OK by RFT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52732343 Date 9/14/12 Initials RJT Region (A B C D)

Site _____ Location 5.8 mi S of Exit 90 on 173 Ave

Q_{100} = 11400 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 11400 (should be Q_{100} unless there is a relief bridge, road overflow, or bridge overtopping)

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

PGRM: "RegionA", "RegionB", "RegionC", or "RegionD"

Bridge Width = 159 ft. Flow angle at bridge = 20 ° Abut. Skew = 30 ° Effective Skew = 10 °

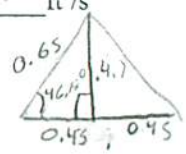
Width (W_2) iteration = _____ _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = _____ _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 156.56 ft* $q_2 = Q_2/W_2$ = 72.9 ft^2/s

Bridge Vel, V_2 = 7.1 ft/s Final $y_2 = q_2/V_2$ = 10.2 ft Δh = 1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 11.3 ft



** NOTE: repeat above calculations until y_2 changes by less than 0.2* *Effective pier width = L sin(q) + a cos(q)*

If y_2 is above LS, then account for Road Overflow using PRGM: RDOVREGA, RDOVREGB, RDOVREGC, or RDOVREGD,

Water Surface Elev. = Q(1%) ft

Low Steel Elev. = 11.7 ft

n (Channel) = 0.040

n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 0.9 ft

Pier Length = 1.25 ft

Piers for 100 yr = 2 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 250 ft

Width of left overbank flow at approach, W_{lob} = 34 ft Average left overbank flow depth, y_{lob} = 1.5 ft

Width of right overbank flow at approach, W_{rob} = 20 ft Average right overbank flow depth, y_{rob} = 1.3 ft

Live Bed Contraction Scour (use if bed material is small cobbles or finer)

x = 9.31 From Figure 9 W_2 (effective) = 154.8 ft y_{cs} = 10.2 ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = _____ ft Average approach velocity, $V_1 = Q_{100}/(y_1 W_1)$ = _____ ft/s

Critical approach velocity, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = _____ ft/s

If $V_1 < V_c$ and $D_{50} >= 0.2$ ft, use clear water equation below, otherwise use live bed scour equation above.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = _____ ft If $D_{50} >= D_{c50}$, $\chi = 0.0$

Otherwise, $\chi = 0.122 y_1 [q_2/(D_{50}^{1/3} y_1^{7/6})]^{6/7} - y_1$ = _____ From Figure 10, y_{cs} = _____ ft

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 1.39 Correction factor for flow angle of attack (from Table 1), K2 = 1.05

Froude # at bridge = 0.39 Using pier width a on Figure 11, ξ = 4.4 Pier scour y_{ps} = 4 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 1.5 ft right abutment, y_{aRT} = 1.3 ft

Shape coefficient K_1= 1.00 for vertical-wall, 0.82 for vertical-wall with wingwalls, 0.55 for spill-through

Using values for y_{aLT} and y_{aRT} on figure 12, ψ_{LT} = 6.3 and ψ_{RT} = 5.5

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 6.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 5.5 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52732343 Date 9/14/12 Initials RaT Region (A B C D)

Site _____ Location 5.8 mi S of Exit 90 on 173 Arc

Q_{500} = 26600 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 14723 (should be Q_{500} unless there is a relief bridge, road overflow, or bridge overtopping)

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

PGRM: "RegionA", "RegionB", "RegionC", or "RegionD"

Bridge Width = 159 ft. Flow angle at bridge = 20 ° Abut. Skew = 30 ° Effective Skew = 10 °

Width (W_2) iteration = _____ _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = _____ _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 156.56 ft* $q_2 = Q_2/W_2$ = 94 ft^2/s

Bridge Vel, V_2 = 8 ft/s Final $y_2 = q_2/V_2$ = 11.7 ft Δh = 1.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 13.0 ft

** NOTE: repeat above calculations until y_2 changes by less than 0.2* *Effective pier width = L sin(q) + a cos(q)*

If y_2 is above LS, then account for Road Overflow using PRGM: RDOVREGA, RDOVREGB, RDOVREGC, or RDOVREGD,

