SEP Appendix E3:
Longitudinal training dams in the river Waal

Summary

Longitudinal training dams with accompanying shore channels form an innovative way of controlling the channel geometry of the river, replacing traditional groynes. During an extensive pilot study in the River Waal, research was carried out into the effects on flow patterns, bed morphology and their management. This was investigated with a combination of an extensive field campaign and physical scale experiments in the Kraijenhoff van de Leur Laboratory for Water and Sediment Dynamics at Wageningen UR. The results reveal how the complex flow pattern at the entrance to the side channel behind the longitudinal dam depends on geometrical properties of the inlet section. In a participatory process where water managers and researchers work together with representatives of the inland shipping sector and the Royal Dutch Angling Association, important advantages are obtained for various stakeholders. These include an increase in the water depth during periods with a low water level, facilitating shipping, and a reduction of peak water levels, yielding higher safety against flooding.

Case Description

Background

Our large rivers have been extensively controlled by infrastructure that avoids bank erosion and sand accretion, by which the main channel has been reduced to a constant width. Traditionally, this has been realised by the construction of groynes. Longitudinal training dams (LTDs) with accompanying side channels form an innovative alternative measure of control (Figures 1 and 2). The aim of such LTDs is to reduce as much as possible the problems in the river network by splitting the river into a fairway, used for commercial shipping, and a side channel where recreation takes place and biodiversity increases. The concept addresses all the functions and interests: not only liveability and safety problems related to high water levels, biodiversity, water management and low water levels, but also the transport of goods, recreation in the floodplains, pleasure cruising and sport fishing.

Research Approach

To evaluate the potential of LTDs as an alternative for groynes, a pilot was set up in 2015 by Rijkswaterstaat, over a length of ten kilometres in the river Waal near Tiel. This pilot was monitored extensively. To be able to use LTDs as effectively as possible, attention was also paid to the dynamic equilibrium of the sandy river bed. As part of collaborative research with stakeholders and research institutions, knowledge was developed about the dominant physical processes for flow and sediment dynamics in the vicinity of the inflow of a shore channel, which resulted in developing handles for managing the river. In this context, WIMEK researchers have conducted field measurements and physical scale experiment at the Kraijenhoff van de Leur laboratory for Water and Sediment Dynamics.

Generic scientific knowledge was gained to optimize the design and management of LTDs in terms of navigation, flood protection and ecological rehabilitation. The physical scale model in a laboratory setting successfully mimicked the river bed morphodynamics observed in the field (Figure 3). Using the model, alternative designs of the subaqueous inlet geometry were tested, showing how geometrical properties influence the exchange of water and sediment at low and high water stages. At low water stages, the penetration of ship-induced waves and flow is reduced such that the disturbing influence of navigation on the flora and fauna in the riparian zone is minimized without disconnecting the side channel completely. At high water stages, flow may impinge on the banks of the river, behind the LTD, which either requires bank protection or an adjustment of the inlet geometry. A number of WIMEK projects have offered thorough understanding of the transport processes associated with an LTD based on field monitoring and laboratory experiments.

Stakeholder involvement

The work on hydrology and quantitative water management within WIMEK enhances the involvement of civil society in water management, for example through the participatory process called *WaalSamen* (WaalTogether). *WaalSamen* was initiated by the **Department of Waterways and Public Works** (Rijkswaterstaat) to promote sustainable and integrated river management by combining improvements for flood safety, inland shipping, nature development, discharge conveyance capacity, maintenance costs and public engagement in water management. Biannual stakeholder meetings are organized with the aim to explore opportunities, risks and uncertainties when monitoring the effects of the LTDs, which are attended by representatives of Rijkswaterstaat, Royal BLN-Schuttevaer, representing professional inland shipping sector, the Royal Dutch Angling Association and various research institutes. Partners within *WaalSamen* have all formally signed a cooperation agreement, which facilitates rapid data and knowledge exchange.

Link to education

WIMEK provides several courses related to understanding river flow processes, sediment transport and river bed morphodynamics. The ongoing rigorous changes the Dutch river landscape related to the introduction of LTDs offer inspiration for updating educational material. Students apply physical concepts and approaches that are used to describe and interpret phenomena of flow, sediment transport, bedform dynamics and regional scale channel morphology. Such phenomena are being illustrated and explained during lectures, working classes, and in practical experiments at the Kraijenhoff van de Leur Laboratory for Water and Sediment Dynamics. Students use numerical modelling tools to simulate and gain understanding of the physical processes at different scales.

Research Highlights

To monitor the active bed in physical scale experiments, a new monitoring system was developed using a laser line scanner that scans the entire bed of the laboratory flume from a computer controlled measurement carriage[1]. The flume experiments revealed the emergence of a sand bar where the flow diverges at the LTD inlet, and where the flow curves into the side channel[2]. A simple theoretical flow model was developed that can be instrumental in minimizing the occurrence of sand bars causing hindrance for shipping[3]. From a detailed analysis of repeated scans of the river bed, the interaction between migrating river dunes with the static bars was investigated, which explains flow resistance[4].

Impact

The pilot project has a positive impact on the ecosystem services of the river, including safety against flooding and the facilitation of navigation, recreational boating and sport fishing. The development of innovative measures to manage rivers helps Dutch consultancy companies to maintain their frontrunner position in river engineering. Through user committees, established by the Domain Applied and Engineering Sciences of the Dutch Scient Foundation (NWO), WIMEK researchers interact with consultancy companies such as Royal HaskoningDHV, Arcadis, Witteveen & Bos and HKV Consultants, and knowledge institutes such as Deltares. Knowledge transfer also takes place through dual appointments of PhD candidates and Postdocs, which emerge when research programmes align with longer term consultancy projects.

