Yellowstone River Conservation District Council

Yellowstone River Recommended Practices & Position Statements

Practical Applications

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Introduction

Background

All who live, work, and/or recreate along the Yellowstone River affect it through their personal actions. Every household, business, farm, government institution, and industry influences the long-term sustainability of the river through their policies and operational protocols. We are all responsible to ensure that the ecological and economic values unique to the Yellowstone River are maintained for generations to come.

This document complements the 2015 Yellowstone River Cumulative Effects Analysis (CEA) that was completed on the Yellowstone River corridor. The analysis was a joint effort led by the Yellowstone River Conservation District Council (YRCDC) and the U.S. Army Corps of Engineers (ACOE) with active participation from multiple federal, state and local agencies and other organizations with a vested interest in the river. The majority of the analysis focused on the Yellowstone River corridor from Yellowstone National Park to its confluence with the Missouri River in North Dakota (565 river miles); however, some components of the analysis encompassed the entire Yellowstone River Basin.

The intent of this document is to offer land management and structure design guidelines that address major impacts identified in the CEA. These guidelines were developed as science-based Yellowstone River Recommended Practices (YRRPs) and Position Statements. They are intended to provide guidance to Yellowstone River landowners, water users, land management agencies, county officials, and other stakeholders when making land management decisions and/or building structures within the river corridor (i.e. 100-yr floodplain).

Reference citations have not been made in this document. Citations have instead been included in Chapter 8 of the 2015 Yellowstone River CEA Report.

Yellowstone River Recommended Practices (YRRPs)

The objective behind the YRRPs is to promote an ecologically sustainable river that is necessary for preserving the long-term economic viability of residents and communities who rely on the Yellowstone River. YRRPs are not rigid prescriptions that should be applied to every situation. Instead, they are offered as guidelines that encourage flexibility and informed decision-making. The YRRPs provide technical and practical information to help stakeholders identify potential problems or opportunities and to direct them towards a course of action that fits their objectives and maintains river integrity.

Associated with each YRRP is an implementation approach that suggests specific activities to encourage the adoption and implementation of the YRRP guidelines. The implementation approaches include outreach and educational activities, agency coordination, restoration project priorities, and future data collection needs. Because they are comprehensive, it is unrealistic to expect any one organization to take the lead in all listed activities. Developing MOUs between the YRCDC and multiple agencies and organizations who work in the Yellowstone River Basin is a necessary precursor for the effective coordination, promotion, and implementation of each YRRP.

Over time, as social norms and technology change, the YRRPs and the implementation approaches will be reviewed and up-dated to remain current and relevant.

Position Statements

Position Statements are explanations, justifications, and/or recommendations for courses of action that reflect the YRCDC's stance on various issues associated with the Yellowstone River. Each statement outlines a consistent viewpoint to be expressed in public meetings, land-use planning strategies, and policy development. Position Statements will be reviewed and up-dated periodically to assure that they speak to the current status of an issue and accurately reflect the YRCDC's perspective.

Acknowledgements

During the development of the YRRPs and Position Statements, the YRCDC and members of their Technical Advisory Committee (TAC) provided extensive reviews of multiple drafts. This final document reflects years of dedicated work invested by the YRCDC, ACOE and TAC in developing the scientific foundation upon which these YRRPs and Positions Statements were developed.

YRRP 1.1 - Floodplain Restoration
Agricultural and Urban/Residential Development

Background

Since the late 1800s, an increasing amount of Yellowstone River's historic floodplain can no longer be accessed by flood water. These traditionally flooded areas have become isolated for two reasons: constructed floodplain barriers (i.e. urban levees, dikes, elevated roads, irrigation ditches, railroad berms, etc.) and a reduction in high flows caused by storage reservoirs on tributaries and irrigation withdrawals. Nearly 5,000 acres of the historic 100-yr floodplain have been lost due to dikes and levees that are associated with agriculture and urban/residential development.

Restoring and maintaining the connection between tributaries, the floodplain and the river's active channel is critical to the long-term sustainability of the river. Values associated with a functional floodplain include:

1. ***Water storage:*** During a flood, it is common for the floodplain to store at least 1 acre-foot of water per acre. Once the flood subsides and the groundwater table begins to decline, stored flood water slowly returns to the river augmenting late summer and fall flows. Many variables affect flood water storage potential: soil texture, vegetation, flood duration, pre-flood groundwater depth, land use, etc.
    - Example: 5,000 acres of floodplain flooded during the early summer stores 1 acre-foot of water per acre. Over the next 2.5 months, the stored flood water (5,000 ac-ft) drains back to the river augmenting flow by 30-35 cfs.
2. ***Agricultural production:*** Frequent overbank flooding deposits sediments and nutrients on the floodplain that rejuvenate agricultural lands and increase crop production. However, there are occasions where large floods may deposit deep layers of sand, heavy clay and floating debris on the floodplain that require debris removal and field shaping after the flood waters subside.
3. ***Energy dissipation:*** By allowing high energy flows to spread across the floodplain, flows are not as concentrated in the main channel; bank erosion and channel scour are less.
4. ***Water quality:*** Floodplain vegetation serves as a filtration system that removes excess sediment and nutrients as floodwaters cross the floodplain.
5. ***Riparian habitat:*** Riparian vegetation provides unique and important habitats for a wide variety of plants, insects, reptiles, amphibians, birds and mammals. Even though periodic flooding can cause short-term impacts to ground-nesting birds and small animals, a functional floodplain is essential for sustaining wildlife habitat.

Old gravel dike pushed up on the floodplain near Billings intended to protect a residential development from flooding.

Recommended Management Guidelines

This YRRP provides general guidelines for the removal or modification of physical dikes and berms on the Yellowstone River 100-yr floodplain associated with agriculture and urban growth/rural small tracts.

- ***Old and Abandoned Structures:*** Remove old structures located on the 100-yr floodplain that are no longer functional or needed. These structures may include abandoned buildings, irrigation infrastructure, solid waste dumps, etc. Non-earthen material (wood, steel, tin, garbage) should be disposed of outside the 100-yr floodplain in an approved landfill or recycling center. Once the structure is removed, the site should be graded back to the normal floodplain elevation. All disturbances should be vegetated with species compatible with surrounding land uses. Monitor and treat weeds until the site is fully restored.

- ***New and Existing Structures:*** New structures should be located outside the 100-yr floodplain. When this is not possible, the structure should be designed to minimize its footprint on the floodplain. Existing structures that are significant floodplain obstacles or barriers should be relocated or modified to minimize their impacts.

- **Elevated Roads:** For an elevated road, modifications can be made to allow a controlled amount of flood water passage. Road modification designs should consider the road's primary purpose, frequency of use, adjacent land uses, drainage patterns, flood water entry/departure points, and alternative means to effectively pass flood waters through a road berm (i.e. bridges, culverts, hardened swales, etc.). When the road provides the only access route to residences, the design should minimize the duration of road overtopping and the isolation of residences. Flood by-pass structures should be designed to pass floodwaters as a shallow sheet-flow rather than a concentrated channelized flow that could erode new gullies across the floodplain. A stable path for floodwaters to return to the river is an important part of the design.

- ***Agricultural Berms:*** Agricultural berms include elevated irrigation ditches, field dikes, and farm roads. These berms not only restrict the spread of floodwaters, but will often catch or collect floating debris that will pile up on fields and pastures. Larger floods will sometimes overtop or breach these berms resulting in concentrated flows that will often erode deep rills and gullies across the fields.
  - **Restoration Approach:** If an agricultural berm is old and has outlived its purpose, total or partial removal of the berm should be considered. The old berm should be graded back to the original floodplain elevation. The berm material should either be transported off the floodplain or thinly spread on-site. For berms still in use, modifications can be made to pass floodwaters and effectively move floating debris. Any proposed design should consider the same criteria outlined above for Elevated Roads.

- ***Urban Areas and Exurban Residential Tracts:*** There are urban areas and rural residential developments where dikes and levees were built to protect homes and property from flooding. As these dikes and levees age, the costs for repair and reconstruction are extremely high. It may be impractical and unpopular to fully reconnect the historic floodplain to the river; however, measures can be taken to mitigate their impacts.
  - **Existing Levees:** When existing levees are repaired or rebuilt, they should be set back from the river to the extent possible. In addition, the inclusion of fail-resistant spillways should be built into the levees so that when the levee design is exceeded, excess flows pass through the spillway preventing catastrophic overtopping or failure of the structure.
  - **New Levees:** New levees should be built as a last resort and only after other measures, especially nonstructural ones, have been fully considered. Levees should never be used as a means to facilitate the development of flood prone lands.

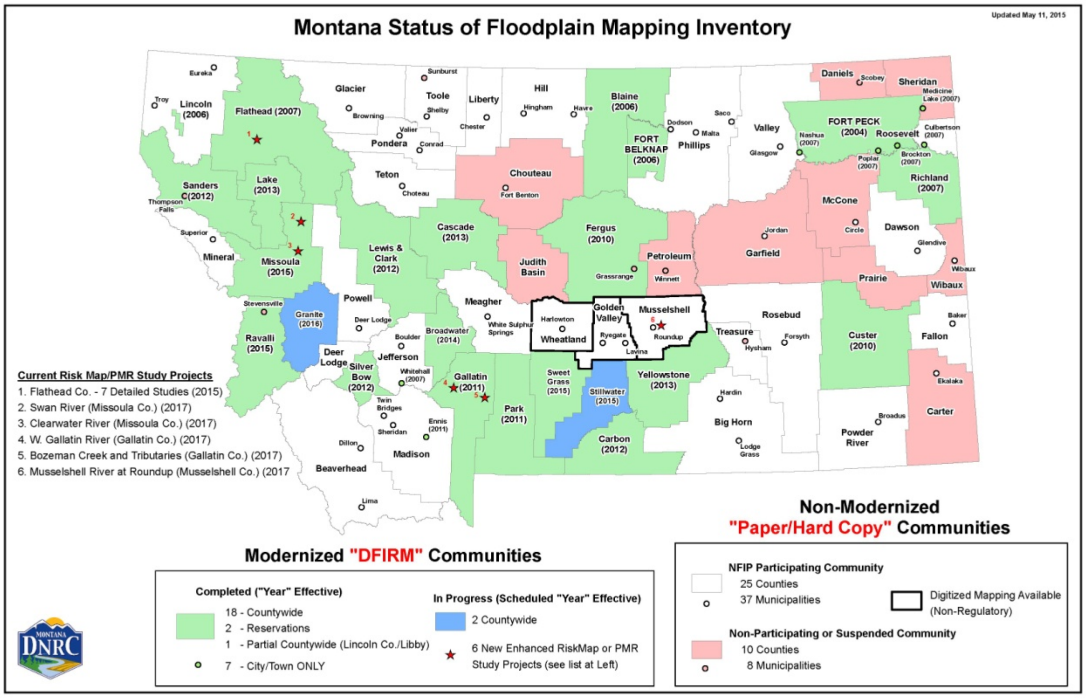
Implementation Approach

1. **Outreach and Education:**
   - The YRCDC will coordinate with the DNRC Floodplain Management Bureau and the Association of Montana Floodplain Managers (AMFM) on presenting Yellowstone River cumulative effects results and associated YRRPs at AMFM's annual conference (March), DNRC's Floodplain Resource Seminar (July), and local "Flood Awareness Days". The targeted audience includes floodplain administrators, consultants, and landowners.
   - YRCDC will work closely with county floodplain administrators using the National Weather Service's *Advanced Hydrological Prediction Service (AHPS)* and NRCS snowpack/streamflow forecast to implement an early warning system that alerts Yellowstone River residents of impending flood conditions.
   - Current information on floodplain restoration incentive programs will be distributed to landowners and city/county officials through the local Conservation District, NRCS, and Extension Service offices.
   - Reach narratives provide brief summaries of floodplain information and unique characteristics for each of the 88 Yellowstone River reaches. Applicable reach narratives will be distributed to landowners, city/county officials, state/federal agencies, and other river users by the local Conservation Districts.

2. **Restoration Guidance:** YRCDC will facilitate the development of detailed restoration guidelines and specifications to assist landowners in determining the most appropriate approach for modifying or removing floodplain dikes and berms. These guidelines will be developed in cooperation with NRCS and the Montana DNRC Floodplain Management Bureau. As a minimum, the guidelines will factor in:
   - Landowner objectives
   - Original intent and current use of the dike or berm to be removed or modified
   - Location of dike and berm on the floodplain.
   - Extent of floodplain to be restored and the expected frequency of inundation
   - Floodwater flow patterns (pre- and post restoration)
   - Restoration effects on existing land uses
   - Restoration effects on fish and wildlife
   - Applicable permit considerations.

3. **100-Yr Floodplain Maps:** Where FEMA-approved floodplain maps are not yet available, the estimated 100-yr floodplain boundaries, developed as part of the Yellowstone River Cumulative Effects Study (2015), should be used as a land use decision-making guide for new developments. These maps are available at Conservation District and County Floodplain offices. It is important to note that these floodplain maps are not FEMA-approved and should only be used as a guide until FEMA-approved maps become available.

4. **FEMA-Approved Floodplain Mapping:** YRCDC will encourage all counties along the Yellowstone River to modernize their FEMA-approved floodplain mapping on the Yellowstone River and major tributaries. A map showing the current inventory of floodplain mapping (May 2015) in Montana is shown below.



5. **Floodplain Easements and Acquisitions:** There are voluntary programs that may provide financial incentives and restoration alternatives for lands subject to frequent flooding and flood damage. The YRCDC will encourage interested landowners to contact the NRCS, county floodplain administrator and non-profit land trusts to determine program provisions and eligibility. YRCDC will encourage Montana's Congressional delegation to support future funding of NRCS's Emergency Watershed Protection Program – Floodplain Easement Program (EWP-FPE).

Floodplain Restoration Priorities – Potential Project Areas

Criteria: Reaches that have more than 5% of the 100-yr floodplain isolated by dikes, berms or levees. Dikes and berms that lie within the 5-yr floodplain will be considered a higher priority for removal or modification.

County	Reach	Description
Yellowstone County	A-18	Agricultural (6.1% - 34 ac): Laurel to Clarks Fork River Confluence
	B-6	Agricultural (11.4% - 209 ac): Upstream from Worden
Treasure County	C-2	Agricultural (18.0% - 495 ac): Upstream from Meyers Bridge
	C-3	Agricultural (8.6% - 233 ac): Meyers Bridge to Yellowstone Diversion
	C-4	Agricultural (19.7% - 324 ac): Below Yellowstone Diversion
	C-5	Agricultural (18.8% - 321 ac): Hysham Area
Rosebud County	C-10	Urban (10.8% - 338 ac): Forsyth Area
Rosebud/Custer	C-14	Agricultural (29.0% - 1,474 ac): Rosebud/Custer County Line
Custer County	C-17	Urban (69.1% - 636 ac): Miles City Area
Dawson County	D-6	Urban (9.2% - 176 ac): Glendive Area

Specific Restoration Project Recommendations

None identified.

Additional Information & Data Needs

1) Water Storage: Quantify the potential for natural water storage of the current and historic Yellowstone River floodplain. Determine the quantity and timing of the return of the floodplain's stored water to the river for

various flood frequencies in priority reaches listed above. Complete an economic analysis on the cost/benefits of restoring floodplain function.

2) Flood Photography: For select flooding events, the YRCDC will proactively coordinate with county flood administrators to sponsor a low-altitude corridor flight using high resolution photography to document actual floodplain coverage. The flood frequency of the recorded event will be determined from the USGS gage stations located along the Yellowstone River.

3) Reach Narrative Up-Dates: Every 10 years, the floodplain information contained in the reach narratives should be reviewed and revised as needed. The next review is scheduled for 2026.

YRRP 1.2 - Floodplain Restoration
Active/Abandoned Railroads & Public Roads

Background

Transportation infrastructure has a relatively small footprint (approximately 3%) on the 100-yr Yellowstone River floodplain. However, transportation corridors in the Yellowstone River Valley have contributed to 37% of the total floodplain isolation.

The Northern Pacific Railroad entered the Yellowstone River Valley at Glendive in 1881. The 424 mile railroad grade parallels the Yellowstone River and is still in operation by Montana Rail Link (MRL) from Livingston to Huntley; and the Burlington Northern Santa Fe (BNSF) from Huntley to Fairview. The Chicago, Milwaukee, & St. Paul Railroad, commonly referred to as the Milwaukee Railroad, arrived 27 years later. The Milwaukee Railroad grade ran between Forsyth and Fallon in the Yellowstone River Valley for 97 miles. It was abandoned in 1980. Another railroad grade that ran between Livingston and Gardiner was abandoned by Burlington Northern in 1981.

The MRL and BNSF railroad grade intermittently cross the historic Yellowstone River 100-yr floodplain for a cumulative total of 102 miles resulting in over 3,500 acres of isolated floodplain. The Milwaukee Railroad intersects the historic floodplain for a total of 25 miles leaving 2,300 acres of floodplain inaccessible to floods. The abandoned railroad grade between Livingston and Gardiner has little effect since Highway 89 lies between the river and the old grade.

Public highways and county roads are more flexible in design and location and encroach upon the river's floodplain less than the railroads; however, they are still responsible for 2,050 acres of isolated floodplain. Most public roads in the floodplain are two-lane highways or county roads. Interstate Highways 90 and 94, completed in the 1970s, make up nearly 415 miles of roadway in the Yellowstone River Valley. They have a relatively small effect on the floodplain since they are generally located on the periphery of the river valley.

The abandoned Milwaukee Railroad grade crosses the historic floodplain west of Miles City. It is currently used as an access road by the Fort Keogh Research Station.

<u>Floodplain Restoration:</u> Maintaining connectivity between tributaries, the historic floodplain and the river's active channel is critical. Values associated with a functional floodplain include:

1. ***Water storage:*** It is common for the floodplain to store at least 1 acre-foot of water per acre during a flood. Stored flood water will eventually return to the river augmenting summer and fall flows.
2. ***Energy dissipation:*** By dispersing high energy flows on the floodplain, flows are less concentrated in the active channel; river bank erosion and channel scour are reduced.
3. ***Water quality:*** Floodplain vegetation serves as a filtration system that removes excess sediment and nutrients from the water as it slowly crosses the floodplain.
4. ***Riparian habitat:*** Unique and important habitats are sustained for a wide variety of plants, insects, reptiles, amphibians, birds and mammals.

Recommended Management Guidelines

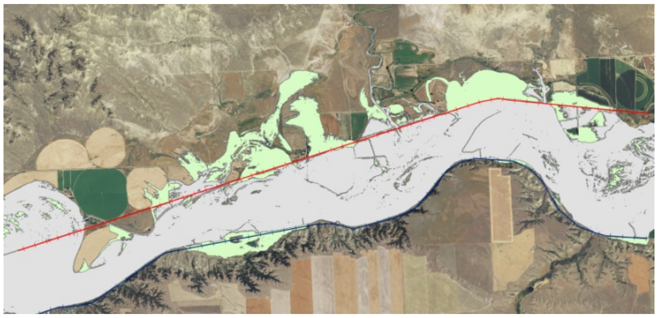
This YRRP provides guidelines on mitigating the effects of railroad and public road berms in the Yellowstone River 100-yr floodplain and tributaries.

- ***Active Railroads:*** Opportunities to reconnect the historic floodplain isolated by the active railroad grade are limited. More practical restoration options may be associated with tributary connectivity and grade stabilization.

    - Tributary Connectivity and Grade Stability: Establishing tributary connectivity to the Yellowstone River would allow for fish passage, reclaim land lost from ponding or salinization, and minimize saturation and slumping of the railroad grade. Culverts, pipes, concrete boxes, or small bridges can be installed through the railroad grade to pass surface run-off from perennial, intermittent, and ephemeral side drainages. These by-pass conduits should be sized to accommodate a 100-yr frequency flow to prevent ponding and backwater against the upslope side of the grade and be designed for fish passage. Discharges through the railroad berm require a stable waterway to the river.

- ***Abandoned Railroad - Milwaukee:*** The Milwaukee railroad grade has been abandoned since 1980. Since it is no longer maintained, it has become increasingly vulnerable to unchecked bank erosion and berm failure that could have severe consequences to property once protected by the old grade.

    - Floodplain Restoration: There is potential for restoring the historic floodplain behind the Milwaukee Railroad at some locations. A systematic evaluation of the old railroad fill should be completed to identify possible projects for flood by-pass structures, strategic breaching points and/or full grade removal.



Light green areas show the historic 100 year floodplain isolated by the two railroad grades. The red line on the north side of the river depicts the abandoned Milwaukee Railroad.

- ***Public Highways and County Roads:*** Most public highways and county roads are either located outside the 100-yr floodplain or buffered by other floodplain berms, often the railroad grade. Installing or enlarging by-pass structures on some public roads would better accommodate side drainage runoff and flood waters from the Yellowstone River. Floodplain restoration opportunities for private driveways and farm roads are outlined in YRRP 1.1 Floodplain Restoration: Agriculture and Urban/Residential Development.

- ***Bridges:*** Over 50 highway and railroad bridges cross over the Yellowstone River. The highway bridges are publically owned while the railroad bridges are private.

    - Active Bridge Crossings: All future bridge construction or replacement should incorporate zero backwater design standards (span, piers, and abutments) to minimize upstream gravel deposition and downstream channel scour. Design standards should assure a bridge capacity that can readily pass 100+ year flood events and not exacerbate localized ice jams.
    - Abandoned Bridge Crossings: For bridges no longer in use, restoration projects should be initiated to remove old bridge abutments and piers, and to grade bridge approaches back to the original floodplain elevation.

