



**Work package 5 “Measures”**  
Dredging and Disposal Strategies

Schelde estuary – MOW

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# 1 *Overview on the estuary and its ports*

## Content:

Position in the estuary, administrative borders and responsibilities

The Schelde estuary lies in the southwest of the Netherlands (Westerschelde) and in the northern part of Belgium (Zeeschelde and tributaries) and it is subject to a complex division of responsibilities, which has its consequences for waterway management (Map 1).

Since the federal Belgian state has given the responsibility for infrastructure and environment to the regions, waterway management is a regional issue. The Belgian part of the Schelde estuary (Zeeschelde) and its tributaries under tidal influence lie completely within the Flemish region. Therefore, the Flemish government is the responsible authority for waterway management. The Westerschelde and most of the estuary mouth belong to Dutch national waters, managed by the Ministry for Infrastructure and Environment. In contrary to land and coast, the Belgian part of the Northsea is federal territory and is managed by the Belgian Federal government.

The Port of Antwerp is the largest port of the estuary and plays an important role in Europe. It is the most inland port of the estuary (appr. 80 km from the mouth). The Port of Ghent is accessible through the locks in Terneuzen and the canal Gent-Terneuzen. The Port of Terneuzen and the Port of Vlissingen both lie adjacent to the Westerschelde and are operated by Zeeland Seaports. Although the Port of Zeebrugge and the Port of Oostende are located along the Northsea, they are called Schelde ports because of their vicinity to the Schelde estuary's mouth. In the context of this report on sediment management strategies in the Schelde estuary, the dredging activities for the accessibility of the Port of Zeebrugge and the Port of Oostende are not discussed.

## 2 Shipping channels

### Content:

Actual depth, further channel deepening if planned

The maritime fairway to Antwerp lies within the Belgian part of the Northsea, the Dutch national waters and the Flemish region (Map 2). It starts on the Northsea with a west to east orientated stretch at the latitude of the estuary mouth ('Scheur'). The fairways to Oostende and Zeebrugge both connect to the Scheur and run to the southeast. Between the Belgian-Dutch border and the Westerschelde the fairway is called 'Wielingen'.

The Westerschelde is a multiple-channel system, consisting of ebb and flood channels with subtidal and intertidal sandbars in between and with tidal flats and supratidal saltmarshes on the outside. The fairway in the Westerschelde lies in the main channel, being mostly the ebb channel. Smaller vessels can use the secondary channels, which is an advantage from point of view of traffic management.

The Zeeschelde has a meandering character with a single channel. The maritime fairway ends upstream the Port of Antwerpen. Further upstream the Zeeschelde and its tributaries under tidal influence are used for inland navigation giving access

- to the Rhine and Meuse via the Port of Antwerp,
- to Brussels via the Seacanal near the confluence of Rupel and Zeeschelde and
- to northern France via the Schelde river catchment.

The design depth of the maritime fairway is currently 14,50 m LAT (Lowest Astronomical Tide) since the 3<sup>rd</sup> deepening was completed early 2011, which gives tide-independent access to vessels with a maximum draught of 13,10 m. Before the 3<sup>rd</sup> deepening the maximum draught was restricted to 11,50 m.

## 3 General aspects of dredging and disposal

### 3.1 Dredging sites and quantities of dredged material

#### Content:

Dredging volumes incl. water injection if applicable, dredging sites, physical and chemical quality of sediments, capital dredging  
Differentiate between areas behind locks and tidally influenced areas of the port, if possible mention the total water area [m<sup>2</sup>] port and total water area fairway [m<sup>2</sup>].

The discussion in this chapter is limited to sediment that is dredged within the estuary, either in the fairway or in open harbours. The sediment quality is good enough for relocation into the estuary. The given quantities of dredged sediment are realised using trailer suction hopper dredgers.

Dredging activities in harbour basins behind locks are not considered because these dredged sediment are not relocated into the estuary.

#### 3.1.1 Dredging sites in the maritime fairway to the Port of Antwerp

Although the maritime fairway to the Port of Antwerp lies within the Belgian part of the Northsea, the Dutch national waters and the Flemish region, it is constructed and maintained by the Flemish Government, Maritime Access Division.

The maritime fairway needs to be dredged at natural sedimentation locations (Map 3). As these dredging locations may vary slightly over time, bounding boxes are used to indicate the dredging locations. The dredged material in the maritime fairway is mostly sandy. Some silt is dredged in the maritime fairway near the open harbour areas in the neighbourhood of the Port of Antwerp.

Figure 1 shows the quantities of dredged material since 2000 as volumes (m<sup>3</sup>) for sand and equivalent volumes (m<sup>3</sup>) for silt<sup>1</sup>. The third deepening (2009-2011) of the fairway is included in the numbers given in this figure.

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<sup>1</sup> Dredging volumes for silt in the Schelde estuary are mostly given as reduced volumes, in which they are reported during dredging operations.

