Yellowstone River Reach Narratives — Reach D10

County	Dawson	**Upstream River Mile**	67.8
Classification	PCA: Partially confined anabranching	**Downstream River Mile**	56.3
General Location	Lowermost Dawson County, Richland County	**Length**	11.50 mi (18.51 km)
General Comments	Vegatated islands		

Narrative Summary

Reach D10 is located in lowermost Dawson County and extends into upper Richland County. The reach is an 11.5 mile long Partially Confined Anabranching (PCA) reach type, indicating some valley wall influence and numerous forested islands.

In 2011 there were just about 730 feet of rock riprap in the reach armoring 0.6 percent of the total stream bank. Prior to that some armor had been lost; between 2001 and 2011, almost 500 feet of rock riprap and 1,050 feet of concrete riprap were destroyed. Some of the greatest damage was at RM 64.2L, where several hundred feet of flow deflectors were flanked, and now are in the river over 100 feet off of the bank. The remaining bank protection in this area continues to flank. Another is at RM 60, where the flanking of concrete riprap has been followed by over 200 feet of erosion behind the original armor.

Similar to many reaches in the Lower Yellowstone Valley, the river channel in Reach D10 has gotten smaller since 1950. The channel contracted by about 404 acres in this reach since 1950, and about 406 acres of riparian vegetation has encroached into old channel areas. This pattern has been consistent in the lower river, and relates primarily to a reduction in flows due to human development. The encroachment was at the expense of open gravel bars; between 1950 and 2001, the reach lost 151 acres of mid-channel bar habitat. Floodplain turnover rates have dropped as well; prior to 1976 measured floodplain turnover rates in this reach were 13.9 acres per year, and post-1976 rages were 7.0 acres per year.

Reach D10 has a relatively high concentration of mapped wetlands; the NWI mapping shows a total of 278 acres of mapped wetland, much of which is emergent marsh and wet meadow.

Land use is dominated by agriculture, with 230 acres of pivot irrigation development since 1950. Some of the irrigation development took place in historic riparian areas; a total of 457 acres of riparian lands were converted for agricultural and other land uses since 1950. This equates to 15 percent of the entire 1950 riparian footprint. There are 97 acres of land under pivot irrigation within the Channel Migration Zone (CMZ) of the river, making these areas especially prone to river erosion.

About 38 percent of the historic 5-year floodplain has become isolated, primarily due to flow alterations.

Reach D10 was sampled as part of the avian study. A total of 57 species were identified in the reach, indicating relatively high bird species richness on the Yellowstone River. Four species identified are considered Potential Species of Concern (PSOC) by the Montana Natural Heritage Center: The Black and White Warbler, Dickscissel, Ovenbird, and Plumbeous Vireo. The Red-headed Woodpecker was also identified which is a Species of Concern. Similar to Reach D9 upstream, Reach D10 has seen an increase in the amount of forest area considered at low risk of cowbird parasitism. In 1950, there were 92 acres per valley mile of such forest, and by 2001, that number had increased to 112 acres per valley mile.

There are about 12 acres of mapped Russian olive in the reach.

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 4,850 cfs to 2,810 cfs with human development, a reduction of 43 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,940 cfs under unregulated conditions to 3,270 cfs under regulated conditions, a reduction of 53 percent.

CEA-Related observations in Reach D10 include:
•Armor flanking and accelerated erosion behind

Recommended Practices (May include Yellowstone River Recommended Practices--YRRPs) for Reach D10 include:
•Removal of flanked armor at RM 60 and RM 64.2L
•Russian olive removal

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

	Downstream Gage	Upstream Gage
Gage No	6329500	6309000
Location	Sidney	Miles City
Period of Record	1911-2015	1929-2015
Distance To (miles)	25.5	116.2

Flood History

Year	Date	Flow on Date	Return Interval
1978	May 23	111,000	10-25 yr
1912	Mar 29	114,000	10-25 yr
1944	Jun 21	120,000	10-25 yr
2011	May 24	124,000	10-25 yr
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		69,700	90,000	103,000	132,000	144,000	173,000	4,450	6,620
Regulated		54,200	74,700	88,100	118,000	130,000	159,000	2,310	2,840
% Change		-22.24%	-17.00%	-14.47%	-10.61%	-9.72%	-8.09%	-48.09%	-57.10%

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	67,400	24,900	7,100
	Regulated	52,000	14,600	5,150
	% Change	**-23%**	**-41%**	**-27%**
Summer	Unregulated	47,500	14,700	6,620
	Regulated	35,300	8,540	2,840
	% Change	**-26%**	**-42%**	**-57%**
Fall	Unregulated	9,870	5,870	1,970
	Regulated	11,300	7,370	3,530
	% Change	**14%**	**26%**	**79%**
Winter	Unregulated	15,600	5,500	2,130
	Regulated	16,200	6,670	3,480
	% Change	**4%**	**21%**	**63%**
Annual	Unregulated	49,800	8,860	2,830
	Regulated	37,000	8,000	3,530
	% Change	**-26%**	**-10%**	**25%**

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	MDT	28-Oct-77	B/W	1:12,000	6329500	5800
1995	USGS DOQQ	7/9/96 - 7/15/96 - 8/8/96	B/W		6329500	35000
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2004	Merrick	3-Jun-04	Color	1:15,840	6329500	9950
2005	NAIP	07/14/2005	color	1-meter pixels	6329500	15900
2009	NAIP	7/11/2009	Color	1-meter pixels	6329500	32600
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/21/2011	Color	1-meter pixels	6329500	46600
2013	NAIP	07/19/2013	color	1-meter pixels	6329500	
2013	NAIP	07/27/2013	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 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	1,175	1.0%	728	0.6%	-447
	Concrete RipRap	1,051	0.9%	0	0.0%	-1,051
	Feature Type Totals	**2,226**	**1.9%**	**728**	**0.6%**	**-1,498**
Other In Channel						
	Bedrock Outcrop	787	0.7%	787	0.7%	0
	Feature Type Totals	**787**	**0.7%**	**787**	**0.7%**	**0**
	Reach Totals	**3,012**	**2.5%**	**1,515**	**1.3%**	**-1,498**

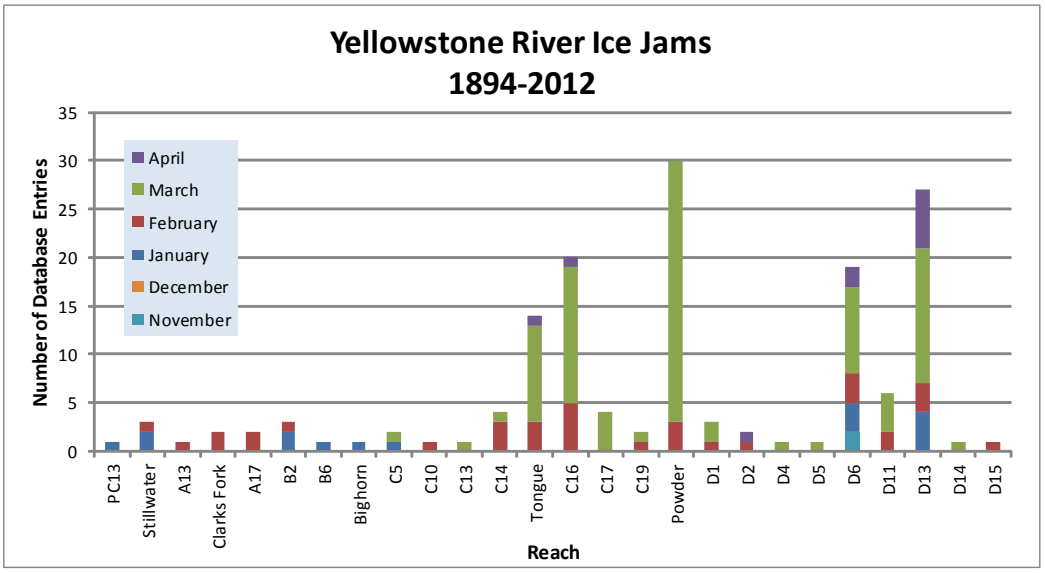
Intent of Bank Protection: 2001

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	1,050	0	0	0	0	0	0	0
Rock RipRap	0	1,174	0	0	0	0	0	0
Totals	**1,050**	**1,174**	**0**	**0**	**0**	**0**	**0**	**0**

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	59,537	92,853	2.56	1950 to 1976:	-4.18%
1976	60,364	87,686	2.45	1976 to 1995:	-3.62%
1995	61,165	83,424	2.36	1995 to 2001:	11.88%
2001	59,913	98,546	2.64	1950 to 2001:	3.33%
Change 1950 - 2001	**376**	**5,693**	**0.09**		

Length of Side Channels Blocked

Pre-1950s (ft)	0
Post-1950s (ft)	0

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.)	94	1.9%		
Agriculture (generally relates to field boundaries)	13	0.3%		
Agriculture (isloated by canal or large ditch)	121	2.5%		
Levee/Riprap (protecting agricultural lands)	0	0.0%		
Levee/Riprap (protecting urban, industrial, etc.)	0	0.0%		
Railroad	423	8.7%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	0	0.0%		
Total Not Isolated (Ac)	4236		2758	
Total Floodplain Area (Ac)	4887		3576	
Total Isolated (Ac)	**651**	**13.3%**	**818**	**38.3%**

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:	121	0	0	**121**

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
526	1,051	4,753	95	2%	233	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	8	0.2%
RipRap			
	Non-Irrigated	44	0.9%
	Totals	**52**	**1.0%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
540.6	0.0	96.5	5.7	1.8

