rijkswaterstaat

deltadienst

nota DDRF-77.158

Policy Analysis of Easternscheldt Alternatives

May 1976

CONTENTS

Chapter I

INTRODUCTION.

The decision about the Easternscheldt is characterized by the great importance of factors which cannot be expressed in terms of money and in some cases are not even quantifiable. These factors have not only been decisive for the decision of the Government in 1974 but will also play a decisive role in the decisions in the future.

The analysis which is now before you intents to offer a systematic reconnaissance of the consequences which will be the result of certain decisions about the Easternscheldt for all kinds of aspects of society.

Interested groups and persons will then be in a position to express their preference for those decisions which correspond most with their own evaluations. This Note will certainly not accomplish that only one specific alternative will be chosen unanimously. It tends, however, to make the problem look more or less alike to all parties concerned. In this way a discussion can be started about one and the same problem and not, without knowing it, about a great number of different ones.

This policy-analysis, drawn up in cooperation with the Rand Corporation of Santa Monica (USA) still shows many deficiencies. Due to the limited time for study (12 months) it was not possible to apply the techniques suggested by Rand in an inter-departmental team, which in fact is essential. Although efforts have been made to produce an understandable and easy to follow presentation, also in the research-period there was not sufficient time available to organise the information in such a way that it could be incorporated with minimum efforts. On the other hand an attempt has been made, to reproduce in the Note the problems and the consequences of each of the alternatives as objectively as possible (1).*

* Figures between brackets refer to the summary of literature.

The frame-work of the decisions contains a number of elements which will be briefly explained hereafter. About the purpose of the works in the Easternscheldt there is little difference of opinion. These works are primarily directed towards providing Zeeland with the safety promised in the Delta Act. At the same time, however, one must see to it that the costs - and in a broad sense therefore also the consequences for the environment, fishing, shipping, etc., etc., - remain as low as possible. There are various possibilities, the so-called alternatives in the policy-analysis, to achieve this objective. Each alternative for the protection of the area around the Easternscheldt against floods consists of a number of interventions which are of direct importance to the objective in view or indirectly necessary in order to make the newly created system function as well as possible. Due to the fact that each alternative consists of a great number of components quite a lot of alternatives are possible. For example: storm surge barriers with openings of various dimensions combined with different ways of compartmentation.

In view of the fact that for each alternative the consequences, the effects in a number of fields will have to be reviewed, it is necessary to limit the alternatives to a small number only. The following alternatives have been studied:

- Closure of the Easternscheldt and compartmentation with the Philipsdam and Wemeldingedam (D4) **
- Closure with a storm-surge barrier and compartmentation with the Philipsdam and Oesterdam (C3).

** The code for the alternatives corresponds with that of the Committee Oosterschelde.

- Open Easternscheldt with a heightening of dikes and compartmentation with the Philipsdam and Oesterdam (A3)*

These alternatives are further discussed in Chapter 2. The employed method makes it possible to study also other alternatives which deviate on one or more points from the main alternatives. The effects of each alternative are felt in a great number of fields which are brought together in the following categories:

- security
- environment
- fishing
- watermanagement
- shipping
- recreation
- costs, duration and execution
- economy and environmental planning.

Efforts have been made to establish the effects which each of the possible alternatives could have on these various fields as clear as possible and to present them in the most surveyable way.

The used norms differ per field. For the environment for example the variety of species and the total quantity of the biomass have been chosen as standards. The consequences for professional fishing have been expressed in the possible losses of labour-opportunities in man/years and a possible loss in added value in millions of guilders per year. With all this, one should, however, bear in mind, that it concerns here consequences of works which will be executed in the future and of which the results can never be predicted with certitude. The insight in this matter has been determined by the experience with such interventions in the past, which in the best of cases has been transformed by studies into knowledge in the form of theories or models.

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* The last alternative is not based on an elaborated study of Rijkswaterstaat; it has been based on studies which were made in 1973 by Provinciale Waterstaat of Zeeland (6)

Experience shows, that an analytical decision-model is indispensable for complex problems. A model portrays the reality. It contains the relevant elements of the reviewed problem and the most real relation of cause and effect between them. Depending on the kind of problem the model will consist for example of a system of mathematical equations, a computer-program or a series of drawings. In the analysis under review mathematical models have been used for example to determine the water-levels occurring during a storm and to determine the salinity in the basins. The expectations about future coast-morphology are based on studies of the results of tidal-calculations and the depth charts of the reviewed areas during the past decennia.

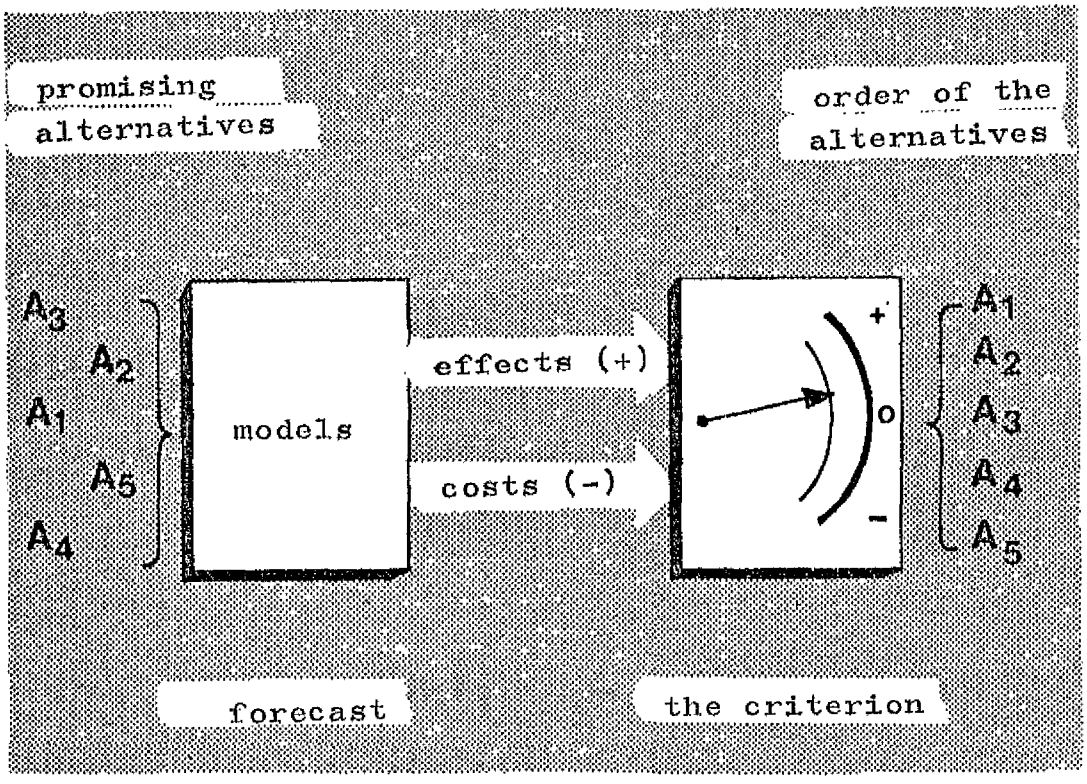


Figure 1. Elements of the frame-work of decisions.

The formal structure of the model provides us with a far better opportunity then an intuitive approach, to consider a great number of factors in a balanced manner and to check our intuition.

One would expect for example that the tide in the mouth of the Easternscheldt would diminish as a result of the construction of the compartmentation dams and would show longer periods of slack-water. Indeed it appears from the study with the model that the velocity of the flood flow decreases; the velocity of the low-tide, however, decreases much less while the periods of slack-water at the mouth of the Easternscheldt for example in the case of the alternative with the Wemeldingedam will decrease rather then increase.