Water Surface Elev. = dry ft

Low Steel Elev. = 11.7 ft

n (Channel) = 0.040

n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 0.9 ft

Pier Length = 1.25 ft

Piers for 500 yr = 2 ft

4.8
1.7 2.1
1.5 +

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 280 ft

Width of left overbank flow at approach, W_{lob} = 70 ft Average left overbank flow depth, y_{lob} = 2.4 ft

Width of right overbank flow at approach, W_{rob} = 34 ft Average right overbank flow depth, y_{rob} = 2.1 ft

3.8 2.5 1.3 4.2

Live Bed Contraction Scour (use if bed material is small cobbles or finer)

x = 11.77 From Figure 9 W_2 (effective) = 154.8 ft y_{cs} = 12.2 ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = _____ ft Average approach velocity, $V_1 = Q_{500}/(y_1W_1)$ = _____ ft/s

Critical approach velocity, $Vc = 11.17y_1^{1/6}D_{50}^{1/3}$ = _____ ft/s

If $V_1 < V_c$ and $D_{50} >= 0.2$ ft, use clear water equation below, otherwise use live bed scour equation above.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = _____ ft If $D_{50} >= D_{c50}$, $\chi = 0.0$

Otherwise, $\chi = 0.122y_1[q_2/(D_{50}^{1/3}y_1^{7/6})]^{6/7} - y_1$ = _____ From Figure 10, y_{cs} = _____ ft

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 1.37 Correction factor for flow angle of attack (from Table 1), K2 = 1.05

Froude # at bridge = 0.41 Using pier width a on Figure 11, ξ = 4.4 Pier scour y_{ps} = 4 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 2.4 ft right abutment, y_{aRT} = 2.1 ft

Shape coefficient K_1= 1.00 for vertical-wall, 0.82 for vertical-wall with wingwalls, 0.55 for spill-through

Using values for y_{aLT} and y_{aRT} on figure 12, ψ_{LT} = 9.5 and ψ_{RT} = 8.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 9.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 8.6 ft

44° 1′ 11.24″
102° 35′ 7.22″

102.56534
44.01979

Route 173 Ave Stream Boxelder Clk MRM _____ Date 9/14/17 Initials RAL

Bridge Structure No. 52732343 Location 5.8 mi S of Exit 90 on 173 Ave

GPS coordinates: N 44° 01' 11.11" W 102° 35' 7.4" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 367.04 sq. mi.

The average bottom of the main channel was 16.1 ft below top of guardrail at a point 95 ft from left abutment.

Method used to determine flood flows: ____Freq. Anal. ____drainage area ratio X regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 11400			Q_{500} = 26600		
Estimated flow passing through bridge	11400			14273		
Estimated road overflow & overtopping	0			11877		
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		X		X		
Chance of Pressure flow		X		X		
Armored appearance to channel		X			X	
Lateral instability of channel		X			X	

7/7

2	367
5	1220
10	2360
25	4720
50	7530
100	11400
500	26600

Riprap at abutments? X Yes ____No ____Marginal

Evidence of past Scour? X Yes ____No ____Don't know minor contraction

Debris Potential? ____High ____Med ____Low

Does scour countermeasure(s) appear to have been designed?

Riprap X Yes ____No ____Don't know ____NA rosequartz on outside abutments, cobblestones in wire mesh under bridge.

Spur Dike ____Yes X No ____Don't know ____NA

Other _____ ____Yes X No ____Don't know ____NA

Bed Material Classification Based on Median Particle Size (D_{50})

Material	Silt/Clay____	Sand____	Gravel X	small Cobbles X	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

Comments, Diagrams & orientation of digital photos

1). left OB
2). main channel
3). right OB.
4). bed material
5). pier
6-7). left abutment
8-9). right abutment
10). main channel

Summary of Results

	Q100	Q500
Bridge flow evaluated	11400	14273
Flow depth at left abutment (yaLT), in feet	1.5	2.4
Flow depth at right abutment (yaRT), in feet	1.3	2.1
Contraction scour depth (ycs), in feet	10.2	12.2
Pier scour depth (yps), in feet	4	4
Left abutment scour depth (yas), in feet	6.3	9.8
Right abutment scour depth (yas), in feet	5.5	8.6
1Flow angle of attack	10	10

See Comments/Diagram for justification where required