Qualitative Rapid Assessment

2023 Status Report

Milltown Reservoir / Clark Fork River NPL Site Clark Fork River Operable Unit, Reach A, Phase 1, Phase 2, and Phases 5 and 6

Prepared for:

Montana Natural Resource Damage Program & Montana Department of Environmental Quality

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Milltown Reservoir / Clark Fork River NPL Site Clark Fork River Operable Unit, Reach A

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Introduction

This document describes the results of the 2023 Qualitative Rapid Assessment (QRA) completed for Phases 1, 2, 5 and 6 of the Clark Fork River Operable Unit (CFROU) Reach A. The QRA is a monitoring protocol for evaluating overall project performance and maintenance needs, and is intended to be conducted periodically, by an adaptive management team (AMT) consisting of project managers, agency personnel and designers (Geum and AGI 2015) and is separate from the performance monitoring conducted by the Montana Department of Environmental Quality (DEQ) as part of the performance monitoring program (see 'CFROU Performance Monitoring Program Background' section for details). The QRA evaluates vegetation and geomorphic conditions of remediated and restored phases that can be visually observed. Goals of the 2023 QRA differ from previously performed QRAs and include:

1. Observe restored and remediated phases to inform future CFROU phase designs.
2. Evaluate progress toward recommended Performance Standards specified in the Record of Decision (ROD) (DEQ and EPA 2004).
3. Determine the need for maintenance or adaptive management.

This QRA provides current streambank and vegetation conditions of remediation and restoration projects completed in Reach A of the CFROU between 2011 and 2023 and includes Phase 1, 2, 5 and 6. Phases 15 and 16 were completed between 2018 and 2019 but occur on Grant Kohrs National Historic Site and are evaluated separately. Phase 3 and 4A were being completed at the time of the 2023 QRA and were not included in the assessment. Table 1 provides an overview of dates completed phases have been monitored, including QRAs and performance monitoring conducted by DEQ. Results of past QRAs are described in Geum and AGI 2015, 2017, and 2019.

In addition to describing the methods and results of the 2023 QRA, this document also provides discussion on how QRA results indicate trends towards meeting ROD performance standards, and recommendations for adaptive such as future design considerations, maintenance recommendations and next steps.

Table 1. Overview of phases evaluated in 2023 QRA.

CFROU Phase	Construction Years	QRA Evaluation Dates [1]	Performance Monitoring Years
1	2013-2014	July 8, 2015 July 11, 2016 September 11, 2017 August 8, 2023	2014 (Year 1) [2] 2019 (Year 5) [3] 2022 (Year 7) [3]
2	2016-2017	September 11, 2017 August 8, 2023	2019 (Year 3) [3] 2021(Year 5) [3]
5	2015-2016	July 12, 2016 September 12, 2017 August 9, 2023	2019 (Year 3) [3] 2021 (Year 5) [3]
6	2015-2017	July 12, 2016 September 12, 2017 August 9, 2023	2019 (Year 3) [3] 2021 (Year 5)

[1] Results from 2015, 2016, and 2017 are reported in Geum and AGI 2017 and 2019.
[2] Vegetation monitoring has been conducted according to methods in Geum and AGI 2015.
[3] Vegetation monitoring has been conducted according to methods in RESPEC 2023.

2023 QRA Methods

This section describes the methods used for the 2023 QRA. The original QRA methods evaluate the four geomorphic metrics included as performance targets in the 2015 Monitoring Plan: channel stability, floodplain stability, floodplain inundation/connectivity, and physical bank conditions; and the four vegetation metrics included as performance targets in the 2015 Monitoring Plan: streambank woody vegetation cover, floodplain woody vegetation cover, floodplain herbaceous vegetation cover, and survival of woody species. Because the monitoring program for Reach A of the CFROU no longer follows the 2015 Monitoring Plan the 2023 QRA took a different approach than previous QRAs and focused on the three goals outlined in the introduction of this document which are:

- Observe restored and remediated phases to inform future CFROU phase designs.
- Evaluate progress toward recommended Performance Standards specified in the Record of Decision (ROD) (DEQ and EPA 2004).
- Determine the need for maintenance or adaptive management.

Data were collected to evaluate progress towards the two vegetation ROD Performance Standards within the 50-foot Streambank and Riparian Corridor Buffer Zone (streambank buffer zone) – percent preferred woody species canopy cover and percent total canopy cover of non-weed perennial vegetation; and the one vegetation ROD performance standard Outside the Streambank and Riparian Corridor Buffer Zone but Within the Historic 100-year Floodplain (outside the streambank buffer zone) – percent total canopy cover of non-weed perennial vegetation (Table 11). Additionally, streambank treatments were observed, locations of noxious weeds recorded, and general observations were made to documenting river and floodplain processes. Table 5 provides a summary of the observation categories included in the 2023 QRA. Each category is described in more detail below. To collect field data, QRA participants divided into two groups, each group walking one side of the river in each phase. At least one person from each group walked and made observations along the streambanks and another person made observations within the floodplain and off channel wetland features.

Drone Imagery Acquisition and Analysis

Prior to conducting field work for the QRA, high-resolution imagery was collected using a DGI Phantom 4 Pro Drone flown at approximately 300 feet above the ground surface on July 10 (Phases 1 and 2) and July 11 (Phases 5 and 6). During this time, flows at the Clark Fork near Galen, MT (12323800) USGS gage were between 265 and 300 cfs. The imagery was reviewed prior to field work and locations where vegetation type or cover were unclear in the imagery were identified as specific locations to visit in the field to verify existing ground conditions and assist in in-office data interpretation. The imagery was also used as a background in field maps of each phase along with as-built streambank treatment and floodplain planting unit locations labeled by types and an individual identification label. Field maps along with a resource grade global positioning system (GPS) and the Avenza Maps cell phone app (Avenza) were used to document observations such as woody vegetation expansion, canopy cover, noxious weeds, and other relevant data. After collecting field data, field notes were digitized in ArcGIS and used in conjunction with the high-resolution imagery to quantify woody vegetation canopy cover and herbaceous cover.

Streambank Treatments

Streambank treatments were observed during the 2023 QRA. All streambanks were observed for low cover or maintenance needs and pertinent observations were recorded using the unique streambank treatment ID on field forms or field maps. In past QRAs, each individual streambank treatment was evaluated for canopy cover and structural integrity. Some streambanks were flagged to observe and monitor in future QRAs. Reasons for flagging a streambank varied and include, for example, low woody canopy cover, compromised treatment integrity, and/or accelerated erosion. All previously flagged streambanks were observed during the 2023 QRA and evaluated for maintenance needs.

Woody Vegetation Cover

As part of the 2023 QRA woody cover of riparian species was observed. Woody cover along the riparian zone is a result of the combination of planted species from remedy and restoration, expansion from streambanks treatments, and natural recruitment.

The lateral extent of woody cover from the streambank into the floodplain was recorded on field maps or using a GPS or Avenza and a relative percent cover assigned to the various polygons. In the office, field data was digitized and refined or extrapolated using the high-resolution imagery to create a continuous woody cover polygon along the streambanks. These polygons were used to evaluate woody vegetation within the ROD specified streambank buffer zone (approximate 50-foot width along the channel) and outside of the streambank buffer zone.

Non-weed Perennial Vegetation Cover

Non-weed perennial vegetation cover was observed throughout each phase and quantified within 30-foot by 30-foot plots. Three to six plots were collected on each side of the river within each phase. Most plots were outside of the streambank buffer zone; six were within the streambank buffer zone. Within each plot, a total relative cover percentage was assigned, a species list was recorded and dominant species were identified. Additionally, areas identified in the high-resolution aerial imagery as unknown or potentially low total cover or areas identified as low cover in the previous 2018 QRA were also visited to verify field conditions.

Noxious Weed and Other Undesirable Species Cover

All areas visited within each phase were observed for noxious weed presence. All observations were recorded on field maps, with a GPS or on digital maps in Avenza. If noxious weed cover was greater than a few individual plants, an approximate polygon size was estimated. Other non-noxious, but invasive and potentially problematic species such as Russian-olive and reed canarygrass were also noted.

General Observations

General observations were documented throughout each phase. General observations included: areas of natural recruitment of willows and cottonwoods, overall vegetation development trends, signs of wildlife use or browse, evidence of natural flood disturbance processes, streambank condition, and other potential adaptive management and maintenance actions.

Table 2. Observation categories and methods for 2023 QRA.

2023 QRA OBSERVATION CATEGORIES and METHODS	
STREAMBANK TREATMENTS	**METHODS DESCRIPTION**
Streambank treatment	• Visit all banks flagged in the 2018 QRA to be monitored in the next QRA. • Note any banks that are low in woody cover or eroding. • Note any issues or positive aspects about brush matrix treatments (the primary treatment that will continue to be used in future phases).
WOODY VEGETATION COVER	**METHODS DESCRIPTION**
Within the Streambank and Riparian Corridor Buffer (50-foot woody vegetation cover zone)	• Spot check widths of woody **riparian** vegetation along the streambanks. • GPS the back edge of woody vegetation at numerous locations. • Record the mechanism of expansion or age classes as appropriate.
Outside of the Streambank and Riparian Corridor Buffer but within the Historic 100-year Floodplain	• Visit areas of high woody vegetation floodplain cover away from streambanks and note mechanism in which the woody vegetation established (i.e. willow expansion from flooding v. container plants). Refer to 2018 QRA inundation maps and planting unit locations to support this.
NON-WEED PERENNIAL VEGETATION COVER	**METHODS DESCRIPTION**
Floodplain vegetation cover - herbaceous	• Collect approx. 5, 30x30' cover plots on each side of the river in each phase and document total percent cover, a species list, and note dominant species. • Visit areas identified as unknown vegetation cover during review of high-resolution imagery prior to field work. • Visit red areas (Category 4, <20% cover) on 2018 QRA herbaceous cover maps.
NOXIOUS WEED COVER	**METHODS DESCRIPTION**
Noxious weeds	• Record all observations of noxious weeds with GPS. • Record undesirable species on field maps or with GPS – this includes Russian olive, reed canarygrass, other new/uncommon invasives, and yellow flowering vegetation apparent on high-resolution imagery which was field verified at several locations in Phase 1 and 2.
GENERAL OBSERVATIONS	**METHODS DESCRIPTION**
Wetland development	Observe all large, constructed wetlands and record observations on species composition, cover, open water, etc.
Point bars	Observe all point bars and record observations on sediment capture, vegetation colonization, bar formation/shape, etc.
Geomorphology	Observe channel stability and document locations of over-widening, aggradation, deposition, pool formation, flood erosion, etc.

2023 QRA Results and Discussion

The 2023 QRA was completed on August 8 and 9, 2023. Participants included Brian Bartkowiak (NRDP), Logan Dudding (DEQ), Jessica Banaszak (DEQ), Molly Roby (EPA), Amy Sacry (Geum), Marisa Sowles (Geum), and Gabi Poupart (Geum). This section includes the results of observations from the 2023 QRA. Attachment A provides a summary of construction timelines for each phases and monitoring completed to data in each phase. Attachment B includes an overview of July 2023 drone imagery and channel stationing for Phases 1 and 2. Attachment C includes an overview of July 2023 drone imagery and channel stationing for Phases 5 and 6. Attachment D provides 2023 photos of Phase 1. Attachment E provides 2023 photos of Phase 2. Attachment F provides 2023 photos of Phase 3.

Floodplain Vegetation Recovery Timeframes

An important consideration when determining the success and status of floodplain revegetation within remediated and restored phases is the duration of time since completion of a phase and conditions needed for vegetation to establish. Time since completion is the primary factor determining the status of vegetation establishment in each Phase. Other key factors are the timing, number, duration, timing, and extent of floods that have occurred since project completion; annual weather patterns, particularly the two years following project completion; invasive species colonization; and land management. This section provides a summary of hydrologic and drought conditions since completion of Phase 1, 2, 5 and 6. Invasive species colonization and land management are considered in later sections.

Analyzing and understanding annual spring flows relative to channel capacity helps determine floodplain vegetation response and understand ground observations. Flows that exceed the design flow channel capacity and flood the adjacent floodplain contribute sediments, organic matter, and seed to the floodplain. Sediments and organic matter help develop floodplain soils and provide a substrate favorable to the establishment of desirable woody riparian vegetation seedlings such as willows and cottonwoods. The timing and duration of out of bank flows can stimulate suckering of riparian vegetation such as willows and greatly speed up the natural expansion of woody riparian vegetation. Additionally, flows higher than the design channel capacity can contribute to streambank erosion and natural channel migration.

Design discharges for channel capacity (Q2) and constructed toe mobility (Q10) for Phases 1,2, 5 and 6 are shown in Table 3. The design flow for channel capacity increases from 522 cfs in Phase 1 to 682 cfs in Phase 6, which is an increase of about 31%. When compared to the measured flows at the USGS Upper Clark Fork River Galen Gage (USGS 12323800), design flows have been exceeded between zero days (2016) and over 50 days (2018) between construction completion and 2023 (Table 4). Phases 1 and 2 saw the 10-year flow return flow interval exceeded for 6 and 2 days respectively in 2018, indicating the potential for some constructed toe mobilization in 2018 (Table 4).

As described above, understanding annual flows, specifically those that accessed the floodplain or potentially influenced channel migration, help interpret QRA field observations. Figure 1 shows hydrographs for flows over 515 cfs for years where the design capacity was met or exceeded for any phase (note: 2015 and 2016 are not included because flows never exceed 515 cfs). In 2016 flows did not exceed 430cfs). Table 5 summarizes the timing and duration of the flows shown in Figure 1.

Meeting or exceeding a design flow; however, does not necessarily tell you the extent to which a floodplain is inundated. This was evaluated by mapping inundation extents during high flows in June 2018. Table 6 provides an overview of inundation area by phase (Geum and AGI 2019). This mapping showed that the extent to which floodplains are inundated during high flows are influenced by the area of floodplain with floodplain features such as side channels, wetlands and floodplain swales. These features increase the extent of floodplain inundation.

Years with extremely low flows also play a role in the current state and future trajectory of floodplain vegetation growth and potential channel migration. In 2015, 2016 and 2021, flows did not exceed design flows for any phases and 2016, 2022 and 2023 were rated as severe to exceptional drought (Figure 2). Years with no out of bank flows and low flows after spring runoff can stress recently planted or naturally recruited riparian vegetation, reducing survival and vegetative cover. Flows were out of bank flow in Phase 1 the first year but not the following two years which also had abnormally dry conditions in summer 2014 and 2015. Phases 2, 5, and 6 were completed during extreme or exceptional drought years and did not experience an out of bank flow until the second or third growing season after completion.

Table 3. Design flows for channel capacity and bank toe mobility (10-year return flow interval).

Phase	Design Channel Capacity (cfs) (return flow interval)	Design Toe Mobility (cfs)
Phase 1	522 (Q2)	1,094
Phase 2	584 (Q2)	1,216
Phase 5 (Above Dry Cottonwood Creek)	641 (Q2)	1,325
Phase 5/6 (Below Dry Cottonwood Creek)	682 (Q2)	1,422

As discussed above, drought years can stress newly installed vegetation and delay establishment, while years with out of bank flows can greatly supplement active revegetation treatments and increase the speed and spatial extent of vegetation establishment by depositing sediment and seed on the floodplain and providing adequate hydrology. Figure 1 below shows Clark Fork River return flow interval exceedances at Deer Lodge by year. There is clear pattern of wetter years, followed by drier years. Because floodplains develop and are self-sustained as a result of flooding events, phases completed preceding a low flow time period will take longer to meet woody cover Performance Standards within the streambank riparian corridor zone. Non-weed cover Performance Standards outside of the streambank riparian corridor zone will take longer to meet performance standard when soil moisture is low, such as during low precipitation years.

Invasive species are more likely to establish on bare floodplain surfaces created post remediation and restoration and can persist during dry years and without management. Once established, these species can be difficult to control and can prevent achievement of non-weed Performance Standards as well as desirable cover and floodplain function and self-sustainability. Land management within remediated and restored areas is critical to the success of a site and the potential to be fully operational and functional as described in the ROD. Both wildlife and livestock browse can reduce floodplain vegetation recovery rates or impact

vegetation to the extent that maintenance actions would be required to meet Performance Standards. It is important to protect areas from these impacts until vegetation is resilient enough to withstand browse. Furthermore, livestock grazing should be managed in such a way that vegetation continues to be self-sustaining. The ROD specifies the development of ranching/grazing management plans to support achievement of the Performance Standards.

