County	Yellowstone	**Upstream River Mile**	383.5
Classification	UB: Unconfined braided	**Downstream River Mile**	368.3
General Location	Laurel to Billings	**Length**	15.20 mi (24.46 km)
General Comments	Extensive armoring u/s Billings; WAI Reaches B,C,D		

Narrative Summary

Reach B1, located in Yellowstone County, extends from the mouth of the Clark Fork River to Billings. It is approximately 15.4 miles long, extending from RM 367.0 to 382.4. It is an Unconfined Braided (UB) reach type indicating minimal influence of the valley wall coupled by extensive open gravel bars and low flow channels. Human impacts in Reach B1 include early bridge construction and stream corridor narrowing, flow consolidation through diking and bank armoring, and loss of side channel due to physical blockages and apparent downcutting. Flow alterations in this reach have been substantial; the mean annual flood has dropped an estimated 17 percent due to human influences, and summer low flows have dropped by 42 percent.

In total there are 57,118 feet of bank armor in Reach B1, which equates to 10.82 miles of bank armor in a 15.4 mile long reach of river. Concrete riprap is the most prevalent type of armor, with about 5.5 miles present in 2011, even after the loss of 2,870 feet of concrete armor protection between 2001 and 2011. There are almost four miles of rock riprap, over 4,000 feet of which was constructed since 2001. There are also 7,616 feet of flow deflectors in the reach, and about 2,500 feet of those flow deflectors were built between 2001 and 2011. The most rapid expansion of armor occurred between 1950 and 1995, when the total length of bank protection expanded from 14,872 feet to 47,339 feet.

Numerous bank armor structures have been eroded out in Reach B1. Typically flanked, failed armor was identified at the following locations:
•RM 383L: 330 feet of flow deflectors totally lost
•RM 382.3R: lower 175 feet of concrete riprap flanked
•RM 281.5R: upper 400 feet of concrete riprap flanked: Idled crude oil pipeline is less than 200 feet behind this flanked armor
•RM 380.2R: lower 600 feet of concrete armor flanked
•RM 377.8: upper 540 feet of concrete armor flanked
•RM 373.8R: upper 300 feet and lower 270 feet of concrete armor flanked

The loss of side channel length through time has been extensive. Prior to 1950, almost a mile of side channels had been blocked on the south side of the river at RM 373.8 and at the South Billings Blvd Bridge at RM 371. Since 1950, another 14,800 feet have been blocked by dikes. One major blockage is located about 2 miles upstream of the Duck Creek Bridge at RM 381 and another near the gravel pit/trailer park complex at RM 373. Other side channels have been lost passively, without blockages. In total, Reach B1 has been characterized by a loss of seven miles of side channel length between 1950 and 2001, the majority of which occurred between 1976 and 1996.

A review of available data indicate that the loss of side channels in Reach B1 is both directly and indirectly related to bank stabilization within the reach. Between 1950 and 1976, a series of dikes were constructed upstream of South Billings Blvd to block the course of a primary channel, isolating several thousand feet of channel. Womack (2000) notes that “the greatest measureable change has occurred due to abandonment of secondary channels, primarily due to construction of dikes and secondarily due to channel armoring. A relatively short dike at the upstream end of a braided reach can have a disproportionate effect, because it may effectively eliminate miles of channel”. These blockages are associated with some of the braiding parameter reduction in Reach B1. However, the most loss of side channels occurred after 1976, when the dikes above South Billings Blvd. were already in place. Some of these channels were abandoned due to blockage by dikes, and other locations of channel abandonment and braiding parameter reduction show no apparent direct relationship to physical features.

The side channels that were passively abandoned in Reach B1 are commonly perched above the main Yellowstone River channel. This perching indicates that abandonment may be related to downcutting of the main channel. Womack (2000) noted that width to depth ratios decreased in heavily armored reaches due to flow consolidation in a single channel. Womack suggests that channel confinement and consolidation into fewer channels has resulted in downcutting and reduction in width to depth ratio. Flow alterations have also likely contributed to side channel abandonment.

Several bridges were constructed in Reach B1 prior to 1950. These bridges all constrict the natural meander corridor of the river and have been associated with channel downcutting. Womack (2000) showed seven feet of degradation immediately upstream of the South Billings Blvd Bridge.

The primary land use in the reach is non-irrigated agriculture although several thousand acres of agricultural land has been developed since 1950. In 2011, there were about 3,000 acres of land under flood irrigation and 240 acres under pivot in Reach B1. Between 1950 and 2011, the extent of urban/exurban land use expanded from 310 acres to over 2,000 acres. The development has extended into the Channel Migration Zone (CMZ). A total of 810 acres of CMZ are developed, with 242 acres of ground developed for urban/exurban use and 84 acres in pivot irrigation. Another 470 acres of land in the CMZ are under flood irrigation. As a consequence of extensive development in the CMZ, about 25 percent of the total CMZ footprint has become restricted due to armoring and dike construction.

There is one animal handling facility within 300 feet of the north riverbank just downstream of the Duck Creek Bridge at RM 377.7.

A total of 610 acres of the historic 100-year floodplain has become isolated from the river, which is 14 percent of the total 100-year

floodplain footprint. Most of the 100-year floodplain isolation is due to transportation infrastructure. Similarly, about 13 percent of the 5-year floodplain (270 acres) has been isolated by transportation infrastructure. There are 184 acres of flood irrigated land in the 5-year floodplain, and 73 acres in pivot. Whereas most of the isolated 100-year floodplain area is behind the I-90 corridor in the city of Billings, most of the isolated 5-year area is in the stream corridor, which supports the interpretation that some downcutting in the reach has perched historic channels and floodplain area.

