AGGRADING SIDE CHANNELS

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THE FILLING IN OF SECONDARY CHANNELS IN THE RIVER RHINE

Side channels are small secondary channels in the river that are constructed to increase the capacity of the river during high flows or to increase the biodiversity in the river. In the last 20 years, more than 20 side channels have been constructed in Rhine branches (Figure 1). As side channels increase the discharge capacity and hence lower the flood water levels, it is important to understand sedimentation processes within the side channels. In most side channels, large amounts of sediment are deposited. Therefore, such channels require regular maintenance in order to keep their function as flood control measure, which is costly. A better understanding of the mechanisms that lead to deposition of sediment can improve the side channel design and might reduce the maintenance needs.

Our research focusses on the mechanisms that cause bed level changes in the side channel. We carried out field measurements and looked at both simple estimation methods and detailed numerical models to study the development of side channel systems. Here, we present the field measurements of a side channel system at Gameren in the river Waal. This research has led to a proposal for a categorization of side channel development, which can be used to derive rules of thumbs for each category of side channel. Those rules of thumb can be used for enhancing operations and maintenance by, for example, Rijkswaterstaat.

Side channel system of Gameren

The side channel system at Gameren (Figure 1) was constructed between 1996 and 1999 to compensate for a water level increase due to

FIG. 1 An overview of the constructed side channels in the Rhine branches with a detail of the side channel system at Gameren in the river Waal. (after images of Rijkswaterstaat and Google Earth)

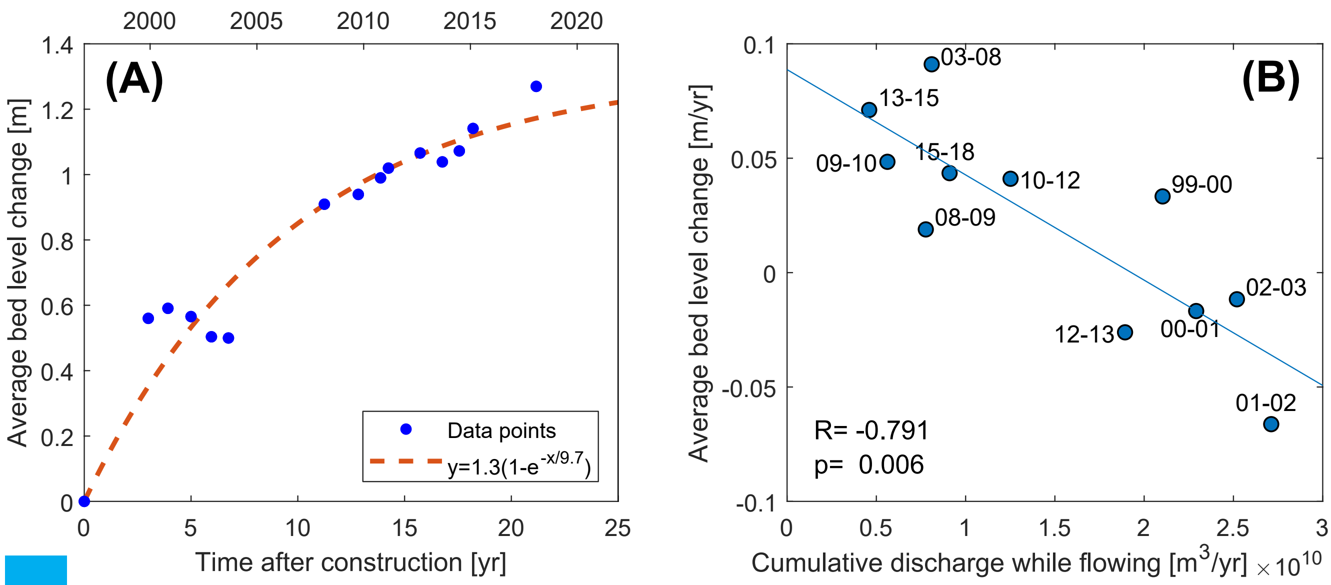

FIG. 2 Bed level change in the East channel of Gameren since its construction in 1996. (B) The average bed level change per year between two measurements related to the cumulative discharge in the river while the side channel is flowing. The cumulative discharge is the volume of water that flows through the river per year.

a dike relocation. The side channel system consists of three side channels. The East and the West channel are both located close to the main channel and their discharge conveyance is controlled with a weir. The Large channel is constructed further into the floodplain and is permanently (without weir) connected with the main channel. Since the construction of the side channels, regular bed level measurements are available and we use these measurements to study the development of the channels in relation with the discharge in the river. We took sediment samples in order to better understand which type of sediment is deposited in the channels and to distinguish the variation of the sediment size between and within each of the channels. Here, we will show the results of the East channel.

