Yellowstone River Reach Narratives — Reach A1

County	Sweet Grass	**Upstream River Mile**	478.8
Classification	PCB: Partially confined braided	**Downstream River Mile**	475.4
General Location	Springdale	**Length**	3.40 mi (5.47 km)

Narrative Summary

Reach A1 is located just downstream of the Springdale Bridge in western-most Sweet Grass County. It is a Partially Confined Braided (PCB) reach type, indicating some influence of the valley wall on river geomorphology, as well as abundant un-vegetated mid-channel bars. The reach is 3.4 miles long. This reach is most prominently characterized by a large meander located at RM 478 that has been very dynamic over recent years. The meander bend has repeatedly migrated to the north and then cut off, leaving broad open gravel bars and a wide active channel corridor. The bendway has been heavily armored on its apex, and partially armored on its downstream limb. With all of the changes at this meander, there has been a net gain of total channel area in the reach of about 50 acres since 1950.

There are about 6,800 feet of rock riprap in the reach, over 1,500 feet of which was constructed since 2001. Several flow deflectors have been eroded out in Reach A1 since 2001. About 25 percent of the bankline was armored as of 2011. There are also over 6,800 feet of mapped transportation encroachment in the river corridor, most of which is the rail line that follows the south bank.

Although the rail line runs along the edge of the river, it is situated on higher terraces and as such has not isolated any 100-year historic floodplain area. However, about 9 percent of the total Channel Migration Zone (CMZ) footprint has become restricted, and these restrictions are due to armoring against both the rail line and irrigated fields. This demonstrates how terraces that may be out of the 100-year floodplain can still be prone to erosion and thus within the CMZ.

The primary land use in the reach is non-irrigated agriculture (~1,100 acres), although there are about 650 acres under some form of irrigation. Pivot irrigation has expanded from 0 acres in 1950 to 302 acres in 2011. Similarly, sprinkler irrigation has expanded from 0 to 250 acres during the same time frame, and the extent of flood irrigated lands dropped from 803 to 123 acres over those 61 years. About 46 acres of land under sprinkler and 10 acres of land under pivot are located within the CMZ.

About 120 acres of wetland have been mapped in the reach, with most of that (84 acres) emergent wetland marsh that is located primarily in the active stream corridor. About 20 acres of wetland have been isolated from the corridor by the rail line near RM 477.8. About 0.7 acres of Russian olive have been mapped in the reach, and these trees are dispersed throughout the corridor.

Hydraulic modeling of the reach shows an extensive network of floodplain channels on the floodplain in Reach A1 that creates some avulsion risk north of the river. Much of the armoring on the large meander at RM 478 has reduced the risk of an avulsion and potential bypass of the Prather Mayborn Westfall Ditch Diversion. In addition, one of the overflow channels has been allowed to activate, which has reduced the potential for additional avulsions. The strategic allowance of channel migration and secondary channel activation has prevented the creation of a severe pinch point at RM 477.4 that may have created long-term instability in the reach.

A large dike at RM 476.7 blocks a ~3,000-foot long side channel and focuses the river towards the south bank and the Prather Mayborn Westfall Ditch Diversion. Although the dike blocks the head of the channel, it is still seasonally accessed by other overflow points from the main river.

This area of the upper Yellowstone River has seen three severe floods in the last 20 years. The 1996 and 1997 floods were very damaging, early-June events that peaked at 37,100 and 38,000 cfs, respectively. At the time, these were considered to be sequential 100-year floods. Then in late June of 2011, the river peaked at 40,600 cfs, which is currently the flood of record at Livingston. This flood exceeded a 100-year event, with both the 1996/1997 events considered to have exceeded a 75-year flood.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 1,750 cfs to 1,570 cfs with human development, a reduction of 10.3 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A1 include:
- Strategic allowance of side channel activation to reduce overall avulsion risk
- Isolation of emergent wetlands by transportation infrastructure
- Blockage of a 3,000-foot long side channel to focus flows to a diversion structure.

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A1 include:
- CMZ management due to level of restriction and avulsion risks on north floodplain
- Bank Stabilization Recommended Practices due to current extent of bank armoring (25 percent of total bankline)
- Irrigation diversion structure management at Prather Mayborn Westfall
- Wetland management/restoration due to high wetland concentrations

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)	23,300	22,900	-1.7%
100 Year (cfs)	43,400	43,200	-0.5%

"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
189.9	216.9	242.7	256.3	66.4

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	6,838	19.2%	1,678
Concrete Riprap	0	0.0%	0
Flow Deflectors	2,092	5.9%	-309
Total	**8,930**	**25.1%**	**1,369**

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	2,970

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	44.0	62.6
Acres/Year	1.7	2.5
Acres/Year/Valley Mile	0.5	0.8

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

-45.46 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)				

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	13.2	7%
100 Year	0.0	0%

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
65.8	9%

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)	1,992.8	1,789.8
Ag. Infrastructure (Ac)	52.1	109.4
Exurban (Ac)	5.4	5.4
Urban (Ac)	0.0	0.0
Transportation (Ac)	47.6	81.5

	1950	2011
Flood (Ac)	803.4	122.6
Sprinkler (Ac)	0.0	254.2
Pivot (Ac)	0.0	301.6

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.
3.7	0.0	3.7	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	7.4	2.3
Emergent	84.3	26.0
Scrub/Shrub	38.0	11.7

Total Wetland Acres **129.8**

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	%
0.7	0.2%

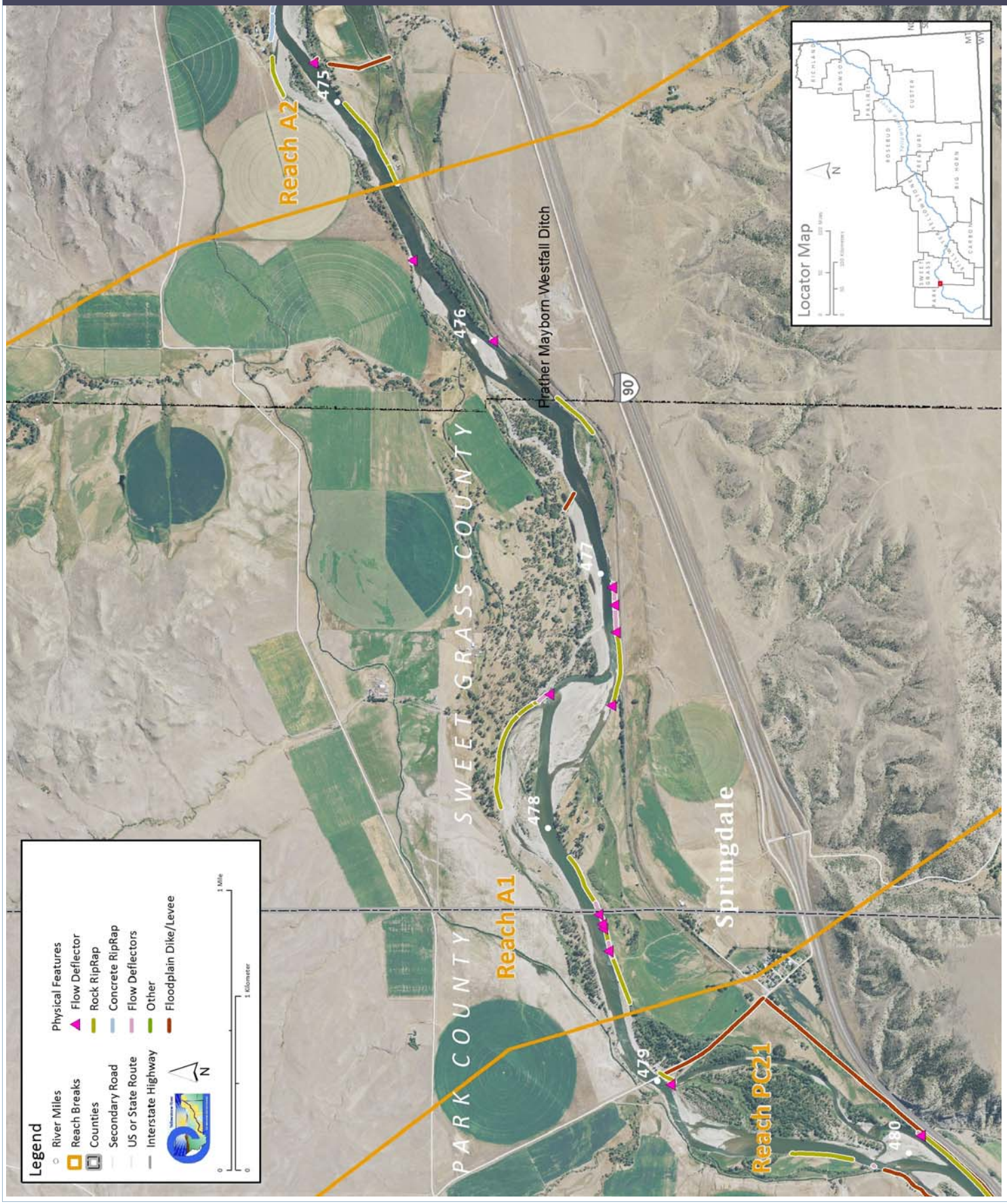
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

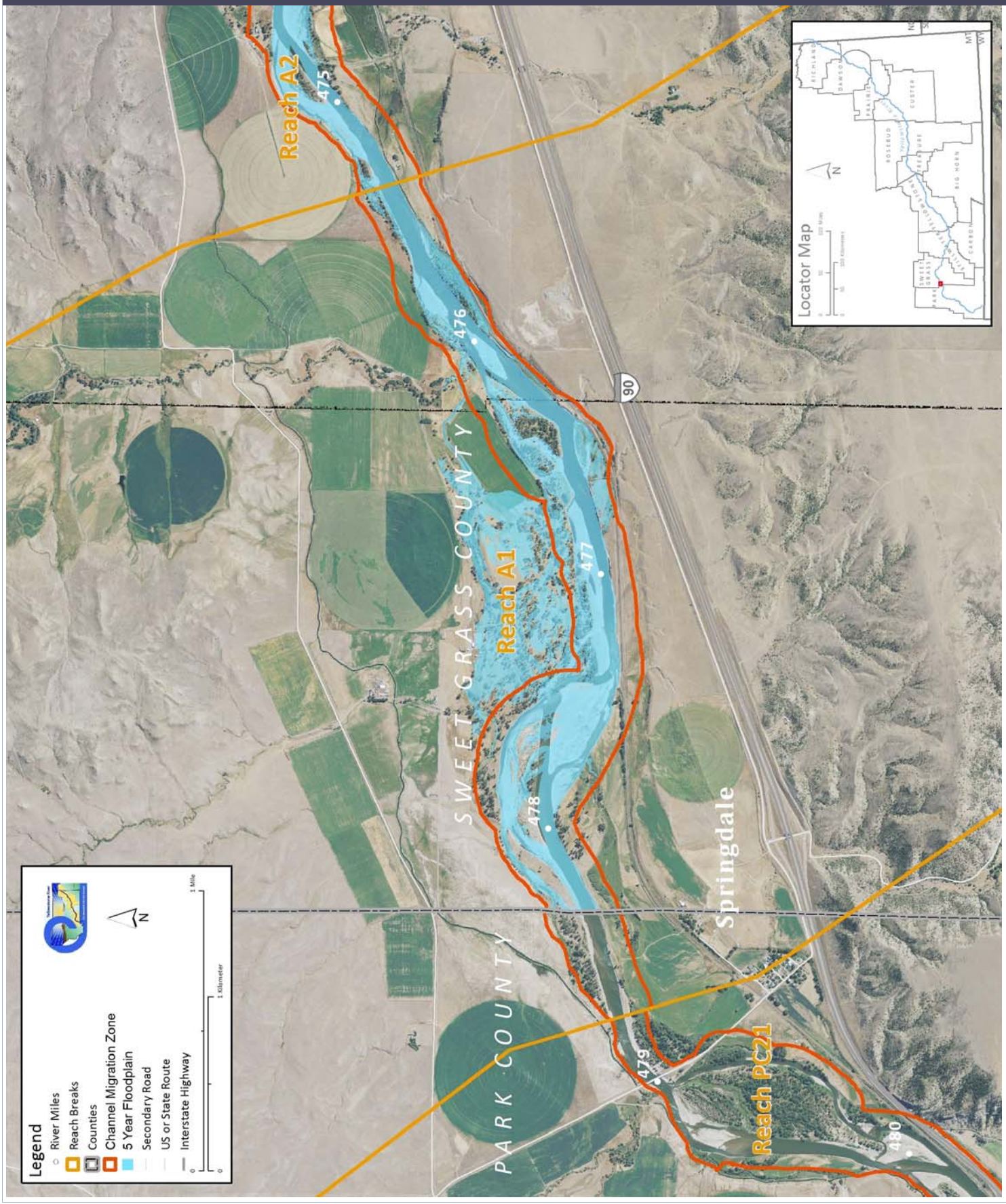
1950	1976	2001	Change 1950-2011
0.0	0.0	0.0	0.0

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	Sweet Grass	**Upstream River Mile**	475.4
Classification	UB: Unconfined braided	**Downstream River Mile**	468.5
General Location	Grey Bear fishing access	**Length**	6.90 mi (11.10 km)

Narrative Summary

Reach A2 is 6.9 miles long and extends from about one mile below the Prather Mayborn Westfall Ditch Diversion to about a mile below the Grey Bear fishing access. Reach A2 is classified as Unconfined Braided (UB), indicating a relatively small influence of the valley wall on reach geomorphology as well as a preponderance of open gravel bars in the channel. Reach A2 has changed markedly since the 1950s due to loss of riparian forest and side channel length.

As a consequence of its unconfined and dynamic nature, there are over two miles of rock riprap in the reach that cover almost 18 percent of the total bankline. Of those 10,633 feet of rock riprap, 1,673 feet was constructed since 2001. The physical features mapping also indicated 945 feet of tree revetments in the reach in 2001, however these were not identified in the 2011 mapping. This is the most upstream-reach with mapped concrete rubble riprap; there are over 1,000 feet of concrete riprap on the left bank at RM 474.6.

Sometime prior to 1950, one 3,125 foot long channel was blocked at RM 473. In 1950, there were still over 6 miles of active anabranching channels, but by 2011 that side channel length had dropped to 4 miles, resulting in a 15 percent reduction of braiding parameter in the reach.

There is also intermittent transportation encroachment by the railroad on the south side of the river. The transportation encroachment, which is due to the rail line, extends over two miles along the south bank and isolates 23 acres of historic floodplain. Similarly, 140 acres of the natural Channel Migration Zone (CMZ) area has been restricted by bank armor and the railroad prism.

Floodplain turnover values show that turnover rates have dropped from 4.5 acres per year to 3.7 acres per year since 1976. The channel has also enlarged by over 30 acres as anabranching channels have consolidated into a larger single thread. About 23 acres of 100-year floodplain area has been isolated by dikes.

Land uses in Reach A2 are primarily agriculture, with about ½ of the total agricultural land in some form of irrigation. About 26 acres of the existing 5-year floodplain are currently under irrigation, most of which is in flood.

Over 300 acres of wetland have mapped in the reach, most of which is emergent marsh-type areas. About 40 acres of emergent wetland are in an area of historic floodplain isolated by the railroad at RM 471.2. Approximately ½ of an acre of Russian olive was mapped in Reach A2.

Reach A2 has had extensive riparian clearing over the last century. In 1950, there were 431 acres of closed timber in the reach, and that footprint had contracted to 275 acres by 2001. Almost 12 acres of riparian forest in the reach per valley mile have been identified as being at low risk of cowbird parasitism due to the distance of those areas from agricultural infrastructure.

This area of the upper Yellowstone River has seen three severe floods in the last 20 years. The 1996 and 1997 floods were very damaging, early-June events that peaked at 37,100 and 38,000 cfs, respectively. At the time, these were considered to be sequential 100-year floods. Then in late June of 2011, the river peaked at 40,600 cfs, which is currently the flood of record at Livingston. This flood exceeded a 100-year event, with both the 1996/1997 events considered to have exceeded a 75-year flood.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 1,760 cfs to 1,580 cfs with human development, a reduction of 10.2 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A2 include:
- Blockage of over 3,000 feet of side channel prior to 1950
- Passive abandonment of over two additional miles of side channel since 1950.
- Loss of over 150 acres of closed timber since 1950, most of which is in the 5-year floodplain.

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A2 include:
- Side Channel Restoration (RM 473)
- CMZ management due to extent of encroachment (140acres restricted)

Yellowstone River Reach Narratives — Reach A2

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)	23,300	22,900	-1.7%
100 Year (cfs)	43,400	43,200	-0.5%

"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
442.3	474.7	464.9	480.2	37.9

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	12,305	16.9%	1,673
Concrete Riprap	1,015	1.4%	1,015
Flow Deflectors	154	0.2%	154
Total	**13,475**	**18.5%**	**2,842**

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
3,125	0

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	117.5	93.0
Acres/Year	4.5	3.7
Acres/Year/Valley Mile	0.7	0.6

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

-30.58 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)				

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	16.1	4%
100 Year	23.4	3%

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
140.5	11%

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)	3,713.3	3,548.8
Ag. Infrastructure (Ac)	141.0	217.9
Exurban (Ac)	0.0	13.4
Urban (Ac)	0.0	0.0
Transportation (Ac)	91.6	150.5

	1950	2011
Flood (Ac)	2,014.7	1,213.3
Sprinkler (Ac)	0.0	93.9
Pivot (Ac)	0.0	737.0

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.
4.3	0.8	5.1	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	17.0	2.6
Emergent	257.8	39.9
Scrub/Shrub	80.9	12.5

Total Wetland Acres: **355.7**

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	%
0.4	0.1%

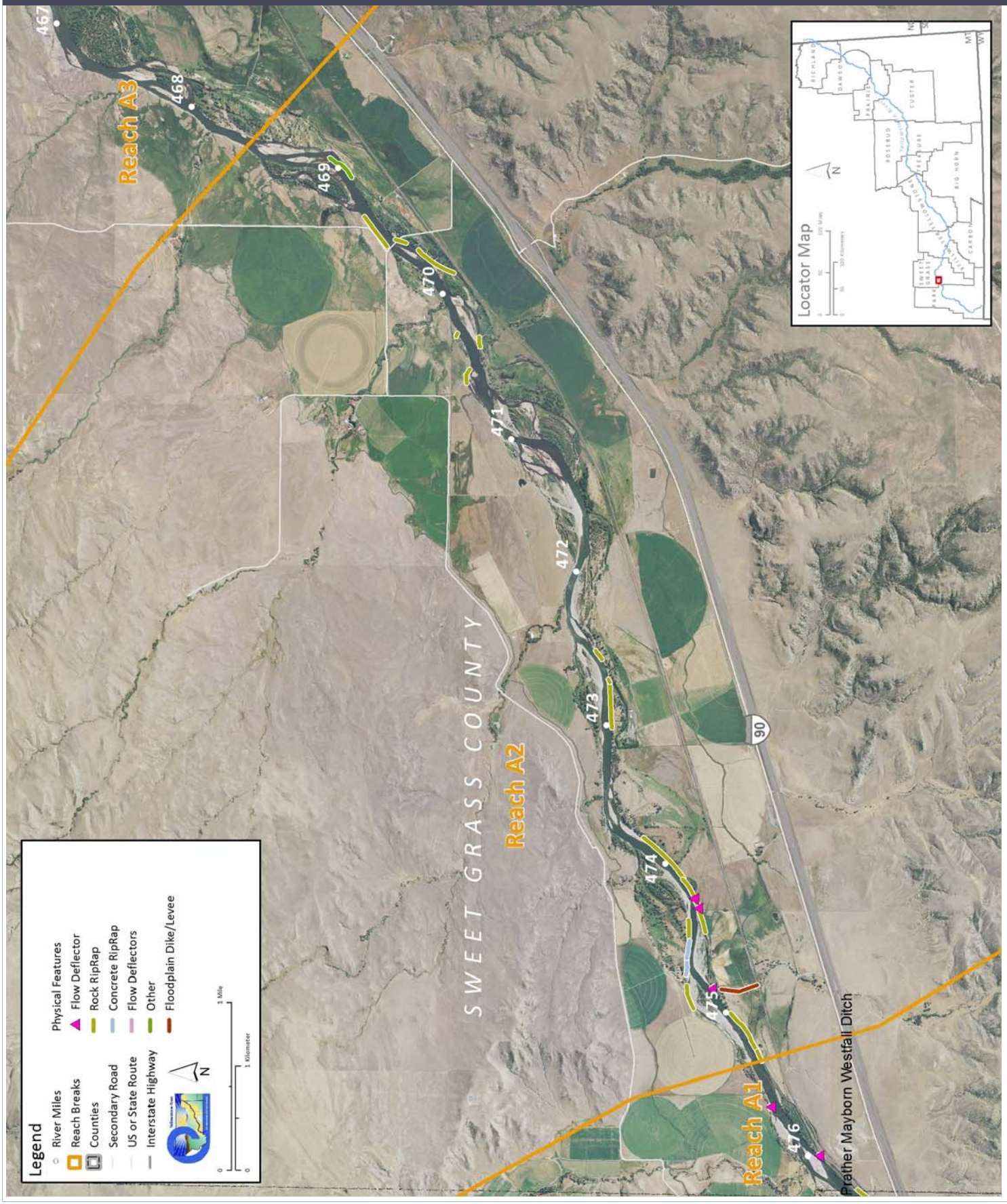
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

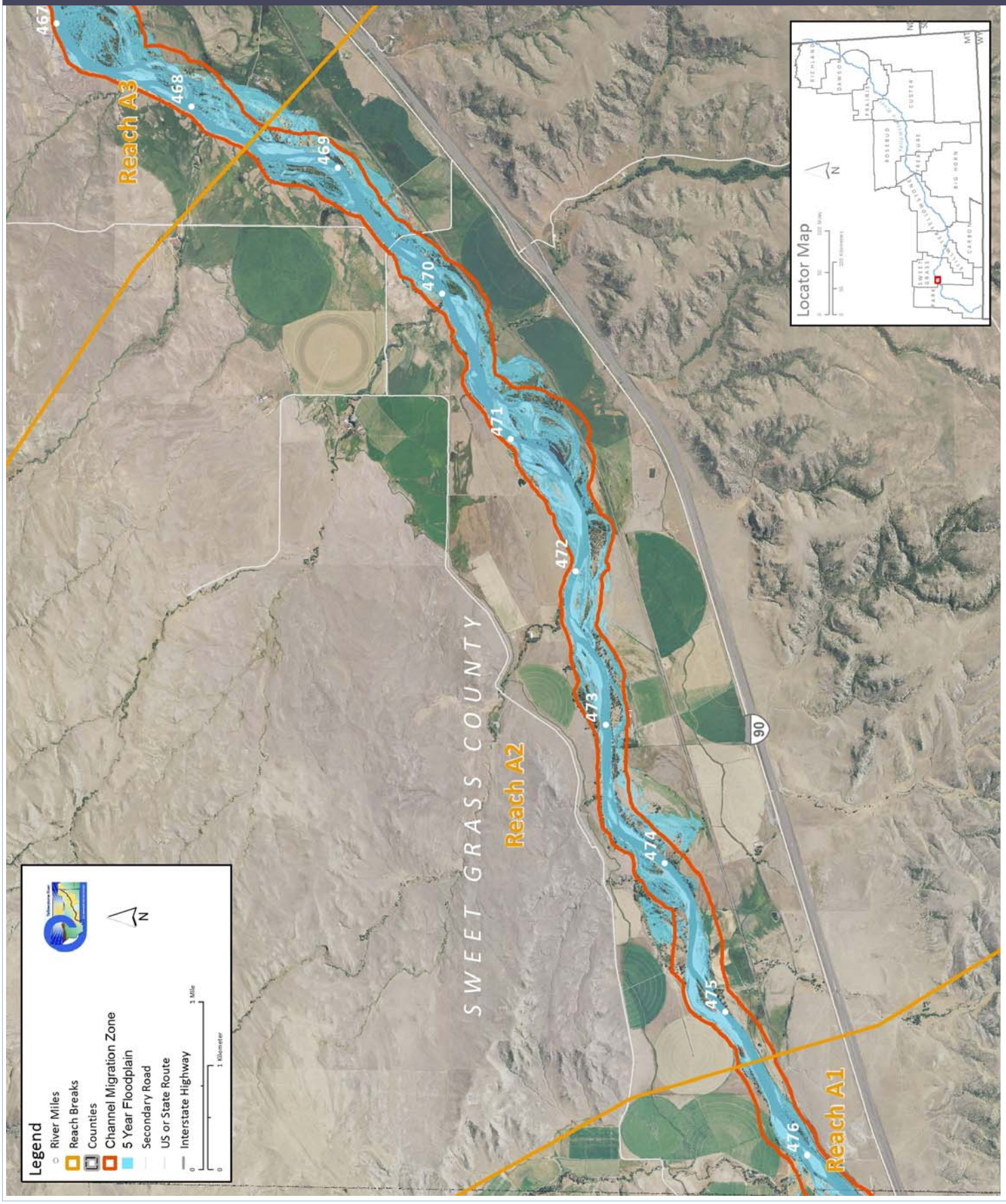
1950	1976	2001	Change 1950-2011
11.6	11.4	6.9	-4.8

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	Sweet Grass	**Upstream River Mile**	468.5
Classification	PCB: Partially confined braided	**Downstream River Mile**	463
General Location	Upstream of Big Timber	**Length**	5.50 mi (8.85 km)

Narrative Summary

Reach A3 is 5.5 miles long and is just located upstream of the town of Big Timber. It is classified as a Partially Confined Braided (PCB) reach type indicating some valley wall influence and relative extensive open gravel bars and low flow secondary channels. This reach shows the passive loss of miles of anabranching channel length since 1950, similar to Reach A2 just upstream. The river has converted from having more than one primary channel to having a dominant main thread with intermittent side channels.

About 12.5 percent of the banks in Reach A3 are armored, with the majority of that armor being rock riprap. Between 2001 and 2011, about 1,700 feet of new bank armor, of which 277 feet are flow deflectors, were installed. There are about 2,000 feet of floodplain dikes in the reach.

Similar to Reach A2 just upstream, this reach has experienced extensive loss of anabranching channel length since 1950. In 1950, the total length of anabranching channels was 6.7 miles, and by 2001 that length had dropped to 4.7 miles, resulting in a reduction in braiding parameter of 17 percent.

Reach A3 shows a reduction in floodplain turnover rates since 1976; prior to that time, average rates of turnover were 103 acres per year, and since that time the average rate of floodplain erosion by the river has been reduced to 65.4 acres per year.

Land use in Reach A3 is predominantly agricultural, with about ½ of all agricultural acreage in flood irrigation. Approximately 13 percent of the 5-year floodplain has been isolated in the reach. This isolation reflects the slight reduction in the magnitude flows in this reach due primarily to irrigation-related withdrawals upstream.

Over 600 acres of wetland have been mapped in Reach A3, most of which is emergent marshes and wet meadows on the south side of the river. The 4.6 acres of Russian olive mapped is dispersed throughout the riparian corridor.

Almost 50 acres of riparian forest per valley mile is considered at low risk of cowbird infestation due to its relative distance from agricultural infrastructure that provides cowbird foraging habitat.