There are several pipeline crossings in Reach B1. At RM 382, two pipelines cross under the river; one is a natural gas pipeline owned by NW Energy LLC, and the other is an idled crude oil pipeline owned by Conoco Phillips. The idled crude oil pipeline follows the river close to the bank at RM 281.5R where concrete armor has been flanked. There are four pipelines at South Billings Blvd; the one of these pipelines that was built to carry crude oil has been idled under nitrogen. The other pipelines are all natural gas.

Over 400 acres of wetland have been mapped in the reach, with most of that (270 acres) emergent wetland marsh that is located primarily in the active stream corridor and in abandoned channels. A total of 42 acres of Russian olive have been mapped in the reach, and these trees are dispersed throughout the corridor.

Reach B1 was sampled as part of the avian study. The average species richness in Reach B1 was 8.0, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for sites evaluated is 8. One bird Species of Concern (SOC), the Black-Billed Cuckoo, was identified in the reach. Three bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were also found, including the Black and White Warbler, Chimney Swift, and Ovenbird. Since 1950, Reach B1 has lost all of its forest that would be considered at low risk of cowbird infestation due to its separation from agricultural infrastructure. In 1950, about 3.5 acres of forest per valley mile were identified as low risk and by 2001 that forest area had been reduced to zero.

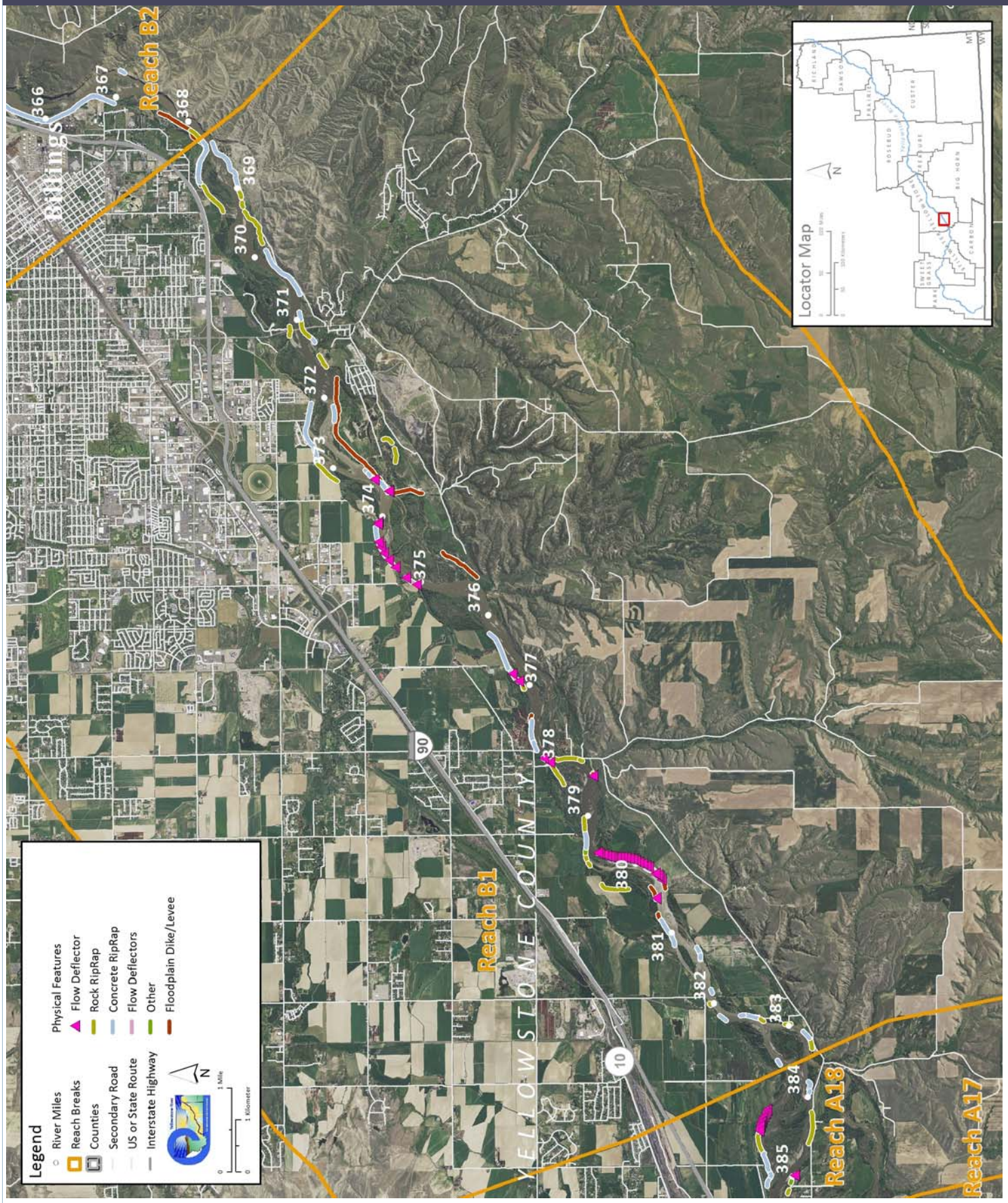
Reach B1 was sampled as part of the fisheries study. A total of 31 fish species were sampled in the reach, and none of these species have been identified by the Montana Natural Heritage Program as Species of Concern (SOC).

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been substantial in this reach. The mean annual flood is estimated to have dropped from 22,800 cfs to 18,900 cfs, a drop of about 17 percent. Low flows have also been impacted; severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,900 cfs to 2,000 cfs with human development, a reduction of 31 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 3,836 cfs under unregulated conditions to 2,227 cfs under regulated conditions at the Billings gage, a reduction of 42 percent.

