RECLAMATION *Managing Water in the West*

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The Knowledge Stream

Research Update

Adaption Rates of Bed Load Gravel With Riverflows

Determining how the rate of gravel movement along the riverbeds adapts to changing flow conditions

Bottom Line

This research examines how gravel transport rates adjust to different local streamflow conditions in a spatially variable flow. Better estimations of this adaptation parameter will help develop more accurate models of the bed load transport.

Better, Faster, Cheaper

Realistic estimates of bed load adaptation can lead to more accurate models, thus providing better information about habitat, infrastructure, and other factors for more effective actions, such as river restoration or river hazard modeling.

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Problem

Predicting river hazards, determining habitat requirements and functions, and stabilizing rivers all require understanding river dynamics. In gravel bed rivers, the gravel and other coarse sediments move along the bottom of the river, in "bed load." In the Trinity River, California, the Trinity Dam prevents this bed load from traveling downstream. Without managing this coarse sediment below the dam, the river would eventually transport all of the available bed load downstream, leaving nothing for habitat (e.g., gravel for spawning beds).

Modeling how a river transports this bed load is critical to understanding gravel bed rivers. However, quantifying this transportation is complex. Bed load transport rates change with the strength of the riverflows, which is usually quantified within terms of shear stress. For a given shear stress, bed load transport equations are available for predicting the corresponding transport rate. But shear stress in a river varies with the shape and slope of the river channel. Consequently, the concentration of bed load moving down the channel is constantly adjusting to match the changes in shear stress.

For example, the shear stress could be near zero in a pool where the water is slow and placid, then suddenly increase in a steep rapid just downstream. The bed load transport rate would be near zero in the pool, whereas the shear stress in the rapid may be enough to drive a high transport rate. Yet it is unrealistic to expect the transport rate at the beginning of the rapid to instantly jump from zero to a large rate. Instead, the transition from a zero transport rate to a large transport rate would take place over some distance along the riverbed. That distance is the bed load adaptation length. Current numerical models used to predict river channel changes incorporate the effects of bed load adaptation with an adjustable model parameter. However, there is no consensus on how to estimate the adaptation distance. Improved methods for quantifying bed load adaption lengths have the potential to improve the accuracy and reliability of model predictions.

The camera videos the grain transport through the plexiglass sidewall.

Solution

There is very little information on bed load adaptation in literature. One hypothesis is that the adaptation distance increases as the intensity of the flow increases. In other words, the greater the final transport rate, the longer the distance would be to reach it. But the opposite has also been proposed—that a greater distance is required to reach the smaller equilibrium rates associated with weaker riverflows, as the lower shear stresses pick up additional gravel at a lower rate.

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Experiments were conducted to measure the bed load adaptation length, a parameter that quantifies the distance required for gravel transport rates to reach equilibrium after encountering a change in the local flow velocities and shear stresses. To determine how riverflows affect the adaptation distance, bed load transport was measured in a laboratory flume. The flume, at the University of California at Berkeley's Richmond Field Station, was operated at three bed slopes to assess bed load transport over a range of hydraulic conditions. Increasing the slope of the bed allowed the bed load transport rates to be measured at three different shear strengths. Instantaneous bed load transport rates were determined by counting passing sediment particles on digital imagery collected at variable distances downstream from a zero-transport boundary in a small flume.

"Understanding how gravel moves along a riverbed and how riverflows influence that movement is critical to managing a gravel river such as the Trinity River."

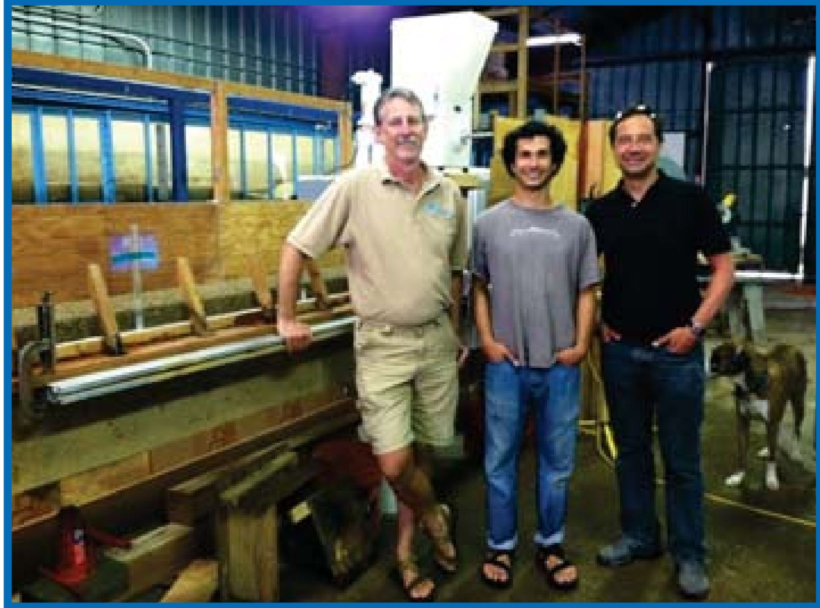
Robin Schrock
Trinity River Restoration Division Program Manager, Reclamation's Mid-Pacific Region

Results and Application

The bed load adaptation length appears to increase with increasing shear stress. Previously proposed equations were reviewed to determine what might be consistent with these results. Thus, equations that more accurately reflect bed load adaptation lengths were suggested. Bounds were also put on how large the adaptation length is, and the research suggested that it is relatively small—that is, a short distance is required to pick up gravel and reach an equilibrium transport rate.

Thus, adaptation rates may not be that vital for certain model applications (e.g., large-scale 2-dimensional mesh). However, proper scaling of the adaptation distance may be critical for modeling small-scale processes, such as scour around large woody debris or other local habitat features.

The results of this research are being used in a gravel augmentation and river rehabilitation project on the gravel-bedded Trinity River in California. They are also being incorporated in SRH-2D, a 2-dimensional hydraulic and morphodynamic model developed at Reclamation's Technical Service Center that is being used in the design of gravel augmentation and channel rehabilitation projects on the Trinity River and elsewhere.



Left to right: David Gaueman, graduate student Omid Arabnia, and San Francisco State University Professor Leonard Sklar.

The flume is running and the computer station is logging data.

Future Plans

This information will inform future modeling development for the sediment models such as the SRH-2D. Future research is recommended to further refine the understanding of the relationship of bed load transport within a dynamic gravel river.

More Information

www.usbr.gov/research/projects/detail.cfm?id=3054