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Evaluation of the Management of the Eastern Scheldt Barrier

Evaluation de l'exploitation du barrage sur l'Escaut oriental

Einschätzung des Managements der Osterscheldebarriere

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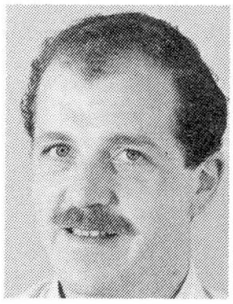

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SUMMARY

Recognition of the ecological value of the Eastern Scheldt has resulted in the construction of a storm-surge barrier instead of a solid dam to provide protection against flooding. The desire to safeguard the ecological features of the area played an important part during the implementation of the Eastern Scheldt project. Efforts have also been made to strike a balance between safety, ecology and the wishes of sections of the public and industry in the management of the area and the storm-surge barrier. A study is currently being carried out to evaluate whether adjustment of the management plans is necessary or desirable in the light of the current situation.

Evaluation de l'exploitation du barrage sur l'Escaut oriental

Résumé

La reconnaissance de la valeur écologique de l'Escaut oriental a eu pour conséquence la construction d'un barrage contre les raz-de-marée au lieu d'une digue solide en vue d'une protection contre les inondations. Le désir de garder les caractéristiques écologiques de la région a joué un rôle important durant l'étude du projet. Des efforts ont été réalisés pour obtenir un équilibre entre la sécurité, l'écologie et les désirs de l'opinion publique et de l'industrie. Une étude est actuellement en cours pour évaluer si une adaptation des plans d'exploitation est nécessaire ou désirable à la lumière de la situation actuelle.

Einschätzung des Managements der Osterscheldebarriere

Zusammenfassung

Aus der Erkenntnis des ökologischen Wertes der Osterschelde hat sich die Konstruktion einer Sturmflutbarriere anstatt eines soliden Damms ergeben, um Schutz vor Ueberschwemmung zu bieten. Der Wunsch, die ökologischen Merkmale des Gebietes zu sichern, spielte eine wichtige Rolle während der Studie des Osterscheldeprojekts. Es wurden auch Anstrengungen gemacht, ein Gleichgewicht zwischen Sicherheit, Oekologie und Wünschen der Oeffentlichkeit und der Industrie in der Bewirtschaftung des Gebietes und der Sturmflutbariere zu treffen. Kürzlich wurde eine Studie angefertigt, um abzuschätzen, ob eine Regelung des Bewirtschaftungsplans im Lichte der laufenden Situation notwendig oder wünschenswert ist.

1. INTRODUCTION

The aim of the Delta Project was to safeguard the southwestern Netherlands against flooding by damming a number of estuaries. At the end of the 1960s, the importance of the rich ecological diversity of these areas began to be recognised and there were increasing calls for this factor to be taken into account in the further implementation of the Delta Project. Attention focused mainly on the Eastern Scheldt, since the other estuaries had either already been dammed or were to be dammed in the near future. As a result of the strong lobbying by nature conservationists and fishermen and on the basis of extensive studies of the technical options and their ecological consequences, the Government decided in 1976 to build a storm-surge barrier in the Eastern Scheldt and to construct two secondary dams in the east (Fig.1). This decision led to fresh insights into the management of both the Eastern Scheldt and the storm-surge barrier itself. The contribution by environmentalists was essential. During the implementation of the Eastern Scheldt project, too, consistent efforts were made to strike a balance between technically feasible, environmentally desirable and socially acceptable solutions to the many problems associated with carrying out a hydraulic engineering project on such a scale.

It was recognised that following the completion of the project, many unforeseen changes would occur in the Eastern Scheldt. This is why the management plans for the area and for the barrier itself include procedures allowing the plans to be modified and adjusted; studies are also being carried out to ensure that any changes are identified promptly and their policy implications indicated.

