County	Treasure	**Upstream River Mile**	298.1
Classification	UA: Unconfined anabranching	**Downstream River Mile**	292.3
General Location	From Bighorn confluence	**Length**	5.80 mi (9.33 km)

Narrative Summary

Reach C1 is located just downstream of the Bighorn River confluence. The Reach is 5.8 miles long and is an Unconfined Anabranching reach type, (UA), indicating the presence of forested islands with minimal valley wall influence on the river. These reach types tend to be the most dynamic of all reach types, with typically high rates of bank migration. At RM 296.5 for example, the river has migrated over 250 feet to the southeast between 2001 and 2011, indicating an average migration rate of over 25 feet per year.

There are about 2,300 feet of rock riprap in the reach, which collectively armors about 4 percent of the total bankline. About 1,000 feet of armor is protecting the rail line and another 500 feet is protecting agricultural ground. The remainder is protecting the Rancher's Ditch Diversion Structure at RM 295.5.

The Rancher's Ditch diversion dam is located approximately 2.5 miles downstream of the Bighorn River confluence. The dam was constructed in the early part of the 20th century and feeds a canal that flows on the north side of the river. There is a large, vegetated island in the Yellowstone River at the point of diversion, and diversion dams block channels on both sides of the island. The 2011 imagery shows that the south channel is becoming progressively abandoned, so that most flow goes over the main diversion structure on the north channel.

Since 1950, there have been over 7,000 feet of side channel blocked by floodplain dikes in the reach. These channels are on the lower end of the reach on the left (northwest) bank at RM 293. Even though side channels have been blocked, there has been a net gain of side channel length in the reach; since 1950, the total anabranching channel length has increased by 3,800 feet.

Since 1950, Reach C1 has experienced over 300 acres of new riparian recruitment, with most of that colonization occurring in old 1950s channel area. In balancing the amount of riparian area eroded out to the colonization acreage, there has still been a net gain of 118 acres of riparian area associated with channel movement. This reflects erosion of non-wooded lands and colonization of resulting open bar surfaces by woody vegetation, as well as the fact that the channel has gotten smaller since 1950; the bankfull area dropped by almost 50 acres (6 percent) between 1950 and 2001.

Whereas 8 percent of the 100-year floodplain has become isolated due to human development, about 47 percent (633 acres) of the 5-year floodplain is no longer inundated at that frequency. About 80 acres of historic 100-year floodplain area has become isolated by the railroad, and another 42 acres due to flow alterations. The loss of 5-year floodplain shows the strong imprint of flow alterations below the mouth of the Bighorn River and of development of those areas that are less frequently inundated; about 216 acres of currently flood irrigated floodplain areas are in the historic 5-year floodplain footprint.

Land use is dominated by agriculture, with 1,212 acres of pivot irrigation development since 1950. About 15 of those acres of pivot are within the Channel Migration Zone (CMZ). Approximately 7 percent of the Channel Migration Zone (CMZ) has been restricted, with about half of the restrictions due to riprap along the railroad, and the other half due to floodplain dikes protecting irrigated lands.

There are several corrals associated with an animal handling facility at RM 296.8R. The river is migrating in the direction of these corrals and is currently about 600 feet from the facility.

Reach C1 supports over 40 acres per valley mile of mapped wetland, which is a relatively high wetland density for the river. There are also over 100 acres of Russian olive mapped in the reach, occupying 2.6 percent of the total floodplain area.

Reach C1 has seen a substantial loss in forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 48 acres per valley mile of such forest, and that number decreased to 20 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 mean annual flood is estimated to have dropped from 60,800 cfs to 47,100 cfs, a drop of about 23 percent. The 2-year flood, which strongly influences overall channel form, has dropped by 20 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 4,600 cfs to 2,950 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 C1 include:
- Blocking of over a mile of side channel by floodplain dikes

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C1 include:
- Fish Passage at Ranchers Ditch Diversion: Structures block two channels at the diversion.
- Watercraft Passage at Ranchers Ditch Diversion
- Irrigation Infrastructure Management at Ranchers Ditch Diversion
- Side channel reactivation at RM 293
- Nutrient management at corrals associated with animal handling facility at RM 296.8R

•Russian olive removal

Yellowstone River Reach Narratives — Reach C1

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
2 Year (cfs)	60,800	47,100	-22.5%
100 Year (cfs)	119,000	99,900	-16.1%

"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.

Bankfull Channel Area (Ac)

1950	1976	1995	2001	1950-2001
775.2	765.3	696.4	728.8	-46.4

Bankful channel area is the total footprint of the river inundated at approx. the 2-year flood.

Physical Features

	2011 Length (ft)	% of Bankline	2001-2011 Change
Rock RipRap	2,306	3.7%	406
Concrete Riprap	0	0.0%	0
Flow Deflectors	0	0.0%	0
Total	**2,306**	**3.7%**	**406**

There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.

Length of Side Channels Blocked (ft)

Pre-1950s	Post-1950s
0	7,171

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	131.9	116.5
Acres/Year	5.1	4.7
Acres/Year/Valley Mile	1.1	1.0

1950-2001 In-channel riparian encroachment (negative number indicates retreat)

118.18 acres

The rate of floodplain turnover reflects how many acres of land are eroded by the river. Tunover is associated with the creation of riparian habitat.

Open Bar Area

	Point Bars	Bank Attached	Mid-Channel	Total
Change in Area '50 - '01 (Ac)	27.4	54.2	1.9	83.5

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.

Floodplain Isolation

	Acres	% of FP
5 Year	633.4	46%
100 Year	152.2	8%

Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.

Restricted Migration Area

Acres	% of CMZ
113.0	6%

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.

Land Use

	1950	2011
Agricultural Land (Ac)	4,744.8	4,661.6
Ag. Infrastructure (Ac)	50.9	40.2
Exurban (Ac)	0.0	4.8
Urban (Ac)	0.0	0.0
Transportation (Ac)	85.4	154.3

	1950	2011
Flood (Ac)	1,894.6	963.6
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	1,212.0

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.

1950s Riparian Vegetation Converted to a Developed Land Use (ac)

To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.
31.9	5.7	37.5	5.0%

Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.

National Wetlands Inventory

	Acres	Acres per Valley Mi
Riverine	2.4	0.5
Emergent	121.5	25.8
Scrub/Shrub	73.2	15.5

Total Wetland Acres: **197.1**

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).

Russian Olive (2001) (Appx. 100-yr Floodplain)

Acres	%
104.5	2.6%

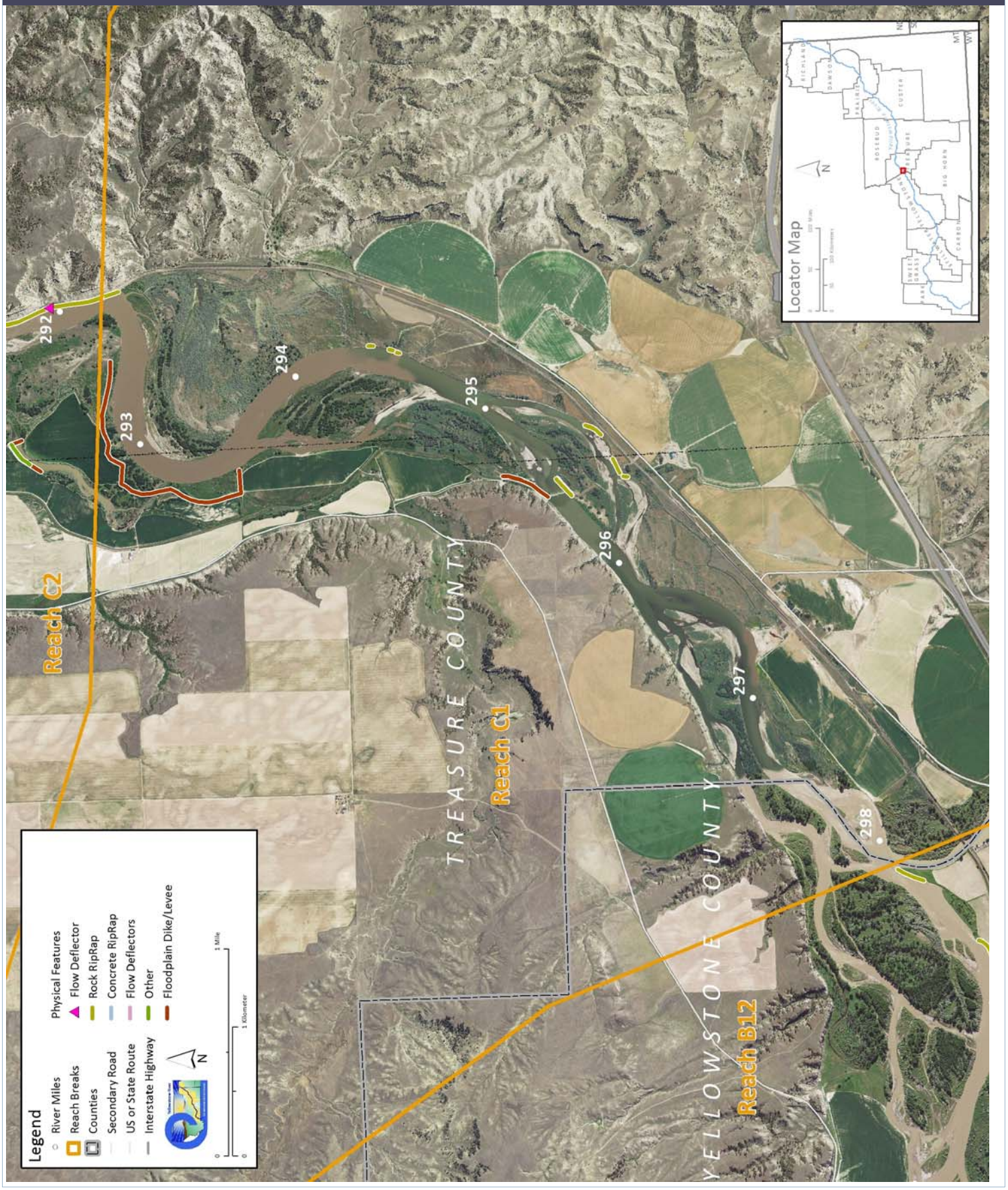
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)

