

County	Dawson	Upstream River Mile	107.1
Classification	PCA: Partially confined anabranching	Downstream River Mile	94.6
General Location	To Glendive	Length	12.50 mi (20.12 km)
General Comments	Long secondary channels; to Glendive		

Narrative Summary

Reach D5 is located just south of Glendive. The reach is a 12.5 mile long Partially Confined Anabranching reach type, indicating the presence of forested islands with some valley wall influence on the river. The downstream end of the reach is at Black Bridge. Within Reach D5, the river flows across the Cedar Creek Anticline, which is a ~115 mile long structure that extends from Glendive to Buffalo South Dakota. Oil was discovered on the anticline in 1951, and since then over a half a billion barrels of oil have been produced from 2,700 wells. As the river flows right through the anticline, the Pierre Shale becomes exposed in the right bluff line and the channel becomes more dynamic than upstream reaches. Active drill pads are located on both sides of the river; several of them are within the 100-year floodplain, and two are mapped within the CMZ.

Reach D5 has just over a mile of bank armor and most of that armor is rock riprap. There are also 1,050 feet of concrete armor and a few flow deflectors. About 640 feet of riprap was built between 2001 and 2011. The majority of the bank armor is protecting either streambank just upstream of Black Bridge. Black Bridge forms a major constriction in the river corridor and bank migration upstream of the bridge has been extensive. The bridge is oriented about 45 degrees off of the axis of the river corridor which further disrupts channel processes upstream. Just upstream of the bridge the river migrated over 1,700 feet eastward between 1950 and 2001, which is over 30 feet per year on average.

Since 1950, a side channel that is over 9,000 feet of side channel has been blocked by a dike at RM 105R. The dike crossing the head of this old channel is about 720 feet long. There are still several side channels in the reach that are perennial (flow year-round) and over a mile long.

Floodplain turnover rates have dropped in Reach D5 since 1976; prior to that time, floodplain turnover rates were about 18.5 acres per year, and since then rates have averaged 14.2 acres per year. The reduction in rates has been coupled by an increase in the extent of woody riparian vegetation of almost 300 acres.

Land use is dominated by agriculture, with 219 acres of pivot irrigation development since 1950. Some of the irrigation development took place in historic riparian areas; a total of 161 acres of riparian lands were converted for agricultural and other land uses since 1950. Development near Glendive has created about 310 acres of urban/exurban land uses in the reach. About 190 acres or 3 percent of the total CMZ has become restricted by physical features. Residential development near Glendive has encroached into the CMZ; in 2011, there were over 75 acres of urban/exurban land uses mapped within the CMZ.

Six dump sites were mapped in the reach in 2001. These sites are at RM 104L, RM 104.2L, RM 101L, RM 98L, RM 97.5L, and RM 97.1L.

One ice jam has been recorded in Reach D5. A breakup event was recorded on March 17, 2011, but no damages were recorded.

There is one pipeline crossing in the reach at RM 100. This crossing is the Poplar Pipeline owned by Bridger Pipeline, a 10 inch crude oil pipeline that ruptured in 2015. The pipeline crossing is located at the downstream end of a large forested island. Bank migration at the site has been relatively slow.

About 8 percent of the total 100-year floodplain has become isolated due to human development and most of that isolated floodplain area is behind floodplain dikes near Black Bridge. The 5-year floodplain is even more affected; 31 percent of the historic 5-year floodplain is no longer inundated at that frequency. There has been over 1,260 acres of woody riparian vegetation recruitment in the reach since 1950, indicating generation of new forest, some of which reflects encroachment due to lower flows and a shrinking river channel. The bankfull area of the channel has dropped by 255 acres since 1950. Some of that riparian expansion has been due to Russian olive colonization; there are just under 50 acres of mapped Russian olive in the Reach D5 floodplain.

Reach D5 was sampled as part of the fisheries study. A total of 33 fish species were sampled in the reach including four identified by the Montana Natural Heritage Program as a Species of Concern (SOC): the Blue Sucker, Pallid sturgeon, Sauger, and Sturgeon chub.

Reach D5 was sampled as part of the avian study. A total of 33 bird species were identified in the reach. One bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) was found, the Plumbeous Vireo. The Red-headed Woodpecker was also observed, which has been identified as a Species of Concern (SOC). Reach D5 has seen a decrease in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 86 acres per valley mile of such forest, and that number decreased to 38 acres per valley mile by 2001.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 2-year flood, which strongly influences overall channel form, has dropped by 22 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 4,800 cfs to 2,720 cfs with human development, a reduction of 436 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,980 cfs under unregulated conditions to 3,220 cfs, a reduction of 54 percent.

