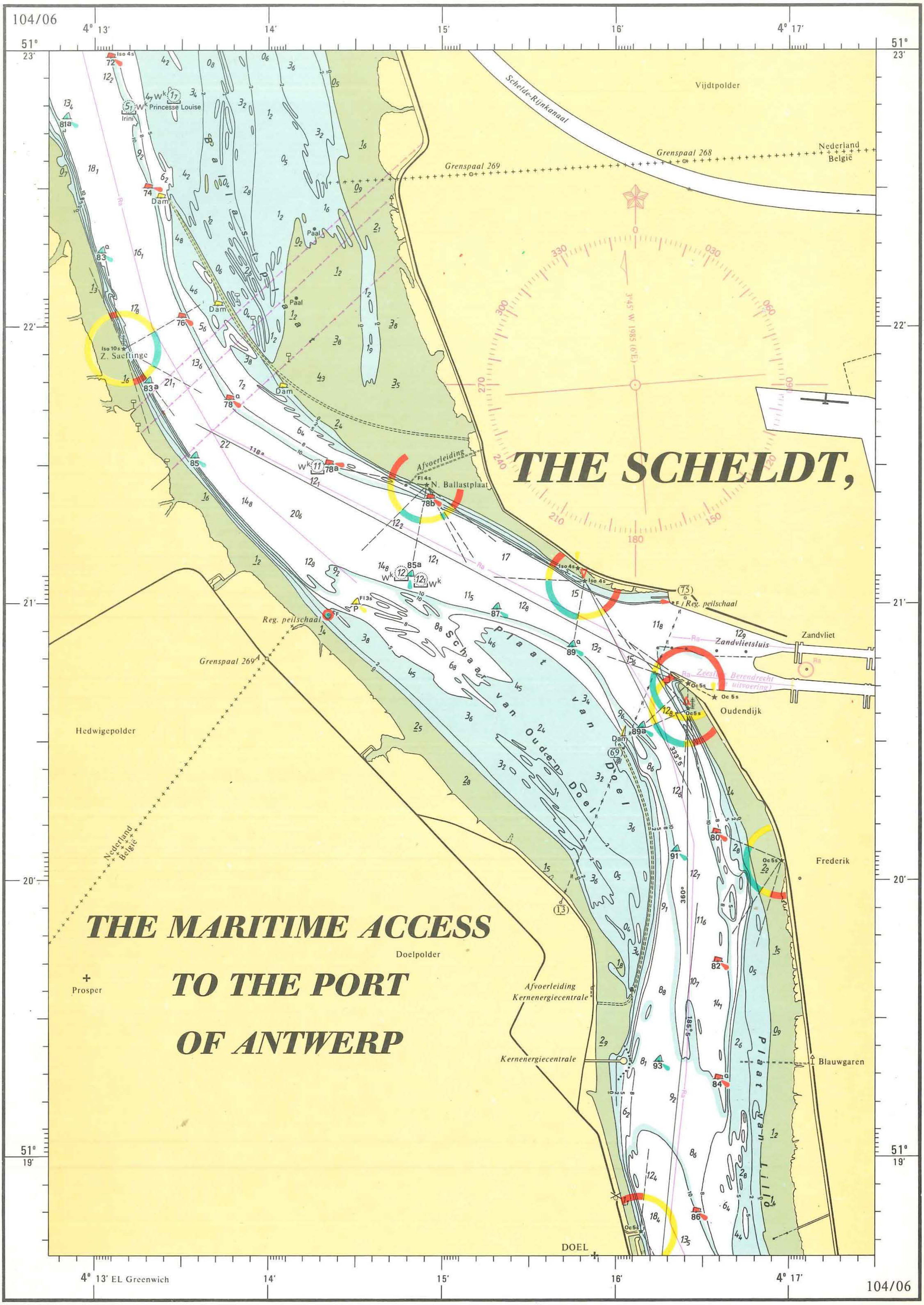
THE SCHELDT, THE MARITIME ACCESS TO THE PORT OF ANTWERP



THE SCHELDT, THE MARITIME ACCESS TO THE PORT OF ANTWERP

by ir. L. MEYVIS

1. PREAMBLE

The river Scheldt rises at a height of about 100m in the department of l'Aisne near St. Quentin and drains a catchment basin of ± 20.000 SQ km. It flows into the sea at Flushing in a large estuary after a course of 430 km.

The drainage basin consists of low plains, mainly covered by quaternary sands and clays. The part of the river upstream of Ghent is the Upper Scheldt. Downstream of the city of Ghent the river is subject to the tides and is known as the Sea Scheldt and further downstream on Dutch territory as the Western Scheldt.

1.1. The Upper Scheldt

The Upper Scheldt has only one important tributary : The Lys. The Lys and the Upper Scheldt form the water transport axis from the hinterlands : Northern France, the Borinage and the Centre to the seaports Ghent, Zeebrugge, Antwerp and Rotterdam.

Both rivers have been regulated and canalized between the French border and Ghent. Modernisation works are in progress to make both navigable for standard European-type lighters of 1350 tonnes. On the Scheldt the programme is already completed.

Prior to the excavation of the Belt canal or Ringvaart, the two rivers flowed together in Ghent.

Now they merge into the Ringvaart.

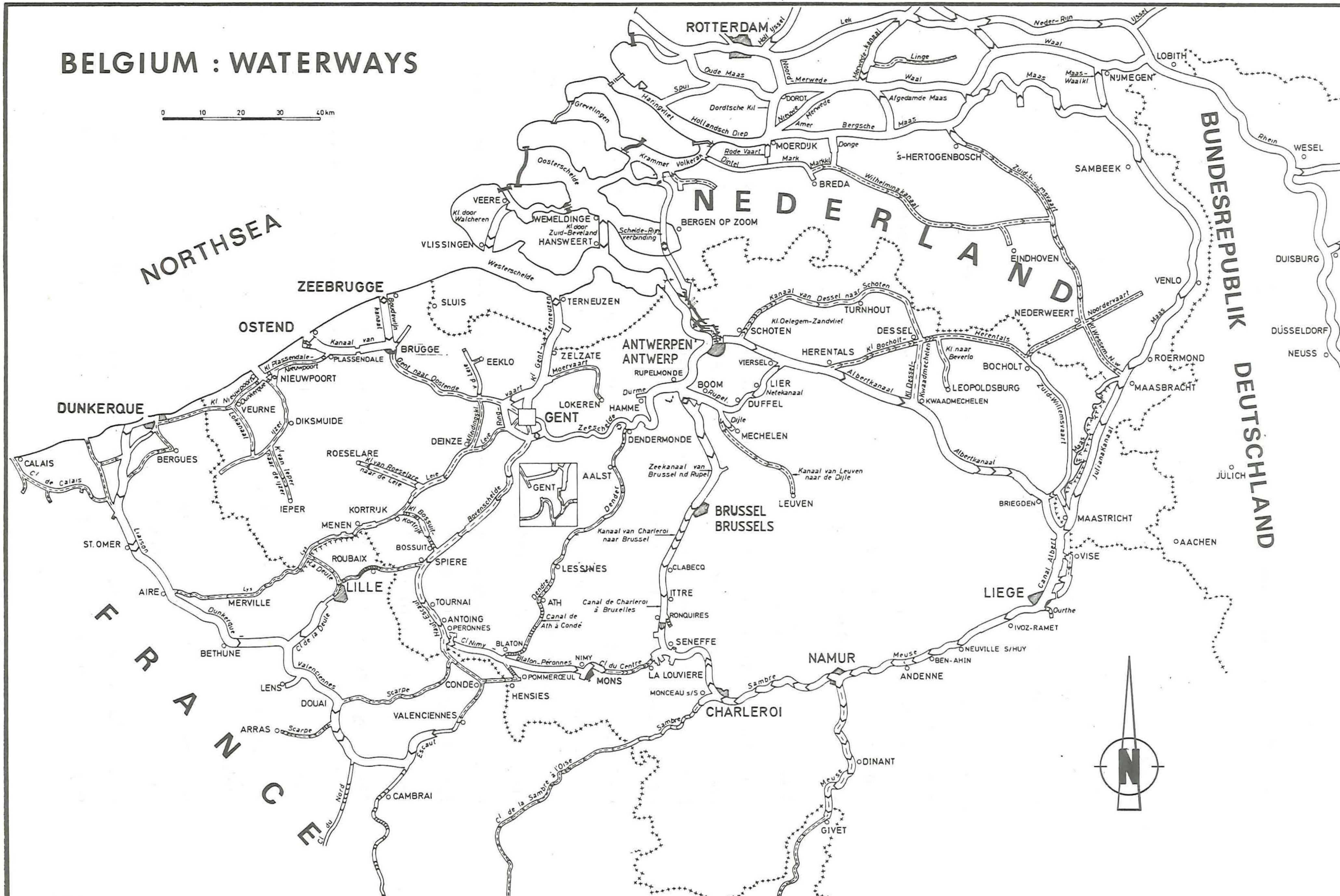
The Ringvaart encircles the city of Ghent and connects both rivers with the canal Bruges-Ghent, the Sea canal of Ghent-Terneuzen, the old arms and canals in the city and the Sea Scheldt.