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	26	26	26	26	0.3%	0.3%	0.3%	0.3%
	Agricultural Roads	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Other Infrastructure	18	18	29	26	0.2%	0.2%	0.4%	0.3%
	Totals	**44**	**44**	**55**	**53**	**0.5%**	**0.5%**	**0.7%**	**0.6%**
Agricultural Land									
	Non-Irrigated	3,863	4,018	4,158	3,825	47.1%	49.0%	50.7%	46.6%
	Irrigated	723	1,130	1,533	1,505	8.8%	13.8%	18.7%	18.3%
	Totals	**4,586**	**5,148**	**5,692**	**5,330**	**55.9%**	**62.8%**	**69.4%**	**65.0%**
Channel									
	Channel	3,546	2,979	2,424	2,788	43.2%	36.3%	29.6%	34.0%
	Totals	**3,546**	**2,979**	**2,424**	**2,788**	**43.2%**	**36.3%**	**29.6%**	**34.0%**
ExUrban									
	ExUrban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Residential	0	5	6	6	0.0%	0.1%	0.1%	0.1%
	Totals	**0**	**5**	**6**	**6**	**0.0%**	**0.1%**	**0.1%**	**0.1%**
Transportation									
	Public Road	5	5	5	5	0.1%	0.1%	0.1%	0.1%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	21	21	21	21	0.3%	0.3%	0.3%	0.3%
	Totals	**26**	**26**	**26**	**26**	**0.3%**	**0.3%**	**0.3%**	**0.3%**
Urban									
	Urban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

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	0	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Pivot	0	0	232	229	0.0%	0.0%	4.1%	4.3%	0.0%	4.1%	0.2%	4.3%
	Flood	723	1,130	1,301	1,275	15.8%	21.9%	22.9%	23.9%	6.2%	0.9%	1.1%	8.2%
	Totals	**723**	**1,130**	**1,533**	**1,505**	**15.8%**	**21.9%**	**26.9%**	**28.2%**	**6.2%**	**5.0%**	**1.3%**	**12.5%**

Non-Irrigated

Multi-Use	3,442	3,567	3,909	3,594	75.1%	69.3%	68.7%	67.4%	-5.8%	-0.6%	-1.2%	-7.6%
Hay/Pasture	421	452	250	231	9.2%	8.8%	4.4%	4.3%	-0.4%	-4.4%	-0.1%	-4.8%
Totals	**3,863**	**4,018**	**4,158**	**3,825**	**84.2%**	**78.1%**	**73.1%**	**71.8%**	**-6.2%**	**-5.0%**	**-1.3%**	**-12.5%**

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	0.8	0.3	0.1	0.3	1.3	1.6	0.0	7.0	5.6
Max	148.9	156.3	88.8	213.5	693.9	870.0	80.0	32.7	42.8
Average	27.8	13.6	16.9	48.9	59.9	53.4	20.8	17.3	24.7
Sum	1,251.2	680.8	796.1	1,760.9	1,797.3	2,083.2	228.3	138.1	172.7

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)	343.0
Channel to Riparian (acres)	748.9
Riparian Encroachment (acres)	**405.9**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	758.1
1950s Floodplain Mapped as 2011 Channel (Ac)	164.3
Total Recruitment (1950s to 2011)(Ac)	**922.3**

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	21.6	136.8	120.4	0.0	**278.7**
Acres/Valley Mile	2.3	14.7	12.9	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	11.90	0.22%	5.79	0.02	5.83	2.33

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.

Low Flow Fisheries Habitat Mapping

	2001 (Acres)		
Habitat	Bankfull	Low Flow	% of Low Flow
Scour Pool	307.2	219.2	9.0%
Rip Rap Bottom	115.7	62.0	2.6%
Bluff Pool	188.0	134.9	5.6%
Secondary Channel	103.1	73.2	3.0%
Secondary Channel (Seasonal)	449.9	415.5	17.1%
Channel Crossover	275.2	148.3	6.1%
Point Bar		248.7	10.3%
Side Bar		20.5	0.8%
Mid-channel Bar		21.3	0.9%
Island	985.0	989.2	40.8%
Dry Channel		91.3	3.8%

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 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.

County	Richland	**Upstream River Mile**	56.3
Classification	PCA: Partially confined anabranching	**Downstream River Mile**	49.9
General Location	Savage; Elk Island	**Length**	6.40 mi (10.30 km)
General Comments	Elk Island: Very wide riparian; marked change in channel course since 1981 geologic map base		

Narrative Summary

Reach D11 is 10.3 miles long, located near Savage and Elk Island. It is a Partially Confined Anabranching reach type (PCA) indicating distinct side channels around vegetated islands with some valley wall influences. The valley wall is comprised of Tertiary-age Fort Union Formation, and a distinct terrace surface borders the active stream corridor. Fort Union Formation rocks are exposed on a right bank bluff on the downstream end of the reach.

There is no mapped bank armor in Reach D11. Prior to 1950, however, about three miles of side channel had been blocked, mostly around Elk Island.

The most striking change in Reach D11 since 1950 is the encroachment of riparian vegetation onto old sand bars. Between 1950 and 2001, the size of the channel has dropped by 313 acres, and there has been 294 acres of riparian encroachment into old channel areas. Much of this encroachment converted open sand bars into forested islands. There has been a loss of over 100 acres of sand bar since 1950. This change has resulted in a conversion of almost 7 miles low flow channels around gravel bars to anabranching side channels around islands.

Reach D11 has had six ice jams-related floods reported since 1943. They all occurred in February or March, and several of them reported flood damages.

Approximately 36 percent of the historic 5-year floodplain has become isolated, largely due to flow alterations.

Land use in the reach is dominated by flood irrigation.

There are about 32 acres of Russian olive mapped in the reach.

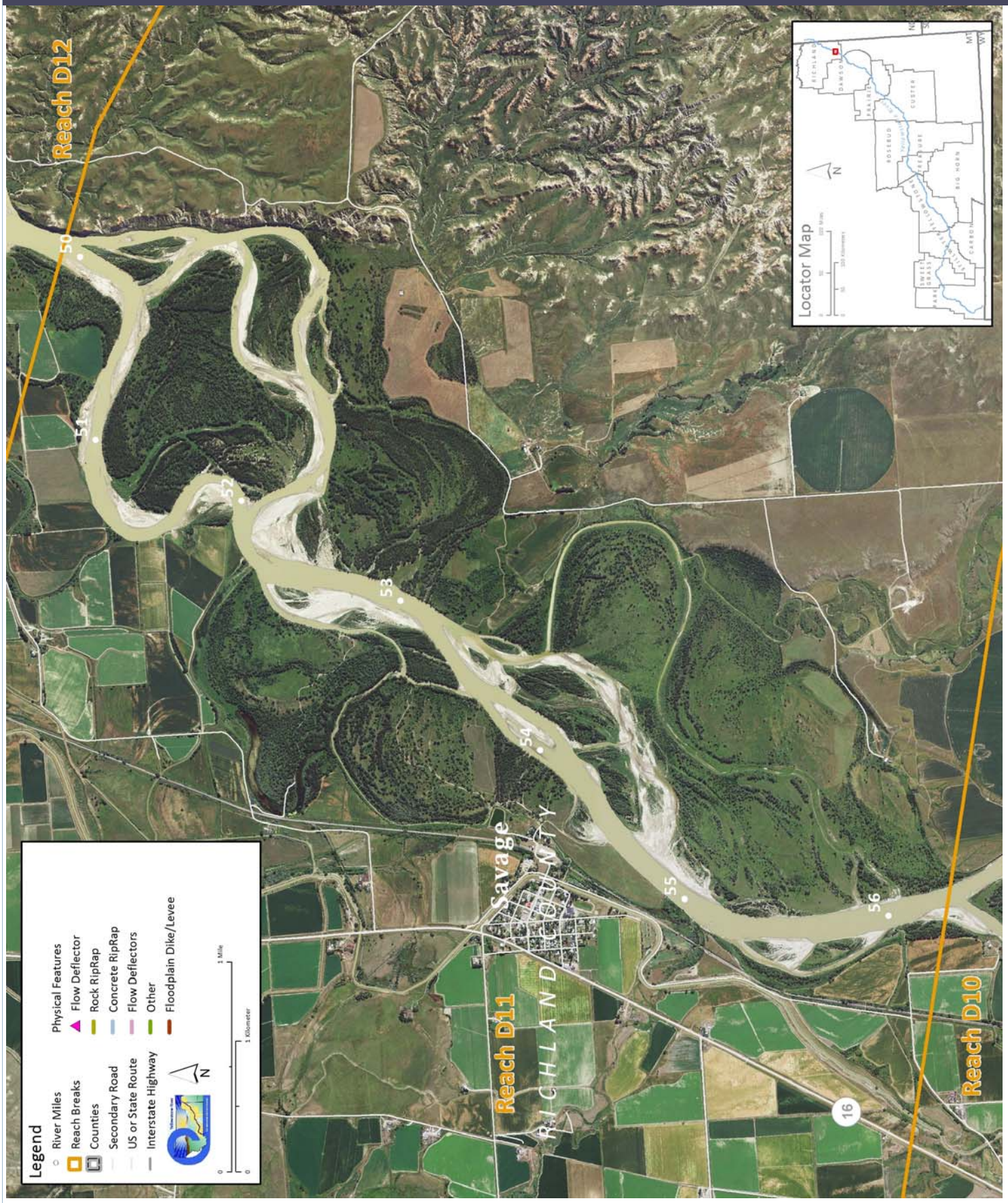
Reach D11 was sampled as part of the avian study. A total of 61 bird species were identified in the reach, indicating high bird species richness. Five bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were found, the Black and white Warbler, Chimney Swift, Dickscissel, Ovenbird, and Plumbeous Vireo. The Red-headed woodpecker was also observed, which has been identified as a Species of Concern (SOC). Reach D11 has seen an increase in the amount of forest area considered at low risk of cowbird parasitism. In 1950, there were 216.4 acres per valley mile of such forest, and by 2001, that number had increased to 247.2 acres per valley mile.

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 4,370 cfs to 2,220 cfs with human development, a reduction of 50 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,540 cfs under unregulated conditions to 2,750 cfs under regulated conditions, a reduction of 59 percent. Fall and winter low flows are about 3,500 cfs; these discharges are about 60 percent to 80 percent higher than they were prior to development.

