Performing Baseline Photographs:

While taking the baseline photographs, it may be difficult to access a suitable location for either, or both, of the required photos (Figures 6-9 example). In this case, additional photos shall be taken to more accurately show the channel or channel degradation or a Channel Cross Section should be taken.

- Find a good angle of the bridge that includes substructure units in water from the upstream side and downstream side
- Take photos or videos. It is recommended that photos are timestamped for documentation and future comparison. Document and label the photos or videos were taken for future comparison.
- Put photos or videos in the bridge file
- Recommend uploading photos to SMS
- Recommend taking photos when the waterway is low

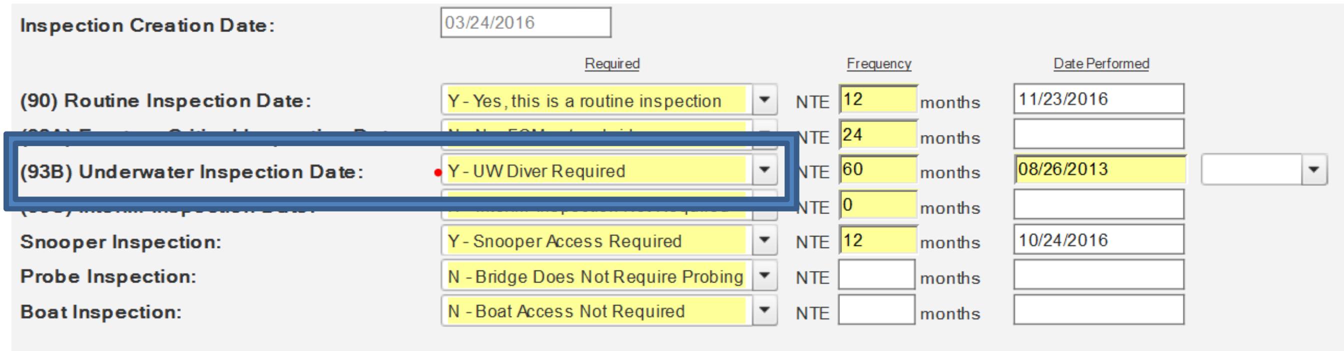
Figure 6- Poor Example of Baseline Photo Looking Upstream from Pedestrian Bridge (Too Far)

Figure 7 – Poor Example of a Baseline Photo Looking Downstream from the south peninsula (Too Far)

Figure 8- Good Example of Baseline Photo Looking Downstream from SE Corner (Best Downstream Option)

Figure 9 –Example of a Supplemental Baseline Photo Looking Downstream and Undercut Bank at SE Corner

Appendix A
Dive Inspection Requirement
(Item 93B SMS Screen Shot and ODOT Manual of Bridge Inspection)



Inspection Creation Date:	03/24/2016				
	Required		Frequency		Date Performed
(90) Routine Inspection Date:	Y - Yes, this is a routine inspection	NTE	12	months	11/23/2016
		NTE	24	months	
(93B) Underwater Inspection Date:	Y - UW Diver Required	NTE	60	months	08/26/2013
		NTE	0	months	
Snooper Inspection:	Y - Snooper Access Required	NTE	12	months	10/24/2016
Probe Inspection:	N - Bridge Does Not Require Probing	NTE		months	
Boat Inspection:	N - Boat Access Not Required	NTE		months	

Dive Inspection

Structures which cannot be inspected visually at low water by wading or probing, will require diving techniques. Typically the threshold is for those substructure units in water deeper than 5-ft but depending on access, tools available, visibility and safety this may need to be adjusted.

Various factors influence the underwater bridge inspection selection criteria. All structures receive routine underwater inspections at intervals not to exceed 60 months. This is the maximum interval permitted between underwater inspections for bridges which are in excellent underwater condition and which are located in passive, nonthreatening environments. The control authority determines the inspection interval that is appropriate for each individual bridge. This is generally considered to be a water depth that prevents an inspector from safely probing around the culvert, pier or abutment.

