FLOOD REDUCTION AND WATER QUALITY IMPROVEMENT BY A CONNECTION BETWEEN THE EASTERN AND THE WESTERN SCHELDT

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FLOOD RISKS IN THE SCHELDT ESTUARY.

The Scheldt Estuary is situated on the European mainland along the southern part of the North Sea and consists of the Western Scheldt on Dutch territory and the Zeeschelde/Bovenschelde river in Belgium (figure 1). It is part of the lower Rhine/Meuse/Scheldt delta with several estuarine branches in the Netherlands, although the Scheldt Estuary is not directly linked with the other branches.

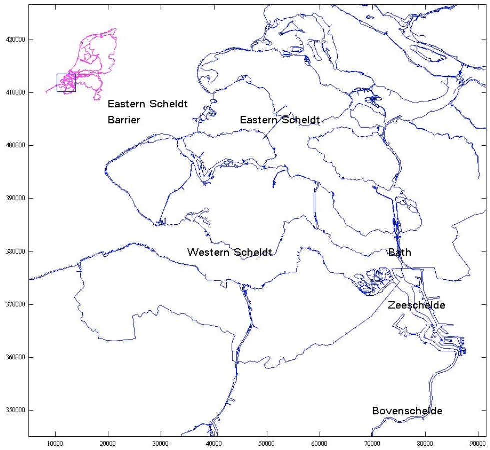

Figure 1

In the past, all of the estuarine branches used to be very vulnerable to coastal flooding. During northwesterly storms the water levels along the borders of the North Sea may increase by several meters on top of the astronomical tide levels within a day. This is because of the shape of the North Sea and the storm tracks in the Northern Atlantic Ocean, during storms which comes from the NW. Fifty years ago, 31st of January and 1st of February 1953, this resulted in a serious flood disaster that hit the east coast of England and the coasts of the Netherlands and Belgium.

In the Netherlands, the government took action immediately after this disaster to increase the safety level of the dikes in the Dutch part of the delta. This resulted among others in the permanent closure of most of the estuaries from the sea. An exception was made for the two most southerly estuaries: the Eastern Scheldt and the Western Scheldt (figure 1).

In the Eastern Scheldt the original plans for permanent closure were changed because of increasing environmental awareness emerging during the nineteen seventies. Instead of a permanent dam, a storm surge barrier was built in the entrance of the estuary. The *Eastern Scheldt Barrier* became operational in 1986 and was closed several times during storms since that time. Under daily conditions, the barrier is open and the tide can go in and out the estuary through the gates of the barrier. The tidal range inside the Eastern Scheldt has reduced 40 % however compared to the original situation.

In the Western Scheldt, permanent closure or the construction of a barrier has never been an option because of the presence of several ports along the borders of the estuary. The Western Scheldt is subject of an old international treaty between the Netherlands and Belgium. This treaty deals among other things with the accessibility of the Port of Antwerp. As an alternative to closure, the crest levels and stability of the dikes along the Dutch part of the estuary were increased substantially. Also along the Flemish (Belgian) part improvements of dikes and revetments were undertaken.

A second aspect of the accessibility of the Port of Antwerp is the increase of vessel size and draft in course of time. This has led to deepening and widening of the bars in the fairway between the North Sea and the port limit. This deepening of the main channels, in combination with other works such as reclamation of intertidal areas along its shores, has resulted in an acceleration of the penetration of the tidal wave in the estuary and an increase of the high water levels.

