PERENNIAL STREAM CROSSINGS

Frenchman Creek MP 25.8

Site	Frenchman Creek MP 25.8	Date	08/03/09	
Done by: GF, ML		Rev	view: EG	

Regional Regression Analysis												
Source	Drainage Area	Average		ļ	Recurren	ce Interva	I					
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100				
Omang (1992)	366.8*	2,656	619	1,787	2,924	4,735	6,472	8,337				

*163mi² of watershed area is located in USA. An evaluation of the relief map showed more than twice of the amount of the watershed is within Canada.

Geomorphology

For Reach (extending at least 3 meander wavelengths or 20 channel widths upstream and downstream of pipeline crossing)

		Channel				Valley	,				
Gradient (%): <0.01				Gradient (%): <0.01						
Width (ft)	min	max	ax mean std o		width	min	max	mean	std dev		
	34	61	47	10	wiath	429	864	633	164		
meander w	vavelength (ft) 1020			describe	e geology:					
meander a	mplitude (ft)	456			n of moder at crossing	n channels	and flood	plains 31			
Sinuosity 1	63				Both sides Judith River Fm: Light brown to light gray, fine- to coarse-grained sandstone with interbeds of gray to black carbonaceous shale, silty shale, and thin coal.						
Sinuosity i	.05				US both sides Bearpaw Fm: Shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds.						
	Upstre	eam (ft)	Downst	ream (ft)	Floodplain						
	distance		distance		FEMA N if yes, describe widths below						
	from crossing	radius of curvature	from crossing	radius of curvature	width	min	max	mean	std dev		
radius of			Ŭ								
curvature (ft)	213	388	731	326							
()	941	245	1784	227	describe	e abundano	ce and loca	ation(s) of:			
	1906	165	2207	275	scroll bars:						
	2767	199			0.6 mi DS						
					Oxbows:						
channel form:						0.8 mi US, probably enhanced for ag use					
	nch				nel cut-off						

channel confinement:	None							
12.74	Relic channels 1.3, 1.8 and 2 mi US							
What is elevation of the channel relative to the floodplain (perched, incised)? What is evidence?								
Same								
Unique features, exceptions, etc								
Tribs: unnamed 0.1, 0.4, 0.6 mi US; 0.5, 0.6, 0.8, 0.9 mi DS. Meanders directly US is especially tortuous (sinuosity=2.43)								
Evidence of landslides upstream or downstream along valley margi	ns (upstream/downstream with distance to pipeline):							
1.6 mi US								
Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline):								
Parallel roads 0.85mi from LB; Concrete dam 2.56mi DS with Fre dam and buildings and road on RB of reservoir	enchman Reservoir (1.5 by 0.75 mi wide), road over							
Describe any direct or indirect evidence of general scour/channel incision:								
None								

LITERATURE REVIEW							
	Г	(check box when searched for, if none, note under source) source(s):					
Existing channel migration zone determination		None					
Reports on local/regional							
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p.					
hydraulics		source(s): None					
sediment transport		source(s): None					
bridge scour		 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources 					

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	Fax 406-444-6155 Mark Goodman Montana Department of Transportation 40-444-6246
Ice jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u>
Turbidity	source(s): None
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) USGS 06158000 Frenchman R ab Eastend Re nr Ravenscrag Sask http://waterdata.usgs.gov/mt/nwis/dv/?site_no=06158000&PARAmeter_cd=00060
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Rock Creek MP 39.2

Site	Rock Creek MP 39.2	Date	08/03/09	
Done by	GF, ML	Rev	view: EG	

Regional Regression Analysis									
Source	Drainage	Average	Recurrence Interval						
Source	Area (mi²)	Elevation (ft)	2	5	10	25	50	100	
Omang (1992)	293.8*	2,603	535	1,570	2,587	4,221	5,791	7,491	

*226 mi² of watershed area is located in USA. An evaluation of the relief map shows an additional 30% of the watershed area is within Canada.

Geomorphology										
NOTE: All measures confinement)	should be ro	ounded to the	e nearest wh	ole number,	except fo	or draina	ge area an	d ratios lil	ke sinuosity o	
For Reach (extendi crossing)	ng at least 3	3 meander v	wavelengths	or 20 chan	nel widt	hs upstro	eam and	downstrea	m of pipelin	
	Ch	annel					Valle	ey		
Gradient (%):	0.1				Gradien	t (%): 0.1				
VV/idth (ft)	min	max	mean	std dev	width	min	max	mean	std dev	
Width (ft)	26	60	43	14	wiath	577	1391	877	307	
meander way	elength (ft)194	45.0			describe	e geology	(lithology, e	erodibility):		
meander amplitude (ft) 361.0						alluvium: g and river	ravel, sand	d, silt, and and floodp	el deposits 63 clay deposits lains 701 ft RB	
Sinuosity 1.45						Claggett Shale on LB: shale with thin, gray sandstone laminae and beds in upper or middle part and calcareous concretions in lower part Judith River Fm on both banks: fi ne- to coarse grained sandstone with interbeds of gray to blac carbonaceous shale, silty shale, and thin coal.				
	Upstre	eam (ft)	Downst	ream (ft)	Floodplain					
					FEMA National Database N					
	distance from	radius of	distance from	radius of	if yes, describe widths below					
	crossing	curvature	crossing	curvature	Width	min	max	mean	std dev	
radius of					(ft)					
curvature (ft)	853	217	3608	501						
	2073	473	4697	470	Describ	e abundar	nce and loc	ation(s) of:		
	3205	211	6314	311	scro	l bars:				
	3946	233			US 0.2, 1.4 mi					
	853	217			oxbo	WS:				
					None	Э				

Channel form (braided, anabranching, single thread):	channel cut-offs:					
Single with occasional islands	None					
Channel confinement at crossing (W $_{v}$ / W $_{c}):$	Relic channel 1.3 and 1.5 mi DS					
37.50						
What is elevation of the channel relative to the floodplain (perched, incised)? What is evidence?						
The channel is incised because the floodplain elevation is greater than the channel's water surface						

Unique features, exceptions, etc:

Tribs: unnamed stream US 0.1, 0.5, 0.77, 0.81, 1.5 mi; DS 0.1, 0.3, 1.2, 0.3 mi.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

See geology above, Listed as high risk by PHMSA NPMS Landslide Hazard Map

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

A number of small roads running parallel to the creek on both sides and a group of buildings 0.9 DS.

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

None

	LITERATURE REVIEW (check box when searched for, if none, note under source)						
Existing channel migration zone determination		source(s): Environmental Impact Statement Rock Cr. http://www.deq.state.mt.us/pcd/RockCreek/Volume%20III.pdf					
Reports on local/regional:							
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water- Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report					
hydraulics		source(s): None					
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005- 5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water- Resources Investigations Report 98-4137, 35 p.					

source(s):
 Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP-90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation
40-444-6246 source(s):
Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation
http://www.fema.gov/news/event.fema?id=635 source(s):
Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Hist orical%20Alterations.pdf
source(s): (note if managed flow, e.g. canals or flow during summer only) USGS 06209010 Rock Cr bl Glacier Lake nr Red Lodge MT http://waterdata.usgs.gov/mt/nwis/dv/?site_no=06209010&PARAmeter_cd=00060
source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Site	Willow Creek MP 40.4		Date	08/03/09
Done by:	GF, ML	Rev	/iew: EG	

Willow	Creek	MP	40 4
	CIECK		40.4

	Regional regression and peak flow analysis										
			Regio	onal Regre	ssion						
Source Drainage Area Average Recurrence Interval											
(mi ²)		Eleva	Elevation (ft)		5	10	25	50	100		
Omang (1992)		273.2 2,658		658	505	1,475	2,428	3,953	5,419	6,999	
Peak Flood Flow											
Gauge Name and	Drainage	Up or	Distance	Range	Recurrence Interval						
Number	Area (mi ²)	Down- stream	Crossing (mi)	to ossing (vears)	2	5	10	25	50	100	
06170200 Willow Creek near Hinsdale MT (Regional Regression)	283.0	DS	1.45	8 (1965- 1973)	517	1,509	2,482	4,039	5,535	7,146	

or Reach (extend	ing at least 3	3 meander w	avelengths o	or 20 channe	widths u	ipstream	and down	stream of	crossing)
			Va	lley					
Gradient (%): <0.001						it (%): 0.0	02		
Width (ft)	min max mean std dev						max	mean	std dev
Width (ft)	27	49	36	7	width	27	49	36	7
meander w	avelength (ft)	: 1288			describe	e geology	(lithology,	erodibility):	
meander a	mplitude (ft):	1078					and gravel ft at crossir		om stream and
Sinuosity:	2.58				fine- to to to black Both sic	coarse-gr carbonad les, from	ained sand ceous shale ust US of c	stone with i e, silty shale crossing DS	n to light gray, interbeds of gray a, and thin coal. Claggett one laminae and
					beds in in lower		middle part	and calcar	eous concretion
					DS on F	RB landsli	de deposit		
radius of curvature	Upstre	eam (ft)	Downst	ream (ft)			Floo	dplain	
(ft)	distance	radius of	distance	radius of			atabase N idths below		
	from curvature crossing		curvature	Width	min	max	mean	std dev	

	805	689	2562	301	
	1141	597	4936	739	Describe abundance and location(s) of:
	2074	402	6422	350	scroll bars:
	2614	390	8095	409	1.6 mi DS and on trib 0.9 mi US
					oxbows:
					none
Channel fo	orm (braided, ana	branching, s	single thread):		channel cut-offs:
Single Thr	ead but several r	elic channel	s, river right		Relic channel US 0.4 mi, DS 0.3, 0.6, 1, 1.4 mi
Channel c	onfinement at cro	ossing (W_v / V	W _c):		
29.31					
What is elevation o	of the channel rela	ative to the fl	oodplain (perc	ched, incise	d)? What is evidence?
Floodplain is highe	r than water surfa	ace elevatior).		
1 0					
Unique features, ex	xceptions, etc				
Flows into Rock Cr	eek 1.5 mi, unna	med tribs: U	S 0.5, 0.8 DS	0.2, 0.3, 0.	6, US Eagle's Nest Coulee 0.86 mi
Evidence of landsl along valley axis?):		r downstrea	m along valle	y margins	(Upstream/downstream? Straight line distance to pipeline
0.4 mi US. Listed a	is high risk by P⊢	MSA NPMS	Landslide Ha	zard Map	
Describe any infra feature, right or left				rlines, etc)	(upstream/downstream with distance to pipeline, if linear
parallel Road cros	ses at Bridge (DS	6 0.84 mi)			
If visible, describe a	any direct or indi	ect evidence	e of general so	cour/channe	el incision (straightened channel, etc):
None					

	LITERATURE REVIEW
	(check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm

		Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u>
		Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf
		Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
		Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
bridge scour		Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
		Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
		Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
		Mark Goodman Montana Department of Transportation 40-444-6246
		source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u>
Ice jams		Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/
		Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u>
Turbidity		source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages		source(s): (note if managed flow, e.g. canals or flow during summer only) 06211500 Willow Creek near Boyd MT http://waterdata.usgs.gov/mt/nwis/dv/?site_no=06211500&PARAmeter_cd=00060
1:24000 geologic maps		Source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Site	Milk River MP 82.7		Date	08/03/09
Done by:	GF, ML	Rev	/iew: EG	

		Regi	onal regress	sion and pe	eak flow a	nalysis						
			Regio	onal Regre	ssion							
Source		Drainage Ar	ea Av	a Average		Recurrence Interval						
Source		(mi ²) Elevation (ff		tion (ft)	2 5		10	25	50	100		
Omang (1992)		22,324*										
			Pea	ak Flood F	low	•	•	•	•	•		
Gauge Name and	Drainage	Up or	Distance	Range	Recurrence Interval							
Number	Area (mi ²)	Down- stream	to Crossing (mi)	of Data (years)	2	5	10	25	50	100		
06174500 Milk River at Nashua MT: Exceedence Probability	22,332	DS	2.49	70 (1939- 2009)	5,750	12,200	17,200	23,700	28,600	33,400		
06174500 Milk River at Nashua MT: Bulletin 17B	22,332	DS	2.49	70 (1939- 2009)	5,452	11,118	15,392	19,673	25,313	29,540		

*Regional Regression developed for watersheds under 2,500 mi²

Geomorphology										
NOTE: All measur	es rounded t	to whole nun	nber, except	for drainage	area and	ratios lik	e sinuosit	y or confir	nement)	
For Reach (extend	ling at least	3 meander w	avelengths o	or 20 channe	el widths u	pstream	and down	stream of	crossing)	
	Channel						Valle	у		
Gradient (S	%): <.001				Gradien	t (%): <0.	01			
	min		min	max	mean	std dev				
width	84	104	95	8	width	2624	3019	2785	148	
meander w	vavelength (ft)): 3343			describe geology (lithology, erodibility):					
meander a	mplitude (ft):	1266			ft wide a	n of mode at crossing Alluvium c	1	Is and flood	d plain 8683	
					RB glac	ial deposi	ts undivide	d		
Sinuosity:	2.80				Bearpay calcared ferrugin bentonit	ous con	Shale wit cretions, cretions,			
radius of curvature	Upstre	eam (ft)	Downst	ream (ft)			Floodpl	ain		
curvalure	distance	radius of	distance	radius of	FEMA N	lational Da	atabase N			

(ft)					if yes, d	escribe w	vidths below	I			
	from crossing	curvature	from crossing	curvature	Width (ft)	min	max	mean	std dev		
	1765	1012	2175	1248							
	15137	3513	7278	932	Describe	e abunda	nce and loc	cation(s) of:			
	21140	2096	8836	842	scrol	l bars:					
	26145	2703	11244	1384	DS 2	2.4 mi; US	6 1.1 mi, 1.9	9 mi			
					oxbo	WS:					
Channel fo	orm (braided, a	anabranching	, single thread	d):	Oxbow	or man m	ade pond E	DS 1.9 mi; L	IS 0.15 mi,		
Single three	ead				chan	inel cut-o	ffs:				
Channel c	onfinement at	crossing (W_v	/ W _c):		none						
90.98					Relic channel						
					DS 0).5 mi, US	6 1.1 mi, 1.9	9 mi, 2.45 m	i		
What is elevation o	f the channel	relative to the	floodplain (p	erched, incise	ed)? What	is evider	ice?				
Incised, the floodpl	ain surroundin	g the channe	l has a highe	r elevation tha	an the cha	nnel					
Unique features, ex	ceptions, etc										
Trib US 2.3 mi, Por	rcupine Creek	2.6 mi DS, ni	umerous irriga	ation canals, f	lows into	Missouri	River 6.1 m	i			
Evidence of lands pipeline along valle		n or downsti	ream along v	alley margin	s (Upstre	am/down	stream? St	traight line	distance to		
US 0.34 mi, mappe	ed for high land	dslide hazard	by the PHMS	SA in NPMS							
Describe any infra linear feature, right				werlines, etc)	(upstrea	m/downst	tream with	distance to	pipeline, if		
US: 1. Road (Riv residences, includin											
If visible, describe a	any direct or ir	ndirect eviden	ce of general	scour/channe	el incision	(straighte	ened chann	el, etc):			
None											

LITERATURE REVIEW									
(check box when searched for, if none, note under source)									
Existing channel migration zone determination		source(s): Fluvial process and the establishment of bottomland trees, Milk River http://www.sciencedirect.com/science? ob=ArticleURL& udi=B6V93-3VWF7VK- N& user=10& rdoc=1& fmt=& orig=search& sort=d& docanchor=&view=c& searchStrld=97666 8765& rerunOrigin=google& acct=C000050221& version=1& urlVersion=0& userid=10&md5=a a6e4538e8adce064615367ef6cc7d40							
Reports on local/regional									
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.]							
		U.S. Geological Survey Water-Data Report							

hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp.rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yéllowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6155 Mark Goodman Montana Department of Transportation 40-444-6155 Mark Goodman Montana Department of Transportation 40-444-6155
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p.

	http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) 06132200 South Fork Milk River near Babb MT 06132500 S F Milk River nr internat'l boundary nr Brown 06132700 Milk River near Del Bonita MT 06133500 N F Milk River ab St. Mary canal nr Browning M
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Missouri River MP 89

Site	Missouri River MP 89	Date	08/03/09	
Done by:	GF, ML	Rev	/iew: EG	

	Regional regression and peak flow analysis										
			Regio	onal Regres	ssion*						
Source		Drainage Ar	ea Av	erage			Recurren	ce Interva	I		
Source		(mi ²) Eleva		Elevation (ft)		5	10	25	50	100	
Omang (1992)		57,565									
Peak Flood Flow											
Gauge Name and	Drainage	Up or	Up or Distance				Recurren	ce Interva	I		
Number	Area (mi ²)	Down- stream	to Crossing (mi)	of Data (years)	2	5	10	25	50	100	
06132000 Missouri River below Fort Peck Dam MT: Bulletin 17B-regional skew	57,556	US	1.81	74 (1934- 2008)	16,900	23,900	28,700	34,800	39,500	44,300	
06132000 Missouri River below Fort Peck Dam MT: Bulletin 17B-station skew	57,556	US	1.81	74 (1934- 2008)	16,127	23,332	28,554	33,985	41,321	47,229	

*Regional regression used is for watersheds less than 2,500 mi²

Geomorphology NOTE: All measu	ires rounded	l to whole nu	mber, excep	t for drainage	e area and	ratios lik	e sinuosit	y or confir	nement)		
For Reach (exter	nding at leas	t 3 meander v	wavelengths	or 20 channe	el widths ι	ıpstream	and down	stream of	crossing)		
	Channel							Valley			
Gradient	(%): 0.02				Gradien	it (%): 0.0)3				
	min	max	mean	std dev		min	max	mean	std dev		
width	656	987	811	147	width	3289	4380	3780	358		
meander	wavelength (ft): 15,009			describe	e geology	(lithology,	erodibility):			
meander	meander amplitude (ft): 5352					Alluvium of modern channels and flood plains 12,651 ft wide Both sides Quaternary landslide deposits, alluvium-colluvium glacial deposits undivided					
					concreti	ions, a b		e of ferru	veral zones of calcareou ginous concretions, ar		
Sinuosity	: 1.35				RB Hell Creek FM: bentonitic claystone that alternates with gray to brown sandstone interbedded with carbonaceous shale						
					RB Fox Hills Fm: fine- to medium-grained, non-calcareous sandstone in upper part, and interbedded sandstone, siltstone, and black shale with calcareous concretion zone in lower part						

	Upstre	am (ft)	Downsti	ream (ft)	Floodplain					
	distance	radius of	distance from	radius of	FEMA National Database N if yes, describe widths below					
	from crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	std dev	
radius of curvature	1765	7017	21140	4255						
(ft)	15137	4773	26145	2787	Describe	e abundar	nce and loc	cation(s) of:		
			2175	2979	scrol	l bars:				
					US 0.5, 1, 1.8, 3.95 mi, DS 0.5 mi at Milk R confluence, mi oxbows:					
					adjao	cent to cro	ossing			
Channel for	rm (braided, a	anabranching	, single thread	d):	chan	nel cut-of	fs:			
Single with	vegetated isl	ands			None					
Channel co	onfinement at	crossing (W_v	/ W _c):		Relic channel possibly DS, but obscured by ag fields					
13.17										
What is elevation of	the channel	relative to the	floodplain (p	erched, incise	ed)? What	is eviden	ce?			
Incised: the flood pla	ain elevation	is higher than	the channel.							
Unique features, ex	ceptions, etc:									
Milk River confluence	e 0.2 mi from	n crossing. Nu	imerous smal	I tribs and irri	gation car	nals.				

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US: 1. Fort Peck Dam 5.5 mi and spillway 0.9 mi, town of Fort Peck and Fort Peck Lake 2. High Voltage Transmission line (0.05mi, perp.) 3. Railroad (0.40 mi left bank par.) DS: 1. Road (0.60 mi river left, par.) 2 reservoirs 3.9 mi US 0.22 sq mi total area, numerous stock ponds off RB

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

None

LITERATURE REVIEW									
	(check box when searched for, if none, note under source)								
Existing channel migration zone determination		source(s): Channel Processes on the Missouri River, Montana http://www.docstoc.com/docs/783910/CHANNEL-PROCESSES-on-the-MISSOURI-RIVER- MONTANA							
Reports on local/regional									
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p.							

	Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868 .]
	U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
oodimont transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.
sediment transport	Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.
	source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u>
	Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. <u>http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf</u>
	Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
	Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
bridge scour	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue
	Helena Mt 59601-6456 Phone: (406) 457-5929 Email: <u>holnbeck@usgs.gov</u>
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
Ice jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u>
	Montana Ice Jam. River Ice and River Ice Processes

	http://www.wrh.noaa.gov/tfx/icejam/
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u> source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical
Turbidity	alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. <u>http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt</u> <u>erations.pdf</u>
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) 06058000 Missouri River at Canyon Ferry MT 06058502 Missouri R bl Canyon Ferry Dam nr Helena MT 06074000 Missouri River at Cascade MT 06078200 Missouri River near Ulm MT 06090300 Missouri River near Great Falls MT 06090800 Missouri River at Fort Benton MT 06109000 Missouri River at Loma MT 06109500 Missouri River at Virgelle MT 06115200 Missouri River near Landusky MT 06058000 Missouri River at Canyon Ferry MT 06058000 Missouri River at Canyon Ferry MT 06065500 Missouri River bl Hauser Dam near Helena MT 06065500 Missouri River bl Holter Dam nr Wolf Cr MT 06071500 Missouri River at Craig MT 06177000 Missouri River near Wolf Point MT 06185500 Missouri River near Culbertson MT
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

West Fork Lost Creek MP 93.8

Site	West Fork Lost Creek MP 93.8	Date	08/03/09	
Done by	: GF, ML	Rev	riew: EG	

Regional Regression Analysis									
Source	Drainage Area	Average Elevation (ft)	Recurrence Interval						
	(mi²)		2	5	10	25	50	100	
Jennings et al. (1994)	0.39	2585	14	50	94	176	259	306	

For Reach (extend	ling at least 3	B meander w	avelengths o	r 20 channel	widths u	pstream	and down	stream of	crossing)
•	-	hannel	-			·	Valle		•
Gradient (%): 2.07				Gradien	t (%): 3.	7		
Width	n min max mean std dev			min	mean	std dev			
*hard to determine where stream is- Bkf=0.6ft	24	42	30	7	width	224	257	238	13
meander v	vavelength (ft)	210			describe	e geology	(lithology,	erodibility):	
					alternate	es with g		entonitic cla n sandstone ous shale	
	Implitude (ft) 1	07			non-calc interbed	careous s ded sand	andstone i dstone, silts	e- to mediur n upper par stone, and s in lower pa	t, and hale with
Sinuosity:	1.54								
	Upstre	am (ft)	Downst	ream (ft)			Floodp	lain	
	distance from	radius of	distance from	radius of			Database N vidths belov		
radius of	crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	std dev
curvature	1059	122	174	55					
(ft)	886	87	259	83	Describe	e abunda	nce and lo	cation(s) of:	
676					scrol	l bars:			
	508	71			None	9			
	361	76			oxbo	WS:			
	31	71			None	Э			
	1		1	1	chan	nel cut-o	ffs:		
<u> </u>	orm (braided, a	<u> </u>	<u> </u>			e visible.			

