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Nature-friendly banks in the IJssel River - Measurements, analyses and recommendations

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Introduction

The EU Water Framework Directive guides and regulates targets on water quality and habitat diversity. Rijkswaterstaat (RWS) has already implemented hundreds of diverse measures in the Netherlands to comply with these ambitions. Nature-friendly banks (natuurvriendelijke oevers, NVOs, in Dutch) constitute one of those measures. They are created by removing existing protections (mostly riprap) up to a metre below average water level. While progress was made on understanding and forecasting the morphological development of NVOs exposed to flow and ship waves in regulated rivers (Duró et al., 2020; Duró, 2021), it remained unclear how NVOs respond to loads in unregulated rivers.

Figure 1. Nature-friendly bank at Welsumer Waarden in 2017, shortly after protection removal and excavation

RWS Oost-Nederland realised 14 new NVOs along the IJssel River in 2016 (e.g. Fig. 1). To prevent too much initial sedimentation in the fairway, the NVOs were pre-excavated during construction, with slopes between 1:10 and 1:3 (Fig. 2). A monitoring programme over 2016–2020 was implemented based on the conceptual model of Baar et al. (2014). The goal of this study was to evaluate the available data to explain differences in morphological evolution of NVOs along the Ijssel and generate generic guidelines for the selection and maintenance of NVOs in the upcoming years.

Figure 2. Example of initial profile design of NVOs

Methodology

We analysed field data of recent NVOs (built in 2016, hereafter “new” NVOs) and previously existing NVOs (hereafter “old” NVOs). The latter consisted of 14 locations, where protections had been removed since 1990s and includes banks that were never protected.

The monitoring programme included yearly topo-bathymetric measurements with LIDAR and sonar since 2016. Moreover, several field records along the NVOs, including photos, sediment characteristics, vegetation cover, and scarp morphology were taken in 2017 and 2020.

Different hypotheses describing the factors that may affect the NVO morphological evolution were evaluated. Parameters to confirm or falsify these included bank geometry (e.g. profile slope and length, see next), water level fluctuations, ship passages, position in the river stretch (straight reach, inner or outer bank), median grain size, presence of cohesive layer, and slump blocks. Three bank profiles were considered in each groyne field (Fig. 3), resulting in a total of 539 bank profiles.

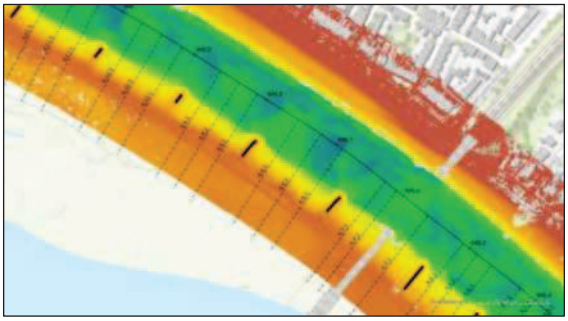

Figure 3. Location of three bank profiles per groyne field in elevation map

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Each bank profile was schematised according to a conceptual model with key features (Fig. 4). An algorithm was used to automate the detection of these points, based on slope changes, elevation and proximity.

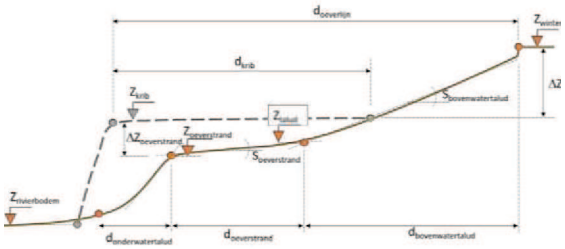

Figure 4. Schematized NVO profile between groynes

Results and interpretation

The four key points of the theoretical profile (circles in Fig. 4) were found in 45% of all analysed bank profiles, whereas another 20% had no clear inflexion point between the terrace and upper bank. The lack of elevation data at many cross profiles partially explains this. Circa 60% of the profiles missed one or more points, which were usually located at the terrace.

For those 65% of profiles, we compared several parameters in search of correlations and causality. Most profiles, however, did not present any clear correlation between potential erosion drivers and morphological changes. A likely explanation is that little morphological changes were observed at the pre-excavated NVOs after 3–4 years of development. Moreover, the new NVOs showed similar terrace and upper-bank slopes as old NVOs (e.g. Fig 5). This suggests that the initial profile of new NVOs closely resembled the long-term or equilibrium profile.

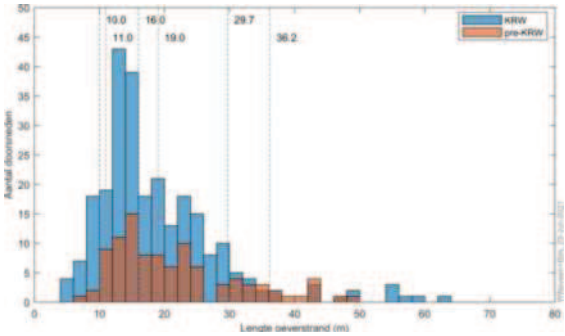

Figure 5. Terrace-length histogram for new and "old" NVOs

The observations indicated:

- Vegetated upper banks presented less morphological changes, on average;
- No relationship was found between median grain size at the terrace and the equilibrium slope;
- Direct sedimentation in the fairway at the location of the NVOs was limited;
- Analytical calculations showed potential indirect sedimentation as a result of the increased cross-section to be 3–10 cm;
- Recent NVOs with cohesive layers developed more slowly than banks without cohesive layers;
- Old NVOs with cohesive layers had a milder equilibrium profile than banks without cohesive layers.

Recommendations

We recommend improving the understanding of the morphological development of NVOs by:

- Continued yearly measurement of NVOs to gain a dataset that covers the full morphological development of the banks;
- Study of development of unprotected lower banks if this has ecological benefit;
- More detailed study of locations with deviating erosion patterns to formulate new hypotheses.

We recommend for future NVOs in the IJssel:

- Keep the usually submerged lower parts of the banks protected;
- Pre-excavate new NVOs to near-equilibrium profiles;
- Place pre-excavated material (if clean) upstream of NVOs as contribution to oppose large-scale channel bed degradation.
- Preferably locate new NVOs downstream of the Twente Canal, where ecology benefits from less ship traffic;
- Locate new NVOs at locations where direct or indirect sedimentation is no obstacle for navigation;
- Locate new NVOs in the upper IJssel if they need to counteract bed degradation.

We recommend further research on:

- Subsurface sand deposits that affect erodibility;
- Detection of cohesive layers at key elevations by soil cores per groyne field prior to selecting new NVO locations (those layers seem to affect erosion rates, e.g. at Welsumer Waarden).

References

Baar, A., Kleinhans, M.G., Stouthamer, E. (2014). Oeverstabiliteit Rivieren Oost Nederland: Opzet van een conceptueel model en aanzet tot projectmonitoring. Utrecht University, Department of Physical Geography.

Duró, G. (2021). Bank erosion in regulated navigable rivers. PhD thesis, Delft University of Technology, the Netherlands. Doi:10.4233/uuid:805eaec5-3b87-4bd6-bbe3-fa896da3b1c5. ISBN 978-94-6366-352-6.

Duró, G., Crosato, A., Kleinhans, M.G., Roelvink, D., & Uijttewaal, W.S.J. (2020). Bank erosion processes in regulated navigable rivers. Journal of Geophysical Research: Earth Surface, 125, e2019JF005441. DOI:10.1029/2019JF005441