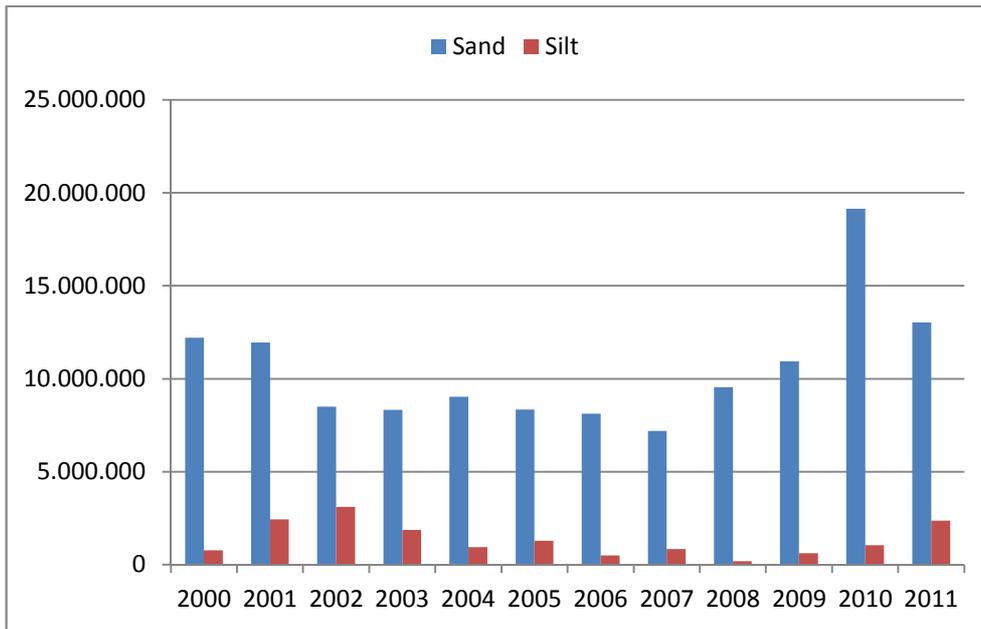


Figure 1 Sediment quantity (in m³) dredged in the maritime fairway to Antwerpen

### 3.1.2 Maintenance dredging in open harbours

Figure 2 shows the quantities of dredged material from the open harbour areas in the neighbourhood of Antwerpen since 2000. The open harbour areas near Antwerpen are located on Map 4. The dredged material is mostly silty. The volumes of sand are caused by occasional maintenance dredging near quay walls.

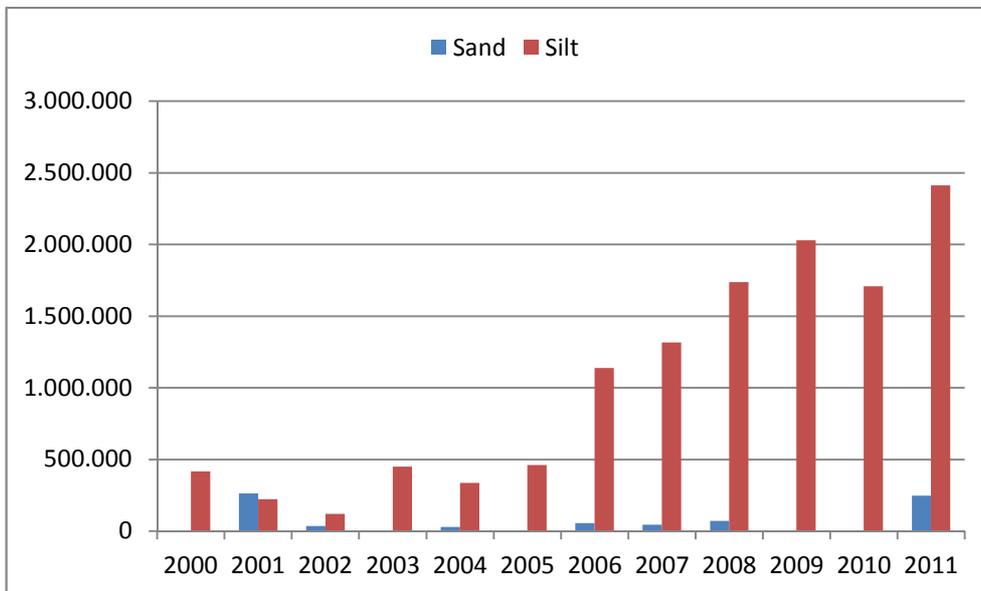
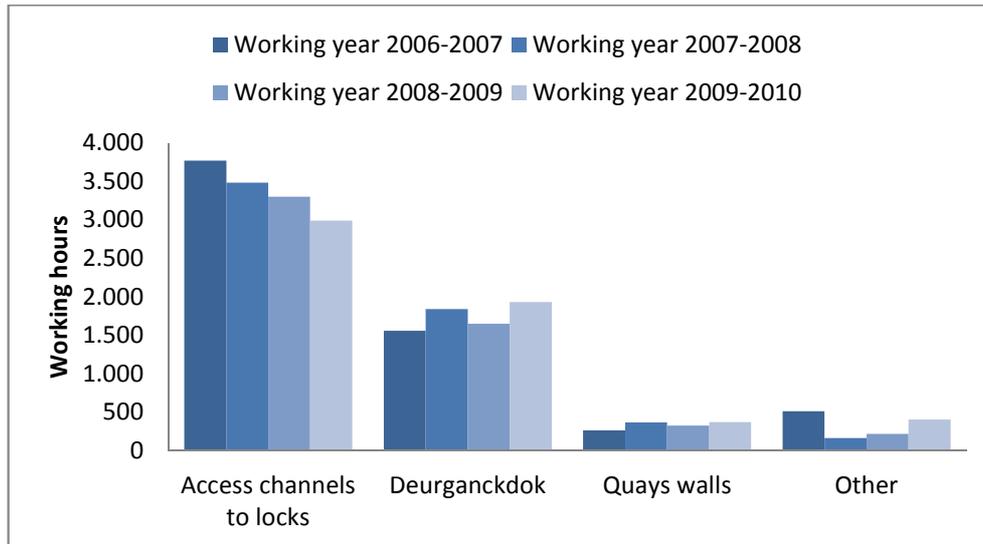


Figure 2 Sediment quantity (in m³) dredged in the open harbour areas in the neighbourhood of Antwerpen

The quantities of dredged material reported above are realised using trailer suction hopper dredgers (TSHD), which have several advantages but cannot operate close to quay walls and in the access channels to the locks. A 'plough' or 'silt scraper' is used to replace (silty) sediment over the river bed from these areas towards nearby locations that can be reached with a trailer suction hopper dredger. Dredging efforts with a plough are not expressed in volumes, but can be reported in working hours.



