ok-RaT

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 41126089 Date 9-18-12 Initials RFT Region ((A) B C D)

Site ______ Location SE of Spearfish

Q_{100} = 2600 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 2600 (should be Q_{100} 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 = 94 ft. Flow angle at bridge = 12 ° Abut. Skew = 5 ° Effective Skew = 7 °

Width (W_2) iteration = 94 79 80 ____

Avg. flow depth at bridge, y_2 iteration = 4.5 4.9 4.9 ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 78.25 ft* $q_2 = Q_2/W_2$ = 33.2 ft^2/s

Bridge Vel, V_2 = 6.8 ft/s Final $y_2 = q_2/V_2$ = 4.9 ft Δh = 0.9 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 5.8 ft

** NOTE: repeat above calculations until y_2 changes by less than 0.2* *Effective pier width = L sin(q) + a cos(q)* y_2 > 7.3 is abut. to abut.

If y_2 is above LS, then account for Road Overflow using PRGM: RDOVREGA, RDOVREGB, RDOVREGC, or RDOVREGD.

road overflow begins approximately at y_2 = 11.8 ft

Water Surface Elev. = dry ft

Low Steel Elev. = 10.0 ft

n (Channel) = .035

n (LOB) = .033

n (ROB) = .033

Pier Width = 1.0 ft

Pier Length = 36 ft

\# Piers for 100 yr = 2 ft

PGRM: Contract

CONTRACTION SCOUR

Width of main channel at approach section W_1 = 101 ft

Width of left overbank flow at approach, W_{lob} = 9 ft Average left overbank flow depth, y_{lob} = 0.8 ft

Width of right overbank flow at approach, W_{rob} = 61 ft Average right overbank flow depth, y_{rob} = 0.8 ft

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

x = ______ From Figure 9 W_2 (effective) = ______ ft y_{cs} = ______ ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = 0.2 ft Average approach velocity, $V_1 = Q_{100}/(y_1 W_1)$ = 2.62 ft/s

Critical approach velocity, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = 8.76 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = .047 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} = 0 ft

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 36 Correction factor for flow angle of attack (from Table 1), K2 = 1.6

Froude # at bridge = 0.54 Using pier width a on Figure 11, ξ = 4.9 Pier scour y_{ps} = 7.1 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 0.8 ft right abutment, y_{aRT} = 0.8 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} = 3.5 and ψ_{RT} = 3.5

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 3.5 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 3.5 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 41126089 Date ________ Initials ________ Region (A B C D) — A circled

Site ________ Location SE of Spearfish

Q_{500} = 6770 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 6770 (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 = 94 ft. Flow angle at bridge = 12 ° Abut. Skew = 5 ° Effective Skew = 7 °

Width (W_2) iteration = 94 ____ ____ ____ Q_{500} is abut. to abut.

Avg. flow depth at bridge, y_2 iteration = 7.6 ____ ____ ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 91.95 ft* $q_2 = Q_2/W_2$ = 73.6 ft^2/s

Bridge Vel, V_2 = 9.7 ft/s Final $y_2 = q_2/V_2$ = 7.6 ft Δh = 1.9 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 9.5 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. = dry ft

Low Steel Elev. = 10.0 ft

n (Channel) = .035

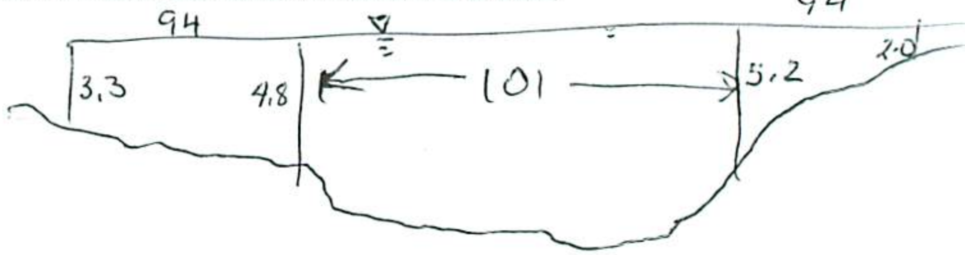
n (LOB) = .033

n (ROB) = .033

Pier Width = 1.0 ft

Pier Length = 36 ft

\# Piers for 500 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 101 ft

Width of left overbank flow at approach, W_{lob} = 94 ft Average left overbank flow depth, y_{lob} = 4.05 ft

Width of right overbank flow at approach, W_{rob} = 94 ft Average right overbank flow depth, y_{rob} = ~~3.55~~ 3.6 ft

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

x = ________ From Figure 9 W_2 (effective) = ________ ft y_{cs} = ________ ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles)

Estimated bed material D_{50} = 0.2 ft Average approach velocity, $V_1 = Q_{500}/(y_1 W_1)$ = 2.47 ft/s

Critical approach velocity, $V_c = 11.17 y_1^{1/6} D_{50}^{1/3}$ = 9.51 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = .091 ft If $D_{50} >= D_{c50}$, χ = 0.0 (circled)

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} = 0 ft

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 36 Correction factor for flow angle of attack (from Table 1), K2 = 1.6

Froude # at bridge = 0.62 Using pier width a on Figure 11, ξ = 4.9 Pier scour y_{ps} = 7.2 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 4.05 ft right abutment, y_{aRT} = ~~3.55~~ 3.6 ft

Shape coefficient K_1= 1.00 for vertical-wall, 0.82 for vertical-wall with wingwalls, 0.55 for spill-through (circled)

Using values for y_{aLT} and y_{aRT} on figure 12, ψ_{LT} = 13.3 and ψ_{RT} = 12.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 13.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 12.6 ft

Route Colorado Blvd Stream False Bottom Ck MRM ______ Date ______ Initials ______

Bridge Structure No. 41126089 Location SE of Spearfish

GPS coordinates: N 44° 28.491' W103° 47.775' taken from: USL abutment X centerline of ⇑ MRM end ____

Datum of coordinates: WGS84 X NAD27 ____

Drainage area = 14.94 sq. mi.

The average bottom of the main channel was 13.8 ft below top of guardrail at a point 26 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 2600			Q_{500} = 6770		
Estimated flow passing through bridge	2600			6770		
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			✓			✓

7/3

Ri	
2	55.7
5	209
10	436
25	946
50	1630
100	2600
500	~~690~~ 6770

Riprap at abutments? X Yes ____No ____Marginal Gabion baskets

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

Debris Potential? ____High ____Med X Low a few small 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 ______________ ____Yes ____No ____Don't know ✓ NA

Bed Material Classification Based on Median Particle Size (D_{50})

Material	Silt/Clay____	Sand____	Gravel____	Cobbles X	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

assume CWCS

Comments, Diagrams & orientation of digital photos

Str. no
approach from bridge
LOB from channel
ROB from channel
Bridge from approach

left abut.
rt. abut.
band of riprap in front of bridge

Summary of Results

	Q100	Q500
Bridge flow evaluated	2600	6770
Flow depth at left abutment (yaLT), in feet	0.8	4.05
Flow depth at right abutment (yaRT), in feet	0.8	3.6
Contraction scour depth (ycs), in feet	0	0
Pier scour depth (yps), in feet	7.1	7.2
Left abutment scour depth (yas), in feet	3.5	13.3
Right abutment scour depth (yas), in feet	3.5	12.6
1Flow angle of attack	12° (7° eff)	12° (7° eff)

See Comments/Diagram for justification where required