The southern section of the Ringvaart flows freely into the Sea Scheldt at Melle.

In Merelbeke, a lock system and a barrage separate the Southern and Western sections of the Ringvaart.

Finally a third barrage in Gentbrugge separates the Scheldt from its original meandering loops and the canal system in the city of Ghent.

BELGIUM : WATERWAYS



1.2. The Sea Scheldt

In Melle, at the confluence of the old arm flowing to Gentbrugge and the southern section of the Ringvaart the navigation channel of the river is nearly 25m wide and 3m deep at low water. This channel widens and deepens downstream and reaches a width of 75m and 3m depth in Dendermonde at the confluence with the Dender.

Lighters up to 350 tonnes can use this section at all times. However, when the tide is taken into account, navigation is possible for barges of 600 and even upto 1000 tonnes.

A development plan allowing navigation in all circumstances for ships of 1350 tonnes, corresponding to the European waterway standards, is under study.

The confluence of the Scheldt and the Durme lies in Tielrode.

Downstream of Tielrode, the navigable channel of the Sea Scheldt has a depth of 5,5m at low tide and a width of 180m and becomes navigable for small coasters and push barges.

The Rupel, the main tributary of the Sea Scheldt has a width of 200m at its mouth extend, up to the lock of Wintham. The depth in the bends is about 8m and 5m above the bars at low tide.

The Wintham lock connects the Rupel with the seacanal Willebroek - Port of Brussels.

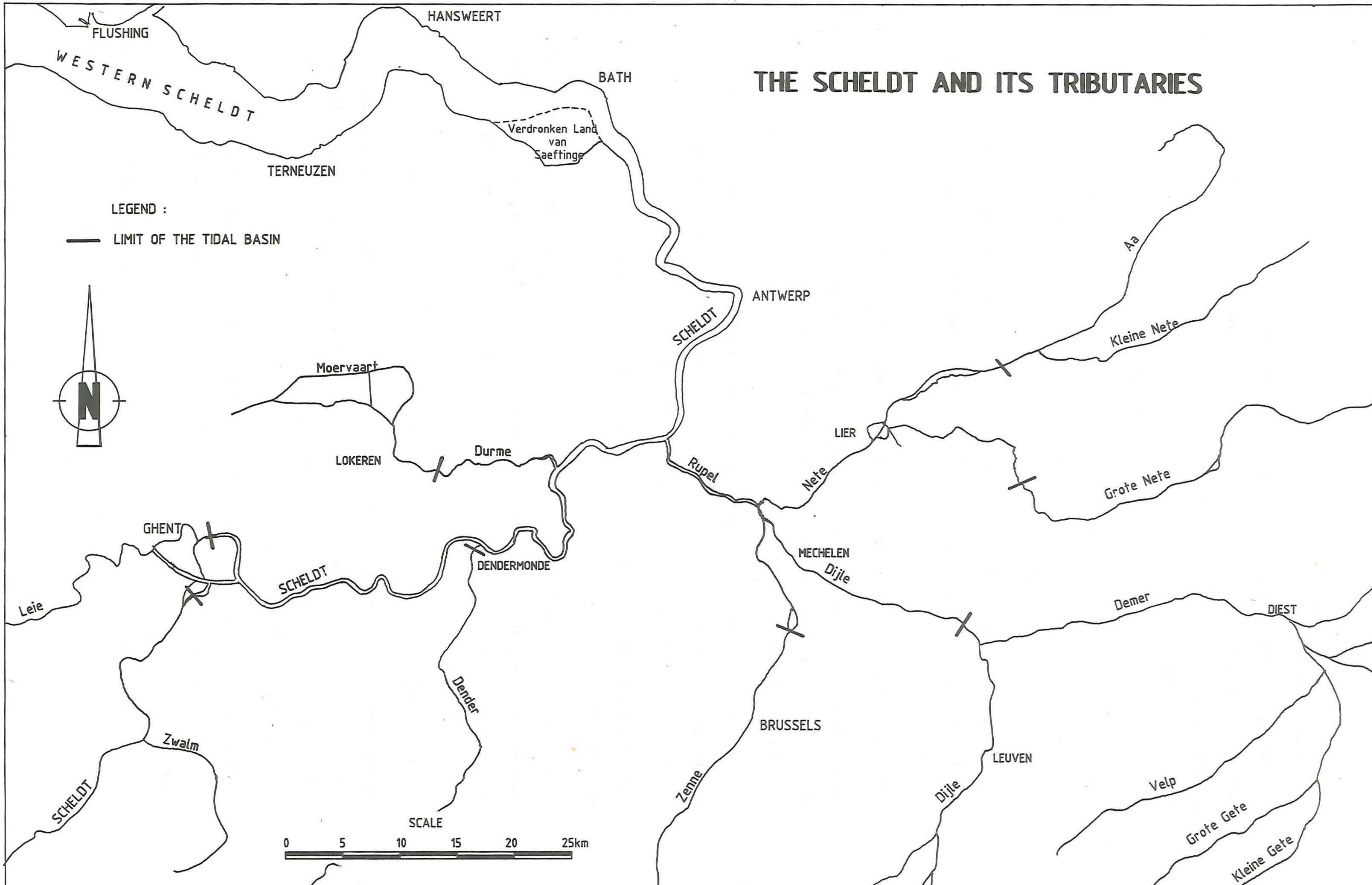
A new lock, situated more downstream and opening directly into the Sea Scheldt in Hingene is nearly completed. After completion, the canal and the port of Brussels will be attainable by large push convoys and vessels up to 10.000 dwt.

Upstream Wintham the depth of the Rupel reduces considerably.

Downstream the mouth of the Rupel, the Sea Scheldt has a narrow but continuous channel, with a depth of more than 8m at low tide, widening and deepening further downstream and reaching a width of more than 350m in the roads of Antwerp.

Downstream of Antwerp the Sea Scheldt flows to the North in the Antwerp Polders forming the maritime access and approach channel to the port.