Single thread					
Channel confinement at crossing (W_v / W_c):					
9.24					
What is elevation of the channel relative to the floodplain (perched, incise	ed)? What is evidence?				
The floodplain elevation is greater than the channel surface.					
Unique features, exceptions, etc					
Tribs DS 0.3 and 0.38 mi. Backwater conditions of dam 0.2 mi DS could	extend as far upstream as the crossing.				
Evidence of landslides upstream or downstream along valley margin pipeline along valley axis?):	s (Upstream/downstream? Straight line distance to				
Landslide deposits 1.25 mi west on Fort Peck Lake, listed as high hazard	d in PHMSA NPMS				
Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):					
US: 1. Road (0.1mi Par.) 2. Electric Lines (0.50 mi Perp.) DS: Earthen dam with pond 0.2 mi					

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc): None

	LITERATURE REVIEW (check box when searched for, if none, note under source)						
Existing channel migration zone determination		source(s): Watershed Restoration Assessment for Lost Creek http://www.archive.org/stream/watershedrestora00harr/watershedrestora00harr_djvu.txt					
Reports on local/regional							
		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p.					
Hydrology		Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at <u>http://water.usgs.gov/pubs/sim/2004/2868</u> .]					
		U.S. Geological Survey Water-Data Report					
hydraulics		source(s): None					
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.					
sedment transport		Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.					
		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u>					
bridge scour		Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. <u>http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf</u>					
		Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.					

	Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u>
lce jams	Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u>
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) 06215500 Lost Creek near Pryor MT 12323840 Lost Creek near Anaconda MT 12323850 Lost Creek near Galen, MT
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Trib. to West Fork Lo	st Creek MP 94.6
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Site	Trib. to West Fork Lost Creek MP 94.6	Date	08/03/09	
Done by: GF, ML		Re۱	/iew: EG	

Regional Regression Analysis								
Source	Drainage Area	Average	Recurrence Interval					
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100
Jennings et al. (1994)	0.39	2588	14	50	93	176	258	305

Geomorphology									
NOTE: All measur			•	-				-	
For Reach (extend	-		avelengths o	or 20 channe	l widths u	pstream			crossing)
	Channel							у	
Gradien (%	Gradien (%): 2.9						6		
Width	min	max	mean	std dev		min	max	mean	std dev
*Vegetation prevented an accurate channel measurement	34	47	39	5	width	37	62	47	8
meander v	vavelength (ft)	: 420			describe	e geology	(lithology,	erodibility):	
					alternate	es with gi		n sandstone	aystone that e
meander a	mplitude (ft) 1	111			non-cald interbed	careous s Ided sand	andstone in dstone, silts		
Sinuosity 1	.23				calcared	ous cor ous cor	ncretions,	a basal	al zones o zone o nerous thir
radius of	Upstre	am (ft)	Downst	ream (ft)	Floodplain				
curvature (ft)					FEMA National Database N				
	distance	radius of	distance	radius of	if yes, d	escribe w	vidths belov	v	
	from crossing	curvature	from crossing	curvature	Width (ft)	min	max	mean	std dev
	640	97	93	90					
	410	63	227	57	Describ	e abunda	ince and lo	cation(s) of:	
			441	102	scrol	l bars:			
			731	64	None	Э			
			1302	86	oxbo	WS:			
			1588	51	None	Э			

		1814	85	channel cut-offs:		
Channel fo	rm (braided, anabranchi	ng, single thread):		None		
Single Thre	ead					
Channel co	onfinement at crossing (W _v / W _c):				
4.21						
What is elevation of	the channel relative to	he floodplain (perc	hed, incised	d)? What is evidence?		
The floodplain eleva	ation is greater than the	channel.				
Unique features, ex	ceptions, etc					
	ng, There is a straighte ssible incision location.	ned section of cha	nnel 0.25 r	mi US of crossing (at the stream crossing with the		
Evidence of landsl pipeline along valle		istream along valle	ey margins	(Upstream/downstream? Straight line distance to		
listed as high hazar	d in PHMSA NPMS, Ian	dslide deposits 2 m	iles west or	n Fort Peck Lake		
	structure (bridges, roads or left bank, perpendicul		rlines, etc)	(upstream/downstream with distance to pipeline, if		
US: 1. Electricity lin	nes (0.25 mi, perp.) 2. I	Hwy 24 with culvert	(0.6 mi, pe	rp.)		
If visible, describe a	ny direct or indirect evic	lence of general sc	our/channe	l incision (straightened channel, etc): None		

LITERATURE REVIEW (check box when searched for, if none, note under source)					
Existing channel migration zone determination		source(s): None			
Reports on local/regional					
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report			
hydraulics		source(s): None			
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.			
bridge scour		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u> Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. <u>http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf</u>			

	1	
		Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
		Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
		Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
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		Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
		Mark Goodman Montana Department of Transportation 40-444-6246
lce jams		source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
		Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity		source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages		source(s): (note if managed flow, e.g. canals or flow during summer only) 06215500 Lost Creek near Pryor MT
1:24000 geologic maps		source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Site	East Fork Prairie Elk Creek MP 127.6		Date	08/03/09
Done by:	GF, ML	Rev	/iew: EG	

East Fork Prairie Elk Creek MP 127.6

	F	legional	regression	and pea	k flow a	analysis				
			Regional	Regress	sion					
Drainage Average Recurrence Interval										
Source	Are	a (mi²)	Elevation (ft)		2	5	10	25	50	100
Omang (1992)	2	0.39	2,58	31	125	407	734	1,278	1,801	2,130
	ł		Peak F	lood Flo	w					
Gauge Name and	Drainago	Up or	Distance	Range		R	ecurren	ce Interv	/al	
Number	Drainage Area (mi ²)	Down- stream	to Crossing (mi)	of Data (years)	2	5	10	25	50	100
06175540 Prairie Elk Creek near Oswego MT	352.0	DS	39.2	10 (1975- 1985)	5,563	18,034	30,150	44,504	56,098	58,943

Geomorphology											
NOTE: All measure	es rounded t	o whole num	nber, except	for drainage	area and	ratios like	sinuosity	or confine	ement)		
For Reach (extend	For Reach (extending at least 3 meander wavelengths or 20 channel widths upstream and downstream of crossing)										
	C	hannel			Val	ley					
Gradient (9	%): <0.1				Gradien	t (%): 0.4					
Width (ft)	min	max	mean	std dev	Width	min	max	mean	std dev		
width (it)	12	60	26	16	(ft)	367	830	538	167		
meander w	avelength (ft)	869			describe	e geology (lithology, e	rodibility):	I		
meander a	mplitude (ft) 5	594			Alluvium at cross		n channels	and flood	plains 505 ft wide		
meander a		5 0-1			Alluvium colluvium US both sides						
					Fort Union Fm:						
					Tullock Member both side just upstream to DS: sandstone interbedded with subordinate shale and thin beds of coal						
Sinuosity 2	2.08				Lebo member both sides US: carbonaceous shale, bentonitic claystone, sandstone, and coal						
						River Merr			idstone, sandy		
radius of	Upstre	eam (ft)	Downst	ream (ft)			Flood	Iplain			
curvature (ft)					FEMA N	lational Da	tabase N				
	distance from radius of from radius of										
	curvature		crossing	curvature	Width	min	max	mean	std dev		
					(ft)						
	256	217	567	263		•	•	•	•		
	1254	240	1194	226	Describe abundance and location(s) of:						

	1969	133	1988	211	scroll bars:		
	2779	373	2762	311	None		
	3897	184			Oxbows:		
					None		
Channel fc	orm (braided, ana	branching, s	ingle thread)):	channel cut-offs:		
single					None		
Channel co	onfinement at cro	ssing (W_v / V	N _c):				
11.59							
What is elevation o	f the channel rela	tive to the fl	oodplain (pe	rched, incised	d)? What is evidence?		
It appears to be perched in some sections. The elevation of the free water surface appears to be higher in some places than the surrounding flood plain, (0.00-0.40 mi US and DS of crossing) Unique features, exceptions, etc:							
0 1				<i>})</i>			
Unique features, ex	ceptions, etc:			,,	ner unnamed trib also with source at pond behind dam.		
Unique features, ex	cceptions, etc: d stream with da ides upstream o	m 0.2 mi fror	n confluence	e, 0.3 mi anoti	ner unnamed trib also with source at pond behind dam. (Upstream/downstream? Straight line distance to pipeline		
Unique features, ex US, 125 ft unnamed Evidence of landsl	cceptions, etc: d stream with dat ides upstream o	m 0.2 mi fror	n confluence	e, 0.3 mi anoti	l l		
Unique features, ex US, 125 ft unnamed Evidence of landsl along valley axis?): Possibly US 0.3 mi	cceptions, etc: d stream with dar ides upstream o structure (bridge	n 0.2 mi fror r downstrea s, roads, bu	n confluence m along val iildings, pow	, 0.3 mi anotl ley margins	l l		
Unique features, ex US, 125 ft unnamed Evidence of landsl along valley axis?): Possibly US 0.3 mi Describe any infra	cceptions, etc: d stream with dat ides upstream of structure (bridge bank, perpendic	n 0.2 mi fror r downstrea s, roads, bu ular or parall	n confluence m along val iildings, pow el):	, 0.3 mi anoti ley margins (rerlines, etc)	(Upstream/downstream? Straight line distance to pipeline (upstream/downstream with distance to pipeline, if linear		
Unique features, ex US, 125 ft unnamed Evidence of landsl along valley axis?): Possibly US 0.3 mi Describe any infras feature, right or left US 1. residence (0	cceptions, etc: d stream with dar ides upstream o structure (bridge bank, perpendic 0.8 mi, river left)	n 0.2 mi fror r downstrea s, roads, bu ular or parall 2. road cros	n confluence m along val iildings, pow el): sing (no brid	e, 0.3 mi anoti ley margins rerlines, etc) ge or culvert)	(Upstream/downstream? Straight line distance to pipeline (upstream/downstream with distance to pipeline, if linear		

	1	(check box when searched for, if none, note under source)								
Existing channel migration zone determination		source(s): None								
Reports on local/regional:										
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.]								
hydraulics		U.S. Geological Survey Water-Data Report source(s): None								
sediment transport		 source(s): Montana Dept. of Transportation Bridge Scour Database: <u>http://www3.mdt.mt.gov:7783/db-pub/pontis40_site.htm</u> Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p. 								

	 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6 thousand bridges in the state): http://www3.mdt.mt.gov:7783/db-pub/pontis40_site.htm Evaluation of Potential Bridge Scour in Montana http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP-90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic
bridge scour	Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources
	Steve Holnbeck. USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes
	http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. <u>http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alter</u> ations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) 06175540 Prairie Elk Creek near Oswego MT
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Redwater River MP 146.6

Site	Redwater River MP 146.6		Date	08/05/09
Done by	: GF, ML	Rev	view: EG	

	Regional regression and peak flow analysis										
	Regional Regression*										
Source Drainage Area Average Elevation Recurrence Interval											
Source		(mi²)		(ft)		5	10	25	50	100	
Omang (1992)		668.3		2765		2,269	3,964	6,468	8,846	10,539	
			Pea	ak Flood Flov	v				I	1	
Gauge Name and	Drainage	Up or	Distance	Range of		Recurrence Interval					
Number	Area (mi ²)	Down- stream	to Crossing (mi)	Data (years)	2	5	10	25	50	100	
06177500 Redwater River at Circle MT (Bulletin 17B)	547.0	US	3.9	85 (1929- 2004)	427	2,253	4,752	8,290	14,575	20,505	

*Use gauge data sine the only major addition to Redwater River between gauge and crossing is Buffalo Spring Creek.

Geomorphology											
NOTE: All measur	es rounded t	o whole num	nber, except	for drainage	area and	ratios like	e sinuosity	y or confin	ement)		
For Reach (extend	ling at least 3	3 meander w	avelengths o	or 20 channel	widths u	ipstream a	and downs	stream of o	crossing)		
	C	hannel			Va	lley					
Gradient (%	%): <0.10				Gradien	(%): <0.1	0				
Width (ft)	min	max	mean	Stnd Dev.	width	min	max	mean	variance		
	21	98	73	25	wiath	2,043	3,211	2,781	4,53		
meander w	vavelength (ft)	2,309			describe	e geology ((lithology, e	erodibility):			
meander a	meander amplitude (ft) 1,495						Alluvium of modern channels and flood plains 2202 ft wide at crossing. Alluvial terrace deposits in places US on LB and DS on RB				
Sinuosity: 2	2.18				Tongue River Member of Fort union FM: sandstone, sandy and silty carbonaceous shale, and coal.						
radius of curvature	Upstre	am (ft)	Downst	ream (ft)	Floodplain						
(ft)	distance from	radius of	distance from	radius of		Vational Da					
	crossing curvature crossing curvature					min	max	mean	variance		
	2051	1089	638	1563		1					
	3677 2703 3516 1499					Describe abundance and location(s) of:					
	6255 923 12641 2415				scroll bars:						

	4841	920	9105	2332	on Buffalo Springs Ck trib US 0.1 mi RB					
	7237	1263	6143	1650	oxbows:					
					None					
Channel fo	orm (braided, a	anabranching,	single thread	:(b	channel cut-offs:					
Single Thr	ead				None					
Channel c	onfinement at	crossing (W_v	/ W _c):		Relic channels adjacent, US 0.25					
12.09										
What is elevation of	of the channel r	elative to the	floodplain (pe	erched, incise	d)? What is evidence?					
The flood plain ele	vation is greate	er than the ch	annel's surfa	ce elevation.						
Unique features, et	xceptions, etc									
Tribs: Buffalo Sprin All are crossed by			ree Creek 0.2	2 mi US; unna	med creeks 0.3, 0.7, and 0.8 mi US, unnamed 0.7 mi DS.					
Evidence of lands along valley axis?	lides upstream	n or downstre	am along va	Illey margins	(Upstream/downstream? Straight line distance to pipeline					
None										
	Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel)									
US 1. Power lines (0.32, river left, par.) 2. Par roads (0. 4 from RB) 3. Road (0.5 from LB) 4. Road and railroad crossings with bridges 1.2 mi 4. Sewage disposal ponds 1.5 mi 5. City of Circle, MT 2.2 mi 6. local airport 1.1 mi										
If visible, describe	any direct or in	direct eviden	ce of general	scour/channe	I incision (straightened channel, etc):					
None	None									

	LITERATURE REVIEW (check box when searched for, if none, note under source)									
Existing channel migration zone determination		source(s): None								
Reports on local/regional										
Hydrology		 source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at <u>http://water.usgs.gov/pubs/sim/2004/2868.</u>] U.S. Geological Survey Water-Data Report 								
hydraulics		source(s): None								
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.								
bridge scour		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S.								

	Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rot_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagase, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246 source(s): Ice Jams in Montana
lce jams	U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alterations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) 06177650 Redwater River near Richey MT
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Buffalo Springs Creek MP 150

Site	Buffalo Springs Creek MP 150		Date	08/03/09
Done by:	GF, ML	Rev	riew: EG	

	R	egional Regression A	nalysis					
Source	Drainage Area	Average Elevation		F	Recurrence	ce Interva	l	
Source	(mi²)	(ft)	2	5	10	25	50	100
Omang (1992)	152.4	2805	119	335	555	937	1,65	1,715

For Reach (extend	ding at least 3	8 meander w	avelengths o	or 20 channe	widths u	pstream	and down	stream of	crossing)	
	С	hannel			Valley					
Gradient (%): 0.6				Gradient (%): 0.8					
Width (ft)	min	max	mean	std dev	width	min	max	mean	std dev	
width (it)	12	21	15	3	width	165	499	383	118	
meander v	vavelength (ft)	855			describe geology (lithology, erodibility):					
meander amplitude (ft) 759						n of mode at crossing		Is and floo	d plains 65	
Sinuosity 1	1.52							Union Fm us shale, ar		
radius of Upstream (ft) Downstream (ft)							Floodp	ain		
curvature (ft)					FEMA National Database N					
	distance from	radius of	distance from	radius of	if yes, describe widths below					
	crossing	crossing	curvature	Width (ft)	min	max	mean	std dev		
	2247	222	725	116						
	3083	155	1215	153	Describe abundance and location(s) of:					
	4184	103	2258	148	scrol	l bars:				
	5029	215	3474	265	None	e				
			5776	271	oxbo	ows:				
			6822	214	none	;				
			725	116	channel cut-offs					
Channel fo	orm (braided, a	anabranching	, single threa	d):	None	Э				
Single Thr	ead				Relic	channels	3			
Channel confinement at crossing (Wv / Wc):					DS.	0.3 mi LB				
23.01										

Unique features, exceptions, etc

Tribs: unnamed US 0.17mi and West Fork Buffalo Springs Creek 1.8 mi US, confluence with Redwater River 3.2 mi DS

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

DS 0.2 mi RB

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Creek in straightened channel bypass starting 0.14 mi US to 0.1 mi DS. DS Road and railway cross at 0.1 mi, then run parallel, Electric Lines parallel to RB

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

There appears to be scour US of bridge due the presence of the levee and constriction of the valley due to the bridge.

	(cl	LITERATURE REVIEW heck box when searched for, if none, note under source)
Existing channel migration zone determination		source(s): None
Reports on local/regional		
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water- Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.]
hydraulics	\boxtimes	source(s): None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.
bridge scour		 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-

[1	90-014, Hydraulic Engineering Circular 20, 195 p.
		90-014, Hydraulic Engineering Circular 20, 195 p.
		Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
		Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: <u>holnbeck@usgs.gov</u>
		Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
		Mark Goodman Montana Department of Transportation 40-444-6246
lce jams		source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf
		Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u>
Turbidity		source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical %20Alterations.pdf
Stream gages	\boxtimes	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps		source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Berry Creek MP 159.2

Site	Berry Creek MP 159.2		Date:	8/02/09
Done by:	GF, EG, ML	Rev	/iew: EG	

Regional Regression Analysis								
Source Drainage Area Average Recurrence Interval							I	
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100
Jennings et al. (1994)	2.47	2996	29	100	185	341	496	595

	C	hannel			Valley				
Gradient (%): 0.2				Gradient (%): 2.4				
Midth (ft)	min	max	mean	std dev	Width	min	max	mean	std dev
Width (ft)	33	134	92	35	(ft)	264	633	432	137
meander w	meander wavelength (ft): 426						(lithology,	erodibility):	
meander amplitude (ft): 390								ember, Fort carbonaceo	Union Fm: ous shale, and c
Sinuosity:	4.62								
Upstream (ft) Downstream (ft)							Flo	odplain	
	distance	radius of	distance	radius of	FEMA National Database No if yes, describe widths below				
	from crossing	curvature	curvature	Width (ft)	min	max	mean	Stnd Dev	
radius of	322	49	920	73					
curvature (ft)	1010	67	1573	49	Describe abundance and location(s) of:				
()	1278	74	1842	87	scrol	l bars:			
	1739	41	2052	44	None	Ð			
	2175	81	2358	103	oxbo	WS:			
	183	52			None	Э			
	444	131			chan	inel cut-o	ffs:		
Channel fo	rm (braided, a	anabranching	, single thread	d):	None	Э			
Single									
Channel co	onfinement at	crossing (W _v	/ W _c): 4.94						
is elevation of	the channel	relative to the	e floodplain (pe	erched, incise	ed)? What	is eviden	ice?		

0.25 mi DS of crossing, confluence into Cottonwood Creek (which pipeline also crosses 0.28 mi NE). Channel widens considerably from 640 - 1780 feet US due to an obstruction (natural sediment dam?) at 700 ft US. Also straightens above that point for .4 mi

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

1 mi US on RB valley wall

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Major road crosses at 0.3 mi DS probably with culvert, spur road parallel 630 ft from RB. Road crosses 0.7 mi US

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

Straightened reach 0.25 mi above crossing may be susceptible to scour.

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.

	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001
	2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation
Ice jams	40-444-6246 source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Clear Creek MP 175.2

Site	Clear Creek MP 175.2		Date:	08/02/09
Done	by: GF, EG, ML	Rev	view: EG	

		Regi	onal regress	sion and pe	eak flow a	analysis				
			Regio	onal Regre	ssion					
Source		Drainage Ar	ea Ave	erage			Recurren	ce Interva	l	
Source		(mi²)	Eleva	Elevation (ft)		5	10	25	50	100
Jennings et al. (199	4)	73.10 3018		187	594	1,064	1,829	2,573	3,093	
			Pea	ak Flood F	low			•	•	•
Course Name and	Dreinere	Up or Distance Range Recurrence I				ce Interva	iterval			
Gauge Name and Number	Drainage Area (mi ²)	Down- stream	to Crossing (mi)	of Data (years)	2	5	10	25	50	100
06326952 Clear Creek near Lindsay MT: regional regression	101.0	DS	9.50	6 (1982- 1988)	2,194	7,253	12,343	18,899	24,342	25,911

For Reach (extending	g at least 3 n	neander wav	elengths or 2	20 channel w	vidths ups	stream an	d downstr	eam of cro	ossing)
	Channel							ey	
Gradient (9	%): 0.03				Gradier	nt (%): 0.34	4		
Width (ft)	min	max	mean	std dev	Width	min	max	mean	std dev
(hard to see channel with vegetation)	22	72	44	19	(ft)	2019	3280	2502	437
meander w	describe	e geology	(lithology,	erodibility):					
meander amplitude (ft): 895						Modern alluvium 1208 ft wide at crossing US off RB Alluvial terrace deposit			
Sinuosity: 8	3.37								rt Union Fm: ous shale &
radius of	Upstre	eam (ft)	Downst	ream (ft)	Floodplain				
curvature (ft)					FEMA National Database: No				
	distance from	radius of	distance from	radius of	if yes, describe widths below				
	crossing	curvature	crossing	curvature	Width	min	max	mean	Stnd Dev
				(ft)					
	2259	830	285	609		•	•		•
	3469	624	1142	496	Describ	e abundar	nce and loo	cation(s) of:	
	4140	144	2078	437	scro	ll bars:			

	5011	367	3249	1211	none				
	5427	161	4280	286	oxbows:				
	5955	402	5381	646	None				
Channe	el form (braide	d, anabranch	ing, single thr	ead):	channel cut-offs:				
Single					US meander adjacent to crossing				
Channe	el confinement	at crossing (W _v / W _c):		Relic channel 0.6 mi US, 0.2 mi DS				
48.8									
What is elevation of	of the channel	relative to the	e floodplain (p	erched, incisec	I)? What is evidence?				
Perched at 0.3 mi	US, channel is	at 2733 feet	while the floo	dplain is at 272	20 ft				
Unique features, e	xceptions, etc								

Tribs: South Fork Clear Creek 0.2 mi US, unnamed trib 0.8 mi DS, Cigar Creek 1.4 mi DS, irrigation ditch 0.6 mi US and joins with Cigar Creek

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US: road with bridge 1.3 mi, parallel road directly on LB; small roads cross 0.4 mi. DS and 0.4 mi US; parallel road directly on RB from 164 ft US down valley, group of building DS 1.1 mi

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

None

	LITERATURE REVIEW
	(check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood
	and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at <u>http://water.usgs.gov/pubs/sim/2004/2868</u> .] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.
	Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.

bridge scour	http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp. 1516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP-90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozema Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 200101 20101
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u>
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) 06142000 Clear Creek near Bearpaw MT 06142400 Clear Creek near Chinook MT
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Side Channel of Yellowstone River MP 195.7

Site	Side Channel of Yellowstone River MP 195.7		Date:	08/02/09
Done by:	GF, EG, ML	Rev	/iew: EG	

		R	egional regr	ession and	d peak flow	<i>w</i> analysis				
			Re	gional Reg	pression*					
Courses		Drainage A	rea Ave	erage			Recurrer	ice Interval		
Source		(mi ²) Ele		tion (ft)	2	5	10	25	50	100
Omang (1992)		52,246								
		1		Peak Floo	d Flow	11				
Gauge Name and	Drainage	Up or	Distance	Range	Recurrence Interval					
Number	Area (mi ²)	Down- stream	to Crossing (mi)	of Data (years)	2	5	10	25	50	100
06309000 Yellowstone River at Miles City MT (Bulletin 17B)	48,253	US	55.3	87 (1922- 2009)	49,918	64,660	73,305	80,910	89,945	96,232
06327500 Yellowstone River at Glendive MT (Bulletin 17B)	66,739	DS	20.3	112 (1897- 2009)	60,923	81,241	94,015	105,828	120,616	131,420

*The regional regression equation is for watersheds (0.04 mi²-2,250 mi²)

Geomorphology

NOTE: All measures rounded to whole number, except for drainage area and ratios like sinuosity or confinement)

	C	hannel			Valley					
Gradient (%	Gradient (%): 0.02					nt (%): 0.4				
\\/;__ (ft)	min	max	mean	std dev	Width	min	max	mean	std dev	
Width (ft)	31	66	47	12	(ft)	2057	2720	2355	241	
meander w	avelength (ft)): 3032			describe	e geology	(lithology, e	erodibility):	_ <u> </u>	
meander a	mplitude (ft):	635			Modern alluvium 2203 ft wide at crossing Both sides alluvial terrace deposit; alluvium/colluvium					
Sinuosity: ·	1.25				claystor Both sic sandy RB Lud	des Lebo M ne, sandsto des Tonguo low Memb	one, and co e River Me er: Gray ar	oal. mber: Yelle	rbonaceous shale, bentoni owish orange sandstone, hale, siltstone, silty or pal.	
radius of	ream (ft)	Floodplain								
curvature (ft)	distance from	radius of curvature	distance from	radius of curvature			atabase N dths below			

	crossing		crossing		Width (ft)	min	max	mean	Stnd Dev	
	429	304	1801	1079						
	1373	2046	3185	1342	Describe	e abundan	ce and loca	ation(s) of:		
	3925	871			scrol	l bars:				
					Adja	cent to cro	ssing, poss	sible set D	S 0.5 mi RB	
					oxbo	WS:				
					none	•				
Channel fo	rm (braided,	anabranchinę	g, single threa	d):	channel cut-offs:					
Single side	channel of a	nabranching	river		none					
Channel co	onfinement at	crossing (W	, / W _c):							
68.99										
What is elevation of	the channel r	elative to the	floodplain (pe	erched, incise	d)? What i	s evidence	?			
Based on DEM, wate	Based on DEM, water surface is 15 ft below elevation of floodplain within							ection.		
Unique features, exc	eptions, etc									
Most of valley floor a	at LB is cover	ed in agriculti	ural fields, so i	more features	s may have	e present b	pefore mod	ification.		

