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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 14130146 Date 5/28/12 Initials cat Region (A B (C) D)

Site ______ Location 31160 University Road, Vermillion River

Q_{100} = ~~17900~~ Q10 9480 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 9480 (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 = 222 ft. 33 Flow angle at bridge = 55 ° Abut. Skew = 0 ° Effective Skew = 55 °

Width (W_2) iteration = 127.33 171 98.08 46 123.89 198 113.57 204 117.01

Avg. flow depth at bridge, y_2 iteration = 12.2 13.9 13.1 13.7 13.5

Corrected channel width at bridge Section = W_2 times cos of flow angle = ~~127.33~~ 117.01 ft* $q_2 = Q_2/W_2$ = 81 ft^2/s

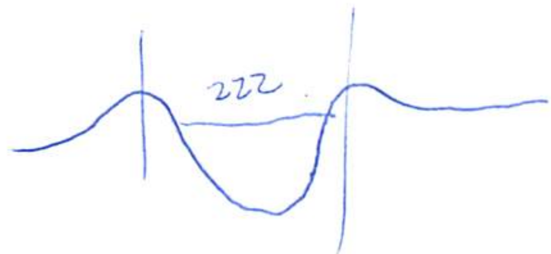
Bridge Vel, V_2 = 6.4 ft/s Final $y_2 = q_2/V_2$ = 12.7 ft Δh = 0.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 13.5 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. = 0-1.5 ft 22.9
Low Steel Elev. = 16.3 ft 6.6
n (Channel) = 0.075 16.3
n (LOB) = 0.045
n (ROB) = 0.030
Pier Width = 4.5 ft
Pier Length = 4.5 ft 7.2 14.2
Piers for 100 yr = 2 ft Dr



PGRM: Contract

CONTRACTION SCOUR

Width of main channel at approach section W_1 = 222 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} = 0 ft Average right overbank flow depth, y_{rob} = 0 ft

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

x = ~~15.59~~ 14.25 From Figure 9 W_2 (effective) = ~~103~~ 108 ft y_{cs} = ~~15.3~~ 14.6 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 = 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 = 14.4 Pier scour y_{ps} = 12.2 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

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

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

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 14130146 Date 5/28/12 Initials RaT Region (A B C D)

Site Qzs Location 31160 University Road

Q_{500} = 32600 17400 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 17017 (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 = 722 ft. Flow angle at bridge = 55 ° Abut. Skew = 6 ° Effective Skew = 55 °

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 = 127.3 ft* $q_2 = Q_2/W_2$ = 133.6 ft^2/s

Bridge Vel, V_2 = 8.2 ft/s Final $y_2 = q_2/V_2$ = 16.3 ft Δh = 1.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 17.7 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. = 617.5 ft

Low Steel Elev. = 616.3 ft

n (Channel) = ~~0.035~~ 0.075

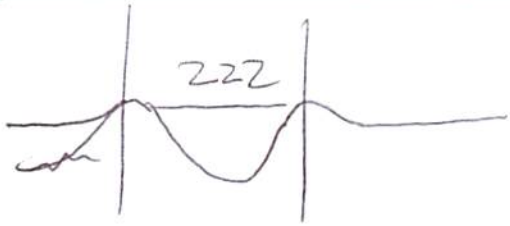
n (LOB) = 0.045

n (ROB) = 0.030

Pier Width = 4.5 ft

Pier Length = 4.5 ft

Piers for 500 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 722 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} = 0 ft Average right overbank flow depth, y_{rob} = 0 ft

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

x = 15.52 From Figure 9 W_2 (effective) = 116.3 ft y_{cs} = 15.3 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, $V_1 = Q_{500}/(y_1W_1)$ = _____ 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

PIER SCOUR CALCULATIONS

PGRM: Pier

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

Froude # at bridge = 0.36 Using pier width a on Figure 11, ξ = 14.4 Pier scour y_{ps} = 12.4 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

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

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

Route University Rd Stream Vermillion River MRM _____ Date 5/28/12 Initials nal

Bridge Structure No. 14130146 Location 31160 University Road

GPS coordinates: N 42° 52' 24.7" taken from: USL abutment X centerline of ⇑ MRM end _____

W 96° 54' 16.0" Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 1734.61 sq. mi.

The average bottom of the main channel was 22.9 ft below top of guardrail at a point 72 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Q25 17400

Flows	~~Q_{100}~~ = ~~Q_{10}~~ 9450			Q_{500} =		
Estimated flow passing through bridge	9486			17017		
Estimated road overflow & overtopping	0			383		
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	

5/12

2	1910
5	5410
10	9480
25	17400
50	25500
100	36200
500	74600

Riprap at abutments? ____Yes X No ____Marginal

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

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 _____	X Yes	~~X~~ No	____Don't know	____NA

- trees along bank

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). main channel
2). piers
3). pier scour
4) right ab
5). right at.
6). left at
7). left ab
8) right OB
9). right OB
10). left OB
11). left OB

~~X~~. Main channel constant position myself safely

Notes

Dikes built in line with abutments at road height eliminates right and left over banks

Summary of Results

	Q~~100~~ 10	Q~~500~~ 25
Bridge flow evaluated	~~9450~~	10717
Flow depth at left abutment (yaLT), in feet	0	0
Flow depth at right abutment (yaRT), in feet	0	0
Contraction scour depth (ycs), in feet	~~15.3~~ 14.6	15.3
Pier scour depth (yps), in feet	12.2	12.4
Left abutment scour depth (yas), in feet	0	0
Right abutment scour depth (yas), in feet	0	0
1Flow angle of attack	55	55

See Comments/Diagram for justification where required