Implementation Approach

1. **MRL and BNSF Railroad Berms:** The YRCDC will collaborate with MRL, BNSF, and adjacent landowners on identifying opportunities for installing new or modifying existing structures through the railroad berms that adequately pass run-off flows from side tributaries to the river. The intent of these structures will be to reduce ponding and the loss of land productivity behind the railroad berms. There may also be fish passage issues in some locations that need to be addressed in the project design. See the Implementation Approach for Position Statement 10.1 Fish Passage and Entrainment.

2. **Public Highways and County Roads:** YRCDC will investigate potential opportunities to install new or modify existing structures through public roadways to allow flood relief from the Yellowstone River and to adequately pass run-off flows from side tributaries to the river. YRCDC will work closely with Montana DOT, county road departments, and adjacent landowners to identify sites where significant ponding and/or land loss is occurring behind public roads. There may also be fish passage issues in some locations that need to be addressed in the project design. See the Implementation Approach for Position Statement 10.1 Fish Passage and Entrainment.

3. **Milwaukee Railroad Berm:** Since this railroad grade is no longer used or maintained, there may be several opportunities to reconnect the historic floodplain to the river.

   - **Landowner Outreach:** Landowners will be personally contacted by the Rosebud and Custer Conservation Districts to discuss restoration opportunities.

   - **Restoration Strategy:** YRCDC will develop a general restoration strategy to assist interested landowners in deciding on the most appropriate method for removing or modifying the railroad berm. The restoration strategy should begin with a detailed evaluation of the Milwaukee Railroad grade to determine potential projects. Prioritization criteria for future restoration projects will include:
     - Landowner(s) interest and objectives
     - Location of the railroad berm on the floodplain
     - Extent of the floodplain to be reclaimed and frequency of inundation
     - Location and stability of ingress (entry through the berm) and egress (pathway back to the river)
     - Floodwater flow patterns (pre- and post restoration)
     - Restoration effects on existing land uses behind the railroad berm
     - Estimated project costs

   - **Floodplain Easements and Acquisitions:** Financial incentive programs may be available for restoring the historic floodplain behind the Milwaukee Railroad grade. The YRCDC will encourage interested landowners to contact their local Conservation District, NRCS, county floodplain administrator and non-profit land trusts to determine program opportunities and eligibility.

Floodplain Restoration Priorities – Potential Project Areas

1) **MRL and BNSF Railroad Berms:** Nearly every reach (PC-14 to D-16) has an active railroad grade in the Yellowstone River Valley. There are no targeted reaches due to insufficient information on specific sites. See the section below on "Additional Information & Data Needs".
2) **Public Highways and County Roads:** Every reach (PC-1 to D-16) has both public highways and county roads in the valley. There are no targeted reaches due to insufficient information on specific roads and tributary by-pass structures.

3) **Milwaukee Railroad Berm:** Priority reaches extend from C-9 (West of Forsyth – Rosebud County) to C-16 (Fort Keogh – Custer County).

Specific Restoration Project Recommendations

None identified.

Additional Information & Data Needs

1) Tributary Connectivity: The YRCDC will coordinate with MFWP and USFWS on an inventory of tributary barriers to fish connectivity that includes roads, irrigation ditches, etc.

2) Milwaukee Railroad: The YRCDC will commission a detailed investigation of the Milwaukee Railroad grade to identify potential floodplain restoration projects.

3) Flood Photography: For select flooding events, the YRCDC will coordinate with county flood administrators to sponsor a low-altitude corridor flight using high resolution photography to document actual floodplain coverage along the Yellowstone River.

YRRP 1.3 - Side Channel Blockage Removal

Background

Numerous side-channels have been disconnected from the Yellowstone River's main channel over the last 120 years. The loss of these side channels is caused by both physical blockages and the reduction in high flows. This YRRP focuses on side-channel blockage removal. Between Gardiner and the Missouri River confluence, 42 miles of side channels have been physically blocked on the Yellowstone River prior to 1950; another 48 miles were blocked between 1950 and 2001. Over 15% of the total number of side channels has some form of blockage.

Functional side channels are one of the most important features on the Yellowstone River for maintaining healthy fish populations. The values associated with side-channels include:

1. ***Habitat:*** Side channels provide critical habitat and refuge for fish, amphibians, reptiles, birds, and other aquatic life on the Yellowstone River. During high flows, side channels tend to be shallower with slower velocities, warmer water temperatures, more habitat diversity, and higher productivity (fish recruitment and food sources) as compared to the main channel.
2. ***Flood Relief:*** Keeping side channels open to high water helps disperse energy. By not allowing high water to access side channels, flow and energy are concentrated in the main channel resulting in accelerated bank erosion, channel scour, and downstream flood damage.

Throughout the 20th century, side channels were blocked for various reasons. Some blockages provided access to islands while others were built to prevent flood damage to adjacent property.

Recommended Management Guidelines

This YRRP provides general guidelines for the removal or modification of physical blockages that would significantly benefit aquatic habitat and flood relief associated with side channels.

- **Total Blockage Removal:** Completely removing a side channel blockage to restore high water flow access is the best alternative for restoring side channel function and value. The pros and cons of complete removal should be considered early on in the site evaluation process.

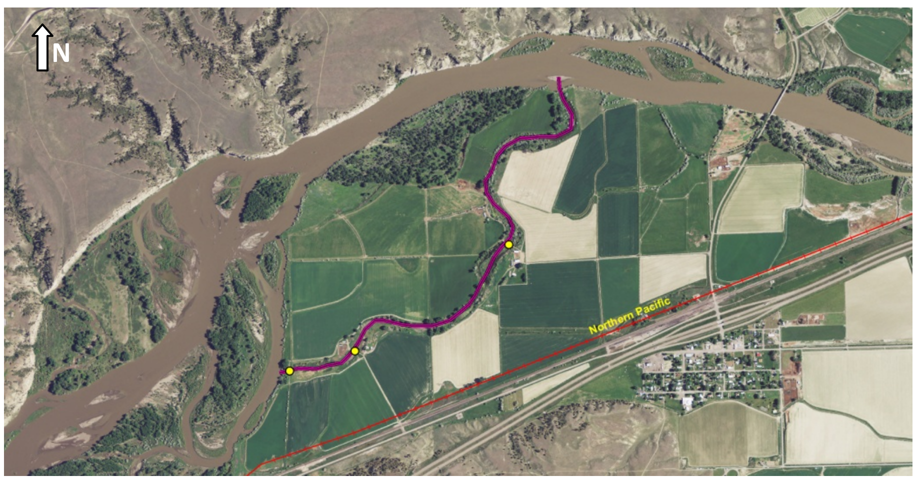
- **Water Control Structures:** Where blockage removal presents too high of a risk (i.e. flooding, river capture, bank destabilization), retrofitting or replacing the physical blockage with a water control structure (i.e. culvert, bridge, constructed overflow channel, etc.) to regulate high flow access and provide fish passage is a viable option. This alternative may not provide full functionality to the side channel, but impacts to aquatic habitat would be reduced.

- **Side Channel Restoration:** Restoration work on the side channel itself is often necessary in addition to modifying or removing the side channel blockage. This may involve removing accumulated sediment from the side channel, reshaping the channel, installing grade control to prevent river capture, removing invasive species that have encroached on the channel, and building fish habitat (i.e. pools, spawning substrate, woody cover, etc.) conducive to the local fisheries.

- **Maintaining Existing Side-Channels:** For side-channels currently connected to the river, their continued function as habitat and flood relief should be an important objective in every landowner's long-term management plan.

- **Adjacent Land Planning:** For reactivated side channels, flood hazard remediation may be necessary to address increased flood potential on fields and infrastructure next to or down-gradient of the side channel. Remediation could be in the form of vegetative buffers, structure relocation or floodplain easements.

- **Restoration Project Monitoring:** A monitoring plan should be developed to determine if the project meets its restoration goals and whether additional "tweaking" is necessary to make the project more effective. Monitoring would also highlight successful restoration approaches that would be applicable to side channels in similar settings.



A side channel in Yellowstone County that has been blocked for over 65 years. The purple line is the side channel and the yellow symbols are locations of the blockages.

Implementation Approach

Side Channel Restoration Strategy

1. **Outreach Program:** The YRCDC will work closely with individual Conservation Districts and Montana FW&P on implementing an outreach program directed towards landowners who own or border blocked side channels. The outreach will include information on side channel restoration; solicit landowner interest in pursuing a demonstration project; and offer on-site visits (NRCS, and/or FWP) to collect more site-specific information.

2. **Project Funding:** YRCDC will assist the landowner in seeking funding to complete the project design and construction. This type of restoration project would be highly competitive in state, federal and private incentive programs. If there is enough interest, YRCDC will work with state and federal agencies, and non-profit organizations, to expand their incentive-based funding programs for side channel restoration.

3. **Monitoring:** YRCDC will coordinate with Montana FW&P on developing monitoring plans for each restoration project to determine effectiveness.

Side Channel Restoration Priorities – Potential Project Areas

Reaches with blocked side channels are included in the priority list below. The blocked side channels listed below were identified using aerial photography. It is sometimes difficult to determine the nature of the blockage. Any errors in the list can be corrected with on-site visits.

County	Reach	Extent	Description
Park	PC-5	3500 feet	Upstream from Big Creek confluence
	PC-7	3000 feet	Upstream from Grey Owl
	PC-10	8450 feet	Near Weeping Wall, Jumping Rainbow
	PC-11	2000 feet	Near Suce Creek confluence; Wineglass Mtn
	PC-14	14150 feet	Livingston Area
	PC-16	1900 feet	Upstream Hwy 89 Bridge
	PC-17	3950 feet	89 Hwy Bridge to Shields River confluence
	PC-18	11400 feet	Mission Creek Area
Sweet Grass	A-1	2970 feet	Springdale Area
	A-2	3125 feet	Grey Bear
	A-4	7575 feet	Big Timber Area
	A-6	2700 feet	Upstream from Greycliff
	A-7	9350 feet	Greycliff
	A-8	4650 feet	Downstream from Greycliff
	A-9	3720 feet	Upstream from Reedpoint
Stillwater	A-9	2700 feet	Reedpoint Area
	A-11	6750 feet	I-90 Bridge Crossing
	A-12	3750 feet	Upstream from Stillwater River confluence
	A-14	18850 feet	Downstream from Columbus
	A-15	1620 feet	Upstream from Park City
	A-17	2000 feet	Upstream from Laurel
Yellowstone	A-17	5650 feet	Upstream from Laurel
	B-1	19800 feet	Downstream from Clarks Fork confluence
	B-2	6570 feet	Billings Area
	B-3	24700 feet	Downstream from Billings

County	Reach	Extent	Description
	B-5	11400 feet	Huntley Area
	B-6	1350 feet	Downstream from Huntley
	B-8	6200 feet	Pompey's Pillar
	B-9	7950 feet	Downstream from Pompey's Pillar
	B-10	3350 feet	Upstream from Custer Bridge
	B-11	1000 feet	Custer Bridge
Treasure	C-1	7170 feet	Downstream from Big Horn River confluence
	C-2	11630 feet	Upstream from Meyers Bridge
	C-5	8830 feet	Hysham Area
	C-6	10910 feet	Mission Valley
	C-7	19800 feet	Mission Valley
	C-8	2320 feet	Treasure/Rosebud County Line
Rosebud	C-8	8500 feet	Treasure/Rosebud County Line
	C-9	19350 feet	Hammond Valley
	C-11	22745 feet	Upstream from Cartersville Bridge
	C-12	9080 feet	Community of Rosebud
	C-13	4575 feet	Downstream from Rosebud
	C-14	15000 feet	Rosebud/Custer County Line
Custer	C-17	1470 feet	Miles City Area
	C-18	1050 feet	Downstream from Miles City
	C-19	17360 feet	Kinsey Bridge Area
Dawson	D-4	8550 feet	Downstream from Prairie/Dawson County Line
	D-5	9070 feet	Upstream from Glendive
	D-6	33500 feet	Glendive
	D-9	21430 feet	Downstream from Intake
Richland	D-11	15600 feet	Elk Island Area
	D-12	14625 feet	Crane Area
	D-14	3600 feet	Upstream from Richland/McKenzie County Line

Specific Restoration Project Recommendations

None identified.

Additional Information & Data Needs

1) On-Site Side Channel Evaluations: The YRCDC will arrange on-site evaluations of blocked side channels with interested landowners to determine: 1) the original purpose for the blockage, 2) current condition of blockage, 3) restoration potential, and 4) landowner interest. This evaluation will include discussions with Montana FW&P on the relative importance of specific side channels for the local fisheries and other aquatic life. The priority list and side channel mapping above will be up-dated as more information is collected.

2) Flood Photography: During future flooding events, the YRCDC will coordinate with county flood administrators to sponsor a low-altitude corridor flight using high resolution photography to document actual side channel inundation. The inundation of side channels will be correlated with flood frequency using USGS gage stations. This information will refine the hydraulic modeling of various flood events completed as part of the cumulative effects analysis (2016).

YRRP 2.1 - Channel Bank Stabilization

Background

The Yellowstone River is a naturally meandering river which causes banks to erode and channels to shift. In winter, anchor ice and ice jams can be another major factor affecting bank erosion. Eroding river banks are a natural function of the river and don't always need to be "repaired". In fact, bank treatments that lock the river channel in place will cumulatively impact the river by restricting riparian forest renewal, degrading fisheries habitat, and lessening the river's ability to adjust to fluctuating flows and bedload. Since the late 1800s, an increasing amount of infrastructure and cropland has been developed on the floodplain without much thought given to the dynamic nature of the Yellowstone River. As is often the case, the river will migrate toward these developments, forcing landowners to decide whether or not investing in bank protection is worth the expense and risk.

As of 2011, there are approximately 136 miles of bank armor on the Yellowstone River from Gardiner to the Missouri River. This is equivalent to 12% of the Yellowstone River (main channel plus active side channels).

The two primary land uses shielded by bank armor are agriculture-related (irrigated lands and infrastructure) at 37% and railroad rights-of-way at 36%. The remaining land uses are urban/exurban, 11%; non-irrigated lands, 9%; and public roads, 7%.

The most common type of bank armor is rock riprap at 75%. Concrete riprap and flow deflectors account for 23%. Car bodies, gabions, steel retaining walls, and soft bioengineering make up the remainder at 2%.

Channel Migration Zone (CMZ) Maps: CMZ maps define areas along the Yellowstone River that are prone to bank erosion over the next 100 years. CMZ map boundaries are based upon detailed geologic mapping of the valley bottom and measured rates of lateral channel migration derived from fifty years of historic aerial photography. The use of CMZ maps are an important tool for decision-makers along the Yellowstone River that can significantly reduce the risk to proposed developments along the river and minimize the necessity for expensive bank armoring. CMZ maps of the Yellowstone River are available at local Conservation District Offices.

Material used for bank armor on the Yellowstone River is mostly quarried sandstone rock. Salvaged concrete is sometimes used near towns and urban areas.

Recommended Management Guidelines

This YRRP outlines guidelines and planning considerations regarding risks and costs associated with bank stabilization. There are three attachments to these guidelines that discuss common materials and techniques used on the Yellowstone River.

Structures – Channel Migration Zone: Landowners and state/local governments invest in bank armor to protect high-value structures (i.e. houses, outbuildings, irrigation sprinklers, roads, etc.) being threatened by the river. Since bank armor is costly to install and maintain, and often subject to failure, building structures outside the Channel Migration Zone is the least expensive option and should always be the first option to consider.

Agricultural Lands

- **Cost/Benefit:** For cropland, riparian forest, pastureland, etc. being threatened by river migration and bank erosion, the CMZ map predicts the amount of land that may be lost if bank stabilization is not pursued. This acreage estimate provides baseline information to calculate economic costs/benefits that compare property values and production losses with bank armor installation and long-term maintenance costs. Although most people do not want to lose land to the river, the expense of bank armor to protect some properties may not be economically justified.
- **Flood Irrigation – Bank Saturation:** Irrigation ditches and flood irrigated fields located too close to the river channel will saturate the river bank. Saturation causes the river bank to become vulnerable to sloughing and accelerated erosion. This often leads to expensive bank armor that is treating the symptom rather than the actual problem. Proven approaches can effectively address bank saturation depending upon field orientation and site conditions:
    - Relocate irrigation ditches away from the river channel
    - Line irrigation ditches or replace with buried pipelines to reduce seepage
    - Develop a flood irrigation tailwater system that transports waste water efficiently off the field
    - Plant a vegetative buffer between the river and irrigated field, ideally the width of the CMZ. The buffer should be planted with deep-rooted native plants.
- **Sprinkler Irrigation:** All new sprinkler systems (above- and below-ground components) should be located outside the CMZ to avoid the expense of system relocation or bank armor in the future. For existing system upgrades, reorienting fields and installing sprinkler pivot points and supply lines outside the CMZ will lessen the likelihood for future bank armor.

Channel Migration Zone (CMZ) Easements: CMZ easements may be an alternative to bank armoring in that they maintain the ability of the river to migrate while offering landowners some financial return on their land. CMZ easements offer compensation to landowners for land that may potentially be lost to the river, either through direct payments or tax incentives. The CMZ easement programs are in their infancy so availability may not meet the demand over the next few years. Inquire with your local Conservation District on CMZ easement opportunities.

Failed Bank Armor Removal: Failed bank armor and flanked flow deflectors inevitably end up as rubble in the active river channel. This rubble will often deflect the current into the bank, accelerating the bank erosion that it was originally intended to stop. It also creates a safety hazard for boaters and recreationists and a potential liability to the landowner. Failed bank armor and flow deflectors should be removed from the active channel. The material should then be either reused or transported off-site.

Rock riprap flanked by high flows that is now located in the middle of the river.

YRRP 2.1 Attachment #1: Rock Riprap Guidelines

Economics: The value of the property or structure to be protected should be compared to the annualized cost of installing rock riprap over its expected lifespan. An objective cost/benefit analysis usually concludes that only high value assets justify the expense of 'hard' bank protection. Installation costs are only the beginning. On a high-energy river like the Yellowstone, frequent expenditures of money and time will be necessary to prevent the bank armor from failing. Maintenance expenses must be included in the calculation of project costs and benefits.

Channel Migration Zone (CMZ) maps provide information on historic channel migration rates and projected land loss over the next 100 years. CMZ maps are based upon historical aerial photos that show how the channel has migrated over the last 50 years. CMZ maps and historic aerial photos are available at the local Conservation District Office.

Example: Cost/Benefit Calculation: The CMZ map predicts that two acres of irrigated hay land valued at $3,000/ac may eventually be lost if the river continues to migrate at its current rate. Net annual production income (irrigated hay – 4 tons/acre at $100/ton) averages $400/acre/year.

Rock Riprap Installation Cost – 200 feet * Cost of Capital – 4%	$40,000
Expected Lifespan	25 years
Annual Maintenance Costs (2%) (Rock replacement, weed control, etc.)	$800
Equivalent Annual Cost (EAC) (Investment Cost + Maintenance Costs)	**$3360**

* Properly installed rock riprap will often exceed $200/linear foot

The EAC of $3360/yr for 25 years is greater than the land value of $6,000 + lost production ($800/yr for 25 years = $20,000). For this example, installing rock riprap to protect two acres of irrigated hay land would not be economically justified.

The EAC analysis described above does not take into account the recreational, intrinsic and ecological values lost by armoring the river channel.

Another financial cost not often considered when planning riprap projects is finding rock of sufficient strength and durability to last 25 years. Adequate rock quality is not readily available along most of the Yellowstone River. This often means that rock must be transported from distant quarries, significantly raising the cost of rock riprap.

Given the high cost of rock riprap, bank armoring is usually limited to sites where high-value property is being threatened. Bridge abutments, permanent irrigation structures, and buildings are sites where the investment in rock riprap may be worthwhile.

Permanent Irrigation Pump: Rock riprap may be economically justified if high-value infrastructure is being threatened.

Risk is defined as the potential for bank armor failure. Rock riprap is considered to be a bank armoring approach that has a high cost with a relatively low risk of failure if properly installed. To reduce the risk of failure, the guidelines listed below should be followed.

Rock Riprap: Design and Installation Guidelines

The following are general guidelines to use when installing rock riprap. To reduce the risk of bank armor failure, a qualified river specialist should evaluate, design, and oversee installation of bank armoring projects.