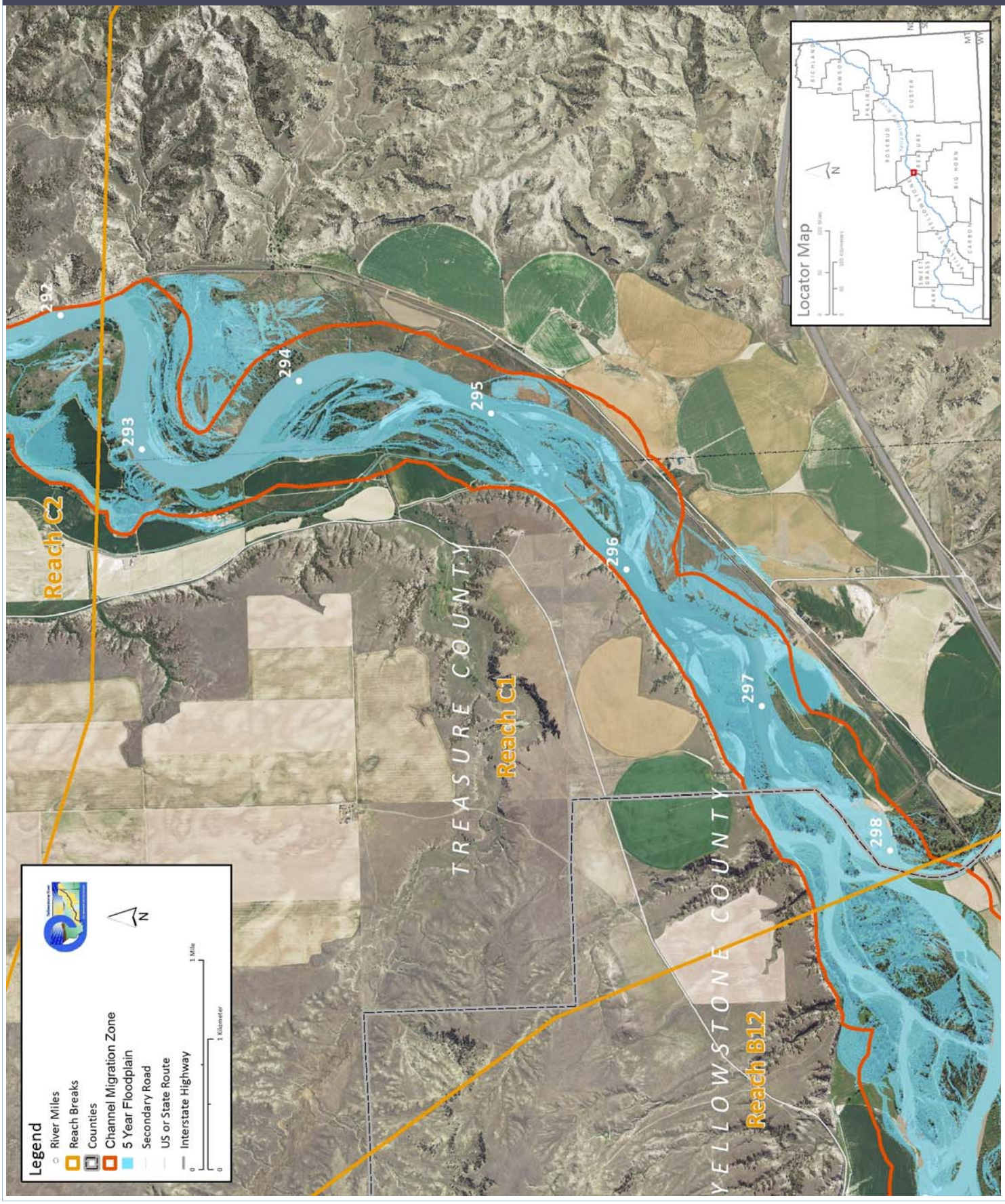
1950	1976	2001	Change 1950-2011
48.3	20.7	19.9	-28.4

Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	**Upstream River Mile**	292.3
Classification	PCB: Partially confined braided	**Downstream River Mile**	286.8
General Location	To Myers Bridge	**Length**	5.50 mi (8.85 km)

Narrative Summary

Reach C2 is located just upstream of Myers Bridge. The Reach is 5.5 miles long and is a Partially Confined Braided (PCB) reach type indicating some valley wall influence on a channel with fairly extensive low flow channels and open gravel bars. The reach follows the southern bluff line along the entire reach, which is almost entirely armored to protect the railroad.

There are over five miles of bank armor in the reach, most of which is rock riprap protecting the rail line. A total of 46 percent of the bank is armored. Since 2001, 1,200 feet of flow deflectors have been built on the right bank just above Myers Bridge.

About two miles of side channel have recently been blocked in Reach C2. In the upper end of the reach, two large side channels were blocked by a several thousand foot long floodplain dike sometime after 1976, and the old island in between these side channels is now cleared and farmed. The heads of these channels are at RM 293, and removal of the plugs at their heads could potentially reactivate over a mile of side channel connectivity. A second channel on the north side of the river at RM 289 appears relatively old, but has access roads crossing it that appear to block seasonal access. Similar to upstream, the isolation of this ~9,000 foot-long side channel has prompted clearing and farming of the old island area that is currently accessible. In total, about 18 percent (162 acres) of the mapped 1950s riparian vegetation in the reach has been cleared and converted to irrigation.

Land use is dominated by agriculture, with 137 acres of pivot irrigation development since 1950. There are several corrals associated with an animal handling facility at RM 289.5L. The corrals are on the edge of a blocked historic side channel that drains to the river. Dikes, levees, and irrigation-related riprap have collectively isolated just over 10 percent of the Channel Migration Zone in Reach C2.

Over 600 acres of 100-year floodplain has been isolated by human development, and all of that isolation is due to agricultural development on the north side of the river. The isolation reflects 23 percent of the total 100-year floodplain. The 5-year floodplain is even more affected; 59 percent of the historic 5-year floodplain is no longer inundated at that frequency. The loss of 5-year floodplain shows the strong imprint of flow alterations below the mouth of the Bighorn River and consequent development of those areas that are less frequently inundated; about 550 acres of currently flood irrigated areas are in the historic 5-year floodplain footprint.

Since 1950, Reach C2 has experienced about 190 acres of new riparian recruitment, with most of that colonization occurring in old 1950s channel area. There has been a net gain of 40 acres of riparian area in the reach associated with channel movement. This reflects encroachment of vegetation into the channel that has experienced a 20 percent reduction in channel forming (2-year) flow. There are about 46 acres of Russian olive in the reach.

Reach C2 was sampled as part of the fisheries study. A total of 32 fish species were sampled in the reach and one of those species was Sauger, which has been identified by the Montana Natural Heritage Program as a Species of Concern (SOC).

Reach C2 has seen a substantial loss in forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 37 acres per valley mile of such forest, and that number decreased to 6 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 mean annual flood is estimated to have dropped from 60,900 cfs to 47,100 cfs, a drop of about 23 percent. The 2-year flood, which strongly influences overall channel form, has dropped by 20 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 4,610 cfs to 2,950 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 C2 include:
- Blocking of over a mile of side channel by floodplain dikes
- Riparian clearing and irrigation development in isolated 5-year floodplain
- Loss of area at low risk of cowbird parasitism with riparian clearing

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C2 include:
- Side channel reactivation at RM 293
- Side channel reactivation at RM 289
- Nutrient management at corrals associated with an animal handling facility at RM 288.8L
- Russian olive removal

Yellowstone River Reach Narratives — Reach C2

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
2 Year (cfs)	60,900	47,100	-22.7%
100 Year (cfs)	119,000	100,000	-16.0%

"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.

Bankfull Channel Area (Ac)

1950	1976	1995	2001	1950-2001
596.8	631.0	578.5	590.0	-6.8

Bankful channel area is the total footprint of the river inundated at approx. the 2-year flood.

Physical Features

	2011 Length (ft)	% of Bankline	2001-2011 Change
Rock RipRap	25,536	43.9%	10
Concrete Riprap	0	0.0%	0
Flow Deflectors	1,256	2.2%	1,256
Total	**26,792**	**46.0%**	**1,266**

There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.

Length of Side Channels Blocked (ft)

Pre-1950s	Post-1950s
1,014	10,614

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	112.9	81.5
Acres/Year	4.3	3.3
Acres/Year/Valley Mile	0.8	0.6

1950-2001 In-channel riparian encroachment (negative number indicates retreat): 38.77 acres

The rate of floodplain turnover reflects how many acres of land are eroded by the river. Tunover is associated with the creation of riparian habitat.

Open Bar Area

	Point Bars	Bank Attached	Mid-Channel	Total
Change in Area '50 - '01 (Ac)	-22.4	9.7	68.5	55.8

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.

Floodplain Isolation

	Acres	% of FP
5 Year	959.1	59%
100 Year	624.5	18%

Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.

Restricted Migration Area

Acres	% of CMZ
167.6	10%

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.

Land Use

	1950	2011
Agricultural Land (Ac)	5,141.4	5,310.8
Ag. Infrastructure (Ac)	68.7	189.6
Exurban (Ac)	0.0	4.8
Urban (Ac)	0.0	0.0
Transportation (Ac)	56.9	53.6

	1950	2011
Flood (Ac)	2,464.8	2,393.8
Sprinkler (Ac)	0.0	79.1
Pivot (Ac)	0.0	137.6

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.

1950s Riparian Vegetation Converted to a Developed Land Use (ac)

To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.
161.7	0.0	161.7	18.0%

Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.

National Wetlands Inventory

	Acres	Acres per Valley Mi
Riverine	2.3	0.4
Emergent	68.1	12.7
Scrub/Shrub	33.6	6.3

Total Wetland Acres: **104.1**

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).

Russian Olive (2001) (Appx. 100-yr Floodplain)

Acres	%
45.8	0.9%

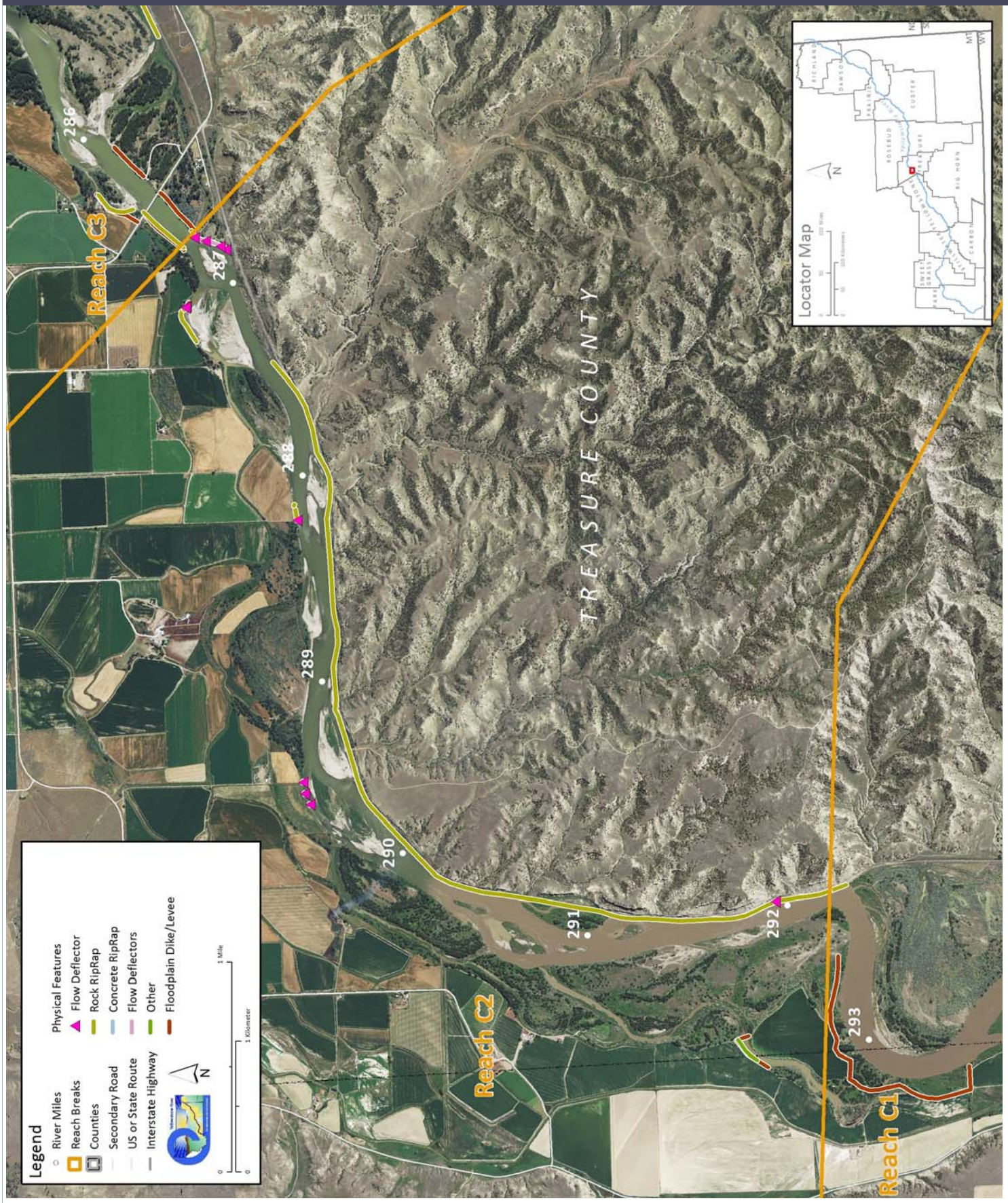
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)

