RECLAMATION Managing Water in the West

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The Knowledge Stream
Research Update

Predicting Erosion in Rivers and Reservoir Settings

Are complex channel processes during dam removal ready to be simulated?

Bottom Line

Using the erosion of the Lake Mills Delta (behind Glines Canyon Dam on the Elwha River, Washington), new geofluvial modules of the SRH-2D model were tested for predicting both vertical and lateral erosion in reservoir sediment deltas. It was found that the current state-of-the-art models can be used to simulate simultaneous vertical and lateral erosion of a reservoir sediment delta during reservoir drawdown or dam removal. However, further research is needed to improve the accuracy of simulations regarding the timing and extent of sediment erosion.

Better, Faster, Cheaper

Numerical modeling that incorporates the hydraulic complexities of reservoirs and rivers, such as bank erosion, can more accurately predict potential sediment impacts and provide critical information for species recovery and river restoration projects, as well as other analyses.

Principal Investigators

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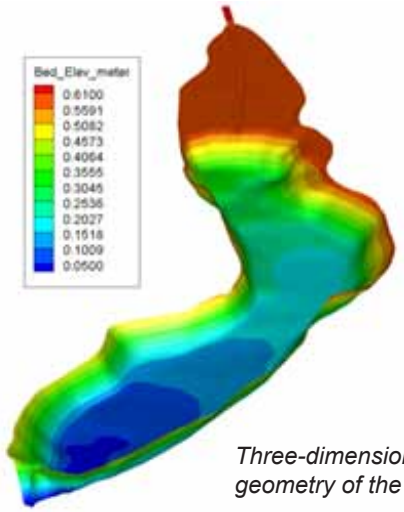
Problem

Erosion of riverbanks and reservoir sediment deltas could lead to temporary increased sediment loads, decreased instream habitat, and risks to downstream infrastructure. When high flows occur or when reservoir levels drop, high velocity flows cut through the sediment (vertical incision) and laterally erode into the banks. Modeling both these erosion processes is critical to predicting how much sediment will be released into the downstream system and how long these releases will last.

As many complex physical processes are involved in reservoir delta and river channel morphological development, many projects rely on qualitative measures rather than quantitative predictions. For some projects, such a qualitative approach is adequate; for others, a more accurate quantitative prediction is needed to reduce uncertainty in designing or operating infrastructure such as pumping plants or for river restoration projects.

The Sedimentation and River Hydraulics–Two-Dimensional Model (SRH-2D) that Reclamation's Technical Service Center developed has been widely used for both hydraulic and sediment modeling for engineering and river restoration projects since 2006. While sediment transport models can predict vertical bed elevation changes numerically, the many complex processes involved in lateral bank erosion have made such modeling elusive. Now, new bank erosion modules have been developed to simulate both vertical and lateral stream erosion processes.

Although SRH-2D has been used to predict dam removal sedimentation processes (for example the Klamath River; the Colorado River in the reservoir pool behind Palo Verde Dam, Arizona/California; and a sediment plug on the Rio Grande River), the model adequacy is yet to be demonstrated for complex channel processes occurring in dam removal scenarios. Determining if SRH-2D, a current state-of-the-art multidimensional sediment and morphological model, can predict both vertical and lateral sediment erosion and deposition processes during dam removal is crucial for using this in future analyses.



Three-dimensional view of the initial geometry of the specific model run, 3xC.

Solution

The large amount of physical model and field data available from the Elwha River Restoration Project near Port Angeles, Washington, provided a unique opportunity to test and verify the Reclamation model. This Reclamation Science and Technology Program research project applied the new SRH-2D model, including bank erosion modules, to simulate the delta processes during the removal of Glines Canyon Dam in the former Lake Mills on the Elwha River.

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Removing two dams on the Elwha River exposed roughly 27 million cubic yards of sediment and wood trapped in the reservoirs. Both vertical and lateral sediment erosion processes were very important during the lowering of the reservoir.

A physical model dataset was compared against the new geofluvial SRH-2D model, which coupled bank erosion modules with the mobile-bed model, to simulate the delta erosion and deposition characteristics when dam notches are removed.

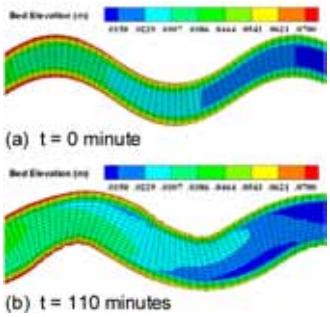
Results and Conclusions

The University of Arizona tested the numerical model against data from a field drawdown case when Lake Mills behind Glines Canyon Dam was lowered 18 feet during April 1994. Comparing the two methods reached these conclusions:

- When erosion processes include both lateral and vertical erosion, modeling bank erosion is critical to incorporate for accurate overall predictions of erosion patterns.
- The Lake Mills test case showed that SRH-2D predicts qualitative erosion and deposition patterns well.
- The new geofluvial SRH-2D model achieved limited success—it can simulate simultaneous vertical and lateral erosion of the delta. However, the model still misses some of the details (e.g., timing and extent) of the lateral erosion.

Looking upstream at sediment terraces left behind from dam removal notching and tree stumps where the river has cut tens of feet down through sediment deposits into the pre-dam floodplain.

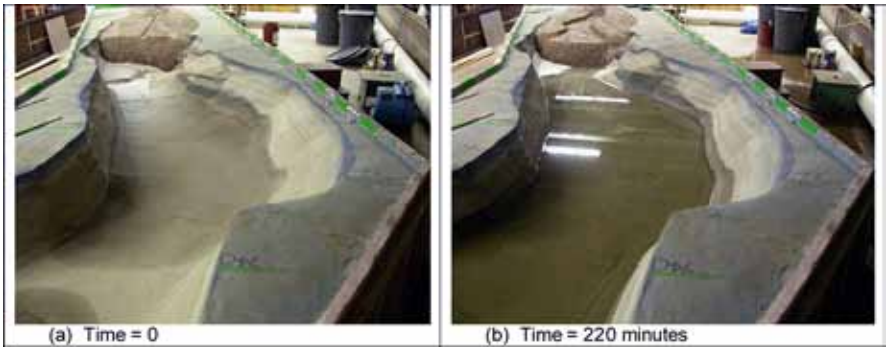
After 3 years of dam removal, the Elwha River has carved a new landscape resulting from multiple phases of vertical and lateral erosion by riverflows.



Initial and final meshes for simulation Run 3 with the moving mesh (contours are bed elevation).

Future Plans

Reclamation can use this new model now on river erosion cases and reservoir deltas to show relative trends related to alternative scenarios for decisionmaking. Additional model research and development are needed to further develop and refine a bank erosion module that can track the region of the channel bank, or bank toe point, in a robust and stable way, particularly for the field situation.



Initial terrain and terrain after 220 minutes during the physical model test. Photographs courtesy of Chris Bromley, University of Nottingham, England.

"The determination of a river channel width has been a problem for centuries. Engineers and scientists have had to simulate river hydraulics with a known channel width. This research advances our understanding of how to simulate streambank erosion and channel width changes over time."

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Collaborators

- **Reclamation's Pacific Northwest Region**
- **University of Arizona**
- **National Park Service**

More information

www.usbr.gov/research/projects/detail.cfm?id=7356

Lai, Y.G., R. Thomas, Y. Ozeren, A. Simon, B.P. Greimann, K. Wu. 2014. *Modeling of Multi-Layer Cohesive Bank Erosion With a Coupled Bank Stability and Mobile-Bed Model*. Forthcoming. Submitted to Geomorphology.