---

[1] De Ruijsscher, T. V., Hoitink, A. J. F., Dinnissen, S., Vermeulen, B., & Hazenberg, P. (2018). Application of a line laser scanner for bed form tracking in a laboratory flume. *Water resources research*, *54*(3), 2078-2094.

[2] De Ruijsscher, T. V., Hoitink, A. J. F., Naqshband, S., & Paarlberg, A. J. (2019). Bed morphodynamics at the intake of a side channel controlled by sill geometry. *Advances in Water Resources*, *134*, 103452.

[3] De Ruijsscher, T. V., Vermeulen, B., & Hoitink, A. J. F. (2020). Diversion of flow and sediment toward a side channel separated from a river by a longitudinal training dam. *Water Resources Research*, *56*(6), e2019WR026750.

[4] De Ruijsscher, T. V., Naqshband, S., & Hoitink, A. J. F. (2020). Effect of non-migrating bars on dune dynamics in a lowland river. *Earth Surface Processes and Landforms*, *45*(6), 1361-1375.

Illustrations

Figure 1: Aerial view on a longitudinal training dam in the River Waal.

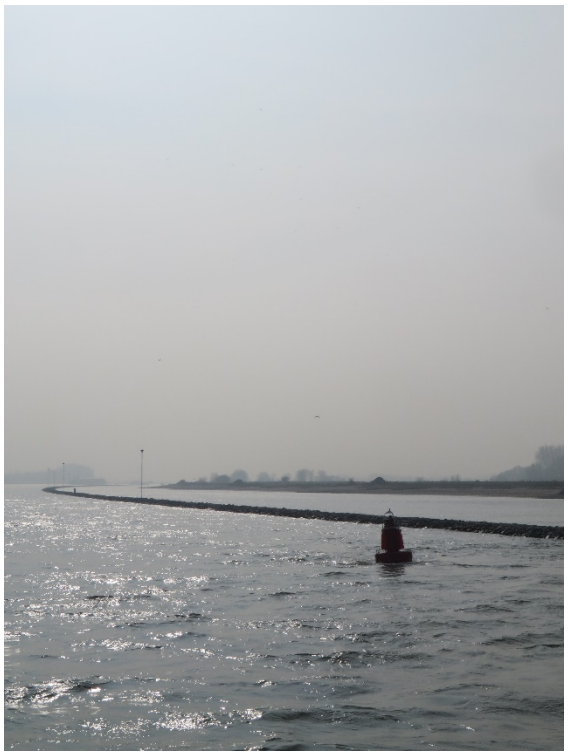

Figure 2: A longitudinal training dam seen from the fairway, where the buoy indicates the foot of the slope.

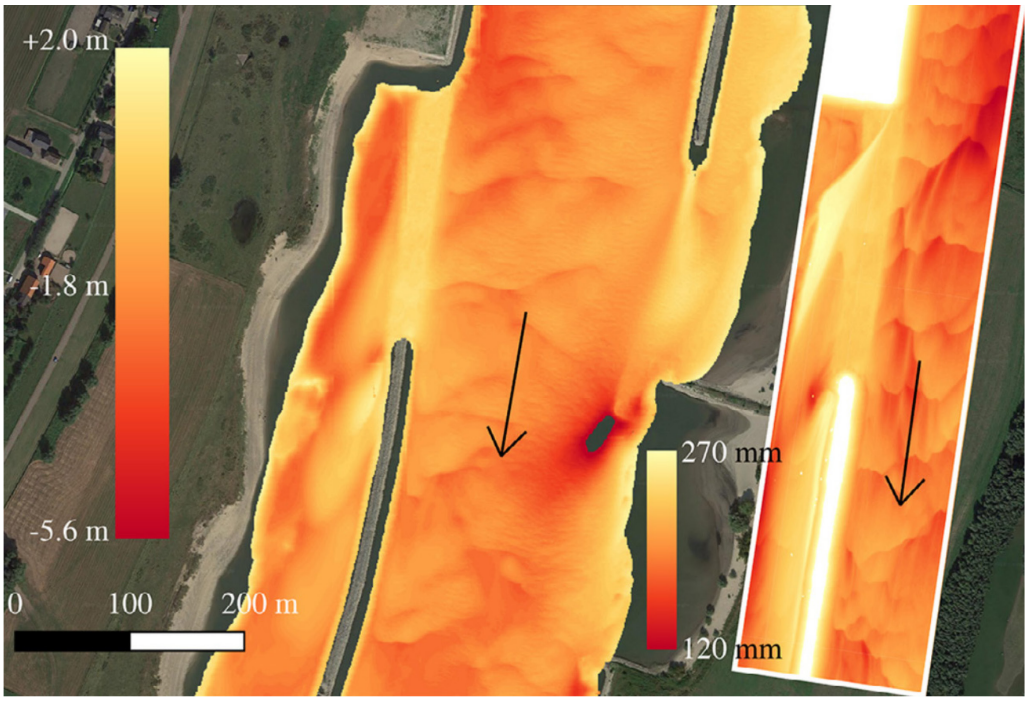

Figure 3: River bed morphology observed at the inlet area of the pilot study in the River Waal (left) and the corresponding physical scale model in a 2.6 m x 14 m current flume of the Kraijenhoff van de Leur Laboratory for Water and Sediment Dynamics, where sediment is being recirculated (right).