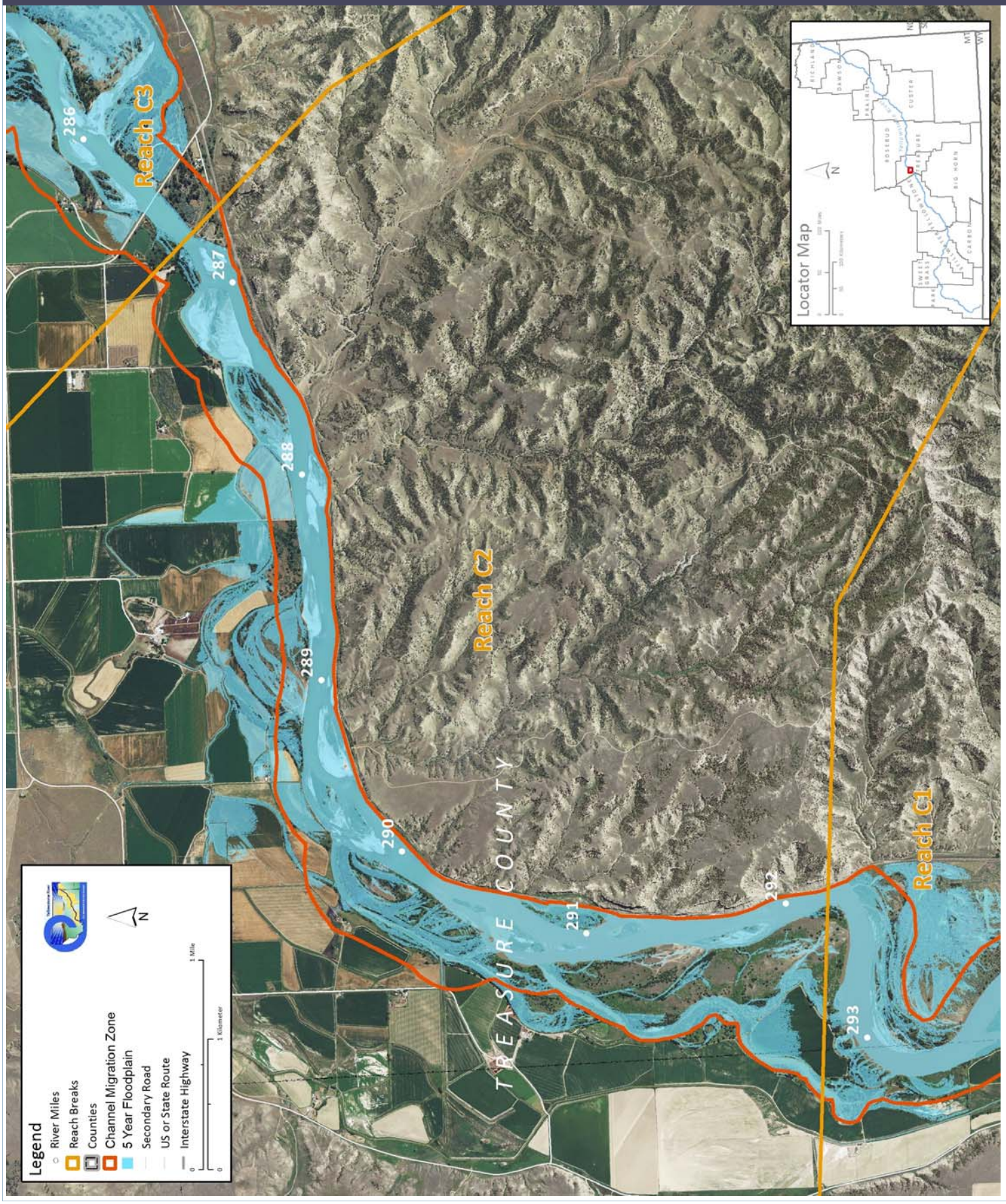
1950	1976	2001	Change 1950-2011
36.8	6.5	6.0	-30.8

Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	**Upstream River Mile**	286.8
Classification	UA: Unconfined anabranching	**Downstream River Mile**	282
General Location	To Yellowstone Diversion	**Length**	4.80 mi (7.72 km)

Narrative Summary

Reach C3 is located in Treasure County, between Myers Bridge and the Yellowstone Ditch Diversion, at the head of the Mission Valley. The reach is a 4.4 mile long Unconfined Anabranching reach type, extending from RM 282.0 to RM 286.4. In this area the alluvial valley bottom is approximately 2.5 miles wide, and this broad valley configuration is due to the presence of relatively erodible Cretaceous-age Bearpaw Shale in the valley walls and valley floor on the west limb of the Porcupine Dome. The Bearpaw Shale consists of dark gray shale that is approximately 800 feet thick. The unit is commonly exposed in the valley walls where the Yellowstone valley bottom is anomalously wide, such as in the Mission and Hammond Valleys, indicating that it is erodible in comparison to the resistant sandstones that typically form the valley margin. Upstream of Myers Bridge, the river has undercut its right bank where Bearpaw Shale underlies Hell Creek sandstone. The rail line follows the river's edge on the sandstone, and land sliding on the shale horizon has resulted in extensive bank armoring to protect the rail line (Womack, 2001).

This reach was used by Koch (1977) to exemplify an especially dynamic river segment where the channel crosses the valley from one valley wall to another. Koch (1977) and Womack (2001) noted that in these areas, the Yellowstone River exhibits a particularly rich and diverse riparian zone.

There are over two miles of bank armor in the reach, all of which is rock riprap. A total of 25 percent of the bank is armored. In addition, approximately 31,000 linear feet of transportation encroachments and floodplain dikes were mapped in the reach. These floodplain features include floodplain dikes at Myers Bridge and the Yellowstone Ditch Diversion, and a long segment of railroad grade that is on a high terrace margin adjacent to an anabranching channel thread. Several of the floodplain dikes are protected by riprap. Land use is dominated by agriculture, with 33 acres of pivot irrigation development since 1950. Physical features such as bank armor, dikes, and levees have isolated 19 percent of the Channel Migration Zone in Reach C3.

The Yellowstone Ditch Diversion Dam is located at the lower end of Reach C3 at River Mile 282. The structure was built in 1909.

Even though Reach C3 has extensive armoring and diking throughout the reach, it has maintained substantial side channel connectivity.

Over 300 acres of 100-year floodplain has been isolated by human development, and all of that isolation is due to agricultural development on the north side of the river. The isolation reflects 12 percent of the total 100-year floodplain. The 5-year floodplain is even more affected; 65 percent of the historic 5-year floodplain is no longer inundated at that frequency. The loss of 5-year floodplain shows the strong imprint of flow alterations below the mouth of the Bighorn River and consequent development of those areas that are less frequently inundated; about 700 acres of currently irrigated areas are in the historic 5-year floodplain footprint.

Reach C3 shows a net encroachment of 192 acres of woody vegetation into the active channel corridor, suggesting that hydrologic alterations may have driven some channel narrowing since 1950. This is also supported by the loss of 121 acres of bankfull area between 1950 and 2001. This reflects encroachment of vegetation into the channel that has experienced a 20 percent reduction in channel forming (2-year) flow. There are about 21 acres of Russian olive in the reach. The reach supports about 30 acres of wetland per valley mile, which is a relatively dense wetland concentration for the corridor.

Reach C3 was sampled as part of the fisheries study. A total of 32 fish species were sampled in the reach and one of those species was Sauger, which has been identified by the Montana Natural Heritage Program as a Species of Concern (SOC).

Reach C3 was sampled as part of the avian study. A total of 39 bird species were identified in the reach. The average species richness in Reach C3 was 8.1, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for sites evaluated is 8. Three bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were also found, the Chimney Swift, the Ovenbird and the Plumbeous Vireo. One species identified as a Species of Concern (SOC) was documented, the Read-headed Woodpecker. In contrast to most other reaches, Reach C3 has seen an increase in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 65 acres per valley mile of such forest, and that number increased to 82 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 4,610 cfs to 2,950 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 C3 include:
- Influence of flow alterations on floodplain inundation and riparian extent
- Increase in area at low risk of cowbird parasitism with riparian encroachment

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C3 include:
- Fish passage at Yellowstone Ditch Diversion RM 282
- Watercraft passage at Yellowstone Ditch Diversion at RM 282

- Irrigation diversion infrastructure management at Yellowstone Ditch Diversion at RM 282
- Russian olive removal

Yellowstone River Reach Narratives — Reach C3

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
2 Year (cfs)	60,900	47,100	-22.7%
100 Year (cfs)	119,000	100,000	-16.0%

"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.

Bankfull Channel Area (Ac)

1950	1976	1995	2001	1950-2001
723.7	682.3	598.0	603.1	-120.6

Bankful channel area is the total footprint of the river inundated at approx. the 2-year flood.

Physical Features

	2011 Length (ft)	% of Bankline	2001-2011 Change
Rock RipRap	12,618	25.4%	62
Concrete Riprap	0	0.0%	0
Flow Deflectors	0	0.0%	0
Total	**12,618**	**25.4%**	**62**

There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.

Length of Side Channels Blocked (ft)

Pre-1950s	Post-1950s
0	0

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	178.8	94.8
Acres/Year	6.9	3.8
Acres/Year/Valley Mile	2.2	1.2

1950-2001 In-channel riparian encroachment (negative number indicates retreat)

192.11 acres

The rate of floodplain turnover reflects how many acres of land are eroded by the river. Tunover is associated with the creation of riparian habitat.

Open Bar Area

	Point Bars	Bank Attached	Mid-Channel	Total
Change in Area '50 - '01 (Ac)	-70.2	56.5	-4.4	-18

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.

Floodplain Isolation

	Acres	% of FP
5 Year	1,197.5	65%
100 Year	313.7	12%

Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.

Restricted Migration Area

Acres	% of CMZ
476.5	19%

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.

Land Use

	1950	2011
Agricultural Land (Ac)	3,275.6	3,177.4
Ag. Infrastructure (Ac)	41.3	108.4
Exurban (Ac)	0.0	7.8
Urban (Ac)	0.0	0.0
Transportation (Ac)	38.9	47.7

	1950	2011
Flood (Ac)	1,881.6	1,777.6
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	33.2

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.

1950s Riparian Vegetation Converted to a Developed Land Use (ac)

To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.
75.3	2.4	77.7	8.0%

Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.

National Wetlands Inventory

	Acres	Acres per Valley Mi
Riverine	6.4	2.0
Emergent	90.6	28.7
Scrub/Shrub	23.2	7.4

Total Wetland Acres: **120.2**

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).