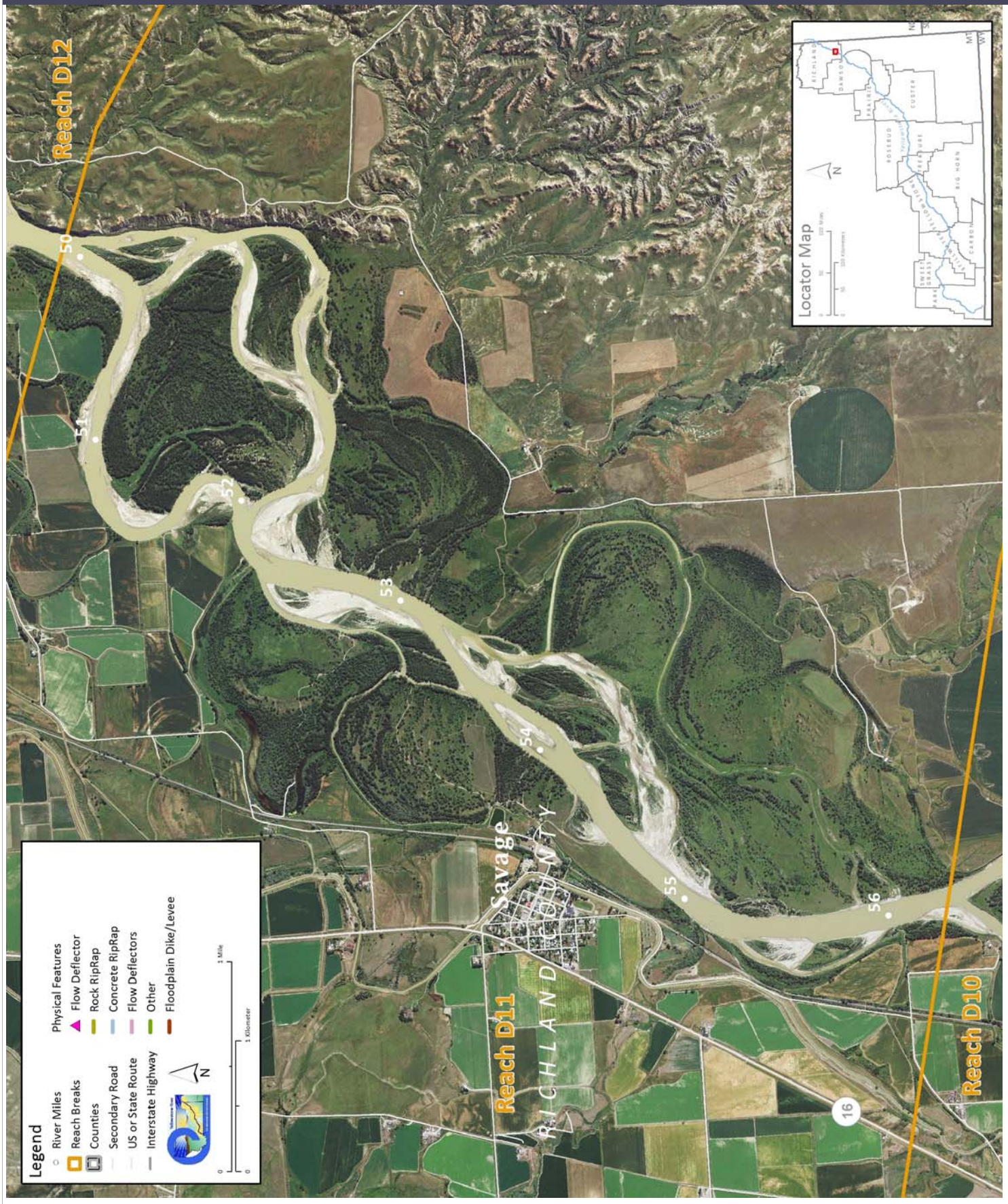
CEA-Related observations in Reach D11 include:
•Reduction in 5-year floodplain footprint with flow alterations
•Increased fall and winter low flows with development
•Reduced summer low flows with development
•Reduced channel forming discharge causing channel contraction
•Extensive riparian encroachment with flow alterations
•Conversion of open sand bars to forested islands

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D11 include:
•Side channel reactivation RM 53L
•Russian olive removal

PHYSICAL FEATURES MAP (2011)



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

	Downstream Gage	Upstream Gage
Gage No	6329500	6309000
Location	Sidney	Miles City
Period of Record	1911-2015	1929-2015
Distance To (miles)	19.1	127.7

Flood History

Year	Date	Flow on Date	Return Interval
1978	May 23	111,000	10-25 yr
1912	Mar 29	114,000	10-25 yr
1944	Jun 21	120,000	10-25 yr
2011	May 24	124,000	10-25 yr
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		69,800	90,100	103,000	132,000	144,000	172,000	4,370	6,540
Regulated		54,200	74,800	88,400	118,000	131,000	161,000	2,220	2,750
% Change		-22.35%	-16.98%	-14.17%	-10.61%	-9.03%	-6.40%	-49.20%	-57.95%

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	67,400	24,800	7,150
	Regulated	52,000	14,500	5,170
	% Change	**-23%**	**-42%**	**-28%**
Summer	Unregulated	47,600	14,700	6,540
	Regulated	35,300	8,440	2,750
	% Change	**-26%**	**-43%**	**-58%**
Fall	Unregulated	9,900	5,850	1,950
	Regulated	11,300	7,350	3,520
	% Change	**14%**	**26%**	**81%**
Winter	Unregulated	15,900	5,550	2,140
	Regulated	16,400	6,720	3,490
	% Change	**3%**	**21%**	**63%**
Annual	Unregulated	49,800	8,840	2,830
	Regulated	37,000	8,000	3,500
	% Change	**-26%**	**-10%**	**24%**

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	MDT	28-Oct-77	B/W	1:12,000	6329500	5800
1995	USGS DOQQ	8/22/97 - 7/9/96	B/W		6329500	35000
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2005	NAIP	07/14/2005	color	1-meter pixels	6329500	15900
2007	Woolpert	10/15/2007 - 11/2/0007	Color		6329500	
2009	NAIP	7/11/2009	Color	1-meter pixels	6329500	32600
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/21/2011	Color	1-meter pixels	6329500	46600
2013	NAIP	07/19/2013	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.

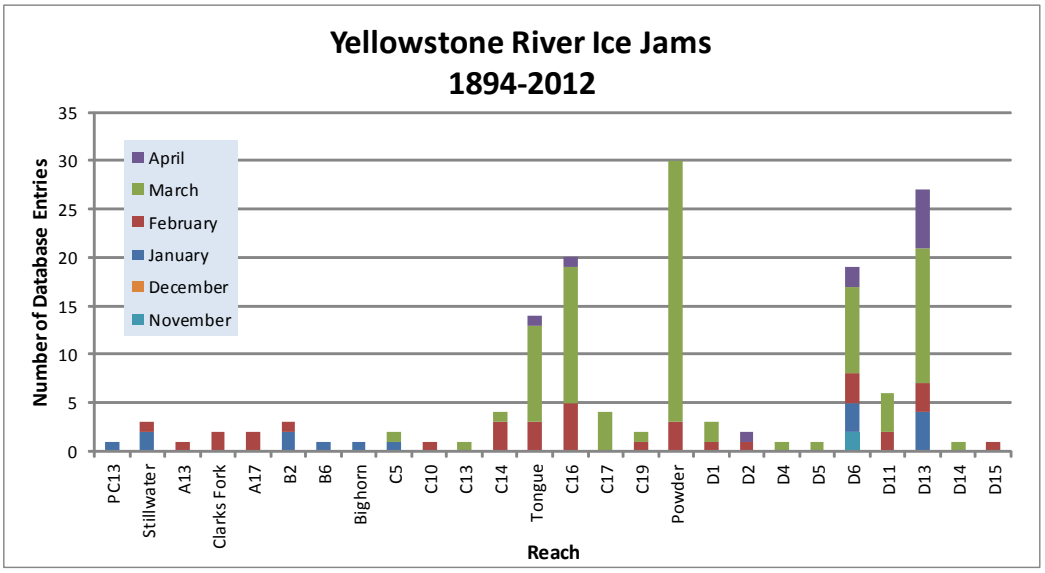
Note: As the goal for each physical features mapping effort were different, with differing mapping extents, there will be descrepancies between total feature lengths (e.g. length of rock riprap) in each data set.

