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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 63210185 Date 5/23/12 Initials RaT Region (A B (C) D)

Site ______ Location 1.4 mi S of Davis on 461 Ave

~~Q_{100}~~ = Q_{50} 17800 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 17800 (should be Q_{100} unless there is a relief bridge, road overflow, or bridge overtopping)

PGRM: "RegionA", "RegionB", "RegionC", or "RegionD"

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

Bridge Width = 245 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 = 241.28 ft* $q_2 = Q_2/W_2$ = 73.8 ft^2/s

Bridge Vel, V_2 = 6.1 ft/s Final $y_2 = q_2/V_2$ = 12.1 ft Δh = 0.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 12.9 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. = 0-3.0 ft 17.8

Low Steel Elev. = 13.3 ft -5.5

n (Channel) = 0.050

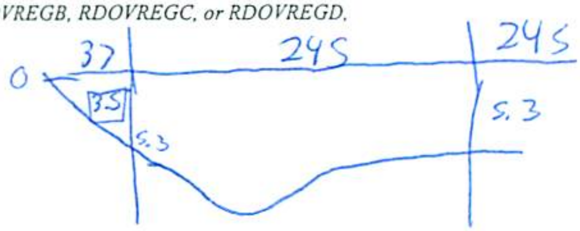
n (LOB) = 0.060

n (ROB) = 0.080

Pier Width = 2.0 ft

Pier Length = 2.0 ft

\# Piers for 100 yr = 4 ft



PGRM: Contract

CONTRACTION SCOUR

$5.3 \cdot \frac{2}{3} = \frac{10.6}{3}$

Width of main channel at approach section W_1 = 245 ft

Width of left overbank flow at approach, W_{lob} = 37 ft Average left overbank flow depth, y_{lob} = 3.5 ft

Width of right overbank flow at approach, W_{rob} = 245 ft Average right overbank flow depth, y_{rob} = 5.3 ft

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

x = 2.76 From Figure 9 W_2 (effective) = 233.3 ft y_{cs} = 3.3 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

PGRM: Pier

PIER SCOUR CALCULATIONS

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

Froude # at bridge = 0.31 Using pier width a on Figure 11, ξ = 8 Pier scour y_{ps} = 6.7 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 3.5 ft right abutment, y_{aRT} = 5.3 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} = 12.4 and ψ_{RT} = 15.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 12.4 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 15.6 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 6321085 Date 5/23/12 Initials Ral Region (A B (C) D)

Site ______ Location 1.4 mi S of Davis Co 461 Ave

Q_{500} = Qoe 25000 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 21456 (should be Q_{500} unless there is a relief bridge, road overflow, or bridge overtopping)

PGRM: "RegionA", "RegionB", "RegionC", or "RegionD"

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

Bridge Width = 245 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 = 241.25 ft* $q_2 = Q_2/W_2$ = 88.9 ft^2/s

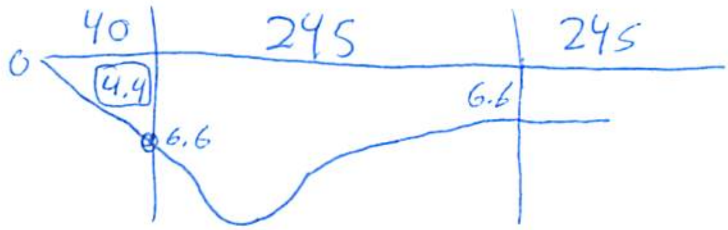
Bridge Vel, V_2 = 6.7 ft/s Final $y_2 = q_2/V_2$ = 13.3 ft Δh = 0.9 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 14.2 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. = 0-3.0 ft
Low Steel Elev. = 13.3 ft
n (Channel) = 0.050
n (LOB) = 0.060
n (ROB) = 0.050
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 = 245 ft

Width of left overbank flow at approach, W_{lob} = 40 ft Average left overbank flow depth, y_{lob} = 4.4 ft ($6.6 \cdot \frac{2}{3} = \frac{13.2}{3} = 4.4$)

Width of right overbank flow at approach, W_{rob} = 245 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 = ~~3.07~~ 3.6 From Figure 9 W_2 (effective) = ~~240.5~~ 233.3 ft y_{cs} = ~~3.7~~ 4.2 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, $V_c = 11.17y_1^{1/6}D_{50}^{1/3}$ = ______ 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: Pie

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

Froude # at bridge = 0.32 Using pier width a on Figure 11, ξ = 8 Pier scour y_{ps} = ~~6.2~~ 6.7 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 4.4 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} = 14 and ψ_{RT} = 17.9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 14 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 17.9 ft

Route 461 Ave Stream Vermillion River MRM ______ Date 5/23/12 Initials RaT

Bridge Structure No. 63210185 Location 1.4 mi S of Davis on 461 Ave

GPS coordinates: N ~~43~~ 43° 14' 13.7" taken from: USL abutment X centerline of ⇑ MRM end ______

W 96° 59' 1.9" Datum of coordinates: WGS84 X NAD27 ______

Drainage area = 1027.97 sq. mi.

The average bottom of the main channel was 17.8 ft below top of guardrail at a point ~~13.7~~ 127 ft from left abutment.

Method used to determine flood flows: ____ Freq. Anal. ____ drainage area ratio X regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	~~Q100 =~~ Q50 = 17800			~~Q500 =~~ Q100 25000		
Estimated flow passing through bridge	17800			21456		
Estimated road overflow & overtopping	0			3544		
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	

5/22

2	1400
5	3960
10	6820
25	12200
50	17800
100	25000
500	49100

Riprap at abutments? ____ Yes ____ No X Marginal

Evidence of past Scour? ____ Yes X No ____ Don't know

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 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). Right abutment
2-3) left abutment
4). main channel
5). left OB
6). main channel
7). right OB

Summary of Results

	~~Q100~~ Q50	~~Q500~~ Q100
Bridge flow evaluated	17800	21456
Flow depth at left abutment (yaLT), in feet	3.5	4.4
Flow depth at right abutment (yaRT), in feet	5.3	6.6
Contraction scour depth (ycs), in feet	3.3	~~3.7~~ 4.2
Pier scour depth (yps), in feet	6.7	6.7
Left abutment scour depth (yas), in feet	12.4	14
Right abutment scour depth (yas), in feet	15.6	17.9
1Flow angle of attack	10	10

See Comments/Diagram for justification where required