**Figure 3 Working with 'plough' in locations where a trailer suction hopper dredger cannot operate**

Zeeland Seaports executes maintenance dredging works in the open parts of the Zeeland harbours, f.i. tidal Sloehaven (Vlissingen) and the Braakmanhaven (Terneuzen). Dredged material is relocated to nearby relocation sites in the estuary (Map 5). The dredged material of the Zeeland harbours is a mixture of sand and silt and is reported in Figure 4 (volume).

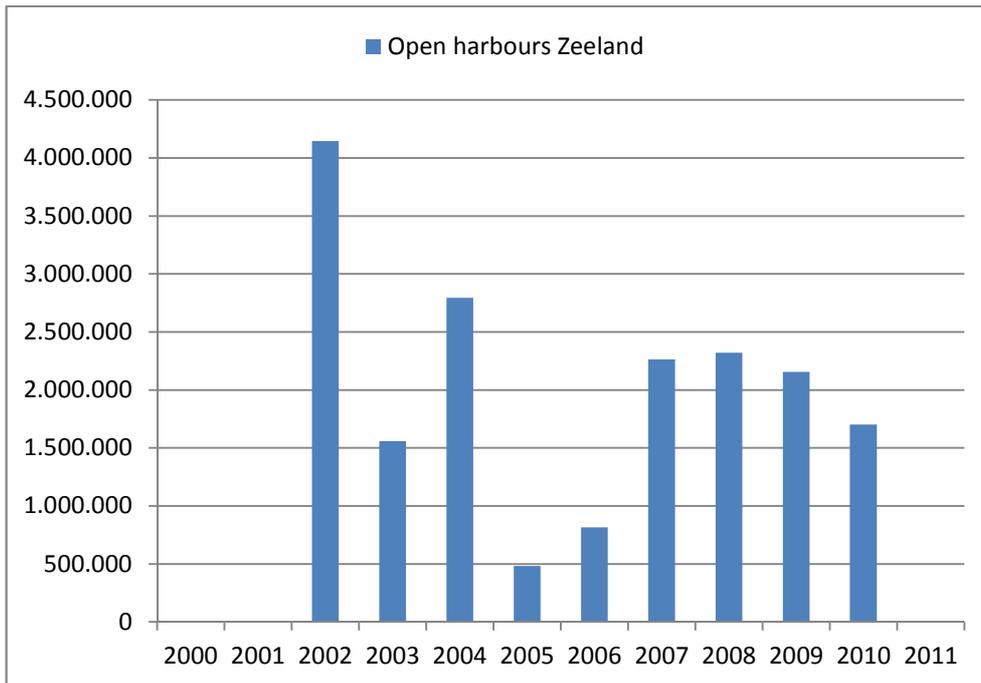


Figure 4 Sediment quantity (in m<sup>3</sup>) dredged in the open harbour areas in Zeeland

### 3.2 Relocation sites

#### Content:

Overview on placement sites and placement options

The environmental permits for relocation of dredged material impose requirements on the quality of the sediments dredged within the estuary. Annual compliance monitoring shows that sediment dredged within the estuary meets these requirements and may be relocated within the estuary.

Sediment that is dredged from the non-tidal docks in the port of Antwerp (outside the estuary) contains a higher level of contamination. This sediment has been stored in subaquatic confined disposal sites and is treated in a mechanical dewatering plant (AMORAS) since 2012.

Most of the sediment that is dredged within the estuary is relocated to a placement site within the estuary. In the period 2000-2010, only a small amount of sand is extracted for construction purposes. The numbers in figure 5 are cumulated for the maritime fairway and the open harbour zones of Zeeland and Antwerp. Note that these numbers include volumes of sand and silt and that silt is expressed as reduced volume for the maritime fairway and the open harbour zones of Antwerp.

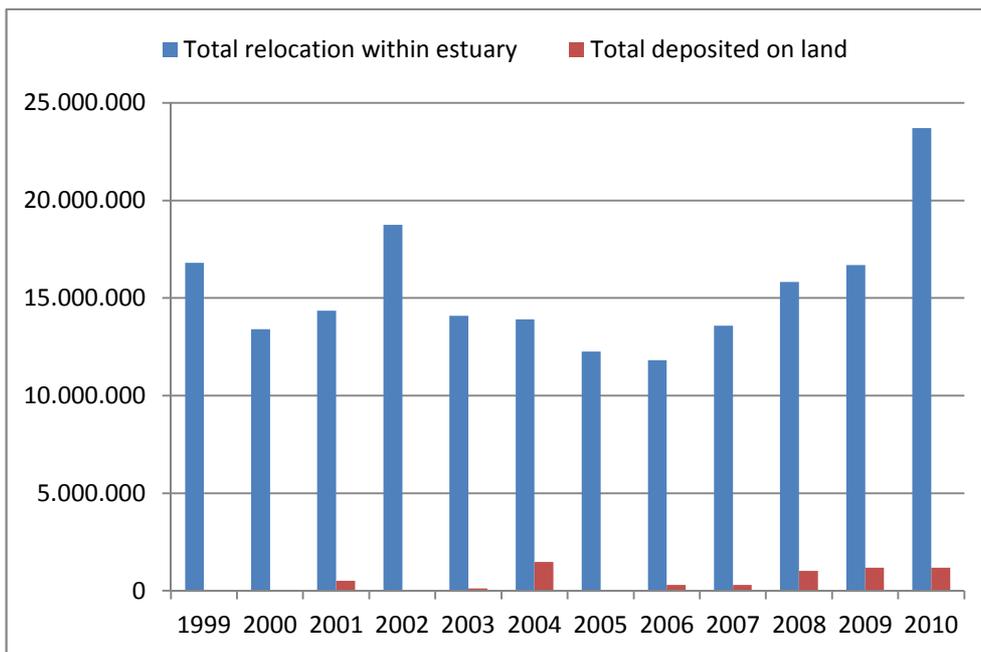


Figure 5 Destination of sediment dredged in the Schelde estuary

Figure 6 breaks down the sediment quantity that is relocated into the estuary into the area of origin.

