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TECHNICAL MEMORANDUM

To: Marisa Sowles, Geum Environmental
From: Karin Boyd, Applied Geomorphology
Date: October 28, 2020
Regarding: Skalkaho Bend, Bitterroot River at Hamilton MT

1.0 Introduction

This memorandum describes my observations of the Bitterroot River geomorphology at Skalkaho Park near Hamilton MT. The intent is to consider the likelihood of substantial channel migration at Skalkaho Bend that will create problems in the future, and to also consider management approaches at the site. The following discussion is limited in that it is based primarily on a remote evaluation of air photos coupled with flow records. Field photos of the site were also provided for review, and I was involved in a field inventory of this section of river in 2002 (Boyd and Thatcher, 2002). Because of its limited extent, this summary should be considered a cursory geomorphic evaluation of recent trends in river planform and associated geomorphic conditions at Skalkaho Bend.

Skalkaho Park is located in a major expansion area of the Bitterroot River braid belt (Gaeuman, 1997). Upstream, the river corridor between Darby and Hamilton is narrow and shows low migration rates. This area marks a rapid expansion in the corridor width and migration rates increase appreciably. The site is located in an area of persistent split flow, and recent migration of the easternmost channel in this area has extended beyond the historic braid belt. Figure 1 shows that there are several flow splits upstream of the eroding bank of interest, and that the complex flow paths have persisted since at least the 1950s.

Some observations regarding the 2017 flow paths include:

- The upstream-most flow split (#1) activates at high water and follows lowermost Skalkaho Creek, which will persist as a flow path to the eroding bank;
- The middle (#2) flow split has persisted and feeds a prominent high flow channel that routes water to the eroding bank;
- The lower (#3) flow split appears to be progressively shifting such that more water is going into the westernmost channel.

The trajectory of the flow distribution in this section of the river is difficult to predict since the paths are so affected by large wood accumulations. The geomorphically complex nature of this multi-threaded segment of the Bitterroot River does indicate, however, that the site has dynamic inputs that can change rapidly, depending on upstream conditions. This uncertainty makes adaptive management an important consideration in project development.

