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Flow Resistance due to Stream Meandering: An Evaluation of Existing Methods and Implications for Streamflow Estimations

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Abstract

Resistance to flow governs flow and sediment transport capacities in rivers and streams and is a critical factor in hydraulic and environmental engineering applications, including projects dealing with flood management, stream restoration and re-naturalization, establishment of environmental flows to sustain aquatic ecosystems, and mitigation of climate change. Flow resistance arises from factors such as bed granular roughness, bed forms, and channel bends. This work focuses exclusively on flow resistance caused by stream meandering. Despite its practical significance, the topic has been the focus of very few studies in the past and at present it is not known whether the methods proposed so far to determine meandering flow resistance yield realistic results. This study aims to fill this gap by analyzing and evaluating two of the existing methods, selected because they appear as the most popular by far and are rooted on the physics of the phenomenon. To this end, a dataset consisting of all laboratory experiments conducted in sine-generated streams over the past 60 years was gathered. The existing methods were used to determine flow velocities. By comparing these to their measured counterparts, it was found that both methods systematically underestimate flow resistance due to stream meandering, leading to significant overestimations of streamflow. This work highlights the need to develop substantially more accurate methods for the prediction of energy losses due to stream meandering.