These polders have been completely transformed since the fifties through the expansion of the port of Antwerp. They have been filled up with spoil


THE SCHELDT AND ITS TRIBUTARIES
FLUSHING
HANSWEERT
WESTERN SCHELDT
BATH
Verdronken Land van Saeftinge
TERNEUZEN
LEGEND :
LIMIT OF THE TIDAL BASIN
ANTWERP
SCHELDT
Aa
Kleine Nete
Moervaart
LIER
LOKEREN
Durme
Rupel
Nete
Grote Nete
GHENT
MECHELEN
DENDERMONDE
SCHELDT
Dijle
Leie
Demer
DIEST
Dender
BRUSSELS
Zwalm
LEUVEN
Velp
SCHELDT
Zenne
Dijle
Grote Gete
SCALE
0 5 10 15 20 25km
Kleine Gete

from the maintenance dredging in the river and the initial dredging for the docks in the port and have become industrial areas.

The Antwerp docks are not in open connection with the river. They are separated by sea locks.

On the right bank downstream of the city of Antwerp, the following locks have been constructed. Kattendijk, Royers, Kruisschans or Van Cauwelaert and Zandvliet.

On the left bank a new lock has been constructed and is in operation since 1983.

The Kattendijk lock is only used for river traffic. The others are sea locks.

The construction works for doubling the lock of Zandvliet, the Berendrecht lock, the worlds largest sealock are in progress. Completion is expected in october 1988.

Upstream both locks along the right bank of the river a new containerterminal with berthing facilities for 4 fourth generation container vessels is under construction. The terminal will be in full operation by mid 1990.

Studies are in hand to replace the Royers lock, built before the first world war by a new lock, allowing acceptance of large push convoys.

Downstream Zandvliet the Sea Scheldt passes the Dutch border reaching a width of more than 2.500m and changes its name, becoming the Western Scheldt.

1.3. Western Scheldt

Geological research studies carried out by Dutch and Belgian institutes prove that at the beginning of our era neither the Western nor Eastern Scheldt existed as estuaries.

At that time the Scheldt flowed through a channel in a North Easterly direction passing East of the Island of Tholen and into the Meuse. The river probably was not subject to the tide.

After a first inundation by the sea (second transgression of Dunkerque) in the Sixth Century, the Eastern Scheldt developed forming the mouth of the Scheldt.

The Western Scheldt, as such, did not exist in the present configuration, but was probably a lagoon known under the name "The Honte" behind the dunes of the North Sea and overflowing into the Scheldt near Bath.

After the formation of the Eastern Scheldt the Scheldt basin with its creeks, muddy low lands, shoals and unembanked alluvial lands was subjected to a restricted tidal movement limited by the sandy plains of Flanders.

Between 1000 and 1200 the third Dunkerque's transgression started. A junction between the sea and the lagoon was made by a breach of the dunes near the Wielingen.

Successive inundations formed the Western Scheldt and transformed completely and definitively the landscape of Flanders and Sealand.

By the beginning of the Twelfth Century the Western Scheldt had almost reached its present form. Sea levels had risen to such an extent that in the interior part of the country construction of houses was no longer possible on lands lying lower than sea level.

The new estuary complex remains unstable and keeps searching for an equilibrium through a natural transformation of its river bed.

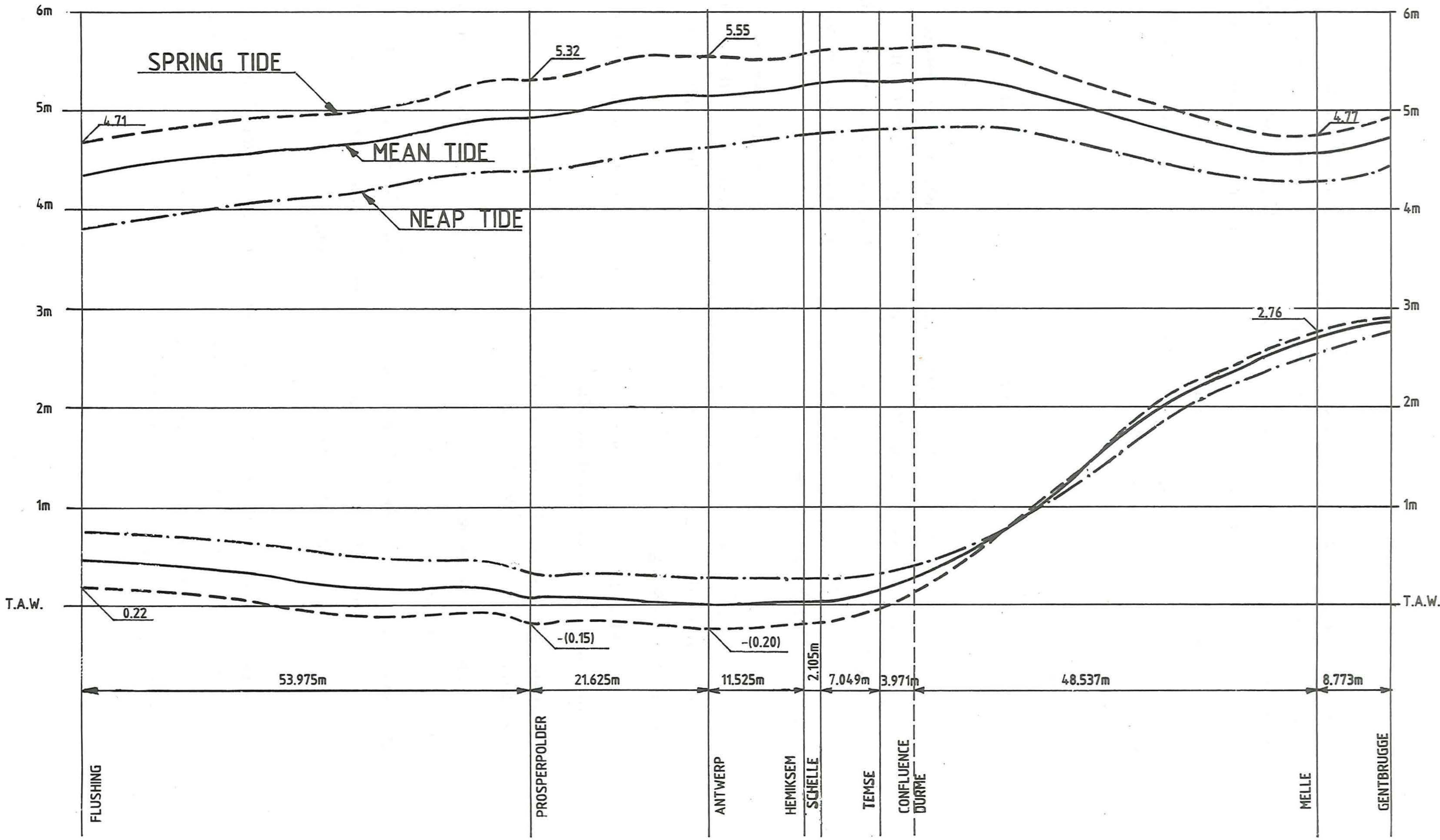
This continuous regulation process in the bed of the river results in the deepening of the normal bed at low water and the silting up of sand banks and shoals.

This facilitates the progression of the tidal wave inland while the lateral water storage area is reduced resulting in a higher water level at high water.

This natural evolution has been supported by the efforts of man who dammed in lowlands and facilitated the artificial silting up of shoals and sand banks and created as such the polders. The first polders were established in the beginning of the Twelfth Century North of Antwerp (Doel, Lillo, Berendrecht, etc..)

This natural evolution continued during the following centuries, sometimes completely interrupted by disastruous inundations caused by surge-tides and dike breaches, sometimes even enforced for strategic purposes.

SCHELDT
SURFACE PROFILES OF THE HIGH AND LOW WATERS 1971-1980



Along the Western Scheldt several locks and harbours have been built. We note successively the lockblock of Hansweert for inland navigation and small coasters giving access to the canal of Zuid Beveland, the former Scheldt Rhine link; the port of Terneuzen and its lockblock with a large sealock and two smaller locks for coasters and lighters giving access to the Sea canal Ghent-Terneuzen and both ports. Finally upstream Flushing the Sloe port has been built, which is unlike the other ports an open port subject to the tide.

