An Improved Method for Calculating the Manning Roughness Coefficient for Estimation of Stream Discharge through Slot Canyons in Southern Utah

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Abstract. Stream discharge through slot canyons is potentially a significant source of groundwater recharge in the arid Southwest. However, these canyons are normally dry except during flash floods, making stream velocity nearly impossible to measure. The discharge could be estimated using the empirical Manning Equation, which requires only the channel geometry, water depth, slope of the water surface, and an empirically-derived roughness coefficient. The objective of this research was to develop an empirical formula for calculating the Manning roughness coefficient *n* for flow through slot canyons by carrying out the first measurements of *n* in slot canyons. Stream discharge was measured at 13 slot canyon sites on tributaries of the Escalante, Paria and Virgin Rivers in southern Utah that are fed by perennial streams, springs or dam outlets. Based on these measurements, the best estimate for the Manning roughness coefficient *n* is $n = (0.871 \pm 0.269) n_J \exp\left[(4.38 \pm 0.72)\alpha\right]$ where α is the aspect ratio defined as $\alpha = A/w^2$, where *A* is cross-sectional area and *w* is width, and $n_J = 0.39 S^{0.38} R^{-0.16}$ is the roughness coefficient estimated by Jarrett (1984) for high-gradient streams ($S > 0.002$), in which *S* is slope of the water surface and *R* is hydraulic radius (ft). The ability of the improved formula to predict discharge increases dramatically, as compared to the formula of Jarrett (1984), as α exceeds 0.2. According to the improved formula, the previous estimate of the discharge of the late Pleistocene Bonneville Flood of 3.30×10^7 cfs is an overestimate by a factor of 1.85, based upon an underestimation of *n*.