RECLAMATION
Managing Water in the West

U.S. Department of the Interior
Bureau of Reclamation

Research Update

Spring 2016
Bulletin 2016-08

Bottom Line

This research project provided a simple, mobile method needed to reliably measure the movement of coarse bed material (bed load) in rivers.

Better, Faster, Cheaper

Bed load measurements are difficult, expensive, and often dangerous to obtain. For these reasons, bed load measurements are infrequently collected. A surrogate device will allow continuous measurements at a reduced cost.

Principal Investigator

**Robert C. Hilldale
Hydraulic Engineer
Sedimentation and
River Hydraulics Group
Technical Service Center
303-445-3135
rhilldale@usbr.gov**

Research Office Contact

**John Whitler
Science and Technology
Program Manager
303-445-2241
jwhitler@usbr.gov**

Listening to Bed Load

Using hydrophones to continuously monitor sediment moving along a riverbed

Problem

Reclamation needs to be able to protect its investment in reservoirs, diversions, and other water supply infrastructure as well as bridges, water treatment plants, and levees. Habitat restoration is also an important objective. Tracking the movement of gravel along a riverbed is critical to achieve these goals. Numerical predictions of sediment transport benefit greatly from direct field observations for model calibration and verification.

Reclamation engineers and scientists studying rivers need an accurate picture of bed load transport to understand a river's sediment transport processes, which in turn provides the insights needed to understand the channel morphology for better prediction of sediment loads. However, physically measuring bed load in rivers is costly, difficult, and often dangerous—particularly as most bed load moves during floods or high flows. As a result, these crucial data are very limited temporally and spatially.

Solution

A hydrophone system for measuring bed load has been developed as a portable and easily deployable way to measure bed load for short or extended periods of time. As gravel particles are transported along the riverbed, they generate sound when they collide with each other, which is termed "self-generated noise." This occurs in every gravel-bed riverbed, but the acoustic environment varies with a river's cross section shape, flow depth, and flow velocity. Hydrophones can record this self-generated noise, which registers as acoustic energy and is recorded with a field-ready data recorder.

Installing Bunte bed load traps immediately downstream of two hydrophones on Halfmoon Creek, Colorado. The hydrophones are installed near the bed using posts and hydrodynamic fairings.

This Reclamation Science and Technology Program research project is working with the U.S. Department of Agriculture's Agricultural Research Service to define the acoustic environment in a river. This information will help inform the placement of hydrophones in the river so that acoustic measurements encompass the entire width of the stream without overlapping the measurement volume between devices.

Application and Results

Past hydrophone deployments have taken place in the Trinity River (California) and Elwha River (Washington). Reclamation has deployed the hydrophones in close proximity to locations where physical bed load measurements were being made. While the correlation between acoustic energy and measured bed load was positive, there were problems understanding the acoustic sound field in a river.

To address this issue, this research project is deploying two hydrophones in two locations in Halfmoon Creek (Colorado), a much smaller channel than previous deployments. To correlate the hydrophone results with other bed load measurements, this project measured bed load using the Bunte bed load traps (a federally approved method for bed load measurement in small streams) at the same place and time.

Researchers from the Agricultural Research Service gathered data to analyze the acoustic sound field. They took acoustic measurements to evaluate flow noise compared to self-generated noise from gravel collisions. Acoustic measurements were also recorded at various distances from an induced underwater signal using a source of known amplitude and frequency.

Future Plans

Future efforts will expand the scale of the measurements and data collected to date. Opportunities to collect acoustic measurements concurrent with physical bed load measurements are rare. As such, the pace of research is often slow to arrive at conclusive determinations. Future work will continue with concurrent acoustic and physical bed load measurements in the Elwha River during spring runoff in 2016. Agricultural Research Service researchers will also be present to explore the acoustic environment and sound propagation in a riverine environment.

The end goal of this research is a portable device that can be used to quantify bed load transport in mass/time values. This will necessarily be accompanied with guidelines for site-specific use and calibration. Recent progress 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=9342

Wren, D.G., B.T. Goodwiller, J.R. Rigby, W.O. Carpenter, R.A. Kuhnle, and J.P. Chambers. 2015. *Sediment-Generated Noise: Laboratory Determination of Measurement Volume.* Proceedings of the 10th Federal Interagency Sedimentation Conference, Reno, Nevada, April 19-23.

Goodwiller, B.T., D.G. Wren, J.R. Rigby, W.O. Carpenter, J.P. Chambers, R.A. Kuhnle, and R.C. Hilldale. 2015. *Design and Implementation of a Field Deployable Passive Acoustic Bedload-Monitoring Surrogate*. Proceedings of the 10th Federal Interagency Sedimentation Conference, Reno, Nevada, April 19-23.

"Knowing and understanding the flow conditions under which bed load is transported in a fluvial system is critical for efforts to improve degraded conditions for improving ecology and aquatic habitat, as well as protecting riverine and riparian infrastructure. A portable system to continually measure bed load movement over a long period of time will provide valuable information for practitioners to greatly improve their understanding of bed load transport."

Robert C. Hilldale
Hydraulic Engineer
Reclamation's Technical Service Center

Collaborators

- **University of Mississippi's National Center for Physical Acoustics**
- **U.S. Department of Agriculture's Agricultural Research Service, Oxford, Mississippi**
- **Colorado State University**
- **Graham Matthews and Associates, Weaverville, California**

For printable version see: www.usbr.gov/research/docs/updates/2016-08-listening-bed-load.pdf