Russian Olive (2001) (Appx. 100-yr Floodplain)

Acres	%
21.2	0.6%

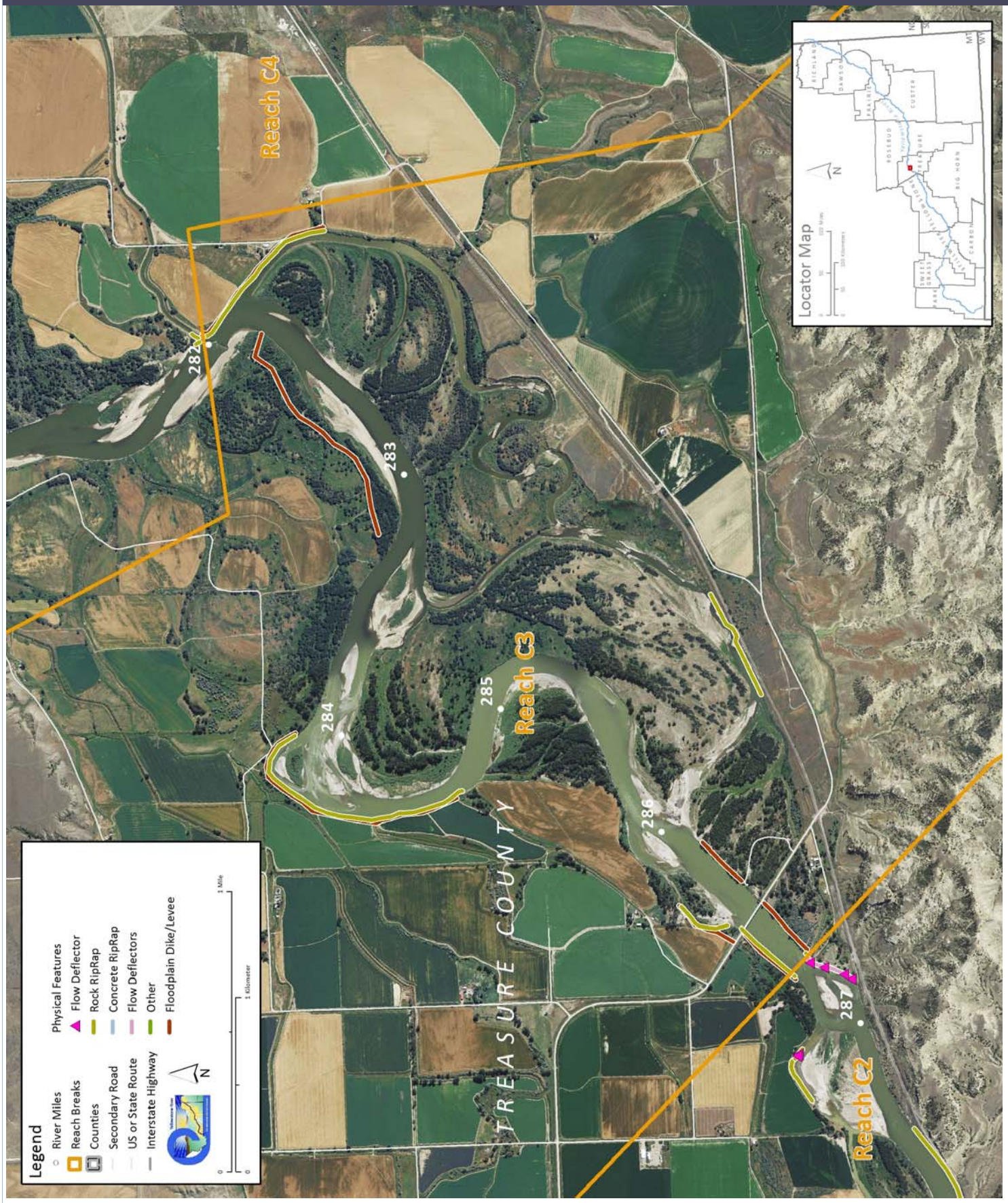
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)

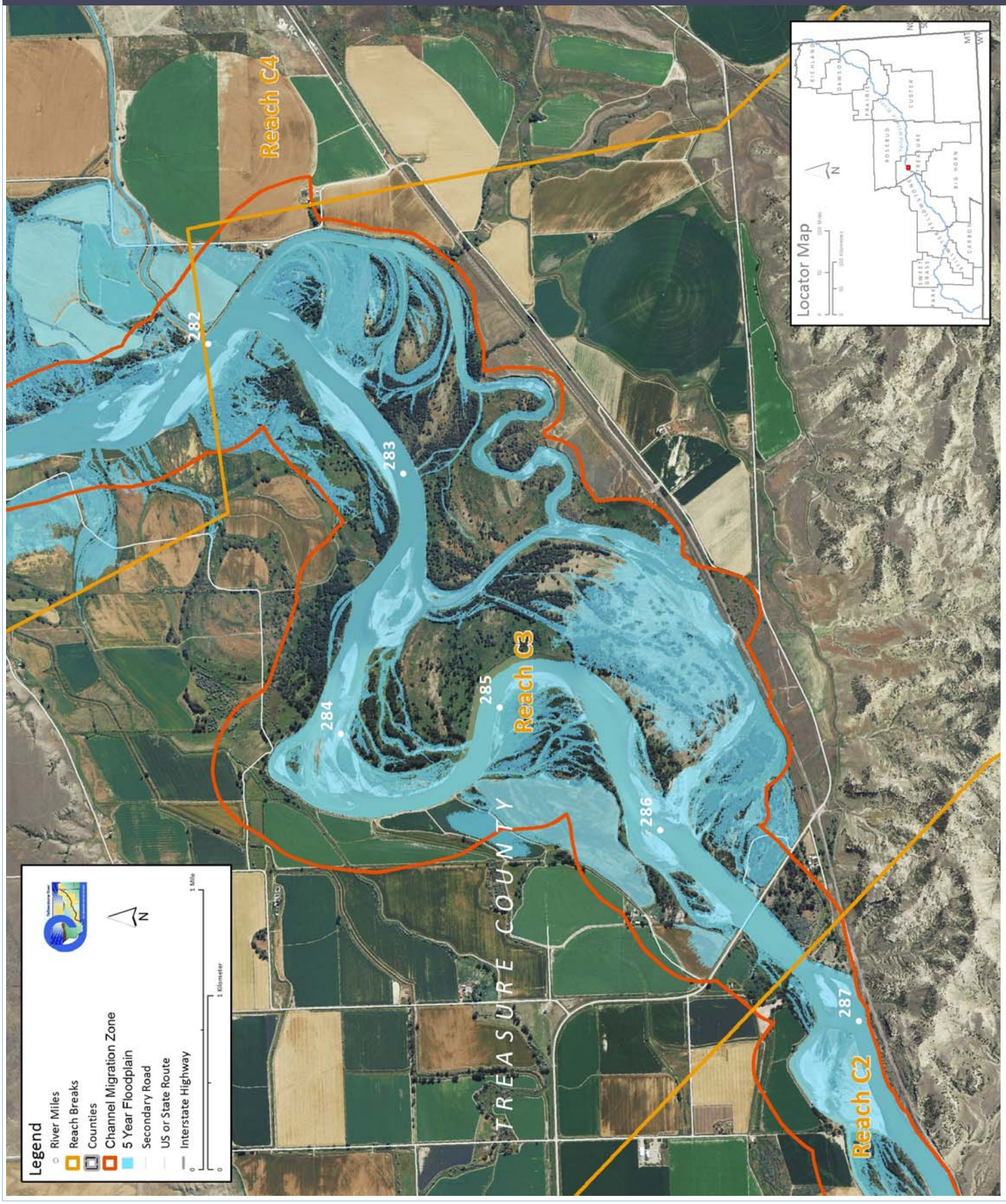
1950	1976	2001	Change 1950-2011
64.9	69.7	81.8	16.9

Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	**Upstream River Mile**	282
Classification	PCB: Partially confined braided	**Downstream River Mile**	278.2
General Location	Below Yellowstone Diversion	**Length**	3.80 mi (6.12 km)

Narrative Summary

Reach C4 is located in Treasure County, below Yellowstone Diversion Dam. Amelia Island Fishing Access Site is located in the middle of the reach. The reach is a 3.8 mile long Partially Confined Braided reach type, indicating some influence of the valley wall along with fairly common mid-channel bars. Within this reach the river trends toward and along the north valley wall near Hysham.

There are almost 5,000 feet of bank armor in the reach, all of which is rock riprap protecting flood irrigated fields at RM 279. Channel migration at the upstream end of this armor will pose risk of flanking as the bankline continues to erode to the south. A total of 13 percent of the bank is armored. Land use is dominated by agriculture, with 371 acres of pivot irrigation development since 1950. Physical features such as bank armor, dikes, and levees have isolated 9 percent of the Channel Migration Zone in Reach C4. All of the armor is protecting agricultural land. There are 22 acres of land in the CMZ under pivot irrigation.

Reach C4 has lost 8,200 feet of side channel length since 1950; however none of those lost channels were mapped as intentionally blocked.

Reach C4 shows a reduction in floodplain turnover rates from 3.4 acres/valley mile/year from 1950-1976 to 1.8 acres/valley mile/year from 1976-2001. There has also been a net loss of 15.5 acres of mid-channel bars since 1950, and a 10 acre increase in bank-attached bars, indicating a loss in overall low flow channel complexity. About 120 acres of riparian area has been cleared for irrigation, which is 18 percent of the total mapped 1950 riparian zone. There are 34 acres of Russian olive in the reach.

Over 300 acres of 100-year floodplain has been isolated by human development, and all of that isolation is due to agricultural development on the south side of the river. The isolation reflects 20 percent of the total 100-year floodplain. The 5-year floodplain is even more affected; 35 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 160 acres of flood irrigated land and 40 acres of pivot within the historic 5-year floodplain.

Reach C4 was sampled as part of the avian study. A total of 39 bird species were identified in the reach. Two bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were also found, the Chimney Swift, and the Ovenbird. In contrast to most other reaches, Reach C4 has seen an increase in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 43 acres per valley mile of such forest, and that number increased to 138 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 4,620 cfs to 2,960 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 C4 include:
- Influence of flow alterations on floodplain inundation and riparian extent
- Increase in area at low risk of cowbird parasitism with riparian encroachment

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C4 include:
- Russian olive removal

Yellowstone River Reach Narratives — Reach C4

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.

	Undev.	Developed	% Change	
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)	60,900	47,100	-22.7%	
100 Year (cfs)	120,000	100,000	-16.7%	

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.
	341.3	398.9	397.1	391.2	49.9	

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	4,971	12.5%	595	
Concrete Riprap	0	0.0%	0	
Flow Deflectors	0	0.0%	0	
Total	**4,971**	**12.5%**	**595**	

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. Tunover is associated with the creation of riparian habitat.
Total Acres	88.4	46.0	12.38 acres	
Acres/Year	3.4	1.8		
Acres/Year/Valley Mile	1.4	0.8		

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)	0	10.1	-15.5	-5.4	

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	363.6	35%	
100 Year	324.1	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.
	114.4	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)	2,756.2	2,680.3	Flood (Ac)	1,279.5	807.6	
Ag. Infrastructure (Ac)	66.2	36.7	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	0.0				
Urban (Ac)	0.0	0.0	Pivot (Ac)	0.0	370.8	
Transportation (Ac)	30.9	30.9				

