

County	Treasure	Upstream River Mile	260.3
Classification	PCS: Partially confined straight	Downstream River Mile	253.8
General Location	Rosebud/Treasure County Line	Length	6.50 mi (10.46 km)

Narrative Summary

Reach C8 is 9.1 miles long and is located on the Rosebud/Treasure County line. It is a Partially Confined Straight reach type, as the river flows straight eastward along the northern bluff line.

There is approximately 4,100 feet of rock riprap in the reach, 800 feet of which was built since 2001. About 6 percent of the total bankline is armored.

Prior to 1950 about 2,300 feet of side channel had been blocked in Reach C8, and since then, floodplain dikes have blocked another 8,500 feet of side channel. Blocked side channels are located at RM 260R and RM 257R. Side channels have also been passively lost; since 1950, there has been a total loss of 2.6 miles of side channel in Reach C8. About four miles of active side channel remain.

About 35 percent of the total 100-year floodplain has become isolated due to human development. Most of the isolation is due to flow alterations. The 5-year floodplain is even more affected; 55 percent of the historic 5-year floodplain is no longer inundated at that frequency. The isolation of the historic 5-year floodplain, due primarily to flow alterations, has been associated with increased development in these areas; currently there are about 240 acres of flood irrigated land within the historic 5-year floodplain. Most of the isolated 5-year floodplain area is occupied by flood irrigated fields south of the river.

Land use is dominated by agriculture, with 342 acres of pivot irrigation development since 1950. There are about 178 acres of flood irrigated land and 12 acres of pivot within the CMZ, and 10 percent of the CMZ is restricted by physical features.

Riparian recruitment analyses show that between 1950 and 2001, there was 193 total acres of riparian colonization in the reach. Taking into account losses due to erosion, there was still a net gain of 94 acres of woody vegetation into the active channel corridor since 1950. This has occurred both on migrating point bars that have become vegetated, as well as within abandoned side channels. The extent of closed timber has increased from 293 acres in 1950 to 604 acres in 2001. There are 43 acres of Russian olive in the reach.

Reach C8 was sampled as part of the fisheries study. A total of 30 fish species were sampled in the reach, including Sauger, which are recognized by the Montana Natural Heritage Program as a Species of Concern (SOC).

Reach C8 was sampled as part of the avian study. A total of 37 bird species were identified in the reach. Two bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were found, the Ovenbird and the Chimney Swift. Reach C8 has seen an increase in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 51 acres per valley mile of such forest, and that number increased to 61 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 23 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 4,680 cfs to 2,990 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions at Reach C10 downstream where the analysis begins, a reduction of 46 percent.

CEA-Related observations in Reach C8 include:

- Active and passive loss of thousands of feet of side channel

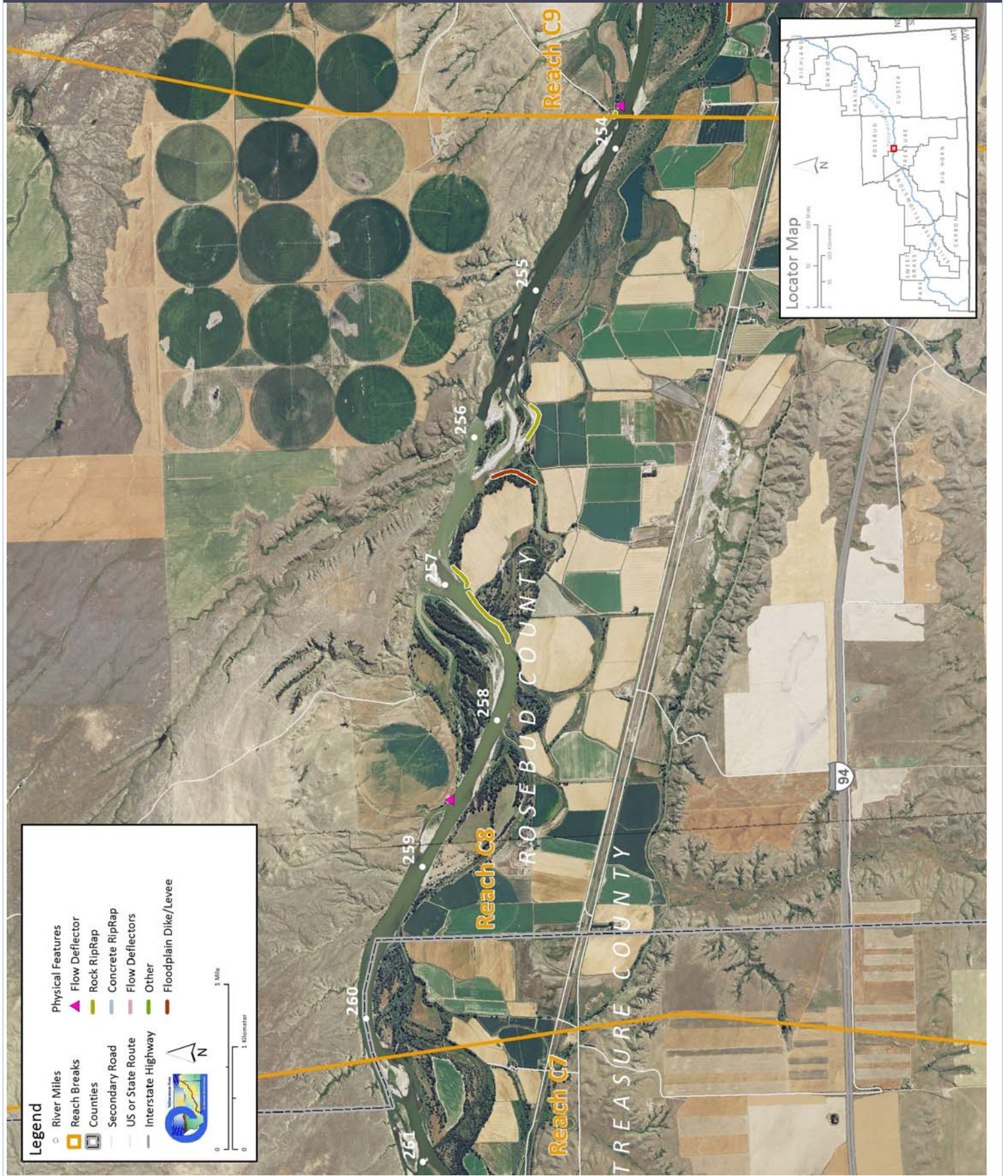
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C8 include:

- Side channel reactivation at RM 260R and RM 257R
- Russian olive removal

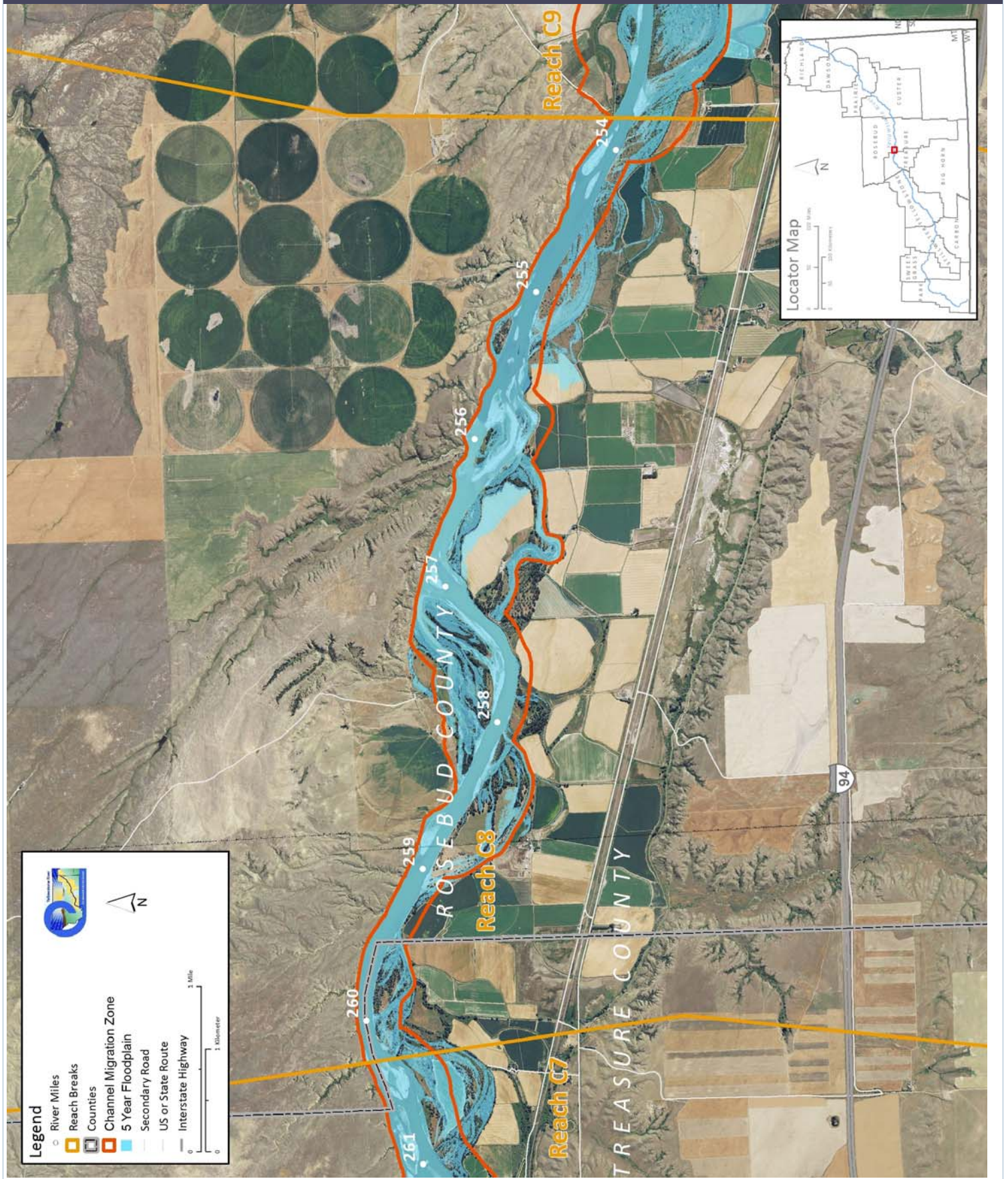
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,100	47,000	-23.1%			
100 Year (cfs)	120,000	100,000	-16.7%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	679.9	688.1	620.0	621.9	-58.0	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	4,093	6.0%	807			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	52	0.1%	52			
Total	4,145	6.1%	859			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	2,323	8,494				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)	The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.		
Total Acres	140.4	52.4				
Acres/Year	5.4	2.1				
Acres/Year/Valley Mile	0.9	0.3	93.58 acres			
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	36.5	28	26.7	91.2		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	670.6	55%				
100 Year	897.7	35%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	166.5	10%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	6,145.6	6,109.7	Flood (Ac)	2,808.1	2,783.3	
Ag. Infrastructure (Ac)	39.5	104.7	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	0.0	Pivot (Ac)	0.0	341.9	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	98.0	97.9				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	75.4	0.0	75.4	9.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	3.8	0.6	125.6			
Emergent	112.2	18.7				
Scrub/Shrub	9.6	1.6				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	43.4	0.9%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	50.7	36.3	60.9	10.3		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Rosebud	Upstream River Mile	253.8
Classification	UA: Unconfined anabranching	Downstream River Mile	243.1
General Location	Hammond Valley	Length	10.70 mi (17.22 km)

Narrative Summary

Reach C9 is 10.7 miles long and is located in the Hammond Valley upstream of Forsyth. The Hammond Valley is an unusually wide segment of the Yellowstone River corridor, similar to the Mission Valley near Hysham. These two valleys owe their shape to the presence of the Bearpaw Shale in the valley wall, which is relatively erodible and prone to mass failure. Because the Mission and Hammond Valleys are so wide, the river has developed a complex series of channels and an expansive riparian forest. These reaches are especially rich in terms of aquatic and riparian habitat extent, diversity, and geomorphic complexity. Reach C9 is an Unconfined Anabranching (UA) reach type, which is typically the most complex and dynamic reach type on the river.

