ok-RAT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 47363476 Date 9-19-12 Initials RFT Region (A (B) C D)

Site ____________ Location ~2.5 mi E & 2.7 mi S of Hereford on New Underwood Rd

Q_{100} = 51900 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 51900 (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 = 352 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 286 314 318 ____

Avg. flow depth at bridge, y_2 iteration = 16.6 15.8 15.7 ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 316.79 ft* $q_2 = Q_2/W_2$ = 163.8 ft^2/s

Bridge Vel, V_2 = 10.5 ft/s Final $y_2 = q_2/V_2$ = 15.7 ft Δh = 2.2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 17.9 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.

road overflow occurs at $y_2 \approx 26$ south of bridge

Water Surface Elev. = ______ ft

Low Steel Elev. = ______ ft

n (Channel) = .025

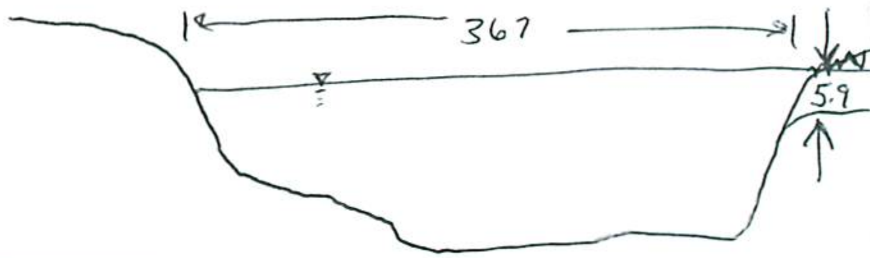
n (LOB) = .030

n (ROB) = .030

Pier Width = 2.0 ft

Pier Length = 23.0 ft

Piers for 100 yr = 3 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 367 ft

Width of left overbank flow at approach, W_{lob} = 0 ft Average left overbank flow depth, y_{lob} = 0 ft

Width of right overbank flow at approach, W_{rob} = 352 ft Average right overbank flow depth, y_{rob} = 5.9 ft

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

x = 5.89 From Figure 9 W_2 (effective) = 310.8 ft y_{cs} = 6.6 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, $V_c = 11.17y_1^{1/6}D_{50}^{1/3}$ = ______ 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 = 11.5 Correction factor for flow angle of attack (from Table 1), K2 = 1.5

Froude # at bridge = 0.47 Using pier width a on Figure 11, ξ = 8 Pier scour y_{ps} = 10.7 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0 ft right abutment, y_{aRT} = 5.9 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} = 0 and ψ_{RT} = 16.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 16.6 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 47363476 Date ______ Initials ______ Region (A (B) C D)

Site ______ Location ~2.5 mi E & 2.7 mi S of Hereford on New Underwood Rd

Q_{500} = 98400 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 98400 (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 = 352 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 352 340 342 ______

Avg. flow depth at bridge, y_2 iteration = 20.8 21.2 21.1 ______

Corrected channel width at bridge Section = W_2 times cos of flow angle = 340.7 ft* $q_2 = Q_2/W_2$ = 288.8 ft^2/s

Bridge Vel, V_2 = 13.7 ft/s Final $y_2 = q_2/V_2$ = 21.1 ft Δh = 3.9 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 25.0 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. = ______ ft

Low Steel Elev. = ______ ft

n (Channel) = .025

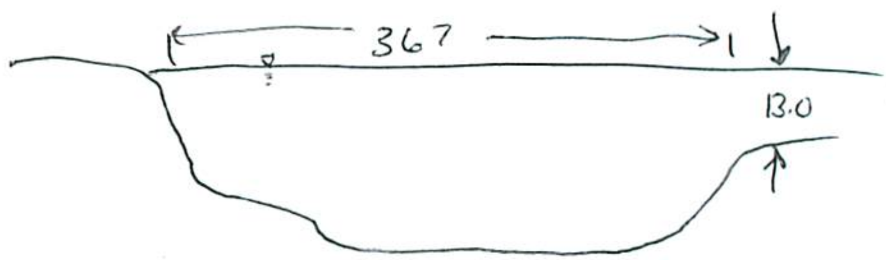
n (LOB) = .030

n (ROB) = .030

Pier Width = 2.0 ft

Pier Length = 23 ft

\# Piers for 500 yr = 3 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 367 ft

Width of left overbank flow at approach, W_{lob} = 0 ft Average left overbank flow depth, y_{lob} = 0 ft

Width of right overbank flow at approach, W_{rob} = 352 ft Average right overbank flow depth, y_{rob} = 13.0 ft

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

x = 9.78 From Figure 9 W_2 (effective) = 334.7 ft y_{cs} = 10.7 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, $V_1 = Q_{500}/(y_1 W_1)$ = ______ 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = ~~13~~ 11.5 Correction factor for flow angle of attack (from Table 1), K2 = 1.5

Froude # at bridge = 0.53 Using pier width a on Figure 11, ξ = 8 Pier scour y_{ps} = 10.9 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0 ft right abutment, y_{aRT} = 13.0 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} = 0 and ψ_{RT} = 23.8

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 23.8 ft

Route New Underwood Rd Stream Belle Fourche R.v MRM ________ Date ________ Initials ________

Bridge Structure No. 47363476 Location ~2.5 mi E + 2.7 mi S of Hereford on New Underwood Rd

GPS coordinates: N 44° 21.062' W 102° 50.247' taken from: USL abutment ✓ centerline of ⇑ MRM end ____

Datum of coordinates: WGS84 ✓ NAD27 ____

Drainage area = 6365.06 sq. mi.

The average bottom of the main channel was 35.4 ft below top of guardrail at a point 75 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 51900			Q_{500} = 98400		
Estimated flow passing through bridge	51900			98400		
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			✓			✓

7/2

2	2960
5	9320
10	16500
25	27200
50	38300
100	51900
500	98400

Riprap at abutments? ____Yes ✓ No ____Marginal

Evidence of past Scour? ____Yes ✓ No ____Don't know

Debris Potential? ____High ✓ Med ____Low

no riprap, but old road grade on rt. side may protect abut.

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 ________ ____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
high left bank from bridge
ROB from bridge
Bridge from left

left abut. from under bridge
right abut. from left downstream

Summary of Results

	Q100	Q500
Bridge flow evaluated	51900	98400
Flow depth at left abutment (yaLT), in feet	0	0
Flow depth at right abutment (yaRT), in feet	5.9	13.0
Contraction scour depth (ycs), in feet	6.6	10.7
Pier scour depth (yps), in feet	10.7	10.9
Left abutment scour depth (yas), in feet	0	0
Right abutment scour depth (yas), in feet	16.6	23.8
1Flow angle of attack	5°	5°

See Comments/Diagram for justification where required