- ***Off-Site Effects:*** Carefully evaluate possible off-site impacts to upstream, downstream and opposite bank properties. Rock rip-rap may divert the current to an unprotected bank, shifting the bank erosion elsewhere.
- ***Rock Quality:*** Use hard angular rock, properly sized and graded. Rock density should exceed 1.3 tons/CY. Round river rock or soft sandstone will not stand up to the Yellowstone River's high energy flows and winter ice for very long.
- ***Filter Blanket:*** Uniformly lay gravel, sand, or crushed rock to a minimum thickness of 8 inches to prevent scouring of fine soils beneath the rock riprap.
- ***Bank Slope:*** Shape the river bank to a 2:1 slope or less. The flatter the slope, the less risk of failure. Excavated bank material should be transported off-site or spread thinly on the adjacent floodplain. There shouldn't be any elevated spoil piles or dikes to impede or deflect over-bank flooding.
- ***Key Rock Into Channel Bed:*** Excavate and "key in" the base or "toe" of the rock riprap below the elevation of anticipated bed scour. The riprap toe is the zone of highest erosive stress from water, ice, and the weight of the rock riprap. A poorly installed toe is often the reason for riprap failure.
- ***Key Rock into Bank:*** Key additional rock into the upstream and downstream ends of the rock riprap to prevent the river from flanking the riprap. The upstream bank key should be oriented at a 30 to 45 degree angle into the bank pointed upstream.
- ***Rock Placement:*** Rock riprap should be carefully placed on the sloped bank by an experienced excavator operator. Some hand work is necessary to fit smaller rocks in the voids between the larger rocks. Soil should be incorporated with the rock to facilitate the establishment of vegetation ("dirty riprap"). Rock should never be dumped off the bank or left on the top of the bank for the river to undermine it. Rock riprap typically does not need to extend up the shaped bank any higher than the "channel-forming" flow event (high water elevation 2 years out of 3).
- ***Vegetation:*** Incorporate deep-rooted native vegetation into the rock riprap. Additional vegetation should be densely planted on the shaped bank above the riprap up to the top of the bank. Aggressively control weeds for three years on all disturbed areas.

Treatment of High Banks – Constructed Bankfull Bench Method

The constructed bankfull bench method is an approach sometimes used to stabilize high, steep banks. This method involves placing gravel fill along the base of the eroding or slumping bank to support a flat narrow floodplain bench 1 to 2 feet above the height of the opposite bank (bankfull elevation). This gravel bench provides drainage and a stable fill to support the riprap.

On rare occasions, instead of placing fill, the bench may be excavated into the existing bank. This alternative does not require the gravel fill, but will generate large quantities of excavated materials that need to be transported off-site. It may also cause the upper bank, above the constructed bench, to be steeper and less stable.

- ***Constructed Bench:*** The bench is flat and usually a minimum of 4 feet wide.
- ***Rock Riprap:*** The fill is graded to a 2:1 slope or less from the toe of the bank to the bench elevation. The fill slope can then be protected using the same guidelines outlined for rock riprap.
- ***Vegetation:*** The bench and upper slope are covered with coir fiber matting and planted with deep rooted native shrubs.

YRRP 2.1 Attachment #2: Concrete Riprap Guidelines

Near towns and urban areas, concrete rubble salvaged from buildings, foundations, and sidewalks is sometimes used as material for bank armor, instead of rock. Salvaged concrete should be used as a last resort, only when suitable rock is not available. Concrete rubble may be cheaper than rock, but the preparation and placement of concrete riprap is a bigger challenge with a higher risk of failure. Concrete riprap is especially susceptible to damage by ice.

Economics: The value of the property or structure to be protected should be compared to the annualized cost of installing concrete riprap over its expected lifespan. An objective cost/benefit analysis usually concludes that only high value assets justify the high cost of 'hard' bank protection. The installation costs are only the beginning. On a high-energy river like the Yellowstone, periodic expenditures of money and time will be necessary to prevent the bank armor from failing. Maintenance expenses should be included in the calculation of project costs and benefits.

Channel Migration Zone (CMZ) maps provide information on historic channel migration rates and projected land loss over the next 100 years. CMZ maps are based upon historical aerial photos that show how the channel has migrated over the last 50 years. CMZ maps and historic aerial photos are available at the local Conservation District Office.

Example: Cost/Benefit Calculation: The CMZ map predicts that two acres of irrigated hay land valued at $3,000 may eventually be lost if not armored. Net annual production income (irrigated hay – 4 tons/acre at $100/ton) averages $400/year.

Concrete Riprap Installation Cost – 200 feet (Cost of Capital: 4%)	$30,000
Expected Lifespan	20 years
Annual Maintenance Costs (2%) (Concrete replacement, weed control, etc.)	$600
Equivalent Annual Cost (EAC) **(Investment Cost + Maintenance Costs)**	**$2805**

The EAC of $2805/yr for 20 years is greater than the land value of $6,000 + lost production ($800/yr for 25 years = $20,000). For this example, investing in concrete riprap to protect two acres of irrigated hay land would not be economically justified.

The EAC analysis described above does not take into account the recreational, intrinsic and ecological values lost by armoring the river channel.

Given the high cost of concrete riprap, bank armoring is usually limited to sites where high-value property is being threatened. Bridge abutments, permanent irrigation structures, and buildings are sites where the expense of bank armor may be worth the investment.

Concrete blocks dumped on the river bank. This attempt at bank armoring will accelerate the rate of bank erosion rather than prevent it.

Risk is defined as the potential for bank armor failure.   Concrete riprap is considered to be a bank armoring approach that often has a high cost with a relatively high risk of failure if not properly installed. To reduce the risk of failure, the guidelines listed below should be followed.

Concrete Riprap: Design and Installation Guidelines

- ***Off-Site Effects:*** Carefully evaluate possible off-site impacts to upstream, downstream and opposite bank properties. Concrete rip-rap may redirect the current to an unprotected bank, shifting the bank erosion elsewhere.
- ***Concrete Quality:*** Concrete must be totally free of rebar, paint, oil, and any other pollutant.
- ***Concrete Rubble Size:*** The proper shape and size of the concrete rubble is critical if it is to withstand high energy flows and winter ice. The length to width ratio of any riprap material should always be 1:3 or less. The thickness should be 2 to 3 times the concrete fragment's average diameter. Large, thin concrete slabs should never be used.   Concrete fragments must be graded to various sizes so smaller pieces will fill the voids between the larger pieces.
- ***Filter Blanket:*** Lay gravel, sand, or crushed rock to a uniform minimum thickness of 8 inches to prevent scouring of fine soils between the sloped bank and the concrete riprap.
- ***Bank Slope:*** Avoid placing concrete riprap on slopes steeper than 2:1. The flatter the slope, the less risk of failure.
- ***Key Concrete Into Channel Bed:*** Excavate and 'key in' the base or 'toe' of the concrete riprap below the elevation of anticipated bed scour. Larger concrete pieces should be used for the key since this is the zone of highest erosive stress from water, ice, and the weight of the concrete riprap.
- ***Concrete Placement:*** Concrete riprap should be carefully placed on the sloped bank. Incorporate soil with the concrete rubble to facilitate the establishment of vegetation ("dirty riprap"). Concrete rubble should never be dumped off the bank or left on the top of the bank for the river to undermine it.
- ***Vegetation:*** Incorporate deep-rooted native vegetation into the concrete riprap. Use concrete fragments with soil incorporated between them to encourage vegetative growth. Aggressively control weeds for three years on all disturbed areas.

YRRP 2.1 Attachment #3: Flow Deflectors Guidelines

When several flow deflectors are arranged along an outside bend, the expectation is that they will deflect flow away from the bank thereby reducing current velocity and erosive energy next to the bank. The amount of material and the installation costs are usually less than rock or concrete riprap, however the design and installation of flow deflectors is complex and the risk of failure is high.

Channel Migration Zone (CMZ) maps provide information on historic channel migration rates and projected land loss over the next 100 years. CMZ maps are based upon historical aerial photos that show how the channel has migrated over the last 50 years. CMZ maps and historic aerial photos are available at the local Conservation District Office.

Economics: The value of the property or structure to be protected should be compared to the annualized cost of installing flow deflectors. An objective cost/benefit analysis usually concludes that only high value assets justify the high cost of bank protection. On a high-energy river like the Yellowstone, continued expenditures of money and time will be necessary to prevent the flow deflectors from failing. Maintenance expenses should be included in the calculation of project costs and benefits.

Risk is defined as the potential for flow deflectors to fail. Flow deflectors are considered to be a bank protection approach that typically has lower installation costs when compared to blanket riprap; however, they also have a very high risk of failure. Flow deflectors are designed for a given channel alignment; but on the Yellowstone River, changes in river alignment commonly render flow deflectors ineffective or prone to severe erosion. This often results in adding riprap between the deflectors. Because of their high risk and continual maintenance, flow deflectors are not recommended on the Yellowstone River.

Bendway Weirs are flow deflectors constructed as a series of strategically spaced, large rock structures that slope down from the eroding bank and project out into the channel. Because of the high energy flows associated with the Yellowstone River, special care needs to be given to the design and construction of bendway weirs. Bendway weirs will often impact downstream banks if adequate spacing and structure numbers do not exactly fit the site. Due to their complexity and high rate of failure, bendway weirs should generally be avoided. The following are general guidelines for bendway weir design, but it must be noted that there are no set criteria for the design and construction of bendway weirs. If bendway weirs are pursued, a qualified engineer should assist with the design and layout.

Bendway weir keyed into the bank and aligned upstream. Its purpose is to deflect the current away from the bank.

Bendway Weirs: Design and Installation

The following are general guidelines for design and installation of bendway weirs:

- **Weir Orientation:** Bendway weirs are normally built at a 30 to 40 degree angle perpendicular to the flow, facing upstream. Height of the weirs should be at or just below the annual high water elevation.
- **Weir Spacing:** Proper spacing of bendway weirs is critical. A rule of thumb is a spacing of 2L (two times the length of the weir) to 3L (three times the length of the weir). But, site conditions (i.e. surface velocity and the curvature of the bend) should determine if more or less spacing between weirs is necessary.
- **Weir Numbers:** The number of weirs depends upon the spacing of weirs, length of the eroding bank, channel geometry, and bedload. The first and last weirs should be placed upstream and downstream of the area to be protected.
- ***Materials and Placement:*** Use hard angular rock, properly sized and graded. Round rock or soft sandstone will not stand up to the Yellowstone River's high energy flows or winter ice. Do not use concrete or any other materials. Weirs should be keyed into the bank from one-half to one-fifth of the in-stream length of the weir. Each weir should be keyed into the channel bed below the anticipated scour level.

Jetties are a type of flow deflector that was once commonly used along the Yellowstone River. Jetties are rock structures, anchored to the eroding bank, that project out into the river channel, usually perpendicular to the bank. As more effective bank armoring techniques have been developed in recent years, jetties are seldom used anymore. Jetties are normally higher than the annual high-water mark, forcing the water around the structure rather than over it. They will deflect the current away from the bank, but they also create large eddies above and below the structure that often accelerate bank erosion rather than prevent it. Their only possible use may be on the lower river (Richland and McKenzie Counties) where river gradient and current velocity are low.

Recommendation: *It is recommended that jetties not be used on the Yellowstone River. This photo shows a large eddy on the downstream side of the jetty that has destabilized the river bank and may eventually flank the jetty.*

Implementation Approach

1. **Project Permits:** The YRCDC will encourage individual Conservation Districts (310 permits), Montana Fish Wildlife and Parks (124 permits) and the Army Corps of Engineers (404 permits) to hand out the YRRP 2.1 Channel Bank Stabilization guidelines and the appropriate attachment to all permit applicants and their consultants when a permit application is requested. YRRP 2.1 will be used as the standard. If a permit application proposes something different than what the guidelines describe, a waiver should be requested from the applicant or their representative clearly explaining the reason.
    - Economic Cost/Benefit Calculation: All permit applicants will be encouraged to complete a simple cost/benefit analysis that objectively compares the costs of bank protection to the value of the structure or property being threatened. Channel Migration Zone (CMZ) maps should be used to depict potential land loss. The cost/benefit analysis would estimate installation and maintenance costs, current land values/production, and the prevailing interest rate. The example in the YRRP attachments will lead them through the analysis.
    - Private Consulting Firms: YRCDC will develop an outreach program that targets private consulting firms who are involved with landowners and city/county/state departments on channel bank stabilization projects on the Yellowstone River and tributaries. The outreach program will review guidelines outlined in the Channel Bank Stabilization YRRP 2.1.
    - Failed Bank Stabilization Projects: Bank armor and flow deflectors that have washed out, ending up in the active river channel, should be removed. The YRCDC and local Conservation Districts will assist willing landowners in seeking technical and financial assistance to complete these removal projects. For new bank stabilization projects, a condition should be included in every permit that if a bank stabilization project fails, the permittee will be responsible for removing all materials from the river and transporting it off-site.
    - State and Federal Permit Coordination: YRCDC will periodically invite Montana Fish, Wildlife and Parks (124 permits), the Army Corps of Engineers (410 permits), and individual Conservation Districts (310 permits) to discuss bank stabilization permitting issues and update the Channel Bank Stabilization YRRP 2.1 as needed.

2. **Information and Training:**
    - River Management Training: YRCDC will collaborate with Montana DNRC on the development of a river management training module for Conservation District supervisors and staff that is specific to the Yellowstone River Basin. The module will be based upon information and recommendations included in the Yellowstone River Cumulative Effects Report (2016). YRCDC will request that DNRC incorporate the module in their on-going Conservation District Supervisor training programs in the Yellowstone River Basin.
    - 404 Mitigation Program: YRCDC will develop an information program in cooperation with the Billings and Helena Army Corps of Engineers offices that clearly outlines the 404 Mitigation Program provisions and options available to permittees to mitigate large bank stabilization projects. This program will be directed towards Conservation District supervisors and staff, county floodplain administrators, private consulting firms, and landowners.

3. **Channel Migration Zone (CMZ)**
    - **Public Outreach:** YRCDC and individual Conservation Districts will make CMZ maps readily available to landowners, river users, small tract residents, and city/county officials. YRCDC will encourage individual Conservation Districts to proactively send out applicable CMZ maps to every landowner that borders the active river channel. The value and use of CMZ maps for land-use decision making will be a recurring topic in local workshops.

- **CMZ Easements:** As an alternative to bank armoring, the YRCDC will work with NRCS, state and federal agencies, and non-profit organizations to develop and promote viable CMZ easement programs. The easement programs would offer landowners financial compensation to not armor the river.

4. **Irrigation:** Over 20,000 acres of irrigated lands are located in the CMZ making them especially vulnerable to the river's migration.
    - Flood Irrigation: The YRCDC will work closely with irrigation districts, private irrigation companies, and individual irrigators to identify large canals, field ditches, and flood irrigated fields that lie within the CMZ to determine if they are contributing to bank saturation and slumping. Those reaches where irrigation is associated with bank instability, treatment options (i.e. ditch lining, pipelines, ditch relocation, conversion to sprinklers, etc.) will be discussed. YRCDC will work with NRCS or other qualified firms to complete on-site investigations, draft engineering designs, and seek financial assistance.
    - Sprinkler Irrigation: The YRCDC will encourage irrigators to locate new sprinkler systems outside the 100-yr CMZ to avoid the necessity of future bank armoring. Relocation of existing sprinkler systems outside the CMZ will also be encouraged. YRCDC will recommend to NRCS and private irrigation engineering firms to consider the CMZ in field layouts and design specifications for new and updated sprinkler systems.

6. **Bank Stabilization Guidelines Update:** YRCDC will work with individual Conservation Districts to systematically follow-up with cooperative landowners on 10 to 20 year old bank stabilization projects. Information collected during these on-site visits will be the basis for refining the YRRP 2.1 guidelines. On-site visits will document the:
    a. original purpose for the bank stabilization project
    b. current condition and effectiveness of bank stabilization
    c. off-site impacts
    d. reasons the bank stabilization has failed or remained intact
    e. reach and channel type
    f. landowner perspectives

7. **MRL and BNSF Railroad:** Over one-third of the bank armor on the Yellowstone River is associated with the active railroad grades. Repairs to existing bank armor or the addition of new bank armor are often completed under emergency permit provisions that preclude review of the proposed bank treatment prior to installation.
    - MRL and BNSF: Representatives from MRL and BNSF will be periodically invited to a YRCDC meeting to discuss railroad-related permitting in the Yellowstone River Basin. Participants will include the YRCDC, ACOE, MFWP, MRL, BNSF, and individual Conservation Districts located along the Yellowstone River. The YRCDC will facilitate the meeting and follow-up on agreed-to items.
    - Proactive Bank Stabilization Approach: The YRCDC will strongly encourage MRL and BNSF to evaluate unprotected sections of railroad that pass through the 100-yr CMZ as possible candidates for proactive bank stabilization treatment. A proactive approach will significantly reduce the need for emergency permits, provide sufficient time to secure the necessary 310 and 404 permits, and lessen the possibility of a catastrophic rail car derailment into the river.

Railroad Grade Protection – Potential Project Areas

The table below lists the reaches where the MRL and BNSF railroad grades intersect the 100-yr CMZ. The unprotected lengths shown in the table are estimates. Site visits would be necessary to verify sections currently armored and those that would benefit from taking a proactive grade protection approach:

County	Reach	Railroad Grade in CMZ	Reach Notes
Park County	PC-15	0.1 mile	Bridge Crossing
	PC-16	0.1 mile	Bridge Crossing
	PC-18	0.1 mile	0.1 mile unprotected
	PC-20	3.4 miles	1.2 miles unprotected
	PC-21	0.9 mile	Fully protected
Sweet Grass County	A-1	1.8 miles	1.2 miles unprotected
	A-2	0.8 mile	0.8 mile unprotected
	A-4	0.2 mile	Fully protected
	A-6	0.1 mile	0.1 mile unprotected
	A-7	0.7 mile	0.6 mile unprotected
	A-8	0.7 mile	0.6 mile unprotected
Sweet Grass - Stillwater	A-9	2.2 miles	2.0 miles unprotected
Stillwater County	A-11	2.7 miles	2.1 miles unprotected;
	A-12	1.6 miles	1.2 miles unprotected
	A-13	1.0 mile	0.9 mile unprotected
	A-14	1.0 mile	0.3 mile unprotected
Yellowstone-Carbon	A-17	0.5 mile	Bridge Crossing
Yellowstone County	B-2	0.3 mile	Bridge Crossing
	B-3	1.1 miles	O.3 mile unprotected
	B-4	1.9 miles	Fully protected
	B-5	0.7 mile	Fully protected
	B-8	2.4 miles	2.0 miles unprotected
	B-9	1.4 miles	0.2 mile unprotected
	B-10	2.0 miles	1.8 miles unprotected
	B-11	2.2 miles	2.2 miles unprotected
	B-12	2.2 miles	0.5 mile unprotected
Treasure County	C-1	0.9 mile	0.7 mile unprotected
	C-2	4.7 mile	0.1 mile unprotected
	C-3	0.5 mile	0.2 mile unprotected
	C-7	2.0 miles	2.0 miles unprotected
Rosebud County	C-9	2.3 mile	2.2 miles unprotected
	C-10	2.2 miles	0.8 mile unprotected
	C-11	6.9 miles	3.8 miles unprotected
	C-12	5.2 miles	5.0 miles unprotected
	C-13	2.8 miles	1.9 miles unprotected
Rosebud-Custer	C-14	5.7 miles	4.4 miles unprotected
Custer County	C-15	2.1 miles	0.8 miles unprotected
	C-16	1.3 miles	0.6 mile unprotected
	C-17	0.5 mile	0.1 mile unprotected
	C-19	3.1 miles	2.9 miles unprotected
	C-20	1.0 mile	1.0 mile unprotected
Prairie County	C-21	1.0 mile	0.8 mile unprotected
	D-1	1.1 miles	1.1 miles unprotected

County	Reach	Railroad Grade in CMZ	Reach Notes
	D-2	0.4 mile	0.4 mile unprotected
Prairie-Dawson	D-3	1.2 miles	1.1 miles unprotected
Dawson County	D-4	2.3 miles	2.3 miles unprotected
	D-5	1.9 miles	1.2 miles unprotected;
	D-6	0.3 mile	Fully protected
	D-7	1.9 miles	1.9 miles unprotected
	D-8	2.2 miles	1.4 miles unprotected
Richland County	D-10	0.4 mile	0.4 miles unprotected
	D-11	1.7 miles	1.7 miles unprotected
	D-12	0.3 miles	0.3 miles unprotected

Failed Bank Armor and Flow Deflector Removal – Potential Project Areas

The following reaches have failed bank armor or flow deflectors that were detected on aerial photography. On-site evaluations would be necessary to determine if the failed bank armor or flow deflectors are creating bank instability and/or posing a safety hazard for recreationists. This list should be up-dated every 10 years when the physical features inventory is up-dated.

County	Reaches
Park County	PC-5, PC-14, PC-16
Sweet Grass County	A4, A7
Stillwater County	A11, A12, A17
Yellowstone County	A18, B1, B4, B5, B10
Treasure County	
Rosebud County	C10, C11, C13, C14
Custer County	
Prairie County	
Dawson County	D6, D8
Richland County	D10
McKenzie County	

Specific Restoration Project Recommendations

None identified.

Additional Information & Data Needs

1) Physical Features Inventory and Reach Narrative Up-Dates: Every 10 years, the physical features inventory will be up-dated to include new bank stabilization projects. Reach maps and narratives will be revised to reflect the inventory up-dates. The inventory will include an evaluation of select bank stabilization projects to document types of bank stabilization, purpose, functionality, and reasons for failure or success. This information would be used to refine the YRRP 2.1 bank stabilization guidelines. The next physical features inventory is scheduled for 2021.

2) Physical Features Inventory - Tributaries: Physical features inventories will be expanded into the major Yellowstone River tributaries using a methodology consistent with the Yellowstone River mainstem physical feature inventory.

3) Channel Migration Rates Update: Channel bank lines should be delineated on new aerial photography (2015 and later) to update channel migration rates. The CMZ map boundaries should be updated to reflect these new rates.

Every 10 years, the most current aerial photography will have channel bank lines delineated and CMZ maps revised. Each time the CMZ maps are revised, there will be a broad-based distribution of CMZ maps to landowners and county officials along the Yellowstone River.

