East Fork Vermillion River

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 44212100 Date 10/9/11 Initials CW Region (A B (C) D)

Site _____ Location E edge of Montrose on 254St

Q50 ~~Q_{100}~~ = 10700 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 8432 (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 = 153 ft. Flow angle at bridge = 35 ° Abut. Skew = 30 ° Effective Skew = 5 °

Width (W_2) iteration = 153

Avg. flow depth at bridge, y_2 iteration = 11.8 → RDOverflow

Corrected channel width at bridge Section = W_2 times cos of flow angle = 152.42 ft* $q_2 = Q_2/W_2$ = 58.6 ft²/s

Bridge Vel, V_2 = 5.4 ft/s Final $y_2 = q_2/V_2$ = 10.8 ft Δh = 0.6 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 11.4 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. = _____ ft

Low Steel Elev. = 10.8 ft

n (Channel) = 0.040

n (LOB) = 0.030

n (ROB) = 0.030

Pier Width = 1.0 ft

Pier Length = 39.0 ft

Piers for 100 yr = 3 ft

CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 155 ft

Width of left overbank flow at approach, W_{lob} = 153 ft Average left overbank flow depth, y_{lob} = 1.8 ft

Width of right overbank flow at approach, W_{rob} = 153 ft Average right overbank flow depth, y_{rob} = 2.1 ft

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

x = 2.07 From Figure 9 W_2 (effective) = 149.4 ft y_{cs} = 2.6 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 39

Froude # at bridge = 0.29

Correction factor for flow angle of attack (from Table 1), K2 = 1.5

Using pier width a on Figure 11, ξ = 4.9 Pier scour y_{ps} = 6.1 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 1.8 ft right abutment, y_{aRT} = 2.1 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} = 7.4 and ψ_{RT} = 8.6

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 7.4 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 8.6 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 44212100 Date 10/9/11 Initials CLV Region (A B C D) 2

Site _____ Location E edge of Montrose on 254 St

Q25 ~~Q_{500}~~ = 7360 by: drainage area ratio____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 7360 (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 = 153 ft. Flow angle at bridge = 35 ° Abut. Skew = 30 ° Effective Skew = 5 °

Width (W_2) iteration = 153

Avg. flow depth at bridge, y_2 iteration = 9.4 Vert. Wall

Corrected channel width at bridge Section = W_2 times cos of flow angle = 152.42 ft* $q_2 = Q_2/W_2$ = 48.3 ft²/s

Bridge Vel, V_2 = 4.9 ft/s Final $y_2 = q_2/V_2$ = 9.8 ft Δh = 0.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 10.3 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. = ~~0.040~~ ft

n (Channel) = ~~0.030~~ 0.040

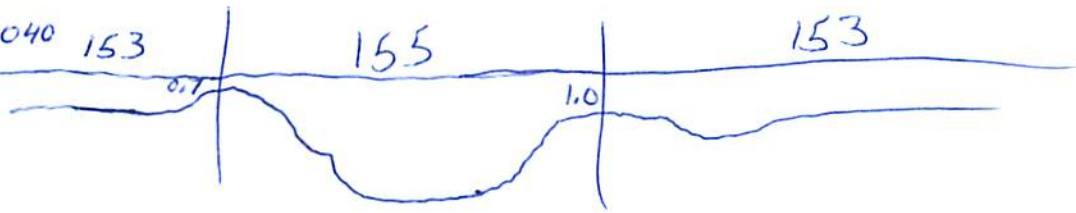
n (LOB) = ~~0.030~~ 0.030

n (ROB) = 0.030

Pier Width = 1.0 ft

Pier Length = 39 ft

Piers for 500 yr = 3 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 155 ft

Width of left overbank flow at approach, W_{lob} = 153 ft Average left overbank flow depth, y_{lob} = 0.7 ft

Width of right overbank flow at approach, W_{rob} = 153 ft Average right overbank flow depth, y_{rob} = 1.0 ft

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

x = 0.53 From Figure 9 W_2 (effective) = 149.4 ft y_{cs} = 1.3 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, $V_1 = Q_{500}/(y_1 W_1)$ = _____ 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

PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 39 Correction factor for flow angle of attack (from Table 1), K2 = 1.5

Froude # at bridge = 0.28 Using pier width a on Figure 11, ξ = 4.9 Pier scour y_{ps} = 6.0 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0.7 ft right abutment, y_{aRT} = 1.0 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} = 3.1 and ψ_{RT} = 4.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 3.1 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 4.3 ft

Route 254 St Stream E Fk Vermillion River MRM _____ Date 10/9/11 Initials CLL

Bridge Structure No. 44212100 Location E Edge of Montrose on 254 St

GPS coordinates: N 43°42' 10.2" W 97° 10' 46.8" taken from: USL abutment ✓ centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 _____ NAD27 _____

Drainage area = (total) 806.38 sq. mi.

The average bottom of the main channel was 14.7 ft below top of guardrail at a point 43 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS

Flows	Q100 = 10700 / 8932			Q25 = 7360 / 7360		
Estimated flow passing through bridge						
Estimated road overflow & overtopping	1768					
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 ____No X Marginal Rip Rap at abuts ⇒ washed away

Evidence of past Scour? ____Yes ____No X Don't know DS cut bank, Not @ bridge

Debris Potential? X High ____Med ____Low

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

Riprap	____Yes	____No	X Don't know	____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 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

10/3/11

Non-contrib = 478.01 mi²

contrib = 328.37 mi²

Total = 806 mi²

64% Reg A

32% Reg B

2	805
5	2360
10	4090
25	7360
50	10700
100	14900
500	28800

Photos

2058 - ID

59 - US

60 ~~US RB~~ ~~US LB~~ US LB

61 - ~~US LB~~ ~~US RB~~ US RB

62 - R. Abut

63 - L. Abut

64 - US Face

65 - Possible Armoring?

66 - Drop Structure

Summary of Results

	~~Q100~~ 50	~~Q500~~ 25
Bridge flow evaluated	8932	7360
Flow depth at left abutment (yaLT), in feet	1.8	0.7
Flow depth at right abutment (yaRT), in feet	2.1	1.0
Contraction scour depth (ycs), in feet	2.6	1.3
Pier scour depth (yps), in feet	6.1	6.0
Left abutment scour depth (yas), in feet	7.4	3.1
Right abutment scour depth (yas), in feet	6.6	4.3
1Flow angle of attack	5	5

See Comments/Diagram for justification where required