Moreover, the use of models in the policy-analysis facilitates communication through unambiguous terminology and it promotes objectivity, because the user is compelled to make clear the hypotheses he is making in those cases where he is lacking in knowledge. The policy-analysis makes it impossible to conceal these hypotheses.

It is for example insufficiently known under what circumstances a dike will collapse. From experience it is known that the dike in general collapses when the waterlevel comes near the crown of the dike or when continuous overtopping of the waves occurs. There are cases known, however, where dikes collapsed with lower waterlevels and with less overtopping of waves. As far as this collapse-mechanism is concerned one makes assumptions which can be checked against the experience with flood-disasters.

Of equal importance to the suppositions about the models to determine the consequences of the alternatives are the suppositions about the developments in our society. One could assume for example that the present situation of unemployment will remain as it is during the next ten years. This and other hypotheses can be laid down in a scenario. A scenario is a description of a hypothetical futural situation in the world. It is the intention that in a scenario only those factors are described, which could influence to a considerable extent the costs or the effects of an alternative. These could be:progress in science and the scarcity of resources, as well as the behaviour-pattern of people, politics and the economic

situation of the Government.
Efforts have been made to reconnoitre the effects of the uncertainties by examining, wherever possible, what the results of the study would be with different hypotheses or scenarios.

For the presentation of the results score-charts are being used, that is a table with a column for each alternative and as many numbers as there are effects. For ease of survey colour has been added as an extra dimension. The order of an alternative with regards to the effect is indicated by a colour-code: green for the alternative with the highest score and red for the alternative with the lowest score. Figure 2 shows a specimen of such a score-chart.

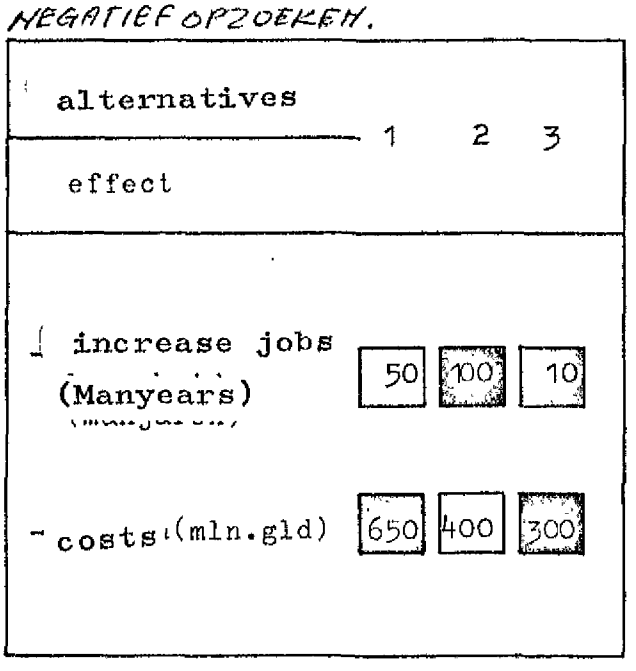
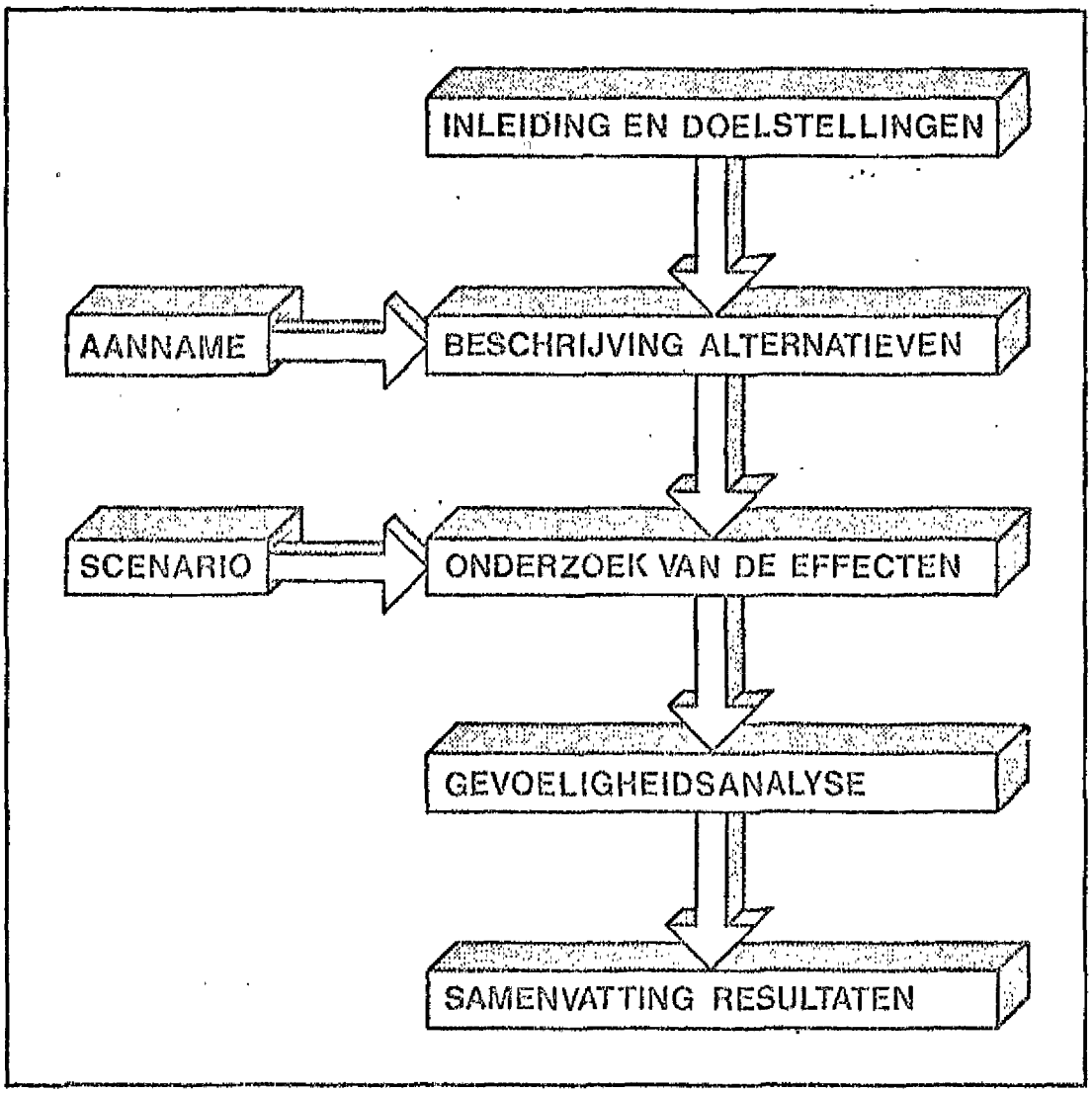


Figure 2. Example of a score-chart.

The following outline shows a further compilation of this Note. Chapter 2 contains a description of the alternatives with the hypotheses. Chapter 3 gives an outline of the effects which the alternatives will bring about in the selected fields as given in the scenario.
Finally, in chapter 4 a broad sensitivity-analysis has been worked out and in chapter 5 the results are being summarised.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Chapter II.

DESCRIPTION OF THE ALTERNATIVES.