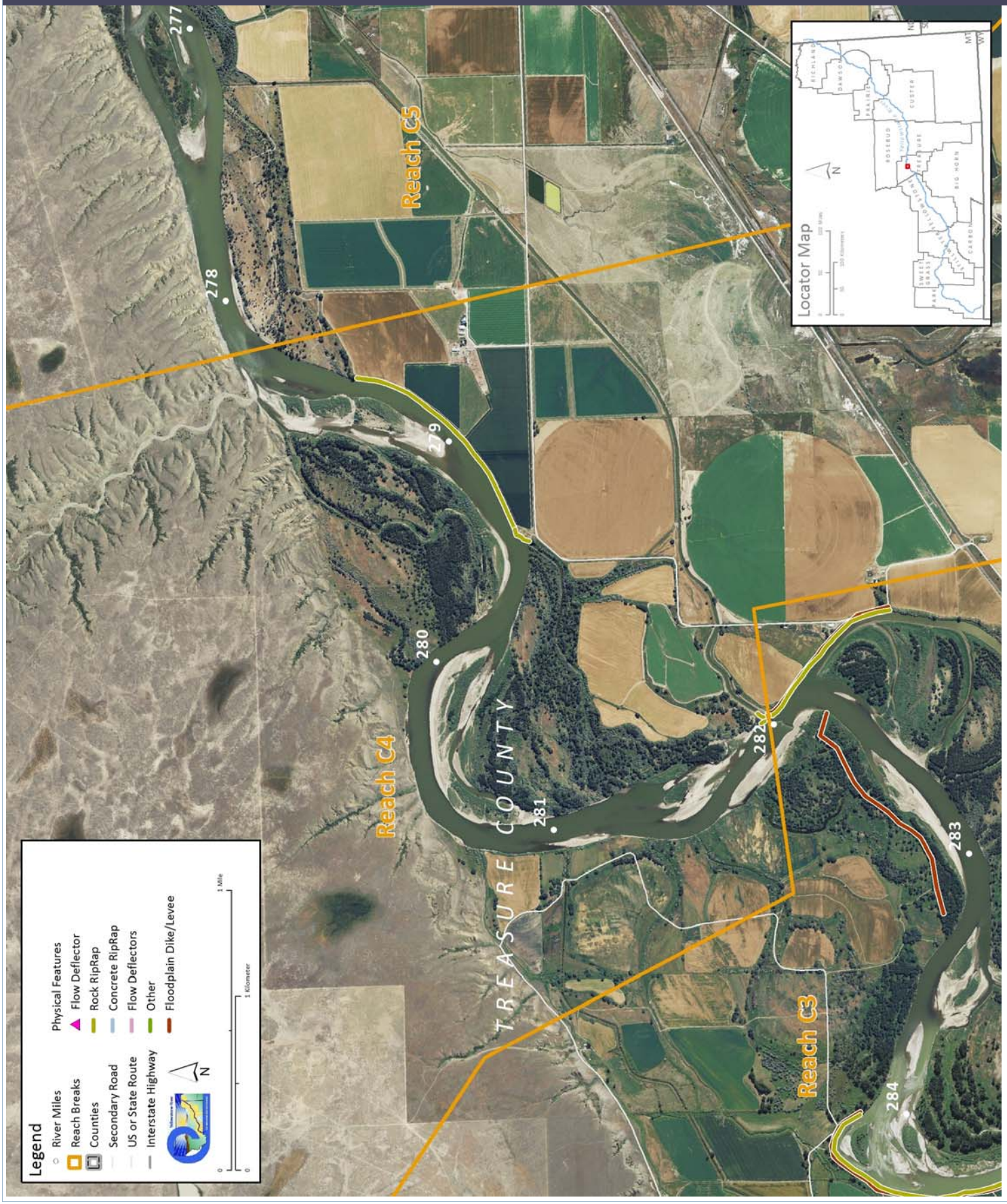
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.
	116.0	3.3	119.3	18.0%	

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	1.8	0.8		
Emergent	30.7	12.9	**57.5**	
Scrub/Shrub	25.1	10.6		

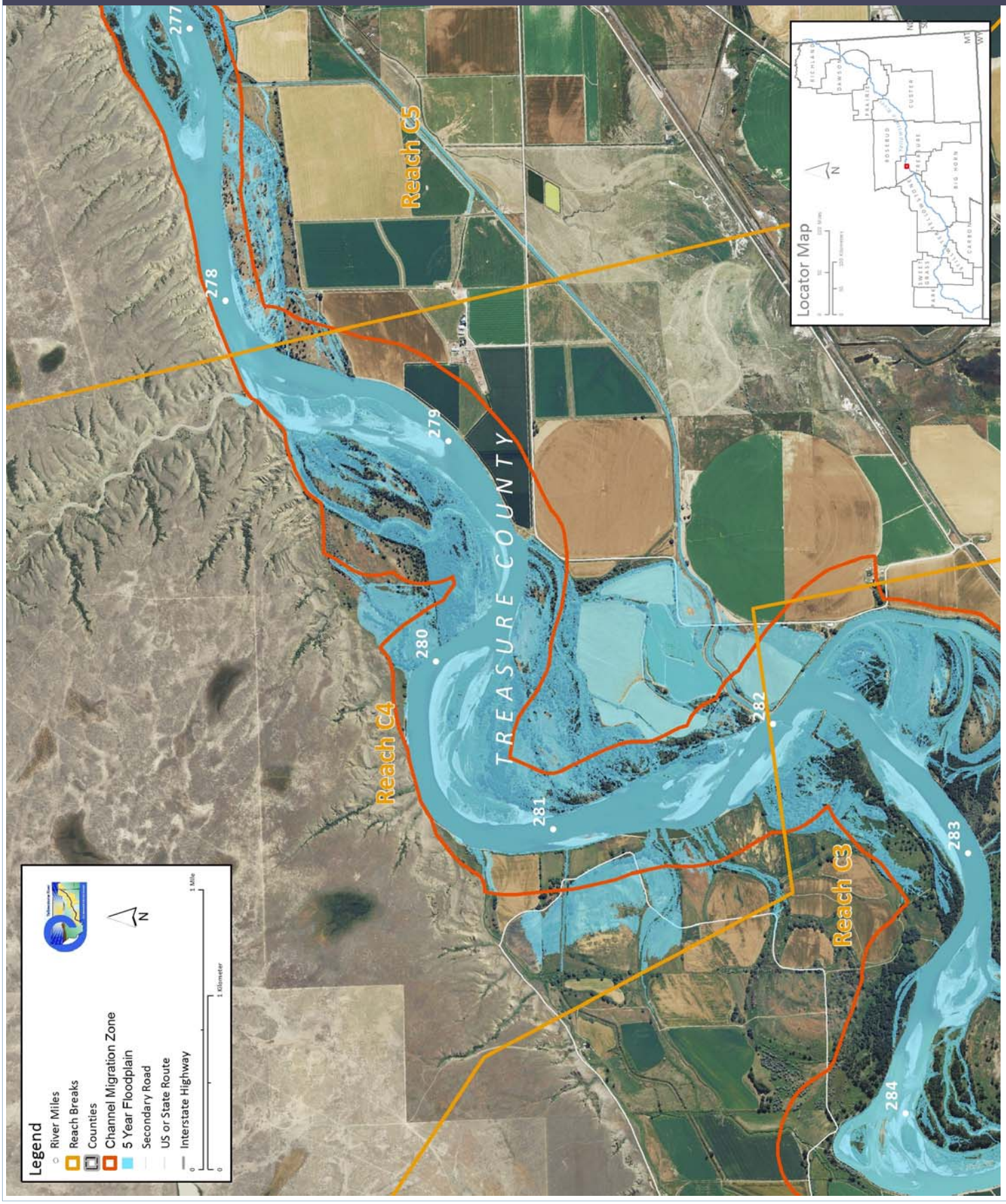
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.
	33.9	1.6%	

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.
	43.3	53.7	138.1	94.8	

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	**Upstream River Mile**	278.2
Classification	PCS: Partially confined straight	**Downstream River Mile**	275
General Location	Hysham	**Length**	3.20 mi (5.15 km)

Narrative Summary

Reach C5 is located north of Hysham. The reach is a 3.2 mile long Partially Confined Straight reach type, as the river flows straight eastward along the northern bluff line.

There is no mapped bank armor in the reach.

One side channel in the upper part of the reach has had land use encroachment and appears to have potentially been blocked prior to 1950. It is a small seasonal channel, however, and thus may have decayed naturally.

Land use is dominated by agriculture, with 181 acres of pivot irrigation development since 1950. There are about 260 acres of flood irrigated land within the CMZ, but due to the lack of bank armor, none of the CMZ has become restricted.

Two ice jams have been recorded in Reach C5. The first was in January 1997, and the second was a break-up event in mid-March of 2003.

Reach C5 shows a net loss of 15 acres of gravel bars 1950. Most of that loss has been associated with mid-channel bars. About 23 acres of riparian area has been cleared for irrigation, which is 6 percent of the total mapped 1950 riparian zone. There are 22 acres of Russian olive in the reach.

About 19 percent of the total 100-year floodplain has become isolated due to human development. The 5-year floodplain is even more affected; 68 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 380 acres of flood irrigated land within the historic 5-year floodplain. The vast majority of isolated 5-year floodplain area is within flood irrigated fields south of the river. The isolation is due to flow alterations.

Reach C5 was sampled as part of the avian study. A total of 35 bird species were identified in the reach. One bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) was found, the Ovenbird. Reach C5 has seen a decrease in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 41 acres per valley mile of such forest, and that number decreased to 26 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 4,630 cfs to 2,960 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 C5 include:
•Influence of flow alterations on floodplain inundation

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C5 include:
•Russian olive removal

Yellowstone River Reach Narratives — Reach C5

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
2 Year (cfs)	60,900	47,100	-22.7%
100 Year (cfs)	120,000	100,000	-16.7%

"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.

Bankfull Channel Area (Ac)

1950	1976	1995	2001	1950-2001
317.0	321.7	312.7	318.9	1.8

Bankful channel area is the total footprint of the river inundated at approx. the 2-year flood.

Physical Features

	2011 Length (ft)	% of Bankline	2001-2011 Change
Rock RipRap	0	0.0%	0
Concrete Riprap	0	0.0%	0
Flow Deflectors	0	0.0%	0
Total	**0**	**0.0%**	**0**

There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.

Length of Side Channels Blocked (ft)

Pre-1950s	Post-1950s
8,829	0

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	33.5	24.0
Acres/Year	1.3	1.0
Acres/Year/Valley Mile	0.4	0.3

1950-2001 In-channel riparian encroachment (negative number indicates retreat)

14.76 acres

The rate of floodplain turnover reflects how many acres of land are eroded by the river. Tunover is associated with the creation of riparian habitat.

Open Bar Area

	Point Bars	Bank Attached	Mid-Channel	Total
Change in Area '50 - '01 (Ac)	-5.7	3.3	-12.1	-14.5

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.

Floodplain Isolation

	Acres	% of FP
5 Year	635.6	68%
100 Year	321.5	19%

Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.

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.

Land Use

	1950	2011
Agricultural Land (Ac)	3,273.5	3,245.1
Ag. Infrastructure (Ac)	66.1	69.8
Exurban (Ac)	0.0	14.6
Urban (Ac)	29.6	29.5
Transportation (Ac)	32.6	32.6

	1950	2011
Flood (Ac)	1,866.0	1,492.2
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	181.2

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.

1950s Riparian Vegetation Converted to a Developed Land Use (ac)

To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.
22.8	0.0	22.8	6.0%

Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.

National Wetlands Inventory

	Acres	Acres per Valley Mi
Riverine	13.6	4.5
Emergent	43.6	14.4
Scrub/Shrub	6.9	2.3

Total Wetland Acres: **64.0**

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).

