Reservoir Sediment Evacuation and Channel Evolution: Upstream Geomorphic Response of the Blackfoot River, Montana, to Removal of Milltown Dam

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Introduction
We investigated upstream reservoir sediment erosion and channel evolution of the Blackfoot River, MT, following the 2008 removal of Milltown Dam, which was located on the Clark Fork River at its confluence with the Blackfoot River. The removal of Milltown Dam has garnered substantial attention because of the presence of contaminated sediments in the Clark Fork arm of Milltown Reservoir, but river erosion of uncontaminated sediments from the Blackfoot arm of Milltown reservoir has provided an opportunity to examine river response to base-level lowering. Increasing our understanding of upstream sediment dynamics and channel evolution in such a context is critical to enhance our ability to plan for and execute future dam removals.

The primary objective of this research is to track the spatial and temporal patterns of river erosion through field measurements and modeling (HEC-RAS). The 9 m base level reduction resulting from the dam removal, combined with a peak flow recurrence interval of approximately 4 years during the 2008 runoff produced erosion and downstream transport of >100 years of accumulated sediment in the first several months following dam breaching.

Study Area
Blackfoot River, MT
• Drainage area = 6,000 km²
• Study reach: Blackfoot R. from Milltown Dam to 8 km upstream
  • Milltown reservoir reach
  • Silt/sand in lower 2 km
  • Gravel/cobble in upper 1 km
  • Upstream reach

Field data
• Topography (RTK-GPS, total station, echo sounder)
• Sediment size
• Aerial photography
Pre-removal: Spring 2008
Post-removal: May-Nov. 2008

Time series aerial photography
Minimal platform changes were possible as the study reach is highly confined.

Figure 1. 2008 hypsographic for Blackfoot River near Bonner, MT, showing water surface profile survey dates. The peak (20 May 2008) had a 4-year return interval.

Figure 2. Blackfoot River water surface profiles upstream from Milltown Dam through 2008 runoff illustrating post-dam removal channel incision. Reach average slope increased from 0.0002 (2003) to 0.002 (2008), post Milltown Dam (and Stimson Dam removal).

Figure 3. Change in cross sectional area vs. distance upstream from Milltown Dam.

Figure 4a, b. c. Pre-removal data collected in March 2008, compared with August-November post. Cross sectional area and surface sediment response in representative sites throughout and upstream of the historic reservoir area.

Figure 5. Change in surface sediment size (D50) from pre-to post removal of Milltown Dam. The lower 2000m of the study reach experienced 3-10x increase in flow and bedload concentration associated with spring 2008 dam breach.

Acknowledgments

Future Directions:
- HEC-RAS modeling to analyze sediment evacuation through the 2008 runoff
- Volumetric estimates of reservoir erosion
- Analysis of evidence of knickpoint migration
- Test exponential decay hypothesis: prediction that post-removal erosion follows exponential decay function

Figure 6. 2004
Stimson Dam
2008
Stimson Dam
Approximate upstream extent of Milltown reservoir

Figure 7. Change in cross sectional area vs. distance upstream from Milltown Dam.