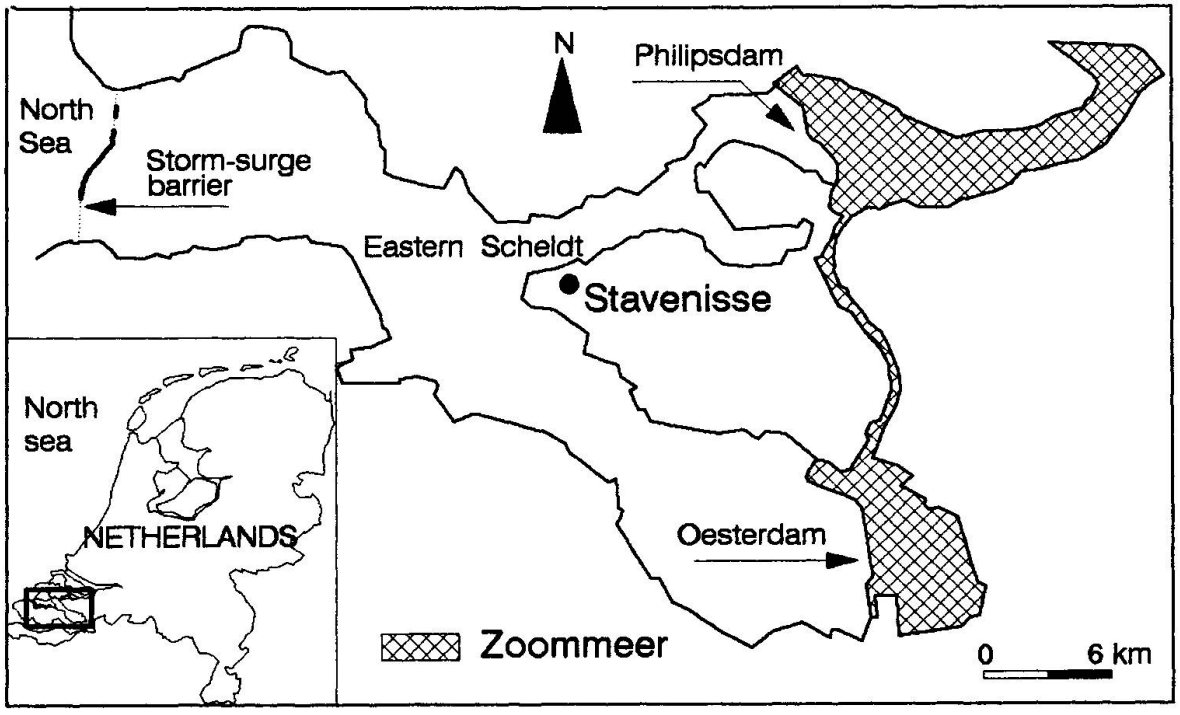

Fig. 1 The Eastern Scheldt Area

2. THE EASTERN SCHELDT PROJECT

2.1. The Eastern Scheldt Barrier

In April 1987 the Eastern Scheldt Project [1] was completed. The main parts of this project were the construction of the storm-surge barrier in the mouth and two secondary compartment dams, the Oester dam and the Philips dam, in the eastern part of the Eastern Scheldt.

The storm-surge barrier was constructed at the mouth of the Eastern Scheldt to safeguard the surrounding region against flooding while preserving the unique saltwater tidal environment that existed in this area. A total of 65 piers were positioned in the three tidal channels known as the Hammen, Schaar and Roompot. Gates were installed between the piers, which are normally kept open but which are lowered if there is a threat of dangerous storm surges. The construction of the storm surge barrier resulted in the opening at the mouth of the Eastern Scheldt being reduced from 80,000 m^2 to about 18,000 m^2.
The Philips dam and Oester dam are intended to guarantee a sufficient difference between low and high water when the storm-surge barrier is open, despite the fact that the mouth of the Eastern Scheldt estuary has been reduced in size. The area behind the dams has now become non-tidal, which complies with the requirements of the Dutch-Belgian Treaty concerning the shipping route between the two countries. In order to improve water supplies for agricultural purposes, a freshwater lake - Zoommeer - was created at this location.

2.2. A Policy Plan for the Eastern Scheldt

After the change of mind regarding the way in which the Eastern Scheldt should be closed it was very soon recognized that a coherent plan would be needed for the management and the development of the area. Various sectors of government policy are involved, and the relevant powers are shared among the three tiers of government (central, provincial and municipal). In order to produce a joint policy for the Eastern Scheldt a broadly constituted steering group was established (the Eastern Scheldt Steering Group), which formulated the following objective for the development and management of the estuary: "the conservation and if possible strengthening of the existing natural features and functions of the area, with due regard to the public and economic interests - notably including fishing - concerned". The pursuit of this objective must not be allowed to have any adverse effects on the primary objective of the Delta Project: the safety of the people living in the area. All the administrative levels supported the policy plan, and it thus became binding. This means that the Steering Group has to be consulted before new activities can be undertaken or existing ones can expand.
Now that the storm-surge barrier has been completed, many environmental changes will occur which cannot be predicted with certainty; this is an important aspect in any consideration of the estuary's potential. Due to these uncertainties the policy plan for the Eastern Scheldt has a flexible nature and can be adjusted if ecological evaluations or changes in public and economic interests require it. As provided for by the policy plan for the Eastern Scheldt this amendment procedure is a system of yearly progress or evaluation reports. These reports include the following elements:

1. a survey of the developments which have taken place in the year;
2. the research results relevant to the policy plan;
3. a summary of the necessary changes or adjustments to policy which are needed in the light of points 1 and 2.

The policy plan that was finalized in 1982 sets out the broad outlines of the policy to be followed regarding the various potential uses of the estuary and the possible means of effecting them. Of particular importance is the management of the storm-surge barrier itself. The various closure strategies needed to be evaluated in the light of their potential impact on the environment, so that a management plan could be prepared which meets the requirements of both safety and conservation. Before such a management plan could be drawn up, it was necessary to have a proper understanding of the nature and functioning of the ecosystem of the Eastern Scheldt.

2.3 Environmental Research

The decision to construct a storm-surge barrier in the mouth of the Eastern Scheldt was intended not only to guarantee safety but also to preserve the natural features and fishing interests of the area. This naturally meant that environmentalists would be involved in the project's implementation, especially since many decisions still had to be taken concerning, for example, the size of the wet cross-section of the storm-surge barrier, the location of the compartmentation dams, the date on which these dams should be completed and the manner in which this should be done. Since the necessary environmental knowledge was almost entirely lacking, an extensive research programme was set up by the Rijkswaterstaat and a number of scientific institutes.

Hydraulic studies in particular were carried out to support the project's implementation. In addition, a programme was drawn up for the periodic approval and adjustment of the policy plan, comprising the following elements:
a. the new basic situation which will arise as a result of the construction of the storm-surge barrier and the compartmentation dams;
b. the potential for the development of the fishing industry;
c. the development of the recreational use of the area;
d. the impact of human activities on the environment;
e. possible and desirable management measures and their effects.

Research was also conducted to facilitate the management of the Eastern Scheldt Barrier, concentrating on the effects of the barrier's closure on dykes and salt marshes in relation to the length of time it is closed and the water levels in the estuary.

The above-mentioned studies were more or less specific project studies and were based on general research into the various types of environment in the Eastern Scheldt and the changes which would occur in them after the completion of the storm-surge barrier. The principal research aspects were the morphology of channels and shallow areas, the impact of changes in the duration of flooding on the salt marshes, the basic food chain and organic communities, such as those living on the hard substratum.

3. MANAGEMENT AND MONITORING

3.1 Interim Management Policy for the Eastern Scheldt Barrier

During the completing stage of the project, from July 1985 to April 1987, the reduction of the tidal motion has been much stronger than the present final reduction [2]. The reasons for this extra reduction were:
1. the secondary dams were closed after completion of the storm-surge barrier;
2. during the completion stage of the barrier and the final stage of construction of the secondary dams the tide was reduced by the completed parts of the storm-surge barrier; the tidal reduction during the final stages of the closure operations of the dams, allowed the remaining closure gaps to be completely filled in with sand, which yielded a saving of 80 million guilders.

During the planning stage for the construction work several different options were considered, although the degree of freedom was limited among other things by the following agreed principles:
1. the lowering of a number of gates in the storm-surge barrier during the period from November 1985 to October 1986 would be permitted, to allow certain work to be completed;
2. the storm-surge barrier was to be used to reduce the flow velocities during completion the Oester dam and Philips dam;
3. the Philips dam could not be completed before the Oester dam, for hydraulic

engineering reasons, since this would have resulted in excessive flow velocities in the Scheldt-Rhine Canal;
4. the completion of the Oester dam and Philips dam had to be carried out in different years to allow a better phasing of the capital expenditure on the project.