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Road parallel to entire side channel .25 mi from LB; cluster of buildings 0.4 mi US off this road. DS: building 0.5 mi, 0.25 mi from LB. Farm roads throughout valley bottom on LB

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

Scour pool at inlet to side channel on DEM

LITERATURE REVIEW										
	(check box when searched for, if none, note under source)									
Existing channel migration zone determination source(s): Yellowstone River Channel Migration Zone Mapping Tony Thatcher, Bryan Swindell DTM Consulting, Inc. 211 N Grand Ave, Suite J. Bozeman, MT 59715 http://dnrc.mt.gov/cardd/yellowstonerivercouncil/2008ChannelMigration/cmzFinalReport.p										
Reports on local/regional										
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report								

hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp.rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yéllowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozema Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6155 Mark Goodman Montana Department of Transportation 40-444-6155 Mark Goodman Montana Department of Transportation 40-444-6155
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p.

	http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) 06186500 Yellowstone River at Yellowstone Lk Outlet YNP 06191500 Yellowstone River at Corwin Springs MT 06192500 Yellowstone River near Livingston MT 06195600 Shields River nr Livingston MT 06195750 Yellowstone River at Springdale, MT 06195950 Yellowstone River at Big Timber, MT 06207500 Clarks Fork Yellowstone River nr Belfry MT 06208000 Clarks Fork Yellowstone River at Edgar MT 06208500 Clarks Fork Yellowstone River at Edgar MT 06208800 Clarks Fork Yellowstone River nr Silesia MT
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Yellowstone River MP 196

Site	Yellowstone River MP 196		Date:	08/02/09
Done by:	GF, EG, ML	Rev	/iew: EG	

		R	egional regre	ession and	d peak flov	v analysis				
			Re	gional Reg	pression*					
Source		erage			Recurren	ce Interval				
Source		(mi²)	Eleva	Elevation (ft)		5	10	25	50	100
Omang (1992)		50,246								
				Peak Flood	d Flow	ľ	•	·	•	
Course Name and	Droinogo	Up or	Distance	Range	Recurrence Interval					
Gauge Name and Number	Drainage Area (mi ²)	Down- stream	to Crossing (mi)	of Data (years)	2	5	10	25	50	100
06309000 Yellowstone River at Miles City MT (Bulletin 17B)	48,253	US	55.3	87 (1922- 2009)	49,918	64,660	73,305	80,910	89,945	96,232
06327500 Yellowstone River at Glendive MT (Bulletin 17B)	66,739	DS	20.3	112 (1897- 2009)	60,923	81,241	94,015	105,828	120,616	131,420

*The regional regression equation is for watersheds 0.04 mi²-2,250 mi².

Geomorphology										
NOTE: All measure For Reach (extendi							-		•	
	C	hannel	-		-			Valley		
Gradient (9	%): 0.05				Gradien	it (%): 0.0	1			
	min	max	mean	std dev	Width	min	max	mean	std dev	
Width (ft)	376	583	485	67	(ft)	932	8635	4131	2634	
meander w	avelength (ft): 10458			describe geology (lithology, erodibility):					
meander a	mplitude (ft):	702			Modern alluvium 2203 ft wide at crossing Both sides alluvial terrace deposit; alluvium/colluvium					
Sinuosity:	1.17				claystor Both sic sandy RB Lud	les Lebo l ne, sands les Tongu	tone, and co le River Me	oal. mber: Yello nd brown s	rbonaceous shale, bentoniti owish orange sandstone, hale, siltstone, silty or val.	
radius of	Upstre	eam (ft)	Downst	ream (ft)	Floodplain					
curvature (ft)	distance from	radius of curvature	distance from	radius of curvature	FEMA National Database No if yes, describe widths below					

	crossing		crossing		Width	min	max	mean	Stnd Dev
					(ft)				
	4756	8466	1296	7406	Describe	e abundan	ice and loc		
	12654	11483	5901	12477	scrol	l bars:			
	17889	6442	9601	5665	DS:	1 mi. on Ll	B, 2.5 mi o	n RB,5.8 r	mi on LB
					US: 3	3.8 mi, 5 n	ni on both b	banks	
	26315	2348	13497	4822	oxbo	WS:			
	32892	3510	17128	4792	none	•			
	40800	8184	21087	4759	chan	nel cut-off	s:		
Channel fo	orm (braided,	anabranching	g, single threa	d):	none)			
Anabranch	ning								
Channel co	onfinement at	crossing (W	v / W _c):						
5.75									
What is elevation of	the channel r	elative to the	floodplain (pe	erched, incise	d)? What i	s evidence	e?		
Channel is incised b	ased on DEM	1: water surfa	ce is 30 ft bel	ow elevation of	of floodplai	in.			
Unique features, exc	ceptions, etc								

Numerous small tribs along study reach, including bad Route Creek 1.4 mi US and Cabin Creek 5.5 mi DS. Most of valley floor on LB is covered in agricultural fields, so more features may have present before modification. Right bank appears to be constrained by terrace of Fort Union Fm overlain by alluvium terrace deposits.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

US: 5 mi on RB valley wall, 2 more possibly just DS.

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US: 2 Freeway bridges (I-94) cross at 7.2 mi, then I-94 runs parallel 2.5 mi from LB; another road also with bridge next to I94, town of Fallon 1.3 mi from RB at 7.2 mi. Powerline crosses 6.6 mi.

Railway on RB, Roads parallel to both banks, 80 ft to 0.75 mi from RB and 150 ft to 1.2 mi from LB. Numerous small farm roads throughout valley bottom.

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

The 5 mi segment US of crossing is straighter and abuts terrace, cross valley slopes also seem steeper here.

	LITERATURE REVIEW									
Existing channel migration zone determination		(check box when searched for, if none, note under source) source(s): Yellowstone River Channel Migration Zone Mapping Tony Thatcher, Bryan Swindell DTM Consulting, Inc. 211 N Grand Ave, Suite J. Bozeman, MT 59715 http://dnrc.mt.gov/cardd/yellowstonerivercouncil/2008ChannelMigration/cmzFinalReport.pdf								
Reports on local/regional										
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey								

	1	Scientific Investigations Map SIM 2868. [Available online only at
		http://water.usgs.gov/pubs/sim/2004/2868.]
		U.S. Geological Survey Water-Data Report
hydroylico		source(s):
hydraulics		None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.
		Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.
		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u>
		Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf
		Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
		Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
bridge scour		Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
		Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
		Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
		Mark Goodman Montana Department of Transportation 40-444-6246
Ice jams		source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u>
ice jailis		Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/
		Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation

	http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) 06186500 Yellowstone River at Yellowstone Lk Outlet YNP 06191500 Yellowstone River at Corwin Springs MT 06192500 Yellowstone River near Livingston MT 06195600 Shields River nr Livingston MT 06195750 Yellowstone River at Springdale, MT 06195950 Yellowstone River at Big Timber, MT 06207500 Clarks Fork Yellowstone River nr Belfry MT 06208000 Clarks Fork Yellowstone River at Edgar MT 06208500 Clarks Fork Yellowstone River at Edgar MT 06208800 Clarks Fork Yellowstone River nr Silesia MT
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Cabin Creek MP 201.4

Site)	Cabin Creek MP 201.4		Date:	08/02/09
Dor	ne by:	GF, EG, ML	Rev	view: EG	

Regional Regression Analysis											
Source	Drainage Area	Average	Recurrence Interval								
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100			
Omang (1992)	235.7	2,592	678	1,780	2,842	4,633	6,049	8,228			

For Reach (extend	ling at least	3 meander w	avelengths of	or 20 channe	l widths u	pstream	and down	stream of o	crossing)				
	C	Channel						Valley					
Gradient (S								Gradient (%): 0.3					
Width (ft)	min	max	mean	std dev		std dev							
(Hard to see channel in aerials)	12	27	19	6	Width (ft)	1553	2471	1934	298				
meander w	vavelength (ft): 1444			describe	e geology	(lithology,	erodibility):					
maandara	malituda (ft).	957			Modern	alluvium	2516 ft wid	e at crossin	g				
meander a	mplitude (ft):	657			Alluvial	terrace de	posits bety	veen left ba	ank and Yellowstone				
Sinuosity:					and silty Both sid	les Tongu carbonad les Ludlov	ceous shal v Member:	e, and coal.	rown shale, siltstone				
	Upstre	eam (ft)	Downst	ream (ft)	Floodplain								
	trom	radius of	distance from crossing	radius of curvature	FEMA National Database No if yes, describe widths below								
		curvature			Width (ft)	min	max	mean	Stnd Dev				
radius of curvature	3407	851	81	218									
(ft)	4143	858	2298	941	Describ	e abundar	nce and loc	ation(s) of:					
	5221	425	3994	777	scrol	l bars:							
	5914	237	5737	251	US C).9 and 0.8	5 mi; DS 0.	5 mi					
	7398	617	7169	420	oxbo	WS:							
	9269	421	8046	364	None	Э							
Channel fo	, single threa	channel cut-offs:											
Single		None	Э										
Channel co	onfinement at	t crossing (W_v	/ W _c): 199.31		Relic	channels	:						
		US 0.4, 1.4 mi; DS 0.2 mi											

What is elevation of the channel relative to the floodplain (perched, incised)? What is evidence?

Perched at 0.85 mi. US and 0.2 mi DS where floodplain is 10 ft below water surface on DEM.

Unique features, exceptions, etc

Trib: Spring Creek US 0.6 mi with ponding behind a channel-spanning structure 0.65 mi US of confluence. Another crossing on Cabin Creek 0.5 US. The channel is much straighter and wider between crossings than US or DS.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

Possibly US 1.9 mi and DS 0.7 on RB valley wall.

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US: Road crosses at 0.3 mi, then runs parallel DS at 0.2 mi away from LB; group of buildings 0.5 mi between Cabin and Spring Creek; perpendicular road from buildings to small parallel road 0.2 to 0.75 mi from LB; series of small farm roads US of buildings; small parallel road 1.5 mi about 0.25 mi from RB.

DS: small road 85 feet to 0.5 mi from RB

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

Straight section of channel vulnerable to scour.

		LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination		source(s): None
Reports on local/regional		
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.]
		U.S. Geological Survey Water-Data Report source(s):
hydraulics	\boxtimes	None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm
		Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u> Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://gnliaguuba.the.gov/cgi/cgi/scourba/gabra/cabra/scours.the.gov/cgi/scourba/scours.the.gov/cgi/scourba/scours.the.gov/cgi/scourba/scours.the.gov/cgi/s
		 <u>http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf</u> Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication

	FHWA NHI 01-001, 378 p.
	Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260
	Fax 406-444-6155 Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Cabin Creek MP 202

Site	Cabin Creek MP 202		Date:	08/02/09
Done by:	GF, EG, ML	Rev	view: EG	

Regional Regression Analysis										
Source	Drainage Area	Average	Recurrence Interval							
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100		
Omang (1992)	235.1	2592	677	1,778	2,838	4,627	6,041	8,218		

each (extend	ling at least	3 meander w	avelengths	or 20 channe	l widths u	pstream	and down	stream of	crossing)	
	C	Channel			Valley Gradient (%): 0.2					
Gradient (%): 0.04									
Width (ft)	min	max	mean	std dev	Width	min	max	mean	std dev	
width (it)	5	25	15	7	(ft)	458	2813	1532	1000	
meander w	vavelength (ft): 1284			describe	e geology	(lithology,	erodibility):		
					Modern	alluvium	1871 ft wid	le at crossir	ng	
meander a	mplitude (ft):	602			Alluvial Yellows		deposits b	etween lef	t bank a	
Sinuosity:	6.13				sandy Both sid	es Tongu and silty es Ludlov , silty or	carbonace v Member:	ous shale, Gray and b	and coal. prown shal	
	Upstre	Floodplain								
					FEMA National Database No if yes, describe widths below					
	distance from	radius of	distance from	radius of						
	crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	Stnd D	
radius of curvature	931	960	210	617						
(ft)	1544	464	1092	421	Describe	e abunda	nce and loo	cation(s) of:		
	3064	851	4428	218	scrol	l bars:		1532 erodibility): le at crossing between left ember: sands ous shale, a Gray and br claystone, sa lain lo v mean cation(s) of: .9		
	4892	858	6605	941	USC).5 and 0.	1 mi; DS 0	.9		
	7070	425	8528	777	oxbo	WS:				
	9359	237	10116	251	None	9				
Channel fo	orm (braided,	anabranching	, single threa	ad):	chan	nel cut-of	fs:			
Single					relic	channels	:			
Channel co	onfinement at	crossing (W	/ W _c): 41.21		USC).95 mi. a	djacent; D	S 0.6		

What is elevation of the channel relative to the floodplain (perched, incise	d)? What is evidence?

Perched at 0.5 mi. US and 1 mi DS where floodplain is 10 ft below water surface on DEM.

Unique features, exceptions, etc

Trib: Spring Creek DS and 400 ft across the valley with ponding behind a channel-spanning structure 0.65 mi US of confluence. Another crossing on Cabin Creek 0.5 DS. The channel is much straighter and wider between crossings than US or DS.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

Possibly US 1.4 mi and DS 1.1 mi on RB valley wall.

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US: Group of buildings 150 ft between Cabin and Spring Creek; perpendicular road from buildings to small parallel road 0.2 to 0.75 mi from LB; series of small farm roads US of buildings; small parallel road 1.5 mi about 0.25 mi from RB.

DS: Road crosses at 750 ft, then runs parallel DS at 0.2 mi away from LB; small spur road runs DS 85 feet to 0.5 mi from RB

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

Straight section of channel vulnerable to scour.

	LITERATURE REVIEW							
		(check box when searched for, if none, note under source)						
Existing channel migration zone determination		source(s): None						
Reports on local/regional								
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood						
rijalology		and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at <u>http://water.usgs.gov/pubs/sim/2004/2868.</u>] U.S. Geological Survey Water-Data Report						
hydraulics		source(s): None						
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.						
sediment transport		Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.						
bridge scour		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u>						
		Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf						

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		Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
		Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
		Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
		Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
		Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
		Mark Goodman Montana Department of Transportation 40-444-6246
lce jams		source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
		Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity		source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. <u>http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt</u> <u>erations.pdf</u>
Stream gages		source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps		source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Dry Fork Creek MP 226.9

Site	Dry Fork Creek MP 226.9		Date	08/03/09
Done by:	GF, ML	Rev	riew: EG	

Regional Regression Analysis										
Source	Drainage	Drainage Average Recurrence Interv						/al		
Source	Area (mi ²)	Elevation (ft)	2	5	10	25	50	100		
Omang (1992)	28.16	2,888	120	390	704	1,228	1,739	2,081		

Innel (completed for two Gradient (%): 0.2, 0.4 min width 21 meander wavelength meander amplitude (Sinuosity 2.59, 2.11 Upstreat distanc from crossin radius of	max 80 (ft) 531 (ft) 390 m East Trib (ft) radius of	mean 52	std dev 22 m of Dam(ft) radius of	width describe Valley a Tongue Formatio coal.	nd floodpl River Mer onSands	max 2276 (lithology, ain on both mber of the stone, sand Floodpl	mean 1496 erodibility): h sides of th Fort Unior dy and silty ain	ne creek: n
width min 21 meander wavelength meander amplitude (Sinuosity 2.59, 2.11 Upstrea distanc from crossin	max 80 (ft) 531 (ft) 390 m East Trib (ft) radius of curvature	52 Downstrear distance	22 m of Dam(ft)	width describe Valley a Tongue Formatio coal.	min 761 e geology nd floodpl River Mer onSands	max 2276 (lithology, ain on both mber of the stone, sand Floodpl	1496 erodibility): h sides of th e Fort Unior dy and silty ain	605 ne creek:
width 21 meander wavelength meander amplitude (Sinuosity 2.59, 2.11 Upstrea distanc from crossin	80 (ft) 531 (ft) 390 m East Trib (ft) radius of	52 Downstrear distance	22 m of Dam(ft)	describe Valley a Tongue Formatio coal.	761 e geology nd floodpl River Mer onSands	2276 (lithology, ain on both mber of the stone, sand	1496 erodibility): h sides of th e Fort Unior dy and silty ain	605 ne creek:
21 meander wavelength meander amplitude (Sinuosity 2.59, 2.11 Upstrea distanc from crossin	(ft) 531 (ft) 390 m East Trib (ft) radius of	Downstrear	m of Dam(ft)	describe Valley a Tongue Formatio coal.	e geology nd floodpl River Mer onSands	(lithology, ain on both mber of the stone, sand Floodpl	erodibility): h sides of the Fort Unior dy and silty	ne creek:
meander amplitude (Sinuosity 2.59, 2.11 Upstrea distanc from crossin	m East Trib (ft)	distance		Valley a Tongue Formatic coal.	nd floodpl River Mer onSands	ain on both mber of the stone, sand	h sides of the Fort Unior dy and silty	e creek: shale and shale and
Sinuosity 2.59, 2.11 Upstrea distanc from crossin	m East Trib (ft)	distance		Tongue Formatio coal.	River Mer onSands	mber of the stone, sand	e Fort Unior dy and silty ain	า
Upstrea distanc from crossin	radius of	distance		FEMA N	lational Da			
distanc from crossin	radius of	distance		FEMA N	lational Da			
from crossin	radius of		radius of	FEMAN	lational Da	atabase N		
crossin	curvature	110111	Taulus U	FEMA National Database N if yes, describe widths below				
radius of		crossing	curvature	Width (ft)	min	max	mean	std de
curvature 156	58 134	2434	176		<u> </u>			
(ft) 21 ⁻	9 75	3159	155	Describe	e abundar	nce and loc	cation(s) of:	
262	.1 107	3628	133	scrol	roll bars:			
338	8 92	4451	167	None	None			
				oxbo	WS:			
				None	3			
Channel form (braide	d, anabranchinę	g, single threa	d):	chan	inel cut-off	fs:		
Single Thread				DS 0.18 mi				
Channel confinemen	at crossing (W	v / W _c):		Oxbo	ow and av	ulsion (0.0	0-0.20 mi ri	iver left)
29.31				Relic	channel	0.5 mi US,	0.4 and 0.5	55 mi DS

Unique features, exceptions, etc.

DS of the crossing is a dam and the channel's width increases when it reaches the area of the backwater effect. Lawrence Creek 0.2 mi US and an unnamed creek 200 feet DS, irrigation canal 0.26 mi DS

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

DS parallel road (0.20 mi River left) with building 0.75 mi, Dam 0.3 mi DS

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

Straightened channel at 0.00-0.15 mi could be due to backwater affect of dam.