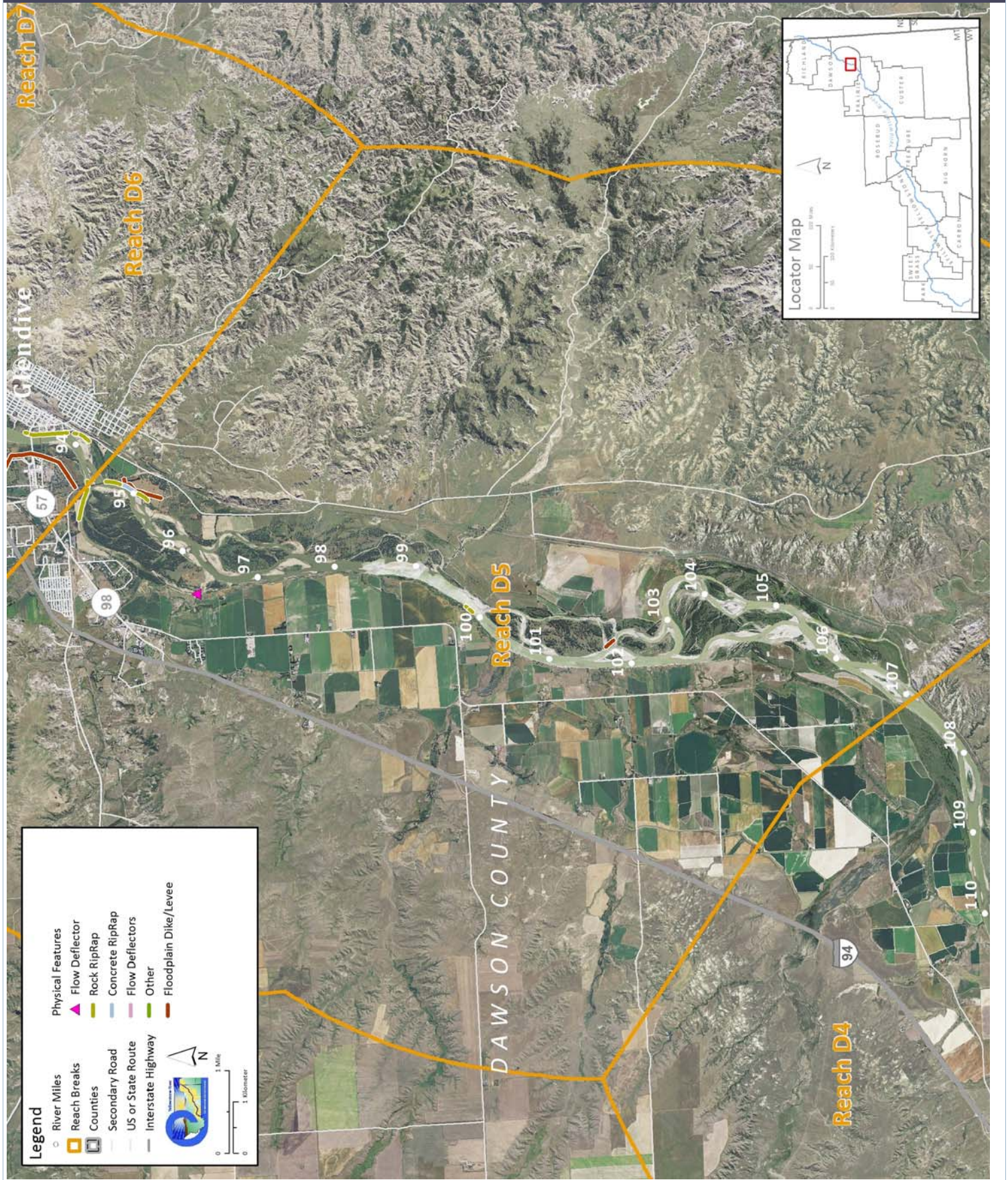
CEA-Related observations in Reach D5 include:

- Channel migration issues upstream of major constriction that is poorly aligned to corridor (Black Bridge)

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D5 include:

- Side channel reactivation at RM 104.5
- Russian olive removal
- Pipeline Crossing Practices at RM 100
- Dump site removal at RM 104L, RM 104.2L, RM 101L, RM 98L, RM 97.5L, and RM 97.1L

