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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 06147200 Date 5-16-12 Initials CW/RT/RaT Region (A B C D)

Site _____ Location 0.7 mi E of intersection of 216St & 468 Av

Q_{100} = Q5 = 5830 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 5830 (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 = 157 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° 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 = 154.61 ft* $q_2 = Q_2/W_2$ = 37.7 ft²/s

Bridge Vel, V_2 = 4.4 ft/s Final $y_2 = q_2/V_2$ = 8.7 ft Δh = 0.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 9 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. = 2.2 ft

Low Steel Elev. = 10.1 ft

n (Channel) = 0.045

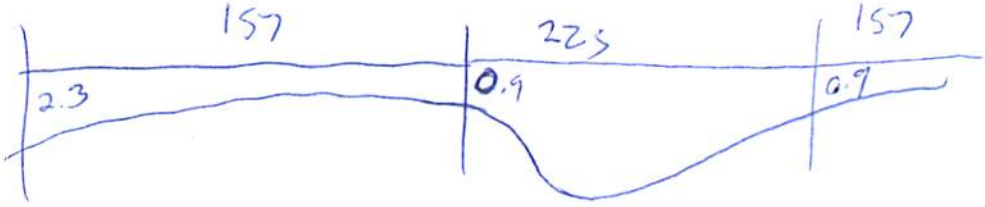
n (LOB) = 0.040

n (ROB) = 0.035

Pier Width = 0.8 ft

Pier Length = 25 ft

Piers for 100 yr = 3 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 225 ft

Width of left overbank flow at approach, W_{lob} = 157 ft Average left overbank flow depth, y_{lob} = ~~4.8~~ 1.6 ft

Width of right overbank flow at approach, W_{rob} = 157 ft Average right overbank flow depth, y_{rob} = ~~1.6~~ 0.9 ft

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

x = 5.12 From Figure 9 W_2 (effective) = 152.2 ft y_{cs} = 5.5 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, $Vc = 11.17y_1^{1/6}D_{50}^{1/3}$ = _____ 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 = ~~25.0~~ 31.25

Froude # at bridge = 0.26

Correction factor for flow angle of attack (from Table 1), K2 = 2.0

Using pier width a on Figure 11, ξ = 3.9 Pier scour y_{ps} = ~~6.7~~ 6.4 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 1.6 ft right abutment, y_{aRT} = 0.9 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} = 6.6 and ψ_{RT} = 3.9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 12.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 7.1 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 06147200 Date _____ Initials _____ Region (A B C D)

Site _____ Location 0.7mi E of intersection 216 St & 468 Av

Q_{500} Q100 9200 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 8080 (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 = 157 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° 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 = 154.6 ft* $q_2 = Q_2/W_2$ = ~~52.5~~ 52.3 ft²/s

Bridge Vel, V_2 = 5.1 ft/s Final $y_2 = q_2/V_2$ = 10.2 ft Δh = 0.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = ~~10.5~~ 10.7 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,

Water Surface Elev. = 21.2 ft

Low Steel Elev. = 10.1 ft

n (Channel) = 0.045

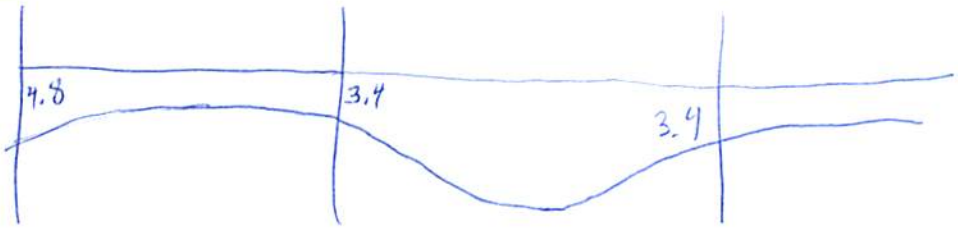
n (LOB) = 0.040

n (ROB) = 0.035

Pier Width = 0.8 ft

Pier Length = 2.5 ft

Piers for 500 yr = 3 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 225 ft

Width of left overbank flow at approach, W_{lob} = 157 ft Average left overbank flow depth, y_{lob} = ~~5.2~~ ~~4.4~~ 4.1 ft

Width of right overbank flow at approach, W_{rob} = 157 ft Average right overbank flow depth, y_{rob} = 3.4 ft

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

x = ~~9.87~~ 10.08 From Figure 9 W_2 (effective) = ~~149.7~~ 152.2 ft y_{cs} = ~~10.7~~ 11.0 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 31.25 Correction factor for flow angle of attack (from Table 1), K2 = 2.0

Froude # at bridge = 0.28 Using pier width a on Figure 11, ξ = 3.9 Pier scour y_{ps} = 6.4 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 4.1 ft right abutment, y_{aRT} = 3.4 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} = 13.4 and ψ_{RT} = 12.2

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 24.6 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 22.2 ft

Route 216 St Stream Big Sioux River MRM _____ Date _____ Initials _____

Bridge Structure No. 06147200 Location 0.7 mi E of intersection of 216 St & 468 Av.

GPS coordinates: N 44° 15' 14.1" W 96° 50' 01.6" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 _____ NAD27 _____

Drainage area = 1939.8 sq. mi.

The average bottom of the main channel was 15.2 ft below top of guardrail at a point 107 ft from left abutment.

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

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MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 5630			Q_{500} = 9200		
Estimated flow passing through bridge	5830			8080		
Estimated road overflow & overtopping				1120		
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		X		X		
Chance of Pressure flow		X		X	X	
Armored appearance to channel		X			X	
Lateral instability of channel			X		X	

2 2280
5 5830
10 9200
25 14700
50 19700
100 25300
500 41000

Riprap at abutments? ____Yes ____No X Marginal

Evidence of past Scour? X Yes ____No ____Don't know - pier scour, contraction scour

Debris Potential? ____High X Med ____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____	Sand X	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

2252 str. no.
2253 approach from bridge
2254 ROB from bridge
2255 LOB from bridge
2256 left abut. from approach
2257 rt. abut. from approach
2258 right abut.
2259 left abut.

Summary of Results

	~~Q100~~ Q_5	~~Q500~~ Q_{10}
Bridge flow evaluated	5830	~~9200~~ 8080
Flow depth at left abutment (yaLT), in feet	1.6	4.1
Flow depth at right abutment (yaRT), in feet	0.9	3.4
Contraction scour depth (ycs), in feet	5.8	~~10.5~~ 11.0
Pier scour depth (yps), in feet	~~6.9~~ 6.4	~~6.4~~ 6.4
Left abutment scour depth (yas), in feet	12.1	~~22.7~~ 24.4
Right abutment scour depth (yas), in feet	7.1	~~24.4~~ 22.2
1Flow angle of attack	10	10

See Comments/Diagram for justification where required