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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52414299 Date 4/1/11 Initials CL Region (A B C D)

Site _____ Location 5th St over Rapid Creek

Q_{100} = 4780 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 4780 (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 = 172 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 172 ~~139~~ 164 166

Avg. flow depth at bridge, y_2 iteration = 4.5 ~~5.0~~ 4.6 4.6

Corrected channel width at bridge Section = W_2 times cos of flow angle = 163.48 ft* $q_2 = Q_2/W_2$ = 29.2 ft^2/s

Bridge Vel, V_2 = 6.4 ft/s Final $y_2 = q_2/V_2$ = 4.6 ft Δh = 0.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 5.4 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. = 9.1 ft

n (Channel) = 0.050

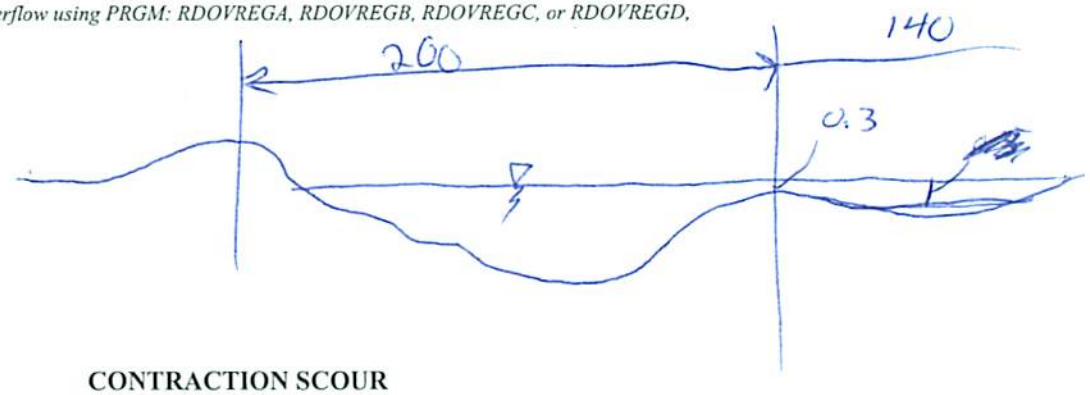
n (LOB) = 0.030

n (ROB) = 0.033

Pier Width = 1.0 ft

Pier Length = 71.0 ft

Piers for 100 yr = 3 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} = 0.0 ft Average left overbank flow depth, y_{lob} = 0.0 ft

Width of right overbank flow at approach, W_{rob} = 140 ft Average right overbank flow depth, y_{rob} = ~~0.3~~ ~~0.5~~ 0.3 ft

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

x = _____ From Figure 9 W_2 (effective) = _____ ft y_{cs} = _____ ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = 0.3 ft Average approach velocity, $V_1 = Q_{100}/(y_1 W_1)$ = 2.6 4.43 ft/s 2=0

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = 9.9 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.04042 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} = 0.0 ft

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 71 Correction factor for flow angle of attack (from Table 1), K2 = 2.0

Froude # at bridge = 0.53 Using pier width a on Figure 11, ξ = 4.9 Pier scour y_{ps} = 8.8 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 0.0 ft right abutment, y_{aRT} = 0.3 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} = 0.0 and ψ_{RT} = 1.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0.0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 1.4 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52414299 Date 4/1/11 Initials CLV Region (A B C D)

Site _____ Location 5th St over Rapid Creek

Q_{500} = 18000 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 14067 (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 = 172 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 172

Avg. flow depth at bridge, y_2 iteration = 9.3 * > LS → RD Overflow 172 cos 10° = 169.4

Corrected channel width at bridge Section = W_2 times cos of flow angle = 169.39 ft* $q_2 = Q_2/W_2$ = 83 ft^2/s

Bridge Vel, V_2 = 10.3 ft/s Final $y_2 = q_2/V_2$ = 8.1 ft Δh = 2.2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 10.3 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. = _____ ft