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): Sidney

Flood History

Year	Date	Flow on Date	Return Interval	Gage No	Downstream Gage	Upstream Gage
1978	May 23	111,000	10-25 yr	6329500	6309000	
1912	Mar 29	114,000	10-25 yr	Location	Sidney	Miles City
1944	Jun 21	120,000	10-25 yr	Period of Record	1911-2015	1929-2015
2011	May 24	124,000	10-25 yr	Distance To (miles)	63.8	76.9
1918	Jun 20	126,000	25-50 yr			
1943	Mar 29	132,000	25-50 yr			
1923	Oct 3	134,000	25-50 yr			
1952	Mar 31	138,000	25-50 yr			
1921	Jun 21	159,000	100-yr			

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated		69,200	89,100	102,000	132,000	145,000	176,000	4,800	6,980
Regulated		54,000	73,700	86,400	113,000	124,000	150,000	2,720	3,220
% Change		-21.97%	-17.28%	-15.29%	-14.39%	-14.48%	-14.77%	-43.33%	-53.87%

Flow Duration

Streamflow, in ft³/s, which was equaled or exceeded for indicated percent of time

Note that these statistics are only available from Reach C10 downstream. See the USGS report for detailed information.

Season		5%	50%	95%
Spring	Unregulated	67,300	25,100	6,900
	Regulated	52,000	15,000	5,040
	% Change	-23%	-40%	-27%
Summer	Unregulated	47,100	14,900	6,980
	Regulated	35,100	8,920	3,220
	% Change	-25%	-40%	-54%
Fall	Unregulated	9,760	5,950	2,040
	Regulated	11,200	7,440	3,580
	% Change	15%	25%	75%
Winter	Unregulated	14,400	5,330	2,110
	Regulated	15,000	6,490	3,430
	% Change	4%	22%	63%
Annual	Unregulated	49,800	8,900	2,820
	Regulated	37,100	8,010	3,650
	% Change	-26%	-10%	29%

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	26-Aug-49	B/W	1:14,800	6329500	2750
1976	USCOE	9-Oct-76	B/W	1:24,000	6329500	9580
1995	USGS DOQQ	12-Jun-96	B/W		6329500	
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2004	Merrick	5/20/2004 - 6/3/04	Color	1:15,840	6329500	5070
2005	NAIP	07/31/2005	color	1-meter pixels	6329500	5280
2009	NAIP	8/10/2009	Color	1-meter pixels	6329500	13700
2009	NAIP	8/1/2009	Color	1-meter pixels	6329500	12600
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/20/2011	Color	1-meter pixels	6329500	48800
2013	NAIP	07/27/2013	color	1-meter pixels	6329500	
2013	NAIP	07/24/2013	color	1-meter pixels	6329500	

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 discrepancies 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	3,771	2.8%	4,409	3.3%	638
	Flow Deflectors	0	0.0%	58	0.0%	58
	Concrete RipRap	1,049	0.8%	1,049	0.8%	0
	Feature Type Totals	4,820	3.6%	5,516	4.1%	696
Floodplain Control						
	Transportation Encroachment	2,815	2.1%	2,815	2.1%	0
	Floodplain Dike/Levee	3,546	2.7%	2,914	2.2%	-632
	Feature Type Totals	6,361	4.8%	5,729	4.3%	-632
	Reach Totals	11,181	8.4%	11,244	8.4%	63

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
Concrete RipRap	0	0	0	0	0	1,050	0	0
Rock RipRap	2,801	558	328	0	0	328	0	0
Totals	2,801	558	328	0	0	1,378	0	0