2001 and 2011 Physical Features Bankline Inventories

Feature Class	Feature Type	2001 Length (ft)	% of Bankline	2011 Length (ft)	% of Bankline	2001-2011 Change
Other In Channel						
	Bedrock Outcrop	674	1.0%	674	1.0%	0
	Feature Type Totals	**674**	**1.0%**	**674**	**1.0%**	**0**
	Reach Totals	**674**	**1.0%**	**674**	**1.0%**	**0**

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
3/10/1943	Break-up	54	Severe flooding
3/4/1994	Break-up	54	?
2/13/1996	Break-up	54	Flooding
2/16/1996	Break-up	52	Flooding
3/18/2003	Break-up		?
3/20/2009	Break-up		unknown

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	35,949	72,196	3.01	1950 to 1976:	7.56%
1976	40,583	90,731	3.24	1976 to 1995:	1.55%
1995	34,282	78,367	3.29	1995 to 2001:	-17.69%
2001	33,705	57,459	2.70	1950 to 2001:	-10.09%
Change 1950 - 2001	**-2,244**	**-14,738**	**-0.30**		

Length of Side Channels Blocked

Pre-1950s (ft)	15,601
Post-1950s (ft)	0

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.)	32	0.8%		
Agriculture (generally relates to field boundaries)	0	0.0%		
Agriculture (isloated 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	72	1.7%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	0	0.0%		
Total Not Isolated (Ac)	4135		2524	
Total Floodplain Area (Ac)	4238		3386	
Total Isolated (Ac)	**104**	**2.5%**	**862**	**35.7%**

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:	130	0	0	**130**

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
686	1,371	4,334	62	1%	30	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
Dike/Levee			
	Railroad	62	1.4%
	Totals	**62**	**1.4%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
256.4	0.0	0.0	0.4	8.5

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	15	15	15	15	0.2%	0.2%	0.2%	0.2%
	Agricultural Roads	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Other Infrastructure	25	35	38	35	0.4%	0.5%	0.6%	0.5%
	Totals	**40**	**50**	**52**	**50**	**0.6%**	**0.8%**	**0.8%**	**0.8%**
Agricultural Land									
	Non-Irrigated	2,727	3,334	3,768	3,788	42.4%	51.9%	58.6%	58.9%
	Irrigated	610	584	739	670	9.5%	9.1%	11.5%	10.4%
	Totals	**3,338**	**3,918**	**4,507**	**4,457**	**51.9%**	**61.0%**	**70.1%**	**69.4%**
Channel									
	Channel	3,003	2,392	1,792	1,845	46.7%	37.2%	27.9%	28.7%
	Totals	**3,003**	**2,392**	**1,792**	**1,845**	**46.7%**	**37.2%**	**27.9%**	**28.7%**
ExUrban									
	ExUrban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Residential	2	2	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**2**	**2**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Transportation									
	Public Road	19	26	27	27	0.3%	0.4%	0.4%	0.4%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	12	12	12	12	0.2%	0.2%	0.2%	0.2%
	Totals	**31**	**37**	**39**	**39**	**0.5%**	**0.6%**	**0.6%**	**0.6%**
Urban									
	Urban Other	0	8	18	18	0.0%	0.1%	0.3%	0.3%
	Urban Residential	13	15	17	17	0.2%	0.2%	0.3%	0.3%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	0	5	0	0	0.0%	0.1%	0.0%	0.0%
	Urban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**13**	**28**	**35**	**35**	**0.2%**	**0.4%**	**0.5%**	**0.5%**

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	0	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Pivot	0	0	11	11	0.0%	0.0%	0.2%	0.3%	0.0%	0.2%	0.0%	0.3%
	Flood	610	584	728	658	18.3%	14.9%	16.1%	14.8%	-3.4%	1.2%	-1.4%	-3.5%
	Totals	**610**	**584**	**739**	**670**	**18.3%**	**14.9%**	**16.4%**	**15.0%**	**-3.4%**	**1.5%**	**-1.4%**	**-3.3%**

Non-Irrigated

Multi-Use	2,328	2,932	3,619	3,641	69.7%	74.8%	80.3%	81.7%	5.1%	5.5%	1.4%	11.9%
Hay/Pasture	400	402	149	147	12.0%	10.3%	3.3%	3.3%	-1.7%	-6.9%	0.0%	-8.7%
Totals	**2,727**	**3,334**	**3,768**	**3,788**	**81.7%**	**85.1%**	**83.6%**	**85.0%**	**3.4%**	**-1.5%**	**1.4%**	**3.3%**

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	0.5	0.1	1.0	0.5	1.4	0.3	0.8	1.7	6.7
Max	256.8	208.6	230.0	415.7	493.5	391.8	232.9	18.4	128.6
Average	29.7	22.2	17.9	49.9	88.4	65.9	53.7	8.6	46.2
Sum	1,037.8	756.3	608.7	1,597.1	2,210.6	2,108.3	483.5	25.8	277.2

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)	355.9
Channel to Riparian (acres)	650.8
Riparian Encroachment (acres)	**294.9**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	700.9
1950s Floodplain Mapped as 2011 Channel (Ac)	74.3
Total Recruitment (1950s to 2011)(Ac)	**775.2**

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	24.4	119.1	44.7	0.0	**188.2**
Acres/Valley Mile	4.5	22.1	8.3	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	31.79	1.05%	34.72	1.00	9.53	3.42

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.

Low Flow Fisheries Habitat Mapping

	2001 (Acres)		
Habitat	Bankfull	Low Flow	% of Low Flow
Scour Pool	303.0	193.9	10.8%
Secondary Channel	211.9	113.8	6.3%
Secondary Channel (Seasonal)	303.9	233.5	13.0%
Channel Crossover	152.9	112.8	6.3%
Point Bar		56.5	3.2%
Side Bar		76.0	4.2%
Mid-channel Bar		44.4	2.5%
Island	820.7	821.5	45.8%
Dry Channel		139.9	7.8%

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 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.

County	Richland	**Upstream River Mile**	49.9
Classification	PCA: Partially confined anabranching	**Downstream River Mile**	36.3
General Location	Seven Sisters	**Length**	13.60 mi (21.89 km)
General Comments	Secondary channel on valley wall; Sinuous; long abandoned secondary channel		

Narrative Summary

Reach D12 is located in Richland County at Seven Sisters. The Seven Sisters Fishing Access Site is located in the lower portion of the reach. The reach is a 13.6 mile long Partially Confined Anabranching reach type, indicating some influence of the valley wall along with extensive forested islands. This reach supports over 20 miles of side channels, and islands that are miles long and over ½ mile wide.

There are almost 7,000 feet of bank armor in the reach, and about one third of that was built since 2001. Most of the armor (3,250 feet) is rock riprap, and there are about 2,000 feet each of concrete riprap and flow deflectors. A total of 5 percent of the bank is armored, which is a relatively low concentration of bank armor for the Yellowstone River. All of the armor is protecting agricultural land, most of it against a flood irrigated field on the left bank in the lower end of the reach at RM 37.

Since 1950, a side channel that is almost three miles long was blocked at RM 45.3L. There have also been some gains in side channel length in the reach, such that the net change in length is a loss of approximately one mile. As of 2001, this reach supported almost 21 miles of anabranching channel.

Land use is dominated by agriculture, with 583 acres of pivot irrigation development since 1950. Physical features such as bank armor, dikes, and levees have isolated 3 percent of the Channel Migration Zone in Reach D12, and as of 2011 there were 224 acres of land in the CMZ under pivot irrigation, and 900 acres under flood.

Reach D12 shows, like most other reaches below the Bighorn River, a shrinking channel with reduced rates of erosion and floodplain turnover. For example, the bankfull channel area in the reach dropped by 480 acres since 1950, and there was almost 600 acres of riparian encroachment into old channel areas. Floodplain turnover rates have dropped from 2.1 acres/valley mile/year from 1950-1976 to 1.3 acres/valley mile/year from 1976-2001. This equates to 330 fewer acres of floodplain turnover since 1976. There has also been a net loss of 159 acres of open bar area as the channel has become smaller and more forested. On the floodplain, riparian acreage has decreased; about 350 acres or 9 percent of the total riparian area was cleared for irrigation since 1950.

There are 75 acres of Russian olive in the reach.

The 100-year floodplain has been isolated in this reach, but compared to other reaches the isolation has been fairly minor. About 300 acres of 100-year floodplain has been isolated by human development, which is 5 percent of the total 100-year floodplain. Although only about 5 percent of the 100-year floodplain has been isolated, the impact of flow alterations on the smaller 5-year floodplain has been much more severe; 42 percent of the historic 5-year floodplain is no longer inundated at that frequency. The isolation of the historic 5-year floodplain, which is due primarily to flow alterations, has been associated with increased development in these areas; currently there are about 300 acres of flood irrigated land and within the historic 5-year floodplain footprint.

There is an animal feeding facility on the right bank at RM 46.8.

Reach D12 was sampled as part of the fisheries study. A total of 37 fish species were sampled in the reach. Three species collected in the reach have been identified by the Montana Natural Heritage Program as Species of Concern (SOC): Pallid Sturgeon, Sauger, and Sturgeon Chub.

Reach D12 was also sampled as part of the avian study. A total of 59 bird species were identified in the reach. All five bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) on the Yellowstone River were also found, the Black and White Warbler, the Chimney Swift, the Dickscissel, the Ovenbird, and the Plumbeous Vireo. Similarly, all three bird species identified as Species of Concern (SOC) were identified: the Black-billed Cuckoo, Bobolink, and Red-headed Woodpecker. In contrast to most other reaches, Reach D12 has seen an increase in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 103 acres per valley mile of such forest, and that number increased to 115 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 4,310 cfs to 2,410 cfs with human development, a reduction of 50 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,470 cfs under unregulated conditions to 2,680 cfs under regulated conditions, a reduction of 59 percent.