Factors to consider in establishing the inspection frequency and levels of inspection include:

- Inspector Access
- Inspector Safety
- Age of Structure & Substructure
- Traffic volume
- Size of Structure
- Susceptibility to collision
- Extent of deterioration
- Performance history of bridge type
- Load rating
- Location
- National defense designation
- Detour length
- Social and economic impacts due to the bridge being out of service
- Type of construction materials
- Environment
- Scour characteristics
- Condition ratings from past inspections
- Known deficiencies

Appendix B
Scour Critical Susceptibility
(Item 113 from the 2011 Revision of the FHWA Recording and Coding Guide)

Item 113 - Scour Critical Bridges 1 digit

Use a single-digit code as indicated below to identify the current status of the bridge regarding its vulnerability to scour. Evaluations shall be made by hydraulic/geotechnical/structural engineers. Guidance on conducting a scour evaluation is included in the FHWA Technical Advisory T 5140.23 titled, "Evaluating Scour at Bridges."[1] Detailed engineering guidance is provided in the Hydraulic Engineering Circular 18 titled "Evaluating Scour at Bridges."[2] Whenever a rating factor of 2 or below is determined for this item, the rating factor for Item 60 -- Substructure and other affected items (i.e., load ratings, superstructure rating) should be revised to be consistent with the severity of observed scour and resultant damage to the bridge. A plan of action should be developed for each scour critical bridge (see FHWA Technical Advisory T 5140.23, HEC 18 and HEC 23[3]). A scour critical bridge is one with abutment or pier foundation rated as unstable due to (1) observed scour at the bridge site (rating factor of 2, 1, or 0) or (2) a scour potential as determined from a scour evaluation study (rating factor of 3). It is assumed that the coding of this item has been based on an engineering evaluation, which includes consultation of the NBIS field inspection findings.

Code Description

N Bridge not over waterway.

U Bridge with "unknown" foundation that has **not been evaluated for scour**. Until risk can be determined, a plan of action should be developed and implemented to reduce the risk to users from a bridge failure during and immediately after a flood event (see HEC 23).

T Bridge over "tidal" waters that has **not been evaluated for scour**, but considered low risk. Bridge will be monitored with regular inspection cycle and with appropriate underwater inspections until an evaluation is performed ("Unknown" foundations in "tidal" waters should be coded U.)

9 Bridge foundations (including piles) on dry land well above flood water elevations.

8 Bridge foundations determined to be stable for the assessed or calculated scour condition. Scour is determined to be above top of footing (Example A) by assessment (i.e., bridge foundations are on rock formations that have been determined to resist scour within the service life of the bridge[4]), by calculation or by installation of properly designed countermeasures (see HEC 23).

7 Countermeasures have been installed to mitigate an existing problem with scour and to reduce the risk of bridge failure during a flood event. Instructions contained in a plan of action have been implemented to reduce the risk to users from a bridge failure during or immediately after a flood event.

6 Scour calculation/evaluation has not been made. **(Use only to describe case where bridge has not yet been evaluated for scour potential.)**

5 Bridge foundations determined to be stable for assessed or calculated scour condition. Scour is determined to be within the limits of footing or piles (Example B) by assessment (i.e., bridge foundations are on rock formations that have been determined to resist scour within the service life of the bridge), by calculations or by installation of properly designed countermeasures (see HEC 23).

4 Bridge foundations determined to be stable for assessed or calculated scour conditions; field review indicates action is required to protect exposed foundations (see HEC 23).

3 **Bridge is scour critical**; bridge foundations determined to be unstable for assessed or calculated scour conditions:

-Scour within limits of footing or piles. (Example B)

-Scour below spread-footing base or pile tips. (Example C)

2 **Bridge is scour critical**; field review indicates that extensive scour has occurred at bridge foundations, which are determined to be unstable by:

-a comparison of calculated scour and observed scour during the bridge inspection, or

-an engineering evaluation of the observed scour condition reported by the bridge inspector in Item 60.