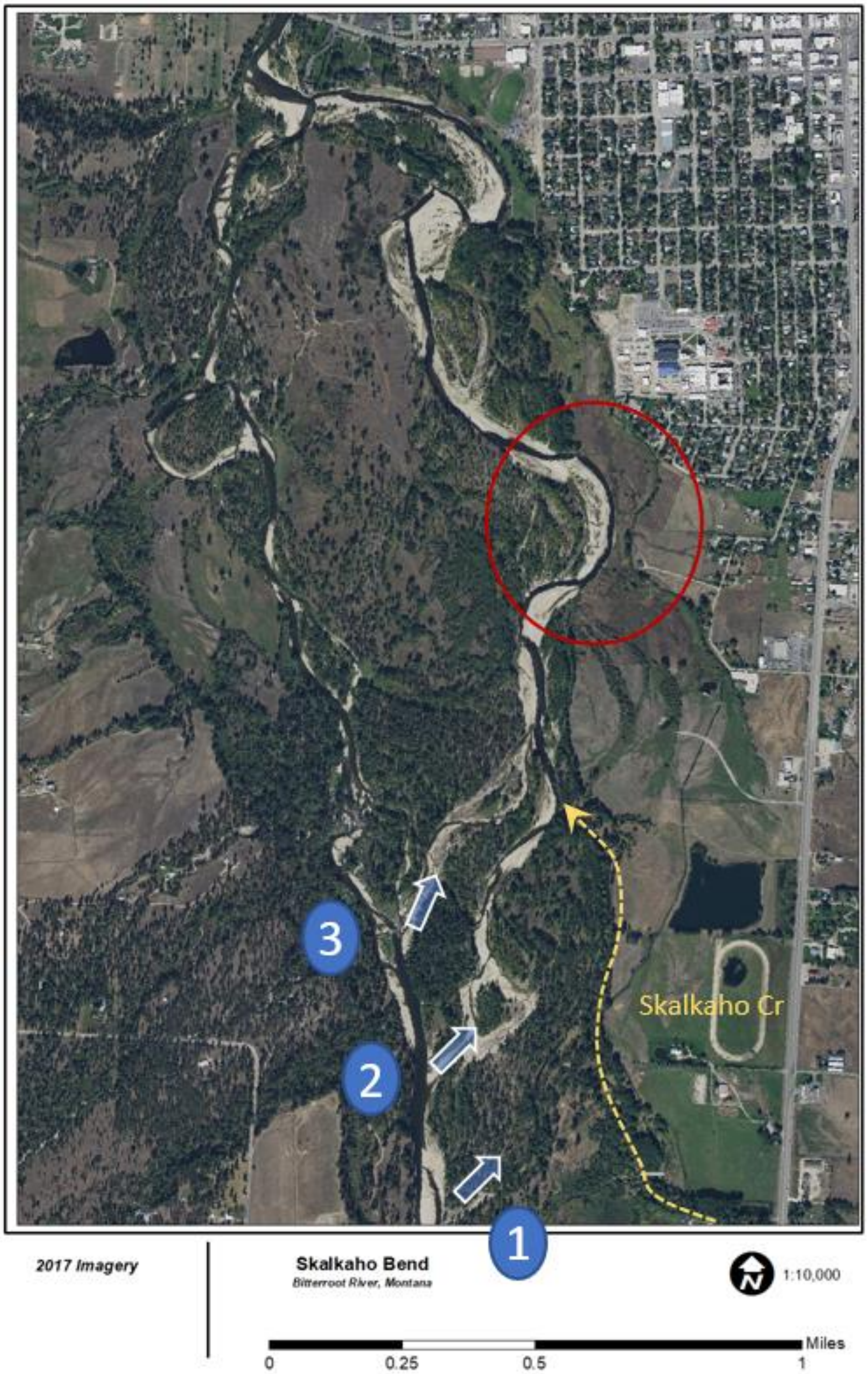

Figure 1. Prominent flow splits on Bitterroot River in 2017—bank of concern is marked by red circle.

With regard to the erosion site itself (Figure 2), some observations include:

- There is a fully developed chute channel through the meander core that will likely continue to enlarge and convey progressively more flow in coming decades.
- The radius of curvature to width ratio of the eroding bend is about 3, which indicates that a wholesale cutoff is ***not*** imminent, and erosion will probably continue in the near-term.
- The downstream portion of the eroding bank consists of a non-cohesive gravel toe that is overlain by fine grained floodplain deposits, whereas the apex of the bend has more cohesive swale/floodplain deposits (Figure 3). In general, the bank is quite erodible with topple failing upper banks that collapse with toe erosion. The photo in Figure 3 was taken during a field inventory of the river in 2002.
- Like most bendways, the erosion is fastest on the downstream portion of the bend. Since 1995, the upper limb of the meander has migrated about 110 feet, whereas the downstream limb has shifted about 180 feet (Figure 4).
- Continued migration of the bend may result in its interception with a prominent ditch that follows the edge of town and Rocky Mountain Laboratories; based on historic rates this will happen in about 20 years (Figure 4). This projection is based on ***average*** migration rates; it is important to note that long duration flooding and changes in upstream flow splits could drive higher rates of bank retreat. Since 1995, the USGS gage near Darby (#12344000) has recorded no events over a 10-year flood (Table 1).

Figure 2. Oblique image from Google Earth looking downstream showing Skalkaho Bend and ditch to right.

