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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 03258060 Date 7/23/12 Initials RaT Region (A B C D)

Site _____ Location 40190 196 St, James River

Q_{100} = 17900 cfs 57400 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 57400 (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 = 296 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 = 291.5 ft* $q_2 = Q_2/W_2$ = 196.9 ft^2/s

Bridge Vel, V_2 = 10 ft/s Final $y_2 = q_2/V_2$ = 19.8 ft Δh = 2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 21.8 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,

12.2-7

Water Surface Elev. = 39 ft

Low Steel Elev. = 22.1 ft

n (Channel) = 0.035

n (LOB) = 0.035

n (ROB) = 0.035

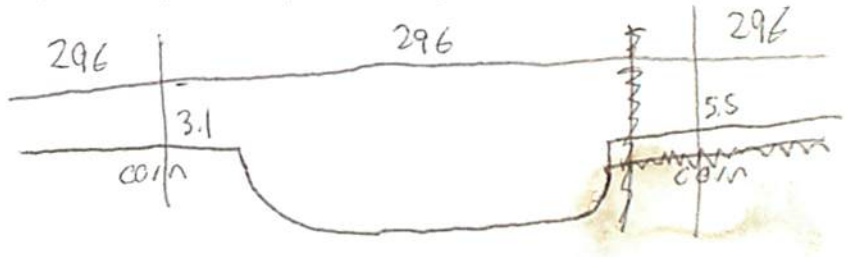
Pier Width = 2.05 ft

Pier Length = 2 ft

Piers for 100 yr = 4 ft

26.4
1.55
1.5
2.25

1
2.25
1.55
1.50
4.30



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 296 ft

Width of left overbank flow at approach, W_{lob} = 296 ft Average left overbank flow depth, y_{lob} = 3.1 ft

Width of right overbank flow at approach, W_{rob} = 296 ft Average right overbank flow depth, y_{rob} = ~~3.1~~ 5.5 ft

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

x = 4.15 From Figure 9 W_2 (effective) = 293.3 ft y_{cs} = 4.8 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, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = _____ 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 = 0.98 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.4 Using pier width a on Figure 11, ξ = 8.1 Pier scour y_{ps} = 7.1 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 3.1 ft right abutment, y_{aRT} = 5.5 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} = 11.7 and ψ_{RT} = 15.9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 11.7 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 15.9 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 03258060 Date 7/23/17 Initials RaT Region (A B C D)

Site _____ Location 40190 196 St

Q_{500} = ~~Q100 32600~~ 91200 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 71675 (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 = 296 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 = 291.5 ft* $q_2 = Q_2/W_2$ = 245.9 ft^2/s

Bridge Vel, V_2 = 11.1 ft/s Final $y_2 = q_2/V_2$ = 22.1 ft Δh = 2.5 ft

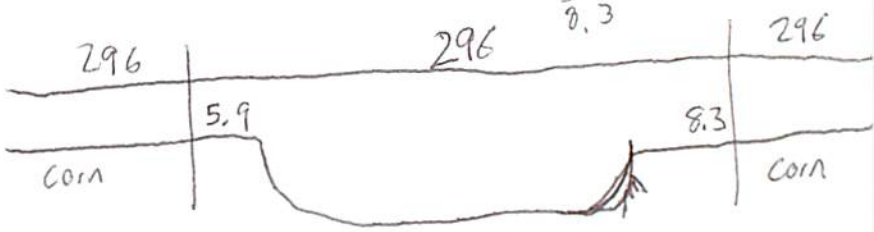
Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 24.6 ft

** NOTE: repeat above calculations until y_2 changes by less by than 0.2* *Effective pier width = L sin(a) + a cos(a)*

If y_2 is above LS, then account for Road Overflow using PRGM: RDOVREGA, RDOVREGB, RDOVREGC, or RDOVREGD,

5.5
2.8
8.3

Water Surface Elev. = 5.9 ft
Low Steel Elev. = 22.1 ft
n (Channel) = 0.035
n (LOB) = 0.035
n (ROB) = 0.035
Pier Width = 2.05 ft
Pier Length = 2.0 ft
Piers for 500 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 296 ft

Width of left overbank flow at approach, W_{lob} = 296 ft Average left overbank flow depth, y_{lob} = 5.9 ft

Width of right overbank flow at approach, W_{rob} = 296 ft Average right overbank flow depth, y_{rob} = 8.3 ft

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

x = 7.69 From Figure 9 W_2 (effective) = 283.3 ft y_{cs} = 8.5 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, $V_1 = Q_{500}/(y_1W_1)$ = _____ ft/s

Critical approach velocity, $Vc = 11.52y_1^{1/6}D_{50}^{1/3}$ = _____ 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, $\chi = 0.122y_1[q_2/(D_{50}^{1/3}y_1^{7/6})]^{6/7} - y_1$ = _____ From Figure 10, y_{cs} = _____ ft

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 0.98 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.42 Using pier width a on Figure 11, ξ = 8.1 Pier scour y_{ps} = 7.1 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 5.9 ft right abutment, y_{aRT} = 8.3 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} = 16.6 and ψ_{RT} = 20

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 16.6 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 20. ft

98.1775

44.54555

44° 32' 43.98"

98° 10' 39"

Route 196 St Stream James River MRM _____ Date 7/23/12 Initials RAT

Bridge Structure No. 03258060 Location 40190 196 ST

GPS coordinates: N 44° 32' 43.6" W 98° 10' 38.5" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = ~~13292.46~~ sq. mi. 13340.98

The average bottom of the main channel was 1076.4 ft below top of guardrail at a point 110 ft from left abutment.

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

7	3
2	1030
5	5900
10	14000
25	33700
50	57400
100	91200
500	221000

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{50} = 57400			Q_{100} = 91200		
Estimated flow passing through bridge	57400			71675		
Estimated road overflow & overtopping	0			19525		
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? X Yes ____No ____Don't know, there is significant pier/contraction/abutment. right abutment has retreated several feet compared to left.

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

Note: cornfields on left/right overbanks. assume flat.

Comments, Diagrams & orientation of digital photos

1). left OB
2). main channel
3). right OB
4). left abutment
5). pier
6-8). right abutment
9). pier scour
10-11). left abutment
12). main channel

Summary of Results

	~~Q100~~ Q50	~~Q500~~ Q100
Bridge flow evaluated	57400	71675
Flow depth at left abutment (yaLT), in feet	3.1	5.9
Flow depth at right abutment (yaRT), in feet	5.5	8.3
Contraction scour depth (ycs), in feet	4.8	8.5
Pier scour depth (yps), in feet	7.1	7.1
Left abutment scour depth (yas), in feet	11.7	16.6
Right abutment scour depth (yas), in feet	15.9	20
1Flow angle of attack	10	10

See Comments/Diagram for justification where required