CEA-Related observations in Reach B1 include:
•Blockage of miles of side channel
•Extensive armoring with CMZ encroachment
•Passive loss of major side channels due to downcutting and flow alterations

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach B1 include:
•Side channel restoration at RM 381 and RM 373
•Pipeline crossing management – natural gas pipeline at RM 382
•Flanked armor removal at RM 383, RM 382.3, RM 281.5, RM 380.2, RM 377.8, and RM 373.8
•CMZ management due to extent of current CMZ restriction (25 percent)
•Russian olive removal
•Pipeline management at crossings and also where concrete armor has flanked where idled crude oil pipeline runs parallel to bank at RM 285.1R
•Nutrient management at corrals that are part of an animal handling facility within 300 feet of river at RM 377.7 just downstream of Duck Creek Bridge.

PHYSICAL FEATURES MAP (2011)



HYDROLOGIC SUMMARY

Hydrologic data available for the Reach Narratives include data from representative gaging stations, modeling from the COE from the Big Horn river upstream, and modeling by the USGS for the Big Horn River to the Missouri River confluence. Gaging stations that best represent the watershed area within any reach are used to describe the flood history within the reach. Hydrology modeling results generated for all reaches provides unregulated and regulated flow values. Seasonal and annual flow duration data generated by the USGS are available for reaches C10 through D13.

Gage Representation (Gage-Based): Billings

Flood History

Year	Date	Flow on Date	Return Interval
1943	Jun 21	61,200	10-25 yr
1996	Jun 12	61,900	10-25 yr
1944	Jun 27	64,800	10-25 yr
1967	Jun 16	66,100	10-25 yr
1975	Jul 7	67,600	10-25 yr
1974	Jun 19	69,500	25-50 yr
2011	Jul 2	70,600	25-50 yr
1918	Jun 15	78,100	50-100 yr
1997	Jun 12	82,000	>100 yr

	Downstream Gage	Upstream Gage
Gage No	6214500	6192500
Location	Billings	Livingston
Period of Record	1929-2015	1929-2015
Distance To (miles)	3.9	123.1

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated	22,800	42,700	52,800	58,900	71,200	76,200	87,400	2,900	3,846
Regulated	18,900	38,500	48,900	55,200	68,300	73,700	85,900	2,000	2,227
% Change	-17.11%	-9.84%	-7.39%	-6.28%	-4.07%	-3.28%	-1.72%	-31.03%	-42.10%

AERIAL PHOTOGRAPHY

A variety of aerial photographic sources provide the basis for much of the Cumulative Effects Assessment analysis. The table below lists the air photos compiled for the reach and the associated discharge at the most representative USGS gaging station.

	Source	Acquisition Date	Type	Scale	Gage	Discharge
1950	USGS-EROS	5/14/51 - 5/15/51	B/W	1:28,400	6214500	12000
1976	USCOE	28-Sep-76	B/W	1:24,000	6214500	5940
1995	USGS DOQQ	23-Aug-96	B/W		6214500	4500
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6214500	1700
2004	Merrick	15-May-04	Color	1:15,840	6214500	5960
2005	NAIP	07/12/2005	color	1-meter pixels	6214500	12600
2005	NAIP	07/08/2005	color	1-meter pixels	6214500	11400
2009	NAIP	7/7/2009	Color	1-meter pixels	6214500	20900
2009	NAIP	7/5/2009	Color	1-meter pixels	6214500	23800
2011	USCOE	October 2012	color	1-ft pixel	6214500	3860
2011	NAIP	7/24/2011	Color	1-meter pixels	6214500	22800
2013	NAIP	06/15/2013	color	1-meter pixels	6214500	

PHYSICAL FEATURES

Several efforts to capture the types and extents of physical features in the corridor have been generated by the CEA study. The 2001 Physical Features Inventory was performed through helicopter/video Rapid Aerial Assessment by the NRCS (NRCS, 2001) and did not include Park County. This inventory includes point and linear features that represent bank armor, irrigation structures, transportation encroachments, and areas of accelerated erosion. Bank armor mapped in the 2001 inventory only reflects features on the active channel margin, and thus excludes off-channel features on historic side channels. Some floodplain restriction features such as dikes and levees in the 2001 Physical Features Inventory may extend well beyond the active channel. In 2013, the 2001 inventory was revised to include Park County. At that time, some attribute inconsistencies in the original data were addressed. This dataset was then updated to reflect conditions in the 2011 NAIP imagery.

For Stillwater, Yellowstone and Dawson Counties, a Physical Features Timeline was generated that includes additional mapping based on aerial photography and assigns approximate dates of feature construction based on observed presence/absence in historic imagery between the 1950s and 2005 (DTM and AGI, 2008). The Physical Features Timeline contains features that were not mapped in the 2001 inventory (e.g. bank armor abandoned in floodplain areas by 2001). As such the total bank armor extent in the 2005 data is commonly greater than that identified in 2001 or 2013.

Note: As the goal for each physical features mapping effort were different, with differing mapping extents, there will be descrepancies between total feature lengths (e.g. length of rock riprap) in each data set.

2001 and 2011 Physical Features Bankline Inventories

Feature Class	Feature Type	2001 Length (ft)	% of Bankline	2011 Length (ft)	% of Bankline	2001-2011 Change
Stream Stabilization						
	Rock RipRap	16,336	10.1%	20,754	12.9%	4,418
	Flow Deflectors	1,228	0.8%	2,034	1.3%	806
	Concrete RipRap	31,621	19.6%	28,751	17.8%	-2,870
	Car Bodies	942	0.6%	718	0.4%	-225
	Between Flow Deflectors	3,835	2.4%	5,582	3.5%	1,748
	Feature Type Totals	**53,961**	**33.5%**	**57,839**	**35.9%**	**3,877**
Floodplain Control						
	Transportation Encroachment	3,902	2.4%	3,902	2.4%	0
	Floodplain Dike/Levee	23,985	14.9%	23,985	14.9%	0
	Feature Type Totals	**27,887**	**17.3%**	**27,887**	**17.3%**	**0**
	Reach Totals	**81,848**	**50.8%**	**85,726**	**53.2%**	**3,877**

Intent of Bank Protection: 2001

The 2001 bank protection features were assessed for the 'intent' of what they protect.

