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Investigation of the flood safety in the Savinja River catchment in Slovenia, Europe

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The Savinja River catchment is one of the areas with the highest flood risk in Slovenia, especially urban areas, as for example cities Celje and Laško, were often severely damaged during the floods in the past. Extreme floods happened in 1954, 1990, 1998 and 2007 in this catchment. Due to the potential further changes (e.g., climate change or variability) the flood risk could increase in the future. Therefore, the effective flood protection measures have to be taken in order to reduce the potential flood damage and at the same time not to worsen the situation downstream at the confluence with the Sava River and consequently at the location of the Krško Nuclear Power Plant and several hydro-power plants that are located in this area (lower Sava River in Slovenia).

In order to correctly evaluate the impact of suggested flood protection measures in the Savinja River catchment that covers 1,851 km2 the combined hydrological-hydraulic analyses were carried out. Hydrological model HBV-light was selected to perform the hydrological modelling; the automatic calibration of the model was carried out using the PEST tools. The hydrological model was divided into 77 sub-catchments. The calibration and validation of the model was performed using the flood data from years 1990, 1998 and 2007. The average value of coefficient of determination for 21 sub-catchments (available data) was 0.95 for the 2007 event (calibration). The average value of the Nash-Sutcliffe coefficient for the validation of the model using the data from 1990 was 0.85. With the calibrated and validated hydrological model and using the flood frequency analysis the design floods were determined (10, 20, 50, 100, 200 and 500 years return period).

Moreover, the two-dimensional hydraulic calculations were performed using the HEC-RAS 5.0.3 model that, among others, enables one- or two-dimensional unsteady flow simulations that were also used in this study. The most important rivers in the Savinja catchment from the flood safety perspective were included in the hydraulic model. In total, more than 110 km (more than 2,400 cross sections were incorporated in the model) of the Savinja River and major tributaries were modelled using the calibrated and validated model. Calibration and validation was carried out using the data from 1990, 1998 and 2007 floods.

Using the combined hydrological and hydraulic models several aspects of the flood safety were investigated. The influence of the suggested flood protection measures were analyzed (flood safety in the Sava River was also taken into account), the impact of high-waters at the river confluences on the design floods were accessed and investigation of the exclusion of large natural flood areas on the downstream flood safety was determined.