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Sediment routing modelling: The use of FLUVIAL-12 to evaluate and re-design flushing flows in the lower Ebro.

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The lower Ebro experiences long-term hydrological and sedimentary alterations due to upstream reservoirs. One of the most important consequences is the disruption of sediment transfer, a fact that reduces the sediment load and affects river morphology. Among other factors, the low rates of sediment transport in the fluvial system favour the development of macrophytes. Macrophytes affect flow resistance, raising the water level locally, altering sediment transport, and clogging riverine infrastructures. Since 2002, flushing flows have been implemented and monitored in the Ebro, attempting to control macrophyte populations. These dam releases have demonstrated significant potential to scour the riverbed and transport sediment (peak flows in these events are higher than those attained during natural floods). They generally eliminate most macrophytes in areas close to the dams (90%), but their capacity to remove aquatic plants diminishes downstream (<5% 28 km downstream). It is thus important to reassess flushing flow effectiveness regularly at various downstream locations, as well to monitor adverse geomorphic effects such as riverbed degradation. Within this context, the sediment routing model FLUVIAL-12 was selected to assess the design of flushing flows and to simulate a range of input hydrographs. FLUVIAL-12 was first calibrated with hydrological and sediment transport data collected during and between floods. Next it was used to simulate a characteristic flushing flow that occurred in May 2008 (Q_{peak}=1277 m^3/s). The Singer-Dune transport formula (Singer and Dunne, 2004) (a total-load bed material transport equation) and roughness coefficient n=0.045 (representing high vegetation density) were found to be the best combination to obtain a good match between modelled and observed sediment transport in the study reach, while representing realistic water levels, cross sectional changes. The preliminary runs demonstrate that sediment supply (primarily) and bed roughness (secondarily) are the main controls on sediment transport in this reach, while bed slope has little impact on the results. For example, increasing Manning's n from 0.025 to 0.065 results in an order of magnitude increase in sediment load at the outlet for a single event (i.e. 325.7 tonnes to 3125 tonnes). The objective of this work was to calculate the influence of the parameter sensibility (roughness, slope, discharge, grain size distribution, etc.) and the impact of changes in bed material composition (controls macrophytes rooting strength) on transport. The aim was to find the best hydrograph design for future flushing flows (best effectiveness in macrophyte removal producing as little impact as possible). FLUVIAL-12 appears to be a useful tool to improve flushing flows design and inform restoration practices e.g., sediment injection that are now being considered in this river.

Keywords: sediment transport, dams, flushing flows, macrophytes, FLUVIAL 12, River Ebro