CEA-Related observations in Reach D12 include:
•Increase in area at low risk of cowbird parasitism with riparian encroachment

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D12 include:
•Nutrient management at animal handling facility at RM 46.8R
•Side channel reactivation at RM 45.3R
•Russian olive removal

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

	Downstream Gage	Upstream Gage
Gage No	6329500	6309000
Location	Sidney	Miles City
Period of Record	1911-2015	1929-2015
Distance To (miles)	5.5	134.1

Flood History

Year	Date	Flow on Date	Return Interval
1978	May 23	111,000	10-25 yr
1912	Mar 29	114,000	10-25 yr
1944	Jun 21	120,000	10-25 yr
2011	May 24	124,000	10-25 yr
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		69,800	90,300	103,000	132,000	144,000	172,000	4,310	6,470
Regulated		54,300	74,900	88,600	119,000	132,000	163,000	2,140	2,680
% Change		-22.21%	-17.05%	-13.98%	-9.85%	-8.33%	-5.23%	-50.35%	-58.58%

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	67,400	24,700	7,180
	Regulated	52,000	14,400	5,190
	% Change	**-23%**	**-42%**	**-28%**
Summer	Unregulated	47,700	14,700	6,470
	Regulated	35,300	8,370	2,680
	% Change	**-26%**	**-43%**	**-59%**
Fall	Unregulated	9,910	5,830	1,940
	Regulated	11,300	7,330	3,510
	% Change	**14%**	**26%**	**81%**
Winter	Unregulated	16,100	5,580	2,140
	Regulated	16,600	6,750	3,490
	% Change	**3%**	**21%**	**63%**
Annual	Unregulated	49,700	8,830	2,830
	Regulated	37,000	8,000	3,480
	% Change	**-26%**	**-9%**	**23%**

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
1957	USDA	???	B/W	1:20,000	6329500	
1976	MDT	28-Oct-77	B/W	1:12,000	6329500	5800
1995	USGS DOQQ	8/3/97 - 8/22/97	B/W		6329500	23000
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2005	NAIP	07/14/2005	color	1-meter pixels	6329500	15900
2007	Woolpert	10/15/2007 - 11/2/0007	Color		6329500	
2009	NAIP	7/11/2009	Color	1-meter pixels	6329500	32600
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/21/2011	Color	1-meter pixels	6329500	46600
2011	NAIP	7/15/2011	Color	1-meter pixels	6329500	57900
2013	NAIP	07/19/2013	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 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						
	Tree Revetments	531	0.4%	404	0.3%	-127
	Rock RipRap	595	0.4%	3,251	2.3%	2,656
	Flow Deflectors	356	0.2%	474	0.3%	118
	Concrete RipRap	1,945	1.4%	1,945	1.4%	0
	Between Flow Deflectors	1,328	0.9%	1,328	0.9%	0
	Feature Type Totals	**4,755**	**3.3%**	**7,402**	**5.2%**	**2,647**
Floodplain Control						
	Floodplain Dike/Levee	350	0.2%	350	0.2%	0
	Feature Type Totals	**350**	**0.2%**	**350**	**0.2%**	**0**
	Reach Totals	**5,106**	**3.6%**	**7,752**	**5.4%**	**2,647**

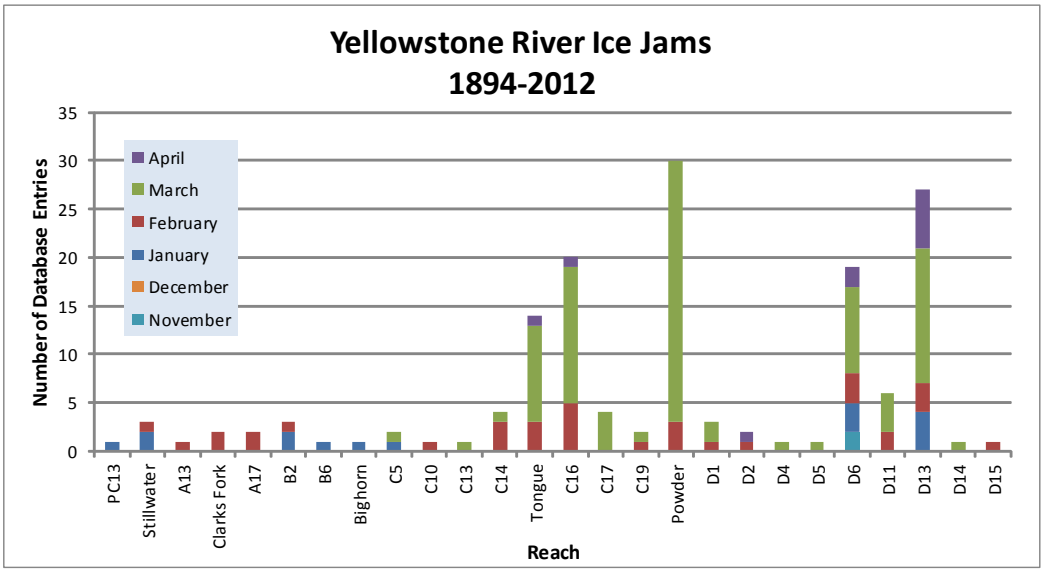
Intent of Bank Protection: 2001

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	1,289	0	656	0	0	0	0	0
Flow Deflectors/Between FDs	1,683	0	0	0	0	0	0	0
Rock RipRap	0	423	171	0	0	0	0	0
Tree Revetments	531	0	0	0	0	0	0	0
Totals	**3,503**	**423**	**827**	**0**	**0**	**0**	**0**	**0**

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	75,467	116,193	2.54	1950 to 1976:	-2.36%
1976	72,988	107,995	2.48	1976 to 1995:	9.36%
1995	70,922	121,394	2.71	1995 to 2001:	-6.48%
2001	71,860	110,374	2.54	1950 to 2001:	-0.15%
Change 1950 - 2001	**-3,607**	**-5,818**	**0.00**		

Length of Side Channels Blocked

Pre-1950s (ft)	0
Post-1950s (ft)	14,624

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.)	11	0.2%		
Agriculture (generally relates to field boundaries)	0	0.0%		
Agriculture (isloated by canal or large ditch)	0	0.0%		
Levee/Riprap (protecting agricultural lands)	285	3.9%		
Levee/Riprap (protecting urban, industrial, etc.)	0	0.0%		
Railroad	49	0.7%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	0	0.0%		
Total Not Isolated (Ac)	6965		4622	
Total Floodplain Area (Ac)	7310		6736	
Total Isolated (Ac)	**345**	**4.7%**	**2113**	**42.4%**

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:	300	0	27	**328**

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
556	1,113	7,034	126	2%	639	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
RipRap			
	Non-Irrigated	46	0.6%
	Irrigated	23	0.3%
Flow Deflectors			
	Irrigated	122	1.6%
Dike/Levee			
	Railroad	7	0.1%
	Totals	**198**	**2.6%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
896.1	0.0	244.1	4.1	6.4

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	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	60	109	166	155	0.6%	1.0%	1.6%	1.5%
	Totals	**60**	**109**	**166**	**155**	**0.6%**	**1.0%**	**1.6%**	**1.5%**
Agricultural Land									
	Non-Irrigated	3,778	3,965	3,128	3,139	36.2%	38.0%	29.9%	30.0%
	Irrigated	2,108	2,241	3,003	2,947	20.2%	21.4%	28.7%	28.2%
	Totals	**5,886**	**6,206**	**6,131**	**6,087**	**56.3%**	**59.4%**	**58.7%**	**58.3%**
Channel									
	Channel	4,458	4,074	4,091	4,146	42.7%	39.0%	39.2%	39.7%
	Totals	**4,458**	**4,074**	**4,091**	**4,146**	**42.7%**	**39.0%**	**39.2%**	**39.7%**
ExUrban									
	ExUrban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Industrial	0	0	2	2	0.0%	0.0%	0.0%	0.0%
	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**	**0**	**2**	**2**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Transportation									
	Public Road	26	42	41	41	0.3%	0.4%	0.4%	0.4%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	17	17	17	17	0.2%	0.2%	0.2%	0.2%
	Totals	**44**	**59**	**59**	**59**	**0.4%**	**0.6%**	**0.6%**	**0.6%**
Urban									
	Urban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

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
Irr													
	Sprinkler	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Pivot	0	0	360	583	0.0%	0.0%	5.9%	9.6%	0.0%	5.9%	3.7%	9.6%
	Flood	2,108	2,241	2,643	2,365	35.8%	36.1%	43.1%	38.9%	0.3%	7.0%	-4.3%	3.0%
	Totals	**2,108**	**2,241**	**3,003**	**2,947**	**35.8%**	**36.1%**	**49.0%**	**48.4%**	**0.3%**	**12.9%**	**-0.6%**	**12.6%**

NoIrr

Multi-Use	3,111	3,170	2,961	2,986	52.8%	51.1%	48.3%	49.1%	-1.8%	-2.8%	0.8%	-3.8%
Hay/Pasture	668	795	167	154	11.3%	12.8%	2.7%	2.5%	1.5%	-10.1%	-0.2%	-8.8%
Totals	**3,778**	**3,965**	**3,128**	**3,139**	**64.2%**	**63.9%**	**51.0%**	**51.6%**	**-0.3%**	**-12.9%**	**0.6%**	**-12.6%**

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	0.5	0.2	0.8	3.1	0.6	0.2	4.0	4.4	4.2
Max	247.0	140.2	87.4	235.5	658.4	804.3	78.4	137.8	189.5
Average	21.5	14.0	11.3	64.5	81.6	71.8	27.1	71.1	33.8
Sum	1,611.4	870.4	473.5	2,128.4	2,856.4	3,517.4	379.5	284.3	337.7

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)	518.6
Channel to Riparian (acres)	1115.6
Riparian Encroachment (acres)	**597.0**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	1123.2
1950s Floodplain Mapped as 2011 Channel (Ac)	578.0
Total Recruitment (1950s to 2011)(Ac)	**1701.2**

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	28.0	117.2	139.8	0.0	**285.0**
Acres/Valley Mile	2.6	10.9	13.0	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	74.77	1.37%	82.86	0.12	25.02	13.06

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	608.4	334.5	8.2%
Rip Rap Bottom	23.1	16.6	0.4%
Rip Rap Margin	24.4	21.9	0.5%
Bluff Pool	16.3	16.9	0.4%
Terrace Pool	40.1	30.7	0.8%
Secondary Channel	122.7	110.7	2.7%
Secondary Channel (Seasonal)	479.7	402.0	9.8%
Channel Crossover	439.8	269.4	6.6%
Point Bar		247.3	6.0%
Side Bar		107.7	2.6%
Mid-channel Bar		69.6	1.7%
Island	2,336.7	2,336.7	57.1%
Dry Channel		127.5	3.1%

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 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.

County	Richland	**Upstream River Mile**	36.3
Classification	PCM/I: Partly confined meandering/islands	**Downstream River Mile**	27.8
General Location	To Sidney	**Length**	8.50 mi (13.68 km)
General Comments			

Narrative Summary

Reach D13 is located just upstream of Sidney. It is 8.5 miles long, and is a PCM/I reach type, indicating a primary meandering channel thread with distinct islands largely formed by historic bendway cutoffs. The reach has multiple pipeline crossings, and the Highway 23 Bridge and approach have confined the river and isolated floodplain area. Floodplain development for irrigated agricultural is extensive, and in many cases irrigated fields intersect the channel bank. These locations are commonly armored, and low field dikes affect floodplain access.