Feature Type	Irrigated	Non-Irrig.	Ag. Infrastr.	Road	Interstate	Railroad	Urban	Exurban
Car Bodies	541	0	400	0	0	0	0	0
Concrete RipRap	7,964	9,719	3,582	951	0	0	0	9,394
Flow Deflectors/Between FDs	4,566	0	328	0	0	0	0	0
Rock RipRap	6,262	0	495	5,169	0	0	0	4,546
Totals	**19,332**	**9,719**	**4,805**	**6,120**	**0**	**0**	**0**	**13,940**

Bankline/Floodplain Inventory: Time Series

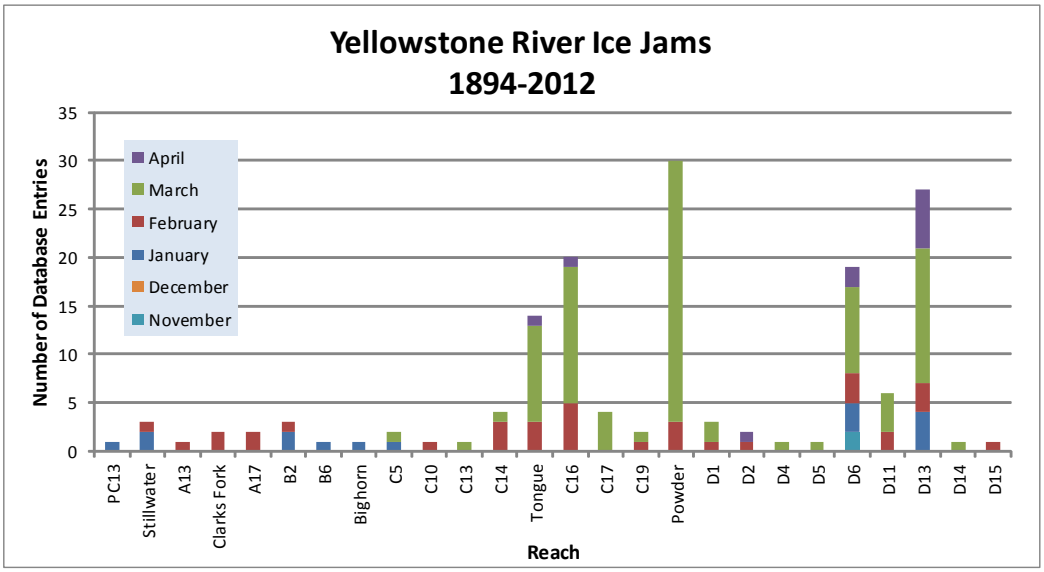
The Human Impacts Timeline assessed physical feature development through time for Yellowstone, Stillwater, and Dawson Counties.

		Sum of Feature Length (ft)					
Feature Class	Feature Type	1950	1976	1995	2001	2004	2005
Irrigation							
	Floodplain Dike/Levee	103	1,954	1,954	1,954	2,284	2,284
	Totals	**103**	**1,954**	**1,954**	**1,954**	**2,284**	**2,284**
Other							
	Floodplain Dike/Levee	0	0	1,210	1,210	1,210	1,210
	Totals	**0**	**0**	**1,210**	**1,210**	**1,210**	**1,210**
Other Off Channel							
	Floodplain Dike/Levee	0	5,137	12,336	18,261	19,342	19,342
	Floodplain Dike/Levee	4,058	7,900	7,370	19,666	19,666	19,666

Totals	**4,058**	**13,037**	**19,706**	**37,927**	**39,008**	**39,008**
Stream Stabilization						
Rock RipRap	7,373	18,198	19,335	19,832	22,285	22,285
Flow Deflector	1,589	914	914	6,024	6,024	6,024
Concrete RipRap	5,569	16,943	25,910	31,257	31,544	31,544
Car Bodies	341	1,039	1,180	1,180	1,180	1,180
Totals	**14,872**	**37,094**	**47,339**	**58,293**	**61,033**	**61,033**
Transportation Encroachment						
Other	11,368	14,402	15,081	15,295	15,295	15,295
Interstate	0	7,583	7,583	7,583	7,583	7,583
County Road	9,792	17,180	15,814	15,814	15,814	15,814
Bridge Approach	3,230	5,909	5,909	5,909	5,909	5,909
Totals	**24,390**	**45,075**	**44,387**	**44,601**	**44,601**	**44,601**

ICE JAMS

Ice jam data were obtained from the National Ice Jam Database maintained by the Ice Engineering Group at Army Corps of Engineers Cold Regions Research and Engineering Laboratory (https://rsgis.crrel.usace.army.mil/icejam/). From this database, Yellowstone River ice jams are summarized by reach in the Yellowstone River Historic Events Timeline (DTM and AGI, 2008b). The basic information for each ice jam is presented as a list of events. The graph represents the number of database entries for a reach. Note that a single jam event may have multiple entries.



GEOMORPHIC

The geomorphology data presented below consist of measured changes in Braiding Parameter since 1950 and blocked side channels. Braiding parameter is a measure of the total length of side channels relative to that of the main channel. The braiding parameter is calculated as the sum of anabranching and primary channel lengths divided by the primary channel length. Secondary channels within the bankfull margins are a function of flow stage and hence were not included in the braiding parameter calculation. If a reach has a braiding parameter of 3, then the total bankfull channel length is three times that of the main channel. The mean braiding parameter measured for all 88 reaches is 1.8.

Blocked side channels that were either plugged with a small dike or cutoff by larger features such as a levee or road prism were identified for the pre and post-1950s eras.

Additional geomorphic parameters are discussed in more detail in the study report and appendices.

