# Best Practices for Longitudinal Training Walls to mitigate channel bed erosion

Czapiga, Matthew; Blom, A.; Viparelli, Enrica

**Publication date**
2022

**Document Version**
Final published version

**Published in**
Anthropogenic Rivers: Book of Abstracts NCR DAYS 2022 13-14 April | TU Delft

# Anthropogenic Rivers

Book of Abstracts

***NCR DAYS 2022***

13-14 April | TU Delft

*Astrid Blom, Laura M. Stancanelli, Jelle A. Dercksen, Clàudia Ylla Arbós, M. Kifayath Chowdhury, Shelby M. Ahrendt, Carolina Piccoli, Ralph M.J. Schielen, Kees Sloff & Jill H. Slinger (eds.)*

**NCR Publication: 49-2022**

Netherlands Centre for River studies

# Best Practices for Longitudinal Training Walls to mitigate channel bed erosion

Matthew Czapiga[a,*], Astrid Blom[b], Enrica Viparelli[a]
[a]University of South Carolina, Department of Civil Engineering, Columbia, South Carolina, USA
[b]Delft University of Technology, Department of Hydraulic Engineering, Delft, the Netherlands

**Keywords —** Morphodynamics, River Engineering, Longitudinal Training Walls

## Introduction

A recent pilot project in the Waal River sought to mitigate long-term riverbed erosion with longitudinal training walls (LTW). Groynes were removed and replaced by three walls that split the river corridor into a primary and an auxiliary channel. Each wall contained an entrance weir, wall notches, and an exit outlet. During floods, the wall is overtopped. Field data show that after five years, the engineered walls reversed some erosion in the primary channel by diverting water discharge from the primary channel toward the auxiliary channels (*Czapiga et al.*, 2021). Here we analyze these data to explain which factors can be of aid in LTW water and sediment partitioning and how our findings influence design practices to mitigate channel bed erosion with LTWs.

## Morphodynamic Controls

Mitigation of channel bed erosion is achieved by increasing the river equilibrium slope (*Czapiga et al.*, 2022). LTWs accomplish this by decreasing discharge in the primary channel without removing the bed material load. As a result, how water and sediment are partitioned between the channels is critical to the success of an LTW project. Fluxes of water and sediment between the primary and the auxiliary channels depend on geometries of the entrance weir, the wall, and the auxiliary channel. Analysis of the pilot project showed that auxiliary channel width controlled discharge partitioning during flood flows (*Czapiga et al.*, 2021). Conversely, sediment fluxes into auxiliary channels were mostly controlled by weir geometry and were unrelated to wall or auxiliary channel geometry (*Czapiga et al.*, 2021). These observations lead to four specific design factors as detailed below and in Figure 1.

## Results

### *Entrance Weir Geometry*

Entrance weirs have no positive effect on erosion mitigation, as they do not influence water discharge partitioning during floods and may extract bed material load from the primary channel, which hampers mitigation. However, weirs extract water at low flow, which is important for ecological reasons. Thus, entrance weir should be designed to extract enough water at low flows and to limit the amount of water diverted into the auxiliary channel during floods.

### *Auxiliary Channel Geometry*

Once the wall is over-topped, more water can enter the auxiliary channel than it can discharge. In other words, the discharge capacity of the auxiliary channel, which is set by channel geometry, controls discharge partitioning during floods. Expanding these channels, either by widening, as illustrated in Figure 1*B*), or deepening (i.e. dredging) removes more water from the primary channel and thus likely enhances erosion mitigation.

### *Slope of the Wall Crest*

The LTW pilot project saw significant sediment accumulation in the primary channel during floods (*Czapiga et al.*, 2021). These deposits were located where flow rapidly entered the auxiliary channel and flow velocity suddenly decreased. Sediment deposited in the primary channel where sediment transport capacity suddenly declined. While deposition in the primary channel is one of the objectives of a LTW project, localized deposits may hamper navigation. Such depositions can be dispersed by making the auxiliary channel inflow more gradual. As a result, sediment transport capacity in the primary channel gently decreases and sediment deposits over a broader area. This can be achieved with a wall crest slope steeper than the adjacent primary channel bed slope (Figure 1*C*), such that upstream portions of the wall are inundated by less water and auxiliary channel inflow is more gradual.
The expected deposition location also changes with discharge level. The largest floods inundate the entire wall and a deposit forms in the primary channel just downstream of the entrance weir. Lower magnitude floods only inundate the downstream part of the wall, so deposition in the primary channel is shifted downstream where flow exits the primary channel.

*Corresponding author
*Email address:* mczapiga@sc.edu (Enrica Viparelli)

Both effects tend to elongate the deposit and reduce its height. While we schematize this effect via wall crest slope alone, a full design must consider notch location and geometry as well.

*Wall Length*

The magnitude of mitigated erosion increases with LTW length (Figure 1*D*). An eroding river continues eroding until it reaches an equilibrium state characterized by a lower slope. LTWs increase equilibrium slope in the primary channel. Long LTWs increase the region with the increased equilibrium slope, but also reduce erosion in the reach upstream. This occurs because the upstream end of the LTW section aggrades more as LTW length increases. The upstream reach then responds by aggrading to maintain its desired channel slope.

## Conclusions

Based on the analysis of field data collected to monitor a pilot project for 5 years, we provide four main design criteria for LTWs: 1) Design the entrance weir to divert water at low flow for ecological purposes and to limit water diversion during floods, 2) expand or deepen auxiliary channels to reduce discharge in the primary channel during floods, 3) increase the slope of the wall crest to disperse the deposit during floods, and 4) increase LTW length to improve mitigations both in the primary channel and in the reach upstream.


## Acknowledgements

This study is carried out as part of the Water2015 project 14508 "Long-term bed degradation in rivers: causes and mitigation", which is funded by the NWO Domain Applied and Engineering Sciences (AES, The Netherlands). There are no conflicts of interest.


## References


Czapiga, M.J., Blom, A., & Viparelli, E. (2021), Impact of Weir Location on Discharge Partitioning in Longitudinal Training Walls, NCR 2021, Enschede, Netherlands

Czapiga, M.J., Blom, A., & Viparelli, E. (2022), Sediment Nourishments to Mitigate Channel Bed Incision in Engineered Rivers, Journal of Hydraulic Engineering, In Press