ok RT Stanley Co.

## SCOUR ANALYSIS AND REPORTING FORM

Bad River

Bridge Structure No. 59391311 Date 7/11/12 Initials RAT Region ( A (B) C D )

Site 06441500 Location approx 1.6 mi SW intersection HWY 83 on Bad Riv. Rd

$Q_{100}$ = ~~42300~~ 117000 by: drainage area ____ flood frequency anal. ~~X~~ regional regression eq. X

Bridge discharge ($Q_2$) = _____ (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 = 418 ft. Flow angle at bridge = 15 ° Abut. Skew = 0 ° Effective Skew = 15 °

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 = 403.76 ft* $q_2 = Q_2/W_2$ = 2698 $ft^2/s$

Bridge Vel, $V_2$ = 13.7 ft/s Final $y_2 = q_2/V_2$ = 21.2 ft $\Delta h$ = 3.9 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 25 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. = 0ri.5 ft

Low Steel Elev. = 29.3 ft 31.5 7.2 used low steel @ bridge depth

n (Channel) = 0.045

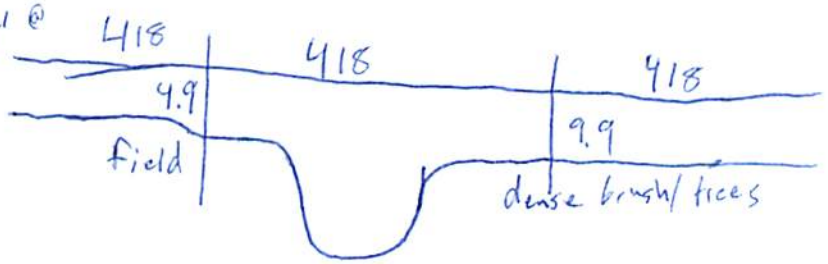
n (LOB) = 0.030

n (ROB) = ~~0.030~~ 0.100

Pier Width = 4 ft

Pier Length = 24.5 ft

# Piers for 100 yr = 4 ft




### CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section $W_1$ = 418 ft

Width of left overbank flow at approach, $W_{lob}$ = 418 ft Average left overbank flow depth, $y_{lob}$ = 4.9 ft

Width of right overbank flow at approach, $W_{rob}$ = 418 ft Average right overbank flow depth, $y_{rob}$ = 9.9 ft

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

$x$ = 7.21 From Figure 9 $W_2$ (effective) = 387.8 ft $y_{cs}$ = 8 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

### PIER SCOUR CALCULATIONS

PGRM: Pier

L/a ratio = 6.125 Correction factor for flow angle of attack (from Table 1), K2 = 1.8

Froude # at bridge = 0.52 Using pier width a on Figure 11, $\xi$ = ~~13~~ 13.1 Pier scour $y_{ps}$ = 21.3 ft

### ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, $y_{aLT}$ = 4.9 ft right abutment, $y_{aRT}$ = 9.9 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, $\psi_{LT}$ = 14.8 and $\psi_{RT}$ = 21.3

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 14.8 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 21.3 ft

## SCOUR ANALYSIS AND REPORTING FORM

Bridge Structure No. 59391311 Date 7/11/17 Initials RAJ Region ( A B C D )

Site 06441500 Location approx 1.6 SW intersection Hwy 83 on Bad River Rd

$Q_{500}$ = 10[illegible]334000 by: drainage area ____ flood frequency anal. ____ regional regression eq. X

Bridge discharge ($Q_2$) = 15245 (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 = 418 ft. Flow angle at bridge = 15 ° Abut. Skew = 0 ° Effective Skew = 15 °

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 = 403.76 ft* $q_2 = Q_2/W_2$ = 376.9 $ft^2/s$

Bridge Vel, $V_2$ = 15.5 ft/s Final $y_2 = q_2/V_2$ = 24.3 ft $\Delta h$ = 5 ft

Average main channel depth at approach section, $y_1 = \Delta h + y_2$ = 29.3 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. = 04.3 ft

