Proc. of the 5th IAHR Europe Congress — New Challenges in Hydraulic Research and Engineering
Editor(s) Aronne Armanini and Elena Nucci
doi:10.3850/978-981-11-2731-1_106-cd

A simple estimation of side channel development

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ABSTRACT

Side channels are a common intervention to reduce the flood levels or to increase the ecological value in the river. Most of the constructed side channels aggrade. We apply a simple method to estimate the development and its time scale of a side channel system.

1 INTRODUCTION

Side channels are small secondary channels that are connected to a significantly larger main channel. In many rivers in Europe and North America, side channels disappeared due to river regulation measures. Nowadays, side channels are (re)constructed to lower flood levels and to increase the ecological value of the river. In the Netherlands, the Room for the River programme was initiated to increase the discharge capacity of the Dutch Rhine branches. Since 1996 more than 20 side channels have been constructed. These constructed side channels show aggradation and this is in many cases undesired. Now, after 20 years, we are able to evaluate the development of the side channels. Using measurements and numerical computations, we try to find rules of thumb for a side channel design such that the aggradation in side channels is minimal and the aggradation rate is small. Here, we will focus on the aggradation in the side channel system near Gameren in the river Waal.

2 SYSTEM DESCRIPTION

The river Waal is one of the Rhine branches. The riverbed mainly consists of sand (0.75–1 mm), the yearly averaged sediment load is 200,000 m^3/yr, and the yearly averaged discharge is 1500 m^3/s. The side channel system at Gameren consists of three side channels (Figure 1). The system was constructed as compensation of a water level increase due to a levee relocation. The West and East channels were constructed in 1996 and the Large channel in 1999.

The bed level changes of the side channels are studied using a combination of echo sounder measurements and Lidar measurements. The three channels aggrade differently. The East channel is after 20 year almost fully terrestrialized and became part of the flood plain. The side channel is mainly filled with fine sand, but recently silt started to deposit and a vegetation cover has developed. Assuming an exponential relation for the aggradation in the side channel, we can easily estimate the equilibrium bed level and the characteristic time scale of the side channel development. For the East channel, the equilibrium bed level increase is estimated to be 1.2 m and the characteristic time scale is 8.3 years.

The West channel was initially constructed lower than the East channel and seems to show less aggradation. The channel is mainly filled with sand that is slightly coarser than the East channel. The sand that is deposited in the two channels (0.25–0.35 mm) corresponds with sediment that during floods is transported in the main channel as suspended bed-material load [2]. The deposition in the Large channel is different. The aggradation rate of the channel is small and a large portion of silt is deposited inside the channel. This difference in the deposited sediment seems to be caused by the geometry of the Large channel that results in low bed shears stresses in the channel. In addition, during floods, a large part of the discharge that is conveyed by the Large channel originates from the upstream flood plain.

3 METHOD

We use the 1D bifurcation model as proposed by Van Denderen et al. (2018). The sediment that is deposited in the side channels of Gameren is suspended bed-material load and for simplicity we assume that the sediment partitioning is only related to the discharge. The Nikuradse roughness length in the main channel is k=0.5 m and in the side channel k=0.2 m. We compute the sediment transport using Engelund & Hansen and we use uniform sediment in each channel. Based on measurements, we assume a grain size of 0.75 mm in the main channel and 0.3 mm in the side channel. We compute the bed level changes in the side channel

Figure 1: An aerial image of the side channels at Gameren. (Source: Ministry of Infrastructure and Water Management)

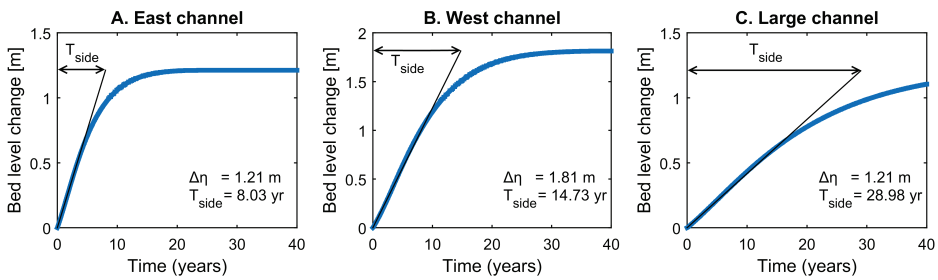

Figure 2: Bed level change in the three side channels at Gameren computed by the 1D bifurcation model [1]. The equilibrium bed level change ($\Delta\eta$) and the characteristic time scale (T_{side}) are given based on the computations.

until it reaches its equilibrium bed level change ($\Delta\eta$) and use a tangent line to compute the characteristic time scale (T_{side}).

4 RESULTS

We computed the bed level change and the characteristic time scale (Figure 2). In the East channel, the values correspond with the measurements. The time scale in the West and Large channel are much larger. The West channel is wider and deeper than the East channel and this results in a longer time scale and a larger bed level increase. The equilibrium bed level is very similar for both channels. The time scale of the Large channel is much larger, because the channel is much longer compared to the main channel [1]. The aggradation rates seem realistic compared to the observed bed level changes. The estimated bed level changes in the Large channel also seem to correspond with the observed changes, but based on measurements we know that important processes are still missing. For example, the bed shear stresses are small such that silt is able to deposit and, in addition, during floods a large part of the discharge originates from the flood plain. These processes should be included to correctly represent the development of the Large channel.

5 DISCUSSION AND CONCLUSIONS

The 1D bifurcation model seems to give a good estimate of the bed level changes and the corresponding time scale until flood plain aggradation processes become important. The estimates by the model show reasonable similarities with the measurements for East and West channel. The method does not seem suitable for the Large channel, because of the deposition of silt in the channel and the influx of discharge from the flood plain.

ACKNOWLEDGMENTS

This research is supported by the Netherlands Organisation for Scientific Research (NWO), which is partly funded by the Ministry of Economic Affairs, under grant number P12-P14 (RiverCare Perspective Programme) project number 13516. This research has benefited from cooperation within the network of the Netherlands Centre for River studies.

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