In 2011 there was almost 16,000 feet of bank armor in the reach, protecting 16 percent of the total bank line. That includes 2,440 feet of car bodies. The car body revetments are all located off of the main channel at RM 32.2L. About ½ mile of rock riprap was constructed between 2001 and 2011.

Although no side channels have been intentionally blocked in the reach, there has still been a net loss of almost two miles of side channel since 1950, reflecting passive abandonment of side channels with flow alterations.

There are three mapped pipeline crossings in the reach, two at the Sidney Bridge and another about a mile upstream. The two on the bridge are apparently installed on the bridge structure itself. The one upstream at RM 32.1 is described as an LPG pipeline installed in 1997; however no more information was available.

Reach D13 has had 28 reported ice jam events since 1917. Especially severe damages were reported in the ice jam of March 25, 1943.

Human development has resulted in isolation of 18 percent of the historic 100-year floodplain and 26 percent of the 5-year floodplain. This isolation includes the effects of transportation infrastructure embankments (mainly Highway 23), low agricultural dikes on the edges of irrigated fields, and reduced flood magnitudes. There has been fairly extensive land use encroachment into the Channel Migration Zone: as of 2011 there were 250 acres of pivot irrigation and 137 acres of urban/exurban land uses within the CMZ, making these areas especially prone to the threat of river erosion. One drill pad was mapped within 1,500 feet of the river at RM 32. There is also a large animal handling facility that drains to an irrigation return flow point at RM 29.

Reach D13 shows, like most other reaches below the Bighorn River, a shrinking channel with reduced rates of erosion and floodplain turnover. The bankfull channel area in the reach dropped by 220 acres since 1950, and there was a similar amount of mapped riparian encroachment into old channel areas. Floodplain turnover rates have dropped from 14.3 acres per year from 1950-1976 to 6.1 acres per year from 1976-2001. There has also been a net loss of 45 acres of open bar area as the channel has become smaller and more forested. On the floodplain, riparian acreage has decreased; about 424 acres or 27 percent of the total riparian area was cleared for irrigation since 1950.

Like numerous reaches below the Bighorn River confluence, Reach D13 exhibits a shift from a largely braided pattern in 1950 to an anabranching pattern today. The pattern shift reflects the fact that side channels that used to flow around open bars (braided) now flow around wooded islands (anabranching). This shift appears largely due to riparian encroachment onto sand bars since 1950. This encroachment reflects the flow alterations identified in the reach, and may also be due to the altered sediment regime imposed by upstream influences including Yellowtail Dam. Changes in sediment loading have not been quantified in the CEA.

There are 45 acres of Russian olive mapped in the reach.

Reach D13 was sampled as part of the fisheries study. A total of 38 fish species were sampled in the reach, including six Species of Concern: the Blue Sucker, Pallid Sturgeon, Sauger, Shortnose Gar, Sicklefin Chub, and Sturgeon Chub.

Reach D13 was also sampled as part of the avian study. A total of 39 bird species were identified in the reach. The Red-headed Woodpecker was found, which is a Species of Concern (SOC). In contrast to most other reaches, Reach D12 has seen a reduction in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 27.6 acres per valley mile of such forest, and that number decreased to 18.1 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 magnitude of the 100-year flood is now 134,000 cfs, which 6 percent lower than it was pre-development (143,000 cfs). 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 4,190 cfs to 2,000 cfs with human development, a reduction of 52 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,340 cfs under unregulated conditions to 2,550 cfs under regulated conditions, a reduction of 60 percent.

Seasonal low flows have increased by 82 percent in the fall and 63 percent in the winter. Both fall and winter base flows are currently about 3,500 cfs.

CEA-Related observations in Reach D13 include:
•Conversion of river pattern from braided to anabranching due to riparian encroachment onto sand bars since 1950.
•Passive side channel abandonment due to hydrologic alterations and potentially downcutting due to CMZ confinement.
•100-year floodplain isolation due to low agricultural field dikes.
•100-year floodplain isolation due to transportation infrastructure.
•Channel Migration Zone (CMZ) restrictions that significantly confine the river corridor, potentially causing downcutting. This may be an important Increase in area at low risk of cowbird parasitism with riparian encroachment

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D13 include:
•Nutrient Management at Animal Handling Facility at RM 29L
•Pipeline Crossing PRACTICE RM 32.1
•Old car body removal RM 32.2L
•Russian olive removal

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

	Downstream Gage	Upstream Gage
Gage No		6329500
Location	#Error	Sidney
Period of Record	#Error	1911-2015
Distance To (miles)	#Error	-5.5

Flood History

Year	Date	Flow on Date	Return Interval
1978	May 23	111,000	10-25 yr
1912	Mar 29	114,000	10-25 yr
1944	Jun 21	120,000	10-25 yr
2011	May 24	124,000	10-25 yr
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		69,900	90,500	104,000	132,000	143,000	170,000	4,190	6,340
Regulated		54,300	75,100	89,100	120,000	134,000	166,000	2,000	2,550
% Change		-22.32%	-17.02%	-14.33%	-9.09%	-6.29%	-2.35%	-52.27%	-59.78%

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	67,400	24,600	7,250
	Regulated	52,000	14,300	5,220
	% Change	**-23%**	**-42%**	**-28%**
Summer	Unregulated	47,800	14,600	6,340
	Regulated	35,300	8,230	2,550
	% Change	**-26%**	**-44%**	**-60%**
Fall	Unregulated	9,950	5,800	1,920
	Regulated	11,300	7,300	3,490
	% Change	**14%**	**26%**	**82%**
Winter	Unregulated	16,500	5,640	2,150
	Regulated	17,000	6,810	3,510
	% Change	**3%**	**21%**	**63%**
Annual	Unregulated	49,700	8,810	2,830
	Regulated	36,900	7,990	3,440
	% Change	**-26%**	**-9%**	**22%**

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	MDT	28-Oct-77	B/W	1:12,000	6329500	5800
1995	USGS DOQQ	7/28/95 - 8/3/97	B/W		6329500	23000
2001	NRCS	August 2-8, 2001	CIR	1:24,000	6329500	4000
2005	NAIP	07/14/2005	color	1-meter pixels	6329500	15900
2007	Woolpert	10/15/2007 - 11/2/0007	Color		6329500	
2009	NAIP	7/11/2009	Color	1-meter pixels	6329500	32600
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/15/2011	Color	1-meter pixels	6329500	57900
2013	NAIP	07/19/2013	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 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						
	Tire Revetment	520	0.6%	0	0.0%	-520
	Rock RipRap	3,976	4.4%	6,387	7.1%	2,410
	Flow Deflectors	962	1.1%	944	1.0%	-18
	Concrete RipRap	3,329	3.7%	3,329	3.7%	0
	Car Bodies	2,437	2.7%	2,437	2.7%	0
	Between Flow Deflectors	3,074	3.4%	3,235	3.6%	161
	Feature Type Totals	**14,298**	**15.8%**	**16,332**	**18.1%**	**2,033**
	Reach Totals	**14,298**	**15.8%**	**16,332**	**18.1%**	**2,033**

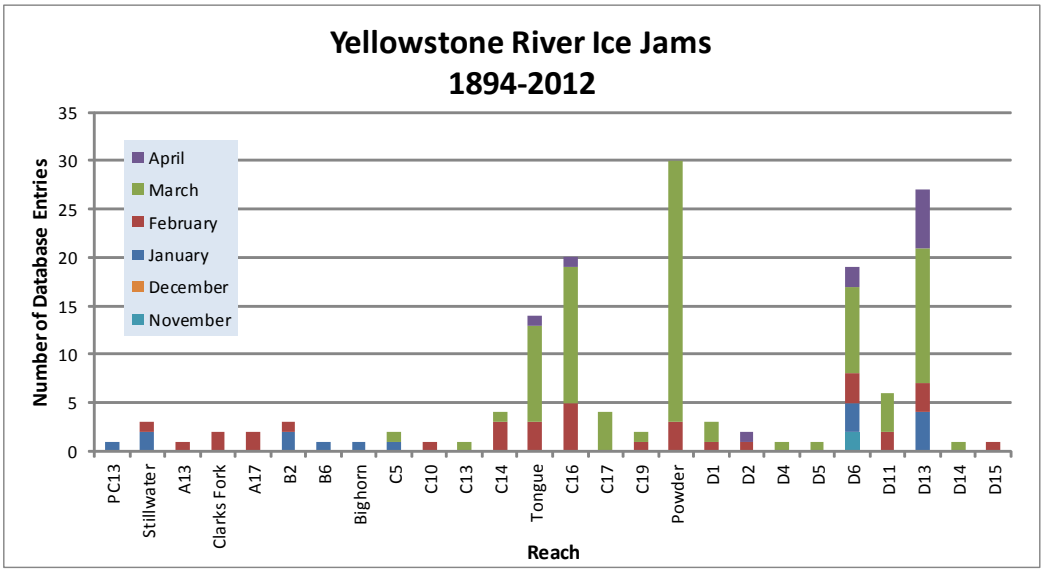
Intent of Bank Protection: 2001

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	2,263	0	0	0	0	0	0	174
Concrete RipRap	2,522	0	0	0	0	0	0	807
Flow Deflectors/Between FDs	1,496	2,394	0	0	0	0	0	0
Rock RipRap	748	0	984	66	0	0	0	2,178
Tire Revetment	518	0	0	0	0	0	0	0
Totals	**7,547**	**2,394**	**984**	**66**	**0**	**0**	**0**	**3,159**

