SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 03220261 Date 10-5-11 Initials RT Region (A B C D)

Site _____ Location 6 ~~West~~ East, 5 north of Alpena on 398th Ave

Q_{100} = 10,300 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 2250 (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 = 40 ft. Flow angle at bridge = 5 ° Abut. Skew = 0 ° Effective Skew = 5 °

Width (W_2) iteration = 39.9 39.9 _____ _____

Avg. flow depth at bridge, y_2 iteration = 22+ 10.6 _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 39.9 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. = 0.7 ft

Low Steel Elev. = 8.0 ft

n (Channel) = 0.027

n (LOB) = 0.027 taller grass

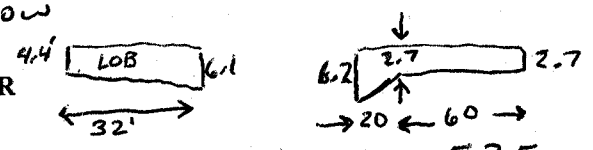
n (ROB) = 0.025 grazed short

Pier Width = NA ft

Pier Length = NA ft

Piers for 100 yr = 0 ft

Bridge not expected to pass Q_{100} Road overflow (North of bridge) will begin at ≈ 8.6 ft. Estimate $Q_{max\,scour}$ ≈ [redacted] (2250cfs) will occur when there is ≈ 2 feet of road overflow



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 81 ft

Width of left overbank flow at approach, W_{lob} = 32 ft (limited because of road overflow) Average left overbank flow depth, y_{lob} = 5.25 ft

Width of right overbank flow at approach, W_{rob} = 80 ft Average right overbank flow depth, y_{rob} = 3.1 ft

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

x = 16.9 From Figure 9 W_2 (effective) = 39.9 ft y_{cs} = 16 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ 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

PGRM: Pier

PIER SCOUR CALCULATIONS

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

Froude # at bridge = N/A Using pier width a on Figure 11, ξ = _____ Pier scour y_{ps} = _____ ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 5.25 ft right abutment, y_{aRT} = 3.1 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} = 15.5 and ψ_{RT} = 11.7

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 23.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 17.4 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 0322 0261 Date _____ Initials _____ Region (A B C D)

Site _____ Location _____

Q_{500} = 22,100 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 = _____ ft. Flow angle at bridge = _____ ° Abut. Skew = _____ ° Effective Skew = _____ °

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 = _____ ft* $q_2 = Q_2/W_2$ = _____ ft^2/s

Bridge Vel, V_2 = _____ ft/s Final $y_2 = q_2/V_2$ = _____ ft Δh = _____ ft

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

Low Steel Elev. = _____ ft

n (Channel) = _____

n (LOB) = _____

n (ROB) = _____

Pier Width = _____ ft

Pier Length = _____ ft

Piers for 500 yr = _____ ft

See Analysis for estimated Qmax scour on top sheet

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = _____ ft

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

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

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

x = _____ From Figure 9 W_2 (effective) = _____ ft y_{cs} = _____ 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

PGRM: Pier

PIER SCOUR CALCULATIONS

L/a ratio = _____

Froude # at bridge = _____

Correction factor for flow angle of attack (from Table 1), K2 = _____

Using pier width a on Figure 11, ξ = _____ Pier scour y_{ps} = _____ ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

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

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

Route 398th Stream Cain Creek MRM _____ Date _____ Initials _____

Bridge Structure No. 03220261 Location 6 ~~west~~ East 5 North of Alpena

GPS coordinates N 44° 15.256' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

W 98° 15.283' Datum of coordinates: WGS84 _____ NAD27 _____

Drainage area = 364.68 sq. mi.

The average bottom of the main channel was 12.6 ft below top of guardrail at a point 10 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 10,300			Q_{500} = 22,100		
Estimated flow passing through bridge	2250			2250		
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

Debris Potential? ____High ____Med ✓Low

Photos
- structure #
- approach from b
- bridge from ROB
- LOB + channel for

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

no piers. flow less than 1 cfs today. Pool under bridge hints to past contraction scour. Road overflow will occur North of the Bridge and past the intersection before Q100. Estimated Qmax scour ≈ 2250 cfs. left overbank flow width is limited because of road overflow North of bridge.

Summary of Results

	Q100	Q500
Bridge flow evaluated	2250	2250
Flow depth at left abutment (yaLT), in feet	5.25	5.25
Flow depth at right abutment (yaRT), in feet	3.1	3.1
Contraction scour depth (ycs), in feet	16	16
Pier scour depth (yps), in feet	NA	NA
Left abutment scour depth (yas), in feet	23.1	~~23.1~~ 23.1
Right abutment scour depth (yas), in feet	17.4	17.4
1Flow angle of attack	5°	5°

See Comments/Diagram for justification where required

Basin Characteristics from Stream Stats on 10-5-11 (Provisional)

Contrib D.A. = 364.68 mi^2

PII = 0.92

100% Subregion B

Q_{100} = 10,300 cfs

Q_{500} = 22,100 cfs