SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 26330038 Date 10-11-11 Initials RT Region (A B (C) D)

Site _____ Location From Milbank, 3E, 3.2N

Q_{100} = 7130 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = _____ (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 = 160 ft. Flow angle at bridge = 13 ° Abut. Skew = 0 ° Effective Skew = 13 °

Width (W_2) iteration = 156 158 ____ ____

Avg. flow depth at bridge, y_2 iteration = 9.7 9.6 ____ ____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 154 ft* $q_2 = Q_2/W_2$ = 46.3 ft^2/s

Bridge Vel, V_2 = 4.8 ft/s Final $y_2 = q_2/V_2$ = 9.6 ft Δh = 0.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 10.1 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. = 1.2 ft

Low Steel Elev. = 12.4 ft

n (Channel) = .027

n (LOB) = .030

n (ROB) = .029

Pier Width = 0.9 ft

Pier Length = 1.2 ft

Piers for 100 yr = 2 ft

assume ROB fenceline acts as a guidebank @ Q_{100} and thus there is no right overbank width at Q_{100}.

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 160 ft

Width of left overbank flow at approach, W_{lob} = 240 ft ← assume 1.5 bridge lengths Average left overbank flow depth, y_{lob} = 0.7 ft

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

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

x = 0.69 From Figure 9 W_2 (effective) = 152.2 ft y_{cs} = 1.1 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, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = _____ 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 = 1.33 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.27 Using pier width a on Figure 11, ξ = 4.4 Pier scour y_{ps} = 3.6 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0.7 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} = 3.1 and ψ_{RT} = 0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 3.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 0 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 26330038 Date _____ Initials _____ Region (A B C D)

Site _____ Location _____

Q_{500} = 11,700 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 = 160 ft. Flow angle at bridge = 13 ° Abut. Skew = 0 ° Effective Skew = 13 °

Width (W_2) iteration = 160 _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = 12.2 _____ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 156 ft* $q_2 = Q_2/W_2$ = 75 ft^2/s

Bridge Vel, V_2 = 6.1 ft/s Final $y_2 = q_2/V_2$ = 12.2 ft Δh = 0.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 13.0 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. = 1.2 ft

Low Steel Elev. = 12.4 ft

n (Channel) = 0.027

n (LOB) = 0.030

n (ROB) = 0.029

Pier Width = 0.9 ft

Pier Length = 1.2 ft

Piers for 500 yr = 2 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 160 ft

Width of left overbank flow at approach, W_{lob} = 240 ft ← assume 1.5 bridge lengths Average left overbank flow depth, y_{lob} = 3.6 ft

Width of right overbank flow at approach, W_{rob} = 320 ft ← assume 2 bridge lengths Average right overbank flow depth, y_{rob} = 1.8 ft

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

x = 3.56 From Figure 9 W_2 (effective) = 154.2 ft y_{cs} = 4.2 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 1.33 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.31 Using pier width a on Figure 11, ξ = 4.4 Pier scour y_{ps} = 3.7 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 3.6 ft right abutment, y_{aRT} = 1.8 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} = 12.6 and ψ_{RT} = 7.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 12.6 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 7.4 ft

Route 482nd Ave Stream N. Fk Whetstone MRM _____ Date _____ Initials _____

Bridge Structure No. 26330038 Location From Milbank, 3 E, 3.2 N

GPS coordinates: N 45° 16.327' taken from: USL abutment ✓ centerline of ⇑ MRM end _____
W 96° 33.336' Datum of coordinates: WGS84 ✓ NAD27 _____

Drainage area = 396.45 (cont.) sq. mi.

The average bottom of the main channel was 17.9 ft below top of guardrail at a point 44 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 7130			Q_{500} = 11,700		
Estimated flow passing through bridge						
Estimated road overflow & overtopping						
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 scour pool under bridge?

Debris Potential? ____High ✓Med ____Low right abutment scour under bridge

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	Boulders
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

Comments, Diagrams & orientation of digital photos

a swale and high-flow side channel in the left overbank will help guide water to the bridge opening and may mitigate some of the left abutment scour.

Photos
structure number
approach section from bridge
left overbank
right overbank
bridge from right approach ↩
↳right abutment under bridge

Summary of Results

	Q100	Q500
Bridge flow evaluated	7130	11,700
Flow depth at left abutment (yaLT), in feet	0.7	3.6
Flow depth at right abutment (yaRT), in feet	0	1.8
Contraction scour depth (ycs), in feet	1.1	4.2
Pier scour depth (yps), in feet	3.6	3.7
Left abutment scour depth (yas), in feet	3.1	12.6
Right abutment scour depth (yas), in feet	0	7.4
1Flow angle of attack	13°	13°

See Comments/Diagram for justification where required

Basin Characteristics from Provisional StreamStats 10-7-11

Cont. D.A. = 396.45 mi^2

PII = 0.97

100% Subregion A

Manually Calculated Peaks

Q_{100} = 7130 cfs

Q_{500} = 11,700 cfs