

Disposal strategy to create ecological valuable habitats in the Western Scheldt estuary

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Abstract

To guarantee optimal accessibility to the port of Antwerp, a deepening of the navigation channel was proposed within the Long Term Vision for the Scheldt estuary. An environmental impact assessment and an appropriate assessment were carried out for this project. From these studies it was concluded that the most preferred scenario for the enlargement of the navigation channel includes a strategy aiming at disposing dredged material near 3 sandbars in the Western Scheldt, creating opportunities for nature. To determine the optimal disposal strategy on a detailed and more practical level, research was performed by Flanders Hydraulics Research. The main objective of this study was to determine a detailed disposal strategy in order to maximize the ecological benefits, i.e. maximizing the potential creation of low dynamic intertidal and shallow water area. This paper describes the studies undertaken by Flanders Hydraulics Research to determine the most optimal disposal strategy. In a next part the most optimal disposal strategy resulting from the research will also be presented, as well as the strategy being used to evaluate this new disposal strategy.

1. INTRODUCTION

The Scheldt estuary is the maritime access to several ports in Flanders and the Netherlands, the largest being the Port of Antwerp, located at some 100 km from the open sea. The Western Scheldt – the part of the estuary between Vlissingen and the Dutch-Belgian border – is a typical multiple channel system, with the navigation route being mainly located in the ebb channel. Up-estuary the Dutch-Belgian border, the estuary evolves to a meandering single channel system. The main driving force from point of view of hydrodynamics is the tidal penetration from the North sea into the estuary: the tide penetrates up to Ghent (a distance of approximately 160 km from the mouth in the North sea) and is blocked there by a weir. The fresh water discharge is hydrodynamically less important, however it has an important influence on the salinity gradient along the estuary.

In 1999 Flanders and the Netherlands agreed to cooperate closely for managing the Scheldt estuary and set up a “Long Term Vision” (LTV), based on 3 pillars: safety against flooding, port accessibility and nature. Parallel to the LTV, the Antwerp Port Authority asked an international expert team

(called Port of Antwerp Expert Team, or “PAET”) to investigate the possibilities of a further deepening of the navigation channel. The PAET proposed the idea of morphological management. As a pilot project they proposed to use dredged material to restore the western tip of the Walsoorden sandbar in the Western Scheldt [Meersschaet et al., 2004; PAET, 2003]. This proposal would not only improve the distribution of the flood currents between the ebb and the flood channel, but would also create benefits for ecology. The feasibility of the Walsoorden pilot project was investigated by Flanders Hydraulics Research using in situ measurements, a physical scale model as well as numerical modelling [FHR, 2003]. Final proof of the feasibility of the morphological disposal near the Walsoorden sandbar was brought by 2 in situ disposal tests [FHR, 2006; FHR, 2009a; Plancke et al., 2009].

In the environmental impact assessment of a further deepening of the navigation channel of the Scheldt estuary, different scenarios were investigated for the Western Scheldt. The scenario in which the material from the capital dredging works was disposed near sandbars (i.e.

morphological disposal as introduced by PAET, see Figure 1 for locations) was the most favorable one: this strategy would not induce any negative effects, on the contrary it would create possibilities for the development of nature [Arcadis-Technum, 2007].

Where the environmental impact assessment investigated the overall effects of the channel enlargement (including disposal) on a large estuary wide scale, Flanders Hydraulics Research was asked to conduct research to optimize the disposal strategy near sandbars on a detailed and more practical level.

2. RESEARCH OPTIMIZING THE DISPOSAL STRATEGY

The goal of the proposed disposal strategy along sandbars was to maximize the creation of ecological valuable ecotopes, i.e. subtidal and intertidal areas with low currents, in a sustainable way. Flanders Hydraulics Research used a combination of different tools to investigate the most optimal disposal strategy: analysis of topobathymetric maps, field measurements and a high resolution 2D hydrodynamic numerical model [Ides et al., 2010]. Moreover, the experience gained near the Walsoorden sandbar [FHR, 2006; FHR, 2009; Plancke et al., 2009] was used as valuable input during this research.