This area of the upper Yellowstone River has seen three severe floods in the last 20 years. The 1996 and 1997 floods were very damaging, early-June events that peaked at 37,100 and 38,000 cfs, respectively. At the time, these were considered to be sequential 100-year floods. Then in late June of 2011, the river peaked at 40,600 cfs, which is currently the flood of record at Livingston. This flood exceeded a 100-year event, with both the 1996/1997 events considered to have exceeded a 75-year flood.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 11,900 cfs to 11,500 cfs, a drop of about 3.4 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 1,770 cfs to 1,580 cfs with human development, a reduction of 11 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A3 include:
- Passive abandonment of over two miles of side channel since 1950.
- Conversion from a river channel with multiple large primary channels to a single main thread with small anabranches.
- Reduced floodplain turnover rates.

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A3 include:
- Russian olive removal
- Wetland management/restoration due to high density of mapped emergent wetland

Yellowstone River Reach Narratives — Reach A3

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)	23,300	22,900	-1.7%
100 Year (cfs)	43,400	43,200	-0.5%

"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
343.5	379.6	366.8	376.5	33.0

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	6,765	12.0%	1,291
Concrete Riprap	0	0.0%	0
Flow Deflectors	277	0.5%	277
Total	**7,042**	**12.5%**	**1,568**

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	103.0	65.4
Acres/Year	4.0	2.6
Acres/Year/Valley Mile	0.9	0.6

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

-7.98 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)				

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	13.2	3%
100 Year	0.0	0%

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
99.5	9%

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)	3,050.1	2,981.2
Ag. Infrastructure (Ac)	7.3	22.0
Exurban (Ac)	0.0	0.0
Urban (Ac)	0.0	0.0
Transportation (Ac)	3.3	6.3

	1950	2011
Flood (Ac)	1,492.4	1,670.4
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	0.0

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.
3.6	0.0	3.6	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	5.1	1.1
Emergent	558.7	120.5
Scrub/Shrub	86.5	18.7

Total Wetland Acres: **650.3**

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	%
4.6	0.3%

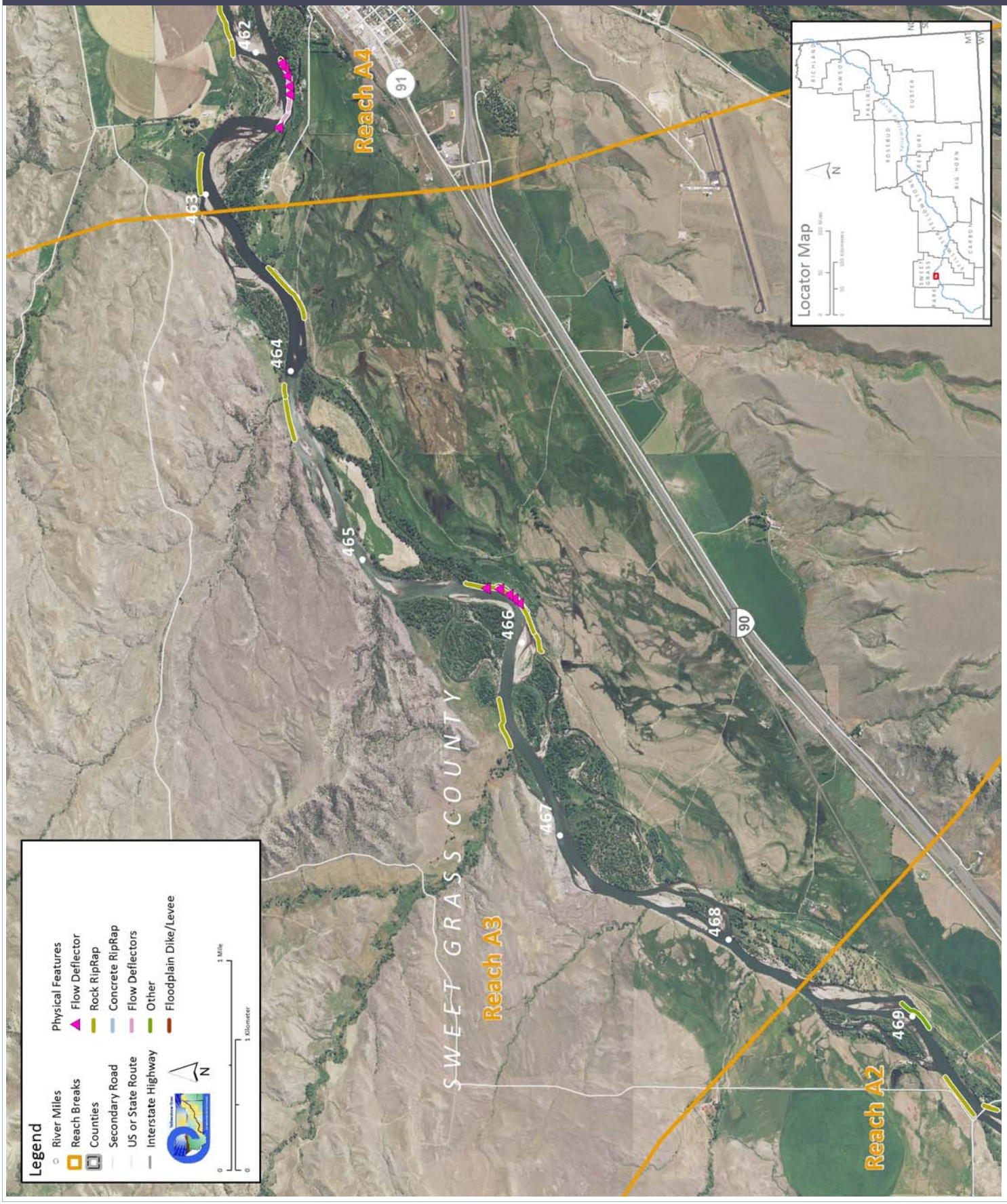
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

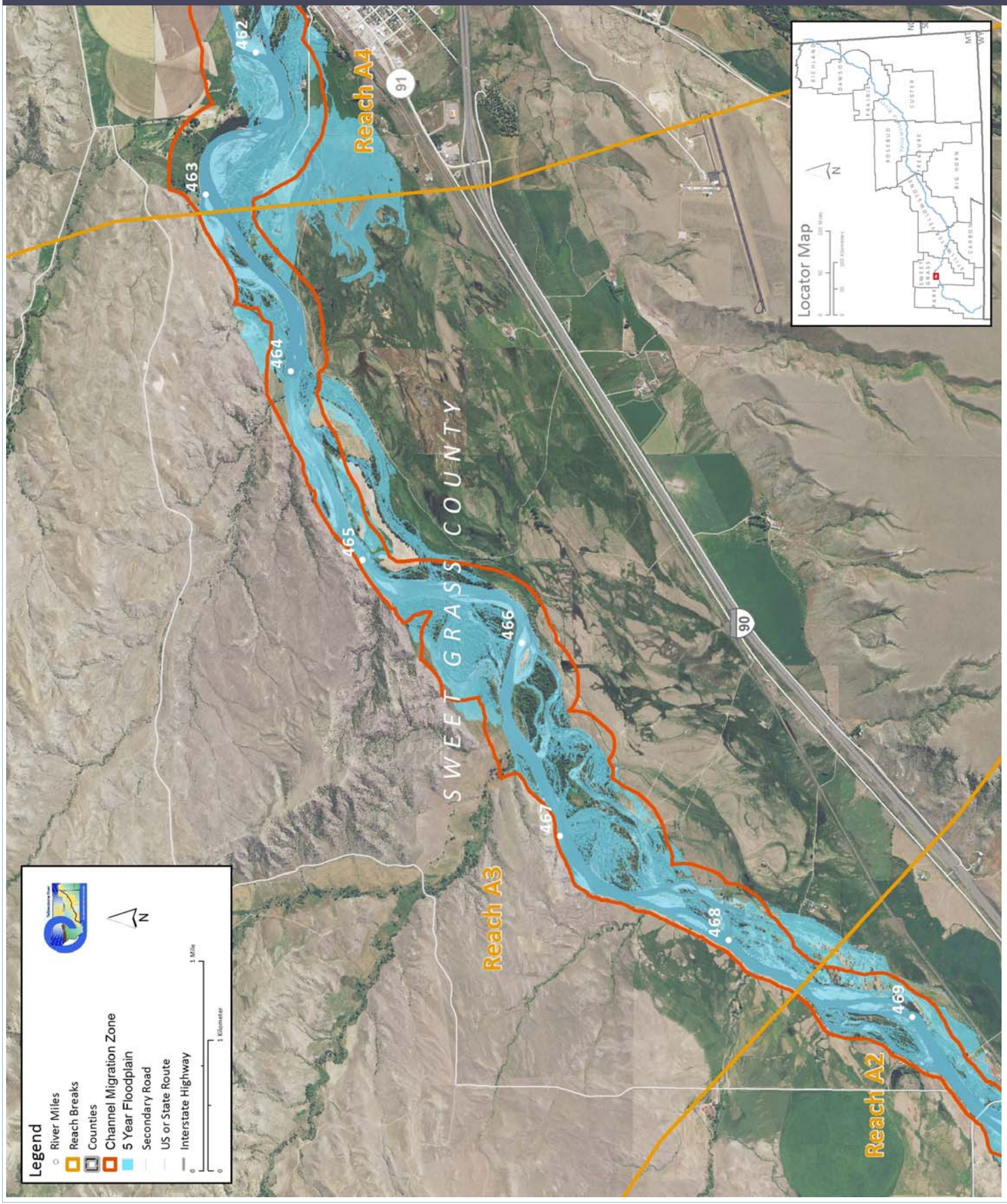
1950	1976	2001	Change 1950-2011
46.4	60.5	49.5	3.0

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	Sweet Grass	**Upstream River Mile**	463
Classification	UB: Unconfined braided	**Downstream River Mile**	459.7
General Location	Big Timber	**Length**	3.30 mi (5.31 km)

Narrative Summary

Reach A4 is approximately 3.3 miles long, extending from near the Sweet Grass County Fairgrounds downstream to the Boulder River confluence. Reach A4 is very dynamic with active channel migration, threats to infrastructure, bank armor, flanked barbs, and active riparian recruitment on raw gravel bars. The most dynamic portion of the reach is upstream of the Highway 191 Bridge; in spring of 2013 a large meander formed a 1,500 foot long chute cutoff near the fairgrounds which abandoned about 3,500 feet of channel to the south.

About 19 percent of the banks in Reach A4 are armored, with the majority of that armor being rock riprap. Between 2001 and 2011, there was a loss of about 1,000 feet of armor in the reach. Over 800 feet of that lost bank protection was flow deflectors; flanked barbs are visible in the middle of the channel downstream of the fairgrounds. With the avulsion of 2013, those flanked barbs are now sitting in the abandoned channel. Similar to reaches upstream, the river channel in Reach A4 has increased in size since 1950 by about 19 acres, and the channel expansion has been at the expense of riparian cover. Almost a quarter of the Channel Migration Zone (CMZ) has been restricted by physical features, and the restrictions are primarily due to bank armor that is protecting agricultural land.

Since 1950, over 7,500 feet of side channels in Reach A4 have been blocked by berms, which have caused a 25 percent drop in braiding parameter for the reach. Russian olive has colonized these historic channels. Like many other reaches the loss of active side channels in this reach has been accompanied by a lengthening of the main thread. Between 1950 and 2001, the main channel lengthened by about 1,000 feet through the 3.3 mile reach.

Land use in Reach A4 is predominantly agricultural, although there are several hundred acres of urban/exurban development associated with the town of Big Timber. Most of the agricultural land is non-irrigated; however there are hundreds of acres of flood, sprinkler, and pivot irrigation in the reach. Almost 150 acres of irrigated ground are within the 5-year floodplain in Reach A4, and most of that commonly flooded ground is south of the fairgrounds. This area also has most of the 160 acres of mapped wetlands in the reach.

There is one mapped dump site in Reach A4, which is on the high terrace edge at Big Timber. There is also one major petroleum product pipeline in the reach that runs parallel to the river on its north side. The pipeline is owned by ConocoPhillips, and passes under both Big Timber Creek and Otter Creek within 1,500 feet of the Yellowstone River.

Almost 200 acres of land in Reach A4 are within the mapped Channel Migration Zone. This includes 83 acres of flood, 42 acres of sprinkler, and 37 acres of pivot. A total of 21 acres of land in the CMZ has been developed to urban/exurban use.

This area of the upper Yellowstone River has seen three severe floods in the last 20 years. The 1996 and 1997 floods were very damaging, early-June events that peaked at 37,100 and 38,000 cfs, respectively. At the time, these were considered to be sequential 100-year floods. Then in late June of 2011, the river peaked at 40,600 cfs, which is currently the flood of record at Livingston. This flood exceeded a 100-year event, with both the 1996/1997 events considered to have exceeded a 75-year flood.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 11,900 cfs to 11,500 cfs, a drop of about 3.4 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 1,880 cfs to 1,620 cfs with human development, a reduction of 14 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A4 include:
- Restriction of the Historic Migration Zone (HMZ) isolating side channels and reducing riparian turnover.
- Primary channel lengthening in association with loss of side channels.
- Rapid migration and channel realignment resulting in barb flanking and abandonment of rock in channel.
- Isolation of historic channels (over 7,500 feet) by berms.
- Russian olive colonization within isolated side channels.
- Riparian recruitment (cottonwood establishment) on islands created by channel migration.

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A4 include:
- Removal of flanked armor at RM 462.3
- Side channel restoration/management (RM 461.2, RM 462)
- CMZ management due to encroachment (200 acres restricted)
- Russian olive removal (2.7 acres)
- Solid waste removal from dump on right bank at RM 461
- Pipeline management at Big Timber Creek and Otter Creek tributary crossings just north of Yellowstone River.

Yellowstone River Reach Narratives — Reach A4

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)	23,300	22,900	-1.7%
100 Year (cfs)	43,400	43,200	-0.5%

"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
203.9	238.6	235.7	257.2	53.3

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	6,143	16.8%	-168
Concrete Riprap	0	0.0%	0
Flow Deflectors	932	2.5%	-854
Total	**7,075**	**19.3%**	**-1,022**

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	7,575

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	64.1	58.2
Acres/Year	2.5	2.3
Acres/Year/Valley Mile	0.8	0.8

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

-35.78 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)				

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	8.5	3%
100 Year	0.0	0%

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
183.0	23%

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)	2,380.8	2,154.9
Ag. Infrastructure (Ac)	112.7	138.6
Exurban (Ac)	22.3	105.2
Urban (Ac)	176.6	268.6
Transportation (Ac)	60.8	64.4

	1950	2011
Flood (Ac)	1,161.8	385.3
Sprinkler (Ac)	0.0	194.7
Pivot (Ac)	0.0	301.5

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.
2.4	8.2	10.6	3.0%

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	3.7	1.3
Emergent	140.0	47.6
Scrub/Shrub	20.5	7.0

Total Wetland Acres: **164.1**

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	%
2.7	0.3%

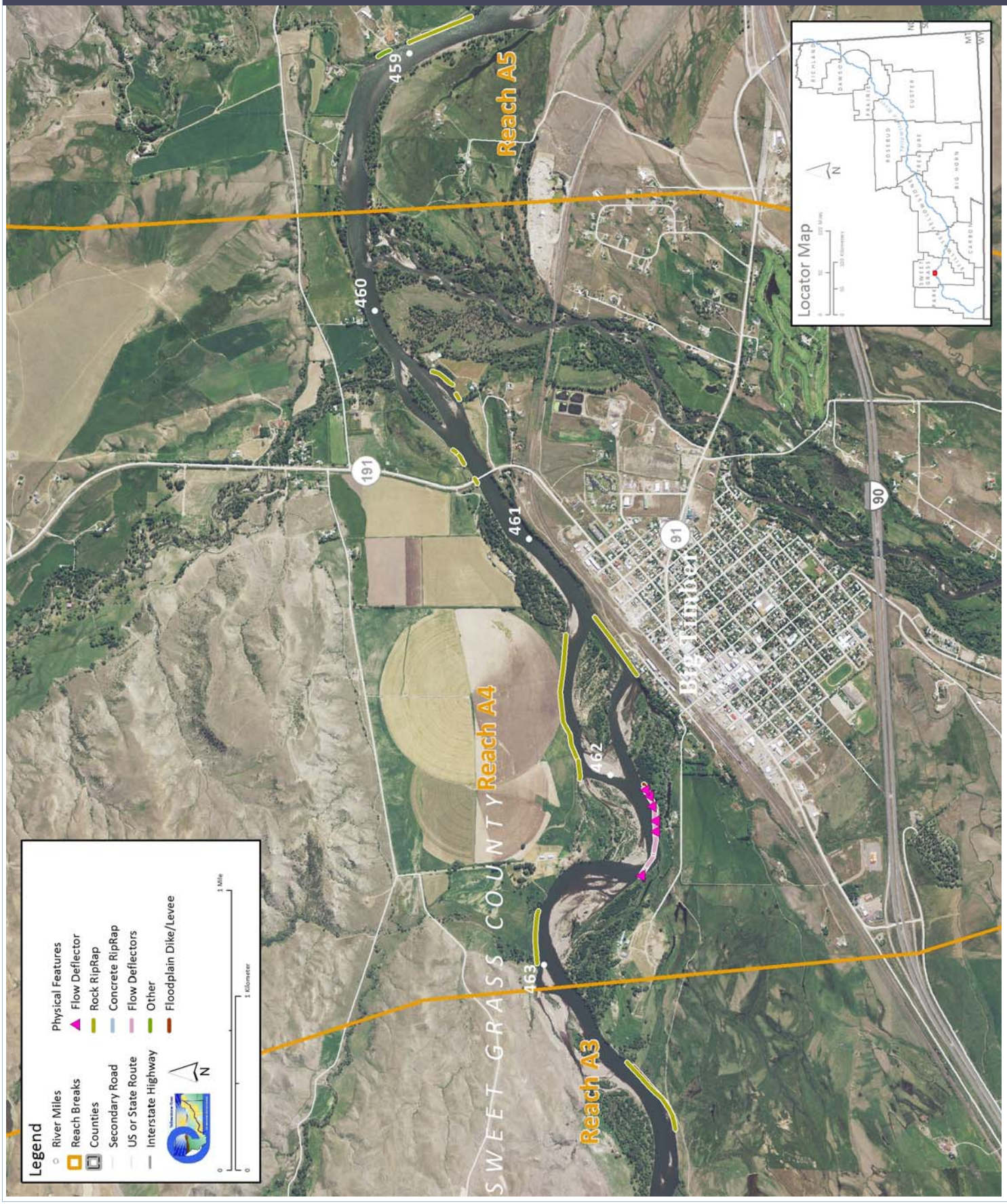
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

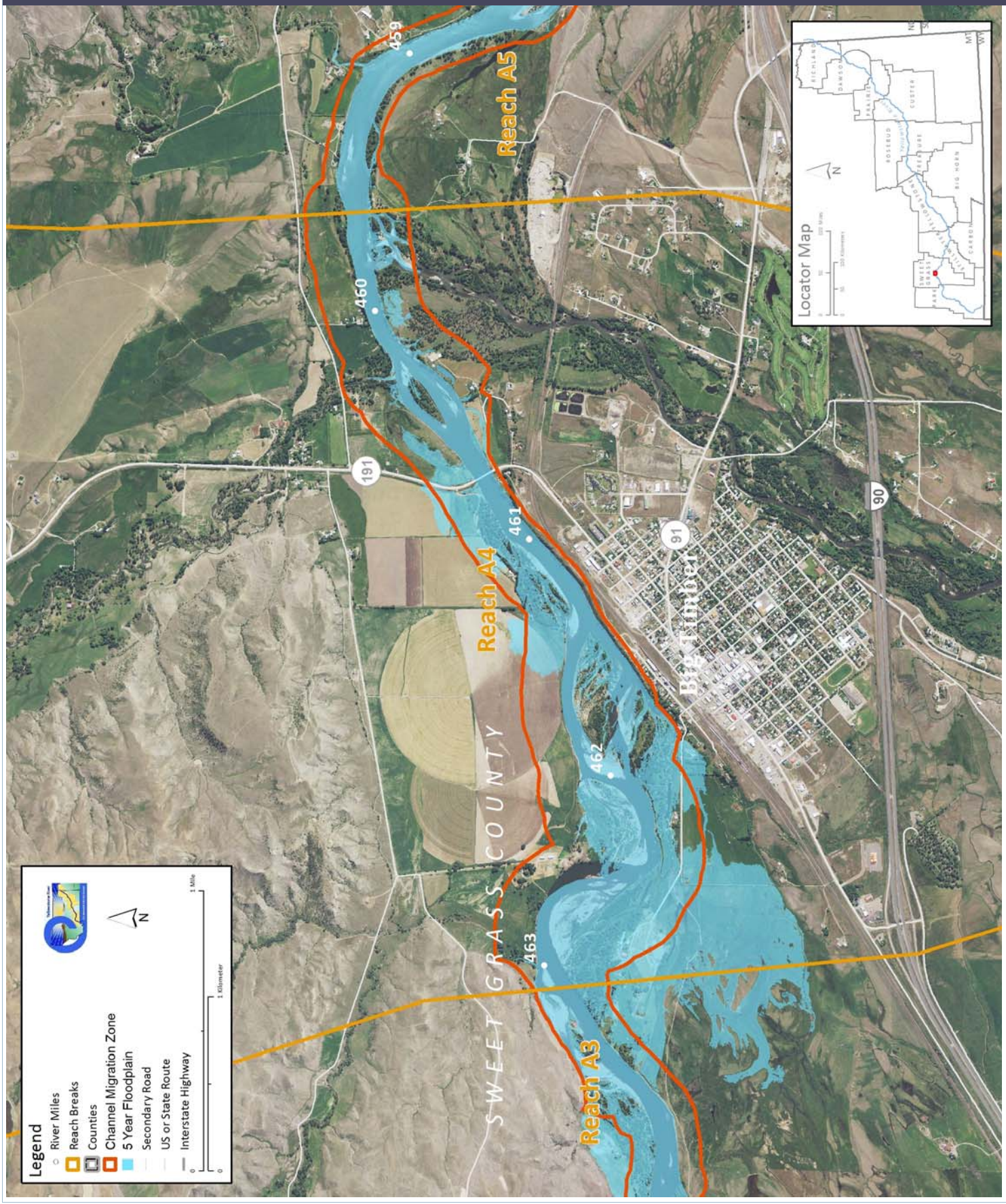
1950	1976	2001	Change 1950-2011
0.0	0.0	0.0	0.0

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	Sweet Grass	**Upstream River Mile**	459.7
Classification	UB: Unconfined braided	**Downstream River Mile**	456.4
General Location	Big Timber Creek	**Length**	3.30 mi (5.31 km)

Narrative Summary

Reach A5 is approximately 3.3 miles long, and is located just below Big Timber near the Otter Creek Fishing Access Site starting just below the mouth of the Boulder River. Reach A5 is shows low migration rates and has a relatively narrow CMZ as a result. Similar to other reaches in Region A, the channel footprint has enlarged since 1950; in this reach the channel shows continual expansion from 1950 to 2001 of about 24 acres. This has been accompanied by a loss of 16 acres of riparian area in the main river corridor.

About 7 percent of the banks in Reach A5 are armored by rock riprap. Another 250 feet of bank is protected by tree revetments which are unusual on the Yellowstone River.

Land use in Reach A5 is predominantly agricultural, although there over 60 acres of urban/exurban development on the outskirts of Big Timber. Most of the agricultural land is non-irrigated, although there are almost 400 acres of ground under flood irrigation and another 150 acres under pivot. There are corrals associated with an Animal Holding Facility on the left bank of the river at RM 459.

Reach A5 has substantial irrigated land in the Channel Migration Zone. Land use mapping for 2011 conditions show 62 acres of flood, 2 acres of sprinkler, and 9 acres of pivot irrigated land within the CMZ boundary.

Reach A5 has seen almost a quarter (18 acres) of its riparian corridor converted to developed land uses since 1950. Most of that (17 acres) was conversion to irrigation.

Over 170 acres of wetland have been mapped in Reach A5. Most of the wetland area is on the eastern portion of the large alluvial fan formed at the mouth of the Boulder River, where there are open water wetlands and wet marsh areas.

This area of the upper Yellowstone River has seen three severe floods in the last 20 years. The 1996 and 1997 floods were very damaging, early-June events that peaked at 37,100 and 38,000 cfs, respectively. At the time, these were considered to be sequential 100-year floods. Then in late June of 2011, the river peaked at 40,600 cfs, which is currently the flood of record at Livingston. This flood exceeded a 100-year event, with both the 1996/1997 events considered to have exceeded a 75-year flood.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 12,600 to 12,100 cfs, a drop of about 4 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 1,910 cfs to 1,630 cfs with human development, a reduction of 15 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A5 include:
- Riparian clearing in support of irrigation.
- Presence of corrals on the edge of the corridor at RM 459.
- Extensive wetland complex on low alluvial ground at the toe of a terrace.
- Encroachment of irrigated land into Channel Migration Zone.