Table 4. Number of days design flows were exceeded for completed phases. Empty gray cells indicate that the project had not been completed. Phase 1 was completed in time for the 2014 growing season. Phase 5 was completed for the 2016 growing season and Phases 2 and 6 were completed in time for the 2017 growing season. Years in red text indication design flows were NOT exceeded for any Phase.

Year	Number of Days Design Q Exceeded				Number of Days Q10 Exceeded			
	Phase 1	Phase 2	Phase 5	Phase 6	Phase 1	Phase 2	Phase 5	Phase 6
2014	2				0			
2015	0				0			
2016	0		0	0	0		0	0
2017	15	8	3	2	0	0	0	0
2018	60	57	53	51	6	2	0	0
2019	27	21	19	14	0	0	0	0
2020	42	31	20	16	0	0	0	0
2021	0	0	0	0	0	0	0	0
2022	4	3	1	1	0	0	0	0
2023	31	20	6	2	0	0	0	0
Total	**181**	**140**	**102**	**86**	**6**	**2**	**0**	**0**

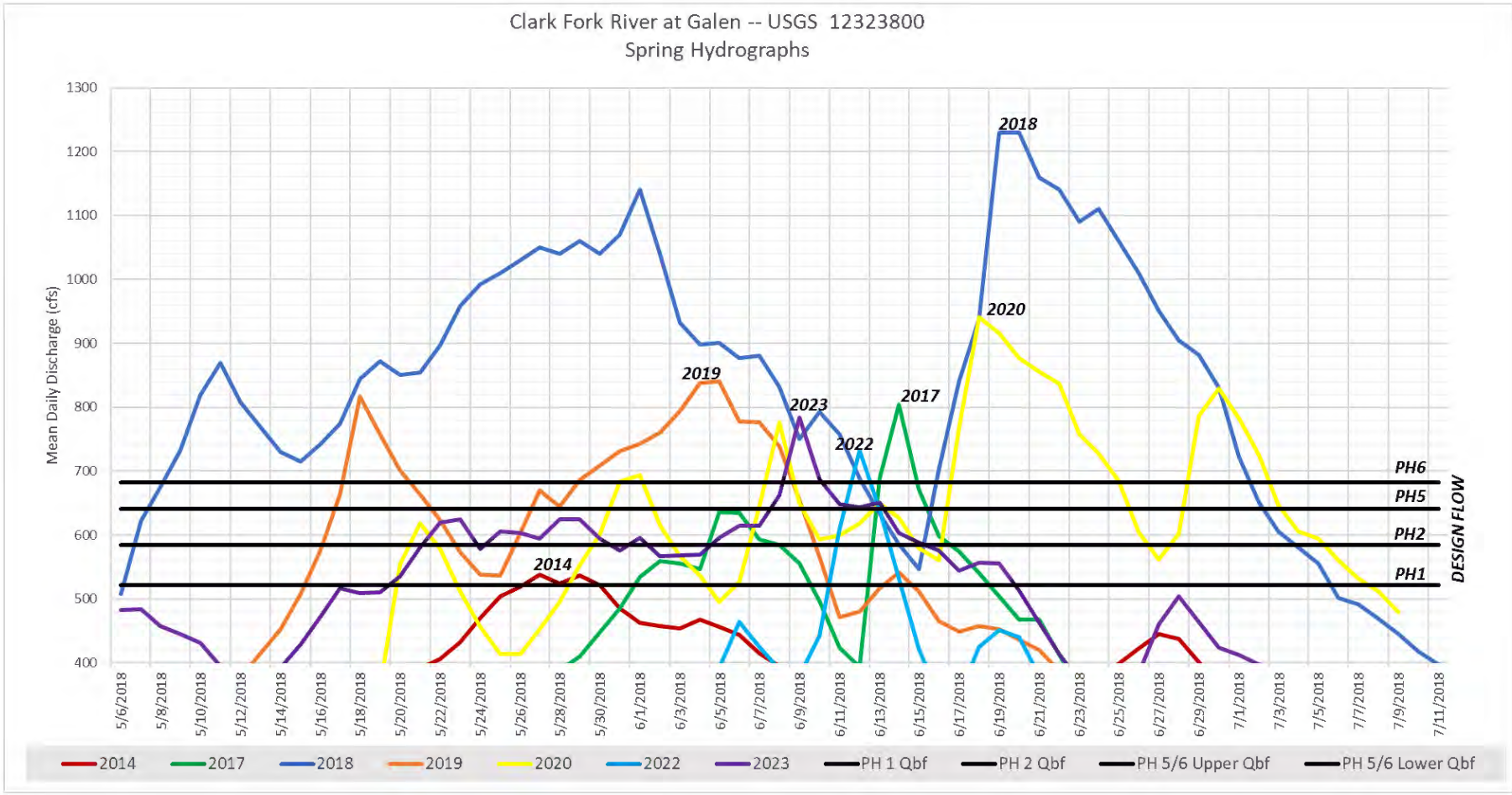

Figure 1. Spring hydrographs for years where flows exceeded phase design flows (2014, 2017, 2018, 2019, 2020, 2022, 2023). Year labels have been placed at the highest flow of each year. cfs =cubic feet per second.

Table 5. Summary of flows exceeding design flows and shown in Figure 1.

Year (Figure 1 line color)	Phases Where Design Q was Exceeded	Phases Where Q10 was Exceeded	Description
2014 (red)	Phase 1	NONE	• Design flow exceeded for two days at the end of May. • Flows close to design flow for approx. 6 days. • Only Phase 1 was completed at this time.
2017 (green)	Phase 1 Phase 2 Phase 5 Phase 6	NONE	• Early June design flow exceedances in Phases 1, 2, & 5. • A short peak in mid-June exceeded design flows in all phases. • All Phases were completed at this time.
2018 (dark blue)	Phase 1 Phase 2 Phase 5 Phase 6	Phase 1 Phase 2	• One peak flow largely sustained from early May - early July with one approx. 4-day long recession below design flows in mid-June.
2019 (orange)	Phase 1 Phase 2 Phase 5 Phase 6	NONE	• Short mid to late May design flow exceedances for all Phases • 10 day peak at the end of June exceeding design flows for all phases. • Phase 1 design flow exceeded for 1 day mid-June
2020 (yellow)	Phase 1 Phase 2 Phase 5 Phase 6	NONE	• Phase 1 and 2 design flow exceedances for 2 days in mid-May. • Second short peak in late May/early June exceeded design flows for all phases. Phase 6 design flow was exceeded for only 2 days. • Third short peak in early June. Phase 6 design flows exceeded for only day. • Fourth, and longest peak between mid and late June. Phase 6 design flows exceeded for 8 days. • Fifth moderate peak late June/ early July. Phase 6 design flows exceeded for 4 days. • Phase 1 and Phase 2 design flows were exceeded for the majority of June through the first week of April.
2022 (light blue)	Phase 1 Phase 2 Phase 5 Phase 6	NONE	• One peak flow exceeding Phase 6 design flow for 1 day. • Extreme drought year (see Figure 2).
2023 (purple)	Phase 1 Phase 2 Phase 5 Phase 6	NONE	• Design flows for Phases 1 and 2 were exceeded between mid-May and mid-June. • One peak in June exceeded Phase 6 design flows for 1 day.

Table 6. June 2018 mapped inundation extents showing flow conditions and percent flow inundation for Phase 1, 2, 5 and 6 (Geum and AGI, 2019).

Phase	Design Q2	Flow (cfs) when UAV imagery was collected (Galen Gage)	Flow (cfs) exceeding design Q2 when UAV imagery was collected	Acreage of floodplain inundated within removal boundary	Percent of floodplain inundated within removal boundary
1	522	898	376	31.5	57%
2	584	899	315	22.4	26%
5	641	901	260	29.4	39%
6	682	901	219	11.5	23%

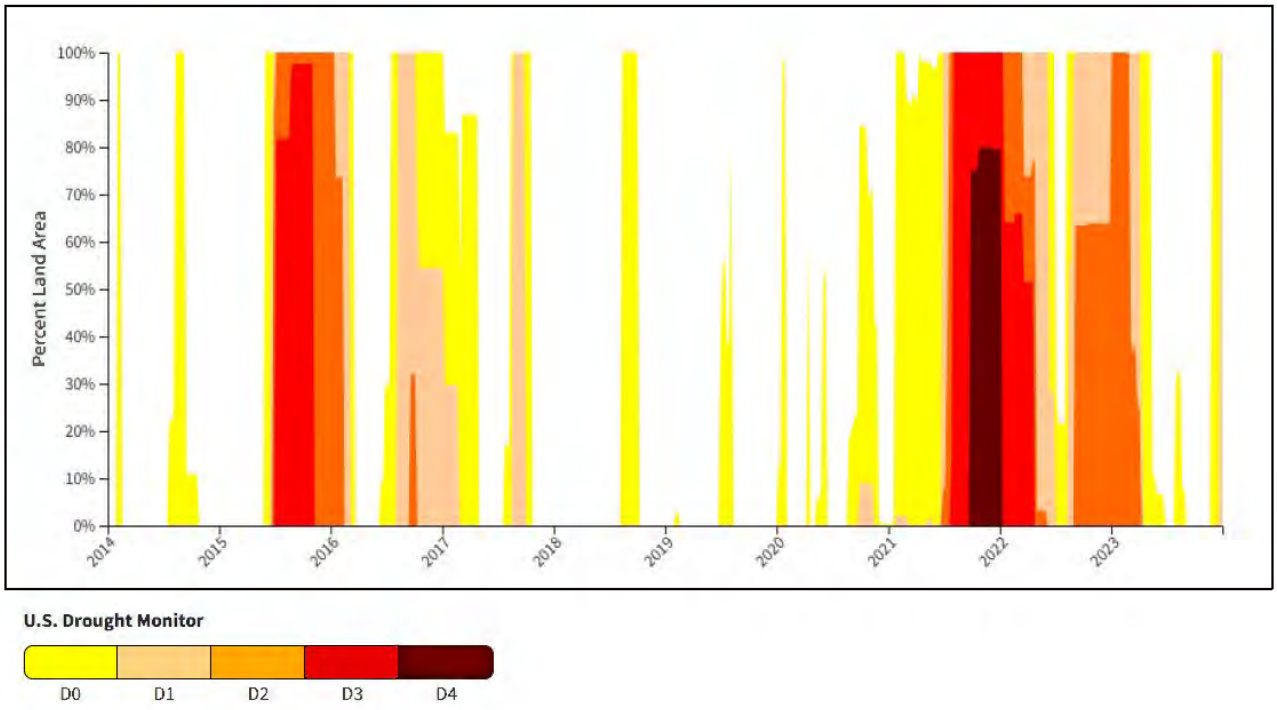

Figure 2. U.S. Drought Monitor data for Powell County between 2018 and 2023. Drought categories are: D0 = Abnormally Dry, D1 = Moderate Drought, D2 = Severe Drought, D3 = Extreme Drought, D4 = Exceptional Drought (NOAA & NIDIS 2023). The X-axis represents the date and the Y-axis represents the percent area within a drought category. Phase 1 was completed in 2024; Phase 5 was completed in 2016 and Phase 2 and 6 were completed in 2017.

Results and Discussion by Observation Category

This section describes results of the 2023 QRA by observation category. Attachment F provides photos of the range of conditions observed in 2023 in Phase 1. Attachment EG provides field photos of the range of conditions observed in 2023 in Phase 2. Attachment H provides field photos of the range of conditions observed in 2023 in Phases 5 and 6. Previous QRAs and as-built documents provide details and locations of treatments installed in each phase.

Streambank Treatments

In 2023 all streambanks in Phase 1, 2, 5 and 6 were observed. Overall, streambank treatments are providing the stability needed for woody vegetation to establish, fulfilling the primary design intent of streambank treatments used to date. In most phases, willow cuttings placed in streambank treatments have become well established and are expanding into the adjacent floodplain. Cover of willows on the face of each treatment varies. Some streambanks on outside meander bends are eroding. Streambanks identified during the last QRA in 2018 to re-visit during the following QRA because erosion had occurred were all observed in 2023. No streambanks were identified for maintenance needs or additional monitoring. Observations and trends for each type of streambank treatment are listed below.

Preserve Vegetation Streambank Treatment

Preserve Vegetation streambank treatments include leaving existing vegetation and soil on a streambank intact during remediation and restoration because the elevation of the bank is near the design bank height and the streambank supports desirable riparian vegetation, either woody or herbaceous. Phase 1 had the most of this treatment type due to the presence of woody riparian vegetation low in the bank. Phase 2 also had several woody preserve vegetation streambank treatments. Phases 5 and 6 had very few woody preserve vegetation streambanks but had several herbaceous preserve vegetation streambanks along passive margins such as straight sections of the channel or inside meander bends. In Phases 5 and 6 low portions of inside meander bends were often preserved with higher portions removed and new point bar features constructed and blended into low preserved vegetation areas. Below is a list of the main observations of this streambank treatment type in 2023:

- In Phase 1 and 2 preserve vegetation streambanks typically consist of willow or birch that extend into the adjacent channel providing cover and roughness to the river (Figure 3). All preserve vegetation streambank treatments with woody vegetation continued to provide high cover in 2023. No erosion or bank instability was observed at these treatment types.
- Preserve vegetation streambanks with herbaceous remained intact and supported some new willow growth (Figure 4).
- Expansion of willows behind preserved streambanks with woody vegetation was typically wide and robust.
- One streambank in Phase 2 and several streambanks in Phases 5 and 6 were not treated because they are naturally high banks where contaminated sediments did not deposit in 1908 (No Treatment streambanks). These banks continue to erode and contribute clean sediment to the river (Figure 5

Figure 3. Examples of preserved streambank treatments with woody vegetation in Phase 1 (top) and Phase 2 (bottom).

Figure 4. Left - Example of preserved streambank with woody vegetation in Phase 5. Right – Example of preserved streambank with herbaceous vegetation in Phase 6 with brush trench installed at the back edge of the preserved vegetation.

Figure 5. No Treatment streambanks in Phase 6.

Vegetated Soil Lift Streambank Treatment

Vegetated soil lift streambank treatments were used in Phase 1, 2, 5 and 6. In Phase 1, all streambanks that could not be preserved and outside of constructed point bar areas were treated with vegetated soil lifts. In Phases 2, 5 and 6 vegetated soil lifts were constructed in streambanks with higher shear stress such as outside meander bends. Below is a list of the main observations of this streambank treatment type in 2023:

- Overall, vegetated soil lifts had high cover of willows and many of these treatments are beginning to establish overhanging woody vegetation cover and undercut features similar to preserve vegetation streambanks (Figure 6).
- Some banks with dense willow cover have not formed undercut banks in areas where cobble placed at the toe of the lifts has not eroded. Streambank toe material has been sized to resist 10-year return interval shear stresses (Figure 7).

- Coir used in vegetated soils lifts is expected to begin degrading by year 5 and all phases monitored in the 2023 QRA had been in place for 6 years or longer (i.e. had been exposed to spring flows a minimum of 6 times). Coir fabric had degraded to varying degrees and on some streambanks the fabric had degraded enough to result in displacement of the coir log placed inside the fabric. Even in areas where a portion of the soil lifts were lost willow cover was generally high behind the bank and did not show signs of accelerated erosion although erosion is occurring at some of these banks (Figure 8).
- Herbaceous wetland species are colonizing coir logs in many locations and in some areas, deposition occurs at the base of the treatment where sedges or willows were colonizing and encroaching into the channel beyond the face of the bank treatment. See Figure 9, right photo below.

Figure 6. Soil lifts with dense woody cover of willows starting to develop habitat features similar to preserved vegetation streambank treatments (top row Phase 1) (middle row Phase 2), bottom row Phase 5-6.

Figure 7. Soil lifts with cobble toe preventing undercut bank formation.

Figure 8. Examples of banks where soil lifts have been lost but willows are suckering out into bank face (photo right) or dense willows occur in the bank behind the lost soil lift (photo left).

Figure 9. Left - Example of vegetated soil lift coir fabric and coir log being replaced with woody vegetation and colonized by herbaceous wetland vegetation.