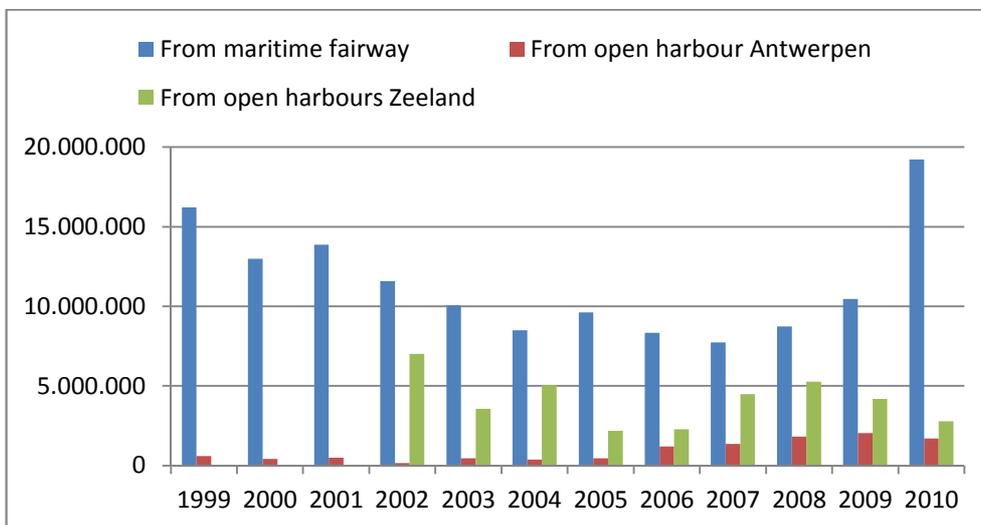


Figure 6 Origin of dredged sediment that is relocated inside the Schelde estuary

## 4 Strategies for dredging

### Content:

Strategies for dredging, placement, disposal, alternative utilisation: objectives, forms of realization, monitoring, experience (evaluation)

### 4.1 Why we dredge

#### Content:

- Mention all border conditions of sediment management
- Methods of dredging, placement and disposal

Dredging works are executed to construct and maintain the maritime fairway, to construct harbour infrastructure and to maintain open harbour areas from siltation. Operationally, dredging works are organised in such a way that cost and effort are minimised. Indeed, relocation sites are selected in the vicinity to the dredging sites where sediment relocation does not hinder the use of the fairway.

However, relocating sediment alters the bathymetry and has consequently an effect on hydrodynamics. Current patterns and tidal propagation may change due to long term repetition of the same dredging and relocation operations. Depending on the desired hydrological and morphological situation, these changes can be wanted or unwanted. A relocation strategy can be designed in which unwanted effects of sediment relocation are minimised and in which sediment relocation can contribute to the achievement of other management goals, like the enhancement of ecosystem functioning.

Two new dredging and relocation strategies were adopted in the Schelde estuary. The first one was introduced with the 2<sup>nd</sup> deepening (see 4.2.2), the second one with the 3<sup>rd</sup> deepening of the maritime fairway (see 4.2.3). After adoption both dredging and relocation strategies were also applied to maintenance dredging.

### 4.2 Capital dredging of fairways

#### Content:

- Fairway depths, Avoidance of maintenance dredging, Dredging methods, Construction periods, Special aspects referring to ecology/water quality/habitats and species protection, Additional estuary specific strategies according to capital dredging of fairways

#### 4.2.1 The 1<sup>st</sup> deepening without specific relocation strategy

In the multiple channel system in the Westerschelde, dredging works traditionally consisted of dredging natural sills in the fairway (main channel) and relocation the dredged material to the more shallow secondary channel.

Due to the increase in vessel size in the sixties, the maritime fairway was deepened with 1,5 – 2 m in the period 1970-1975. The guaranteed depth for maritime traffic increased up

to 11,7 m GLLWS (mean lowest low water at spring) at Hansweert, over 12,0 m GLLWS at Bath and Valkenisse, 12,1 m GLLWS at Borssele and up to 12,5 m GLLWS at Zandvliet, just downstream of the locks to the port of Antwerp. The width of the fairway is 300m in the stretch from Zandvliet to Hansweert and 500m downstream from Hansweert, except Drempeel van Borssele which also has a width of 300m. Dredged sediment was partially extracted from the estuary for use in construction works and partially relocated within the estuary to secondary channels in the vicinity of dredging sites.

#### *4.2.2 The 2<sup>nd</sup> deepening applying the East-West strategy*

In preparation of the 2<sup>nd</sup> deepening a new relocation strategy was established. It was observed that relocating sediments in the traditional way was not sustainable in the eastern part of the Westerschelde because of the narrow character of the multiple channel system. There might be a danger of degeneration of the multiple channels system in the eastern part of the Westerschelde if the prevailing relocation strategy would be used.

