Adapted waterways engineering towards varied hydrological conditions due to climate changes

Verfügbar unter/Available at: https://hdl.handle.net/20.500.11970/106000

Vorgeschlagene Zitierweise/Suggested citation:

Standardnutzungsbedingungen/Terms of Use:
Die Dokumente in HENRY stehen unter der Creative Commons Lizenz CC BY 4.0, sofern keine abweichenden Nutzungsbedingungen getroffen wurden. Damit ist sowohl die kommerzielle Nutzung als auch das Teilen, die Weiterbearbeitung und Speicherung erlaubt. Das Verwenden und das Bearbeiten stehen unter der Bedingung der Namensnennung. Im Einzelfall kann eine restriktivere Lizenz gelten; dann gelten abweichend von den obigen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Documents in HENRY are made available under the Creative Commons License CC BY 4.0, if no other license is applicable. Under CC BY 4.0 commercial use and sharing, remixing, transforming, and building upon the material of the work is permitted. In some cases a different, more restrictive license may apply; if applicable the terms of the restrictive license will be binding.
Adapted Waterways Engineering Towards Varied Hydrological Conditions due to Climate Changes

S. Wumms, P.M. Schröder, R.B. Weichert, L. Hahne

Due to the apparent climate change, the probability of extreme hydrological events, droughts as well as flood events, might be increased. In consequence, lowered water levels during droughts would result in a reduction of maximum transportation capacity of inland vessels and in the constriction of navigable fairway width. Thus, the efficiency of inland shipping would decrease as well as the safety and reliability of navigation.

Using the example of the River Rhine from Mainz to St. Goar, river training measures are analysed that focus on the maintenance of required minimum flow depths in free flowing waterways under extreme low water conditions. Especially, the potential of a width-reduced, deepened “Depth stepped fairway”, in terms of gaining flow depth during droughts is investigated.

1. Area under investigation: Rhine-km 493.0-557.5

The chosen stretch from Mainz to St.Goar contains the least guaranteed fairway depth within the whole free flowing Rhine, which is only 1.90 m below GdW2002 between Rhine-km 508.0 and 557.0. GdW2002 is the water level corresponding to GlQ2002, which is the discharge, that just falls below a gauge on 10 or 20 ice-free days per year in a long-time average.

2. Identification of hydraulic bottlenecks

Projections of future discharge conditions contain uncertainties due to the climate scenarios chosen and the various possible combinations of climate and hydrological models. Thus, potential future hydraulic bottlenecks are identified from numerical simulations with TELEMAC-2D (EdF) for a bandwidth of extreme low water discharges between the defined low water discharge GlQ2002 and GdW2002 — 25%.

Considering the minimum water depths and volume deficits within the fairway it can be shown that the present river training and maintenance strategies have to be adapted to guarantee minimum flow depths within the fairway in case of a reduced discharge level.

3. Adaptation strategy “Depth stepped fairway”

With the objective of gaining flow depth during reduced low water conditions, a width reduced “Depth stepped fairway”; deepened to 2.10 m related to the water level corresponding to GlQ2002 — 25% is implemented into the model.

The minimum widths of the “Depth stepped fairway” result from the addition of both swept paths of upstream and downstream going one-row, one-column push low units and common safety distances (outer: 10 m; inner: 5 m each ship). Swept paths are determined by means of the standard BAW model PeTra1D and the higher level tool PeTra2D, which considers e.g. the explicit calculation of cross current impacts, reduced rudder forces at low under keel clearance and more realistic steering commands from an autopilot.

Implementing the “Depth stepped fairway” into the numerical model results in local decreases of calculated water levels less than 0.01 m at mean discharge. Within the areas where the bed level had to be dredged within the model, reductions of the bed shear stresses occur. As a consequence, tendencies towards aggradations rise within these areas. Additional regulation structures were designed to compensate decreased bed shear stresses in relevant locations on the basis of the hydrodynamic model. The regulation structures have to be optimised in the morphologically sense in a further step to yield a dynamic equilibrium of the river bed and to keep up the implemented "Depth stepped fairway".

4. Conclusions

Depending on the level of a possible reduction of low water discharges due to climate changes, the present river training and maintenance strategies have to be adapted to be able to guarantee required flow depths within the fairway in the future. From a technical point of view, a width reduced, deepened “Depth stepped fairway” is a promising measure for the purpose of gaining flow depth.