YRRP 3.1 – Riparian and Wetland Management

Background

The loss and alteration of riparian and wetland habitats have a substantial cumulative effect on the Yellowstone River corridor. Riparian forests and wetlands are distinctly different from the upland landscape because of their unique soil and vegetative characteristics, strongly influenced by a high ground water table and periodic flooding.

Early records and historical documents indicate that the pre-settlement Yellowstone River corridor supported extensive stands of cottonwood and other native species. Much of this was cleared and converted to other land uses in the last 120 years. As of 2001, 21% of the 100-yr floodplain remains in riparian vegetation.

Noxious weeds and invasive woody plant infestations are spreading rapidly throughout the river corridor, crowding out native vegetation. Russian olive alone occupies approximately 3,000 acres of floodplain.

Brown-headed cowbirds, often associated with human and livestock-dominated landscapes, are nest parasites that lay their eggs in the nests of other bird species. As native riparian forests are converted to other land uses, there is a growing threat from brown-headed cowbirds on other native bird species that breed in the remaining cottonwood forests.

Brown-headed cowbirds are common in the Yellowstone River Valley.

Benefits and values associated with maintaining healthy riparian forests and wetland areas include:

1. ***Flood Energy Relief:*** Riparian ground cover slows the advance of floodwaters across the floodplain, dissipating energy and trapping nutrient-rich sediment.
2. ***Forage Production:*** Riparian forage production is up to five times greater than upland native rangeland. Through proper grazing management, livestock production can be a viable use of the river corridor without compromising other values associated with a sustainable riparian and wetland plant community.
3. ***Bank Stabilization:*** River bank stability is influenced by the extent and type of deep-rooted riparian vegetation that border the river.
4. ***Important Wildlife Habitat:*** Important habitats exist for a wide variety of plants, insects, fish, reptiles, amphibians, birds and mammals along the Yellowstone River corridor. The river corridor is the most productive part of the landscape, providing food, cover, and migration routes for a diversity of wildlife.
5. ***Recreation:*** The Yellowstone River corridor provides many forms of recreational opportunities that include wildlife viewing, birding, hunting, boating, and fishing.

A stand of young plains cottonwood trees growing along the river.

Recommended Management Guidelines

Floodplain Restoration: Since the late 1800s, an increasing amount of the Yellowstone River's historic riparian forests are no longer accessed by flood water. These traditionally flooded areas have become isolated for two reasons: constructed floodplain barriers (i.e. urban levees, dikes, elevated roads, irrigation ditches, railroad berms, etc.) and a reduction in high flows (tributary storage, reservoir storage and irrigation withdrawals). Refer to YRRP 1.1 and YRRP 1.2 for guidelines on removing or modifying floodplain barriers; and YRRP 6.1 for irrigation water management.

Agriculture: Seasonal grazing strategies, winter feeding and calving pasture management, and properly locating concentrated livestock holding facilities are important factors in maintaining a healthy and productive riparian area.

- **Livestock Grazing Strategies:** Livestock grazing strategies developed for the riparian corridor will maintain age and structural diversity of native plant communities that are necessary for the long-term sustainability of riparian forests and riverine wetlands. Grazing strategies should be site-specific that include landowner objectives, type(s) of livestock, river reach characteristics, and the maintenance of the native plant community. The attachment to this YRRP provides more detail on season of use, grazing intensity and duration, livestock distribution, and monitoring.
- **Feeding and Calving Pastures:** Riparian pastures where livestock are held for prolonged periods, such as winter feeding or calving areas, are a challenge to manage. These pastures concentrate livestock numbers in a relatively small area that will cause long-term damage to both soil and vegetation.
  - Winter feeding or calving areas should be located outside the 50-yr floodplain whenever possible. This may require additional water development, fencing and weather protection.
  - Livestock concentrated in the riparian/wetland area during the winter should be rotated among several wintering sites to minimize impacts. Livestock should not remain at any given winter feeding location for longer than 3 months. Each site should not be used for more than 2–5 consecutive years.
- **Livestock Holding Facilities:** New holding facilities (i.e., corrals and feedlots) should be built outside the river corridor (100-yr floodplain). Existing holding facilities should eventually be relocated outside the river corridor as well. Until then, manure should be regularly collected and transported off-site to minimize surface and ground water pollution.
- **Invasive Species and Noxious Weeds:** Refer to YRRP 3.2 Invasive Woody Plant Control and YRRP 3.3 Noxious Weed Control for details on management and control.

Small Tracts: Many small tract "ranchettes" include small pastures for horses, llamas, cows, sheep, etc. These pastures can experience heavy use causing soil compaction, overgrazing, weed infestations, and manure accumulation. It is difficult to properly manage riparian/wetlands vegetation in small pastures; but, by balancing stocking rates with pasture size, providing supplemental feed, and implementing rotation grazing, damage to the riparian vegetation can be minimized.

- Rule of thumb for stocking rates (6-7 months grazing period)
  - Subirrigated/irrigated pasture: 3-4 acres/horse; dryland pasture: 12-15 acres/horse
  - Rotation grazing can increase stocking rates by as much as 50% if done properly. Portable power fencing will suffice in most situations.
  - For small pastures along the river, fencing may be necessary to keep animals from trampling and overgrazing vegetation that is stabilizing the river bank.

YRRP 3.1 Attachment #1: Riparian and Wetland Grazing Management Guidelines

This YRRP attachment provides general livestock grazing guidelines on season of use, grazing intensity and duration, distribution of livestock, and vegetation cover monitoring. For site specific grazing options, the local Natural Resources Conservation Service office should be requested to assist in developing a site-specific grazing plan.

Season of Use: There is no universally applicable "best season" in which to graze riparian and wetland areas, however different seasons have certain characteristics that result in predictable outcomes. If landowner objectives are well defined and livestock grazing is closely monitored, livestock use can serve as a beneficial management tool.

Early Season (Spring) Use

- *Advantages:*
  - ➢ Livestock tend to distribute themselves better throughout the pasture, especially if there are upland areas associated with the river bottom pasture.
  - ➢ Reduced browsing on trees and shrubs.
  - ➢ Allows time for vegetation regrowth following spring grazing.

- *Challenges:*
  - ◊ Wet soil conditions can cause soil compaction and excessive river bank trampling.
  - ◊ Livestock may alter habitat for ground and shrub-nesting birds and disrupt wildlife birthing/nursing areas.

Hot Season (Mid-summer) Use

- *Advantages:*
  - ➢ River banks are generally drier and more resilient during the summer.

- *Challenges:*
  - ◊ The "hot season" is the period of greatest stress on the plant community. Summer is often the most detrimental time to graze livestock, especially continuous grazing on the same pasture, summer after summer.
  - ◊ If grazing extends into late summer, there may not be sufficient time for regrowth. Plants will not be able to replenish their reserves and become stressed going into the winter.
  - ◊ As grasses dry out and become less palatable, livestock will increasingly shift to browsing trees and shrubs, especially young seedlings and sprouts.
  - ◊ Livestock seeking shade, water, and forage tend to loiter in the riparian areas.

Late Season (Fall) Use

- *Advantages:*
  - ➢ River banks are generally drier and more resilient during the fall months.
  - ➢ Most plants have completed their growth cycle so grazing will have less impact on plant health.
  - ➢ There are no conflicts with breeding birds and wildlife birthing/nursing.
  - ➢ Cattle will distribute better during cooler weather.

- *Challenges:*
  - ◊ There is a strong tendency for livestock to browse trees and shrubs during the fall months.

Winter Use

- *Advantages:*
  - Winter is usually the least detrimental time of year for grazing riparian and wetlands.
  - Soil compaction and bank trampling are limited because of frozen ground.
  - Plants are dormant and are able to withstand a higher level of use.
  - Livestock distribution is often easier through location of watering facilities and feeding stations.

- *Challenges:*
  - ◊ Overgrazing winter-dormant plants lessens their ability to provide bank protection and sediment trapping during spring run-off. Over time, these plants will become weaker and may eventually die.
  - ◊ Small trees and shrubs are brittle during winter months making them more vulnerable to physical damage from trampling and rubbing.

Livestock Grazing Management: An effective grazing management plan will incorporate the following principles:

- *Forage Use:* Forage production varies substantially from one riparian pasture to another, and in some cases, within the same pasture. Moderate livestock grazing should not remove any more than 40 to 50% of the current year's growth. This level of use translates into leaving a stubble height of 3-4 inches for most grasses and sedges.
- *Pasture Rotation:* The amount of rest that a riparian pasture receives between grazing periods is critical. The longer the recovery period, the better. A well designed pasture rotation will minimize grazing impacts by providing sufficient time for plant recovery. Most pasture rotations require some degree of fencing. Portable power fencing is a good option for its low cost and ability to be easily moved.
- *Livestock Distribution:* Alternative sources of drinking water will help keep livestock from congregating on the river bank. Supplemental salt, minerals, or feed can also be strategically placed to lure livestock away from the river.
- *Fencing:* Fencing out livestock from the river bank is usually not needed if proper grazing techniques are applied. There are a few exceptions. If a river bank or riparian area is receiving heavy use by livestock, temporary exclusion may be necessary to allow recovery. In small tract pastures where riparian management is difficult, permanent exclusion of livestock from the river may be the only option. Wildlife-friendly fencing is recommended.
- *Monitoring:* A simple monitoring program will document forage use, shrub browse, and grass stubble height. These are the indicators that will help determine grazing timing, duration and livestock numbers.

Cattle grazing in the riparian corridor along the Yellowstone River.

Implementation Approach

1. **Outreach and Education:**
   - *Small Acreage Landowners:* The YRCDC will work with Montana MSU Extension on developing and offering ½ day small-acreage landowner workshops and longer multi-week small-acreage management courses. The program could be patterned off the Master Gardeners Program where landowners can become "certified". The YRCDC will also coordinate the distribution of MSU Extension Service's *Big Sky Small Acres* publication (published three times per year) to realtors and small landowners.
   - *Small Acreage Landowners:* Develop and implement an outreach and assistance program to help small tract landowners better understand how to minimize their impacts on the river. This program would offer on-site visits by a qualified person to discuss noxious weed management, water rights, septic maintenance, suitable building locations, riparian vegetation, and basic river dynamics. Small tract landowners in Park, Sweet Grass, Stillwater, and Yellowstone Counties (Regions PC, A, and B) would be the primary audience.
   - *Traditional Agriculture:* YRCDC will collaborate with individual Conservation Districts, NRCS, and MSU Extension to include riparian and wetland management presentations in local and regional land management workshops (ex: grazing seminars, pesticide applicator training, floodplain awareness, etc.). The 26 minute video *Path to Eden* may provide good information to newcomers to Montana who are considering the purchase of large ranches in the upper Yellowstone River Basin.
   - *Financial and Technical Assistance:* Information on riparian and wetland management incentive programs will be distributed to landowners through the local Conservation District, NRCS, and Extension Service offices.

Specific Restoration Project Recommendations

None identified.

Additional Information & Data Needs

1) Riparian and Wetland Site Evaluations: Continue the systematic riparian/wetland characterization of the Yellowstone River riparian and wetland resources that was initiated in 2007. This characterization documents native plant communities, invasive species infestations, and current riparian and wetland management approaches. These characterizations are important to understanding how the riparian and wetland plant communities respond to various management approaches. This information would be incorporated into future versions of the Riparian and Wetland Management YRRP.

YRRP 3.2 – Invasive Woody Plant Control

Background

Invasive woody plants pose a long-term threat to the economic and ecological values associated with the Yellowstone River riparian and wetland plant communities. They are rapidly expanding along the Yellowstone River and its tributaries. It has only been in the last 15 years that state/federal agencies, landowners and county weed districts have recognized the scale of the problem and have initiated aggressive campaigns to curb their expansion. Russian olive and saltcedar are the two most common invasive woody shrubs present along the Yellowstone River.

Major economic and ecological impacts from invasive woody plants include:

1. **Native Plant Competition:** Invasive woody plants have the ability to dominate and eventually crowd out native riparian and wetland plant communities.
2. **Reduced Forage Production:** Over time, Russian olive will expand into monotypic thickets that exclude most other species in the riparian corridor. It will often spread to adjacent pastures reducing the amount and quality of forage available to livestock and wildlife.
3. **Wildlife Habitat Impacts:** The displacement of native plant communities results in changes to the composition, density, and structure of available habitat directly affecting the distribution, abundance, and diversity of wildlife species (insect, mammal, amphibian and bird).
4. **Influence on the River Channel:** Dense infestations of Russian olive and saltcedar growing on stream banks, gravel bars and islands may lead to gravel/silt build-up that can narrow the river channel, increase flood elevations, plug side channels, alter aquatic habitat, and accelerate bank erosion.
5. **Soil Salinization:** Saltcedar contains salt that is deposited on the soil from the plant's leaves. Some native plants are unable to tolerate the salty soil conditions leaving only dense stands of saltcedar.

As of 2008, Russian olive occupied about 3,000 acres of the Yellowstone River's 100-yr floodplain. Infestations generally increase in a downstream direction from Park County to Custer County. From Custer County to the Missouri River confluence, Russian olive infestations taper off. Saltcedar is more common on the lower Yellowstone River, but can be found in all Yellowstone River counties and is rapidly expanding its range.

Russian Olive: *Russian olive trees encroaching on the Yellowstone River floodplain. It is classified as a "Priority Regulated Plant" in Montana which means that it is an introduced species with the potential to have significant negative ecological and economic impacts.*

Saltcedar: *Saltcedar shrub in bloom. It is currently classified as a "Priority Noxious Weed" in Montana. Over the last 15 years, it has become a targeted invasive species by most county weed districts along the Yellowstone River.*

Common Buckthorn: *Common buckthorn trees have been recently discovered growing in the Yellowstone River corridor. It is an introduced shrub that is toxic to humans and animals. Learn to identify this plant and immediately remove plants that are found.*

Recommended Management Guidelines

The following information has been summarized from the publication: *Long-Term Strategy for Russian Olive and Saltcedar Management (May 2013)* and is available at local Conservation District Offices.

- ***Uninfested Sites - Prevention:*** There are tracts along the Yellowstone River where Russian olive and saltcedar are not present. The cheapest and most effective means to combat invasive woody plants is through proper land management that promotes good perennial native grass/shrub/tree cover and minimizes ground disturbance. Additionally, the adoption of an aggressive, early detection and rapid response approach – "search and destroy" – of new woody invasive plant infestations is critical.
- ***Light Infestations:*** On tracts where invasive woody plants are scattered, total removal of all invasive plants is a realistic goal. New invasive plants like common buckthorn should be especially targeted. Once a tract is clear of all invasive plants, enter into a prevention mode to keep the site uninfested. This will require a frequent walk-through to detect new sprouts from previously treated areas or young plants generated from seed.
- ***Moderate Infestations:*** Moderate infestations include small patches of invasive plants and/or multiple individual plants growing throughout the tract. These areas require an immediate approach of containing the infestations by targeting the older trees that produce viable seed. The long-term treatment is to eventually eradicate all invasive plants. Once removed, annual detection and control is necessary indefinitely to eliminate new plants that sprout from the existing seed bank or from seed brought it by other means.
- ***Dense Infestations:*** Dense stands of invasive plants can be large and totally crowd out all native plants. The short-term goal is containment, keeping the infestations from spreading. Over the long-term, targeting older seed-bearing trees and working the fringes of large patches will gradually shrink the infestation.

Treatment Alternatives

For the alternatives below that include herbicides, contact the local weed district for recommendations on the herbicide and rates that would be most effective for your property.

- **Cut Stump Herbicide Application:** Older, larger diameter trees can be treated using a low volume application of herbicide to a freshly-cut stump just above ground level. For best results, the stump should be sprayed within 10 minutes of being cut. Retreatment of sprouts over the next couple years is usually necessary.
- **Foliar Herbicide Application:** Apply to stems and leaves of invasive plants less than 6 feet high. This method may affect non-targeted native plants and is generally not recommended except for sprouts from previously treated plants or new seedlings. Aerial herbicide applications in the riparian areas are not recommended.
- **Basal Herbicide Application:** Apply basal herbicide to small plants (stems less than 2-3 inches diameter, less than 8 feet high) using a backpack or ATV mounted sprayer when plants are not dormant.
- **Manual Removal:** Young plants (up to one year old and less than 2 feet high) can be hand pulled or grubbed out if infestations are light.
- **Mechanical Treatment:** Mechanical removal by heavy equipment is not recommended in riparian areas. The level of disturbance can open an area for infestations of other noxious weeds and may severely impact native plants. This type of treatment may be applicable in pastures and along irrigation canals.

Implementation Approach

1. **Woody Invasive Plants Control Project:** YRCDC will cooperate with county weed districts, NRCS, and MSU Extension to coordinate and implement an aggressive, long-term basin-wide woody invasive plants control effort that targets Russian olive and saltcedar. Funding for this project may be possible under the Montana Department of Agriculture's Local Cooperative Program and NRCS cost-share programs. Other public and private funding sources will be explored. Invasive woody plant control and prioritization is based upon the following infestation levels and river locations:

   - *High Priority*
     - Prevention is always the most effective and cost-effective strategy. Uninfested sites should be regularly monitored. Any new invasive plants discovered should be immediately removed.
     - Early Detection. YRCDC will communicate regularly with county weed districts and the Montana Department of Agriculture to determine if there are new invasive plants entering the Yellowstone River Basin that need to be targeted. YRCDC will assist with an information campaign that alerts landowners and recreationists about the new threat. Common buckthorn, mentioned below, is an example of such a threat.
     - Regions PC and A. These are the uppermost regions of the Yellowstone River (Gardiner to Park City). These regions have small, scattered infestations of invasive plants that lend themselves to a "search and destroy" approach.
     - Areas of Special Concern. This YRRP identifies reaches where plant and animal species of concern, historical sites, and public access areas are located. Specific treatment plans will be developed with the responsible land manager to eradicate woody invasive plants while protecting the special values and features found in these areas.
     - Common Buckthorn should be immediately removed whenever detected along the entire length of the river. YRCDC will work with the county weed districts on developing an information campaign that informs landowners about this new invasive plant.
   - *Medium Priority*
     - Moderate Infestations. Riparian and floodplain areas with moderate infestations (< 5%) should be approached with the short-term goal to curb the spread of invasive woody plants. The long-term goal is to eradicate all woody invasive plants from these areas.
     - Confined Channel Types. Target reaches that have confined channel types and relatively small acreages of floodplain and riparian/riverine wetlands. The goal is to eradicate Russian olive and saltcedar stands regardless of infestation levels.
   - Low Priority
     - Dense Infestations. Densely infested areas are defined as occupying more than 5% of the 100-yr floodplain. Large patches of invasive woody plants should be initially treated to create a mosaic of smaller patches and open ground. The immediate goal is to keep infestations at 5% or less. The long-term goal is to continually work the infestation fringes and target the more mature seed-bearing trees to contain the threat.

2. **Public Outreach:**
    - **Demonstration Projects:** YRCDC will support and seek funding for individual Conservation Districts to continue demonstration projects that showcase innovative control technologies and land management strategies. Tours and workshops will be organized to highlight treatment approaches and to illustrate the interrelationship that exists between invasive woody plant infestation levels and land disturbance (i.e. winter feeding areas, riparian forest clearing, heavy grazing, etc.).
    - **Pesticide Applicator Training:** YRCDC will encourage the Montana Department of Agriculture and the MSU Extension Service to include woody invasive plant control in their recertification pesticide training sessions for farmers, dealers, commercial, and government applicators throughout the Yellowstone River Basin.

3. **Public Lands – State and Federal:** YRCDC will encourage Montana Fish, Wildlife and Parks (Fishing Access Sites – 2,500 acres), the Montana Department of Natural Resources and Conservation (School Trust Lands), the Agricultural Experiment Stations, the Bureau of Land Management, and the Bureau of Reclamation to aggressively remove all invasive woody plants from lands they manage in the Yellowstone River corridor and tributaries.

4. **Treatment Monitoring:** YRCDC may collaborate with local weed districts, NRCS, Conservation Districts, and landowners to develop a simple monitoring program that will consistently evaluate treated sites to determine the effectiveness of various management techniques and document the recovery rate of the native plant community. Monitoring may include repeatable photo points, plots, and/or transects. More detail on monitoring is outlined in the YRCDC's *Long Term Strategy for Russian Olive and Saltcedar Management (May 2013).*

5. **Montana Saltcedar Team Representation:** YRCDC will contact the Montana Saltcedar Team to determine if their program to combat saltcedar is applicable to the Yellowstone River Basin. If so, YRCDC will assign a representative to be a member of the Team.

Reach Priorities – Russian Olive Control

Region C (Bighorn River to the Powder River) has the largest Russian olive infestation partly due to the wide floodplain. Region B (Clark's Fork River to the Bighorn River) has fewer acres, but a higher density of Russian olive within the 100-yr floodplain. Russian olive populations drop off dramatically above Reach A-16. Project prioritization criteria are outlined on Page 39.

Specific Restoration Project Recommendations

None identified.

Additional Information & Data Needs

1) Academic Research: The YRCDC will partner with Montana's academic institutions and the USDA - Agricultural Research Service (Fort Keogh and Sidney) to target financial and technical resources on developing more effective control and riparian restoration technologies that address woody invasive plant infestations throughout the Yellowstone River Basin. Emphasis for research and field trials will be on cost-effective treatments that minimize environmental impacts to the riparian and wetland plant communities.