1.1. Historical topo-bathymetric analysis

Since it is important that the disposal strategy will not work against the natural evolution, a morphological analysis – based on topobathymetric maps from 1931 to 2005 – was made for each sandbar location. Besides observation of the morphological evolutions, the causes for these evolutions were investigated trying to understand the morphodynamics of the estuarine system.

1.2. In situ measurements

Insight in the local hydrodynamic conditions was obtained by intensive flow (GPS floats and ADCP) and sediment transport measurements on the 4 potential disposal locations. Besides gaining insight in the local conditions, these measurements

would also serve as a T0 situation, in order to evaluate the effect of the disposal.

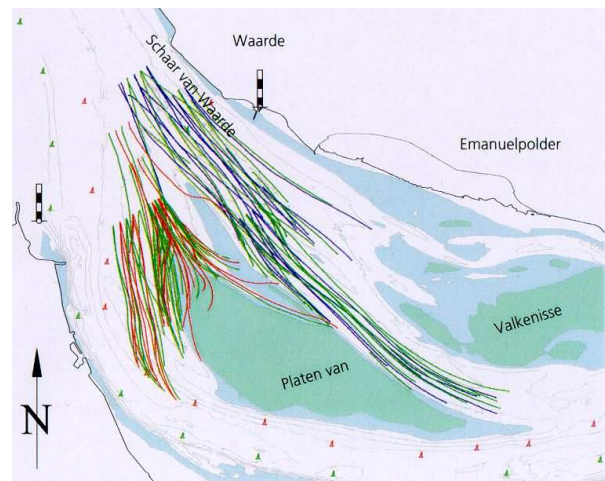


Figure 2. Results of float measurements at the Walsoorden sandbar.

1.3. Numerical hydrodynamic model

As a next step a detailed numerical hydrodynamic model was set up for each sandbar location, which was calibrated using all available measurement data [Ides et al., 2010]. Since local hydrodynamics were to be represented very accurately by the model (cfr. goal to create low dynamic area), special attention was paid to the flow velocities. Where the flow velocities in the deep and shallow water areas were good reproduced by the model, limited data availability in the intertidal area prevented a good calibration of the models in this reach. Therefore an additional validation of the intertidal area was carried out based on the maps of ecotopes, which define several classes in regard to their ecological value. One fundamental aspect in the definition of the ecotopes is the hydrodynamic character, which is related to the flow velocities. Figure 3 shows some results of the calibration of the model based on the maps of ecotopes for the Rug van Baarland.

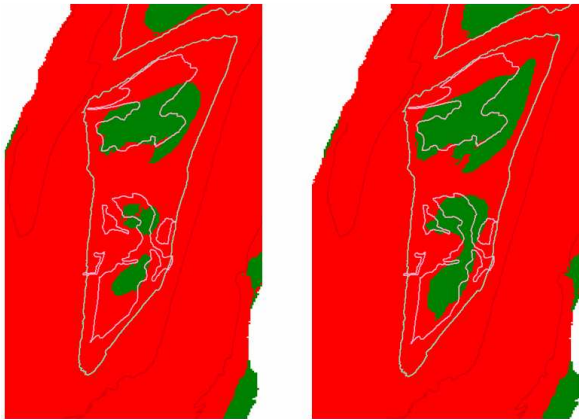


Figure 3. Calibration of the numerical model in the intertidal zone using ecotope classification for Baarland. The green contour indicates the intertidal area, the pink contour indicates the low dynamic intertidal area as indicated on the ecotope classification. The colors indicate respectively high dynamic (red) and low dynamic (green) area as calculated by the numerical model. The 2 figures show different results during the calibration of the model.

