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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 37100124 Date 6/12/12 Initials RaT Region (A B C D)

Site _____ Location 4.4 mi N of Crow Lake on 373 Ave

Q_{100} = 3520 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. X

Bridge discharge (Q_2) = 3520 (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

Bridge Width = 105 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 = 103.4 ft* $q_2 = Q_2/W_2$ = 34 ft^2/s

Bridge Vel, V_2 = 4.1 ft/s Final $y_2 = q_2/V_2$ = 8.2 ft Δh = 0.3 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 8.6 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,

PGRM: "RegionA", "RegionB", "RegionC", or "RegionD"

Water Surface Elev. = 0-1.4 ft

Low Steel Elev. = ~~9.5~~ ft

n (Channel) = 0.045

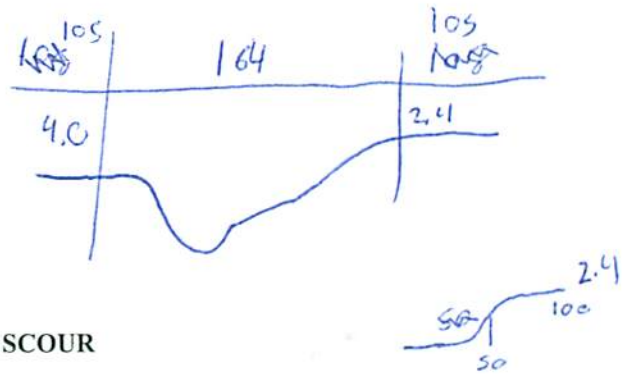
n (LOB) = 0.035

n (ROB) = 0.03<

Pier Width = 1.65 ft

Pier Length = 1.65 ft

Piers for 100 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 164 ft

Width of left overbank flow at approach, W_{lob} = ~~105~~ 105 ft Average left overbank flow depth, y_{lob} = 4.0 ft

Width of right overbank flow at approach, W_{rob} = ~~105~~ 105 ft Average right overbank flow depth, y_{rob} = 2.4 ft

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

x = ~~10.75~~ 10.75 From Figure 9 W_2 (effective) = 96.8 ft y_{cs} = ~~11.7~~ 11.7 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, $Vc = 11.17y_1^{1/6}D_{50}^{1/3}$ = _____ 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 = 0.25 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} = 4.0 ft right abutment, y_{aRT} = 2.4 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} = 13.3 and ψ_{RT} = 9.4

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 13.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 9.4 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 37100124 Date 6/12/12 Initials RAT Region (A B C D)

Site _____ Location 4.4 mi N of Crow Lake on 373 Ave

Q_{500} = 7100 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. Y

Bridge discharge (Q_2) = 4647 (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 = 105 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 = 103.4 ft* $q_2 = Q_2/W_2$ = 45.3 ft^2/s

Bridge Vel, V_2 = 4.8 ft/s Final $y_2 = q_2/V_2$ = 9.5 ft Δh = 0.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 10 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. = 0-1.4 ft

Low Steel Elev. = 9.3 ft

n (Channel) = 0.045

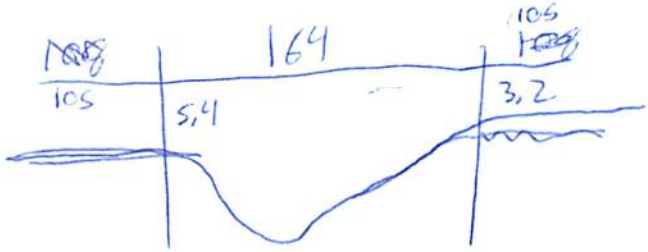
n (LOB) = 0.035

n (ROB) = 0.035

Pier Width = 1.65 ft

Pier Length = 1.65 ft

Piers for 500 yr = 4 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 164 ft

Width of left overbank flow at approach, W_{lob} = 105 ft Average left overbank flow depth, y_{lob} = 5.4 ft

Width of right overbank flow at approach, W_{rob} = 105 ft Average right overbank flow depth, y_{rob} = 3.2 ft

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

x = 14.02 From Figure 9 W_2 (effective) = 96.8 ft y_{cs} = 14.5 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, $V_c = 11.17 y_1^{1/6} D_{50}^{1/3}$ = _____ 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

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = 1 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 = 6.9 Pier scour y_{ps} = 5.7 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 5.4 ft right abutment, y_{aRT} = 3.2 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} = 15.7 and ψ_{RT} = 11.9

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 15.7 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 11.9 ft

78° 43.713
44° 1.032

98.7655
44.0172
PSS6
top left

Route 373 Ave Stream _____ MRM _____ Date 8/12/17 Initials Kal

Bridge Structure No. 37100124 Location 4.4 mi N of Crow Lake on 373 Ave

GPS coordinates: N 44 01' 1.411 taken from: USL abutment____ centerline of ⇑ MRM end _____

W 96° 43' 42.71" Datum of coordinates: WGS84____ NAD27____

Drainage area = 67.06 sq. mi.

The average bottom of the main channel was 13.3 ft below top of guardrail at a point 54 ft from left abutment.

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

5/30

~~5/24~~

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 3520			Q_{500} = 7100		
Estimated flow passing through bridge	3520			4687		
Estimated road overflow & overtopping	0			2413		
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	

2	98.9
5	400
10	796
25	1600
50	2440
100	3520
500	7100

Riprap at abutments? ____Yes X No ____Marginal

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

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

1) left abut
2) main channel
3) right abut
4-5) piers
~~6-7) right~~
6-7) right abutment
8-9) left abutment
10) large thing in ~~stream~~ Bridge channel
11) main channel

Summary of Results

	Q100	Q500
Bridge flow evaluated	3520	4687
Flow depth at left abutment (yaLT), in feet	4.0	5.4
Flow depth at right abutment (yaRT), in feet	2.4	3.2
Contraction scour depth (ycs), in feet	11.7	M, S
Pier scour depth (yps), in feet	5.6	5.7
Left abutment scour depth (yas), in feet	13.3	15.7
Right abutment scour depth (yas), in feet	9.8	11.9
1Flow angle of attack	10	10

See Comments/Diagram for justification where required