BSDMS Summary Report

86 SR 370 over Bitterroot River at Bell Crossing near Victor, MT

Site Location:

Site ID: 86

Site Name: SR 370 over Bitterroot River at Bell Crossing near Victor, MT

County: Ravalli

Nearest City: Victor

State: MT

Latitude: 462636

Longitude: 1140722

USGS Station ID: 12350250

Route Number: 370

Route Class: State

Service Level: Other

Route Direction:

Highway Mile Point:

Stream Name: Bitterroot River

River Mile: 38.3

Contact:

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Publication:

Analysis of Scour Potential for Bridge Structure No. S00370 000+0.5361 Crossing Bitterroot River at Secondary Route 370, 2 Miles Northeast of Victor, Montana

WRD, US Geological Survey, Helena, MT in cooperation with the Montana Department of Transportation

June- 1999

Site Description:

The Bell Crossing bridge over the Bitterroot River is part of a roadway that connects the East Side highway with US 93. Due to the expansivness of the Bitterroot river floodplain in the vicinity of the Bell Crossing bridge, there are many relief structures along the connector roadway that assist in conveying high-flow events. A USGS gaging station is located at Bell Crossing (12350250) and has provided seasonal records since 1987. Discharge measurments are made from July through September to help regulate to intense irrigation pressure from the surronding farmlands during the late summer. Water from the Bitterroot river is diverted upstream of the bridge for irrigation of about 80,000 acres. The Painted Rocks Lake (station number 12342000) provides some regulation at the site. At high stages, the left bank overflows and the channel becomes braided with trees and vegetation creating some amount of backwater. The right bank above and below the bridge is riprapped and will overflow at extremely high stages. Bypass flow will occur through 8 ft wide culverts located 500 ft from both ends of the bridge and through a bridge opening 1/2 mile to the east of the site. The nature of the streambed in the vicinity of the site is highly unstable also prone to a large volume of debris.

The Bell Crossing is a 4 span bridge having three, 4.5 ft wide sharp-nosed, webbed piers.

No real-time measurements were made on the upstream side of the bridge or the approach section during the flood event. A level 2 scour analysis was however,

conducted on the site using the WSPRO computer model. The model was used to conduct a step-backwater calculations for the 100-year and 500-year peak discharges at the bridge. The 100-year discharge passed through the bridge as free-surface flow without any overtopping of the roadway. Upon analysis of the 500-year discharge, it was determined that unsubmerged pressure flow conditions would be used in the scour assessment. The scour results are probably conservative and overstate the hydraulic conditions for the 500-year discharge because of the relief that the bridge would likely receive from nearby overflow structures.

WSPRO Hydraulic Results:

Uncontracted Section 100-yr
Average Velocity = 3.96 ft/s Depth = 8.51
Main Channel K = 593320 Left K = 46136 Rigth K = 138971

Bridge Section 100-yr
Worst Case K-tube velocity = 8.82 area = 141.7 sq. ft.

Uncontracted Section 500-yr
Average velocity = 4.20 ft/s Depth = 10.37 ft
Main Channel K=824755 Left K=78353 Right K=235360

Bridge Section 500-yr
Worst Case K-tube = 9.24 area = 183.9 sq ft

Elevation Reference

Datum: Local

MSL (ft): 3219.75

Description of Reference Elevation:

The elevation of the gage is 3330 ft above sea level; this value was determined from a topographic map rather than directly surveyed.

RM #1 - standard brass cap set in right downstream bridge wingwall 50ft upstream from gage house.
Elevation is 21.51 ft above gage datum.
RM#2 - is the head of lag screw in a power pole 9ft upstream and 9ft shoreward from gage house.
Elevation is 12.85 ft above gage datum.
RM#3 - is the head of a lag screw in pine tree 50 ft downstream from gage house.
Elevation is 11.79 ft above gage datum.
RP - is a yellow paint mark on the streamward end of a flat boulder, 15ft streamward from the gage house.
Elevation is 10.43 ft above gage datum.

