

Hydraulic conditions of flood flows in a Polish Carpathian river subjected to variable human impacts

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Channel morphology of the Czarny Dunajec River, Polish Carpathians, has been considerably modified as a result of channelization and gravel-mining induced channel incision, and now it varies from a single-thread, incised or regulated channel to an unmanaged, multi-thread channel. We investigated effects of these distinct channel morphologies on the conditions for flood flows in a study of 25 cross-sections from the middle river course where the Czarny Dunajec receives no significant tributaries and flood discharges increase little in the downstream direction. Cross-sectional morphology, channel slope and roughness of particular cross-section parts were used as input data for the hydraulic modelling performed with the 1D steady-flow HEC-RAS model for discharges with recurrence interval from 1.5 to 50 years. The model for each cross-section was calibrated with the water level of a 20-year flood from May 2014, determined shortly after the flood on the basis of high-water marks. Results indicated that incised and channelized river reaches are typified by similar flow widths and cross-sectional flow areas, which are substantially smaller than those in the multi-thread reach. However, because of steeper channel slope in the incised reach than in the channelized reach, the three river reaches differ in unit stream power and bed shear stress, which attain the highest values in the incised reach, intermediate values in the channelized reach, and the lowest ones in the multi-thread reach. These patterns of flow power and hydraulic forces are reflected in significant differences in river competence between the three river reaches. Since the introduction of the channelization scheme 30 years ago, sedimentation has reduced its initial flow conveyance by more than half and elevated water stages at given flood discharges by about 0.5-0.7 m. This partly reflects a progressive growth of natural levees along artificially stabilized channel banks. By contrast, sediments of natural levees deposited along the multi-thread channel and subsequently eroded in the course of lateral channel migration and floodplain reworking; as a result, they do not reduce the conveyance of floodplain flows in this reach.

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