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SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 07103073 Date 7/22/12 Initials RGT Region (A B C [✓ D])
Site 0647 1350 Location West edge Frederick, Maple River
~~Q_{100}~~ = Q_{50} ~~9380~~ 7470 by: drainage area ratio____ flood freq. anal.____ regional regression eq. X
Bridge discharge (Q_2) = 7470 (should be Q_{100} unless there is a relief bridge, road overflow, or bridge overtopping)

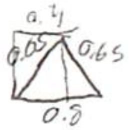
Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

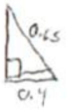
PGRM: "RegionA", "RegionB", "RegionC", or "RegionD"

Bridge Width = 137 ft. Flow angle at bridge = 20 ° Abut. Skew = 30 ° 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 = 134.92 ft* $q_2 = Q_2/W_2$ = 55.4 ft^2/s
Bridge Vel, V_2 = 3.7 ft/s Final $y_2 = q_2/V_2$ = 15.2 ft Δh = 0.3 ft
Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 15.4 ft

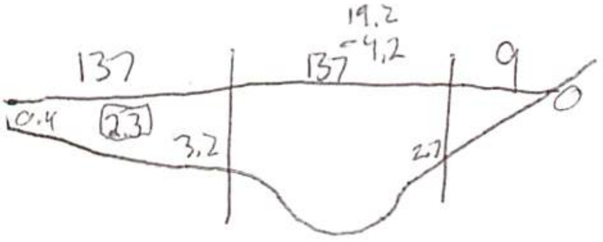
** NOTE: repeat above calculations until y_2 changes by less than 0.2* *Effective pier width = L sin(q) + a cos(q)*

If y_2 is above LS, then account for Road Overflow using PRGM: RDOVREGA, RDOVREGB, RDOVREGC, or RDOVREGD.





Water Surface Elev. = 2-4 ft
Low Steel Elev. = 40.8 ft
n (Channel) = 0.035
n (LOB) = 0.030
n (ROB) = 0.035
Pier Width = 0.8 ft
Pier Length = 1.31 ft
\# Piers for 100 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 137 ft
3.2-6.4
Width of left overbank flow at approach, W_{lob} = 137 ft Average left overbank flow depth, y_{lob} = 2.3 ft
Width of right overbank flow at approach, W_{rob} = 9 ft Average right overbank flow depth, y_{rob} = 1.3 ft

Live Bed Contraction Scour (use if bed material is small cobbles or finer)
x = 1.22 From Figure 9 W_2 (effective) = 133.3 ft y_{cs} = 1.7 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, $Vc = 11.52y_1^{1/6}D_{50}^{1/3}$ = ____ 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}, χ = 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 = 1.64 Correction factor for flow angle of attack (from Table 1), K2 = 1.07
Froude # at bridge = 0.17 Using pier width a on Figure 11, ξ = 3.9 Pier scour y_{ps} = 3.2 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 2.3 ft right abutment, y_{aRT} = 1.3 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} = 9.4 and ψ_{RT} = 5.5
Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 14.0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 8.1 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 07103073 Date 7/22/12 Initials RAL Region (A B C [✓ D])

Site 01647 1350 Location West edge Frederick

Q_{500} = ~~Q100 16600~~ 11200 by: drainage area ratio____ flood freq. anal. ✓ regional regression eq. X

Bridge discharge (Q_2) = ~~16578~~ 11200 (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 = 137 ft. Flow angle at bridge = 20 ° Abut. Skew = 30 ° 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 = 134.92 ft* $q_2 = Q_2/W_2$ = ~~[illegible]~~ 83 ft^2/s

Bridge Vel, V_2 = 4.4 ft/s Final $y_2 = q_2/V_2$ = ~~[illegible]~~ 18.9 ft Δh = ~~[illegible]~~ 0.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = ~~[illegible]~~ 19.2 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. = 24 ft