2.1. DESCRIPTION OF ALTERNATIVE C3 (Storm-surge caisson dam)

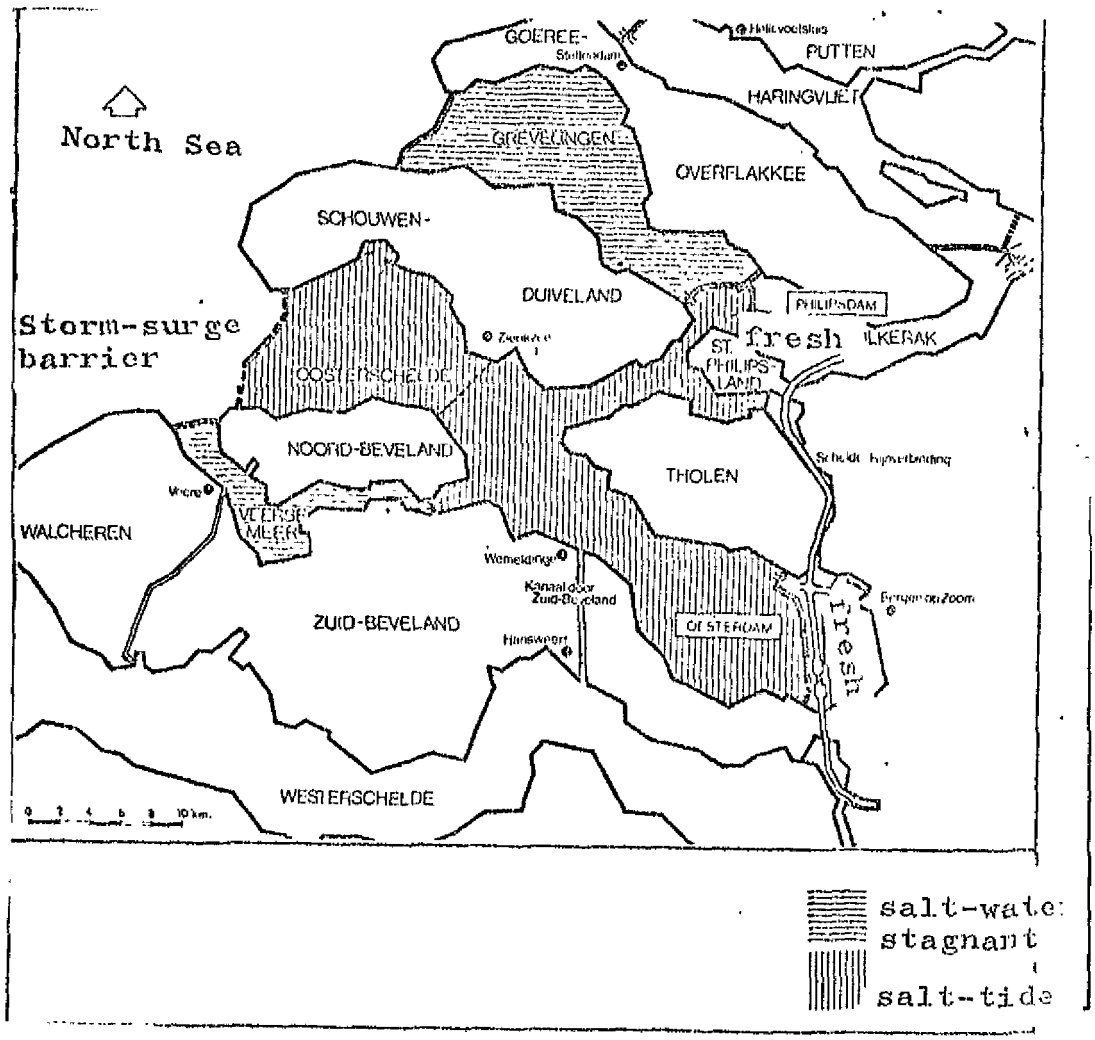


Figure 3. Alternative C3.

Storm-surge caisson dam.

In C3 the Easternscheldt is being closed with a storm-surge caisson dam. The major part of the basin (80%) remains under normal conditions under the influence of the tide. (fig.3) Based on the conclusions and the recommendations in the Final Report Storm-Surge Caisson dam Easternscheldt (10) it has been assumed in this alternative

that the storm-surge caisson dam will be of the type "pillars founded in pits" with a wet-cross section of about 11.500 m2. The average tide-difference at Yerseke is 2,3 m.

Partial heightening of the dikes.

The closure of the Easternscheldt with a storm-surge caisson dam will be finished about 7 years later than the closure conform the original plans. For that reason it was decided to execute a partial dike-heightening in order to augment the safety during the period of construction of the storm-surge caisson dam. As a basis for these dike-improvements an exceedance-frequency of about 1/500 times per year was taken or in other words a chance of about 15% in a life-time of 80 years.

Compartmentation.

If the Easternscheldtwill be closed with a storm-surge caisson dam then there are three reasons why it is necessary to separate the eastern part of the basin by dams from the tidal area:

(1) In the treaty between Belgium and the Netherlands it has been stipulated that the Scheldt-Rhine Canal will be tide-free in the future. The choice of the trajectory is also aimed at that feature. The sill-depth of the locks and the height of the bridges over the Canal have also been designed with that in view. At the same time the disappearance of tidal currents will improve the navigation possibilities for shipping. The provisions for the separation of salt- and fresh-water near the Kreekrak locks indicate the forming of a tide-free fresh-water eastern section of the Easternscheldt.

(2) For the watermanagement of the northern Delta area it is important, that the salt-intrusion via the Volkerak locks will come to an end. If the tide would continue to reach up to the Volkerak locks, then there would be a continuous and undesirable salt-water load on the Haringvliet-Hollandsch Diep.

The fight against salinity and the supply of fresh-water from the northern Delta area will both benefit from the fact that a fresh-water lake will be formed south of the Volkerakdam.
This fresh-water "Zoommeer"(lake) will guarantee at the same time the supply of fresh-water to a part of the southern Delta area in the future.

(3) With a reduction of the tide to 2,3 m at Yerseke, the drainage of the West-Brabant rivers and the polders into the Volkerak would become difficult without compartmentation; in some cases it would even be impossible to take place under natural head-loss.

In april 1975 the C.C.O. (2) reported to the Minister of Transport and Public Works about the various possibilities of compartmentation. In December, 1975, the Government decided, in conformity with the recommendations of the Board of Waterstaat and the National Committee for Town and Country Planning that, in case a storm-surge caisson dam is to be built, the Easternscheldt will be divided into compartments according to alternative C3 - Canal through South-Beveland, from hereon called C3. The eastern part of the Easternscheldt, and the Volkerak, together forming the Zoommeer, will then be separated from the tidal area by two compartmentation dams:

- The Philipsdam through the Krammer, between St. Philipsland and the Grevelingendam;
- The Oesterdam in the eastern part of the Easternscheldt, between South-Beveland and Tholen, immediately west of the Scheldt-Rhine Canal.

The existing Canal through South-Beveland will be improved on behalf of the through-going shipping-traffic between the Westernscheldt and the Volkerak. The locks at Wemeldinge will fall into disuse, so that the total number of lock passages will not be higher than it is now. The reduced tidal basin in the Easternscheldt will now have access to the Canal via a new open mouth at Wemeldinge.
With C3 a number of basins with varying characteristics will be created in the southern Delta area; table 1 indicates

a number of these typical differences.

Table 1. Characteristics of basins with C3.

	type	area on NAP (ha.)	levels
Easternscheldt	salt-tide	31.000	measured tide-difference 2,3m at Yersek
Zoommeer	fresh-water	8.000	almost constant on NAP
Grevelingenmeer	salt-water	11.000	almost constant on NAP - 0,2 m.
Veerse Meer	salt-water	2.000	almost constant on NAP

In the plans for the creation of the Zoommeer it has been assumed that the Verdronken Land of the Marquisate of Bergen op Zoom will be embanked. This ring-embankment would be desirable during the construction of the Oesterdam in order to avoid a troublesome cross-flow for the navigation in the Scheldt-Rhine Canal north of the Kreekrak locks. Later on this sub-compartmentation has the advantage that within this area which is separated from the shipping-route a better environmental management will be possible.

Navigation locks and salt-/fresh-water exchange.