Russian Olive (2001) (Appx. 100-yr Floodplain)

Acres	%
22.4	0.8%

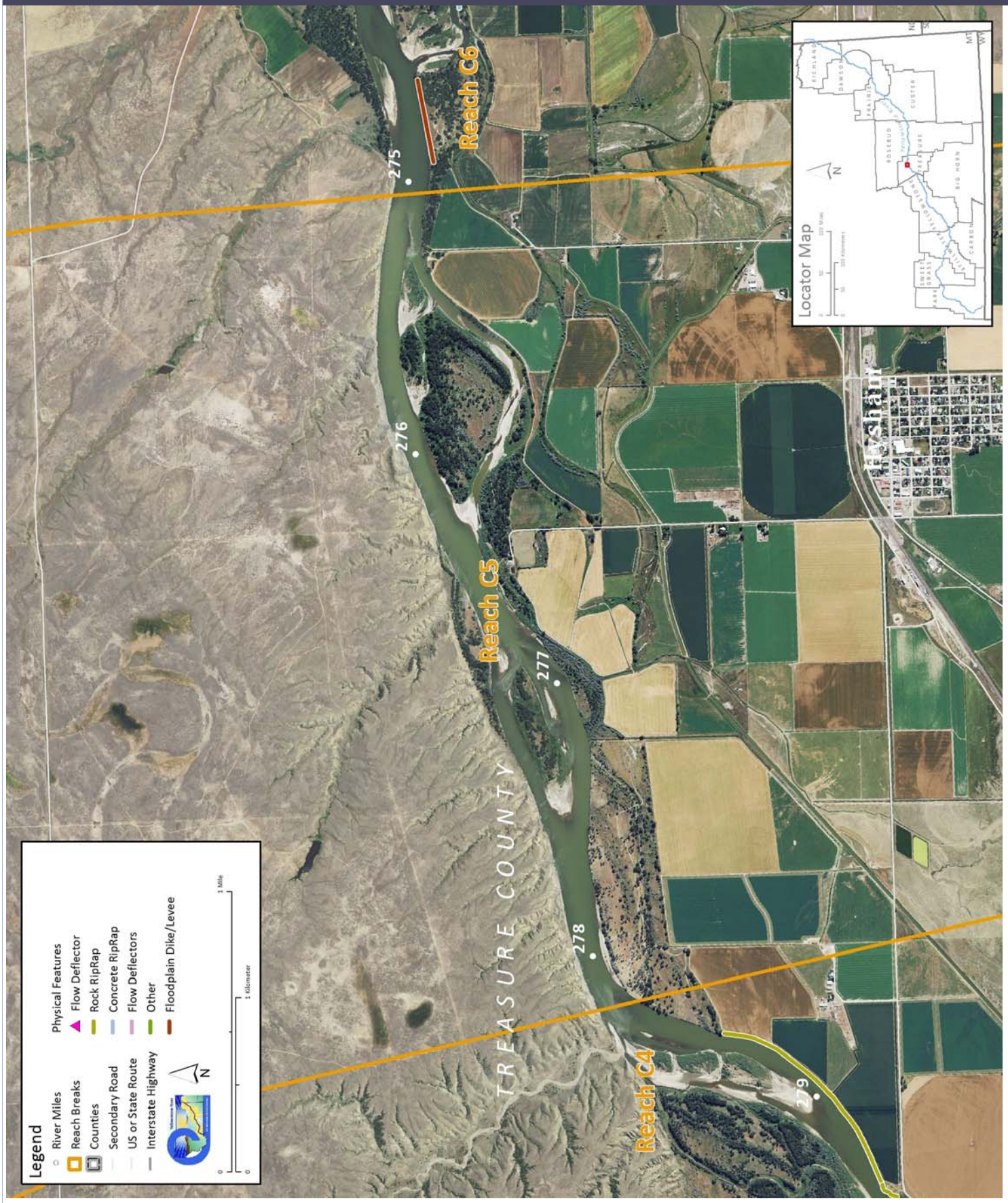
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)

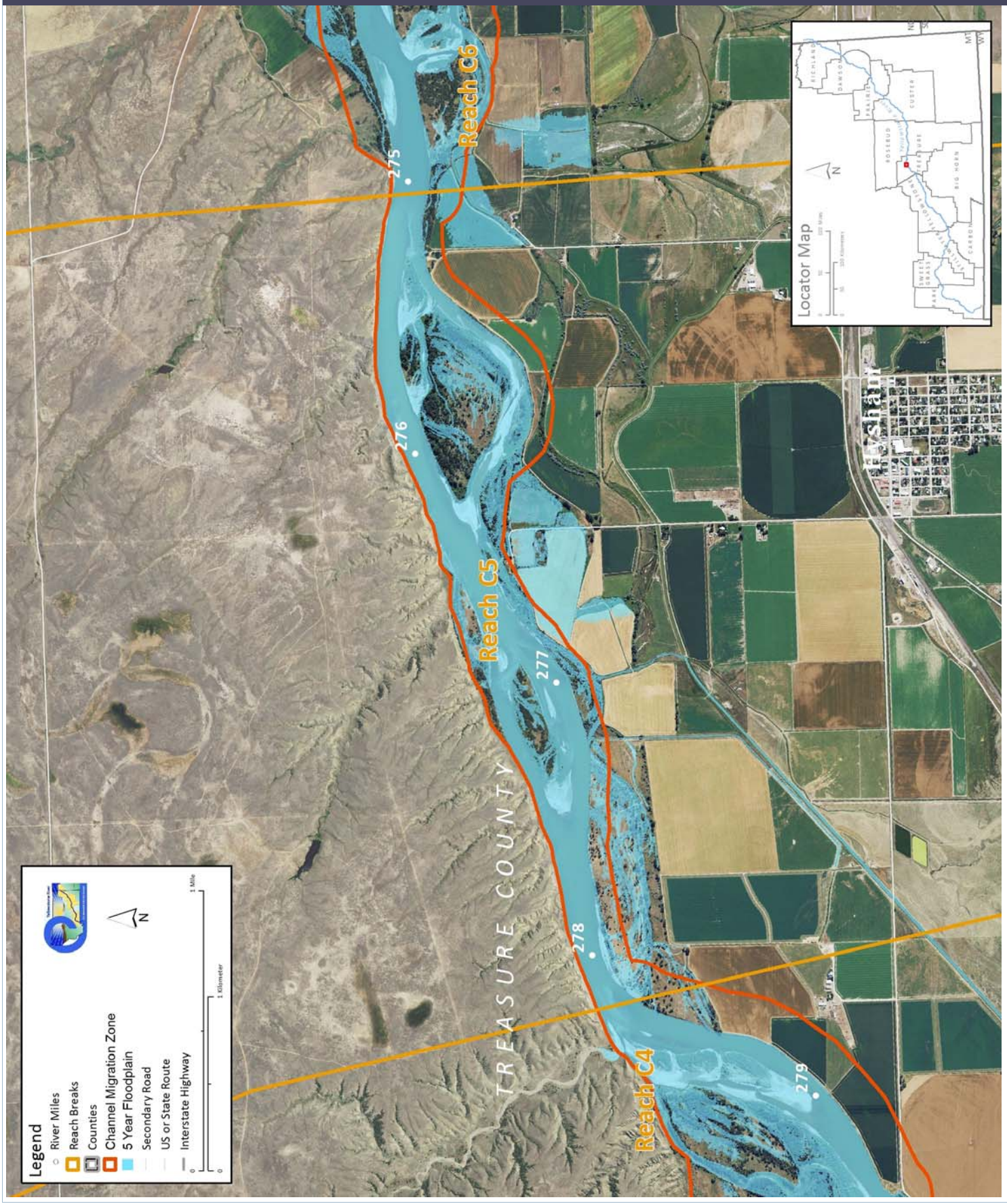
1950	1976	2001	Change 1950-2011
41.2	21.1	26.4	-14.8

Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	**Upstream River Mile**	275
Classification	UA: Unconfined anabranching	**Downstream River Mile**	269.4
General Location	Mission Valley	**Length**	5.60 mi (9.01 km)

Narrative Summary

Reach C6 is located in the Mission Valley north of Hysham. The reach is a 5.6 mile long Unconfined Anabranching reach type, indicating minimal valley wall influence and extensive side channels and forested islands. In this area the alluvial valley bottom is approximately 2.5 miles wide, and this broad valley has formed in the relatively erodible Cretaceous-age Bearpaw Shale.

There are just over 3,000 feet of bank armor in the reach, which covers 5.1 percent of the total bankline. About 600 feet of a floodplain dike at RM 273.2R appears to have been eroded out since 2001.

Almost 11,000 feet of side channels have been blocked by physical features in the reach since 1950. One floodplain dike that blocked a side channel at RM 227.8L in 2001 was eroded out and has since been rebuilt. Additional side channel length has been lost passively, overall, there has been about a three mile reduction in side channel length in this reach since 1950.

About 20 percent of the total 100-year floodplain has become isolated due to human development. The 5-year floodplain is even more affected; 70 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 650 acres of flood irrigated land and 200 acres of pivot land within the historic 5-year floodplain. The vast majority of isolated 5-year floodplain area is within irrigated fields south of the river, and the isolation appears to be due to both flow alterations and agricultural dikes.

Land use is dominated by agriculture, with 188 acres of pivot irrigation development since 1950. There are about 260 acres of flood irrigated land within the CMZ, but due to the lack of bank armor, none of the CMZ has become restricted.

Riparian mapping data show a net gain of 158 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. Since 1950, the total area of open timber increased by approximately 250 acres. There are 40 acres of Russian olive in the reach.

Reach C6 was sampled as part of the fisheries study. A total of 26 fish species were sampled in the reach.

Reach C6 was sampled as part of the avian study. A total of 32 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. In contrast to most reaches, Reach C6 has seen an increase in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 55 acres per valley mile of such forest, and that number increased to 106 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 4,630 cfs to 2,960 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 C6 include:
- Active and passive loss of thousands of feet of side channel
- Reconstruction of side-channel blockage following its failure post-2001.

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C6 include:
- Side channel reactivation at RM 275R and RM 271L
- Russian olive removal

Yellowstone River Reach Narratives — Reach C6

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
2 Year (cfs)	61,000	47,000	-23.0%
100 Year (cfs)	120,000	100,000	-16.7%

"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.

Bankfull Channel Area (Ac)

1950	1976	1995	2001	1950-2001
654.7	611.0	545.8	548.9	-105.8

Bankful channel area is the total footprint of the river inundated at approx. the 2-year flood.

Physical Features

	2011 Length (ft)	% of Bankline	2001-2011 Change
Rock RipRap	2,478	4.1%	0
Concrete Riprap	574	1.0%	0
Flow Deflectors	0	0.0%	0
Total	**3,052**	**5.1%**	**0**

There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.

Length of Side Channels Blocked (ft)

Pre-1950s	Post-1950s
0	10,910

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	123.2	92.5
Acres/Year	4.7	3.7
Acres/Year/Valley Mile	1.4	1.1

1950-2001 In-channel riparian encroachment (negative number indicates retreat)

158.33 acres

The rate of floodplain turnover reflects how many acres of land are eroded by the river. Tunover is associated with the creation of riparian habitat.

Open Bar Area

	Point Bars	Bank Attached	Mid-Channel	Total
Change in Area '50 - '01 (Ac)	-9.2	7.6	0.3	-1.4

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.

Floodplain Isolation

	Acres	% of FP
5 Year	1,663.9	70%
100 Year	731.8	20%

Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.

Restricted Migration Area

Acres	% of CMZ
176.0	8%

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.

Land Use

	1950	2011
Agricultural Land (Ac)	3,400.5	3,584.1
Ag. Infrastructure (Ac)	34.4	48.3
Exurban (Ac)	0.0	0.0
Urban (Ac)	0.0	0.0
Transportation (Ac)	16.0	16.6

	1950	2011
Flood (Ac)	1,754.0	1,365.9
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	187.6

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.

1950s Riparian Vegetation Converted to a Developed Land Use (ac)

To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.
5.9	0.0	5.9	1.0%

Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.

National Wetlands Inventory

	Acres	Acres per Valley Mi
Riverine	19.0	5.5
Emergent	89.1	25.8
Scrub/Shrub	22.5	6.5

Total Wetland Acres: **130.5**

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).