The bed level change in the East channel is initially large (Figure 2A) and is locally up to 1.5 m within the first three years. This is mainly caused by an initial adaptation of the designed channel to the conditions of the river. The bed level changes in the following years are much smaller. Currently, the bed level has reached a height at which vegetation is able to grow and the channel seems to have become part of the floodplain. The bed level changes show clear relation with the flow conditions of the river (Figure 2B). The relations show that the more discharge that flows through the river each year the less sediment is deposited in the side channel. During the years that long periods of large peak flows occurred, for example between 2000 and 2003, this can even lead to erosion in the side channel. From this can be concluded that the more discharge flows through the side channel, the less deposition of sediments occur. Inclusion of the temporal aspect in Figure 2B is important. If we only look at the value of the peak discharge, we did not find a correlation with the average bed level change.

The sediment size that is deposited in the three side channels varies, but consists in each channel mainly out of fine sand (Figure 3). The size of the fine sand is very similar to the sand that in the main channel is transported in suspension near the bed (suspended bed-material load transport). The sediment deposited in the East channel is finer than in the West channel because the bed level of the East channel is higher. In the Large channel, the bed shear stresses are low due to the length of the channel and its variation in width. Therefore, more silt (<0.063 mm) is deposited. This is also reflected by the green curve in Figure 3 which for small grain sizes deviates from the dashed curves that represent the suspended bed-material load in the main channel.

Categorization of side channel development

From the side channel system at Gameren we can distinguish two types of side channels. In the West and the East channel mainly suspended bed-material load transport is deposited. In the Large channel we find, in addition to the fine sand, a large fraction of silt, which in the main channel is transported as wash load. A third category has not yet been observed in the Nether-

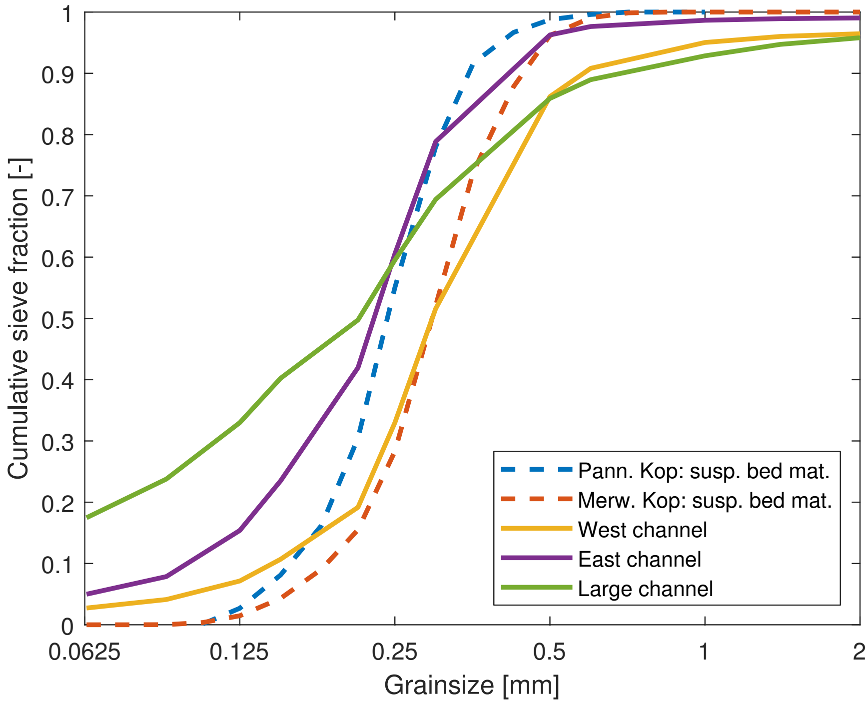

FIG. 3 Sieve curves of the sediment that is transported in suspension in the main channel (Measurements from the Pannerdensche kop and the Merwede kop) and the sediment that is deposited in the side channels.

lands, but was found in a side channel system in the river Ain in France (Van Denderen et al., 2018). In this side channel mainly gravel was deposited, which in the main channel is transported as bed load. Combining these findings, we end up with three side channel categories: bed load dominant, suspended bed-material load dominant and wash load dominant (Figure 4). The categories can change with increasing bed level as can be seen in the East channel at Gameren where from a certain bed level also wash load is deposited. In addition, a changing flow regime can cause erosion in the side channel and flush out the finer material, and can therefore also result in a change of category.