Brush Matrix Streambank Treatment

Brush matrix streambank treatments were used in Phase 2, 5 and 6. In Phases 2, 5 and 6 brush matrix treatments were constructed in streambank locations between areas of higher shear stress and inside bends or constructed point bars (i.e. straight sections of the channel). Brush matrix treatments were built primarily with woody material cleared from the floodplain prior to contamination removal. These banks were constructed with varying densities of salvaged brush. Willow cuttings were installed in all brush matrix treatments. Below is a list of the main observations of this streambank treatment type in 2023:

- Brush used to construct brush matrices was still intact at nearly all treatments.
- Willow growth and expansion was observed at nearly all treatments.
- Brush matrices located in more passive sections of the river included deposition at the base of the treatment where sedges or willows were establishing and encroaching into the channel beyond the face of the treatment.
- Brush matrices that had slumped (uncommon) provided a surface for willows to colonize on the face of the treatment. See left photo in Figure 10.
- Brush material in some brush matrices extends well into the channel providing overhanging cover. See right photo in Figure 10.

Figure 10. Left - Example of brush matrix providing overhanging cover and willows colonizing the face of the treatment (Phase 5). Right – Example of brush matrix with high woody cover behind bank and undercutting.

Bifurcation and Large Wood Streambank Treatments

Bifurcation treatments were used in Phase 1 and Phase 5 at split flow locations. A large wood streambank treatment (Logan's matrix) was installed in Phase 5 where the channel abuts the former railroad grade to transition into existing riprap These treatments are built similar to but with larger diameter wood material than Brush Matrix streambank treatments. Below is a list of the main observations of this streambank treatment type in 2023:

- Treatments remained intact in 2023 and are maintaining deep pools (Figure 11).
- Woody vegetation is expanding in all locations.
- Coarse wood is beginning to accumulate at structure locations (Figure 11, left photo).

Figure 11. Top left - Phase 2 Bifurcation treatment. Top right - Phase 2 Large Wood streambank treatment. Bottom – Phase 5 Bifurcation treatment at head of island.

Woody Vegetation Cover

Woody vegetation within the streambank buffer zone (approximate 50-foot width along the channel) (buffer zone) and outside of the streambank buffer zone but within the historic 100-year floodplain was documented both in the field and remotely in the office using the high-resolution imagery with support of field notes and GPS data. Using ArcGIS, all mature and establishing woody vegetation was mapped and quantified. Figure 15 shows the results of woody vegetation mapping for Phase 1. Figure 16 shows the results of woody vegetation mapping for Phase 2. Figure 17 shows the results of woody vegetation mapping for Phase 5. Figure 18 shows the results of woody vegetation mapping for Phase 6. Table 7 provides acres and percent of area of woody cover by phase within the buffer zone and outside the buffer zone. Phase 1 had the highest percentage of the buffer zone occupied by woody vegetation with 49.7%; Phases 2, 5 and 6 had similar percentage of area within the buffer zone with woody vegetation with 26.8%; 29.4% and 30.7% respectively. Attachments D, E and F include photos that show woody vegetation cover in each phase.

In general, woody cover was observed within areas where out of bank flows accessed the floodplain, or where the floodplain was low enough to intercept groundwater within the root zone during portions of the growing season. In Phase 1, willow expansion and cover behind streambanks is extensive in some areas and willow cover closely follows 2014 and 2018 high flow paths through the floodplain (see Geum and AGI, 2019 for more details) (Figure 12). Phase 1 has also experienced more days out of bank based on design flows than any other phase (Table 4). Along streambanks, very few containerized plants were recognizable in Phase 1 and had either been replaced by natural recruitment and streambank willow expansion or are now mature and part of the riparian buffer vegetation community. Further from the streambank some planted shrubs are still found, primarily silver buffaloberry (*Shepherdia argentea*) which was heavily browsed throughout the site (Figure 13). Outside of the streambank buffer zone woody vegetation is concentrated in floodplain features and along high flow erosion pathways. The side channel on the west side of the channel at the downstream end of Phase 1 has dense cover of willows from flood activation (left bank Station 110+00 to 123+00). Larger floodplain swales support woody vegetation but many smaller swales support cattails. Phase 1 has a greater percentage of the constructed floodplain area with floodplain features compared to other phases (13.% of total area compared to 4.5% in Phase 2, 3.7% in Phase 5 and 0% in Phase 6). This translated to a much higher percent of the floodplain being inundated in 2018 compared to other phases (57% of the area within the removal boundary compared to 26% in Phase 2, 39% in Phase 5 and 23% in Phase 6) (Geum and AGI, 2019).

In Phase 2, willow expansion from streambanks in the streambank buffer zone was observed; however, the width of expansion is much narrower compared to Phase 1. This is likely a direct response to less floodplain inundation as described above. Containerized plant survival was high and numerous planted species were observed. As described in the revegetation as-built report for Phase 2, most woody vegetation was planted within the streambank buffer zone, in meander cores or in constructed floodplain features. Willow cover was very high in constructed floodplain features on both sides of the river at the upstream end of the phase with many swales having 100% cover and willows starting to expand beyond the edges of the swale feature. Woody vegetation cover was low in floodplain features on the west side (station 150+00 to 180+00) where the floodplain was re-built to the 10-year return flow elevation. Willow cover is also high in the constructed oxbow near the upstream end of Phase 2 (right bank station 140+00) and on the island on the east side of the channel between station 197+00 and

205+00. Several non-willow species were observed including black cottonwood (*Populus trichocarpa*), red-osier dogwood (*Cornus sericea*), water birch (*Betula occidentalis*), alder (*Alnus incana*), and silver buffaloberry. Browse was moderate to heavy on planted species. Ungulate browse on planted shrubs and trees was moderate in Phase 2 (Figure 14). Many planted areas were also characterized by very high cover of sweet clover (*Melilotus officinalis*) and tumble mustard (*Sisymbrium altissimum*). These species are non-native but generally considered naturalized. They are annuals or biennials and typically don't persist for more than a couple of years. They may be preventing some growth of containerized plants or other naturally colonizing woody vegetation but they also appear to be creating cooler, moister conditions for woody seedlings, may help build organic matter and fix nitrogen in the soil, and may also be preventing noxious weed expansion and protecting seedlings and smaller planted shrubs from ungulate browse. Numerous planted cottonwood trees were greater than 15 feet tall. Those protected with metal cages were much taller in height than unprotected cottonwoods.

In Phases 5 and 6 woody cover within the streambank buffer zone varied but was generally high within 10 feet of the streambank. Willow cover persisted to approximately 20 feet from the streambank on average but cover was much less compared to the first 10 feet. Containerized plants were observed throughout Phase 5 and 6. The most common species observed included buffaloberry, inland gooseberry (*Ribes setosum*), water birch, willow species (*Salix spp*), quaking aspen (*Populus tremuloides*), black cottonwood and, in Phase 6, alder. Similar to Phase 2, some cottonwood trees were greater than 15 feet tall.

Table 7. Total acres within and outside of the streambank riparian corridor zone by phase and percent cover of the streambank riparian corridor zone with woody cover.

Phase	Total acres woody cover within 50-foot Streambank and Riparian Buffer	Total percent woody cover 50-foot Streambank and Riparian Buffer	Additional acres of mapped woody vegetation outside of 50-foot Streambank and Riparian Buffer
Phase 1	10.43	49.7	5.9
Phase 2	7.3	26.8	1.8
Phase 5	8.7	29.4	1.7
Phase 6	7.9	30.7	3.5

Figure 12. Phase 1 island right bank station 85+00 that has been frequently activated by high flow events in 2015 1 year after planting (left) and in 2023 (right).

Figure 13. Heavy browse on silver buffaloberry planted in Phase 1. These plants are more than 10 years old and should be 10-15 feet tall.

Figure 14. Ungulate browse on planted black cottonwood (left) and red-osier dogwood in Phase 2.

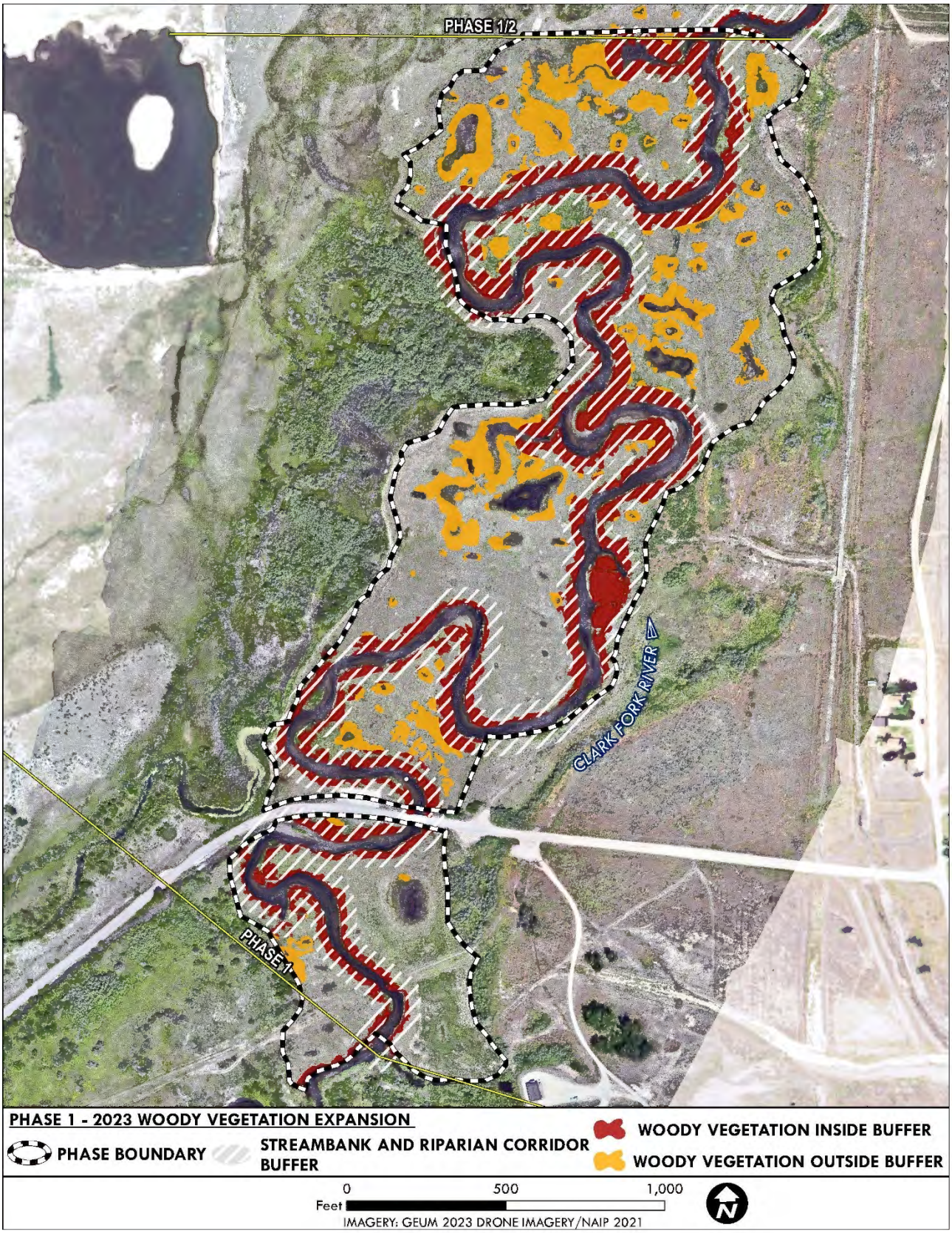

Figure 15. Estimated woody vegetation cover within the 50-foot Streambank and Riparian Corridor Buffer Zone and outside this Zone but within construction limits for Phase 1.

Figure 16. Estimated woody vegetation cover within the 50-foot Streambank and Riparian Corridor Buffer and outside this zone but within construction limits for Phase 2.

Figure 17. Estimated woody vegetation cover within the 50-foot Streambank and Riparian Corridor Buffer Zone and outside this zone but within construction limits for Phase 5.

Figure 18. Estimated woody vegetation cover within the 50-foot Streambank and Riparian Corridor Buffer Zone and outside this zone but within construction limits for Phase 6.

Non-weed Perennial Vegetation Cover

Non-weed perennial vegetation cover within the constructed floodplain (inside and outside of the streambank buffer zone) was considered well established by the QRA AMT. Very few areas of bare ground were observed and these areas were not large in size or located in an area at risk of an avulsion or scour. Figure 19 shows the locations of vegetation cover plots sampled during the 2023 QRA in Phases 1 and 2. Figure 20 shows the locations of vegetation cover plots sampled during the 2023 QRA in Phases 5 and 6. Total cover by species was recorded for each plot. Cover did not differentiate between perennial, biennial, or annual vegetation, nor did it differentiate between native or non-native species, or non-weed species. Non-weed, a term used in the ROD, is not well defined and therefore difficult to evaluate. Attachments D, E and F include photos that show vegetation cover in each phase.

Of the 35 total cover plots, 26 had vegetation cover of 90% or higher. Table 8 and Table 9 show the average, minimum, and maximum cover recorded by phase within the streambank buffer zone and outside the streambank buffer zone respectively. These data show that Phase 6 has the lowest average cover within the streambank buffer zone (60%) and Phase 2 has the lowest average cover outside of the streambank buffer zone (82%). Table 10 lists dominant species observed and specifies in which phases the species was observed. This table also indicates which dominant species are native or introduced and which were seeded as part of remediation work. Great Basin wildrye (*Leymus cinereus*) and slender wheatgrass (*Elymus trachycaulus*) were the most common dominant species, occurring in all four phases. Both species were seeded.

Table 8. Canopy cover plot averages, minimums, and maximums by phase within the 50-foot Streambank and Riparian Corridor Buffer Zone.

PHASE	Average Cover	Minimum Cover	Maximum Cover
Phase 1	100	100	100
Phase 2	100	100	100
Phase 5	85	85	85
Phase 6	60	60	60

Note: n = 5

Table 9. Canopy cover plot averages, minimums, and maximums by phase Outside the Streambank and Riparian Corridor Buffer Zone but Within the Historic 100-year Floodplain.

PHASE	Average Cover	Minimum Cover	Maximum Cover
Phase 1	99	94	100
Phase 2	82	60	98
Phase 5	86	50	100
Phase 6	89	60	98

Note: n = 30

Figure 19. Locations of herbaceous vegetation cover plots in Phases 1 and 2.

Figure 20. Locations of herbaceous vegetation cover plots in Phases 5 and 6.

Table 10. Dominant species observed within cover plots and phases where species where observed.

DOMINANT SPECIES OBSERVED			PHASE OF SPECIES OBSERVATION			
COMMON NAME	**SCIENTIFIC NAME**	**Native Status**	**Phase 1**	**Phase 2**	**Phase 5**	**Phase 6**
meadow foxtail	*Alopecurus pratensis*	I	1			
thickspike wheatgrass	*Elymus lanceolatus*	N, S	1			
redtop	*Agrostis stolonifera*	I	1		1	
Arctic rush	*Juncus Arcticus*	N	1			
Great Basin wildrye	*Leymus cinereus*	N, S	1	1	1	1
slender wheatgrass	*Elymus trachycaulus*	N, S	1	1	1	1
other wheatgrass	*Agropyron spp*	--	1			
sweet clover	*Melilotus officinalis*	I		1		1
common yarrow	*Achillea millefolium*	N, S		1		1
alfalfa	*Medicago sativa*	N, S**			1	1
Basin big sagebrush	*Artemisia tridentata*	N, S			1	
Western wheatgrass	*Pascopyrum smithii*	N, S			1	1
purple aster	*Aster spp*	N				1

*N=native; I=introduced, S=seeded

**only seeded in Phase 1

Phase 1 vegetation cover was most commonly characterized by seeded upland grasses, planted wetland sedges and rushes, or naturally colonized native and introduced grasses (Figure 21). Dominant species observed in cover plots included slender wheatgrass and Great Basin wildrye which were also dominants in all other phases. Dominant species also included Arctic rush (*Juncus arcticus*) and thickspike wheatgrass (*Elymus lanceolatus*) which were not observed in other phases as a dominant species. Redtop (*Agrostis stolonifera*) and meadow foxtail (*Alopecurus pratensis*), both introduced grass species, were also dominant species in Phase 1. Areas of low cover are rare in Phase 1 but some patchy areas occur near the upstream end on both sides of the channel and in areas where soil compaction occurred along access routes.

Phase 2 vegetation cover was most commonly characterized by seeded upland grasses or naturally colonized native and introduced grasses. Phase 2 had high cover of sweet clover, a non-native biennial. This species often increases in years of high moisture such as 2023 and is expected to be outcompeted by other native perennial vegetation as the site matures and experiences flood disturbance. Native herbaceous species and planted woody species were often observed beneath the dense sweet clover cover. Phase 2 also had high cover of common yarrow (*Achillea millefolium*), slender wheatgrass, and Great basin wildrye, all native, seeded species. A large area of floodplain on the west side of the river between station 147+00 and

170+00 was constructed at a higher elevation compared to the rest of the floodplain. The dry conditions in this area have resulted in lower overall vegetation cover (Figure 22).

