

Measuring and modeling the development of side channels

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Introduction

Side channel construction is a common intervention to reduce the flood risk of the river or to increase the river's ecological value. In the Netherlands, over 20 side channels have been constructed since 1996. Such artificial side channels generally aggrade (e.g., [Van Denderen et al., 2019](#)), which in most cases is undesired and therefore, regular maintenance is required. A better understanding of the mechanisms that lead to morphodynamic changes in a side channel can improve its design, operation and maintenance. We evaluate the development of side channels using measurements of the side channel system at Gameren in the river Waal and numerical computations.

System description

The side channel system at Gameren in the river Waal (the Netherlands) is an example of an artificial side channel system (Fig. 1). The three side channels were constructed between 1996 and 1999, and their objective is to compensate a water level increase that was a result of a levee relocation. At the upstream side of the East channel and the West channel, weirs were constructed to control the discharge in the channels such that the East channel flows 100 d/yr and the West channel flows 265 d/yr. The Large channel is much longer compared to the other two channels and is permanently connected to the main channel.

Method

Data analysis

In the first few years after the construction of the channels, regular bed level measurements are available. Unfortunately, from 2003 the main source of bed level data is LIDAR measurements, which only gives the bed level data of the East channel because the other channels are permanently inundated. In addition, we collected sediment samples in 2017 in the three side channels of the deposited sediment to analyze and to characterize the development of the side channels.

Hydrodynamic and morphodynamic model

We use a hydrodynamic model (Delft3D Flexible Mesh) to estimate the flow conditions in the side channels. Using the model results we estimate the variation of the bed shear stress and the streamlines as a function of the discharge in the river. The morphodynamic model is used to get more insight into the temporal development of a side channel system. We use a two-dimensional depth-averaged version of Delft3D in combination with the mixed-sediment morphodynamic module ([Sloff et al., 2001](#)). We look at an idealized version of a side channel system in which we neglect the effect of the floodplains. The discharge at the upstream boundary is given by a repeated averaged yearly hydrograph. We use four sediment-size classes and we compute the sediment transport for bed load transport and for suspended bed-material load transport separately. Using the model, we study the effect of varying hydrodynamic conditions on the bed level development and on the sediment that is deposited in the side channel.

Results

Data analysis

Here, we focus mainly on the bed level development of the East channel. The East channel has reached a bed level at which vegetation is able to grow and at which wash load is deposited in the channel (Fig. 2). Therefore, the channel seems to have become part of the floodplain. The bed level measurements show a clear relation with the hydrodynamic regime of the river (Fig. 2B). With increasing flow frequency of the channel, the aggradation rate of the bed reduces. A similar relation is found between the cumulative discharge conveyed by the side channel and the aggradation rate. The more the side channel flows, the less aggradation occurs. This explains partly why the aggradation rate of the West channel is much smaller.

Hydrodynamic and morphodynamic model

The hydrodynamic model gives insight into the spatial and temporal variation of the transport capacity in the side channels at Gameren. Furthermore, the streamlines give valuable information on the flow patterns and thereby, give

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Figure 1: An aerial image of the West, East and Large side channel at Gameren in the river Waal. The three side channels were constructed between 1996 and 1999. (After images of Rijkswaterstaat)

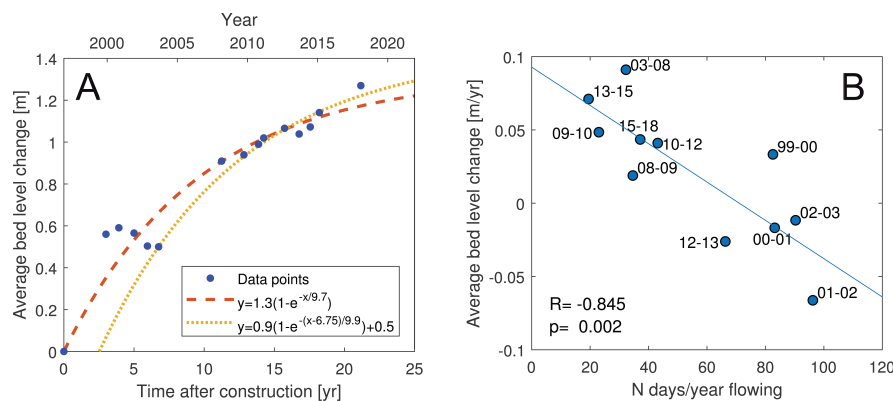


Figure 2: (A) The average bed level change in the East channel of Gameren from its construction in 1996. (B) The average bed level change per year related to the yearly-average flow frequency of the East channel. The correlation is computed using Spearman's rank correlation and a first-order fit is shown.

an indication of the temporal and spatial variation of the sediment supply to the side channels. The morphodynamic model confirms that varying hydrodynamic conditions have a large effect on the aggradation rate of the side channel. We computed the bed level development using a repeated hydrograph and found that at lower bed levels the largest bed level increase occurs at bankfull discharge. With increasing bed level, the peak flow becomes more important for the continuing aggradation of the side channel. The sediment that is deposited in the side channel also varies in time. During low flow conditions mainly the fine sediment classes are deposited in the side channel and during peak flow mainly the coarse sediment classes. With increasing bed level, the supply of coarser sediment classes to the side channel reduces.

Discussion and conclusions

The analysis of the side channel system at Gameren is valuable to better understand the development and the temporal variation in development of side channels in general. Unfortunately the measuring frequency is too low to study the effect of single flood events on the side channel development. The numeri-

cal model is used to fill in these knowledge gaps. We find that both the aggradation rate and the sediment that is deposited in the channel, show a relation with the bed level of the side channel and the hydrodynamic conditions of the river.

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