Braiding (Bankfull)

	Primary Chan. Length (ft)	Anab. Ch. Length (ft)	Bankfull Braiding Parameter		% Change in Braiding
1950	79,617	120,036	2.51	1950 to 1976:	-3.18%
1976	77,560	110,757	2.43	1976 to 1995:	-18.58%
1995	81,942	80,054	1.98	1995 to 2001:	2.88%
2001	80,555	83,280	2.03	1950 to 2001:	-18.90%
Change 1950 - 2001	**938**	**-36,757**	**-0.47**		

Length of Side Channels Blocked

Pre-1950s (ft)	4,970
Post-1950s (ft)	14,812

HYDRAULICS

Available hydraulic information includes county-based HEC-RAS modeling efforts by the Army Corps of Engineers with the exclusion of Park County. Floodplain modeling was performed for four conditions representing a developed and undeveloped floodplain, and unregulated and regulated flows for the 1.5, 2, 5, 10, 20, 50, 100, 200, and 500-year events. Park County has limited FEMA hydraulic modeling and was not included in the analysis.

The results of HEC-RAS modeling for the 5 and 100-year flood events were assessed to compare the extents of inundated area for the pristine (undeveloped floodplain, unregulated flows) and developed (developed floodplain, regulated flows) conditions. The data sets provided for each flow condition were unioned in the GIS to identify areas where the inundated extent differed. These area areas of human-caused floodplain isolation due to either flow alterations or physical features such as levees. For the 100-year flood event, isolated areas greater than 5 acres were attributed with the interpreted reason for isolation (railroad, levee, etc.). The resulting values are presented as acres and percent of the pristine floodplain that has been isolated. The pristine floodplain is defined as the total floodplain footprint minus the area of the mapped 2001 bankfull channel (mapped islands were included in the floodplain area).

Floodplain Isolation

	100-Year		5-Year	
	Isolated Acres	% of Floodplain	Isolated Acres	% of Floodplain
Non-Structural (hydrology, geomorphic, etc.)	0	0.0%		
Agriculture (generally relates to field boundaries)	0	0.0%		
Agriculture (isloated by canal or large ditch)	0	0.0%		
Levee/Riprap (protecting agricultural lands)	11	0.2%		
Levee/Riprap (protecting urban, industrial, etc.)	0	0.0%		
Railroad	0	0.0%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	600	13.3%		
Total Not Isolated (Ac)	3899		3470	
Total Floodplain Area (Ac)	4509		3737	
Total Isolated (Ac)	**611**	**13.5%**	**267**	**13.1%**

The 5-year floodplain is a good allegory for the extent of the riparian zone. Thus, irrigated areas within the 5-year floodplain tend to represent riparian zones that have been converted to agrigulture and may result in additional bank protection to protect the agricultural production and irrigation infrastructure.

	Flood	Sprinkler	Pivot	Total
Irrigated Acres within the 5 Year Flooplain:	184	3	73	**260**

CHANNEL MIGRATION ZONE

A series of Channel Migration Maps were developed for the Yellowstone River from Gardiner to its mouth in McKenzie County, North Dakota (Thatcher, Swindell, and Boyd, 2009). These maps and their accompanying report can be accessed from the YRCDC Website. The channel migration zone (CMZ) developed for the Yellowstone River is defined as a composite area made up of the existing channel, the historic channel since 1950 (Historic Migration Zone, or HMZ), and an Erosion Buffer that encompasses areas prone to channel erosion over the next 100 years. Areas within this CMZ that have been isolated by constructed features such as armor or floodplain dikes are attributed as "Restricted Migration Areas" (RMA). Beyond the CMZ boundaries, outlying areas that pose risks of channel avulsion are identified as "Avulsion Potential Zones".

Mean 50-Yr Migration Distance (ft)	Erosion Buffer (ft)	Total CMZ Acreage	Restricted CMZ Acreage	% Restricted Migration Area	Total AHZ Acreage	Restricted AHZ Acreage	% Restricted Avulsion Area
362	724	4,742	1,192	25%	355	91	26%

2011 Restricted Migration Area Summary

Note that these data reflect the observed conditions in the 2011 aerial photography (NAIP for Park and Sweet Grass Counties, COE for the rest of the river).

Reason for Restriction	Land Use Protected	RMA Acres	Percent of CMZ
Road/Railroad Prism			
	Other Infrastructure	6	0.1%
	Non-Irrigated	28	0.5%
RipRap/Flow Deflectors			
	Irrigated	192	3.8%
RipRap			
	Public Road	178	3.5%
	Other Infrastructure	35	0.7%
	Non-Irrigated	227	4.5%
	Irrigated	142	2.8%
	Exurban Residential	52	1.0%
	Canal	10	0.2%
Dike/Levee			
	Non-Irrigated	416	8.1%
	Totals	**1,285**	**25.2%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
466.6	0.0	83.9	241.9	16.5

LAND USE

Land uses were mapped from aerial photography Gardiner to the confluence of the Missouri River in North Dakota for four time periods: 1950s, 1976, 2001, and 2011. Mapping was performed at approximately 1:6,000 to ensure consistent mapping across all data sets. Typically, if a feature could not be easily mapped at the target mapping scale, it was not separated out from the adjacent land use.

A four-tiered system was used to allow analysis at a variety of levels. Tier 1 breaks land use into Agricultural and Non-Agricultural uses. Tier two subdivided uses into productive Agricultural Land and Infrastructure for the Agricultural land, and Urban, Exurban and Transportation categories for the Non-Agricultural land. Tier three further breaks down land uses into more refined categories such as Irrigated or Non-Irrigated and Residential, Commercial, or Industrial. Finally, Tier 4 focuses primarily on the productive agricultural lands, identifying the type of irrigation (Pivot, Sprinkler or Flood).