Russian Olive (2001) (Appx. 100-yr Floodplain)

Acres	%
40.0	0.9%

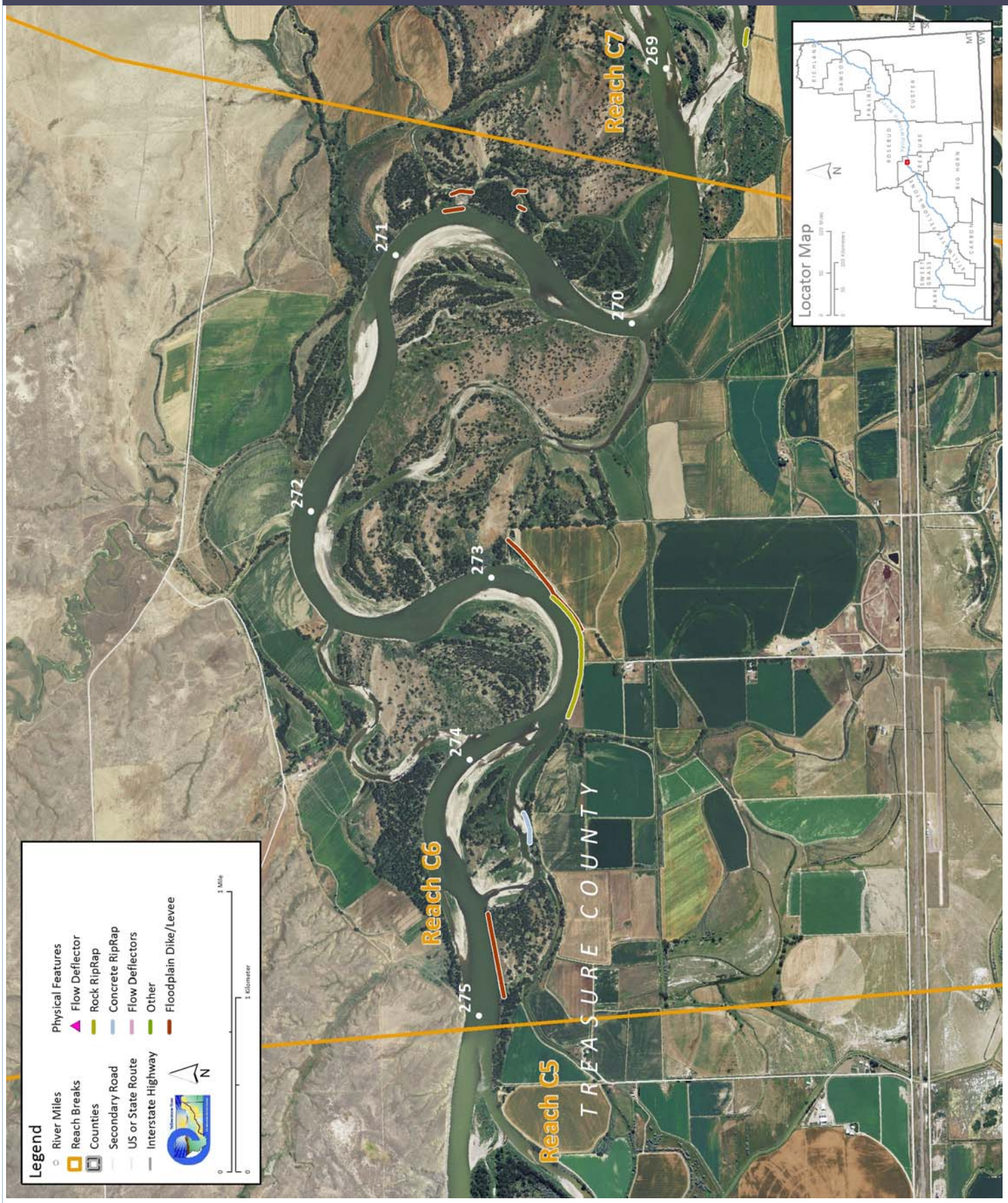
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)

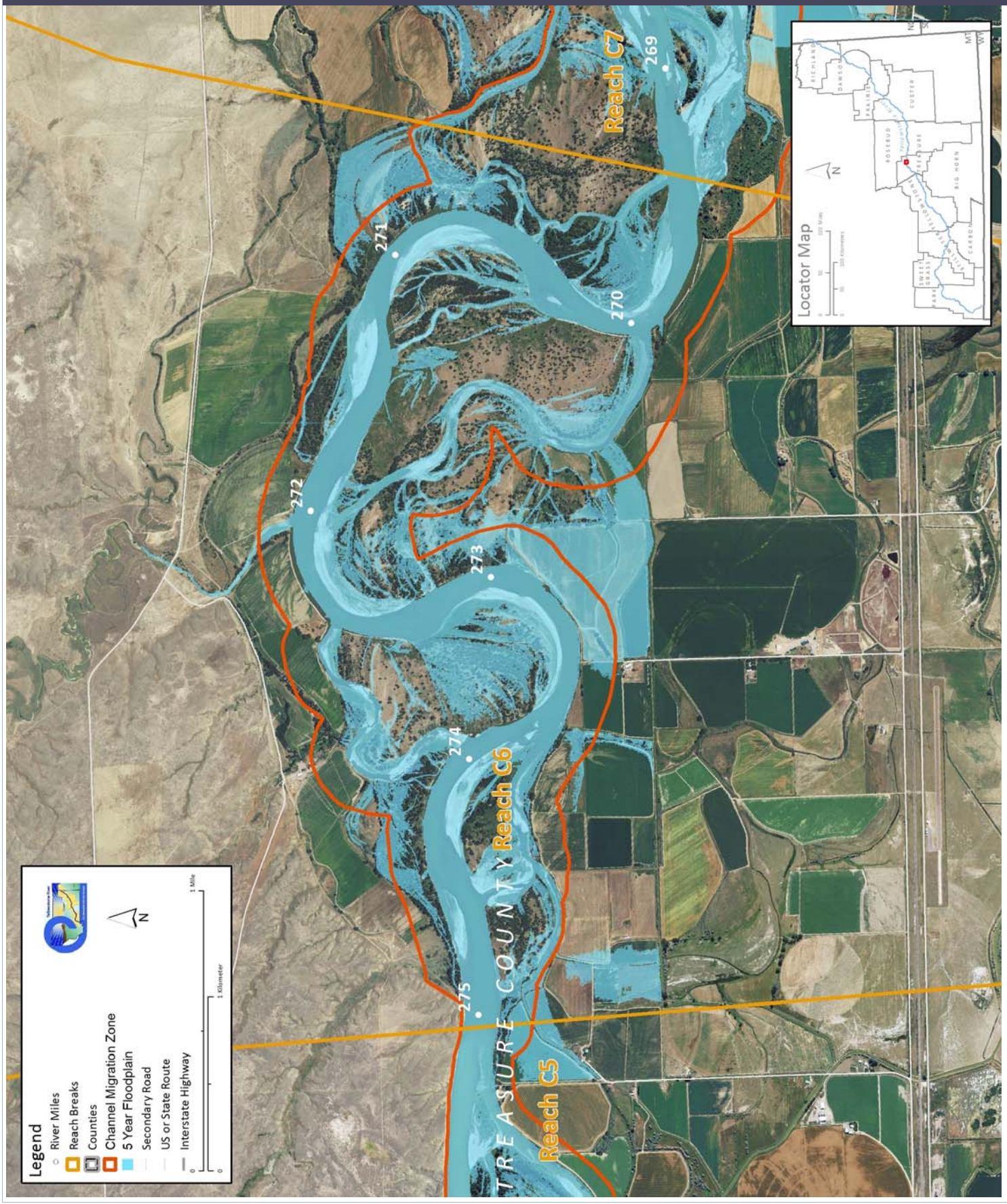
1950	1976	2001	Change 1950-2011
54.8	86.2	106.1	51.3

Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Treasure	**Upstream River Mile**	269.4
Classification	UA: Unconfined anabranching	**Downstream River Mile**	260.3
General Location	Mission Valley	**Length**	9.10 mi (14.65 km)

Narrative Summary

Reach C7 is 9.1 miles long and is located in the Mission Valley downstream of Hysham. It is an Unconfined Anabranching reach type, which indicates little in the way of valley wall influence coupled with extensive side channels and forested islands. The Mission Valley owes its width to the presence of the Bearpaw Shale in the valley wall. Because this Cretaceous-age shale is relatively erodible and prone to mass failure, over time the river has been able to erode the valley wall more easily than in other reaches, creating the large distinct valleys present today. Because the Mission and Hammond Valleys are so wide, the river 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.

Just over 2,000 feet of rock riprap lines the banks in Reach C7, protecting 2.3 percent of the bankline.

Prior to 1950 about 4,200 feet of side channel had been blocked in Reach C7, and since then, floodplain dikes have blocked another three miles of side channel. Blocked side channels are located at RM 270.8L, RM 263.5R, and RM 261R. Even with all of the blockages, Reach C7 still has on the order of 17 miles of functional side channel length.

Reach C7 appears to be experiencing an active major avulsion just north of Sanders, where an anabranching channel has been developing into a primary channel over the last decade. As rerouting of the river would shorten the main thread by approximately 1.5 miles, an avulsion is very likely to occur in this area over the next several years. The rate at which the anabranching side channel fully captures the main thread will depend on flood events, as floods will accelerate the avulsion process. This avulsion would take pressure off of the main channel to the south, which is currently threatening the rail line at RM 264.8R and RM 266.2R.

About 9 percent of the total 100-year floodplain has become isolated due to human development in Reach C7. The 5-year floodplain is even more affected; 41 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 95 acres of flood irrigated land and 56 acres of pivot land within the historic 5-year floodplain. Much of the isolated 5-year floodplain area is within the active stream corridor and riparian zone however, exemplifying the potential impacts of flow alterations on frequent floodplain inundation.

Land use is dominated by agriculture, with 277 acres of pivot irrigation development since 1950. There are about 350 acres of flood irrigated land and 31 acres of pivot within the CMZ, but only 4 percent of the CMZ is restricted by physical features.

Riparian mapping data show a net gain of 780 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. Reach C7 has about 90 acres of wetland per valley mile, which makes it one of the most concentrated wetland areas in the corridor. There are also 164 acres of Russian olive in the reach.

Reach C7 was sampled as part of the fisheries study. A total of 27 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 C7 was sampled as part of the avian study. A total of 69 bird species were identified in the reach. Four bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were found, the Black and White Warbler, the Plumbeous Vireo, the Ovenbird, and the Chimney Swift. Two Species of Concern (SOC) were identified, the Black Billed Cuckoo and the Bobolink. Brown Headed Cowbirds were also present. Reach C7 has seen an increase in the forested area that is at low risk of cowbird parasitism since 1950. At that time, there were 86 acres per valley mile of such forest, and that number increased to 102 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 C7 include:
•Active and passive loss of thousands of feet of side channel

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach C7 include:
•Side channel reactivation at RM 270.8L, RM 263.5R, and RM 261R
•Russian olive removal

Yellowstone River Reach Narratives — Reach C7

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
2 Year (cfs)	61,100	47,000	-23.1%
100 Year (cfs)	120,000	100,000	-16.7%

"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.

Bankfull Channel Area (Ac)

1950	1976	1995	2001	1950-2001
1,264.9	1,329.6	1,230.4	1,217.0	-47.9

Bankful channel area is the total footprint of the river inundated at approx. the 2-year flood.

Physical Features

	2011 Length (ft)	% of Bankline	2001-2011 Change
Rock RipRap	2,173	2.3%	0
Concrete Riprap	0	0.0%	0
Flow Deflectors	0	0.0%	0
Total	**2,173**	**2.3%**	**0**

There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.

Length of Side Channels Blocked (ft)

Pre-1950s	Post-1950s
4,230	15,593

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	447.8	278.9
Acres/Year	17.2	11.2
Acres/Year/Valley Mile	2.8	1.8

1950-2001 In-channel riparian encroachment (negative number indicates retreat)

169.5 acres

The rate of floodplain turnover reflects how many acres of land are eroded by the river. Tunover is associated with the creation of riparian habitat.