A number of boundary conditions were subsequently formulated based on a detailed understanding of the environment in the Eastern Scheldt, which were intended to minimise the potential damage the construction work might cause:
1. the mean tidal range at Stavenisse was not allowed to drop below 2.30 m, which meant that up to about 4,200 m^2 of the open area of the barrier could be closed, except during the final phase of the construction work, when the entire barrier was closed for short periods;
2. during the final phase of the dam's construction, the barrier was not to be completely closed for longer than two days.

After extensive discussions it was agreed that spring or autumn would be the most acceptable periods for the completion of the Oester dam, and the Philips dam, both from an environmental point of view and in the interests of the fishing industry in the area.
Although extensive investigations had been carried out prior to the hydraulic engineering work in the Eastern Scheldt and assessments had been made of the environmental implications of such operations, it was not possible to give firm guarantees that permanent damage could be avoided. The major uncertainties concerned the weather and the possibility of setbacks occurring in the engineering work. This meant that the situation had to be reconsidered at each a stage of the project. A close watch was therefore kept on developments in the estuary to ensure a ready supply of up-to-the-minute information for making the necessary decisions.

During the change-over phase from the original to the new tidal situation, a large number of parameters were carefully monitored. This monitoring exercise was primarily intended to serve as an early warning system. More detailed investigations were instituted if it was discovered that readings from the field lay outside the natural variations in the original conditions.
Observations and measurements were taken on a more or less continuous basis during the final stages of the construction of the compartmentation dams. The information that was collected was processed and interpreted at once, so as to allow immediate corrective action to be taken if necessary. The way in which the storm-surge barrier was used was modified several times as a result of these observations. For instance, during a later construction phase, a severe storm took place which coincided with the completion of the Oester dam in October 1986. As a result delays were encountered at a time when the tide had already been greatly reduced. It was observed that birds were no longer foraging in the extremely inclement and cold weather conditions, while at the same time the size of the feeding grounds had been severely restricted. Under these circumstances, a significant increase in the mortality rate among the birds was anticipated. It was therefore decided to deviate from the original planning and temporarily reduce the water level in the Eastern Scheldt before starting work on the final stage of the dam's construction. This greatly increased the availability of foraging areas with an adequate supply of food and led to the birds making effective use of the opportunity presented.

The fact that the secondary dams were completed later than the storm-surge barrier caused only a few adverse effects on the environment. Parts of the salt marshes in the Eastern Scheldt suffered some damage as a result of dehydration in the summer of 1986. Changes in the soil structure due to drying-out and settling were reported in some places.

3.2. Management of the Storm-Surge Barrier

Under normal circumstances the storm-surge barrier remains open to allow water to flow in and out freely. The barrier is closed only if the expected water level exceeds a predetermined "predicted critical level" [3]. In such a situation the actual water level in the North Sea will continue to rise until the storm surge has reached its peak. Meanwhile the water in the Eastern Scheldt will become virtually semi-stagnant. It has been decided to adopt a predicted critical level of Mean Sea Level (MSL) + 3 m for a period of several years, in order to evaluate the system. During this period there will be an opportunity to gain some experience in operating the barrier.

The decision to close the barrier will be based on a predicted water level. This will allow the authorities to fix the desired water level in the Eastern Scheldt by choosing the appropriate moment to close the barrier. In the case of storm-surges that peak more than once, the water level in the Eastern Scheldt could remain stagnant during the whole period of the storm if the barrier is kept closed. It is also possible to open the storm-surge barrier after the first and second high water peaks and to close the barrier again before the next high water occurs, thereby fixing a new water level in the Eastern Scheldt. The various management strategies based on these options have been examined in detail with regard to safety. Some of the strategies did not comply with the required safety level specified for this region. A final choice between the remaining options that satisfied the required safety criterion was made on the basis of environmental concerns and of the likely impact on fishing in the area.
After analyzing the various strategies, it was concluded that the alternating mode of operation offered significant advantages in terms of the environment and the preservation of fishing interests, as compared with other strategies based on the maintenance of fixed levels. This led to the 1-2-1 alternating strategy (1st peak: inner level MSL + 1 m; 2nd peak MSL + 2 m; 3rd peak: MSL + 1 m) being adopted as the basis on which the system would be operated. It was anticipated that this mode of operation would prevent serious erosion occurring in the intertidal area, since such phenomena are mainly associated with water levels close to MSL. Furthermore, this strategy should limit the amount of disruption caused to the environment by parts of the salt marshes being washed away.