In C3 there are two main shipping routes through the southern Delta area:

- the Scheldt-Rhine connection, between the docks of Antwerp and the Volkerak through the eastern part of the Easternscheldt;
- the route via the Canal through South-Beveland, between the Westernscheldt - the region of Gent-Terneuzen, Sloe-area etc., etc.-and the Volkerak, across the mid-waters Keeten, Mastgat, Zijpe and Krammer.

Navigation via the Canal through South-Beveland must pass the Philipsdam. This route must be suitable for push-tow and "high" navigation. The Philipsdam needs

also a yachting-lock. The lock in the Oesterdam is above all important in order to keep the port of Bergen op Zoom attainable for high (coastal) shipping and yachting. The dimensions of the various navigation-locks in the southern Delta region are in C3 as follows:
Table 2. Dimensions of navigation-locks in C3.

	Number	width	length	salt-/fresh water separation
Philipsdam, push-tow locks	2	24	280	yes
Philipsdam, yachting-locks	1	9	75	yes
Oesterdam locks	1	12	90	yes
New locks Hansweert	2	24	280	no
Kreekrak locks	2	24	320	yes

The consumption of fresh-water of these navigation locks and the inherent remaining salt-loads on the fresh-water Zoommeer are broadly indicated in table 3. These data are based on the assumption that all locks are always working at full capacity. These values are based on model research; they have not yet been tested in practice. The values will increase, if the Philipsdam locks and the Kreekrak locks due to enhanced shipping-traffic will have to be expanded with a third push-tow navigation lock.

Table 3. Loss of fresh-water and salt-loads on the Zoommeer.

	fresh-water loss from Zoommeer (m^3/s)	Salt-load on Zoommeer (kg Cl^-/s)
Philipsdam locks	20	5 to 8
Oesterdam locks	1 to 2	0,1 to 0,5
Kreekrak locks	20	1 to 5

Discharge-medium Zoommeer.

At the southern side of the Zoommeer a discharge-medium onto the Westernscheldt will be necessary; it (the lake) will have to be desalted immediately after closure of the compartmentation dams and after that it can be

flushed from north to south. The Zoommeer will be permanently burdened by salt-loads via the navigation-locks and drainage of the polders. The discharge-medium offers at the same time the possibility to control the contents of nutrients in the water. Also for control of the level a discharge-medium in the Zoommeer will be necessary. In order to be able to maintain an almost fixed level even in extreme wet periods a total discharge-capacity of about 100 m^3/sec. will be required.

Grevelingenmeer.

In it's "Red Note" the National Committee for Town and Country Planning expresses it's preference for a salt-water Grevelingenmeer, this in the interest of a proper aquatic environment. Moreover, a salt-water circular flow from the Grevelingenmeer in C3 is favourable in order to be able to increase the salinity on the stretch Zijpe-Mastgat-Keeten. In this case we also assume that in C3 the Grevelingenmeer will remain salt in the near future.

In order to be able to maintain the grade of salinity high enough - at least at 15,5 g Cl^-/l flushing with seawater will be necessary. Sluices in the Brouwersdam and in the Grevelingendam will make this possible. The duct-capacity of these sluices are designed for approx. 100 m^3/sec.

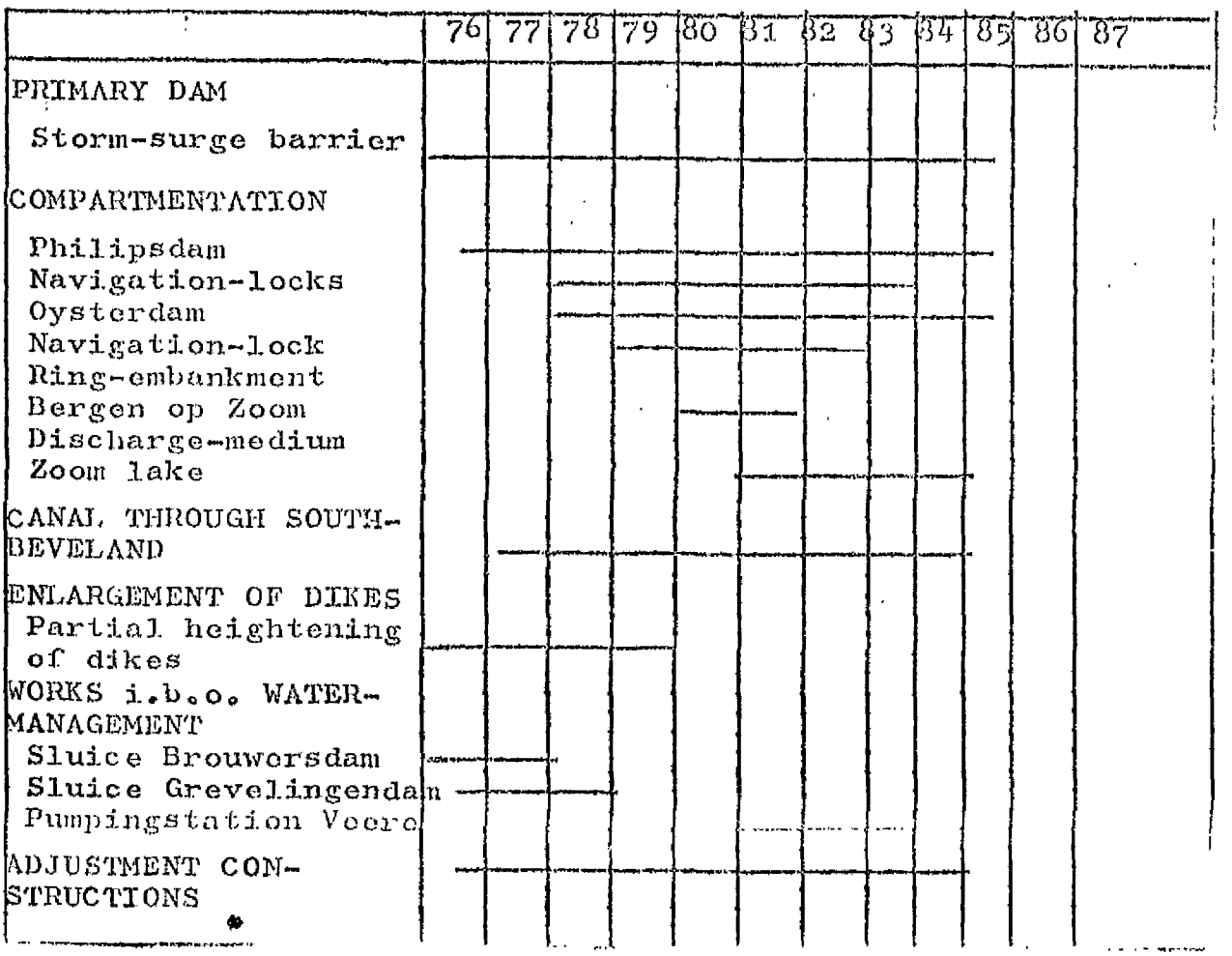
Based on the recommendations of the Board of Waterstaat about the report of the C.C.O. (3, 11) the Philipsdam will be linked with the Grevelingendam in such a way that the possibility remains open to de-salt the Grevelingenmeer completely or partially if for example that would become necessary in order to create a storage-basin for the supply of drinking-water.

Veerse Meer.

From the point of view of watermanagement the now rather brackish Veerse Meer is less attractive. An increase of the salinity in the Veerse Meer can be achieved with a flushing of approx. 20 m^3/sec. from the Easternscheldt via the Canal through Walcheren to the Westernscheldt.