2) Russian Olive Inventory and Analysis: Using 2019 aerial imagery when it becomes available, replicate the Russian olive digital mapping and analysis that used 2008 NAIP imagery. Design the analysis to show the 10 year trend and to determine if there are correlations between Russian olive infestation densities and soil types, elevation, and land uses. Reaches C14 and C15, in particular, should be investigated to determine why there are significantly lower populations of Russian olive than adjacent reaches.

3) Saltcedar Inventory: An inventory technique should be developed and coordinated among all Yellowstone River counties to provide a consistent river-wide inventory of saltcedar. The results of this inventory could be used to prioritize reaches for saltcedar control.

YRRP 3.3 – Noxious Weed Control

Background

Noxious weeds found along the Yellowstone River corridor impose a significant economic and ecological impact on the riparian and wetland plant communities. Infestations continue to spread, not just along the Yellowstone River, but up most tributaries. County weed districts and many landowners have carried out aggressive noxious weed control efforts in the past with limited success.

Primary impacts from noxious weeds include:

1. ***Native Plant Displacement:*** Noxious weeds directly affect riparian and wetland health and sustainability by their ability to dominate and replace native riparian plant communities over time.
2. ***Reduced Forage Production:*** Unpalatable noxious weeds drastically reduce forage production (up to 75%) and quality.
3. ***Wildlife Habitat Impacts:*** The displacement of native plant communities changes the composition, density, and structure of available habitat which directly affects the distribution, abundance, and diversity of wildlife species (insect, mammal, amphibian and bird).

Noxious Weeds – Yellowstone River Corridor: There are several noxious weeds along the Yellowstone River. The following is a list of the major noxious weeds that have widespread distribution. Contact the local weed district to find out about other noxious weeds in your area.

Leafy Spurge: *Perennial, up to 3 feet tall, reproduces by a vigorous root system and seed. The seed can be thrown 20 feet by an exploding seed capsule. Roots can penetrate up to 30 feet into the soil. The deep and extensive root system makes the plant resistant to grazing, cultivation, and most herbicides.*

Spotted Knapweed: *Biennial or short-lived perennial, 1 to 3 feet tall, with a large tap root. Their early spring growth makes them competitive for soil moisture and nutrients. Spotted knapweed is a prolific seed producer that yields up to 1,000 seeds per plant with a viability of more than 8 years. There is evidence that the plant releases a chemical inhibiting surrounding vegetative growth.*

Russian Knapweed: *Long-lived perennial, up to 3 feet tall, that forms dense colonies. Instead of producing large numbers of seeds like other knapweeds, Russian knapweed puts its energy into developing a deep, spreading root system that can penetrate over 8 feet into the soil. It does not do well in the shade and is more vigorous in open, dry areas of the riparian corridor. The plant is slow to establish, but more difficult to eradicate than other knapweeds. If horses eat enough Russian knapweed, they can acquire a disorder called "chewing disease" that is often lethal.*

__Dalmatian Toadflax:__ Perennial, up to 3 feet tall, that reproduces by seed and underground root stalks. One plant can produce 500,000 seeds. It is an aggressive invader that is capable of spreading rapidly and pushing out native grasses. Dalmatian toadflax contains a poison that is reportedly toxic to livestock. It is not found along the entire length of the Yellowstone, but is a major problem in the Mammoth to Gardiner area.

__Canada Thistle:__ Perennial, 1 to 4 feet tall, that has deep and extensive horizontal roots. It spreads rapidly from both a creeping rootstock and seed forming dense patches. Even though it can be controlled relatively easily by herbicide, it is difficult to control because the plant is so widespread and can grow in dense, hard-to-access riparian areas.

__Houndstongue:__ Biennial, 1 to 4 feet tall, with burr-like seeds that spread rapidly by attaching to wildlife, livestock, people, and domestic pets. The leaves are rough and resemble a hound's tongue. It is found along the entire length of the Yellowstone River and can be toxic to both cattle and horses. Similar to Canada thistle, it is relatively easy to control with herbicides, but is difficult to fully eradicate because it is so widespread.

Recommended Management Guidelines

- The following is a general outline on approaches for combating noxious weeds. Each landowner should develop a detailed weed management plan that is unique to their tract. The local weed district staff is available to assist in developing this plan.
- **Early Detection and Plant Identification:** Learn to identify noxious weeds common to the area and the growth characteristics of each weed (roots, flower color, seed type, leaf shape, etc.). Through the growing season, repeatedly inspect your land for the presence of noxious weeds. When new infestations are discovered, mark the spot on the ground and/or map. Document the site with GPS coordinates.
- **Chemical Control:** Use herbicides that can be safely applied in riparian areas and near surface water. Spot spraying noxious weeds using a backpack or ATV mounted sprayer will minimize damage to native riparian plants. Aerial applications of herbicide should not be used in riparian areas. Consult with the local weed district on recommended chemical herbicides and application rates.
- **Mechanical Control:** Hand pulling or clipping can be effective if weed densities are low, the plants are relatively young, and they reproduce by seed rather than roots. Light infestations of houndstongue and spotted knapweed can be controlled through mechanical means since they are short-lived and reproduce only by seed. However, perennial noxious weeds such as Russian knapweed or leafy spurge, with their extensive root systems, require a different approach.
- **Biological Control:** This method of control primarily uses insects to kill or stress specific noxious weeds. Biological control is effective, but rarely successful as a stand-alone treatment. Contact your local weed district to see if biological control agents are available for noxious weeds growing in your area.
- **Integrated Pest Management (IPM):** Noxious weeds are most effectively controlled using an IPM approach. This is a coordinated approach using a combination of treatments (i.e. chemical, biological, and/or mechanical) that are most applicable to the targeted weeds.

Implementation Approach

1. **Project Permits:** The YRCDC will encourage individual Conservation Districts (310 permits), Montana Fish Wildlife and Parks (124 permits) and the Army Corps of Engineers (404 permits) to offer the YRRP 3.3 Noxious Weed Control guidelines to all permit applicants. A stipulation will be included in all approved permits requiring disturbed areas to be seeded to perennial grasses and monitored for noxious weeds until fully vegetated.

2. **Public Outreach:**
   - **Demonstration Projects:** YRCDC will support local weed districts in organizing and seeking grant monies for demonstration projects that will showcase innovative control technologies and management strategies. Tours and workshops will be scheduled to highlight treatment approaches and successes.

   - **Community Weed Management Projects:** YRCDC will assist local weed districts and Conservation Districts in identifying landowners in the river corridor who have an interest in pursuing cooperative weed management projects emphasizing an Integrated Pest Management (IPM) approach. One possible source of financial assistance is the Montana Noxious Weed Trust Fund.

3. **Yellowstone River Basin Weed Control Association:** YRCDC will encourage the formation of the Yellowstone River Basin Weed Control Association to facilitate coordination among Yellowstone River Basin weed districts. The group would typically meet annually in the off-season and cooperate on regional weed events throughout the year.

Specific Restoration Project Recommendations

None identified.

Additional Information & Data Needs

1) Biological Control Research: The YRCDC will actively support Montana's academic institutions and the USDA - Agricultural Research Service (Fort Keogh and Sidney) on developing effective biological controls to curb noxious weed infestations found in the Yellowstone River Basin.

2) Noxious Weed Surveys: A consistent corridor-wide survey of noxious weed infestations should be undertaken to determine the time and financial resources necessary for large scale weed management/control. A similar survey in 10 – 20 years will provide a measure of accomplishment over time. Baseline surveys also provide information in which to prioritize scarce financial and technical resources. Most counties have some level of noxious weed mapping which provides an excellent starting point for a coordinated survey.

YRRP 4.1 – Water Quality – Nutrient Reduction
Agricultural Land Use

Background

Although concentrations of phosphorus and nitrogen in the Yellowstone River are relatively low compared to other major rivers in the United States, some nutrient enrichment does occur along the Yellowstone River and tributaries; primarily the Clarks Fork, Bighorn and Powder Rivers. The main indicator of nutrient enrichment is the excessive growth of algae.

Agriculture is the primary land use within the Yellowstone River Basin. It is estimated that farm fertilizer contributes up to 40% of the nitrogen and 10% of the phosphorus load in the basin. Livestock holding facilities, feedlots, and calving areas (manure pack) contribute only 3% of the nitrogen, but are responsible for 22% of the phosphorus pollution.

Excessive nutrients and algal growth affect the following uses:

1. ***Drinking Water:*** Algal growth can produce undesirable odors and taste in drinking water. Excessive algal growth and nutrient concentrations also increase the cost of municipal water treatment.
2. ***Irrigated Agriculture:*** Floating algae plugs irrigation pump intake screens, filters, sprinkler heads, and ditches resulting in higher labor costs and reduced water use efficiency.
3. ***Fisheries:*** High concentrations of algae deplete the water of dissolved oxygen that in turn stresses fish and other aquatic animals. Thick mats of algae will degrade habitat and displace aquatic animals.
4. **Recreation:** Excessive algal blooms are unsightly, have a disagreeable odor, and often limit recreational activities such as swimming, boating, and fishing.

Excessive algal growth covers the river bottom in early summer. Later in the summer, algae will break loose, plugging pump inlets and impacting recreational activities and tourism.

Recommended Management Guidelines

Soil Health Management: Soil health management is an integrated system of cropland management practices that focuses on soil health as a way of optimizing nutrient, pesticide, and irrigation water applications, minimizing their loss through surface runoff and deep percolation. Production costs are typically less; crop yields and quality generally increase in time. The following guidelines should be considered when designing a soil health management system. To assist with setting up a field-specific system, a qualified agriculturist (i.e. experienced farmer, NRCS conservationist, or professional agronomist) should be consulted.

- **Undisturbed Root Systems - Reduced Tillage:** Minimize soil disturbance. Tillage that results in bare or compacted soil is contrary to good soil health. Undisturbed root systems are key contributors to better water holding capacity, increased organic matter, and improved soil structure.

- **Ground Cover:** Keep the soil covered at all times with growing plants or crop residue. Ground cover conserves moisture, reduces soil erosion, suppresses weed growth, and provides habitat for important soil organisms. To maintain adequate amounts of crop residue, the soil should be disturbed as little as possible.
- **Crop Rotation:** A planned sequence of crops provides plant diversity that will help break insect, disease and weed cycles. A guiding principle is that diversity above ground (plants) equals diversity below ground (soil organisms) which is essential for improving soil health. Depending upon landowner objectives, the rotation may involve rotating high residue crops such as corn or wheat with low residue crops such as sugar beets. Using short-term perennial forage plants can be very effective in crop rotations.
- **Cover Crops:** Following the harvest of annual crops, plant a cover crop "cocktail" mix to provide additional ground cover, organic matter, soil nutrients, and livestock forage through the remainder of the growing season.
- **Irrigation Water Management:** For irrigated fields, an efficient sprinkler system is an important component of a soil health management system. Managing water and nutrients with a flood irrigation system is challenging. When setting up a soil health management system, converting an existing flood irrigation system to sprinklers should be considered.

Managing cropland for healthy soil provides long-term economic and ecological benefits.

Feeding and Calving Pastures: Riparian pastures where livestock are held for prolonged periods (i.e. winter feeding or calving areas) can be a significant source of nutrients to the river from surface run-off and shallow groundwater returns.

- Winter feeding or calving areas should be located outside the 50-yr floodplain whenever possible. This may require additional water development, permanent or portable fencing and fabricated wind protection.
- Livestock concentrated in the riparian/wetland area during the winter should be rotated between multiple wintering sites to minimize manure buildup, soil compaction, and damage to riparian vegetation. Livestock should not remain at any given winter feeding location for longer than 3 months. Each site should not be used for more than 2–5 consecutive years.

Livestock Holding Facilities: New holding facilities (i.e., corrals and feedlots) should be built outside the river corridor (100-yr floodplain). Existing livestock facilities should eventually be replaced and relocated outside the river corridor. Until these facilities are moved, manure should be collected on a regular basis and transported off-site to minimize surface and ground water pollution.

YRRP 4.2 – Water Quality – Nutrient Reduction
Residential Development – Small Tracts

Background

Although concentrations of phosphorus and nitrogen in the Yellowstone River are relatively low compared to other major rivers in the United States, nutrient enrichment has been identified across much of the Yellowstone River and tributaries; primarily on the Clarks Fork, Bighorn and Powder Rivers. The main indicator of nutrient enrichment is the excessive growth of algae. The primary sources of nutrients include atmospheric deposition, residential development, urban areas, and irrigated agriculture.

Excessive nutrients and algal growth will impact the following uses:

1. ***Drinking Water:*** Algal growth can produce undesirable odors and taste in drinking water. Excessive algal growth and nutrient concentrations also increase the cost of municipal water treatment.
2. ***Irrigated Agriculture:*** Floating algae plugs irrigation pump intake screens, filters, sprinkler heads, and ditches resulting in higher labor costs and reduced water use efficiency.
3. ***Fisheries:*** High concentrations of algae will deplete the water of dissolved oxygen that stresses fish and other aquatic animals. Thick mats of algae will degrade habitat and displace aquatic animals.
4. **Recreation:** Excessive algal blooms are unsightly, have a disagreeable odor, and often limit recreational activities such as swimming, boating, and fishing.

Houses built close to the river often contribute high levels of nutrients to the river from lawn fertilizer, septic systems and storm water run-off.

Recommended Management Guidelines

The upper Yellowstone River and tributaries have a growing number of small tracts being developed along the waterways. These developments often generate bank stabilization (rock rip-rap, jetties, retaining walls, dikes, etc), storm water run-off, septic systems, riparian clearing, and noxious weed infestations. Individual residential tracts usually have a negligible impact on surface and groundwater quality, but cumulatively they pose a growing threat to the long-term water quality of the Yellowstone River and its tributaries.

Septic System Management: Poorly designed or neglected septic disposal systems can be a major source of nutrients to the Yellowstone River and its tributaries. The following guidelines provide general information on preventing new septic systems from failing and for correcting existing systems that are malfunctioning. A number of factors cause on-site disposal systems to fail, including unsuitable soil conditions, improper design and installation, and poor maintenance practices.

New Septic System Installation:

- Permits: All new septic systems require an approved county permit before construction can begin. The design and installation must follow the standards outlined in Montana Department of Environmental Quality Circular-4. Septic tank size and drain field configuration are determined by the number of bedrooms in the house, soil type, ground water table, and the estimated daily volume of wastewater entering the system. If designed and installed correctly, most septic systems will have a lifetime of 20 to 30 years.

- New Structures: All new structures that require a septic disposal system should be located outside the 100-yr floodplain. In the event that a new septic system is approved within the 100-yr floodplain, special design considerations need to be made to assure flood waters never inundate the drain field. It must also be a suitable distance above the ground water table and be located at least 100 feet from any domestic wells. Nearby domestic wells that draw from a shallow ground water aquifer should be tested for bacteria at least once per year, usually in the spring.

Existing Septic System Maintenance:

- Septic Tank Pumping: Tanks need to be evaluated every two to five years, and pumped if necessary. Keep a record of pumping. A rule of thumb for pumping frequency is:
  - 1,000 gallon tank size – 2 people: every 6 years.
  - 1,000 gallon tank size – 4 people: every 2 to 3 years
  - 1,500 gallon tank size – 4 people: every 4 years

Regular inspections and the periodic pumping septic tanks by a qualified company are necessary in keeping septic systems functional and preventing contamination of shallow ground water.

- Drain Field: The area over the drain filed should have grass cover that is not fertilized and is mowed regularly. Grass clippings should be removed. Deep-rooted shrubs or trees will clog drain lines and should not be planted on or near a drain field. Do not over-water the area and be sure there is adequate surface drainage.
- Wastewater: What goes down the drain has the most influence on a septic system's ability to function efficiently and how long before repairs or replacement become necessary. Avoid the use of a kitchen garbage disposal, do not pour grease or cooking oil down the drain, eliminate caustic drain cleaner for clogged drains, dispose of excess pharmaceuticals in the garbage, and reduce the volume of household water that enters the system.
- Additives: It is not necessary to use additives to enhance the performance of a properly operating septic system. If microbial activity is low, it is usually because household disinfectants or bleach-based cleaners are being flushed into the system. Chemical additives are especially harmful to septic systems.

Implementation Approach

YRRP 4.1 Agricultural Land Use - Education and Outreach

1. **Information Campaign:** The YRCDC will assist individual Conservation Districts, NRCS, and Montana State University Extension with local soil health management workshops and demonstration tours that target farmers in the Yellowstone River valley and major tributaries. Farmers who are successfully implementing a soil health management system, especially those using irrigation, will be recruited as speakers for workshops and tours.

2. **Montana Soil Health Strategy:** YRCDC will actively partner with NRCS in promoting and implementing the Montana Soil Health Strategy that:
    - Develops information/education outreach campaigns targeting local landowners and agribusinesses operating in the Yellowstone River Basin.
    - Identifies research needs related to soil health management systems.
    - Forges a strong partnership between Conservation Districts and NRCS to promote soil health management.

    YRCDC will periodically meet with the Montana Congressional Delegation to request their support for NRCS programs that provide financial incentives to farmers that encourage adoption of soil health management systems.

3. **Nutrient Trading:** YRCDC will encourage and possibly broker the use of nutrient trading in the Yellowstone River Basin where it can effectively address nutrient pollution. Funding credits from non-agricultural point sources may be available for agriculturally-related non-point source projects. Such projects may include relocating animal feeding operations, improving irrigation water efficiencies, and purchasing CMZ easements.

YRRP 4.2 Urban & Small Tract Residential Land Use - Education and Outreach

1. **Small Tract Landowners:** The YRCDC will collaborate with Montana DNRC and MSU Extension on developing and offering half-day small-tract landowner workshops and longer multi-week small-tract landowner management courses. The program could be set up similar to the Master Gardeners Program where landowners would become “certified”. Septic system maintenance, storm water management, and lawn care would be emphasized in the training sessions. They will also arrange for distribution of MSU Extension Service’s *Big Sky Small Acres* publication, published three times per year, to realtors and small landowners.
2. **Small Tract Assistance Program:** Develop and implement an outreach and assistance program to help small tract landowners better understand how to minimize their impacts on the river. This program, sponsored by the YRCDC and local Conservation Districts, would offer on-site visits by a qualified person to discuss noxious weed control, water rights, septic system maintenance, storm water run-off/drainage, suitable building locations, riparian vegetation management, and basic river dynamics. It would focus on small tract landowners in Park, Sweet Grass, Stillwater, and Yellowstone Counties.
3. **Septic System Reminders:** YRCDC will work with the county sanitarians to develop a notification process that reminds septic system owners of the need to schedule septic system inspections and pumping.

Priority Subwatersheds – Potential Project Areas

Nutrient Pollution – Priorities: Total Nitrogen and total phosphorus levels have been estimated using a nutrient model that compiled and analyzed county-level water quality data. The model prioritizes subwatersheds in the Yellowstone River Basin for development and implementation of nutrient reduction strategies.

Subwatershed	Relative Priority Nitrogen Yields	Relative Priority Phosphorus Yields
Shoshone	High	High - Moderate
Upper Yellowstone – Pompey	High	High
Upper Yellowstone – Lake Basin	High	High
Shields River	High	High - Moderate
Clarks Fork Yellowstone	High	High - Moderate
Lower Yellowstone	High	Moderate
Pryor	High	High - Moderate
Upper Yellowstone	High - Moderate	High
Lower Bighorn	High - Moderate	High
Stillwater	High - Moderate	High
Lower Yellowstone - Sunday	High - Moderate	High - Moderate
Little Bighorn	Moderate	High
Yellowstone Headwaters	Moderate	High
Big Porcupine	Moderate	High
Upper Tongue	Moderate - Low	Moderate
Lower Tongue	Moderate - Low	Low

Subwatershed	Relative Priority Nitrogen Yields	Relative Priority Phosphorus Yields
Rosebud	Moderate - Low	Low
O'Fallon	Moderate - Low	Moderate - Low
Middle Powder	Moderate - Low	Moderate
Lower Powder	Moderate - Low	Moderate - Low
Little Powder	Low	Low
Mizpah	Low	Low

Nitrogen Sources: The major target for reducing nitrogen loads in the basin is farm fertilizer use. Other significant sources of nitrogen, primarily in the upper subwatersheds, are urban and small tract development (septic systems, storm water run-off, and urban waste water treatment plants). Atmospheric deposition of nitrogen (up to 40 percent) is a major contributor in each subwatershed.

Phosphorus Sources: The main target for phosphorus load reduction includes livestock manure (confined and unconfined), farm fertilizer, and urban/small tract development. Stream channel sediments are also a major contributor of phosphorus. Excessive amounts of accelerated bank erosion and sediment are often caused by riparian clearing and development within the channel migration zone (CMZ). Establishing or maintaining a healthy riparian buffer in the CMZ is the most cost-effective treatment.

Specific Restoration Project Recommendations

None identified.

Additional Information & Data Needs

1) Soil Health Management Research: The YRCDC will support NRCS, Agricultural Experiment Stations, and Montana State University in identifying research opportunities to advance the technology and optimize the costs of implementing successful soil health management systems in the Yellowstone River Basin. Research topics would include irrigation water management, crop rotations, cover crop selection, insect and weed control, nutrient management, etc.

2) Water Temperature: YRCDC will collaborate with USGS and MFWP on the development and implementation of a water temperature data collection network to evaluate seasonal changes in water temperature along the Yellowstone River corridor, and to determine the basis for those changes.

