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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50192040 Date 9-12-10 Initials RRL Region (A B C D)

Site 06481000 Location From I-29, exit 98, 0.5E, 2S, 1.2E

Q_{100} = 33,000 by: drainage area ratio ____ flood freq. anal. ✓ regional regression eq. ____

Bridge discharge (Q_2) = 33,000 (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 = 268 ft. Flow angle at bridge = 16 ° Abut. Skew = 0 ° Effective Skew = 16 °

Width (W_2) iteration = 260 268 ____ ____

Avg. flow depth at bridge, y_2 iteration = 16.2 16 ____ ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 257.62 ft* $q_2 = Q_2/W_2$ = 128.1 ft^2/s

Bridge Vel, V_2 = 8.0 ft/s Final $y_2 = q_2/V_2$ = 16.0 ft Δh = 1.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 17.3 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. = 7.3 ft

Low Steel Elev. = 17.5 ft

n (Channel) = 0.035

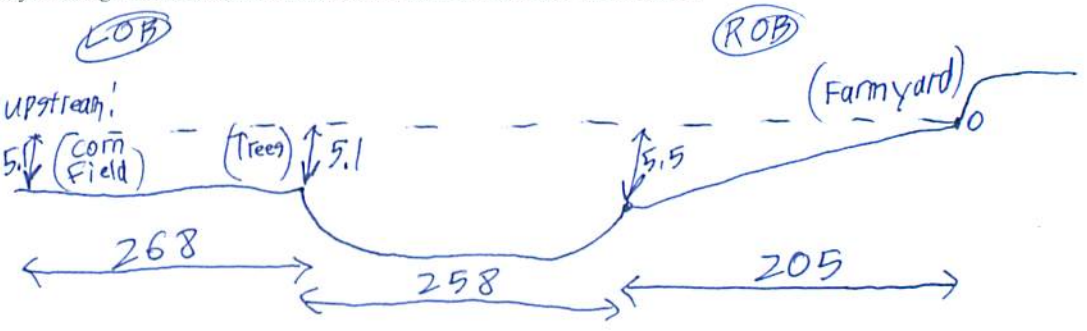
n (LOB) = 0.060

n (ROB) = 0.040

Pier Width = 2.0 ft

Pier Length = 30 ft

Piers for 100 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 258 ft

Width of left overbank flow at approach, W_{lob} = 268 ft Average left overbank flow depth, y_{lob} = 5.1 ft

Width of right overbank flow at approach, W_{rob} = 205 ft Average right overbank flow depth, y_{rob} = 2.75 ft

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

x = 2.26 From Figure 9 W_2 (effective) = 253.6 ft y_{cs} = 2.8 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

Froude # at bridge = 0.35

Correction factor for flow angle of attack (from Table 1), K2 = 2.5

Using pier width a on Figure 11, ξ = 8 Pier scour y_{ps} = 17.1 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 5.1 ft right abutment, y_{aRT} = 2.75 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} = 15.2 and ψ_{RT} = 11.1

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 15.2 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 11.1 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50192040 Date 9-12-10 Initials KRL Region (A B C D)

Site 06481000 Location From I-29 Exit 98, 0.5E, 2S, 1.2E

Q_{500} = 55,300 by: drainage area ratio ____ flood freq. anal. V regional regression eq. ____

Bridge discharge (Q_2) = 39,692 (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 = 268 ft. Flow angle at bridge = 16 ° Abut. Skew = 0 ° Effective Skew = 16 °

Width (W_2) iteration = 268

Avg. flow depth at bridge, y_2 iteration = 17.5

Corrected channel width at bridge Section = W_2 times cos of flow angle = 257.62 ft* $q_2 = Q_2/W_2$ = 154.1 ft^2/s

Bridge Vel, V_2 = 8.8 ft/s Final $y_2 = q_2/V_2$ = 17.5 ft Δh = 1.6 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 19.1 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. = 7.3 ft

Low Steel Elev. = 17.5 ft

n (Channel) = 0.038

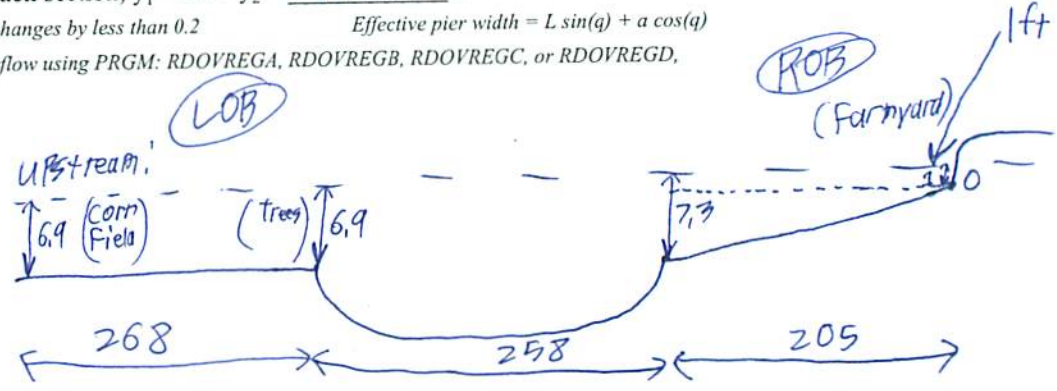
n (LOB) = 0.060

n (ROB) = 0.040

Pier Width = 2.0 ft

Pier Length = 30 ft

Piers for 500 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 258 ft

Width of left overbank flow at approach, W_{lob} = 268 ft Average left overbank flow depth, y_{lob} = 6.9 ft

Width of right overbank flow at approach, W_{rob} = 205 ft Average right overbank flow depth, y_{rob} = 4.65 ft

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

x = 3.77 From Figure 9 W_2 (effective) = 253.6 ft y_{cs} = 4.4 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

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 15

Froude # at bridge = 0.37

Correction factor for flow angle of attack (from Table 1), K2 = 2.5

Using pier width a on Figure 11, ξ = 8 Pier scour y_{ps} = 17.2 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 6.9 ft right abutment, y_{aRT} = 4.65 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} = 18.4 and ψ_{RT} = 14.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 18.4 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 14.4 ft

Route 248th St, Stream Big Sioux River MRM _____ Date 9-12-10 Initials RAL

Bridge Structure No. 50192040 Location From I-29 Exit 98, 0.5E, 29, 1.2E

GPS coordinates: N43° 47.437' W96° 44.700' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

Datum of coordinates: WGS84____ NAD27____

Drainage area = 3056.92 sq. mi.

The average bottom of the main channel was 23.8 ft below top of guardrail at a point 98 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 33,000			Q_{500} = 55,300		
Estimated flow passing through bridge	33,000			39,692		
Estimated road overflow & overtopping	0			15,608		
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

Evidence of past Scour? ____Yes ____No ___X_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

Pictures: 1 - Bridge Deck
2 - Looking Upstream
3 - Looking Downstream
4 - Left Overbank
5 - Right Overbank
6 - Left Abutment
7 - Right Abutment
8 - Piers

Comments: Left overbank had very thick tree cover. Triangulated heights.

Summary of Results

	Q100	Q500
Bridge flow evaluated	33,000	39,692
Flow depth at left abutment (yaLT), in feet	5.1	6.9
Flow depth at right abutment (yaRT), in feet	2.75	4.65
Contraction scour depth (ycs), in feet	2.8	4.4
Pier scour depth (yps), in feet	17.1	17.2
Left abutment scour depth (yas), in feet	15.2	18.4
Right abutment scour depth (yas), in feet	11.1	14.4
1Flow angle of attack	16	16

See Comments/Diagram for justification where required