Because the water-level in the Canal through Walcheren averages NAP + 0,9 m., a pumping-station at Veere will be required. Level-control on the Veerse Meer now takes place under natural head-loss via the navigation-locks at Kats. However, with a reduced tide on the Easternscheldt the flushing-capacity of this navigation-lock will probably be too small in wet periods. The relatively small Veerse Meer namely functions as a basin for a rather large drainage area. Via the new pumping-station at Veere the discharge of superfluous water into the Westernscheldt can also take place.
For environmental reasons it is desirable to maintain during the whole year an almost constant level on the Veerse Meer, contrary to the presently used summer-level of NAP - 0,7 m. Further research will have to show whether duration of polder-discharges from the Veerse Meer to the Eastern- and Westernscheldt will be necessary.

Time-schedule C3.



Costs C3.

A survey from January 1st, 1976 onwards of the costs of the most important works is shown in figure 4.

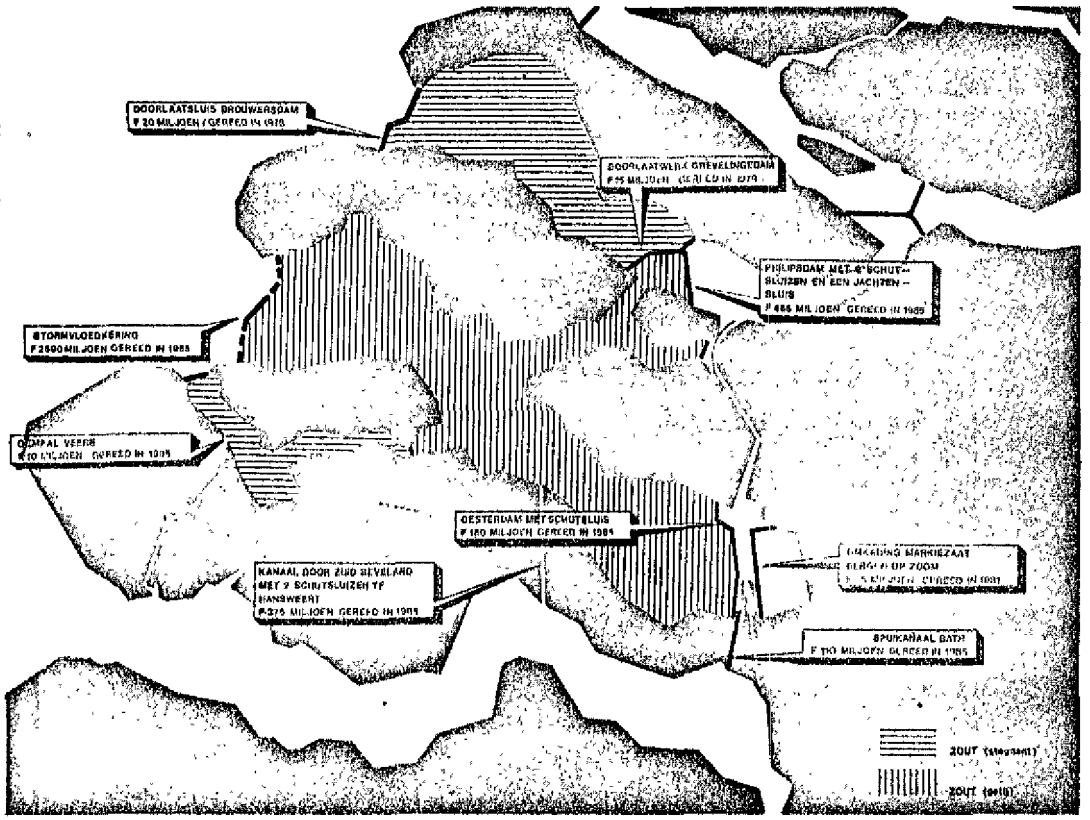


Figure 4. Survey Costs C3.

2.2. DESCRIPTION OF ALTERNATIVE D4 (CLOSED EASTERNSCHELDT)

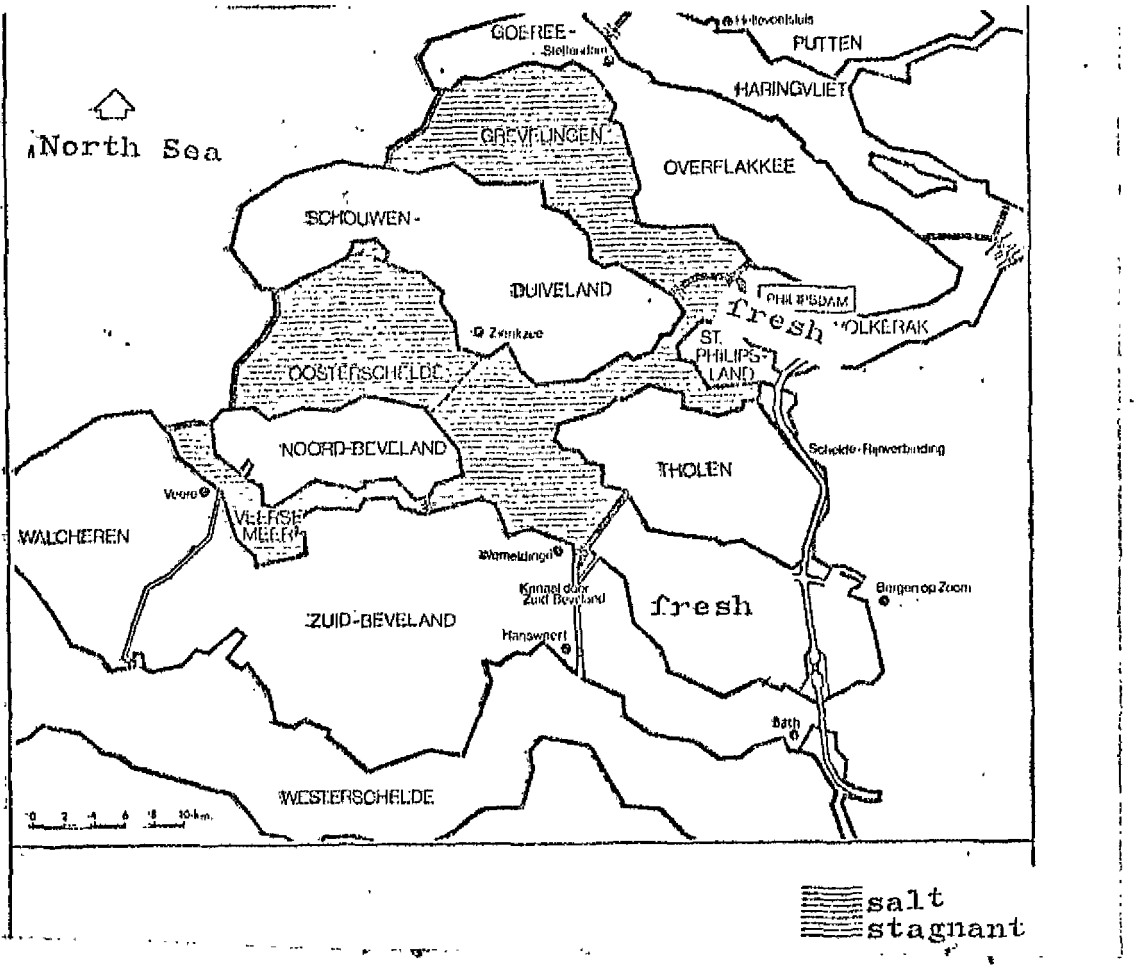


Figure 5. Alternative D4.

Easternscheldt-dam.

In D4 the Easternscheldt is closed according to the original plans. In the Easternscheldt at the place of the construction-island a sluice has been projected. On the Roggenplaat, immediately behind the Easternscheldt-dam a revitalisation- and storage-basin for mussels can be made, in which the tide is maintained via a sluice to the sea. (5).

Partial dike-heightening.

