Coal Bank Creek

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 32395080 Date 10/29/11 Initials CW Region (A B C D)

Site _____ Location 6.5 mi E of US 85 on Ludlow Rd

25 Q_{100} = 862 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 862 (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 = 32 ft. Flow angle at bridge = 3° Abut. Skew = 0 ° Effective Skew = 3°

Width (W_2) iteration = 32

Avg. flow depth at bridge, y_2 iteration = 6.1 Vert Wall

Corrected channel width at bridge Section = W_2 times cos of flow angle = 31.96 ft* $q_2 = Q_2/W_2$ = 27.0 ft²/s

Bridge Vel, V_2 = 4.4 ft/s Final $y_2 = q_2/V_2$ = 6.1 ft Δh = 0.4 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 6.5 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. = 7.0 ft

n (Channel) = 0.045

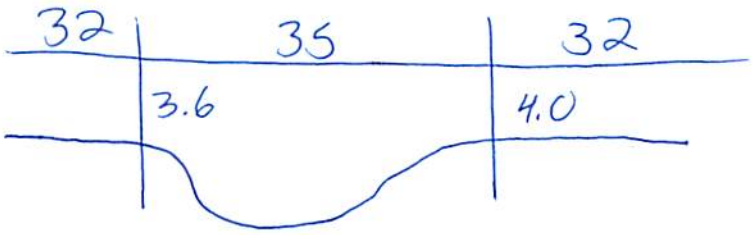
n (LOB) = 0.035

n (ROB) = 0.035

Pier Width = — ft

Pier Length = — ft

Piers for 100 yr = 0 ft



CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section W_1 = 35 ft

Width of left overbank flow at approach, W_{lob} = 32 ft Average left overbank flow depth, y_{lob} = 3.6 ft

Width of right overbank flow at approach, W_{rob} = 32 ft Average right overbank flow depth, y_{rob} = 4.0 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)

Estimated bed material D_{50} = 0.4 ft Average approach velocity, $V_1 = Q_{100}/(y_1W_1)$ = 1.34 ft/s

Critical approach velocity, $Vc = 11.17y_1^{1/6}D_{50}^{1/3}$ = 11.24 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.07 ft If $D_{50} >= D_{c50}$, χ = 0.0

Otherwise, $\chi = 0.122y_1[q_2/(D_{50}^{1/3}y_1^{7/6})]^{6/7} - y_1$ = 0.0 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} = 3.6 ft right abutment, y_{aRT} = 4.0 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} = 12.6 and ψ_{RT} = 13.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 22.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 24.1 ft

SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 32395080 Date 10/29/11 Initials CW Region (A (B) C D)

Site _____ Location 6.5 mi E of Ludlow on Ludlow Rd.

50 Q_{500} = 1180 by: drainage area ratio ____ flood freq. anal. ____ regional regression eq. ✓

Bridge discharge (Q_2) = 1133 (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 = 32 ft. Flow angle at bridge = 3 ° Abut. Skew = 0 ° Effective Skew = 3 °

Width (W_2) iteration = 32

Avg. flow depth at bridge, y_2 iteration = 7.2 → RD Overflow

Corrected channel width at bridge Section = W_2 times cos of flow angle = 31.96 ft* $q_2 = Q_2/W_2$ = 35.5 ft²/s

Bridge Vel, V_2 = 5.1 ft/s Final $y_2 = q_2/V_2$ = 7.0 ft Δh = 0.5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = ~~7.5~~ ft 7.5

** 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. = 7.0 ft

n (Channel) = 0.045

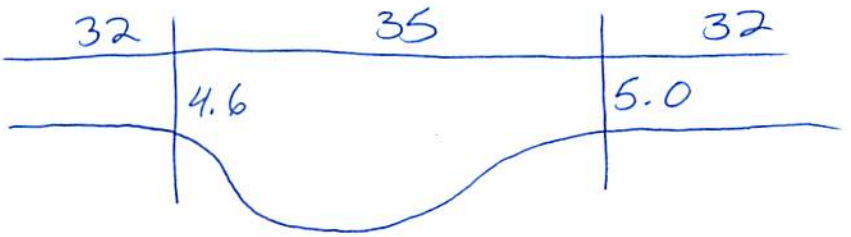
n (LOB) = 0.035

n (ROB) = 0.035

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 = 35 ft

Width of left overbank flow at approach, W_{lob} = 32 ft Average left overbank flow depth, y_{lob} = 4.6 ft

Width of right overbank flow at approach, W_{rob} = 32 ft Average right overbank flow depth, y_{rob} = 5.0 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)

Estimated bed material D_{50} = 0.4 ft Average approach velocity, $V_1 = Q_{500}/(y_1W_1)$ = 1.56 ft/s

Critical approach velocity, $Vc = 11.17y_1^{1/6}D_{50}^{1/3}$ = 11.51 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.

$D_{c50} = 0.0006(q_2/y_1^{7/6})^3$ = 0.023 ft If $D_{50} >= D_{c50}$, $\chi = 0.0$

Otherwise, $\chi = 0.122y_1[q_2/(D_{50}^{1/3}y_1^{7/6})]^{6/7} - y_1$ = 0.0 From Figure 10, y_{cs} = 0.0 ft

PGRM: Pier

PIER SCOUR CALCULATIONS

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

PGRM: Abutment

ABUTMENT SCOUR CALCULATIONS

Average flow depth blocked by: left abutment, y_{aLT} = 4.6 ft right abutment, y_{aRT} = 5.0 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} = 14.3 and ψ_{RT} = 15.0

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 26 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 27.3 ft

Route Ludlow Rd Stream Coal Bank Ck MRM _____ Date 10/29/11 Initials CW

Bridge Structure No. 323950080 Location 6.5 mi E of Ludlow on Ludlow Rd

GPS coordinates: N 45°50' 04.4" taken from: USL abutment X centerline of ⇑ MRM end _____

W 103°14'36.3" Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 12.08 sq. mi.

The average bottom of the main channel was 11.1 ft below top of guardrail at a point 9 ft from left abutment.

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

MISCELLANEOUS CONSIDERATIONS 50

Flows 25	~~Q100~~ = 862			~~Q500~~ = 1180		
Estimated flow passing through bridge	862			1133		
Estimated road overflow & overtopping	—			47		
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? X Yes ____No ____Marginal

Evidence of past Scour? ____Yes X No ____Don't know

Debris Potential? ____High ____Med X Low

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

Riprap X Yes ____No ____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____	Sand____	Gravel X	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

10/4/11

2	103
5	306
10	529
25	862
50	1180
100	1550
500	2650

Photos

2174- us

75- us RB

76- us LB

77- L. Abut

74- R. Abut

74- us Face

2189- ID

Summary of Results

	~~Q100~~ 25	~~Q500~~ 50
Bridge flow evaluated	25	50
Flow depth at left abutment (yaLT), in feet	3.6	4.6
Flow depth at right abutment (yaRT), in feet	4.0	5.0
Contraction scour depth (ycs), in feet	0.0	0.0
Pier scour depth (yps), in feet	—	—
Left abutment scour depth (yas), in feet	22.8	26.0
Right abutment scour depth (yas), in feet	24.1	27.5
1Flow angle of attack	3	3

See Comments/Diagram for justification where required