Resistance partitioning in step-pool channels

Andrew Wilcox¹, E. Wohl, and R. Turner.
Dept. of Geosciences Colorado State University Fort Collins, CO

Abstract. Step-pool stream channels are characterized by complex hydraulics, with flow resistance created by large woody debris (LWD), clasts, spill over step-pool bedforms, and other factors. In order to allow quantification of variations in total resistance caused by changes in LWD configurations, discharge, and slope, as well as measurement of resistance partitioning between grains, steps, and woody debris, we manipulated variables contributing to flow resistance in step-pool channels via a series of flume runs. For each of over 300 flume runs, total resistance (represented here by Darcy-Weisbach friction factor) was calculated based on measurement of reach-averaged velocity in a flume configured to resemble a step-pool channel. The variables that were tested for their effect on flow resistance included discharge, slope, presence/absence of steps and grains, and LWD density, orientation, piece length, and arrangement. A factorial design was used to facilitate analysis of interactions between resistance features and estimates of the partitioning of resistance. Total resistance was measured for flume runs with and without grains, steps, and woody debris, and at multiple slopes and discharges, providing a means of quantifying the relative contributions of grain resistance, spill resistance, and debris resistance to total resistance. For comparison, independent estimates of resistance partitioning were developed based on calculations of grain resistance and drag force created by woody debris. Discharge had the largest effect on resistance of all variables tested, and the effect of LWD configuration on roughness tended to be drowned out at high discharges. Debris density, debris orientation, slope, and certain 2-way and 3-way interactions also had highly significant effects on total friction factor. Calculations of resistance partitioning indicated that spill resistance and debris resistance were responsible for the largest components of total resistance, and that grain roughness was a small component of total resistance when steps and/or debris were present. The relative contributions of grain, spill, and debris resistance depended on discharge, with debris resistance dominating at higher discharges, and debris density, with similar contributions from spill and debris components at low debris densities and greater debris roughness at higher debris densities.

¹ Dept. of Geosciences Colorado State University Fort Collins, CO 80523 970-491-2524
awilcox@cnr.colostate.edu