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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 51100030 Date 6/15/10 Initials CW Region (A B C D)

Site _____ Location 3.5 mi E of I-29 exit 121 on 223rd St

Q_{100} = 23800 by: drainage area ✓ flood frequency anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 23800 (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 = 235 ft. Flow angle at bridge = 0 ° Abut. Skew = 0 ° Effective Skew = 0 °

Width (W_2) iteration = 235 227 _____ _____

Avg. flow depth at bridge, y_2 iteration = 14.2 14.4 _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 227 ft* $q_2 = Q_2/W_2$ = 104.8 ft^2/s

Bridge Vel, V_2 = 7.3 ft/s Final $y_2 = q_2/V_2$ = 14.4 ft Δh = 1.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 15.5 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. = _____ ft

Low Steel Elev. = 1647 ft

n (Channel) = 0.035

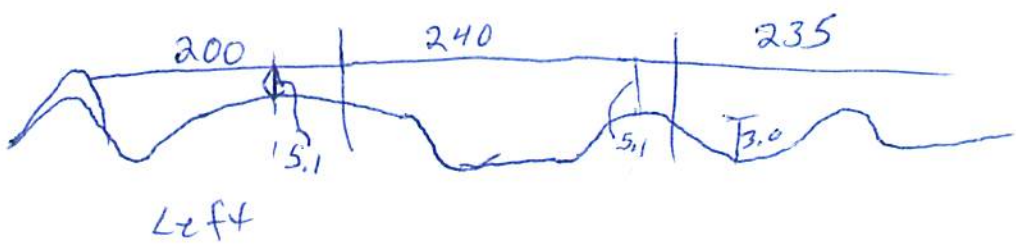
n (LOB) = 0.035

n (ROB) = 0.037

Pier Width = 2.0 ft

Pier Length = 2.0 ft

Piers for 100 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 240 ft

Width of left overbank flow at approach, W_{lob} = 200 ft Average left overbank flow depth, y_{lob} = 6.0 ft

Width of right overbank flow at approach, W_{rob} = 235 ft Average right overbank flow depth, y_{rob} = 6.6 ft

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

x = 8.19 From Figure 9 W_2 (effective) = 219 ft y_{cs} = 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ ft/s

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = _____ 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: Pier

L/a ratio = 1.0 Correction factor for flow angle of attack (from Table 1), K2 = 1.0

Froude # at bridge = 0.34 Using pier width a on Figure 11, ξ = 8 Pier scour y_{ps} = 6.8 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 6.0 ft right abutment, y_{aRT} = 6.6 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} = 16.8 and ψ_{RT} = 17.9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 16.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 17.9 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 51100030 Date 8/18/10 Initials CW Region (A B C D)

Site _____ Location 3.5 mi E of I-29 exit 121 on 223rd St

Q_{500} = 35800 by: drainage area ✓ flood frequency anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 32969 (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 = 235 ft. Flow angle at bridge = 0 ° Abut. Skew = 0 ° Effective Skew = 0 °

Width (W_2) iteration = 235 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 17.4 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 235 ft* $q_2 = Q_2/W_2$ = 140.3 ft^2/s

Bridge Vel, V_2 = 8.4 ft/s Final $y_2 = q_2/V_2$ = 16.7 ft Δh = 1.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 18.1 ft

** NOTE: repeat above calculations until y_2 changes by less by 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. = _____ ft

Low Steel Elev. = 16.7 ft

n (Channel) = 0.035

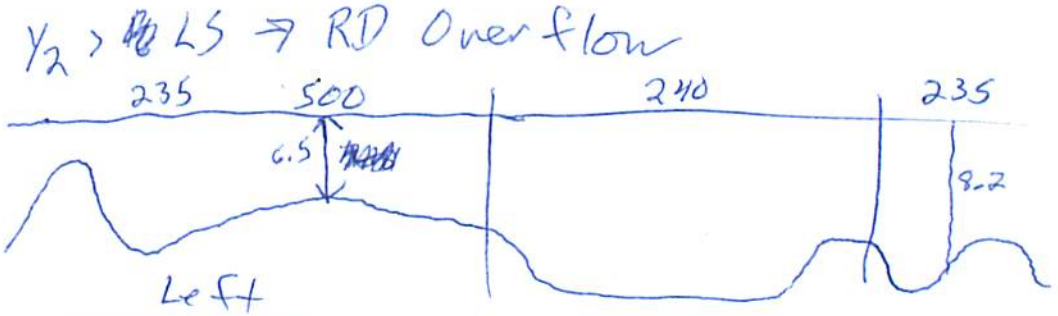
n (LOB) = 0.035

n (ROB) = 0.037

Pier Width = 2.0 ft

Pier Length = 2.0 ft

Piers for 500 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 240 ft

Width of left overbank flow at approach, W_{lob} = 235 ft Average left overbank flow depth, y_{lob} = ~~8.4~~ 7.6 ft

Width of right overbank flow at approach, W_{rob} = 235 ft Average right overbank flow depth, y_{rob} = 8.2 ft

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

x = 10.19 From Figure 9 W_2 (effective) = 227 ft y_{cs} = 11.2 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, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = _____ 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: Pier

L/a ratio = 1.0 Correction factor for flow angle of attack (from Table 1), K2 = 1.0

Froude # at bridge = 0.36 Using pier width a on Figure 11, ξ = 8 Pier scour y_{ps} = 6.9 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = ~~8.4~~ 7.6 ft right abutment, y_{aRT} = 8.2 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} = 19.5 and ψ_{RT} = 19.9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 19.5 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 19.9 ft

Route 223rd St Stream Big Sioux River MRM _____ Date 8/18/10 Initials CW

Bridge Structure No. 51100030 Location 3.5 mi E of I-29 Exit 121 on 223rd St

GPS coordinates: N 44°09'09.6" W 096°41'16.4" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 2520.48 sq. mi.

The average bottom of the main channel was 21.4 ft below top of guardrail at a point 52 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 23800			Q_{500} = 35800		
Estimated flow passing through bridge	23400			32969		
Estimated road overflow & overtopping				2831		
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	

Riprap at abutments? ____Yes ____No X Marginal Mostly washed away

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

Debris Potential? ____High X Med ____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	____No	____Don't know	X 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

1155 - Bridge #
56 - US
57 - US RB
58 - US LB
59 - US LB
60 - US LB Abut.
61 - US LB Abut.
62 - US LB Abut.
63 - US RB Abut.
64 - US face of Bridge
65 - US face of Bridge

There looks to be natural levees → I don't think they are designed

Summary of Results

	Q100	Q500
Bridge flow evaluated	23800	32969
Flow depth at left abutment (yaLT), in feet	6.0	7.6
Flow depth at right abutment (yaRT), in feet	6.6	8.2
Contraction scour depth (ycs), in feet	9.0	11.2
Pier scour depth (yps), in feet	6.8	6.9
Left abutment scour depth (yas), in feet	16.8	19.5
Right abutment scour depth (yas), in feet	17.1	19.9
1Flow angle of attack	0	0

See Comments/Diagram for justification where required