DUP

OK-RAT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 473784 44 Date 9-19-12 Initials RFT Region (A (B) C D)

Site _____ Location 5 mi NE Hereford on New Underwood Rd

Q_{100} = 38100 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 38100 (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 = 388 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 388 301 343 327 333

Avg. flow depth at bridge, y_2 iteration = 12.0 13.7 12.8 13.1 13.0

Corrected channel width at bridge Section = W_2 times cos of flow angle = 331.73 ft* $q_2 = Q_2/W_2$ = 114.9 ft²/s

Bridge Vel, V_2 = 8.8 ft/s Final $y_2 = q_2/V_2$ = 13.0 ft Δh = 1.6 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 14.6 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,

center two pier sets are different than outer two for this analysis, treat all sets like center two

irrigation ridges on either side of the channel will help guide flow toward bridge; may mitigate some abutment scour

Water Surface Elev. = _____ ft

Low Steel Elev. = ≈20.0 ft

n (Channel) = .033

n (LOB) = .040

n (ROB) = .040

Pier Width = 3.0 ft

Pier Length = 3.0 ft

Piers for 100 yr = 4 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 388 ft

Width of left overbank flow at approach, W_{lob} = 388 ft Average left overbank flow depth, y_{lob} = 2.5 ft

Width of right overbank flow at approach, W_{rob} = 388 ft Average right overbank flow depth, y_{rob} = 0.85 ft

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

x = 4.02 From Figure 9 W_2 (effective) = 319.7 ft y_{cs} = 4.7 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ 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 $D_{50} >= D_{c50}$, χ = 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 = 0.43 Using pier width a on Figure 11, ξ = 10.7 Pier scour y_{ps} = 9.4 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 2.5 ft right abutment, y_{aRT} = 0.85 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} = 10.2 and ψ_{RT} = 3.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 10.2 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 3.7 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 47378444 Date _____ Initials _____ Region (A (B) C D)

Site _____ Location _____

Q_{500} = 98000 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 98000 (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 = 388 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 388 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 19.7 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 386.52ft* $q_2 = Q_2/W_2$ = 253.5 ft^2/s

Bridge Vel, V_2 = 12.9 ft/s Final $y_2 = q_2/V_2$ = 19.7 ft Δh = 3.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 23.1 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,

talked to landowner. he has been here ≈ 60 years and has never seen flow reach low steel.

Water Surface Elev. = _____ ft

Low Steel Elev. = ≈ 20.0 ft

n (Channel) = .033

n (LOB) = .040

n (ROB) = .040

Pier Width = 3 ft

Pier Length = 3 ft

Piers for 500 yr = 4 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 388 ft

Width of left overbank flow at approach, W_{lob} = 388 ft Average left overbank flow depth, y_{lob} = 11 ft

Width of right overbank flow at approach, W_{rob} = 388 ft Average right overbank flow depth, y_{rob} = 9.35 ft

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

x = 10.94 From Figure 9 W_2 (effective) = 374.5 ft y_{cs} = 11.9 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 = 0.51 Using pier width a on Figure 11, ξ = 10.7 Pier scour y_{ps} = 9.7 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 11 ft right abutment, y_{aRT} = 9.35 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} = 22.2 and ψ_{RT} = 20.8

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 22.2 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 20.8 ft

New

Route Underwood Rd Stream West Elm Ck MRM _____ Date _____ Initials _____

Bridge Structure No. 47378444 Location 5 mi NE from Hereford on New Underwood Rd

GPS coordinates: N 44° 23.920'; W 102° 48.501' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 ✓ NAD27 _____

Drainage area = 392 sq. mi.

The average bottom of the main channel was 27.6 ft below top of guardrail at a point 141 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 38100			Q_{500} = 98000		
Estimated flow passing through bridge	38100			98000		
Estimated road overflow & overtopping	0			0		
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		✓			✓	
Chance of Pressure flow		✓			✓	
Armored appearance to channel		✓			✓	
Lateral instability of channel			✓			✓

Riprap at abutments? ____Yes ✓No ____Marginal

Evidence of past Scour? ✓Yes ____No ____Don't know pierscour, Cont. Scour pool under bridge

Debris Potential? ____High X Med ____Low trees upstream

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

Riprap	____Yes	____No	____Don't know	✓NA
Spur Dike	____Yes	____No	____Don't know	✓NA
Other guide bank	✓Yes	____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

Str. no.
approach from bridge
LOB from channel
ROB from channel
ROB irrigation berm
ROB irrigation berm

bridge from approach
center pier sets
outer piers, left side
left abut. under bridge
rt. abut. under bridge

Summary of Results

	Q100	Q500
Bridge flow evaluated	38100	98000
Flow depth at left abutment (yaLT), in feet	2.5	11
Flow depth at right abutment (yaRT), in feet	0.85	9.35
Contraction scour depth (ycs), in feet	4.7	11.9
Pier scour depth (yps), in feet	9.4	9.7
Left abutment scour depth (yas), in feet	10.2	22.2
Right abutment scour depth (yas), in feet	3.7	20.8
Flow angle of attack	5°	5°

See Comments/Diagram for justification where required