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A5 include:
- Nutrient management at corrals at RM 459
- Wetland management/restoration due to extent of emergent marsh (>170 acres)

Yellowstone River Reach Narratives — Reach A5

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)	24,500	24,000	-2.0%
100 Year (cfs)	45,500	45,200	-0.7%

"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
188.3	195.7	203.1	219.2	30.9

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	2,117	6.2%	851
Concrete Riprap	0	0.0%	0
Flow Deflectors	0	0.0%	
Total	**2,117**	**6.2%**	

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	24.7	29.3
Acres/Year	0.9	1.2
Acres/Year/Valley Mile	0.3	0.4

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

-15.9 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)				

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	1.2	0%
100 Year	0.0	0%

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
16.1	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)	1,580.8	1,447.0
Ag. Infrastructure (Ac)	18.0	62.8
Exurban (Ac)	0.8	64.2
Urban (Ac)	0.0	0.0
Transportation (Ac)	7.1	7.1

	1950	2011
Flood (Ac)	733.8	391.5
Sprinkler (Ac)	0.0	8.3
Pivot (Ac)	0.0	154.4

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.
16.6	1.4	18.0	24.0%

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	6.3	2.1
Emergent	157.3	52.8
Scrub/Shrub	9.5	3.2

Total Wetland Acres: **173.2**

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	%
0.2	0.1%

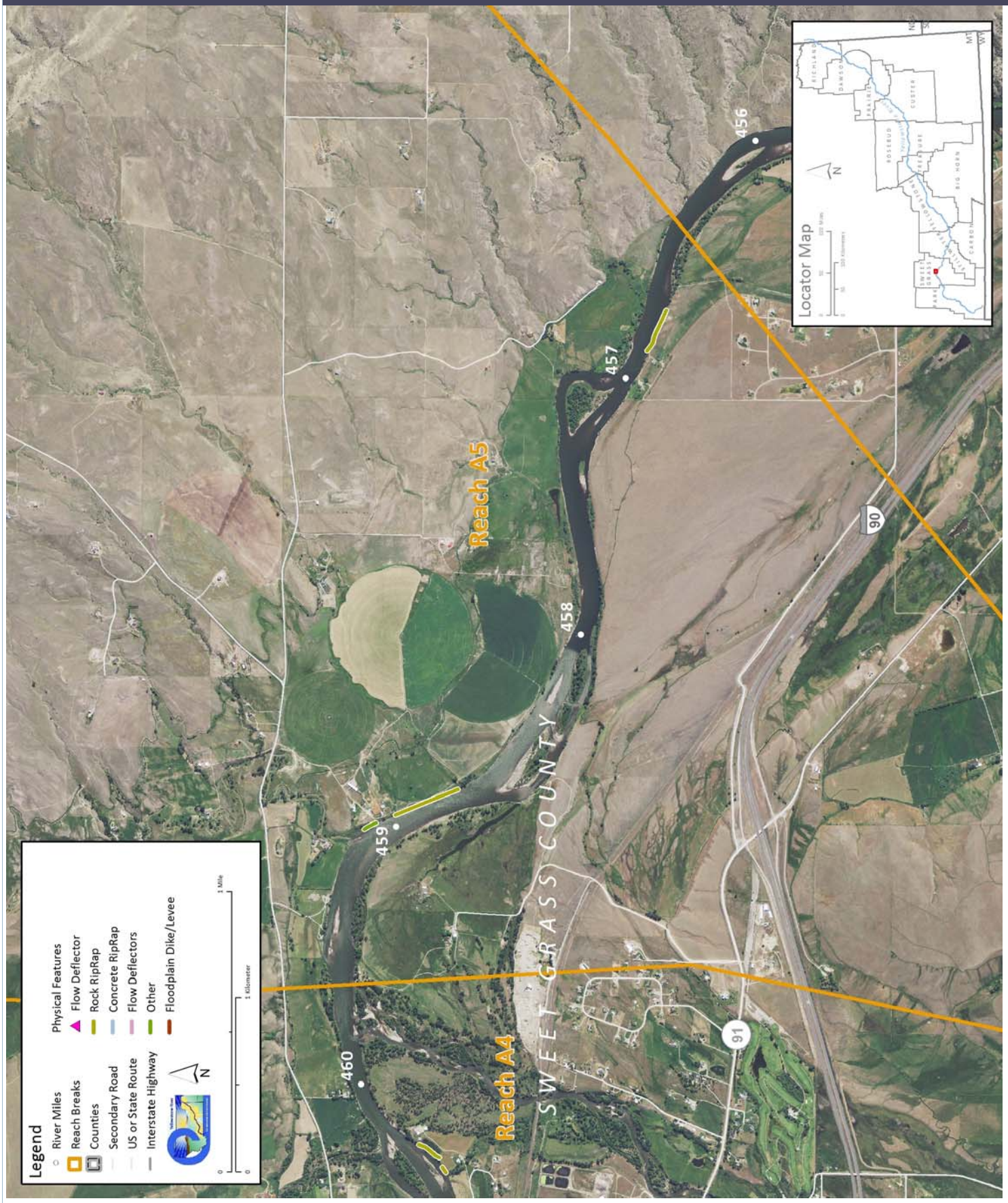
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

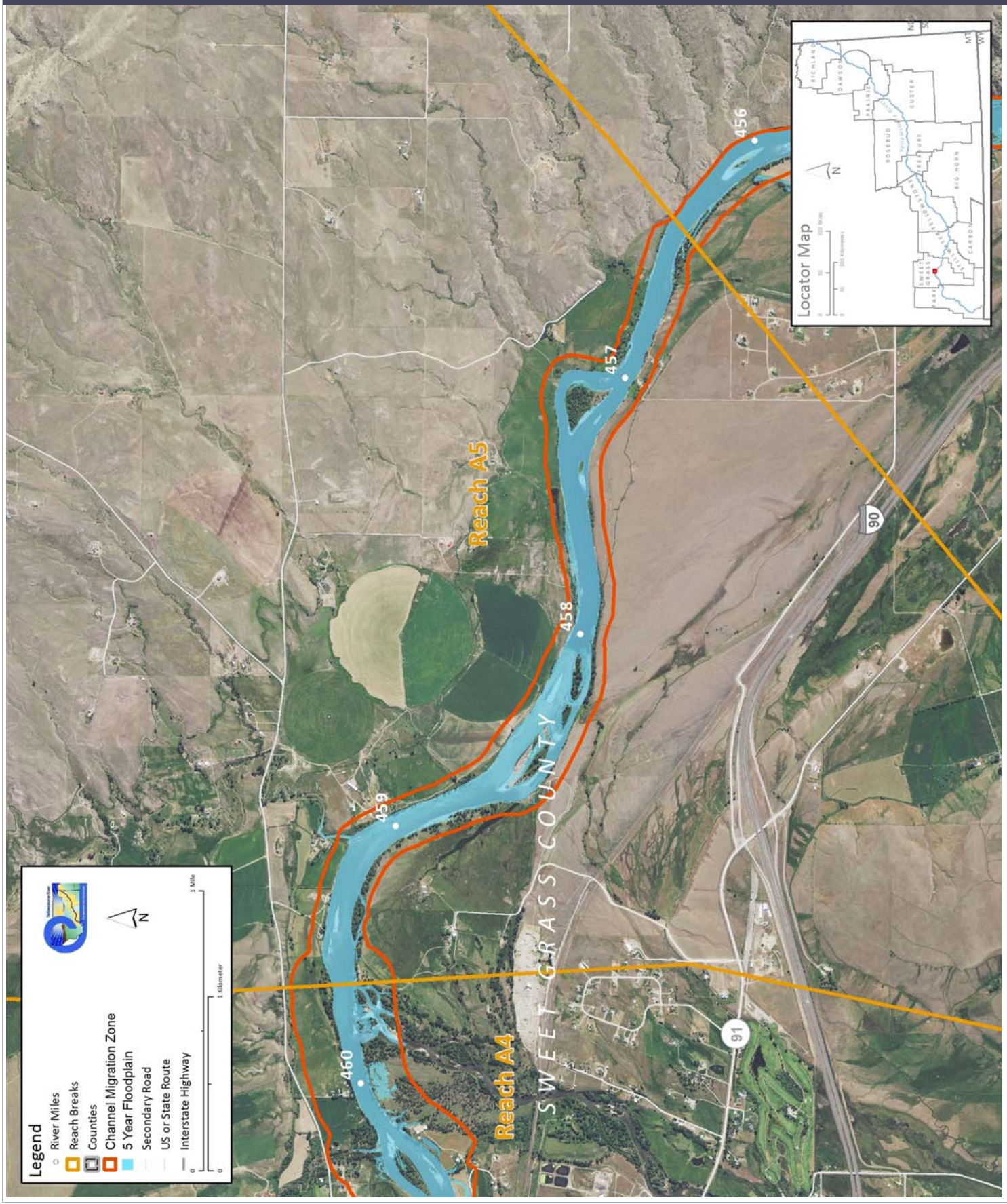
1950	1976	2001	Change 1950-2011
3.6	3.3	2.3	-1.3

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	Sweet Grass	**Upstream River Mile**	456.4
Classification	PCS: Partially confined straight	**Downstream River Mile**	453.3
General Location	Below Big Timber	**Length**	3.10 mi (4.99 km)

Narrative Summary

Reach A6 is approximately 3.1 miles long, and is located below Big Timber. The reach is classified as Partially Confined Straight (PCS), which indicates some valley wall influences on river form and minimal meandering. Within this reach, the river consistently follows the northern bluff line of the river valley which is comprised of Cretaceous-age Hell Creek Formation sandstones and mudstones. The other side of the river consists of low floodplain and terrace deposits. Because of the valley wall confinement, migration rates are low in the reach and the Channel Migration Zone (CMZ) is narrow.

Similar to other reaches in Region A, the overall footprint of the river channel has increased in size since 1950. In 1950, the channel footprint was 161 acres but by 2001 it had expanded to 202 acres.

About 7 percent of the banks in Reach A6 are armored, and most of that bank protection is flow deflectors (2,165 feet). There is another 650 feet of rock riprap, all of which was constructed between 2001 and 2011.

One side channel in Reach A6 was blocked prior to 1950. It is about 2,700 feet long and is blocked by a dike as well as flow deflectors along the bank. The side channel currently hosts riverine and emergent wetland areas.

Land use in Reach A6 is predominantly agricultural, although there almost 200 acres of exurban development on the low terraces between the river and I-90. Most of the agricultural land is non-irrigated, although there are 760 acres of ground under flood irrigation and another 64 acres under pivot. A total of 35 acres of flood irrigated land are in the Channel Migration Zone.

Reach A6 has seen 28 percent (18 acres) of its riparian corridor converted to developed land uses since 1950. Most of that (17 acres) was conversion to irrigation.

This area of the upper Yellowstone River has seen three severe floods in the last 20 years. The 1996 and 1997 floods were very damaging, early-June events that peaked at 37,100 and 38,000 cfs, respectively. At the time, these were considered to be sequential 100-year floods. Then in late June of 2011, the river peaked at 40,600 cfs, which is currently the flood of record at Livingston. This flood exceeded a 100-year event, with both the 1996/1997 events considered to have exceeded a 75-year flood.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 12,600 to 12,100 cfs, a drop of about 4 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 1,910 cfs to 1,630 cfs with human development, a reduction of 15 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

The reduction in flows is evident by the contraction of the 5-year floodplain area in Reach A6 by 4.8 acres, or 30 percent.

CEA-Related observations in Reach A6 include:
- Riparian clearing in support of irrigation.
- Side Channel Blockage
- Contraction of 5-year floodplain due to flow alterations.

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A6 include:
- Side channel restoration at RM 454.5

Yellowstone River Reach Narratives — Reach A6

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)	24,500	24,000	-2.0%
100 Year (cfs)	45,500	45,200	-0.7%

"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
160.9	160.3	176.7	201.9	41.0

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	648	2.1%	648
Concrete Riprap	0	0.0%	0
Flow Deflectors	2,165	6.9%	42
Total	**2,814**	**9.0%**	**690**

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
2,691	0

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	11.5	22.6
Acres/Year	0.4	0.9
Acres/Year/Valley Mile	0.2	0.3

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

-6.51 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)				

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	4.8	30%
100 Year	0.0	0%

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
20.1	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)	1,821.9	1,538.8
Ag. Infrastructure (Ac)	16.8	6.4
Exurban (Ac)	0.0	198.5
Urban (Ac)	0.0	0.0
Transportation (Ac)	19.1	77.4

	1950	2011
Flood (Ac)	936.4	761.1
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	64.1

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.
16.9	0.8	17.7	28.0%

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	14.3	5.1
Emergent	23.3	8.3
Scrub/Shrub	1.1	0.4

Total Wetland Acres: **38.6**

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	%
0.1	0.0%

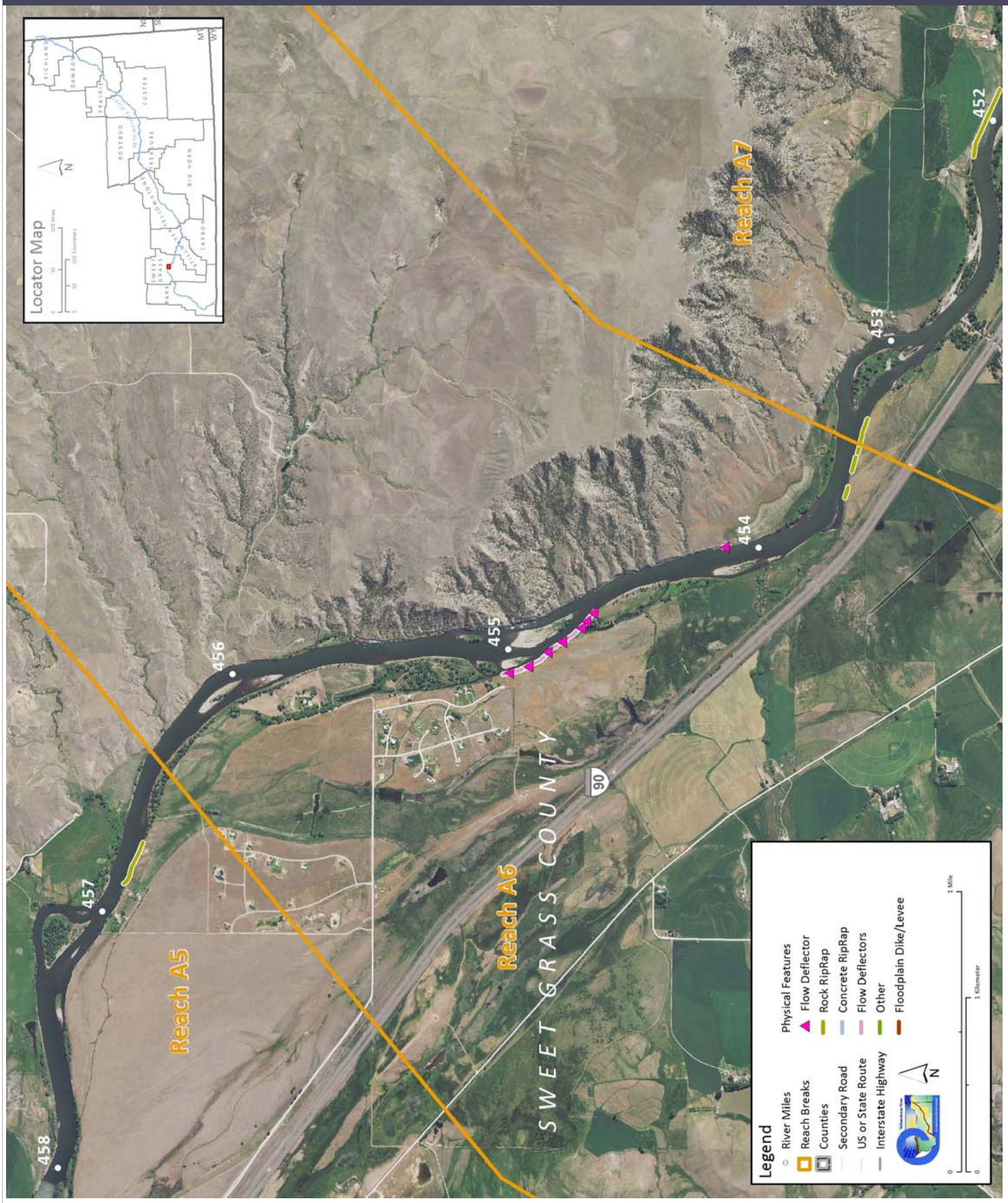
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

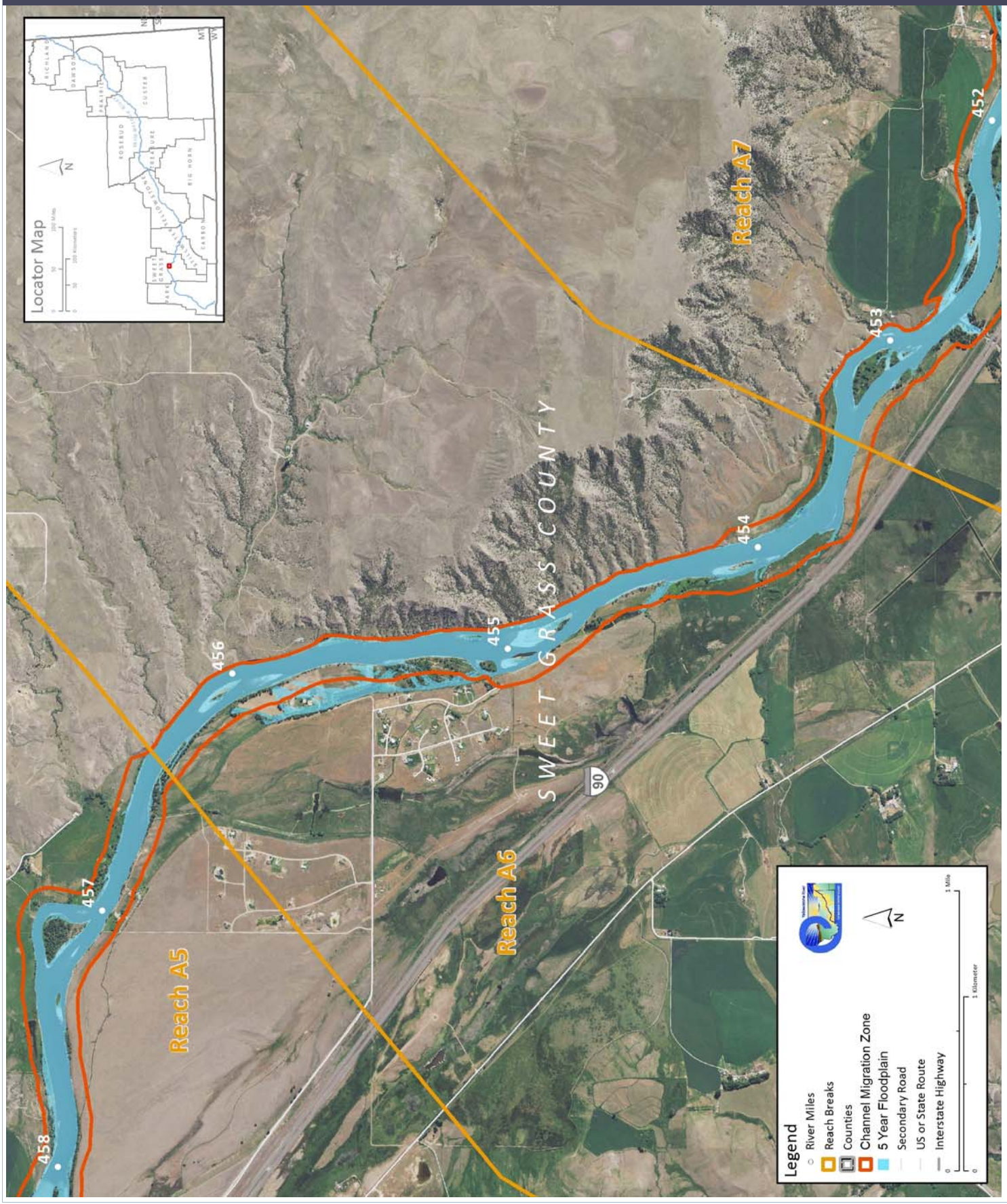
1950	1976	2001	Change 1950-2011
0.8	0.0	0.7	-0.1

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	Sweet Grass	**Upstream River Mile**	453.3
Classification	PCB: Partially confined braided	**Downstream River Mile**	443.6
General Location	Greycliff	**Length**	9.70 mi (15.61 km)

Narrative Summary

Reach A7 is approximately 9.7 miles long, and is at Greycliff. The reach is classified as Partially Confined Braided (PCB), which indicates some valley wall influences on river form and relatively extensive gravel bars and low flow channel complexity. Within this reach, the river intermittently follows the northern bluff line of the river valley which is comprised of Cretaceous-age Hell Creek Formation sandstones and mudstones. The other side of the river valley consists of low floodplain and terrace deposits. In several places, such as at Greycliff Bridge, the terrace toe is sandstone. Several tributaries enter the river in this reach, including Sweet Grass Creek and Deer Creek.

Similar to other reaches in Region A, the overall footprint of the river channel has increased in size since 1950. In 1950, the channel footprint was 613 acres but by 2001 it had expanded to 723 acres.

As of 2011, about 12 percent of the banks in Reach A7 were armored, and most of that bank protection is rock riprap (11,254 feet). There are also 1,500 feet of flow deflectors in the reach. Between 2001 and 2011, about 2,400 feet of riprap and 230 feet of flow deflectors were constructed. There are also minor amounts of gabions and steel retaining wall in the reach.

Reach A7 has experienced the loss of thousands of feet of side channels both pre- and post- 1950. Prior the collection of the 1950s imagery, a channel that was almost a mile long was blocked in multiple places. The land that this blocked side channel is about ½ mile downstream of the Greycliff Bridge on the right bank and is part of the Pelican Fishing Access Site. Currently, only the downstream portion of this channel has good definition; the upper end has largely decayed. Since 1950, side channels have been blocked at RM 445 and RM 452. Both of these side channels were relatively small features that flowed on the south side of the river corridor. In total, 4,600 feet of channel were blocked post-1950. Since 1950 there has been a net loss of about 9,000 feet of side channel in the reach, indicating some passive loss as well as loss due to blockages.

In contrast to the general trend on the river, floodplain turnover rates in Reach A7 have increased since 1976. From 1950-1976 the average floodplain turnover rate in this reach was 3.4 acres per year, and from 1976-2001, that rate had increased to 5.5 acres per year.

Land use in Reach A7 is predominantly agricultural, although there almost 140 acres of exurban development on the low terraces between the river and I-90. Transportation infrastructure also comprises almost 300 acres of the mapping footprint. Most of the agricultural land is non-irrigated, although there are 1,500 acres of ground under flood irrigation, 225 acres under sprinkler and another 914 acres under pivot. A total of 267 acres of developed land are in the Channel Migration Zone. Most of that is in flood irrigation (196 acres), but 51 acres are in pivot. At RM 450, pivots extend to the active streambank on both sides of the river. About 10 percent of the CMZ is restricted by physical features.

Reach A7 has seen 5 percent (33 acres) of its riparian corridor converted to developed land uses since 1950. Most of that (23 acres) was conversion to irrigation. Currently, there are about 26 acres of land under pivot irrigation within the mapped 5-year floodplain.

Reach A7was sampled as part of the avian study. The average species richness in Reach A7 was 9.9, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for sites evaluated is 8. One bird Species of Concern (SOC), the Bobolink, was identified in the reach. Three bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC) were also found, including the Chimney Swift, Dickscissel, and Ovenbird.

On area in Reach A7 that has become persistently problematic is the Greycliff Bridge at RM 448.5. Bank migration upstream of the bridge has approached 1,000 feet of lateral movement since 1950. Bank armor has been flanked and now sits In the middle of the river. The county road that lies in the CMZ has been threatened; it was treated with buried revetment that has become exposed in recent years. Efforts are ongoing to develop an optimal strategy to funnel the river meanderbelt through the bridge without disrupting sediment transport patterns and causing accelerated erosion.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 13,200 cfs to 12,700 cfs, a drop of about 4 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,000 cfs to 1,670 cfs with human development, a reduction of 17 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

The reduction in flows is evident by the contraction of the 5-year floodplain area in Reach A7 by 62 acres, or 25 percent.

CEA-Related observations in Reach A7 include:
- Flanking of armor and accelerated erosion behind.
- Side Channel Blockage
- Contraction of 5-year floodplain due to flow alterations.

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A7 include:
- Side channel restoration RM 452, RM 447.9, RM 445
- Bank armor removal upstream of Greycliff Bridge

•CMZ management due to encroachment of pivots

Yellowstone River Reach Narratives — Reach A7

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)	25,600	25,100	-2.0%
100 Year (cfs)	47,400	47,100	-0.6%

"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
613.3	627.0	632.6	722.7	109.3

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	11,254	10.8%	2,338
Concrete Riprap	0	0.0%	0
Flow Deflectors	1,507	1.4%	226
Total	**12,761**	**12.2%**	**2,564**

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
4,756	4,610

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	89.2	138.5
Acres/Year	3.4	5.5
Acres/Year/Valley Mile	0.4	0.6

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

-3.83 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)				

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	62.2	25%
100 Year	12.6	2%

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
164.2	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)	5,652.9	5,154.6
Ag. Infrastructure (Ac)	77.6	167.7
Exurban (Ac)	17.2	138.4
Urban (Ac)	0.0	0.0
Transportation (Ac)	110.1	295.9

	1950	2011
Flood (Ac)	2,027.4	1,465.8
Sprinkler (Ac)	0.0	224.5
Pivot (Ac)	0.0	913.8

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	9.7	32.5	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	14.1	1.6
Emergent	56.6	6.2
Scrub/Shrub	42.5	4.7

Total Wetland Acres: **113.2**

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	%
0.5	0.0%

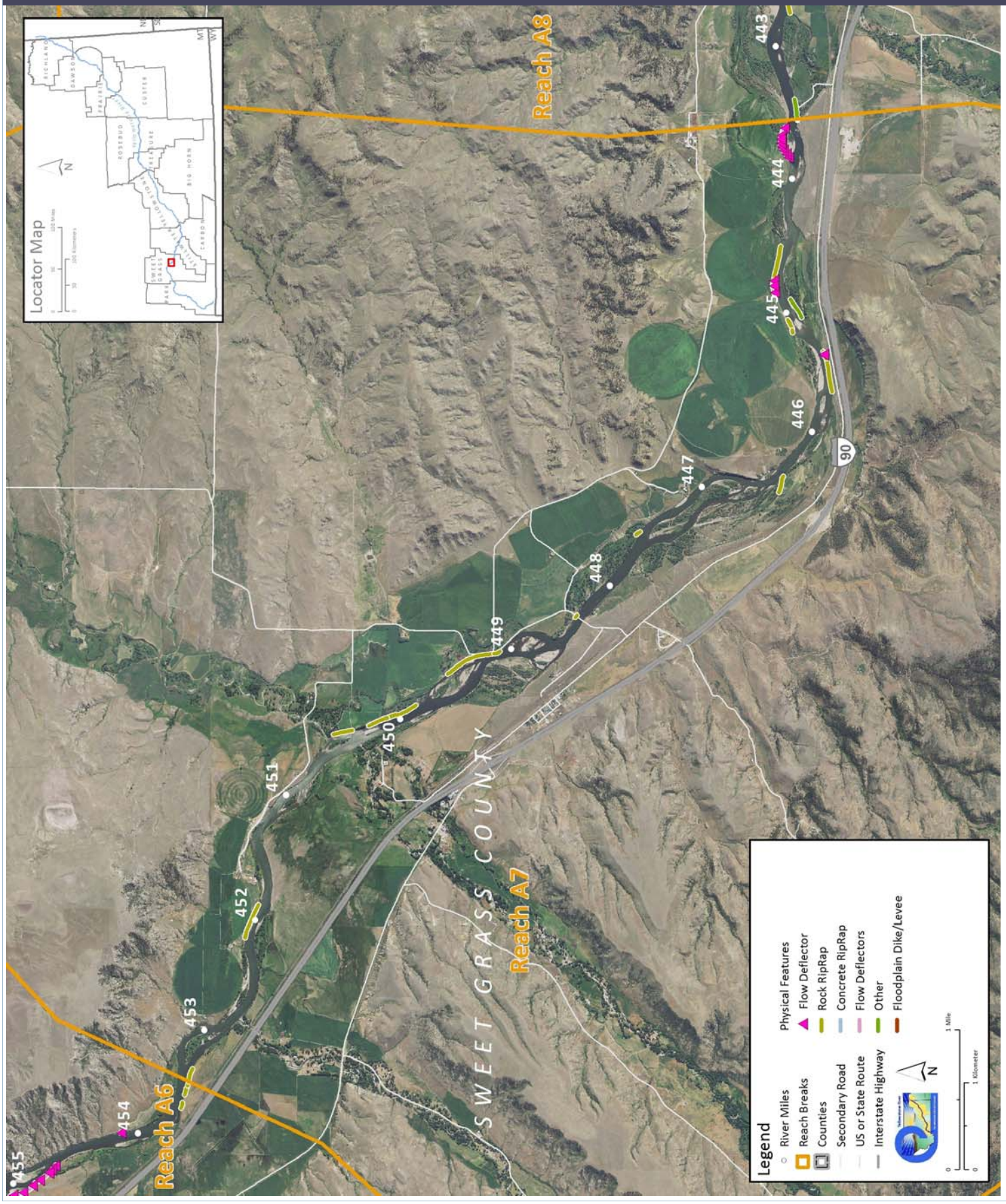
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

