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de Wit, Lynyrd; Cronin, Katherine; Kirichek, Alex ; van Kessel, Thijs

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Detailled modelling and monitoring of WID as an efficient harbor siltation maintenance strategy

L. de Wit[1], K. Cronin[1], A. Kirichek[1,2], T. van Kessel[1]

[1]Department of Marine and Coastal Systems, Deltares, Delft, Netherlands. Lynyrd.deWit@Deltares.nl
[2]Department of Hydraulic Engineering, Delft University of Technology, Delft, Netherlands.

1. Introduction

Water Injection Dredging (WID) can be used as an efficient maintenance dredging technique. The technique consists of fluidizing mud with jets close to the bed injecting water into the bed (PIANC 2013, Winterwerp et al. 2002). The fluidized layer will act as a density current moving in horizontal direction by forces of nature. The fluidized layer remains close to the bed and surface turbidity is limited. We present detailed near and far field modelling and monitoring results for WID in the Port of Rotterdam.

2. Near field modelling

In the near field modelling the flow of the fluidized mud layer in the first few hundred metres from the WID dredge is simulated. A CFD model is used to capture the flow details in the near field in great detail (De Wit 2015). The WID dredge is simulated by a moving sediment and fluid source term working along the same line six times in a row. The simulated WID density current after the sixth pass is shown in Figure 1 where the WID worked along a 300m stretch indicated by a black dashed line. The WID density current does not move in the direction of the dashed line but mainly moves in lateral direction down a weak slope in the bathymetry.

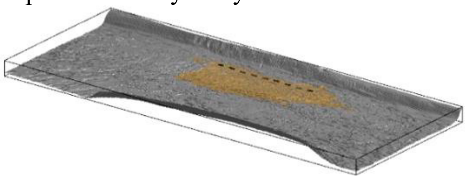

Figure 1: Near field simulation WID density current.

3. Far field modelling

Far field simulations for the Rhine Meuse Delta including the entire Port of Rotterdam area have been conducted with Delft3D including density feedback and WID plume input from the near field model.

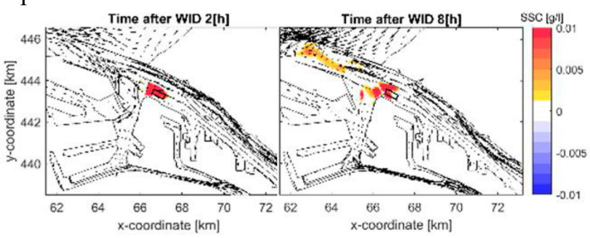

Figure 2: Far field plume spreading of WID at HW-1h.

The moment of carrying out WID with respect to the tidal phase turns out to be an important factor for the WID plume flow direction and area of deposition. When 8 hours of WID work starts 1h before high water (HW) the WID near bed plume mainly moves in seaward direction, see Figure 2. When WID starts 1h before low water (LW) it moves into the harbor basin. These insights are used to optimize the WID strategy.

4. Monitoring

An example of in-situ monitoring of density and strength profiles in a sediment trap filled with mud fluidized by WID is given in Figure 3. Initially a rather weak fluidized mud layer is generated by WID which in the following weeks consolidates reducing layer thickness and increasing density and strength. These measurements illustrate the potential to apply WID in combination with a yield stress criterium of for example 100 Pa for defining the nautical bottom instead of a density of 1200 kg/m^3 criterium which is now used in Rotterdam and in other ports (Kirichek et al 2018, McAnally 2007). A density of 1200 kg/m^3 is reached in 2 weeks after WID is finished but building up a yield stress of 100 Pa takes ~11 weeks.

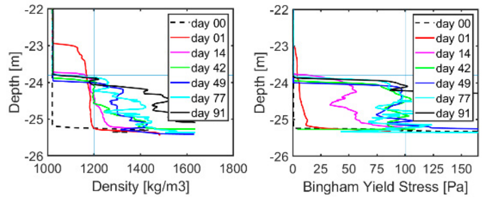

Figure 3. Rheotune density and yield stress profiles

3. Conclusions

Detailed near and far field modelling and monitoring of WID fluid mud layers have been carried out to increase our knowledge of the movement and rheological behaviour of WID fluidized layers and to optimize WID operations as an efficient maintenance dredging strategy.

Acknowledgments

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