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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 07190389 Date 7/20/12 Initials RaT Region (A B C D)

Site _____ Location 6 mi. S of Bath corner on 395 Ave

Q_{100} = Qs 969 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 969 (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 = 79 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

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 = 77.8 ft* $q_2 = Q_2/W_2$ = 11.2 ft^2/s

Bridge Vel, V_2 = 1.7 ft/s Final $y_2 = q_2/V_2$ = 6.5 ft Δh = 0.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 6.5 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. = 0.5 ft

Low Steel Elev. = 9.5 ft

n (Channel) = 0.026

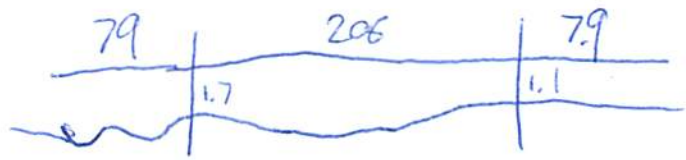
n (LOB) = 0.040

n (ROB) = 0.040

Pier Width = 0.95 ft

Pier Length = 0.83 ft

Piers for 100 yr = 1 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 206 ft

Width of left overbank flow at approach, W_{lob} = 79 ft Average left overbank flow depth, y_{lob} = 1.7 ft

Width of right overbank flow at approach, W_{rob} = 79 ft Average right overbank flow depth, y_{rob} = 1.1 ft

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

x = 11.96 From Figure 9 W_2 (effective) = 77 ft y_{cs} = 13 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

PIER SCOUR CALCULATIONS

PGRM: Pier

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

Froude # at bridge = 0.12 Using pier width a on Figure 11, ξ = 4.1 Pier scour y_{ps} = 3 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 1.7 ft right abutment, y_{aRT} = 1.1 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} = 7 and ψ_{RT} = 4.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 7 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 4.7 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 07190389 Date 7/20/17 Initials RAT Region (A B C (D))

Site _____ Location 6mi S of Bath corner

~~Q_{500}~~ = Q_{10} 1950 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 1795 (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 = 79 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

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 = 77.8 ft* $q_2 = Q_2/W_2$ = 22.9 ft^2/s

Bridge Vel, V_2 = 2.4 ft/s Final $y_2 = q_2/V_2$ = 9.5 ft Δh = 0.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 9.6 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. = 0.5 ft

Low Steel Elev. = 9.5 ft

n (Channel) = 0.040

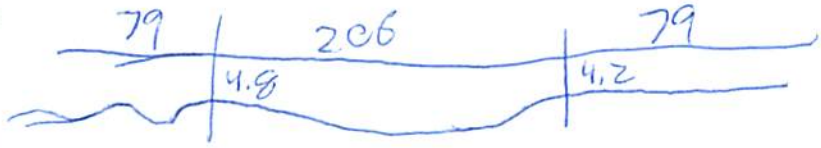
n (LOB) = 0.040

n (ROB) = 0.040

Pier Width = 0.85 ft

Pier Length = 0.85 ft

Piers for 500 yr = 1 ft



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CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 206 ft

Width of left overbank flow at approach, W_{lob} = 79 ft Average left overbank flow depth, y_{lob} = 4.8 ft

Width of right overbank flow at approach, W_{rob} = 79 ft Average right overbank flow depth, y_{rob} = 4.2 ft

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

x = 2.69 From Figure 9 W_2 (effective) = 77 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, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = _____ 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 = 0.14 Using pier width a on Figure 11, ξ = 4.1 Pier scour y_{ps} = 3.1 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 4.8 ft right abutment, y_{aRT} = 4.2 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} = 14.7 and ψ_{RT} = 13.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 14.7 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 13.6 ft

-99.32965

45.37209

45° 22' 19".464

99° 19' 46".74

Route 395 Alt Stream Moccasin Clk MRM _____ Date 7/20/12 Initials DaT

Bridge Structure No. 07190389 Location 6 mi S of Bath Corner on 395 Alt

GPS coordinates: N 45° 22' 19.51" W 96° 19' 47.01" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 359.64 sq. mi.

The average bottom of the main channel was 13.7 ft below top of guardrail at a point 48 ft from left abutment.

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

7/2

2	182
5	869
10	1850
25	3980
50	6310
100	9390
500	20000

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = Q5 869			Q_{500} = Q10 1850		
Estimated flow passing through bridge	869			1785		
Estimated road overflow & overtopping	0			65		
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? X Yes ____No ____Marginal

Evidence of past Scour? X Yes ____No ____Don't know minor pier/ cont. erosion

Debris Potential? ____High ____Med X Low

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

Riprap	X Yes	____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 abt
2). main channel
3). right abt
4-5). pier
6). left abutment
7). right abutment
8). right abutment
9). left abutment
10). main channel

Summary of Results

	~~Q100~~ Q5	~~Q500~~ Q10
Bridge flow evaluated	869	1785
Flow depth at left abutment (yaLT), in feet	1.7	4.8
Flow depth at right abutment (yaRT), in feet	1.1	4.2
Contraction scour depth (ycs), in feet	13	19.6
Pier scour depth (yps), in feet	3	3.1
Left abutment scour depth (yas), in feet	~~NA~~ 7	~~NA~~ 14.7
Right abutment scour depth (yas), in feet	~~NA~~ 4.7	~~NA~~ 13.6
1Flow angle of attack	10	10

See Comments/Diagram for justification where required