Therefore, a relocation strategy was adopted in which sediments dredged in the eastern part were partially relocated in the western part of the estuary, the so-called 'East-West' strategy.

The 2<sup>nd</sup> deepening was realised in 1997-1998. An amount of 7,5 million m<sup>3</sup> was relocated during capital dredging works. With the 2<sup>nd</sup> deepening the tide-independent navigable depth of 11,85m was realised.

#### *4.2.3 The 3<sup>rd</sup> deepening applying 'Flexible relocation'*

Transporting dredged sediment over long distances from East to West is neither a sustainable practice. Consequently, there was a growing need for an alternative relocation strategy in 2000-2005, regardless of the execution of the 3<sup>rd</sup> deepening. The alternative relocation strategy should be adaptable when gaining new insights and when monitoring results came available. Hence, it is called 'Flexible relocation' strategy.

The Flexible relocation strategy came into practice with the start of the 3<sup>rd</sup> deepening and will be applied for the maintenance dredging works afterwards. With the 3<sup>rd</sup> deepening the tide-independent navigable depth of 13,10m was realised, meaning a water depth of 14,7 m GLLWS. The fairway is widened in the stretch between Deurganckdok and Zandvliet from 250m up to 370m.

Next to relocation sites in the secondary channel, alternative relocation sites were found in the subtidal areas near sandbars and in deep parts of the fairway. The alternative relocation sites put the idea of morphological management into practice.

The idea to apply morphological management in the Schelde estuary has been introduced in 2001 during the early stages of preparation of the 3<sup>rd</sup> deepening. Morphological management can be regarded as a win-win solution in which dredged material is used to fulfil goals that enhance the state or functioning of the estuary and finally contribute to the main use functions of the Schelde estuary:

- Safety against flooding
- Accessibility for maritime navigation
- Naturalness.

The reconstruction of the sandbar of Walsoorden was chosen as a case to bring morphological management into practice. The feasibility of reconstructing the Walsoorden sandbar has been investigated by physical and numerical modelling. After a feasibility study including physical and numerical modelling, two similar pilot projects (in situ relocation tests) were executed. More information about the pilot projects and an evaluation thereof can be found in Plancke et al. (2009). The pilot projects indicated that the Schelde estuary benefits from relocating dredged material to sandbars:

- an alternative is offered to relocating dredged material into secondary channels with limited capacity
- an outlook is given to the creation of low-dynamic and highly valuable shallow water habitat

Relocation of dredged sediment to (re)construct shallow water habitats on sandbars on 4 locations in the Westerschelde was adopted as part of the relocation strategy that is applied during the 3<sup>rd</sup> deepening in 2010 and for the maintenance dredging works since 2010.

#### 4.3 *Maintenance dredging of fairways*

##### Content:

- General strategy, Avoidance of maintenance dredging , Construction periods, Special aspects referring to ecology/water quality/habitats and species protection, Sustainable aspects, Additional estuary specific strategies according to maintenance dredging of fairways

The maritime fairway to the Port of Antwerp has been maintained since early 20<sup>th</sup> century.

The ‘East-West’ strategy was also applied to maintenance dredging after the 2<sup>nd</sup> deepening (since 1999). The licensed relocation capacity of all relocation sites together was large enough to allow less intense use of relocation sites when necessary and to anticipate on unwanted morphological evolutions. The capacity of each relocation site is calculated using the sand-balance approach (Taal, 2012), which can be regarded as a tool.

Since 2007 the capacity of the relocation sites in secondary channels in the Westerschelde were determined using the cell concept, in which morphological cells were considered existing of parts the main channel, the secondary channel and the sandbar in between those channels. The total annual capacity of all relocation sites together is larger than the expected annual relocation volume, which allows adaptation of the distribution of dredged material between the relocation sites following insights gained during the monitoring program.

After the 3<sup>rd</sup> deepening, since 2010, relocation sites in the primary channel (maritime fairway) and on sandbars are used as part of the 'Flexible relocation' strategy, next to relocation sites in secondary channels.

