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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 31001085 Date 6/5/12 Initials RAL Region (A B C D)

Site ________ Location 25250 Old Mill Road, James River

Q_{100} = 28700 41150 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 41300 (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 = 333 ft. Flow angle at bridge = 40 ° Abut. Skew = 0 ° Effective Skew = 40 °

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 = 255.09 ft* $q_2 = Q_2/W_2$ = 162.7 ft^2/s

Bridge Vel, V_2 = 9 ft/s Final $y_2 = q_2/V_2$ = 18 ft Δh = 1.7 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 19.7 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. = 5.6 ft

Low Steel Elev. = 10.1 ft 25.5 −7.4 18.1

n (Channel) = 0.033

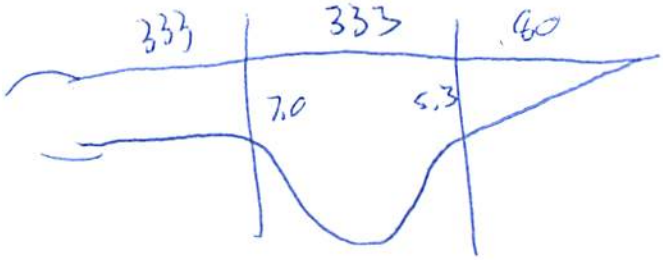
n (LOB) = 0.040

n (ROB) = 0.050

Pier Width = 2.5 ft

Pier Length = 2.5 ft

\# Piers for 100 yr = 3 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 333 ft

Width of left overbank flow at approach, W_{lob} = 333 ft Average left overbank flow depth, y_{lob} = 7.0 ft (8.0 · 2/3, 16.0)

Width of right overbank flow at approach, W_{rob} = 80 ft Average right overbank flow depth, y_{rob} = 5.3 ft

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

x = 11.16 From Figure 9 W_2 (effective) = 247.6 ft y_{cs} = 12.2 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, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = ________ 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

PIER SCOUR CALCULATIONS

PGRM: Pier

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

Froude # at bridge = 0.37 Using pier width a on Figure 11, ξ = 9.5 Pier scour y_{ps} = 8.2 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 7 ft right abutment, y_{aRT} = 5.3 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} = 18.6 and ψ_{RT} = 15.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 18.6 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 15.6 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 31001085 Date ~~[illegible]~~ 6/5/12 Initials RaT Region (A B (C) D)

Site ______ Location 25250 Old Mill Road

Q_{500}^{50} = ~~56000~~ 109000 by: drainage area ratio [illegible] flood freq. anal. _____ regional regression eq. X

Bridge discharge (Q_2) = 47048 (should be Q_{500} unless there is a relief bridge, road overflow, or bridge overtopping)

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

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

Bridge Width = 333 ft. Flow angle at bridge = 40 ° Abut. Skew = 0 ° Effective Skew = 40 °

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 = 255.09 ft* $q_2 = Q_2/W_2$ = 164.8 ft^2/s

Bridge Vel, V_2 = 9.1 ft/s Final $y_2 = q_2/V_2$ = 18.1 ft Δh = 1.7 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 19.8 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. = 56 ft

Low Steel Elev. = 18.1 ft

n (Channel) = 0.033

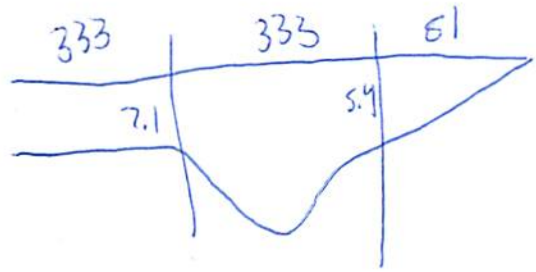
n (LOB) = 0.040

n (ROB) = 0.050

Pier Width = 2.5 ft

Pier Length = 2.5 ft

\# Piers for 500 yr = 3 ft



PGRM: Contract

CONTRACTION SCOUR

Width of main channel at approach section W_1 = 333 ft

Width of left overbank flow at approach, W_{lob} = 333 ft Average left overbank flow depth, y_{lob} = 7.1 ft

Width of right overbank flow at approach, W_{rob} = 81 ft Average right overbank flow depth, y_{rob} = 5.4 ft

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

x = 11.3 From Figure 9 W_2 (effective) = 247.6 ft y_{cs} = 12.3 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, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = ________ 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 = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.38 Using pier width a on Figure 11, ξ = 9.5 Pier scour y_{ps} = 8.2 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 7.1 ft right abutment, y_{aRT} = 5.4 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} = 18.8 and ψ_{RT} = 15.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 18.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 15.7 ft

97.96384
43.72515

Route old Mill Rd Stream James River MRM ______ Date 6/5/12 Initials RaT

Bridge Structure No. 31001085 Location 25250 Old Mill Road

GPS coordinates: N43° 43' 30.7" W 97° 57' 50.0" taken from: USL abutment X centerline of ⇑ MRM end ______

Datum of coordinates: WGS84 X NAD27 ______

Drainage area = 16323.76 sq. mi. 16333.9

The average bottom of the main channel was 25.5 ft below top of guardrail at a point 194 ft from left abutment.

Method used to determine flood flows: ____ Freq. Anal. ~~X~~ drainage area ratio X regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} =	~~[illegible]~~ Q25 41500		Q_{500} = ~~[illegible]~~ Q50	70800	
Estimated flow passing through bridge	41500			42048		
Estimated road overflow & overtopping	0			28752		
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	

5/30

2	1350
5	7370
10	17300
25	41500
50	70800
100	113000
500	276000

Riprap at abutments? ____ Yes ____ No X Marginal [illegible]

Evidence of past Scour? X Yes ____ No ____ Don't know pier contraction

Debris Potential? ____ High ____ Med X Low see picture 10

Does scour countermeasure(s) appear to have been designed? rose quartz along left abutment

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). main channel
2). piers
3). right abutment
4). left abutment
5). right OB
6). main channel
7-8) left OB
9). left abutment
10). debris
11). right abutment

Summary of Results

	~~Q100~~ Q25	~~Q500~~ Q50
Bridge flow evaluated	41500	42048
Flow depth at left abutment (yaLT), in feet	7.0	7.1
Flow depth at right abutment (yaRT), in feet	5.3	5.4
Contraction scour depth (ycs), in feet	12.2	12.3
Pier scour depth (yps), in feet	8.2	8.2
Left abutment scour depth (yas), in feet	18.6	18.8
Right abutment scour depth (yas), in feet	15.6	15.7
1Flow angle of attack	40	40

See Comments/Diagram for justification where required