Land Use Timeline - Tiers 2 and 3

		Acres				% of Reach Area			
Feature Class	Feature Type	1950	1976	2001	2011	1950	1976	2001	2011
Agricultural Infrastructure									
	Canal	21	21	21	21	0.2%	0.2%	0.2%	0.2%
	Agricultural Roads	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Other Infrastructure	200	222	294	333	1.5%	1.7%	2.3%	2.6%
	Totals	**221**	**243**	**316**	**354**	**1.7%**	**1.9%**	**2.4%**	**2.7%**
Agricultural Land									
	Non-Irrigated	6,549	5,213	4,985	4,742	50.3%	40.1%	38.3%	36.5%
	Irrigated	2,905	3,060	3,637	3,190	22.3%	23.5%	28.0%	24.5%
	Totals	**9,454**	**8,273**	**8,623**	**7,931**	**72.7%**	**63.6%**	**66.3%**	**61.0%**
Channel									
	Channel	2,913	3,120	2,221	2,318	22.4%	24.0%	17.1%	17.8%
	Totals	**2,913**	**3,120**	**2,221**	**2,318**	**22.4%**	**24.0%**	**17.1%**	**17.8%**
ExUrban									
	ExUrban Other	0	6	107	125	0.0%	0.0%	0.8%	1.0%
	ExUrban Undeveloped	10	17	27	22	0.1%	0.1%	0.2%	0.2%
	ExUrban Industrial	3	65	107	194	0.0%	0.5%	0.8%	1.5%
	ExUrban Commercial	0	0	0	7	0.0%	0.0%	0.0%	0.1%
	ExUrban Residential	129	240	302	362	1.0%	1.8%	2.3%	2.8%
	Totals	**142**	**328**	**544**	**710**	**1.1%**	**2.5%**	**4.2%**	**5.5%**
Transportation									
	Public Road	102	94	98	103	0.8%	0.7%	0.8%	0.8%
	Interstate	0	48	48	48	0.0%	0.4%	0.4%	0.4%
	Railroad	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**102**	**141**	**145**	**151**	**0.8%**	**1.1%**	**1.1%**	**1.2%**
Urban									
	Urban Other	0	23	25	25	0.0%	0.2%	0.2%	0.2%
	Urban Residential	148	608	876	1,020	1.1%	4.7%	6.7%	7.8%
	Urban Commercial	0	14	16	19	0.0%	0.1%	0.1%	0.1%
	Urban Undeveloped	0	134	100	109	0.0%	1.0%	0.8%	0.8%
	Urban Industrial	27	123	142	369	0.2%	0.9%	1.1%	2.8%
	Totals	**175**	**902**	**1,159**	**1,542**	**1.3%**	**6.9%**	**8.9%**	**11.9%**

Land Use Timeline - Tiers 3 and 4

		Acres				% of Reach Area				Change Between Years (% of Agricultural Land)			
Feature Class	Feature Type	1950	1976	2001	2011	1950	1976	2001	2011	'50-76	'76-01	'01-11	'50-11
Irrigated													
	Sprinkler	0	0	26	26	0.0%	0.0%	0.3%	0.3%	0.0%	0.3%	0.0%	0.3%
	Pivot	0	0	192	241	0.0%	0.0%	2.2%	3.0%	0.0%	2.2%	0.8%	3.0%
	Flood	2,905	3,060	3,420	2,922	30.7%	37.0%	39.7%	36.8%	6.3%	2.7%	-2.8%	6.1%
	Totals	**2,905**	**3,060**	**3,637**	**3,190**	**30.7%**	**37.0%**	**42.2%**	**40.2%**	**6.3%**	**5.2%**	**-2.0%**	**9.5%**

Non-Irrigated

Multi-Use	3,762	3,367	4,503	4,089	39.8%	40.7%	52.2%	51.6%	0.9%	11.5%	-0.7%	11.8%
Hay/Pasture	2,787	1,846	482	653	29.5%	22.3%	5.6%	8.2%	-7.2%	-16.7%	2.6%	-21.2%
Totals	**6,549**	**5,213**	**4,985**	**4,742**	**69.3%**	**63.0%**	**57.8%**	**59.8%**	**-6.3%**	**-5.2%**	**2.0%**	**-9.5%**

RIPARIAN

Riparian mapping data are derived from the Yellowstone River Riparian Vegetation Mapping study (DTM/AGI 2008). This study coarsely mapped the riparian vegetation communities using 1950's, 1976-1977, and 2001 aerial imagery in a GIS environment. The polygons are digitized at a scale of approximately 1:7,500, with a minimum mapping unit of approximately 10 acres. The goal of the delineation was to capture areas of similar vegetation structure as they appeared on the aerial imagery, while maintaining a consistent scale.

The "Riparian Turnover" values quantify the total area within the active channel area that converted from either woody vegetation to open bar or water, or from open bar or water to woody vegetation. A comparison of these values allows some consideration of overall riparian encroachment into the river corridor from 1950 to 2001.

Riparian Mapping

	Shrub (Acres)			Closed Timber (Acres)			Open Timber (Acres)		
Statistic	1950	1976	2001	1950	1976	2001	1950	1976	2001
Min	0.9	0.4	0.5	0.4	0.2	0.8	1.9	1.1	0.0
Max	44.3	211.9	49.8	97.4	139.8	253.9	132.1	43.4	168.8
Average	11.5	12.8	12.8	27.4	20.1	34.6	25.3	15.1	17.8
Sum	402.4	539.4	500.4	1,262.6	1,367.5	1,385.2	556.9	272.5	446.2

Riparian Turnover

Conversion of riparian areas to channel, or from channel to riparian between the 1950's and 2001 data set.

