RECLAMATION Managing Water in the West

Fall 2014
Research and
Development Office
Bulletin 2014-24

The Knowledge Stream

Research Update

Looking at Bed Load 24 Hours a Day

Using acoustics to continuously measure coarse bed load movement in a river

Bottom Line

This research project is the first in North America to install bed load impact plates on a riverbed, which is a new method to measure gravel transport in stream channels, also known as bed load.

Better, Faster, Cheaper

Long-term monitoring of bed load movement will provide invaluable data for studying bed load transport during and after dam removal. This permanent installation saves time and money by automating bed load measurements and provides continuous measurement under all flow conditions. Furthermore, this reduces the risk of sending staff to collect measurements during high riverflows, when most bed load moves.

Principal Investigator

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

Research Office Contact

Miguel Rocha
Science and Technology
Program Manager
303-445-2841
mrocha@usbr.gov

Collaborators

- **National Center for Physical Acoustics (University of Mississippi)**
- **Graham Matthews & Associates**
- **U.S. Geological Survey**
- **National Park Service**

Problem

Hard to Measure Bed Load Transport. Moving sediment on or near the bed of a river (by rolling, sliding, or "saltating"—like skipping or jumping along the bottom) is vital to a river's health. However, quantifying that motion 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.

Challenges to bed load transport measurements have prevented a thorough understanding of the physical processes responsible for bed load motion, from initiation to sustained transport. Data collected with the bed load impact plate system will increase our understanding of the transport of coarse bed load in gravel-bed rivers.

Measurements Are Critical to Understanding Impacts From Dam Removal. Sediment has accumulated behind the Elwha and Glines Canyon Dams for nearly a century, and nearly 10 million cubic yards of sediment have been released from the two reservoirs. Removing the dams has re-established the natural flow of sediment from the Olympic Mountains down to the Strait of San Juan de Fuca, restoring the estuary, beaches, and shellfish beds along the mouth of the river.

This sediment underlies the entire ecosystem and is critical for building aquatic and riparian habitat. As the dams were removed, sediment that accumulated behind the dams was transported down the river creating high sediment loads in the lower river, significantly impacting the river and nearshore ecosystems.

Because this impact plate installation is just downstream from these two dam removal projects, bed load transport during and after dam removal will also be better understood. Monitoring bed load movement during and after dam removal is critical for many reasons, primarily for the implications that bed load has on channel morphology (form). Sediment erosion from reservoir delta deposits, and its ensuing transport and fate, has not been previously well documented or understood.

Graham Matthews & Associates personnel using classic methods to measure bed load for calibration.

This sedimentation monitoring program involves many Federal agencies, such as Reclamation, U.S. Geological Survey (USGS), and the National Park Service. Monitoring and interpreting sediment transport along the river from the former dams to the ocean will provide key data to manage the Elwha River Restoration Project, and it will provide a better understanding of the impacts of large-scale dam removal on downstream ecosystems.

Solution

This Reclamation Science and Technology Program research project has installed and is calibrating an innovative bed load impact plate system, the first permanent installation of its kind in North America. The impact plate system consists of a series of 72 plates (approximately 20 inches by 14 inches) mounted adjacently, providing continuous measurement along the riverbed at one cross section. Forty-six plates are equipped with a geophone and 26 plates with an accelerometer. This instrumentation measures the deformation of the steel plate as sediment contacts it, but the geophones and accelerometers provide different electrical signals. Three streamside computers manage the continuous data collection, pre-process, and store the data. The computers can be accessed remotely to manage the data collection parameters and download data.

Application and Results

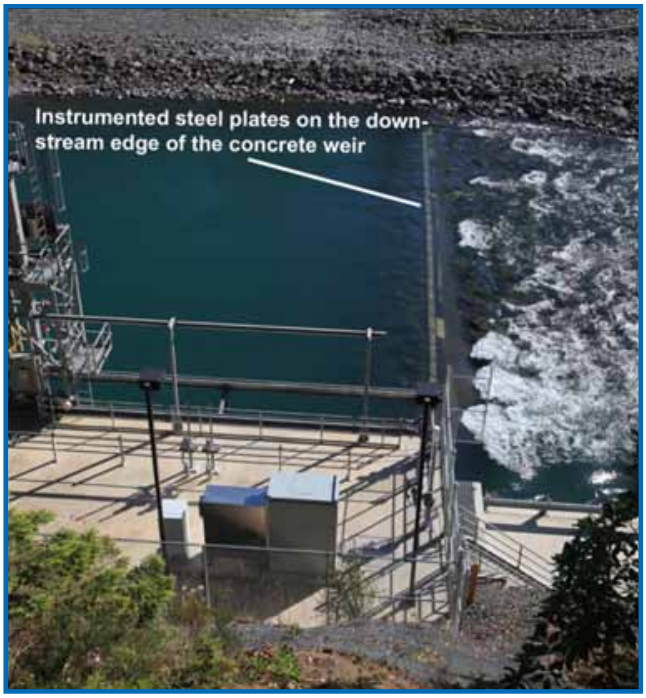
Before obtaining reliable sediment measurements from the bed load impact plates, the system must be calibrated. To compare the performance of the 46 geophone plates to traditional measurements, bed load was measured with a TR-2 pressure-difference bed load sampler (suspended from a crane mounted on the raft). These data are being compared in this ongoing calibration process. Four separate bed load measurement campaigns have been completed and more are planned.

Using this preliminary calibration, approximations of bed load being released from both reservoirs during the first 2 years of dam removal have been made. USGS is continuously measuring suspended sediment transport at the same cross section, providing a picture of sediment transported in the water column. Combined, these data provide a nearly complete picture of all sediment being transported past this measurement cross section, one of only a few such data collection sites in the world.

Future Plans

Electrical signals produced by the geophones are reasonably well understood, although the same understanding of the signals generated by an accelerometer and calibrating these measurements on site still need to be developed. Reclamation is partnering with the U.S. Department of Agriculture's Agricultural Research Service and will place a two-plate impact system equipped with accelerometers in a gravel and water recirculating flume at the National Sedimentation Laboratory in Oxford, Mississippi, to determine appropriate measurement algorithms with which to measure bed load transport. The accelerometers produce a richer signal, providing more detailed information about the sediment transport process.

After a complete system calibration, the computer management system will be automated, where data are completely processed, backed up, and published on the web. This will greatly decrease the involvement of Reclamation's Technical Service Center personnel in managing the system and processing the data, further reducing cost.



Photograph of the bed load impact plate system on the Elwha River, Washington. Photograph courtesy of Graham Matthews & Associates.

"The installation and operation of the bed load impact sensors on the Elwha River near Port Angeles, Washington, are a cutting edge achievement in the continuous monitoring of gravel transport. This installation is the first of its kind in North America and Reclamation should be proud."

Tim Randle
Manager, Sedimentation and River Hydraulics Group, Reclamation's Technical Service Center

More Information

www.usbr.gov/research/projects/detail.cfm?id=115

Hilldale, R.C. 2013. *Calibration of Bed Load Impact Plates on the Elwha River*, USA. Presented at the International Workshop on Acoustic and Seismic Monitoring of Bed load and Mass Movement, Zurich/ Birmensdorf, Switzerland.

www.wsl.ch/dienstleistungen/veranstaltungen/veranstaltungskalender/bedload_massmovements/abstract_Hilldale.pdf /

www.youtube.com/watch?v=GdoP2nQNYdg.

Hilldale, R.C., W.O. Carpenter, B. Goodwiller, J.P. Chambers, and T.J. Randle. 2014. *Installation of Impact Plates to Continuously Measure Bed Load: Elwha River, Washington, USA*. In Review. Submitted to Journal of Hydraulic Engineering.

Magirl, C.S., R.C. Hilldale, C.A. Curran, J.D. Duda, T.J. Straub, M. Domanski, and J.R. Foreman. 2014. *Large-Scale Dam Removal on the Elwha River, Washington, USA: Fluvial Sediment Load.* In review. Submitted to Geomorphology.