It is also possible to close the Eastern Scheldt Barrier for reasons other than safety, as was done during the completion of the Philips dam and Oester dam. Following a thorough analysis of these reasons, it was decided to pursue a very restrained policy in this regard, mainly in view of the provisions of the policy plan. The Eastern Scheldt Barrier will be closed entirely or partially only to prevent disasters, e.g. following dyke subsidence or serious storm damage.

4. EVALUATING THE NEW SITUATION

During the period April 1987 to April 1991 an assessment is being made of the effects of operating the storm-surge barrier and the presence of a new infrastructure. The aim of this evaluation is to consider the main aspects of water management and safety in relation to the original forecasts.
The safety evaluation is concentrating on the strenghth of the barrier and the dykes, and the wave forces acting on them during the period of closure for flood protection. In the period from 1 May 1987 to 1 December 1990 the Eastern Scheldt Barrier was closed (Table 1.) several times to prevent excessive water levels in the estuary (Fig. 2).

date	expected waterlevel sea side	highest waterlevel sea side	highest waterlevel Stavenisse	maximum duration of stagnancy
861218	MSL + 2.85 m *	MSL + 2.73 m	MSL + 1.03 m	6 hours
861219	MSL + 2.85 m *	MSL + 2.71 m	MSL + 0.97 m	5.2 hours
890214	>MSL + 3 m	MSL + 3.17 m	MSL + 1.60 m **	5.5 hours
900227	MSL + 2.98 m	MSL + 3.17 m	MSL + 1.02 m	6.5 hours
900227	MSL + 3.40 m	MSL + 3.69 m	MSL + 2.06 m	3.2 hours
900228	MSL + 3.14 m	MSL + 3.25 m	MSL + 1.06 m	6 hours
900301	MSL + 3.00 m	MSL + 3.25 m	MSL + 1.07 m	6 hours

* predicted critical level of MSL + 2.75 m
** prediction was not available in time