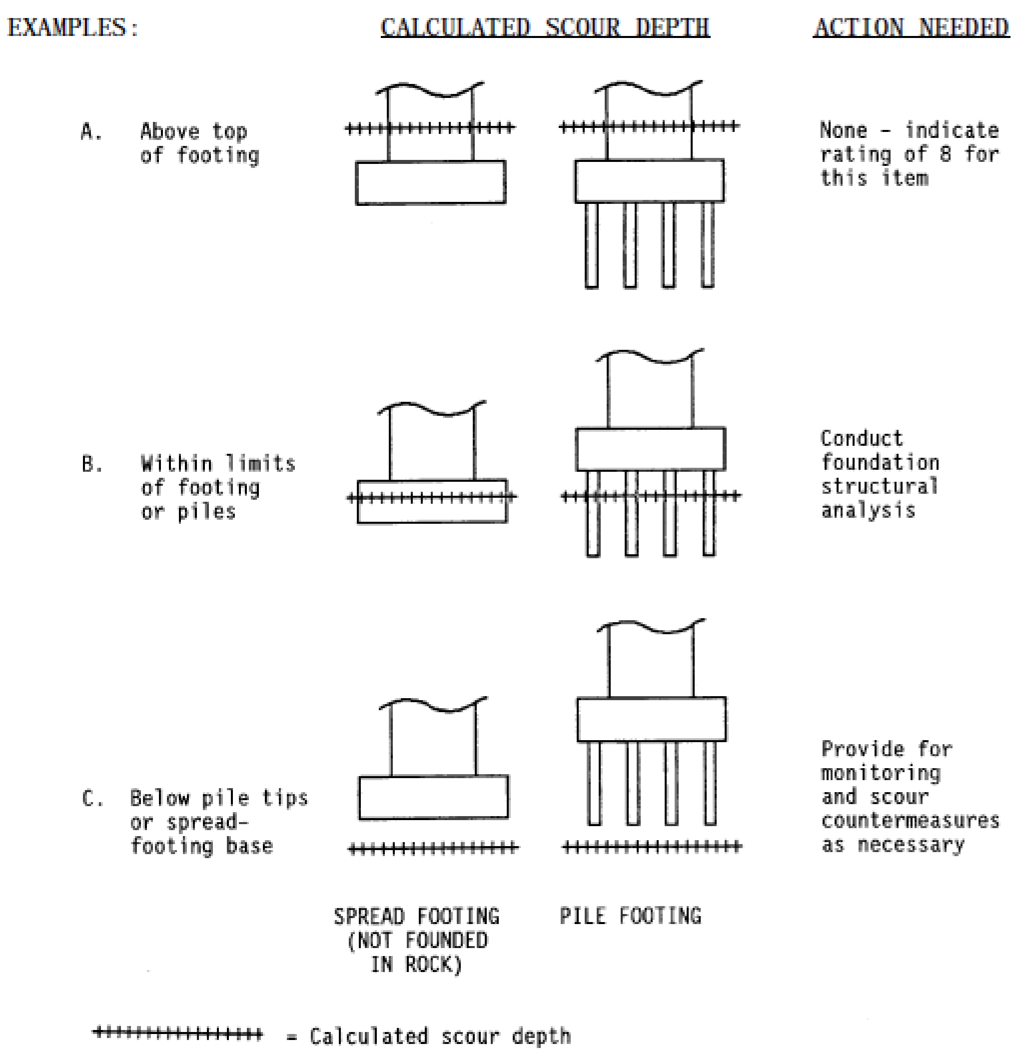
1 **Bridge is scour critical**; field review indicates that failure of piers/abutments is imminent. Bridge is closed to traffic. Failure is imminent based on:

-a comparison of calculated and observed scour during the bridge inspection, or

-an engineering evaluation of the observed scour condition reported by the bridge inspector in Item 60.

0 **Bridge is scour critical**. Bridge has failed and is closed to traffic.

[1] FHWA Technical Advisory T 5140.23, Evaluating Scour at Bridges, dated October Ò8, 1991.[2] HEC 18, Evaluating Scour at Bridges, Fourth Edition.[3] HEC 23, Bridge Scour and Stream Instability Countermeasures, Second Edition. [4] FHWA Memorandum "Scourability of Rock Formations," dated July 19, 1991.



Appendix C
Example 1 – Stable Stream with ½ Span Measurements

Bridge: BEL-001SP-0051 _ (0726184)
Feature: North Fork BARKCAMP CREEK
Year Built: 1965
Profile Date, Insp: 11/30/2016, MB
Channel Condition (item 61): 7-Good
Waterway Adequacy (item 71): 8 – Bridge Deck above Approaches
Scour Critical (item 113): 5-Scour within Limits of Footing
Offset Distance: 3'-4" Top of Concrete Surface of Railing to underside of slab
Notes: Measurements begin at 0'-0" at rear abutment (cardinal west) on the upstream fascia (cardinal south). Vertical drops taken at the Substructure units, edge of water, abrupt change in elevation and ½ span.