Flow alterations in Reach C9 have been driven primarily by changes in flows on the Bighorn River and water use for irrigation. The 2-year discharge, which is an important flow statistic because it approximately defines the channel capacity, has dropped by 14,400 cfs, or 23.5 percent, due to flow alterations on the river. That reduction in flow has been accompanied by a reduction in the bankfull channel area, or channel size, by 209 acres since 1950.

There are over 10,000 feet of rock riprap in Reach C9, as well as 1,100 feet of flow deflectors. This reach experienced severe bank erosion during the 2011 flood when some banks migrated several hundred feet. In response to that erosion, several thousand feet of bank armor were constructed after 2001, mostly on the south side of the river. This riprap represents both new projects and extensions on older projects. Some flow deflectors in the reach were flanked during the flood and now sit in the middle of the river. Other impacts in Reach C9 include almost four miles of side channel that have been blocked by dikes. This loss is due to the blockage of one very long side channel on the north side of the corridor that was clearly active in 1950, but by 1976 was plugged on its upper end.

The combination of bank armoring and reduced energy due to flow alterations has resulted in a reduced floodplain turnover rate in Reach C9 from 22.2 acres per year to 12.9 acres per year. The area of open bar habitat mapped under low flow conditions dropped by almost 100 acres since 1950, reflecting riparian expansion into the channel, reduced sediment recruitment from banks, and reduced sediment loading from the Bighorn River.

Over 40 percent of the land area that was historically inundated by a 5-year flood now remains dry during that frequency event. Most of these isolated areas currently typically flood irrigated fields, some of which were riparian forest in the 1950s. The vast majority of irrigated land in Reach C9 is under flood irrigation (3,900 acres) while 515 acres are under pivot. In the upstream end of the reach, pivots on either side of the river extend into the Channel Migration Zone. About 6 percent of the total CMZ has been restricted by physical features.

There are several animal handling facilities in Reach C9 that are adjacent to the main river channel or smaller side channels, tributaries, or swales. These are located at RM 252L (side channel), RM 248L (tributary), and RM 245R (main channel).

Reach C9 was sampled as part of the avian study. A total of 73 bird species were identified in the reach. Five bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were found, the Black and White Warbler, Dickcissel, Plumbeous Vireo, Ovenbird, and Chimney Swift. Three Species of Concern (SOC) were identified, the Black-billed Cuckoo, Bobolink, and Red-headed Woodpecker. With the expansion of agriculture in the reach, the extent of forest at low risk of cowbird parasitism dropped from 108 acres per valley mile in 1950 to 64 acres per valley mile in 2001.

Reach C9 has 74 acres of mapped Russian olive, which appears to be concentrated on the banks of isolated side channels and sloughs, but also distributed through cottonwood forest in the downstream portion of 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 24 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 4,720 cfs to 3,020 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions at Reach C10 downstream where the analysis begins, a reduction of 46 percent.

CEA-related observations in Reach C9 include:

- Reduced floodplain and riparian turnover rates due to flow alterations and bank armoring
- Lost side channel extent due to side channel plugs
- Expansion of Russian olive into abandoned side channels and riparian forest
- 5-year floodplain isolation due to agricultural dikes and flow alterations
- Encroachment of pivot irrigation into Channel Migration Zone
- Increased risk of cowbird parasitism with agricultural expansion

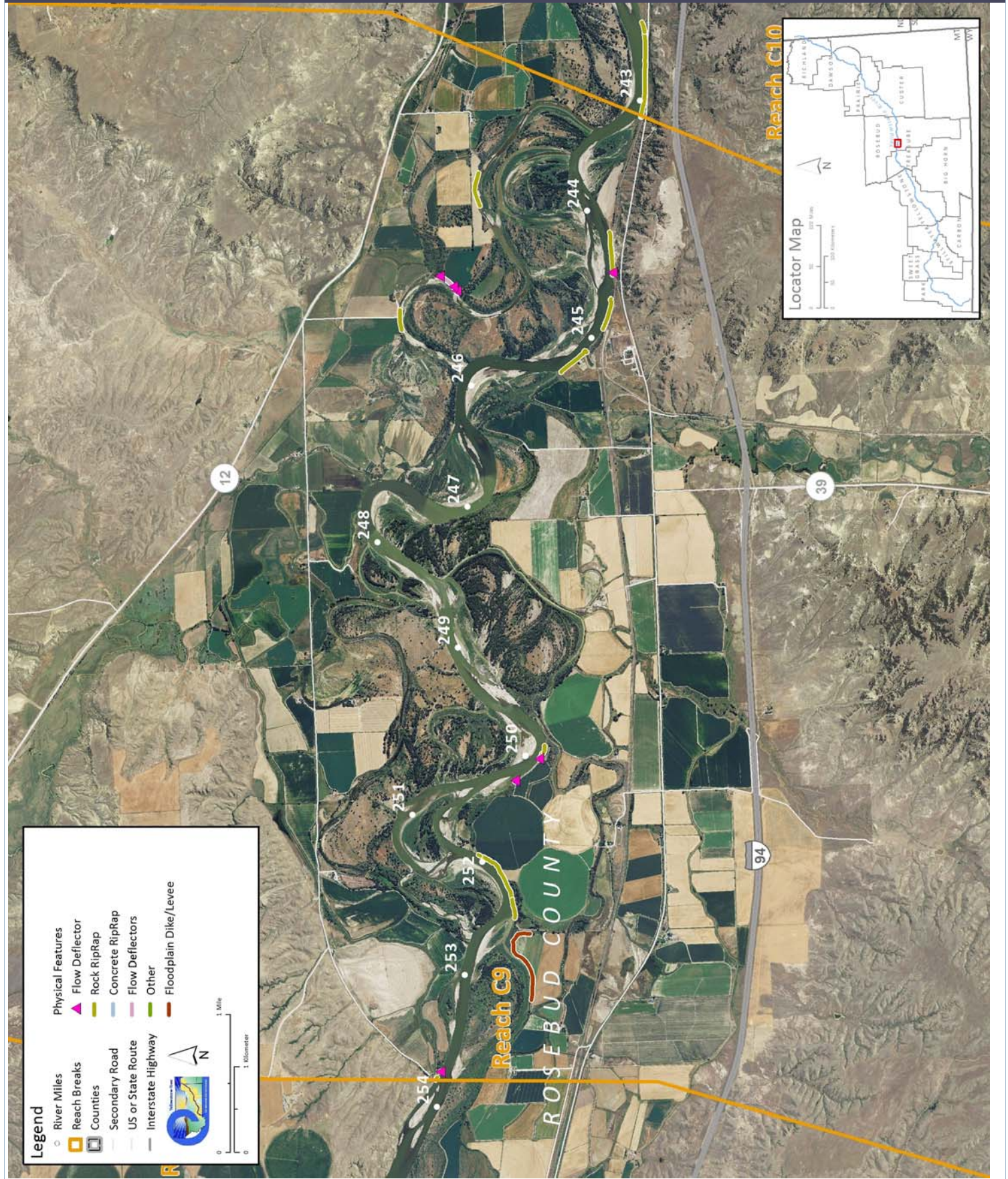
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C9 include:

- Side channel reactivation at RM 252L
- Nutrient management associated with animal handling facilities at RM 252L, RM 248L, and RM 245R.
- Russian olive removal

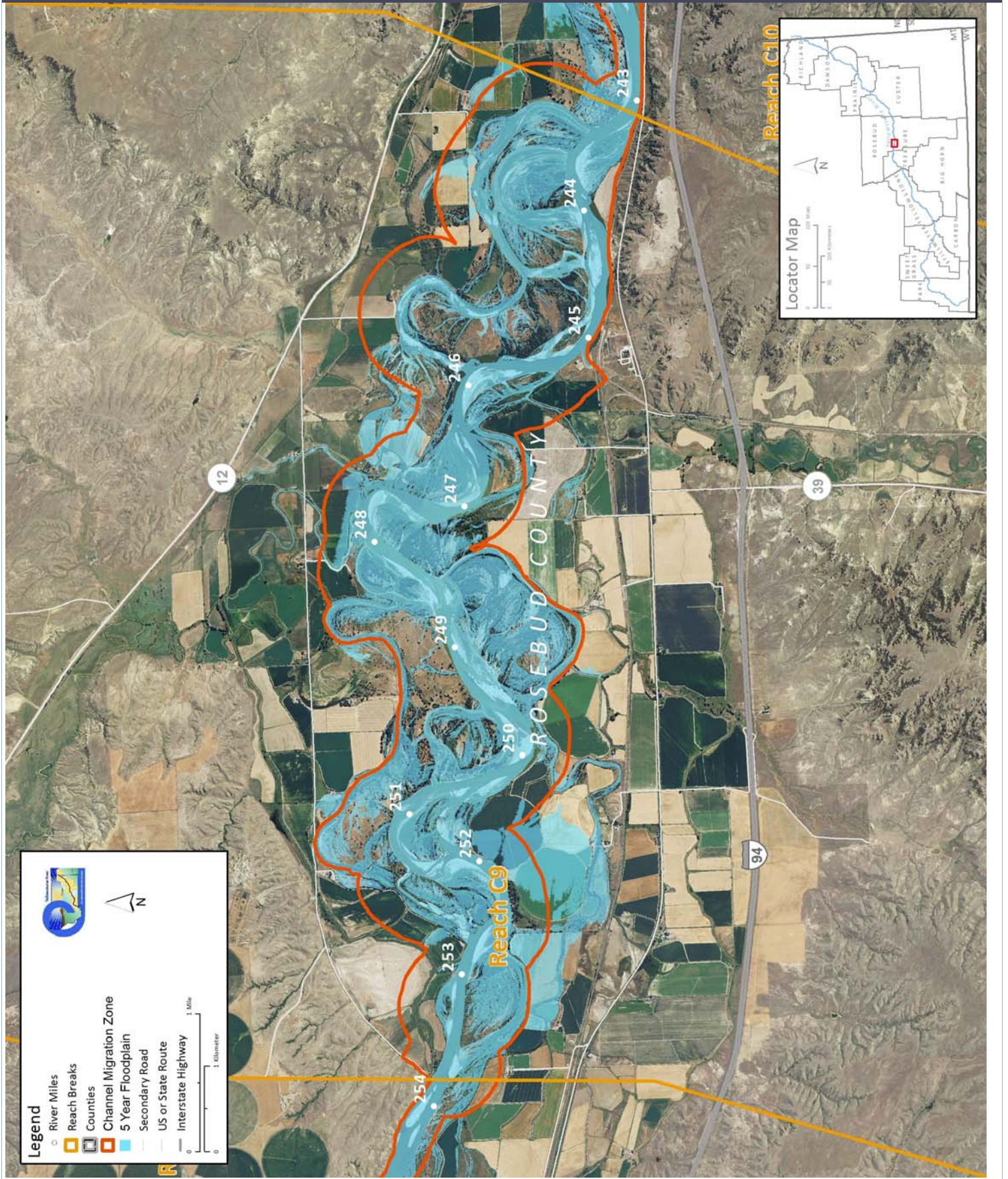
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,300	46,900	-23.5%			
100 Year (cfs)	121,000	101,000	-16.5%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	1,562.4	1,537.8	1,336.0	1,353.3	-209.1	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	10,283	9.1%	4,427			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	1,113	1.0%	160			
Total	11,396	10.1%	4,587			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	19,348				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)	The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.		
Total Acres	576.1	323.2				
Acres/Year	22.2	12.9				
Acres/Year/Valley Mile	2.9	1.7	384.59 acres			
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-71.6	17	-44.2	-98.8		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	2,045.9	43%				
100 Year	300.4	5%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	333.2	6%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	8,021.5	8,458.6	Flood (Ac)	3,895.4	3,498.6	
Ag. Infrastructure (Ac)	88.2	312.0	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.9	27.5	Pivot (Ac)	0.0	515.0	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	115.4	104.6				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	253.9	0.0	253.9	8.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	29.2	3.8	582.1			
Emergent	308.5	40.0				
Scrub/Shrub	244.4	31.7				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	74.0	0.7%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	108.0	65.4	64.1	-44.0		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Rosebud	Upstream River Mile	243.1
Classification	PCM: Partially confined meandering	Downstream River Mile	236.3
General Location	Forsyth	Length	6.80 mi (10.94 km)