Low Steel Elev. = 18.8 ft

n (Channel) = 0.035

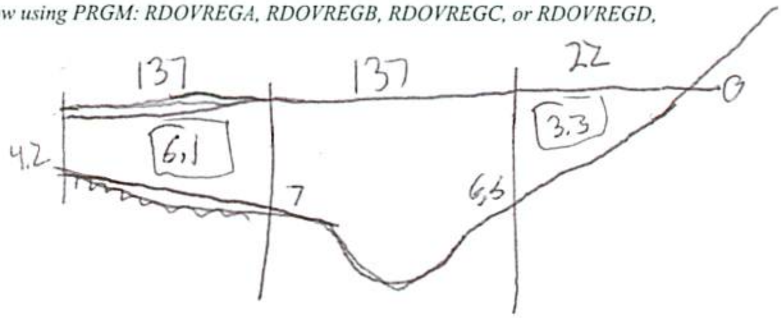
n (LOB) = 0.030

n (ROB) = 0.035

Pier Width = 0.8 ft

Pier Length = 1.31 ft

\# Piers for 500 yr = 2 ft



CONTRACTION SCOUR

7-4.2

PGRM: Contract

Width of main channel at approach section W_1 = 137 ft

Width of left overbank flow at approach, W_{lob} = 137 ft Average left overbank flow depth, y_{lob} = 6.1 ft

Width of right overbank flow at approach, W_{rob} = 22 ft Average right overbank flow depth, y_{rob} = 3.3 ft

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

x = 4.1 From Figure 9 W_2 (effective) = 133.3 ft y_{cs} = 4.7 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, $V_1 = Q_{500}/(y_1W_1)$ = ________ ft/s

Critical approach velocity, $V_c = 11.52y_1^{1/6}D_{50}^{1/3}$ = ________ 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: Pie

L/a ratio = 1.64 Correction factor for flow angle of attack (from Table 1), K2 = 1.07

Froude # at bridge = 0.18 Using pier width a on Figure 11, ξ = ~~[illegible]~~ 3.9 Pier scour y_{ps} = 3.2 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 6.1 ft right abutment, y_{aRT} = 3.3 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} = 17 and ψ_{RT} = 12

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 25.3 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 18 ft

98.51219

45,83223

45° 49' 56"
98° 30' 43".8

Route 107.3 St Stream Maple River MRM _____ Date 7/22/12 Initials MaT
Bridge Structure No. 07103073 Location West edge- Frederick
GPS coordinates: N 45° 49' 56.0" taken from: USL abutment X centerline of ⇑ MRM end _____
W 98° 30' 44.3" Datum of coordinates: WGS84 X NAD27 _____
Drainage area = ~~799.71~~ 520.17 sq. mi. 520.17
The average bottom of the main channel was 23.6 ft below top of guardrail at a point 104 ft from left abutment.
Method used to determine flood flows: ~~X~~ Freq. Anal. ____ drainage area ratio X regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	~~Q100~~ = Q50 [illegible] 7476			~~Q500~~ = Q100 [illegible] 11200		
Estimated flow passing through bridge	7470			11200 ~~10898~~		
Estimated road overflow & overtopping	0			0 [illegible]		
Consideration	Yes	No	Possibly	Yes	No	Possibly
Chance of overtopping						X
Chance of Pressure flow				[illegible]		X
Armored appearance to channel					X	
Lateral instability of channel					X	

712.

2	196
5	984
10	2440
25	4670
50	7470
100	11200
500	24000

Riprap at abutments? _____ Yes _____ No X Marginal There is riprap on the banks next to the abutment but nothing under the bridge
Evidence of past Scour? X Yes _____ No _____ Don't know minor abutment, some pier/contraction
Debris Potential? _____ High X Med _____ Low There is one live tree at the entrance of the bridge that could fall is the bank is scour. bank extends out infront of the abutment so its vulnerable to scour.

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 X	Gravel X	Cobbles X	Boulders ____
Size range, in mm	<0.062	0.062-2.00	2.00-64	64-250	>250

lots of gravel/cobbles from riprap at bridge entrance. turns to silt/sand towards ~~[illegible]~~ down stream side

Comments, Diagrams & orientation of digital photos

1). left OB
2). main channel
3) right OB
4). pier
5). left abutment
6) right abutment
7). dam
8). right abutment
9). left abutment
10). main channel

Note; there is a small dam ~~[illegible]~~ ~85 ft from the bridge opening.
Bridge is arced, took low steel at bridge depth location.

Summary of Results

	~~Q100~~ Q50	~~Q500~~ Q100
Bridge flow evaluated	7476	~~10898~~ 11200
Flow depth at left abutment (yaLT), in feet	2.3	6.1
Flow depth at right abutment (yaRT), in feet	1.3	3.3
Contraction scour depth (ycs), in feet	1.7	4.7
Pier scour depth (yps), in feet	3.2	3.2
Left abutment scour depth (yas), in feet	14.0	25.3
Right abutment scour depth (yas), in feet	8.1	18
1Flow angle of attack	10	10

See Comments/Diagram for justification where required