OK RJ

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 69158176 Date 8/10/11 Initials CW Region (A (B) C D)

Site _____ Location 4.25 mi NW of int of 224 Ave & 167 St

Q_{100} = 36300 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 36300 (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

Bridge Width = 332 ft. Flow angle at bridge = 19 ° Abut. Skew = 10 ° Effective Skew = 5 °

Width (W_2) iteration = 332 195 204 200

Avg. flow depth at bridge, y_2 iteration = 12.7 16.8 16.4 16.6

Corrected channel width at bridge Section = W_2 times cos of flow angle = 199.24 ft* $q_2 = Q_2/W_2$ = 182.2 ft^2/s

Bridge Vel, V_2 = 11 ft/s Final $y_2 = q_2/V_2$ = 16.6 ft Δh = 2.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 19.1 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,

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

Water Surface Elev. = _____ ft

Low Steel Elev. = _____ ft

n (Channel) = 0.033

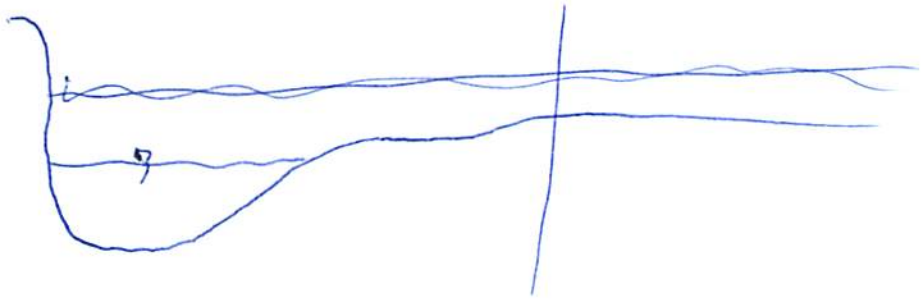
n (LOB) = 0.035

n (ROB) = 0.030

Pier Width = 2.55 ft

Pier Length = 30 ft

Piers for 100 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = ~~340~~ 332 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 = 13.46 From Figure 9 W_2 (effective) = 194.1 ft y_{cs} = 14.2 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ 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 = 11.4 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 = 9.7 Pier scour y_{ps} = 13.0 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, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0.0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0.0 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 69154178 Date 8/10/11 Initials CL Region (A B C D)

Site _____ Location 0.25 mi NW of int of 224 Ave & 157 St

Q_{500} = 61100 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 61100 (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 = 332 ft. Flow angle at bridge = 15 ° Abut. Skew = 10 ° Effective Skew = 5 °

Width (W_2) iteration = 332 203 223 218 221

Avg. flow depth at bridge, y_2 iteration = 16.7 21.6 20.3 20.8 20.7

Corrected channel width at bridge Section = W_2 times cos of flow angle = 220.16 ft* $q_2 = Q_2/W_2$ = 277.5 ft^2/s

Bridge Vel, V_2 = 13.4 ft/s Final $y_2 = q_2/V_2$ = 20.7 ft Δh = 3.7 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 24.4 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. = _____ ft

n (Channel) = 0.033

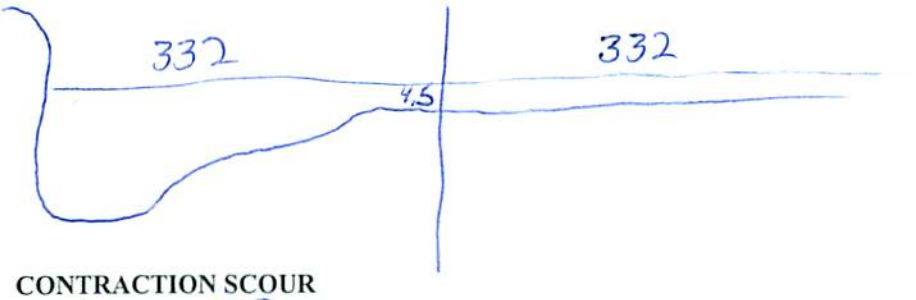
n (LOB) = 0.035

n (ROB) = 0.030

Pier Width = 2.55 ft

Pier Length = 30 ft

Piers for 500 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = ~~344~~ 332 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} = 332 ft Average right overbank flow depth, y_{rob} = 4.5 ft

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

x = 15.74 From Figure 9 W_2 (effective) = 215.1 ft y_{cs} = 15.4 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, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = _____ 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 = 11.8 Correction factor for flow angle of attack (from Table 1), K2 = 1.5

Froude # at bridge = 0.52 Using pier width a on Figure 11, ξ = 9.7 Pier scour y_{ps} = 13.1 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 0.0 ft right abutment, y_{aRT} = 4.5 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} = 14.1

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0.0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 14.1 ft

Route Thunder Butte Rd Stream Moreau River MRM _____ Date 8/10/11 Initials CM

Bridge Structure No. 69158178 Location 8.25 mi NW of int of 224 Ave & 157 St

GPS coordinates: N 45° 12' 58.8" W 101° 41' 43.4" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 2955 sq. mi.

The average bottom of the main channel was 41.8 ft below top of guardrail at a point 77 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 36300			Q_{500} = 61100		
Estimated flow passing through bridge	36300			61100		
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

Pk calc'd on 8/8

Pk 2	2350
5	7350
10	12800
25	20500
50	27900
100	36300
500	61100

Riprap at abutments? ____Yes X No ____Marginal

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

Debris Potential? X High X Med ____Low

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

Riprap	____Yes	____No	____Don't know	X NA
Spur Dike	X Yes	____No	____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 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

Large log jam on pier

1477 - 1D
74 - Spur dike
79 - US Face
80 - US Face
81 - R. Abut

Summary of Results

	Q100	Q500
Bridge flow evaluated	36300	61100
Flow depth at left abutment (yaLT), in feet	0.0	0.0
Flow depth at right abutment (yaRT), in feet	0.0	4.5
Contraction scour depth (ycs), in feet	14.2	15.4
Pier scour depth (yps), in feet	13.0	13.1
Left abutment scour depth (yas), in feet	0.0	0.0
Right abutment scour depth (yas), in feet	0.0	14.1
1Flow angle of attack	5	5

See Comments/Diagram for justification where required