3. THE PROPOSED DISPOSAL STRATEGY

The research carried out by Flanders Hydraulics Research revealed that fundamental differences exist between the 4 proposed locations (see Figure 1). On one hand both the locations near the Walsoorden sandbar and the Hooge Platen West are located near the seaward tip of a sandbar, attacked by flood currents. It is expected that sediment disposed at these locations will gradually be transported towards the sandbar. On the other hand the locations near Rug van Baarland and Hooge Platen North are located along a sandbar, guiding the currents. It is expected that sediment disposed at these locations, will be transported along the sandbar. For the Walsoorden sandbar and the Hooge Platen West (see Figure 4) the disposal strategy aims at creating a subtidal “megadune” which will migrate towards the sandbar under influence of the flood-dominated currents. This can be seen as an application of the “working with nature” principle. This so-called megadune aims for the creation of an underwater barrier which will reduce the currents between the barrier and

the sandbar, creating a low dynamic shallow water area.

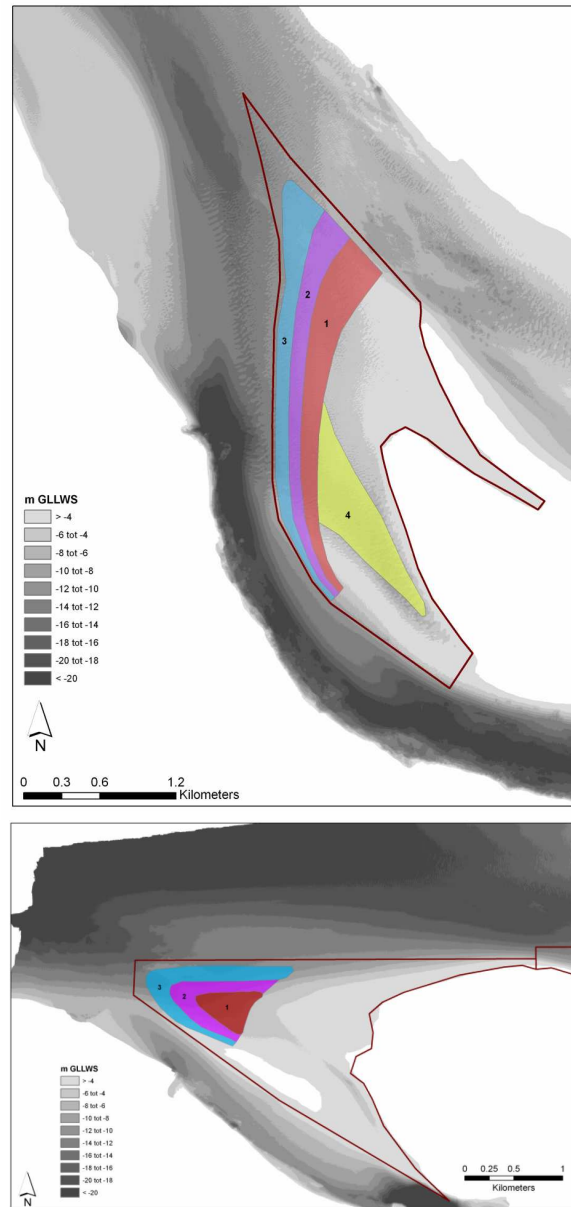


Figure 4. Megadune proposed at Walsoorden sandbar (above) and Hooge Platen West (below).

Near Rug van Baarland and Hooge Platen North (see Figure 5) the disposal strategy aims at constructing a “sand spit” near the tip of the sandbar. This new sand spit, in combination with the existing one, aims for the creation of an underwater barrier reducing the currents

between the barrier and the sandbar, creating a low dynamic shallow water area.