Feature at Upstream (Cardinal South) Side	Horizontal Distance from Rear Abutment	Date: 11/30/2016 Drop Distance (Vertical Offset 3'-4", included)	Date: ___ Drop Distance (Vertical Offset ___, ___)
Rear Abut (A1)	0	6'-5"	
Top Slope	12	8'-3"	
Waterline	16	10'-2"	
Pier 1	23	13'-5"	
½ Span	37	15'-5"	
Pier 2	51	13'-7"	
Waterline	57	10'-3"	
Top of Slope	61	8'-3"	
Fwd Abut (A2)	74	7'-0"	

Appendix D
Example 2 –Poor Channel With Measurements at each Rail Post

Bridge: FRA-00674-0248 _(2517302)
Feature: LITTLE WALNUT CREEK #
Year Built: 1963
Profile Date, Insp: 1/5/2017, MB
Channel Condition (item 61): 4-Poor
Waterway Adequacy (item 71): 7-Slight Chance
Scour Critical (item 113): 5-Scour within Limits of Footing
Offset Distance: 70" top railing to underside of bottom flange
Notes: Measurements begin at 0'-0" at rear abutment (cardinal south) on the upstream fascia (cardinal east). Vertical drops taken at each rail post roughly 6'-2" apart.

Feature at Upstream	Horizontal Distance (FT)	Date: 01/05/2016 Drop Distance (Vertical Offset 5'-10", included)	Date: ___________ Drop Distance (Vertical Offset ___,____________)
Rear Abut (A1) South	0.0	19' 10"	
Rail Post 1	2.5	20' 6"	
Rail Post 2	8.7	22' 3"	
Rail Post 3	14.8	23' 4"	
Rail Post 4	21.0	24' 0"	
Rail Post 5 (debris field)	27.2	17' 7"	
Rail Post 6 (debris field)	33.4	17' 10"	
Rail Post 7 (debris field)	39.5	18' 3"	
Rail Post 8 (debris field)	45.7	17' 1"	
Rail Post 9 (Pier 1)	51.9	22' 6"	
Rail Post 10 (new post)	58.0	25' 0"	
Rail Post 11 (new post)	64.2	24' 2"	
Rail Post 12	70.4	24' 8"	
Rail Post 13	76.5	23' 4"	
Rail Post 14	82.7	22' 1"	
Rail Post 15	88.9	23' 8"	
Rail Post 16	95.1	24' 2"	
Rail Post 17	101.2	23' 4"	
Rail Post 18 (Pier 2)	107.4	21' 5"	
Rail Post 19 (edge of bank)	113.6	18' 8"	
Rail Post 20	119.7	17' 6"	
Rail Post 21	125.9	17' 0"	
Rail Post 22	132.1	15' 9"	
Rail Post 23	138.2	14' 9"	
Rail Post 24	144.4	14' 3"	
Rail Post 25	150.6	13' 10"	
Fwd Abut (A2) North	153.1	13' 10"	

Appendix E
Global Statements for
County, Municipality and State Bridge Inspection Jurisdictions

a. Bridges with County Engineer Inspection Responsibility

The County Engineer in Ohio is an elected position, and therefore he or she must reside in the county where they hold office. By living in the county with an average professional tenure of 26 years, the 88 County Engineers in Ohio have firsthand knowledge of the behavior of the streams in both normal flow and flood conditions.

The County Engineer is responsible for all disciplines of Civil Engineering (Hydraulic, Geotechnical, Structural, Transportation etc.) in the county where they hold office. They are a Registered Professional Engineer (P.E.) and a Registered Professional Surveyor (P.S.). To achieve both accreditations requires a college degree in engineering and surveying, four years additional experience in engineering and surveying, and 16 hours of testing for each license. Ohio has the most rigorous standards in the United States for qualifying its County Engineers.

County Engineers are familiar with their local watershed(s), factors that affect long-term bed elevation changes, runoff behavior, stream hydraulics and soils in their county. Therefore the County Engineer is able to apply their professional judgment to assess the potential for bridge scour and hereby affirms the SMS scour coding in "Item 113-Scour Critical Susceptibility" for bridges in their county.

b. Bridges with Municipality Inspection Responsibility

Since 1985, the legislative authority of a municipality has designated a municipal official to have responsibility for inspection of all or portions of bridges within such municipality, except for bridges on the state highway system and the county highway system.

Such inspection has been made at least annually by a professional engineer or other qualified person under the supervision of a professional engineer, or more frequently if required by the legislative authority, in accordance with ODOT's manual of bridge inspection. The legislative authority may contract for inspection services directly with a consultant firm or opt-into the States' Municipal Bridge Inspection Program. This task order contract has been in effect since 2012 tasking consulting firms to perform all aspects of the bridge inspection program, as detailed in the 23 Metrics, up to and including, scour critical assessments. The consultants on board inspect all municipal bridges annually and they will look for any signs of unusual scour conditions each time. Item 113 in SMS is assessed and revised, if needed, with associated documentation of the justification for the change. Additionally, ODOT's Office of Structural Engineering routinely evaluates the scour condition to monitor for condition changes in previous inspections and consequently sets up the new task orders to include scour plan of action for the bridges in concern. Consulting firms are required to have professional engineers that meet the minimum requirements of the NBI Program Managers supervise all aspects of the inspection.

