OK RT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 14120183 Date 5/27/12 Initials RaT Region (A B C D)

Site 06479010 Location 31530 University Road, Vermillion River

Q_{100} = ~~18200~~ 36700 by: drainage area ratio____ flood freq. anal. ✓ regional regression eq. ____

Bridge discharge (Q_2) = ______________ (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 = 200 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 199.24 174.33 181.31 178.32

Avg. flow depth at bridge, y_2 iteration = 19.1 20.5 20.1 20.2

Corrected channel width at bridge Section = W_2 times cos of flow angle = ~~199.24~~ 178.32 ft* $q_2 = Q_2/W_2$ = ~~164.2~~ 205.6 ft^2/s

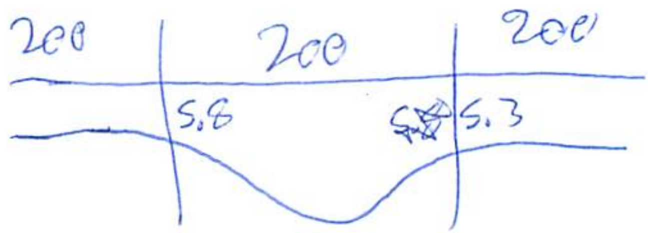
Bridge Vel, V_2 = ~~8.6~~ 10.7 ft/s Final $y_2 = q_2/V_2$ = ~~19.1~~ 20.2 ft Δh = ~~1.8~~ 2.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = ~~20.9~~ 22.3 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. = UNK ft 24 29.25
Low Steel Elev. = 24.9 ft 4.35 29.90
n (Channel) = 0.030
n (LOB) = 0.035
n (ROB) = 0.035
Pier Width = 1.95 ft circular
Pier Length = 1.95 ft
\# Piers for 100 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 200 ft

Width of left overbank flow at approach, W_{lob} = 200 ft Average left overbank flow depth, y_{lob} = 5.8 ft

Width of right overbank flow at approach, W_{rob} = 200 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 = 14.17 From Figure 9 W_2 (effective) = 170.5 ft y_{cs} = 14.5 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, $Vc = 11.52y_1^{1/6}D_{50}^{1/3}$ = _____________ 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 = 0.4 Using pier width a on Figure 11, ξ = 7.8 Pier scour y_{ps} = ~~6.8~~ 6.8 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 5.8 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} = 16.5 and ψ_{RT} = 15.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 16.5 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 15.6 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 14120183 Date 5/27/12 Initials Rel Region (A B (C) D)

Site 06479010 Location 31530 University Road

Q_{500} = ~~33100~~ 74600 by: drainage area ratio ___ flood freq. anal. ✓ regional regression eq. ✗

Bridge discharge (Q_2) = 62216 (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 = 200 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

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 = 199.24 ft* $q_2 = Q_2/W_2$ = 312.2 ft²/s

Bridge Vel, V_2 = 12.5 ft/s Final $y_2 = q_2/V_2$ = 24.9 ft Δh = 3.2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 28.1 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. = — ft

Low Steel Elev. = 24.9 ft

n (Channel) = 0.070

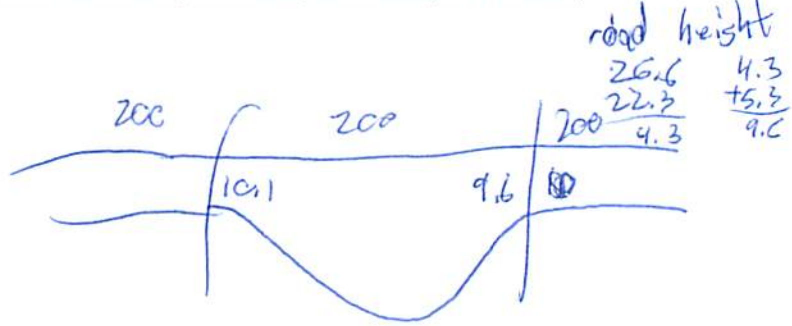
n (LOB) = 0.035

n (ROB) = 0.35

Pier Width = 1.95 ft

Pier Length = 1.95 ft

\# Piers for 500 yr = 4 ft



PGRM: Contract

CONTRACTION SCOUR

Width of main channel at approach section W_1 = 200 ft

Width of left overbank flow at approach, W_{lob} = 200 ft Average left overbank flow depth, y_{lob} = 10.1 ft

Width of right overbank flow at approach, W_{rob} = 200 ft Average right overbank flow depth, y_{rob} = 9.6 ft

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

x = 21.73 From Figure 9 W_2 (effective) = 191.4 ft y_{cs} = 18.6 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, $V_1 = Q_{500}/(y_1 W_1)$ = ___ ft/s

Critical approach velocity, $V_c = 11.52 y_1^{1/6} D_{50}^{1/3}$ = ___ 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

PGRM: Pie

PIER SCOUR CALCULATIONS

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

Froude # at bridge = 0.44 Using pier width a on Figure 11, ξ = 7.8 Pier scour y_{ps} = 6.9 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 10.1 ft right abutment, y_{aRT} = 9.6 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} = 21.4 and ψ_{RT} = 21

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 21.4 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 21 ft

Route University Rd Stream Vermillion River MRM ________ Date 5/27/12 Initials RaT

Bridge Structure No. 14120183 Location 31530 University Road

GPS coordinates: N 42° 49' 1.4" W: 96° 55' 27.2" taken from: USL abutment x centerline of ⇑ MRM end ____

Datum of coordinates: WGS84 x NAD27 ____

Drainage area = 1775.17 sq. mi.

The average bottom of the main channel was 29.25 ft below top of guardrail at a point 71 ft from left abutment.

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

from at-site frequency analysis

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = ~~[illegible]~~ 36700			Q_{500} = ~~33100~~ 74600		
Estimated flow passing through bridge	36700			62210		
Estimated road overflow & overtopping	~~[illegible]~~ 0			12390		
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 — yes, on left abutment and bank, no on right

Evidence of past Scour? X Yes ____ No ____ Don't know — pier, contraction

Debris Potential? ____ High ____ Med X 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 both banks, and riprap along right bank

Bed Material Classification Based on Median Particle Size (D_{50})

Material	Silt/Clay X	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

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

Note: Q values used in this analysis are based on Stream Stats results and are larger than the Q_{100} and Q_{500} values determined for the streamgage at this location.

5/22

2	355
5	1670
10	3610
25	7700
50	12700
100	19200
500	42200

Note: Flows from stream stats do not match previous values upstream are lower than upstream values. I will used up upstream numbers also much less than downstream numbers Form 1413046

2	1910
5	5410
10	9480
25	17400
50	25300
100	36700
500	74600

~2 miles upstream

Summary of Results

	Q100	Q500
Bridge flow evaluated	36700	62210
Flow depth at left abutment (yaLT), in feet	5.8	10.1
Flow depth at right abutment (yaRT), in feet	5.3	~~[illegible]~~ 9.6
Contraction scour depth (ycs), in feet	14.5	18.6
Pier scour depth (yps), in feet	6.8	6.9
Left abutment scour depth (yas), in feet	~~[illegible]~~ 16.3	21.4
Right abutment scour depth (yas), in feet	15.6	21
1Flow angle of attack	5	5

See Comments/Diagram for justification where required