# THE UNCERTAINTY OF DISCHARGE MEASUREMENTS AND THE WATER BALANCE AT RIVER BIFURCATIONS


Discharge time series are mainly derived from rating curves based on continuously measured water levels. Rating curves rely on periodic discharge measurements which are often performed with the moving-boat ADCP method. However, not every part of the river cross-section can be measured with an ADCP instrument, especially those near the water surface, the bed, the banks and at inundated floodplains. The discharge in these unmeasured zones must be estimated by extrapolation and this introduces uncertainty in the total discharge measurement, which directly translates into uncertainty in rating curves and the derived discharge data. Currently, rating curves do not show a closing water balance at the Pannerdensche Kop, which is the bifurcation of the Bovenrijn into the Waal and the Pannerdensch Kanaal. This is a direct indication of errors in the rating curves, which are partly due to uncertainties in the periodic discharge measurements. Therefore, the main aim of this research is to quantify the uncertainty of high discharge measurements and its influence on the water balance at the Pannerdensche Kop.

Firstly, the uncertainties introduced in the discharge measurements are quantified and propagated to the overall uncertainty. Of all uncertainties, only the random and systematic uncertainty have a significant influence on the overall uncertainty. The overall uncertainties in the Bovenrijn are fairly constant over all measurements, ranging from 3.1% to 5.3% (see Figure 1). In the Waal and the Pannerdensch Kanaal, there are larger fluctuations in the overall uncertainties over time, both ranging from approximately 3.7% to 9.8%. However, the largest uncertainties in the Waal are probably overestimated compared to the lowest uncertainties due to a negative correlation with the number of transects.

Secondly, the uncertainty was also estimated for all discharge components individually. Although the measured discharge has the lowest degree of uncertainty, it has the greatest influence on the overall uncertainty as its discharge is responsible for a large fraction of the total discharge. After that, the top and bottom discharges account for the second and third largest fraction of the total discharge but also have the second and third smallest degree of uncertainty. Therefore, fully inundated floodplains generally have a larger influence on the overall uncertainty than the top and bottom discharges. Although surrounded by uncertainty, the edge discharges generally have a small influence on the overall uncertainty.

Finally, the comparison between the measured ADCP discharges and the historically derived discharges showed no systematic over- or underestimation of the discharge by the rating curves for any of the branches. Additionally, it was found that by including the uncertainties in the river branches into the water balance error, the perfect water balance closure falls within the 95% confidence intervals. Therefore, the water balance error can be explained by the uncertainties in the three branches and there seems to be no river branch that most likely caused the water balance error at the Pannerdensche Kop.


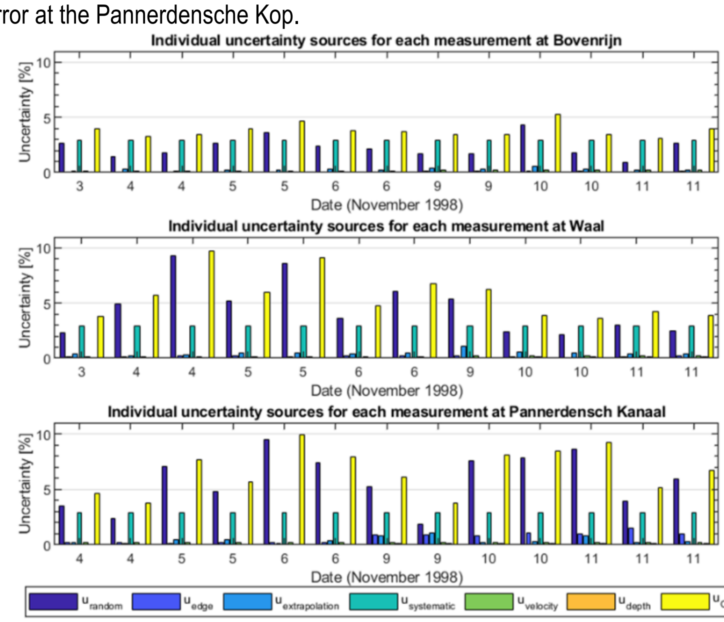


*Figure 1: Individual uncertainty sources and overall uncertainty (at 95% confidence level) over time for the three river branches, expressed as a percentage of the total discharge.*


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