SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 06120012 Date 5-18-12 Initials CW/RaT Region (A B (C) D) Brookings Co

Site ____________ Location 466 Ave, 3 mi. S, 1 mi. E of SW corner of Estelline

Q_{100} = Q_5 3920 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 3920 (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 = 245 ft. Flow angle at bridge = 60 ° Abut. Skew = 0 ° Effective Skew = 60 °

Width (W_2) iteration = ________ ________ ________ ________

Avg. flow depth at bridge, y_2 iteration = ________ ________ ________ ________

Corrected channel width at bridge Section = W_2 times cos of flow angle = 122.5 ft* $q_2 = Q_2/W_2$ = 32 ft^2/s

3.8

Bridge Vel, V_2 = 4 ft/s Final $y_2 = q_2/V_2$ = 8 ft Δh = 0.3 ft

.9

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.3 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 ft

Low Steel Elev. = 9.2 ft -2.9 13 14.11

n (Channel) = 0.033 2 -4.9

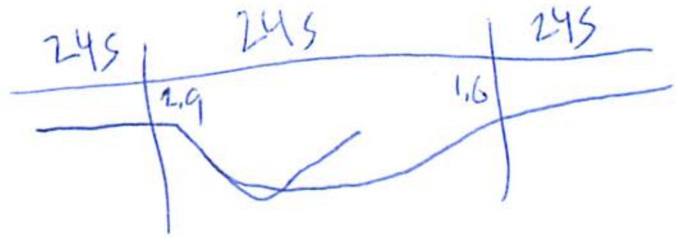
n (LOB) = 0.033 -4.9 9.2

n (ROB) = 0.033

Pier Width = 2 ft

Pier Length = ~~2.6~~ 9.4 ft 3.9+4.5+1

\# Piers for 100 yr = 6 ft 6



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 245 ft

Width of left overbank flow at approach, W_{lob} = 245 ft Average left overbank flow depth, y_{lob} = 2.9 ft

Width of right overbank flow at approach, W_{rob} = 245 ft Average right overbank flow depth, y_{rob} = 1.6 ft

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

x = 14.48 From Figure 9 W_2 (effective) = 110.5 ft y_{cs} = 14.7 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, $V_1 = Q_{100}/(y_1W_1)$ = ________ 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 = 4.7 Correction factor for flow angle of attack (from Table 1), K2 = 2.7

Froude # at bridge = 0.25 Using pier width a on Figure 11, ξ = 4 Pier scour y_{ps} = 12.5 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 2.9 ft right abutment, y_{aRT} = 1.6 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} = 11.3 and ψ_{RT} = 6.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 11.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 6.6 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 06120012 Date ____________ Initials ________ Region (A B (C) D)

Site ______________________ Location 466 Ave, 3 mi; S, 1 mi; E of SW corner of Estellin-

Q_{500} = Q_{10} 6280 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 5207 (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 = 245 ft. Flow angle at bridge = 60 ° Abut. Skew = 0 ° Effective Skew = 60 °

Width (W_2) iteration = ________ ________ ________ ________

Avg. flow depth at bridge, y_2 iteration = ________ ________ ________ ________

Corrected channel width at bridge Section = W_2 times cos of flow angle = 122.5 ft* $q_2 = Q_2/W_2$ = 42.5 ft^2/s

Bridge Vel, V_2 = 4.6 ft/s Final $y_2 = q_2/V_2$ = 9.2 ft Δh = 0.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 9.6 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.

Water Surface Elev. = 1 ft

Low Steel Elev. = 9.2 ft

n (Channel) = 0.033

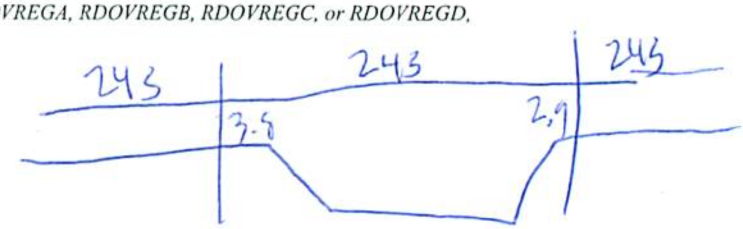
n (LOB) = 0.033

n (ROB) = 0.035

Pier Width = 2 ft

Pier Length = 9.4 ft

Piers for 500 yr = 6 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 245 ft

Width of left overbank flow at approach, W_{lob} = 245 ft Average left overbank flow depth, y_{lob} = 3.8 ft

Width of right overbank flow at approach, W_{rob} = 245 ft Average right overbank flow depth, y_{rob} = 2.9 ft

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

x = 19.32 From Figure 9 W_2 (effective) = 110.5 ft y_{cs} = 17.3 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, $V_1 = Q_{500}/(y_1W_1)$ = ________ ft/s

Critical approach velocity, $Vc = 11.17y_1^{1/6}D_{50}^{1/3}$ = ____________ 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: Pie

L/a ratio = 4.7 Correction factor for flow angle of attack (from Table 1), K2 = 2.7

Froude # at bridge = 0.27 Using pier width a on Figure 11, ξ = 8 Pier scour y_{ps} = 17.7 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 3.8 ft right abutment, y_{aRT} = 2.9 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} = 12.9 and ψ_{RT} = 11.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 12.9 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 11.3 ft

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Route 466 Ave Stream Big Sioux River MRM________ Date ____________ Initials________

Bridge Structure No. 06120012 Location 466 Ave, 3mi S & 1mi E of SW corner Estelline

GPS coordinates: N 44° 31' 43.9" W 96° 53' 20.2" taken from: USL abutment_____ centerline of ⇑ MRM end ______

Datum of coordinates: WGS84_____ NAD27_____

Drainage area = 1484 sq. mi.

The average bottom of the main channel was 14.1 ft below top of guardrail at a point 112 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	~~Q_{100}~~ = ~~Q~~ Q_5 3920			~~Q_{500}~~ = Q_{10} = 6280		
Estimated flow passing through bridge	3920			5207		
Estimated road overflow & overtopping				1093		
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	

5/13

2	1480
5	3920
10	6280
25	10200
50	13700
100	17800
500	29000

Riprap at abutments? _____Yes _____No __+__Marginal - On right bank - yes, left - no

Evidence of past Scour? __X__Yes _____No _____Don't know - pier, contraction

Debris Potential? _____High _____Med __X__Low

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

Riprap	_____Yes	__X__No	_____Don't know	_____NA
Spur Dike	_____Yes	__X__No	_____Don't know	_____NA
Other ________________	_____Yes	__X__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

2337 Str. no.
2338 approach from bridge
2339 ROB from bridge
2340 LOB from bridge
2341 Bridge from approach
2342 bridge from rt. abutment
2343 bridge from approach

Summary of Results

	~~Q100~~ Q_5	~~Q500~~ Q_{10}
Bridge flow evaluated	3920	~~6280~~ 5207
Flow depth at left abutment (yaLT), in feet	~~3.9~~ 2.9	3.9
Flow depth at right abutment (yaRT), in feet	~~2.9~~ 1.6	2.9
Contraction scour depth (ycs), in feet	~~17.3~~ 14.7	17.3
Pier scour depth (yps), in feet	~~17.7~~ 17.5	17.7
Left abutment scour depth (yas), in feet	~~12.9~~ 11.3	12.9
Right abutment scour depth (yas), in feet	~~11.3~~ 6.6	11.3
1Flow angle of attack	60°	60°

See Comments/Diagram for justification where required