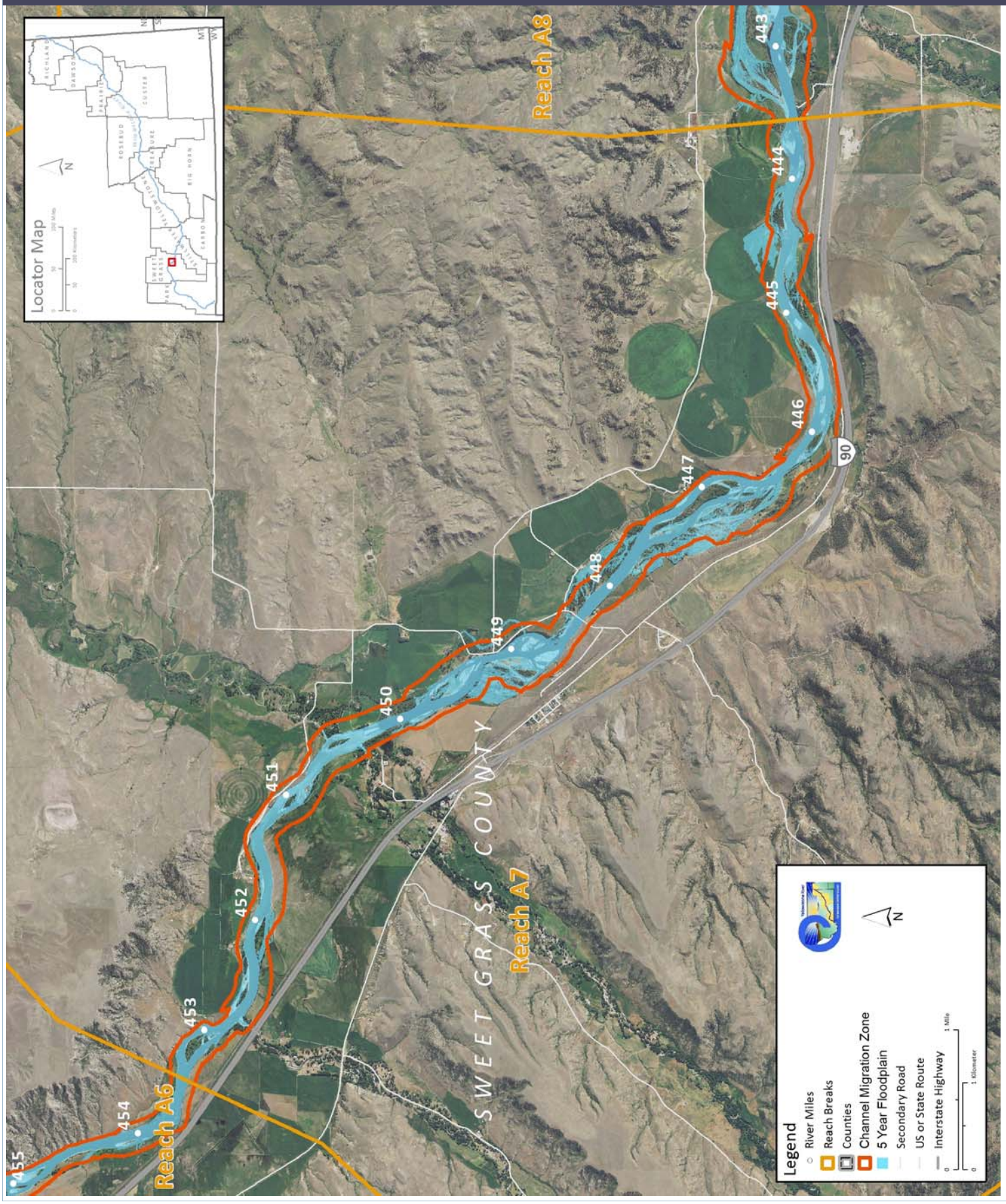
1950	1976	2001	Change 1950-2011
9.0	1.3	0.0	-9.0

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	Sweet Grass	**Upstream River Mile**	443.6
Classification	PCB: Partially confined braided	**Downstream River Mile**	438.5
General Location	Bridger Creek	**Length**	5.10 mi (8.21 km)

Narrative Summary

Reach A8 is 5.1 miles long, and is at Bridger Creek. The reach is classified as Partially Confined Braided (PCB), which indicates some valley wall influences on river form and relatively extensive gravel bars and low flow channel complexity. Within this reach, the river intermittently follows the northern bluff line of the river valley which is comprised of Cretaceous-age Hell Creek Formation sandstones and mudstones. The other side of the river valley consists of low floodplain and terrace deposits. The Bratten fishing access site is located in the lower end of the reach.

Similar to other reaches in Region A, the overall footprint of the river channel has increased in size since 1950. In 1950, the channel footprint was 436 acres but by 2001 it had expanded to 482 acres.

As of 2011, about 10 percent of the banks in Reach A8 were armored by almost 4,000 feet of rock riprap and 1,400 feet of flow deflectors. There is also a ~760 foot long retaining wall on the right bank at the very upstream most end of the reach that protects several structures. At Rm 441.1, rock riprap on both sides of the river has constricted the channel corridor to essentially the width of the active channel, which is about 550 feet. Physical features also occupy the floodplain; over three miles of transportation encroachment and 1,800 feet of floodplain dikes have been mapped in the reach. Transportation infrastructure and agriculture-related dikes have isolated 25 percent of the historic 100-year floodplain in the reach.

Reach A8 has experienced the loss of almost a mile of side channel since the 1950s due to dike construction. All of the side channel loss is from one project at the mouth of Bridger Creek, where the lower portion of the creek was channelized downstream of the I-90 Bridge. This channelization included re-routing the creek through a channelized section to an active side channel of the Yellowstone River. The channelization included construction of a dike that guides Bridger Creek into the side channel, and blocks the side channel at the intersection, essentially turning the lower portion of the side channel into lowermost Bridger Creek. The channelization of lower Bridger Creek occurred between 1950 and 1976.

Even though Reach A8 has experienced some side channel loss, it still supports extensive side channel length. As of 2001 there were 6.6 miles of active side channel in the 5.1 mile long reach.

Land use in Reach A8 is predominantly agricultural, although there almost 230 acres of transportation-related development in the mapping footprint. Most of the agricultural land is non-irrigated, although there are 900 acres of ground under flood irrigation and 56 acres under pivot. A total of 236 acres of developed land are in the Channel Migration Zone. Most of that is in flood irrigation (211 acres), but 8 acres are in pivot and 4 are in exurban development. About 16 percent of the CMZ is restricted by physical features.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 13,700 cfs to 13,000 cfs, a drop of about 5 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,020 cfs to 1,670 cfs with human development, a reduction of 17 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

The reduction in flows is evident by the contraction of the 5-year floodplain area in Reach A8 by 24 acres, or 11 percent.

CEA-Related observations in Reach A8 include:
- Side channel loss as part of tributary channelization
- Isolation of 25 percent of historic 100-year floodplain primary due to transportation infrastructure
- Contraction of 5-year floodplain due to flow alterations.

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A8 include:
- Side channel restoration at RM 442
- Floodplain restoration/reconnection on south side of interstate at RM 439.5
- CMZ management due to extent of CMZ restriction (16 percent)

Yellowstone River Reach Narratives — Reach A8

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)	26,600	25,800	-3.0%
100 Year (cfs)	49,000	48,500	-1.0%

"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
436.3	445.2	460.7	482.4	46.1

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	3,970	7.4%	274
Concrete Riprap	0	0.0%	0
Flow Deflectors	1,415	2.6%	-134
Total	**5,386**	**10.1%**	**140**

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	4,657

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	107.8	106.2
Acres/Year	4.1	4.2
Acres/Year/Valley Mile	0.9	0.9

1950-2001 In-channel riparian encroachment (negative number indicates retreat): 33.22 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)				

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	23.6	11%
100 Year	197.0	25%

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
195.8	16%

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)	3,285.3	3,019.8
Ag. Infrastructure (Ac)	63.0	128.0
Exurban (Ac)	0.0	10.2
Urban (Ac)	0.0	0.0
Transportation (Ac)	54.6	228.8

	1950	2011
Flood (Ac)	1,161.0	903.6
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	55.9

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.
1.1	3.6	4.7	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	14.8	3.2
Emergent	73.1	15.7
Scrub/Shrub	24.6	5.3

Total Wetland Acres: **112.5**

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	%
0.4	0.0%

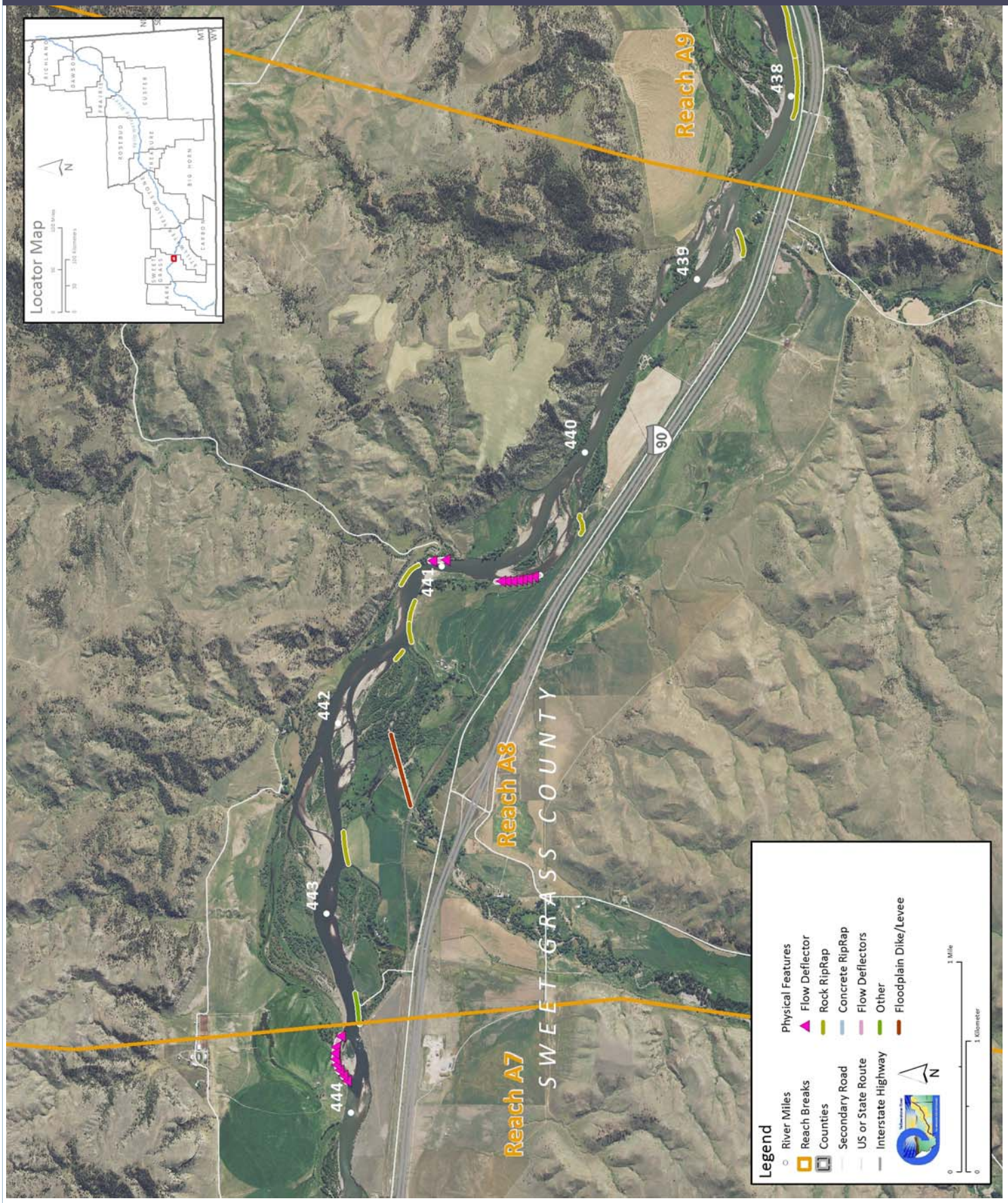
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

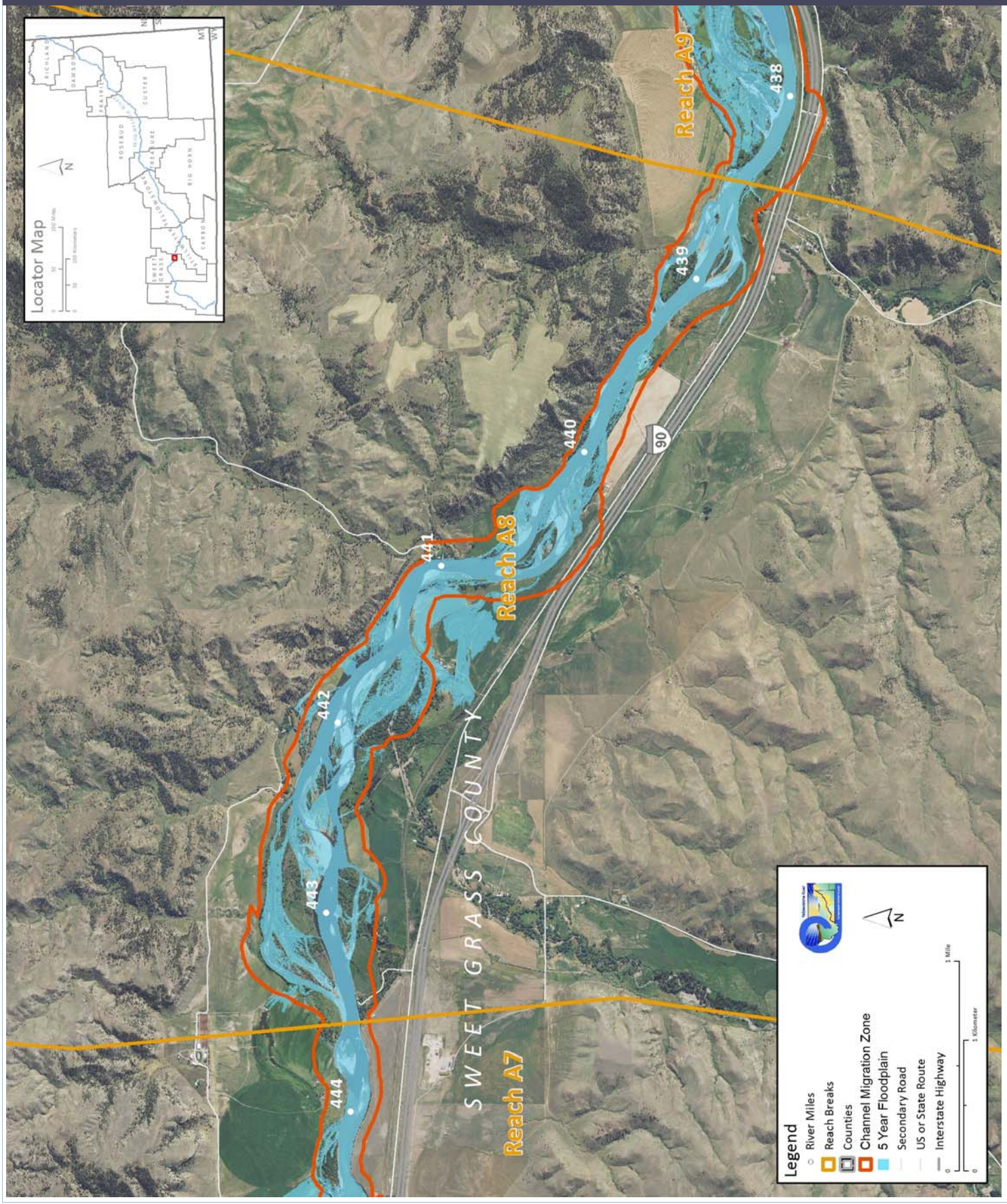
1950	1976	2001	Change 1950-2011
0.0	2.2	0.0	0.0

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	Sweet Grass	**Upstream River Mile**	438.5
Classification	UA: Unconfined anabranching	**Downstream River Mile**	434.7
General Location	Reed Point	**Length**	3.80 mi (6.12 km)

Narrative Summary

Reach A9 is located in lowermost Sweet Grass County, just upstream of the Sweet Grass/Stillwater county line near Reed Point. The reach is an Unconfined Anabranching reach type. The reach is 3.8 miles long, extending from RM 434.7 to RM 438.5. The lower reach break is the bridge crossing just north of Reed Point. This bridge was originally constructed in 1911 and rebuilt in 2000.

Reach A9 provides an excellent example of a dynamic, largely unmodified Unconfined Anabranching reach type. The stream corridor is typically one half mile wide through the reach, with significant narrowing of that corridor in the downstream direction as the river approaches the bridge at Reed Point. In the uppermost portion of the Reach (RM 437-438.5), the northern valley margin consists of an alluvial fan deposit that is currently irrigated with center pivots. Downstream, the river abuts Cretaceous-age Hell Creek Formation on the northern valley wall, which contains sandstones that tend to form steep cliffs. The reach is characterized by high displacement ratios, extensive split flow and islands, and riparian turnover. Although riparian turnover is evident, the rates of that turnover have gone down in the reach since 1976. Prior to that time (1950-1976), average turnover rates were 5.9 acres per year; from 1976 to 2001 that average rate dropped to 3.6 acres of riparian turnover per year.

Bank armor in Reach A9 consists primarily of 10,000 linear feet of riprap which drapes about 24 percent of the stream bank. About 2,000 feet of that armor was constructed since 2001. This new armor is on the right bank at RM 437.8 where the river was rapidly migrating southward toward the rail line. By the time the bank was armored, the river was within 60 feet of the tracks.

Much of the riprap in Reach A9 is located along the south bank of the river on lower end of the reach where the Yellowstone River approaches the bridge near Reed Point. This bridge marks a major narrowing of the river corridor from about 2,000 feet wide ½ mile upstream of the bridge to 360 feet at the bridge itself. The narrowing is achieved by a ~mile long section of bank armor on the right bank that on its lower end runs due north/south, which is perpendicular to the overall east/west trend of the river. This has caused the river to consolidate into a main thread and abandon an historic side channel just upstream of the bridge at the Indian Fort Fishing Access Site.

Reach A9 has experienced the loss of almost about 3,700 feet of side channel since the 1950s due to dike construction. All of the side channel loss is from one project at the upstream end of the reach, where a side channel was blocked on the north side of the river at RM 438.5.

Even though Reach A9 has experienced some side channel loss, it still supports extensive side channel length. As of 2001 there were 5.1 miles of active side channel in the 3.8 mile long reach. Large islands have persisted in the reach since 1950.

Land use in Reach A9 is predominantly agricultural, although there several hundred acres of non-agricultural uses due to the proximity of the transportation corridor as well as the town of Reed Point. Since 1950, 160 acres of agricultural land have been converted to pivot. A total of 300 acres of developed land are in the Channel Migration Zone. Most of that is in flood irrigation (250 acres), but 40 acres are in transportation. About 13 percent of the CMZ is restricted by physical features.

There is natural gas one pipeline that crosses under the Yellowstone River in Reach A9. It crosses at the upper most end of the reach at RM 438.5 and is consists of a 6 inch pipeline that is owned by Northwestern Energy.

Since 1950, Reach A9 has lost most of its forest that would be considered at low risk of cowbird infestation due to its separation from agricultural infrastructure. In 1950, about 17 acres of forest per valley mile were identified as low risk and by 2001 that forest area had been reduced to 2.5 acres due to development within the reach.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 14,000 cfs to 13,300 cfs, a drop of about 5 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,030 cfs to 1,680 cfs with human development, a reduction of 17 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

The reduction in flows is evident by the contraction of the 5-year floodplain area in Reach A9 by 15 acres, or 6 percent.

CEA-Related observations in Reach A9 include:
- Reduced floodplain turnover rates since 1976
- Approximately 3,700 feet of side channel has been lost due to channel plugging between 1950 and 2011
- Meander belt encroachment at bridge crossing
- Side channel loss as part of armoring at bridge approach

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A9 include:
- Side channel restoration at RM 438.5
- CMZ management due to extent of CMZ restriction (13 percent)
- Pipeline management for 6-inch natural gas pipeline that crosses under the river at RM 438.5

Yellowstone River Reach Narratives — Reach A9

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)	27,100	26,300	-3.0%
100 Year (cfs)	49,900	49,400	-1.0%

"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
351.0	420.9	364.2	403.1	52.1

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	9,898	24.2%	2,012
Concrete Riprap	0	0.0%	0
Flow Deflectors	107	0.3%	107
Total	**10,005**	**24.4%**	**2,119**

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	3,717

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	154.6	90.0
Acres/Year	5.9	3.6
Acres/Year/Valley Mile	1.8	1.1

1950-2001 In-channel riparian encroachment (negative number indicates retreat): 45.11 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)				

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	14.9	6%
100 Year	19.0	4%

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
150.9	13%

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)	2,009.3	1,760.1
Ag. Infrastructure (Ac)	27.7	26.9
Exurban (Ac)	0.0	67.4
Urban (Ac)	15.6	48.0
Transportation (Ac)	54.4	169.1

	1950	2011
Flood (Ac)	462.8	450.6
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	163.4

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.
16.2	0.0	16.2	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	9.8	2.9
Emergent	32.5	9.7
Scrub/Shrub	30.9	9.2

Total Wetland Acres: **73.2**

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	%
0.1	0.0%

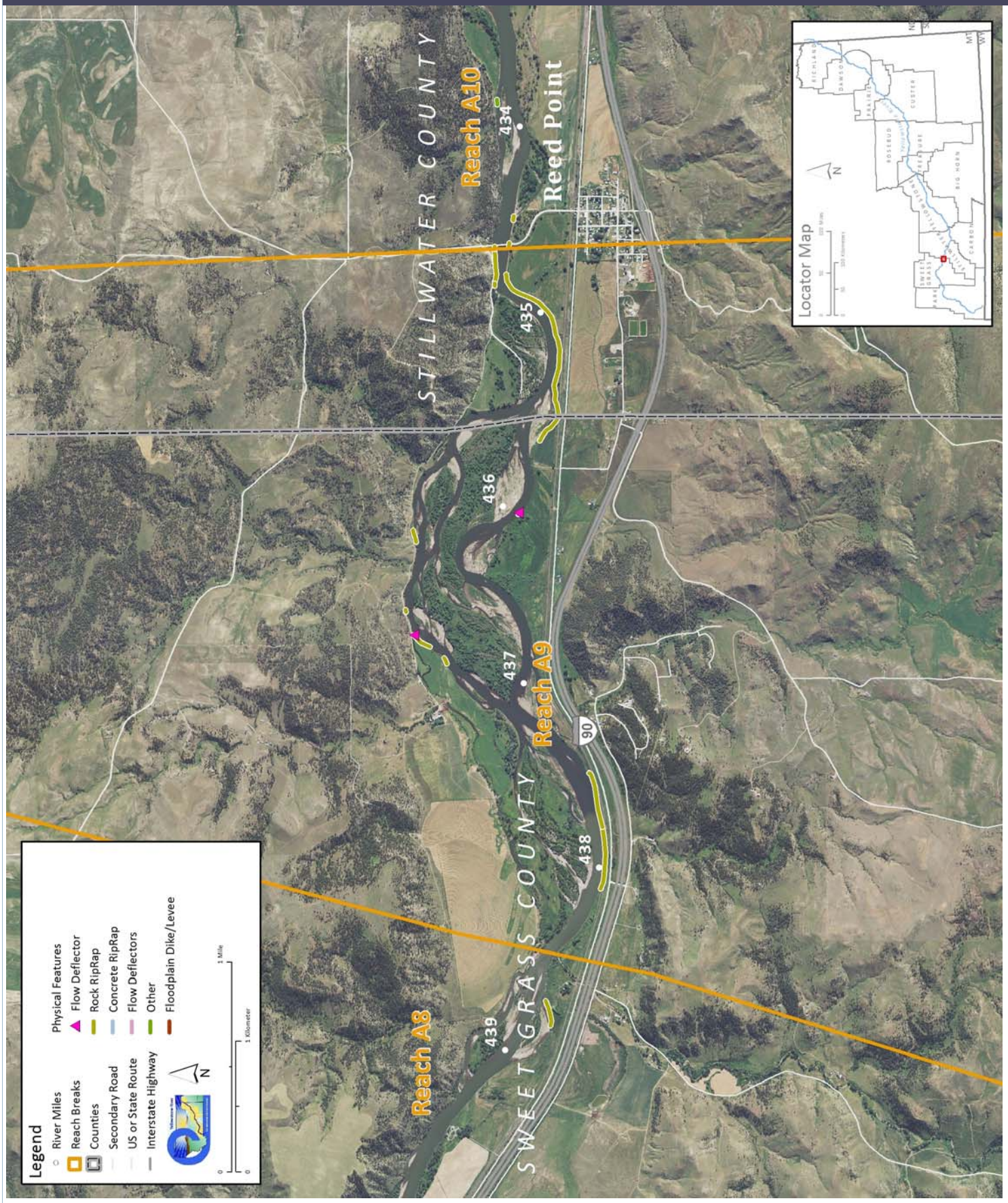
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

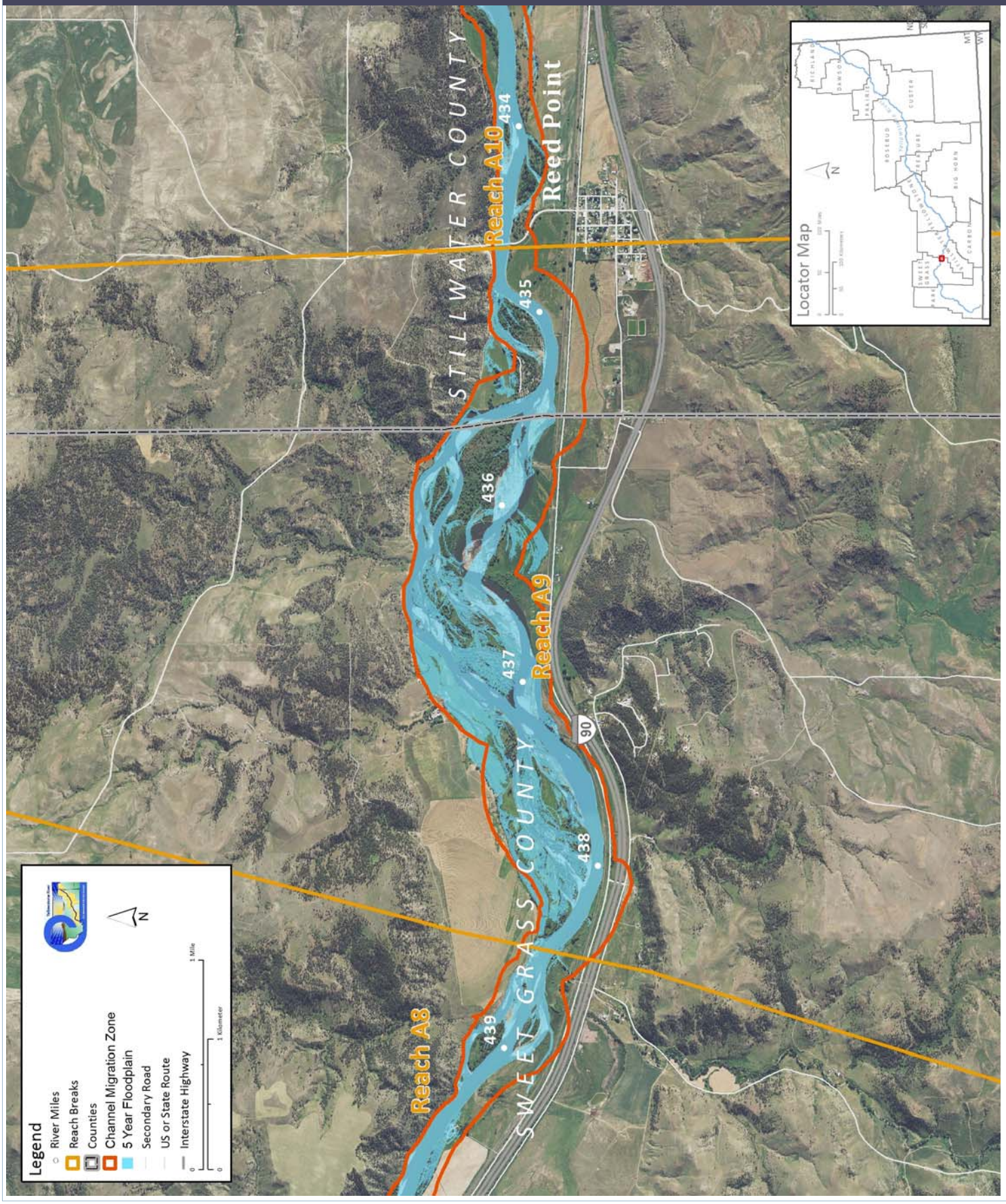
1950	1976	2001	Change 1950-2011
16.6	2.1	2.5	-14.2

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	Stillwater	**Upstream River Mile**	434.7
Classification	PCS: Partially confined straight	**Downstream River Mile**	430.3
General Location	Reed Point	**Length**	4.40 mi (7.08 km)

Narrative Summary

Reach A10 is 4.4 miles long and begins at Reed Point. The reach is a Partially Confined Straight (PCS) reach type, indicating valley wall influences and minimal meandering. The river flows closely along the north valley wall sandstones of the Hell Creek Formation. Migration activity to the south off of the valley wall has been limited and relatively slow, resulting in a fairly narrow Channel Migration Zone and relatively little bank armor. There is only 500 feet of bank armor in the reach, which protects less than 2 percent of the bankline.
No side channels have been physically blocked in Reach A10, however there still has been a net loss of almost 2 miles of side channel length since 1950. This is in part due to the loss of a several thousand foot side channel on the south side of the corridor at RM 431. The entrance to the side channel is just downstream of a series of flow deflectors that appear to have contributed to aggradation at the entrance to the side channel.