YRRP 5.1 – Solid Waste Removal

Background

Several old solid waste dumps can be found along the Yellowstone River. Up until 40 years ago, disposing of solid waste on or near the river bank by both private landowners and communities was a common practice. Most dumps are no longer used; but as the river moves, some are now being exposed. Car bodies, sheet metal, used lumber, household and agricultural waste, fencing, concrete chunks, and other waste materials can be seen sloughing off the eroding bank into the active river channel. This material is affecting water quality, degrading important aquatic habitat, and creating a serious safety hazard for river recreationists.

Old dump site along the Yellowstone River.

Recommended Management Guidelines

The following guidelines should be considered when removing solid waste from private and public dump sites located within the Yellowstone River corridor (100-yr floodplain). It is no longer acceptable to simply dig a hole and bury the solid waste rather than using proper off-site removal and restoration techniques. The long-term risk to water quality (ground water and surface water), devaluation of property, and environmental liability makes solid waste removal economically worthwhile in nearly every case.

1. **Dump Site Assessments:** Where site assessments have not been completed, they should be initiated on all private and public solid waste sites located within the Yellowstone River corridor. The first set of priorities is solid waste sites located within the CMZ. The second set of priorities is unlicensed sites located in the 100-yr floodplain. Site assessments will include a description of solid waste volume and content, nearest disposal locations, post-removal remediation, and estimated costs for removal, disposal, and remediation.
2. **Solid Waste Disposal:**
    - Metal: For most dumps, the majority of solid waste material consists of steel, cast iron, car bodies, tin, and old machinery. This material can be recycled through a local metal recycler. Payment received for the salvaged metal may offset part of the removal costs.
    - Used Lumber, Tree Slash, Concrete, and other Garbage: These items should be disposed of outside the river corridor in an approved landfill, composted, or recycled. There may be landfill disposal costs if there is a large volume of non-recyclable material.
    - Pesticide Containers: Pesticide containers, whether plastic or metal, can be accepted into the Montana Department of Agriculture's disposal program. It is a non-regulatory service program that accepts pesticide containers at four or five collections sites throughout Montana, usually in September. The service is free unless there are a large number of containers or they contain dioxin or heavy metals. Contact Montana

Extension Service or the Montana Department of Agriculture for specific collection site locations and dates. Licensed pesticide applicators will receive a monetary credit when they participate in the disposal program.

- Hazardous Waste: Most old dumps do not have hazardous waste in them. However, during the site assessment or while the material is being removed, if hazardous materials are discovered, they will likely need to be collected, packaged, and disposed of using prescribed procedures. The county solid waste management department should be contacted ahead of time to determine how to handle and dispose of hazardous materials in the event that they are uncovered.
- Contaminated Soil: If contaminated soils are discovered during the site assessment or during excavation, the soil should be collected and, depending upon the contaminant, either transported to an approved disposal site or thinly spread across a field outside the river corridor.

3. **Site Reclamation:** Following the removal of the solid waste, all disturbances must be reclaimed. The site should be graded to the natural floodplain elevation and planted with native grasses, shrubs and trees. Noxious weeds should be monitored and treated on the disturbed area. If material is removed off the river bank, bank stabilization may be necessary. Refer to YRRP 2.1 Channel Bank Stabilization for design guidelines and recommendations.

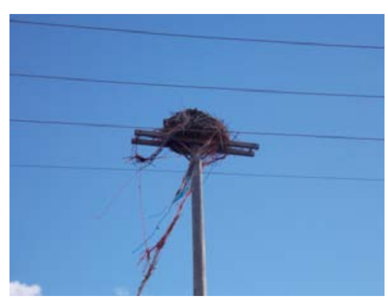
Removing concrete rubble off the river bank before it sloughs into the river.

Where significant ground disturbance is anticipated, the solid waste site assessments, disposal, and post-removal reclamation should be completed under the oversight of a qualified environmental consultant. There may also be permits required. Contact your local Conservation District office.

Osprey Nests – Baling Twine: Baling twine is a solid waste material that is directly affecting nesting osprey. Ospreys line their nests with soft materials such as moss and grass, but also gather baling twine left in fields and on fence posts. Recent research in the Yellowstone River valley estimates 10-15 percent of osprey chicks are killed annually by becoming tangled in baling twine brought to their nests.

Recommendation: After baling twine is removed from a hay or straw bale, dispose of it immediately in a location where osprey or other animals can't access it.

Plastic baling twine tangled up in an osprey nest.



Implementation Approach

1. **Outreach and Education:**
   - *Solid Waste Removal Demonstration Projects:* The YRCDC will work with Conservation Districts to identify landowners willing to remove and reclaim old dump sites within the Yellowstone River 100-yr floodplain. The YRCDC will seek funding for the reclamation work and explore ways for landowners to secure a "safe harbor" agreement with the EPA or MDEQ that waives potential penalties if hazardous wastes are found. Solid waste removal demonstration projects will be used for workshop presentations and landowner tours.

   - *Plastic Baling Twine Information Campaign:* YRCDC will develop an information campaign targeting livestock producers and rural small tract owners encouraging them to properly dispose of plastic baling twine immediately after its use.

   - *Financial and Technical Assistance:* Information on solid waste removal incentive programs will be distributed to landowners and communities through the local Conservation District, NRCS, and Extension Service offices.

2. **River Cleanup:** YRCDC will encourage and help sponsor local river cleanup events on the Yellowstone River and tributaries. These events may be river-wide, region-wide, or county-wide. They typically involve local organizations, agencies, community service groups, and citizen volunteers. A short reach of the Yellowstone River in Yellowstone County was the focus of a 2014 cleanup that yielded 3.5 tons of metal and 35 tires.

Potential Restoration Project Sites

The solid waste sites identified in the table below should be used as an initial screening for restoration projects. If an on-site assessment hasn't already been completed, this would be the initial step in determining project priority and feasibility. There are likely other sites that were not detected during the physical features inventories.

Reach	Solid Waste Site Location (River Mile)
A4	Big Timber RM461
A11	RM425.8
B3	RM361.5 RM360.6
B5	RM351.2L, RM347.1L
B8	RM326.5R
C14	RM 196.3L
C17	RM 184R
D1	RM137.5R
D2	RM 135.1R
D3	RM 125.6R, RM 124.2L, and RM 122L
D4	RM 117.8L
D5	RM104L, RM104.2L, RM101L, RM98L, RM97.5L, and RM97.1L
D7	RM84R, RM85.9R
D14	RM 25R, RM24.3L, RM 17L, RM15.8L, and RM 15.8R

Specific Restoration Project Recommendations

Richland and McKenzie Counties: In 2011, detailed site assessments were completed on 18 bank revetment and waste disposal sites along the Yellowstone River. Even though these projects are deemed "shovel ready", an on-site visit will be necessary to determine if the 2011 assessment recommendations are still relevant. Projects will be coordinated with willing landowners, the local Conservation Districts, Montana Fish, Wildlife & Parks, and the nearest licensed disposal location.

Additional Information & Data Need

1) Solid Waste Site Inventory and Assessments: In 2002, the physical features inventory included old solid waste sites along the banks of the Yellowstone River that were detected from an aircraft. An expanded inventory of solid waste sites is needed that encompasses the Yellowstone River 100-yr floodplain and the major tributaries.

2) Osprey Nests: The YRCDC will consult with MFWP to identify reaches in the Yellowstone River Basin that have a high concentration of osprey nests. An information campaign will be directed towards landowners who feed livestock in these reaches. They will also consult with local recycling centers on accepting plastic baling twine and netting.

YRRP 6.1 – Irrigation Water Management

Background

Approximately 90 percent of the Yellowstone River's 100-yr floodplain is used for agriculture: crop production and livestock grazing. Over half of these agricultural lands are currently irrigated and account for approximately 90,000 acres. Much of this land has been cleared and developed on what was formerly riparian forest and wetland habitat. Associated with the development of these lands, extensive irrigation infrastructure was built to support them: diversion structures, portable and permanent pumps, canal systems, on-farm ditches, sprinklers, buried pipelines, access roads, and power lines. Irrigated lands are extremely important to the economics of the Yellowstone River Basin. Developed irrigated lands have a cumulative effect on the river and its tributaries in the following ways:

1. Water Use: Irrigation water withdrawals are the largest water use in the Yellowstone River Basin, accounting for nearly 95 percent of the water used. The remaining water use is attributed to municipal, industrial, and thermoelectric purposes. The total consumptive use by irrigation is estimated to be 22 percent of the amount withdrawn while the rest eventually returns to the river. During the irrigation season, irrigation withdrawals reduce mean monthly flows in the Yellowstone River by up to 30 percent. Later in the fall, as stored irrigation water in the shallow groundwater returns to the river, flows will often increase by 2 to 10 percent.
2. Isolated Floodplain: Over 3,700 acres of the historical 100-yr floodplain have been isolated due to agricultural-related dikes, elevated ditches, roads, and field shaping. This accounts for 17 percent of the total isolated floodplain area along the Yellowstone River.
3. Bank Armor: Approximately 45 percent of the bank armor on the river is associated with agricultural operations (37 percent attributed to irrigated lands and 9 percent to non-irrigated agriculture).
4. Fisheries: There are six cross-channel irrigation diversions that limit or prevent passage of fish. This has reduced the historic range of many species and, in a few cases, threatens their future existence. There are also irrigation systems that entrain large numbers of fish that often do not return to the river.
5. Riparian and Wetland Conversion: Much of the irrigated land was developed over the last 120 years by clearing riparian forest and draining wetlands. A net total of nearly 5,500 acres have been converted to irrigated land since 1950, mostly on the lower reaches of the river.
6. Water Quality: Elevated levels of salts, sediment, and nutrients are often discharged into the river from irrigation surface runoff and shallow groundwater returns. Low concentrations of herbicides and pesticides have also been detected along some reaches of the Yellowstone River and its tributaries.

Inefficient irrigation systems will often contribute to excessive soil degradation, water quality problems, water shortages, and require substantial inputs of labor, energy, and capital to operate. On the other hand, a well-managed irrigation system will lessen those impacts by being well designed and effectively managed to make efficient use of the water taken from the river. Irrigation systems can be multi-user with a common headgate and conveyance system that delivers water to thousands of acres, or they can be relatively small, single user systems, and service just a few fields. Regardless of size, an irrigation system can be designed and managed to minimize their impacts on the river.

Over the last 20 years, an increasing number of flood irrigation systems have been converted to sprinkler irrigation.

This YRRP outlines guidelines and planning considerations regarding irrigation water management systems for large multi-user systems as well as small single-user systems. Advances in irrigation technology have resulted in newly accepted approaches in system design and water application that are proving to be cost-effective while minimizing impacts on the river.

Efficient irrigation water management will lower production expenses, maximize crop yields, and reduced environmental impacts on the Yellowstone River.

Recommended Management Guidelines

An irrigation water management system includes three basic components. The following attachments provide design and management considerations for each of these components

1. **Irrigation Headworks** include diversions, check structures, headgates, and pumps used to withdraw water from the river. See Attachment #1.

2. **Irrigation Conveyance - Canals and Pipelines** transfer water from the headworks to the fields. See Attachment #2.

3. **On-Farm Irrigation Water Distribution Systems** apply water to the fields. See Attachment #3.

YRRP 6.1 Attachment #1: Irrigation Headworks

Irrigation Headworks include all structures located in or near the river channel making it possible to withdraw water from the river and divert it into an irrigation canal or pipeline.

Most headworks are located at the site where they were originally built. It is likely that they will remain there whether or not it is the most suitable site. However, when new headworks are being considered, or existing headworks replaced, the location and design of the headworks should factor in river channel characteristics at the proposed site. Given proper design and placement, headwork structures will operate more efficiently, require less maintenance and last longer. A qualified engineer who understands river dynamics should be consulted for headwork placement and design.

Pumps: Ideally, pump sites are located on a stable reach of the river where water depths are sufficient for pumping and a power source is readily available. There are two types of pumps used on the Yellowstone River:

- Permanent Pumps: Permanent pumping stations are often used by multi-user groups with large acreages that require a high volume of water. For most systems, a permanent pumping station is used only if the irrigation system cannot be adequately served by a portable pump. When constructing new or relocating permanent irrigation pump stations, site location is critical. If possible, a pumping station should not be located where the channel is continually shifting or where there is evidence of channel scour or gravel/silt deposition. Active river bends should be avoided due to high channel migration rates and the never-ending expense of protecting the structure.

Permanent irrigation pump in Sweet Grass County that required rock riprap for protection.

- Portable Pumps: Portable pumps are the most common type of headworks found on the Yellowstone River. Portable pumps can be pulled back from the river during high water events and winter months to prevent damage from floods and ice. They operate in relatively shallow water, maintenance is low, and seldom do they require expensive bank armoring to protect them. And, they can be moved to accommodate a shifting river channel (relocating a pump may require authorization for a "point of diversion" change from Montana DNRC).

Portable floating pump in Custer County can easily be moved when necessary.

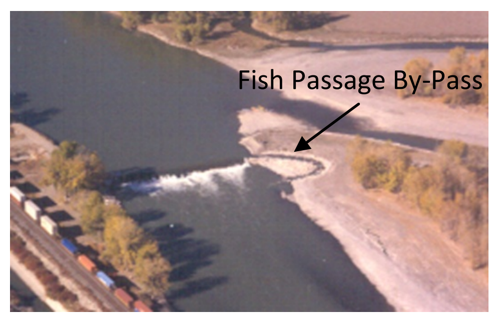
- Pump Screens: An effective screen on a pump inlet will limit the capture of juvenile fish into an irrigation system. Pump screens also reduce plugging of pump inlets from floating debris and algae that can restrict water flow and damage the pump. Manual cleaning of pump screens requires constant attention. It is often worth the investment to purchase a self-cleaning screen that saves time, fuel, and maintenance costs. The cost of fish screens vary widely depending upon the size of pump inlet, mechanical verses self-cleaning, and other site conditions.

A rotary drum self-cleaning pump screen is relatively low maintenance.

Diversions/Check Structures: There are over twenty irrigation headworks on the Yellowstone River including headgates, in-channel diversions, and check structures that divert water from the river into an irrigation system. In-channel diversions range from multi-million dollar cross-channel structures to simple rock weirs that extend a short distance into the river. Headgates associated with these diversion/check structures are designed to control the amount of water entering the irrigation system.

- Cross-Channel Structures: There are six cross-channel check structures on the Yellowstone River that withdraw large volumes of water during the irrigation season. Most of these structures limit or prevent upstream fish passage as well as pose a safety hazard to recreationists. Designs to rebuild or retrofit these structures should include fish passage, prevent fish entrainment into the irrigation system, be able to withstand high flows and winter ice, assure a reliable volume of water into the irrigation system, incorporate measuring devices, and provide watercraft passage. These large structures require a complex design and substantial funding that is possible only if a strong partnership is forged between the water users and other vested interests (nonprofit organizations, state and federal agencies).

The Huntley Irrigation Diversion in Yellowstone County that has recently been retrofitted to provide a fish by-pass channel.



- Low-Head Permanent Structures: Less than twenty low-head irrigation diversions/check structures exist on the Yellowstone River. Most are built with large rocks extending part way into the channel. These rock structures are subject to high energy flows, floating debris, and winter ice. A detailed design addressing rock gradation, rock placement/alignment, sediment transport, and debris passage is crucial to structure effectiveness and longevity.
- Seasonal Low-Head Structures: There are opportunities on the Yellowstone River to use seasonal irrigation diversions/check structures. There are several types, but portable concrete blocks (6 to 8 feet long) are commonly used throughout Montana. These structures are placed in the river during late summer, low flow months. They are then removed after the irrigation season, leaving the channel unobstructed for the remainder of the year. Seasonal structures are especially applicable on secondary channels.

YRRP 6.1 Attachment #2: Irrigation Conveyance - Canals and Pipelines

Irrigation Conveyance is the method used to deliver water from the irrigation headworks to an on-farm distribution system. This is usually accomplished through an open canal or buried pipeline.

Conveyance efficiency is determined by how much water is lost between the headworks and the irrigated fields. This loss is usually due to canal seepage and evaporation. A long irrigation canal in porous soils can lose 40% or more of its water from seepage. Seepage can have both beneficial and adverse impacts to the adjacent land and river. It is considered to be an important source of aquifer recharge and late summer return flows to the Yellowstone River. This "slow release water" augments river flow during late summer and early fall months. Seepage may also support seasonal wetlands down-gradient from the canal. However, on the flip side, excessive canal seepage will sometimes waterlog and salinize adjacent lands making them unsuitable for crop production. It may also affect water quality by contributing excessive amounts of salt and nutrients to the river.

For most conveyance canals or ditches, the amount of seepage varies throughout the irrigation season. Irrigation canals tend to leak more early in the season than during late summer months. How much and where the seepage occurs is dependent upon the amount of water (head) in the canal and the soil texture/bedrock that the canal passes through. Certain sections of a canal are usually more susceptible to leakage than other sections.

Most irrigation canals along the Yellowstone River that deliver water from the river to on-farm irrigation systems are open and unlined.

Canal/Ditch Lining: If a canal/ditch is unable to deliver sufficient water to meet irrigation needs or if adjacent lands are being waterlogged or salinized, canal lining may be an option.

- Locate Major Canal Seepage Sections: Before initiating any canal lining, locate the section(s) of canal with the most seepage. This allows the water users to identify the most severe canal seepage problems for treatment. Priority seepage sections can sometimes be identified by simply noting downslope wet areas, although these observations do not always lead to the worst seeps. Periodic flow measurements along the canal, over the course of an irrigation season, will quantify seepage loss and help pinpoint canal sections to line.
- Canal Lining: Traditional canal lining material includes reinforced concrete and compacted earth liners. New products that have recently come on the market include various types of synthetic liners and installation techniques. Selection of a liner material is not a simple task. Climate conditions, soil texture, livestock/wildlife access, size of canal, expected longevity, ease of installation, and available budget must all be carefully considered before a selection is made. Once a liner is selected, it is essential that the canal liner be installed by an experienced contractor. Improper installation of canal liners is the most common reason for liner failure.

Irrigation Pipelines: Another option for preventing seepage, evaporation, and canal breaches is to replace small open canals with a pipeline. It is a common practice in the Yellowstone River Valley to use plastic pipelines as an alternative to small canals or ditches. Large diameter reinforced concrete, PVC, high-density PE, or steel pipe are sometimes used to replace sections of large canals. High costs usually limit the scope of these projects to short sections.

- Design Considerations: A detailed field survey and engineering design is necessary to determine the most suitable pipeline material and size. The design will address pressure, volume of water to be conveyed, soil type and depth, pipeline length, and cost. The installation of the pipeline is critical. All pipe sections, fittings, joints, and couplers must be carefully inspected prior to installation to be sure there are no cracks, holes, discoloration, or other defects in materials or workmanship. If the pipeline is buried, proper trench dimensions and careful bedding/compaction of the pipe are essential to the effectiveness and longevity of the pipeline. All pipelines should be set back from the river's edge to minimize the potential of failure from channel migration. Refer to the Channel Migration Zone map for that river segment, available at the local Conservation District office.

Trench width, depth, bedding materials, and compaction standards should be included in the buried pipeline design.

Fish Entrainment: Fish entrainment is the incidental capture and trapping of fish in an irrigation canal. The location, inlet design, timing, and water volume determine an irrigation system's potential to entrain fish. Depending upon fish species and river location, some factors may be more important than others. Very few canal systems on the Yellowstone River have been evaluated for fish entrainment. It is likely that some irrigation canals are a significant source of mortality for Yellowstone River fish.

1) Canal Assessment: Before a fish entrainment project is initiated, the irrigation management system should be assessed to determine type and numbers of fish species entrained in the canal. The assessment would include estimated mortality rates and whether fish, once entrained, have the opportunity to find their way back to the river via irrigation waste ditches or control structures. This assessment should be completed by Montana Fish, Wildlife & Parks or other qualified fish biologists.

2) Fish Screens: A physical inventory of pumps, irrigation canals and diversion structures on the Yellowstone River and seven major tributaries indicate about 16 percent of the irrigation withdrawal structures are screened. A common approach to prevent fish entrainment is to install a screen on the headgate, the pump intake, or at a wastewater by-pass at the top of the canal. Most fish screens are designed to block fish from entering an irrigation canal and/or to divert them back to the river through a bypass structure. To maximize fish screen effectiveness, the design needs to consider approach velocities, swimming abilities of the targeted fish, volume of floating debris, installation costs, and long-term maintenance requirements.

3) Canal Drawdown: At the end of the irrigation season, irrigation headworks are often abruptly closed causing a sudden change in the water level, leaving a series of disconnected pools where fish and aquatic animals become stranded. For irrigation headworks not screened, a phased, incremental draw-down of the canal at the end of the irrigation season will cue some fish to move out of the system and back to the river.

YRRP 6.1 Attachment #3: On-Farm Irrigation Water Distribution Systems

There are two broad categories of on-farm irrigation water distribution systems being used along the Yellowstone River: flood and sprinklers. The types of crops grown in the Yellowstone River Valley do not lend themselves to drip/micro-irrigation although this technique is occasionally used for shelterbelts and residential landscaping. Flood irrigation efficiencies range from 15 to 60 percent while sprinkler irrigation efficiencies are often much higher (60 to 85 percent).

Sprinkler Irrigation: Along the Yellowstone River, nearly 15% of the irrigated cropland is served by sprinkler systems. Over the last 20 years, center pivot sprinklers have become increasingly popular following advances in sprinkler system technology. Sprinkler systems using older technology (laterally-moving wheel lines and hand-move pipe) have steadily declined during this same period. A sprinkler irrigation system will typically use less than half the water that is required for flood irrigation. They generally require less labor and increase crop yields by as much as 40 percent. There is an initial equipment/installation investment and energy to run the system becomes an operation expense, but over time the economic benefits will outweigh the costs.