2. THE TIDES

The map gives an overall view of the Scheldt and its tributaries which are subject to tidal movements.

The tide movement can be best described by a transit wave generated at the mouth and moving through the river system while modifying itself. In the movement of this tidewave we note two distinct movements of the water levels : first the vertical tide, secondly the movement of the water particles the horizontal tide.

The water level of the high tide is rising from Flushing, reaching a maximum near St.-Amands-Drijgoten at the confluence with the Durme dropping from there till Melle and rising again until Ghent where it is stopped by a barrage.

The low water level goes down from the mouth until Hansweert and then remains nearly constant until Schelle.

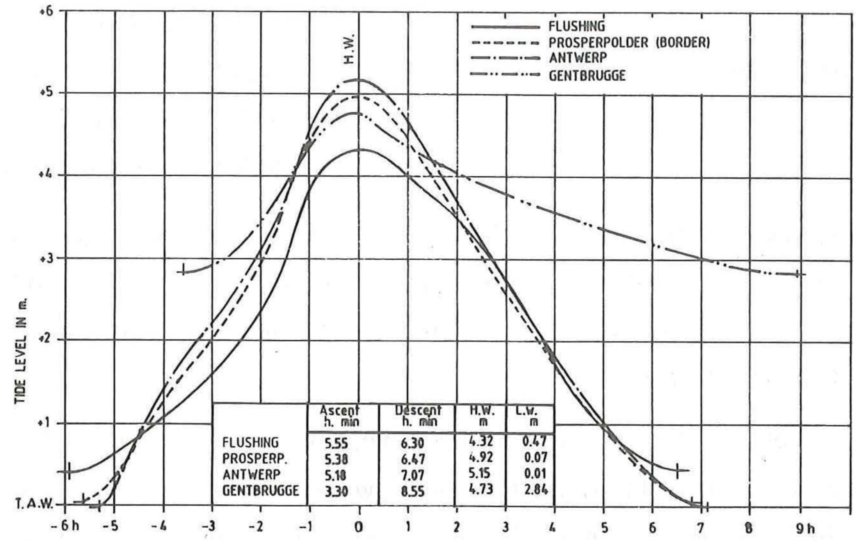
Upstream of Schelle the low water level rises considerably due to the reduction of the water depth in the river.

The following drawing gives an overall view of the evolution of the amplitude of the tidewave along the river.

The maximum occurs near Schelle with an amplitude of 5.24m at mean tide i.e. nearly 1.00m higher than in Flushing and more than 3.00m greater than in Gentbrugge where the average amplitude is not more than 2.00m.

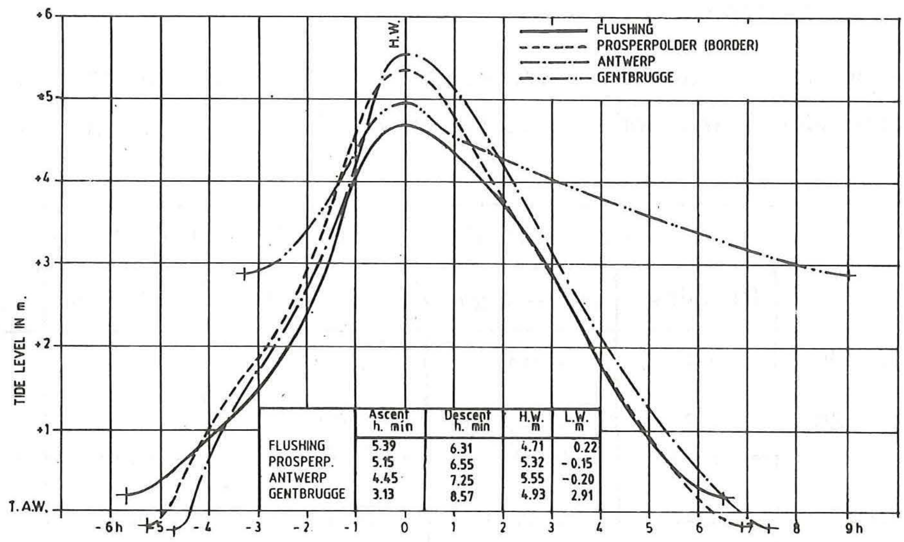
The following drawings give the mean tide curves registered during the period 1971 - 1980 at Flushing, Prosperpolder, Antwerp and Gentbrugge. We note that the flood is shorter on spring tides than with a meantide, while the ebb is shortest at neap tide.

MEAN TIDE CURVE 1971-1980



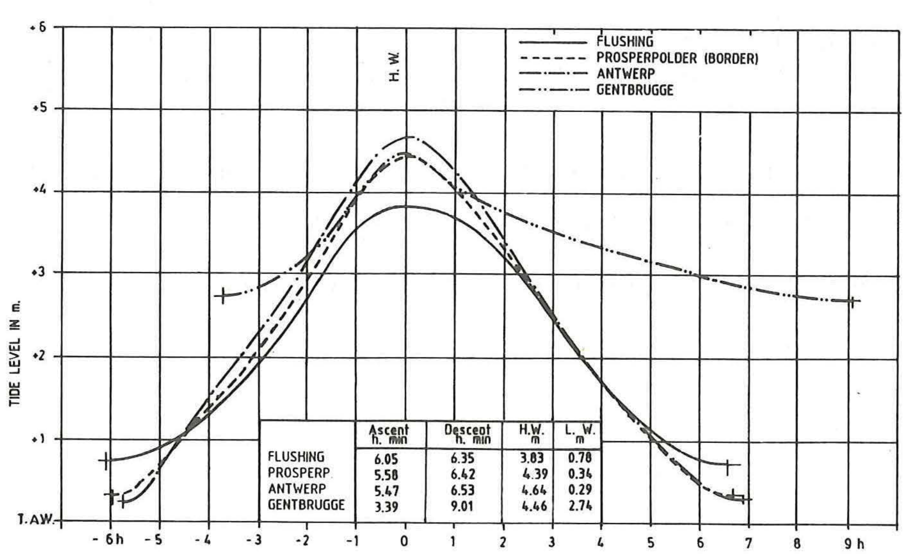
	Ascent h. min	Descent h. min	H.W. m	L.W. m
FLUSHING	5.55	6.30	4.32	0.47
PROSPERP.	5.38	6.47	4.92	0.07
ANTWERP	5.18	7.07	5.15	0.01
GENTBRUGGE	3.30	8.55	4.73	2.84

MEAN SPRING TIDE CURVE 1971 - 1980



	Ascent h. min	Descent h. min	H.W. m	L.W. m
FLUSHING	5.39	6.31	4.71	0.22
PROSPERP.	5.15	6.55	5.32	- 0.15
ANTWERP	4.45	7.25	5.55	-0.20
GENTBRUGGE	3.13	8.57	4.93	2.91

MEAN NEAP TIDE CURVE 1971 - 1980



	Ascent h. min	Descent h. min	H.W. m	L.W. m
FLUSHING	6.05	6.35	3.83	0.78
PROSPERP.	5.58	6.42	4.39	0.34
ANTWERP	5.47	6.53	4.64	0.29
GENTBRUGGE	3.39	9.01	4.46	2.74

Starting from Flushing going upstream the period of the flood reduces

For a meantide we count
5h55' at Flushing
5h38' at Prosperpolder
5h18' at Antwerp
3h30' at Gentbrugge

Over the years the tidal pattern has continuously changed; this evolution is still going on and is promoted by man through the endiking of low lands and especially by the dredging carried out for nautical purposes since the early thirties.