It is assumed that with D4 the execution of the partial dike-heightening, which started in 1975, will be finished

because the definite safety will already be reached in 1980. Other ill-effects of the dike-heightening on the scenery and the environment might then not occur.

Compartmentation.

The argumentation for compartmentation of a closed Easternscheldt according to alternative D4 is being shown in appendix I. In view of the water-quality one prefers rather a salt-water lake immediately behind the Easternscheldt-dam instead of a completely fresh-water basin. Compartmentation will then become necessary in order to be able to create a fresh-water basin in the eastern part on behalf of the watermanagement. The salinity in a closed salt-water lake is considerably more sensitive to fresh-water loads than in a salt-water tidal area. In a closed salt-water lake a sufficiently high salinity can only be achieved if the fresh-water load is minimal. With compartmentation of D3 with the Philipsdam and Oesterdam and with a big fresh-water load of approx. 20 $m^3/s.$ via the Philipsdam locks the required chloride-content of 15,5 g Cl^-/l cannot be met. It is probably feasible with compartmentation D4 with the Philipsdam and the Wemeldingedam and a minimal fresh-water input at the locks in these dams. Moreover D4, could be finished by 1980 and D3, due to the construction of the huge lock-complex in the Philipsdam not before 1984.
In D4 is reckoned with the creation of a stagnant salt-water lake behind the Easternscheldt-dam. The Zoommeer will then be separated from this salt-water area by two compartmentation dams:

- the Philipsdam through the Krammer, between St. Philips-land and the Grevelingendam;
- the Wemeldingedam, between Tholen and South-Beveland; the connection in South-Beveland is located between the existing mouth of the Canal through South-Beveland at Wemeldinge and the projected new - eastern - mouth of this Canal.

The Canal through South-Beveland will be improved on behalf of the through-going navigation which will then be led via the Eendracht-section of the Scheldt-Rhine connection. This Canal will at the same time fulfil a function for the discharge of fresh-water from the Zoommeer.

The southern Delta area in D4 is subdivided into a number of basins of a different nature; the characteristics of these basins are shown in table 4.

Table 4. Characteristics of basins in D4.

	Type	area on NAP (ha)	levels
Easternscheldt	salt-water	21.000	almost constant on NAP
Zoommeer	fresh-water	18.000	almost constant on NAP
Grevelingenmeer	salt-water	11.000	almost constant on NAP -0,20 m
Veerse Meer	salt-water	2.000	almost constant on NAP

In order to be able to maintain in D4 a sufficiently high salinity in the salt-water lake behind the Easternscheldt-dam, flushing with seawater will be necessary. The best results will be obtained by a circular flow in the direction North Sea- Easternscheldt-Grevelingenmeer; less effective is a flow-direction Easternscheldt-Veerse Meer - Canal through Walcheren - Westernscheldt. In this Note it is assumed that in D4 sections of the Zoommeer will not be separated by subcompartmentation.

Navigation-locks and salt-/fresh-water exchange.

In model D4 the through-going navigation is being led through the Canal through South-Beveland and further via the new eastern - mouth at Wemeldinge through the Scheldt-Rhine connection. Due to the fact that this main shipping route is situated outside the salt-water lakes, relatively small locks in the Philipsdam and Wemeldingedam will suffice for the remaining traffic.

The dimensions of the various locks are shown in table 5.

Table 5. Dimensions of navigation-locks in D4.

	number	width (m)	length (m)	salt-/fresh-water separation
Philipsdam lock	1	21	120	yes
Philipsdam, yachting-lock	1	9	75	yes
Wemeldingedam lock	1	12	90	yes
New locks at Hansweert	2	24	280	yes
Kreekrak locks	2	24	320	yes

In table 6 the consumption of fresh-water and the inhaerent remaining salt-load in the fresh-water Zoommeer are roughly indicated. It is assumed that all locks are always working at full capacity. These values will augment if the new lock-complex at Hansweert and the Kreekrak locks will have to be expanded, due to increased shipping-traffic, with a third push-tow navigation lock.

Table 6. Loss of fresh-water and salt-loads in the Zoommeer.

	Loss of fresh-water from the Zoommeer (m^3/s.)	Salt-load on the Zoommeer (kg Cl^-/s)
Philipsdam locks	3	1
Wemeldingedam locks	1 to 2	0,1 to 0,5
New locks at Hansweert	20	1 to 5
Kreekrak locks	20	1 to 5

Discharge-medium Zoommeer.

For the de-salting, flushing and level-control of the Zoommeer a discharge-medium onto the Westernscheldt will be necessary.

When the whole improvement-plan for the Canal through South-Beveland will be completed - this will be around 1985 - the superfluous water can be discharged via the scouring-sluice near the new navigation-locks at Hansweert. In order to be able to have a discharge-medium available for the discharge of superfluous water immediately after the closure of the compartmentation dams , the following projects must be finished by mid-1980:

- the new open canal-mouth at Wemeldinge and the profile-constriction near the Postbrug south of Wemeldinge must be eleminated ;
- the small West-lock at Hansweert, which is in disuse after the opening of the Scheldt-Rhine connection must be remodelled to function as a scouring-sluice.

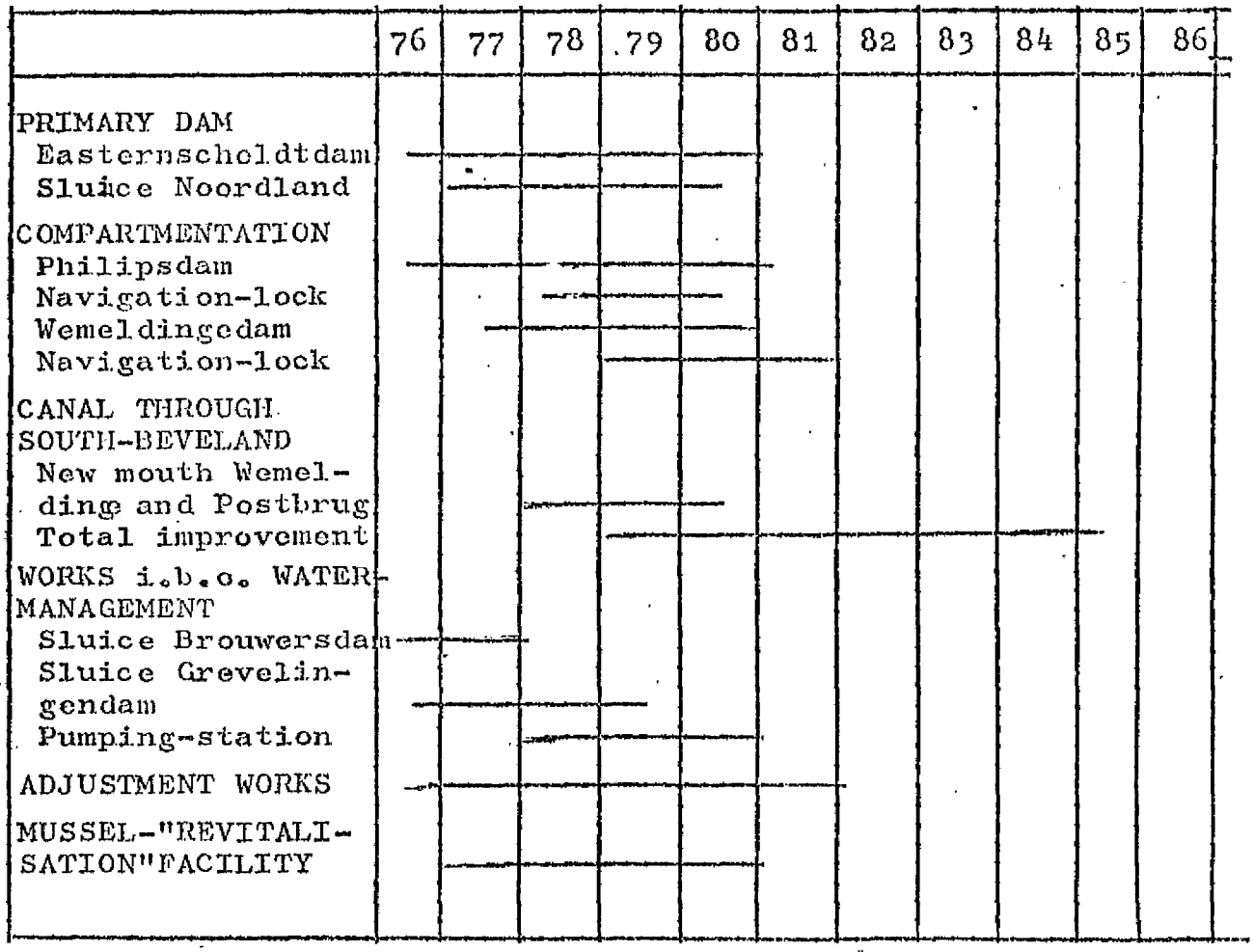
It is assumed in this Note that these works will be finished in time. That means that while selecting model D4 a decision about these works will have to be made simultaneously.