Narrative Summary

Reach C10 is 6.8 miles long and is located at Forsyth. It is a Partially Confined Meandering reach type, as the river flows within a primary meandering thread that is partially confined by the northern bluff line at the Forsyth Bridge.

There is approximately three miles of rock riprap in the reach, 500 feet of which was built since 2001. About a mile of armor is protecting the active rail line on the south side of the river, and another 3,700 feet are protecting the city of Forsyth. Just below Cartersville Dam, a ~330 foot-long stretch of bank armor was flanked sometime between 2001 and 2011. The river has since migrated to the south about 50 feet past the abandoned armor. As of 2011 there were 1,600 feet of flow deflectors mapped in the reach. About 22 percent of the total bankline is armored by either rock riprap or flow deflectors. There is also about a mile of floodplain dikes/levees in the reach, which are located on the south bank at Forsyth.

Cartersville Dam is located at RM 238.5 in the town of Forsyth. This diversion dam was constructed in the early 1930's and consists of a rock rubble riprap core that is capped by concrete. The structure is 800 feet long, spanning the width of the Yellowstone River. The river flows within a single thread at the structure, flowing along the northern bluff line of the Yellowstone River valley. Because of its impacts on the Yellowstone River fishery, efforts have begun to develop suitable alternatives and bypass designs to promote fish passage at Cartersville.

About 20 percent of the total 100-year floodplain has become isolated due to human development. The isolation is due to a combination of floodplain dikes that protect the city of Forsyth and the active railroad. The 5-year floodplain is even more affected; 50 percent of the historic 5-year floodplain is no longer inundated at that frequency. Most of the isolated 5-year floodplain area is occupied by flood irrigated fields north of the river, and by urban development in Forsyth. At RM 238 the river is migrating northward, and has reached the toe of the abandoned Milwaukee Rail Line embankment. Migration through this grade will increase floodplain access on the north side of the river downstream of Cartersville Dam. As this is an urban reach, strategic floodplain reconnection in this area could be beneficial.

One ice jam was reported in Reach C10 in February of 1996. No damages were reported.

Land use is dominated by agriculture (~4,700 acres), with 280 acres of pivot irrigation development since 1950. There are about 850 acres of urban/exurban development in the reach. About 4 percent of the CMZ is restricted by physical features, and most of that area is in town.

There are 250 acres of Russian olive in the reach, most of which is dispersed in riparian areas. Russian olive densities are especially high downstream of Cartersville Diversion dam on the south bank of the river near the water treatment plant.

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 24 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 4,730 cfs to 3,020 cfs with human development, a reduction of 36 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,150 cfs under unregulated conditions to 3,320 cfs under regulated conditions, a reduction of 46 percent.

CEA-Related observations in Reach C10 include:

- Floodplain isolation due to urban/exurban development.
- Extensive Russian olive colonization in urbanized reach

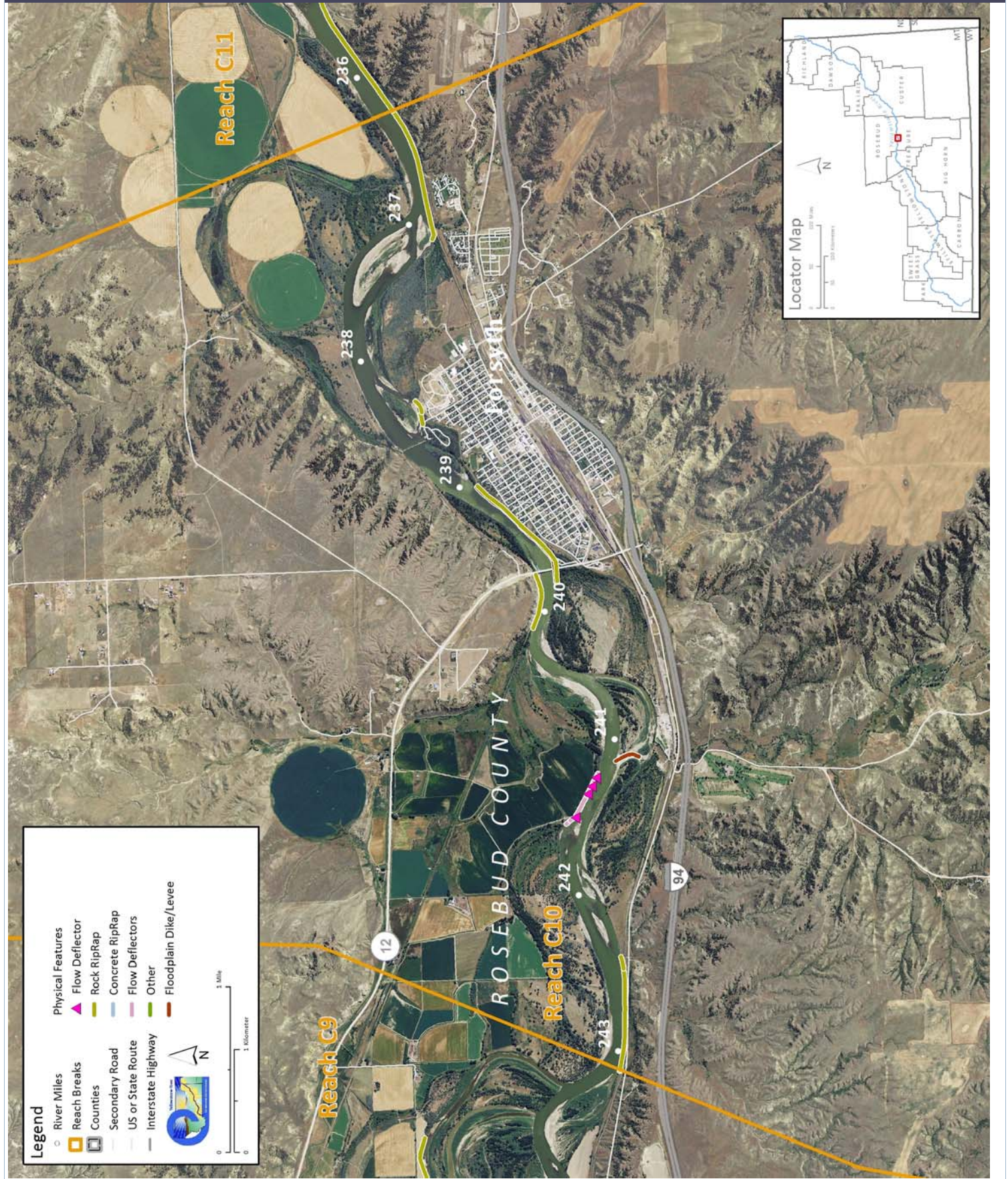
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C10 include:

- Floodplain reconnection at RM 238L behind abandoned Milwaukee rail line.
- Diversion structure management at Cartersville Dam
- Watercraft passage at Cartersville Dam
- Fish Passage at Cartersville Dam
- Flanked bank armor removal at RM 238.4R
- Russian olive removal

