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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52320312 Date 9/24/16 Initials CW Region (A B C D)

Site _____ Location on Thunderhead Falls Rd, near intersection with HW 44

Q_{100} = 860 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 860 (should be Q_{100} unless there is a relief bridge, road overflow, or bridge overtopping)

Neg?

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

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

Bridge Width = 39 ft. Flow angle at bridge = 10 ° Abut. Skew = 15 ° Effective Skew = 5 °

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 = 38.85 ft* $q_2 = Q_2/W_2$ = 22.1 ft^2/s

Bridge Vel, V_2 = 5.6 ft/s Final $y_2 = q_2/V_2$ = 3.9 ft Δh = 0.6 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 4.6 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. = 2.3 ft

Low Steel Elev. = _____ ft

n (Channel) = 0.040

n (LOB) = 0.035

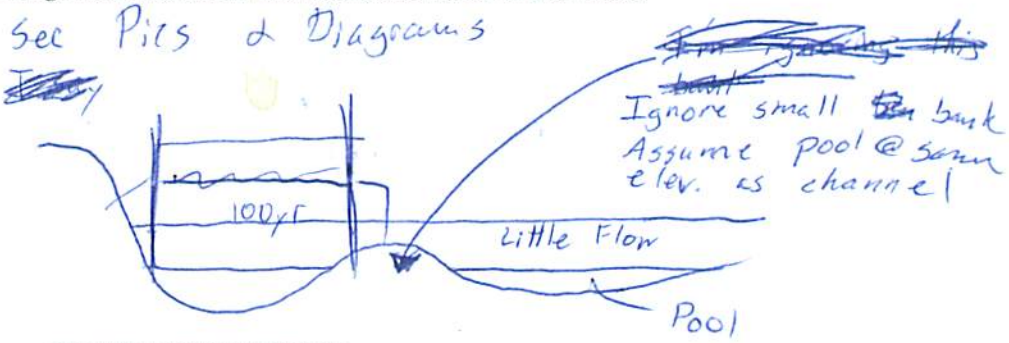
n (ROB) = 0.045

Pier Width = ~ ft

Pier Length = ~ ft

Piers for 100 yr = 0 ft

See Pics & Diagrams



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 45 ft

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

Width of right overbank flow at approach, W_{rob} = 139 ft Average right overbank flow depth, y_{rob} = 4.6 ft

Live Bed Contraction Scour (use if bed material is small cobbles or finer) ~~2 = 0.93~~

x = _____ From Figure 9 W_2 (effective) = _____ ft y_{cs} = ~~4.15~~ ft

PGRM: CWCSNEW

Clear Water Contraction Scour (use if bed material is larger than small cobbles) 2 = ~~0.93 0.648~~ 0

Estimated bed material D_{50} = 0.20 ft Average approach velocity, $V_1 = Q_{100}/(y_1 W_1)$ = ~~4.15~~ ft/s 2.23

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = 8.42 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.0310 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} = 0.0 ft

PIER SCOUR CALCULATIONS

PGRM: Pier

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

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

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0 ft right abutment, y_{aRT} = 4.6 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} = 0.0 and ψ_{RT} = 14.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = ~~26~~ Ch 21.3 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 52320312 Date 9/24/10 Initials CW Region (A B C D)

Site _____ Location on Thunderhead Falls Rd, near intersection with HWY 44

Q_{500} = 1280 by: drainage area ratio ✓ flood freq. anal. ____ regional regression eq. ____

Bridge discharge (Q_2) = 1280 (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 = 39 ft. Flow angle at bridge = 10 ° Abut. Skew = 15 ° Effective Skew = 5 °

Width (W_2) iteration = _____ _____ _____ _____

Avg. flow depth at bridge, y_2 iteration = ~~34.85~~ ~~37.~~ _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 34.45 ft* $q_2 = Q_2/W_2$ = 32.9 ft^2/s

Bridge Vel, V_2 = 6.4 ft/s Final $y_2 = q_2/V_2$ = 4.9 ft Δh = 0.9 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 5.8 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,