Salt-water lakes Easternscheldt, Grevelingenmeer and Veerse Meer.

In order to be able to maintain a sufficiently high salinity of at least 15,5 g Cl^-/l in these salt-water lakes, the de-salting as a result of precipitation and brackish polder-discharges must be fought by flushing with salt seawater. In D4 an almost complete flushing of the salt-water lake in the Easternscheldt and the Grevelingenmeer can be achieved by a salt-water circular flow around Schouwen-Duiveland. To this end seawater must be taken in at the sluice Noordland in the Easternscheldt-dam and must be discharged into the sea again via the ducts in the Grevelingedam and Brouwersdam. Rough calculations show that the salinity in the Easternscheldt and the Grevelingemeer would meet the requirements with a circular flow of about 100 m^3/sec. The salinity of the Veerse Meer could, as in C3, be augmented by a flushing of about 20 m^3/sec. from the Easternscheldt into the Westernscheldt. For this flushing and for the level-control of the Veerse Meer after closure of the Easternscheldt, a pumping-station at Veere would be required.

Further research will have to show whether deviation of polder-discharges from the Veerse Meer into the Eastern- and Westernscheldt will be necessary.

Time-schedule D4.



Costs D4.

A survey from January 1st, 1976, onwards of the costs of the most important works is given in figure 6.

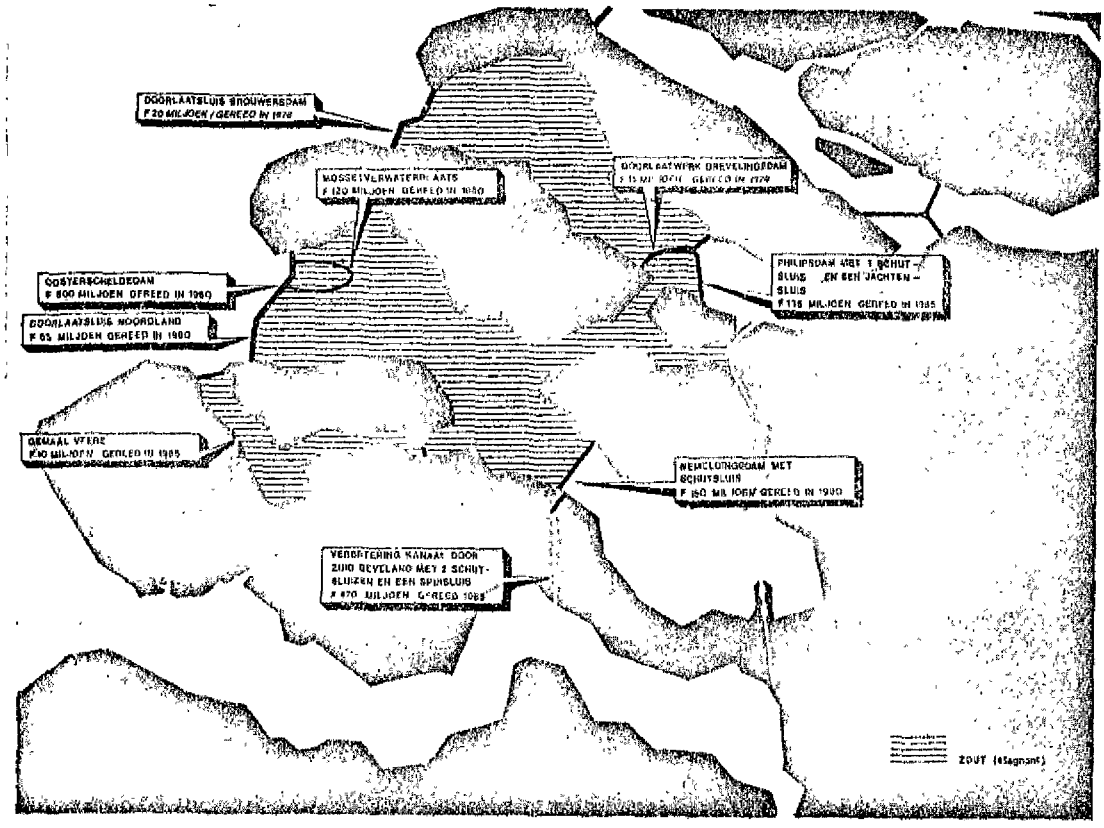


Figure 6. Survey of costs D4.