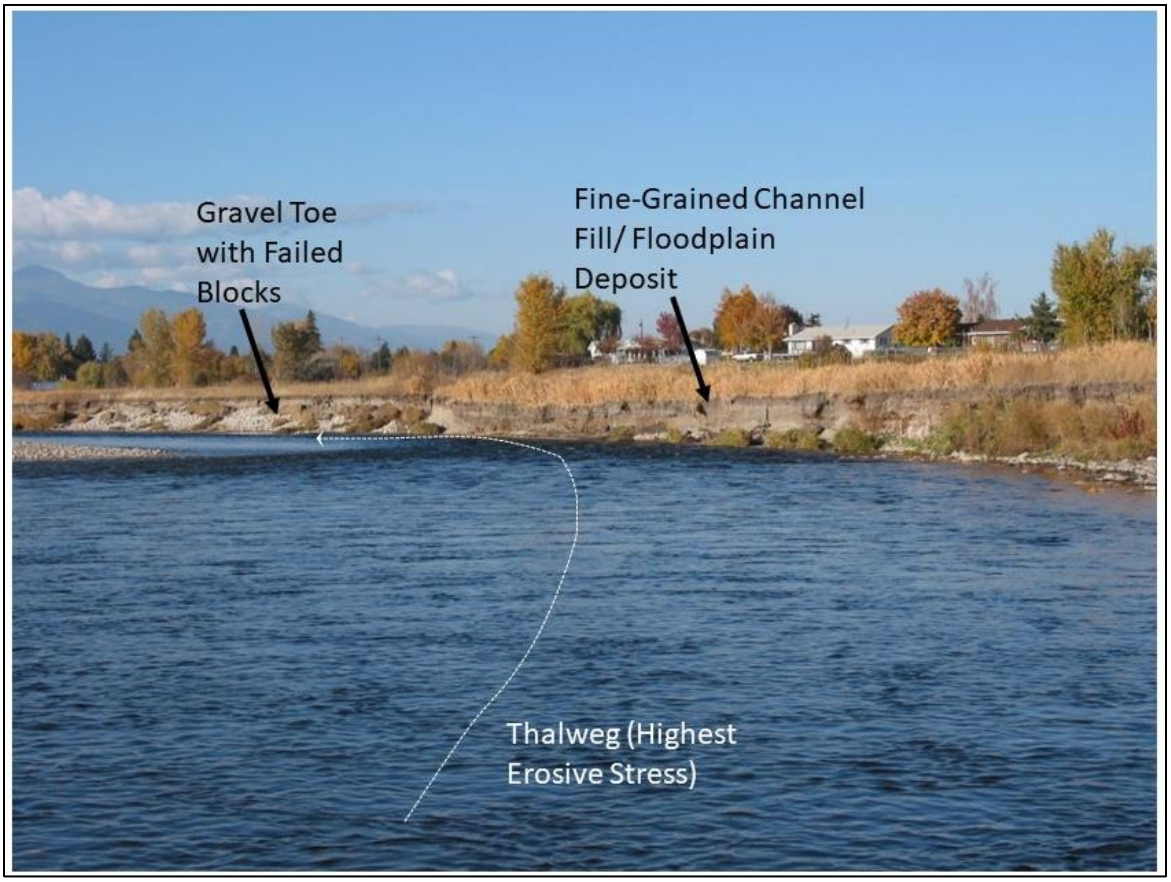

Figure 3. Eroding bank at Skalkaho Bend as photographed in 2002.