A comparison of the average tidal levels for the period 1921-30 and 1971-80 shows for example that the high water level, at Flushing increased by 15cm. The low water level by 6cm and the amplitude by 9cm. The high water level rises even more, upstream : 30cm at Antwerp, 46cm at Schelle. The amplitude rises also : 29cm at Zandvliet, 49cm in Antwerp and 73cm in Hemiksem-Schelle.

This tendancy is further affected by a subsidence of the low countries along the North Sea and the elevation of the main sea water level.

Mean Tide Data 1921-1930 and 1971-1980							
		Flushing	Hansweert	Prosperpolder	Antwerp	Schelle	Gentbrugge
HW in m + T.A.W.	1921-1930	4.17	4.43	4.72	4.85	4.82	4.63
	1971-1980	4.32 + 0.15	4.66 + 0.23	4.92 + 0.20	5.15 + 0.30	5.28 + 0.46	4.73 + 0.10
LW in m + T.A.W.	1921-1930	0.41	0.12	0.16	0.20	0.31	2.80
	1971-1980	0.47 + 0.06	0.18 + 0.06	0.07 - 0.19	0.01 - 0.19	0.04 - 0.27	2.84 + 0.04
Tidal amplitude	1921-1930	376	431	4.56	4.65	4.51	1.83
	1971-1980	385 + 0.09	448 + 0.17	4.85 + 0.29	5.14 + 0.49	5.24 + 0.73	1.89 + 0.06

The horizontal tide movements have a great importance i.e. the currents, the flow and the volumes of ebb and flood.

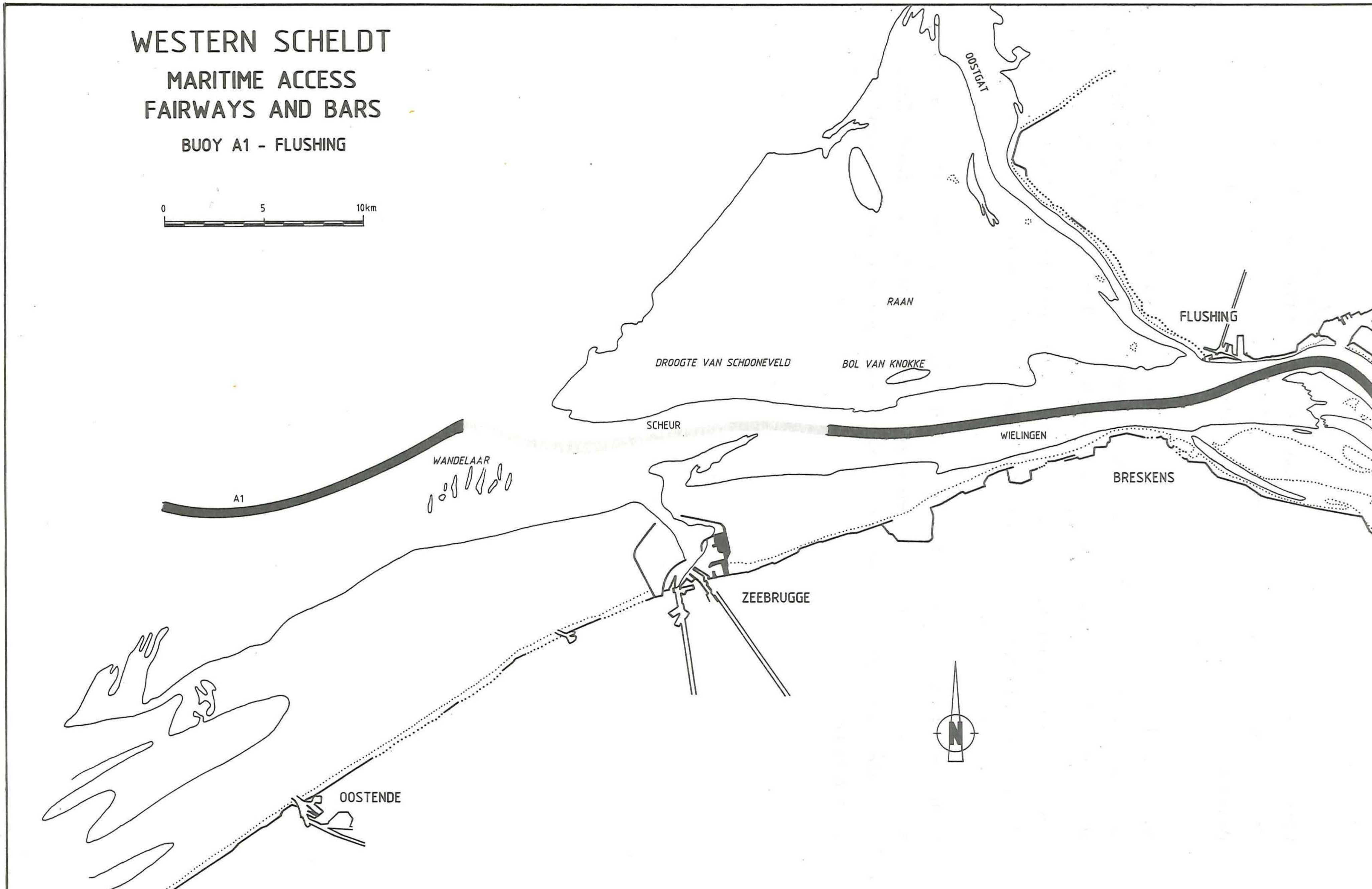
For a mean tide the following volumes have been calculated.

	Flood volume	Ebb volume
Flushing	1.063 mio m^3	1.066 mio m^3
Prosperpolder Zandvliet	144 mio m^3	147 mio m^3
Antwerp	67 mio m^3	70 mio m^3

We note that there is very little difference between the flood volume and the ebb volume due to the small river discharge in the Scheldt calculated at an average of 100 cum/sec near Schelle at the confluence of the Rupel.

However going upstream from the mouth, the volumes of the flood and the ebb reduce considerably. At the Dutch border the volume of the flood is calculated at 1/7 of the volume at Flushing.

Finally water currents vary depending on the site, the moment and the height of the tide. The strongest currents are measured during the flood. During springtides short periods with velocities up to 2 and 3 meters a second have been measured.



WESTERN SCHELDT
MARITIME ACCESS
FAIRWAYS AND BARS
BUOY A1 - FLUSHING
0
5
10km
OOSTGAT
RAAN
FLUSHING
DROOGTE VAN SCHOONEVELD
BOL VAN KNOKKE
SCHEUR
WIELINGEN
WANDELAAR
BRESKENS
A1
ZEEBRUGGE
N
OOSTENDE

3. MORPHOLOGY OF THE RIVER

3.1. The mouth

In the North Sea three sea channels lead to the mouth of the Scheldt at Flushing.

In the West, the channels are the "Wielingen" and "Scheur" with minimal water depths of 9 and 14m below low water respectively. In the North, we have the "Oostgat" with a minimal water depth of 8m. Between the channels is a large area of sand banks : Vlakte van Schooneveld, The Raan, etc...

3.2. The Western Scheldt

3.2.1. Generalities

The Western Scheldt has the appearance of an estuary with an irregular pattern. Despite of this irregularity the river respresents a continuous profile, looping from one bank to the other, passing over a section, with reduced depth called bar.

The main navigation channel is the ebb channel forming the approach to the port for all ships with large draught.

Downstream of the bar the deep channel extends upstream in the form of a short branch. This extension, whose upstream part is normally shallower is called flood channel. The flood channels are normally not navigable except those lying West of Hansweert which are navigable for coasters and vessels with limited draught.