Stream Data

Drainage Area (sq mi):	1963	**Floodplain Width:**	Narrow
Slope in Vicinity(ft/ft):	.0017	**Natural Levees:**	Little
Flow Impact:	Unknown	**Apparent Incision:**	None

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Channel Evolution	Aggradation	**Channel Boundary:**	Alluvial
Armoring:	Partial	**Banks Tree Cover:**	
Debris Frequency:	Occasional	**Sinuosity:**	Meandering
Debris Effect:	Both	**Braiding:**	Generally
Stream Size:	Medium	**Anabranching:**	None
Flow Habit:	Perennial	**Bars:**	Irregular
Bed Material:	Gravel	**Stream Width Variability:**	Random
Valley Setting:	High		

Roughness Data

Manning's n Values

	Left Overbank	Channel	Right Overbank
High:			
Typical	0.035	0.035	0.08
Low:			

Bed Material

Measurement Number	Yr	Mo	Dy	Sampler	D95 (mm)	D84 (mm)	D50 (mm)	D16 (mm)	SP	Shape	Cohesion
1				Grab on Bed	46.9	33	15.8				Non-Cohesive

Bed Material Comments

Measurement No: 1

Diameters taken from a VA analysis of a grab sample from the bed at low flow near both sides of pier #4.
Results:

Size (mm)	4	9.5	12.5	19	25	31.5	37.5	50	63
% < than	23	32	40	60	75	83	89	97	100

Bridge Data

Structure No: S00370 000+0.5361

Length(ft): 406

Width(ft): 31.5

Number of Spans: 4

Vertical Configuration: Sloping

Low Chord Elev (ft): 115.94

Upper Chord Elev (ft): 116.41

Overtopping Elev (ft): 121.06

Skew (degrees): -20

Guide Banks: None

Waterway Classification: Main

Year Built:

Avg Daily Traffic:

Plans on File: 0

Parallel Bridges No

Upstream/Downstream: N/A

Continuous Abutment: 0

Distance Between Centerlines:

Distance Between Pier Faces:

Bridge Description:

Piers are numbered from left to right, #1 being pile-bent on the left abutment and #5 being lpile-bent on the right abutment. Piers #2 - #4 are located from left to right in the channel.

Abutment Data

Left Station: 0

Right Station: 406

Left Skew (deg): 5

Right Skew (deg) 5

Left Abutment Length (ft): 150

Right Abutment Length (ft) 150

Left Abutment to Channel Bank (ft): 0

Right Abutment to Channel Bank (ft): 0

Left Abutment Protection: Riprap

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Right Abutment Protection	Riprap
Contracted Opening Type:	III
Embankment Skew (deg):	30
Embankment Slope (ft/ft):	2
Abutment Slope (ft/ft)	2
Wingwalls:	No
Wingwall Angle (deg):	

Pier Data

Pier ID	Bridge Station(ft)	Alignment	Highway Station	PierType	# Of Piles	Pile Spacing(ft)
2	100	30		Single		
3	200	30		Single		
4	300	30		Single		

Pier ID	Pier Width(ft)	Pier Shape	Shape Factor	Length(ft)	Protection	Foundation
2	4.5	Sharp		42.5	Unknown	Poured
3	4.5	Sharp		42.5	Unknown	Poured
4	4.5	Sharp		42.5	Unknown	Poured

Pier ID	Top Elevation(ft)	Bottom Elevation(ft)	Foot or Pile Cap Width(ft)	Cap Shape	Pile Tip Elevation(ft)
2	96.19	88.19	8.5	Square	
3	95.98	87.98	7.5	Square	
4	96.41	88.41	8.5	Square	

Pier Description

Pier ID 2

Pier ID 3

Pier ID 4

Pier Scour Data

Pier ID	Date	Time	USOrDS
2	6/25/96	18:00	Downstream
3	6/25/96	17:30	Downstream
4	6/25/96	16:50	Downstream

Pier ID	Scour Depth	Accuracy (ft)	Side Slope (ft/ft)	TopWidth (ft)	Apprch Vel (ft/s)	Apprch Depth(ft)	Effective Pier Width	Skew to Flow(deg)
2	6	0.5					8.5	16
3	8	1					7.5	10
4							8.5	7

PierID	Sediment Transport	Bed Material	BedForm	Trough (ft)	Crest (ft)	Sigma	Debris Effects
2	Live-bed	Non-Cohesive	Unknown				Unknown
3	Live-bed	Non-Cohesive	Unknown				Unknown
4	Live-bed	Non-Cohesive	Unknown				Unknown

PierID	D95 (mm)	D84 (mm)	D50 (mm)	D16 (mm)
2				
3				

4

Pier Scour Comments

Pier ID 2 **Time:** 18:00 **US/DS:** Downstream

Pier ID 3 **Time:** 17:30 **US/DS:** Downstream

WSPRO Results:
100-yr (HEC-18)

Qbridge (cfs)	K1	K2	K3	a	Y1 (ft)	V1 (ft)	Fr	Ys (fps) (ft)
25000	1.0	2.1	1.1	4.7	12.06	8.82	.45	21.4