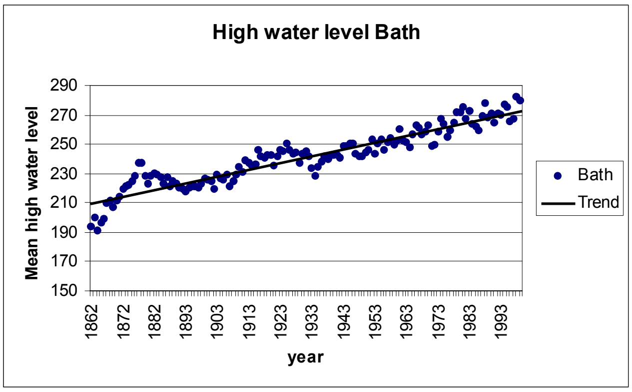

Figure 2

In the last century the Mean High Water Level (MHW) of the station Bath (near the Belgian-Dutch border) has increased by some 0.50 metre (figure 2, ref. 1). The increase of storm surge levels in the same period was even more.

The development of the high water levels in future is uncertain. in addition to further deepening of the fairway and changes in intertidal areas, it is likely that global effects of climate change and sea level rise will have an impact on the surge levels. In figure 2 this is arbitrarily indicated by a linear extrapolation of the MHW levels at Bath throughout the present century. Ongoing impact studies will more precisely indicate what increases can be expected in detail. For the purpose of this paper it is sufficient to conclude that a further increase of the water levels in the Scheldt Estuary is expected.

In other words; 50 years after the “Great Flood” flood risk management in the Scheldt Estuary is still essential to anticipate increasing storm surge levels in future.

THE “OVERSCHELDE”.

In anticipation of increasing flood levels in the future, a number of options can be considered.

The traditional approach would be to further increase the levels of the dykes. When evaluating this option, it should be realised that raising crest levels cannot be continued indefinitely. Apart from the stability aspects of very high dikes and the impact on the landscape, the destructive consequences of a breach on the low lying land behind the dyke has to be considered

Other options to increase the safety levels of the land behind the Scheldt dikes include:

- the construction of a storm surge barrier upstream of the Port of Antwerp. Such a barrier has only postitive effect in the area upstream of Antwerp; downstream the surge levels might even go up.
- the arrangement of controlled overflow areas along the borders of the estuary.

Both options are being considered in the current implementation of the Belgian action plan for increasing the level of safety against flooding (Sigmaplan).

A new concept came up recently in the discussion on safety awareness in the Scheldt Estuary. This concept uses the presence of both estuaries (Eastern and Western Scheldt) next to each other. By closing the *Eastern Scheldt Barrier* in an early phase of

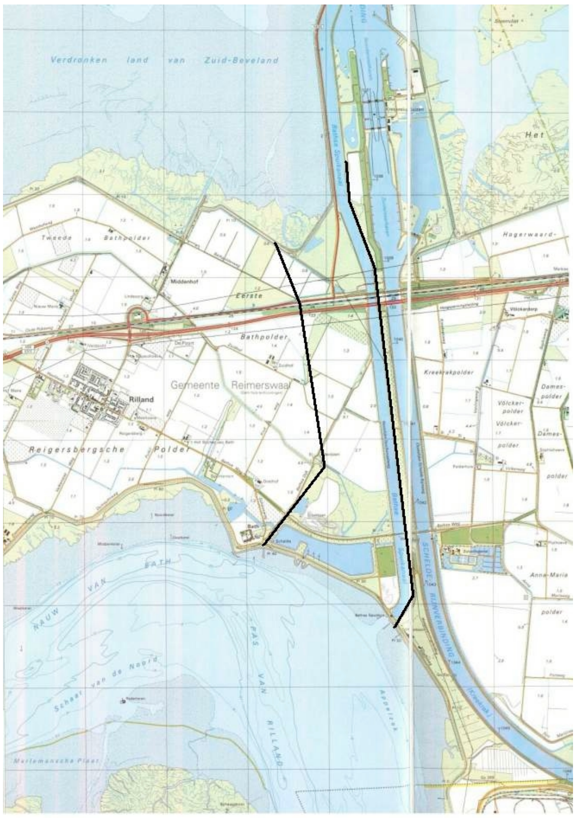

Figure 3

a storm, a large area (about 350 km2) is created with a low and almost static water level (almost static because of the leak discharge through the barrier).