Open Bar Area

	Point Bars	Bank Attached	Mid-Channel	Total
Change in Area '50 - '01 (Ac)	-116	58.7	-33.6	-91

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.

Floodplain Isolation

	Acres	% of FP
5 Year	1,107.4	41%
100 Year	378.0	9%

Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.

Restricted Migration Area

Acres	% of CMZ
172.8	4%

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.

Land Use

	1950	2011
Agricultural Land (Ac)	6,777.9	6,695.6
Ag. Infrastructure (Ac)	77.0	128.1
Exurban (Ac)	0.0	7.5
Urban (Ac)	0.0	0.0
Transportation (Ac)	101.9	104.3

	1950	2011
Flood (Ac)	3,276.6	1,951.2
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	276.3

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.

1950s Riparian Vegetation Converted to a Developed Land Use (ac)

To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.
29.7	0.4	30.1	1.0%

Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.

National Wetlands Inventory

	Acres	Acres per Valley Mi
Riverine	15.7	2.5
Emergent	406.2	65.4
Scrub/Shrub	130.4	21.0

Total Wetland Acres: **552.3**

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).

Russian Olive (2001) (Appx. 100-yr Floodplain)

Acres	%
164.4	2.1%

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.

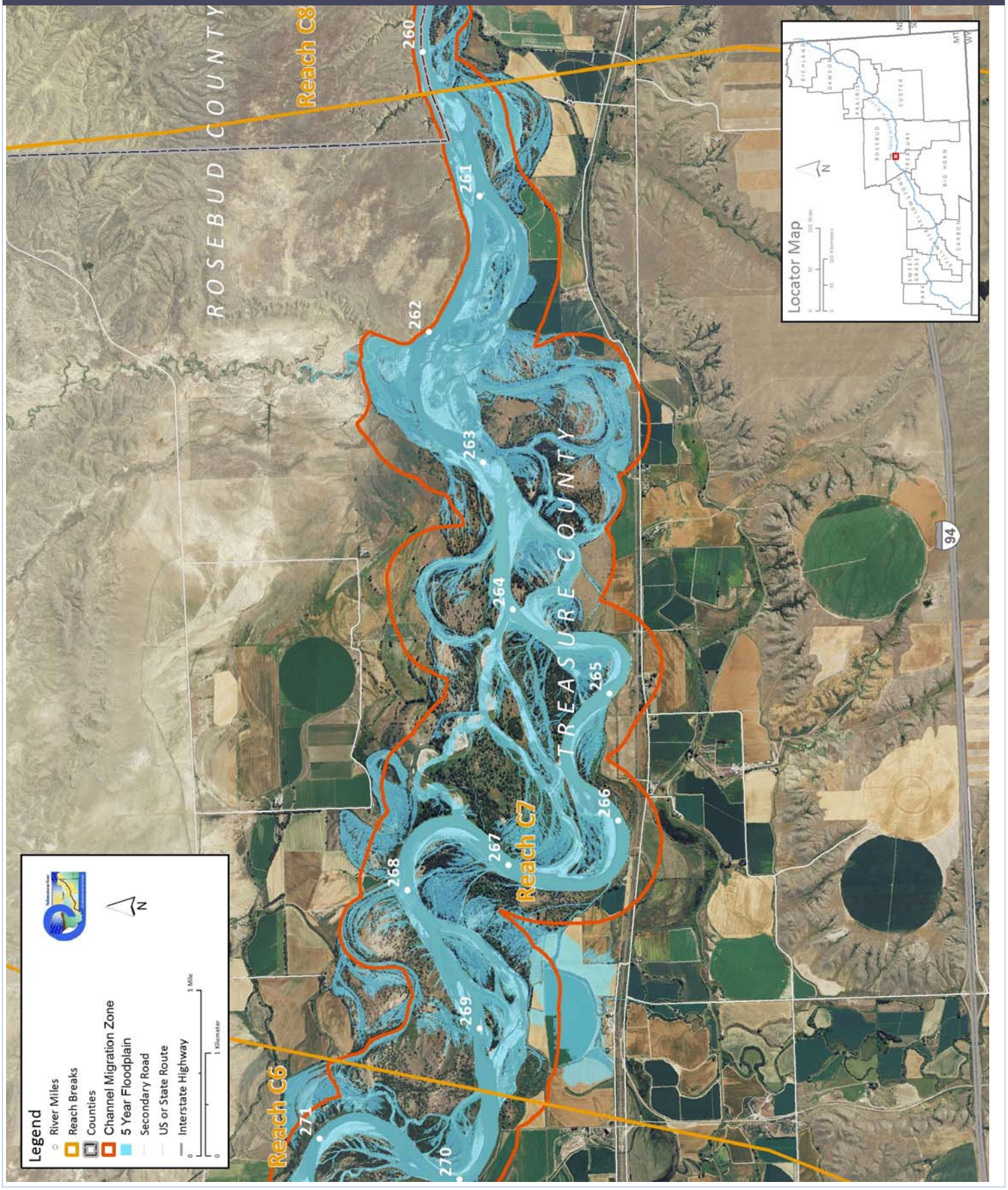
Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)

1950	1976	2001	Change 1950-2011
86.2	76.9	100.3	14.0

Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.

PHYSICAL FEATURES MAP (2011)

CHANNEL MIGRATION ZONE MAP



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

Yellowstone River Reach Narratives — Reach C8

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
2 Year (cfs)	61,100	47,000	-23.1%
100 Year (cfs)	120,000	100,000	-16.7%

"Undeveloped" flows represent conditions prior to significant human development, whereas "developed" flows reflect the current condition of both consumptive and non-consumptive water use.

Bankfull Channel Area (Ac)

1950	1976	1995	2001	1950-2001
679.9	688.1	620.0	621.9	-58.0

Bankful channel area is the total footprint of the river inundated at approx. the 2-year flood.

Physical Features

	2011 Length (ft)	% of Bankline	2001-2011 Change
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**

There are additional types of bank armor such as car bodies and steel retaining walls, but they are relatively minor.

Length of Side Channels Blocked (ft)

Pre-1950s	Post-1950s
2,323	8,494

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	140.4	52.4
Acres/Year	5.4	2.1
Acres/Year/Valley Mile	0.9	0.3

1950-2001 In-channel riparian encroachment (negative number indicates retreat)

93.58 acres

The rate of floodplain turnover reflects how many acres of land are eroded by the river. Tunover is associated with the creation of riparian habitat.

Open Bar Area

	Point Bars	Bank Attached	Mid-Channel	Total
Change in Area '50 - '01 (Ac)	36.5	28	26.7	91.2

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.

Floodplain Isolation

	Acres	% of FP
5 Year	670.6	55%
100 Year	897.7	35%

Floodplain isolation refers to area that historically was flooded, but has become isolated do to flow alterations or physical features such as levees.

Restricted Migration Area

Acres	% of CMZ
166.5	10%

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.

Land Use

	1950	2011
Agricultural Land (Ac)	6,145.6	6,109.7
Ag. Infrastructure (Ac)	39.5	104.7
Exurban (Ac)	0.0	0.0
Urban (Ac)	0.0	0.0
Transportation (Ac)	98.0	97.9

	1950	2011
Flood (Ac)	2,808.1	2,783.3
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	341.9

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.

1950s Riparian Vegetation Converted to a Developed Land Use (ac)

To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.
75.4	0.0	75.4	9.0%

Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.

National Wetlands Inventory

	Acres	Acres per Valley Mi
Riverine	3.8	0.6
Emergent	112.2	18.7
Scrub/Shrub	9.6	1.6

Total Wetland Acres: **125.6**

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).

Russian Olive (2001) (Appx. 100-yr Floodplain)

Acres	%
43.4	0.9%

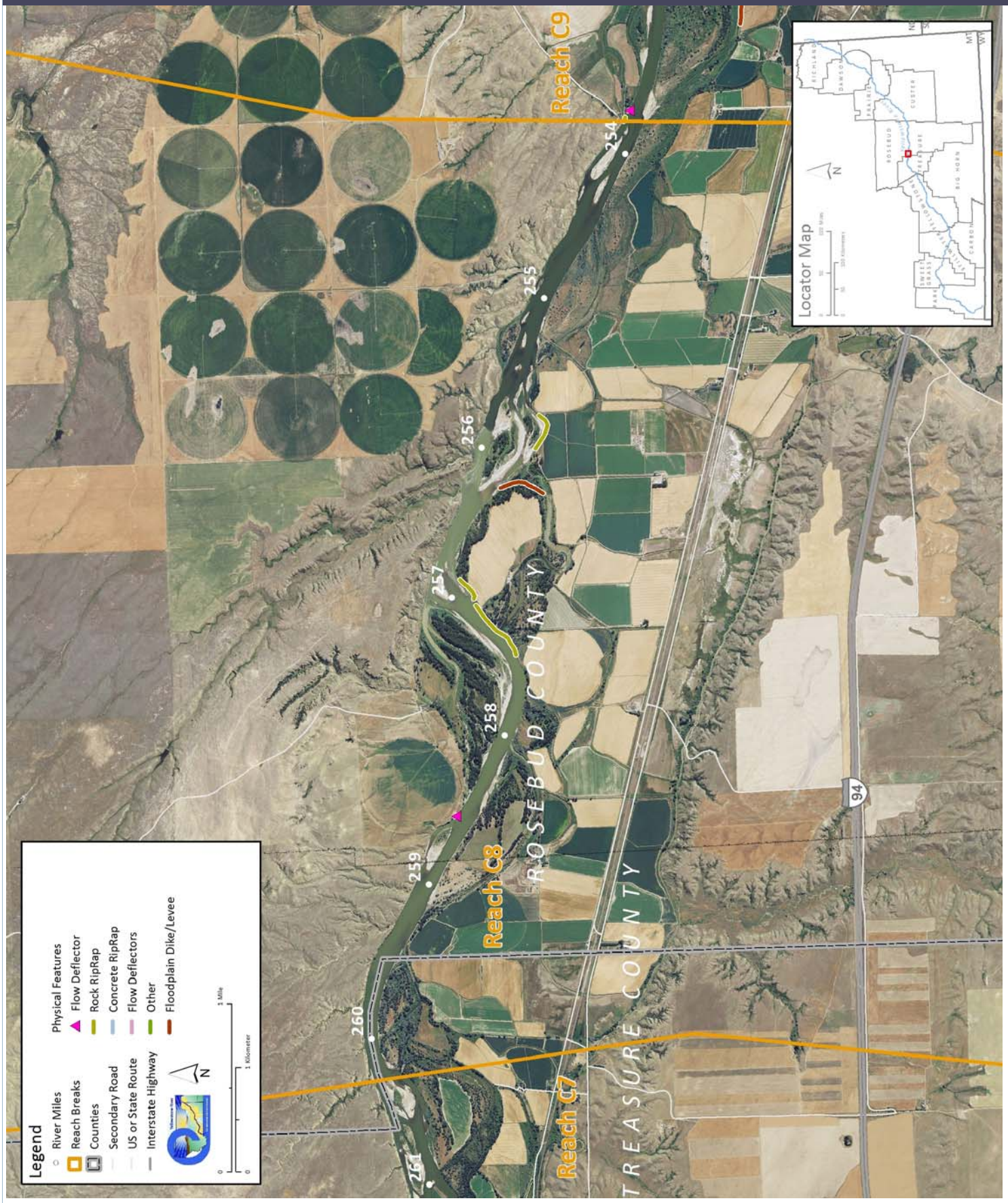
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

Riparian Forest at low risk of Cowbird Parasitism (Ac/Valley Mile)

1950	1976	2001	Change 1950-2011
50.7	36.3	60.9	10.3

Cowbirds are associated with agricultural and residential development, displacing native bird species by parasitizing their nests.

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP