Abstract

The decommissioning of dams, as an approach to restoring longitudinal connectivity and to managing aging infrastructure, presents valuable opportunities for integrated study of channel responses to sediment pulses. Experiments with physical and numerical models suggest that rivers process coarse sediment pulses through a series of fundamental processes: dispersion, advection, and sediment waves. A better understanding of these processes may lead to a more complete appreciation of their relative importance and role in long-term sediment dynamics. While the reported physical and numerical experiments have provided valuable insights into expectations for channel dynamics, they are largely unconfirmed by field observations.

To explore whether dispersion dominates the processing of gravel pulses in natural rivers, we investigated downstream channel changes associated with three barrier removals in Oregon, ranging from very small (Oak Creek culvert, height = 1.5m), small (Brownsville Dam, height = 2.5m), to medium (Savage Rapids Dam, height = 12m). Each project trapped coarse sediment during construction, after which bedload passed over, or through, the barrier. Material behind the barrier was finer than the dominant grains downstream at Oak Creek and Savage Rapids, but was coarser than dominant channel grains at Brownsville. We present results from two years of post removal bathymetric and substrate surveys at each site. Net deposition and scour were calculated for cross sections and the thalweg profile, both in the reservoir and downstream of the former barrier.

At our sites, sediment appears to be processed by both dispersion and translation, though dispersion appears to be the more dominant process. That is, we see evidence of the material both decaying in place, suggesting dispersion, as well as some skewing of the sediment wave in the downstream direction, indicative of translation of the material. Further, the channels processed sediments rapidly, eroding substantial amounts of reservoir material within the first two years following removal of the barrier.

These results suggest that, in the case of small to medium reservoirs filled with non-cohesive material that is coarser than downstream sediments, substantial aggradation will likely be limited to local areas directly downstream of the barrier. As the sediment pulse decays, the wavelength of the sediment release increases while amplitude decreases, such that effects beyond the reach immediately downstream of the dam are likely to be negligible, particularly if the barrier passed bed load before removal.

Discussion and Conclusions

For Oak Creek and Brownsville, the relative wave amplitude is low and near a common for gravel-bedded rivers (0.001) where dispersive movement of waves dominates (Lisle et al. 2001). However, the channel slopes are also low, in a range (0.1%) where Froude numbers are generally low, leading to translational movement of the sediment wave. Based on the scour/deposition figures at these sites, we evidence that both the height of the wave decreases two years post removal and generally is decaying in place. For Savage Rapids, where the amplitude is high and the wave material is smaller than the dominant channel particles, we anticipate stronger evidence of wave movement by advection in the second survey following removal.

In this preliminary analysis, we acknowledge the subjectivity in identifying wave axes and edges, but also believe that this information, supported by further analysis, can provide some insights into the movement of sediment after barrier removal in coarse bed, low gradient streams.

Ongoing work. In addition to analyzing the second field survey at Savage Rapids, ongoing analysis includes calculation of Froude numbers at the annual peak flows and establishing error estimates for scour and deposition calculations.

References

USBR. 2010. Memorandum. Travel Report to investigate reservoir sediment erosion and deposition at the former site of Savage Rapids Dam.

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