Vegetation cover in both Phase 5 and 6 was most commonly characterized by seeded upland grasses. In both Phase 5 and Phase 6 western wheatgrass (*Pascopyrum smithii*) and alfalfa (*Medicago sativa*) were observed as dominant species (and not observed in Phase 1 or Phase 2 as dominant species). Western wheatgrass is a native species and alfalfa is an introduced crop species. Alfalfa was not seeded in Phase 5 and 6 but may be encroaching from irrigated fields adjacent to the site. Big sage (*Artemisia tridentata*) and redtop were dominant species in Phase 5. Lower total cover was observed primarily within meander cores where elevations relative to baseflow are high and the floodplain is vegetated with Great Basin wildrye and big sage (Figure 23). Sweet clover was observed in Phase 6. A purple aster (*aster spp*) was observed as a dominant species in one plot with high species diversity. Similar to Phase 1 and 2, overall cover is high with just small areas of lower cover. In Phase 6 low cover is mostly related to microtopography features that were constructed higher than design specifications resulting in very dry microsite conditions. Grasses are growing in the depressions in these areas but cover is low on the higher mound features.

Figure 21. Left - Example of small area of bare ground and low cover in Phase 1. Right – Example of high cover of yarrow, Great Basin wildrye and slender wheatgrass in Phase 1 floodplain.

Figure 22. Area in Phase 2 with lower vegetation cover due to dry site conditions.

Figure 23. One of the largest areas of low cover observed in all phases is located in Phase 6.

Noxious Weeds and Other Undesirable Species

Overall noxious weed cover is low in all four phases and was most often observed as a single or very few individual plants. DEQ completes annual weed control in completed phases for 5 years post-remediation, after which each landowner is responsible for weed control. Noxious weeds observed included leafy spurge (*Euphorbia esula*) (Phases 1,2, and 5), common tansy (*Tanacetum vulgare*) (Phase 2), yellow toadflax (*Linaria vulgaris*) (Phase 5), perennial pepperweed (*Lepidium latifolium*) (Phase 1), and spotted knapweed (*Centaurea maculosa*) (Phase 5). It is likely other species are present and not recorded during the QRA as the reaches were not completely inventoried for weeds.

Several other invasive species are present in Phase 1, 2, 5 and 6 but are not on state or county noxious weed lists. The primary species of concern include Russian olive (*Elaeagnus angustifolia*), reed canarygrass (*Phalaris arundinacea*) and cheatgrass (*Bromus tectorum*). Russian-olive is a Priority 3 Regulated species (not listed as noxious weed) and is a non-native, invasive tree species that is problematic on in floodplains in eastern Montana and was observed in all Phases, primarily Phase 1 and 2 (Figure 25). The locations of Russian olive trees were recorded to support maintenance follow up. Cheatgrass, another Priority 3 Regulated species, was observed in large patches in Phase 2 and smaller patches in other phases (Figure 25). Reed canarygrass is not a noxious or regulated weed but is an introduced pasture grass that can be highly invasive in floodplains forming monocultures that prevent remove native species and can prevent woody riparian vegetation establishment. Reed canarygrass is primarily present on point bar features in all phases (Figure 24).

Figure 24. Left - reed canarygrass dominated point bar in Phase 1; this bar was preserved and not constructed. Right – reed canarygrass colonizing downstream end of constructed point bar in Phase 1 where fine sediment has accumulated.

Figure 25. Russian olive tree in Phase 1 (left) and cheatgrass in Phase 2 (right).

General Observations

This section describes general observations made of constructed wetlands, point bars and channel geomorphology during the 2023 QRA.

Wetland Development

All large constructed wetland features were observed during the 2023 QRA. Attachments D, E and F include photos of these features under the 'Floodplain Features' heading for each phase. The following are the main general observations for these areas:

- Consistent with previous year's observations, vegetation cover and diversity remains highest in constructed floodplain features with those wetlands connected to the main river channel having the most habitat diversity.
- Evidence of wildlife and waterfowl use of these features remains high.
- No erosion was observed in any of these features.
- No invasion by reed canarygrass was observed in these features.

Figure 26 through Figure 29 provide comparisons of wetland features within a year after construction and in 2023.

Figure 26. Phase 1 wetland feature in 2015 and in 2023.

Figure 27. Phase 1 side channel wetland in 2015 and in 2023.

Figure 28. Phase 2 oxbow wetland in 2017 and 2023.

Figure 29. Phase 5 borrow area wetlands in 2017 and 2023.

Point Bars

All point bars were observed during the 2023 QRA. Attachments D, E and F include photos of these features under the 'Point Bars' heading for each phase. The following are the main general observations for point bars:

- Constructed point bars have colonized with willow and cottonwood seedlings and herbaceous wetland vegetation. Perennial vegetation is present on most constructed point bars, indicating the channel width is adjusting to the average (bankfull) flows in each phase. The bankfull flow is marked by the presence of perennial vegetation. The line of perennial vegetation in some areas is several feet inside the constructed brush trench delineating the top of bank or constructed bankfull channel width. Figure 30 shows examples of vegetation colonization on constructed point bars in Phase 1, Phase 2 and Phase 5 over time. Figure 31 shows an example of perennial point bar establishment and channel narrowing over time. This trend was observed to varying extents in all phases.
- Point bars often support several age classes of willows representing different flood events that have occurred since construction. See left photo in Figure 32.
- Sandbar willow is the predominant woody species colonizing point bar features. Black cottonwood seedlings were observed on point bars in all phases but to a much lesser extent that sandbar willow and no stands of black cottonwoods have established on point bar features.
- Deposition at the downstream end of point bars was common along with racked wood recruited from the floodplain or streambank treatments (Figure 32).
- Point bars sometimes had dense patches of reed canarygrass, typically on more steeply sloped point bars, rather than on wide, shallow sloped point bars. Reed canarygrass establishment may also occur where fine sediment deposition occurs.
- Backwater areas were common at the downstream end of point bars (these areas were typically existing features that were preserved during point bar construction or in some areas these features were constructed to mimic those natural features). These backwater alcoves support dense native sedges and some establishing willows.

Figure 30. Phase 1 point bar in 2014 and 2023 (top). Phase 2 point bar in 2017 and 2023 (middle). Phase 5 point bar in 2016 and 2023 (bottom).

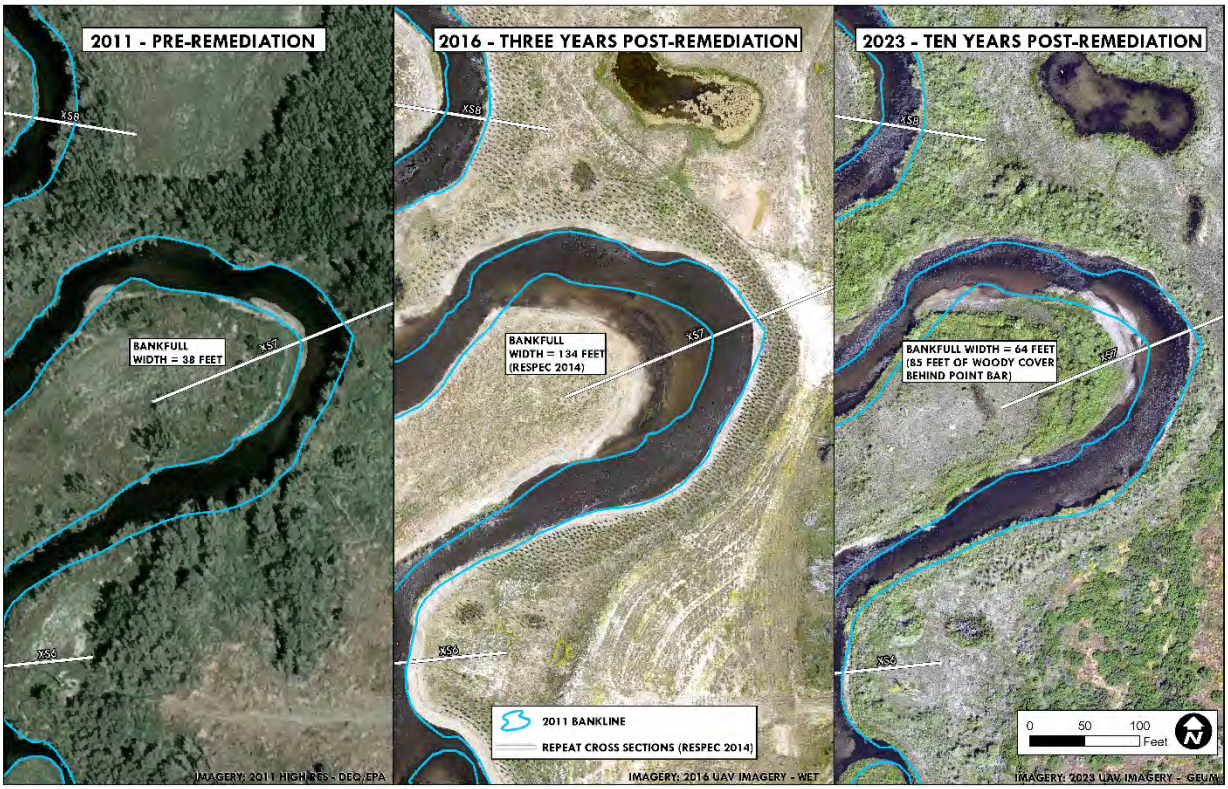

Figure 31. Point bar evolution in Phase 1. The left panel shows pre-remediation conditions, the middle panel shows conditions three years after remediation and the right panel shows the point bar ten years after remediation. The point bar was constructed wide to provide capacity for sediment storage and support natural colonization of willows and cottonwoods. The bankfull channel has narrowed 70 feet relative to 2016 conditions but is still wider than pre-remediation conditions.

Figure 32. Fine sediment deposition on downstream end of point bar in Phase 5 creating diverse habitat that will likely support sedges or woody vegetation in the future. These areas of fine sediment deposition are also a risk for reed canarygrass colonization.

Geomorphology and Aquatic Habitat

Channel morphology and aquatic habitat were observed during the 2023 QRA. The channel was observed primarily to document any significant shifts in channel location or over-widening. Resource managers have expressed concerns about the potential loss of aquatic habitat as a result of remediation actions, particularly the loss of near bank habitat provided by existing streambanks and the potential for over-widening of the channel that could result in shallower channel conditions and less cover. The primary aquatic habitat features in the Clark Fork River in Reach A include pools, riffles, over hanging vegetation that provides cover including woody vegetation or herbaceous sod mats along eroding banks, undercut banks and microhabitat features such as woody debris in the channel. Aquatic habitat has not been considered during the design process or monitoring program to date. Attachments D, E and F include photos of existing channel conditions in all phases. The following are the main general observations of channel geomorphology and aquatic habitat:

- No new split flows or channel avulsions were observed.
- Only minor channel migration was observed in a few locations.
- No areas of new channel bed aggradation or erosion were observed.
- Preserve vegetation streambank treatments provide overhanging vegetation and undercut banks.
- Brush matrix bank treatments that have brush extending into the channel are providing some in channel cover.
- As described in the Vegetated Soil Lift Streambank Treatment section some soil lifts are developing overhanging woody vegetation and undercut banks similar to preserve vegetation woody streambanks. Some are not forming undercut banks, possibly due to the low potential for toe material scour in some areas. Toe material is sized to resist shear stresses below the 10-year return interval flow. Flows have only exceeded the 10-year design flow in 2018 in Phase 1 and 2.
- Flow at the Galen gage on August 8-9, 2023 was between 123 and 163 cubic feet per second which was more than 50 cfs greater than the same dates in 2022 and 2021. Under the 2023 flow conditions no issues with water depth or available habitat were observed. The channel was generally wetted from bank to bank and no signs of excessive aquatic vegetation or algae were observed. In response to higher streamflows in 2023 there were also much fewer days where stream temperatures exceeded 70° F.

QRA Results Related to ROD Performance Standards

This section compares 2023 QRA results for woody vegetation and herbaceous cover to ROD performance standards. Table 11 provides a value for the ‘Percent Preferred Woody Species Canopy Cover’ within the Streambank and Riparian Corridor Buffer Zone and the ‘Percent Preferred Woody Species Canopy Cover’ and ‘Percent Total Cover of Non-Weed Perennial Vegetation’ outside the Streambank and Riparian Corridor Buffer Zone ROD performance standards based on data collected during the 2023 QRA. No phases meet the woody vegetation cover performance standards. Phase 1 is the closest with 46.3% woody cover in the buffer zone. 80% woody vegetation cover within the buffer zone is required by the ROD by Year 10. Phase 1 and Phase 2 cover plots indicate those phases may meet the perennial vegetation cover performance standards within the buffer zone and that Phase 1 may meet the standard outside the buffer zone. The ROD requires 98% cover for Year 4 through 10 for both the buffer zone and outside the buffer zone. Phase 1 and 2 cover plots within the buffer zone

had 100% cover. Phase 1 cover plots outside the buffer zone also had 100% cover. All other phases had cover under 90%.

Despite no phases meeting woody species cover performance standard values and only Phase 1 and 2 plots indicating those phases may meet the non-weed perennial vegetation cover performance standard, the QRA team agreed that all phases appeared to have sufficient woody and herbaceous cover given the number of years each phase has been complete. General observations indicate all phases are well vegetated and the floodplain is resistant to erosion, rilling and other potential disturbances that could compromise remediation and restoration treatments.

This information should only be used as a general idea of whether a ROD Performance Standard has been met because only limited quantitative data were collected. No attempt was made to determine what vegetation is considered non-weed or preferred woody species; however, Russian olive is the only undesirable woody species that occurs in completed phases.

Table 11. Progress toward meeting ROD Performance Standards by phase. Green cells indicate the performance standard has been met, orange cells indicate the performance standard has not been met. Measured metrics from the 2023 QRA are reported within each cell and Performance Standards for the appropriate year based on the numbers of years since construction specified in the ROD are in parenthesis.

ROD MONITORING YEAR	ROD PERFORMANCE STANDARD			
	Within Streambank and Riparian Corridor Buffer Zone			Outside Streambank and Riparian Corridor Buffer Zone
	Percent Planted[1] Woody Species Survival	Percent Preferred[2] Woody Species Canopy Cover	Percent Total[3] Canopy Cover of Non Weed Perennial Vegetation	Percent Total Canopy[4] Cover of Non-Weed Perennial Vegetation
PHASE 1 (YEAR 10)	NA	46.3% (80%)	100 (98%)	98.9 (98%)
PHASE 2 (YEAR 7)	No areas > 10'x10' lacking live plants of preferred woody species	20.4% (60%)	100% (98%)	82% (98%)
PHASE 5 (YEAR 8)	No areas > 10'x10' lacking live plants of preferred woody species	25.8% (60%)	85% (98%)	86.1% (98%)
PHASE 6 (YEAR 7)	No areas > 10'x10' lacking live plants of preferred woody species	22.0% (60%)	60% (98%)	88.9% (98%)

[1]Individual plant survival is no longer relevant after year 2. This metric was not evaluated during the QRA.
[2]Percent cover calculated using field data of woody cover extents behind the streambank and mapped in ArcGIS using high-resolution imagery.
[3]Percent cover calculated from cover plot data collected in the field (1 plot within Phase 1, 2 plots within Phase 2, 1 plot within Phase 5, and 1 plot within Phase 6).
[4]Percent cover calculated from cover plot data collected in the field (9 plots within Phase 1, 4 plots within Phase 2, 10 plot within Phase 5, and 7 plot within Phase 6)

Summary by Project Phase

Overall, the QRA adaptive management team observed a trend toward increasing woody vegetation cover in all phases along with the replacement of installed streambank treatments with live woody roots. Browse is limiting woody vegetation expansion to some extent in all phases, most notably Phases 5 and 6. The QRA team observed a similar overall vegetation cover condition as previous year's assessments with consistently high cover of grasses in each phase. Noxious weed cover remains low in all phases but Phase 2 and Phase 6 had high cover of sweet clover and Phase 1 and 2 had increasing numbers of Russian olive trees. Constructed floodplain features such as wetlands, oxbows and side channels continue to provide significant habitat diversity in each phase. No observations of floodplain instability, such as channel avulsions or headcuts were observed in any phase and the adaptive management team did not identify the need for any additional or supplemental data collection to verify site trends. Beaver activity was observed in all phases. This section provides an overview of observations specific to each phase included in the 2023 QRA.

