OK RJ

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52399300 Date 4/1/11 Initials CW Region (A B C D)

Site _____ Location W. Main St. over Rapid Creek

Q_{100} = 4720 by: drainage area ratio ✓ flood freq. anal. _____ regional regression eq. _____

Bridge discharge (Q_2) = 4720 (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 = ~~310~~ 301 ft. Flow angle at bridge = 20 ° Abut. Skew = 15 ° Effective Skew = 5 °

Width (W_2) iteration = 310 282 286 _____

Avg. flow depth at bridge, y_2 iteration = 3.2 3.4 3.3 _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 28491 ft* $q_2 = Q_2/W_2$ = 16.6 ft^2/s

Bridge Vel, V_2 = 4.9 ft/s Final $y_2 = q_2/V_2$ = 3.3 ft Δh = 0.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 3.8 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. = 9.9 ft

n (Channel) = 0.045

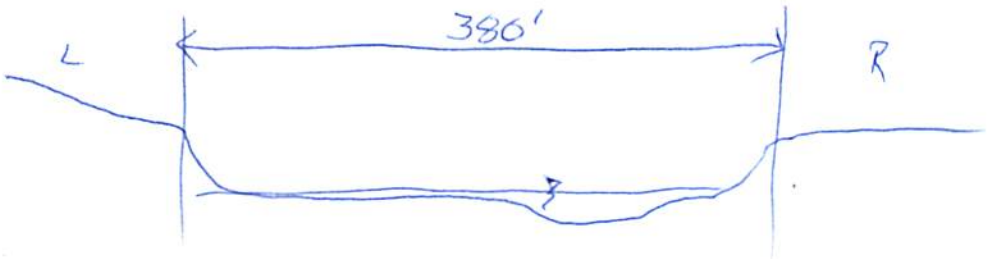
n (LOB) = 0.035

n (ROB) = 0.055

Pier Width = 1.0 ft

Pier Length = 73.0 ft

Piers for 100 yr = 5 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 380 ft

Width of left overbank flow at approach, W_{lob} = 0 ft Average left overbank flow depth, y_{lob} = 0.0 ft

Width of right overbank flow at approach, W_{rob} = 0 ft Average right overbank flow depth, y_{rob} = 0.0 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) z=0

Estimated bed material D_{50} = 0.3 ft Average approach velocity, $V_1 = Q_{100}/(y_1 W_1)$ = 3.27 ft/s

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = 9.34 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.0256 ft If $D_{50} >= D_{c50}$, χ = 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 = 73 Correction factor for flow angle of attack (from Table 1), K2 = 1.5

Froude # at bridge = 0.44 Using pier width a on Figure 11, ξ = 4.9 Pier scour y_{ps} = 6.5 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

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

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

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52399300 Date 4/1/11 Initials CW Region ((A) B C D)

Site _____ Location W. Main St. over Rapid Creek

Q_{500} = 17700 by: drainage area ratio ✓ flood freq. anal. _____ regional regression eq. ____

Bridge discharge (Q_2) = 17700 (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 = ~~310~~ 301 ft. Flow angle at bridge = 20 ° Abut. Skew = 15 ° Effective Skew = 5 °

Width (W_2) iteration = ~~310~~ 301 → Vert Abutment

Avg. flow depth at bridge, y_2 iteration = ~~6.6~~ 6.7 _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 299.85 ft* $q_2 = Q_2/W_2$ = 59 ft^2/s

Bridge Vel, V_2 = 8.8 ft/s Final $y_2 = q_2/V_2$ = 6.7 ft Δh = 1.6 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.3 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. = 9.9 ft

n (Channel) = 0.045

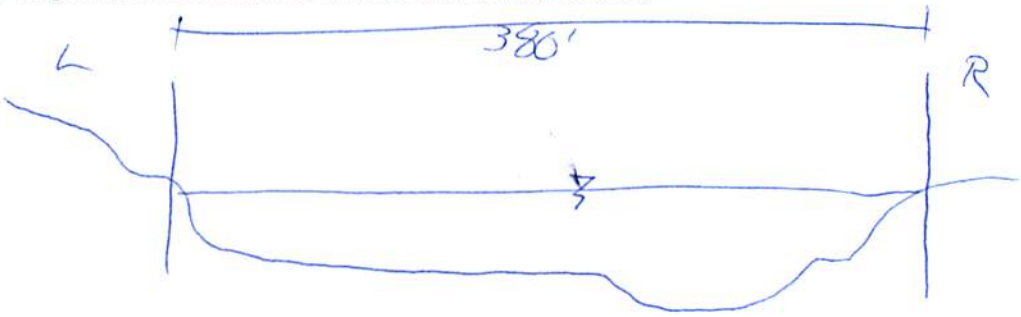
n (LOB) = 0.035

n (ROB) = 0.055

Pier Width = 1.0 ft

Pier Length = 73.0 ft

Piers for 500 yr = 5 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 380 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} = 0.0 ft Average right overbank flow depth, y_{rob} = 0.0 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, $V_1 = Q_{500}/(y_1 W_1)$ = 5.61 ft/s z=0

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = 10.64 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.0744 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 73 Correction factor for flow angle of attack (from Table 1), K2 = 1.5

Froude # at bridge = 0.60 Using pier width a on Figure 11, ξ = 4.9 Pier scour y_{ps} = 6.8 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

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

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

Route W. Main St. Stream Rapid Creek MRM _____ Date 4/1/11 Initials CL

Bridge Structure No. 52399300 Location W. Main St. over Rapid Creek

GPS coordinates: N 44° 04' 54.0" W 103° 15' 22.9" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 408.66 sq. mi.

The average bottom of the main channel was 15.4 ft below top of guardrail at a point 180 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 4720			Q_{500} = 17700		
Estimated flow passing through bridge	4720			17700		
Estimated road overflow & overtopping	—			—		
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 X Don't know ____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

1523 - Bridge ID

24 - US

25 - US RB

26 - US LB

27 - R. Abut

28 - US Face bridge looking left

29 - L. Abut

30 - US Face bridge looking right

31 - US Face bridge

32 - Approach XS looking right

33 - Approach XS looking left

Summary of Results

	Q100	Q500
Bridge flow evaluated	4720	17700
Flow depth at left abutment (yaLT), in feet	0.0	0.0
Flow depth at right abutment (yaRT), in feet	0.0	0.0
Contraction scour depth (ycs), in feet	0.0	0.0
Pier scour depth (yps), in feet	6.5	6.8
Left abutment scour depth (yas), in feet	0.0	0.0
Right abutment scour depth (yas), in feet	0.0	0.0
1Flow angle of attack	5°	5°

See Comments/Diagram for justification where required