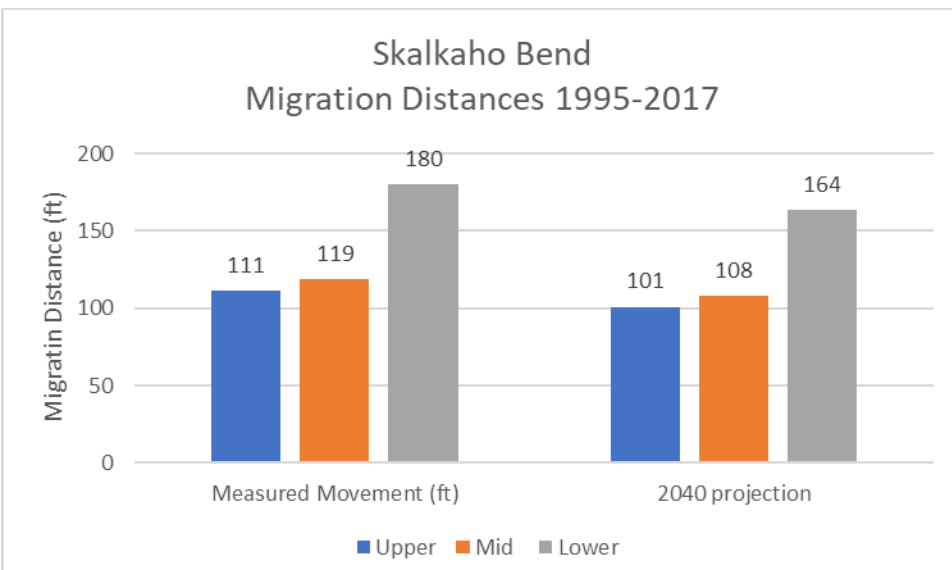

Figure 4. Migration distances on eroding bend (left) and projected movement through 2040 (right).

