Perkins Co.

N. Fork Grand River

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 53290102 Date 7/13/11 Initials CW Region (A (B) C D)

Site 06355500 Location approx. 9.5 mi S White Butte on 183rd Ave

Q_{100} = 8730 by: drainage area ____ flood frequency anal. ✓ regional regression eq. ____

Bridge discharge (Q_2) = 8730 (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 = 154 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 154 ~~85~~ 83 86

Avg. flow depth at bridge, y_2 iteration = 9.0 ~~10.3~~ 12.5 12.3

Corrected channel width at bridge Section = W_2 times cos of flow angle = 84.69 ft* $q_2 = Q_2/W_2$ = 103.1 ft^2/s

Bridge Vel, V_2 = 8.4 ft/s Final $y_2 = q_2/V_2$ = 12.3 ft Δh = 1.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 13.7 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) = 0.040

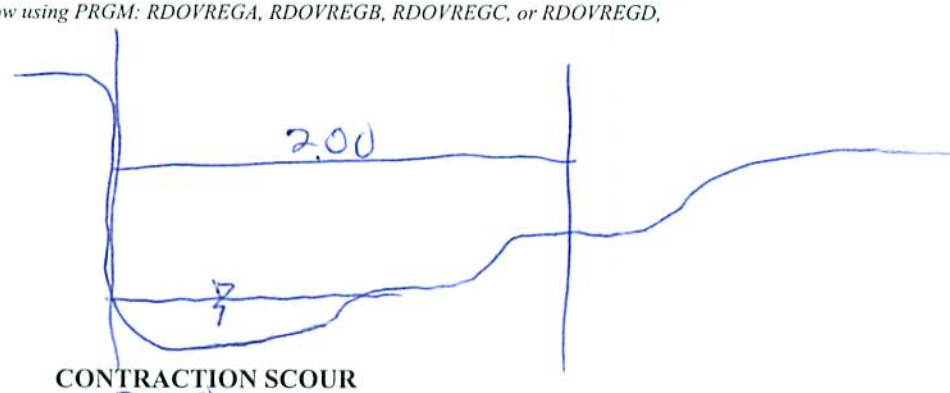
n (LOB) = 0.045

n (ROB) = 0.045

Pier Width = 2.0 ft

Pier Length = 30 ft

Piers for 100 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 200 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} = ~~25~~ 0 ft Average right overbank flow depth, y_{rob} = ~~1.5~~ 0 ft

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

x = 20.26 From Figure 9 W_2 (effective) = 90.7 ft y_{cs} = 17.4 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, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = ____ 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 = 15

Froude # at bridge = 0.42

Correction factor for flow angle of attack (from Table 1), K2 = 2.0

Using pier width a on Figure 11, ξ = 6.0 Pier scour y_{ps} = 14.0 ft

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 0 ft right abutment, y_{aRT} = 0 ft

Shape coefficient K_1 = L (1.00) for vertical-wall, 0.82 for vertical-wall with wingwalls, R (0.55) for spill-through

Using values for y_{aLT} and y_{aRT} on figure 12, ψ_{LT} = 0 and ψ_{RT} = 0

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

~~0.78~~ W

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 53290102 Date 7/13/11 Initials CH Region (A (B) C D)

Site 06355500 Location approx 9.5 mi S White Butte on 183rd Ave

Q_{500} = 14700 by: drainage area ____ flood frequency anal. ✓ regional regression eq. ____

Bridge discharge (Q_2) = 14700 (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 = 154 ft. Flow angle at bridge = 10 ° Abut. Skew = 0 ° Effective Skew = 10 °

Width (W_2) iteration = 154 ~~165~~ 95 ~~93~~

Avg. flow depth at bridge, y_2 iteration = 11.9 16.3 15.3 15.5

Corrected channel width at bridge Section = W_2 times cos of flow angle = 91.59 ft* $q_2 = Q_2/W_2$ = 160.5 ft^2/s

Bridge Vel, V_2 = 10.4 ft/s Final $y_2 = q_2/V_2$ = 15.5 ft Δh = 2.2 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 17.7 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) = 0.040

