SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 03350048 Date 10-6-11 Initials RT Region (A B C D)

Site _____ Location 8.5 N Yale on 111th Ave

Q_{100} = 4770 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 4770 (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 = 96 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 88.6 ~~76~~ 65 64 _____

Avg. flow depth at bridge, y_2 iteration = 10.4 ~~12.3~~ 12.2 _____ _____

Corrected channel width at bridge Section = W_2 times cos of flow angle = 63 ft* $q_2 = Q_2/W_2$ = 75.7 ft^2/s

Bridge Vel, V_2 = 6.2 ft/s Final $y_2 = q_2/V_2$ = 12.3 ft Δh = 0.8 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 13.0 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. = 5.2 ft

Low Steel Elev. = 20.3 ft

n (Channel) = .025

n (LOB) = .027

n (ROB) = .026

Pier Width = 4.25 ft

Pier Length = 4.25 ft

Piers for 100 yr = 2 ft

Piers are 2¼' square, which have been reinforced for, abe the bottom half of their height (see photo). Q = 4.25'

High water mark from this spring is above the estimated Q_{100} level

~~4.98'~~

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 68 ft

Width of left overbank flow at approach, W_{lob} = 10 ft Average left overbank flow depth, y_{lob} = 0.3 ft

Width of right overbank flow at approach, W_{rob} = 137 ft Average right overbank flow depth, y_{rob} = 2.9 ft

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

x = 4.98 From Figure 9 W_2 (effective) = 57 ft y_{cs} = 5.7 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, $V_1 = Q_{100}/(y_1 W_1)$ = _____ ft/s

Critical approach velocity, $Vc = 11.17 y_1^{1/6} D_{50}^{1/3}$ = ~~N/A~~ _____ 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 = 0.31 Using pier width a on Figure 11, ξ = 13.8 Pier scour y_{ps} = 11.5 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 0.3 ft right abutment, y_{aRT} = 2.9 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} = 1.4 and ψ_{RT} = 11.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 1.4 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 11.3 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 00350048 Date _____ Initials _____ Region (A B C D)

Site _____ Location _____

Q_{500} = 9580 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 9580 (should be Q_{500} unless there is a relief bridge, road overflow, or bridge overtopping)

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

Analytical Procedure for Estimating Hydraulic Variables Needed to Apply Method

Bridge Width = 96 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 88 67 76 72 74 73

Avg. flow depth at bridge, y_2 iteration = 14.7 17 16 16.4, 16.2

Corrected channel width at bridge Section = W_2 times cos of flow angle = 72 ft* $q_2 = Q_2/W_2$ = 133.3 ft^2/s

Bridge Vel, V_2 = 8.2 ft/s Final $y_2 = q_2/V_2$ = 16.3 ft Δh = 1.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 17.6 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. = 5.2 ft

Low Steel Elev. = 20.3 ft

n (Channel) = .025

n (LOB) = .027

n (ROB) = .026

Pier Width = 4.25 ft

Pier Length = 4.25 ft

Piers for 500 yr = 2 ft

PGRM: Contract

CONTRACTION SCOUR

Width of main channel at approach section W_1 = 72 ft

Width of left overbank flow at approach, W_{lob} = 66 ft Average left overbank flow depth, y_{lob} = 2.25 ft

Width of right overbank flow at approach, W_{rob} = 160 ft Average right overbank flow depth, y_{rob} = 5.9 ft

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

x = 8.77 From Figure 9 W_2 (effective) = 66 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, $V_1 = Q_{500}/(y_1W_1)$ = _____ 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 = 1 Correction factor for flow angle of attack (from Table 1), K2 = 1

Froude # at bridge = 0.36 Using pier width a on Figure 11, ξ = 13.8 Pier scour y_{ps} = 11.8 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 2.25 ft right abutment, y_{aRT} = 5.9 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} = 9.2 and ψ_{RT} = 16.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 9.2 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 16.6 ft

Route 411th Ave Stream Shue Creek MRM _____ Date _____ Initials _____

Bridge Structure No. 0035 0048 Location 8.5 N Yale

GPS coordinates: N 44° 33.712' taken from: USL abutment ✓ centerline of ⇑ MRM end _____

W 97° 59.864' Datum of coordinates: WGS84 ✓ NAD27 _____

Drainage area = 119.83 sq. mi.

The average bottom of the main channel was 26.1 ft below top of guardrail at a point 37 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 4770			Q_{500} = 9580		
Estimated flow passing through bridge	4770			9580		
Estimated road overflow & overtopping	NA			NA		
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

Quartzite riprap is present on abutments under the bridge and along the low-flow channel to approx. the approach section. Possibly past contraction scour.

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

Most, if not all of the abutment and pier scour will be mitigated by the existing riprap. Pier scour was calculated using the lower (larger) diameter of 4.25', so pier scour may be overestimated.

photos
structure number
approach section from bridge
bridge section from approach
right abutment from left
piers from left abutment

Summary of Results

	Q100	Q500
Bridge flow evaluated	4770	9580
Flow depth at left abutment (yaLT), in feet	0.3	2.25
Flow depth at right abutment (yaRT), in feet	2.9	5.9
Contraction scour depth (ycs), in feet	5.7	9.7
Pier scour depth (yps), in feet	11.5	11.8
Left abutment scour depth (yas), in feet	1.4	9.2
Right abutment scour depth (yas), in feet	11.3	16.6
1Flow angle of attack	10°	10°

See Comments/Diagram for justification where required

Basin Characteristics from StreamStats on 10-5-11 (Provisional)

Contrib D.A. = 119.83

PII = 0.92

18% Subregion A

Q_{100} = 3020 cfs $.18Q_{100}$ = 543.6

Q_{500} = 4940 cfs $.18Q_{500}$ = 889.2

82% Subregion B

Q_{100} = 5150 cfs $.82Q_{100}$ = 4223

Q_{500} = 10,600 cfs $.82Q_{500}$ = 8692

Area weighted

Q_{100} = 4766.4 ≈ **4770 cfs**

Q_{500} = 9581.2 ≈ **9580 cfs**