	LITERATURE REVIEW (check box when searched for, if none, note under source)							
Existing channel migration zone determination		source(s): Yellowstone River Channel Migration Zone Mapping Tony Thatcher, Bryan Swindell DTM Consulting, Inc. 211 N Grand Ave, Suite J. Bozeman, MT 59715 http://dnrc.mt.gov/cardd/yellowstonerivercouncil/2008ChannelMigration/cmzFinalReport.pdf Channel Processes On The Missouri River, Montana http://www.docstoc.com/docs/783910/CHANNEL-PROCESSES-on-the-MISSOURI-RIVER- MONTANA						
Reports on local/regional								
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U U.S. Geological Survey Water-Data Report USGS 06158000 Frenchman R ab Eastend Re nr Ravenscrag Sask http://waterdata.usgs.gov/mt/nwis/dv/?site_no=06158000&PARAmeter_cd=00060 USGS 06209010 Rock Cr bl Glacier Lake nr Red Lodge MT http://waterdata.usgs.gov/mt/nwis/dv/?site_no=06209010&PARAmeter_cd=00060 06211500 Willow Creek near Boyd MT http://waterdata.usgs.gov/mt/nwis/dv/?site_no=06211500&PARAmeter_cd=00060						
hydraulics		source(s): None						
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.						

bridge scour	source(s): Montana DOT Bridge Scour Data Base (constructional stability for almost 6 thousand bridges in the state) http://www3.mdt.mt.gov:7783/db-pub/pontis40_site.htm Evaluation of Potential Bridge Scour in Montana http://int.water.usgs.gov/cgi-bir/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD-95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpl_516.pdf Richardson, E.V., and Davis, S.R., 1995, Evaluating scour at bridges, 3d ed.: U.S. Department of Transportation, Federal Highway Administration Hydraulic Engineering Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP-90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck. USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59801-0101 406-444-6155 Mark Goodman Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59820-1001 40-444-6155 Mark Goodman Montana Department of Transportation 40-444-6155
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation
Turbidity	http://www.fema.gov/news/event.fema?id=635 source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Al terations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) 06100000 Dry Fork Marias River near Valier MT 06100500 Dry Fork Marias River at Fowler MT

1:24000 geologic maps	\boxtimes	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp
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Pennel Creek MP 234.5

Site	Pennel Creek MP 234.5		Date	08/03/09
Done by:	GF, ML	Re۱	view: EG	

TABLE X Regional Regression Analysis									
Source	Drainage Area Average				Recurrence Interval				
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100	
Omang (1992)	67.7	3,034	178	564	1,102	1,743	2,456	2,953	

Geomorphology NOTE: All measure	oo roundod f		abor oxeent	for drainage	area and	ration like	cinuccity	voroonfin	(amont)
For Reach (extend			•	•				-	
	С	hannel			Valley	/			
Gradient (9	%): 0.1	Gradien	t (%): 0.3						
	min	max	mean	std dev		min	max	mean	std dev
Width (ft)	10	17	13	3	width	1472	3112	2355	590
meander w	vavelength (ft)	1,312			describe	e geology (lithology, e	erodibility):	
meander a	mplitude (ft)	793				of moder t crossing		s and flood	d plains 505
Sinuosity 2		Both sides Fort Union Fm:Tongue River Member: sandstone, sandy and silty carbonaceous shale, and coalLudlow Member: shale, siltstone, silty or bentonitic claystone, sandstone, and coal.Both sides Hell Creek Fm: bentonitic claystone that alternates with gray to brown sandstone							
					Both sid Timber I noncalc Trail Cit black sh	areous, hu y Member: ale with ca	ls Fm: ber: fine- t mmocky-b wavy-bec alcareous	o mediumg bedded san Ided siltstor concretion	dstone. ne and zone.
					Both sides Pierre Fm: partly silty shale with abundant bentonite beds and zones of gray,				
radius of	Upstre	am (ft)	Downst	ream (ft)	calcareous concretions. Floodplain				
curvature (ft)					FEMA N	lational Da	tabase N		
	distance from	radius of	distance from	radius of	if yes, d	escribe wie	dths below	,	
	crossing	curvature	crossing	curvature	Width	min	max	mean	std dev
					(ft)				
	2617	745	2932	312					
	4497	322	3985	378	Describ	e abundan	ce and loc	ation(s) of:	
	6376	580	4789	159	scrol	l bars:			
	7328	292	5776	237	none	•			

					oxbows:			
					None			
Channel fo	orm (braided,	anabranching	channel cut-offs:					
Single Thr	ead		relic channel					
Channel c	Channel confinement at crossing (W $_{\rm v}$ / W $_{\rm c}):$				DS 0.1, 0.55, 0.65, 0.72 mi; US 0.6, 0.78, 0.95, 1, 1.4			
175.1								
What is elevation of	of the channel	relative to the	e floodplain (p	erched, incise	d)? What is evidence?			

The channel's surface water elevation is mostly lower than the surrounding flood plain.

Unique features, exceptions, etc

Tribs: 0.1, 0.5, 1.1 mi; DS 1.65, 1.8 mi US. Numerous stock ponds on tribs in valley, including 3 on closest trib 0.5, 0.66, 1. mi from confluence.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

DS 1. Road Crossing Bridge or culvert (0..28 mi, perp.) 2. Private residence (0.30 mi, river left,), US road crossing and buildings 1.54 mi

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc): None

	LITERATURE REVIEW (check box when searched for, if none, note under source)							
Existing channel migration zone determination		source(s): None						
Reports on local/regional								
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report						
hydraulics		source(s): None						
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.						

bridge scour	source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp.rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozema Avenue Helena Mt. 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT. 59620-1001 406-444-6200 Fax 406-444-6155 Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u> source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical
Turbidity	alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. <u>http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt</u> <u>source(s):</u> (note if managed flow, e.g. canals or flow during summer only)
Stream gages	None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Little Beaver Creek MP 262.4

Site		Little Beaver Creek MP 262.4		Date	08/03/09
Don	ne by:	GF, ML	Rev	view: EG	

Regional Regression Analysis										
Source	Drainage Area	Average	Recurrence Interval							
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100		
Omang (1992)	391.9	3,385	412	1,118	1,828	3,3038	4,032	5,427		

Reach (extend	ling at least 3	3 meander w	avelengths o	or 20 channel	widths u	pstream a	and down	stream of	crossing)
	C	hannel			Valle	/			
Gradient (9	%): 0.20	Gradien	t (%): 0.4	0					
Width (ft)	min	max	mean	std dev	width	Min	max	mean	std de
vvidiri (it)	18	44	29	10	width	1607	2246	1891	237
meander w	vavelength (ft)	2158			describe	geology	(lithology,	erodibility):	
meander a	mplitude (ft):	1548			ft wide a	t crossing		s and flood n river righ	
						nt bentonit		partly silty d zones of	
Sinuosity: 2	2.34				Adjacent and US both sidesHell Creek Fm: bentonitic claystone that alternates with sandstone interbedded with carbonaceous shale.				
						, silty or b		· Fort Unior laystone, sa	
	Upstre	am (ft)	Downst	ream (ft)			Floodpl	ain	
					FEMA National Database N				
	distance	radius of	distance from	radius of	if yes, describe widths below				
	from crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	std de
radius of					(11)				
curvature (ft)	8945	892	2680	706					
(/	4336	1335	5865	669	Describe	e abundan	ice and loo	ation(s) of:	
	2040	612			scroll bars:				
	420	553			DS 0	.82 mi			
		1			oxbows:				
					None				
					None)			

Single Thread	None
Channel confinement at crossing (W_v / W_c):	Relic channels DS 0.47 mi and 0.7 mi and US 1.2 mil
72.0	
What is elevation of the channel relative to the floodplain (perched, i	ncised)? What is evidence?
The elevation of the floodplain is at the same elevation or higher that	n the water surface elevation
Unique features, exceptions, etc:	

Unnamed tribs US 0.42, 0.67, 0.87 mi; DS 0.2, 1, and 1.2 mi

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US Private residence (0.55 mi River left) with small road parallel to trib, DS 1.3 mi additional small roads with crossing

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

None

		LITERATURE REVIEW						
(check box when searched for, if none, note under source)								
Existing channel migration zone determination		source(s):						
Reports on local/regional								
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and						
, ,,		flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at <u>http://water.usgs.gov/pubs/sim/2004/2868</u> .] U.S. Geological Survey Water-Data Report						
hydraulics		source(s): None						
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.						
		Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.						
bridge scour		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u>						
bridge scour		Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. <u>http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf</u>						
		Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S.						

	Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
	Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929
	Email: <u>holnbeck@usgs.gov</u> Kent Barnes, P.E.
	Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect
	Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u>
Ice jams	Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical% 20Alterations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) 06167500 Beaver Creek near Hinsdale MT
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Boxelder Creek MP 291.4

Site	Boxelder Creek MP 291.4		Date	08/03/09
Done by:	GF, ML	Re	/iew: EG	

	Regional regression and peak flow analysis												
			Regi	onal Regre	ssion								
Source	Source Drainage Area Average Recurrence Interval												
Source		(mi ²) Elevation (f		ation (ft)	2	5	10	25	50	100			
Omang (1992)		1088.9	3	3,408		1,885	3,055	5,028	6,608	8,890			
	Peak Flood Flow												
Gauge Name and	Drainaga	Up or	Distance	Range	Recurrence Interval								
Number	Drainage Area (mi ²)	Down- stream	to Crossing (mi)	of Data (years)	2	5	10	25	50	100			
06334630 Box Elder Creek at Webster MT (Bulletin 17B)	1092.0	DS	1.82	13 (1960- 1973)	1,936	5,223	9,001	14,300	24,432	35,223			

eomorphology OTE: All measur	es rounded t	to whole nun	nber, except	for drainage	area and	ratios like	e sinuosity	/ or confin	ement)
or Reach (extend	ling at least 3	3 meander w	avelengths o	or 20 channe	widths u	pstream a	and downs	stream of o	crossing)
	C	hannel	Valley						
Gradient (9	Gradien	t (%): 0.00	2						
\\/;_\\ (ft)	min	max	mean	std dev	: al é la	min	max	mean	std dev
Width (ft)	38	69	52	11	width	1168	4303	3017	1134
meander w	l /avelength (ft)) 4,188			describe	e geology (lithology, e	erodibility):	
meander a	mplitude (ft)	3,598				n of moder at crossing	n channels	and flood	plains 460
					Landslide deposits 3.9 mi US				
						, silty or be	Member F entonitic cla		,
Sinuosity 2	2.21				RB Hell Creek Fm: bentonitic claystone that alternates with sandstone interbedded with carbonaceous shale.				
					medium	-grained s	er Fort Uni andstone ir shale and	nterbedded	d with
radius of	Upstre	eam (ft)	Downst	ream (ft)			Floodpla	ain	
curvature (ft)	<u> </u>				FEMA N	lational Da	tabase Y/	N	
	distance from	radius of	distance from	radius of	if yes, de	escribe wid	dths below		
	crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	std dev
	6471	1544	6606	847					

	11467	1047	13609	2034	Describe abundance and location(s) of:
	15341	1540	19106	731	scroll bars:
	20185	1458			US 2mi, I mi; DS 0.4 mi
					oxbows:
					None
Channel fo	orm (braided, and	abranching,	single thread):		channel cut-offs:
Single Thr	ead with a few is	slands, inclu	ding at crossing	g	none
Channel c	onfinement at cr	ossing (W _v /	W _c):		Relic Channel DS 0.6 mi
51.27					
What is elevation o	of the channel rel	ative to the	floodplain (perc	ched, incise	d)? What is evidence?
The elevation of the	e flood plain is a	reater than t	ha channal's w	ator surface	a elevation
Unique features, ex	xceptions, etc:				
Tortuous meanders	s 2 mi DS				
Tribs: US Unname	d at 0.85 and 1.6	3 mi, Horse (Creek at 0.5 mi	. DS unnam	ned at 0.2, 0.4, 1.1 mi Coal Bank Creek at 1.8 mi
Evidence of lands pipeline along valle		or downstre	am along val	ley margins	G (Upstream/downstream? Straight line distance to
N					
None					
				rlines, etc)	(upstream/downstream with distance to pipeline, if
Describe any infra linear feature, right	or left bank, per	pendicular c	or parallel):		(upstream/downstream with distance to pipeline, if pstream trib that flows in floodplain 650 ft from LB
Describe any infra linear feature, right Buildings and road	or left bank, per s 1.1 and 1.8 mi	pendicular c	or parallel): 5 mi DS. Dams	2.2 mi on u	

		LITERATURE REVIEW
		(check box when searched for, if none, note under source)
Existing channel migration zone determination		source(s): None
Reports on local/regional		
		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p.
Hydrology		Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at <u>http://water.usgs.gov/pubs/sim/2004/2868.</u>]
		U.S. Geological Survey Water-Data Report.
hydraulics	\boxtimes	source(s): None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.
		Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.

bridge scour	source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp.rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 Helena, MT 59620-1001 Helena, MT 59620-1001 Helena, MT 59620-1001 Hode-444-6155 Mark Goodman Montana Department of Transportation 40-444-6155
Ice jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u> source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical
Turbidity	alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. <u>http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alterations.pdf</u> source(s): (note if managed flow, e.g. canals or flow during summer only)
Stream gages	06334630 Box Elder Creek at Webster MT
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

INTERMITTENT STREAM CROSSINGS

Corral Coulee MP 20.8

Site	Corral Coulee MP 20.8		Date	08/03/09
Done by:	GF, ML	Rev	/iew: EG	

Regional Regression Analysis										
Source	Drainage	Average	Recurrence Interval							
Source	Area (mi ²)	Elevation (ft)	2	5	10	25	50	100		
Omang (1992)	8.91	2,768	47	155	272	470	665	885		

		hannel					Valle			
Gradient (%	Gradient (%): 1.2									
	,	1			Gradier					
Width (ft) vegetation made	min	max	mean	stnd dev		min	max	mean	stnd dev	
t difficult to assess channel width	15	37	26	7	width	107	584	278	153	
meander w	avelength: (f	t) 806			describe	e geology	(lithology,	erodibility):		
meander a	mplitude (ft) 2	218			Floodpla at the ci		rn alluvium	, approx. 3	64 feet wid	
Sinuosity:	1.33				with sev basal zo	eral zone	s of calcar	rpaw Form eous concre oncretions, a ds.	etions, a	
·					grained	sandston	e with inter	Fm: fine- to beds of gra ale, and th	y to black	
	Upstre	eam (ft)	Downst	ream (ft)	Floodplain					
					FEMA National Database N					
	distance from	radius of	distance from	radius of	if yes, d	describe widths below				
	crossing	curvature	crossing	curvature	Width	min	Max	mean	variance	
radius of					(ft)					
curvature	244	227	413	199					1	
(ft)	413	165	977	132	Describ	e abunda	nce and lo	cation(s) of:		
	977	110	1469	124	scro	l bars:				
	131	None								
					oxbows:					
					None					
Channel fo	rm (braided,	anabranching	, single threa	d):	char	inel cut-of	fs:			
	None									

Channel confinement at crossing (W $_{v}$ / W $_{c}):$	Relic channels
17.45	0.38 mi DS and 0.16 US
What is elevation of the channel relative to the floodplain (perched	, incised)? What is evidence?
The channel appears to be incised because the surrounding val elevation of the channel in the DEM.	ley elevation is generally 8.0-10ft above the surface water
Unique features, exceptions, etc	
Another crossing on Corral Coulee 0.6 mi DS	
Unnamed tributaries at crossing, US 1.22 mi, confluence with Fren	nchman Creek DS 4.5 mi
Evidence of landslides upstream or downstream along valley marg	jins:
None, but listed as high risk by PHMSA NPMS Landslide Hazard	Мар
Describe any infrastructure (bridges, roads, buildings, powerlines,	etc)
Dam with stock pond on closest trib 0.33 mi from confluence, on US	US trib 0.12 mi from confluence. Small road crosses 0.4 mi
If visible, describe any direct or indirect evidence of general scour/	channel incision (straightened channel, etc):
The channel appears to be incised because of width of the flood pl	lain is almost the same as the width as the river valley.

LITERATURE REVIEW (check box when searched for, if none, note under source)								
Existing channel migration zone determination		source(s): None						
Reports on local/regional								
		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood						
Hydrology		and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at <u>http://water.usgs.gov/pubs/sim/2004/2868</u> .]						
		U.S. Geological Survey, various dates, Water resources data, Montana, water year: U.S. Geological Survey Water-Data Report.						
hydraulics	\boxtimes	source(s): None						
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.						
		Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.						
		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u>						
bridge scour		Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p.						
		FHWARD-95-184, "Channel Scour at Bridges in the United. States FHWA-IP-90-017, HEC						

	 No.18, 1995, US. Department of Transportation, http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456
	Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation
lce jams	40-444-6246 source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Corral Coulee MP 21.5

Site	Corral Coulee MP 21.5		Date	08/03/09
Done by:	GF, ML	Rev	view: EG	

Regional Regression Analysis									
Source	Drainage Area	Average Elevation	Recurrence Interval						
Source	(mi²)	(ft)	2	5	10	25	50	100	
Omang (1992)	9.79	2,768	50	165	289	501	707	941	

For Reach (extend	-		avelengths o	or 20 channe	widths u	pstream			crossing)	
Channel						Valley				
Gradient (%): 1.1				Gradien	t (%): 1.8				
Width (ft) Vegetation made it difficult to determine width	min max		mean	std dev		Min	max	mean	std dev	
	11	20	15	4	width	179	571	319	142	
meander v	vavelength (ft)	570			describe	geology	(lithology,	erodibility):		
meander amplitude (ft) 184					Floodplain: modern alluvium, approx. 350 feet wide at the crossing					
Sinuosity 1.44					Both sides of the creek: Bearpaw Formation: shale with several zones of calcareous concretions, a basal zone o ferruginous concretions, and numerous thin bentonite beds.					
					Both sides DS Judith River Fm: fine- to coarse-grained sandstone with interbeds of gray to black carbonaceous shale, silty shale, and thin coal.					
	Upstre	am (ft)	Downst	ream (ft)	Floodplain					
	distance from crossing	radius of curvature	distance from crossing 200	radius of curvature 84	FEMA National Database N					
					if yes, describe widths below					
					Width (ft)	min	max	mean	std dev	
radius of										
curvature (ft)	91	63								
	200	59	636	60	Describe abundance and location(s) of:					
	636	70	1062	137	scroll bars:					
			1426	79	None					
					oxbows:					
					None					
Channel form (braided, anabranching, single thread):					channel cut-offs:					
Single					None					
Channel confinement at crossing (W _v / W _c):					Relic channels					

31.0	0.24 US and 0.04 mi DS
What is elevation of the channel relative to the floodplain (perch	ned, incised)? What is evidence?
The channel is incised because the valley's elevation is much g	reater than the water surface of the channel.
Unique features, exceptions, etc :	
Another crossing on Corral Coulee 0.6 mi US	
Unnamed tributary US 0.1 mi, confluence with Frenchman Cree	ek DS 3.8 mi
Evidence of landslides upstream or downstream along valley m valley axis?):	hargins (Upstream/downstream? Straight line distance to pipeline along
None, but listed as high risk by PHMSA NPMS Landslide Hazar	rd Map
Describe any infrastructure (bridges, roads, buildings, power feature, right or left bank, perpendicular or parallel):	rlines, etc) (upstream/downstream with distance to pipeline, if linear
Dam with stock pond on closest trib 0.16 mi from confluence.	
If visible, describe any direct or indirect evidence of general sco	ur/channel incision (straightened channel, etc):
The channel appears to be incised because the flood plain wi walls.	idth and valley floor width are about equal and there are steep valley

		LITERATURE REVIEW		
(check box when searched for, if none, note under source)				
Existing channel migration zone determination		source(s): None		
Reports on local/regional				
		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p.		
Hydrology		Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868 .]		
		U.S. Geological Survey, various dates, Water resources data, Montana, water year: U.S. Geological Survey Water-Data Report.		
hydraulics		source(s): None		
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.		
sediment transport		Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.		
		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u>		
bridge scour		Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p.		
		FHWARD-95-184, "Channel Scour at Bridges in the United. States FHWA-IP-90-017, HEC No.18, 1995, US. Department of Transportation,		

		http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf
		Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
		Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
		Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
		Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center
		3162 Bozeman Avenue
		Helena Mt 59601-6456 Phone: (406) 457-5929
		Email: <u>holnbeck@usgs.gov</u>
		Kent Barnes, P.E.
		Bridge Bureau Montana Department of Transportation
		PO Box 201001
		2701 Prospect Helena, MT 59620-1001
		406-444-6260
		Fax 406-444-6155
		Mark Goodman
		Montana Department of Transportation
		40-444-6246 source(s):
		Ice Jams in Montana
		U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire
	N 7	http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf
Ice jams		Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/
		Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation
		http://www.fema.gov/news/event.fema?id=635
Turbidity		source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt
		erations.pdf
Stream gages		source(s): (note if managed flow, e.g. canals or flow during summer only) None
1.24000 goola sia mana		source(s):
1:24000 geologic maps	\boxtimes	State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp
		······································

Hay Coulee MP 38

Site	Hay Coulee MP 38		Date	08/03/09
Done by:	GF, ML	Rev	view: EG	

	Regional Regression Analysis											
Source or Gage	Drainage	Upstream /	Distance to	Range of data	recurrence interval							
name and number	Area (mi²)	Downstream	crossing (mi)	(years)	2	5	10	25	50	100		
Omang (1992)	1.68				15	54	99	178	256	348		

Reach (extend	ing at least 3	s meander w	avelengths o	or 20 channel	l widths u	pstream	and dowr	istream of	crossing)	
	C	hannel					Valle	у		
Gradient (%): 1.6				Gradien	t (%): 2. ⁻	1			
Width (ft)	min	max	mean	stnd dev	width	min	max	mean	stnd de	
Width (ft)	14	22	17	3	width	526	240	331	114	
meander w	vavelength (ft)	954			describe	e geology	(lithology,	erodibility):		
meander a	mplitude (ft)1	35			Alluvium 327 ft	n from m	iodern cha	nnels and	flood plai	
Sinuosity 1	.30					es Judith s of shale		Sandstone	with	
	Upstre	am (ft)	Downst	ream (ft)			Floodp	lain		
					FEMA N	lational D	atabase N	1		
	distance from	radius of	distance from	radius of	if yes, d	escribe w	vidths below	hs below		
	crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	varianc	
radius of curvature	377	108	413	100						
(ft)	751	79	647	89	Describe	e abunda	nce and lo	cation(s) of		
	1502	126	1045	76	scrol	l bars:				
	2073	141	1265	70	None	Э				
	54	65			oxbo	WS:				
					None	9				
Channel fo	rm (braided, a	anabranching	, single threa	d):	chan	nel cut-o	ffs:			
Single Thre	ead							meander /e occurred		
Channel co	onfinement at	crossing (W_v	/ W _c):							
7.29										

Incised. The channel near the crossing is straighter than US and DS. The amplitudes of the meanders are smaller at the crossing than US and DS amplitudes

Unique features, exceptions, etc:

None

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None, Listed as high risk by PHMSA NPMS Landslide Hazard Map

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Bud Reservoir 0.34 and stock pond 0.97 mi US and 0.45 mi DS, small road crosses 0.86 mi DS.

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

The channel appears to be straighter at the crossing than upstream. The confinement ratio is low meaning the channel does not have the ability to move within the confines of the valley

Evicting channel migration		(check box when searched for, if none, note under source) source(s):
Existing channel migration zone determination		None
Reports on local/regional		
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.]
		U.S. Geological Survey Water-Data Report source(s):
hydraulics	\bowtie	None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour		 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP-

	90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: <u>holnbeck@usgs.gov</u>
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. <u>http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt</u> erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Lime Creek 44.9

Site	Lime Creek 44.9		Date	08/03/09
Done by:	GF, ML	Rev	view: EG	

Regional Regression Analysis										
Source Drainage Area Avera			Recurrence Interval							
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100		
Omang (1992)	8.89	2627	48	161	283	495	703	941		

each (extend	ling at least 3	8 meander w	avelengths o	or 20 channel	widths u	pstream	and down	stream of o	crossing)	
	С	hannel					Valley	/		
Gradient (%	%): 0.4				Gradien	t (%): 0.5				
Width (ft)	min	max	mean	stnd dev.	width	min	max	mean	stnd dev	
width (it)	9	15	12	2	width	107	584	278	154.0	
meander w	vavelength (ft)	551			describe	e geology	(lithology, o	erodibility):		
meander a	mplitude (ft)	179			Quatern crossing		d and Gr	avel 705	ft wide a	
					sandsto	ne with	interbeds	fine- to coa of gray ale, and thi	to blac	
Sinuosity 1	.81				zones o	f calcared	ous concre	ion: shale tions, a ba and num	asal zone (
	Upstre	am (ft)	Downst	ream (ft)	Floodplain					
			trom	radius of	FEMA National Database N					
	distance from	radius of			if yes, describe widths below					
	crossing	curvature	crossing	curvature	Width	min	max	mean	stnd de	
radius of					(ft)					
curvature (ft)	172	105	535	84						
(11)	587	143	1348	46	Describe	e abundar	nce and loc	ation(s) of:		
	1174	168	1729	91	scrol	l bars:				
	1774	146	1988	48	None)				
					oxbo	WS:				
					None	9				
Channel fo	rm (braided, a	anabranching	, single threa	d):	chan	nel cut-of	fs:			
Single Thre	ead				None	9				
Channel co	onfinement at	crossing (W _v	/ W _c): 47.72		Relic DS	channel	0.23, 0.68	mi US, 0	.11, 0.38 ı	

What is elevation of the channel relative to the floodplain (perched, incised)? What is evidence?

