OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50 239171 Date 9-14-10 Initials RKL Region (A B C D)

Site _____ Location From I-90 Exit 402, 0.69

Q_{100} = 34,700 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 21,654 (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 = 449 ft. Flow angle at bridge = 25 ° Abut. Skew = 0 ° Effective Skew = 25 °

Width (W_2) iteration = 226 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 14.5 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 204.83 ft* $q_2 = Q_2/W_2$ = 105.7 ft^2/s

Bridge Vel, V_2 = 7.3 ft/s Final $y_2 = q_2/V_2$ = 14.5 ft Δh = 1.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 15.6 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. = 8.6 ft

Low Steel Elev. = 14.5 ft

n (Channel) = 0.03

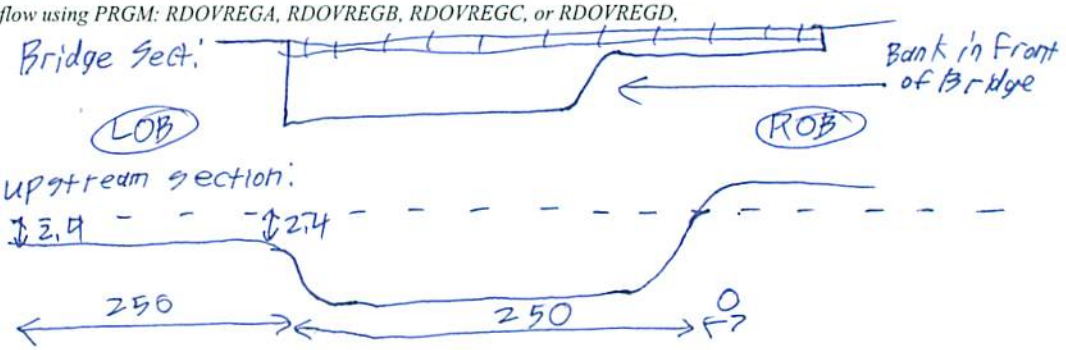
n (LOB) = 0.06

n (ROB) = 0.04

Pier Width = ~~35~~ 2.2 ft

Pier Length = ~~2.2~~ 35 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} = 250 ft Average left overbank flow depth, y_{lob} = 2.4 ft

Width of right overbank flow at approach, W_{rob} = 0 ft Average right overbank flow depth, y_{rob} = 0 ft

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

x = 4.29 From Figure 9 W_2 (effective) = 200.4 ft y_{cs} = 4.9 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, $V_1 = Q_{100}/(y_1W_1)$ = _____ ft/s

Critical approach velocity, $Vc = 11.52y_1^{1/6}D_{50}^{1/3}$ = _____ 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 = 15.9 Correction factor for flow angle of attack (from Table 1), K2 = 3.1

Froude # at bridge = 0.34 Using pier width a on Figure 11, ξ = 8.6 Pier scour y_{ps} = 22.7 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 2.4 ft right abutment, y_{aRT} = 0 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} = 9.8 and ψ_{RT} = 0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 9.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 502391171 Date 9-14-10 Initials RKL Region (A B C D)

Site _____ Location From I-90 Ex. 14 402, 0, 6 S

Q_{500} = 59,700 by: drainage area ratio ✓ flood freq. anal. _____ regional regression eq. _____

Bridge discharge (Q_2) = 21,654 (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 = 449 ft. Flow angle at bridge = 25 ° Abut. Skew = 0 ° Effective Skew = 25 °

Width (W_2) iteration = 226 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 14.5 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 204.8 ft* CW $q_2 = Q_2/W_2$ = 105.7 ft^2/s CW

Bridge Vel, V_2 = 7.3 ft/s Final $y_2 = q_2/V_2$ = 14.5 ft Δh = 1.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 15.6 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,

See 100yr Diag.

Water Surface Elev. = 8.6 ft

Low Steel Elev. = 14.5 ft

n (Channel) = 0.03

n (LOB) = 0.06

n (ROB) = 0.04

Pier Width = 2.2 ft

Pier Length = 35 ft

Piers for 500 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} = 250 ft Average left overbank flow depth, y_{lob} = 2.4 ft

Width of right overbank flow at approach, W_{rob} = 0 ft Average right overbank flow depth, y_{rob} = 0 ft

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

x = 4.29 From Figure 9 W_2 (effective) = 200.4 ft y_{cs} = 4.9 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, $Vc = 11.52y_1^{1/6}D_{50}^{1/3}$ = _____ 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 15.9 Correction factor for flow angle of attack (from Table 1), K2 = 3.1

Froude # at bridge = 0.34 Using pier width a on Figure 11, ξ = 8.6 Pier scour y_{ps} = 22.7 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 2.4 ft right abutment, y_{aRT} = 0 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} = 9.8 and ψ_{RT} = 0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 9.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0 ft

Route 478 Ave Stream Big Sioux River MRM _____ Date 9-14-10 Initials RRL

Bridge Structure No. 50239171 Location From I-90 Exit 402, 0.65

GPS coordinates: N43° 36, 020' W96° 34, 126' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

Datum of coordinates: WGS84____ NAD27____

Drainage area = 3820.76 sq. mi.

The average bottom of the main channel was 23 ft below top of guardrail at a point 83 ft from left abutment.

Method used to determine flood flows: ____Freq. Anal. ✓drainage area ratio ____regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 34,700			Q_{500} = 59,700		
Estimated flow passing through bridge	21,654			21,654		
Estimated road overflow & overtopping						
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping	X	~~X~~		X		
Chance of Pressure flow	X			X		
Armored appearance to channel		X			X	
Lateral instability of channel			X			X

Riprap at abutments? ____Yes ____No X Marginal

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

Debris Potential? X High ____Med ____Low

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

Riprap ____Yes ____No X Don't know ____NA

Spur Dike ____Yes ____No X Don't know ____NA

Other _____ ____Yes ____No X Don't know ____NA

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

Material	Silt/Clay X	Sand____	Gravel____	Cobbles____	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

Comments, Diagrams & orientation of digital photos

1-Bridge Deck
2-Looking Upstream
3-Looking Downstream
4-Left Overbank
5-Right Overbank
6-Left Abutment
7-Right Abutment
8-Piers
9-Bank at Bride
10-13-Bank at Bridge Pics.

Notes: Bridge on curve, Method 1.5 may be questionable due to bank in front of bridge. Bank is 164 ft long.

Summary of Results

	Q100	Q500
Bridge flow evaluated	21,654	21,654
Flow depth at left abutment (yaLT), in feet	2.4	2.4
Flow depth at right abutment (yaRT), in feet	0	0
Contraction scour depth (ycs), in feet	4.9	4.9
Pier scour depth (yps), in feet	22.7	22.7
Left abutment scour depth (yas), in feet	9.8	9.8
Right abutment scour depth (yas), in feet	0	0
1Flow angle of attack	25	25

See Comments/Diagram for justification where required