OK-Rat

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 41092060 Date 9-18-12 Initials RFT Region (A B C D)

Site _____ Location South Service Rd off I-90 exit 10

Q_{100}^{50} = ~~12100~~ 7350 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 6936 (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 = 172 ft. Flow angle at bridge = 50 ° Abut. Skew = 45 ° Effective Skew = 5 °

Width (W_2) iteration = 119 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 8.5 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 76.49 ft* $q_2 = Q_2/W_2$ = 90.7 ft^2/s

~~76.49~~ 76.49

Bridge Vel, V_2 = 10.7 ft/s Final $y_2 = q_2/V_2$ = 8.5 ft Δh = 2.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 10.8 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.

Low point in road (west of bridge) ≈ 7.4' Assume $y_{max\ scour}$ ≈ 8.5

Water Surface Elev. = _____ ft

Low Steel Elev. = 9.3 ft at low end

n (Channel) = 0.075

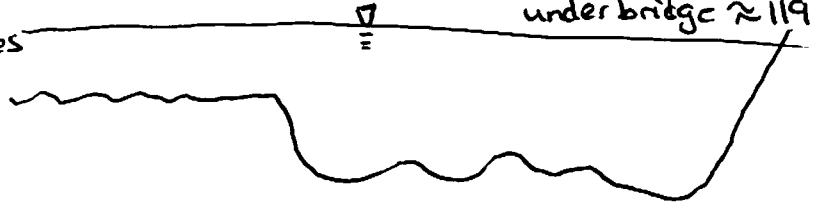
n (LOB) = 0.060 mowed trees

n (ROB) = 0.040

Pier Width = 2.75 ft

Pier Length = 2.75 ft

Piers for 100 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 75 ft

Width of left overbank flow at approach, W_{lob} = 100 ft Average left overbank flow depth, y_{lob} = 8 ft

Width of right overbank flow at approach, W_{rob} = 85 ft Average right overbank flow depth, y_{rob} = 1.5 ft

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

x = 12.2 From Figure 9 W_2 (effective) = 71 ft y_{cs} = 13.3 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ 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 $D_{50} >= D_{c50}$, $\chi = 0.0$

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 = 0.65 Using pier width a on Figure 11, ξ = 10.1 Pier scour y_{ps} = 9.5 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 8 ft right abutment, y_{aRT} = 1.5 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} = 19.8 and ψ_{RT} = 6.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 19.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 6.3 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 41092060 Date _____ Initials _____ Region (A B C D)

Site _____ Location _____

~~Q_{500}~~ 25 7350 4170 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = _____ (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 = 172 ft. Flow angle at bridge = ~~4350~~° Abut. Skew = 45 ° Effective Skew = 5 °

Width (W_2) iteration = 100 118 116 ____

Avg. flow depth at bridge, y_2 iteration = 7.1 6.5 6.5 ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 74.56 ft* $q_2 = Q_2/W_2$ = 55.9 ft²/s

Bridge Vel, V_2 = 8.6 ft/s Final $y_2 = q_2/V_2$ = 6.5 ft Δh = 1.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.0 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. = 9.3 ft at low end

n (Channel) = .075

n (LOB) = .060

n (ROB) = .04

Pier Width = 2.75 ft

Pier Length = 2.75 ft

Piers for 500 yr = 2 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 75 ft

Width of left overbank flow at approach, W_{lob} = 100 ft Average left overbank flow depth, y_{lob} = 5.2 ft

Width of right overbank flow at approach, W_{rob} = 80 ft Average right overbank flow depth, y_{rob} = ~~80~~ 0 ft

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

x = 7.75 From Figure 9 W_2 (effective) = 69.1 ft y_{cs} = 8.6 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, $V_1 = Q_{500}/(y_1 W_1)$ = _____ 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 = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = .59 Using pier width a on Figure 11, ξ = 10.1 Pier scour y_{ps} = 9.4 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 5.2 ft right abutment, y_{aRT} = 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} = 15.4 and ψ_{RT} = 0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 15.4 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0 ft

Route South Serv. Rd Stream Spearfish Ck MRM _____ Date _____ Initials _____

Bridge Structure No. 4109 2060 Location South Service Rd off I-90 exit 10

GPS coordinates: N 44° 31.078' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

W 103° 51.933' Datum of coordinates: WGS84 ✓ NAD27 _____

Drainage area = 172.39 sq. mi.

The average bottom of the main channel was 17.6 ft below top of guardrail at a point 36 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	$Q_{\cancel{50}\,100}$ = 12100 7350			$Q_{\cancel{50}\,25\,500}$ = ~~7350~~ 4170		
Estimated flow passing through bridge	6936 ← Qmax scour			4170		
Estimated road overflow & overtopping	5164					
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping		✓			✓	
Chance of Pressure flow	✓				✓	
Armored appearance to channel		✓			✓	
Lateral instability of channel		✓			✓	

pk	Q
2	217
5	865
10	1850
25	4170
50	7350
100	12100
500	33200

Gabion baskets on left abutment, some riprap on upstream rt.

Riprap at abutments? X Yes ____No ____Marginal

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

Debris Potential? ____High ~~X~~ Med ____Low trees upstream

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

Riprap X 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____	Sand____	Gravel X	Cobbles____	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

Comments, Diagrams & orientation of digital photos low flow channel has rock & cobble, but flood channel & overbanks are finer

assume live bed contraction scour

Str. no.

approach from bridge

LOB

ROB

riprap on rt abutment

left abutment under bridge

bridge from near left abut.

Summary of Results

	$Q_{\cancel{100}}$ 50	Q_{500} 25
Bridge flow evaluated	6936 = Qmax scour	4170
Flow depth at left abutment (yaLT), in feet	8	5.2
Flow depth at right abutment (yaRT), in feet	1.5	0
Contraction scour depth (ycs), in feet	13.3	8.6
Pier scour depth (yps), in feet	9.5	9.4
Left abutment scour depth (yas), in feet	19.8	15.4
Right abutment scour depth (yas), in feet	6.3	0
1Flow angle of attack	50° (5° off)	50° (5° off)

See Comments/Diagram for justification where required