OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 15196190 Date 7/31/12 Initials RT Region (A B C D) [C circled]

Site ______ Location Big Sioux River on 20th Ave S in Watertown

Q_{100} = ~~6220~~ 6810 by: drainage area ~~X~~ flood frequency anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 6810 (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 = 374 ft. Flow angle at bridge = 55 ° Abut. Skew = 45 ° Effective Skew = 10 °

Width (W_2) iteration = 374 327 331 ____

Avg. flow depth at bridge, y_2 iteration = 6.1 6.5 6.5 ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 325.97 ft* $q_2 = Q_2/W_2$ = 20.9 ft^2/s

Bridge Vel, V_2 = 3.2 ft/s Final $y_2 = q_2/V_2$ = 6.5 ft Δh = 0.2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 6.7 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.

182 7/π
192
374
100

Water Surface Elev. = 0.7 ft

Low Steel Elev. = 11.5 ft

n (Channel) = 0.045

n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 2.2 ft

Pier Length = 2.2 ft

\# Piers for 100 yr = 3 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 340 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} = 100 ft Average right overbank flow depth, y_{rob} = 1.7 ft

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

x = 0.75 From Figure 9 W_2 (effective) = 319.4 ft y_{cs} = 1.2 ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles) [crossed out]

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

PIER SCOUR CALCULATIONS

PGRM: Pier

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

Froude # at bridge = 0.22 Using pier width a on Figure 11, ξ = 8.6 Pier scour y_{ps} = 6.9 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0 ft right abutment, y_{aRT} = 1.7 ft

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

Using values for y_{aLT} and y_{aRT} on figure 12, ψ_{LT} = 0 and ψ_{RT} = 7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 7 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 15196190 Date 7/31/12 Initials RAJ Region (A B C D)

Site 11200 Location Big Sioux River on 20th Ave S in Watertown

Q_{500} = ~~9130~~ 10180 by: drainage area ~~#~~ flood frequency anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 11700 (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 = 374 ft. Flow angle at bridge = 55 ° Abut. Skew = 45 ° Effective Skew = 10 °

Width (W_2) iteration = 374 336 340 ____

Avg. flow depth at bridge, y_2 iteration = 7.8 8.2 8.2 ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 334.63 ft* $q_2 = Q_2/W_2$ = 33.4 ft²/s

Bridge Vel, V_2 = 4.1 ft/s Final $y_2 = q_2/V_2$ = 8.2 ft Δh = 0.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.5 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. = 0-1 ft

Low Steel Elev. = 11.5 ft

n (Channel) = 0.045

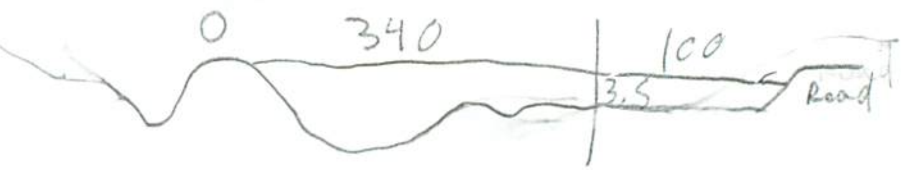
n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 2.2 ft

Pier Length = 2.2 ft

Piers for 500 yr = 3 ft



320

340
-120
220

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 340 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} = 100 ft Average right overbank flow depth, y_{rob} = 3.5 ft

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

x = 1.19 From Figure 9 W_2 (effective) = 328.3 ft y_{cs} = 1.7 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, $V_1 = Q_{500}/(y_1 W_1)$ = ____ ft/s

Critical approach velocity, $V_c = 11.52 y_1^{1/6} D_{50}^{1/3}$ = ____ 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: Pie

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 = 8.8 Pier scour y_{ps} = 7 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0 ft right abutment, y_{aRT} = 3.5 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} = 0 and ψ_{RT} = 12.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 12.4 ft

44° 52′ 35.6″
97° 5′ 51.6″

97.09766
44.87656

Route 20th Ave S Stream Big Sioux River MRM ________ Date 7/31/17 Initials [illegible]

Bridge Structure No. 15196190 Location Watertown

GPS coordinates: N 44° 52' 35.7'' W 97° 5' 51.1'' taken from: USL abutment X centerline of ⇑ MRM end ______

Datum of coordinates: WGS84 X NAD27 ______

Drainage area = 396.14 sq. mi.

The average bottom of the main channel was 18.2 ft below top of guardrail at a point 226 ft from left abutment.

Method used to determine flood flows: ____Freq. Anal. ✓ drainage area adjustment X regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = ~~6220~~ 6810			Q_{500} = ~~9130~~ ~~10180~~ 11200		
Estimated flow passing through bridge	6810			11200		
Estimated road overflow & overtopping	0			0		
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	517
5	1440
10	2350
25	3860
50	5240
100	6810
500	11200

Riprap at abutments? X Yes ____No ____Marginal

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

Debris Potential? ____High ____Med X Low

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

Riprap	X Yes	____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). pier scour
6-7). left abutment
8-9). right abutment
10). main channel

Note: Profile taken ~325ft from right abutment

Summary of Results

	Q100	Q500
Bridge flow evaluated	6810	11200
Flow depth at left abutment (yaLT), in feet	0	0
Flow depth at right abutment (yaRT), in feet	1.7	3.5
Contraction scour depth (ycs), in feet	1.2	1.7
Pier scour depth (yps), in feet	6.9	7
Left abutment scour depth (yas), in feet	0	0
Right abutment scour depth (yas), in feet	7	12.4
1Flow angle of attack	10	10

See Comments/Diagram for justification where required