SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 15268139 Date 10-12-11 Initials RT Region (A B (C) D)

Site ________ Location from Kranzburg, 1 W, 3.7 N

Q_{100} = 2930 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 2930 (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 = 80 ft. Flow angle at bridge = 0 ° Abut. Skew = 0 ° Effective Skew = 0 °

Width (W_2) iteration = 80 ____ ____ ____

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

Corrected channel width at bridge Section = W_2 times cos of flow angle = 80 ft* $q_2 = Q_2/W_2$ = 36.6 ft^2/s

Bridge Vel, V_2 = 4.3 ft/s Final $y_2 = q_2/V_2$ = 8.5 ft Δh = 0.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.9 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,

bridge flows abutment to abutment at Q_{100}

Water Surface Elev. = 0.8 ft

Low Steel Elev. = 9.0 ft

n (Channel) = .030

n (LOB) = .027

n (ROB) = .027

Pier Width = 1.65 ft

Pier Length = 1.65 ft

\# Piers for 100 yr = 3 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 80 ft

Width of left overbank flow at approach, W_{lob} = 160 ft Average left overbank flow depth, y_{lob} = 1.4 ft

Width of right overbank flow at approach, W_{rob} = 160 ft Average right overbank flow depth, y_{rob} = ~~3.8~~ 1.6 ft

assume 2X bridge length

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

x = 2.76 From Figure 9 W_2 (effective) = 75.1 ft y_{cs} = 3.3 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, $V_1 = Q_{100}/(y_1W_1)$ = ________ 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

N/A

PIER SCOUR CALCULATIONS

PGRM: Pier

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

Froude # at bridge = 0.26 Using pier width a on Figure 11, ξ = 6.9 Pier scour y_{ps} = 5.6 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 1.4 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} = 5.9 and ψ_{RT} = 6.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 8.7 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 9.9 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 15268139 Date ________ Initials ________ Region (A B (C) D)

Site ________ Location ________

Q_{500} = 4710 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 4520 (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 = 80 ft. Flow angle at bridge = 0 ° Abut. Skew = 0 ° Effective Skew = 0 °

Width (W_2) iteration = 80 ________ ________ ________

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

Corrected channel width at bridge Section = W_2 times cos of flow angle = 80 ft* $q_2 = Q_2/W_2$ = 56.5 ft^2/s

Bridge Vel, V_2 = 5.3 ft/s Final $y_2 = q_2/V_2$ = 10.6 ft Δh = 0.6 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 11.2 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. = 0.8 ft

Low Steel Elev. = 9.0 ft

n (Channel) = ~~[illegible]~~ .030

n (LOB) = .027

n (ROB) = .027

Pier Width = 1.65 ft

Pier Length = 1.65 ft

\# Piers for 500 yr = 3 ft

$Q_{max\ scour} < Q_{500}$ assume maximum scour occurs at verge of road overflow $\approx y = 10.6$

$Q_{max\ scour} \approx 4520$

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 80 ft

Width of left overbank flow at approach, W_{lob} = 160 ft Average left overbank flow depth, y_{lob} = 3.8 ft

Width of right overbank flow at approach, W_{rob} = 160 ft Average right overbank flow depth, y_{rob} = 3.7 ft

assume 2x bridge length

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

x = 9.31 From Figure 9 W_2 (effective) = 75.1 ft y_{cs} = 10.2 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

N/A

PIER SCOUR CALCULATIONS

PGRM: Pier

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

Froude # at bridge = 0.29 Using pier width a on Figure 11, ξ = 6.9 Pier scour y_{ps} = 5.7 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 3.8 ft right abutment, y_{aRT} = 3.7 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} = 12.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 19.2 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 19.0 ft

Route 463rd Ave Stream Willow Creek MRM ________ Date ____________ Initials ________

Bridge Structure No. 15268139 Location From Kranzburg, 1W, 3.7 N

GPS coordinates: N 44° 56.918' W 96° 56.842' taken from: USL abutment X centerline of ⇑ MRM end ______

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 71.91 sq. mi.

The average bottom of the main channel was 12.9 ft below top of guardrail at a point 30 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 2930			Q_{500} = 4710		
Estimated flow passing through bridge	2930			4520		
Estimated road overflow & overtopping	0			190		
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

Debris Potential? ____High ____Med ✓ Low

Left abutment is scoured, right abutment has some field stone rip rap, but is also scoured. No obvious pier scour, but one pier on downstream side of bridge has been reinforced and has a larger diameter now.

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 X	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

In this setting, the bridge appears to be at the low point in the road grade. If road overflow occurs, it will be at the bridge.

Photos
structure number
approach from bridge
LOB from bridge
ROB from bridge
Bridge from left approach
left abut. under bridge
right abut under bridge
reinforced pier

Summary of Results

	Q100	Q500
Bridge flow evaluated	2930	4520
Flow depth at left abutment (yaLT), in feet	1.4	3.8
Flow depth at right abutment (yaRT), in feet	1.6	3.7
Contraction scour depth (ycs), in feet	3.3	10.2
Pier scour depth (yps), in feet	5.6	5.7
Left abutment scour depth (yas), in feet	8.7	19.2
Right abutment scour depth (yas), in feet	9.9	19.0
1Flow angle of attack	0°	0°

See Comments/Diagram for justification where required

Basin Characteristics from Provisional StreamStats 10-7-11

Cont. D.A. = 71.91 mi2

PII = 0.97

100% Subregion A

Manually Calculated Peaks

Q_{100} = 2930 cfs

Q_{500} = 4710 cfs