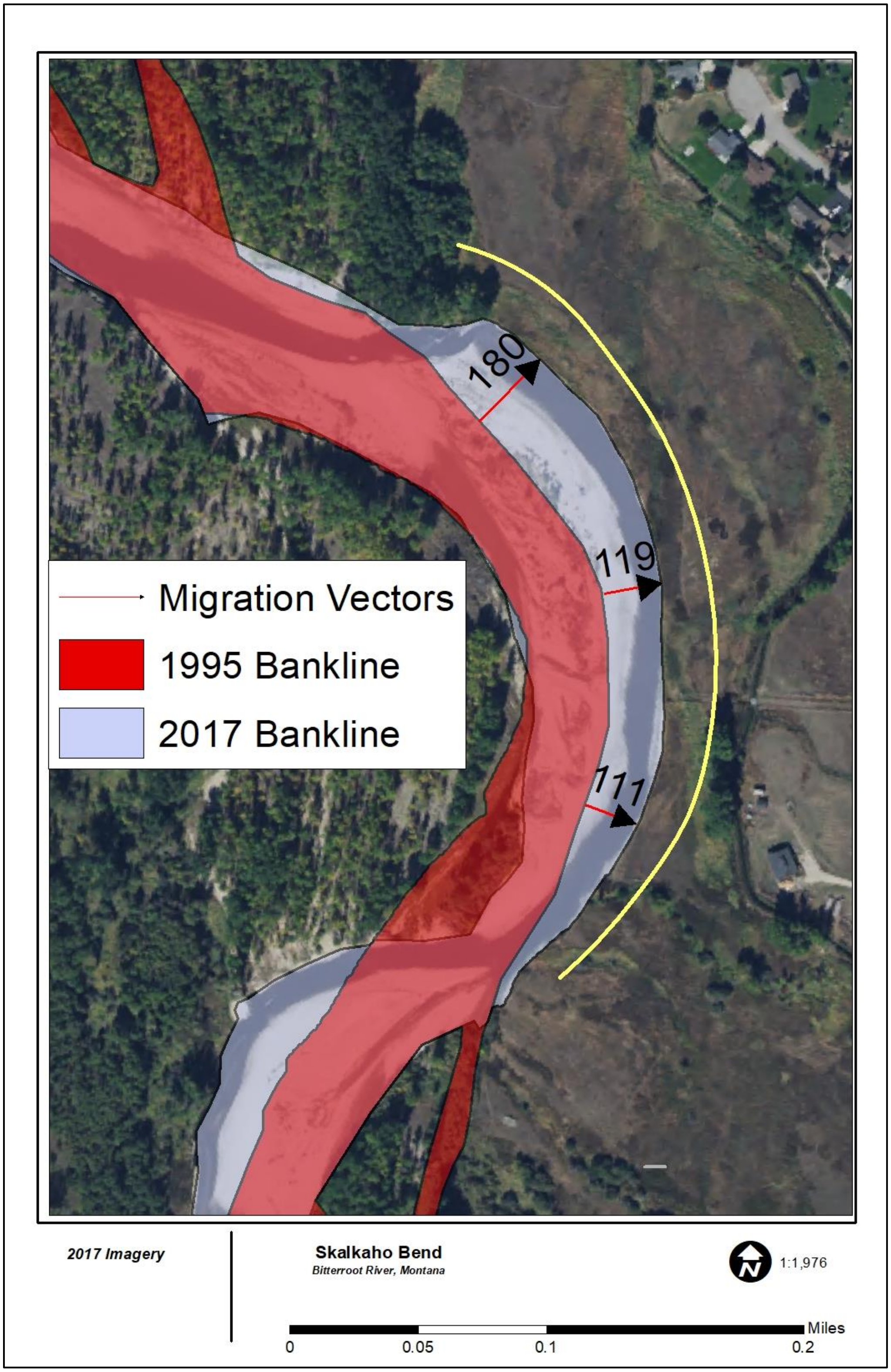

Figure 5. Measured 1995-2017 migration distances along bend showing estimated 2040 bank location (yellow) based on average annual erosion rates.

Table 1. 1995-2017 Flow history and estimated flood frequencies from USGS Gage #12344000-- Bitterroot River near Darby MT.

Year	Peak Flow (cfs)	Date	Gage Height (ft)	Frequency
1995	5,160	Jun. 04, 1995	6.4	
1996	9,320	Jun. 09, 1996	8.26	5-Year
1997	10,100	May 17, 1997	8.43	10-year
1998	3,650	May 27, 1998	5.14	
1999	6,660	May 26, 1999	6.89	
2000	3,310	May 23, 2000	4.86	
2001	3,670	May 16, 2001	5.03	
2002	6,140	May 31, 2002	6.57	
2003	10,300	May 31, 2003	8.45	10-year
2004	2,950	Jun. 06, 2004	4.51	
2005	3,600	May 19, 2005	5	
2006	7,970	May 20, 2006	7.48	
2007	4,410	Nov. 08, 2006	5.6	
2008	9,220	May 20, 2008	8.05	5-Year
2009	9,510	May 20, 2009	8.18	5-Year
2010	6,570	Jun. 05, 2010	6.78	
2011	8,620	Jun. 08, 2011	7.65	5-Year
2012	7,780	Apr. 27, 2012	7.27	
2013	6,050	May 14, 2013	6.7	
2014	8,230	May 24, 2014	7.84	
2015	4,180	May 17, 2015	5.32	
2016	4,190	May 9, 2016	5.5	
2017	6,720	Jun. 13, 2017	6.8	
2018	8,870	May 10, 2018	7.88	5-Year
2019	5,700	May 18, 2019	6.24	

Figure 6 shows a view downstream of the upper part of the bend in 2002; at this point the river was about 200 feet from the edge of the cottonwoods and the ditch; in the 2017 imagery it is about 130 feet away.

Figure 6. View downstream from 2002 showing cottonwood grove along ditch line.

2.0 Implications of Geomorphic Conditions for Developing a Management Strategy

This site does not show any clear need for short-term erosion control. As the site continues to evolve, there are some factors that will lean towards no need for treatment, and others that will make erosion control necessary and appropriate. Table 2 lists some aspects of the site that would tend to support No Action at this time. It also identifies some conditions that would minimize the geomorphic impacts of any erosion control.

Table 2. Positive aspects of site conditions.

