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Error propagation in hydrodynamics of lowland rivers due to uncertainty in vegetation roughness parameterization

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Accurate water level prediction for the design discharge of large rivers is of main importance for the flood safety of large embanked areas in The Netherlands. Within a larger framework of uncertainty assessment, this report focusses on the effect of uncertainty in roughness parameterization in a 2D hydrodynamic model. Two key elements are considered in this roughness parameterization. Firstly the manually classified ecotope map that provides base data for roughness classes, and secondly the lookup table that translates roughness classes to vegetation structural characteristics. The aim is to quantify the effects of these two error sources on the following hydrodynamic aspects:
1. the discharge distribution at the bifurcation points within the river Rhine
2. peak water levels at a stationary discharge of 16000 m3/s.

To assess the effect of the first error source, new realisations of ecotope maps were made based on the current ecotope map and an error matrix of the classification. Using these realisations of the ecotope maps, twelve succesfull model runs were carried out of the Rhine distributaries at design discharge. The classification error leads to a standard deviation of the water levels per river kilometer of 0.08, 0.05 and 0.10 m for Upper Rhine-Waal, Pannerdensch Kanaal-Nederrijn-Lek and the IJssel river respectively. The range is maximum range in water levels is 0.40, 0.40 and 0.57 m for these river sections respectively. Largest effects are found in the IJssel river and the Pannerdensch Kanaal.

For the second error source, the accuracy of the values in the lookup table, a compilation was made of 445 field measurements of vegetation structure was carried out. For each of the vegetation types, the minimum, 25-percentile, median, 75-percentile and maximum for vegetation height and density were computed. These five values were subsequently put in the lookup table that was used for the hydrodynamic model. The interquartile range in vegetation height and density in the lookup table led to a difference in water levels of 0.20, 0.20, and 0.36 m for Upper Rhine- Waal, Pannerdensch Kanaal-Nederrijn-Lek and the IJssel river respectively.

The discharge distribution at the Pannerdensche Kop bifurcation point is 165 m3/s for both error sources, classification and lookup table. The discharge distribution at the IJsselkop is more sensitive for classification error than for errors in the lookup table (160 vs. 70 m3/s for range in classification error and interquartile range in lookup table error). Priority should be given to increasing the classification accuracy as this generates the largest error for water levels as well as discharge distribution.

The quantification of the uncertainty in water levels and discharge distribution will help to make decisions more realistically as the error bands are substantiated. It can also influence the assessment of the height of the embankments as insight is given in the variability of the outcome of the flow models at design discharge. Moreover, the error bands may serve as an incentive to quantify the desired accuracy in the vegetation structural characteristics. This means that an upper limit can be put on the variation in water levels that is accepted from errors in the roughness parameterization.