RECLAMATION
Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

Research Update

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Bottom Line

This research project will help determine the appropriate signal processing from impact plates instrumented with an accelerometer to provide an alternate means to measure bed load on the Elwha River using plates. The impact plate system is currently measuring bed load with geophones.

Better, Faster, Cheaper

Physical measurements of bed load are dangerous and expensive. This technology could provide continuous, safe measurements critical for designing and protecting infrastructure and habitat.

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Registering Bed Load Impacts on the Riverbed for Surrogate Bed Load Measurement

Quantifying coarse bed load transport rates at fixed cross sections of a riverbed

Problem

Measuring how gravel and rocks move along a riverbed is a critical component for understanding a river's geomorphology, which is needed to understand the channel morphology for better prediction of sediment transport. This is especially crucial downstream from a dam removal to determine how channels form—and where very little sediment measurement data exist.

Quantifying the movement of bed sediment in a river (the bed load) is difficult because bed load moves only during high flow events, perhaps once a year under normal conditions. Measuring bed load transport using classical means, with pressure difference bed load samplers, only provides snapshots (1 to 2 minutes) of data at discrete times and locations across the channel and is dangerous during floods. To truly understand bed load transport, a reliable way to continuously measure its movement is needed.

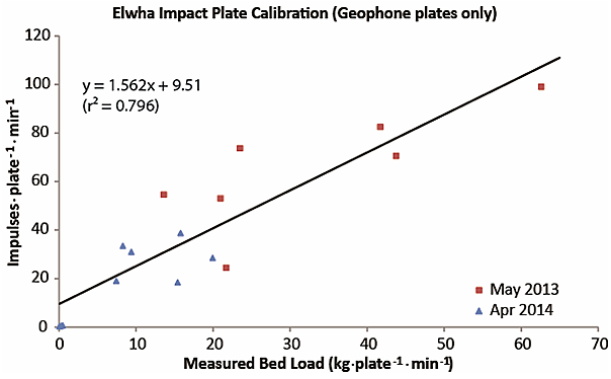
To perform continuous measurements, a series of bed load impact plates have been installed on the Elwha River for measuring bed load during and after dam removal. Each plate is instrumented with either a geophone (46 plates) or accelerometer (26 plates). Either sensor can be used to quantify bed load. These instrumented steel plates are mounted adjacent to one another and span the active channel.

While these plates can measure the signals generated as bed load moves across them, the signals need to be interpreted. Characterizing bed load based on these signals requires understanding these signals—which signals indicate what amount and type of sediment movement?

Photograph looking down on the Elwha River impact plate system and surface water diversion structure (left). Closeup photograph of the impact plates mounted on the downstream side of a concrete weir (right). In both images the flow of water is from left to right.

Solution

To date, the impact plate system has had a preliminary calibration for the impact plates instrumented with geophones.



Most recent calibration of the geophone impact plates.

In 2015, this Reclamation Science and Technology Program research project performed flume experiments with a full-scale two-plate system instrumented with accelerometers. These experiments were done in cooperation with the U.S. Department of Agriculture's Agricultural Research Service and the University of Mississippi's National Center for Physical Acoustics. These experiments will provide valuable information regarding the best method to process the accelerometer signals to quantify bed load transport and possibly determine particle size.

Future Plans

Future efforts include additional physical bed load measurements (spring 2016) for *in situ* calibration of the accelerometer plates and additional calibration information for the geophone plates.

This bed load impact plate system will provide continuous measurement of bed load downstream from two former dams on the Elwha River and contain valuable information regarding bed load transport during and after dam removal. Recent research on this topic will be presented at River Flow 2016, eighth international conference on fluvial hydraulics, in St. Louis, Missouri.

More Information

www.usbr.gov/research/projects/detail.cfm?id=4542

www.usbr.gov/research/docs/updates/2014-24-bed-load.pdf

Hilldale, R.C., W.O. Carpenter, B.T. Goodwiller, J.P. Chambers, and T.J. Randle. 2015. "Installation of Impact Plates to Continuously Measure Bed Load: Elwha River, Washington, USA." *Journal of Hydraulic Engineering*, #141, DOI:10/1061/(ASCE) HY.1943-7900.0000975.

Magirl, C.S., R.C. Hilldale, C.A. Curran, J.J. Duda, T.D. Straub, M. Damanski, and J.R. Foreman. 2015. "Large-Scale Dam Removal on the Elwha River, Washington, USA: Fluvial Sediment Load." *Geomorphology*, #246, pp. 669-686.

Hilldale, R.C. 2015. *Continuous Bed Load Measurement With Impact Plates on the Elwha River, Washington*. Proceedings, Joint Sedimentation and Hydrologic Modeling Conference, Reno, Nevada, April 19-23.

"Monitoring sediment during and after dam removal is a significant step forward in understanding the transport of bed material in a gravel-bed river. The impact plates on the Elwha River, using geophones and accelerometers, will not only provide valuable information for the Elwha River, but will advance technologies to continuously measure bed load in other rivers."

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Photograph looking upstream at the Agricultural Research Service's recirculating flume (left). Closeup photograph of two full-scale impact plates instrumented with accelerometers (right).

Collaborators

- **U.S. Department of Agriculture's Agricultural Research Service**
- **The University of Mississippi's National Center for Physical Acoustics**

For printable version see: www.usbr.gov/research/docs/updates/2016-07-registering-bed-load.pdf