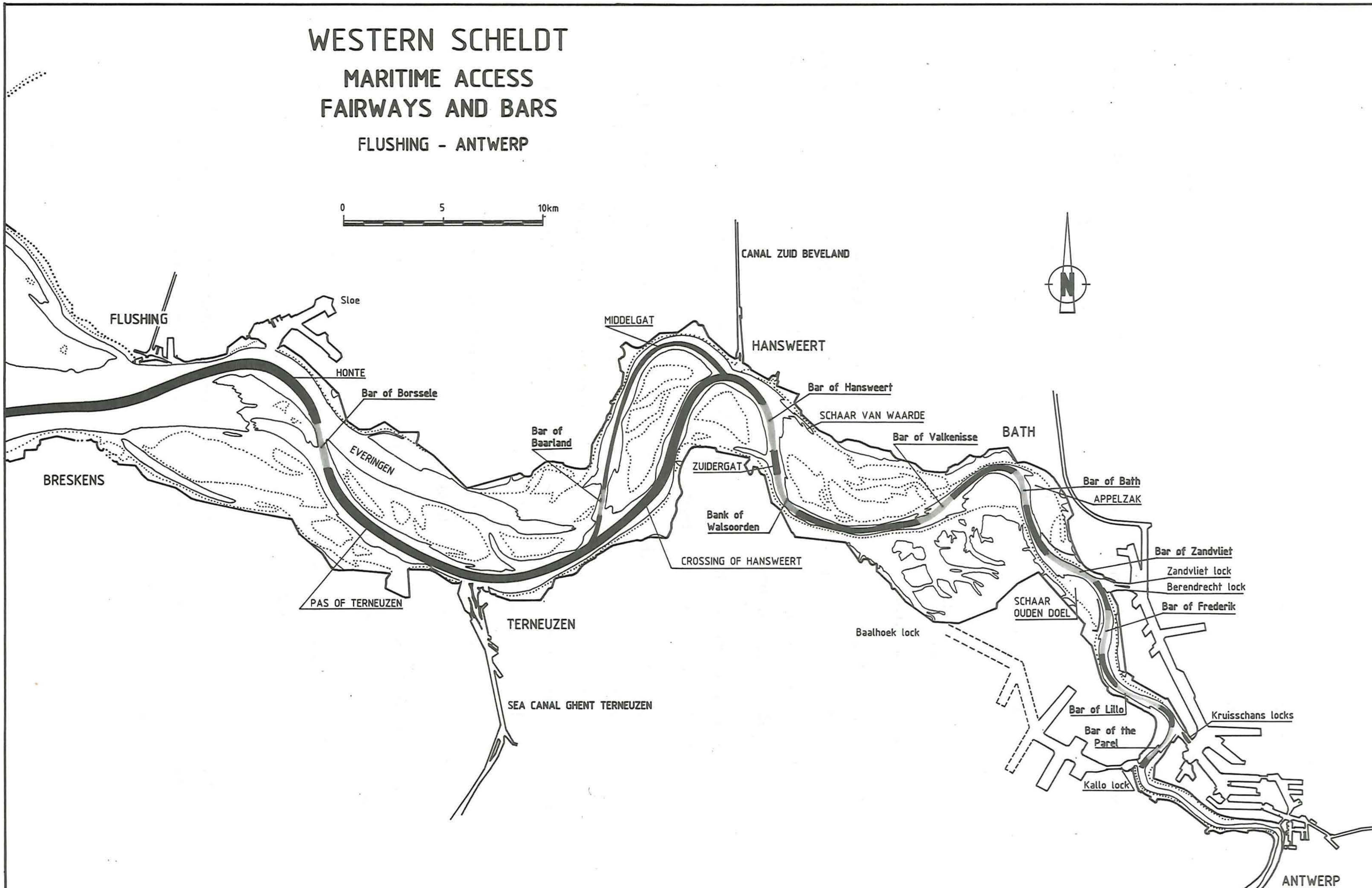
Large shallow areas with sand banks emerging at low water lie between the main channels and the flood channels.

The bottom layers of those channels and bars consist mainly of sand and are consequently very mobile.

3.3. Description of the channels

In the roads of Flushing the channel occupies the complete width of the estuary.

Following this deep and continuous channel upstream, we note that it follows the North bank, called the Honte before looping to the South bank, called Pas van Terneuzen.


WESTERN SCHELDT
MARITIME ACCESS
FAIRWAYS AND BARS
FLUSHING - ANTWERP
0
5
10km
CANAL ZUID BEVELAND
N
Sloe
FLUSHING
MIDDELGAT
HANSWEERT
HONTE
Bar of Borssele
Bar of Hansweert
SCHAAR VAN WAARDE
Bar of Baarland
Bar of Valkenisse
BATH
EVERINGEN
ZUIDERGAT
BRESKENS
Bar of Bath
APPELZAK
Bank of Walsoorden
CROSSING OF HANSWEERT
Bar of Zandvliet
Zandvliet lock
Berendrecht lock
SCHAAR OUDEN DOEL
Bar of Frederik
PAS OF TERNEUZEN
TERNEUZEN
Baalhoek lock
SEA CANAL GHENT TERNEUZEN
Bar of Lillo
Kruisschans locks
Bar of the Parel
Kallo lock
ANTWERP

At the changeover from one bank to the other lies the Bar of Borssele.

The flood channel of the Honte is called the Everingen channel. The "Pas van Terneuzen" is extended to the North bank by the Middelgat and the bar of Baarland.

The flood channel of the Pas of Terneuzen is the crossing of Hansweert. About 25 years ago this channel developed into a deep and continuous channel and has become the main navigation channel.

The channel of Zuidergat follows the Middelgat or the crossing of Hansweert separated by the bar of Hansweert.

The secondary channel of the Middelgat is called Schaar van Waarde. The Schaar van Waarde is separated from the Zuidergat by the sand banks of Valkenisse and Walsoorden.

The Bent of Bath lies upstream of the Zuidergat along the Northern bank. The bar between both channels is the bar of Valkenisse, the secondary channel is called : Schaar van de Noord.

Near Bath the Scheldt increases in width in a Southern direction. This widening covers the extensive mud flats and salt pastures of the inundated Land of Saaftinge.

The flood channel of Bath is the Appelzak.

The main channels in the Western Scheldt are relatively deep, especially in sections with pronounced bends.

For example : in the Honte water depths of 40m at low water, in the Pas of Terneuzen 30 to 50m in the Middelgat 30m, Zuidergat and the Nauw van Bath 20m are found.

The water depths over the bars are much less.

Antwerp Maritime Services guarantee a minimum depth of 122dm in Borssele, 117dm on the crossing and the bar of Hansweert, 120dm on the bars of Valkenisse, Bath and Zandvliet.

From the Dutch border onward the Scheldt is becoming a river. The flood channels are much less outlined and disappear nearly completely. The last flood channel of any importance is "The Schaar van den Ouden Doel".

Sailing further upstream we meet the bar of Zandvliet, downstream of the lock with the same name and downstream the sealocks Kruisschans and Boudewijn : the bars of Frederik and Lillo, and downstream the lock of Kallo the bar of the Parel.

The water depths in the channel reduce progressively and above the bars upstream of Zandvliet and downstream of Royers lock water depths between 12.00 and 8.50m are found.

4. DREDGING

4.1. The quantities and the dredging sites

Antwerp Maritime Services guarantee a minimum depth on the different bars. As the natural depth is much lower, maintenance and capital dredging are necessary. Without any dredging, the depth over the bars would vary between 5 and 9 metres. The first dredging works started at the end of the 19th century, immediately downstream of the city between the Plaat van Boomke and Fort Philip.

Before 1930 dredging was carried out sporadically and with the main purpose of regulating the river. Since 1930, maintenance dredging has become more regular and more and more we are forced to dredge the downstream bars.

