Vertical Drop Barrier

U.S. ARMY CORPS OF ENGINEERS **Building Strong®**

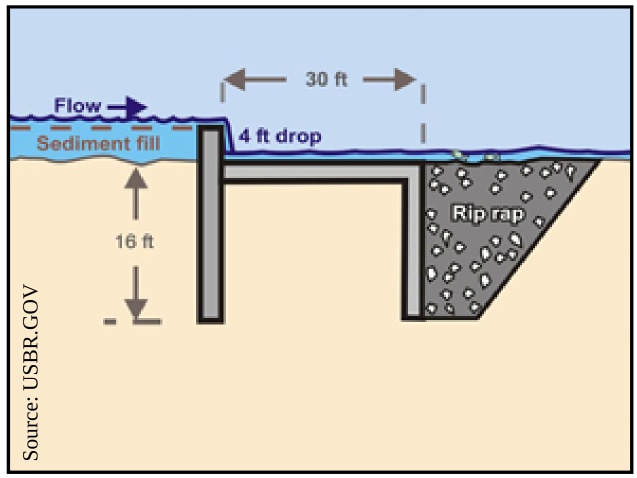
ANS Control: Vertical Drop Barrier

Targeted Species: This Control may be effective at preventing the upstream transfer via aquatic pathways of all ANS of Concern – CAWS[1]. See *General Effectiveness* and *Operating Constraints* sections for more information.

Selectivity: This Control is a unidirectional barrier, meaning that it only stops upstream movement of organisms and is non-selective.

Developer/Manufacturer/Researcher: The U.S. Bureau of Reclamation has experience in constructing vertical drop barriers.

Brief Description: A basic design for a drop barrier consists of a vertical concrete wall that rises 4 to 5 feet above a concrete apron on the channel bottom. The vertical wall typically follows the configuration of the channel bottom so that a 4 to 5 feet drop extends across the entire bottom of the channel. The apron is designed to produce uniform water velocities that exceed fish swimming abilities, thereby precluding upstream passage. Jumping ability, swimming speed, and swimming endurance must all be taken into account when developing a vertical drop, as it must be designed to a height that exceeds the leaping abilities of fish when combined with the shallow, fast-flowing water over the apron. Upstream movements of fish during floods are not expected in mid-channel because of high current velocities and sediment loads, but potential movements along the edges of floodwaters will be prevented by the maintained vertical drop (Clarkson & Marsh 2010). Sediment accumulates in the pool upstream of the barrier over time.



Cross section of a vertical drop barrier

Prior Applications: Stuart (1962) described the ability of fish to take advantage of the kinetic energy in the submerged wave at the foot of a fall to obtain a lift in jumping. Stuart's studies indicate that under favorable conditions, trout and juvenile salmon not only jump several feet from the crest of a submerged wave, but also use visual aids in orienting the height and direction of the leap. The fish may also swim for short distances vertically up a waterfall and, on occasion, successfully ascend a weir crest in this manner.

Horizontal screening racks can be added to the crest to prevent ANS from leaping over small vertical drops. These racks can be designed to be self-cleaning and alter flow conditions to hinder fish from jumping (Flick 1968).

[1] For a complete list of the 39 specific ANS of Concern – CAWS, please see Table 1 of the main report.

General Effectiveness: Vertical drops are effective at stopping most varieties of organisms from moving upstream during normal flow conditions, but are ineffective at stopping downstream movement of organisms. Large flood events would reduce or eliminate the effectiveness of a vertical drop barrier due to the leveling of the water surface elevation above and below the barrier during high discharge. Under these high water conditions, fish could either leap or swim over and around the barrier. Silver carp are well-known for their leaping ability (Kolar et al. 2007).

Operating Constraints: A vertical drop is a unidirectional barrier, meaning that it stops upstream movement of fish only. In the construction of any vertical drop barrier, all factors contributing to the ability of a fish to jump should be taken into consideration including height of the vertical drop at all river stages including flood stage, and the velocity, hydraulic flow pattern, and depth of the tailwater. Other issues that need to be considered include; the interruption of migration patterns of native fishes and potential interference with navigation.

Cost Considerations:

Implementation: Implementation costs would include the construction of the barrier, as well as equipment access corridors and warning signage. Site conditions, such as waterway depth, subsurface soils, and accessibility, may have significant cost impacts. Planning and design activities in this phase may include research and development of this Control, modeling, site selection, site-specific regulatory approval, plans and specifications, and real estate acquisition. Design will also include analysis of this Control's impact to existing waterway uses including, but not limited to, flood risk management, natural resources, navigation, recreation, water users and dischargers, and required mitigation measures.

Operations and Maintenance: Operations and maintenance costs would involve periodic inspection, removal of debris, and replacement of eroded materials.

Mitigation: Design and cost for mitigation measures required to address impacts as a result of implementation of this Control cannot be determined at this time. Mitigation factors will be based on site-specific and project-specific requirements that will be addressed in subsequent, more detailed, evaluations.

Citations:

Clarkson, R.W. & P.C. Marsh. 2010. Effectiveness of the Barrier-and-Renovate Approach to Recovery of Warmwater Native Fishes in the Gila River Basin. In *Proceedings of the Colorado River Basin Science and Resource Management Symposium, November 18-20, 2008, Scottsdale, Arizona,* T.S. Mellis, J.F. Hamill, L.G. Coggins, Jr., P.E. Grams, T.A. Kennedy, D.M. Kubly, & B.E. Ralston (eds.) U.S. Geological Survey Scientific Investigations Report 2010-5135, 372 pp

Flick, W.A. 1968. Effectiveness of three types of barrier panels in preventing upstream migration of fish. *The Progressive Fish Culturist,* vol. 30(2), pp. 100-103

Kolar, C.S., D.C. Chapman, W.R. Courtenay, Jr., C.M. Housel, J.D. Williams, & D.P. Jennings. 2007. Bigheaded carps: a biological synopsis and environmental risk assessment. American Fisheries Society, Special Publication 33, Bethesda, MD. 204 pp

Stuart, T.A. 1962. Leaping behaviour of salmon and trout at falls and obstructions. Department of Agriculture and Fisheries of Scotland. 46pp