Channel's water surface elevation is lower than the surrounding flood plains.

Unique features, exceptions, etc

Unnamed trib DS 1.4 mi

There are several instances of relic channels which appear US and DS of the crossing giving the appearance the channel moves regularly.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

US 100 ft, Listed as high risk by PHMSA NPMS Landslide Hazard Map. Mapped landslide deposits 3.5 mi west on Rock Creek.

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Numerous stock ponds in channel especially US, building 0.5 mi DS, dirt roads parallel

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

There are several scour holes along the stream corridor near the crossing. US. (0.04, 0.20, 0.30 mi). Also: The valley width widens has the stream approaches the crossing and then narrows again DS.

		LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination		source(s): None
Reports on local/regional		
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	\boxtimes	source(s): None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u> Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. <u>http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf</u> Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.

	-	
		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
		Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
		Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
		Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: <u>holnbeck@usgs.gov</u>
		Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
		Mark Goodman Montana Department of Transportation 40-444-6246
lce jams		source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
		Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity		source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages		source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps		source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Brush Fork MP 51.1

Site	Brush Fork MP 51.1		Date	08/03/09
Done by:	GF, ML	Rev	riew: EG	

Regional Regression Analysis											
Source	Drainage Area	ainage Area Average		Recurrence Interval							
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100			
Omang (1992)	7.13	2,726	40	136	239	417	592	790			

Reach (extend	ling at least 3	3 meander wa	avelengths o	or 20 channel	widths u	pstream	and dowr	stream of	crossing)
	C	hannel					Valle	у	
Gradient (%	%): 0.5				Gradien	t (%): 1.2	2		
\\/;dtb /ft)	Min	max	mean	stnd dev.	width	min	max	mean	stnd de
Width (ft)	8	16	11	3	width	508	774	648	102
meander w	l /avelength (ft)	324			Describ	e geology	(lithology,	erodibility)	
meander a	mplitude (ft) 8	32				n of mode crossing	rn channe	ls and flood	plains 627
					of calca	reous cor ous concr	cretions, a	ale with se a basal zone d numerous	e of
Sinuosity 1	.93				grained	sandston		Fm: fine- to rbeds of ca oal.	
							laxville Fm canic ash l	n: gravel, sa ocally	and, and s
	Upstre	am (ft)	Downst	ream (ft)			Floodp	lain	
					FEMA National Database N				
	distance from	radius of	distance from	radius of	if yes, d	escribe w	Floodplain ional Database N cribe widths below		
	crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	stnd de
radius of curvature	79	70	109	56					
(ft)	417	65	227	35	Describ	e abunda	nce and lo	cation(s) of	
	866	70	571	58	scro	l bars:			
	699	64			None	Э			
	1545	56			oxbo	WS:			
	1747	70			None	Э			
Channel fo	rm (braided, a	anabranching	, single threa	d):	char	inel cut-ol	fs:		
Single thre						0.08 mi			

Channel confinement at crossing (W_v / W_c):	Relic channel:						
	DS near confluence with Bear Creek 1.39 mi						
75.56							
What is elevation of the channel relative to the floodplain (perched, incise	d)? What is evidence?						
The flood plain elevation is greater than the elevation of the channel's water surface.							
Unique features, exceptions, etc:							
Flows into Bear Creek 1.39 mi DS							

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

Listed as high risk by PHMSA NPMS Landslide Hazard Map. Mapped landslide deposits 3.5 mi west on Rock Creek. US (0.0-0.10 mi, river right, minor sloughing of material appears to exist)

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

DS road crossing 0.34 mile; Stock ponds 4.5 mi on US trib and 5.5 mi US in channel and more smaller one DS

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

No straightened sections of the channel exist near the crossing.

	LITERATURE REVIEW (check box when searched for, if none, note under source)							
Existing channel migration zone determination		source(s): None						
Reports on local/regional								
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report						
hydraulics		source(s): None						
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.						
bridge scour		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u> Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. <u>http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf</u>						

	-	
		Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
		Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
		Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
		Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
		Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
		Mark Goodman Montana Department of Transportation 40-444-6246
lce jams		source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
		Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity		source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages		source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps		source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Bear Creek MP 52.3

Site	Bear Creek MP 52.3		Date	08/03/09
Done by:	GF, ML	Rev	riew: EG	

Regional Regression Analysis								
Source	Drainage Area	Average	Recurrence Interval					
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100
Omang (1992)	4.49	2,768	29	99	176	310	441	591

For Reach (extend	ding at least 3	3 meander w	avelengths o	or 20 channel	widths u	upstream	and dowr	stream of	crossing)		
	C	hannel					Valle	у			
Gradient (Gradient (%): 1.4										
Width (ft)	min	max	mean	stnd dev.		min	max	mean			
vegetation made it difficult to assess channel width	9	18	13	3	width	179	394	257	86		
meander v	vavelength (ft)	359			describ	e geology	(lithology,	erodibility):			
meander a	amplitude (ft) 2	224			Alluviur wide	n of mode	ern channe	ls and flood	plains 906		
					of calca	reous cor ous conci	ncretions, a	ale with se a basal zone d numerous	e of		
Sinuosity	1.61				DS RB Judith River Fm: fine- to coarse-grained sandstone with interbeds of carbonaceous shale silty shale, and thin coal.						
							laxville Fm canic ash l	n: gravel, sa ocally	and, and si		
	Upstre	am (ft)	Downst	ream (ft)	Floodplain						
					FEMA N	National D	atabase N	1			
	distance from	radius of	distance from	radius of	if yes, c	lescribe w	vidths below	v			
	crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	stnd dev		
radius of					(11)						
curvature (ft)	310	52	11	49							
()	554	60	333	38	Describ	e abunda	nce and lo	cation(s) of			
	873	160	686	62	scroll bars:						
	1519	103	1089	56	None						
	213	51			oxbo	ows:					

Single Thread	None
Channel confinement at crossing (W_v / W_c):	Relic channel:
16.75	Near confluence with Brush Fork 0.8 mi DS
What is elevation of the channel relative to the floodplain (perche	ed, incised)? What is evidence?
The elevation of the floodplain is great than the elevation of the	channel's water surface.
Unique features, exceptions, etc:	
Brush Fork joins 0.79 mi DS; unnamed trib 0.89 mi DS; Joins Mi	ilk River 6.8 mi DS; US 1. Scour Hole (<0.1 mi, river left)
Evidence of landslides upstream or downstream along valley pipeline along valley axis?):	y margins (Upstream/downstream? Straight line distance to
None, Listed as high risk by PHMSA NPMS Landslide Hazard M	lap. Mapped landslide deposits 3.5 mi west on Rock Creek.
Describe any infrastructure (bridges, roads, buildings, powerli linear feature, right or left bank, perpendicular or parallel):	nes, etc) (upstream/downstream with distance to pipeline, if
Stock pond 0.77 mi DS on trib; small road parallel to left bank	
If visible, describe any direct or indirect evidence of general score	ur/channel incision (straightened channel, etc):
The valley's width is narrow at some locations US (0.00-0.20 r cannot build a floodplain.	mi). There might be incision at these locations if the channel

		LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination		source(s): None
Reports on local/regional		
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey, various dates, Water resources data, Montana, water year: U.S.
hudrouling		Geological Survey Water-Data Report. source(s):
hydraulics	\boxtimes	None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p.

	 FHWARD-95-184, "Channel Scour at Bridges in the United. States FHWA-IP-90-017, HEC No.18, 1995, US. Department of Transportation, http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
	Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
Ice jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Unger Coulee MP 53.3

Site	Unger Coulee MP 53.3		Date	08/03/09
Done by:	GF, ML	Rev	view: EG	

Regional Regression Analysis								
Source	Drainage Area	Average	Recurrence Interval					
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100
Omang (1992)	4.45	2,686	29	101	180	317	453	609

Reach (extend	ling at least 3	8 meander w	avelengths o	or 20 channe	widths u	pstream	and dowr	stream of	crossing)
	С	hannel					Valle	У	
Gradient (%	%): 0.7	Gradien	t (%): 1.2	2					
Midth (ft)	min	max	mean	stnd dev.		min	max	mean	stnd de
Width (ft)	7	13	10	1	width	289	463	365	58
meander w	vavelength (ft)	282			describe	e geology	(lithology,	erodibility):	
meander a	mplitude (ft) 9	90			Alluvium wide	n of mode	ern channe	l and flood	plains 552
					of calca	reous cor ous concr	cretions, a	ale with sev a basal zone d numerous	e of
Sinuosity 1	.66				DS both sides Judith River Fm: fine- to coarse- grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal.				
							laxville Fm canic ash l	n: gravel, sa ocally	and, and s
	Upstre	am (ft)	Downst	ream (ft)			Floodp	lain	
			distance from	radius of	FEMA National Database N				
	distance from	radius of			if yes, describe widths below				
	crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	varianc
radius of curvature	1179	50	163	40					
(ft)	918	43	295	38	Describe	e abunda	nce and lo	cation(s) of	
	688	28	499	42		l bars:		,	
	71	19	685	28	None)			
	210	32			oxbo	WS:			
	355	28			None				
Channel form (braided, anabranching, single thread):						channel cut-offs:			
Single Thre					None				

Channel confinement at crossing (W_v / W_c):	relic channel								
36.79	US 0.8 mi, DS 0.05 mi								
What is elevation of the channel relative to the floodplain (perche	d, incised)? What is evidence?								
The elevation of the flood plain appears to be greater than the elevation of the channel's water surface.									
Unique features, exceptions, etc	Unique features, exceptions, etc								
Flows into Buggy Creek 6.4 mi DS, US Scour Holes (0.00-0.25 mi, river center).									
Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):									
Listed as high risk by PHMSA NPMS Landslide Hazard Map.									
Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):									
Road crosses 4.5 mi DS with culvert or bridge, stock ponds in channel 0.1 and 0.3 mi US, 0.06 and 0.2 mi DS									
If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):									
There appear to be areas that look like scour holes which could be	be signs of incision.								

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey
	Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868 .] U.S. Geological Survey, various dates, Water resources data, Montana, water year: U.S. Geological Survey Water-Data Report.
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.
	Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.
	source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u>
bridge scour	Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p.
	FHWARD-95-184, "Channel Scour at Bridges in the United. States FHWA-IP-90-017, HEC No.18, 1995, US. Department of Transportation, http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf

		Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
		Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
		Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
		Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
		Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
		Mark Goodman Montana Department of Transportation 40-444-6246
lce jams		source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf
ice jame		Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u>
Turbidity		source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	\boxtimes	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps		source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Buggy Creek MP 55.3

Site	Buggy Creek MP 55.3	Date	08/03/09	
Done by:	GF, ML	Rev	view: EG	

Regional regression and peak flow analysis										
	Regional Regression									
Source		Drainage Area Average				Recurren	ce Interva	al		
Source		(mi²)	Elevation (ft)		2	5	10	25	50	100
Omang (1992)		92.1	2,798		237	702	1,172	1,934	2,667	3,467
	Peak Flood Flow									
Gauge Name and	Drainage	Up or	Distance	Range	Recurrence Interval					
Number	Area (mi ²)	Down- stream	to Crossing (mi)	of Data (years)	2	5	10	25	50	100
06172200 Buggy Creek near Tampico MT	105	DS	5.41	10 (1957- 1967)	607	2,886	5,248	7,792	11,069	13,326

	rphology All measure	es rounded t	o whole num	nber, except	for drainage	area and	ratios like	sinuosity	or confine	ement)
For Rea	ch (extend	ling at least 3	3 meander w	avelengths o	or 20 channe	l widths u	pstream a	nd downs	tream of c	rossing)
		С	hannel					Valley		
	Gradient (%	%): 0.50				Gradien	t (%): 1.1			
	Width (ft)	min	max	mean	std dev	width	min	max	mean	stnd dev
	width (it)	9	14	11	2	width	381	977	719	208
	meander w	vavelength (ft)	669	I		describe	e geology (lithology, e	rodibility):	I
	meander a	mplitude (ft) 1	76			Alluvium ft wide	of moder	n channel	and floodp	lains 1,735
						Both sides Bearpaw Fm: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds				
	Sinuosity 1	.47				DS both sides Judith River Fm: fine- to coarse- grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal.				
						US both sides Flaxville Fm: gravel, sand, and silt with marl and volcanic ash locally				
	radius of Upstream (ft) Downstream (ft)						Floodplain			
	(ft)	distance from	radius of	is of from	radius of	FEMA National Database N if yes, describe widths below				
		crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	stnd dev
						(11)				

	55	100	438	72				
	1807	231	758	67	Describe abundance and location(s) of:			
	2601	172	1214	121	scroll bars:			
	3218	115	1597	153	None			
	3418	91	2135	112	oxbows:			
	3979	96			None			
Channel fe	orm (braided, a	anabranching,	single thread)):	channel cut-offs:			
Single Th	read				None			
Channel c	confinement at	crossing (W_v /	W _c):		Relic Channels			
40.98					US. 0.18, 0.75 mi; adjacent, DS 1.8, 0.4 mi			
What is elevation of	of the channel	relative to the	iloodplain (pe	rched, incise	d)? What is evidence?			
US 1. (0.25 mi) Ch	annel's surfac	e water elevati	on appears to	be higher tl	nan area down slope.			
Unique features, e	xceptions, etc							
Tribs: US Crooked 7.5 mi DS	I Creek 0.47 m	ni, Canyon Cr	eek 1.08 mi;	DS Spring C	Creek 3.8 mi, Unger Coulee 5.2 mi. Joins Milk River			
US 1. Meander Be elevation of the floor					ater) are very different than others in this valley. The puth.			
0.4 mi adjacent to	crossing straig	hter than rest	of creek					
Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):								
None. Listed as high risk by PHMSA NPMS Landslide Hazard Map.								
Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):								
DS 1. Road cross	es 0.5 mi, Dan	n with pond on	unnamed trib	0.95 mi DS				
If visible, describe	any direct or ir	ndirect evidenc	e of general s	cour/channe	el incision (straightened channel, etc):			
US & DS (0.00-0.30 mi) meander wavelengths are larger here and amplitudes smaller than other places in the river channel, appears straightened. Scouring can be seen from aerial photo.								

LITERATURE REVIEW (check box when searched for, if none, note under source)						
Existing channel migration zone determination		source(s): None				
Reports on local/regional						
Hydrology		 source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey, various dates, Water resources data, Montana, water year: U.S. Geological Survey Water-Data Report. 				

hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	 4137, 35 p. Source(S): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD-95-184, 140 p. FHWARD-95-184, "Channel Scour at Bridges in the United. States FHWA-IP-90-017, HEC No.18, 1995, US. Department of Transportation, http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP-90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holhoeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-06456 Phone: (406) 457-5293 Email: holhoeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6155 Mark Goodman Montana Department of Transportation 40-444-6155 <
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation

	http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Spring Creek MP 59.8

Site	Spring Creek MP 59.8	Date	08/03/09	
Done by:	GF, ML	Review: EG		

Regional Regression Analysis								
Source	Drainage Area	Average	Recurrence Interval					
Source	(mi²)	Elevation (ft)	2 5 10			25	50	100
Omang (1992)	10.7	2,699	54	178	311	539	763	1,016

Reach (extend	ling at least 3	8 meander w	avelengths o	or 20 channe	l widths u	pstream	and down	stream of	crossing)		
Channel						Valley					
Gradient (%): 0.6						t (%): 0.9	9				
Width (ft)	min	max	mean	stnd. dev	Width	min	max	mean	stnd dev		
width (it)	8	12	10	2	(ft)	492	1099	7756	253		
meander w		describe	e geology	(lithology,	erodibility):	I					
meander a	mplitude (ft) 1	63			Alluvium ft wide	n of mode	ern channe	ls and floo	d plains 56		
					of calca	reous cor ous conci	ncretions, a	ale with sev basal zone d numerous	e of		
Sinuosity 1	.43				DS both sides Judith River Fm: fine- to coarse- grained sandstone with interbeds of carbonaceous shale, silty shale, and thin coal.						
							laxville Fm canic ash l	i: gravel, sa ocally	and, and s		
	Upstre	am (ft)	Downst	ream (ft)			Floodp	lain			
					FEMA National Database N						
	distance from	radius of	distance from	radius of	if yes, describe widths below						
	crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	stnd. de		
radius of curvature	97	28	221	53							
(ft)	489	56	495	65	Describe	e abunda	nce and lo	cation(s) of			
	817	58	738	71	scrol	l bars:					
	1348	50	1076	50	None	Э					
					oxbo	WS:					
					None	Э					
Channel fo	rm (braided, a	anabranching	, single threa	d):	chan	inel cut-of	ffs:				
Single thread						None					

Channel confinement at crossing (W_v / W_c) :	Relic channel
68.88	US and adjacent off RB
What is elevation of the channel relative to the floodplain (perche	d, incised)? What is evidence?
The channel's water surface elevation is lower than the flood plai	n's elevation.
Unique features, exceptions, etc	
Tribs DS: Wire Grass Coulee 0.64 mi, Alkali Coulee 1.7 mi, Bugg mi DS	gy Creek 3.3 mi, Unger Coulee 4.4 mi; joins Buggy Creek 3.3
Evidence of landslides upstream or downstream along valley pipeline along valley axis?):	margins (Upstream/downstream? Straight line distance to
0.76 mi US. Listed as high risk by PHMSA NPMS Landslide Haza	ard Map.
Describe any infrastructure (bridges, roads, buildings, powerlin linear feature, right or left bank, perpendicular or parallel):	nes, etc) (upstream/downstream with distance to pipeline, if
Stock ponds US 80 ft, 0.34, 0.5 mi, 0.76 mi; road parallel to LB Dam on Wire Grass Coulee with Cornwall Reservoir (empty in p from confluence, possibly an irrigation ditch between Wire Grass	photo) 0.77 mi from confluence, dam with stock pond 0.5 mi
If visible, describe any direct or indirect evidence of general scou	r/channel incision (straightened channel, etc):
None	

		LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination		source(s): None
Reports on local/regional		
		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p.
Hydrology		Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868 .]
		U.S. Geological Survey, various dates, Water resources data, Montana, water year: U.S. Geological Survey Water-Data Report.
hydraulics	\boxtimes	source(s): None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.
		Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.
		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u>
bridge scour		Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p.

	 FHWARD-95-184, "Channel Scour at Bridges in the United. States FHWA-IP-90-017, HEC No.18, 1995, US. Department of Transportation, http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
	Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
Ice jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Cherry Creek MP 66.9

Site	Cherry Creek MP 66.9		Date	08/03/09	
Done by: GF, ML		Rev	view: EG		

TABLE X Regional Regression Analysis								
Source	Drainage Area	Average	Recurrence Interval					
Jource	(mi²)	Elevation (ft)	2	5	10	25	50	100
Omang (1992)	54.2	2,657	165	516	877	1,474	2,054	2,697

Gradient (%	C												
Gradient (%		Channel						Valley					
): 0.3				Gradien	t (%): 0.	3						
Width (ft)	min	max	mean	stnd dev	width	min	max	mean	stnd de				
widdir (it)	10	16	12	2	width	695	1312	1059	258				
meander wa	meander wavelength (ft) 627						(lithology,	erodibility):					
maandaran	malituda (ft) (Alluvium 1,465 ft		ern channels	s and flood	plains				
meander an	nplitude (ft) 2	.04				School Se n/colluviu	ction Coule	e, DS neai	milk Rive				
Sinuosity 1	.49				of calca	reous coi ous conc	oaw Fm: sha ncretions, a retions, and	basal zone	e of				
							laxville Fm canic ash lo		and, and s				
	Upstre	eam (ft)	Downst	ream (ft)	Floodplain								
ľ			distance from	radius of	FEMA National Database N								
	distance from	radius of			if yes, describe widths below								
	crossing	curvature	crossing	curvature	Width	min	max	mean	stnd de				
radius of					(ft)								
curvature	5307	62	1617	86					1				
(ft)	5779	76	2116	95	Describe	e abunda	nce and loc	ation(s) of					
ŀ	6344	75	2436	56	scrol	l bars:							
			3611	160	None	e							
F			4595	73	oxbo	WS:							
ŀ					None	Э							

Single Thread	none					
Channel confinement at crossing (W $_v$ / W $_c$):	Relic channel					
47.1	Adjacent to crossing and US 0.14 mi, 0.5 mi, DS 0.25 mi					
What is elevation of the channel relative to the floodplain (perchec	d, incised)? What is evidence?					
The floodplain elevation is greater than the elevation of the channel	el's water surface.					
Unique features, exceptions, etc: There are several road crossing	g (possibly with culverts) near this crossing.					
Tribs: US Unnamed 0.2 mi, School Section Coulee 1.3 mi, West Fork Cherry Creek 6 mi; DS East Fork Cherry 2.2, Martin Coulee 3.7. Joins Milk River 7.7 mi						
difficult to determine floodplain features due to land use activity						
Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):						
mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System.						
Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):						
US 1. Road (0.30 mi river left, par.) 2. Road crossing 0.16 and 0.3 mi 2. Buildings (0.40 mi river right) DS 1. Buildings (0.40, 1.1, 1.5 mi) 2. road crossing 1.1 mi with bridge, 1.65 mi						

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

It appears that the channel near has longer wavelength and smaller amplitudes at this location as compared to US & DS.

	LITERATURE REVIEW (check box when searched for, if none, note under source)					
Existing channel migration zone determination		source(s): None				
Reports on local/regional						
		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p.				
Hydrology		Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at <u>http://water.usgs.gov/pubs/sim/2004/2868</u> .]				
		U.S. Geological Survey, various dates, Water resources data, Montana, water year: U.S. Geological Survey Water-Data Report.				
hydraulics		source(s): None				
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.				
		Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.				
bridge scour		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u>				

	Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p.
	FHWARD-95-184, "Channel Scour at Bridges in the United. States FHWA-IP-90-017, HEC No.18, 1995, US. Department of Transportation, http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf
	Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
	Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes
	http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation
Turbidity	http://www.fema.gov/news/event.fema?id=635 source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Stock Pond MP 69.2

Site	Stock Pond MP 69.2		Date 08/03/09			
Done by: GF, ML		Rev	view: EG			

Regional Regression Analysis											
Source or Gage	Drainage	Range of data	recurrence interval								
name and number	Area (mi²)	Downstream	crossing (mi)	(years)	2	5	10	25	50	100	
Omang (1992)	0.93				11	40	76	141	207	286	

Geomorphology													
NOTE: All measur				•				-					
For Reach (extend	-		avelengths o	or 20 channe	l widths u	pstream			crossing)				
	C	hannel				v	alley						
Gradient (9	%): 0.8			Gradient (%): 0.7									
\\/;d+b /f+) *	min	max	mean	stnd dev	width	min	max	mean	stnd dev				
Width (ft) *	11	19	17	3	wiath	169	571	363	166				
*The lack of water i channel width	n the channel	made it hard	to determine	the					1				
meander w	vavelength (ft)	1030			describe	e geology	(lithology,	erodibility):					
meander amplitude (ft) 233						Both sides Bearpaw Fm: Shale with several zones of calcareous concretions							
Sinuosity	1.24												
	Upstream (ft) Downstream (ft)							Floodplain					
				radius of curvature	FEMA National Database N								
	distance	from radius of	distance from crossing		if yes, describe widths below								
	crossing				Width	min	max	mean	stnd dev				
radius of					(ft)								
curvature	1099	99	1797	114									
(ft)	1788	132	2680	94	Describ	e abunda	nce and lo	cation(s) of:					
	2211	88	2977	78	scro	l bars:							
	2726	177	3563	117	Nor	ne							
					oxbows:								
					None								
Channel fo	rm (braided, a	anabranching	, single threa	d):	chan	inel cut-o	ffs:						
Single Thre	ead				None	Э							
Channel co	onfinement at	crossing (W _v	/ W _c):										

What is elevation of the channel relative to the floodplain ((perched, incised)? What is evidence?

