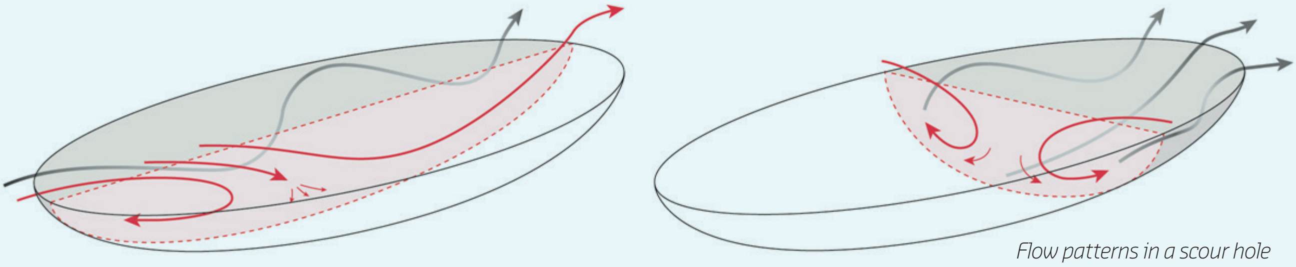


Flow patterns in a scour hole

SCOUR HOLES IN RIVER DELTAS

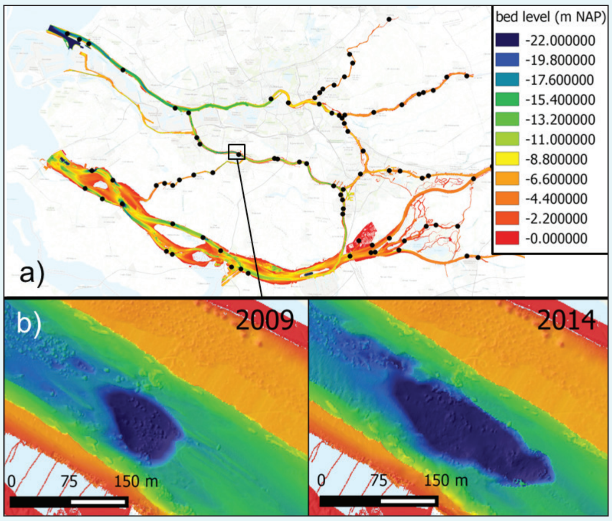
Scour holes exacerbate the risk of dike and riverbank instability and structural damage. River deltas are particularly prone to sudden scour-hole formation due to the heterogeneity of the subsoil lithology. It is necessary to predict the development of scour holes in order to assess and mitigate the related risks. Knowledge from different fields of expertise is therefore needed: detailed hydrodynamics, larger-scale river morphodynamics, geology and geotechnics. This study combined the analysis of field data, numerical modelling and scale-model experiments with the aim of establishing a full understanding of the process of scour-hole formation.

Field data consisting of annual measurements of bed topography from 1976 till 2017 were available for over 100 scour holes in the Rhine-Meuse Delta. These field data were combined with the geological subsurface model. The analysis showed that geological composition is the main determinant of the emergence and growth rates of scour holes. Erosion processes are retarded in riverbeds composed of poorly erodible clay or peat. However, when thin sections of the clay or peat layers erode, the underlying sand patches are incised and large scour holes can develop within a short time. Two types of scour-hole growth were found. In the first type, the scour hole becomes deeper only because thick layers of peat or clay at the edges of the scour hole prevent further growth in the horizontal direction. In the second type, the layer of peat or clay is only thin. In this case, the scour hole becomes deeper, and also wider because the edges crumble away. The analysis emphasises that an understanding of the structure of the subsurface is indispensable to predict future growth and the related risks affecting the stability of dikes or other structures.

The impact of flow velocity, water depth and scour-hole geometry on the growth rates was investigated systematically using scale-model experiments with a simplified heterogeneous subsoil. The new empirical relations we found indicate that the horizontal extent of the scour hole is the dominant determinant factor for the maximum depth. Early intervention to limit the diameter of the scour hole is therefore advisable. Preliminary experiments suggest that this could be done by taking steps to protect the edges only.

Detailed numerical simulations using OpenFOAM were used successfully to reproduce the flow structures as measured in the scale-model experiments. The simulations identified the areas with the highest shear stresses, allowing for the subsequent derivation of the areas most susceptible to erosion. The next step will be to run numerical simulations of real-scale river scour holes and to include morphodynamic evolution in the simulations.

This research was carried out by Deltares in collaboration with Delft University of Technology and Rijkswaterstaat.



Rhine-Meuse bed topography (2012) and the location of the scour holes (black dots). b) Scour-hole development near Beerenplaat (Oude Maas River).

Contact:
Ymkje Huismans, Ymkje.Huismans@deltares.nl t +31 (0)6 2129 2740
Kees Sloff, Kees.Sloff@deltares.nl, t +31 (0)6 5757 0335

Further reading:
MSc theses (2017) by H. Koopmans, S. Bom and J.G. Stenfert (2017). Available on https://repository.tudelft.nl/islandora/search/?collection=education