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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50300199 Date 10-10-10 Initials KRL Region (A B C D)

Site _____ Location From I-90 Exit 406, 3.7 SW, 3E, 0.2 N

Q_{100} = 6500 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 6500 (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 = 126 ft. Flow angle at bridge = 50 ° Abut. Skew = 0 ° Effective Skew = 50

Width (W_2) iteration = 126 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 12.6 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 80.99 ft* $q_2 = Q_2/W_2$ = 80.3 ft^2/s

Bridge Vel, V_2 = 6.4 ft/s Final $y_2 = q_2/V_2$ = 12.6 ft Δh = 0.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 13.5 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. = 1.0 ft

Low Steel Elev. = 14.7 ft

n (Channel) = 0.03

n (LOB) = 0.035

n (ROB) = 0.035

Pier Width = 1.5 ft

Pier Length = 1.5 ft

Piers for 100 yr = 4 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 82 ft

Width of left overbank flow at approach, W_{lob} = 80 ft Average left overbank flow depth, y_{lob} = 4.1 ft

Width of right overbank flow at approach, W_{rob} = 6 ft Average right overbank flow depth, y_{rob} = 2.25 ft

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

x = 3 From Figure 9 W_2 (effective) = 75 ft y_{cs} = 3.6 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, $V_1 = Q_{100}/(y_1W_1)$ = _____ 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 = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.32 Using pier width a on Figure 11, ξ = 6.4 Pier scour y_{ps} = 5.4 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 4.1 ft right abutment, y_{aRT} = 2.25 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} = 13.4 and ψ_{RT} = 9.2

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 13.4 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 9.2 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 50300199 Date 10-10-16 Initials RRL Region (A B C D)

Site _____ Location From I-90 Exit 406, 3.7 SW, 3E, 0.2N

Q_{500} = 10300 by: drainage area ratio ✓ flood freq. anal. _____ regional regression eq. ____

Bridge discharge (Q_2) = 8801 (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 = 126 ft. Flow angle at bridge = 50 ° Abut. Skew = 0 ° Effective Skew = 50 °

Width (W_2) iteration = 126 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 14.7 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 80.99 ft* $q_2 = Q_2/W_2$ = 108.7 ft^2/s

Bridge Vel, V_2 = 7.4 ft/s Final $y_2 = q_2/V_2$ = 14.7 ft Δh = 1.1 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 15.8 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. = 1.0 ft

Low Steel Elev. = 14.7 ft

n (Channel) = 0.03

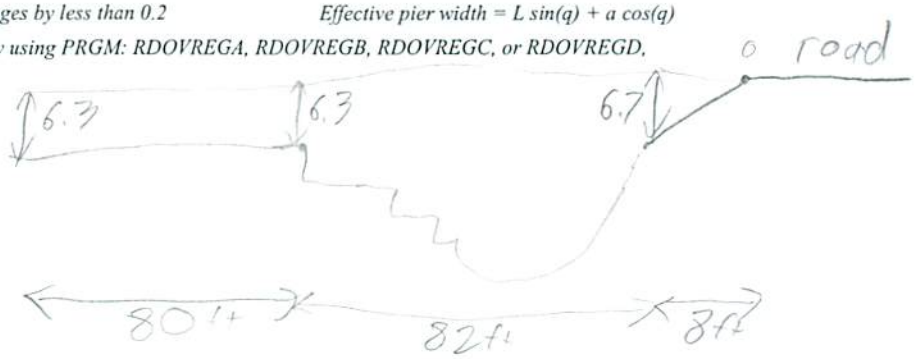
n (LOB) = 0.035

n (ROB) = 0.035

Pier Width = 1.5 ft

Pier Length = 1.5 ft

Piers for 500 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 82 ft

Width of left overbank flow at approach, W_{lob} = 80 ft Average left overbank flow depth, y_{lob} = 6.3 ft

Width of right overbank flow at approach, W_{rob} = 8 ft Average right overbank flow depth, y_{rob} = 3.35 ft

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

x = 4.71 From Figure 9 W_2 (effective) = 75 ft y_{cs} = 5.4 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, $V_1 = Q_{500}/(y_1W_1)$ = _____ 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 = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.34 Using pier width a on Figure 11, ξ = 6.4 Pier scour y_{ps} = 5.5 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 6.3 ft right abutment, y_{aRT} = 3.35 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} = 17.3 and ψ_{RT} = ~~17.4~~ 12.1

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 17.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = ~~17.4~~ ft 12.1

Route 484 Ave Stream Beaver Creek MRM________ Date 10-10-10 Initials RRL

Bridge Structure No. 5030 0199 Location From I-90 Exit 406, 3.7 SW, 3E, 0.2 N

GPS coordinates: N43° 33.640' W96° 31.910' taken from: USL abutment_____ centerline of ⥣ MRM end _____

Datum of coordinates: WGS84_____ NAD27_____

Drainage area = 130.45 sq. mi.

The average bottom of the main channel was 18.3 ft below top of guardrail at a point 34 ft from left abutment.

Method used to determine flood flows: ____Freq. Anal. ✓ drainage area ratio ____regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 6500			Q_{500} = 10300		
Estimated flow passing through bridge	6500			8801		
Estimated road overflow & overtopping	0			1499		
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 ____No X Marginal

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

Debris Potential? ____High ____Med X Low

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

Riprap ____Yes ____No X Don't know ____NA

Spur Dike ____Yes ____No X Don't know ____NA

Other ________________ ____Yes ____No X 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- Bridge Deck
2- Upstream
3- Downstream
4- LOB
5- ROB
6- Left Abutment
7- Right Abutment
8- Piers

Notes: Steep angle into bridge. Significant sand deposition on right side bridge.

Summary of Results

	Q100	Q500
Bridge flow evaluated	6500	8801
Flow depth at left abutment (yaLT), in feet	4.1	6.3
Flow depth at right abutment (yaRT), in feet	2.25	3.35
Contraction scour depth (ycs), in feet	3.6	5.4
Pier scour depth (yps), in feet	5.4	5.5
Left abutment scour depth (yas), in feet	13.4	17.3
Right abutment scour depth (yas), in feet	9.2	~~17.4~~ 12.1
1Flow angle of attack	50	50

See Comments/Diagram for justification where required