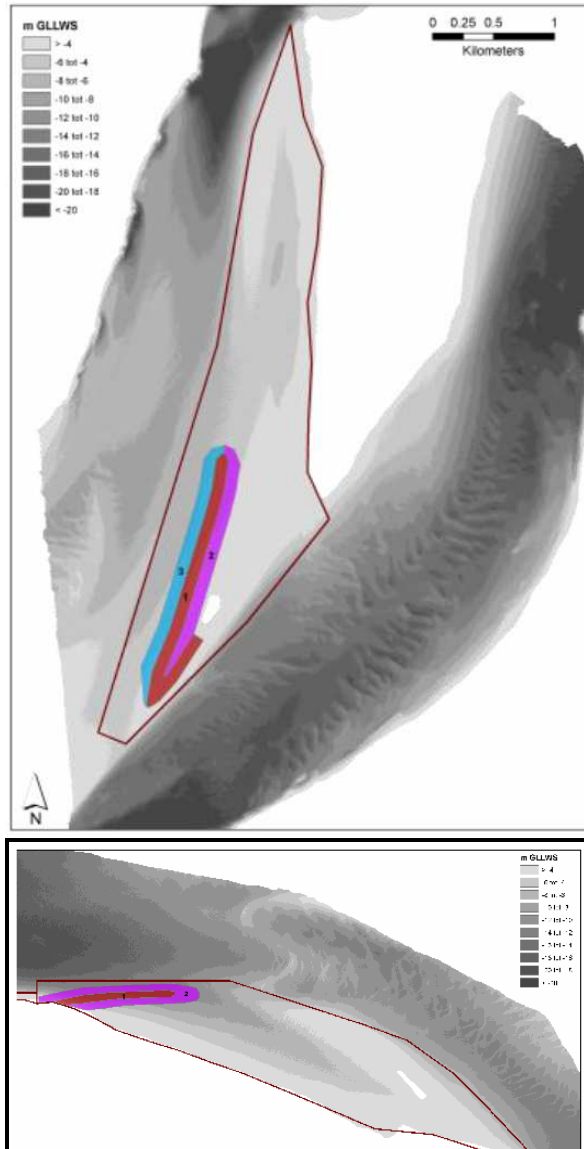


Figure 5. Sand spit proposed at Rug van Baarland (above) and Hooge Platen North (below).

4. EXECUTION & EVALUATION OF NEW DISPOSAL STRATEGY

On February 12th 2010 dredging works for the enlargement of the navigation channel in the Western Scheldt started. During a period of one year all necessary capital dredging works (7,7 Mm³ of sandy material) were executed. The

sediments were disposed near the 4 proposed locations along sandbars. In the deeper areas near the sandbars, the disposal was performed using the conventional “clapping” technique with hoppers. In the shallower areas, the trailing suction hopper dredgers connected to a floating line which was connected to a diffuser (see Figure 6). This technique allowed the disposal of sandy material in zones up to 2m below low water. Simultaneously with the capital dredging works, maintenance dredging works had to take place. Part (20%) of the dredged sediments from the maintenance works, are disposed near the sandbars, while the other part is disposed in the main or secondary channels. Over the first 2 years a total of 12.4 Mm³ of sediments have been disposed near all 4 sandbars, which is 63 % of the amount foreseen to be disposed in 5 years (see Table 1).



Figure 6. TSHD connected to floating line (above) and detail of diffuser head (below).

Location	Capacity over 5 yr [Mm ³]	Disposal Year 1 [Mm ³]	Disposal Year 2 [Mm ³]	Disposal Year 1+2 [Mm ³]	Stability [%]
Hooge Platen West	8.20	1.95	0.58	2.53	70
Hooge Platen North		3.50	0.51	4.01	105
Rug van Baarland	5.00	0.70	0.58	1.28	268
Walsoorden sandbar	6.50	3.72	0.82	4.54	62

Table 1. Overview of quantities to be disposed near sandbars and initial stability.

To evaluate the possible effects of the deepening of the navigation channel and the new disposal strategy, an extensive monitoring programme was set up [Plancke et al., 2012]. This monitoring programme consists among others of high frequent multi-beam echo soundings, current measurements, RTK height measurement and determination of grain size.