Municipalities must report the condition of all bridges to the municipal legislative authority no later than sixty days after the annual inspection, or shall report more frequently if required by the legislative authority. Any bridge for which the municipality has inspection or maintenance responsibility which, at any time, is found to be in a condition that is or may be a potential danger to life or property, shall be identified in reports and if such official determines that the condition of such a bridge represents an immediate danger, he shall immediately report the condition to the legislative authority. With respect to those bridges where there exists joint maintenance responsibility, the municipal official shall furnish a copy of his report to each party responsible for a share of maintenance.

c. Bridges with State Inspection Responsibility

The director of transportation is responsible for inspection of all bridges on the state highway system inside and outside of municipalities, all bridges connecting Ohio with another state for which the department of transportation has inspection authority, and all other bridges or portions of bridges for which responsibility for inspection is by law or agreement assigned to the department. Such inspection shall be made annually by a professional engineer or other qualified person under the supervision of a professional engineer, or more frequently if required by the director, in accordance with the manual of bridge inspection.

Team Leaders are required to complete a bridge inspection report during every annual inspection. Bridge Inspectors in Ohio code the 9-0 FHWA RC guide condition fields 60. Substructure, 62. Culvert and 61. Channel and appraisal field 113 Scour Critical. Item 113 is assessed and revised if needed with associated documentation of the justification for the change. ODOT's Office of Structural Engineering supports scour condition evaluations, if requested, to monitor for condition changes in previous inspections, and coordinates with the Office of Hydraulics for the bridges in concern.

In addition to the NBI fields, every year, inspectors assign more granular condition codes relevant to changing scour and channel movement. The agency defined fields relevant to scour include: Item 4. Approach Embankment, Item 40. Substructure Wing Walls, Item 42. Substructure Scour, Item 43. Substructure Slope Protection, Item 48. Culvert Headwall/End Wall, Item 49. Culvert Scour, Item 51. Channel Alignment, Item 52. Channel Protection and Item 53. Hydraulic Opening. Prescriptive guidance is available within the Manual of Bridge Inspection for the correct assignment of these codes. The manual requires that such inspections be performed by a professional engineer or Team Leader under the supervision of a professional engineer. Each annual inspection is reviewed and approved by a professional engineer.

Protecting channels and bridges from scour has been a consistent effort throughout the past several decades:

- Before 1970: Annual inspections have been performed on the state system in Ohio beginning as early as 1915.

- 1970's: The ODOT Bridge Design Manual (BDM) has called for all waterway bridges to be founded on deep foundations since the 1970's. The current Bridge Inspection regulation was established in 1973. Since then, inspectors have been monitoring and assigning condition codes directly and indirectly related to scour in the field every year.

- 1980's: The BDM has required design scour evaluations for all bridge rehabilitation and new bridge projects since 1987.

- 1990’s: In response to updates to the FHWA Coding Guide guidance, ODOT started to evaluate state bridges for scour in the late 1990s in accordance with FHWA Technical Advisory T 5140.23, Evaluating Scour at Bridges, dated October 28, 1991. Prior to 1991, Ohio has historically been a deep foundation state. Early in the process, it became apparent that the scour analysis equations, which were based on granular bed material, were not predicting reasonable scour depths in cohesive soil. Ohio’s soils are largely cohesive material and the equations were predicting excessive scour depths. ODOT opted to evaluate bridges for scour using non analytic methods as allowed by the HEC-18 Ver. 3 guidance at the time. Scour specific presentations were made at: Ohio Technical Engineering Conference (OTEC), Ohio Bridge Conference, District Bridge Engineers Meetings, and dedicated training sessions since the early 1990’s. Scour analysis training instructed the bridge be rated considering a variety of factors, including: Watersheds, channel morphology, bed material, velocities, flow volume, foundations, bridge age and attributes and historic data.

- 2000’s: As most analysis consisted of visual on-site evaluation rather than design calculations, many bridge files do not contain documentation of the process and details used in the analysis process. ODOT completed evaluating all bridges prior to the local agencies. ODOT effectively completed evaluations for scour in 2008. ODOT had multiple contracts with USGS and universities working on evaluating bridges for scour in Ohio.