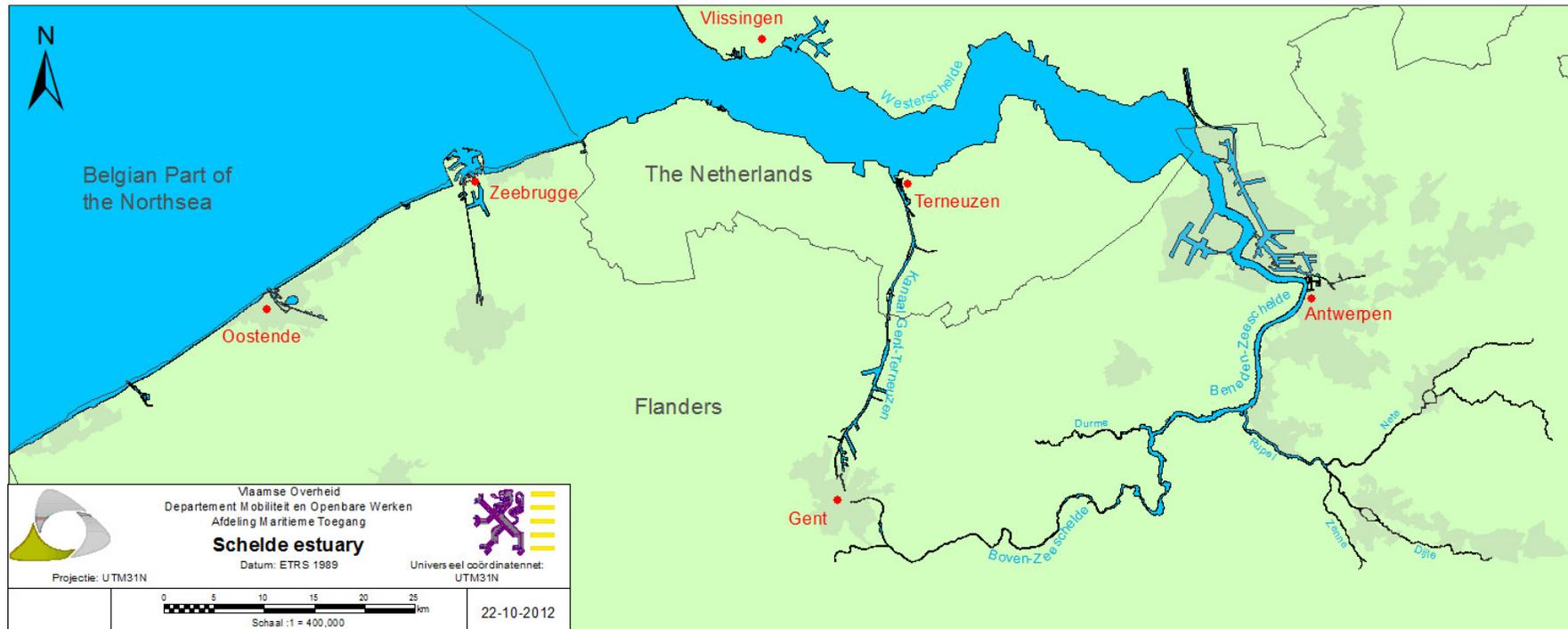
An optimized relocation pattern for the next generation of permits for relocation of dredged material within the estuary is currently subject of investigation. These results are expected in 2013.

## *5 References*

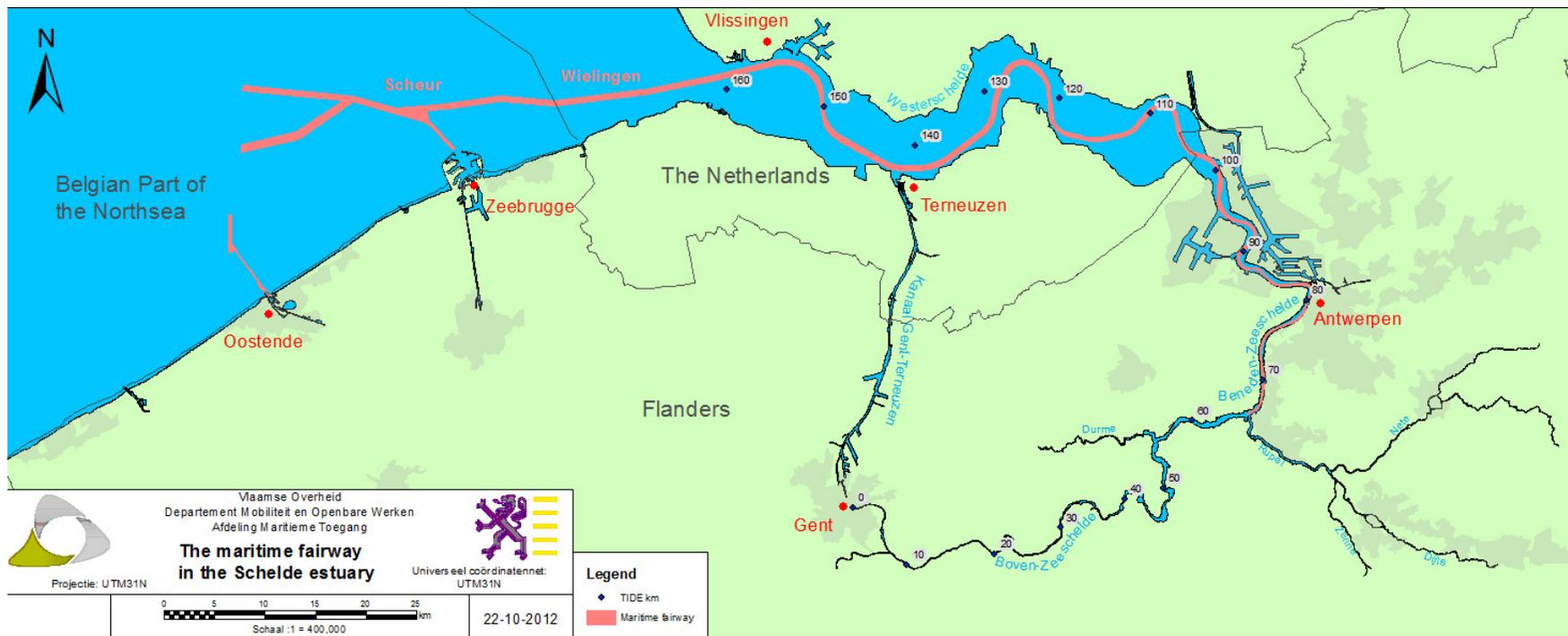
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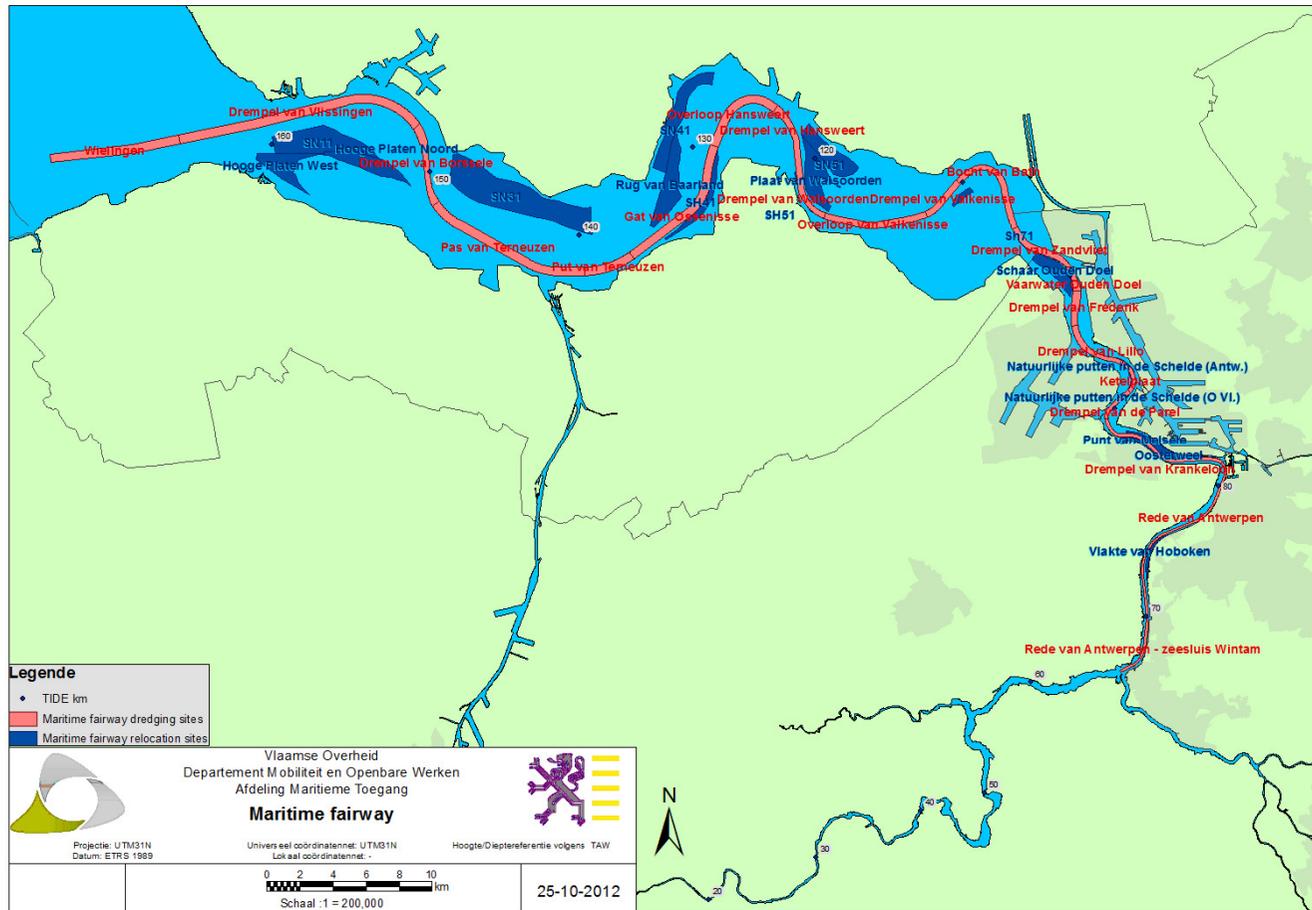
# Maps