Riparian mapping in Reach A10 shows a reduction in total acreage of closed timber from 222 acres in 1950 to 155 acres in 2001.

One of the most evident impacts in Reach A10 is floodplain isolation. Due to the transportation encroachment into the reach by the rail line, approximately 30 percent of the 100 year floodplain has become isolated from the river.

Land use in Reach A10 is predominantly agricultural, although there several hundred acres of non-agricultural uses due to the proximity of the transportation corridor as well as the town of Reed Point. All of the irrigated land is in flood. A total of 163 acres of developed land are in the Channel Migration Zone. Almost all of that ground is in flood irrigation. Less than 1 percent of the CMZ is restricted by physical features.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 14,000 cfs to 13,300 cfs, a drop of about 5 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,060 cfs to 1,690 cfs with human development, a reduction of 18 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A10 include:
- Passive loss of anabranching channels, some potentially correlated to flow deflectors
- Floodplain isolation by active rail line.

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A10 include:
- Floodplain restoration/reconnection behind rail line at RM 430.1
- Side channel restoration at RM 431

Yellowstone River Reach Narratives — Reach A10

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)	27,100	26,300	-3.0%
100 Year (cfs)	49,900	49,400	-1.0%

"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
255.8	268.7	286.2	290.6	34.8

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	270	0.6%	82
Concrete Riprap	0	0.0%	0
Flow Deflectors	255	0.6%	255
Total	**525**	**1.2%**	**338**

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	44.4	45.1
Acres/Year	1.7	1.8
Acres/Year/Valley Mile	0.4	0.4

1950-2001 In-channel riparian encroachment (negative number indicates retreat): -2.51 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)				

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	8.4	22%
100 Year	191.5	30%

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
6.1	1%

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)	2,550.7	2,370.7
Ag. Infrastructure (Ac)	23.4	27.9
Exurban (Ac)	0.0	30.0
Urban (Ac)	46.2	56.4
Transportation (Ac)	55.1	158.2

	1950	2011
Flood (Ac)	636.2	597.4
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	0.0

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.
4.3	1.1	5.4	2.0%

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	0.3	0.1
Emergent	15.9	3.9
Scrub/Shrub	6.4	1.6

Total Wetland Acres: **22.6**

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	%
0.0	0.0%

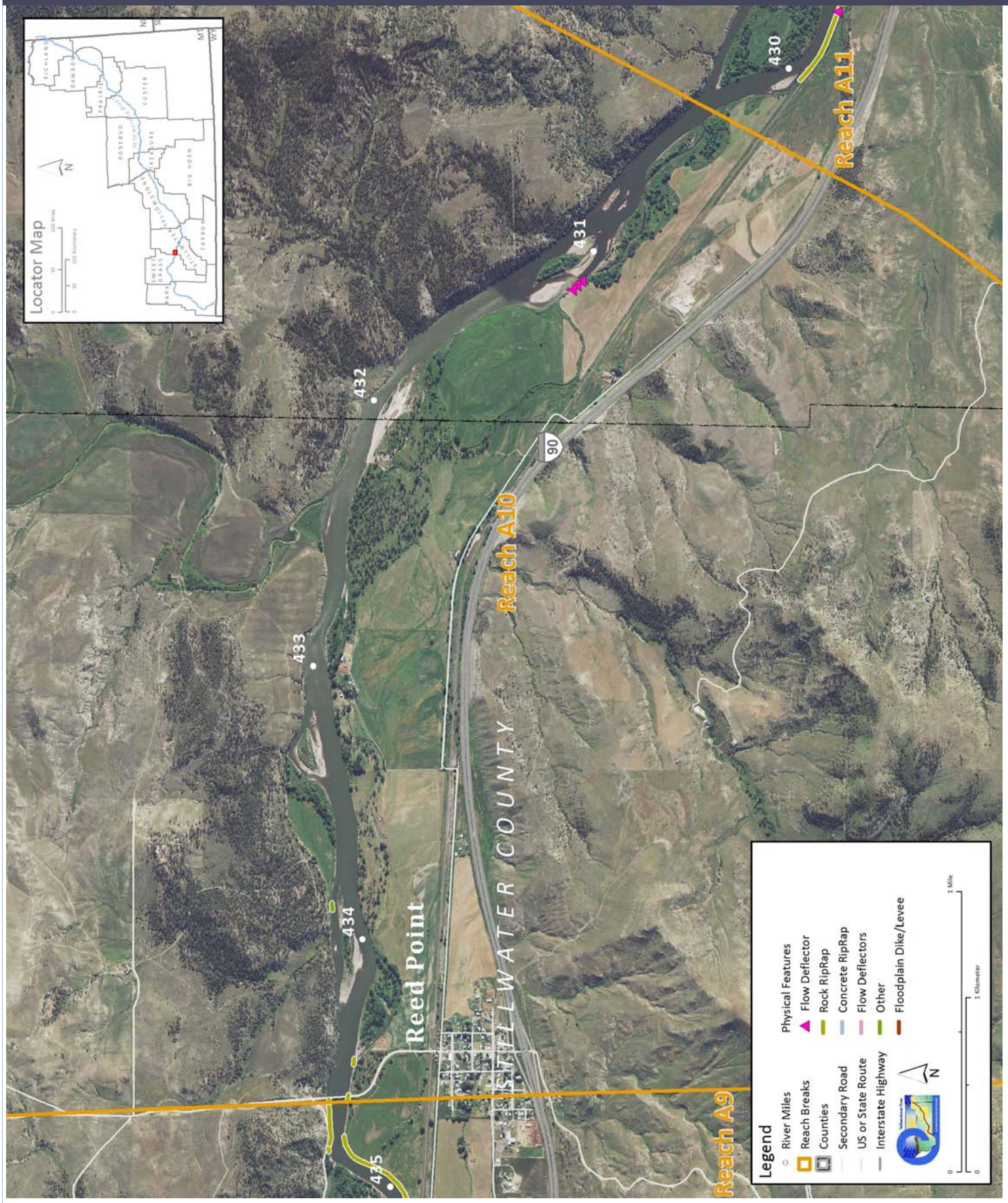
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

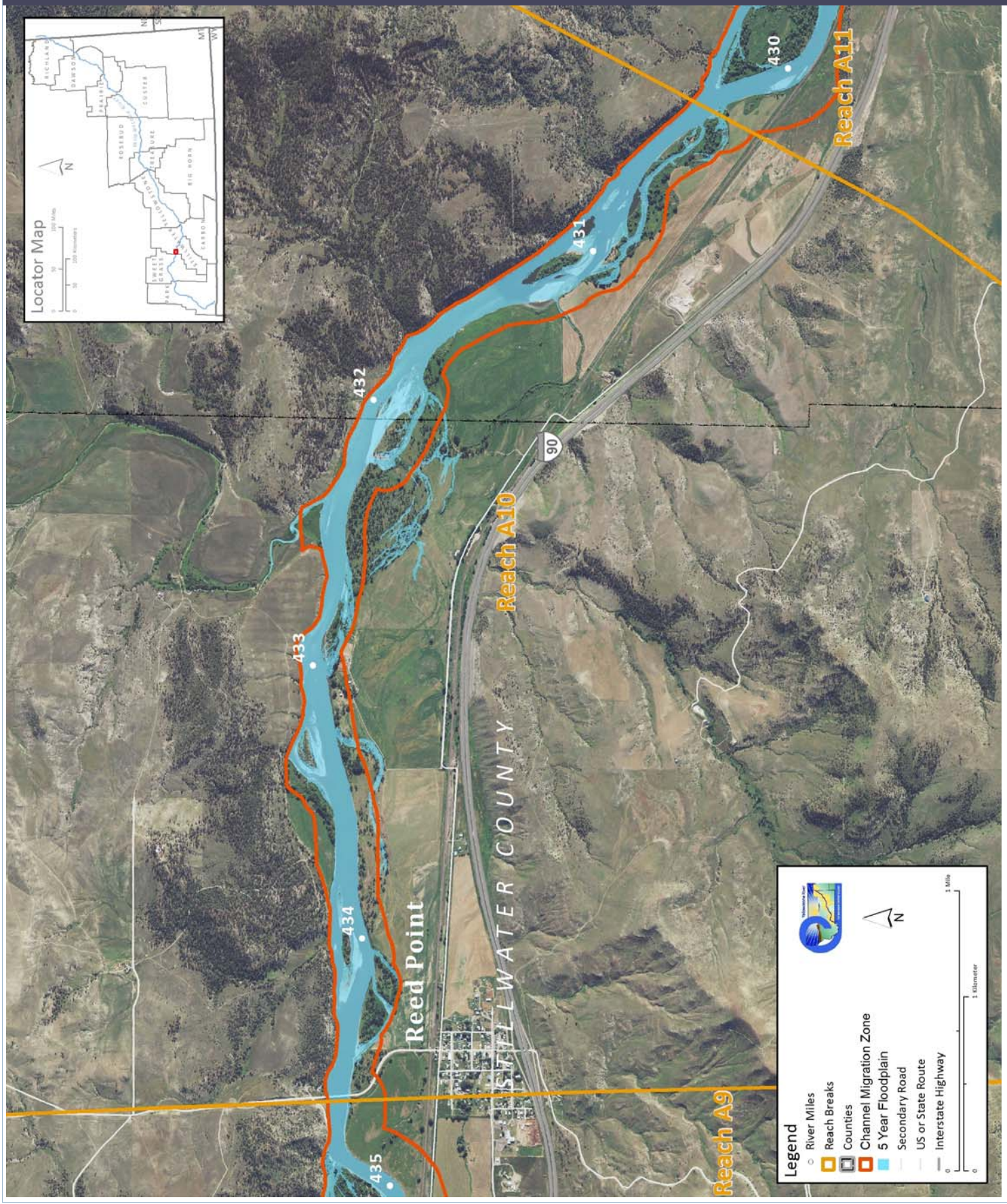
1950	1976	2001	Change 1950-2011
3.9	2.6	2.7	-1.3

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	Stillwater	**Upstream River Mile**	430.3
Classification	PCB: Partially confined braided	**Downstream River Mile**	423.3
General Location	I-90 bridge crossing	**Length**	7.00 mi (11.27 km)

Narrative Summary

Reach A11 is seven miles long and is located at the I-90 Bridge crossing below Reed Point. The reach is a Partially Confined Braided (PCB) reach type, indicating valley wall influences and relatively extensive open gravel bars and small islands. The valley is relatively narrow in this reach, and the river swings from the north valley wall upstream of the bridge to the south valley wall downstream. The valley wall consists of erosion-resistant sandstone cliffs of the Hell Creek Formation. The river has been extremely dynamic in this reach, and over a thousand feet of bank armor has been flanked since 2001. Since 1950, numerous areas have experienced over 500 feet of bank movement.

Similar to other reaches in Region A, the overall footprint of the river channel has increased in size since 1950. In 1950, the channel footprint was 451 acres but by 2001 it had expanded to 567 acres.

About 13 percent of the banks in Reach A11 are armored, with the majority of that armor being rock riprap. Between 2001 and 2011, there was a loss of about 1,200 feet of armor in the reach. Rock riprap was eroded out from the left (north) bank at RM 424.5, where the river flanked about a thousand feet of rock between 2005 and 2011. Since that time, the river has migrated at least 250 feet behind the armor. At least one flow deflector was lost on the same bankline just upstream. About 320 feet of the lost bank protection was flow deflectors.

Over a mile of side channels have been physically blocked in Reach A11 since 1950. The loss has occurred at RM 424, where a road/field dike crosses the old side channel at two locations.

Land use in Reach A11 is predominantly agricultural, although there several hundred acres of transportation-related use associated with I-90 and the rail line. All of the irrigated land is in under flood irrigation. A total of 210 acres of developed land are in the Channel Migration Zone. Almost all of that ground is in flood irrigation, and about 50 acres of the transportation corridor are within the CMZ. About 17 percent of the CMZ is isolated by physical features.

There is one diversion structure on the right bank at RM 428.3 that feeds the Merrill Columbus Ditch. The diversion is located just downstream of the railroad and county road bridges, which are about 2,100 feet upstream of the I-90 Bridge.

There is one dump site mapped in Reach A11 at RM 425.8.

Riparian mapping in Reach A11 shows a reduction in total acreage of closed timber from 400 acres in 1950 to 230 acres in 2001. Similarly, the extent of mapped shrubs dropped from 170 acres to 82 acres for the same timeframe.

Reach A11 was sampled as part of the avian study. The average species richness in Reach A11 was 9.6, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for all sites evaluated is 8. One bird Species of Concern (SOC), the Bobolink, was identified in the reach. One bird species identified by the Montana Natural Heritage Program as a Potential Species of Concern (PSOC), the Ovenbird, was also found.

Since 1950, Reach A11 has lost most of its forest that would be considered at low risk of cowbird infestation due to its separation from agricultural infrastructure. In 1950, about 35 acres of forest per valley mile were identified as low risk and by 2001 that forest area had been reduced to 13 acres due to development within the reach.

Reach A11 marks a distinct jump in the extent of Russian olive present in the river corridor. The reach has approximately 2.3 acres of mapped Russian olive, which is most concentrated in the vicinity of the bridges.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 14,200 cfs to 13,400 cfs, a drop of about 6 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,070 cfs to 1,690 cfs with human development, a reduction of 18 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A11 include:
- Accelerated erosion behind 1,000 feet of flanked rock riprap.
- Blockage of several thousand feet of side channel
- At least one flanked barb
- Expansion of Russian olive infestation relative to upstream.
- Reduction in both closed timber and shrub riparian extent.

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A11 include:
- Floodplain restoration/reconnection behind rail line at RM 430
- Side channel restoration at RM 424

- Bank armor removal at RM 424.5
- CMA management due to extent of CMZ restriction (17 percent)
- Russian olive removal—this is the most upstream reach of major Russian olive colonization
- Solid waste removal from right (south) bank area at RM 425.8
- Irrigation diversion structure management at Merrill Columbus Ditch Diversion at RM 428.3

Yellowstone River Reach Narratives — Reach A1 I

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)	27,500	26,700	-2.9%
100 Year (cfs)	50,600	50,100	-1.0%

"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
451.0	492.6	532.9	568.8	117.9

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	9,701	13.2%	-956
Concrete Riprap	0	0.0%	0
Flow Deflectors	286	0.4%	-321
Total	**9,987**	**13.6%**	**-1,277**

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	6,747

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	135.3	121.7
Acres/Year	5.2	4.9
Acres/Year/Valley Mile	0.8	0.8

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

-65.23 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)				

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	49.7	21%
100 Year	38.7	5%

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
235.8	16%

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)	2,872.2	2,357.0
Ag. Infrastructure (Ac)	49.4	107.7
Exurban (Ac)	0.0	70.6
Urban (Ac)	0.0	0.0
Transportation (Ac)	94.4	326.5

	1950	2011
Flood (Ac)	351.2	530.6
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	0.0

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.
26.6	14.9	41.5	7.0%

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	20.2	3.2
Emergent	28.3	4.6
Scrub/Shrub	30.2	4.9

Total Wetland Acres: **78.7**

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	%
2.3	0.1%

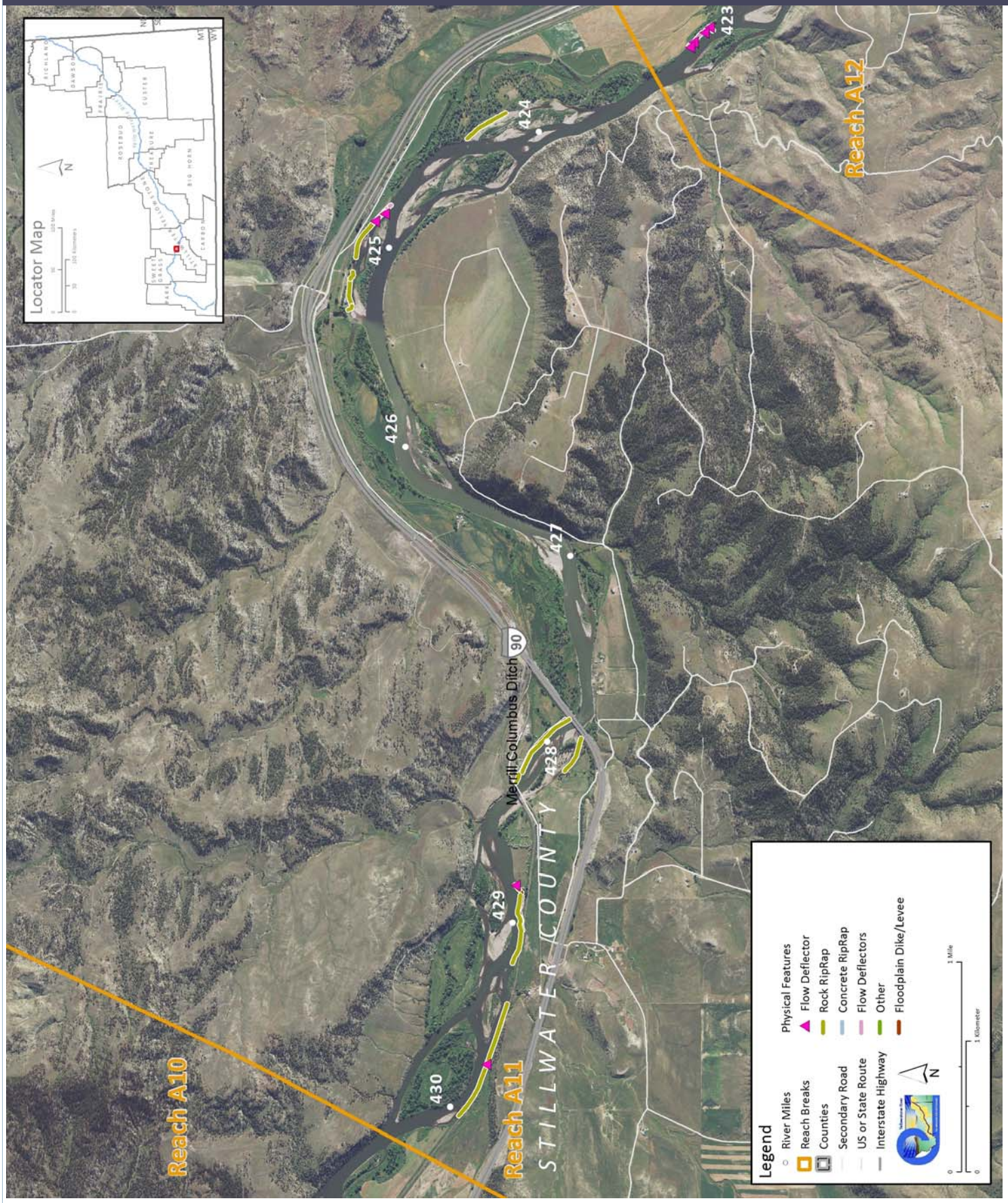
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

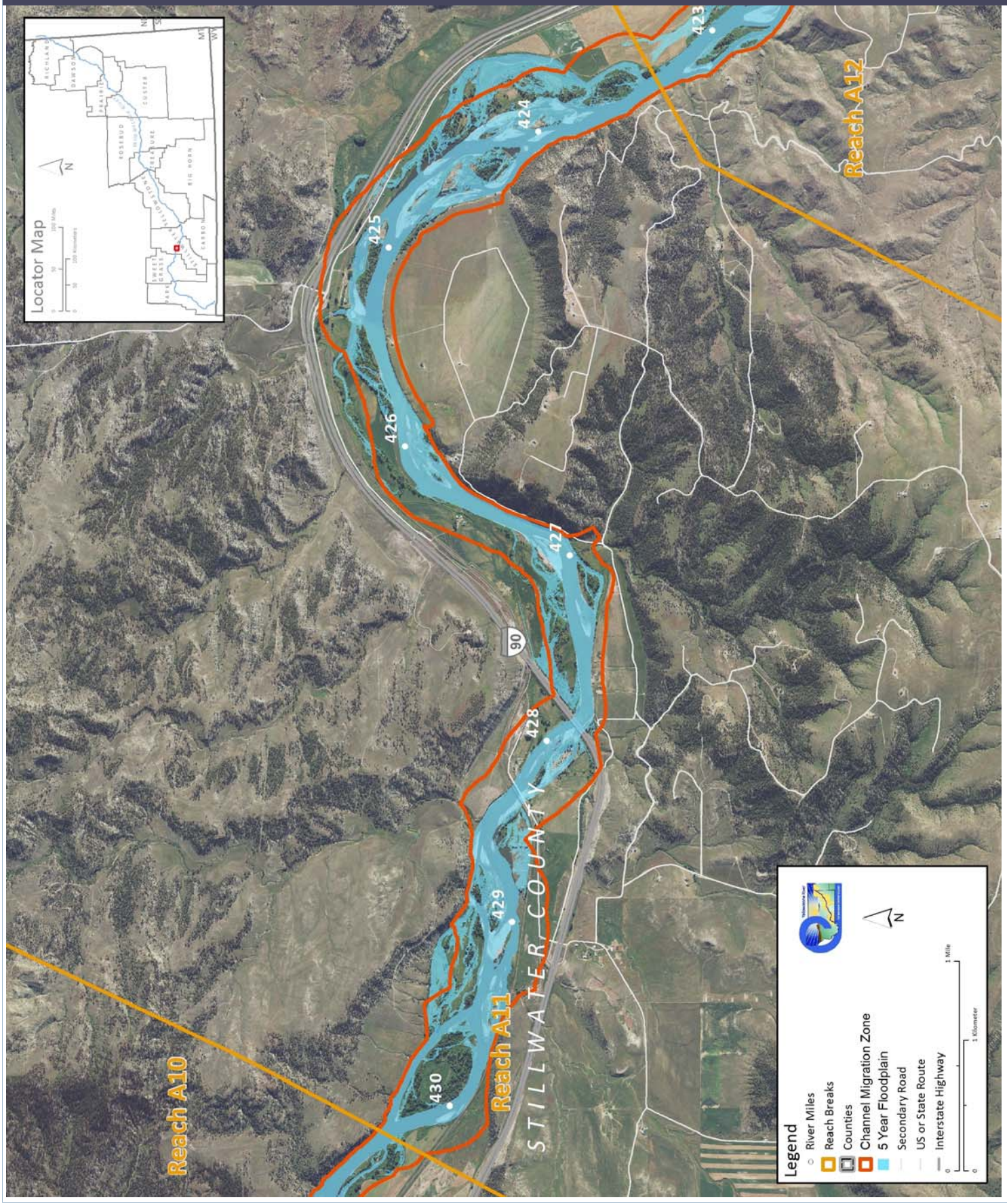
1950	1976	2001	Change 1950-2011
34.8	21.2	13.4	-21.4

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	Stillwater	**Upstream River Mile**	423.3
Classification	PCB: Partially confined braided	**Downstream River Mile**	417.3
General Location	To Stillwater confluence	**Length**	6.00 mi (9.66 km)

Narrative Summary

Reach A12 is seven miles long and is located just upstream of the mouth of the Stillwater River. The reach is a Partially Confined Braided (PCB) reach type, indicating valley wall influences and relatively extensive open gravel bars and small islands. The valley wall consists of erosion-resistant sandstone cliffs of the Hell Creek Formation. The river is confined by the valley wall to the south and by transportation infrastructure to the north. The river has been extremely dynamic in this reach; in some places the banks have migrated over a thousand feet since 1950.

Similar to other reaches in Region A, the overall footprint of the river channel has increased in size since 1950. In 1950, the channel footprint was 434 acres but by 2001 it had expanded to 570 acres.

About 13 percent of the banks in Reach A12 are armored, with the majority of that armor being rock riprap. Between 2001 and 2011, there was a gain of about 1,182 feet of rock riprap and 560 feet of flow deflectors in the reach. At least one flow deflector has been flanked on the right bank just upstream of the Stillwater confluence at RM 418.5. About two miles of transportation encroachments were mapped in Reach A12.

On side channel that is almost four thousand feet long at RM 421 was physically blocked in Reach A12 since 1950. More recently, however, the river has migrated back into the side channel such that the majority of it is now active.

Land use in Reach A12 is predominantly agricultural, although there are several hundred acres of exurban development in the reach. Almost a thousand acres of land is under flood irrigation. A total of 293 acres of developed land are in the Channel Migration Zone. Almost all of that ground is in flood irrigation, although 14 acres are in exurban development and 16 acres are in transportation. About 6 percent of the CMZ is isolated by physical features.

Riparian mapping in Reach A12 shows a reduction in total acreage of open timber from 43 acres in 1950 to 23 acres in 2001.

Reach A12 was sampled as part of the avian study. The average species richness in Reach A12 was 7.6, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for all sites evaluated is 8. One bird species identified by the Montana Natural Heritage Program as Potential Species of Concern (PSOC), the Dickscissel, was identified in the reach.