By using the Eastern Scheldt as a controlled overflow area for water from the Western Scheldt, the storm surge levels in the Western Scheldt and the Belgian waters can be reduced substantially.

This concept has been given the name "Overschelde". In this name, especially in the Dutch language, the element of linking both Scheldt estuaries is underlined.

Hydraulic calculations have shown that the link has best performance if it is located as far upstream as possible (ref. 2). In figure 3 such a location is shown: a channel of approximately 1 km wide at the eastern limit of the Eastern Scheldt, parallel to the inland shipping canal between Scheldt (Antwerp) and Rhine (Rotterdam), just east of the village of Bath.

The "Overschelde" link would be equipped with a controlled barrier system that has to be operated in close collaboration with the *Eastern Scheldt Barrier*. It would be opened just before critical levels of the storm surge in the Western and Belgian Scheldt are reached. In this way the reduction in the storm surge is greatest, and the impact on the water level in the Eastern Scheldt is least.

To achieve a significant reduction of flood levels in the Western and Belgian Scheldt, a substantial size of the channel is required. For a reduction of 0.6 to 0.8 m at Antwerp, the overflow connection should have a discharge capacity of 15,000 to 20,000 m3/sec. Typical dimensions that reflect this discharge are about 1,000 m width and about 10 m depth in the centre.

The size of existing connections between both estuaries for inland shipping is clearly insufficient to meet this requirement. The same applies for the existing fresh water discharge canal "Bathse Spuikanaal", although this canal could be integrated in the new "Overschelde" link.

In figure 4 (ref.4) the calculated impact on the water levels in both estuaries during the storm of February 1990 is given (comparison of levels with and without "Overschelde"). It appears that

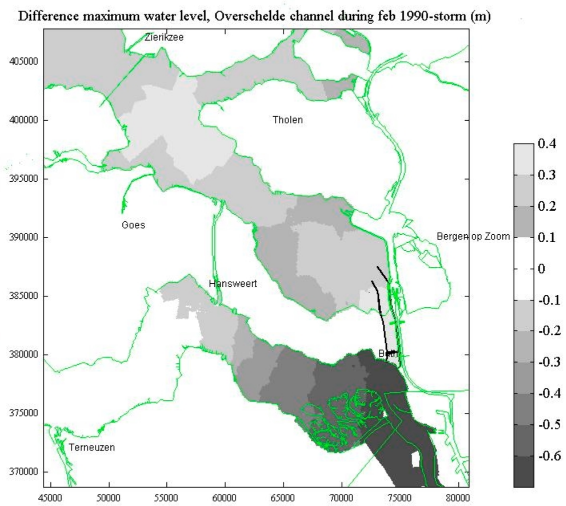

Figure 4

the water level near Antwerp can be reduced by 0.65 m. In the Dutch part of the estuary the reduction gradually decreases, almost to zero in the western section. The rise of water level in the Eastern Scheldt is limited to approximately 0.30 m at maximum. Further optimisation of the “Overschelde” dimensions and the joint operation strategy with the *Eastern Scheldt Barrier* may even improve these figures.

It can be concluded that construction of the “Overschelde” is a serious option to reduce the storm surge levels in the inner part of the Western Scheldt and along the Flemish (Belgian) Scheldt substantially.

THE “OVERSCHELDE” UNDER DAILY CONDITIONS.

As discussed above, the “Overschelde” can be a valuable tool for reduction of critical flood levels. This implies that the usage of the channel for storm level reduction purposes is very limited, probably only once per 10 years or less. This does not mean that the link cannot have a function for the other 99.9 percent of time. An initial concept of such daily use is presented here. As with the management of the “Overschelde” during storm conditions, the daily use is still subject to further evaluation and optimisation.