100-yr (Froehlich Eqn)

phi	a'	Y1 (ft)	Fr	D50 (ft)	Ys (ft)
1.0	14.8	8.5	.45	.049	19.9

500-yr (HEC-18)

Qbridge (cfs)	K1	K2	K3	a	Y1 (ft)	V1 (ft)	Fr	Ys (fps) (ft)
34000	1.0	2.1	1.1	4.7	14.39	9.24	.43	22.3

500-yr (Froehlich Eqn)

phi	a'	Y1 (ft)	Fr	D50 (ft)	Ys (ft)
1.0	14.8	10.4	.43	.049	20.3

Pier ID 4 **Time:** 16:50 **US/DS:** Downstream

Abutment Scour

Measurement Number	Abutment	Date	Time	US/DS	Scour Depth (ft)	Accuracy	Sediment Transport
1	Left	6/25/96		Unknown	5	1	Unknown
2	Right	6/25/96		Unknown	4.5	0.5	Unknown

Measurement Number	Velocity at Abut(ft/s)	Depth at Abut(ft)	Discharge Blocked(cfs)	Avg Velocity Blocked(ft/s)	Avg Depth Blocked(ft)
1					
2					

Measurement Number	Embankment Length (ft)	Bed Material	D50 (mm)	Sigma	Debris Effect
1		Non-Cohesive	15.8		Unknown

2 Non-Cohesive 15.8 Unknown

Abutment Scour Comments

MeasurementNo 1

100-yr Left Abutment

Ae	Qe	Ve	a'	Ya	Fr	K1	Theta	K2	Ys
1603	6250	3.9	226	7.09	.26	.55	70	.97	23.7 ft

Because ratio of a'/Ya exceeds 25, use Eqn 25 from Hec-18 for left abutment scour - Ys=18.1ft
Adjust calculated scour for abutment scew from fig11, HEC-18, theta=70, adustment=.91 Ys=16.5 ft

100-yr Right Abutment

Ae	Qe	Ve	a'	Ya	Fr	K1	Theta	K2	Ys
3229	10302	3.19	541	5.97	.23	.55	110	1.03	27.6

Because ratio of a'/Ya exceeds 25, use Eqn 25 from Hec-18 for right abutment scour - Ys=14.7
Adjust calculated scour for abutment scew from fig11, HEC-18, theta=110, adustment=1.03 Ys=15.1 ft

500-yr Left Abutment

Ae	Qe	Ve	a'	Ya	Fr	K1	Theta	K2	Ys
2016	7753	3.85	233.5	8.63	.23	.55	70	.97	26.2 ft

Because ratio of a'/Ya exceeds 25, use Eqn 25 from Hec-18 for left abutment scour - Ys=21.3ft
Adjust calculated scour for abutment scew from fig11, HEC-18, theta=70, adustment=.91 Ys=19.4 ft

500-yr Right Abutment

Ae	Qe	Ve	a'	Ya	Fr	K1	Theta	K2	Ys
4232	13954	3.30	548.7	7.71	.21	.55	110	1.03	31.5

Because ratio of a'/Ya exceeds 25, use Eqn 25 from Hec-18 for right abutment scour - Ys=18.4
Adjust calculated scour for abutment scew from fig11, HEC-18, theta=110, adustment=1.03 Ys=19.0 ft

MeasurementNo 2

100-yr Left Abutment

Ae	Qe	Ve	a'	Ya	Fr	K1	Theta	K2	Ys
1603	6250	3.9	226	7.09	.26	.55	70	.97	23.7 ft

Because ratio of a'/Ya exceeds 25, use Eqn 25 from Hec-18 for left abutment scour - Ys=18.1ft
Adjust calculated scour for abutment scew from fig11, HEC-18, theta=70, adustment=.91 Ys=16.5 ft

100-yr Right Abutment

Ae	Qe	Ve	a'	Ya	Fr	K1	Theta	K2	Ys
3229	10302	3.19	541	5.97	.23	.55	110	1.03	27.6

Because ratio of a'/Ya exceeds 25, use Eqn 25 from Hec-18 for right abutment scour - Ys=14.7
Adjust calculated scour for abutment scew from fig11, HEC-18, theta=110, adustment=1.03 Ys=15.1 ft

500-yr Left Abutment

Ae	Qe	Ve	a'	Ya	Fr	K1	Theta	K2	Ys
2016	7753	3.85	233.5	8.63	.23	.55	70	.97	26.2 ft