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
	NA	31	35K USD estimated rural damages
4/3/1917	NA	31	?
3/31/1923	NA	31	?
1/1/1927	NA	31	21,400 USD estimated rural damages
3/2/1938	NA	31	?
3/22/1939	NA	31	?
3/25/1943	NA	31	484,800 USD estimated rural damages
1/1/1944	NA	31	86,600 USD estimated rural damages
1/1/1946	NA	31	50,400 USD estimated rural damages
1/1/1948	NA	31	11,300 USD estimated rural damages
3/8/1949	NA	31	50,500 USD estimated rural damages
4/4/1950	NA	31	?
3/27/1951	NA	31	Severe flooding, evacuations, 100,000s USD in damages
4/1/1952	Freeze-up	31	44,900 USD estimated rural damages,severe flooding
4/3/1955	NA	31	1,800 USD estimated rural damages
3/26/1956	NA	31	?
3/21/1959	NA	31	30K USD estimated rural damages
3/21/1960	NA	31	69K USD estimated rural damages
3/17/1961	NA	31	?
4/7/1965	NA	31	?
4/7/1965	NA	31	?
3/26/1969	Break-up	31	230K USD and 14,000 acres flooded
3/19/1979	NA	31	?
2/27/1986	NA	31	?
3/6/1994	NA	31	?
2/13/1996	Break-up	31	High water
2/14/1997	NA	31	?
3/19/2011	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	44,020	49,325	2.12	1950 to 1976:	-1.37%
1976	43,740	47,743	2.09	1976 to 1995:	1.60%
1995	44,321	49,858	2.12	1995 to 2001:	-12.40%
2001	45,127	38,872	1.86	1950 to 2001:	-12.22%
Change 1950 - 2001	**1,106**	**-10,453**	**-0.26**		

Length of Side Channels Blocked

Pre-1950s (ft)	0
Post-1950s (ft)	0

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.)	31	0.7%		
Agriculture (generally relates to field boundaries)	552	13.1%		
Agriculture (isloated by canal or large ditch)	0	0.0%		
Levee/Riprap (protecting agricultural lands)	38	0.9%		
Levee/Riprap (protecting urban, industrial, etc.)	16	0.4%		
Railroad	0	0.0%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	129	3.1%		
Total Not Isolated (Ac)	3434		2297	
Total Floodplain Area (Ac)	4200		2764	
Total Isolated (Ac)	**766**	**18.2%**	**467**	**25.6%**

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:	163	0	19	**183**

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
521	1,042	3,541	598	17%	0	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			
	Public Road	177	5.0%
RipRap/Flow Deflectors			
	Irrigated	233	6.6%
RipRap			
	Irrigated	128	3.6%
Flow Deflectors			
	Irrigated	101	2.9%
	Totals	**639**	**18.1%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
585.1	0.0	250.7	136.9	9.9

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	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	73	163	209	210	1.1%	2.4%	3.0%	3.1%
	Totals	**73**	**163**	**209**	**210**	**1.1%**	**2.4%**	**3.0%**	**3.1%**
Agricultural Land									
	Non-Irrigated	1,843	1,799	1,831	1,780	26.8%	26.2%	26.6%	25.9%
	Irrigated	3,210	3,141	3,230	3,218	46.7%	45.7%	46.9%	46.8%
	Totals	**5,052**	**4,940**	**5,061**	**4,998**	**73.4%**	**71.8%**	**73.6%**	**72.7%**
Channel									
	Channel	1,695	1,543	1,343	1,398	24.6%	22.4%	19.5%	20.3%
	Totals	**1,695**	**1,543**	**1,343**	**1,398**	**24.6%**	**22.4%**	**19.5%**	**20.3%**
ExUrban									
	ExUrban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Industrial	0	158	185	192	0.0%	2.3%	2.7%	2.8%
	ExUrban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Residential	5	19	24	24	0.1%	0.3%	0.4%	0.4%
	Totals	**5**	**176**	**209**	**216**	**0.1%**	**2.6%**	**3.0%**	**3.1%**
Transportation									
	Public Road	44	47	47	47	0.6%	0.7%	0.7%	0.7%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	9	9	9	9	0.1%	0.1%	0.1%	0.1%
	Totals	**53**	**57**	**57**	**57**	**0.8%**	**0.8%**	**0.8%**	**0.8%**
Urban									
	Urban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

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
Irr													
	Sprinkler	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Pivot	0	0	316	894	0.0%	0.0%	6.3%	17.9%	0.0%	6.3%	11.6%	17.9%
	Flood	3,210	3,141	2,913	2,324	63.5%	63.6%	57.6%	46.5%	0.0%	-6.0%	-11.0%	-17.0%
	Totals	**3,210**	**3,141**	**3,230**	**3,218**	**63.5%**	**63.6%**	**63.8%**	**64.4%**	**0.1%**	**0.2%**	**0.6%**	**0.9%**

NoIrr

Multi-Use	1,549	1,546	1,731	1,747	30.7%	31.3%	34.2%	35.0%	0.6%	2.9%	0.7%	4.3%
Hay/Pasture	293	253	100	33	5.8%	5.1%	2.0%	0.7%	-0.7%	-3.2%	-1.3%	-5.1%
Totals	**1,843**	**1,799**	**1,831**	**1,780**	**36.5%**	**36.4%**	**36.2%**	**35.6%**	**-0.1%**	**-0.2%**	**-0.6%**	**-0.9%**

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	0.5	0.2	0.7	2.2	0.3	2.0	3.7	5.3	8.8
Max	175.6	31.2	43.2	110.3	279.9	346.3	51.5	31.8	19.4
Average	26.7	6.6	11.6	32.0	31.7	41.1	22.9	16.8	14.1
Sum	987.8	277.2	372.7	641.0	1,014.0	1,273.4	114.5	67.4	28.2

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)	231.2
Channel to Riparian (acres)	522.9
Riparian Encroachment (acres)	**291.7**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	546.4
1950s Floodplain Mapped as 2011 Channel (Ac)	104.1
Total Recruitment (1950s to 2011)(Ac)	**650.5**

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	65.0	126.5	60.6	0.0	**252.0**
Acres/Valley Mile	8.5	16.6	7.9	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	44.74	3.16%	145.58	2.81	22.19	6.15

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	256.0	134.5	10.0%
Rip Rap Bottom	262.2	125.6	9.4%
Rip Rap Margin	25.8	18.2	1.4%
Secondary Channel (Seasonal)	222.7	209.0	15.6%
Channel Crossover	176.1	163.4	12.2%
Point Bar		88.1	6.6%
Side Bar		27.8	2.1%
Mid-channel Bar		37.7	2.8%
Island	400.6	401.2	29.9%
Dry Channel		137.9	10.3%

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 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.

Yellowstone River Reach Narratives — Reach D14

County	Richland	**Upstream River Mile**	27.8
Classification	PCM/I: Partly confined meandering/islands	**Downstream River Mile**	13.5
General Location	To Fariview	**Length**	14.30 mi (23.01 km)
General Comments	Into Mckenzie County, North Dakota: High sinuosity		

Narrative Summary

Reach D14 is located upstream of Fairview. The reach is a 14.3 mile long Partially Confined Meandering with Islands (PCM/I), indicating some valley wall influence, and a meandering main thread with cutoff channels through meander cores forming persistent forested islands.

There is just over a mile of bank armor in the reach, including 3,900 feet of rock riprap and 2,500 feet of flow deflectors. Most of the rock riprap was constructed between 2001 and 2011 (2,300 feet).

Prior to 1950, 3,600 feet of side channel was blocked in the reach at RM 23L.

Similar to many reaches in the Lower Yellowstone Valley, the river channel in Reach D14 has gotten smaller since 1950. The channel contracted by about 309 acres in this reach since 1950, and about 460 acres of riparian vegetation has encroached into old channel areas. This pattern has been consistent in the lower river, and relates primarily to a reduction in flows due to human development. Floodplain turnover rates have dropped from 14.4 acres per year pre-1976 to 6.1 acres per year post-1976. There has also been a major loss of open bar habitat area in the channel; between 1950 and 2001, there was a loss of 510 acres of mid-channel bar area, which can be important habitat to certain species such as least tern.

Land use is predominantly agricultural, with just over a thousand acres of pivot irrigation development since 1950. Development in the reach included conversion of 1,063 acres of 1950s riparian area to other land uses (mostly irrigated agriculture); that represented 36 percent of the entire 1950s riparian footprint. There are 93 acres of pivot irrigated land and 113 acres of urban/exurban development within the Channel Migration Zone (CMZ), making these areas especially susceptible to river erosion. At RM 26L there are three drill pads within the CMZ.

Several dump sites have been mapped on the banks: RM 25R, RM 24.3L, RM 17L, RM 15.8L, and RM 15.8R.

There is one pipeline crossing in Reach D14 at RM 27. It is an 8-inch crude oil pipeline that has been Horizontally Directionally Drilled.

About 41 percent of the historic 5-year floodplain has become isolated, primarily due to flow alterations.

One ice jam was reported in the reach. It was a break-up flood event on March 17, 2011.

There are about 36 acres of mapped Russian olive in the reach.

Reach D14 was sampled as part of the avian study. A total of 30 bird species were identified in the reach. Two bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) on the Yellowstone River were found, the Ovenbird and the Plumbeous Vireo. Reach D14 has seen a decrease in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 25.6 acres per valley mile of such forest, and that number dropped to 19.6 acres per valley mile by 2001.