Ignore small ridge
Assume pool @ same elev as channel

Water Surface Elev. = 2.3 ft

Low Steel Elev. = _____ ft

n (Channel) = 0.040

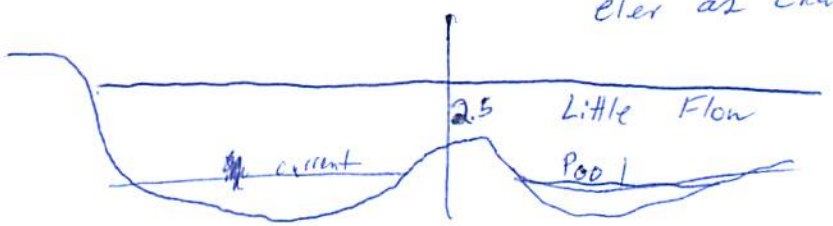
n (LOB) = 0.035

n (ROB) = 0.045

Pier Width = ~~—~~ ft

Pier Length = ~~—~~ ft

Piers for 500 yr = 0 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 45 ft

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

Width of right overbank flow at approach, W_{rob} = 39 ft Average right overbank flow depth, y_{rob} = 5.8 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) 2 = ~~0.93~~ 0.0

Estimated bed material D_{50} = 0.20 ft Average approach velocity, $V_1 = Q_{500}/(y_1 W_1)$ = ~~4.9~~ ft/s 2.63

Critical approach velocity, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = 8.76 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = ~~0.043~~ ft 0.045 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} = 0.0 ft

PIER SCOUR CALCULATIONS

PGRM: Pier

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

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

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0 ft right abutment, y_{aRT} = 5.4 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} = 0 and ψ_{RT} = 16.5

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = ~~29.4~~ 24.5 ft

4.6 2.3 2.
5.8 2.3/2.5

Route Thunderhead Falls Road Stream Rapid Creek MRM _____ Date 9/24/10 Initials CG

Bridge Structure No. 52320312 Location on Thunderhead Falls Rd, near intersection with HWY44

GPS coordinates: N 44° 03' 53.2" W 103° 24' 45.4" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 337.33 sq. mi.

The average bottom of the main channel was 14.1 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} = 860			Q_{500} = 1280		
Estimated flow passing through bridge		860			1280	
Estimated road overflow & overtopping		—			—	
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 Scour US L. Abut

Debris Potential? X High ____Med ____Low

Does scour countermeasure(s) appear to have been designed?

Riprap ____Yes ____No ____Don't know X NA

Spur Dike ____Yes ____No ____Don't know X NA

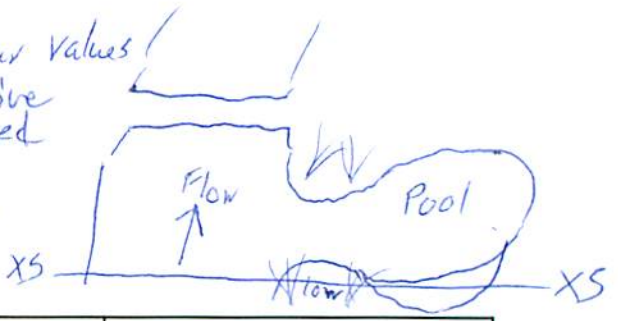
Other _____ ____Yes ____No ____Don't know X NA

Bed Material Classification Based on Median Particle Size (D_{50})

Material	Silt/Clay____	Sand____	Gravel____	Cobbles X	Boulders____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

Comments, Diagrams & orientation of digital photos

1264 - ID
65 - US RB US
66 - LB US
67 - LB US
68-70 - Graffiti
71 - R. Abut.
72 - L. Abut
73 - US face of bridge R. Abut Scour values very conservative b/c I ignored small bank
74 - Scour hole/pool
75 - snake
76-77 - Pool
79 - Bed Material
80 - Pool



Summary of Results

	Q100	Q500
Bridge flow evaluated	860	1280
Flow depth at left abutment (yaLT), in feet	0	0.0
Flow depth at right abutment (yaRT), in feet	4.6	5.4
Contraction scour depth (ycs), in feet	0.0	0.0
Pier scour depth (yps), in feet	~~0.0~~ NA	~~0.0~~ NA
Left abutment scour depth (yas), in feet	0.0	0.0
Right abutment scour depth (yas), in feet	~~cr 26~~ 21.3	~~cr 29.4~~ 24.5
1Flow angle of attack	5°	5°

See Comments/Diagram for justification where required