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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 02186050 Date 6/12/12 Initials RaT Region (A B (C) D)

Site ____________ Location 0.5 mi East of HWY 281 on 243rd St - Aurora Co.

Q_{100} = Q82.5 682 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 682 (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 = 34 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

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 = 33.48 ft* $q_2 = Q_2/W_2$ = 20.4 ft²/s

Bridge Vel, V_2 = 3.2 ft/s Final $y_2 = q_2/V_2$ = 6.4 ft Δh = 0.2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 6.6 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. = 2.6 ft

Low Steel Elev. = 7.0 ft

n (Channel) = ~~0.055~~ 0.050

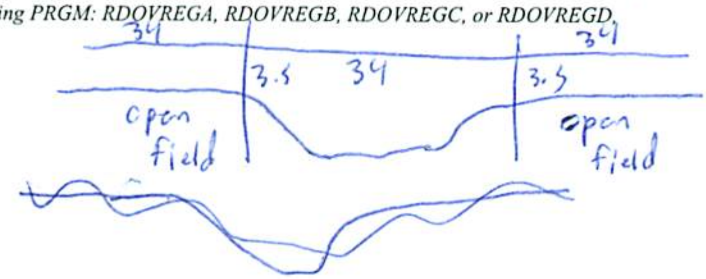
n (LOB) = ~~0.025~~ 0.030

n (ROB) = ~~0.025~~ 0.030

Pier Width = 1.05 ft

Pier Length = 1.05 ft

Piers for 100 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 34 ft

Width of left overbank flow at approach, W_{lob} = 34 ft Average left overbank flow depth, y_{lob} = 3.5 ft

Width of right overbank flow at approach, W_{rob} = 34 ft Average right overbank flow depth, y_{rob} = 3.5 ft

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

x = 8.63 From Figure 9 W_2 (effective) = 31.4 ft y_{cs} = 9.7 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 = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.22 Using pier width a on Figure 11, ξ = 5 Pier scour y_{ps} = 4 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 3.5 ft right abutment, y_{aRT} = 3.5 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} = 12.4 and ψ_{RT} = 12.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 18.5 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 18.5 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 02186050 Date 6/12/12 Initials RAL Region (A B (C) D)

Site ____________ Location 0.5 E of HWY 281 on 243rd St

Q_{500} = Q_{50} 1010 by: drainage area ratio_____ flood freq. anal. _____ regional regression eq. X

Bridge discharge (Q_2) = 823 (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 = 34 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

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 = 33.46 ft* $q_2 = Q_2/W_2$ = 24.6 ft^2/s

Bridge Vel, V_2 = 3.5 ft/s Final $y_2 = q_2/V_2$ = 7 ft Δh = 0.2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 7.2 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. = 2.6 ft

Low Steel Elev. = 7.0 ft

n (Channel) = 0.050

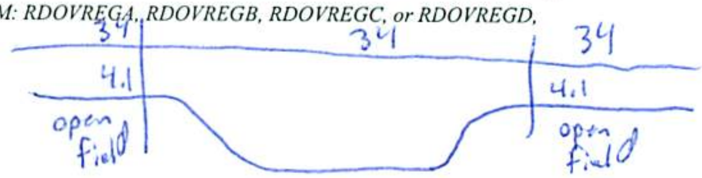
n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 1.05 ft

Pier Length = 1.05 ft

\# Piers for 500 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 34 ft

Width of left overbank flow at approach, W_{lob} = 34 ft Average left overbank flow depth, y_{lob} = 4.1 ft

Width of right overbank flow at approach, W_{rob} = 34 ft Average right overbank flow depth, y_{rob} = 4.1 ft

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

x = 10.77 From Figure 9 W_2 (effective) = 31.4 ft y_{cs} = 11.8 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: Pier

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

Froude # at bridge = 0.23 Using pier width a on Figure 11, ξ = 5 Pier scour y_{ps} = 4 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 4.1 ft right abutment, y_{aRT} = 4.1 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} = 13.4 and ψ_{RT} = 13.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 20 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 20 ft

Route 243rd St Stream ______ MRM ______ Date 6/12/12 Initials RaT

Bridge Structure No. 02186050 Location 0.5 East of Hwy 281 on 243rd St

GPS coordinates: N 43° 51' 51.7" W 98° 26' 25.4" taken from: USL abutment X centerline of ⇑ MRM end ______

Datum of coordinates: WGS84 X NAD27 ______

Drainage area = 14.97 sq. mi.

8/22

The average bottom of the main channel was 10.6 ft below top of guardrail at a point 23 ft from left abutment.

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

PK2	54.2
5	192
10	360
25	681
50	1010
100	1410
500	2710

MISCELLANEOUS CONSIDERATIONS

Flows	Q~~100~~ 25 = 681			Q~~500~~ 50 = 1010		
Estimated flow passing through bridge	681			823		
Estimated road overflow & overtopping	0			187		
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	

Riprap at abutments? ____Yes X No ____Marginal

Evidence of past Scour? X Yes ____No ____Don't know - road damage. No external abutment wall! minor abutment scour under bridge & contraction scour

Debris Potential? ____High ____Med ____Low

5/94	
2	54.2
5	192
10	360
25	682
50	1010
100	1410
500	2710

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____	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

1). left GB
2). main channel
3). right GB
4-5) left abutment Road damage (up & downstream
6). right abutment
7). left abutment
8-9) piers
10). left abutment
11). right abutment
12). main channel

Note: No external abutment all.

Summary of Results

	Q~~100~~ 25	Q~~500~~ 50
Bridge flow evaluated	~~681~~ 682	823
Flow depth at left abutment (yaLT), in feet	3.5	4.1
Flow depth at right abutment (yaRT), in feet	3.3	4.1
Contraction scour depth (ycs), in feet	9.7	11.8
Pier scour depth (yps), in feet	4	4
Left abutment scour depth (yas), in feet	18.5	20
Right abutment scour depth (yas), in feet	18.5	20
1Flow angle of attack	10	10

See Comments/Diagram for justification where required