To monitor the stability of the disposed sediment, high frequent multi-beam echo soundings (MBES) of the total disposal area were performed. In the period during the execution and 1 month after the last disposal, one sounding every 2 weeks was made. After this period, the intensity was reduced to one sounding per month and finally to one every 3 months. Additionally to these “disposal zone” soundings, a MBES of a larger area took place twice a year to monitor the morphological changes in case the sediment would be transported out of the disposal zone.

The flow velocities are measured on 10 transects over 2 full spring-neap-tide cycles. Each transect consists of 3 points in the intertidal area (measured with Nortek AquaDopp | 2MHz – figure 7) and 1 undep subtidal point (RDI ADCP | 1200 kHz). The AquaDopps in the intertidal zone were dug in the sandbar and look upward, allowing maximal vertical resolution when flooded during the tidal cycle. To present measurement data, scatterplots are generated showing the maximum flow velocity (flood or ebb) versus the tidal range (rising or falling) (figure 7). Before the start of the deepening, the reference situation was monitored for all 40 locations, measuring continuously over 2 spring-neap tidal cycles. Since the start of the works, new measuring campaigns at all locations have been executed to evaluate the effect of the disposal activities. During the next 6 years this monitoring will continue, allowing the

evaluation of the new disposal strategy on the longer term.

Besides these measurements, a calibrated 2D-numerical model [Ides *et al.*, 2010] is used to evaluate the developments of the flows near the sandbars. Simulations are performed on regular basis (every 3 – 6 months), using the most actual topo-bathymetry near the sandbars. All 40 measurement points are defined in the model and similar analyses is performed. Additionally, spatial maximum flow maps are generated and changes in these maps are evaluated (figure 7).

A special “protocol”, containing several morphological (stability of disposed material) and ecological (evolution of ecotopes) criteria is appended to the disposal license to, quasi continuously, evaluate the monitoring data. An independent group of experts (“Commission Monitoring Western Scheldt”) will supervise the evaluation of the monitoring and advices at least every 2 years on the disposal strategy.

5. CONCLUSIONS

Within the enlargement project of the navigation channel in the Scheldt-estuary, a new disposal strategy was chosen, aimed at creating new ecological valuable habitats. The combination of the morphological analysis, the in situ measurements, the numerical model as well as the experience with 2 in situ disposal tests at the Walsoorden sandbar resulted in detailed specifications for the disposal strategy. It was found that fundamental differences exists between the 4 proposed locations. On one hand both the locatons near the Walsoorden sandbar and the Hooge Platen West are located near the seaward tip of a sandbar, under attack by flood currents. It is expected that sediment disposed at these locations will be gradually transported towards the sandbar. On the other hand the location near Rug van Baarland and Hooge Platen North are located along a sandbar, guiding the currents. It is expected that sediment disposed at these locations will be rather transported along the sandbar. Therefore a

different disposal strategy was proposed for both type of locations.

An extensive monitoring programme was set up to evaluate the success of this new strategy, focusing on topo-bathymetry (using MBES) and flow characteristics (using Acoustical Doppler techniques). Additionally, hydrodynamic numerical simulations were performed to investigate the changes in flow patterns near the disposal locations. This extensive monitoring and analysis of the measurement data will allow a final evaluation 5 years after the start of enlargement project.