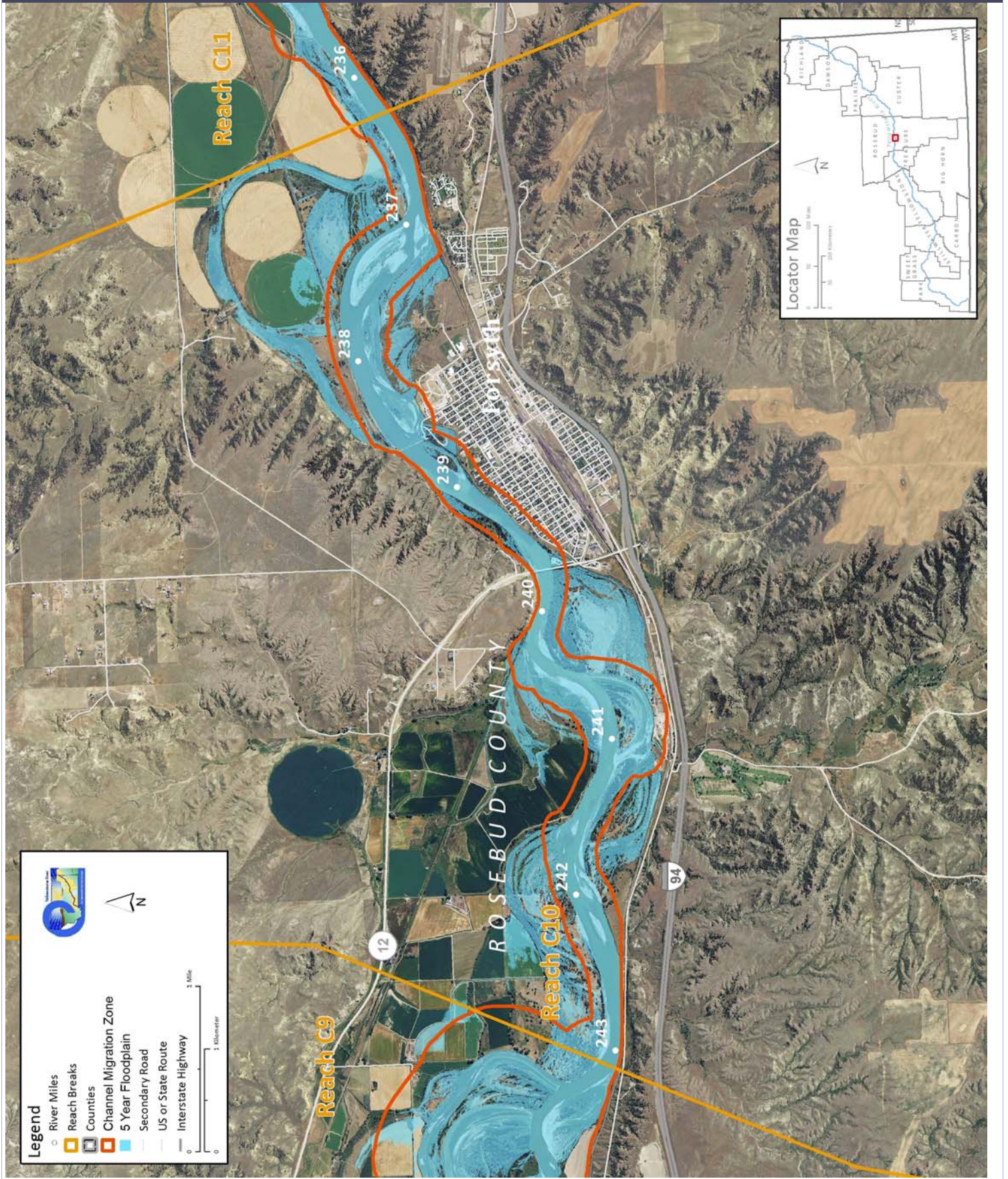
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Discharge										"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
	2 Year (cfs)	61,300	46,900	-23.5%								
	100 Year (cfs)	121,000	101,000	-16.5%								
Bankfull Channel Area (Ac)												
	1950	1976	1995	2001	1950-2001					Bankful channel area is the total footprint of the river inundated at approx. the 2-year flood.		
	647.9	683.5	628.3	629.8	-18.2							
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.								
	Rock RipRap	14,306	19.8%	493								
	Concrete Riprap	0	0.0%	0								
	Flow Deflectors	1,648	2.3%	-262								
	Total	15,953	22.1%	231								
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.									
	0	0										
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)				The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.					
	Total Acres	92.4	61.3	32.02 acres								
	Acres/Year	3.6	2.5									
	Acres/Year/Valley Mile	0.6	0.4									
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.							
	Change in Area '50 - '01 (Ac)	-11.2	-7	-11	-29.2							
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.									
	5 Year	1,118.9	50%									
	100 Year	635.9	20%									
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.									
	72.6	4%										
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.							
	Agricultural Land (Ac)	5,392.3	4,716.9	Flood (Ac)	904.3	874.1						
	Ag. Infrastructure (Ac)	28.7	103.6	Sprinkler (Ac)	0.0	0.0						
	Exurban (Ac)	0.0	141.6	Pivot (Ac)	0.0	278.3						
	Urban (Ac)	483.8	728.0									
	Transportation (Ac)	107.1	247.6									
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.							
	0.0	20.5	20.5	1.0%								
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).								
	Riverine	11.6	1.9	131.2								
	Emergent	89.6	14.8									
	Scrub/Shrub	30.1	5.0									
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.									
	250.5	5.7%										
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.							
	82.0	15.1	20.2	-61.8								

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Rosebud	Upstream River Mile	236.3
Classification	PCM/I: Partially confined meandering/islands	Downstream River Mile	225
General Location	Forsyth to Cartersville Bridge	Length	11.30 mi (18.19 km)

Narrative Summary

Reach C11 is located in Rosebud County, just downstream from the community of Forsyth. The reach is an 11.3 mile long Partially Confined Meandering channel type, extending from RM 225.0 to RM 236.3. The partial confinement is imposed by bedrock bluffs south of the river. The floodplain area north of the river has become isolated by about 9 miles of abandoned railroad grade. Rosebud Creek enters the Yellowstone River in the lowermost end of the reach from the south, and Little Porcupine Creek and Horse Creek flow in from the north. The Far West fishing access is located on the north bank at the downstream end of the reach. Reach C11 is relatively dynamic with most erosion and bank migration occurring on the downstream limbs of major meanders.

In Reach C11, the river commonly runs along the southern bluff line that is made up of Cretaceous age Lance Formation and Hell Creek Formation. The BNSF line follows this edge of the valley, and as a result much of the bluff line is armored. According to Womack (2001), the Hell Creek Formation in this area consists of resistant cemented sandstone that forms a 12 foot cap over claystone, which is subject to small slumps on the very steep slope below the rail line, thus driving the need for bank armor. Bank migration is also very active in the reach; at RM 229 for example, the river has migrated almost 700 feet southward since 1950 and is now within 100 feet of the rail line.

As of 2011 there were over 4.5 miles of bank armor protecting about 20 percent of the total bankline in Reach C11, and almost all of that armor is rock riprap protection against the active rail line. Since 2001, about 1,500 feet of flow deflectors have been built in the reach as well to protect irrigated fields on the north bank. Physical features mapping indicates the loss of 500 feet of car bodies between 2001 and 2011 at RM 230.1L where the bank has eroded behind the car bodies which are now up to 70 feet out in the river. A ~500 foot-long stretch of rock riprap on the north side of the river at RM 226.6R is currently protecting flood irrigated land, but is becoming flanked on its upstream end.

Reach C11 has seen major losses of side channels due to small floodplain dikes. Since 1950, 4.3 miles of side channel have been blocked. Three major side channels have dikes blocking them; at RM 232R across from the mouth of Porcupine Creek, at RM 230L below the mouth of Horse Creek, and at RM 229R. All of these channels appear to have good potential for reactivation. There are other older dikes that block swales that could also be potentially reactivated (e.g. RM 234R).

Similar to other reaches downstream of the Bighorn River confluence, the river channel has become smaller in Reach C11 since 1950. In 2001, the bankfull footprint was about 130 acres smaller than it was in 1950, and riparian mapping shows over 200 acres of riparian encroachment into old channel areas. Floodplain turnover rates are also lower; from 1950-1975 the average annual rate of floodplain turnover was 9.3 acres per year, and since 1975 it has been 6.4 acres per year.

On the north side of the river, the abandoned Milwaukee rail line isolates extensive historic floodplain area. At the 100 year event, 767 acres of contiguous area is isolated by the old rail line embankment, accounting for 17 percent of the mapped 100-year floodplain area. Just upstream of the mouth of Horse Creek, however, the river has migrated through the embankment. That erosion through the embankment will continue as the river is actively flanking rock riprap at the mouth of Horse Creek. The active BNSF line also isolates pockets of historic floodplain on the south side of the river.

A total of 328 acres of land that would normally be in the river's natural Channel Migration Zone (CMZ) have become restricted by physical features, which represents about 9 percent of the total CMZ area.

Land uses in Reach C11 are predominantly agricultural, with some conversion from flood irrigation to pivot since 1950. As of 2011 there were about 450 acres under pivot irrigation in the reach, and 76 of those acres are within the 5-year floodplain. Pivot irrigation has also encroached into the CMZ; about 65 acres that were developed for pivot are within the CMZ footprint. This area under pivot is at RM 227.5R, where a large pivot field has been developed in the core of a major meander. Irrigation development included riparian clearing; between 1950 and 2011 about 124 acres of riparian area was cleared for irrigation, which is 8 percent of the total 1950s riparian area.

Reach C11 hosts a relatively dense concentration of wetlands; there are almost 40 acres of wetland per valley mile in the reach, most of which is emergent marshes and wet meadows. There are also 183 acres of mapped Russian olive in the reach, which is distributed throughout the riparian zone and locally concentrated in blocked side channels.

Reach C11 was sampled as part of the fisheries study. A total of 27 species were sampled in the reach, including Sauger and Blue Sucker, both of which have been identified as Species of Concern by the Montana Natural Heritage Program.

Reach C11 was also sampled as part of the avian study. A total of 42 bird species were identified in the reach, including three Species of Concern: The Chimney Swift, Ovenbird, and Plumbeous Vireo. Reach C11 has seen a reduction in the extent of riparian forest considered at low risk of cowbird parasitism. In 1950, there were 31.3 acres of such forest per valley mile, and by 2001 that forest extent had dropped to 19.8 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 24 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 4,820 cfs to 3,060 cfs with human development, a reduction of 37 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,300 cfs

under unregulated conditions to 3,370 cfs under regulated conditions, a reduction of 47 percent.

Fall and winter base flows have increased in Reach C11 by about 60 percent.

CEA-Related observations in Reach C11 include:

- Extensive floodplain isolation by the abandoned Milwaukee rail line on the north bank.
- Extensive blocking of side channels
- A regionally high extent of Russian olive possibly associated with the loss of side channels.
- Extensive armoring with CMZ encroachment
- Flanking of car bodies
- Active flanking of riprap

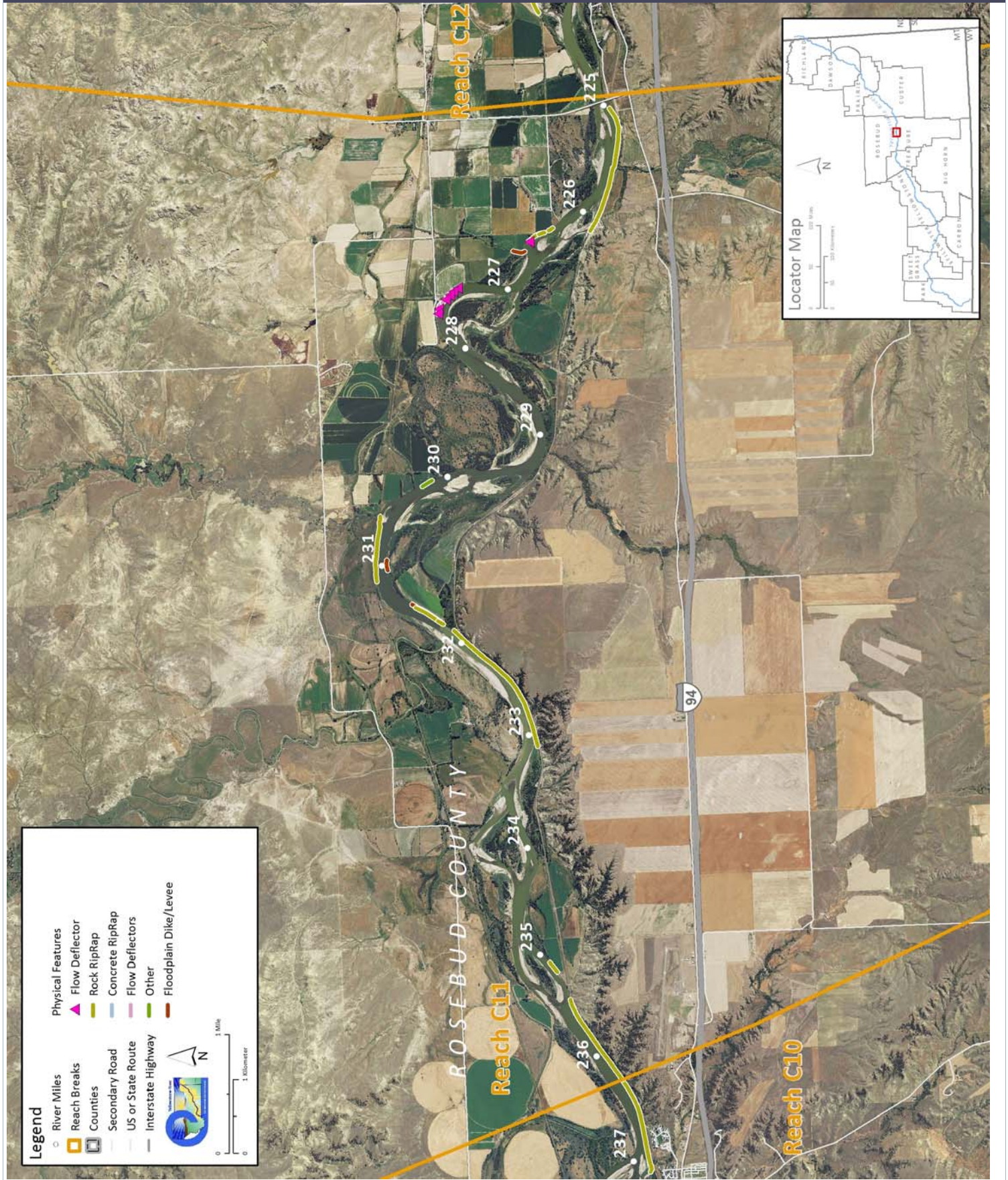
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C11 include:

