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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 55240041 Date 8/3/17 Initials RaT Region (A B C D)

Site _____ Location 0.3 mi N of Rosholt on 473 Ave

Q_{100} = Q25 1320 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 1320 (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 = 56 ft. Flow angle at bridge = 45 ° Abut. Skew = 0 ° Effective Skew = 45 °

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 = 39.6 ft* $q_2 = Q_2/W_2$ = 33.3 ft^2/s

Bridge Vel, V_2 = 4.1 ft/s Final $y_2 = q_2/V_2$ = 8.1 ft Δh = 0.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.5 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. = 0-0.5 ft

Low Steel Elev. = 9.4 ft

n (Channel) = 0.045

n (LOB) = 0.030

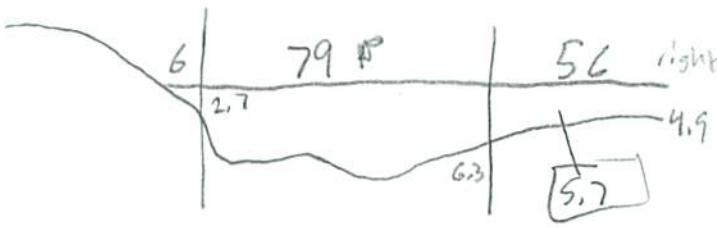
n (ROB) = 0.030

Pier Width = 1.55 ft

Pier Length = 1.55 ft

Piers for 100 yr = 2 ft

= left 6.3 → 4.9 sc



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 79 ft

Width of left overbank flow at approach, W_{lob} = 56 ft Average left overbank flow depth, y_{lob} = 5.7 ft

Width of right overbank flow at approach, W_{rob} = 6 ft Average right overbank flow depth, y_{rob} = 1.4 ft

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

x = 20.05 From Figure 9 W_2 (effective) = 36.5 ft y_{cs} = 17.7 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, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = _____ 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 = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.25 Using pier width a on Figure 11, ξ = 6.6 Pier scour y_{ps} = 5.4 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 5.7 ft right abutment, y_{aRT} = 1.4 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} = 16.3 and ψ_{RT} = 5.9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 16.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 5.9 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 55240041 Date 8/3/12 Initials AaT Region (A B C D)

Site _____ Location 0.3 mi N of Rosholt on 473 Ave

Q_{500} = (Qsc) 1600 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 1757 (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 = 56 ft. Flow angle at bridge = 45 ° Abut. Skew = 0 ° Effective Skew = 45 °

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 = 39.6 ft* $q_2 = Q_2/W_2$ = 44.41 ft^2/s

Bridge Vel, V_2 = 4.7 ft/s Final $y_2 = q_2/V_2$ = 9.4 ft Δh = 0.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 9.8 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. = 0-0.5 ft

Low Steel Elev. = 9.4 ft

n (Channel) = 0.045

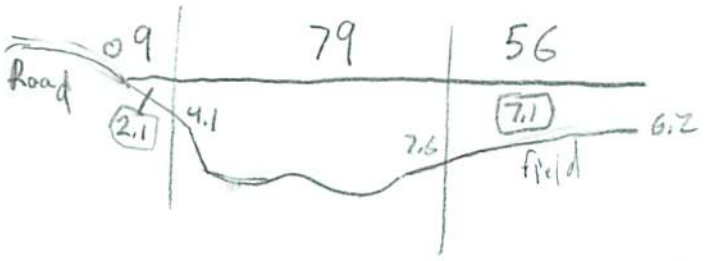
n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 1.55 ft

Pier Length = 1.55 ft

Piers for 500 yr = 2 ft



7.6 6.2

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 79 ft

Width of left overbank flow at approach, W_{lob} = 56 ft Average left overbank flow depth, y_{lob} = 7.1 ft

Width of right overbank flow at approach, W_{rob} = 9 ft Average right overbank flow depth, y_{rob} = 2.1 ft

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

x = 24.87 From Figure 9 W_2 (effective) = 36.5 ft y_{cs} = 20.3 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, $V_1 = Q_{500}/(y_1 W_1)$ = _____ 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 = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.27 Using pier width a on Figure 11, ξ = 6.6 Pier scour y_{ps} = 5.4 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 7.1 ft right abutment, y_{aRT} = 2.1 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} = 18.8 and ψ_{RT} = 8.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 18.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 8.6 ft

Route 473 Ave Stream Big Slough Clk MRM _____ Date 8/13/12 Initials [illegible]

Bridge Structure No. 55240041 Location 0.3 mi N of Rosholt on 473 Ave

GPS coordinates: N 45° 52' 35.2" taken from: USL abutment X centerline of ⇑ MRM end _____

W 96° 43' 46.2" Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 89.29 sq. mi.

The average bottom of the main channel was 13.2 ft below top of guardrail at a point 24 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = Q10 Q25 1320			Q_{500} = Q50 1800		
Estimated flow passing through bridge		1320			1757	
Estimated road overflow & overtopping		0			43	
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		X				X
Chance of Pressure flow		X		X		
Armored appearance to channel		X				
Lateral instability of channel		X			X	

7/3

2	162
5	474
10	789
25	1320
50	1800
100	2350
500	3850

Riprap at abutments? ____Yes ____No X Marginal heavy abutment, significant contraction

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

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 _____ ____Yes X No ____Don't know ____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

1). left CB

2). main channel

3). right CB

4-6). right abutment

7-8). pier

9-11). left abutment

12). main channel

Note: noticeable flow west-east which contradicts map. Local resident confirmed flow moves west to east.

Summary of Results

	Q100 Q25	Q500 Q50
Bridge flow evaluated	1320	1757
Flow depth at left abutment (yaLT), in feet	5.7	7.1
Flow depth at right abutment (yaRT), in feet	4.4	2.1
Contraction scour depth (ycs), in feet	17.7	20.3
Pier scour depth (yps), in feet	5.4	5.4
Left abutment scour depth (yas), in feet	16.3	15.8
Right abutment scour depth (yas), in feet	5.9	6.6
1Flow angle of attack	45	45

See Comments/Diagram for justification where required