- **Pivot Sprinkler Design:** A properly designed pivot system will be economical, highly reliable, efficient, and have low operation and maintenance requirements. Pivots should be equipped with drop tubes to limit evaporative losses and wind drift. It is also important that the pivot be located outside the channel migration zone to avoid having to relocate the system or install expensive bank armor in the future.
- **Soil Health Management:** Sprinkler irrigation is more amendable than flood irrigation to reduced tillage, optimizing fertilizer and pesticide use, and incorporating cover crops in crop rotations. Sprinkler irrigation is an important component of the soil health management approach that is becoming increasingly popular in the Yellowstone River Valley. Through the efficient application of water by sprinklers, there is seldom any irrigation runoff resulting in very little sediment, nutrients, and pesticides being discharged into the river. Deep percolation is also curtailed, significantly reducing nutrient and pesticide leaching to the shallow ground water. Converting from an on-farm flood irrigation system to sprinklers should be seriously considered when adopting a soil health management program.

Center pivot sprinklers have become a common sight along the Yellowstone River. Their initial cost is high, but they often pay for themselves within 5 to 7 years.

Flood Irrigation: Even with the recent trend to convert flood irrigation to sprinkler irrigation, over 85% of the irrigated lands in the Yellowstone River Valley are still under flood irrigation. Field features – such as land shaping, contour ditches, border dikes, and furrows – have traditionally been used to control water distribution on these systems.

Improved Flood Irrigation Systems: Flood irrigation is seldom as efficient as sprinkler irrigation; however there are ways to improve water use efficiency.

- <u>On-Farm Conveyance Pipelines:</u> Replacement of irrigation delivery ditches with buried pipe can reduce seepage, ditch erosion, and maintenance costs. Ditches with flow capacities up to 5 cfs are candidates for buried pipeline.

Most on-farm pipelines are 24 inch diameter or less, with 8 to 15 inch pipelines being more common. A detailed field survey and engineering design is necessary to determine the most suitable pipeline material and size.

- Field Leveling and Shaping: Periodically, flood irrigated fields should be re-leveled or reshaped to eliminate variations in field gradient and side slopes. This allows for better control of water application and improves the uniformity of soil saturation. Laser level technology provides opportunities for setting precise field grades and improving the uniformity of water application.

- Gated Pipe: Since the late 1980s, gated pipe has made significant inroads on increasing flood irrigation efficiencies in the Yellowstone River Basin. It is versatile enough to be used on steep upper-basin haylands as well as flat lower-basin sugar beets. Gated pipe eliminates the need for contour or field ditches thereby reducing water evaporation, seepage, and ditch erosion. Water management is more efficient and labor is less than traditional flood irrigation. For some irrigated lands, primarily where furrow crops are being grown, modifications to a gated pipe system such as surge valves (timed releases) and cablegation (moveable plug) can further improve water use efficiency.

Gated pipe has been widely adopted throughout the Yellowstone River Basin over the last 30 years.

- Irrigation Water Management: In addition to the flood irrigation improvement opportunities discussed above, the actual application of the water is crucial if water is to be used efficiently and return flows reduced. On-farm irrigation water management requires a field-specific approach that optimizes water use by factoring in water volume, crops being grown, soil types, field slope, time of application, and the distance between laterals. NRCS personnel or qualified consultants can assist with developing an effective on-farm flood irrigation management system.

- Tailwater Recovery: Tailwater recovery and reuse systems may be applicable to some flood irrigation systems, especially where excess irrigation water flows off the end of an irrigated field. Tailwater recovery is particularly useful with furrow irrigation systems. It is not unusual for runoff to be 15 percent or more of the amount of water applied to the field. A tailwater system normally consists of a ditch at the bottom of the field that collects excess water and delivers it to a small storage reservoir. The system often includes a pump and pipeline to convey waste water back to the irrigated field for reuse. Most tailwater systems can reuse 0.5 to 1.5 acre-feet of water per acre of irrigated land each year. The capture and reuse of tailwater will significantly reduce the amount of sediment and nutrients discharged into the river.

Implementation Approach

1. **Information and Outreach Campaign:**
   Soil Health Management – Irrigated Farms: The YRCDC will work closely with individual Conservation Districts, NRCS, and Montana State University Extension to sponsor local soil health management workshops and demonstration tours targeting landowners with irrigated farms in the Yellowstone River valley and major tributaries. An important component of the information campaign will highlight how well-managed irrigation systems complement a soil health management program. Farmers who are successfully implementing a soil health management system will be recruited as speakers for workshops and tours.

2. **Fish Passage – Yellowstone River Cross-Channel Irrigation Structures:** There are six cross-channel structures on the Yellowstone River that divert large volumes of water during the irrigation season. Several of these structures limit or prevent upstream fish passage as well as pose a safety hazard to recreationists. Designs to rebuild or retrofit these structures should accommodate fish passage, prevent fish from being entrained into the irrigation system, withstand high flows and winter ice, and divert a reliable volume of water into the system. This requires a complex design and substantial financial resources that will not be possible unless a strong partnership is forged between the water users and other vested interests (nonprofit organizations, state and federal agencies). YRCDC encourage and support constructive dialogue between all parties to reach a mutually agreeable alternative on providing fish passage at each structure. YRCDC will offer staff time in helping secure financial support for project design and construction, when appropriate.

Reach	Cross-Channel Diversions
B4	Huntley Diversion
B9	Waco Custer
C1	Ranchers
C4	Yellowstone
C10	Cartersville
D8	Intake

3. **Fish Passage - Tributaries:** Yellowstone River tributaries are important to both cold-water and warm-water species by providing spawning and larval rearing habitat. Several tributaries have fish passage barriers that include road/railroad crossings, irrigation structures, and in-channel ponds. The Montana Fish, Wildlife and Parks (MFWP) have identified some of these barriers, but more evaluations are needed. YRCDC will assist the MFWP in identifying priority fish passage barriers where landowners/water users may be willing to pursue a fish passage project.

4. **Water Loss – Irrigation Conveyance Systems:** YRCDC will work closely with the NRCS to develop and implement an outreach strategy that identifies irrigation districts/companies along the Yellowstone River and tributaries that agree to evaluate their canals for seepage and water loss. YRCDC will assist the local Conservation Districts and irrigation groups in developing demonstration projects that highlight various canal liners and installation techniques.

5. **Fish Entrainment – Irrigation Conveyance Systems:** YRCDC will partner with the MFWP Regional Offices in an outreach effort that identifies irrigation districts/companies along the Yellowstone River and tributaries that are willing to have their canals checked for fish entrainment. For canals found to have a significant fish entrainment

issue, the YRCDC will pursue voluntary, practical solutions with MFWP and the water users to reduce the number of fish captured in the canal each year. Any project designed to limit fish entrainment will not affect the volume of irrigation water diverted or significantly altering the operation and maintenance of the system.

6. **Montana 2015 State Water Plan:** YRCDC will support Montana DNRC Water Resources Division with the implementation of the 2015 State Water Plan's "Major Findings and Key Recommendations"; especially those pertaining to water use efficiency and water conservation on irrigated lands in the Yellowstone River Basin.

7. **Drought Response Planning:** The most important lesson learned in recent years is that the best time to address the impacts of drought is before they occur. Drought conditions present a variety of problems for water users. In addition to diminished water supplies, legal and practical obstacles hinder timely changes in water allocation during drought. YRCDC will organize a Yellowstone River Basin Drought Committee that will develop a voluntary basin-wide drought response plan to mitigate the effects of future droughts. The committee will include representatives from irrigation water users, Bureau of Reclamation, Montana DNRC, conservation groups, and other interested entities. Minimum flows and maximum water temperatures thresholds that trigger a drought response will be developed and agreed upon by all vested interests.

On-Farm Irrigation Water Management – Priority Reaches

Criteria: The priority reaches listed in the table below include three reaches per county that have the highest density of flood irrigated acres in the 100-yr floodplain. Additional priority reaches have been included where there are more than 100 acres of flood irrigation per river mile. This prioritization is the initial step for identifying potential on-farm irrigation water efficiency projects. These projects are intended to optimize water use and minimize nutrient, pesticide, and salt run-off and leaching from flood irrigated fields.

County	Reach	Reach Length (Miles)	Flood Irrigation 100-yr Inundation Zone (Total Acres--Acres/River Mile)
Park	PC18	8.5	188 ac--22 ac/RM
	PC19	4.4	140 ac--32 ac/RM
	PC21	3.7	64 ac--17 ac/RM
Sweet Grass	A3	8.6	682 ac--79 ac/RM
	A6	4.8	319 ac--66 ac/RM
	A8	8.2	780 ac--95 ac/RM
Sweet Grass Stillwater	A9	6.2	356 ac--57 ac/RM
	A10	6.9	590 ac--85 ac/RM
	A14	12.5	808 ac--64 ac/RM
Yellowstone	A18	3.8	547 ac--144 ac/RM
	B4	6.1	683 ac--112 ac/RM
	B7	8.8	1339 ac--152 ac/RM
Treasure	C2	8.9	3030 ac--340 ac/RM
	C3	7.6	1979 ac--260 ac/RM
	C4	6.1	702 ac--115 ac/RM
	C5	5.1	1420 ac--278 ac/RM

County	Reach	Reach Length (Miles)	Flood Irrigation 100-yr Inundation Zone (Total Acres--Acres/River Mile)
	C6	9.1	1758 ac--193 ac/RM
	C7	7.2	2163 ac--147 ac/RM
Treasure Rosebud	C8	10.4	2804 ac--270 ac/RM
Rosebud	C9	17.2	3689 ac--214 ac/RM
	C11	18.3	2797 ac--153 ac/RM
	C12	16.2	3612 ac--223 ac/RM
	C13	10.8	2380 ac--220 ac/RM
Rosebud Custer	C14	19.6	3770 ac--192 ac/RM
Custer	C17	7.2	829 ac--114 ac/RM
	C18	5.2	990 ac--190 ac/RM
	C19	17.9	2982 ac--166 ac/RM
Custer Prairie	C20	12.2	2064 ac--169 ac/RM
Prairie	C21	15.2	2105 ac--138 ac/RM
	D1	19.5	439 ac--23 ac/RM
Prairie Dawson	D3	13.4	818 ac--61 ac/RM
Dawson	D4	17.7	1438 ac--81 ac/RM
	D9	5.6	705 ac--126 ac/RM
Dawson Wibaux	D10	18.3	2348 ac--128 ac/RM
Richland	D11	10.3	1135 ac--110 ac/RM
	D12	21.9	4054 ac--185 ac/RM
	D13	13.8	1902 ac--138 ac/RM
	D14	23.1	5089 ac--220 ac/RM
McKenzie	D15	9.6	4823 ac--502 ac/RM
	D16	11.9	7359 ac--618 ac/RM

Specific Restoration Project Recommendations

None identified.

Additional Information & Data Needs

1) Fish Passage and Entrainment Inventory: YRCDC will work cooperatively with MFWP to inventory fish passage and fish entrainment mitigation opportunities on the Yellowstone River mainstem and tributaries. Tributary barriers (i.e. roads, ditches, railroad grades, irrigation check structures, etc.) will be documented. Irrigation conveyance canals will be evaluated to determine their level of fish entrainment. This comprehensive inventory will determine the extent of the problem, outline potential solutions, and gage the willingness of water users to pursue a restoration project.

2) Montana 2015 State Water Plan Recommendations: There are several recommendations in the 2015 State Water Plan that include water-related investigations. They include long-term monitoring of irrigation water distribution systems, research on innovative water management and conservation strategies, feasibility studies on using the natural storage capacity of wetlands, riparian areas, and floodplains to store water, etc. Where State Water Plan recommendations are compatible with YRCDC priorities, YRCDC will offer to support and/or sponsor certain investigations in cooperation with Montana DNRC Water Resources Division.

7.1 Position Statement – Oil/Gas/Brine Water Pipeline Crossings

<u>Position Statement:</u> The Yellowstone River Conservation District Council (YRCDC) promotes the use of Horizontal Directional Drilling (HDD) technology for all buried oil, gas, and brine water pipelines that cross under the Yellowstone River and tributaries. Channel Migration Zone (CMZ) maps should be used to locate HDD entry and exit points.

Background

Immediately following the 2011 pipeline rupture and oil spill from the ExxonMobil Silvertip Pipeline near Laurel, the YRCDC commissioned a hazardous material pipeline risk assessment that was completed in 2012. The pipeline risk assessment shows the presence of 39 pipelines intersecting the Yellowstone River Channel Migration Zone (CMZ) at 21 crossings. Thirty of the pipelines cross the channel while nine pipelines are located within the CMZ.

A second pipeline oil spill near Glendive in January 2015 again heightened public awareness of the vulnerability of these pipelines and the environmental damage that can result from these spills. Factors that affect pipeline failure risk are either internal or external. Internal factors are intrinsic to the pipeline itself, such as corrosion, weld failure or age. External factors are those that are a function of the environment through which the pipeline must pass. These external factors include lateral channel migration and channel bed scour that can expose shallowly buried pipelines. Depth of cover, bank armoring, and “pinch points”, such as bridges, can exacerbate the potential for pipeline exposure by concentrating erosive forces from floods and ice.

Exposed pipeline at risk of being ruptured.

Recommended Installation and Management Guidelines

The following are guidelines for new and existing pipeline river crossings. The YRCDC encourages the Pipeline and Hazardous Materials Administration (PHMSA), the Federal Energy Regulatory Commission (FERC), and all pipeline companies working in the Yellowstone River Basin to adopt these guidelines as a minimum standard.

Horizontal Directional Drilling: All new pipeline crossings will use Horizontal Directional Drilling (HDD) technology that places the pipeline at a minimum of 30 feet beneath the river channel bottom. Crossings will be located on a stable straight channel reach where possible. River bends and braided sections should be avoided. The HDD entry and exit points will lie outside the CMZ boundary. All drilling pads, staging areas and disturbed areas will be reclaimed following the HDD pipeline installation.

- **Existing Pipelines:** All existing at-risk pipeline crossings installed using open-cut methods will be replaced using HDD technology following the same criteria as outlined for new pipelines. Pipelines that do not cross the river, but are buried within the CMZ should be inspected regularly and, if possible, be relocated outside the CMZ as soon as possible.

- **Abandoned Pipelines:** All abandoned pipelines should be removed within the CMZ boundary. Old bank armor and physical features associated with the abandoned pipeline will be evaluated to determine if they should be removed.
- **Oversight:** State and federal oversight agencies should require HDD technology be used on all new pipeline crossings on the Yellowstone River mainstem and the perennial/intermittent tributaries that feed into the Yellowstone River.
- **Spill Detection:** Spill detection and remote shutoff valve technology will be incorporated into all pipelines to minimize the volume of spilled material and expedite response time in the event of a pipeline rupture.
- **Pipeline Inspections:** Pipeline companies need to conduct annual inspections of pipeline crossings with special attention given to real-time monitoring during major flood and ice jams.

Implementation Approach

1. Pipeline Crossings Review: The YRCDC will work with member Conservation Districts on a consistent policy that clarifies their role in the review of new proposed pipeline crossings and the replacement of existing crossings in their respective counties. The policy will clarify the applicability of 310 permits for pipeline crossings.
2. State and Federal Agency Coordination: The YRCDC will periodically host meetings with the local Conservation Districts and state/federal oversight agencies to discuss the status of pipeline crossings throughout the Yellowstone River Basin. Discussion topics will include design criteria, pipeline inspection frequency, permit requirements, and agency oversight.

Specific Restoration Project Recommendations

None identified.

Additional Information & Data Needs

1) Pipeline Risk Assessment: Expand and update YRCDC's 2012 Pipeline Risk Assessment. Depth of cover data within the CMZ for all 39 pipelines will be requested from the National Pipeline Mapping System (NPMS) under the jurisdiction of PHMSA. There will be a detailed "risk of exposure" assessment completed on each pipeline based on depth of cover and a site-specific scour analysis.

8.1 Position Statement – Altered Flows

<u>Position Statement:</u> The Yellowstone River Conservation District Council (YRCDC) encourages irrigation water users to improve irrigation water use efficiencies. There will be regular discussions with the U.S. Bureau of Reclamation on Bighorn River storage reservoir releases that allow the lower Yellowstone River hydrograph to more closely reflect historic levels.

Background

Yellowstone River flow alterations are primarily due to irrigation withdrawals throughout the Yellowstone River Basin and large storage reservoirs located in the Bighorn River Basin.

Irrigation Withdrawals: On the upper Yellowstone River, there is a reduction in historic peak flows from Gardiner to the Bighorn River confluence due to irrigation withdrawals. Below the Bighorn River confluence, both irrigation withdrawals and Bighorn Basin storage reservoirs combine to significantly affect the river's hydrology. Some tributaries to the Yellowstone River are significantly dewatered due to irrigation withdrawals that contribute to lower summer flows in the river. Refer to YRRP 6.1 Irrigation Water Management for irrigation water use efficiency guidelines.

Bighorn River Basin: Below the mouth of the Bighorn River, there is an abrupt change in traditional peak flows on the Yellowstone River. Flows have dropped 16 percent (19,100 cfs) for the 100-year flood and nearly 23 percent (13,700 cfs) for the 2-year flood. The influence of these reservoirs also significantly lowers late summer flows on the lower Yellowstone River. Fall and winter flows are slightly increased. These flow alterations have a long-term effect on channel-forming processes, aquatic habitat, riparian forest recruitment, and water quality.

Implementation Approach

1. **Bighorn River System Issues Group:** The YRCDC will send representative(s) to the Bighorn River System Issues Group that currently meets twice each year. The Bighorn River Systems Issues Group was formed to identify, explore, and recommend alternative courses of action to local, state, and federal entities responsible for managing the Bighorn Lake and the Bighorn River system. The U.S. Bureau of Reclamation organizes and facilitates all Bighorn River System Issues Group meetings. The YRCDC will represent lower Yellowstone River interests and advocate for reasonable adjustments of the Bighorn River reservoir releases to mitigate their effects on the lower Yellowstone River.

Yellowtail Dam on the lower Bighorn River has a significant effect on the lower Yellowstone River hydrograph.

2. **Water Marketing:** The YRCDC will collaborate with Montana DNRC to explore opportunities, challenges, and water right implications for using water marketing and banking as tools to maintain or improve flows in the Yellowstone River and tributaries.
3. **Irrigation Water Management:** YRCDC will work with individual Conservation Districts, irrigation water users, and technical agencies on promoting the guidelines outlined in the YRRP 6.1 Irrigation Water Management.

9.1 Position Statement – Channel Migration Zone Maps

<u>Position Statement:</u> The Yellowstone River Conservation District Council (YRCDC) encourages the use of Channel Migration Zone (CMZ) maps by landowners, land management agencies, and local governments in making more informed decisions regarding future development and infrastructure maintenance within the Yellowstone River corridor.

Background

The Yellowstone River is a relatively unique river. It is not controlled and locked in place like so many rivers in the West. Over most of its length, the river still has the ability to move laterally across its floodplain. The Channel Migration Zone (CMZ) maps define areas along the Yellowstone River that are prone to channel migration and avulsions (meander cut-offs) during the next 100 years. CMZ map boundaries are based on local geologic mapping and measured rates of lateral channel change derived from fifty years of historic aerial photography.

The development of CMZ maps for the Yellowstone River, from Gardiner, Montana to its confluence with the Missouri River in McKenzie County, North Dakota, supports several of the Yellowstone River Conservation District Council's Yellowstone River Recommended Practices (YRRPs). The use of CMZ maps by decision-makers along the Yellowstone River can preempt damage to infrastructure and reduce the need for expensive bank armoring.

Channel Migration Zone Map Uses

Landowners and resource managers are often called upon to make land use decisions along the Yellowstone River in the absence of substantive information regarding channel migration. The CMZ maps are intended to inform the public and affected parties depicting 100-year channel migration and avulsion hazard zone designations.

The CMZ maps were not developed to be regulatory. These maps are derived from remote sensing tools, as well as general geological mapping. They are intended to be an informational tool for landowners and residents. The CMZ maps should be used to:

- Raise awareness and understanding of the dynamic nature of the Yellowstone River.
- Identify channel migration threats to existing and proposed infrastructure within the stream corridor.
- Quantify the potential land loss from channel migration to assist landowners weigh the economic cost/benefits of installing bank armoring.
- Identify restoration opportunities where bank armor and floodplain dikes have restricted channel migration and causing detrimental effects.
- Support local and regional land use planning by identifying areas within the Yellowstone River corridor that are at high risk due to channel migration. CMZ maps should be referenced by permitting entities, county planning departments, and private interests when making decisions on proposed developments within the river corridor.

The red boundary is the 100-year CMZ where development should be limited.

Implementation Approach

1. Channel Migration Rates Update: Channel bank lines should periodically be digitized on new aerial photography (2015 and later) to document future channel migration rates. The CMZ map boundaries will be updated to reflect these new rates. Every 10 years, the most current aerial photography will have channel bank lines delineated and CMZ maps revised. Each time the CMZ maps are revised, they should be redistributed to the public.