Phase 1

Attachment A provides the construction timeline and monitoring history for Phase 1. Attachment B provides an overview of July 2023 drone imagery for Phase 1. Attachment D includes 2023 ground photos for Phase 1. The following general observations were made in Phase 1 during the 2023 QRA:

- Phase 1 was completed in 2014 and in 2023 was nine years post remediation. In that time, out of bank flows have occurred in all but three years (2015, 2016 and 2021). Significant high flow events occurred in 2018 (60 days above design flow), 2020 (42 days above design flow), and 2023 (31 days above design flow). The 10-year return interval flow has been exceeded once (2018 for 6 days). In 2018, 57% of the floodplain was inundated. Extreme Drought occurred in 2015, Exceptional Drought occurred in 2021 and Severe Drought occurred in 2022. All other years had No Drought or were Abnormally Dry. 2017 and 2020 were Moderate Drought years.
- Phase 1 is owned by the State and receives recreational impacts, largely from anglers walking along banklines, but no livestock grazing.
- In response to high flows immediately after construction and again in 2018, combined with relatively few extreme drought years, a greater percent of area with floodplain features (wetlands and side channels), and more out of bank flow days than any other phase, Phase 1 has the highest cover of woody vegetation of any phase. Woody riparian vegetation is very dense in some areas which is creating cooler, shadier, moister understory conditions allowing other species such as red-osier dogwood to begin to establish.
- Point bars are accumulating sediment and becoming well vegetated with a mix of willows and wetland vegetation and encroaching beyond the brush trench placed at bankfull reflecting flow conditions since construction. Some erosion at the upstream end of point bars was observed in Phase 1 indicating channel migration is occurring, which is a natural desirable process that builds floodplains over time.
- The wetland side channel complex on the west side of the river at the downstream end of Phase 1 has high cover of willows and wetland vegetation. This area is densely vegetated and diverse and supports a wide range of riparian and floodplain functions including habitat for a number of wildlife species.

- In general, woody vegetation cover is not limited by browse in Phase 1 with one exception. The floodplain area on the west side of the river downstream of Morel Road near the remedial boundary is very wet and woody expansion including Bebb willow is occurring around wetlands and floodplain swales. Browse in this location is heavy and is preventing shrubs from growing and expanding and providing more cover and habitat.
- Willow cover on streambanks is high and many vegetated soil lifts are beginning to support over-hanging woody vegetation and developing undercut banks.
- A few vegetative soil lifts have been lost and these banks are eroding but limited by dense woody vegetation in the adjacent. Woody vegetation is suckering into the bank face in some of these locations.
- Herbaceous cover is high in Phase 1 and dominated by seeded grass species.
- Weed cover is low; however Russian olive trees are increasing and should be removed.
- Beaver activity was observed sporadically through Phase 1 primarily in the form of fresh cuttings, tracks and food caches. No dam building activity was observed. It is possible beaver are starting to build dams in streambanks as they do in other sections of the Clark Fork River.
- Trails have formed along many of the streambanks indicating recreational use by the public.
- Phase 1 is well on the way to achieving a diverse mosaic of riparian and floodplain vegetation types.
- Continued noxious weed control and removal of Russia olive trees are the only maintenance actions required to maintain this trajectory.

Phase 2

Attachment A provides the construction timeline and monitoring history for Phase 2. Attachment B provides an overview of July 2023 drone imagery for Phase 2. Attachment E includes 2023 ground photos for Phase 2. The following general observations were made in Phase 2 during the 2023 QRA:

- Phase 2 was completed in 2017 and in 2023 was six years post remediation. In that time, out of bank flows have occurred in all but one year (2021). Significant high flow events occurred in 2018 (57 days above design flow), 2020 (31 days above design flow), and 2023 (20 days above design flow). The 10-year return interval flow has been exceeded once (2018 for two days). In 2018, 26% of the floodplain was inundated. Exceptional Drought occurred in 2021 and Severe Drought occurred in 2022. All other years had No Drought or were Abnormally Dry. 2017 and 2020 were Moderate Drought years.
- Phase 2 is owned by Montana Fish, Wildlife and Parks on the west side of the river from the Phase 1 boundary downstream to approximately station 150+00. A Fishing Access Site (FAS) is present on this property and the public can drive to the edge of the floodplain. Two separate landowners privately own the rest of Phase 2. Livestock fencing was installed along the riparian corridor; however, this corridor is sometimes narrower than 50 feet. The upstream landowner grazes the entire project area. The downstream landowner has not yet grazed within the project area. One mixed alfalfa grass hayfield was reconstructed in Phase 2 on the east side of the river upstream of Galen Road.

- Woody vegetation cover in Phase 2 is much less compared to Phase 1 and is probably a direct reflection of fewer out of bank flow days. Woody vegetation is expanding along streambanks but appears limited by higher elevation transitions close to constructed banks in some areas. Woody vegetation is expanding from plantings in floodplain swales in many areas; however many of these features are dominated by cattails. Woody vegetation cover is also high in large floodplain features including the constructed oxbow wetland and side channel and island.
- Woody vegetation cover is limited by browse in Phase 2. There are many surviving container plants within the streambank buffer zone and in windbreak planting units but most are suppressed by browse and could be much larger and contributing more to woody vegetation cover and riparian habitat. Containerized plants within individual browse protectors were generally very tall emphasizing the effect of browse on planted woody vegetation.
- Like Phase 1, point bars are becoming well vegetated with woody and wetland vegetation and encroaching beyond the brush trench placed at the design bankfull elevation.
- Herbaceous cover is high in Phase 2 with the exception of some areas that are high in elevation and have dry conditions.
- Noxious weed cover is low; however numerous Russian olive trees are present and should be removed. Cheatgrass is also present in dry areas of the floodplain. Some areas of the floodplain have high cover of sweet clover, a non-native biennial species. The effect of this species on floodplain vegetation development is unclear but sweet clover rarely persists for more than a couple of years and often increases in wet years such as 2023.
- The side channel on the west side of the river between station 197+00 and 205+00 provides a unique habitat with wide, shallow flows and no primary channel. Within the channel vegetation is characterized mainly by common spikerush (*Eleocharis palustris*), sedges and some common cattail (*Typha latifolia*) and willow along the fringes of wetlands. A large buck was observed in the area. The island between this side channel and the main river channel has high cover of woody vegetation from plantings and active beaver.]
- The reconstructed oxbow on the east side of the river at station 140+00 supports diverse wetland habitat. The island formed by the oxbow wetland supports high cover of woody vegetation from plantings.
- Trails have formed along the streambanks on public land indicating recreational use by the public.
- Grazing is occurring with construction limits on one private landowners' property in Phase 2. Grazing is impacting woody vegetation cover, reducing overall cover and increasing cover of non-native species.
- The remediated hayfield on the east side of the river at the downstream end of the phase had good overall cover but patchy cover of alfalfa. It does not appear that this area is being irrigated.
- Some areas in Phase 2, such as the constructed oxbow and side channel island complex, are trending towards achieving a diverse mosaic of riparian and floodplain vegetation types. Other areas of Phase 2 are high and dry and may be on a slower recovery trajectory.

- Continued noxious weed control and removal of Russia olive trees are the only maintenance actions required to maintain this trajectory; however, browse control measures to increase woody vegetation cover should be considered. Creating additional low elevation floodplain features would also speed up the recovery period and increase vegetation and habitat diversity.

Phase 5

Attachment A provides the construction timeline and monitoring history for Phase 5. Attachment C provides an overview of July 2023 drone imagery for Phase 5. Attachment F includes 2023 ground photos for Phases 5 and 6. The following general observations were made in Phase 5 during the 2023 QRA:

- Phase 5 was completed in 2016 and in 2023 was seven years post remediation. In that time, out of bank flows have occurred in all but two years (2016, 2021). Significant high flow events occurred in 2018 (53 days above design flow), 2019 (19 days above design flow), and 2020 (20 days above design flow). Flows were only above design flows for 6 days in 2023. The 10-year return interval flow has not been exceeded in Phase 5. In 2018, 39% of the floodplain was inundated. Extreme Drought occurred in 2016, Exceptional Drought occurred in 2021 and Severe Drought occurred in 2022. All other years had No Drought or were Abnormally Dry. 2017 and 2020 were Moderate Drought years.
- Phase 5 is privately owned and under a conservation easement. No livestock grazing occurs in Phase 5.
- Woody vegetation cover in Phase 5 is much less compared to Phase 1 similar to Phase 2 and a direct reflection of fewer out of bank flow days. Woody vegetation is expanding along streambanks. Woody vegetation is also expanding from plantings in floodplain swales in many areas; although similar to Phase 2 many of the swales in Phase 5 support cattails and little woody vegetation.
- Woody vegetation cover is limited by browse in Phase 5. There are many surviving container plants within the streambank buffer zone and meander core planting units but most are suppressed by browse and could be much larger and contributing more to woody vegetation cover and riparian habitat. Containerized plants within individual browse protectors were generally very tall emphasizing the effect of browse on planted woody vegetation.
- Point bars in Phase 5 are being colonizing by woody and wetland vegetation. Phase 5 point bars consist of numerous areas of preserved vegetation. Point bars were constructed to tie into these preservation areas. Phase 5 point bar vegetation is not as extensive and diverse as Phase 1 and Phase 2 and the higher point bar elevations required to tie into preservation areas may be a cause of this.
- Herbaceous cover is high in Phase 5 and dominated by seeded grasses.
- Noxious weed cover is low; however cheatgrass is present in dry areas of the floodplain. Some areas of the floodplain have high cover of sweet clover, a non-native biennial species. The effect of this species on floodplain vegetation development is unclear but sweet clover rarely persists for more than a couple of years and often increases in wet years such as 2023. A few Russian olive trees were observed and should be removed.
- Borrow area ponds on the west side of the river have high wetland and woody vegetation cover and being used by waterfowl and other terrestrial wildlife such as

beaver, muskrat, and ungulates. In some areas Arctic rush cover is so dense it may be preventing woody vegetation expansion. The areas between the ponds are very wet and support wetland herbaceous species such as Nebraska sedge (*Carex nebrascensis*), hardstem bulrush (*Schoenoplectus acutus*), Arctic rush, and willow species.

- The wetland complex excavated to provide material for right bank reconstruction (activity that occurred after remediation) is connected to the main channel at high flows and includes woody check structures to prevent scour. The wetlands are dominated by cattails but Booth's willow is establishing along the edges of the pond. These willows are heavily browsed. On the downstream end of the wetland complex, the return flow path is wide and includes piles of racked woody debris.
- Some areas in Phase 5, such as the borrow ponds on the west side of the channel, wetland complex and constructed oxbow on the east side of the channel, and the wetland complex on the west side of the channel constructed post remediation are trending towards achieving a diverse mosaic of riparian and floodplain vegetation types. Woody vegetation is expected to slowly expand into other areas of the Phase 5 floodplain but will take many years and additional high flow events.
- Continued noxious weed control and removal of Russian olive trees are the only maintenance actions required to maintain the recovery trajectory; however, browse control measures to increase woody vegetation cover should be considered. Creating additional low elevation floodplain features would also speed up the recovery period and increase vegetation and habitat diversity.

Phase 6

Attachment A provides the construction timeline and monitoring history for Phase 6. Attachment C provides an overview of July 2023 drone imagery for Phase 6. Attachment F includes 2023 ground photos for Phases 5 and 6. The following general observations were made in Phase 6 during the 2023 QRA:

- Phase 6 was completed in 2016 and in 2023 was seven years post remediation. In that time, out of bank flows have occurred in all but two years (2016, 2021). Significant high flow events occurred in 2018 (51 days above design flow), 2019 (14 days above design flow), and 2020 (16 days above design flow). Flows were only above design flows for 2 days in 2023. The 10-year return interval flow has not been exceeded in Phase 6. In 2018, 23% of the floodplain was inundated. Extreme Drought occurred in 2016, Exceptional Drought occurred in 2021 and Severe Drought occurred in 2022. All other years had No Drought or were Abnormally Dry. 2017 and 2020 were Moderate Drought years.
- Phase 6 is privately owned and under a conservation easement except for a small parcel at the downstream end on the west side of the river. Livestock grazing occurs on this parcel but nowhere else in Phase 6.
- Phase 6 is characterized by high terraces on the outside of most meander bends that were not contaminated and therefore not included in remediation work. These terraces intercept the channel as tall, vertical eroding streambanks. This limits floodplain reconstruction to the inside of meander bends only.
- Woody vegetation cover in Phase 6 is similar to Phase 2 and Phase 5 and a direct reflection of fewer out of bank flow days. Woody vegetation is expanding along streambanks. Woody vegetation is also expanding from plantings in floodplain swales in

many areas; although similar to Phase 2 and 5 many of the swales in Phase 6 support cattails and little woody vegetation. Meander cores planted with woody vegetation had dry conditions and low survival and only silver buffaloberry and currant species were observed.

- Woody vegetation cover is limited by browse in Phase 6. There are many surviving container plants within the streambank buffer zone and meander core planting units but most are suppressed by browse and could be much larger and contributing more to woody vegetation cover and riparian habitat. Containerized plants within individual browse protectors were generally very tall emphasizing the effect of browse on planted woody vegetation.
- Herbaceous cover is high in Phase 6 and dominated by seeded grasses. Some areas of lower cover occur where microtopography features were built much taller than design specifications creating very dry microsites on the top of mound features.
- Noxious weed cover is low. Some areas of the floodplain have high cover of sweet clover, a non-native biennial species. The effect of this species on floodplain vegetation development is unclear but sweet clover rarely persists for more than a couple of years and often increases in wet years such as 2023.
- Borrow area ponds on the east side of the river have high wetland and woody vegetation cover and are being used by waterfowl and other terrestrial wildlife such as beaver, muskrat, and ungulates. This wetland complex receives irrigation return from adjacent fields and has an outlet channel that connects to the Clark Fork River.
- The preserved oxbow wetland on the west side of the river at station 125+00 supports diverse willow and herbaceous wetland vegetation. The outlet of these feature has a small channel that connects to the Clark Fork River. Evidence of beaver and muskrat use of this wetland was observed along with several songbird species.
- In general point bars are narrower and steeper in Phase 6 compared to other phases. Reed canary grass is common. Wider point bars included a mix of woody and wetland vegetation similar to other phases.
- Modesty Creek within the Clark Fork River floodplain was reconstructed as part of remediation work in Phase 6. Muskrat and otter sign were observed along Modesty Creek. Streambanks were constructed with wetland sod mats and willow cuttings and currently consist of dense sedge cover with no woody vegetation The channel bottom has dense cover of aquatic macrophytes.
- Two cottonwood stands were preserved in Phase 6. Cottonwood seedlings were observed in swales adjacent to these stands.
- The high terrace on the west side of the river near station 158+00, on the outer bend just downstream of the westside ditch diversion, is eroding and may begin to compromise ditch infrastructure.
- The private land parcel on the west side of the river starting at station 214+00 has been heavily grazed and vegetation cover is low. The streambank is fenced and some larger woody plants occur along the streambank.
- Some areas in Phase 6, such as the borrow ponds on the east side of the channel and the preserved oxbow wetland complex on the east side of the channel are trending towards achieving a diverse mosaic of riparian and floodplain vegetation types. Woody vegetation is expected to slowly expand into other areas of the Phase 6 floodplain but will take many years and additional high flow events.

- Continued noxious weed control is the only maintenance action required to maintain the recovery trajectory; however, browse control measures to increase woody vegetation cover should be considered.

Adaptive Management and Next Steps

This section describes adaptive management measures for completed CFROU Reach A phases including Phases 1, 2, 5 and 6. Specifically, this section includes a list of potential maintenance actions, future design recommendations based on QRA observation, and potential next steps for evaluating remediation and restoration actions.

Maintenance

Continued control of noxious weeds, including Russian olive, was the only highly recommended maintenance action identified during the 2023 QRA. Many Russian olive trees are too large to kill with direct application of herbicide and will require cutting and treating the stumps with herbicide.