Pros	Explanation
The ditch is not at imminent risk of capture.	There is still a substantial buffer between the river and ditch.
The ditch could provide a water source for vegetative treatments	If floodplain work were undertaken to improve its resilience, there may be irrigation potential from the ditch.
The river corridor is over a half-mile wide	The eroding bank is on the edge of the active stream corridor and there is a substantial likelihood that flow shifts will remove pressure from the eroding bank in coming years. Also, if bank armor is ever built here, the site is on the edge of the wide historic channel migration zone such that impacts to ecological function will be much lower than mid-corridor work.
The reach is highly dynamic	The river is constantly shifting in this reach such that bank treatments may be abandoned—as a result the need should be demonstrably clear to maximize cost/benefit of any project.
The eroding bank is sub-parallel to the stream corridor	As the site is at a low angle to the river corridor axis, any treatment on site will minimally intrude into the Historic Migration Zone
The floodplain in this area has vigorous riparian growth rates	Historic air photos show excellent riparian expansion on low floodplain surfaces since the 1950s, which supports riparian revegetation efforts as a part of or in lieu of rock treatments.
Recent flow shifting patterns suggest that the west channel may continue to enlarge	The west channel has enlarged in recent decades and that trend may continue, reducing erosive pressure on the site.
Large wood accumulations limit flows to the east channel	LWD jams at the northernmost flow split contribute to flow deflections to the west, away from the site.
The eroding bank has a prominent debris jam on its lower end	This debris jam effectively pins the lower end of the eroding meander, providing a good tie in point for any treatment. The jam also reduces any avulsion potential into cottonwoods due north of the meander.

Although there are clearly some aspects of the site that would allow managers to “rest easy”, there are other factors that complicate matters and could cause problems in the future (Table 3).

Table 3. Negative aspects of site conditions.

Cons	Explanation
The shape of the bend makes it prone to continued movement	The Radius of Curvature to Width Ratio (Rc/W) is about 3 for the meander bend, which places it in a phase of relatively active development. But the development of a chute channel across the meander may create a substantial flow split in coming years.
The 1995-2019 flood history is subdued	There have been no floods on the river that have exceeded a 10-year event since 1995. A major flood could drive rapid erosion and shifts in flow patterns.
The bank has poor erosion resistance	The bank consists of an unconsolidated gravel toe with some fine-grained channel remnants exposed. There is no deeply rooted woody vegetation to resist erosion.
Other channel changes in the area could exacerbate erosion rates	The cottonwood grove downstream of the migrating meander is dissected by capillary/overflow channels that could become activated and shift erosion rates and patterns locally.
Long Treatment (impacts)	Any bank treatment on site would be quite long (>1,000 feet) which would create high localized velocities and potentially accelerate erosion downstream.
Long Treatment (construction and mitigation costs)	Bank protection and mitigation would relatively be costly on a per foot basis.
Tributary inputs	Although flows may shift to the west, Skalkaho Creek will continue to feed the east channel, making the site vulnerable to flooding on that tributary.

3.0 Recommendations

Although my review has been limited to air photo review and some long-term familiarity with the Bitterroot River, I would suggest that this site does not require imminent, aggressive bank armor but would benefit from perhaps softer vegetative measures and careful monitoring. To that end, I would recommend you consider the following:

1. Identify the maximum tolerance for bank movement—create a floodplain management boundary east of the eroding bank. Use this as a monitoring parameter that would trigger a large erosion control project.

2. Implement short-term treatments if there is interest. These may include:
   a. Relocating the ditch further east
   b. Excavating low swales in the floodplain and plant them aggressively with cottonwoods and willows. The lower portion of the bend (~800 feet) would be the most critical area to grade/plant.
   c. Only build a rock treatment if it's an imminent concern. If this approach is taken, include a coarse immobile rock toe, floodplain bench, and dense plantings.

4.0 References Cited

Boyd, K.B. and T. Thatcher, 2002. Bitterroot River Geomorphic Summary: Mainstem Channel and Bridge Crossings, Ravalli County, Montana: Report prepared for Montana Department of Transportation, May 2008, 93p.

Gaeuman, D. 1997. Historical channel changes and processes of the central Bitterroot River, Ravalli County, Montana. M.A. Thesis. University of Montana, Missoula, Montana, 78 p.