Not perched, the thalwag of the channel is below the elevation of the floodplain.

Unique features, exceptions, etc

The dam created downstream of the crossing could create backwater conditions near the crossing.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None, Listed as high risk by PHMSA NPMS Landslide Hazard Map

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

1. Railroad: (US & DS perp.) 2. Road (US & DS < 0.30 mi, perp. and Par.), dam that forms pond is 800 ft DS from crossing

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

Near the crossing, the channel could have been straightened at one time during the construction of the dam. There could be incision below the dam.

LITERATURE REVIEW								
	(check box when searched for, if none, note under source)							
Existing channel migration zone determination		source(s): None						
Reports on local/regional								
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report						
hydraulics		source(s): None						
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.						
bridge scour		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u> Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. <u>http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf</u> Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.						

		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation
lce jams		40-444-6246 source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	\boxtimes	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages		source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps		source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Spring Coulee MP 70.4

Site	Spring Coulee MP 70.4	Date	08/03/09	
Done by: GF, ML		Rev	view: EG	

Regional Regression Analysis										
Source	Drainage Area	Average	Recurrence Interval							
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100		
Omang (1992)	18.2	2,624	78	256	446	767	1,081	1,438		

Reach (extend	ling at least 3	meander w	avelengths o	or 20 channel	widths u	pstream	and dowr	stream of	crossing)
	C			Valle	У				
Gradient (%	Gradien	t (%): 1.0)						
	min	max	mean	stnd dev		Min	max	mean	stnd de
Width (ft)	10	15	12	2	width	332	669	431	133
meander w	vavelength (ft)	468			describe	geology	(lithology,	erodibility):	
meander a	mplitude (ft) 1	35			Alluvium	/colluviur	n 597 ft wi	de	
Sinuosity 1	.43				of calcar	eous cor	cretions, a	ale with sev a basal zone d numerous	e of
							laxville Fm canic ash l	i: gravel, sa ocally	and, and s
	Upstre	am (ft)	Downst	ream (ft)	Floodplain				
					FEMA National Database N				
	distance from radi	radius of	distance from crossing	radius of	if yes, describe widths below				
	crossing			curvature	Width (ft)	min	max	mean	stnd de
radius of curvature	93	65	278	59					
(ft)	759	66	420	63	Describe abundance and location(s) of:				
	961	56	1804	103	scroll bars:				
	1132	69	2145	65	None)			
	1410	141	2441	59	oxbo	WS:			
	1788	86			None)			
Channel form (braided, anabranching, single thread):						channel cut-offs:			
Single Thre	ead				None)			
Channel co	onfinement at	crossing (W _v	/ W _c):		Relic channels:				
28.52						1 mi US			

What is elevation of the channel relative to the floodplain (perched, incised)? What is evidence?

The channel's water surface is lower than the elevation of the flood plain.

Unique features, exceptions, etc:

Confluence with East Fork Cherry Creek 0.6 mi, unnamed trib 4.4 mi US

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None, mapped for high landslide hazard by the Pipeline and Hazardous Materials Safety Administration in their online National Pipeline Mapping System.

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US Gravel pit that appears to cut through channel 0.5 mi; Buildings 0.3, 0.9, 1.1 mi; Road with bridge or culvert 1.1 mi. DS road crossings 0.5 mi and 0.6 mi; buildings 0.18 and 0.48 mi. Road parallel 0.5 mi to RB; railway 1 mi from RB

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

The channel appears straightened just US of crossing and does not have the same stream pattern as further US & DS

Existing channel migration		(check box when searched for, if none, note under source) source(s):					
zone determination		None					
Reports on local/regional							
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report					
hydraulics	\boxtimes	source(s): None					
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.					
bridge scour		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.					

		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	Ø	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u>
Turbidity		source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	\boxtimes	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps		source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

East Fork Cherry Creek MP 70.9

Site)	East Fork Cherry Creek MP 70.9	Date	08/03/09	
Dor	Done by: GF, ML			view: EG	

Regional Regression Analysis								
Source	Drainage Area	Average	Recurrence Interval					
Jource	(mi²)	Elevation (ft)	2	5	10	25	50	100
Omang (1992)	27.7*	2,496	107	348	605	1,042	1,470	1,955

*The crossing is assumed to occur downstream of the confluence of the two tributaries

Geomorphology NOTE: All measur	es rounded t	o whole num	ber except	for drainage	area and	ratios lik	e sinuositv	or confin	ement)			
For Reach (extend			•	-			-		-			
	С	hannel			Valley							
Gradient (%	Gradient (%): 0.3						Gradient (%): 0.3					
	Min	max	mean	stnd dev.		min max mea			stnd dev.			
Width (ft)	7	14	11	3	width	289	963	556	263			
meander w	avelength (ft)	549			describe	e geology	(lithology, e	erodibility):				
maandara	meander amplitude (ft) 70						n channels	and floodp	plains 1138 ft			
meander a							US on Hawk Coulee and near confluence Alluvium/colluvium					
Sinuositv 1	Sinuosity 1.26						Both sides Bearpaw Fm: shale with several zones of calcareous concretions, a basal zone of ferruginous concretions, and numerous thin bentonite beds					
	-						axville Fm ash locally		and, and silt with			
	Upstre	am (ft)	Downsti	ream (ft)	Floodplain							
	distance from	radius of	distance from	radius of	FEMA National Database N f if yes, describe widths below							
	crossing	curvature	crossing	-	curvature	Width	min	max	mean	stnd dev.		
radius of					(ft)							
curvature	739	70	197	63								
(ft)	1042	86	141	45	Describe abundance and location(s) of:							
	1374	46	1014	81	scroll bars:							
	1485 41 1358 58				None							
	1694	74	74 1583 67			oxbows:						
	1883	46			None	9						
Channel fo	rm (braided, a	anabranching	, single thread	d):	chan	nel cut-of	fs:					
Single Thre	Single Thread											

Channel confinement at crossing (Wv / Wc):	Relic Channels:
32	US 1 mi
What is elevation of the channel relative to the floodplain (perche	ed, incised)? What is evidence?
The elevation of the flood plain is greater than the elevation of th	e channel's water surface.
Unique features, exceptions, etc.	
Tribs: US unnamed 2.9 mi, Hawk Coulee 80 ft; DS Spring Coulee	e 0.7 mi, Foss Coulee 2.2 mi; joins Cherry Creek 3.1 mi

DS 1. Deep incision (0.15 mi, River right,)

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None. Listed as high risk by PHMSA NPMS Landslide Hazard Map.

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US & DS 1. Transmission Lines (0.15 mi, river left, perp.) US buildings 1.3 mi, small road crossing 0.8 mi DS 1. Road (<0.10 mi, river left, par.) 2. Residence (<0.10 mi, river left), small gravel pit 0.4 mi, road crossing with bridge 1 mi, small roads and buildings in vicinity of Spring Coulee confluence 0.7 mi, gravel pit at 1.74 mi, 2.2 mi, 2.8 mi

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

The valley narrows near the crossing, DS 0.15 mi, there is evidence of incision, river left.

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140

	1	p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf
		p. http://onlinepubs.trb.org/Onlinepubs/ncnrp/ncnrp_rpt_516.pdf
		Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.
		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
		Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
		Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
		Personal Communication Sources Steve Holnbeck
		USGS Montana Water Science Center 3162 Bozeman Avenue
		Helena Mt 59601-6456
		Phone: (406) 457-5929
		Email: <u>holnbeck@usgs.gov</u>
		Kent Barnes, P.E.
		Bridge Bureau
		Montana Department of Transportation PO Box 201001
		2701 Prospect
		Helena, MT 59620-1001
		406-444-6260
		Fax 406-444-6155
		Mark Goodman
		Montana Department of Transportation
		40-444-6246
		source(s): Ice Jams in Montana
		U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire
		http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf
Ice jams	\boxtimes	Mentene lee Jam Diver lee and Diver lee Dresses
-		Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/
		Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation
		http://www.fema.gov/news/event.fema?id=635 source(s):
		Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical
Turbidity	\boxtimes	alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p.
		http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt
		erations.pdf source(s): (note if managed flow, e.g. canals or flow during summer only)
Stream gages	\boxtimes	None
		source(s):
1:24000 geologic maps	\boxtimes	State Geologic Mapping Program
		http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Espiel Coulee MP 77.9

Site	Espiel Coulee MP 77.9		Date	08/03/09
Done by:	GF, EG, ML	Rev	riew: EG	

	Re	TABLE X gional Regression	Analysis	6					
Source	Drainage	Average	Recurrence Interval						
Source	Area (mi ²)	Elevation (ft)	2	5	10	25	50	100	
Omang (1992)	5.86	2,368	37	132	238	426	613	833	

					1					
	-	Channel					Valle	y		
Gradient (%	6): 0.89				Gradient (%): 0.53					
width	min	max	mean	stnd dev	width	min	max	mean	stnd de	
maan	12	39	21	75	maar	344	820	579	172	
meander wavelength: 1033						e geology	(lithology,	erodibility):		
meander ar	mplitude: 541	i			Alluviun	n/colluviur	n 375 ft wi	de at crossi	ng	
Sinuosity: 1	.62				several zone of	zones of	calcareous us concreti	aw Fm: Sha concretion ions, and nu	s, a basal	
	Upstre	eam (ft)	Downst	tream (ft)			Floodp	lain		
-				FEMA National Database No						
	distance	radius of	distance from crossing	radius of	if yes, describe widths below					
	from crossing	curvature		curvature	Width (ft)	min	max	mean	stnd de	
radius of curvature	135	370	35	232						
(ft)	1713	128	155	111	Describe abundance and location(s) of: scroll bars:					
	2957	382	319	49						
	3729	606	572	81	None	e				
	4457	86	820	482	oxbo	WS:				
	5909	249	1282	75	None					
Channel for	rm (braided,	anabranching	g, single threa	ıd):	char	nel cut-of	fs:			
single					None					
Channel confinement at crossing (Wv / Wc):					Relic channel 0.5 mi US					
25.7										

Unique features, exceptions, etc

Tribs: unnamed creeks 0.1 and 0.8 mile upstream on the right and 0.3 mile downstream left bank. Flows into Milk River 2.3 mi

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Dam on trib (0.8 mi US) 340 ft from confluence, perpendicular road 0.3 mi US of crossing with groups of buildings associated.

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc): None

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	 source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey, various dates, Water resources data, Montana, water year: U.S. Geological Survey Water-Data Report.
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. FHWARD-95-184, "Channel Scour at Bridges in the United. States FHWA-IP-90-017, HEC No.18, 1995, US. Department of Transportation, http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.

	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation
Ice jams	40-444-6246 source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Shade Creek MP 110.4

Site	Shade Creek MP 110.4	Date:	08/02/09	
Done by:	GF, EG, ML	Rev	view: EG	

Source or Gage	ency Analysi Drainage	s (from region Upstream /	al regressio Distance to	n equation Range of data	and stre	and stream gage shapefile or report if available) recurrence interval					
name and number	Area (mi ²)	Downstream	crossing (mi)	(years)	2	5	10	25	50	100	
Omang (1992)	8.99				87	291	529	930	1,317	1,551	

Geomorphology NOTE: All measu	res rounded	to whole nur	nber, except	for drainage	e area and	ratios lil	ke sinuosit	y or confir	nement)
For Reach (exten	ding at least	3 meander w	avelengths	or 20 channe	el widths ເ	ıpstream	and down	stream of	crossing)
	C	Channel					Va	ley	
Gradient	Gradient (%): 0.1								
Width (ft)*	min	max	mean	std dev	Width	min	max	mean	std dev
width (it)	7	12	8	2	(ft)	365	1715	668	467
*Very difficult to se	ee channel at t	he resolution	of aerials.						
meander	wavelength (ft): 337			describe	egeology	(lithology, e	erodibility):	
meander	amplitude (ft):	186			Modern	alluvium	480 ft		
Sinuosity	6.80				clayston	e alternat	reek Fm: Li es with gra carbonacec	y to brown	
	Upstre	eam (ft)	Downstream (ft)		Floodplain				
	distance from crossing	radius of curvature	distance from crossing	from curvature	FEMA National Database No if yes, describe widths below Width min Max mean Stnd Dev				Stnd Dev
radius of					(ft)				
curvature (ft)	204	184	142	133					
	409	130	390	79	Describe	e abundai	nce and loc	ation(s) of:	
	773	149	710	56	scro	ll bars:			
	1187	218	883	169	Non	e			
	1464	180	1345	134	oxbo	WS:			
1797 119 1873 271						sibly US 1	20 ft on RE	and DS 3	40 ft on LB.
Channel form (braided, anabranching, single thread):						nel cut-o	ffs:		
Single	Single						US 270 ft c	on RB; 550	ft RB;
Channel	confinement at	t crossing (W _v	, / W _c):						
82.97	Channel confinement at crossing (W _v / W _c): 82.97								

Meander 0.2 mi US is 3-4 feet above floodplain in DEM.

Unique features, exceptions, etc

The 3 Shade Creek crossings are all within 300 feet of each other.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

landslide deposits mapped in geology (1:100,000) layer in hills 1 mi from RB of creek but only 0.4 mi from pipeline.

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Parallel (but looping away) road 2.4 mi from LB. Stock pond 0.2 mi up trib 0.3 mi DS, Goose Island Reservoir 0.1 mi up trib 1 mi US, Teds Reservoir 0.5 mi up trib 1.7 mi US

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc): None

		LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination		source(s): None
Reports on local/regional		
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	\boxtimes	source(s): None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour		 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.

	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation
lce jams	40-444-6246 source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Shade Creek MP 110.5

Site	Shade Creek MP 110.5		Date:	08/02/09
Done by:	GF, EG, ML	Rev	view: EG	

Peak Flood Frequency Analysis (from regional regression equation and stream gage shapefile or report if available)										
Source or Gage name and	Drainage	Upstream /	Distance to	Range of data			recurrenc	e interval		
number	Area (mi ²)	Downstream	crossing (mi)		2	5	10	25	50	100
Omang (1992)	8.99				87	291	529	930	1,317	1,551

	C	hannel					Valle	v		
Gradient	Gradien	t(%): 1.1								
	min	max	mean	std dev		min max mean sto				
Width (ft)*	7	12	8	2	Width (ft)	365	1715	668	467	
Very difficult to se	ee channel at t	he resolution	of aerials.							
meander	wavelength (ft): 337			describe	e geology	(lithology,	erodibility):		
meander	amplitude (ft):	186			Modern	alluvium	480 ft			
Sinuosity	: 6.80				clayston	e alterna	reek Fm: Li tes with gra carbonaceo	y to brown		
	Upstre	eam (ft)	Downst	tream (ft)	Floodplain					
	distance from crossing	radius of	distance from crossing	radius of curvature	FEMA National Database No if yes, describe widths below Width min Max mean					
	el cecellig				Width (ft)					
radius of curvature (ft)	102	133	60	79						
	121	184	157	56	Describe	e abunda	nce and loc	ation(s) of:		
	184	130	210	169	SCrO	ll bars:				
	295	149	351	134	None					
	421	218	512	271	oxbo	ows:				
	505	180	594	184	Pos	sibly US 2	200 ft on RE	3 and DS 2	260 ft on LB	
Channel f	form (braided,	anabranching	g, single threa	ad):	char	nnel cut-o	ffs:			
Single					Relie	c channel	US 190 ft (on RB; 630	ft RB;	

Meander 0.2 mi US is 3-4 feet above floodplain in DEM.

Unique features, exceptions, etc

The 3 Shade Creek crossings are all within 300 feet of each other.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

Landslide deposits mapped in geology (1:100,000) layer in hills 1 mi from RB of creek but only 0.4 mi from pipeline.

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Parallel (but looping away) road 2.4 mi from LB. Stock pond 0.2 mi up trib 0.3 mi DS, Goose Island Reservoir 0.1 mi up trib 1 mi US, Teds Reservoir 0.5 mi up trib 1.7 mi US

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc): None

		LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination		source(s): None
Reports on local/regional		
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	\boxtimes	source(s): None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour		 Source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP-90-017, 132 p.

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		Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect
		Helena, MT 59620-1001 406-444-6260
		Fax 406-444-6155
		Mark Goodman Montana Department of Transportation 40-444-6246
lce jams		source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
		Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity		source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages		source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps		source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Shade Creek MP 110.55

Site	Shade Creek MP 110.55	Date:	08/02/09	
Done by:	GF, EG,ML	Revie	w: EG	

	Regional Regression Analysis										
Source or Gage name and number	Drainage	Upstream / Downstream	Distance to crossing (mi)	rtango		recurrence interval					
	Area (mi ²)			(years)	2	5	10	25	50	100	
Omang (1992)	8.99				87	291	529	930	1,317	1,551	

•	-		avelengths		- Wiatrio e	ipotream			orossing)		
	C	hannel			Valley						
Gradient	(%): 0.1				Gradient (%): 1.1						
Width (ft)*	min	max	mean	std dev	Width	min max mean			std dev		
width (it)	7	12	8	2	(ft)	365	1715	668	467		
Very difficult to se	ee channel at t	he resolution	of aerials.								
meander	wavelength (ft): 337			describe	egeology	(lithology,	erodibility):			
meander	amplitude (ft):	186	Modern	alluvium	480 ft						
Sinuosity	6.80				clayston	e alterna	reek Fm: Li tes with gra carbonaceo	y to brown			
	Upstre	eam (ft)	Downst	Floodplain							
			trom		FEMA National Database No						
	trom	radius of		radius of curvature	if yes, de	escribe w	idths below	,			
	crossing	curvature			Width (ft)	min	Max	mean	Stnd Dev		
radius of	63	80	42	56	. ,						
curvature (ft)	141	133	95	169	Describe	abunda	nce and loc	ation(s) of			
	236	184	236	134		ll bars:					
	299	130	397	271	Non						
	410	149	479	184	oxbo	-					
	536	218	548	113			860 ft on RE	and DS 1	00 ft on LB		
Channel	form (braided,	-		-		nel cut-o					
			, engle thee								
Single						c channel					
Channel	confinement at	crossing (W_v	/ W _c):		US 3	350 ft on I	RB; 630 ft F	RB			

Meander 0.2 mi US is 3-4 feet above floodplain in DEM.

Unique features, exceptions, etc

The 3 Shade Creek crossings are all within 300 feet of each other.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

Landslide deposits mapped in geology (1:100,000) layer in hills 1 mi from RB of creek but only 0.4 mi from pipeline.

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Parallel (but looping away) road 2.4 mi from LB. Stock pond 0.2 mi up trib 0.3 mi DS, Goose Island Reservoir 0.1 mi up trib 1 mi US, Teds Reservoir 0.5 mi up trib 1.7 mi US

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc): None

		LITERATURE REVIEW
	1	(check box when searched for, if none, note under source) source(s):
Existing channel migration zone determination		None
Reports on local/regional		
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics		source(s): None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour		 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic

	Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: <u>holnbeck@usgs.gov</u>
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

South Fork Shade Creek MP 114.2

Site	South Fork Shade Creek MP 114.2		Date:	08/02/09
Done by:	GF, EG, ML	Rev	view: EG	

	Regional Regression Analysis										
Source or Gage name and number	Drainage	Upstream /	Distance to crossing (mi)	Range of data	recurrence interval						
	Area (mi ²)	Downstream		(years)	2	5	10	25	50	100	
Omang (1992)	4.88				61	204	374	666	950	1,120	

•	ing at least 3	8 meander w	avelengths o	or 20 channe	l widths u	pstream	and down	stream of	crossing)	
	C	hannel					Valle	у		
Gradient (%): 0.17				Gradien	t (%): 0.3	6			
Width	min	max	mean	std dev	Width	min	max	mean	std dev	
(ft)*	9	13	11	2	(ft)	265	1020	581	275	
* Difficult to	o see channel	with resolution	on of aerial ph	notos.						
meander w	vavelength (ft)	: 427			describe	e geology	(lithology,	erodibility):		
meander a	mplitude (ft): 2	255	Modern	alluvium	400 ft					
					clayston	e alterna		ight gray, b ay to brown ous shale.		
Sinuosity:	6.23				RB and US Tullock Member of Fort union Fm: Yellow sandstone interbedded with subordinate grayish brown and black shale and thin beds of coal.					
	Upstre	am (ft)	Downst	ream (ft)	Floodplain					
					FEMA National Database No					
	distance from	radius of	distance from	radius of	if yes, describe widths below					
	crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	Stnd De	
radius of					(11)					
curvature (ft)	88	145	157	116						
(11)	362	124	587	141	Describe	e abunda	nce and loo	cation(s) of	:	
	757	102	1211	124	scrol	l bars:				
	1036	113	1581	90	none)				
	1299	115	1978	92	oxbo	WS:				
	1552	84	2497	101	none	;				
Channel fo	orm (braided, a	anabranching	, single threa	d):	chan	nel cut-o	ffs:			
					USS					

Channel confinement at crossing (W $_{\rm v}$ / W $_{\rm c}$):	Relic channels US 75 ft LB, 400 ft on LB and RB, 900 ft RB. DS 275 ft, 0.2 mi and possibly 930 ft.							
78.14								
What is elevation of the channel relative to the floodplain (perched, incis	What is elevation of the channel relative to the floodplain (perched, incised)? What is evidence?							
US 775 ft and DS 700ft and 0.2 from crossing channel is 1-4 ft above flo	odplain based on DEM.							
Unique features, exceptions, etc								
Confluence with unnamed creeks US 410 ft and DS 600 ft.								

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

US 0.2 and 0.4 mi right, DS 1.1 mi left, several landslide deposits mapped 2 to 3 mi west

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Stock ponds 0.1 mi and 1 mi up trib 0.1 mi DS, 0.1 mi up trib 0.95 mi DS, small road crosses 0.38 mi US

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

Although aerial photo resolution is low for size of creek, channel appears to very mobile in floodplain.