The following issues should continue to be observed but there were no recommended maintenance actions identified:

- **Areas with low herbaceous cover.** Herbaceous cover is high in all phases with only small areas of low cover. Low vegetation cover typically occurs away from the channel in drier areas of the constructed floodplain such as where microtopography features were constructed higher in elevation than designed or where access routes were located and soil compaction occurred.
- **Areas with high cover of non-noxious weeds.** Phase 2 and areas of Phases 5 and 6 have high cover of annual and biennial non-native species such as sweet clover. These species typically do not persist long-term but may limit grass cover and native forbs over time if it persists.
- **Expansion of aggressive introduced grasses such as reed canarygrass.** Currently, reed canarygrass occurs on point bars, both constructed and preserved. It would not be feasible to control reed canarygrass in these areas due to the annual influx of fluvially transported seeds that deposit in these areas. Reed canarygrass was not observed in constructed wetland features in 2023 but if it does start to colonize these features it may be desirable to control it while cover is low as it will eventually dominate these areas and form a monotype.
- **Browse of planted and naturally recruited woody shrubs and trees.** Browse was observed on surviving containerized plants and naturally establishing woody vegetation in all phases. It is likely that with continued time suppressed woody vegetation will have years where browse pressure is low. These plants are between six and ten years old and have well-established root systems and should grow rapidly if given relief from continual browse. At this point, browse is unlikely to kill these plants but is restricting overall riparian cover and function by limiting the full growth form. A small number of individual browse protectors remain in Phases 2, 5, and 6 and could be removed or removed from dead plants and placed on plants that are being suppressed by browse. Additionally, small fences could be constructed in areas where numerous surviving planted shrubs and trees with restricted growth due to continuous browse were observed. Recommendations by phase are included below:

- In Phase 1, woody cover is widespread and dense enough that browse pressure is unlikely to prohibit continued woody expansion and overall riparian function. One area within Phase 1 (east floodplain downstream of Morel Road) has young willows that are heavily browsed. Supplemental protection could be considered for this area to increase woody vegetation cover and habitat area.
- In Phase 2, some surviving containerized plants remain protected by individual browse protectors and are very tall, while other planted shrubs and trees are alive, but heavily browsed and may remain small and stunted without protection. Some trees inside protectors are dead and these protectors could be removed and placed on surviving trees or shrubs near the channel that are being suppressed by browse. Small fences could be installed in select areas in Phase 2 to increase woody vegetation cover in the streambank buffer zone.
- In Phases 5 and 6, as in Phase 2, some surviving containerized plants remain protected by individual browse protectors and are very tall, while other planted shrubs and trees are alive, but heavily browsed and may remain small and stunted without protection. Some trees inside protectors are dead and these protectors could be removed and placed on surviving trees or shrubs near the channel that are being suppressed by browse. Small fences could be installed in select areas in Phase 2 to increase woody vegetation cover in the streambank buffer zone.

Future Design Recommendations

The QRA process has included members of design teams from several phases of the CFROU Reach A project. This has allowed designers to evaluate the effectiveness of various treatments and implementation methods used to date. Design modifications that have been implemented as the result of the QRA process include:

- Use a lower return interval for design bankfull. Phase 3 and 4 used the 1.5-year return interval instead of the 2-year return interval in response to faster vegetation recover with higher frequency of out of bank flows and streambanks and constructed surfaces in closer proximity to late season groundwater levels.
- Ensure streambank treatments are not set back from pre-remediation locations.
- Reduce the use of vegetated soil lift streambank treatments and increasing the use of brush matrix treatments.
- Transition from small, deep depression swale features to large, shallow depressions that maximize the area of the floodplain at a lower elevation to support woody riparian vegetation.

Based on 2023 QRA observations and past recommendations that have not yet been implemented, the following sections describe recommended future design considerations. Some of these were implemented in Phases 3 and 4.

Floodplain Elevations and Features

1) **Continue to design floodplains to the 1.5-year return interval elevation.** As noted throughout this and past QRA's, the more out of bank flow that occurs and the closer streambanks and floodplain surfaces are to low flow groundwater the more rapidly floodplain vegetation will establish and expand.

2) **Maximize connected floodplain features such as side channels and connected wetland features**. Hydrologically connected floodplain features result in the highest cover of woody vegetation or dense wetland vegetation as a result of a consistent water source and exposure to flood disturbances. In future phases, floodplain remediation and restoration will include a narrower corridor than previous phases and it will be important to include connected features where possible.

Streambanks

1) **Increase the use of streambank treatments constructed from woody debris.** Brush matrix streambank treatments provide a significant amount of near channel roughness which dissipates flow energy reducing the need for cobble toe material and providing immediate in channel cover. The transition to woody debris based streambank treatments began in Phase 3 and in Phase 4A no vegetated soil lifts were constructed, only woody debris streambank treatments.
2) **Reduce or eliminate the use of toe material for streambank construction.** Adding toe material resistant to 10-year flow shear stresses can limit the formation of undercut banks. Phase 7 streambanks will not include toe reconstruction.
3) **If toe reconstruction is needed, consider including woody debris instead of or in addition to cobble.** Woody debris would break up flow energy and reduce the potential for scour along the bankline, may prevent ice buildup, and would provide additional in channel cover and aquatic habitat.
4) **Incorporate larger wood treatments into streambanks to enhance aquatic habitat.** This treatment would use imported root wads and larger wood material to build structures in areas of high shear stress to support pool development and provide in channel cover were. These treatments were constructed in Phase 4A and are being integrated into the Phase 7 design.
5) **Incorporate live willow cuttings or willow clumps into the face of brush matrix streambank treatments.** This would speed up the establishment of overhanging woody vegetation.
6) **Consider narrower point bar features.** Wide point bars, as previously built, have supported sediment storage and natural riparian vegetation colonization and expansion. These wide features however distribute flows across a large area and may change the hydrodynamics of the river which could degrade aquatic habitat during the recovery period where vegetation establishes and the bankfull channel narrows. To eliminate this short-term effect, point bars could be constructed smaller; however, this would delay or reduce the establishment of desirable woody vegetation.
7) **Incorporate microhabitat features where possible.** In addition to overhanging woody vegetation and undercut banks, fish the Clark Fork River also utilize smaller clumps of wood and shrubs that deposit on deposition features in the river. Some of these microhabitat features are lost during remediation activities. This design recommendation includes placing clumps of woody debris along the approximate edge of water in constructed deposition features to sustain aquatic habitat.

Meander Cores and Potential Avulsion Paths

1. **Remove additional avulsion path stability measures.** Mapped avulsion paths have been constructed at a higher elevation and with a mix of vegetative backfill and alluvium to reduce short-term erosion potential. These measures have resulted in dry conditions that do not

support woody vegetation which is needed for long-term stability of these areas. Removal of these measures is recommended for future designs. Also, revegetating these areas with willow cuttings instead of containerized plants that can be planted much deeper is recommended. Willow cuttings installed in trenches perpendicular to the meander core will increase the chance of woody vegetation establishment while dispersing high flow energy to reduce the risk for the development of preferential flow paths and potential headcut formation in the floodplain.

2. **Incorporate floodplain roughness into meander cores.** Microtopography and wood can further reduce avulsion risks and increase floodplain diversity through the development of microsites.

Floodplain Revegetation

1. **Reduce the use of containerized plants.** Containerized plants are costly and the survival rate is low overall. Consider containerized plants only in areas connected to groundwater hydrology.
2. **Incorporate willow trenches into the floodplain.** Willow trenches are trenches dug approximately 4 feet deep or to a depth that intercepts the low flow groundwater elevation with willow cuttings placed in the trench intercepting the groundwater depth. In Phase 4A (the most recently constructed phase), willow trenches should be constructed perpendicular to streambanks (except along point bars) and oriented perpendicular to the primary down valley high flow paths across inside meander bends (Figure 33).
3. **Consider installation of browse protection after a year 1 evaluation of vegetation survival and browse pressure.** Wildlife browse pressure can limit woody vegetation survival and growth rates and is affecting woody vegetation cover in Phase 2, 5 and 6. Because there are many variables influencing survival of containerized plants, it is recommended browse protection measures be installed after the first year to ensure browse protection is installed on living plants.
4. **Consider using natural willow and cottonwood seed sources** where possible. Collecting willow and cottonwood branches with flowering seed and placing them in floodplain swale features mimics natural willow and cottonwood colonization methods and may promote rapid establishment of woody vegetation. This technique was used in Phase 15-16 and was successful with supplemental irrigation.
5. **Restrict the use of non-native species in seed mixes.** Non-native species can be weedy and reduce diversity and should not be included in seed mixes.

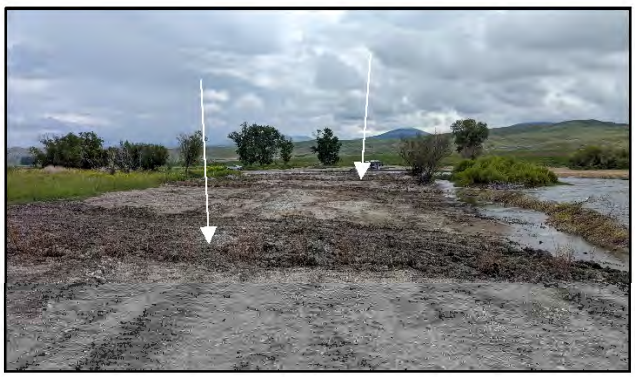

Figure 33. Willow trenches installed in Phase 4A perpendicular to streambanks.

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Attachment A. Phase Specific Construction and Monitoring Details

This section provides a brief background of remediation and restoration construction and monitoring completed by phase to provide context for the discussion of assessment results.

Phase 1

Construction Summary

Floodplain and streambank construction was completed in Phase 1 in December 2013 and revegetation occurred in spring and fall 2014. Revegetation activities in Phase 1 occurred in spring and fall 2014.

Monitoring Summary

The following monitoring has been completed in Phase 1:

- 2014: Year 1 geomorphology following 2015 Monitoring Plan
- 2014-2015: Year 1 vegetation monitoring following 2015 Monitoring Plan
- 2019: Year 5 vegetation monitoring using ROD performance standards
- 2022: Year 7 vegetation monitoring using ROD performance standards
- 2016, 2017, 2018 QRAs

Tables with results from each performance monitoring cycle and QRA are included below:

Results of 2014 (Year 1) geomorphic monitoring.

Monitoring Parameter	2014 Result	Performance Target (2015 Monitoring Plan)
Residual Pool Depth (ft) (mean)	3.3	≥2.4
Pool Frequency (pools per mile)	18.5	≥14.3
Bankfull width (ft) (mean)	60	44-66
Bankfull depth (ft) (mean)	2.7	2.2-3.2
Width to Depth Ratio (mean)	23	18-27
Cross-sectional area (sq ft)	163	119-179

Results of 2014 (Year 1) vegetation monitoring (applies to all installed vegetation through summer 2014).

Monitoring Parameter	2014 Result	Performance Target (2015 Monitoring Plan)
Woody plant survival (percent)	87.7	80
Streambank cover (percent)	15.2	40

Results of 2015 (Year 1) vegetation monitoring (applies to vegetation installed after 2014 monitoring).

Monitoring Parameter	2015 Result	Performance Target (2015 Monitoring Plan)
Woody plant survival (percent)	85.8	80
Native* herbaceous cover (percent)	31.0	> 20
Noxious weed cover (percent)	0.1	< 5

*Total cover was 51.0%; **Note:** Mean woody cover in planted areas in the floodplain was 14.8%.

Results of 2019 (Year 5) vegetation monitoring. The year 5 performance standards are highlighted in green. This table includes additional metrics recorded by RESPEC in italics.

VEGETATION ZONE	MONITORING METRIC	YEAR 7 RESULT	PERFORMANCE STANDARD BY YEAR (post-remediation)						
			1	2	3	4	5	7	10
Riparian	Planted woody species survival (%)	**NA**	90	90	-	-	-	-	-
	Preferred woody species survival (%)	**33.2**	-	-	-	-	50	60	80
	Total canopy cover of non-weed perennial vegetation (%)	**51.6**	90	95	-	98	98	98	98
Riparian EXTRA	*Total canopy cover of undesirable species (%)*	***25.0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	***4.3***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Transition	Total canopy cover of non-weed perennial vegetation (%)	**42.0**	90	95	98	-	98	-	-
Transition EXTRA	*Total canopy cover of undesirable species (%)*	***11.4***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	***5.9***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Upland	Noxious weed cover (%)	**0**	-	-	-	-	-	-	<5
	Total canopy cover of non-weed perennial vegetation (%)	**56.3**	-	-	-	-	-	-	45
	Species richness (per 100 sq. meters)	**NA**	-	-	-	-	-	-	5
Upland EXTRA	*Total canopy cover of undesirable species (%)*	**16.3**	*X*	*X*	*X*	*X*	*X*	*X*	*X*

Results of 2022 (Year 7) vegetation monitoring. The year 7 performance standards are highlighted in green. This table includes additional metrics recorded by RESPEC in italics.

VEGETATION ZONE	MONITORING METRIC	YEAR 7 RESULT	PERFORMANCE STANDARD BY YEAR (post-remediation)						
			1	2	3	4	5	7	10
Riparian	Planted woody species survival (%)	**NA**	90	90	-	-	-	-	-
	Preferred woody species survival (%)	**62.2**	-	-	-	-	50	60	80
	Total canopy cover of non-weed perennial vegetation (%)	**72.0**	90	95	-	98	98	98	98
Riparian EXTRA	*Total canopy cover of undesirable species (%)*	***5.8***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	***1.0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Transition	Total canopy cover of non-weed perennial vegetation (%)	**63.2**	90	95	98	-	98	-	-
Transition EXTRA	*Total canopy cover of undesirable species (%)*	***9.7***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	***0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Upland	Noxious weed cover (%)	**0**	-	-	-	-	-	-	<5
	Total canopy cover of non-weed perennial vegetation (%)	**60**	-	-	-	-	-	-	45
	Species richness (per 100 sq. meters)	**NA**	-	-	-	-	-	-	5
Upland EXTRA	*Total canopy cover of undesirable species (%)*	**0**	*X*	*X*	*X*	*X*	*X*	*X*	*X*

Phase 1 2015 QRA geomorphology results and trends.

Metric	2015 QRA Results		Performance Trend
	Category	Results	
Channel Stability	Category 1 (Likely degrading) Category 2 (Largely stable with potential aggradational/ degradational trend) Category 3 (Likely aggrading)	Category 2: Largely Stable (avg score 3.2).	Some sediment deposition was indicated by weak gravel accumulation in riffles and fine bar deposition, however all indicators of channel morphology indicate a geomorphically stable condition.
Floodplain and Secondary Channel Stability	Category 1 (Low risk/consequence of avulsion) Category 2 (Moderate risk/consequence of avulsion) Category 3 (High risk/consequence of avulsion) Category 4 (Avulsion has occurred)	No floodplain channels creating elevated avulsion risk beyond Category 1.	Following repairs of fall 2014, no floodplain channels are present that pose a high avulsion risk.
Floodplain Connectivity	None	Clear evidence of floodplain inundation with wood mobilization and fine sediment deposition.	Positive—results provided to design engineers.
Streambank	None	Some localized areas of toe erosion, bank slumping and degradation of fabrics used to construct banks.	Toe erosion was localized to areas of high shear stress and typically only occurred along a small section of the treated bank - overall streambank trend is positive.

Phase 1 2016 QRA geomorphology results and trends.

Metric	2016 QRA Results		Performance Trend
	Category	Results	
Channel Stability	Category 1 (Likely degrading) Category 2 (Largely stable with potential aggradational/ degradational trend) Category 3 (Likely aggrading)	Category 2: Largely Stable (avg score 3.6).	Some field indication of sediment aggradation relative to 2015.
Floodplain and Secondary Channel Stability	Category 1 (Low risk/consequence of avulsion) Category 2 (Moderate risk/consequence of avulsion) Category 3 (High risk/consequence of avulsion) Category 4 (Avulsion has occurred)	No out of bank flows in spring 2016 so not assessed.	No out of bank flows in spring 2016 so not assessed.
Floodplain Connectivity	None	No out of bank flows in spring 2016 so not assessed.	No out of bank flows in spring 2016 so not assessed.
Streambank	None	Twenty four streambank treatments were noted for continued observation regarding fabric condition, toe stability, and/or poor willow growth.	Uncertain – continued monitoring is recommended. No management actions are recommended at this time.

Phase 1 2017 QRA geomorphology results and trends.