Since 1950, Reach A12 has lost all of its forest that would be considered at low risk of cowbird infestation due to its separation from agricultural infrastructure. In 1950, about 4 acres of forest per valley mile were identified as low risk and by 2001 that forest area had been reduced to zero.

Reach A12 has approximately 3 acres of mapped Russian olive, which is most concentrated on the north side of the river on the banks of the main channel, side channels, and sloughs.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 14,400 cfs to 13,600 cfs, a drop of about 6 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,080 cfs to 1,690 cfs with human development, a reduction of 19 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A12 include:
- Recapture of previously blocked side channel
- Flanking of barbs

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A12 include:
- Bank armor removal at RM 418.5
- Russian olive removal (3 acres)

Yellowstone River Reach Narratives — Reach A12

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)	27,900	27,000	-3.2%
100 Year (cfs)	51,300	50,800	-1.0%

"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
434.2	466.7	457.0	569.8	135.6

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	7,315	11.4%	1,182
Concrete Riprap	0	0.0%	0
Flow Deflectors	855	1.3%	556
Total	**8,170**	**12.7%**	**1,739**

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	3,771

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	134.0	158.7
Acres/Year	5.2	6.3
Acres/Year/Valley Mile	0.9	1.1

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

-12.71 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)				

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	14.0	14%
100 Year	0.0	0%

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
91.1	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)	3,331.1	2,990.0
Ag. Infrastructure (Ac)	60.8	79.4
Exurban (Ac)	6.5	143.3
Urban (Ac)	0.0	0.0
Transportation (Ac)	70.2	96.2

	1950	2011
Flood (Ac)	1,201.2	979.6
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	1.4

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.
5.3	0.0	5.3	2.0%

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	5.7	1.0
Emergent	55.5	9.9
Scrub/Shrub	69.1	12.3

Total Wetland Acres: **130.4**

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	%
2.9	0.2%

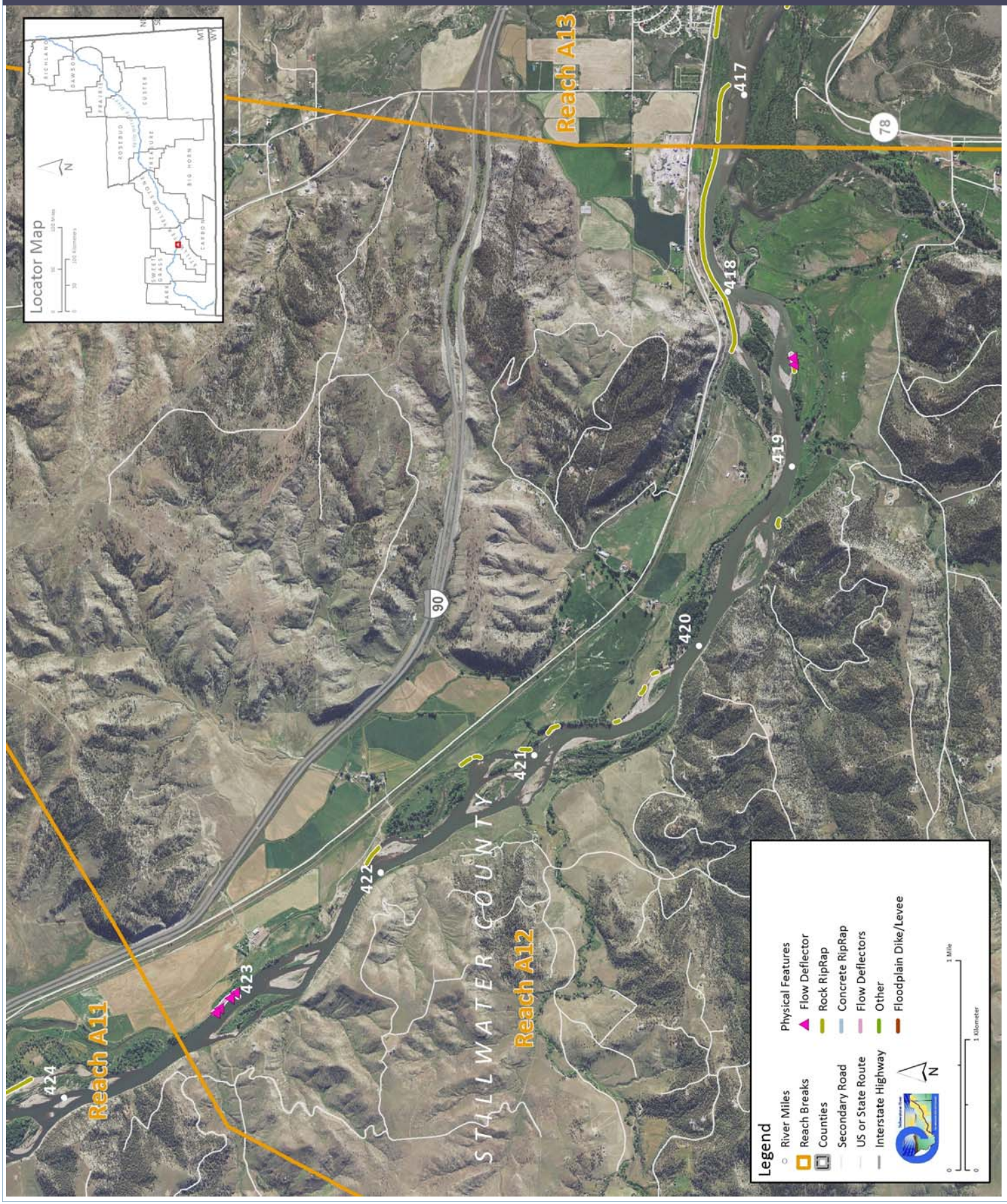
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

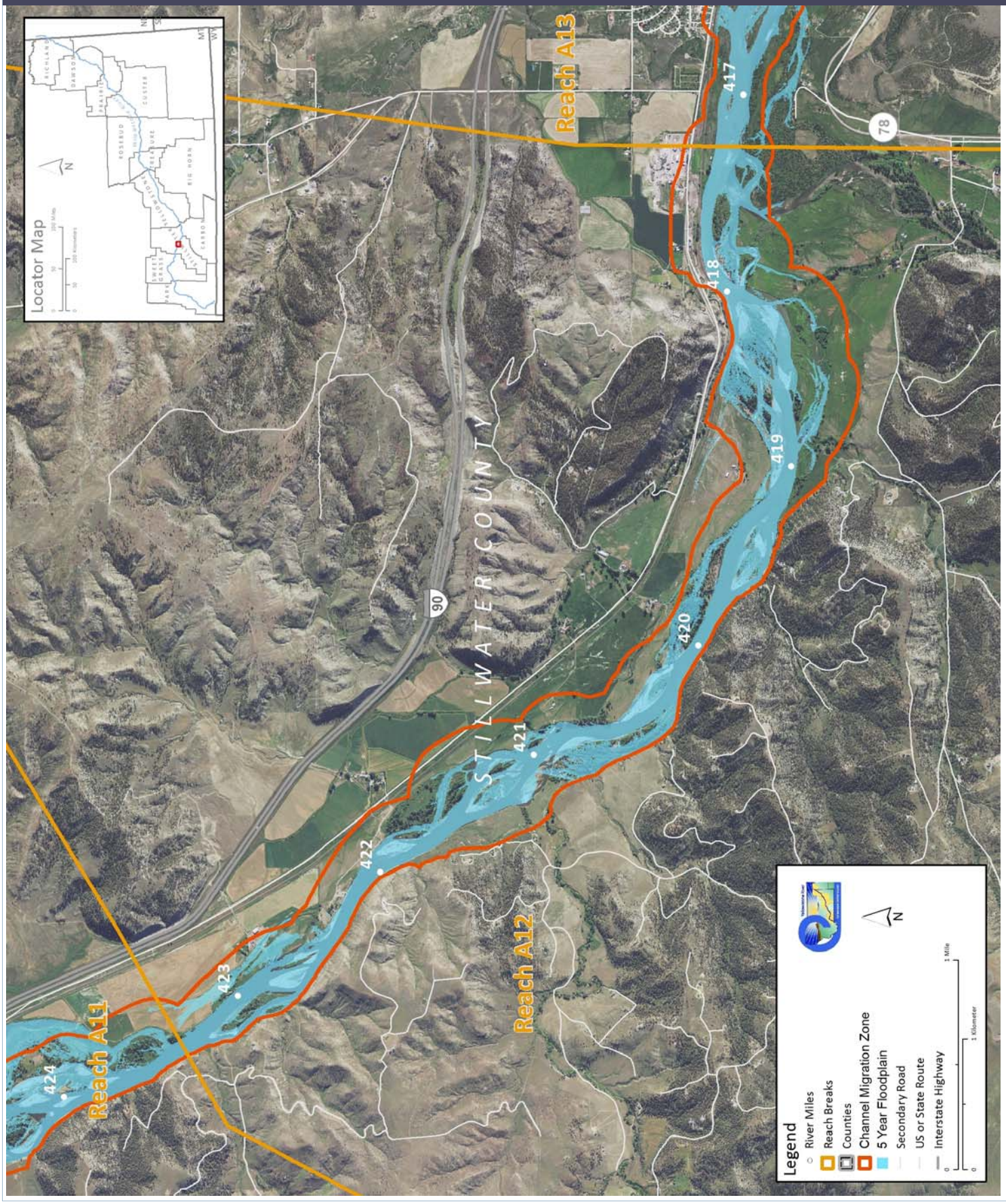
1950	1976	2001	Change 1950-2011
4.1	0.0	0.0	-4.1

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	Stillwater	**Upstream River Mile**	417.3
Classification	PCA: Partially confined anabranching	**Downstream River Mile**	413.7
General Location	Columbus	**Length**	3.60 mi (5.79 km)

Narrative Summary

Reach A13 is 3.6 miles long and is located at Columbus. The reach is a Partially Confined Anabranching (PCA) reach type, indicating some valley wall influence and relatively extensive forested islands. Reach A13 marks an abrupt widening in the river valley as the erosion resistant sandstone cliffs of the Hell Creek Formation transition downstream into the more erodible Bearpaw Shale. The reach is urbanized with most development concentrated on the north side of the river. Migration rates since 1950 have been moderate in this reach largely due to extensive bank armoring.

Similar to other reaches in Region A, the overall footprint of the river channel has increased in size since 1950. In 1950, the channel footprint was 258 acres but by 2001 it had expanded to 327 acres. This was accompanied by a net loss of about 40 acres of riparian area to channel during that same timeframe.

About 28 percent of the banks in Reach A13 are armored, with the majority of that armor being rock riprap. Reach A13 has almost 3,000 feet of concrete riprap, reflecting an abrupt increase in the use of concrete as armor relative to upstream. The concrete is on the north bank of the river just upstream of the Columbus Bridge. Between 2001 and 2011, there was a gain of about 2,800 feet of rock riprap in the reach; most of this was on the north side of the river adjacent to town.

Land use in Reach A13 is predominantly agricultural, although there are over 600 acres of exurban/exurban development within the mapping footprint. Approximately one half of the agricultural land is in flood irrigation (600 acres). No other types of irrigation were mapped in the reach. A total of 133 acres of developed land are in the Channel Migration Zone, and about half of that is in urban/exurban development. About 13 percent of the CMZ is isolated by physical features, most of which is armor protecting the railroad in Columbus.

About 18 percent of the historic 100-year floodplain has become isolated from the river due primarily to the downstream shadow caused by the Columbus Bridge embankment on the north side of the river.

There is one pipeline crossing in Reach A13, a natural gas crossing called the Lake Basin-Absarokee Line owned by NW energy. The pipeline crosses the river at RM 417.

One ice jam has been recorded in this reach. On February 6, 1996, an ice jam break-up was reported to cause local flooding.

There are corrals that are part of an animal handling facility in the reach, north of the river at RM 414.

Riparian mapping in Reach A13 shows a reduction of about 50 acres of closed timber in the reach since 1950.

Reach A13 has approximately 5 acres of mapped Russian olive, which is spread out both within the riparian corridor and through the town of Columbus. There are also over 100 acres of mapped wetland in the each, most of which is emergent marshes and wet meadows.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 14,400 cfs to 13,600 cfs, a drop of about 6 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,270 cfs to 1,760 cfs with human development, a reduction of 22 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A13 include:
- A jump in the use of concrete armor relative to upstream
- Armoring associated with urbanization
- Urban/Exurban development in CMZ

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A13 include:
- CMZ management at Columbus due to high level of encroachment
- Nutrient management at corrals at RM 414
- Bank Stabilization Recommended Practices due to extent of armoring in reach (28 percent)
- Russian olive removal (5 acres)
- Pipeline management (natural gas) for main river crossing at RM 417
- Wetland restoration/management due to extent of mapped wetland (110 acres)

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)	31,000	29,800	-3.9%	
100 Year (cfs)	56,600	55,900	-1.2%	

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.
	258.2	280.0	301.0	326.6	68.4	

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	7,874	20.7%	2,783	
Concrete Riprap	2,837	7.5%	0	
Flow Deflectors	0	0.0%	0	
Total	**10,711**	**28.2%**	**2,783**	

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	65.5	62.6	-38.55 acres	
Acres/Year	2.5	2.5		
Acres/Year/Valley Mile	0.8	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)					

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	11.1	13%	
100 Year	71.7	18%	

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.
	100.8	13%	

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)	1,778.1	1,332.0	Flood (Ac)	686.0	599.0	
Ag. Infrastructure (Ac)	43.8	79.2	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	13.1	245.8	Pivot (Ac)	0.0	0.0	
Urban (Ac)	270.5	384.9				
Transportation (Ac)	68.1	66.5				

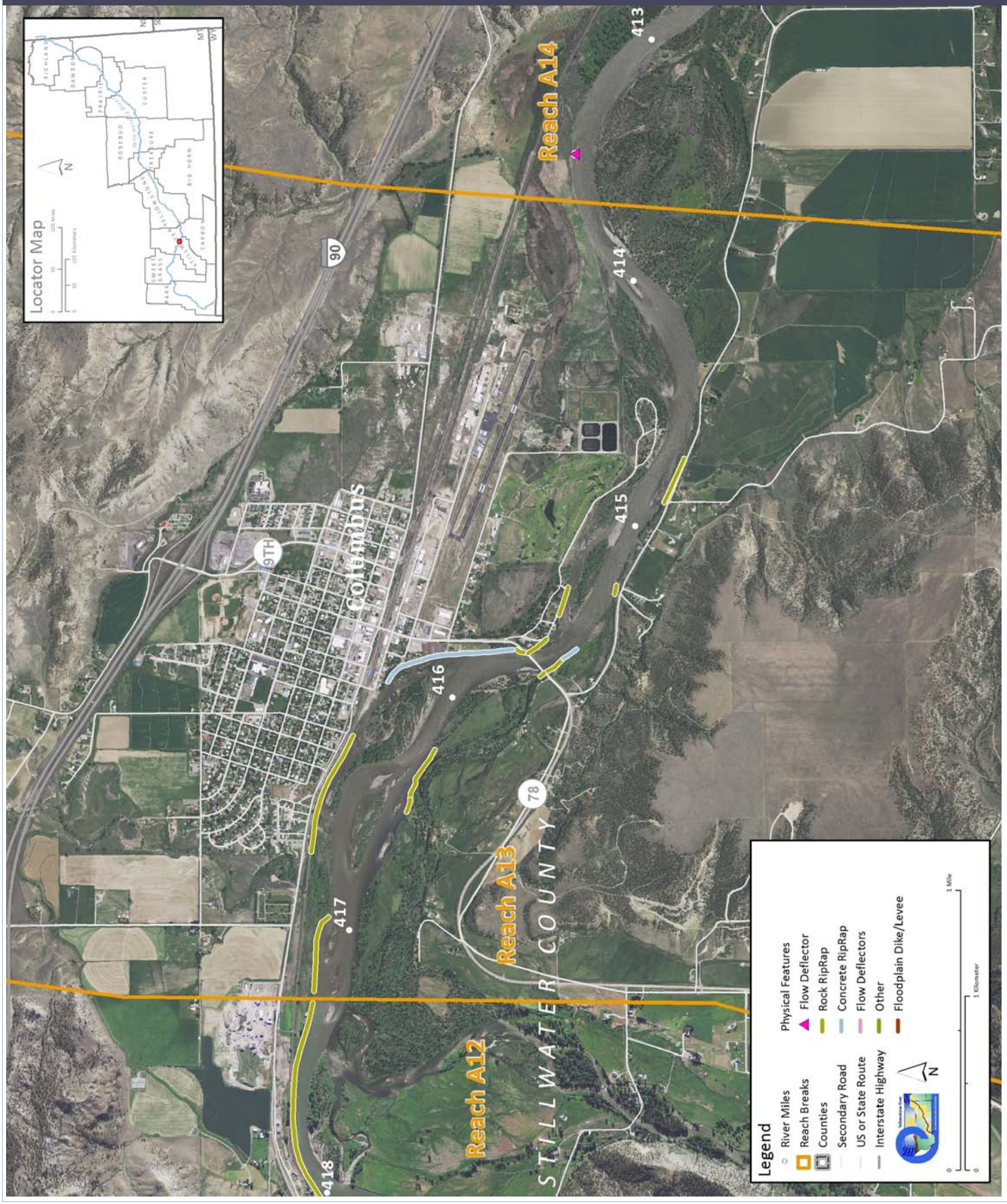
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.
	18.9	36.7	55.6	14.0%	

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	18.1	5.7		
Emergent	75.8	23.8	**110.1**	
Scrub/Shrub	16.2	5.1		

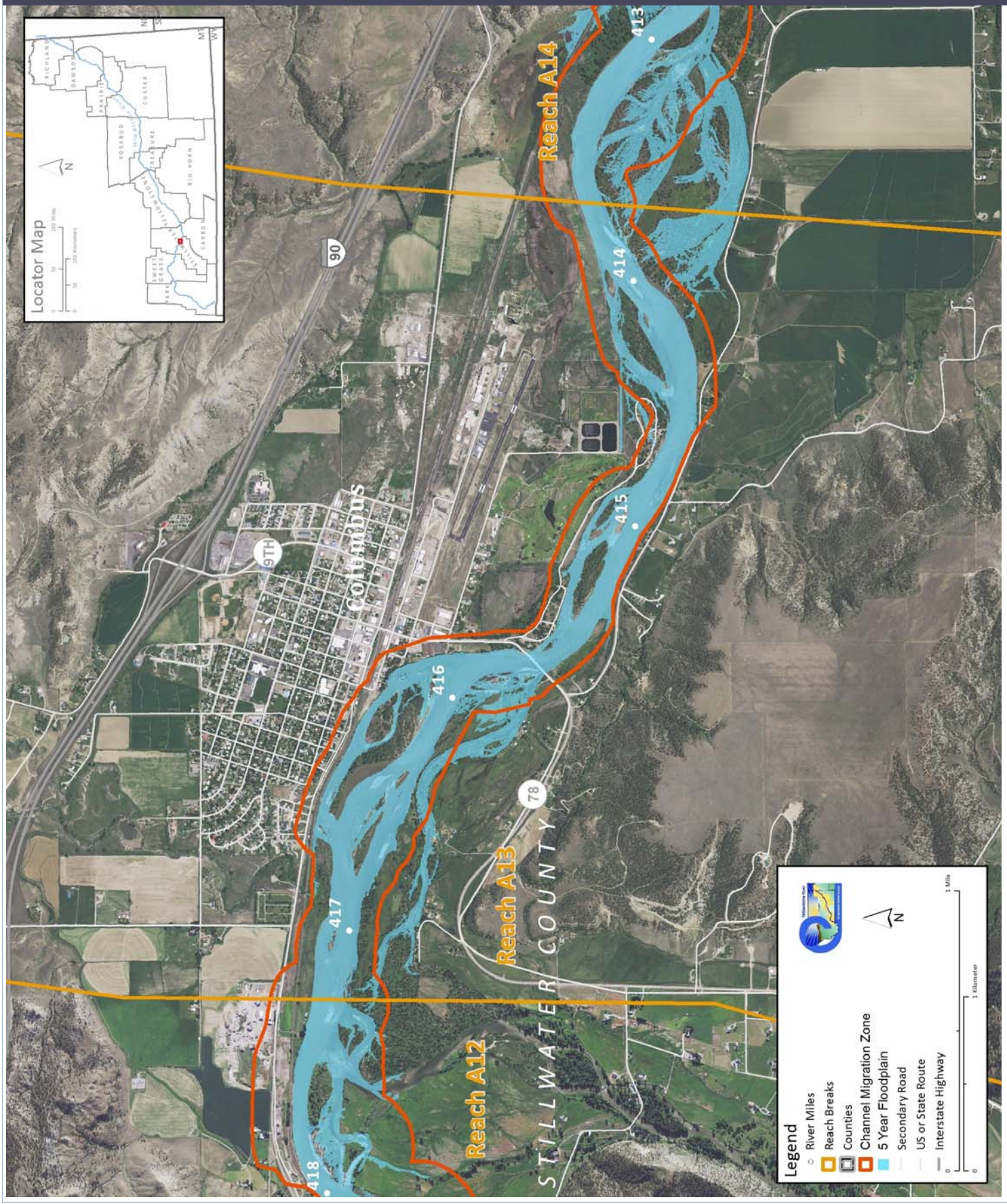
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.
	5.0	1.1%	

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.
	0.0	0.0	0.0	0.0	

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Stillwater	**Upstream River Mile**	413.7
Classification	PCA: Partially confined anabranching	**Downstream River Mile**	405.9
General Location	Below Columbus	**Length**	7.80 mi (12.55 km)

Narrative Summary

Reach A14 is located in Stillwater County, just downstream of Columbus. The reach is a Partially Confined Anabranching (PCA) reach type, reflecting some valley while influence coupled with relatively extensive forested islands. The reach is 7.8 miles long, extending from RM 405.9 to RM 413.7. The partial geologic confinement within Reach A14 is created by interbedded sandstone and shale of the Cretaceous-age Judith River Formation that intermittently forms the active channel margin on either its right or left bank. The Parkman Sandstone, a massive cliff-forming unit within the Judith River Formation, forms cliffs against the channel that are commonly over 150 feet high.

Similar to other reaches in Region A, the overall footprint of the river channel has increased in size since 1950. In 1950, the channel footprint was 637 acres but by 2001 it had expanded to 728 acres. This was accompanied by a net loss of about 32 acres of riparian area to channel during that same timeframe.

Approximately 16 percent of the bankline in Reach A14 is armored, and the armor is almost entirely rock riprap, with a very short section of flow deflectors. The armor is located almost entirely on the northern corridor margin, where transportation infrastructure (mainly railroad) follows the edge of the valley.

Over three miles of side channels have been blocked in Reach A14, with about half of the blockages occurring prior to 1950 and half after. The losses occurred on two distinct channels, one at RM 410 on the south side of the corridor and one at RM 407 on the north side.

Land use in Reach A14 is almost entirely agricultural, with almost 260 acres mapped as agricultural infrastructure. This in part reflects corrals that are part of an animal handling facility on the north side of the river at RM 409. There are 1,300 acres under flood irrigation in the reach, and 144 acres in pivot. A total of 227 acres of developed land are in the Channel Migration Zone, most of that is in flood irrigation (215 acres). Less than 2 percent of the CMZ is isolated by physical features, all of which is behind the armored rail line on the north side of the river.

There is one major diversion in Reach A14; Cove Ditch diverts water from the north bank at RM 410.

Reach A14 was sampled as part of the avian study. The average species richness in Reach A14 was 7.9, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for all sites evaluated is 8. Riparian mapping in Reach A14 shows a reduction of about 100 acres of closed timber in the reach since 1950. Since 1950, Reach A14 has lost most of its forest that would be considered at low risk of cowbird infestation due to its separation from agricultural infrastructure. In 1950, about 10.5 acres of forest per valley mile were identified as low risk and by 2001 that forest area had been reduced to 0.5 acres per valley mile.