Riparian to Channel (acres)	509.3
Channel to Riparian (acres)	718.4
Riparian Encroachment (acres)	**209.1**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	763.3
1950s Floodplain Mapped as 2011 Channel (Ac)	185.9
Total Recruitment (1950s to 2011)(Ac)	**949.2**

WETLANDS

Wetland areas were mapped to National Wetland Inventory standards by the Montana Natural Heritage Program. Palustrine wetlands within the mapped 100-year inundation boundary were extracted and summarized into four categories: Riverine (Unconsolidated Bottom - UB, Aquatic Bed - AB, and Unconsolidated Shore - US), Emergent - EM, Scrub-Shrub - SS, and Forested - FO.

	Riverine	Emergent	Scrub/Shrub	Forested	Total
Mapped Acres	81.4	269.3	70.9	0.0	**421.6**
Acres/Valley Mile	6.2	20.4	5.4	0.0	

RUSSIAN OLIVE

Russian olive is considered an invasive species and its presence in the Yellowstone River corridor is fairly recent. As such, its spread can be used as a general indicator of invasive plants within the corridor. It has the added benefit of being easily identified in multi-spectral aerial photography, making it possible to inventory large areas using remote techniques.

In 2011, Natural Resources Conservation Service (NRCS) in Bozeman, MT conducted an inventory of Russian olive locations in the Yellowstone River watershed. This study utilized the Feature Analyst extension within ArcGIS to interpret multi-spectral 2008 NAIP imagery for the presence of Russian olive. The resulting analysis was converted from raster format to a polygon ESRI shape file for distribution and further analysis within a GIS environment.

This work scope was tasked with integrating the resulting Russian olive inventory into the Yellowstone River Conservation Districts Council (YRCDC) Cumulative Effects Assessment (CEA) GIS and associated reach-based database. Additionally, analysis of Russian olive within the corridor was conducted to characterize its distribution in throughout the corridor and its association with other corridor data sets.

	Floodplain Area (Ac)	% of Floodplain	Other Area (Ac)	Inside RMA (Ac)	Inside '50s Channel (Ac)	Inside 50s Island (Ac)
Russian Olive in Reach	41.60	1.83%	90.90	8.05	10.44	3.48

FISHERIES SUMMARY

Fisheries data available for the Reach Narratives include low-flow and high-flow habitat mapping of 2001 conditions for 406 miles of river, extending from the mouth upstream to a point approximately 8 miles upstream of Park City. Habitat mapping was performed remotely on the 2001 CIR aerial photography utilizing habitat classifications developed by Montana Fish, Wildlife, and Parks (DTM 2009). Historic habitat mapping using the 1950's imagery is limited to Reach B1 (high-flow) and D9 (low and high-flow).

Fisheries field sampling data have been provided by Ann Marie Reinhold (MSU). In this study, the Yellowstone River from Park City to Sidney was divided into five segments. Within each segment, fish were sampled in reaches modified by riprap ("treatment reaches") and relatively unmodified reaches ("control reaches"). Fish sampling was conducted during summer and autumn of 2009, 2010, and 2011. Boat electrofishing, trammel nets, mini-fyke nets and bag seines were used to collect data from river bends.

Fish presence data is only presented for those reaches that were sampled.

The Low Flow Habitat Mapping followed schema deveoped by Montana Fish Wildlife and Parks to identify key habitat units for certain aquatic species.

Fish Species Observed in Reach/Region

Species of Concern

Reach	Region		Reach	Region		Reach	Region		Reach	Region	
☑	☑	Bigmouth buffalo	☑	☑	Flathead chub	☐	☐	Northern redbelly dace	☑	☑	Stonecat
☐	☑	Black bullhead	☐	☐	Freshwater drum	☐	☐	Pallid sturgeon	☐	☐	Sturgeon chub
☑	☑	Black crappie	☑	☑	Goldeye	☑	☑	Pumpkinseed	☑	☑	Sucker species
☐	☐	Blue sucker	☑	☑	Green sunfish	☑	☑	Rainbow trout	☑	☑	Sunfish species
☑	☑	Bluegill	☑	☑	Lake chub	☑	☑	River carpsucker	☐	☐	Walleye
☑	☑	Brook stickleback	☑	☑	Largemouth bass	☐	☐	Rock bass	☑	☑	Western silvery minnow
☑	☑	Brown trout	☑	☑	Longnose dace	☐	☑	Sand shiner	☐	☐	White bass
☑	☑	Burbot	☑	☑	Longnose sucker	☐	☑	Sauger	☑	☑	White crappie
☐	☐	Catfish species	☑	☑	Minnow species	☑	☑	Shorthead redhorse	☑	☑	White sucker
☑	☑	Channel catfish	☐	☑	Mottled sculpin	☐	☐	Shortnose gar	☐	☐	Yellow bullhead
☑	☑	Common carp	☑	☑	Mountain sucker	☐	☐	Shovelnose sturgeon	☐	☑	Yellow perch
☐	☐	Creek chub	☑	☑	Mountain whitefish	☐	☐	Sicklefin chub			
☑	☑	Emerald shiner	☐	☐	Northern pike	☑	☑	Smallmouth bass			
☑	☑	Fathead minnow	☐	☐	Northern plains killifish	☐	☐	Smallmouth buffalo			

Low Flow Fisheries Habitat Mapping

Habitat	2001 (Acres) Bankfull	Low Flow	% of Low Flow
Scour Pool	256.7	146.5	6.6%
Rip Rap Bottom	319.3	143.7	6.5%
Rip Rap Margin	191.5	100.1	4.5%
Bluff Pool	15.4	5.2	0.2%
Terrace Pool	34.6	35.2	1.6%
Secondary Channel	149.0	64.9	2.9%
Secondary Channel (Seasonal)	436.3	259.2	11.7%
Channel Crossover	259.7	175.9	7.9%
Point Bar		131.6	5.9%
Side Bar		86.8	3.9%
Mid-channel Bar		153.1	6.9%
Island	558.6	562.1	25.3%
Dry Channel		356.9	16.1%

AVIAN

Birds were sampled in 2006 and 2007 by Danielle Jones of Montana State University. Point count methods were used at 304 randomly chosen sites in 21 braided or anabranching reaches. Each site was visited multiple times within a season, and sites were visited in both years. Birds were sampled in grassland, shrubland, and cottonwood forest habitats. Additional bird data was collected by Amy Cilimburg of Montana Audubon in summer 2012. High priority areas for data collection were identified with the assistance of the YRCDC Technical Advisory Committee. The Audubon methodology recorded data for a wider variety of bird species relative to the MSU study, including raptors and waterfowl.