Metric	2017 QRA Results		Performance Trend
	Category	Results	
Channel Stability	Category 1 (Likely degrading) Category 2 (Largely stable with potential aggradational/ degradational trend) Category 3 (Likely aggrading)	Category 2: Largely Stable (avg score 3.6).	Some field indication of sediment aggradation relative to 2015.
Floodplain and Secondary Channel Stability	Category 1 (Low risk/consequence of avulsion) Category 2 (Moderate risk/consequence of avulsion) Category 3 (High risk/consequence of avulsion) Category 4 (Avulsion has occurred)	No floodplain channels creating elevated avulsion risk beyond Category 1.	Following repairs of fall 2014, no floodplain channels are present that pose a high avulsion risk.
Floodplain Connectivity	None	Clear evidence of floodplain inundation with high water marks, wood mobilization and fine sediment deposition.	Floodplain activation occurred as expected for spring 2017 flows and is supporting establishment of woody riparian vegetation in the floodplain.
Streambank	None	Twenty-three streambank treatments were noted for continued observation regarding fabric condition, toe stability, and/or poor willow growth.	Continued QRA monitoring is recommended for one specific streambank. No management actions are recommended at this time.

Phase 1 2018 QRA geomorphology results and trends.

Metric	2018 QRA Results		Performance Trend
	Category	Results	
Channel Stability	Category 1 (Likely degrading) Category 2 (Largely stable with potential aggradational/ degradational trend) Category 3 (Likely aggrading)	Category 2: Largely Stable (avg score 3.4).	Additional indicators of sediment aggradation on point bars and floodplain.
Floodplain and Secondary Channel Stability	Category 1 (Low risk/consequence of avulsion) Category 2 (Moderate risk/consequence of avulsion) Category 3 (High risk/consequence of avulsion) Category 4 (Avulsion has occurred)	No floodplain channels creating elevated avulsion risk beyond Category 1.	Following repairs of fall 2014, no floodplain channels are present that pose a high avulsion risk.
Floodplain Connectivity	None	Clear evidence of floodplain inundation with high water marks, wood mobilization and fine sediment deposition.	Broad floodplain activation occurred as expected for June 2018 flows creating high water marks typically 6 inches higher than 2017.
Streambank	None	Fabric actively decaying, vegetation is effectively providing bank integrity. Coir logs commonly decayed or slumping.	Well performing transition to vegetation-driven bank integrity. Recommend repair of a portion of Bank LB-N-14-N-16 PV.

Phase 1 2015 Vegetation QRA results and trends.

Metric	2015 QRA Results		Performance Trend
	Category	Percent of Plots/Transects in Category	
Canopy cover woody vegetation on streambanks	Category 1 (> 40%) Category 2 (10 to 40%) Category 3 (<10%)	26% 59% 13%	Meeting or trending toward meeting short term target of 40%.
Canopy cover woody vegetation on floodplain	Category 1 (> 30%) Category 2 (10 to 30%) Category 3 (<10%)	13% 13% 74%	Low woody vegetation cover in the floodplain is expected in Year 1 and should increase significantly over the next several years.
Canopy cover herbaceous vegetation on floodplain[2]	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (20 to 50%) Category 4 (<20%)	35% 34% 12% 18%	Only 18% of the area not meeting the Year 1 target of 20% cover. Most of the species composition was native.
Woody vegetation survival	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (<50%)	56% 40% 4%	Monitoring results indicate Year 1 survival of 85.5%[1]. QRA results indicate that overall survival may have declined between 2014 and 2015 with only 56% of observed plots having greater than 80% survival.

[1]RESPEC, 2016 a, b

[2] For purposes of the QRA, total canopy cover of herbaceous species is evaluated not just cover of native herbaceous species.

Phase 1 2016 Vegetation QRA results and trends.

Metric	2016 QRA Results		Performance Trend
	Category	Percent of plots/transects in Category[1] 2016 (2015)	
Canopy cover woody vegetation on streambanks	Category 1 (> 40%) Category 2 (10 to 40%) Category 3 (<10%)	33% (26%) 50% (59%) 17% (13%)	Slight shift between Category 1 and 2 but overall trending toward 40% canopy cover to meet 5 year short term target.
Canopy cover of woody vegetation on floodplain	Category 1 (> 30%) Category 2 (10 to 30%) Category 3 (<10%)	24% (13%) 26% (13%) 50% (74%)	Despite lower survival, woody cover is increasing and trending toward 30% canopy cover to meet 5 year short term target.
Canopy cover of herbaceous vegetation on floodplain[2]	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (20 to 50%) Category 4 (<20%)	36% (35%) 30% (34%) 31% (12%) 3% (18%)	Increasing in areas where it was very low in Year 1 and trending toward 80% cover to meet 5 year short term goal. Most of the species composition is native.
Woody vegetation survival	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (<50%)	47% (56%) 45% (40%) 8% (4%)	Survival has decreased and majority of plots do not meet the year 1 80% survival performance target – as long as overall woody cover is increasing this should not be considered a negative trend.

[1] The value provided in () is the 2015 value included for comparison.

[2] For purposes of the QRA, total canopy cover of herbaceous species is evaluated not just cover of native herbaceous species.

Phase 1 2017 Vegetation QRA results and trends.

Metric	2017 QRA Results		Performance Trend
	Category	Percent of plots/transects in Category[1] 2017 (2016, 2015)	
Canopy cover woody vegetation on streambanks	Category 1 (> 40%) Category 2 (10 to 40%) Category 3 (<10%)	61% (33%, 27%) 37% (50%, 61%) 2% (15%, 12%)	Willows in streambanks continue to increase in cover and expand towards the floodplain.
Canopy cover of woody vegetation on floodplain	Category 1 (> 30%) Category 2 (10 to 30%) Category 3 (<10%)	33% (24%, 13%) 36% (26%, 13%) 31% (50%, 74%)	Canopy cover of woody vegetation continues to increase as surviving plants grow and expand; units with very low survival continue to have low woody vegetation cover.
Canopy cover of herbaceous vegetation on floodplain[2]	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (20 to 50%) Category 4 (<20%)	12% (36%, 35%) 80% (30%, 34%) 7% (31%, 12%) 1% (3%, 18%)	Herbaceous cover continues to increase in the floodplain; the shift in cover categories is likely due to use of a different methodology for estimating cover in 2017. Species composition remains primarily native.
Woody vegetation survival	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (<50%)	27% (47%, 56%) 52% (45%, 40%) 21% (8%, 4%)	Overall decrease in survival, particularly in left bank planting units where dry conditions and heavy browse were factors.

[1] The values provided in () are the 2016, 2015 values included for comparison.

[2] For purposes of the QRA, total canopy cover of herbaceous species is evaluated not just cover of native herbaceous species.

Phase 1 2018 Vegetation QRA results and trends.

Metric	2018 QRA Results		Performance Trend
	Category	Percent of plots/transects in Category[1] 2018 (2017, 2016, 2015)	
Canopy cover woody vegetation on streambanks	Category 1 (> 40%) Category 2 (10 to 40%) Category 3 (<10%)	70% (61%, 33%, 27%) 27% (37%, 50%, 61%) 3% (2%, 15%, 12%)	Willows in streambanks continue to increase in cover and expand towards the floodplain.
Canopy cover of woody vegetation on floodplain[3]	Category 1 (> 30%) Category 2 (10 to 30%) Category 3 (<10%)	37% (33%, 24%, 13%) 21% (36%, 26%, 13%) 42% (31%, 50%, 74%)	Canopy cover of woody vegetation continues to increase in 2013 planting units and flood activated areas and remain low in 2014 planting units.
Canopy cover of herbaceous vegetation on floodplain[2]	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (20 to 50%) Category 4 (<20%)	49% (12%, 36%, 35%) 47% (80%, 30%, 34%) 3% (7%, 31%, 12%) 0.4% (1%, 3%, 18%)	Herbaceous cover continues to increase in seeded areas. Weedy species decreased in 2018. Herbaceous cover decreased in flood activated areas.
Woody vegetation survival[4]	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (<50%)	N/A (27%, 47%, 56%) N/A (52%, 45%, 40%) N/A (21%, 8%, 4%)	This is a short-term monitoring metric. No survival data were collected in 2018.

[1] The values provided in () are the 2017, 2016, and 2015 values included for comparison.

[2] For purposes of the QRA, total canopy cover of herbaceous species is evaluated not just cover of native herbaceous species.

[3] Woody vegetation cover was mapped for the entire phase in 2018.

[4] No survival data were collected in 2018.

Phase 2

Construction Summary

Streambank construction was completed in Phase 2 in spring 2016. Floodplain construction was completed in summer 2016. Revegetation activities were completed in fall 2015, spring 2016 and fall 2016.

Monitoring Summary

The following monitoring has been completed in Phase 2:

- 2017: Year 1 vegetation monitoring following 2015 Monitoring Plan
- 2019: Year 3 vegetation monitoring using ROD performance standards
- 2021: Year 5 vegetation monitoring using ROD performance standards
- 2017, 2023 QRAs

Results of 2019 (Year 3) vegetation monitoring. The year 3 performance standards are highlighted in green. This table includes additional metrics recorded by RESPEC in italics.

VEGETATION ZONE	MONITORING METRIC	YEAR 7 RESULT	PERFORMANCE STANDARD BY YEAR (post-remediation)						
			1	2	3	4	5	7	10
Riparian	Planted woody species survival (%)	**NA**	90	90	-	-	-	-	-
	Preferred woody species survival (%)	**NA**	-	-	-	-	50	60	80
	Total canopy cover of non-weed perennial vegetation (%)	**38.7**	90	95	-	98	98	98	98
Riparian EXTRA	*Total canopy cover of undesirable species (%)*	***NA***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	***0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Transition	Total canopy cover of non-weed perennial vegetation (%)	**60.5**	90	95	98	-	98	-	-
Transition EXTRA	*Total canopy cover of undesirable species (%)*	***NA***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	***0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Upland	Noxious weed cover (%)	**0**	-	-	-	-	-	-	<5
	Total canopy cover of non-weed perennial vegetation (%)	**65.0**	-	-	-	-	-	-	45
	Species richness (per 100 sq. meters)	**NA**	-	-	-	-	-	-	5
Upland EXTRA	*Total canopy cover of undesirable species (%)*	**NA**	*X*	*X*	*X*	*X*	*X*	*X*	*X*

Results of 2021 (Year 5) vegetation monitoring. The year 5 performance standards are highlighted in green. This table includes additional metrics recorded by RESPEC in italics.

VEGETATION ZONE	MONITORING METRIC	YEAR 7 RESULT	PERFORMANCE STANDARD BY YEAR (post-remediation)						
			1	2	3	4	5	7	10
Riparian	Planted woody species survival (%)	**NA**	90	90	-	-	-	-	-
	Preferred woody species survival (%)	**NA**	-	-	-	-	50	60	80
	Total canopy cover of non-weed perennial vegetation (%)	**45.0**	90	95	-	98	98	98	98
Riparian EXTRA	*Total canopy cover of undesirable species (%)*	***26.9***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	***0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Transition	Total canopy cover of non-weed perennial vegetation (%)	**35.3**	90	95	98	-	98	-	-
Transition EXTRA	*Total canopy cover of undesirable species (%)*	***12.0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	***0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Upland	Noxious weed cover (%)	**0**	-	-	-	-	-	-	<5
	Total canopy cover of non-weed perennial vegetation (%)	**31.7**	-	-	-	-	-	-	45
	Species richness (per 100 sq. meters)	**NA**	-	-	-	-	-	-	5
Upland EXTRA	*Total canopy cover of undesirable species (%)*	**1.7**	*X*	*X*	*X*	*X*	*X*	*X*	*X*

Phase 2 2017 QRA geomorphology results and trends.

Metric	2017 QRA Results		Performance Trend
	Category	Results	
Channel Stability	Category 1 (Likely degrading) Category 2 (Largely stable with potential aggradational/ degradational trend) Category 3 (Likely aggrading)	Category 2: Largely Stable (avg score 3.2).	Positive trend: smooth transitions on point bars, single thread, some indication of sediment aggradation.
Floodplain and Secondary Channel Stability	Category 1 (Low risk/consequence of avulsion) Category 2 (Moderate risk/consequence of avulsion) Category 3 (High risk/consequence of avulsion) Category 4 (Avulsion has occurred)	No floodplain channels creating elevated avulsion risk beyond Category 1.	No floodplain channels are present that pose a high avulsion risk.
Floodplain Connectivity	None	Clear evidence of floodplain inundation with high water marks, wood mobilization and fine sediment deposition.	Positive trend: results provided to design engineers.
Streambank	None	One streambank treatment was noted for continued observation regarding toe stability.	Uncertain trend: continued monitoring is recommended for one specific bank. No management actions are recommended at this time.

Phase 2 2018 QRA geomorphology results and trends.

Metric	2018 QRA Results		Performance Trend
	Category	Results	
Channel Stability	Category 1 (Likely degrading) Category 2 (Largely stable with potential aggradational/degradational trend) Category 3 (Likely aggrading)	Category 2: Largely Stable (avg score 3.0).	Sediment transport apparent with floodplain deposition and point bar growth; good stability in flood year.
Floodplain and Secondary Channel Stability	Category 1 (Low risk/consequence of avulsion) Category 2 (Moderate risk/consequence of avulsion) Category 3 (High risk/consequence of avulsion) Category 4 (Avulsion has occurred)	No floodplain channels creating elevated avulsion risk beyond Category 1.	No floodplain channels are present that pose a high avulsion risk. Some stripping of vegetative backfill on floodplain.
Floodplain Connectivity	None	Clear evidence of floodplain inundation with high water marks, wood mobilization and fine sediment deposition.	Abundant evidence of floodplain inundation with high water marks up to 1.5 feet above floodplain, up to 2 inches of sand deposition in near-channel floodplain areas.
Streambank	None	One streambank treatment was noted for continued observation regarding toe stability.	The ten-year flood event resulted in substantial toe loss and soil lift failure; two sites recommended for toe material augmentation.

Phase 2 2017 Vegetation QRA results and trends.

Metric	2017 QRA Results		Performance Trend
	Category	Percent of plots/transects in Category[1]	
Canopy cover woody vegetation on streambanks	Category 1 (> 40%) Category 2 (10 to 40%) Category 3 (<10%)	52% 38% 10%	Willow cover on streambanks is trending towards achieving the short-term performance target of 40% cover by Year 5. Over half of the constructed streambanks have already met the target.
Canopy cover of woody vegetation on floodplain	Category 1 (> 30%) Category 2 (10 to 30%) Category 3 (<10%)	7% 59% 34%	Low woody vegetation cover in the floodplain is expected in Year 1 and should increase significantly over the next several years.
Canopy cover of herbaceous vegetation on floodplain[1]	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (20 to 50%) Category 4 (<20%)	22% 35% 37% 7%	Only 7% of the area is not meeting the Year 1 target of 20% cover; however, high cover is attributed to exotic species in several areas on the west side of the floodplain. Species composition is a mix of native and exotic species.
Woody vegetation survival	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (<50%)	73% 23% 4%	Despite some areas with low survival, overall survival is high and meeting short-term performance targets.

[1]For purposes of the QRA, total canopy cover of herbaceous species is evaluated not just cover of native herbaceous species.

Phase 2 2018 Vegetation QRA results and trends.

Metric	2018 QRA Results		Performance Trend
	Category	Percent of plots/transects in Category[1] 2017 (2016)	
Canopy cover woody vegetation on streambanks	Category 1 (> 40%) Category 2 (10 to 40%) Category 3 (<10%)	39% (52%) 52% (38%) 9% (10%)	Willow cover on streambanks was lower in 2018 compared to 2017 but is still trending towards achieving the short-term performance target of 40% cover by Year 5.
Canopy cover of woody vegetation on floodplain[2]	Category 1 (> 30%) Category 2 (10 to 30%) Category 3 (<10%)	32% (7%) 43% (59%) 24% (34%)	Woody vegetation cover increased in the floodplain, particularly in flood activated areas.
Canopy cover of herbaceous vegetation on floodplain[3]	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (20 to 50%) Category 4 (<20%)	31% (22%) 43% (35%) 20% (37%) 6% (7%)	Only 6% of the area is not meeting the Year 1 target of 20% cover. Exotic cover was lower in 2018 but still high overall. Species composition remains a mix of native and exotic species.
Woody vegetation survival	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (<50%)	54% (73%) 41% (23%) 5% (4%)	Survival has decreased and majority of plots do not meet the year 1 80% survival performance target – as long as overall woody cover is increasing this should not be considered a negative trend.

[1] The values provided in () are the 2017 values included for comparison.

[2] Woody vegetation cover was mapped for the entire phase in 2018.

[3] For purposes of the QRA, total canopy cover of herbaceous species is evaluated not just cover of native herbaceous species.