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u> Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. <u>http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf</u> Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of

	 Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water
	Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman
_	Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Mediana Dense Disease Dense Dense Dense Dense Deil Octomation
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u>
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Flying V Creek MP 118.6

Site	Flying V Creek MP 118.6		Date:	08/02/09
Done by:	GF, EG, ML	Rev	view: EG	

	Regional Regression Analysis											
Source or Gage name and	Drainage	Upstream / Downstream	Distance to crossing (mi)	Range of data		recurrence interval						
number	Area (mi ²)			(years)	2	5	10	25	50	100		
Omang (1992)	7.21				73	244	444	786	1,118	1,320		

	-		avelengths o			ipstream			lossing)	
	С	hannel			Valley					
Gradient (9	%): 1.2				Gradient (%): 3.5					
Width (ft)	min	max	mean	std dev	Width	min	max	mean	std dev	
width (it)	8	23	14	5	(ft)	524	1092	864	211	
meander w	vavelength (ft)	: 346		I	describe geology (lithology, erodibility):					
meander a	mplitude (ft):	162			Modern	alluvium	635 ft			
Sinuosity:	2.04		Fort Union Fm: Both sides Tullock Member: sandstone interbedded with subordinate shale and thin beds of coal. Both sides Lebo Member: carbonaceous shale, bentonitic claystone, sandstone, and coal.							
	ream (ft)			Flo	odplain					
radius of	distance from	from radius of		radius of	FEMA National Database Y/N if yes, describe widths below					
curvature (ft)*	crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	Stnd Dev	
	29	122	382	112				1	•	
*Last 2 US	226	154	601	53	Describ	e abundar	nce and loc	ation(s) of:		
meanders are behind dam	576	143	848	47	SCrO	ll bars:				
	745	72	985	40	none	Э				
	1801	271	1142	73	oxbo	ows:				
	2043	211	1306	171	US: 500 ft and possibly 0.2 mi on LB					
Channel fo	orm (braided, a	anabranching	, single thread	char	nnel cut-of	fs:				
Single	US:	320 ft RB;	DS: 720 ft	LB						
	onfinement at	oroccing (M	/ \\\ .							

DS of crossing, channel is about 5 ft above floodplain at a cutoff on DEM.

Unique features, exceptions, etc

Channel much straighter directly DS of earthen dam for 0.2 mi (see infrastructure note below); channel widening effects of dam extend US 0.25 mi. Confluence with unnamed creek 475 ft DS.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US: stock pond 0.2 mi, 1.4 mi. 2.3 mi and 2.8 mi; stock pond 0.35 up trib that joins at 0.2 mi and 1.8 mi up trib that joins 0.7 mi US; road crosses at 0.8 mi then runs DS parallel to LB 0.25 mi away; small spur road to dammed pond. DS: stock pond 2.3 mi, road crosses 1.7 mi

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

Straightened reach below dam appears to be incised in aerial photos.

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic

	Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Figure 8 Creek MP 122.3

Site	Figure 8 Creek MP 122.3		Date:	08/02/09
Done by:	GF, EG, ML	Rev	riew: EG	

	Regional Regression Analysis											
Source or Gage name and	Drainage	Upstream /	Distance to	Rungo		recurrence interval						
number	Area (m ²) Downstream	crossing (mi)	ng (years)	2	5	10	25	50	100			
Omang (1992)	19.63				126	414	746	1,296	1,825	2,155		

	С	hannel			el widths upstream and downstream of crossing) Valley Gradient (%): 0.81				
Gradient (%	%): 0.11								
	min	max	mean	std dev	Width	min	max	mean	std dev
Width (ft)	8	14	10	2	(ft)	208	703	476	204
meander w	l vavelength (ft)	: 370			describe	e geology	(lithology,	erodibility):	
meander a	mplitude (ft):	215			Modern	alluvium	534 ft; alluv	/ium-colluvi	um
Sinuosity: 2	2.19				subordir Both sid	les Tulloc nate shale les Lebo I	and thin c Member: ca one, and c	oal beds. arbonaceou oal.	interbedded with s shale, bentonitic
	Upstre	Downsti	ream (ft)			Fle	oodplain		
	distance	from radius of	distance from crossing	radius of	FEMA National Database No if yes, describe widths below				
radius of	-			curvature	Width (ft)	min	max	mean	Stnd Dev
curvature	418	110	172	225					1
(ft)	671	129	392	82	Describ	e abunda	nce and loo	cation(s) of:	
	1096	122	469	84	scro	ll bars:			
	1633	56	549	129	None	е			
	1759	70	812	91	oxbo	WS:			
	2059	105	1007	174	None	е			
Channel fo	rm (braided, a	, single thread	char	nnel cut-of	fs:				
Single			None	e					

DS of crossing channel is about 3 ft above floodplain in DEM.

Unique features, exceptions, etc

Terrace of alluvium-colluvium about 2 feet above floodplain along length of study reach. Confluence DS 750 ft with trib that has a dammed pond 580 feet US of confluence.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance along valley axis?):

1.9 mi US Right

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

DS: Road with bridge or culvert at 0.3 mi; group of buildings off this road 0.9 mi from RB; Parallel road 0.6 mi from LB. stock pond 0.2 mi. Stock ponds 1.2 mi and 0.33 mi up trib at 0.14 mi

US Stock pond 0.8 mi up trib that joins 0.4 mi, 0.3 mi up trib 1.7 mi. small road crosses 1.5 mi

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

From limited resolution of aerials, channel seems to be incising floodplain.

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	 Source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic

	Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes
	http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Lone Tree Creek MP 146.2

Site	Lone Tree Creek MP 146.2		Date:	08/02/09
Done by:	GF, EG, ML	Rev	riew: EG	

	Regional Regression Analysis										
Source or Gage name and	Drainage	Upstream /	Distance to crossing (mi)	Range of data	recurrence interval						
number	Area (mi ²)	Downstream		(years)	2	5	10	25	50	100	
Omang (1992)	8.51				78	261	475	840	1,194	1,141	

	-	hannel	avelengths o	20 01121110		.pou cum				
	-	nannei			Valley					
Gradient (%): 0.87				Gradient	t (%): 2.2				
Width (ft)*	min	max	mean	std dev	Width	min	max	mean	std dev	
(1)	13	28	20	5	(ft)	266	1222	731	369	
*Difficult to see cha	annel in aerial	photos.				1			1	
meander v	vavelength (ft)	: 292			describe	egeology	(lithology, e	erodibility):		
meander a		Modern	alluvium 1	770 ft						
Sinuosity:		Both sides Tongue River Member of Fort Union Formation: sandstone, sandy and silty carbonaceous shale, coal.								
	Upstre	am (ft)	Downstr	ream (ft)*	Floodplain					
-	distance from crossing	distance from	radius of	FEMA National Database No if yes, describe widths below						
radius of		curvature	crossing	curvature	Width (ft)	min	max	mean	Stnd Dev	
curvature (ft)	0	244	*No meand	o meanders DS						
* Crossing at last meander US of	315	143			Describe abundance and location(s) of:					
confluence with Redwater River	523	97			scro	ll bars:				
	947	109			US:	possibly 4	40 ft			
	1346	171			oxbo	WS:				
	2301	168			None	e				
	2504	74			char	nel cut-of	fs:			
Channel fo	orm (braided, a	anabranching	, single threa	d):	US:	0.3 mi				
Single			5		Polic	channel	600 ft (just	DS of road	(crossing)	
-	onfinement at		()		ivenc		ooo n gust			

Channel 250 ft US is 6 to 15 feet above floodplain in DEM.

Unique features, exceptions, etc

Confluence with Redwater River 250 ft DS, confluence with unnamed creek 0.25 mi US

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance along valley axis?): None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (US/DS with distance to pipeline, right or left bank, perp. or parallel):

US: road crossing at 700 ft and 2.7 mi —looks like creek is in culverts under road; spur road 475 ft from LB; small farm road 0.4 mi from LB roughly parallel; small road crossing at 1.79

Stock ponds 0.9 mi US and at 0.3 mi and 0.75 mi up trib at 1.85 mi US

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

DEM shows scour pool just below confluence with Redwater River 600 ft DS of crossing.

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.

	1	
		Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929
		Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
		Mark Goodman Montana Department of Transportation 40-444-6246
lce jams		source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
		Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u> source(s):
Turbidity		Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	\boxtimes	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps		source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Buffalo Springs Creek MP 147.5

Site	Buffalo Springs Creek MP 147.5		Date:	08/03/09
Done by:	GF, ML	Rev	view: EG	

	Regional Regression Analysis									
Source or Gage name and number	Drainage	Upstream /	Distance to	Range of data			recurrenc	e interval		
	Area (mi²)	Downstream	crossing (mi)	(years)	2	5	10	25	50	100
Omang (1992)	18.82				141	393	648	1,089	1,466	1,989

	Cha	annel			-		Valley	,	
Gradient (%			Gradien	t (%): <0.	-				
	min	max	mean	std dev		min	max	mean	std de
Width (ft)	7	12	10	2	Width (ft)	179	449	285	84
meander w	avelength (ft	877	_		describe		(lithology,	erodibility):	
meander w							ern channe		Inlaina 7
meander ar	mplitude (ft) 2	281			ft				
							e River Me		
Sinuosity 1	.45				Union F coal.	m: Sands	stone, sand	y and silty s	shale and
	Upstre	eam (ft)	Downst	ream (ft)			Floodpla	ain	
					FEMA N	lational D	atabase N		
	distance radius of	distance	radius of	if yes, describe widths below					
	from crossing	trom	trom	curvature	Width	min	max	mean	Stnd
					(ft)				Dev
radius of									
curvature	547	101	124	92					
(ft)	955	134	406	86	Describ	e abunda	nce and loc	cation(s) of:	
	1772	308	947	101	scro	ll bars:			
	2680	129	670	78	Non	Э			
			2929	156	oxbo	WS:			
			3552	117	Non	Э			
			4097	127	char	nel cut-o	ffs:		
Channel for	rm (braided,	anabranching	, single threa	d):	DS (0.10, rive	r left, 0.30 i	mi, river rigl	nt)

18.28	
What is elevation of the channel relative to the floodplain (perched, incised)?	What is evidence?
The elevation of the floodplain is lower than the channel's water surface	
Unique features, exceptions, etc	
None	
Evidence of landslides upstream or downstream along valley margins (Upst along valley axis?):	ream/downstream? Straight line distance to pipeline
None	
Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upst feature, right or left bank, perpendicular or parallel):	tream/downstream with distance to pipeline, if linear
US & DS 1. Road (0.40 mi river left) US. 1. Transmission line (<0.10 mi, Line (0.30 mi, river right par.) DS 1. Road crosses 0.58 mi with culvert, US	
If visible, describe any direct or indirect evidence of general scour/channel in	cision (straightened channel, etc):

Near the crossing the valley is narrower than US & DS. There could be incision at this location.

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.

	Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
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lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation
Turbidity	http://www.fema.gov/news/event.fema?id=635 source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Buffalo Springs Creek MP153.2

Site	Buffalo Springs Creek MP153.2		Date:	08/03/09
Done by:	GF, ML	Rev	view: EG	

	Regional Regression Analysis										
Source or Gage name and number	Drainage	Upstream /	Distance to	Range of data			recurrenc	e interval			
	Area (mi ²)	Downstream	crossing (mi)	(years)	2	5	10	25	50	100	
Omang (1992)	0.01				2	6	11	21	30	41	

	ling at least 3	hannel	avelengtins t			ipstream			crossing)
			Valle	У					
Gradient (%	Gradien	t (%): 3.8							
Width (ft)	Width (ft)		mean	std dev	Width	min	max	mean	std dev
width (it)	7	10	8	1	(ft)	322	636	457	100
meander w	vavelength (ft)	1092	1		describe	e geology	(lithology,	erodibility):	
meander a	mplitude (ft) 1	42			Alluvium	n of mode	rn channe	ls and flood	plains DS
Sinuosity 1	.13				Both sid Fm: Sar	les Tongu ndstone, s	e River Me sandy and	ember of the silty shale a	e Fort Unio and coal.
	Upstre	am (ft)	Downst	ream (ft)			Floodp	lain	
			trom	radius of curvature	FEMA National Database N				
	distance	from radius of			if yes, describe widths below				
	crossing	curvature			Width	min	max	mean	Stnd De
radius of					(ft)				
curvature	470	111	No Meande	ers DS				I	
(ft)	465	70			Describe abundance and location(s) of:				
	1598	135			scro	l bars:			
					None	Э			
					oxbo	WS:			
					None	Э			
Channel fo	orm (braided, a	anabranching	, single threa	d):	char	inel cut-o	ffs:		
Single					None	Э			
Channel co	onfinement at	crossing (W _v	/ W _c):						
This chanr	nel's valley wi	dth is part of	the larger B	uffalo Creek					
valley.	-		-						

The elevation of the channel is lower than the surrounding flood plain.

Unique features, exceptions, etc

The channel appears to be a drainage ditch because there is a 0.01 mi² watershed and low sinuosity.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US 1. Small road crosses 420 ft

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

There is low sinuosity and the channel appears to be straightened, especially near the crossing with the unnamed road.

		LITERATURE REVIEW
	T	(check box when searched for, if none, note under source)
Existing channel migration zone determination		source(s): None
Reports on local/regional		
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics		source(s): None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour		 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u> Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. <u>http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf</u> Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.

	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation
lce jams	40-444-6246 source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Cottonwood Creek MP 156.7

Site	Cottonwood Creek MP 156.7		Date:	08/03/09
Done by: GF, ML		Rev	view: EG	

			Regional R	egression	Analysis						
Source or Gage name and	Drainage	Upstream / Downstream	Distance to crossing (mi)	Range of data	recurrence interval						
number	Area (mi²)			(years)	2	5	10	25	50	100	
Omang (1992)	5.02				56	161	272	466	638	864	

	C	hannel					Valle	у	
Gradient (%	%): 0.5				Gradien	t (%): 0.6			
	min	max	mean	std dev	Width	min	max	std dev	
Width (ft)	7	12	9	2	(ft)	153	544	349	158
meander w	vavelength (ft)	771			describe	e geology	(lithology,	erodibility):	
meander a	mplitude (ft) 1	34			Alluvium	of mode	rn channel	s and flood	plains 274
Sinuosity 1	.22							ember of the silty shale a	
	Downst	ream (ft)	Floodplain						
			distance from	radius of	FEMA National Database N				
radius of	trom	radius of			if yes, d	escribe w	idths below	V	
		curvature	crossing	curvature	Width (ft)	min	max	mean	Stnd De
curvature	103	49	875	137					
(ft)	354	30	1322	214	Describe	e abundai	nce and loo	cation(s) of:	
	598	57	1783	165	scrol	l bars:			
	1506	55	2280	136	None)			
	2114	150			oxbo	WS:			
	488	88			None	9			
Channel fo	rm (braided, a	anabranching	, single threa	d):	chan	nel cut-of	fs:		
Single Cha	nnel				DS (0.15, riveı	right,)		
Channel co	onfinement at	crossing (W _v	/ W _c):						

US (0.10-0.30 mi) the elevation of the channel's water surface appears to be higher than the floodplain elevation

Unique features, exceptions, etc

None

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

1.5 mi US river left

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Stock pond 0.1 mi up trib that joins 0.4 mi US. Road crossing 0.8 mi US and 0.2 mi DS with culvert. 2. Electric line (0.50 mi, perp. DS)

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

The channel appears t o be straightened DS (0.10-0.20 mi) of crossing to accommodate the road crossing

	(check box when searched for, if none, note under source) source(s):
Existing channel migration zone determination	None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.

	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Hay Creek MP 163.1

Site	Hay Creek MP 163.1		Date:	08/03/09
Done by:	GF, ML	Rev	view: EG	

			Regional R	egression	Analysis							
Source or Gage name and	Drainage	Upstream / Downstream	Distance to crossing (mi)	Rungo		recurrence interval						
number	Area (mi²)			(years)	2	5	10	25	50	100		
Omang (1992)	4.04				41	119	203	351	485	654		

	C	hannel					Valle	у		
Gradient (9	%): <0.1				Gradier	it: (%) 0.2	2			
Width	Min	max	mean	std dev	Width	min	min max		std dev	
(ft)*	8	14	11	2	(ft)	168	694	326	192	
*Vegetatio	n made it diffi	cult to determ	ine channel v	vidth						
meander w	vavelength (ft)	293			describe geology (lithology, erodibility):					
meander a	mplitude (ft)	104			Alluvial	terrace d	eposit 226	ft		
Sinuosity	1.42			Tongue River Member: sandstone, sandy and silty carbonaceous shale, and coal Tongue River Member: sandstone, sandy and silty carbonaceous shale, and coal						
	Upstre	am (ft)	Downst	ream (ft)			Floodp			
	distance from crossing	radius of curvature	distance from crossing	radius of curvature	FEMA National Database N if yes, describe widths below Width min max mean Stnd D					
radius of			-		(ft)					
curvature	32	34	108	37						
(ft)	138	34	296	51	Describ	e abunda	nce and lo	cation(s) of:	:	
	413	55	501	37	scro	ll bars:				
	664	33	743	71	Non	e				
	1117	87			oxbo	ows:				
					Non	е				
Channel form (braided, anabranching, single thread): Single Channel						nnel cut-o	ffs:			
						е				

The main channel's elevation is higher than its floodplain near the confluence of the DS tributary.

Unique features, exceptions, etc

The valley floor widens greatly DS 0.10 mi as another tributary enters the main channel. The main channel is at a higher elevation DS than its floodplain.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US & DS 1. Road (0.10 mi river right, par.) 2. Railroad (0.10 mi, river right, par.), stock pond 725 ft US on a trib 0.4 mi DS

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

None

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic

	Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes
	http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Upper Seven Mile Creek MP 166.2

Site	Upper Seven Mile Creek MP 166.2		Date:	08/03/09
Done by: GF, ML			view: EG	

Peak Flood Frequency Analysis (from regional regression equation and stream gage shapefile or report if available)											
Source or Gage name and	Drainage	Upstream / Downstream	Distance to crossing (mi)	Range of data	recurrence interval						
number	Area (mi ²)			(years)	2	5	10	25	50	100	
Omang (1992)	6.16				82	151	255	440	605	816	

-	-	hannel	avelengths o						3)	
Gradient (%): 0.1					Valley Gradient (%): 0.3					
										Width (ft)
width (it)	7	13	9	3	144	562	248	149		
meander wavelength (ft) 765						describe geology (lithology, erodibility):				
meander amplitude (ft) 412					Alluvium of modern channels and floodplains 539					
Sinuosity 1.67					Both sides Tongue River Member: sandstone, sandy and silty carbonaceous shale, and coal					
radius of curvature (ft)	Upstre	am (ft)	Downstream (ft)		Floodplain					
	distance from crossing	radius of curvature	distance from crossing	radius of curvature	FEMA National Database N					
					if yes, describe widths below					
					Width (ft)	min	max	mean	Stnd De	
	452	51	953	116						
	997	124	1565	138	Describe abundance and location(s) of:					
	1829	78	2185	118	scroll bars:					
			2768	124	None					
			3162	73	oxbows:					
					US 1. (0.20 mi, in channel) DS 1. (0.20 mi, channel)					
Channel form (braided, anabranching, single thread):					channel cut-offs:					
Single Thread					None.					
Channel co	onfinement at	crossing (W_v	/ W _c):							
14.11										

The flood plain's elevation is higher than the water surface elevation of the channel.

Unique features, exceptions, etc

It appears the channel is cutting into river left valley walls near the crossing as shown by the step transition from the upper terrace to the valley floor.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

0.79 mi DS on river right

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US 1. Roads cross at 0.40 mi, 1.46 mi, US & DS 1. Road (0.20 mi, river right, perp.), Stock pond 0.15 mi up trib at 0.48 mi DS

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

US. The valley is narrower near the crossing and it appears the channel is cutting into the valley walls as seen through river right bank failure.

Existing channel migration Zone determination		(check box when searched for, if none, note under source) source(s): None	
Reports on local/regional			
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report	
hydraulics		source(s): None	
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Mo 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Rep 4137, 35 p.	
bridge scour		 Source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 	

	90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: <u>holnbeck@usgs.gov</u>
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. <u>http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt</u> erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

West Fork Hay Creek MP 208

Site	West Fork Hay Creek MP 208		Date:	08/03/09
Done by:	GF, ML	Rev	view: EG	

	Regional Regression Analysis										
Source or Gage name and	Drainage Upstream / to of data recurrence interval										
number	Area (mi²)	Downstream	am crossing (mi)	0	(years)	2	5	10	25	50	100
Omang	8.62				110	307	507	855	1,154	1,569	

<u> </u>	<u> </u>	3 meander w	,						3,	
	-	hannel					Valle	y		
Gradient (%	%): 0.2				Gradient (%): 0.4					
Width (ft)	min	max	mean	std dev	Width	min	max	mean	std dev	
width (it)	9.0	11	10	1	(ft)	345	747	546	170	
meander w	avelength (ft)) 696			describe	e geology	(lithology,	erodibility):		
meander a	mplitude (ft)	465			Modern	alluvium	718 ft wide	9		
Sinuosity 2	.07							r Member: us shale, ar		
	Upstre	eam (ft)	Downst	ream (ft)			Floodp	lain		
	distance from crossing					FEMA National Database N				
		radius of	distance from crossing	radius of curvature	if yes, describe widths below					
		curvature			Width	min	max	mean	Stnd De	
radius of					(ft)					
curvature	115	112	454	98						
(ft)	1421	249	1099	182	Describe abundance and location(s) of:					
	2224	141	4002	101	scrol	l bars:				
	2868	137	4602	121	None	e				
	3478	193	5384	105	oxbo	WS:				
	<u> </u>				None	Э				
Channel fo	rm (braided,	anabranching	, single threa	d):	chan	inel cut-o	ffs:			
Single Thre	ead				US (0.15 mi ri	ver left)			
Channel co	onfinement at	crossing (Wv	/ W _c):							
71.46			-							
t is elevation of	the share f		a	<u> </u>						

Unique features, exceptions, etc.

None

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

US 1. Road (0.50 mi river left, par.) Road crossing 1.2 mi DS

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

none

		LITERATURE REVIEW
		(check box when searched for, if none, note under source) source(s):
Existing channel migration zone determination		None
Reports on local/regional		
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics		source(s): None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour		 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability

	at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau
	Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u>
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Hay Creek MP 209.1

Site	Hay Creek MP 209.1	Date:	08/02/09	
Done by:	GF, ML	Rev	view: EG	

	Regional Regression Analysis											
Source or Gage name and	Drainage Upstream / to of data recurrence interval											
number	Area (mi ²)	Downstream	crossing (mi)	(years)	2	5	10	25	50	100		
Omang (1992)	6.57				94	265	439	742	1,005	1,367		

Reach (extend		hannel			1	•	Valle		0,
	-	nannei						y	
Gradient (%	%): 0.4				Gradien	t (%): 0.5			
Width (ft)			Width	min	max	mean	std dev		
Width (ity	6	12	9	2	(ft)	243	663	486	145
meander w	vavelength (ft)	368	1	1	describe	e geology	(lithology,	erodibility):	
meander a	mplitude (ft) 2	276			Alluvium	n of mode	rn channel	ls and flood	plains 545
Sinuosity 7	1.65							r Member: us shale, ar	
	Upstre	am (ft)	Downst	ream (ft)			Floodp	lain	
	distance from crossing			radius of curvature	FEMA National Database N				
		radius of	distance from crossing		if yes, describe widths below				
		curvature			Width	min	max	mean	Stnd De
radius of					(ft)				
curvature	58	36	1133	29					
(ft)	235	55	1403	88	Describe	e abunda	nce and lo	cation(s) of:	
	389	45	1809	98	scroll bars:				
	684	83	2451	138	None				
	1117	87			oxbo	WS:			
					None	Э			
Channel fo	rm (braided, a	anabranching	, single threa	d):	chan	inel cut-o	ffs:		
Single Thre	ead				None	Э			
-	onfinement at	crossing (W.	/ W_c):						
84.47									
	f the channel								

Unique features, exceptions, etc:

The straightened section of channel immediately DS might be evidence of incision, the valley also narrows DS of the crossing

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

DS 1. Road (1.30 mi river left, par.), Buckley Dam 1.22 mi US

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

DS (0.00) There is a straighter section of channel that does not resemble the US or DS meander pattern.