- Removal of car bodies in river at RM 230.1L
- Side channel reactivation at RM 232R, RM 230L, and RM 229 R.
- Floodplain reconnection behind abandoned railroad grade RM 231L
- Russian olive removal

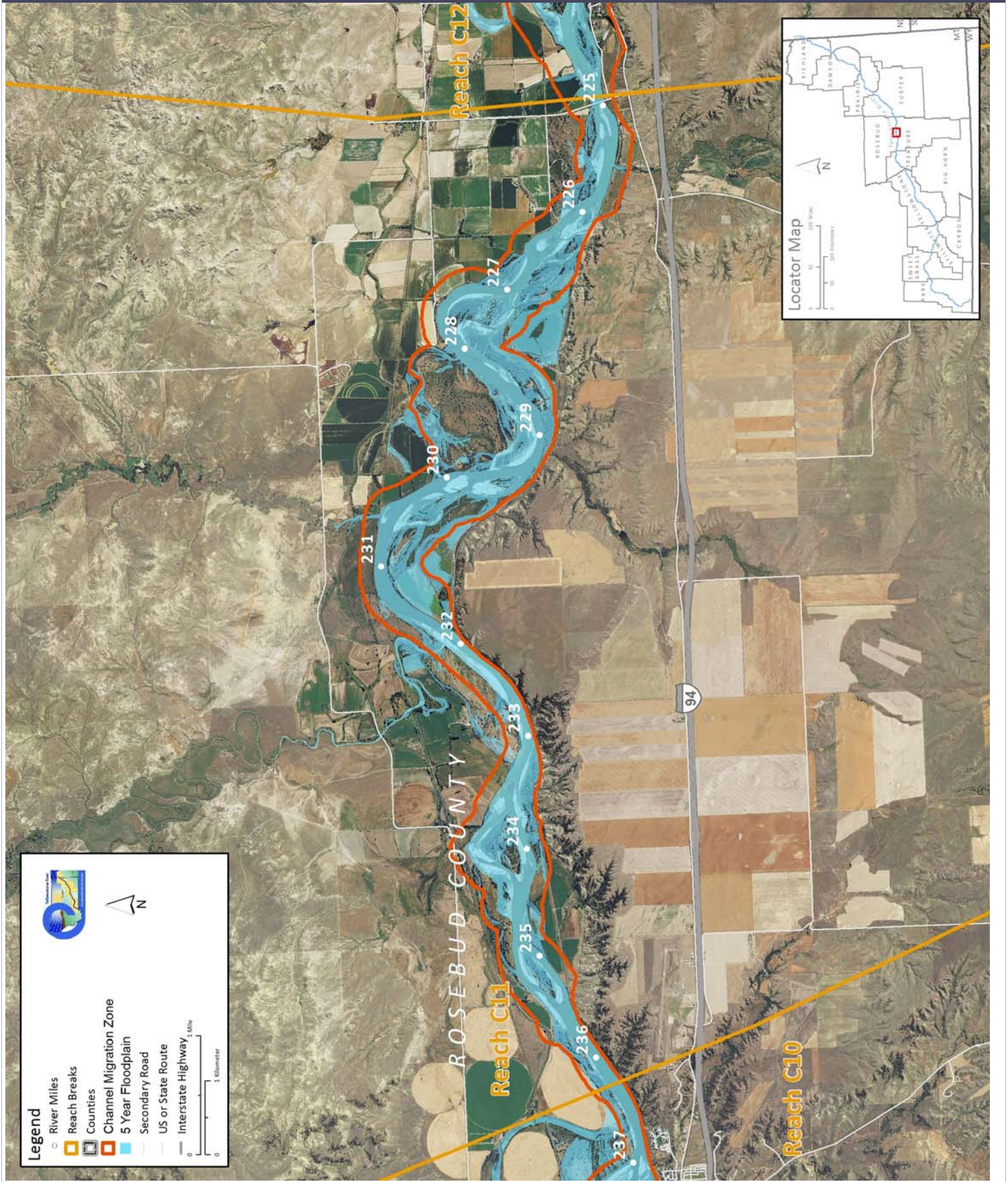
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,800	47,200	-23.6%			
100 Year (cfs)	120,000	99,000	-17.5%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	1,314.1	1,280.1	1,149.5	1,190.3	-123.8	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	22,607	18.8%	816			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	1,511	1.3%	1,511			
Total	24,118	20.1%	2,328			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	22,745				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	241.5	159.1	211.61 acres			
Acres/Year	9.3	6.4				
Acres/Year/Valley Mile	1.1	0.7				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-50.3	41.6	44.5	35.9		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	1,289.7	51%				
100 Year	1,123.9	25%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	328.1	9%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	8,045.7	8,737.7	Flood (Ac)	3,056.3	2,655.9	
Ag. Infrastructure (Ac)	67.8	86.7	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	0.0	Pivot (Ac)	0.0	451.4	
Urban (Ac)	2.0	2.0				
Transportation (Ac)	148.6	123.6				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	123.5	1.7	125.1	8.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	51.2	5.8	356.8			
Emergent	230.5	26.1				
Scrub/Shrub	75.1	8.5				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	182.6	2.3%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	31.3	22.5	19.8	-11.5		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Rosebud	Upstream River Mile	225
Classification	PCM/I: Partially confined meandering/islands	Downstream River Mile	214.8
General Location	Rosebud	Length	10.20 mi (16.42 km)

Narrative Summary

Reach C12 is 10.2 miles long and extends from the Rosebud Bridge at RM 225 downstream to RM 215. The reach classified as Partially Confined Meandering with Islands (PCM/I), indicating some influence of the valley wall, a main meandering channel thread, and numerous meander cutoffs that have generated large islands. The reach is relatively dynamic; at RM 221.5 for example the river has migrated over 900 feet to the northwest since 1950. At RM 217.2R, the river migrated over 300 feet between 2001 and 2011. Most of the rapid migration is on the outer edges (apices) and downstream limbs of large meanders.

As of 2011 there were 4,700 feet of bank armor protecting about 4 percent of the total bankline in Reach C12, and almost all of that armor is rock riprap. About one half of the armor was built between 2001 and 2011. One short section (200 feet) of flow deflectors was also built between 2001 and 2011. The bank armor is protecting agricultural land and the active rail line. Almost 2,000 feet of the mapped bank armor is north of the town of Rosebud on a channel that has been largely abandoned. This channel abandonment has focused flows in the south channel, which currently flows against the town of Rosebud which has minimal erosion protection.

Prior to 1950, about ½ miles of side channel in Reach C12 were blocked. One short channel is just upstream of the town of Rosebud, and a much longer channel is on the south side of the river at RM 219R.

Similar to other reaches downstream of the Bighorn River confluence, the river channel has become smaller in Reach C12 since 1950. In 1950, the bankfull footprint was about 56 acres larger than it was in 2001, and riparian mapping shows over 211 acres of riparian encroachment into old channel areas. Some of that encroachment has been onto mid-channel bars; there was a net loss of 36 acres of open bars since 1950. Floodplain turnover rates are also lower; from 1950-1975 the average annual rate of floodplain turnover was 8.9 acres per year, and since 1975 it has been 5.8 acres per year.

Over a thousand acres of the 100-year floodplain has become isolated from the river, most of which is north of the abandoned rail line. Several pockets of historic 100-year floodplain have also been isolated on the south side of the river between the rail line and bluff area. In total, 29 percent of the entire historic 100-year floodplain has become isolated. Isolation of the 5-year floodplain has been even more substantial; 1,340 acres or 47 percent of the 5-year floodplain has become isolated at that event. Much of this isolated 5-year floodplain is on flood irrigated fields north of the river.

A total of 216 acres of land that would normally be in the river's natural Channel Migration Zone (CMZ) have become restricted by physical features, which represents about 6 percent of the total CMZ area. At Rosebud, 59 acres of urban/exurban land has been mapped within the CMZ.

Land uses in Reach C12 are predominantly agricultural, with some conversion from flood irrigation to pivot since 1950. As of 2011 there were about 430 acres under pivot irrigation in the reach, and 197 of those acres are within the 5-year floodplain. Pivot irrigation has also encroached into the CMZ; about 200 acres that were developed for pivot are within the CMZ footprint. Irrigation development largely occurred prior to 1950, but additional development since then has included riparian clearing; between 1950 and 2011 about 45 acres of riparian area was cleared for irrigation, which is 5 percent of the total 1950s riparian area.

One animal handling facility was mapped at RM 222L that extends to the river bank.

There are 206 acres of mapped Russian olive in the reach, which is distributed throughout the riparian zone.

Reach C12 was sampled as part of the fisheries study. A total of 37 species were sampled in the reach, including Sauger and Blue Sucker, both of which have been identified as Species of Concern by the Montana Natural Heritage Program.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 100-year flood has dropped by 17 percent and the 2-year flood, which strongly influences overall channel form, has dropped by 24 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 4,830 cfs to 3,060 cfs with human development, a reduction of 37 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,310 cfs under unregulated conditions to 3,380 cfs under regulated conditions, a reduction of 46 percent.

Fall and winter base flows have increased in Reach C12 by about 60 percent.