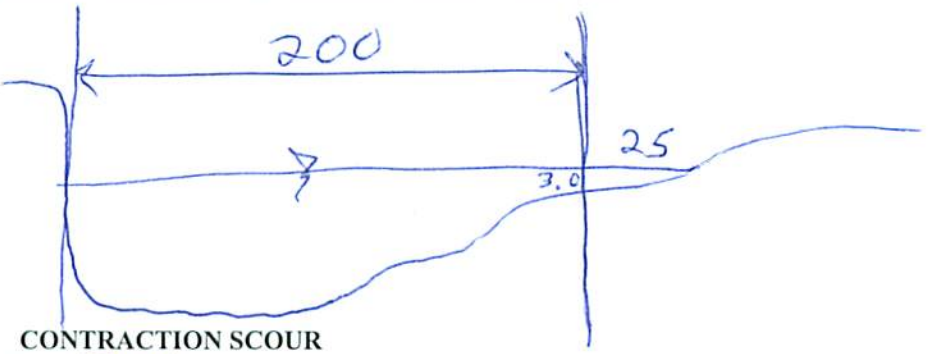
n (LOB) = 0.045

n (ROB) = 0.045

Pier Width = 2.0 ft

Pier Length = 30 ft

Piers for 500 yr = 2 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 200 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} = 25 ft Average right overbank flow depth, y_{rob} = 1.5 ft

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

x = 22.79 From Figure 9 W_2 (effective) = 87.6 ft y_{cs} = 19.2 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, $Vc = 11.52 y_1^{1/6} D_{50}^{1/3}$ = ____ 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 = 15 Correction factor for flow angle of attack (from Table 1), K2 = 2.0

Froude # at bridge = ~~22.79~~ 0.47 Using pier width a on Figure 11, ξ = ~~87.6~~ 8.0 Pier scour y_{ps} = ~~19.2~~ 14.2 ft

ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, y_{aLT} = 0 ft right abutment, y_{aRT} = 1.5 ft

Shape coefficient K_1 = ~~1.00~~ for vertical-wall, 0.82 for vertical-wall with wingwalls, ~~0.55~~ for spill-through 0.82

Using values for y_{aLT} and y_{aRT} on figure 12, ψ_{LT} = 0 and ψ_{RT} = 6.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 0 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = ~~8.9~~ 6.3 ft

Route 183 Ave Stream N. Fork Grand Riv MRM _____ Date 7/13/11 Initials CW

Bridge Structure No. 53290102 Location Approx 9.5 mi S White Butte on 183rd Ave

GPS coordinates: N 45° 45' 08.5" W 102° 21' 44.2" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 1201.76 sq. mi. 29.8

The average bottom of the main channel was ~~30.3~~ ft below top of guardrail at a point 56 ft from left abutment.

Method used to determine flood flows: ✓ Freq. Anal. ____drainage area adjustment ____regional regression equations.

MISCELLANEOUS CONSIDERATIONS

Flows	Q_{100} = 8730			Q_{500} = 14700		
Estimated flow passing through bridge	8730			14700		
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

Debris Potential? ____High X 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 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

* Used constricted section – not full width – Old bridge abut on LB constricts flow to L. pier → L pier to R. Abut used for width

1422 - us
23 - us Old Bridge Abut on L. B
24 - us RB
25 - us LB
26 - R. Abut
27 - L. Abut
28 - us Face
29 - ID

Summary of Results

	Q100	Q500
Bridge flow evaluated	8730	14700
Flow depth at left abutment (yaLT), in feet	0.0	0.0
Flow depth at right abutment (yaRT), in feet	0.0	1.5
Contraction scour depth (ycs), in feet	17.8	19.2
Pier scour depth (yps), in feet	14.0	14.2
Left abutment scour depth (yas), in feet	0.0	0.0
Right abutment scour depth (yas), in feet	0.0	~~6.4~~ 6.3
1Flow angle of attack	10	10

See Comments/Diagram for justification where required