Bankline/Floodplain Inventory: Time Series

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

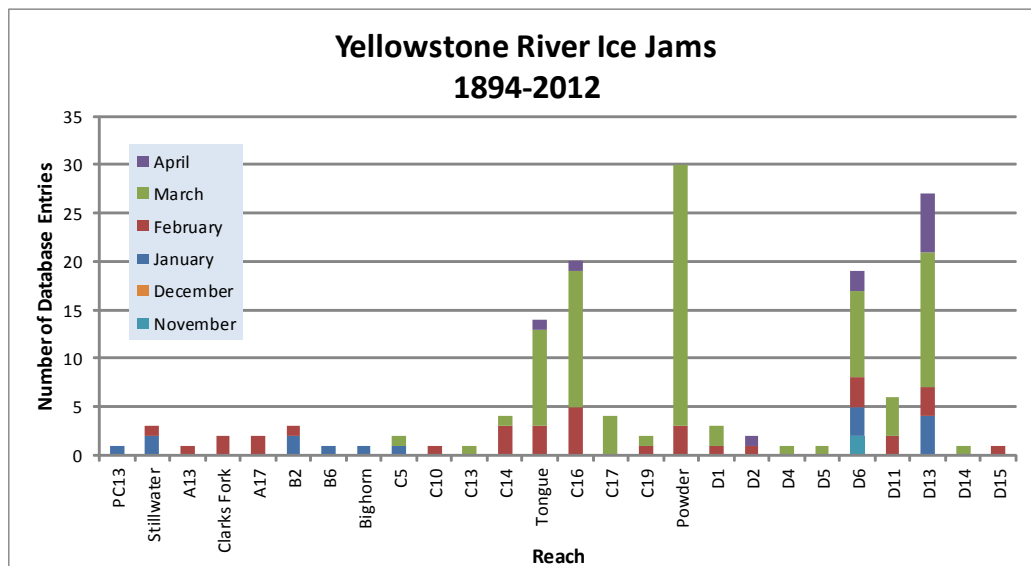
Feature Class	Feature Type	Sum of Feature Length (ft)					
		1950	1976	1995	2001	2004	2005
Irrigation							
	Floodplain Dike/Levee	6,008	6,008	6,008	6,008	6,008	6,008
	Totals	6,008	6,008	6,008	6,008	6,008	6,008
Other							
	Floodplain Dike/Levee	0	1,233	2,007	2,007	2,007	2,007
	Totals	0	1,233	2,007	2,007	2,007	2,007
Other Off Channel							
	Floodplain Dike/Levee	1,760	6,350	9,893	9,893	10,262	10,262
	Totals	1,760	6,350	9,893	9,893	10,262	10,262
Stream Stabilization							
	Rock RipRap	0	3,844	3,844	3,844	3,844	3,844
	Concrete RipRap	0	0	0	1,036	1,036	1,036
	Totals	0	3,844	3,844	4,879	4,879	4,879

Transportation Encroachment

Railroad	13,917	13,917	13,917	13,917	13,917	13,917
Other	2,394	3,975	6,409	6,409	6,409	6,409
County Road	13,899	13,899	13,899	13,899	13,899	13,899
Bridge Approach	1,707	1,707	1,707	1,707	1,707	1,707
Totals	31,917	33,499	35,933	35,933	35,933	35,933

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.



Jam Date	Jam Type	River Mile	Damages
3/17/2011	Break-up		

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	65,846	96,726	2.47	1950 to 1976: 1.76%
1976	66,784	101,011	2.51	1976 to 1995: 16.27%
1995	59,770	114,837	2.92	1995 to 2001: -13.84%
2001	66,626	101,078	2.52	1950 to 2001: 1.95%
Change 1950 - 2001	780	4,352	0.05	

Length of Side Channels Blocked

Pre-1950s (ft)	
Post-1950s (ft)	9,066

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 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.)	60	1.9%		
Agriculture (generally relates to field boundaries)	0	0.0%		
Agriculture (isolated by canal or large ditch)	0	0.0%		
Levee/Riprap (protecting agricultural lands)	0	0.0%		
Levee/Riprap (protecting urban, industrial, etc.)	0	0.0%		
Railroad	101	3.1%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	88	2.7%		
Total Not Isolated (Ac)	2974		3035	
Total Floodplain Area (Ac)	3222		3571	
Total Isolated (Ac)	248	7.7%	536	30.8%

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 agriculture 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:	14	0	0	14

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
481	962	5,721	190	3%	24	0	0%

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		
	Railroad	35	0.6%
RipRap	Irrigated	98	1.7%
Dike/Levee	Railroad	56	1.0%
Totals		190	3.3%

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ExUrban	Transportation
466.3	0.0	2.2	75.2	10.7

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

Feature Class	Feature Type	Acres				% of Reach Area			
		1950	1976	2001	2011	1950	1976	2001	2011
Agricultural Infrastructure									
	Canal	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Agricultural Roads	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Other Infrastructure	25	56	100	114	0.2%	0.5%	0.9%	1.1%
	Totals	25	56	100	114	0.2%	0.5%	0.9%	1.1%
Agricultural Land									
	Non-Irrigated	6,204	5,054	4,598	4,469	58.4%	47.6%	43.3%	42.1%
	Irrigated	865	1,664	1,927	1,910	8.1%	15.7%	18.1%	18.0%
	Totals	7,069	6,718	6,526	6,379	66.6%	63.3%	61.4%	60.1%
Channel									
	Channel	3,422	3,471	3,523	3,612	32.2%	32.7%	33.2%	34.0%
	Totals	3,422	3,471	3,523	3,612	32.2%	32.7%	33.2%	34.0%
ExUrban									
	ExUrban Other	0	0	11	0	0.0%	0.0%	0.1%	0.0%
	ExUrban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Industrial	0	15	23	24	0.0%	0.1%	0.2%	0.2%
	ExUrban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	0	15	34	24	0.0%	0.1%	0.3%	0.2%
Transportation									
	Public Road	43	40	40	40	0.4%	0.4%	0.4%	0.4%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	63	63	62	62	0.6%	0.6%	0.6%	0.6%
	Totals	106	103	103	102	1.0%	1.0%	1.0%	1.0%
Urban									
	Urban Other	0	9	28	28	0.0%	0.1%	0.3%	0.3%
	Urban Residential	0	174	203	203	0.0%	1.6%	1.9%	1.9%
	Urban Commercial	0	7	13	20	0.0%	0.1%	0.1%	0.2%
	Urban Undeveloped	0	23	25	55	0.0%	0.2%	0.2%	0.5%
	Urban Industrial	0	46	68	85	0.0%	0.4%	0.6%	0.8%
	Totals	0	258	337	391	0.0%	2.4%	3.2%	3.7%