6. ACKNOWLEDGMENT

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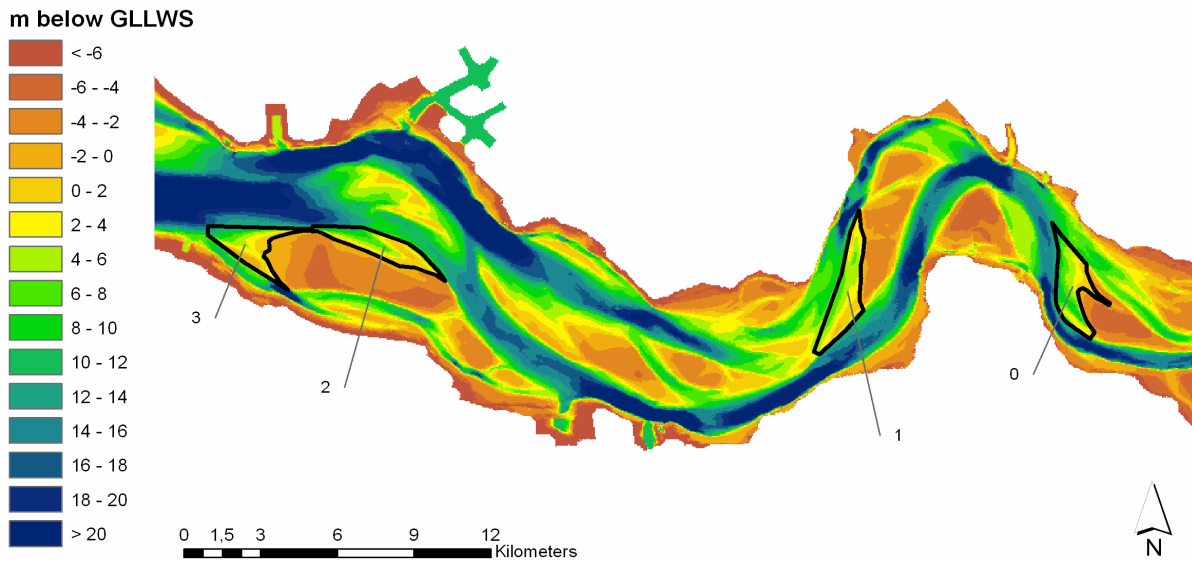


Figure 1. Overview of the present topo-bathymetry of the Western Scheldt (bathymetry expressed in meters below mean low spring water level). The black contours indicate the different disposal areas near sandbars studied in the environmental impact assessment. 0: sandbar of Walsoorden; 1: Rug van Baarland; 2: Hooge Platen North; 3: Hooge Platen West.

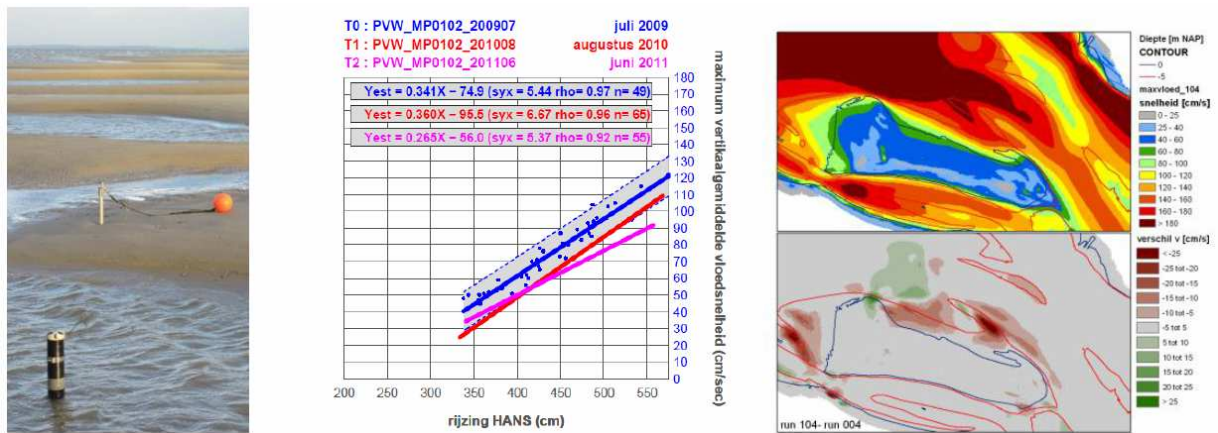


Figure 7. AquaDopp (left), scatterplot from ADP-measurement rising vs. maximum flood velocity (mid) and flood velocities and difference (T0+15months – T0) from numerical model (right).