Bird Species Observed in Reach/Region

Species of Concern | Potential Species of Concern

Reach	Region		Reach	Region		Reach	Region		Reach	Region	
☑	☑	American Robin	☐	☑	Chipping Sparrow	☐	☐	Killdeer	☑	☑	Song Sparrow
☐	☑	American Crow	☐	☑	Clay-collared Sparrow	☐	☐	Lark Bunting	☑	☑	Spotted Sandpiper
☑	☑	American Goldfinch	☐	☐	Cliff Swallow	☐	☑	Lark Sparrow	☑	☑	Spotted Towhee
☐	☐	American Kestrel	☑	☑	Common Grackle	☑	☑	Lazuli Bunting	☐	☐	Sharp-shinned Hawk
☑	☑	American Redstart	☐	☐	Common Merganser	☑	☑	Least Flycatcher	☑	☑	Swainson's Thrush
☐	☑	Bald Eagle	☐	☐	Common Nighthawk	☑	☑	Mallard	☐	☐	Sandhill Crane
☐	☐	Baltimore Oriole	☐	☑	Common Raven	☐	☐	Mountain Bluebird	☑	☑	Tree Swallow
☑	☑	Barn Swallow	☑	☑	Common Yellowthroat	☑	☑	Mourning Dove	☐	☐	Turkey Vulture
☐	☑	Belted Kingfisher	☐	☐	Cooper's Hawk	☑	☑	Northern Flicker	☐	☐	Upland Sandpiper
☑	☑	Black-billed Cuckoo	☐	☑	Dickcissel	☐	☐	Orchard Oriole	☑	☑	Vesper Sparrow
☑	☑	Black-billed Magpie	☑	☑	Downy Woodpecker	☑	☑	Osprey	☑	☑	Violet-green Swallow
☑	☑	Black-capped Chickadee	☐	☐	Eastern Bluebird	☑	☑	Ovenbird	☑	☑	Warbling Vireo
☑	☑	Black-and-white Warbler	☑	☑	Eastern Kingbird	☑	☑	Plumbeous Vireo	☐	☑	Western Kingbird
☑	☑	Black-headed Grosbeak	☐	☐	Eurasian Collared-dove	☐	☑	Red-headed Woodpecker	☐	☑	Western Meadowlark
☐	☑	Blue Jay	☑	☑	European Starling	☐	☐	Red-naped Sapsucker	☑	☑	Western Wood-pewee
☐	☐	Bobolink	☑	☑	Field Sparrow	☐	☐	Red Crossbill	☑	☑	White-breasted Nuthatch
☑	☑	Brewer's Blackbird	☐	☐	Franklin's Gull	☑	☑	Ring-necked Pheasant	☐	☑	White-throated Swift
☑	☑	Brown-headed Cowbird	☐	☐	Grasshopper Sparrow	☑	☑	Red-tailed hawk	☐	☐	Wild Turkey
☐	☐	Brown Creeper	☑	☑	Gray Catbird	☑	☑	Rock Dove	☑	☑	Wood Duck
☑	☑	Brown Thrasher	☐	☐	Great Blue Heron	☑	☑	Red-winged Blackbird	☐	☐	Yellow-bellied Sapsucker
☑	☑	Bullock's Oriole	☐	☐	Great Horned Owl	☑	☑	Red-eyed Vireo	☐	☐	Yellow-billed Cuckoo
☑	☑	Canada Goose	☑	☑	Hairy Woodpecker	☐	☐	Red-breasted Grosbeak	☑	☑	Yellow-breasted Chat
☑	☑	Cedar Waxwing	☑	☑	House Finch	☐	☐	Say's Phoebe	☐	☐	Yellow-headed Blackbird
☑	☑	Chimney Swift	☑	☑	House Wren	☑	☑	Savannah Sparrow	☑	☑	Yellow Warbler

CULTURAL INVENTORY SUMMARY

The Yellowstone River Cultural Inventory - 2006 documents the variety and intensity of different perspectives and values held by people who share the Yellowstone River. Between May and November of 2006, a total of 313 individuals participated in the study. They represented agricultural, civic, recreational, or residential interest groups. Also, individuals from the Crow and the Northern Cheyenne tribes were included.
There are three particular goals associated with the investigation. The first goal is to document how the people of the Yellowstone River describe the physical character of the river and how they think the physical processes, such as floods and erosion, should be managed. Within this goal, efforts have been made to document participants' views regarding the many different bank stabilization techniques employed by landowners. The second goal is to document the degree to which the riparian zone associated with the river is recognized and valued by the participants. The third goal is to document concerns regarding the management of the river's resources. Special attention is given to the ways in which residents from diverse geographical settings and diverse interest groups view river management and uses. The results illustrate the commonalities of thought and the complexities of concerns expressed by those who share the resources of the Yellowstone River.

Summary of Cultural Views in Region B

The study segment Big Horn to Laurel includes data from the people of one large county, Yellowstone County. Three themes dominate conversations with the four interest groups. One theme focuses on the evolving communities of Yellowstone County, most of which are influenced by the economic success and sheer growth of Billings. The second theme focuses on the evolving relationships that the people have with the river. While traditional agricultural activities continue in the county, many people discuss notions related to urban and residential experiences and how the river becomes an asset that improves one's quality of life as an urban dweller. The third theme involves a complex tangle of pressures and demands that require managerial strategies capable of dealing with a future that has arrived.