CEA-Related observations in Reach D14 include:
•Flow alteration impacts on floodplain access

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach D14 include:
•Solid waste removal at dump sites at RM 25R, RM 24.3L, RM 17L, RM 15.8L, and RM 15.8R.
•Side channel reactivation at RM 23L
•Pipeline crossing Management at RM 27.
•Russian olive removal

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
1978	May 23	111,000	10-25 yr
1912	Mar 29	114,000	10-25 yr
1944	Jun 21	120,000	10-25 yr
2011	May 24	124,000	10-25 yr
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

	Downstream Gage	Upstream Gage
Gage No		6329500
Location	#Error	Sidney
Period of Record	#Error	1911-2015
Distance To (miles)	#Error	3.0

Discharge

	1.01 Yr	2 Yr	5 Yr	10 Yr	50 Yr	100 Yr	500 Yr	7Q10 Summer	95% Sum. Duration
Unregulated								NA	NA
Regulated								NA	NA
% Change								NA	NA

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
1949	USGS-EROS	26-Aug-49	B/W	1:14,800	6329500	2750
1976	MDT	28-Oct-77	B/W	1:12,000	6329500	5800
1995	USGS DOQQ	28-Jul-95	B/W		6329500	25000
2001	NRCS	???	CIR	1:24,000	6329500	4000
2005	NAIP	07/14/2005	color	1-meter pixels	6329500	15900
2007	Woolpert	10/15/2007 - 11/2/0007	Color		6329500	
2009	NAIP	7/11/2009	Color	1-meter pixels	6329500	32600
2009	NAIP	7/9/2009	Color	1-meter pixels	6329500	35400
2011	USCOE	October 2012	color	1-ft pixel	6329500	9030
2011	NAIP	7/25/2011	Color	1-meter pixels	6329500	41100
2011	NAIP	7/15/2011	Color	1-meter pixels	6329500	57900
2013	NAIP	07/19/2013	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 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	1,613	1.1%	3,906	2.6%	2,293
	Flow Deflectors	935	0.6%	1,208	0.8%	273
	Between Flow Deflectors	1,297	0.9%	1,297	0.9%	0
	Feature Type Totals	**3,845**	**2.5%**	**6,411**	**4.2%**	**2,566**
	Reach Totals	**3,845**	**2.5%**	**6,411**	**4.2%**	**2,566**

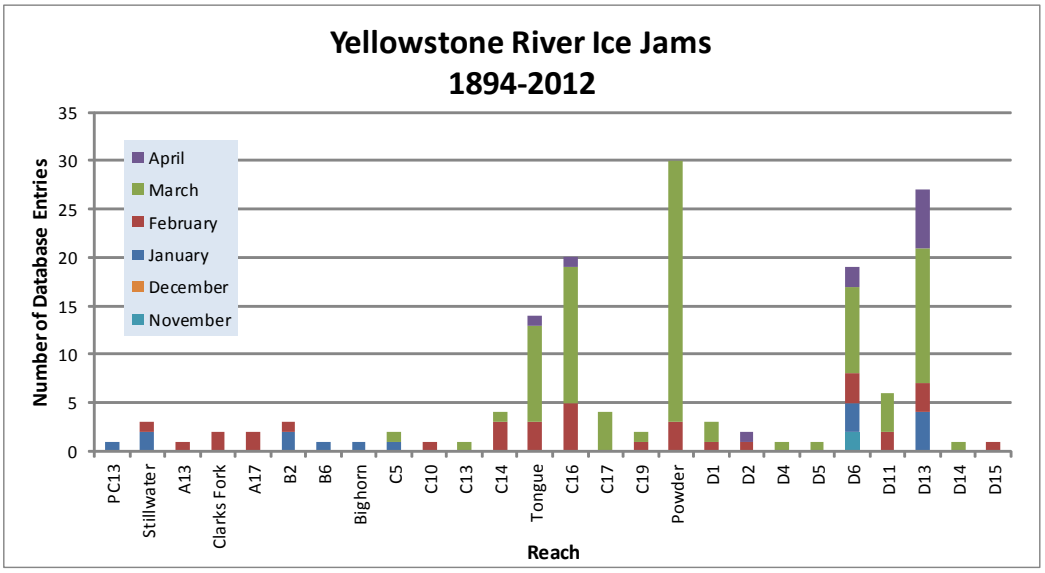
Intent of Bank Protection: 2001

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
Flow Deflectors/Between FDs	1,971	0	0	0	0	0	0	259
Rock RipRap	0	0	446	0	0	0	0	1,168
Totals	**1,971**	**0**	**446**	**0**	**0**	**0**	**0**	**1,427**

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	76,083	3,723	1.05	1950 to 1976:	31.63%
1976	75,267	28,654	1.38	1976 to 1995:	24.21%
1995	75,888	54,254	1.71	1995 to 2001:	-16.71%
2001	75,901	32,508	1.43	1950 to 2001:	36.17%
Change 1950 - 2001	**-182**	**28,786**	**0.38**		

Length of Side Channels Blocked

Pre-1950s (ft)	3,595
Post-1950s (ft)	0

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)	1451	17.4%		
Agriculture (isloated 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	0	0.0%		
Abandoned Railroad	0	0.0%		
Transportation (Interstate and other roads)	0	0.0%		
Total Not Isolated (Ac)	6895		3410	
Total Floodplain Area (Ac)	8346		4456	
Total Isolated (Ac)	**1451**	**17.4%**	**1046**	**40.9%**

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:	132	0	33	**164**

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
538	1,077	5,428	118	2%	633	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			
	Public Road	14	0.2%
RipRap/Flow Deflectors			
	Irrigated	1	0.0%
RipRap			
	Non-Irrigated	12	0.2%
	Exurban Industrial	69	1.1%
Flow Deflectors			
	Irrigated	65	1.1%
	Totals	**161**	**2.7%**

Land Uses within the CMZ (Acres)

Flood Irrigation	Sprinkler Irrigation	Pivot Irrigation	Urban/ ExUrban	Trans-portation
1586.3	0.0	93.1	113.0	10.9

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	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	49	98	143	153	0.5%	0.9%	1.3%	1.4%
	Totals	**49**	**98**	**143**	**153**	**0.5%**	**0.9%**	**1.3%**	**1.4%**
Agricultural Land									
	Non-Irrigated	4,570	3,488	3,179	3,085	42.6%	32.6%	29.7%	28.8%
	Irrigated	3,833	4,692	4,966	4,994	35.8%	43.8%	46.3%	46.6%
	Totals	**8,402**	**8,180**	**8,145**	**8,079**	**78.4%**	**76.3%**	**76.0%**	**75.4%**
Channel									
	Channel	2,199	2,353	2,196	2,249	20.5%	22.0%	20.5%	21.0%
	Totals	**2,199**	**2,353**	**2,196**	**2,249**	**20.5%**	**22.0%**	**20.5%**	**21.0%**
ExUrban									
	ExUrban Other	0	0	23	23	0.0%	0.0%	0.2%	0.2%
	ExUrban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	ExUrban Industrial	0	15	135	139	0.0%	0.1%	1.3%	1.3%
	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**	**158**	**161**	**0.0%**	**0.1%**	**1.5%**	**1.5%**
Transportation									
	Public Road	62	66	70	70	0.6%	0.6%	0.7%	0.7%
	Interstate	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Railroad	3	3	3	3	0.0%	0.0%	0.0%	0.0%
	Totals	**65**	**69**	**73**	**73**	**0.6%**	**0.6%**	**0.7%**	**0.7%**
Urban									
	Urban Other	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Residential	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Commercial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Undeveloped	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Urban Industrial	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Totals	**0**	**0**	**0**	**0**	**0.0%**	**0.0%**	**0.0%**	**0.0%**

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
Irr													
	Sprinkler	0	0	0	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Pivot	0	0	436	1,003	0.0%	0.0%	5.3%	12.4%	0.0%	5.3%	7.1%	12.4%
	Flood	3,833	4,692	4,530	3,990	45.6%	57.4%	55.6%	49.4%	11.7%	-1.7%	-6.2%	3.8%
	Totals	**3,833**	**4,692**	**4,966**	**4,994**	**45.6%**	**57.4%**	**61.0%**	**61.8%**	**11.7%**	**3.6%**	**0.8%**	**16.2%**

NoIrr

Multi-Use	3,964	3,206	2,956	2,842	47.2%	39.2%	36.3%	35.2%	-8.0%	-2.9%	-1.1%	-12.0%
Hay/Pasture	606	283	223	243	7.2%	3.5%	2.7%	3.0%	-3.8%	-0.7%	0.3%	-4.2%
Totals	**4,570**	**3,488**	**3,179**	**3,085**	**54.4%**	**42.6%**	**39.0%**	**38.2%**	**-11.7%**	**-3.6%**	**-0.8%**	**-16.2%**

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	0.8	0.2	0.8	2.6	0.0	0.7	6.5	3.7	5.5
Max	500.7	159.2	118.8	246.1	421.8	478.2	28.9	8.4	13.3
Average	58.8	28.6	13.9	55.5	70.4	74.5	14.4	6.2	9.6
Sum	2,000.5	885.6	556.3	1,110.9	1,479.0	1,863.1	129.7	18.7	38.4

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)	270.6
Channel to Riparian (acres)	729.7
Riparian Encroachment (acres)	**459.1**

Riparian Recruitment

Creation of riparian areas between 1950s and 2001.

1950s Channel Mapped as 2011 Riparian (Ac)	736.1
1950s Floodplain Mapped as 2011 Channel (Ac)	97.3
Total Recruitment (1950s to 2011)(Ac)	**833.4**

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	8.1	137.1	144.3	0.0	**289.5**
Acres/Valley Mile	0.6	10.9	11.5	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 (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	35.69	0.77%	53.75	0.15	15.92	0.02

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.

Low Flow Fisheries Habitat Mapping

	2001 (Acres)		
Habitat	Bankfull	Low Flow	% of Low Flow
Scour Pool	805.0	536.5	24.0%
Rip Rap Bottom	149.6	127.5	5.7%
Rip Rap Margin	61.0	48.0	2.1%
Bluff Pool	71.9	69.6	3.1%
Terrace Pool	40.0	57.3	2.6%
Secondary Channel	53.2	73.2	3.3%
Secondary Channel (Seasonal)	232.9	175.0	7.8%
Channel Crossover	486.2	301.4	13.5%
Point Bar		65.0	2.9%
Side Bar		113.1	5.1%
Mid-channel Bar		138.6	6.2%
Island	337.6	337.6	15.1%
Dry Channel		191.5	8.6%

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 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.