Before 1969, maintenance dredging had to be carried out only upstream of Hansweert, since then we were obliged to dredge at Baarland and since 1972 at Borssele.

We are now dredging on all bars of the Western Scheldt and on the bars of Zandvliet, Frederik, Lillo and the Parel in the Seascheldt.

Further down, near Walsoorden dredging outside the channels along the sandbanks is needed to prevent the banks from slipping into the channel.

Similar dredging is carried out along the banks of Saaftinge which is shifting into the channel downstream of Bath.

There is no need for any dredging work on the bars situated upstream of the Parel. Dredging upstream the Kallolock is only occasionnaly carried out e.g. along a berth or a quay. Before 1970, regular dredging was necessary to maintain the navigable channel.

During the last years a yearly average of 14 mio cum has been dredged from the river, of which 12 mio come from Holland and about 2 mio from Belgium.

In the beginning of the seventies deepening works started on the bars of Hansweert, Valkenisse, Bath and Zandvliet. Consequently the depth on the bars has been increased by about 2 meters but the amount of maintenance dredging has increased accordingly.

Until 1980 nearly 2.5 mio cum have been dredged annually from the river and reclaimed. The surplus is returned to the river.

Since 1981, the reclamation of the polders in order to establish industrial areas has nearly stopped due to the economic recession.

In the Scheur a channel of 22 km long and 500 m wide has to be maintained and deepened.

For the period 1980-1987, the yearly average of the dredged volumes amounted to 21 million cubic metres.

4.2. Nature of the dredged spoil

On the bars of the Western Scheldt, the spoil consists mainly of sand with average grain sizes varying between 150 and 200 micron.

In the Seascheldt on the bars Zandvliet, Frederik, Lillo and Parel the dredged spoil consists of a fine sand mixed with a varying volume of mud, depending of the season and the site.

In the Western section of the Scheur mainly sand is dredged. The mixture in the Eastern part East of Ribzand is rather low in sand.

Even on some sites mud has been found.

4.3. The dumping of the fill

During the last 20 years the sand coming from the dredging has been used for hydraulic reclamation of the polders in order to obtain industrial areas on the right and left bank of the Scheldt and also for the construction of the embankment and foundations of highways.

Now, all areas on the right bank North of Antwerp are reclaimed.

Within the framework of the Deltaworks the Netherlands have utilized several mio cum of fill from dredging for the reinforcement and raising of their dikes. Belgium is doing the same in the framework of its Sigma plan.

However the greater part of the dredged sand is dumped in the river, by preference in the flood channels, in order to guide the current through the main channel and avoid oblique currents over the bars.

Sand has also been dumped in the very deep areas or the deepest parts of the main channel and also along some banks to stop erosion and to increase the radius of the main channel in bends. It is not only for economic reasons that the reclamation is limited. Indeed, excessive evacuation of spoil from the bed of the river would harm the dynamic equilibrium of the river system. For that reason the annual volume evacuated is now limited to the estimated amounts of solids conveyed by the sea and deposited in the riverbed.

5. THE NAVIGATION TO THE PORT OF ANTWERP

5.1. The Treaties on the Scheldt navigation

When after the insurrection in 1585 against the Spanish domination and the secession of the Northern and Southern Netherlands the Scheldt was blocked up by Holland and Sealand, the golden age of Antwerp as a port and commercial center came to an end.

Only during the French occupation (1795-1815) and the following period of the United Kingdom of the Netherlands (1815-1830) the blockade had been raised. In 1830 after the Belgian revolution the Dutch again closed the river Scheldt. In 1839 in the treaty of London the sovereingty of the Belgian State was recognised and special stipulations were inserted about the navigation on the river Scheldt.

Free navigation on the river Scheldt for all nations was granted, but the Netherlands were allowed to levy a toll on all passing vessels. The year 1863 brougt the redemption of the toll by the nations with trade interests in Antwerp.

As a consequence of the Treaty of London a common superintendence on pilotage, buoyage, navaids and the maintenance of the channels in the river Scheldt, was instituted.

The supervision is performed by special named Permanent Commissaries (2 Belgians and 2 Dutch) for the supervision on Scheldt navigation.

After the second world war a Technical Scheldt Commission also has been set up by both governments in order to study all technical problems related to navigability on the river, the morphology, the movement of the channels, sand banks etc. The commission consists mainly of engineers and seamen representing the proper ministries of both governments.

5.2. The development of the maritime transport

During the last twenty years spectacular developments have occured in the marine transport sector. These developments are related to the increase in the sizes of the vessels and the techniques of transport and cargo handling. The increase in the amounts of cargo shipped over sea and the need to reduce the transport cost were determining factors for the increase in the size of the vessels.

Higher wages, rising maintenance and operating costs have definitively influenced cargo handling techniques. New techniques have been introduced such as pallets, containers, lash, Ro-Ro etc. The purpose of all these techniques is to reduce the port time of the vessel and the cost of cargo handling. This has resulted in the development of ultra fast vessels. Developments in cargo handling techniques and the operating costs of the vessels compel shipowners to adhere to strict time schedules. Departure time is determined by smooth and efficient loading and unloading of the cargo and port time is often reduced to some hours.

Even small delays can disorganise the sailing schedules of these new vessels. For that reason, it is necessary that the arrival and departure of such vessels is given top priority or better for the vessels to sail independently of the height of the tide.

The dimensions of these ships have been developed and stabilized. The largest are third and fourth generation container ships. The ascent of the Scheldt is nearly always possible for those vessels the descent is not possible for full laden vessels at some moments of the tide.

Transport of bulk materials such as ore, coal and grain is done for the same reasons with larger and specially built ships.

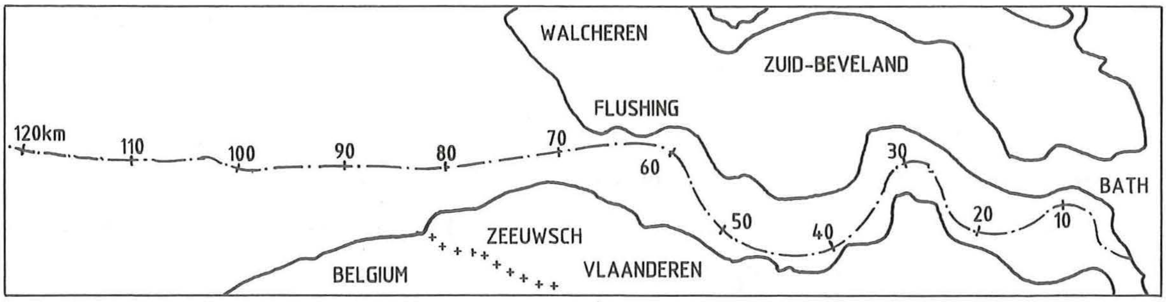
This trend is promoted by some additional factors such as deepening of the ports of departure, the price of fuel and the reduction of the economical cruising speed. Some years ago most bulk carriers measured 75 - 80.000 DWT. Now, a tendancy is appearing for bulk carriers of ca 150.000 DWT with a loaded draught of 55' feet. Such vessels cannot navigate in the Scheldt fully loaded.