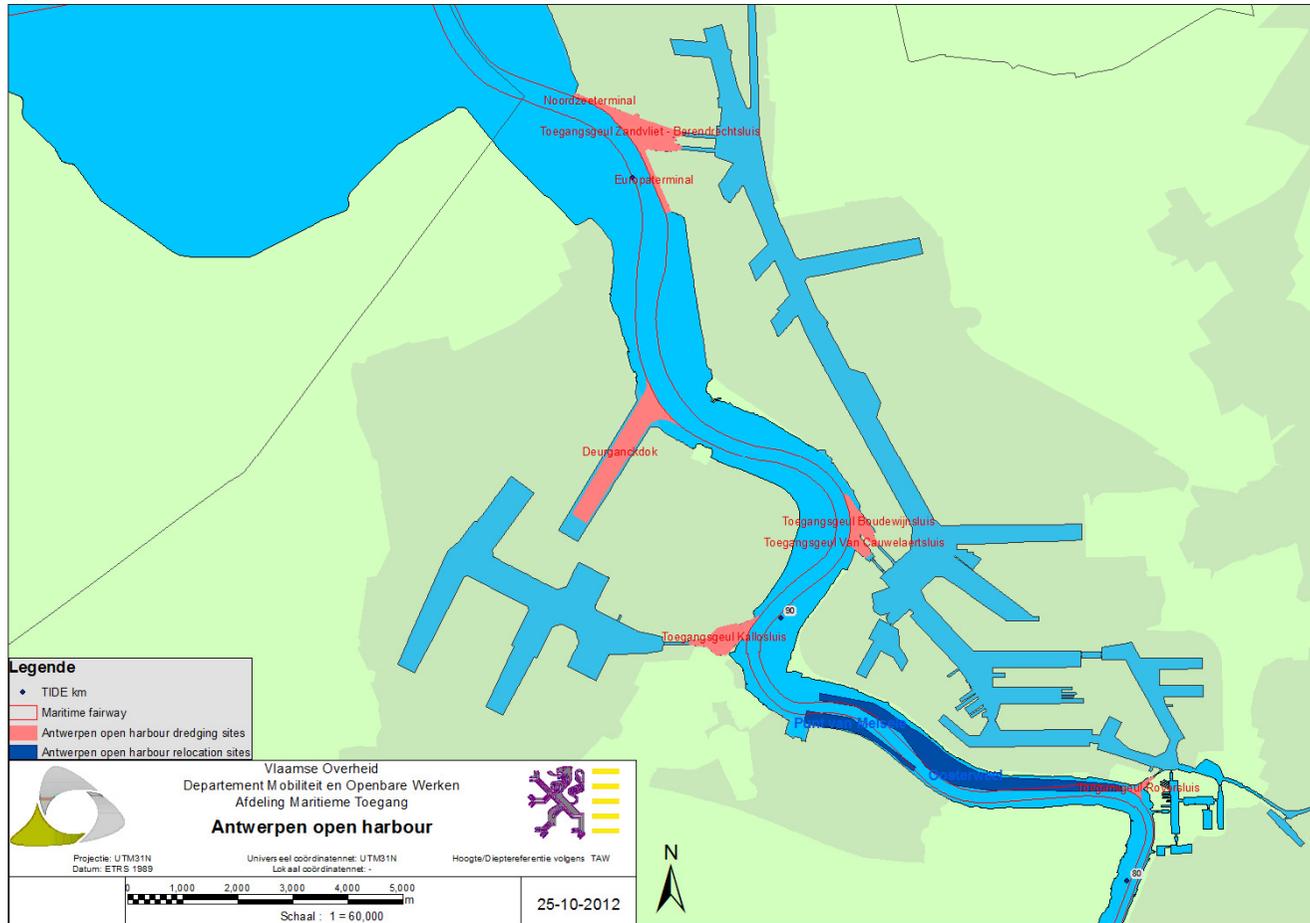
Map 1 Position of the Schelde estuary into its administrative context