Because ratio of a'/Ya exceeds 25, use Eqn 25 from Hec-18 for left abutment scour - Ys=21.3ft
Adjust calculated scour for abutment scew from fig11, HEC-18, theta=70, adustment=.91 Ys=19.4 ft

500-yr Right Abutment

Ae	Qe	Ve	a'	Ya	Fr	K1	Theta	K2	Ys
4232	13954	3.30	548.7	7.71	.21	.55	110	1.03	31.5

Because ratio of a'/Ya exceeds 25, use Eqn 25 from Hec-18 for right abutment scour - Ys=18.4
Adjust calculated scour for abutment scew from fig11, HEC-18, theta=110, adustment=1.03 Ys=19.0 ft

ContractionScour

Measurement Number	Contracted Date	Contracted Time	Uncontracted Date	Uncontracted Time	US/DS	Scour Depth(ft)
1						
2						

Measurement Number	Accuracy	Contracted Avg Vel(ft/s)	Contracted Discharge(cfs)	Contracted Depth(ft)	Contracted Width(ft)
1					
2					

Measurement Number	Uncontracted Avg Vel(ft/s)	Uncontracted Discharge(cfs)	Uncontracted Depth(ft)	Uncontracted Width(ft)	Channel Contraction Ratio
1					
2					

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Measurement Number	Pier Contraction Ratio	Scour Location	Eccent-ricity	Sediment Transport	Bed Form	Debris Effects
1		Main Channel		Unknown	Unknown	Unknown
2		Unknown		Unknown	Unknown	Unknown

Measurement Number	D95 (mm)	D84 (mm)	D50 (mm)	D16 (mm)	Sigma Bed Material	Bed Material
1						Non-Cohesive
2						Unknown

Contraction Scour Comments

Measurement No. 1

WSPRO Calculations: 500- yr Live-Bed Calculations Y1=10.37 Qmc1=24631 Qmc2=34000 Wc1= 565 Wc2 = 338.2 K1 =.59 Y2 = 18.51 Ys = 8.1 Clear-Water Calculations Y1=10.37 D50=.049 Dm = .062 W2=338.2 Ys = 4.5 -------- 100-yr Live-Bed Calculations Y1= 8.51 Qmc1=19055 Qmc2=25000 Wc1=565 Wc2=322.2 K1 = .59 Y2 = 14.92 Ys=6.5 Clear-Water Calculations Y1=8.51 D50=.049 Dm=.062 W2=322.2 Ys=3.4

Measurement No. 2

Stage and Discharge Data

Peak Discharge year	mo	dy	hr	mi	Flow (cfs)	Qacc	Peak Stage year	mo	dy	hr	mi	Stage (ft)	Water Temp (C)	Return Period(yr)
					6,480					17:00		7.40		1.25
					34,000									500
					25,000									100

Hydrograph

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Supporting Files

bellcrossing.xls - Excel worksheet with real-time, post-flood, and bridge-plan survey data and the resulting plot of bathymetry profiles used to estimate depth of scour during the 1996 flood.

bittbell.txt - WSPRO input file used to model the hydraulics and scour at the Bell Crossing bridge over the Bitterroot River.

Photos of the Site (Dscn prefix; .jpg formats):

#	Description
176.	Looking upstream from bar on left side
177.	Looking upstream from bar on left side
178.	Looking at center pier from bar
179.	Looking upstream to right from downstream bar
180.	Looking upstream to right at downstream right edge of bridge
181.	Looking at pier on left, note buried debris
182.	Looking downstream along right side of left pier
183.	same as 182
184.	Looking upstream at left pier
185.	Looking at potential abutments scour on left abutment
186.	same as 185
187.	same as 185
188.	same as 185
189.	Looking from right to left along upstream side of bridge
190.	Looking from right bank at upstream edge of bridge
191.	Looking from right bank at center upstream of bridge
192.	Looking from right bank at right side of bridge
193.	Looking from right bank at right abutment
194.	Montana crew with knee board
195.	From bridge looking right to left
196.	Looking upstream along right bank
197.	Looking upstream at right floodplain
198.	Looking upstream into right floodplain
199.	Looking down road into right floodplain
200.	Looking upstream at left bank
201.	Looking upstream at hole along left abutment
202.	Looking from center of bridge towards left bank.
203.	Same as 202
204.	Looking downstream at abutment scour on left bank
205.	same as 204
206.	Looking downstream from bar on downstream left bank
207.	Looking downstream into left floodplain