Damage due to low flows on the Meuse

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Abstract
In this research the damage due to low discharges on the Meuse has been analysed to get a better view on the scope of the low flow problem. The research area consists of the Dutch and the Flemish part of the Meuse upstream of Roermond and the canals fed by it. A model has been developed to assess the total damage and the distribution over different regions and economic sectors in a number of situations. Total damage varies from a few million Euros in a medium dry year to ten times that much in an extreme dry year. Most of the damage occurs in the navigation sector and the power generation sector. Climatological and economical development will increase future damage substantially. On the other hand, much can be gained by applying appropriate management strategies.

Introduction
The main aim of this research is to create insight into the damage due to low discharges of the Meuse (Fig. 1). This insight can help water managers (e.g. Rijkswaterstaat) to evaluate international, national and regional agreements concerning the distribution of low flows. It can also give direction in the development of strategies to alleviate the low flow problem now and in the future. The research area consists of the Dutch and the Flemish part of the Meuse upstream of Roermond and the canals fed by it (like the Albert Canal, Juliana Canal and Zuid-Willemsvaart).

Figure 1. Low flows on the Meuse in 2003

Damage model
A model has been developed to assess the total damage and the distribution of the damage over several regions and economic sectors in a number of situations. The model calculates the damage that would occur in the current system, if it would be confronted with certain characteristic discharge series, in three steps. First, the distribution of the discharge over the main branches of the water system is determined. Then water shortages are quantified for each economic sector, by comparison of water supply and demand. In the last step, the financial damage is assessed for the relevant economic sectors: navigation, agriculture and power generation. Damage to navigation and agriculture is caused by water shortages, but damage to power generation is caused by high temperatures of the river water, which is used for cooling purposes.

Results
The damage that can be expected in the current situation has been computed for a number of characteristic years, based on the yearly cumulative discharge deficit. The damage varies from about 6 million Euros in a 50%-dry year to over 30 million Euros in a 1%-dry year (Fig. 2). In a 50%-dry year almost 90% of the damage occurs in the power sector, but in a 1%-dry year that fraction is only about 30%. In a 1%-dry year most of the damage occurs in the navigation sector. The damage is caused by the increasing delay of ships at locks, when more economical lock procedures are applied. The damage to navigation is particularly high on the Albert Canal in Flanders, where – in contrast to in the Netherlands - no pumps are installed to pump back the locking water. In the agricultural sector substantial water shortages do occur, but the damage caused by these shortages is negligible.

To develop insight into the possible future increase of damage, the model has been applied to a number of scenarios for climatological and economical development. In the most extreme of the two applied climate change scenarios, the damage in a 10%-dry year nearly doubles in 100 years time. A substantial part of the extra damage is caused by an increase in the water temperature. The scenario for economical development predicts an increase in damage of about 20% in 10 years time. The increase in damage is mainly caused by an increased intensity of ships on the Juliana Canal and the Lateral Canal. If the economical growth will continue with the same rate, the increase in water demand will add more to the low flow problem then the decrease of the water availability due to climate change.

Finally, the model has been used to identify beneficial solutions to the low flow problem, by assessing the damage that occurs under several management strategies. The damage to power generation is not taken into consideration in the evaluation of management strategies, because the strategies do not influence the water temperature. Since the damage to agriculture is already very limited, the strategies are mainly aimed at decreasing the damage to navigation.

The appropriate management strategies lead to a decrease of the total damage of nearly 20% to over 50% in a 10%-dry year. First of all, much can be gained by adjustment of the water distribution over the economic sectors and the regions in the research area. To decrease total damage, more water should be made available for navigation at the Juliana Canal and the Albert Canal. The distribution of water over the river system can however not be adjusted without (political) effort. Beside operational measures, a couple of appropriate strategical measures can be identified, among which the installation of pumps to pump back the locking water.

Discussion

The possible fault in the calculated damage is caused by various sources. First of all, a few economical sectors and processes are excluded from the model. Secondly, the model schematisation is a little inaccurate due to the fixed discharge distribution and the simplified damage functions. Finally, the uncertainty in the input and the model parameters – mainly the parameters for the power generation and navigation sector - cause quite some uncertainty in the output. Therefore, the total uncertainty in the calculated damage is substantial.

Conclusions and recommendations

Low flows on the Meuse are mainly a problem to navigation and power generation. Part of the damage is unavoidable and has to be accepted. Nonetheless, the total yearly damage can be decreased substantially by applying appropriate management strategies. Especially with regard to the expected increase of the low flow problem due to climate change and economical development, it seems to be wise to implement a combination of operational and strategical measurses. To establish a widely accepted package of effective and efficient measures, it is recommended to consider all financial and non-financial effects to the interested parties.

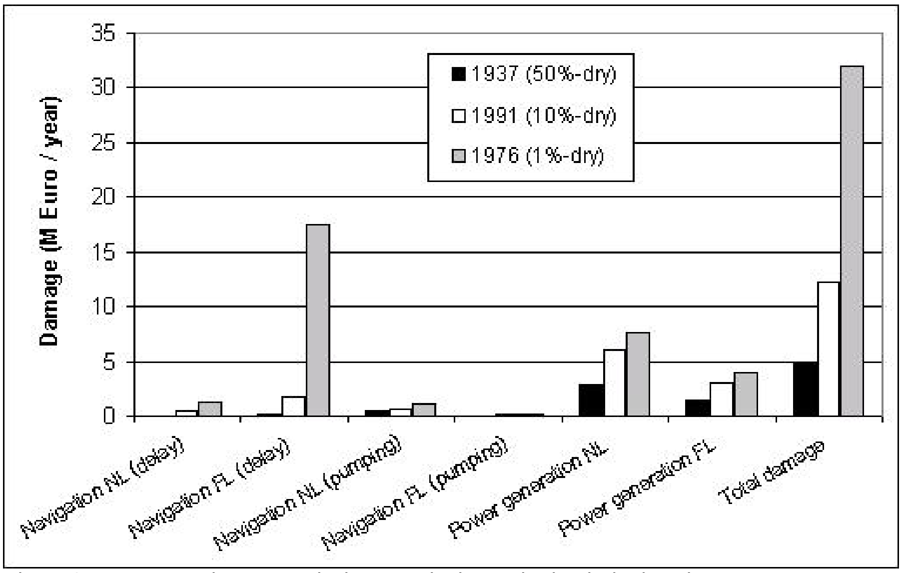

Figure 2. Damage to the economical sectors in the Netherlands (NL) and Flanders (FL) in characteristic years.