Phases 5 and 6

Construction Summary

Streambank construction was completed in Phases 5 and 6 in winter 2015. Floodplain construction was completed in Phase 5 in winter 2015. Floodplain construction and all remaining construction activities were completed in Phase 6 in July, 2016. Revegetation activities were completed for most of Phase 5 in spring, 2016. Revegetation activities were completed for remaining areas of Phase 5 and all of Phase 6 in October, 2016.

Monitoring Summary

The following monitoring has been completed in Phase 5 and 6:

- 2017: Year 1 vegetation monitoring following 2015 Monitoring Plan
- 2019: Year 3 vegetation monitoring using ROD performance standards
- 2021: Year 5 vegetation monitoring using ROD performance standards
- 2016, 2017, 2023 QRAs

Results of 2019 (Year 3) Phase 5 vegetation monitoring. The year 3 performance standards are highlighted in green. This table includes additional metrics recorded by RESPEC in italics.

VEGETATION ZONE	MONITORING METRIC	YEAR 7 RESULT	PERFORMANCE STANDARD BY YEAR (post-remediation)						
			1	2	3	4	5	7	10
Riparian	Planted woody species survival (%)	**NA**	90	90	-	-	-	-	-
	Preferred woody species survival (%)	**NA**	-	-	-	-	50	60	80
	Total canopy cover of non-weed perennial vegetation (%)	**46.4**	90	95	-	98	98	98	98
Riparian EXTRA	*Total canopy cover of undesirable species (%)*	**NA**	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	**0**	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Transition	Total canopy cover of non-weed perennial vegetation (%)	**48.5**	90	95	98	-	98	-	-
Transition EXTRA	*Total canopy cover of undesirable species (%)*	**NA**	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	**0**	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Upland	Noxious weed cover (%)	**NA**	-	-	-	-	-	-	<5
	Total canopy cover of non-weed perennial vegetation (%)	**NA**	-	-	-	-	-	-	45
	Species richness (per 100 sq. meters)	**NA**	-	-	-	-	-	-	5
Upland EXTRA	*Total canopy cover of undesirable species (%)*	**NA**	*X*	*X*	*X*	*X*	*X*	*X*	*X*

Results of 2021 (Year 5) Phase 5 vegetation monitoring. The year 5 performance standards are highlighted in green. This table includes additional metrics recorded by RESPEC in italics.

VEGETATION ZONE	MONITORING METRIC	YEAR 7 RESULT	PERFORMANCE STANDARD BY YEAR (post-remediation)						
			1	2	3	4	5	7	10
Riparian	Planted woody species survival (%)	**NA**	90	90	-	-	-	-	-
	Preferred woody species survival (%)	**NA**	-	-	-	-	50	60	80
	Total canopy cover of non-weed perennial vegetation (%)	**27.2**	90	95	-	98	98	98	98
Riparian EXTRA	*Total canopy cover of undesirable species (%)*	***1.0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover (%)	***0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Transition	Total canopy cover of non-weed perennial vegetation (%)	**26.8**	90	95	98	-	98	-	-
Transition EXTRA	*Total canopy cover of undesirable species (%)*	***8.4***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover (%)	***0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Upland	Noxious weed cover (%)	**0**	-	-	-	-	-	-	<5
	Total canopy cover of non-weed perennial vegetation (%)	**25.4**	-	-	-	-	-	-	45
	Species richness (per 100 sq. meters)	**NA**	-	-	-	-	-	-	5
Upland EXTRA	*Total canopy cover of undesirable species (%)*	***14.4***	*X*	*X*	*X*	*X*	*X*	*X*	*X*

Results of 2019 (Year 3) Phase 6 vegetation monitoring. The year 3 performance standards are highlighted in green. This table includes additional metrics recorded by RESPEC in italics.

VEGETATION ZONE	MONITORING METRIC	YEAR 7 RESULT	PERFORMANCE STANDARD BY YEAR (post-remediation)						
			1	2	3	4	5	7	10
Riparian	Planted woody species survival (%)	**NA**	90	90	-	-	-	-	-
	Preferred woody species survival (%)	**NA**	-	-	-	-	50	60	80
	Total canopy cover of non-weed perennial vegetation (%)	**45.1**	90	95	-	98	98	98	98
Riparian EXTRA	*Total canopy cover of undesirable species (%)*	***NA***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	***0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Transition	Total canopy cover of non-weed perennial vegetation (%)	**47.1**	90	95	98	-	98	-	-
Transition EXTRA	*Total canopy cover of undesirable species (%)*	***NA***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	***0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Upland	Noxious weed cover (%)	**0**	-	-	-	-	-	-	<5
	Total canopy cover of non-weed perennial vegetation (%)	**23.5**	-	-	-	-	-	-	45
	Species richness (per 100 sq. meters)	**NA**	-	-	-	-	-	-	5
Upland EXTRA	*Total canopy cover of undesirable species (%)*	**NA**	*X*	*X*	*X*	*X*	*X*	*X*	*X*

Results of 2021 (Year 5) Phase 6 vegetation monitoring. The year 5 performance standards are highlighted in green. This table includes additional metrics recorded by RESPEC in italics.

VEGETATION ZONE	MONITORING METRIC	YEAR 7 RESULT	PERFORMANCE STANDARD BY YEAR (post-remediation)						
			1	2	3	4	5	7	10
Riparian	Planted woody species survival (%)	**NA**	90	90	-	-	-	-	-
	Preferred woody species survival (%)	**NA**	-	-	-	-	50	60	80
	Total canopy cover of non-weed perennial vegetation (%)	**31.9**	90	95	-	98	98	98	98
Riparian EXTRA	*Total canopy cover of undesirable species (%)*	***19.3***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	***0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Transition	Total canopy cover of non-weed perennial vegetation (%)	**37.7**	90	95	98	-	98	-	-
Transition EXTRA	*Total canopy cover of undesirable species (%)*	***4.6***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
	Noxious weed cover	***0***	*X*	*X*	*X*	*X*	*X*	*X*	*X*
Upland	Noxious weed cover (%)	**0.05**	-	-	-	-	-	-	<5
	Total canopy cover of non-weed perennial vegetation (%)	**39.8**	-	-	-	-	-	-	45
	Species richness (per 100 sq. meters)	**NA**	-	-	-	-	-	-	5
Upland EXTRA	*Total canopy cover of undesirable species (%)*	**0.5**	*X*	*X*	*X*	*X*	*X*	*X*	*X*

Phases 5 and 6 2016 QRA geomorphology results and trends.

Metric	2016 QRA Results		Performance Trend
	Category	Results	
Channel Stability	Category 1 (Likely degrading) Category 2 (Largely stable with potential aggradational/ degradational trend) Category 3 (Likely aggrading)	Category 2 – Largely Stable, with some indicators of fine sediment deposition in slackwater areas.	Geomorphically stable, with some localized deposition.
Floodplain and Secondary Channel Stability	Category 1 (Low risk/consequence of avulsion) Category 2 (Moderate risk/consequence of avulsion) Category 3 (High risk/consequence of avulsion) Category 4 (Avulsion has occurred)	No out of bank flows in spring 2016 so not assessed	No out of bank flows in spring 2016 so not assessed.
Floodplain Connectivity	None	No out of bank flows in spring 2016 so not assessed	No out of bank flows in spring 2016 so not assessed.
Streambank	None	Thirty nine streambank treatments were noted for continued observation regarding fabric condition, toe stability, and/or poor willow growth.	Uncertain trend: continued monitoring is recommended. No management actions are recommended at this time.

Phases 5 and 6 2017 QRA geomorphology results and trends.

Metric	2017 QRA Results		Performance Trend
	Category	Results	
Channel Stability	Category 1 (Likely degrading) Category 2 (Largely stable with potential aggradational/ degradational trend) Category 3 (Likely aggrading)	Category 2: Largely Stable (avg score 3.2).	Geomorphically stable, with some localized deposition.
Floodplain and Secondary Channel Stability	Category 1 (Low risk/consequence of avulsion) Category 2 (Moderate risk/consequence of avulsion) Category 3 (High risk/consequence of avulsion) Category 4 (Avulsion has occurred)	No floodplain channels creating elevated avulsion risk beyond Category 1.	No floodplain channels are present that pose a high avulsion risk.
Floodplain Connectivity	None	Variable evidence of floodplain inundation with high water marks, wood mobilization and fine sediment deposition.	Floodplain inundation indicators were less robust than expected—results provided to design engineers.
Streambank	None	Notably increased growth in brush matrix treatments.	Uncertain trend: continued monitoring is recommended for three specific banks. No management actions are recommended at this time.

Phases 5 and 6 2018 QRA geomorphology results and trends.

Metric	2018 QRA Results		Performance Trend
	Category	Results	
Channel Stability	Category 1 (Likely degrading) Category 2 (Largely stable with potential aggradational/ degradational trend) Category 3 (Likely aggrading)	Category 2: Largely Stable (avg score 3.6).	Geomorphically stable, with some localized deposition.
Floodplain and Secondary Channel Stability	Category 1 (Low risk/consequence of avulsion) Category 2 (Moderate risk/consequence of avulsion) Category 3 (High risk/consequence of avulsion) Category 4 (Avulsion has occurred)	No floodplain channels creating elevated avulsion risk beyond Category 1.	No floodplain channels are present that pose a high avulsion risk.
Floodplain Connectivity	None	Variable evidence of floodplain inundation with high water marks, wood mobilization and vegetative backfill reworking in microtopography.	Floodplain inundation indicators were less robust than anticipated—results provided to design engineers.
Streambank	None	Numerous DVSL treatments lost coir logs in 2018, attributable to ice and high flows that mobilized toe material as designed.	Uncertain trend: continued monitoring is recommended for seven specific banks. One small fencing action is recommended where foot traffic pressure is heavy on a damaged bank.

Phases 5 and 6 2016 Vegetation QRA results and trends.

Metric	2016 QRA Results		Performance Trend
	Category	Percent of Plots/Transects in Category	
Canopy cover woody vegetation on streambanks	Category 1 (> 40%) Category 2 (10 to 40%) Category 3 (<10%)	42% 48% 10%	Many banks already meet the Year 5 short term performance target of 40% cover and only 10% were at risk of not meeting the target.
Canopy cover of woody vegetation on floodplain	Category 1 (> 30%) Category 2 (10 to 30%) Category 3 (<10%)	0% 11% 89%	Most plants were installed in fall 2015/Spring 2016 and are in the first growing season so low cover is expected.
Canopy cover of herbaceous vegetation[1]	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (20-50%) Category 4 (<20%)	No data collected	Herbaceous vegetation cover varies throughout the floodplain but most areas meet the >20% cover target for year 1 – exotic species cover is high in some areas. Based on visual observations most areas are likely in Category 2 and 3, few areas are Category 1.
Woody vegetation survival	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (<50%)	71% 25% 4%	Most of the observed planting units meet the 80% survival performance target for year 1.

[1] For purposes of the QRA, total canopy cover of herbaceous species is evaluated not just cover of native herbaceous species.

Phases 5 and 6 2017 Vegetation QRA results and trends.

Metric	2017 QRA Results		Performance Trend
	Category	Percent of Plots/Transects in Category[1] 2017 (2016)	
Canopy cover woody vegetation on streambanks	Category 1 (> 40%) Category 2 (10 to 40%) Category 3 (<10%)	75% (42%) 23% (48%) 2% (10%)	Willows in streambanks continue to increase in cover.
Canopy cover of woody vegetation on floodplain	Category 1 (> 30%) Category 2 (10 to 30%) Category 3 (<10%)	2% (0%) 49% (11%) 49% (89%)	Canopy cover of woody vegetation continues to increase as surviving plants grow and expand; units with very low survival continue to have low woody vegetation cover.
Canopy cover of herbaceous vegetation[2, 4]	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (20-50%) Category 4 (<20%)	17% 60% 23% 1%	Herbaceous cover is high, however exotic species cover is also high in some areas.
Woody vegetation survival	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (<50%)	74%[3], 57% (71%) 10%[3], 22% (25%) 16%[3], 21% (4%)	Overall decrease in survival, particularly in higher elevation planting units where dry conditions were a factor.

[1] The value provided in () is the 2016 value included for comparison.
[2] No data collected in 2016.
[3] The first number reports survival of planting units planted in 2016 (Year 1 for those units). The second number is for all planting units evaluated, including those planted in 2015 (Year 2) and 2016.
[4] For purposes of the QRA, total canopy cover of herbaceous species is evaluated not just cover of native herbaceous species.

Phases 5 and 6 2018 Vegetation QRA results and trends.

Metric	2018 QRA Results		Performance Trend
	Category	Percent of Plots/Transects in Category[1] 2018 (2017, 2016)	
Canopy cover woody vegetation on streambanks	Category 1 (> 40%) Category 2 (10 to 40%) Category 3 (<10%)	84% (75%, 42%) 24% (23%, 48%) 2% (2%, 10%)	Willows in streambanks continue to increase in cover and expand into the floodplain.
Canopy cover of woody vegetation on floodplain[5]	Category 1 (> 30%) Category 2 (10 to 30%) Category 3 (<10%)	10% (2%, 0%) 43% (49%, 11%) 47% (49%, 89%)	Canopy cover of woody vegetation increased; however, woody cover overall is low.
Canopy cover of herbaceous vegetation[2, 4]	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (20-50%) Category 4 (<20%)	26% (17%) 64% (60%) 9% (23%) 0.7% (1%)	Herbaceous cover increased and exotic species cover decreased.
Woody vegetation survival	Category 1 (> 80%) Category 2 (50 to 80%) Category 3 (<50%)	23% (74%[3], 57%), (71%) 55% (10%[3], 22%), (25%) 23%, (16%[3], 21%), (4%)	Continued decrease in survival, particularly in higher elevation planting units where dry conditions were a factor.

[1] The values provided in () are the 2017 and 2016 values included for comparison.
[2] No data collected in 2016.
[3] The first number reports survival of planting units planted in 2016 (Year 1 for those units). The second number is for all planting units evaluated, including those planted in 2015 (Year 2) and 2016.
[4] For purposes of the QRA, total canopy cover of herbaceous species is evaluated not just cover of native herbaceous species.
[5] Woody vegetation cover was mapped for the entire phase in 2018.

Attachment B. July 2023 Drone Imagery Phase 1 and Phase 2


PHASE 1/2
PHASE 2/3A
CLARK FORK RIVER
CLARK FORK RIVER
PHASE 1
PHASE 1/2
PHASE 1
PHASE 2
0 250 500
Feet
0 500 1,000
Feet
PHASE BREAK
PHASE BOUNDARY
IMAGERY: GEUM 2023 DRONE IMAGERY/NAIP 2021

Attachment C. July 2023 Drone Imagery Phases 5 and 6


PHASE 5/6
PHASE End 6
CLARK FORK RIVER
CLARK FORK RIVER
PHASE 4/5
PHASE 5/6
PHASE 5
PHASE 6
PHASE BREAK
PHASE BOUNDARY
0
500
1,000
Feet
IMAGERY: GEUM JULY 2023 DRONE IMAGERY/NAIP 2021

Attachment D. Phase 1 Field Photos

Streambanks
















Riparian Buffer






Point Bars

Floodplain Features











Floodplain Vegetation Cover











Other

Attachment E. Phase 2 Field Photos

Streambanks











Riparian Buffer

Point Bars



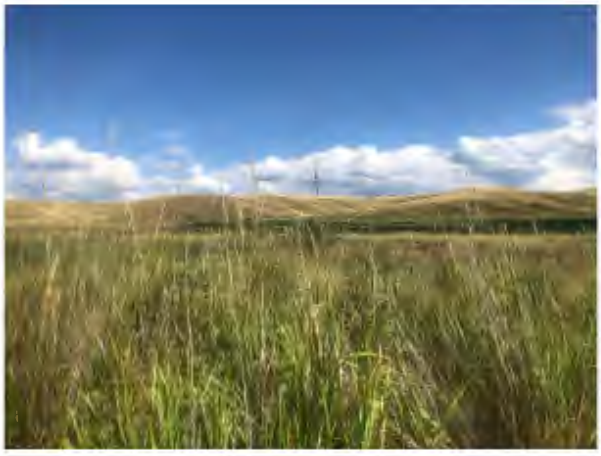



Floodplain Features






Floodplain Vegetation Cover






Other






Attachment F. Phase 5-6 Field Photos

Streambanks


























Riparian Buffer
















Point Bars
























Floodplain Features






Floodplain Vegetation Cover






Other