	LITERATURE REVIEW
	(check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at <u>http://water.usgs.gov/pubs/sim/2004/2868.</u>] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability

	at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation <u>http://www.fema.gov/news/event.fema?id=635</u>
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Sandstone Creek MP 244.3

Site	Sandstone Creek MP 244.3	Date:	08/03/09	
Done by:	GF, ML	Rev	view: EG	

			Regional R	egression	Analysis					
Source or Gage name and	Drainage	Upstream /	Distance to	Range of data	recurrence interval					
number	Area (mi ²)	Downstream	crossing (mi)	(years)	2	5	10	25	50	100
Omang (1992)	53.3				185	514	848	1,423	1,911	2,584

-	-		avelenguis	or 20 channe		pstream			crossing)	
	С	hannel			Valley					
Gradient (%	%): 0.2				Gradient (%): 0.6					
Width (ft)	min	max	mean	std dev	Width	Min	max	mean	std dev	
width (it)	11	16	14	2	(ft)	395	870	695	165	
meander w	vavelength (ft)	815			describe	e geology	(lithology,	erodibility):		
meander a	mplitude (ft) 5	32			Alluvium	of mode	ern channe	ls and flood	plains 400	
Sinuosity 2	.10				and brow clayston RB US I alternate	wn shale, e, sands Hell Cree es with gr	siltstone, sitstone, stone, and c k Fm: bent ay to brow carbonace	onitic clays n sandston ous shale	onitic tone that	
	Upstre	am (ft)	ream (ft)			Floodp	lain			
	distance from	radius of		radius of	FEMA National Database N if yes, describe widths below					
	crossing	curvature	crossing	curvature	Width (ft)	min	max	mean	Stnd De	
radius of curvature	89	228	41	135						
(ft)	751	149	52	171	Describe	e abunda	nce and lo	cation(s) of		
	1659	179	58	191	scrol	l bars:				
	2271	224	42	138	None	9				
			63	206	oxbo	WS:				
					DS (left)	0.30, 0.4	0 mi, river	left) US (0).10 mi, riv	
Channel form (braided, anabranching, single thread):						nel cut-o	ffs:			
Single Thre	ad				None	9				

73.07

What is elevation of the channel relative to the floodplain (perched, incised)? What is evidence?

The surface of the water channel appears to be higher than its flood plain near the crossing US & DS (0.00-0.30) mi

Unique features, exceptions, etc Several Oxbows DS.

Valley rim (river right) delineated by railroad bed. Valley expands as it approaches crossing

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Stock pond on floodplain 0.77 mi, 3 sewage disposal ponds 1.3 mi, Lake Baker and town of Baker 2.75 mi US. DS 0.1 mi up trib 1 mi, 0.36 up trib 0.36 mi. Railroad and road cross with bridge 2.27 mi US.

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.

		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation
lce jams		40-444-6246 source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	\boxtimes	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages		source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps		source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Red Butte Creek MP 246.2

Site	Red Butte Creek MP 246.2		Date:	08/03/09
Done by:	GF, ML	Rev	view: EG	

			Regional R	egression	Analysis					
Source or Gage	Source or Gage name and number Drainage Area (mi ²)	Upstream / Downstream	Distance to crossing (mi)	Range of data	recurrence interval					
				(years)	2	5	10	25	50	100
Omang (1992)	16.06				92	263	439	747	1,016	1,373

	- C	hannel		or 20 channe	[•	Valle				
Cradiant (-				Gradient (%): 0.5						
Gradient (%	,				Gradien						
Width (ft)	min	max	mean	std dev	Width	min	max	mean	std de		
	7	12	11	2	(ft)	429	1489	858	331		
meander w	avelength (ft)	637			describe	e geology	(lithology,	erodibility):			
meander amplitude (ft) 232						e, silty or l I.	w Member: bentonitic c	laystone, s	andstone,		
Sinuosity 1.66						Both sides US Hell Creek Fm: bentonitic claystone that alternates with gray to brown sandstone interbedded with carbonaceous shale					
	Upstre	am (ft)	Downst			Floodpl	ain				
			distance from		FEMA N	lational D	atabase N				
	distance	from radius of		radius of	if yes, d	escribe w	vidths belov	V			
	crossing		curvature	curvature	crossing	curvature	Width	min	max	mean	Stnd D
radius of					(ft)						
curvature	63	172	541	74							
(ft)	677	135	823	72	Describe abundance and location(s) of:						
	1684	208	1062	61	scro	l bars:					
	2722	82	1334	67	none	;					
	3067	42			oxbo	WS:					
					US (0.10, rive	r right) DS	(0.20, 0.30) river right		
Channel fo	rm (braided, a	anabranching	, single threa	d):	char	inel cut-o	ffs:				
Single Thread						US 1. (0.20, 0.30 river right) DS (0.20, river right)					

What is elevation of the channel relative to the floodplain (perched, incised)? What is evidence?

DS 1. (0.10-0.40 mi) The creek's surface water elevation appears higher than the flood plain elevation.

Unique features, exceptions, etc:

The valley width expands as the creek approaches the crossing due to several tributaries entering the valley near the crossing. DS 1. Possible avulsion (0.20 mi, river right) leading to the oxbows.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Red Butte Dam 1.1 mi DS. Stock pond 0.5 mi up trib at 0.3 mi US. Road crosses with bridge 0.96 mi US. Road (0.60 mi river left, par.), Residence (1.1 mi, river right) US

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	 Source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at

	bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation
lce jams	40-444-6246 source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Hidden Water Creek MP 258.4

Site	Hidden Water Creek MP 258.4		Date:	08/03/09
Done by:	GF, ML	Rev	view: EG	

			Regional R	egression	Analysis					
Source or Gage name and	ne and Area (mi ²)	Upstream /	Distance to	Range of data	recurrence interval					
number		Downstream	crossing (mi)	(years)	2	5	10	25	50	100
Omang (1992)	25.25				108	306	511	868	1,178	1,589

•	ing at least 3	s meander w	avelengths o	or 20 channel	widths u	pstream	and dowr	istream or	crossing)	
	С	hannel			Valley Gradient (%): 0.3					
Gradient (%	%): 0.1									
\\\!; - 4 - (ft)	min	max	mean	std dev	Width	min	max	mean	Std dev	
Width (ft)	13	19	16	3	(ft)	124	672	446	215	
meander w	avelength (ft)	1304			describe	e geology	(lithology,	erodibility):	1	
meander amplitude (ft) 322						n of mode	ern channe	Is and flood	dplains 126	
Sinuosity 1	.92				abundar calcared Both sid that alte	nt benton ous concr es US He rnates wi	ite beds ar etions. ell Creek F	: partly silty ad zones of m: bentoniti prown sand ous shale.	gray, ic claystone	
	Upstre	am (ft)	Downsti			Floodp	lain			
	distance radius of		distance from radius of		FEMA National Database N if yes, describe widths below					
	from crossing	curvature	crossing	curvature	Width	min	max	mean	Stnd De	
radius of					(ft)					
curvature	807	266	271	160						
(ft)	3674	266	1109	108	Describe	e abunda	nce and lo	cation(s) of	:	
	5770	156	2125	161	scrol	l bars:				
	7331	303	2739	117	None)				
	8243	188	3280	193	oxbo	WS:				
					DS (0.10, rive	r left)			
Channel form (braided, anabranching, single thread):						nel cut-o	ffs:			
Single Branch						US (0.00, 0.50 mi, river left, 0.30 0.60, rive right DS (0.00 river right)				

27.14	
What is elevation of the channel relative to the floodplain (perched, incise	ed)? What is evidence?
US (0.20 mi,) the channel's water surface elevation appears to be higher	than the elevation of the flood plain.
Unique features, exceptions, etc:	
The valley appears to narrow considerably upstream of crossing (0.20 r right) there appears to be a section of bank failure on the outside of the	

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

1.1 mi US on LB

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Stock pond 0.67 mi up trib at 0.6 mi DS, 0.24 mi up trib 1.37 mi US. Road crossing 1 mi DS, small road crosses 0.97 mi US. Road (1.0 mi, river left, par.)

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

	LITERATURE REVIEW
	(check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.]
	U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p.
	Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98-4137, 35 p.
	source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100
bridge scour	Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. <u>http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf</u>
	Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p.

	-	
		Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
		Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
		Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
		Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: <u>holnbeck@usgs.gov</u>
		Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
		Mark Goodman Montana Department of Transportation 40-444-6246
lce jams		source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
		Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity		source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages		source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps		source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Soda Creek MP 272.1

Site	Soda Creek MP 272.1		Date:	08/03/09
Done by:	GF, ML	Rev	/iew: EG	

			Regional R	egression	Analysis					
Source or Gage name and	Drainage	Upstream / Downstream	Distance to crossing (mi)	Range of data			recurrenc	e interval		
number	Area (mi ²)			(years)	2	5	10	25	50	100
Omang (1992)	1.16				20	61	105	183	256	346

Reach (exten	aing at least 3	s meander wa	avelengths o	or 20 channel	l widths u	pstream	and dowr	istream of	crossing)	
	С	hannel			Valle	у				
Gradient (%)	: 0.05	Gradien	t (%): 0.3							
Width (ft) *	min	max	mean	std dev	Width	min	max	mean	std dev	
width (it)	4	14	9	2	(ft)	109	303	167	66	
*Difficult to de	etermine from a	aerial due to v	vegetation							
meander way	velength (ft) 34	12			describe	e geology	(lithology,	erodibility):		
meander am Sinuosity 1.2					alternate carbona Both sid shale, si	es with sa <u>ceous sh</u> es US Lu	andstone in ale idlow Mem silty or bent	entonitic cl terbedded ber Fort Un onitic clays	with	
	Upstre	am (ft)	Downst	ream (ft)			Floodp	lain		
	distance from	radius of	distance from	radius of	FEMA National Database N if yes, describe widths below					
an d'an a f	crossing	curvature	crossing	curvature	Width (ft)	min	Max	mean	Stnd De	
radius of curvature	169	33	307	48						
(ft)	321	41	497	40	Describe	e abunda	nce and lo	cation(s) of	:	
	687	47	648	34	scrol	l bars:				
	947	35	937	86	None	9				
	1049	108			oxbo	WS:				
					None					
Channel form (braided, anabranching, single thread):						nel cut-o	ffs:			
Single Thread						0.20 mi ri	ver right)			

19.14

What is elevation of the channel relative to the floodplain (perched, incised)? What is evidence?

The elevation of the floodplain is greater than the elevation of the channel's water surface.

Unique features, exceptions, etc:

Another crossing 100 ft to the south called Soda Creek 272.2 is actually on trib that joins 100 ft DS.

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Stock ponds 1.5 mi US and on tribs at 0.63 and 1.15 mi US and 2 at 0.45 and 0.55 mi up trib that joins 100 ft DS.

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

	LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination	source(s): None
Reports on local/regional	
Hydrology	source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics	source(s): None
sediment transport	source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour	 Source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp rpt 516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at

	bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155 Mark Goodman Montana Department of Transportation
lce jams	40-444-6246 source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf Montana Ice Jam. River Ice and River Ice Processes http://www.wrh.noaa.gov/tfx/icejam/ Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

Soda Creek MP 272.2

Site	Soda Creek MP 272.2		Date:	08/05/09
Done by:	GF, ML	Rev	/iew: EG	

			Regional R	egression	Analysis					
Source or Gage	Drainage	Upstream /	Distance to crossing (mi)	Range of data			recurrenc	e interval		
number	Area (mi ²)	Downstream		(years)	2	5	10	25	50	100
Omang (1992)	1.76				26	76	131	228	318	429

or Reach (exten	ding at least 3	s meander w	avelengths o	or 20 channel	l widths u	pstream	and dowr	istream of	crossing)
			Valle	У					
Gradient (%)	Gradient (%): 0.4								
Width (ft)*	min max m		mean	std dev	Width	Min	max	mean	std dev
width (it)	7	14	10	2	(ft)	129	303	174	60
*Difficult to de	etermine from a	aerial becaus	e of vegetatio	on					
meander way	velength (ft): 25	59			describe	e geology	(lithology,	erodibility):	
meander am	plitude (ft): 59				alternate carbona	es with sa iceous sh	andstone in Iale	entonitic cl terbedded	with
Sinuosity 1.3	0				shale, s		silty or bent	ber Fort Un onitic clays	
	Upstre	am (ft)	Downst	ream (ft)			Floodp	lain	
					FEMA N	lational D	Database N	1	
	distance from	radius of	distance from	radius of	if yes, describe widths below		v		
	crossing	curvature	crossing	curvature	Width	min	max	mean	Stnd De
					(ft)				
radius of curvature	148	40	307	48				•	
(ft)	258	38	497	40	Describ	e abunda	nce and lo	cation(s) of	:
	352	36	648	34	scro	l bars:			
	500	34	937	86	None	Э			
					oxbo	WS:			
					A po mad		s 0.50 mi u	pstream, p	robably ma
Channel form (braided, anabranching, single thread):						inel cut-o	ffs:		
Single Thread						e			

22.6

What is elevation of the channel relative to the floodplain (perched, incised)? What is evidence?
The surface of the floodplain is higher than the water surface of the channel.
Unique features, exceptions, etc: none:
Another crossing 100 ft to the north called Soda Creek 272.1 on main branch of Soda Creek that joins 100 ft DS.
Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):
None
Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):
Stock ponds at 0.45 and 0.55 mi US. Stock ponds 1.5 mi US on main branch and on tribs. Road (0.50 mi, river right, par.)
If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

none

		LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination		source(s): None
Reports on local/regional		
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.] U.S. Geological Survey Water-Data Report
hydraulics		source(s): None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour		 source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) http://mt.water.usgs.gov/cgi-bin/projects?14100 Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic

	Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p.
	Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p.
	Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p.
	Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center 3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov
	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u>
	Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation http://www.fema.gov/news/event.fema?id=635
Turbidity	source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

North Fork Coal Bank Creek MP 276.1

Site	North Fork Coal Bank Creek MP 276.1		Date	08/03/09
Done by:	GF, EG, ML	Re۱	view: EG	

	Regional Regression Analysis										
Source or Gage	Drainage	Upstream /	Distance to	Range of data	recurrence interval						
name and number	Area (mi ^z)	Downstream	crossing (mi)	(years)	2	5	10	25	50	100	
Omang (1992)	8.97				62	180	304	521	714	964	

Geomorphology NOTE: All measu		to whole nur	nhor oxcont	for drainage	aroa and	ratios lik	sinuositu	or confin	omont)
For Reach (exter			•	•			-		•
		Valley							
Gradient		Gradient (%): 0.69							
	min	max	mean	stnd dev		min	max	mean	stnd dev
width	6	27	11	48	width	377	1620	1005	390
meander	wavelength: 1	185			describe	geology (lithology, e	rodibility):	
meander	amplitude: 507	7			Alluvium	of moderr	n channels	and floodp	lains 668 ft
Sinuosity	: 1.98				bentoniti RB US E	es Ludlow ic clayston Ekalaka Me ne interbeo	e, sandstor ember: Fine	ne and coa e- to mediu	
		(A-)	<u> </u>	(11)					
	Upstre	eam (ft)	Downst	tream (ft)			Flood	plain	
	distance from crossing	radius of curvature	distance from	radius of curvature		ational Da		_	
		cuivature	crossing	Curvature	Width (ft)	min	max	mean	stnd dev
	591	132	103	62		abundan	ce and loca	ition(s) of:	
radius of curvature (ft)	1874	152	1135	87		l bars			
				-					
	2825	92	1915	102	poss	ibly 1575 f	t US on lef	t bank	
	3847	60	2978	87	oxbo	WS:			
	4710	46	3573	51	none)			
	5193	49			chan	nel cut-off	s:		
	6503	56			none)			
Channel	form (braided,	anabranching	j, single threa	id):	Relic	channels:			
Single					400 fe	et, 0.44 m	i, 0.66 mi l	JS	

Channel confinement at crossing (W $_{\rm v}$ / W $_{\rm c}):$	
79.68	
What is elevation of the channel relative to the floodplain (perch	ed, incised)? What is evidence?
(0.2 mi DS of crossing, channel may be incised based on DEM	cross valley slopes
Unique features, exceptions, etc	
Meanders downstream from crossing at confluence with unnam	ed creek are very tortuous

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None	
------	--

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Stock ponds on tribs that join 0.17, 1 and 2.1 mi US and 0.34 mi DS. Road crosses with culvert 2.7 mi US and small road crosses 235 ft DS; group of buildings on DS road about 0.5 mile from left bank of crossing.

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

		LITERATURE REVIEW (check box when searched for, if none, note under source)
Existing channel migration zone determination		source(s): None
Reports on local/regional		
Hydrology		source(s): Parrett, Charles, and Johnson, D.R., 2004, Methods for estimating flood frequency in Montana based on data through water year 1998: U.S. Geological Survey Water-Resources Investigations Report 03-4308, 101 p. Parrett, Charles, Holnbeck, S.R, and Chase, K.J., 2004, Water-surface elevation data and flood and floodway boundaries for the upper Yellowstone River, Montana: U.S. Geological Survey Scientific Investigations Map SIM 2868. [Available online only at http://water.usgs.gov/pubs/sim/2004/2868.]
		U.S. Geological Survey Water-Data Report. source(s):
hydraulics	\boxtimes	None
sediment transport		source(s): Holnbeck, S.R., 2005, Sediment-transport investigations of the upper Yellowstone River, Montana, 1999 through 2001: Data collection, analysis, and simulation of sediment transport: U.S. Geological Survey Scientific Investigations Report 2005-5234, 69 p. Lambing, J.H., 1998, Estimated 1996-97 and long-term average annual loads for suspended sediment and selected trace metals in streamflow of the upper Clark Fork basin from Warm Springs to Missoula, Montana: U.S. Geological Survey Water-Resources Investigations Report 98- 4137, 35 p.
bridge scour		source(s): Montana DOT Bridge Scour Database (constructional stability for almost 6000 bridges in the state) <u>http://mt.water.usgs.gov/cgi-bin/projects?14100</u> Landers, M.N., and Mueller, D.S., 1996, Channel scour at bridges in the United States: U.S. Department of Transportation, Federal Highway Administration Publication FHWARD- 95-184, 140 p. <u>http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_516.pdf</u>

	 Richardson, E.V., and Davis, S.R., 2001, Evaluating scour at bridges, 4th ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA NHI 01-001, 378 p. Richardson, E.V., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges, 2d ed.: U.S. Department of Transportation, Federal Highway Administration, Hydraulic Engineering Circular 18, Publication FHWA-IP- 90-017, 132 p. Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., and Chang, F., 1991, Stream stability at highway structures: U.S. Department of Transportation Publication FHWA-IP-90-014, Hydraulic Engineering Circular 20, 195 p. Montana Department of Natural Resources and Conservation, 1976, River mile index of the Yellowstone River: Montana Department of Natural Resources and Conservation, Water Resources Division, 61 p. Personal Communication Sources Steve Holnbeck USGS Montana Water Science Center
	3162 Bozeman Avenue Helena Mt 59601-6456 Phone: (406) 457-5929 Email: holnbeck@usgs.gov Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
lce jams	source(s): Ice Jams in Montana U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire <u>http://www.crrel.usace.army.mil/ierd/tectran/IEbul19.pdf</u> Montana Ice Jam. River Ice and River Ice Processes <u>http://www.wrh.noaa.gov/tfx/icejam/</u> Montana Severe Storms, Ice Jams, Snowmelt, Flooding, Extreme Soil Saturation
Turbidity	http://www.fema.gov/news/event.fema?id=635 source(s): Blevins, D.W., 2006, The response of suspended sediment, turbidity, and velocity to historical alterations of the Missouri River: U.S. Geological Survey Circular 1301, 8 p. http://www.nwk.usace.army.mil/regulatory/MO%20River%20Dredging/USGS%20Historical%20Alt erations.pdf
Stream gages	source(s): (note if managed flow, e.g. canals or flow during summer only) None
1:24000 geologic maps	source(s): State Geologic Mapping Program http://www.mbmg.mtech.edu/gmr/gmr-statemap.asp

South Fork Coal Bank Creek MP 279.2

Site	Site South Fork Coal Bank Creek MP 279.2			07/27/09
Done by	: GF, EG, ML	Rev	view: EG	

Regional Regression Analysis										
Source	Drainage Area	Average	Recurrence Interval							
Source	(mi²)	Elevation (ft)	2	5	10	25	50	100		
Omang (1992)	13.80	3,191	78	223	375	641	875	1,181		

each (extend	ling at least	3 meander w	avelengths of	or 20 channe	l widths u	pstream	and down	stream of	crossing)
	C	Channel					Valle	у	
Gradient (%): 0.4						t (%): 0.0	2		
width	min	max	mean	Stnd Dev	width	min	max	mean	Stnd De
width	10	39	18	10	width	230	1086	554	309
meander v	vavelength (ft): 453			describe	e geology	(lithology,	erodibility):	I
meander a	mplitude (ft):	406			Alluvium wide	n of mode	rn channel	s and flood	plains 643
Sinuosity:	2.1				Gray an clayston Some or medium	d brown s e, sandst utcrops U -grained s	one and co S LB of Ek sandstone	one, silty o	ber: fine- t d with
	Upstre	Upstream (ft) Downstream (ft)			Floodplain				
	distance from crossing	radius of curvature	distance from crossing	radius of curvature			atabase: 1 idths belov max		Stnd De
radius of curvature	564	33	46	49					
(ft)	787	41	597	49	Describe	e abunda	nce and lo	cation(s) of:	
	1168	90	1253	69	scrol	l bars:			
	1879	46	2188	59	None	9			
	2545	33	2549	49	oxbo	WS:			
	2988	56	3559	167	None	9			
Channel fo	orm (braided,	anabranching	g, single threa	ad):	chan	nel cut-of	fs:		
Single				none					
Channel co	onfinement at	crossing (W _v	, / W _c):		Relic	channels	6		
106.8					USO	.3 mi, DS	0.2 mi		

Stream elev. is 10 to 30 feet below valley on DEM. Incision on downstream end of study area where stream elev. and valley elev. diverge more. At crossing, floodplain on right bank may be higher that channel on DEM.

Unique features, exceptions, etc

Tribs: US unnamed 4.1 mi, meets North Fork Coal Bank Creek to form Coal Bank Creek 0.72 DS

Evidence of landslides upstream or downstream along valley margins (Upstream/downstream? Straight line distance to pipeline along valley axis?):

None

Describe any infrastructure (bridges, roads, buildings, powerlines, etc) (upstream/downstream with distance to pipeline, if linear feature, right or left bank, perpendicular or parallel):

Dams US 1.5 mi and 1.9 mi, latter associated with buildings and 480 foot wide pond. Small road crosses US at 0.4 mi, then runs parallel US; a perpendicular road crosses with culvert at 0.57 mi US of crossing.

If visible, describe any direct or indirect evidence of general scour/channel incision (straightened channel, etc):

Possibly some incision further downstream, about 0.37 mi from crossing, based on DEM.

Existing channel migration zone determination		(check box when searched for, if none, note under source) source(s): None	
Reports on local/regional			
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	Kent Barnes, P.E. Bridge Bureau Montana Department of Transportation PO Box 201001 2701 Prospect Helena, MT 59620-1001 406-444-6260 Fax 406-444-6155
	Mark Goodman Montana Department of Transportation 40-444-6246
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