Land Use Timeline - Tiers 3 and 4

Feature Class	Feature Type	Acres				% of Reach Area				Change Between Years (% of Agricultural Land)			
		1950	1976	2001	2011	1950	1976	2001	2011	'50-76	'76-01	'01-11	'50-11
Irrigated													
	Sprinkler	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Pivot	0	0	0	218	0.0%	0.0%	0.0%	3.4%	0.0%	0.0%	3.4%	3.4%
	Flood	865	1,664	1,927	1,691	12.2%	24.8%	29.5%	26.5%	12.5%	4.8%	-3.0%	14.3%
	Totals	865	1,664	1,927	1,910	12.2%	24.8%	29.5%	29.9%	12.5%	4.8%	0.4%	17.7%

Non-Irrigated

Multi-Use	5,911	4,695	4,329	4,243	83.6%	69.9%	66.3%	66.5%	-13.7%	-3.5%	0.2%	-17.1%
Hay/Pasture	294	360	269	226	4.2%	5.4%	4.1%	3.5%	1.2%	-1.2%	-0.6%	-0.6%
Totals	6,204	5,054	4,598	4,469	87.8%	75.2%	70.5%	70.1%	-12.5%	-4.8%	-0.4%	-17.7%

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

Statistic	Shrub (Acres)			Closed Timber (Acres)			Open Timber (Acres)		
	1950	1976	2001	1950	1976	2001	1950	1976	2001
Min	0.6	0.3	0.2	0.4	3.7	1.1	3.4	0.5	6.5
Max	174.6	163.1	121.9	127.9	121.5	182.7	61.9	175.9	181.9
Average	22.6	18.6	18.9	39.0	31.6	39.5	19.4	40.9	42.6
Sum	1,490.2	1,298.6	1,249.1	819.3	662.6	948.2	330.4	654.9	511.5

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) 505.9

Channel to Riparian (acres) 800.4

Riparian Encroachment (acres) 294.4

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac) 850.2

1950s Floodplain Mapped as 2011 Channel (Ac) 410.1

Total Recruitment (1950s to 2011)(Ac) 1260.3

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	23.7	152.8	102.2	0.0	278.7
Acres/Valley Mile	2.2	14.3	9.5	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 (YRDC) 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	48.95	2.58%	112.24	0.44	24.58	7.97

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

Low Flow Fisheries Habitat Mapping

Habitat	2001 (Acres)		
	Bankfull	Low Flow	% of Low Flow
Scour Pool	430.8	270.5	7.7%
Rip Rap Bottom	27.7	21.7	0.6%
Terrace Pool	317.0	298.3	8.5%
Secondary Channel	280.9	177.4	5.0%
Secondary Channel (Seasonal)	483.7	320.2	9.1%
Channel Crossover	291.0	201.0	5.7%
Point Bar		116.4	3.3%
Side Bar		51.2	1.5%
Mid-channel Bar		187.1	5.3%
Island	1,691.8	1,693.7	48.0%
Dry Channel		189.8	5.4%

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

A review of the interview data for the segment, Missouri River to Powder River, suggests that people in this area engage in four primary discussions when asked about the Yellowstone River. First, the notion of Eastern Montana is not simply a geographic reference. It is a defining concept that captures the agricultural roots and the cultural values of the people living in the study segment, and the river is an essential element within their notion of Eastern Montana. Second, the river is discussed as a wholesome recreational outlet. However, shifting landownership is noted as an important change in the recreational context. Third, even though agricultural practices are viewed as the mainstay of the local economies, many participants discuss the long-term economic viability of their communities as a concern. Industrial and residential developments along the river's edge are seemingly remote possibilities and are generally discussed with references to flood plain restrictions and the stability of nearby dikes. Finally, discussions of managing the river are limited, but a variety of opinions are offered regarding bank erosion and stabilization techniques.