The basis of the “daily use concept” is to apply the link in the opposite direction compared to that during a storm. During storms large volumes of water are discharged in a short period of time from the Western to the Eastern Scheldt, during daily conditions it is proposed to discharge lower volumes of water from the Eastern to the Western Scheldt. In this way the “Overschelde” may play a role in the improvement of the natural conditions in both estuaries.

To understand this properly, the history of both estuaries should be kept in mind. Up to the 19th century, a natural link was present, being a remainder of medieval morphology of the area. The tidal motion in the area was dictated by the tides in both estuaries. Under daily conditions, the current velocities in the Overschelde region were very limited; thanks to meteorological effects a shallow channel was kept open. As a result of constructing a railway line, the link was closed in 1868.
Since that time, the estuaries on both sides of the railway have experienced a completely different development.

The Eastern Scheldt lost part of its tidal activity and morphodynamics after construction of the *Eastern Scheldt Barrier*, especially in the eastern sections of the estuary. The tidal range and the currents reduced, resulting among others in loss of equilibrium between natural channels, intertidal areas, banks and mud flats. Regression of intertidal areas is now encountered.

The Western Scheldt experienced an opposite development. Ongoing reclamation activities, deepening of the fairway and other effects resulted in an increase of the tidal movement. The development of MHW at Bath (figure 2) demonstrates this development.

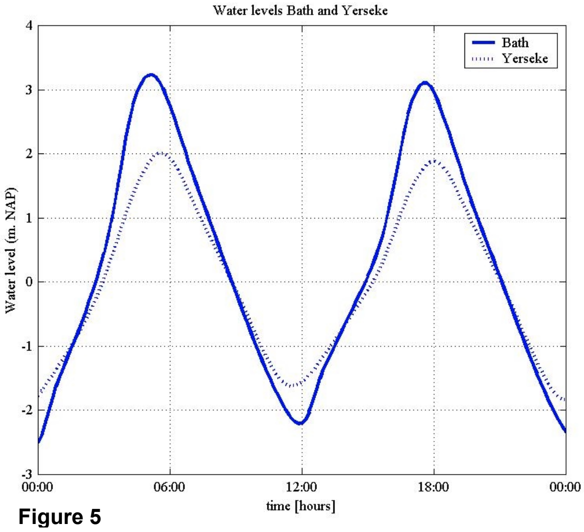

Figure 5

In figure 5 the average tidal curve at both ends of the "Overschelde" link is given. It appears that the phase at both ends is more or less the same, but the range differs significantly. In the Western Scheldt, MHW is much higher (almost 1 meter) than in the Eastern Scheldt. Mean Low Water (MLW) however is about 0.50 m lower in the Western Scheldt. This difference in MLW can be used to generate a tidal driven southward flow in the "Overschelde" during the "low" half of each tide. The barrier in the "Overschelde" will be opened as soon as the water level gradient generates a southward flow, and closed again as soon as the gradient changes direction.

If the capacity of the barrier is fully applied, the maximum discharge towards the Western Scheldt during a spring tide amounts to 2,000 – 2,500 m3/sec. The actual discharge volume (from zero up to the capacity) can easily be managed by the operational regime of the "Overschelde" barrier.

Operating the "Overschelde" under daily conditions, opposite to the storm regime, has a number of advantages in terms of the sustainability of both estuarine systems.

A preliminary indication (subject to further analysis and optimisation) is given below.

A. Eastern Scheldt.
- The tidal dynamics improve; long term development of the inner part will become more sustainable in terms of estuarine dynamics.
- The tidal range in the inner section increases, resulting in an improvement of the intertidal area and a step back towards the original and more natural situation.
- The flushing of shellfish areas (mussels, oysters) improves.

B. Western Scheldt.
- The tidal range in the inner section decreases, resulting in a reduction of the intertidal area.
- The tidal dynamics tend more towards the original situation of the estuary. The increased artificial "river discharge" (due to the "Overschelde") fits better in the increased demand for discharge because of the deepening of the fairway.
- Maintenance dredging volumes in the fairway to Antwerp will go down as a result of the higher artificial river discharge.
- Water quality in the Western Scheldt is given a boost. In combination with measures at the source in Belgium water quality will improve.