Reach A14 has approximately 2.5 acres of mapped Russian olive, which is concentrated along ditches and low riparian/wetland areas north of the river. There are also over 250 acres of mapped wetland in the each, most of which is emergent marshes and wet meadows. About 27 acres of emergent wetland have been isolated from the river corridor by the rail line at RM 413.5.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 16,200 cfs to 15,100 cfs, a drop of about 7 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,280 cfs to 1,770 cfs with human development, a reduction of 22 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A14 include:
- Isolation of large wetland area by rail line
- Over 3 miles of side channel blockages
- Large corrals that are part of an animal handling facility within 1,000 feet of the riverbank

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A14 include:
- Side channel restoration at RM 410 and RM 407
- Russian olive removal (2.5 acres)
- Nutrient management at corrals that are part of an animal handling facility at RM 409
- Irrigation diversion structure management at Cove Ditch Diversion
- Wetland management/restoration at large complex isolated from river by rail line at RM 413.5

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)	31,000	29,800	-3.9%	
100 Year (cfs)	56,600	55,900	-1.2%	

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.
	637.3	675.2	635.5	727.9	90.6	

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	13,457	16.4%	1,807	
Concrete Riprap	0	0.0%	0	
Flow Deflectors	64	0.1%	0	
Total	**13,521**	**16.5%**	**1,807**	

Length of Side Channels Blocked (ft)	Pre-1950s	Post-1950s	Numerous side channels have been blocked by small dikes.
	9,672	9,176	

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	185.7	141.7	-31.84 acres	
Acres/Year	7.1	5.7		
Acres/Year/Valley Mile	1.0	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)					

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	40.7	13%	
100 Year	0.0	0%	

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.
	25.7	1%	

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)	4,716.0	4,443.6	Flood (Ac)	1,663.6	1,319.8	
Ag. Infrastructure (Ac)	73.7	258.5	Sprinkler (Ac)	0.0	0.0	
Exurban (Ac)	0.0	0.0				
Urban (Ac)	0.0	0.0	Pivot (Ac)	0.0	144.0	
Transportation (Ac)	90.2	188.5				

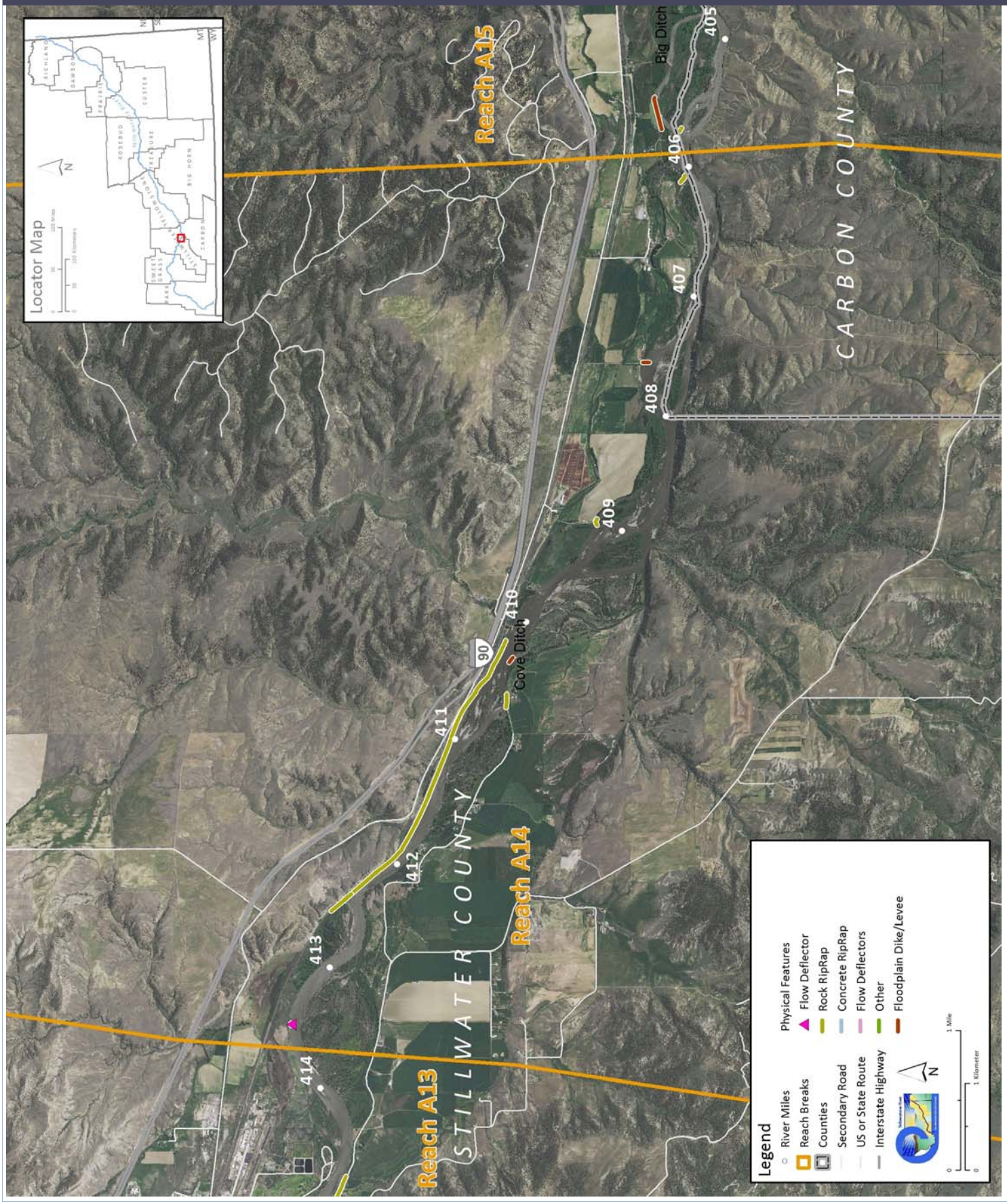
1950s Riparian Vegetation Converted to a Developed Land Use (ac)	To Irrigated	To Other Use	Total Rip. Converted	% of 1950s Rip.	Changes in the extents of riparian vegetation are influenced by land use changes within the corridor.
	11.7	3.2	14.9	2.0%	

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	14.4	2.0		
Emergent	211.3	29.3	**283.3**	
Scrub/Shrub	57.6	8.0		

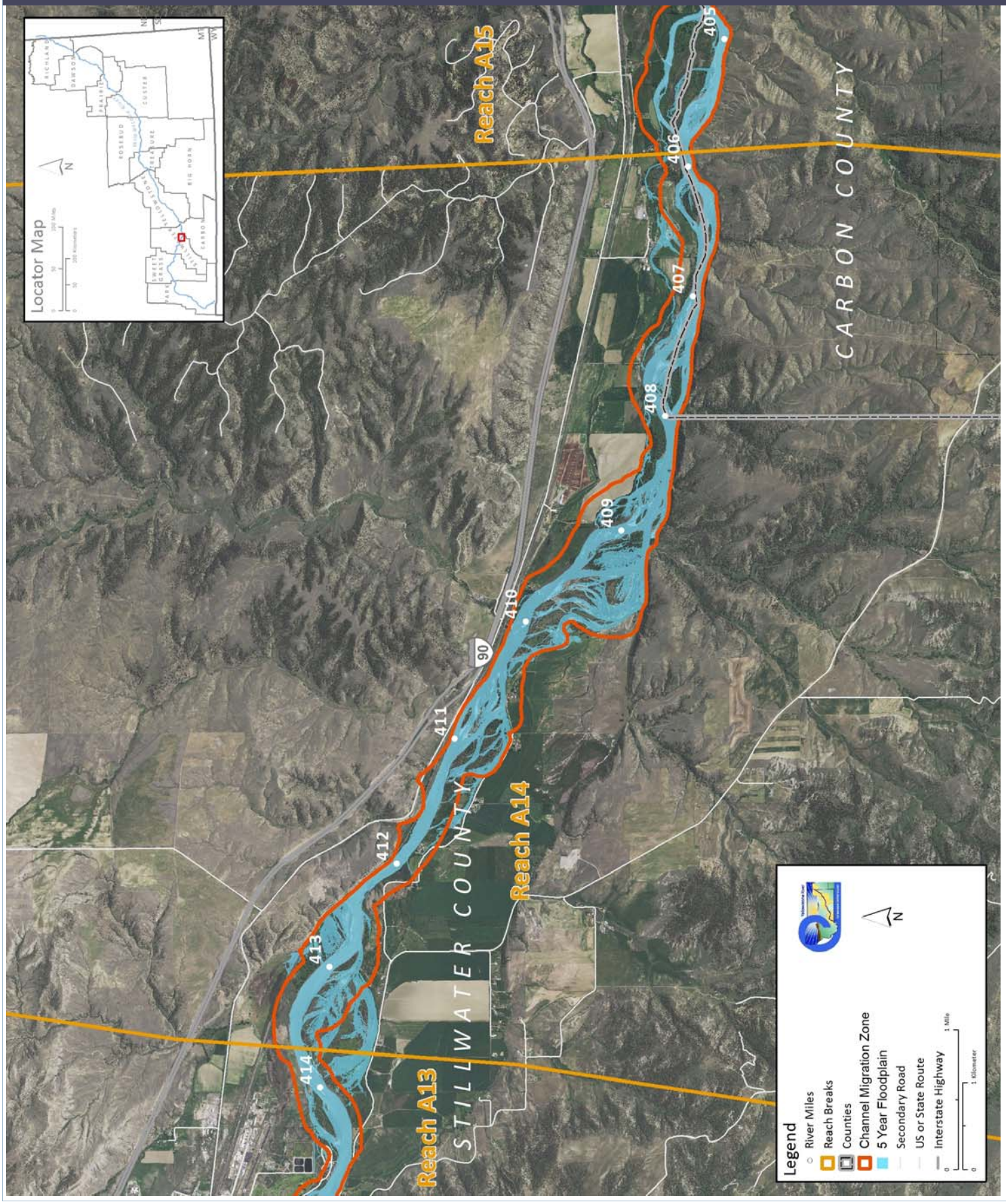
Russian Olive (2001) (Appx. 100-yr Floodplain)	Acres	%	Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.
	2.5	0.1%	

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.
	10.5	0.5	0.5	-10.0	

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP



County	Stillwater	**Upstream River Mile**	405.9
Classification	PCB: Partially confined braided	**Downstream River Mile**	400
General Location	Follows Stillwater/Carbon County line	**Length**	5.90 mi (9.50 km)

Narrative Summary

Reach A15 is located in Stillwater County between Columbus and Park City. The reach is a Partially Confined Braided (PCB) reach type, reflecting some valley wall influence coupled with relatively extensive open gravel bars and low flow channels. The reach is 5.9 miles long. The partial geologic confinement within Reach A15 is created by interbedded sandstone and shale of the Cretaceous-age Judith River Formation that intermittently forms the active channel margin on its right bank. The Parkman Sandstone, a massive cliff-forming unit within the Judith River Formation, forms cliffs against the channel that are commonly over 150 feet high.

Approximately 8 percent of the bankline in Reach A15 is armored, and the armor is almost entirely rock riprap, with a very short section of concrete armor. The armor is entirely located on the north bank of the river, across from the bluffs to the south.

Although no side channels have been mapped as blocked in the reach, the total anabranching channel length has dropped from 6.2 miles in 1950 to 4.2 miles in 2001.

Land use in Reach A15 is almost entirely agricultural, with over 200 acres mapped as agricultural infrastructure. This includes a large corral complex that is part of an animal handling facility on the north side of the river at RM 404. The corrals are behind a canal, but within a few hundred feet of the riverbank. There are 528 acres under flood irrigation in the reach, and 81 acres in pivot. A total of 119 acres of developed land are in the Channel Migration Zone, and all of that land is in flood irrigation. About 9 percent of the CMZ is isolated by physical features, all of which is behind armored canals associated with the Big Ditch Diversion, which diverts water from the north bank at RM 405.3. The Big Ditch Diversion structure fully spans a side channel of the river that is about 275 feet wide.

Riparian mapping in Reach A15 shows a reduction of about 60 acres of closed timber in the reach since 1950. Riparian recruitment rates have been relatively high; between 1950 and 2001 there were 200 acres of areas that recruited new riparian vegetation, and most of that was in old 1950s channels that were abandoned and became colonized. These abandoned channels also have high concentrations of Russian olive. Since 1950, Reach A15 has lost almost all of its forest that would be considered at low risk of cowbird infestation due to its separation from agricultural infrastructure. In 1950, about 20 acres of forest per valley mile were identified as low risk and by 2001 that forest area had been reduced to 1.

There are also over 150 acres of mapped wetland in the each, most of which is emergent marshes and wet meadows. Large expanses of emergent wetlands have developed in side channels that have been passively lost since 1950 (“passively” meaning not blocked but abandoned).

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 16,200 cfs to 15,100 cfs, a drop of about 7 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,286 cfs to 1,770 cfs with human development, a reduction of 23 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A15 include:
- Passive loss of 2 miles of side channel
- Russian olive colonization in abandoned side channels
- Emergent wetland development in abandoned side channels
- Large corrals that are part of an animal handling facility within 300 feet of the riverbank

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A15 include:
- Side channel restoration to reactivate 2 miles of passively lost channels
- Russian olive removal (1.2 acres)
- Nutrient management at corrals that are part of an animal handling facility at RM 404
- Consideration of watercraft passage at Big Ditch Diversion Structure
- Consideration of fish passage limitations at Big Ditch Diversion Structure
- Wetland management/restoration due to extent of mapped wetland (150 acres)

Yellowstone River Reach Narratives — Reach A15

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)	31,000	29,800	-3.9%
100 Year (cfs)	56,600	55,900	-1.2%

"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
450.3	488.7	440.1	511.1	60.8

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	4,667	7.5%	35
Concrete Riprap	483	0.8%	0
Flow Deflectors	0	0.0%	0
Total	**5,150**	**8.3%**	**35**

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
1,617	0

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	141.8	120.0
Acres/Year	5.5	4.8
Acres/Year/Valley Mile	1.1	0.9

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

4.7 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)				

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	27.2	25%
100 Year	0.0	0%

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
122.4	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)	2,738.8	2,533.8
Ag. Infrastructure (Ac)	96.8	213.3
Exurban (Ac)	0.0	2.2
Urban (Ac)	0.0	0.0
Transportation (Ac)	59.4	144.9

	1950	2011
Flood (Ac)	924.9	527.9
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	80.5

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.
9.1	0.1	9.3	2.0%

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	10.4	2.0
Emergent	131.1	25.4
Scrub/Shrub	27.4	5.3

Total Wetland Acres: **168.9**

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	%
1.2	0.1%

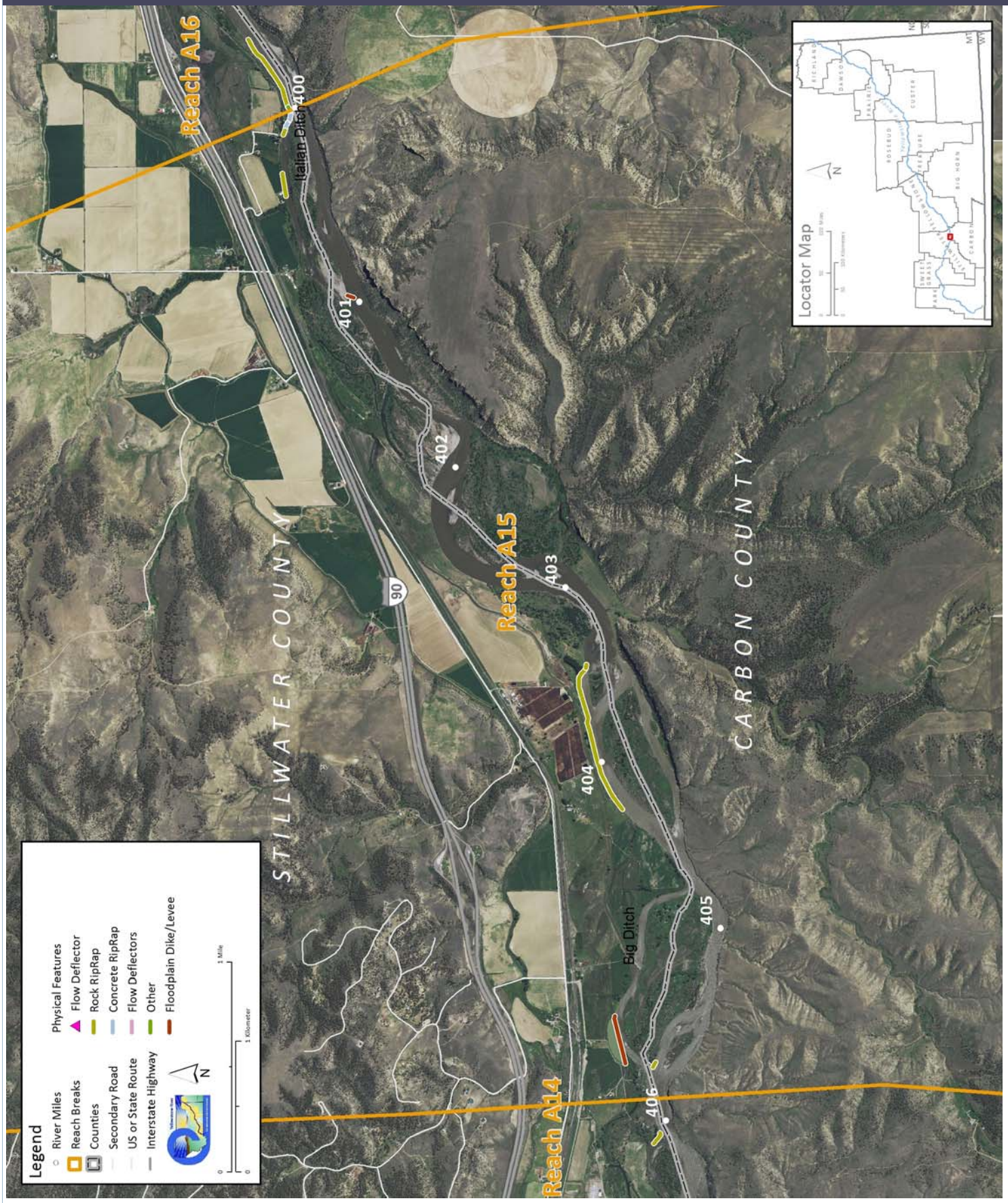
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

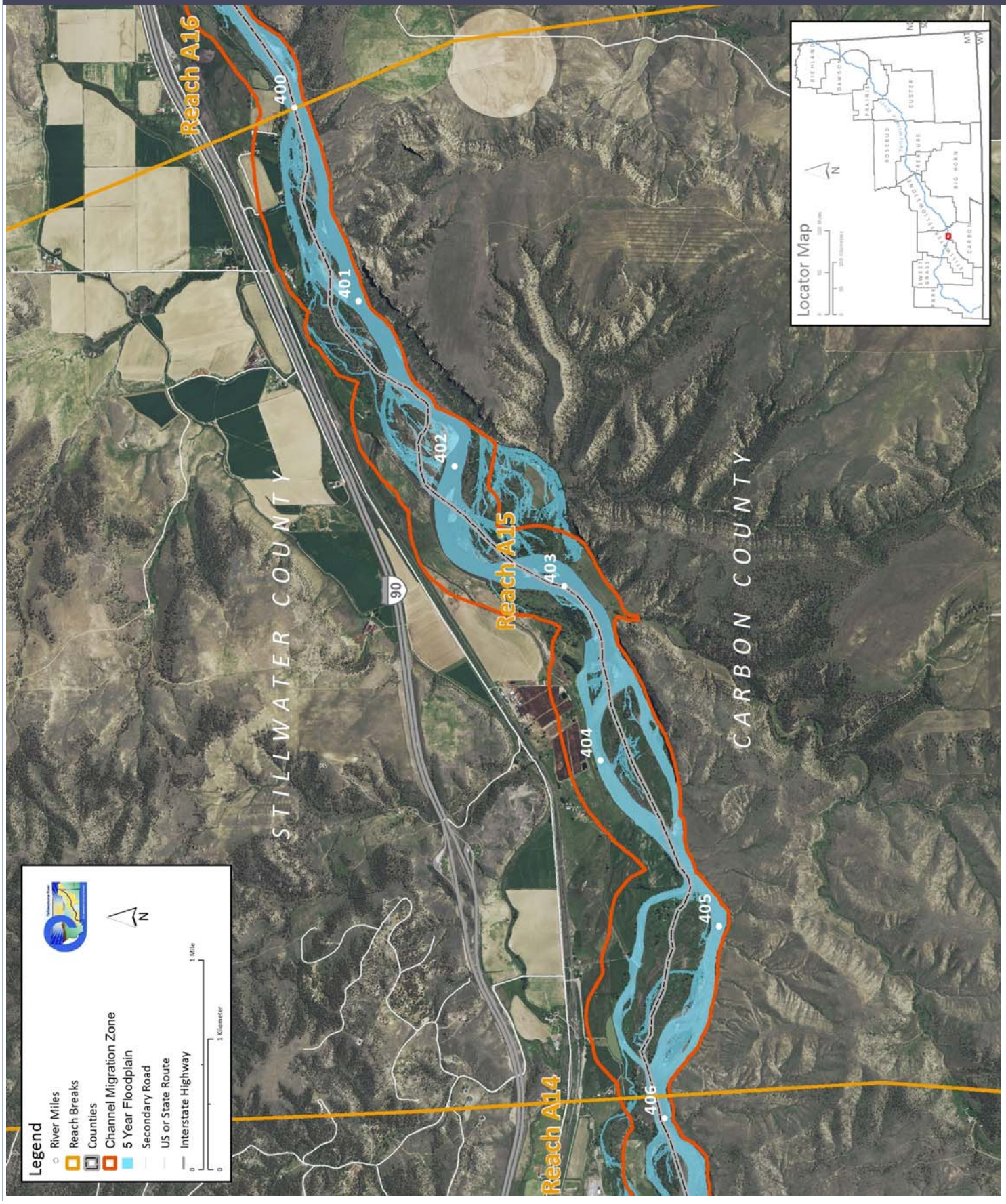
1950	1976	2001	Change 1950-2011
19.9	17.5	21.2	1.2

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	Stillwater	**Upstream River Mile**	400
Classification	PCA: Partially confined anabranching	**Downstream River Mile**	392.4
General Location	Park City	**Length**	7.60 mi (12.23 km)

Narrative Summary

Reach A16 is 7.6 miles long and is located just south of Park City. The reach is a Partially Confined Anabranching reach type, indicating some valley wall influences as well as relatively extensive forested islands. The partial geologic confinement within Reach A16 is created by interbedded sandstone and shale. In addition, both low and high alluvial terraces intermittently form the active river corridor margin.

Approximately 9 percent of the bankline in Reach A16 is armored, and the armor is almost entirely rock riprap, some short sections of concrete armor and flow deflectors. The armor is located almost entirely on the northern corridor margin, against terrace margins. Its use is split evenly between protecting agricultural and exurban residential land uses. On the upstream end of the reach, rock armor protects the Italian Ditch Diversion and Canal, which divert water on the north bank of the river at RM 400. Over four miles of floodplain dikes have been mapped in the reach, most of which follow ditches on the north floodplain.

Although there is no evidence that side channels have been intentionally blocked off in Reach A16, there has still been a net loss of over a mile of side channel since 1950. Similar to most reaches in Region A, the loss of side channels has been accompanied by an overall increase in the total channel footprint; since 1950, the bankfull channel area of Reach A16 has increased by 40 acres.

Land use in Reach A16 is almost entirely agricultural, although there are almost 300 acres of urban/exurban development in the mapping footprint. There are corrals that are part of an animal handling facility within 1,000 feet of an abandoned river swale at RM 395. Over a thousand acres under of ground in Reach A16 are under flood irrigation, and about 11 are in pivot. About 150 acres of developed land are in the Channel Migration Zone, and almost 40 acres of that is in urban/exurban development. About 6 percent of the total CMZ is restricted by bank armor and dikes.

There is one pipeline crossing in Reach A16. It crosses under the river at RM 396.7 and consists of a 24 inch crude oil pipeline that is owned by Kinder Morgan Pipelines. This pipeline was horizontally drilled during its installation.

Reach A16 was sampled as part of the avian study. The average species richness in Reach A16 was 8.5, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for all sites evaluated is 8. An average of one cowbird was observed during the field sampling visits. Reach A16 has lost about one half of its riparian forest considered at low risk of cowbird parasitism since 1950. At that time, there were about 12 acres of forest per valley mile considered to be isolated enough from agricultural infrastructure and urban/exurban development to be considered at low risk. By 2011, about 6.6 acres considered low risk remained.

There are over 250 acres of mapped wetland in the reach, with most of that emergent marshes wand wet meadows. Many of these wetland areas occupy old river swales on the floodplain north of the river, or abandoned channels in the active corridor.

The reach has extensive Russian olive, with almost 30 acres of mapped footprint in the reach.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 16,900 cfs to 15,500 cfs, a drop of about 8 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,310 cfs to 1,780 cfs with human development, a reduction of 23 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A16 include:
- Passive loss of over a mile of side channel
- Russian olive colonization in abandoned side channels
- Emergent wetland development in abandoned side channels

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A16 include:
- Diversion structure management at Italian Ditch Diversion RM 400
- Nutrient management at corrals that are part of an animal handling facility at RM 395.
- Russian olive removal (29 acres)
- Wetland management/restoration due to extent of mapped emergent wetland (214 acres emergent, 270 acres total wetland)

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)	32,200	30,600	-5.0%
100 Year (cfs)	58,600	57,600	-1.7%

"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
746.5	772.1	676.5	812.6	66.1

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	6,789	8.4%	2,351
Concrete Riprap	9	0.0%	-158
Flow Deflectors	128	0.2%	128
Total	**6,926**	**8.5%**	**2,321**

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	203.1	214.4
Acres/Year	7.8	8.6
Acres/Year/Valley Mile	1.2	1.3

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

-4.96 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)				

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	42.3	13%
100 Year	0.0	0%

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
104.4	5%

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)	4,008.9	3,532.8
Ag. Infrastructure (Ac)	70.7	132.8
Exurban (Ac)	0.0	268.0
Urban (Ac)	0.0	0.0
Transportation (Ac)	21.5	73.5

	1950	2011
Flood (Ac)	1,587.8	1,095.2
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	10.6

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.
7.2	3.5	10.6	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	10.7	1.6
Emergent	214.0	32.0
Scrub/Shrub	43.3	6.5

Total Wetland Acres: **268.0**

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	%
28.7	1.8%

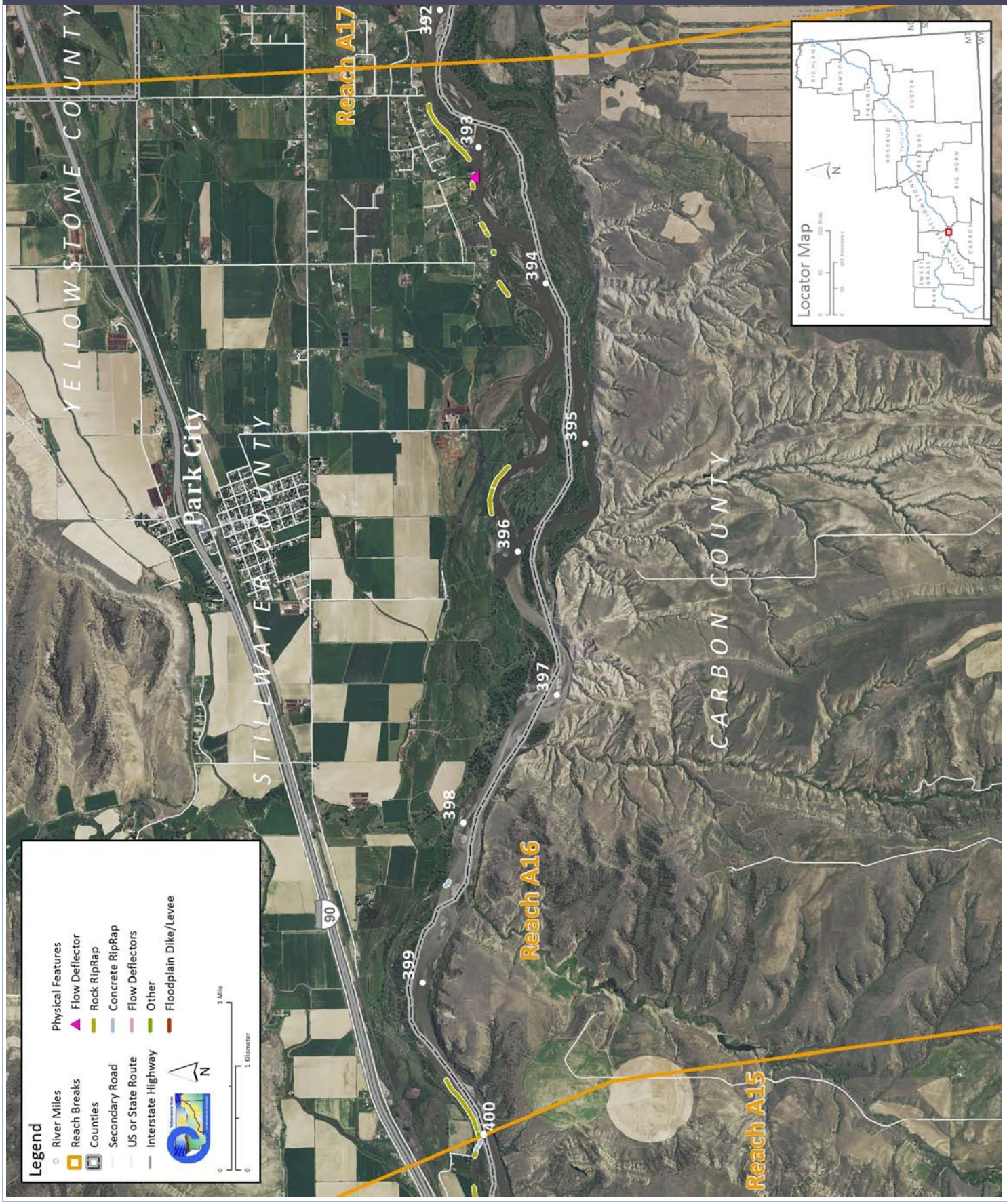
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

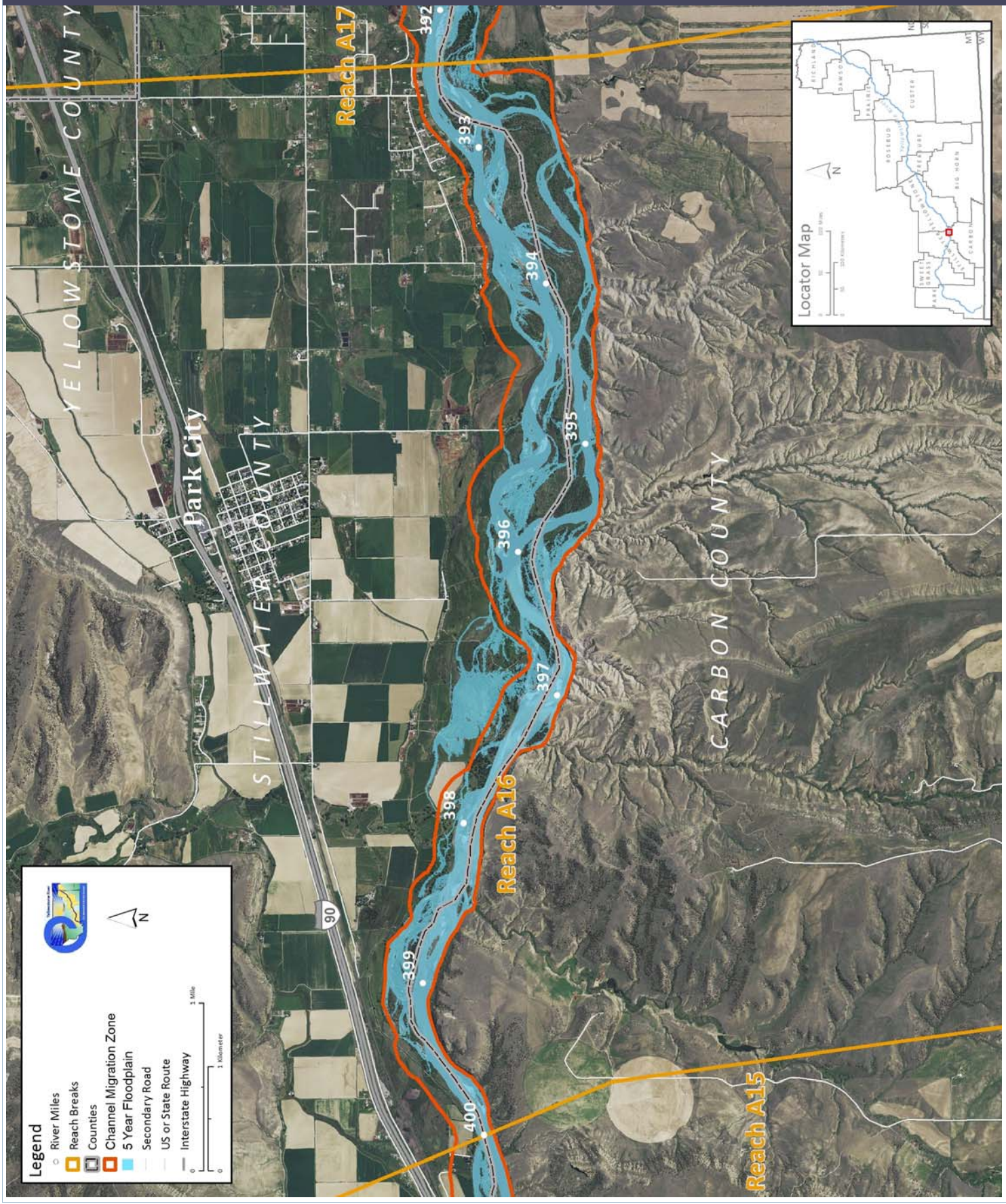
1950	1976	2001	Change 1950-2011
12.1	14.5	6.6	-5.5

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	Yellowstone	**Upstream River Mile**	392.4
Classification	UA: Unconfined anabranching	**Downstream River Mile**	386
General Location	To Laurel	**Length**	6.40 mi (10.30 km)

Narrative Summary

Reach A17 is 7.6 miles long and is located just above Laurel. The reach is classified as Unconfined Anabranching (UA), which is characteristically one of the most dynamic reach types on the river. The river is flowing in the alluvial valley with minimal influences of the valley wall and through numerous forested islands. There are sites in Reach A17 where the river has migrated almost 1,000 feet since 1950.