CEA-Related observations in Reach C12 include:

- Extensive floodplain isolation by the abandoned Milwaukee rail line on the north bank.
- Blocking of side channels

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C12 include:

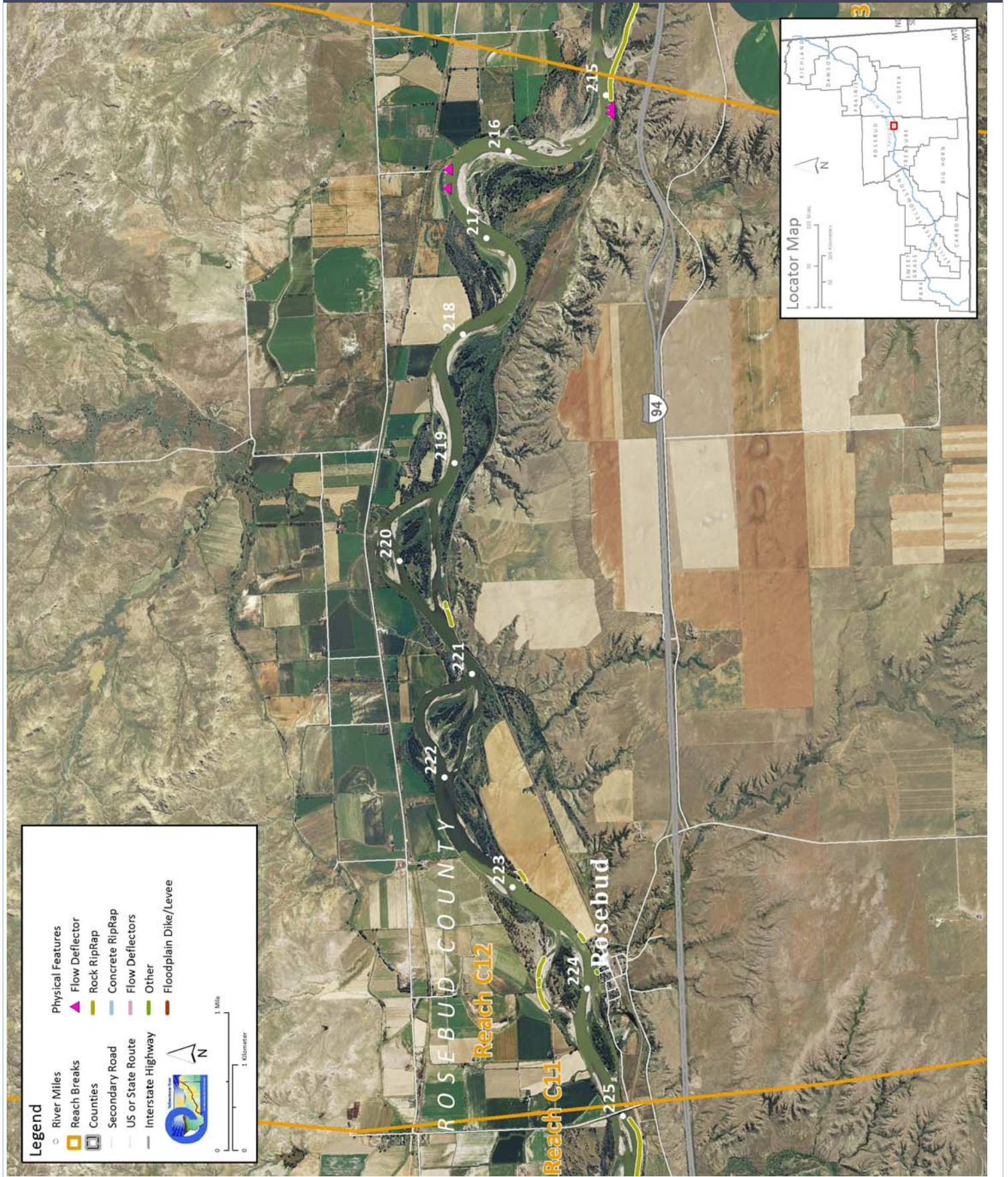
- Side channel reactivation at RM 219 R.
- Floodplain reconnection behind abandoned railroad grade RM 220L
- Nutrient management at Animal Handling Facility at RM 222L

- Russian olive removal

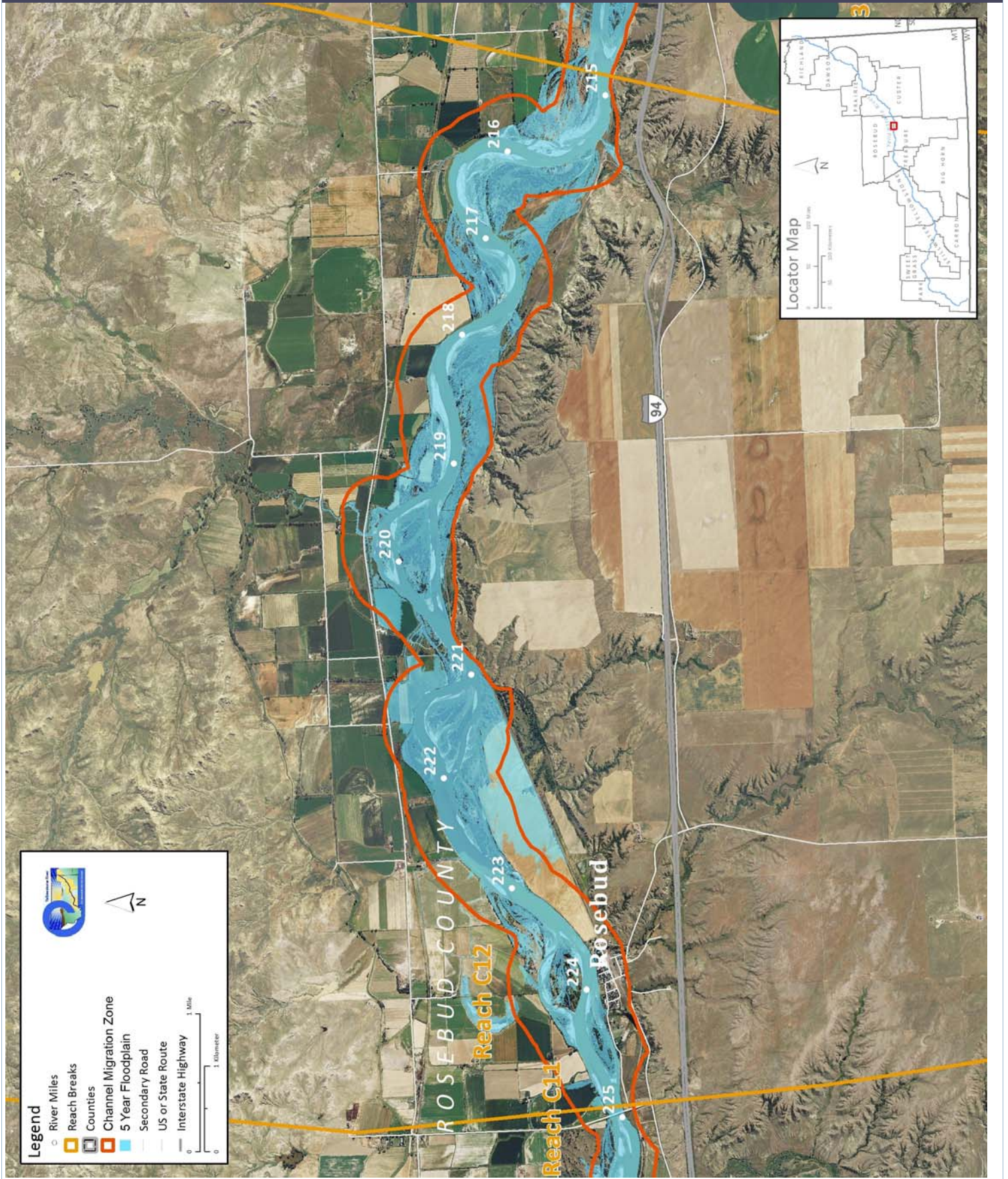
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,900	47,300	-23.6%			
100 Year (cfs)	120,000	98,900	-17.6%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	1,087.9	1,069.8	1,020.0	1,033.1	-54.8	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	4,510	4.2%	1,833			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	192	0.2%	192			
Total	4,702	4.4%	2,025			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	9,079	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)	The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.		
Total Acres	230.2	145.9	211.32 acres			
Acres/Year	8.9	5.8				
Acres/Year/Valley Mile	1.1	0.7				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-40	49.8	-45.7	-36		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	1,339.7	47%				
100 Year	1,237.1	29%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	216.0	6%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	7,038.5	7,052.1	Flood (Ac)	3,834.0	2,866.5	
Ag. Infrastructure (Ac)	76.1	128.5	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	1.6	Pivot (Ac)	0.0	429.5	
Urban (Ac)	61.1	59.5				
Transportation (Ac)	162.9	136.7				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	45.4	2.5	47.9	5.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	23.3	2.9	230.4			
Emergent	122.7	15.3				
Scrub/Shrub	84.4	10.6				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	205.6	2.8%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	18.8	14.2	31.0	12.2		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Rosebud	Upstream River Mile	214.8
Classification	PCM/I: Partially confined meandering/islands	Downstream River Mile	208.1
General Location	Hathaway	Length	6.70 mi (10.78 km)

Narrative Summary

Reach C13 is 6.7 miles long and extends from RM 215 to RM 208 in Rosebud County. The reach classified as Partially Confined Meandering with Islands (PCM/I), indicating some influence of the valley wall, a main meandering channel thread, and numerous meander cutoffs that have generated large islands. Within this reach the river crosses the valley bottom from the southern bluff line in the upper portion of the reach to the northern bluff line downstream. The length of river between bluff lines is about three miles. Reach C13 locally exhibits very rapid meander migration; at RM 211 for example, the river has migrated 960 feet to the northwest over the last 50 years. At this location the river is now within 65 feet of the abandoned Milwaukee rail line which forms a defacto flood control levee on the north side of the river.

As of 2011 there were about three miles of riprap and flow deflectors protecting 26 percent of the total bankline in Reach C13, including 13,400 feet of rock riprap, 750 feet of concrete riprap, and 4,600 feet of flow deflectors. Most of the rock riprap is protecting the rail line on the south bluff line and the abandoned rail line on the north bluff line. Another 1,350 feet of bankline is protected by old car bodies at RM 201R. All of the flow deflectors, concrete riprap, and car bodies are protecting irrigated fields. Between 2001 and 2011, about 4,000 feet of flow deflectors that were mapped at RM 212.3R were evidently destroyed. It is difficult to tell from the imagery alone whether all of these flow deflectors were flanked, however at RM 212.0, flow deflectors are sitting in the river about 60 feet off of the bank.

Since 1950, a side channel that is about 4,600 feet long was blocked at RM 211.5R. This channel cuts through the core of a large meander, and appears to be naturally reactivating as the bendway translates down the river valley.

Similar to other reaches downstream of the Bighorn River confluence, the river channel has become smaller in Reach C13 since 1950. In 1950, the bankfull footprint was about 76 acres larger than it was in 2001, and riparian mapping shows about 120 acres of riparian encroachment into old channel areas. Floodplain turnover rates are also slightly lower; from 1950-1975 the average annual rate of floodplain turnover was 5.0 acres per year, and since 1975 it has been 4.1 acres per year.

Over 600 acres of the 100-year floodplain has become isolated from the river due to flow alterations, agricultural development, and the abandoned railroad grade. In total, 20 percent of the entire historic 100-year floodplain has become isolated. Isolation of the 5-year floodplain has been even more substantial; 921 acres or 45 percent of the 5-year floodplain has become isolated at that frequency event. Much of this isolated 5-year floodplain is on flood irrigated fields both north and south of the river.

One ice jam was reported in the reach as a break-up event that occurred on March 15, 2011. No damages were reported.

A total of 221 acres of land that would normally be in the river's natural Channel Migration Zone (CMZ) have become restricted by physical features, which represents about 11 percent of the total CMZ area.

Land uses in Reach C13 are predominantly agricultural, with some conversion from flood irrigation to pivot since 1950. As of 2011 there were about 330 acres under pivot irrigation in the reach. Irrigation development largely occurred prior to 1950, but additional development since then has included riparian clearing; between 1950 and 2011 about 133 acres of riparian area was cleared for irrigation, which is 11 percent of the total 1950s riparian area.

There are 216 acres of mapped Russian olive in the reach, which is notably concentrated in abandoned side channels. Reach C13 also has fairly extensive mapped wetlands; there are over 32 mapped wetland acres per valley mile in the reach, most of which is emergent marsh and wet meadows in floodplain swales.

Reach C13 was sampled as part of the fisheries study. A total of 27 species were sampled in the reach, including Sauger and Blue Sucker, both of which have been identified as Species of Concern by the Montana Natural Heritage Program.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 100-year flood has dropped by 18 percent and the 2-year flood, which strongly influences overall channel form, has dropped by 24 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 4,840 cfs to 3,070 cfs with human development, a reduction of 37 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,320 cfs under unregulated conditions to 3,380 cfs under regulated conditions, a reduction of 47 percent.

Fall and winter base flows have increased in Reach C13 by about 60 percent.

CEA-Related observations in Reach C13 include:

- Floodplain isolation by the abandoned Milwaukee rail line on the north bank.
- Blocking of side channels
- Post-1950s riparian clearing for irrigation development

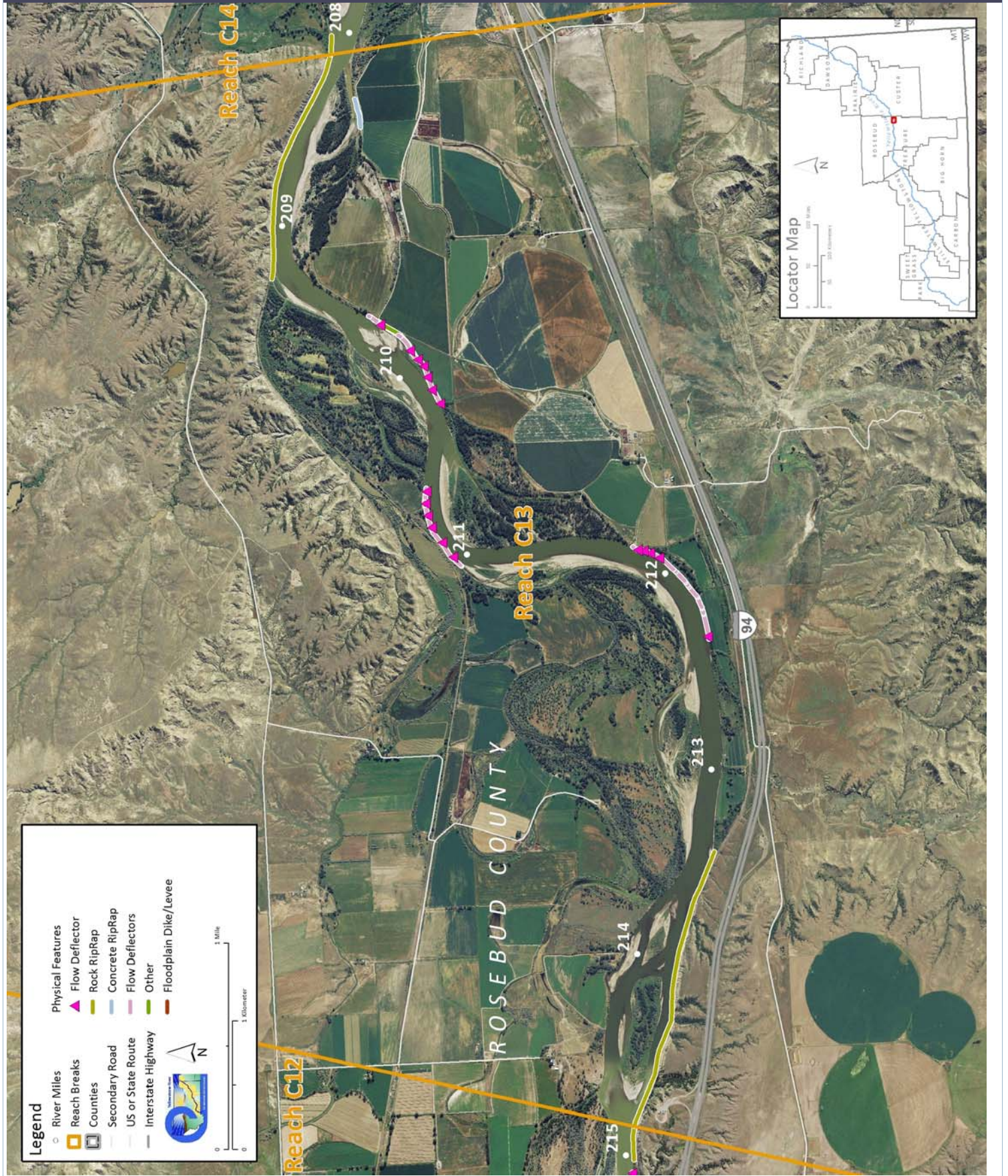
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C13 include:

- Removal of flanked barb at RM 212.
- Side channel reactivation at RM 211.6 R.
- CMZ Management due to extent of CMZ restriction (11 percent)

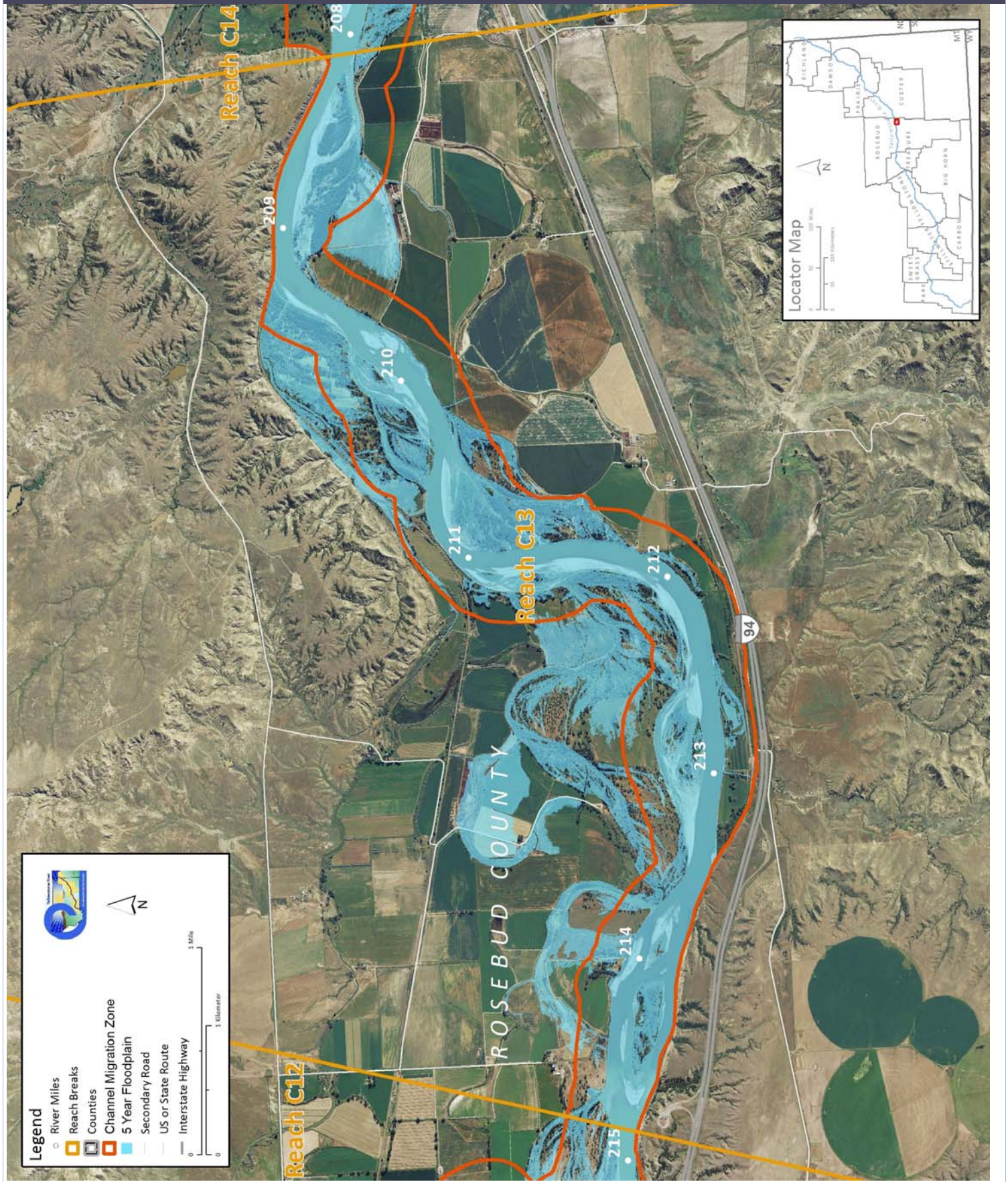
The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,900	47,300	-23.6%			
100 Year (cfs)	120,000	98,800	-17.7%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	783.2	689.3	711.3	707.5	-75.7	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	13,403	18.8%	0			
Concrete Riprap	744	1.0%	0			
Flow Deflectors	4,567	6.4%	-3,969			
Total	18,714	26.3%	-3,969			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	0	4,575				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)		The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.	
Total Acres	129.8	103.2	117.07 acres			
Acres/Year	5.0	4.1				
Acres/Year/Valley Mile	0.8	0.7				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	18.4	23.4	-51	-9.1		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	920.7	45%				
100 Year	640.6	20%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	222.1	11%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	6,899.7	6,620.2	Flood (Ac)	3,571.5	2,411.6	
Ag. Infrastructure (Ac)	60.1	132.9	Sprinkler (Ac)	0.0	0.1	
Exurban (Ac)	0.0	23.8	Pivot (Ac)	0.0	327.6	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	104.8	242.3				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	133.3	0.0	133.3	11.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	21.1	3.5	209.6			
Emergent	134.3	22.5				
Scrub/Shrub	54.1	9.1				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	215.8	3.8%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	62.3	30.2	26.6	-35.7		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Rosebud	Upstream River Mile	208.1
Classification	PCM/I: Partially confined meandering/islands	Downstream River Mile	195.9
General Location	Sheffield	Length	12.20 mi (19.63 km)

Narrative Summary

Reach C14 is 12.2 miles long and is located near Sheffield, which is about 15 miles upstream of Miles City. The reach straddles the Rosebud/Custer County Line. The reach is characterized by a dominant main thread that shows a distinct meandering pattern, with several islands persisting where meander bends have historically cut off. The river intermittently flows along the south valley wall. As a result it is classified as Partially Confined Meandering with Islands (PCM/I). In this section of river the valley bottom is consistently about 1.8 miles wide, and bound by Tertiary-age Fort Union Formation. The active meanderbelt of the Yellowstone River is about 3,000 feet wide.

The large meander features in Reach C14 have experienced significant migration since 1950 and also in recent years; one site at RM 204.5 migrated 977 feet southward between 1950 and 2001, and then over the next ten years continued to migrate another 400 feet so that it is now at the toe of the active rail line. At RM 200.5, the river has migrated 700 feet northward since 2001; eroding out irrigated lands and threatening structures.

As of 2011 there were about four miles of armor protecting 17 percent of the total bankline in Reach C14, including 15,087 feet of rock riprap and 6,300 feet of flow deflectors. Most of the rock riprap is protecting the rail line as it flows along the south bluff of Fort Union Formation, whereas flow deflectors are more commonly used to protect agricultural land. Between 2001 and 2011, about 3,000 feet of flow deflectors were evidently destroyed. Barbs can be seen in the river at RM 205.3R; the bank behind has since been partially armored with rock riprap. Another barb was flanked at RM 204.7L, and the river has migrated over 200 feet behind that structure towards the rail line. Another series of barbs were flanked at RM 203.6L and have since been replaced by rock riprap. Those flanked rock structures are visible on the 2011 air photos almost 200 feet out into the channel. At RM 200.8L, new riprap was built after older armor scoured out in 2011, which was followed by hundreds of feet of northward bank migration during the 2011 flood. Some of the new riprap appears to be trenched behind the bank. About 1,300 feet of rock riprap mapped in 2001 on the left bank at RM 196.9 has been flanked, and is now up to 70 feet out in the river.

Prior to 1950, about 3 miles of side channels were blocked in Reach C14. Chute channels formed through meander tabs have been blocked by small dikes such as at RM 198. Several historic anabranching channels appear to have been blocked prior to 1950 such as at RM 207.8. These areas provide excellent restoration/mitigation opportunities for side channel re-activation.

Similar to other reaches downstream of the Bighorn River confluence, the river channel has become smaller in Reach C14 since 1950. In 1950, the bankfull footprint was about 38 acres larger than it was in 2001, and riparian mapping shows about 208 acres of riparian encroachment into old channel areas. Floodplain turnover rates are also slightly lower; from 1950-1975 the average annual rate of floodplain turnover was 15.6 acres per year, and since 1975 it has been 12.5 acres per year.

Over two thousand acres of the 100-year floodplain has become isolated from the river due to flow alterations, agricultural development, and the abandoned railroad grade. In total, 40 percent of the entire historic 100-year floodplain has become isolated. Most of the isolation is associated with agricultural land development (29 percent of the historic floodplain), with another 10 percent of the isolation due to the abandoned rail grade. Isolation of the 5-year floodplain has been even more substantial; 2,321 acres or 59 percent of the 5-year floodplain has become isolated at that frequency event. Much of this isolated 5-year floodplain is on flood irrigated fields north of the river.

Bank armor on the north side of the river commonly narrows the natural meanderbelt of the river, which has resulted in large extents of the CMZ being restricted to migration. About 740 acres which represents 16 percent of the total CMZ has become restricted by physical features.

Four ice jams have been reported in the reach, including February of 1996, 1997, and 1998, and March of 2003. All of the ice jams in the 1990s were associated with lowland flooding.

One dump site was mapped on the left bank at RM 196.3.

Reach C14 has seen extensive riparian clearing since 1950s. Typically, riparian clearing for agriculture occurred prior to 1950 along the Yellowstone River. In this reach, however, 760 acres of riparian area were cleared since 1950, which represents 30 percent of the total 1950s riparian corridor. In several cases, this includes riparian clearing on large meander tabs. With this clearing, the reach has seen a substantial loss of forest area considered at low risk of cowbird parasitism. In 1950, the reach had 91.8 acres of such forest per valley mile and by 2001 that forest extent had dropped to 51.4 acres per valley mile.

Reach C14 has fairly extensive mapped wetland area; there are over 45 acres of mapped wetlands per valley mile, most of which is emergent marsh and wet meadow. A total of 22 acres of Russian olive were mapped in the reach, which reflects an abrupt reduction in Russian olive extent relative to upstream, where Reaches C10 through C13 have on the order of 200 acres of RO over similar valley distances.

Reach C14 was sampled as part of the fisheries study. A total of 36 species were sampled in the reach, including Sauger which has been identified as Species of Concern by the Montana Natural Heritage Program.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been major in this reach. The 100-year flood has dropped by 18 percent and the 2-year flood, which strongly influences overall channel form, has dropped by 24 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 3,070 cfs with human development, a reduction of 37 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 6,330 cfs under unregulated conditions to 3,390 cfs under regulated conditions, a reduction of 47 percent.

Fall and winter base flows have increased in Reach C14 by about 60 percent.

CEA-Related observations in Reach C14 include:

- Passive side channel abandonment due to flow alterations
- Flanking of barb structures on migrating meander bends
- Extensive floodplain isolation by agricultural dikes and abandoned railroad grade
- Pre-1950s blocking of side channels by agricultural dikes
- Armoring of bluff pool habitat against active railroad
- Floodplain isolation by the abandoned Milwaukee rail line on the north bank
- Post-1950s riparian clearing for irrigation development

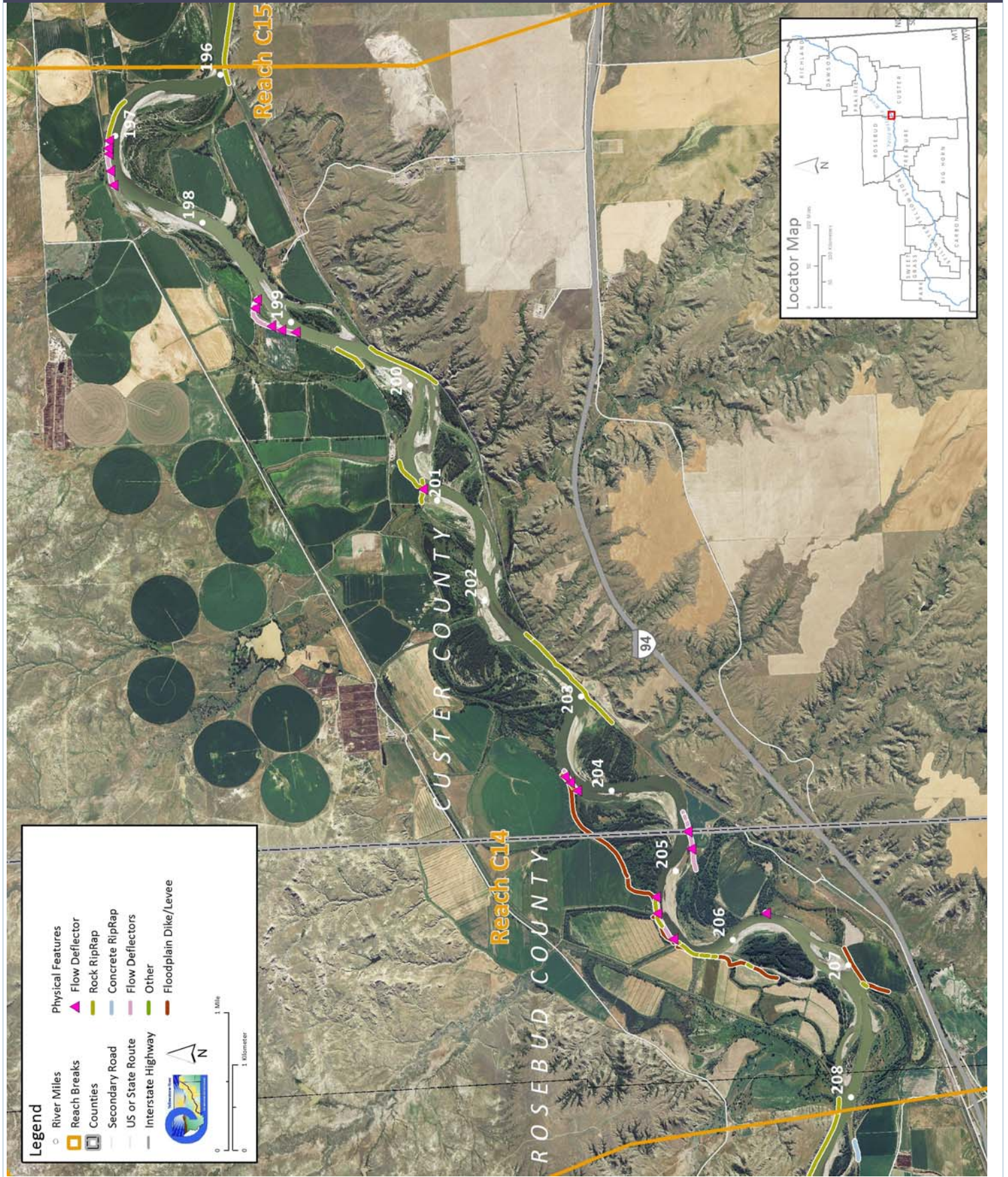
Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C14 include:

- Removal of flanked barb at RM 205.3
- Side channel reactivation at RM 208L
- CMZ Management due to extent of CMZ restriction (11 percent)
- Dump removal on left bank at RM 196.3L
- Russian olive removal

The following table summarizes some key CEA results that have been used to describe overall condition and types of human influences affecting the river. The values are specific to this single reach. Blanks indicate that a particular value was not available for this area. This information is consolidated from a large dataset that is presented in more detail in the full reach narrative report.

Discharge	Undev.	Developed	% Change	"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.		
2 Year (cfs)	61,900	47,300	-23.6%			
100 Year (cfs)	120,000	98,600	-17.8%			
Bankfull Channel Area (Ac)	1950	1976	1995	2001	1950-2001	Bankfull channel area is the total footprint of the river inundated at approx. the 2-year flood.
	1,355.6	1,388.0	1,289.0	1,318.2	-37.5	
Physical Features	2011 Length (ft)	% of Bankline	2001-2011 Change	There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.		
Rock RipRap	15,087	11.7%	1,773			
Concrete Riprap	0	0.0%	0			
Flow Deflectors	6,295	4.9%	-2,958			
Total	21,381	16.6%	-1,185			
Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.			
	14,986	0				
Floodplain Turnover	1950 - 1976	1976 - 2001	1950-2001 In-channel riparian encroachment (negative number indicates retreat)	The rate of floodplain turnover reflects how many acres of land are eroded by the river. Turnover is associated with the creation of riparian habitat.		
Total Acres	406.4	311.8	207.7 acres			
Acres/Year	15.6	12.5				
Acres/Year/Valley Mile	1.6	1.3				
Open Bar Area	Point Bars	Bank Attached	Mid-Channel	Total	The type and extent of open sand and gravel bars reflect in-stream habitat conditions that can be important to fish, amphibians, and ground-nesting birds such as least terns.	
Change in Area '50 - '01 (Ac)	-68.8	25.9	-32.3	-75.2		
Floodplain Isolation	Acres	% of FP	Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.			
5 Year	2,320.7	59%				
100 Year	2,048.9	40%				
Restricted Migration Area	Acres	% of CMZ	Channel Migration Zone restrictions refer to the area and percent of the CMZ that has been isolated by features such as bank armor, dikes, levees, and transportation embankments.			
	739.2	16%				
Land Use	1950	2011	1950	2011	Changes in land use reflect the development of the river corridor through time. The irrigated agricultural are is a sub-set of the mapped agricultural land.	
Agricultural Land (Ac)	9,424.9	9,016.5	Flood (Ac)	2,516.5	3,398.1	
Ag. Infrastructure (Ac)	76.7	105.6	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	6.4	Pivot (Ac)	0.0	660.0	
Urban (Ac)	0.0	0.0				
Transportation (Ac)	130.9	171.4				
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.	
	755.3	4.8	760.1	30.0%		
National Wetlands Inventory	Acres	Acres per Valley Mi	Total Wetland Acres	Wetlands units summarized from National Wetlands Inventory Mapping include Riverine (typically open water sloughs), Emergent (marshes and wet meadows) and Shrub-Scrub (open bar areas with colonizing woody vegetation).		
Riverine	48.6	5.0	462.9			
Emergent	292.7	30.0				
Scrub/Shrub	121.6	12.5				
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.			
	21.6	0.2%				
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)	1950	1976	2001	Change 1950-2011	Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.	
	91.8	25.4	51.4	-40.4		

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP

