RECLAMATION Managing Water in the West

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The Knowledge Stream
Research Update

Designing Fish Ladders to Automatically Adjust to Varying Water Surface Levels

Self-regulating articulated fish ladders use a constant flow with varying water surfaces

Bottom Line

This research project helped develop and test a fish ladder for small diversion dams that uses a constant amount of water, even when reservoir levels vary. This provides a constant fish ladder discharge without adversely affecting the hydraulics in the fish ladder.

Better, Faster, Cheaper

This fish ladder can operate automatically at remote locations, saving staff time and travel expenses. Moreover, as this prevents the fish ladder from discharging more water than needed, irrigators can divert their allotted water without impacting the fish ladder. This avoids costly operations and maintenance issues for rural fish ladders.

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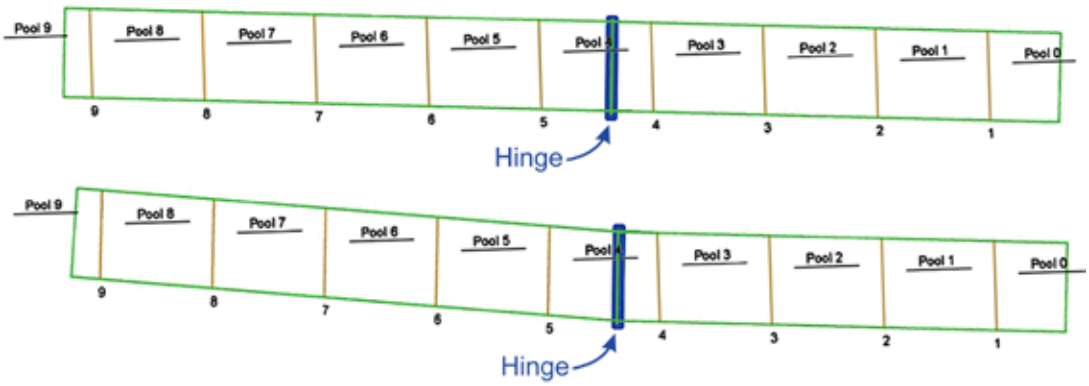
Problem

Fish ladders constructed on small diversion dams may take on more water than they need for fish passage if the water elevations change. In very low head dams with reservoir water surface elevations that fluctuate by less than 3 feet and with limited instream flows, a small reservoir rise could double or triple the amount of flow in the fish ladder (for example, rising from 2 to 8 cubic feet per second [cfs]). With these small dams, when the irrigators only divert 2 to 3 cfs, any change in flow diversions becomes problematic for irrigators. This often results in the fish ladders being shut down during high diversion periods or weir boards placed in the fish ladder to restrict flows—and also fish passage.

The Klamath Basin Area Office in Reclamation's Mid-Pacific Region and the Oregon Department of Fish and Wildlife (ODF&W) need to develop a fish ladder suitable for endangered sucker species and other native fish indigenous to the highly regulated streams in the Western United States. For effective fish passage, these fish ladders need to be able to pass a constant flow over a range of headwater elevations. They also need to work remotely without close supervision.

Solution

This Reclamation Science and Technology Program research project designed a fish ladder that can be installed at low head diversion structures where the reservoir water surface elevation fluctuates regularly. The fish ladder automatically adjusts to the change in water surface elevation, providing a constant fish ladder discharge without adversely affecting the hydraulics in the fish ladder.



Elevation view of the articulated fish ladder. The hinge in the middle allows the upstream half of the fish ladder to rotate up and down with the changing upstream water surface elevations.

In a typical fish ladder, the upstream end where fish exit has a fixed elevation. Therefore, when the upstream headwater increases, the flow through the fish ladder also increases. In this self-regulating articulated fish ladder design, the downstream

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half of the fish ladder is at a fixed elevation and the upstream half can pivot around a hinge in the middle of the fish ladder. Thus, when the water level in the reservoir rises, the upstream half of the fish ladder rises, maintaining a constant inflow in the fish ladder. As the water elevations in these diversion dams vary by only 1 to 3 feet, a slope change of less than 6 degrees is sufficient to maintain the constant flow needed for fish passage without diverting more water than needed.

Irrigation Diversion in Whychus Creek, Oregon.

Application and Results

This fish ladder was evaluated in the laboratory to investigate the hydraulic conditions when the fish ladder is bent in the middle, creating two different slopes within the same fish ladder. A dual vertical slot technical fish ladder with nine pools was tested in the hydraulics laboratory. The fish ladder was 2 feet wide and 1.5 feet deep, and each pool within the ladder was 2 feet long. This model can be scaled up to larger sizes of fish ladders. In this study, the downstream half of the fish ladder was kept at a constant slope of 3 degrees for all tests, and the upstream half of the fish ladder was tested at slopes ranging from 0.2 to 5.7 degrees. Pool water surface elevations were measured, velocity through the slot and Energy Dissipation Factors were calculated, and each test configuration was visually observed.

Results from the laboratory study indicated that fish could navigate the dual slope of the fish ladder—there were no adverse hydraulic conditions that would hinder fish passage.

Future Plans

This type of a fish ladder will only be successful if it can self-regulate as the upstream water surface changes. The next research steps are to investigate effective ways for the upstream part of the fish ladder to move automatically with changing water surface elevations (for example with an automatic hoist using an associated water level sensor or with large floats attached to the sides of the upstream end of the fish ladder). In the laboratory, small floats were added to the fish ladder in an attempt to self-regulate. Given the fish ladder setup location in the laboratory, it was not possible to attach large floats. Attaching large floats (55-gallon drums) to the sides of the fish ladder could be a successful way to self-regulate.

Reclamation is also working with ODF&W to identify a test site and install this for field evaluation. After installation, research will be required to determine the efficacy of the test site and then to determine the most effective installation configurations for other locations. This fish ladder could be used Reclamation-wide on diversion dams in small rivers, and it is recommended that Reclamation planners work with local and state resource agencies to identify opportunities to build these fish ladders.

"A standard design for a fish ladder that automatically adjusts to changing headwater elevations to control flows could help provide fish passage for endangered sucker species and other native fish indigenous to highly regulated streams in the West."

Brent Mefford
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Collaborators

- **Reclamation's Klamath Basin Area Office**
- **Oregon Department of Fish and Wildlife**

More Information

www.usbr.gov/research/projects/detail.cfm?id=9548