Approximately 13 percent of the bankline in Reach A17 is armored by rock riprap, concrete riprap and flow deflectors. Between 2001 and 2011 the total length of rock riprap increased by about a half of a mile. At RM 387, a ~750 foot long stretch of flow deflectors on the left bank have been flanked, and by fall 2011 the river had migrated about 120 feet behind the flanked armor. The deflectors are still visible in the channel. In some places such as at RM 389.8, bank armor on both sides of the river narrows the corridor to about one channel width, or 1,000 feet.

Over a mile of side channels in Reach A17 were blocked prior to 1950. Two major channels were blocked on the north side of the river, one at the Buffalo Mirage Fishing Access Site at RM 391.5, and the other at Rm 389.5. These channels, as well as other secondary channels that were passively loss, host fairly dense concentrations of Russian olive. Similar to most reaches in Region A, the loss of side channels has been accompanied by an increase in the total river footprint, indicating that flow concentration into the main river channel has caused it to enlarge. Between 1950 and 2001, the size of the channel increased from 560 acres to 645 acres.

Land use in Reach A17 is primarily agricultural, although there are almost 600 acres of urban/exurban development in the reach as the river approaches the City of Laurel. Since 1950, there has been a reduction in flood irrigated acres of about 550 acres, and an increase in pivot irrigation from 0 acres in 1950 to 284 acres in 2011. A total of 383 acres of developed ground are in the mapped Channel Migration Zone; and about 11 percent of the CMZ has been isolated by physical features protecting those land uses.

At RM 388.5, a headgate diverts water into an old side channel that has been converted to a canal on the north side of the river. About ½ mile downstream, the canal is riprapped where it was recently threatened by rapid northward river migration. At this location, the river has migrated over 800 feet northward since 1950. The main channel of the river now flows along the riprapped canal embankment for about 750 feet.

There are corrals that are part of an animal handling facility within 600 feet of the north riverbank at RM 392.

Side channel loss and channel migration in Reach A17 has resulted in relatively high rates of riparian recruitment. Since 1950, there has been 330 acres of land that experience recruitment of new riparian vegetation. Most of that recruitment was in abandoned channels (200 acres) and about 27 acres of recruitment was direct result of channel migration.

Two ice jams have been recorded in Reach A17, in 1996 and 1997. Both occurred during the month of February, and were reported to have occurred at the Laurel Bridge.

There are over 200 acres of mapped wetland in the reach, with most of that emergent marshes and wet meadows. Many of these wetland areas occupy river swales on the floodplain north of the river, or abandoned channels in the active corridor.

Almost 22 acres of Russian olive has been mapped in the floodplain.

Reach A17 was sampled as part of the avian study. The average species richness in Reach A17 was 7.7, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for all sites evaluated is 8. An average of 0.9 Cowbirds (a bird that parasitizes other bird's nests) were observed in cottonwood habitats during the field sampling visits. Reach A17 has lost about two thirds of its riparian forest considered at low risk of cowbird parasitism since 1950. At that time, there were about 28 acres of forest per valley mile considered to be isolated enough from agricultural infrastructure and urban/exurban development to be considered at low risk. By 2011, about 10 acres per valley mile considered low risk remained.

A total of three Potential Species of Concern (PSOCs) were observed in Reach A17 during the avian study, including the Black and White Warbler, Chimney Swift, and Ovenbird. One Species of Concern (SOC), the Bobolink, was also observed in Reach A17.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 16,900 cfs to 15,500 cfs, a drop of about 8 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,320 cfs to 1,780 cfs with human development, a reduction of 23 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A17 include:
- Flanking of flow deflectors and accelerated erosion behind flanked structures
- Physical blockage of over a mile of side channel
- Russian olive colonization in abandoned side channels

•Emergent wetland development in abandoned side channels
•Ice jamming potentially associated with the Laurel Bridge

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A17 include:
•Bank armor removal (flanked flow deflectors), RM 387
•Side channel restoration at RM 391.5 and RM 389.5
•Nutrient management associated with corrals that are part of an animal handling facility at RM 392.
•Russian olive removal (22 acres)
•Wetland management/restoration due to extent of mapped wetland (200 acres)
•Irrigation diversion structure management at headgate on side channel at RM 388.5

Yellowstone River Reach Narratives — Reach A17

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)	32,200	30,600	-5.0%
100 Year (cfs)	58,600	57,600	-1.7%

"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
560.0	608.9	557.5	644.6	84.6

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	6,184	9.1%	2,584
Concrete Riprap	2,205	3.2%	0
Flow Deflectors	671	1.0%	-176
Total	**9,060**	**13.3%**	**2,407**

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
7,639	0

Numerous side channels have been blocked by small dikes.

Floodplain Turnover

	1950 - 1976	1976 - 2001
Total Acres	195.3	180.6
Acres/Year	7.5	7.2
Acres/Year/Valley Mile	1.3	1.3

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

-19.75 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)				

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	46.4	9%
100 Year	89.9	7%

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
245.6	11%

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)	4,530.2	4,110.3
Ag. Infrastructure (Ac)	68.6	118.5
Exurban (Ac)	59.1	292.3
Urban (Ac)	95.4	203.9
Transportation (Ac)	50.2	50.2

	1950	2011
Flood (Ac)	1,927.0	1,384.1
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	283.8

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.
6.0	0.8	6.8	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	9.4	1.6
Emergent	203.4	35.6
Scrub/Shrub	13.4	2.3

Total Wetland Acres: **226.2**

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	%
21.8	6.7%

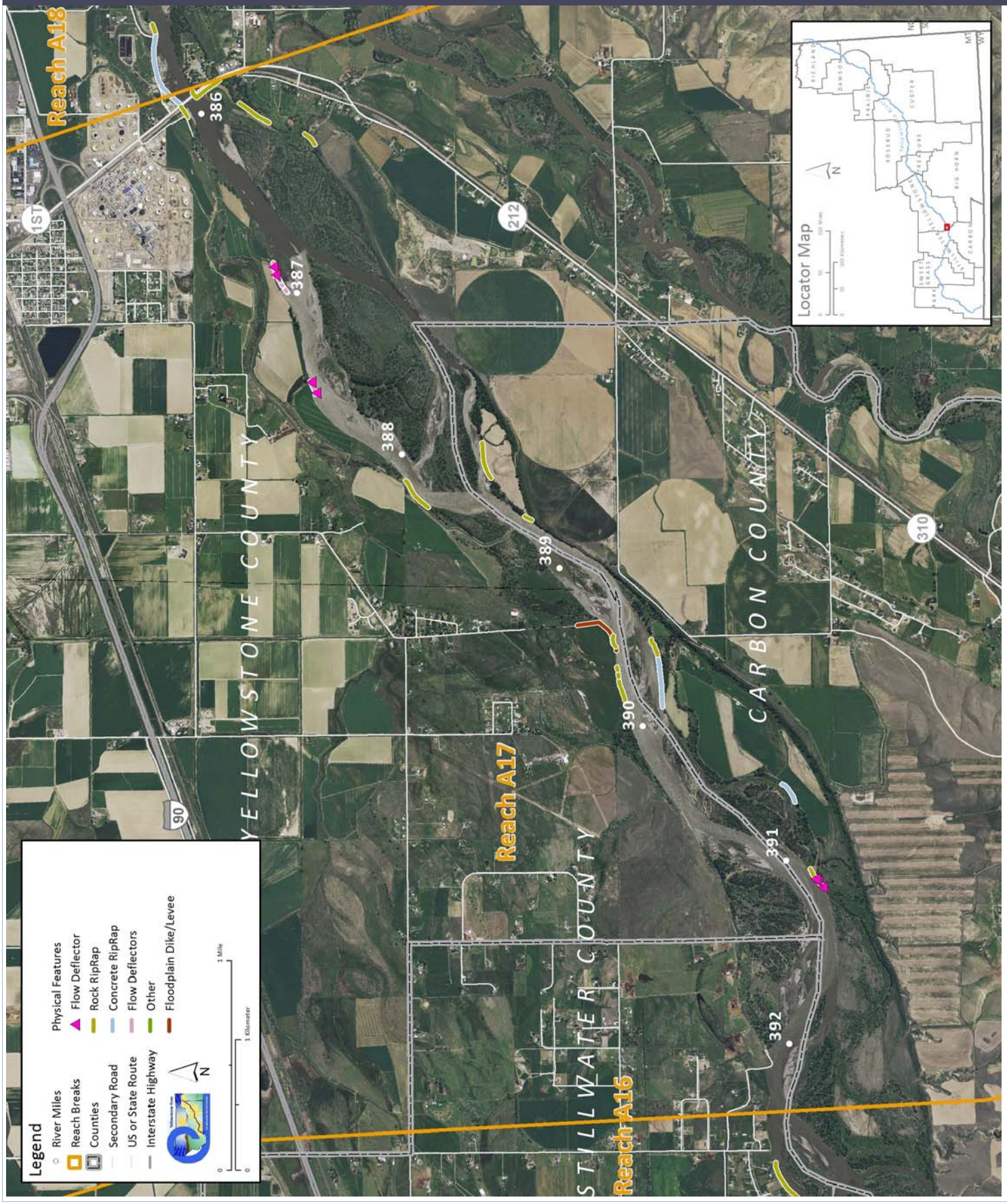
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

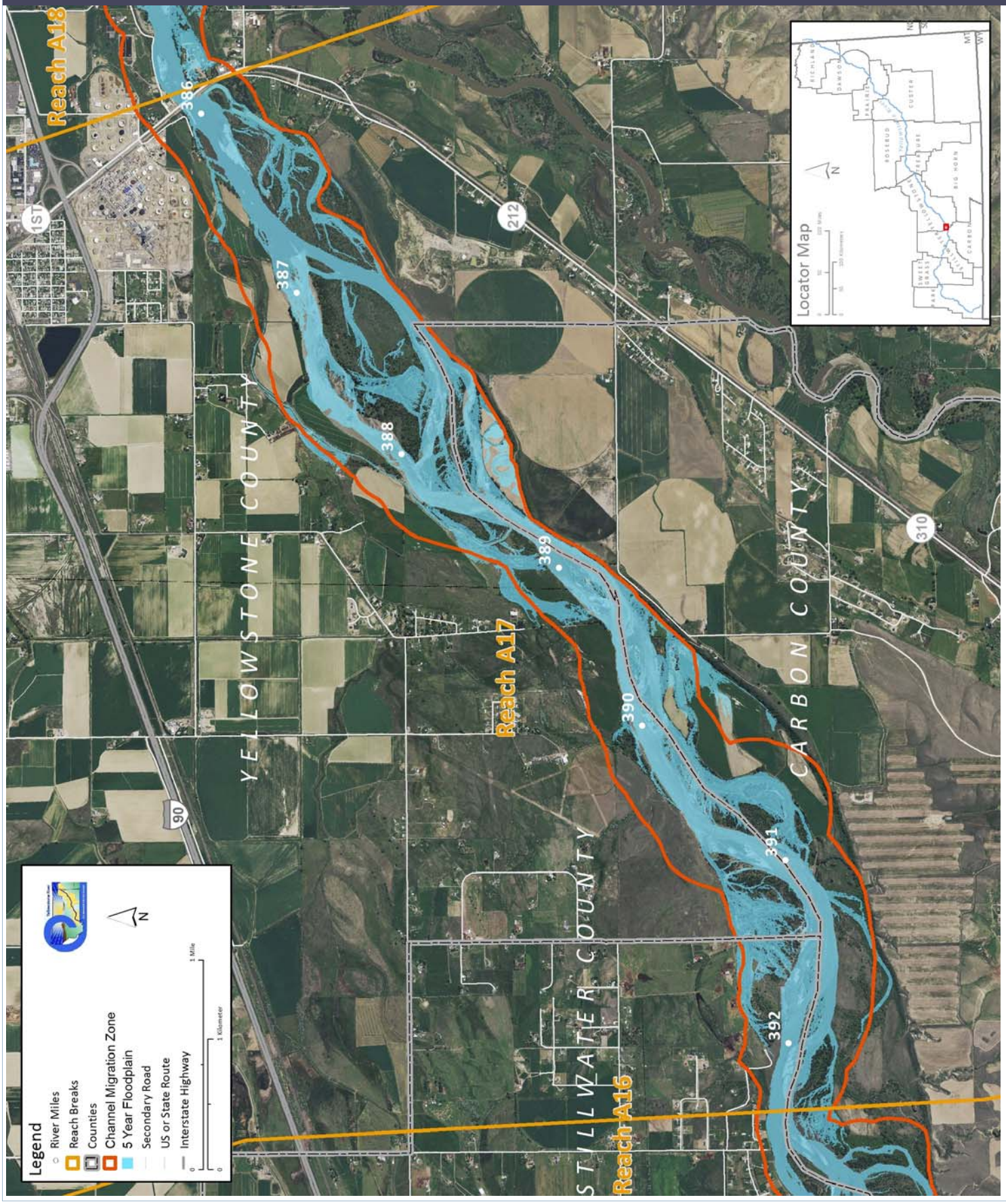
1950	1976	2001	Change 1950-2011
27.7	64.2	9.7	-18.0

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	Yellowstone	**Upstream River Mile**	386
Classification	UA: Unconfined anabranching	**Downstream River Mile**	383.5
General Location	To Clarks Fork	**Length**	2.50 mi (4.02 km)

Narrative Summary

Reach A18 is 2.5 miles long and extends from Laurel to the mouth of the Clarks Fork River. The reach is classified as Unconfined Anabranching (UA), which is characteristically one of the most dynamic reach types on the river. The reach has one large island and even though it is fairly intensively armored through Laurel, there has been over 1,100 feet of southward channel migration since 1950 at one location about ½ mile downstream of the bridge.

Reach A18 is perhaps best known by the series of pipeline crossings below the Laurel Bridge. In 2011, floodwaters on the Yellowstone River peaked on July 2 at 70,600 cfs, which is an estimated 25-50 year flood event. On July 1, the day before the peak, a 12-inch diameter crude oil pipeline called the ExxonMobil Silvertip Pipeline, ruptured just downstream of the bridge in Reach A18. The pipeline was originally installed in a trench across the river that was 5-7 feet deep. The rupture spilled an estimated 50,000 gallons of oil into the Yellowstone River; the incident received national attention and millions of dollars were spent on cleanup. The Silvertip Pipeline and several others at this location have been replaced by HDD (Horizontal Directionally Drilled) lines.

The industrial land uses at Laurel uses coupled with the dynamic nature of the Yellowstone River in Reach A18 has resulted in the armoring of almost 40 percent of the river in this reach. That armor consists of rock riprap, concrete riprap, and flow deflectors. Almost all of the armor is located on the north bank where it protects the City of Laurel sewage treatment facility, as well as a canal that leaves the river at RM 385.7. There is one small section of concrete armor on the north bank, and it appears that the upper 300 feet of this armor has been flanked and now is visible in the middle of the river. Recent concerns over the main intake structure for the city's water supply sheds some light on the dynamics of the river, and potentially the influence of high density bank armor on channel stability. The 2011 flood evidently caused the river to downcut at the intake, perching the structure, such that there are current efforts in motion to relocate the intake several miles upstream. This downcutting may be related to the high density of armor between Laurel and Billings that effectively focuses flow into the main channel and can drive channel incision (downcutting). Reach conditions just downstream in Reach B1 support this hypothesis.

There are over three miles of mapped dikes in Reach A18. Dikes, levees, and transportation encroachment features have isolated about one half of the historic 100-year floodplain in the reach. Almost 17 percent of the 5-year floodplain has become isolated from the river. Most of the isolated 100-year floodplain area is south of the river, between the Yellowstone and Clarks Fork Rivers.

Land use in Reach A18 is primarily agricultural, although there are almost 380 acres of urban/exurban development in the reach as the river passes south of the City of Laurel. All of the irrigated land in Reach A18 is in flood irrigation. A total of 110 acres of developed ground are in the mapped Channel Migration Zone; and the over 90 percent of that is in urban/exurban land use. A total of 31 percent of the CMZ has become isolated by physical features.

Riparian mapping indicates that since 1950, about 67 acres in the reach were cleared to support irrigation and other land uses. There are about 18 acres of mapped Russian olive in the floodplain.

Since 1950, about 150 acres of land in Reach A18 was colonized by new riparian vegetation. There are over 140 acres of mapped emergent wetland in the reach, which consists primarily of emergent marshes and wet meadows.

Almost 18 acres of Russian olive has been mapped in the floodplain.

Reach A18 was sampled as part of the avian study. The average species richness in Reach A17 was 7.1, which indicates the average number of species observed during site visits to the reach in cottonwood habitats. The average species richness for all sites evaluated is 8. On average, of 0.9 Cowbirds were observed in cottonwood habitats during the field sampling visits. Reach A18 has lost all of its riparian forest considered at low risk of cowbird parasitism since 1950. At that time, there were 3.4 acres of forest per valley mile considered to be isolated enough from agricultural infrastructure and urban/exurban development to be considered at low risk. By 2011, that had been reduced to zero.

A hydrologic evaluation of flow depletions indicates that flow alterations over the last century have been moderate in this reach. The mean annual flood is estimated to have dropped from 16,900 cfs to 15,500 cfs, a drop of about 8 percent. The biggest influence has been on low flows: severe low flows described as 7Q10 (the lowest average 7-day flow anticipated every ten years) for summer months has dropped from an estimated 2,780 cfs to 1,950 cfs with human development, a reduction of 30 percent. More typical summer low flows, described as the summer 95% flow duration, have dropped from 1,760 cfs under unregulated conditions to 1,680 cfs under regulated conditions at the Livingston gage, a reduction of 4.6 percent.

CEA-Related observations in Reach A18 include:
- Flanking of concrete armor
- Pipeline rupture in highly armored reach
- Water intake perching in highly armored reach
- Russian olive colonization
- Emergent wetland development in abandoned side channels
- Floodplain isolation at confluence between Clarks Fork and Yellowstone River from transportation-related infrastructure

•Extensive CMZ encroachment in urbanized reach

Recommended Practices (may include Yellowstone River Recommended Practices--YRRPs) for Reach A18 include:
•Irrigation diversion structure management at headgate on at a canal at RM 385.7
•Flanked concrete armor removal RM 384
•Russian olive removal (18 acres)
•Floodplain restoration between lower Clarks Fork River and Yellowstone River
•Pipeline Management for several crossings at Laurel.

Yellowstone River Reach Narratives — Reach A18

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)	32,200	30,600	-5.0%
100 Year (cfs)	58,600	57,600	-1.7%

"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
198.9	250.8	227.3	280.8	82.0

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	3,885	15.6%	220
Concrete Riprap	3,782	15.2%	-736
Flow Deflectors	1,525	6.1%	58
Total	**9,192**	**37.0%**	**-459**

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	85.7	94.5
Acres/Year	3.3	3.8
Acres/Year/Valley Mile	1.6	1.8

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

-57.18 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)				

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	15.0	17%
100 Year	303.5	54%

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
274.8	31%

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)	2,401.7	1,767.8
Ag. Infrastructure (Ac)	46.8	46.4
Exurban (Ac)	27.2	332.4
Urban (Ac)	2.5	42.6
Transportation (Ac)	22.8	23.0

	1950	2011
Flood (Ac)	945.9	893.5
Sprinkler (Ac)	0.0	0.0
Pivot (Ac)	0.0	0.0

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.
39.9	27.3	67.2	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	15.8	7.7
Emergent	139.7	68.2
Scrub/Shrub	33.2	16.2

Total Wetland Acres: **188.7**

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	%
17.9	2.7%

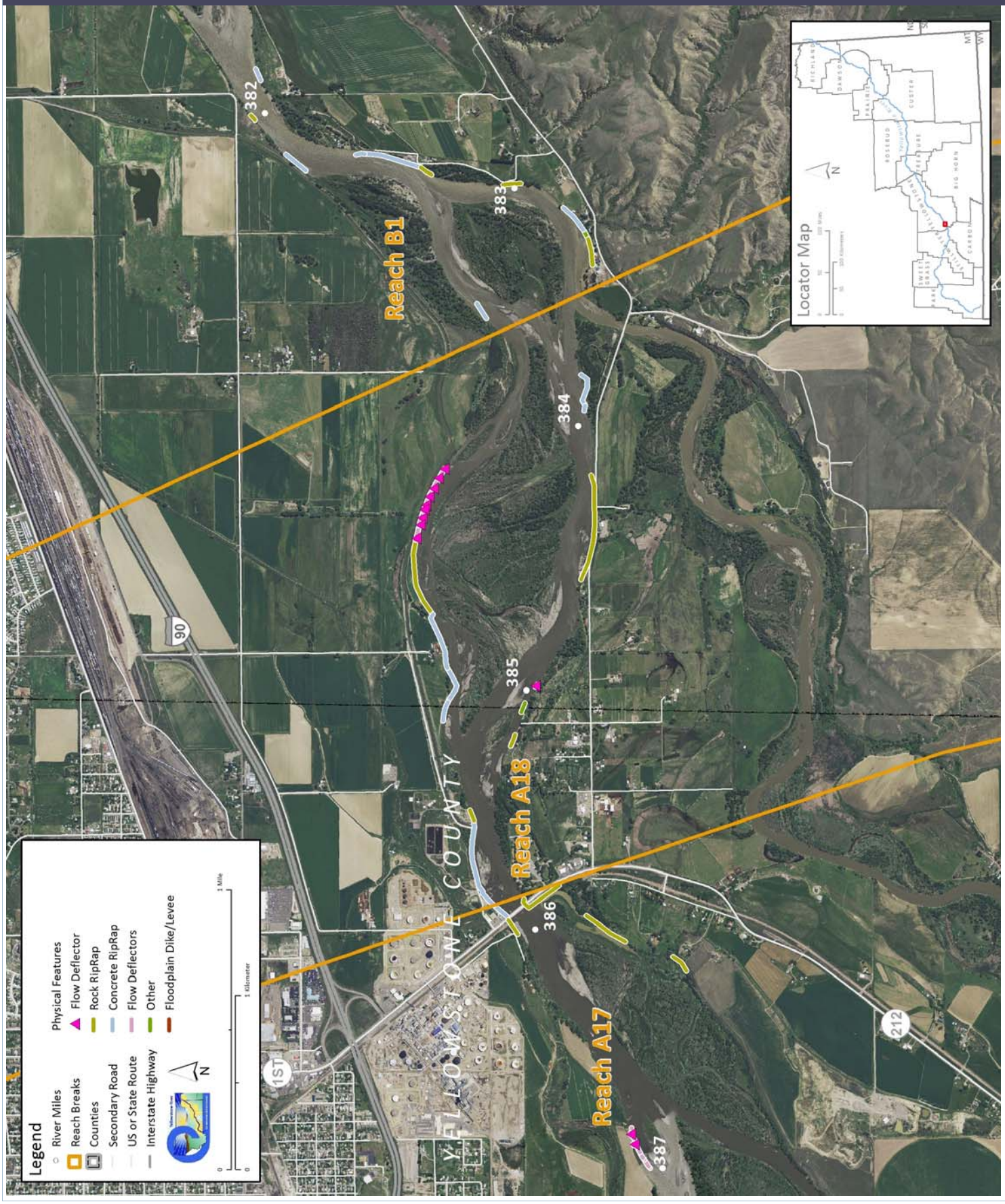
Russian olive is considered an invasive species and its presence in the corridor is fairly recent. Its spread can be used as a general indicator of invasive plants within the corridor.

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

1950	1976	2001	Change 1950-2011
3.4	0.0	0.0	-3.4

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

PHYSICAL FEATURES MAP (2011)



CHANNEL MIGRATION ZONE MAP