OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 29270144 Date 7/3/12 Initials RAT Region (A B C D)

Site _____ Location 2.5 mi S of Dempster on 463 Arc

Q_{100} = Q100 5250 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 5250 (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 = 185 ft. Flow angle at bridge = 20 ° Abut. Skew = 0 ° Effective Skew = 20 °

Width (W_2) iteration = 185 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 7.8 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 173.84 ft* $q_2 = Q_2/W_2$ = 30.2 ft²/s

Bridge Vel, V_2 = 3.9 ft/s Final $y_2 = q_2/V_2$ = 7.8 ft Δh = 0.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.1 ft

4 8.4 −2.9 2.5

** 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,

0.9

Water Surface Elev. = 0- 3.2 ft

Low Steel Elev. = 9.9 ft

n (Channel) = 0.045

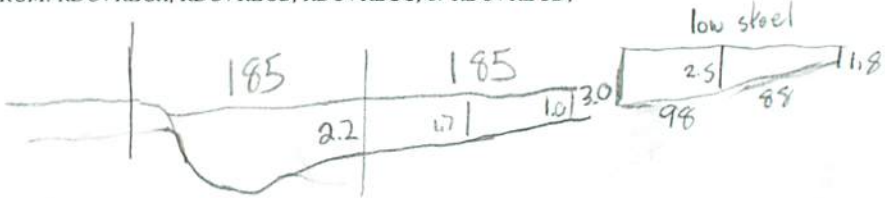
n (LOB) = 0.030

n (ROB) = 0.035

Pier Width = 2.05 ft

Pier Length = 20.5 ft

Piers for 100 yr = 3 ft



CONTRACTION SCOUR

PGRM: Contract

5.0 5.4 5.4 98 back 196 top 388 290 202

Width of main channel at approach section W_1 = 185 ft

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

Width of right overbank flow at approach, W_{rob} = 185 ft Average right overbank flow depth, y_{rob} = 1.4 ft

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

x = 1.77 From Figure 9 W_2 (effective) = 167.7 ft y_{cs} = 2.3 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 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.25 Using pier width a on Figure 11, ξ = 8.1 Pier scour y_{ps} = 6.6 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0 ft right abutment, y_{aRT} = 1.8 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} = 0 and ψ_{RT} = 2.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 2.4 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 29270144 Date 7/31/12 Initials RAL Region (A B C D)

Site _____ Location 2.5 mi S of Dempster on 463 Ave

Q_{500} = Q75 - 8530 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 6915 (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 = 185 ft. Flow angle at bridge = 20 ° Abut. Skew = 0 ° Effective Skew = 20 °

Width (W_2) iteration = 185 _____ _____ _____

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

Corrected channel width at bridge Section = W_2 times cos of flow angle = 173.84 ft* $q_2 = Q_2/W_2$ = 39.8 ft^2/s

Bridge Vel, V_2 = 4.5 ft/s Final $y_2 = q_2/V_2$ = 8.9 ft Δh = 0.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 9.3 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. = 0 ft

Low Steel Elev. = 8.9 ft

n (Channel) = 0.045

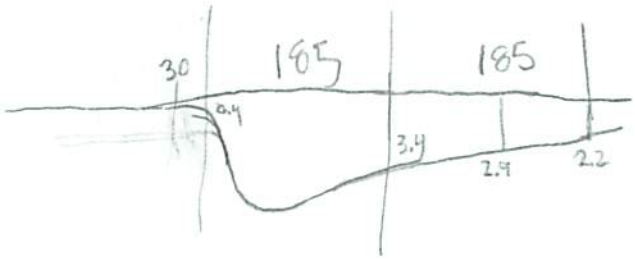
n (LOB) = 0.030

n (ROB) = 0.035

Pier Width = 2.05 ft

Pier Length = 2.05 ft

Piers for 500 yr = 3 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 185 ft

Width of left overbank flow at approach, W_{lob} = 30 ft Average left overbank flow depth, y_{lob} = 0.4 ft

Width of right overbank flow at approach, W_{rob} = 185 ft Average right overbank flow depth, y_{rob} = 3.0 ft

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

x = ~~2.83~~ 2.97 From Figure 9 W_2 (effective) = ~~169.7~~ 167.7 ft y_{cs} = ~~3.4~~ 3.6 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 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.27 Using pier width a on Figure 11, ξ = 8.1 Pier scour y_{ps} = 6.7 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = ~~8.9~~ 1.9 ft right abutment, y_{aRT} = ~~3.0~~ 11.5 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} = 1.9 and ψ_{RT} = 11.5

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 1.9 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 11.5 ft

44° 35' 45".564
96° 56' 44".736

96.94576
41.59599

Route 463 Ave Stream Big Sioux River MRM _____ Date 7/31/12 Initials RAT

Bridge Structure No. 29270144 Location 2.5 mi S of Dempster on 463 Ave

GPS coordinates: N 44° 35' 45.1" W 96° 56' 44.4" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 1272.53 sq. mi.

The average bottom of the main channel was 14.0 ft below top of guardrail at a point 91 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = Q_{10} 5250			Q_{500} = Q_{25} 8530		
Estimated flow passing through bridge	5250			6915		
Estimated road overflow & overtopping	0			1615		
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	

7/3

2	1210
5	3250
10	5250
25	8530
50	11600
100	15000
500	24600

Riprap at abutments? ____Yes X No ____Marginal

Evidence of past Scour? X Yes ____No ____Don't know some pier/contraction & left abutment

Debris Potential? ____High ____Med X Low

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

Riprap ____Yes X No ____Don't know ____NA

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 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). left OB
2). main channel
3). right OB
4). pier
5). right abutment
6&8). left abutment
9). right abutment
10). main channel.

Summary of Results

	Q100 Q_{10}	Q500 Q_{25}
Bridge flow evaluated	5250	6915
Flow depth at left abutment (yaLT), in feet	0	0.4
Flow depth at right abutment (yaRT), in feet	1.8	3.0
Contraction scour depth (ycs), in feet	2.3	~~3.4~~ 3.6
Pier scour depth (yps), in feet	6.6	6.7
Left abutment scour depth (yas), in feet	0	1.9
Right abutment scour depth (yas), in feet	7.4	11.5
1Flow angle of attack	20	20

See Comments/Diagram for justification where required