Table 1 Closures of the Eastern Scheldt Barrier during storm surges

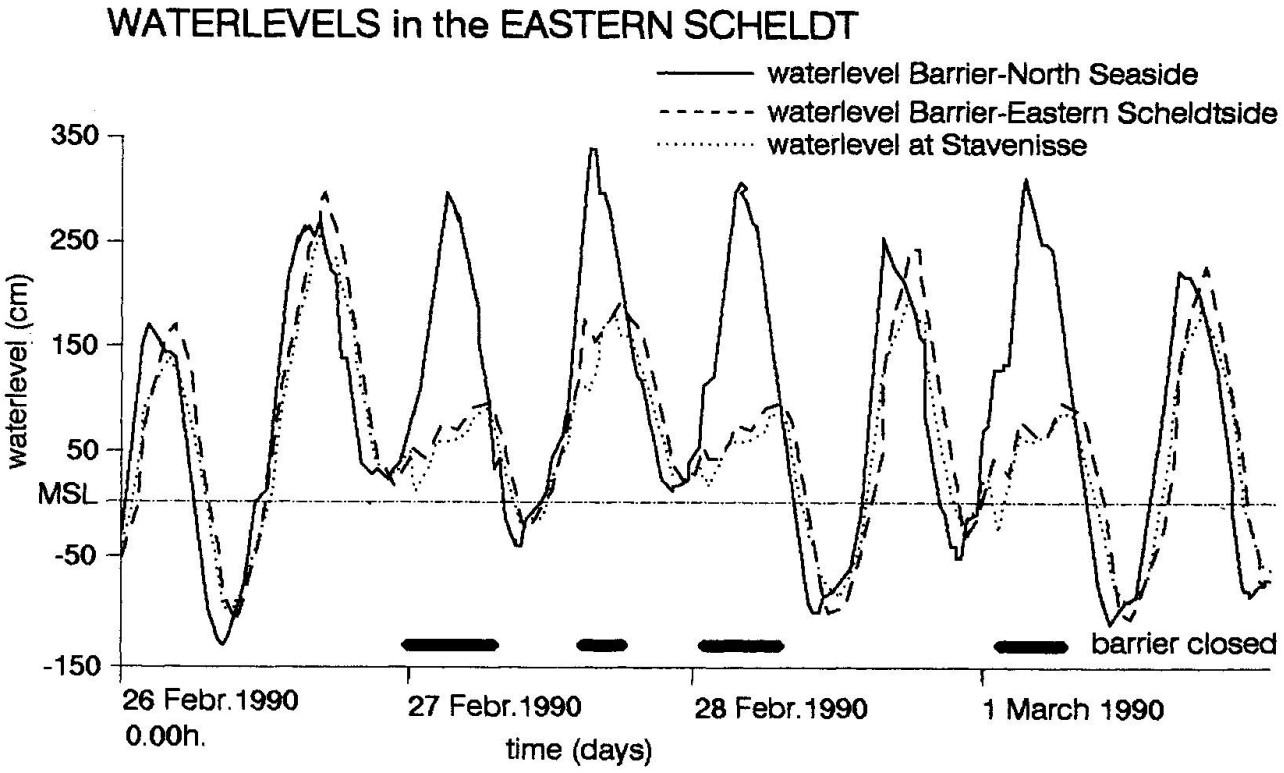

Fig.2 Water Levels in the Eastern Scheldt during storm-surges.

Following each period in which the storm-surge barrier was closed, civil engineers and environmentalists carried out observations to ascertain whether dykes, intertidal areas and fishing areas had sustained greater damage than they would have done if the barrier had not been closed. So far there is no evidence that this is the case. These observations form part of an extensive monitoring programme, which carefully follows the development of the ecosytem towards a new state of equilibrium. Research is aimed at verifying earlier predictons (Table 2) and at adjusting earlier models. The physical circumstances which are evaluated are changes in water movement, salinity and the bed.

aspect	before 1987	expected	measured after 87
total area (km^2)	452	351	351
waterarea at MSL (km^2)	362	304	304
intertidal areas (km^2)	183	109	118
salt marches (km^2)	17.2	6.4	6.4
cross-section of mouth of Eastern Scheldt (m^2)	80,000	16,500	17,600
average tidal range at Stavenisse (m)	3.7	3.1	3.28
maximum flow velocity (m/s)	1.5	-	1.0
residence time (days)	5-50	10-100	10-150
average tidal volume (m^3*10^6)	1230	880	880
freshwater discharges (m^3/s)	70	40	10
salinity (g Cl^-/l)	15.5-17.5	-	16-18

Table 2 Changes in the Eastern Scheldt

The monitoring programme also focuses on the biological components of the ecosystem. The results largely correspond to predictions. It should be noted, however, that the evalution period is fairly short; changes such as the adaptation of channels to the new hydraulic situation and related developments in intertidal areas and salt marshes proceed very slowly. Many consequences for the biological component of the ecosystem will only become visible in the longer term. Constant monitoring therefore remains a necessity. On the basis of the evaluation which is now almost complete, recommendations will be formulated as to how the Eastern Scheldt Barrier should be used, the type of policy needed to develop specific functions in the area and the requirements for future monitoring of the water system.

5. CONCLUSIONS

The decision to construct the Eastern Scheldt Barrier has led to greater knowledge about the area and the storm-surge barrier itself. Ecological features played a prominent role in the decisions made on this matter. During the change-over from the old to the new tidal regime no large-scale damage occurred to the environment or the fishing industry, despite the fact that the storm-surge barrier was used to modify the water movements in the estuary so as to facilitate part of the construction work. Use of the barrier for this purpose led to considerable savings in time and money. Detailed understanding of the ecology of the Eastern Scheldt together with effective environmental safeguards allowed the risks to the environment and fishing industry to be reduced to acceptable proportions. In this way, long-term ecological research can be seen as having yielded direct benefits for society since it enabled work to be carried out more cheaply without harming the environment. Studies need to be conducted to enable management plans for the area or the Eastern Scheldt Barrier to be modified, should the situation require it.

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