The development of a side channel is determined by an imbalance between the sediment that is supplied to the side channel and the sediment that can be transported out of the side channel: the transport capacity. Each category is related a set of processes that can affect both the sediment supply and the transport capacity of the side channel. For example, bed load sediment transport is affected by bed slope effects, because the sediment rolls and skips over the bed and gravity plays a role; sedi-

FIG. 4 Gamerensche waarden 1e fase 095. Oude situatie Rijkswaterstaat Stroomlijn Staatsbosbeheer. | Photo: RWS Beeldbank

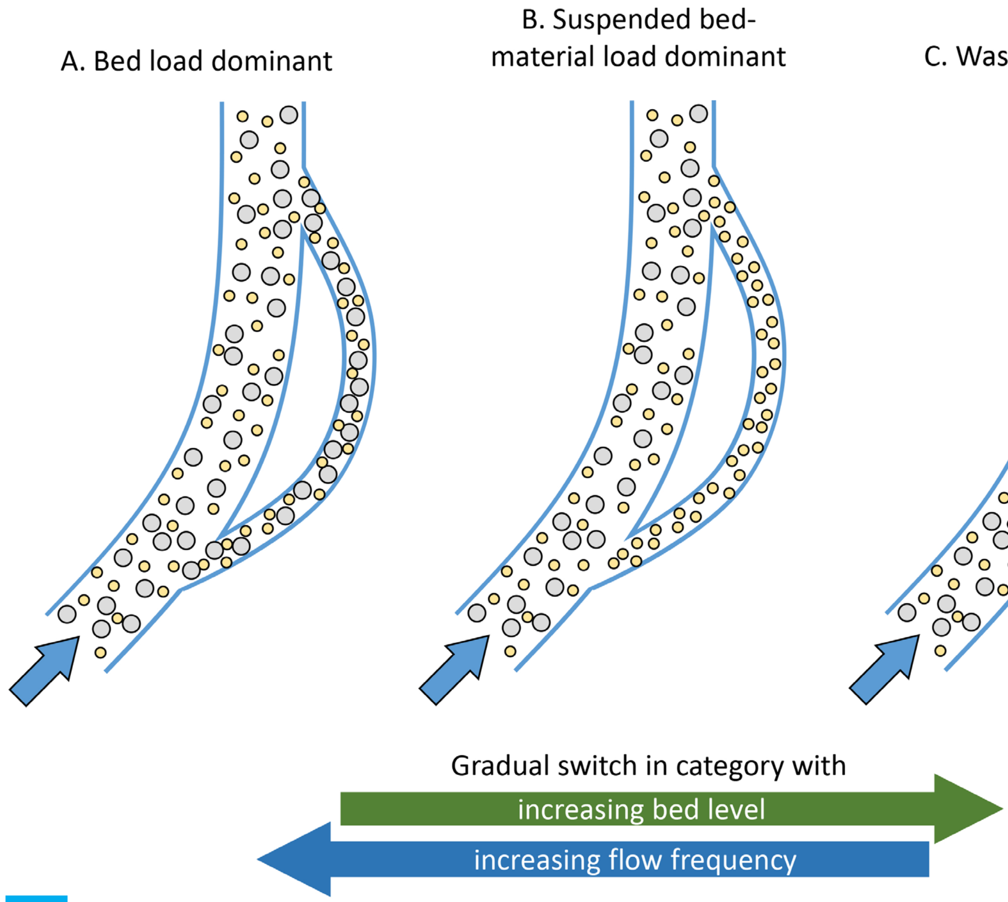

FIG. 5 The three categories of side channels in which the grain size that is deposited in the side channel changes with the category of side channel. The largest gray circles represent sediment transported in the main channel as bed load, the smaller yellow circles represent sediment transported in the main channel as suspended bed-material load and the shaded areas denote deposited wash load.

ment is more easily transported downhill than uphill. Suspended bed material load is much less effected by the bed slope, because it is transported in suspension and has much less contact with the bed. The transport capacity is also affected by the category. In a bed load dominant side channel the sediment transport is limited due to the large sediment size, while in a suspended bed-material load dominant side channel the sediment transport occurs more easily due to the smaller grain size. Therefore each category is connected with several characteristics and using these, we can estimate the transport capacity and the sediment supply of the side channel and thereby its development. Our method gives a first estimate of the side channel development, but for more detailed results a more sophisticated 2D-morphodynamic model is needed.

Concluding remarks

Side channels generally aggrade and our measurements of the side channel at Gameren are a good example of how the aggradation rate is related to the characteristics of the river and its flow regime. We show that the sediment that is deposited inside the side channel is important to characterize the development of a side channel. With our proposed categorization we can estimate the time scale of the side channel development and can develop rules of thumb with respect to sedimentation and erosion. These can assist river managers in operation and maintenance strategies.

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SOURCES

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