2. Outreach: Make Yellowstone River CMZ information understandable and easily accessible to the public.
   - YRCDC will sponsor information workshops for residents, county officials and realtors on the criteria used to create the CMZ maps, the value of the maps for decision-making, and the intended uses of the maps.
   - Each Conservation District will distribute CMZ maps and reach narratives to landowners who live along the Yellowstone River and city/county officials. They will also be available on the Yellowstone River Clearinghouse Web page for the general public.
   - Each Conservation District and local MFWP will provide pertinent CMZ maps and the YRRP 2.1 Channel Bank Stabilization to all 310 (Conservation District) and 124 (MFWP) permit applicants who are proposing to install bank armor on the Yellowstone River. The Army Corps of Engineers will be encouraged to follow this same procedure with their 404 permit applicants.

10.1 Position Statement – Fish Passage and Entrainment

<u>Position Statement:</u> The Yellowstone River Conservation District Council (YRCDC) encourages cooperative projects between irrigation water users and other vested interests that provide fish passage through irrigation diversion structures and prevent fish entrainment in irrigation systems.

Background

Fish passage and entrainment are two resource issues intertwined with irrigation along the Yellowstone River. Where irrigation water is derived by diversion structures spanning the entire river channel, the movements or migrations of various fish species can be affected. Where water is withdrawn from the river either via gravity diversions or pumps, there is a risk of entraining fish. Data have established that the distributions and movements of many fish species in the Yellowstone River, including the federally endangered pallid sturgeon, are affected by low-head diversion dams. In addition, studies of unscreened diversions indicate that substantial numbers of fish are often entrained at water diversion points. Across the United States and in Montana, fish passage and entrainment protection measures have been utilized effectively to prevent loss of fish, restore connectivity with habitat, and increase fish abundance without negatively affecting agricultural practices.

The Yellowstone River mainstem has been longitudinally fragmented by six diversion structures. Researchers have suggested that blockage of seasonal migrations for spawning and feeding may be a leading cause of the decline in fishes native to large river systems.

A fish entrainment study on Intake Diversion Dam found 36 species of fish passed into the irrigation canal during their sample years (1996, 1997, and 1998). Screens have since been installed on the canal. It has also been estimated that up to 30 percent of the adult sauger are lost due to entrainment in irrigation canals.

Pallid Sturgeon found on the lower Yellowstone River is especially susceptible to fish passage barriers created by cross-channel irrigation diversions.

Implementation Approach

1. **Fish Passage - Cross Channel Structures:** There are six cross-channel check structures on the Yellowstone River that withdraw large volumes of water during the irrigation season. Several of these structures limit or prevent upstream fish passage and pose a safety hazard to recreationists. Designs to rebuild or retrofit these structures must accommodate fish passage, prevent fish from being entrained into the irrigation system, be able to withstand high flows and winter ice, and divert a reliable volume of water into the system. This requires a complex design and substantial financial resources that will not be possible unless a strong partnership is forged between the water users and other vested interest groups (nonprofit organizations, state and federal agencies). YRCDC is willing to facilitate discussion between all parties to reach a mutually agreeable alternative on providing fish passage at each structure. YRCDC will also provide staff time in helping secure financial support for project design and construction.

2. **Fish Passage - Tributaries:** Yellowstone River tributaries are important to both cold-water and warm-water species by providing spawning and larval rearing habitat. Several tributaries have fish passage barriers that include road/railroad crossings, irrigation structures, and in-channel ponds. The Montana Fish, Wildlife and Parks (MFWP) have identified some tributary barriers, but more evaluations are needed. YRCDC will assist the MFWP in identifying priority fish passage barriers and landowners/water users interested in pursuing a fish passage project.

3. **Fish Entrainment – Irrigation Conveyance Systems:** YRCDC will work closely with the MFWP Regional Offices in developing an outreach strategy that identifies interested irrigation districts/companies along the Yellowstone River and tributaries that are willing to have their canals evaluated for fish entrainment. For canals found to have a significant fish entrainment issue, the YRCDC will explore voluntary, practical solutions with MFWP and the water users to reduce the number of fish captured in the canal while not affecting the amount of irrigation water transported through the canal or significantly altering the operation and maintenance of the system.

4. **Outreach:**
    - YRCDC will host information workshops and tours for irrigation water users that explain the effects of irrigation systems on Yellowstone River fish populations and the types of improvements that would reduce their impact.
    - YRCDC will work with member Conservation Districts to distribute the YRRP 6.1 Irrigation Water Management to all irrigation water users on the Yellowstone River. This YRRP contains guidelines on methods to minimize fish entrainment and fish passage.

11.1 Position Statement – Watercraft Safety

<u>Position Statement:</u> The Yellowstone River Conservation District Council (YRCDC) will develop solutions to improve safe passage of watercraft through or around irrigation diversion structures without disrupting irrigation system operations.

Background

Recreational use of the Yellowstone River by watercraft, both powered and unpowered, is an increasingly important use of the river. Power boaters, canoeists, rafters and float tubers are common along the entire length of the river to fish, hunt, bird watch, or just to enjoy the scenery that the river has to offer. Several irrigation diversion structures currently span the width of the river, preventing the safe passage of watercraft. Public access points that allow launching of boats are often separated by these structures. This restricts the use of the river and may contribute to trespass issues for boaters wanting to use the river but unable to access it. These structures also pose an extreme danger to anyone who inadvertently goes over them into the turbulent pool below. There has been loss of life in the past. Most structures do not have an adequate warning system informing boaters that they are approaching a potentially life-threatening situation.

Recommended Management Guidelines

Following are guidelines that would help alleviate watercraft safety issues on the Yellowstone River:

- <u>New Structures:</u> Any new irrigation structure that could impede movement of watercraft should incorporate design provisions that provide reasonable watercraft passage through or around the structure. This includes upstream passage by powerboats.

- <u>Existing Structures:</u> When existing structures are replaced, modified or maintained, structure design will provide for watercraft passage when possible.

- <u>Warning Signs – Structure Location:</u> Every cross-channel irrigation structure that impedes passage of watercraft should have warning signs on the riverbank above the structure to alert boaters of the existence of the structure and the appropriate side of the river to portage or boat around the structure.

- <u>Warning Signs – Public Access Sites:</u> Public river launch sites should have signs warning boaters of hazardous structures below and above the launch site.

Yellowstone River Conservation District Council members installing a warning sign upstream from an irrigation structure.

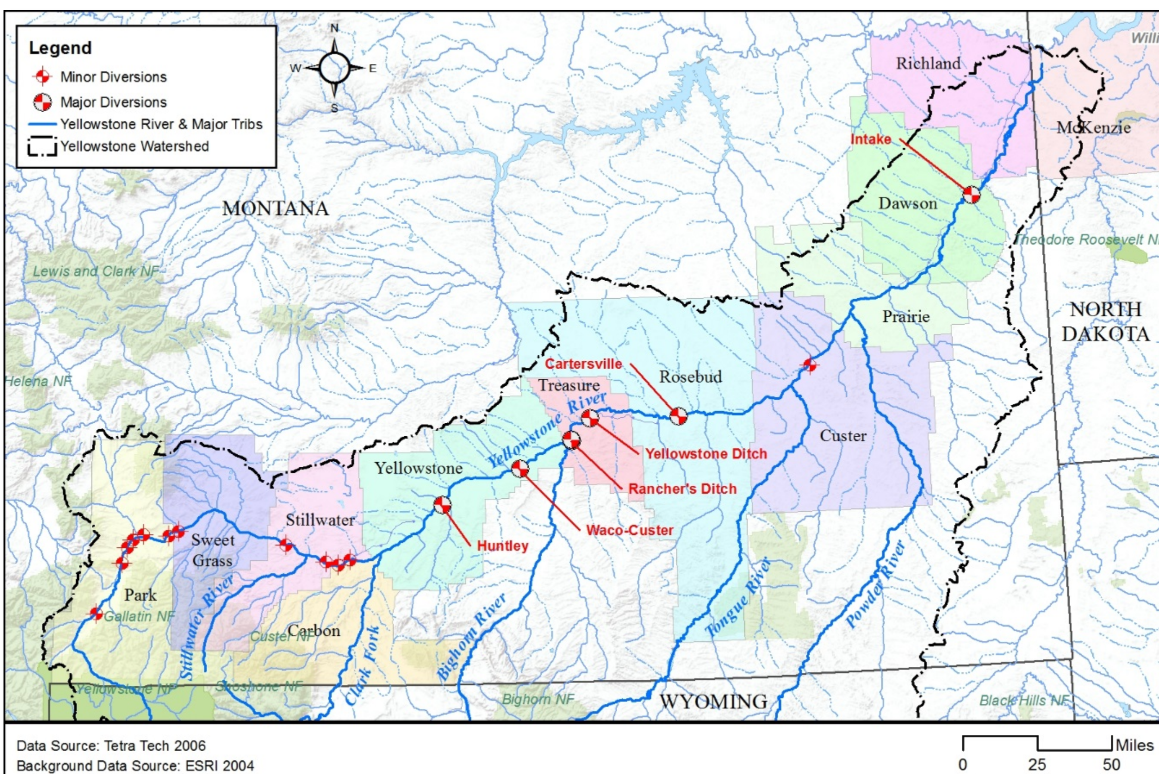
- <u>Failed Bank Armor:</u> All bank armoring (i.e. rock riprap, bendway weirs, concrete rubble, car bodies, etc.) that has failed or been flanked by the river should be removed from the active channel so it no longer poses a human safety threat. More information can be found under YRRP 2.1 Channel Bank Stabilization.

Implementation Approach

1. Structure Design Review: YRCDC and their technical advisors will review proposed designs for channel structures advocating for watercraft passage and safety provisions to be incorporated into the design. YRCDC will facilitate discussions between irrigation water users, recreation user groups and agencies to find reasonable solutions.

2. Warning Signs: YRCDC will encourage the installation and maintenance of warning signs above all structures by forging agreements between irrigation water users, recreational user groups, and riverbank landowners. They will also work with public land agencies to install signage at public river access points and include information in floaters' guides. YRCDC will help local recreation organizations and wildlife agencies secure funding for developing signage, information guides, and equipment for the local search and rescue. YRCDC will also coordinate with MFWP each year to determine if any of the existing warning signs need to be maintained or replaced.

3. Portages: YRCDC will encourage agreements between recreational user groups and landowners to establish portage routes around cross-channel irrigation structures where crossing private property is the only safe option. Portages may involve signage, building a trail to accommodate the transport of people and watercraft around the structure, and possibly fencing to avoid conflicts with livestock and river users. The irrigation headworks that may require portage routes include:
   - Huntley Irrigation District (Yellowstone County)
   - Waco-Custer (Yellowstone County)
   - Rancher's Ditch (Treasure County)
   - Yellowstone Ditch (Treasure County)
   - Cartersville (Rosebud County)
   - Intake - Lower Yellowstone Irrigation District (Dawson County)



12.1 Position Statement – Information Management

<u>Position Statement:</u> The Yellowstone River Conservation District Council (YRCDC) will assure that all pertinent information and data collected during the Yellowstone River Cumulative Effects Analysis (CEA) will be readily available for land use management decision-making along the Yellowstone River corridor and throughout the Basin. The Council recognizes that this information and data will need to be continually maintained, up-dated, and expanded upon to remain relevant.

Background

From 2004 to 2015, an unprecedented number of data sets, databases, technical reports, reach narratives, maps, and aerial photography series were generated to support the Yellowstone River Cumulative Effects Analysis (2016); however, the value and utility of this information is more far-reaching. The Council expects that this information will be extensively used by landowners, county officials, state and federal agencies, irrigation water users, and recreationists to make informed decisions that affect the economic viability and ecological integrity of the Yellowstone River corridor far into the future. For the information to remain relevant, it requires a long-term commitment to keep this information available to the public, updated as conditions change, and expanded upon to continue building upon our understanding of the Yellowstone River, tributaries, and basin.

Implementation Approach

1. <u>Information and Data Management:</u> YRCDC will continue working with the Montana State Library (MSL) to post the information and data on the Yellowstone River corridor and basin so it is readily available to the public. The YRCDC staff will regularly meet with MSL to discuss further processing, posting, and formatting of information on the Yellowstone River Clearinghouse Web Page. A long-term maintenance strategy will be followed and reviewed annually to assure the web page is current.
http://geoinfo.msl.mt.gov/Home/data/yellowstone_river_corridor_resource_clearinghouse

2. <u>Yellowstone River Reach Narratives:</u> As existing information is up-dated and new information collected, the 88 reach narratives for the Yellowstone River mainstem will be periodically reviewed, revised, and redistributed to the public at least every 5 to 10 years.

3. <u>Future Research and Data Collection:</u> YRCDC will initiate new data collection/research projects that augment existing studies and fill data gaps identified in the CEA and Yellowstone River Recommended Practices (YRRPs). For new research proposals associated with the Yellowstone River Basin, the YRCDC will determine what their level of participation and support will be based upon its usefulness and practical applications for decision-makers in the Yellowstone River Basin. In some cases, the YRCDC will assist organizations, agencies, and universities secure funding and/or provide local outreach to successfully complete their research or data collection. Specific research and data needs have been listed in the individual YRRPs. They should be reviewed regularly to be sure they will adequately address resource concerns and information needs.

4. <u>Technology Transfer:</u> Most YRRPs have an outreach/education component in their “Implementation Approach” section. It provides recommendations on the most appropriate venue(s) for conveying information to a specific audience and/or the general public.

- YRPP Implementation Monitoring - The YRCDC will collaborate with individual Conservation Districts and state/federal agencies to periodically evaluate the effectiveness of the "Implementation Approaches" included with each YRRP. Adjustments will be made as needed.

- Yellowstone River Technology Forum - Organize a biennial forum for applied scientists, academic researchers, conservation organizations, agencies, and landowners to report on their current research, experiences, and observations related to the health and function of the Yellowstone River.

Appendix A Reach Summary - Restoration Priorities

Reach Identification	Length (km)	County	YRRP 1.1 - Floodplain Restoration	YRRP 1.2 - Floodplain Restoration – MRL and BNSF Railroad Berms	YRRP 1.2 - Floodplain Restoration – Public Highways and County Roads	YRRP 1.2 - Floodplain Restoration - Milwaukee Railroad Berm	YRRP 1.3 - Side Channel Blockage Removal - Side Channel Restoration	YRRP 2.1 - Channel Bank Stabilization - Railroad Grade Protection	YRRP 2.1 - Channel Bank Stabilization - Failed Bank Armor and Flow Deflector Removal	YRRP 3.2 - Invasive Woody Plant Control - Russian Olive Control	YRRP 5.1 - Solid Waste Removal	YRRP 6.1 - On-Farm Irrigation Water Management	YRRP 6.1 - Fish Passage
PC-1	7.6	Park			x					x			
PC-2	5.0	Park			x					x			
PC-3	16.6	Park			x					x			
PC-4	5.8	Park			x					x			
PC-5	6.2	Park			x		x	x	x	x			
PC-6	6.9	Park			x					x			
PC-7	9.9	Park			x		x			x			
PC-8	20.3	Park			x					x			
PC-9	3.1	Park			x					x			
PC-10	5.6	Park			x		x			x			
PC-11	3.8	Park			x		x			x			
PC-12	3.2	Park			x					x			
PC-13	2.5	Park			x					x			
PC-14	5.6	Park		x	x		x	x	x	x			
PC-15	2.9	Park		x	x			x		x			
PC-16	6.9	Park		x	x		x	x	x	x			
PC-17	3.2	Park		x	x		x			x			
PC-18	8.5	Park		x	x		x	x		x		x	
PC-19	4.4	Park		x	x					x		x	
PC-20	7.2	Park		x	x			x		x			
PC-21	3.7	Park		x	x			x		x		x	
A-1	5.4	Sweet Grass		x	x		x	x		x			
A-2	11.1	Sweet Grass		x	x		x	x		x			
A-3	8.6	Sweet Grass		x	x					x		x	
A-4	5.6	Sweet Grass		x	x		x	x	x	x	x		
A-5	5.2	Sweet Grass		x	x					x			
A-6	4.8	Sweet Grass		x	x		x	x		x		x	
A-7	15.9	Sweet Grass		x	x		x	x	x	x			
A-8	8.2	Sweet Grass		x	x		x	x		x		x	
A-9	6.2	Sweet Grass Stillwater		x	x		x	x		x		x	
A-10	6.9	Stillwater		x	x					x		x	
A-11	11.2	Stillwater		x	x		x	x	x	x	x		

Reach Identification	Length (km)	County	YRRP 1.1 - Floodplain Restoration	YRRP 1.2 - Floodplain Restoration – MRL and BNSF Railroad Berms	YRRP 1.2 - Floodplain Restoration – Public Highways and County Roads	YRRP 1.2 - Floodplain Restoration - Milwaukee Railroad Berm	YRRP 1.3 - Side Channel Blockage Removal - Side Channel Restoration	YRRP 2.1 - Channel Bank Stabilization - Railroad Grade Protection	YRRP 2.1 - Channel Bank Stabilization - Failed Bank Armor and Flow Deflector Removal	YRRP 3.2 - Invasive Woody Plant Control - Russian Olive Control	YRRP 5.1 - Solid Waste Removal	YRRP 6.1 - On-Farm Irrigation Water Management	YRRP 6.1 - Fish Passage
A-12	9.8	Stillwater		x	x		x	x	x	x			
A-13	5.8	Stillwater		x	x			x		x			
A-14	12.5	Stillwater		x	x		x	x		x		x	
A-15	9.5	Stillwater Carbon		x	x		x			x			
A-16	12.4	Stillwater Carbon		x	x					x			
A-17	10.4	Stillwater Yellowstone		x	x		x		x				
A-17	10.4	Yellowstone Carbon		x	x			x					
A-18	3.8	Yellowstone	x	x	x				x	x		x	
B-1	24.6	Yellowstone		x	x		x		x				
B-2	9.8	Yellowstone		x	x		x	x					
B-3	7.0	Yellowstone		x	x		x	x			x		
B-4	6.1	Yellowstone		x	x			x	x	x		x	x
B-5	12.0	Yellowstone		x	x		x	x	x		x		
B-6	9.9	Yellowstone	x	x	x		x						
B-7	13.9	Yellowstone		x	x								
B-8	14.7	Yellowstone		x	x		x	x			x		
B-9	7.5	Yellowstone		x	x		x	x		x			x
B-10	11.6	Yellowstone		x	x		x	x	x	x			
B-11	13.1	Yellowstone		x	x		x	x		x		x	
B-12	7.3	Yellowstone		x	x			x		x			
C-1	9.5	Treasure		x	x		x	x					x
C-2	8.9	Treasure	x	x	x		x	x		x		x	
C-3	7.6	Treasure	x	x	x			x		x		x	
C-4	6.1	Treasure	x	x	x					x		x	x
C-5	5.1	Treasure	x	x	x		x			x		x	
C-6	9.1	Treasure		x	x		x			x		x	
C-7	14.7	Treasure		x	x		x	x				x	
C-8	10.4	Treasure Rosebud		x	x		x			x		x	
C-9	17.2	Rosebud		x	x	x	x	x				x	
C-10	11.0	Rosebud	x	x	x	x		x	x				x
C-11	18.3	Rosebud		x	x	x	x	x	x			x	
C-12	16.2	Rosebud		x	x	x	x	x				x	

Reach Identification	Length (km)	County	YRRP 1.1 - Floodplain Restoration	YRRP 1.2 - Floodplain Restoration – MRL and BNSF Railroad Berms	YRRP 1.2 - Floodplain Restoration – Public Highways and County Roads	YRRP 1.2 - Floodplain Restoration - Milwaukee Railroad Berm	YRRP 1.3 - Side Channel Blockage Removal - Side Channel Restoration	YRRP 2.1 - Channel Bank Stabilization - Railroad Grade Protection	YRRP 2.1 - Channel Bank Stabilization - Failed Bank Armor and Flow Deflector Removal	YRRP 3.2 - Invasive Woody Plant Control - Russian Olive Control	YRRP 5.1 - Solid Waste Removal	YRRP 6.1 - On-Farm Irrigation Water Management	YRRP 6.1 - Fish Passage
C-13	10.8	Rosebud		x	x	x	x	x	x			x	
C-14	19.6	Rosebud Custer	x	x	x	x	x	x	x	x	x	x	
C-15	6.0	Custer		x	x	x		x		x			
C-16	11.6	Custer		x	x	x		x					
C-17	7.2	Custer	x	x	x		x	x			x	x	
C-18	5.2	Custer		x	x		x					x	
C-19	17.9	Custer		x	x		x	x				x	
C-20	12.2	Custer Prairie		x	x			x				x	
C-21	15.2	Custer Prairie		x	x			x		x		x	
D-1	19.5	Prairie		x	x			x			x	x	
D-2	17.0	Prairie		x	x			x		x	x		
D-3	13.4	Prairie Dawson		x	x			x		x	x	x	
D-4	17.7	Dawson		x	x		x	x			x	x	
D-5	20.3	Dawson		x	x		x	x			x		
D-6	8.9	Dawson	x	x	x		x	x	x	x			
D-7	12.3	Dawson		x	x			x		x	x		
D-8	16.4	Dawson		x	x			x	x	x			x
D-9	5.6	Dawson		x	x		x			x		x	
D-10	18.3	Dawson Wibaux Richland		x	x			x	x	x		x	
D-11	10.3	Richland		x	x		x	x				x	
D-12	21.9	Richland		x	x		x					x	
D-13	13.8	Richland		x	x							x	
D-14	23.1	Richland McKenzie		x	x		x				x	x	
D-15	9.6	McKenzie		x	x					x		x	
D-16	11.9	McKenzie		x	x					x		x	