Low Steel Elev. = 8.1 ft

n (Channel) = 0.050

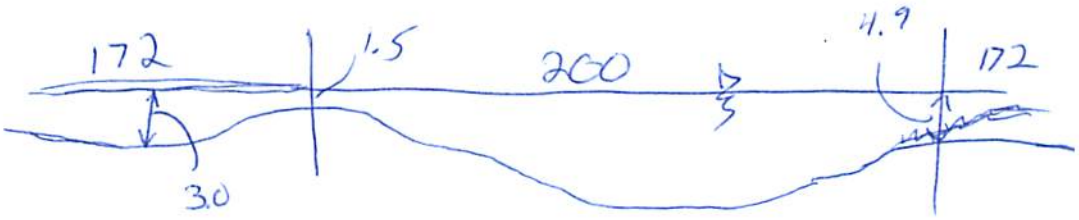
n (LOB) = 0.030

n (ROB) = 0.033

Pier Width = 1.0 ft

Pier Length = 71 ft

Piers for 500 yr = 3 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 200 ft ~ 3.0

Width of left overbank flow at approach, W_{lob} = 172 ft Average left overbank flow depth, y_{lob} = ____ ft

Width of right overbank flow at approach, W_{rob} = 172 ft Average right overbank flow depth, y_{rob} = 4.9 ft

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

x = _____ From Figure 9 W_2 (effective) = _____ ft y_{cs} = _____ ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = 0.3 ft Average approach velocity, $V_1 = Q_{500}/(y_1 W_1)$ = 2.51 / 6.63 ft/s Z=0

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = 11.03 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.0974 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} = 0.0 ft

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 71 Correction factor for flow angle of attack (from Table 1), K2 = 2.0

Froude # at bridge = 0.64 Using pier width a on Figure 11, ξ = 4.9 Pier scour y_{ps} = 9.1 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 3.0 ft right abutment, y_{aRT} = 4.9 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} = 11.5 and ψ_{RT} = 14.8

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 11.5 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 14.8 ft

Route 5th St Stream Rapid Creek MRM _____ Date 4/1/11 Initials CG

Bridge Structure No. 52414299 Location 5th St over Rapid Creek

GPS coordinates: N44° 05' 06.5" W103° 13' 26.3" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 416.90 sq. mi.

The average bottom of the main channel was 13.7 ft below top of guardrail at a point 100.0 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 4780			Q_{500} = 18000		
Estimated flow passing through bridge	4780			14067		
Estimated road overflow & overtopping				3933		
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 X No ____Marginal

Evidence of past Scour? ____Yes X No ____Don't know

Debris Potential? X High ____Med ____Low

Does scour countermeasure(s) appear to have been designed?

Riprap ____Yes ____No ____Don't know X NA

Spur Dike ____Yes ____No ____Don't know X NA

Other _____ ____Yes ____No ____Don't know X NA

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

Material	Silt/Clay____	Sand____	Gravel X	Cobbles____	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

Comments, Diagrams & orientation of digital photos

Photos

1535- 1D

36- App XS @ RB

37- US Face Bridge

38- App XS @ LB

39- ~~US LB~~ US

40- US RB

41- US LB

42- Pond on RB

43- Pond on RB

44- L. Abut

45- R. Abut

Summary of Results

	Q100	Q500
Bridge flow evaluated	4780	14067
Flow depth at left abutment (yaLT), in feet	0.0	3.0
Flow depth at right abutment (yaRT), in feet	0.3	4.9
Contraction scour depth (ycs), in feet	0.0	0.0
Pier scour depth (yps), in feet	4.6	9.1
Left abutment scour depth (yas), in feet	0.0	11.5
Right abutment scour depth (yas), in feet	1.4	14.9
1Flow angle of attack	10	10

See Comments/Diagram for justification where required

7 9 9 10

18000

14067

3933