Low Steel Elev. = 24.3 ft

n (Channel) = 0.045

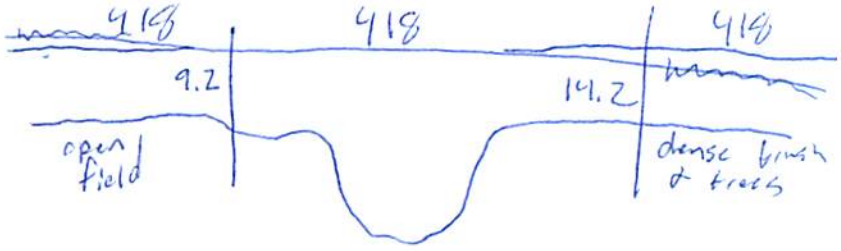
n (LOB) = 0.030

n (ROB) = 0.100

Pier Width = 4 ft

Pier Length = 24.5 ft

# Piers for 500 yr = 4 ft




### CONTRACTION SCOUR

PGRM: Contract

Width of main channel at approach section $W_1$ = 418 ft

Width of left overbank flow at approach, $W_{lob}$ = 418 ft Average left overbank flow depth, $y_{lob}$ = 9.2 ft

Width of right overbank flow at approach, $W_{rob}$ = 418 ft Average right overbank flow depth, $y_{rob}$ = 14.2 ft

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

$x$ = 1341 From Figure 9 $W_2$ (effective) = 387.8 ft $y_{cs}$ = 14.1 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, $Vc = 11.52y_1^{1/6}D_{50}^{1/3}$ = _____ 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: Pier

L/a ratio = 6.125 Correction factor for flow angle of attack (from Table 1), K2 = 1.8

Froude # at bridge = 0.55 Using pier width a on Figure 11, $\xi$ = 13.1 Pier scour $y_{ps}$ = 21.5 ft

### ABUTMENT SCOUR CALCULATIONS

PGRM: Abutment

Average flow depth blocked by: left abutment, $y_{aLT}$ = 9.2 ft right abutment, $y_{aRT}$ = 14.2 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, $\psi_{LT}$ = 20.7 and $\psi_{RT}$ = 24.8

Left abutment scour, $y_{as} = \psi_{LT}(K_1/0.55)$ = 20.7 ft Right abutment scour $y_{as} = \psi_{RT}(K_1/0.55)$ = 24.8 ft

Route Bad River Road Stream Bad River MRM _____ Date 7/18/12 Initials RAT

Bridge Structure No. 59391311 Location approx 1.6 SW intersection Hwy 83 on Bad River Rd

GPS coordinates: N 44° 19' 34.0" W 100° 23' 3.91" taken from: USL abutment X centerline of ⇑ MRM end _____

Datum of coordinates: WGS84 X NAD27 _____

Drainage area = 3147 sq. mi.

The average bottom of the main channel was _____ ft below top of guardrail at a point 161 ft from left abutment.

Method used to determine flood flows: X Freq. Anal. ____ drainage area adjustment X regional regression equations.

## MISCELLANEOUS CONSIDERATIONS

| Flows | $Q_{100}$ = 117000 | | | $Q_{500}$ = 334000 | | |
|---|---|---|---|---|---|---|
| Estimated flow passing through bridge | 117000 | | | 152185 | | |
| Estimated road overflow & overtopping | 0 | | | 181815 | | |
| 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 | |

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| | |
|---|---|
| 2 | 2070 |
| 5 | 8100 |
| 10 | 17400 |
| 25 | 40200 |
| 50 | 70400 |
| 100 | 117000 |
| 500 | 334000 |

Riprap at abutments? X Yes ____ No ____ Marginal

Evidence of past Scour? X Yes ____ No ____ Don't know minor pier/ contraction

Debris Potential? ____ High ____ Med X Low

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 ____ | 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

Note: 2 different pier designs. Used low steel @ bridge depth

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

Note: very dense brush on R right overbank. Hard to accurately measure depth/ profile

Summary of Results

| | Q100 | Q500 |
|---|---|---|
| Bridge flow evaluated | 117000 | 152183 |
| Flow depth at left abutment (yaLT), in feet | 4.9 | 9.2 |
| Flow depth at right abutment (yaRT), in feet | 4.9 | 14.7 |
| Contraction scour depth (ycs), in feet | 8 | 14.1 |
| Pier scour depth (yps), in feet | 21.3 | 21.5 |
| Left abutment scour depth (yas), in feet | 14.8 | 20.7 |
| Right abutment scour depth (yas), in feet | 21.3 | 24.8 |
| 1Flow angle of attack | 15 | 15 |

See Comments/Diagram for justification where required