The development of the "Overschelde" link fits very well in the target picture that was defined recently for the Western Scheldt estuary by the bordering countries Belgium and the Netherlands. The long-term vision (year 2030 target) describes an improvement of the conditions for three main functions of the estuary:

- safety, especially against flooding;
- accessibility, especially to the Port of Antwerp;
- naturalness and sustainability of the estuarine processes.

Last but not least, the year 2030 target also includes joint management of the Western Scheldt estuary by both countries. The “Overschelde” is located on Dutch territory, but its main impact, in terms of flood risk reduction, is felt in Belgium. The realisation of the “Overschelde” project is an example of such joint management.

MISCELLANEOUS CONSIDERATIONS.

The area where the “Overschelde” channel is projected is situated in the eastern (inner) part of the estuaries, in the area where the natural link was closed in 1868. Since that time, only minor developments have taken place in the area. The main land use today is agriculture. The construction impact of the channel on existing landuse is, therefore, only limited.

Figure 6

Moreover, the present canals (one for inland shipping and one for fresh water discharge) already cause a significant separation between both sides of the canals. See figure 6, which is a photo of the present situation looking from south to north.

The shape of these canals and their borders does not fit properly in a natural landscape of mud flats and fine sand estuaries. The straight man made slopes with artificial (stone) protection do not correspond well with the long-term target of naturalness. In figure 7 an artist impression is given of the same area after construction of the “Overschelde”. The fresh water canal is integrated in the new channel. The new channel has natural borders consisting of mud flats and intertidal areas. Only the shipping canal still has its original shape and alignment. As such, this canal fits in the tradition of inland shipping canals in the Netherlands.

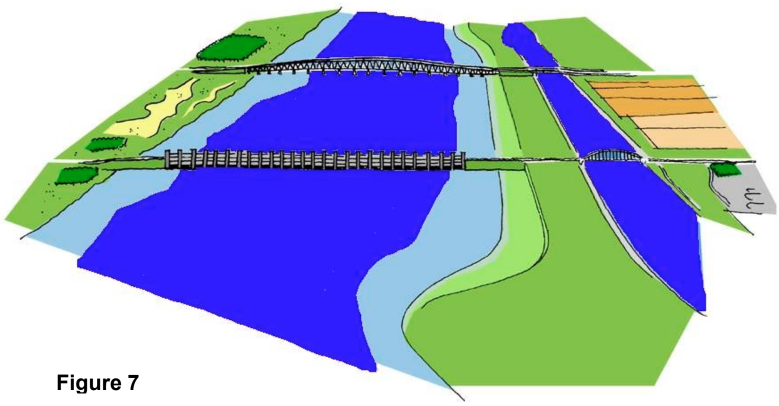

Figure 7

The present canals are crossed by a number of bridges: two for local traffic, one for a motorway and of course the railway bridge. In the future situation, the number of crossings will be the same. It is important that the design of these crossings takes into account the existing landscape. The open environment of natural estuaries does not correspond nicely with concrete slabs on concrete piles each 20 metres. At the same time, the flat landscape with highest level being the dike crest, does not tune well with a high bridge structure. The combination of these two, almost conflicting, criteria, has resulted in a preliminary design of 2 connections.

The first (main) connection combines the motorway, the railway and a local road in one bridge. A preliminary design of this bridge is presented here as an example showing how the conflicting criteria can be met. The design includes an upper deck for the motorway (2 lanes and hard shoulder each direction) and the local road (one lane in each direction) and a lower deck for the railway (figure 8). Key elements of this design are transparency of the structure, large spans and limited structure height.