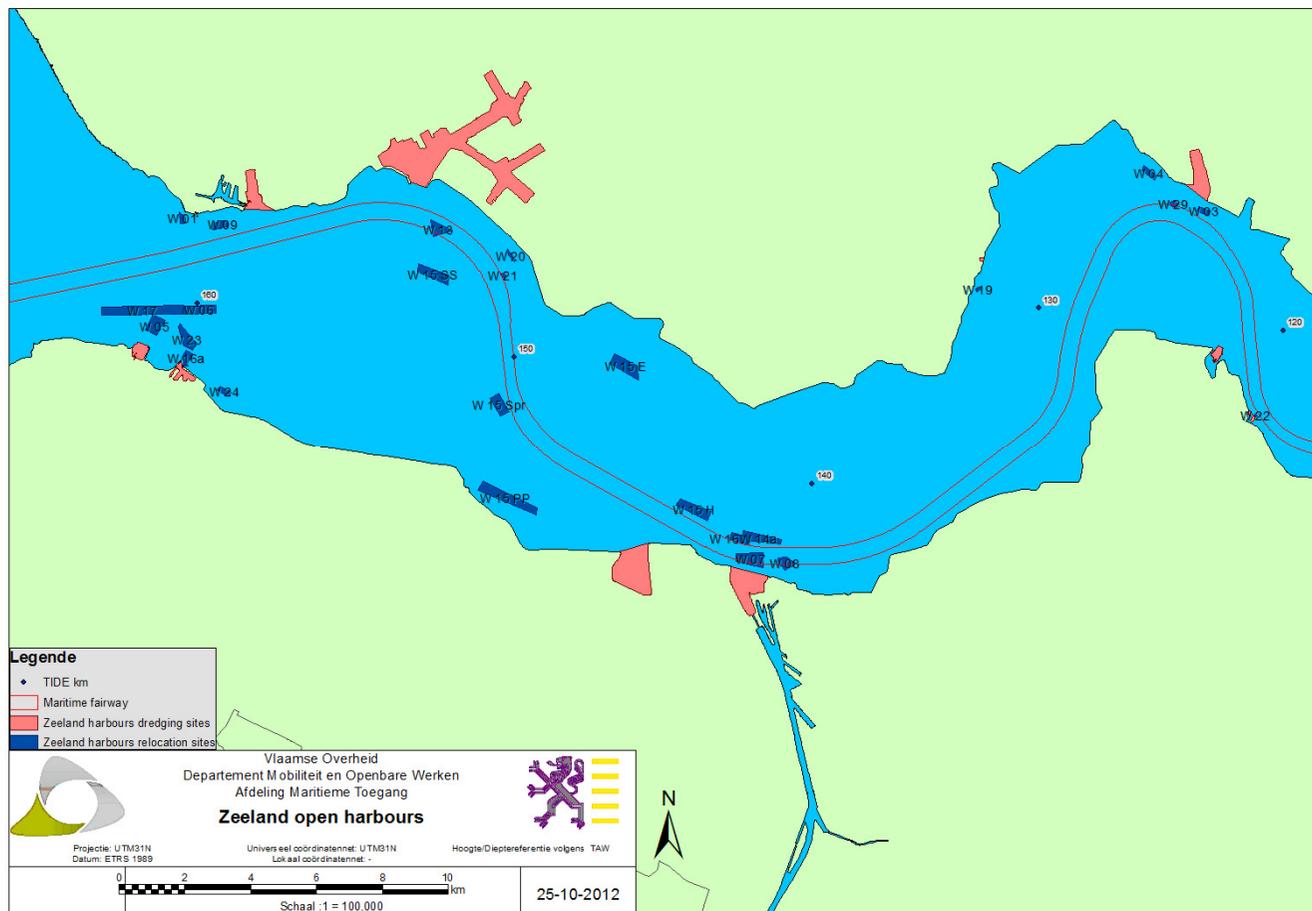
Map 2 Maritime fairway (marked in red) in the Schelde estuary



Map 3 Maritime fairway dredging and relocation sites



Map 4 Dredging and relocation sites for the open harbour in the vicinity of Antwerpen



Map 5 Dredging and relocation sites for the Zeeland open harbours