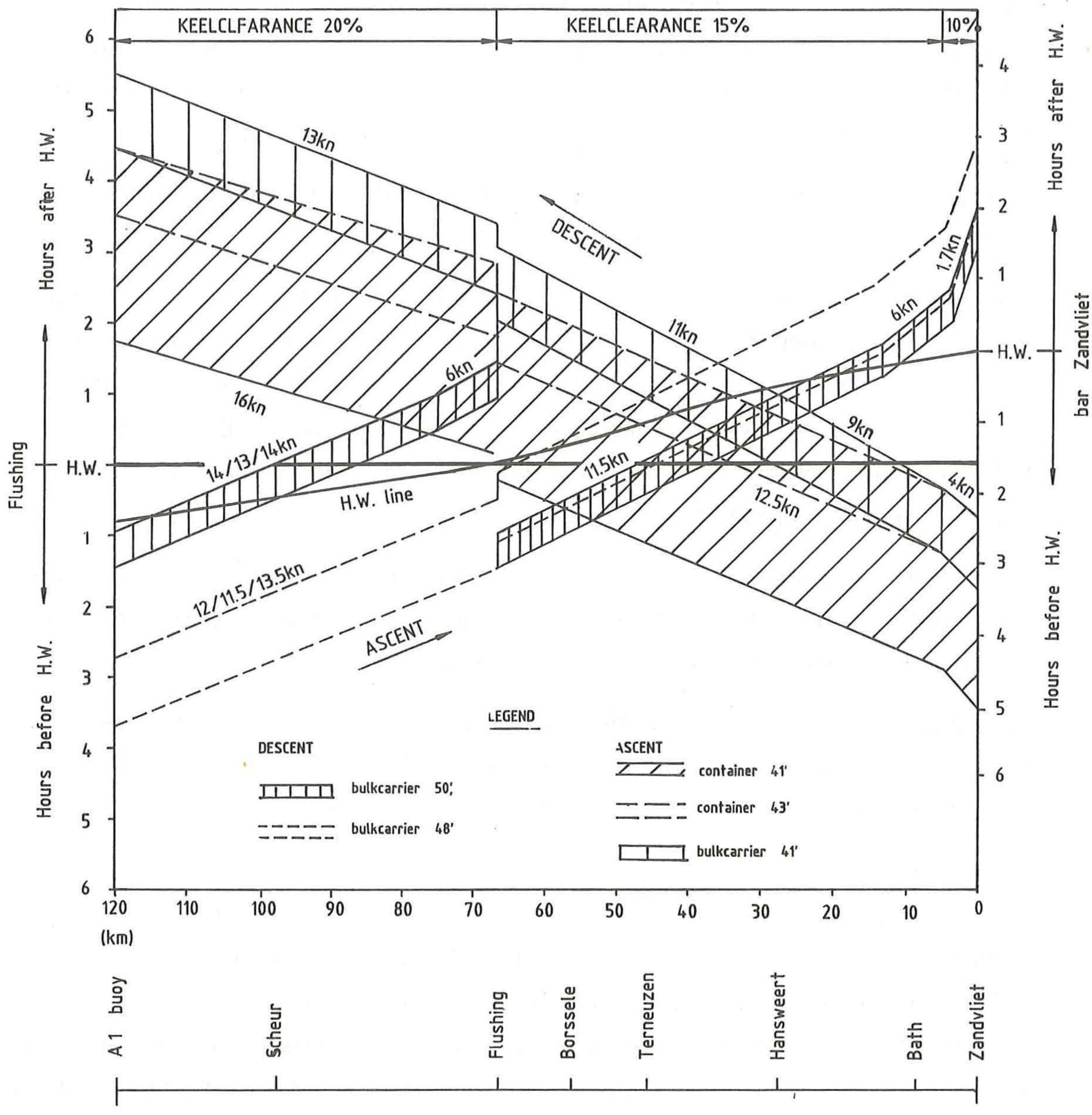
Partlial transsshipment of cargo into barges in the Put van Terneuzen or the flood channel of the Everingen is not economical and for that reason this trade is often diverted to other ports.

An increase of the waterdepth with a few feet will allow the passage of partly loaded, very large bulk carriers (150.000 - 230.000 DWT) to Antwerp and allow them to deliver and discharge their cargo on a more economical scale.

A deepening of the Scheldt and its access channels is proposed allowing in-bound passage for bulk carriers of a draught of 48 to 50 feet with a wider time margin and under all tide conditions, and the out-bound traffic for full laden third and fourth generation containers. This deepening will not only strengthen the competitive position of Antwerp but will also positively affect the Belgian economy.

NAVIGATION DIAGRAM





5.3. The actual possibilities of the navigation

Vessels with a deep draught try as much as possible to take advantage of the tidal height. The ideal solution would be that upbound vessels could follow the speed of the tidal wave, especially the transit speed of the top of the wave and take advantage of the greatest depth on each bar.

This however is impossible as the top of the tidal wave moves at a speed unattainable by navigation. Indeed, between Flushing and the lock of Zandvliet, the average speed is about 60km/h or 32 knots.

A vessel normally sails on the Western Scheldt at a speed between 9 and 15 knots. In other words, the navigation has to accept a compromise based on the actual height of the tide at the time of passage, the depth over the bar, the speed and the draught of the vessel.

In order to get maximum profit from the tide, the Maritime Services have computed navigation diagrams based on the local tidal conditions and the momentary surface profiles. These diagrams allow us to evaluate wether the ascent or descent of a large draught vessel is possible. They also provide estimates of the time margins that allow to calculate the ideal departure and arrival times taking into account the speed and the draught of the vessel. Owing to the intensive dredging and the use of these diagrams the navigation with large draught vessels has considerably improved.

In the beginning of the seventies, the maximum draught allowed on the passage Flushing to Antwerp was limited to 40 feet.

Now, on the same river section, ships with a draught of 45 upto 49 feet are under favourable tidal conditions transiting for Antwerp. The tonnage of the ships bound for Antwerp has increased accordingly. Many of these larger bulk carriers bound for Antwerp are sailing with a reduced draught, as they are partially discharged in another port.

On the diagrams, we see that large draught vessels leave Antwerp or Zandvliet against the tidal current. In order to reach Hansweert at high water, downstream of Hansweert the tide is falling and the vessel will arrive at the buoy A-1 nearly at low water. Consequently the further we are away from Hansweert the less tidal depths we encounter. Bound for the sea, the allowable draughts have increased from 36 to 41 feet. The draught of vessels sailing independently of the tide has increased to 34 feet. Despite of this the present possibilities are still insufficient for todays maritime trade.

5.4. Projects

A programme for the optimum improvement of the approach to the port has been developed by the Technical Scheldt Commission and awaits the final approval by both Governments.

5.4.1. The 48'43' program

This scheme consists in a deepening through dredging of the Scheur and the Western Scheldt between Flushing and Zandvliet. This deepening programme would mean that under all tidal conditions the ascent of the channel in one tide becomes possible for a bulk carrier with a draught of 48 feet and with a tidal window of 1 hour and in 2 tides for a bulk carrier with 50 feet draught with a tidal window of 1/2 hour. The arrival at Zandvliet would occur 1-2 hours after local high water.
At the same time, the descent of the Scheldt to the buoy A-1 would become possible in one tide for bulk carriers with a draught of 41 feet with a tidal window of 1 hour.
For containers with a draught of 41 feet, respectively 43 feet, a tidal window of 3 respectively 1 hour would become reality.

Finally the maximum draught of vessels sailing independently of the tide would be increased from 34 to 38 feet.

5.4.2. The Baalhoek lock

The full development of the left bank of the port of Antwerp will only be possible with the construction of a larger lock complex connecting the port with the Western Scheldt.

The site of Baalhoek on Dutch territory, situated downstream of the troublesome bend of Bath has been chosen. The lock would have the same dimensions as the Berendrecht lock and would be connected with the port by a 4 km long canal on Dutch territory.

5.5. Shore Radar Chain

Within the framework of the improved navigability of the river Scheldt, the Belgian and Dutch Government concluded a treaty to set up and extend a complete fixed shore radar chain covering all the access channels to the different ports in the estuary. The chain will be fully operational by 1990.

The data recorded by the radar sensors and all traffic information will be processed by computers. This computer aided Vessel Traffic Control System will largely improve the safety and the flexibility of navigation under all weather conditions.

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