The second connection combines the second local road with the barrier structure that is required for the operational management of the "Overschelde" channel (ref.3). The local road may also serve as service road for the barrier. Typical dimensions of the barrier are: effective width 400 m and a sill level of MSL – 4 m. These dimensions are still subject to further optimisation.

Figure 8

The integration of the fresh water channel "Bathse Spuikanaal" in the Overschelde implies that another location should be found for the fresh water discharge. Two options are considered for this location:

(a) the area just north of the Overschelde; similar to the present situation the fresh water will flow almost straight towards the Western Scheldt;
(b) an area further to the north of the Eastern Scheldt; the fresh water will then cause a brackish zone in the Eastern Scheldt that will have a positive effect on the ecological system.

The impact of the project on the *fishing industry* in the Eastern Scheldt is expected to be positive because of the increased flushing of the Eastern Scheldt by water from the North Sea and by fresh water from the new fresh water inlet (if option b is chosen). Brackish zones are good spawning and breeding grounds for shellfish.

In the Western Scheldt the *water quality* will improve significantly. The ecological system will benefit from this improvement, especially in the large intertidal zone "Land van Saeftinge". The fishing industry in the Western Scheldt will also benefit.

Agriculture is effected negatively by the project. A loss of at least 200 ha of agriculture area is expected, including about 20 ha of greenhouses. There would need to be an extension to the existing fresh water siphon to ensure fresh water remains available for irrigation and to stop salt intrusion.

The Overschelde is also an important area for *extensive recreation*; activities such as: (guided) visits to the intertidal areas, angling from land and from small craft, bicycle routes and viewing points. Allowance of these activities by the authorities may improve the acceptance of the project by the local communities. Nature conservation and the recent declaration of the Eastern Scheldt as "National Park" have reduced people's historical 'right of access' to the estuary significantly. The Overschelde may compensate for this loss. Outstanding architecture of the project and the bridges may further increase the local acceptance.

The *costs* of the Overschelde connection are considerable. Preliminary estimates indicate an amount of almost 500 million Euro. However, compared to the costs of raising the dike levels yet again, by 0.5 to 1.0 metre over a length of about 200 km, these costs are low. Also, the costs of arranging large overflow areas on land would be very high. Apart from costs, the overall social and environmental impact of these alternatives is much worse than the overall impact of the Overschelde.

A complicating factor of the Overschelde is that the investment has to be done in the Netherlands, while the major part of the benefits (as far as flood risks are considered) is gained in Belgium. To solve this issue political willingness and courage is required. In this respect, the Overschelde project may become the test case for the year 2030 target of the long term vision on joint estuarine management by both countries.

CONCLUSIONS.

The communities bordering the Western Scheldt estuary have experienced a substantial increase of flood levels over the last century. Raising the dike levels to meet the flood risks was the common answer of the second half of the 20th century, after the “Great Flood” of 1953. However, this is not the end: a further increase of flood levels in the new era is likely.

A wide and deep channel between the Western Scheldt and the neighbouring estuary Eastern Scheldt reduces the flood levels along the Western Scheldt and the Belgian Scheldt by 0.5 to 1.0 metre, provided that the channel is operated like a tap. The tap should be opened just before the peak of the storm surge, and closed immediately after the peak. The operational management of the “tap” should be tuned strictly with the management of the storm surge barrier in the entrance of the Eastern Scheldt to assure that the water influx does not increase the flood risks around the Eastern Scheldt basin.

In daily circumstances the “tap” can be operated in opposite direction, i.e. to divert water from the Eastern to the Western Scheldt. This daily use has a range of advantages for the ecosystem, morphodynamics and fishing industry in both estuaries.

The capital and operational expenses of the “Overschelde” (the name of the “tap”) compete well with alternative measures to reduce the flood risks in the Western Scheldt estuary.

The decision process about the Overschelde project may become a test case for political willingness for real international co-operation between the two countries that border the Scheldt estuary: The Netherlands and Belgium.

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