Short-term gains – long-term regrets: the effects of engineering large rivers in France and the Netherlands

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Erik MOSSELMAN
Deltares & Delft University of Technology
P.O. Box 177, 2600 MH Delft, the Netherlands

Interventions in reaches of large rivers set off a morphological response that may last decades to centuries and may extend over hundreds of kilometres. This response is complex because areas of initial sedimentation may eventually turn into areas of erosion and vice versa. The main intervention in large lowland rivers of Europe has been river training to increase the safety against flooding and to improve the conditions for navigation. This river training consisted of narrowing of the main channel by means of groynes and the closure of secondary channels. The rivers responded by a slow but persistent incision of the river bed, often still continuing today. Incision of the Rhine between Basle and Strasbourg progressed till hitting on inerodible bedrock after around 10 m of bed degradation, rendering navigation on the river impossible and hence necessitating the construction of the parallel Grand Canal d'Alsace. Bed degradation of the Loire between Angers and Nantes deteriorated its ecological conditions and its original morphology rich of sand bars. This has led to plans to stop further degradation of the bed by implementing a transverse structure on the bed at Bellevue. Bed degradation on the branches of the Rhine delta in the Netherlands are now causing a wide range of undesired effects. First, local inerodible portions of the river bed are becoming obstacles for navigation at low flows. The irony is here that some of these inerodible portions of the river bed are the result of interventions in the 1990s to improve the navigability of river bends. Second, rivers are part of a larger network of inland waterways, but the canals, port facilities and sluices of this network do not follow the lowering of the rivers. Third, continued bed degradation undermines banks and hydraulic structures, involving higher costs for maintenance. Fourth, differences in the rates of bed degradation in different branches of the delta may change the division of discharges at the bifurcations. The resulting changes in distribution of water over the branches imply also changes in the distribution of flooding risk and navigability. These undesired effects have triggered a re-evaluation of traditional approaches to river management and river training. New lines of thought include the lowering of groynes to mitigate bed degradation, the replacement of groynes by longitudinal structures, and the use of softer, recurrent interventions such as sediment nourishment. The morphological effects of these measures are investigated by means of a 2D depth-averaged morphodynamic model with two special features. Its first special feature lies in an efficient treatment of the discharge hydrograph, thus considerably increasing the speed of computations for decades of morphological development. The second special feature is the possibility of adding pre-defined strategies of dredging and dumping to the computation of the morphological development.