2.3. DESCRIPTION OF ALTERNATIVE A3 (OPEN EASTERNSCHELDT)

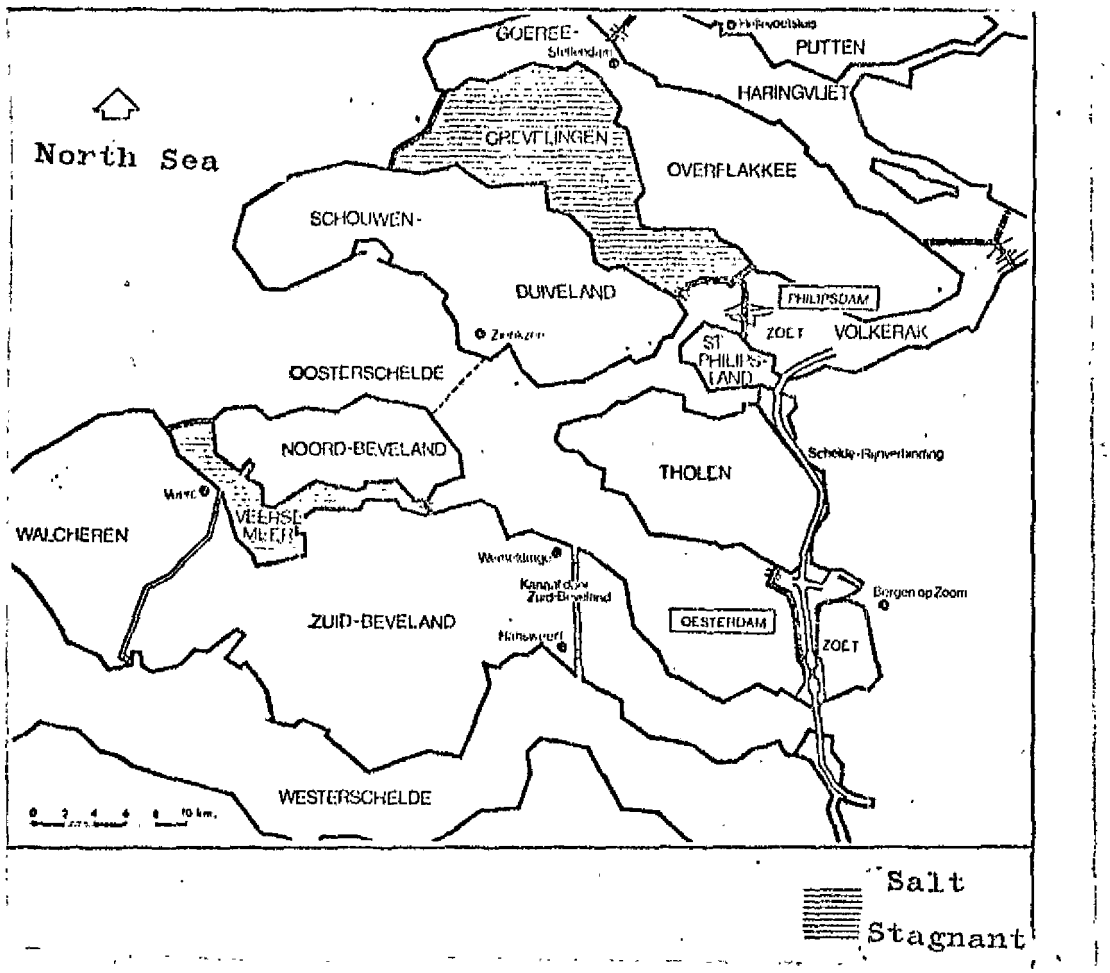


Figure 7. Alternative A3.

Mouth of the Easternscheldt.

With model A3 the mouth of the Easternscheldt remains open. The works already executed, that is, the three construction-islands and the dam-section Geul with behind it the construction-docks for caissons, have already closed off 15% of the original wet-cross section. In connection with the displacement of the channel near the construction-islands and the safety of the banks of North- Beveland and Schouwen-Duiveland, it might be necessary to remove the works at the mouth of the Easternscheldt; it is also quite possible that an additional layer of rubble will prove to be sufficient.

Further studies will have to prove this. For the time being it is assumed in this Note that the works will have to be removed.

Dike-heightening.

For the improvement of the flood-retaining structures along the Easternscheldt to "Delta-standards" a few studies have been made, based on experience with dike-heightening elsewhere. An orientation-plan for dike-heightening was made in the Note of the Provincial Waterstaat of Zeeland on behalf of the Committee Oosterschelde (6). This Note is based in broad lines on the suggestions about dike-heightening made in that plan. As a starting-point a exceedance-frequency of 1/4000 time per year has been applied. In the area east of the compartmentation dams, partial dike-heightening will be executed, because those dams will only be completed around 1985.

Compartmentation.

Even when the Easternscheldt stays open, compartmentation, as in C3, remains necessary, because of the screening off of the Scheldt-Rhine connection and because of the water-management. Moreover, with the construction of the Philipsdam and the Oesterdam the total length of the dikes which are to be improved, will be shortened from approx. 240 km to about 145 km.

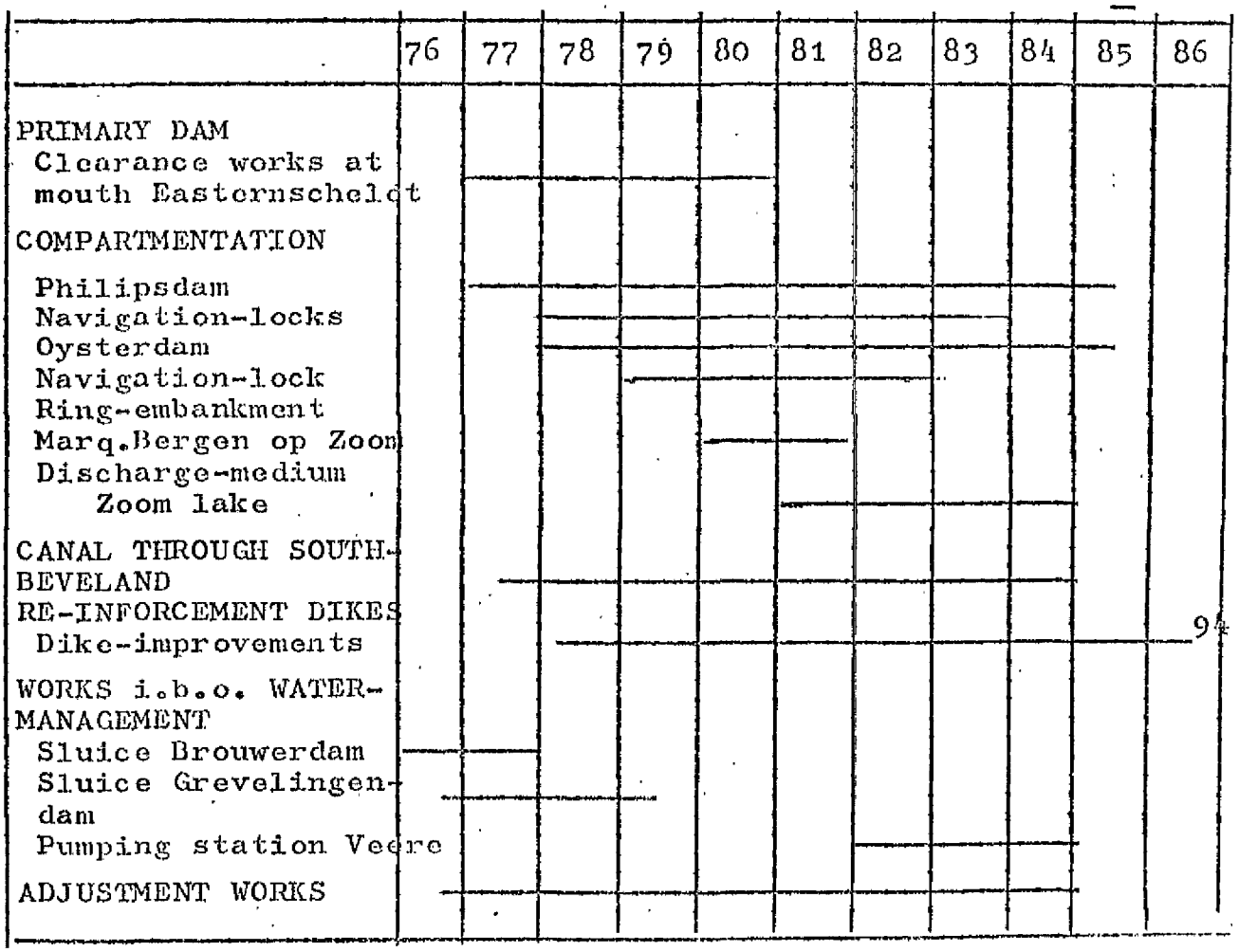
The choice of compartmentation with A3 is based on the same considerations as with C3. A number of aspects, however, are different: i.e.

- the Canal through South-Beveland cannot - for safety reasons - simply remain in open connection at Wemeldinge with an open Easternscheldt.

Moreover, the new Vlaketunnel in National Route 58 is not designed for high water-levels which could occur in an open Easternscheldt. In order to prevent an increase of the number of lock-passages between the Westernscheldt and the Haringvliet, a movable storm-surge caisson dam should be built in the new canal-mouth at Wemeldinge, with next to it, a navigation-lock for the "high" navigation.

- the construction of the Philipsdam and the Oesterdam - to be completed in 1985 - causes an increase of the tidal range west of these dams and consequently a rise of the storm-surge levels;
- due to greater tidal range, the sills of the navigation-locks will have to be about 1 m lower than in model C3; the exchange of salt-/fresh-water will, as a result thereof increase with 15 to 20%;
- the compartmentation dams and the locks therein should be designed as a primary water-retaining structure.

Time-schedule A3.



Costs A3.

A survey from January 1st, 1976 onwards of the costs of the most important works has been given in figure 8.

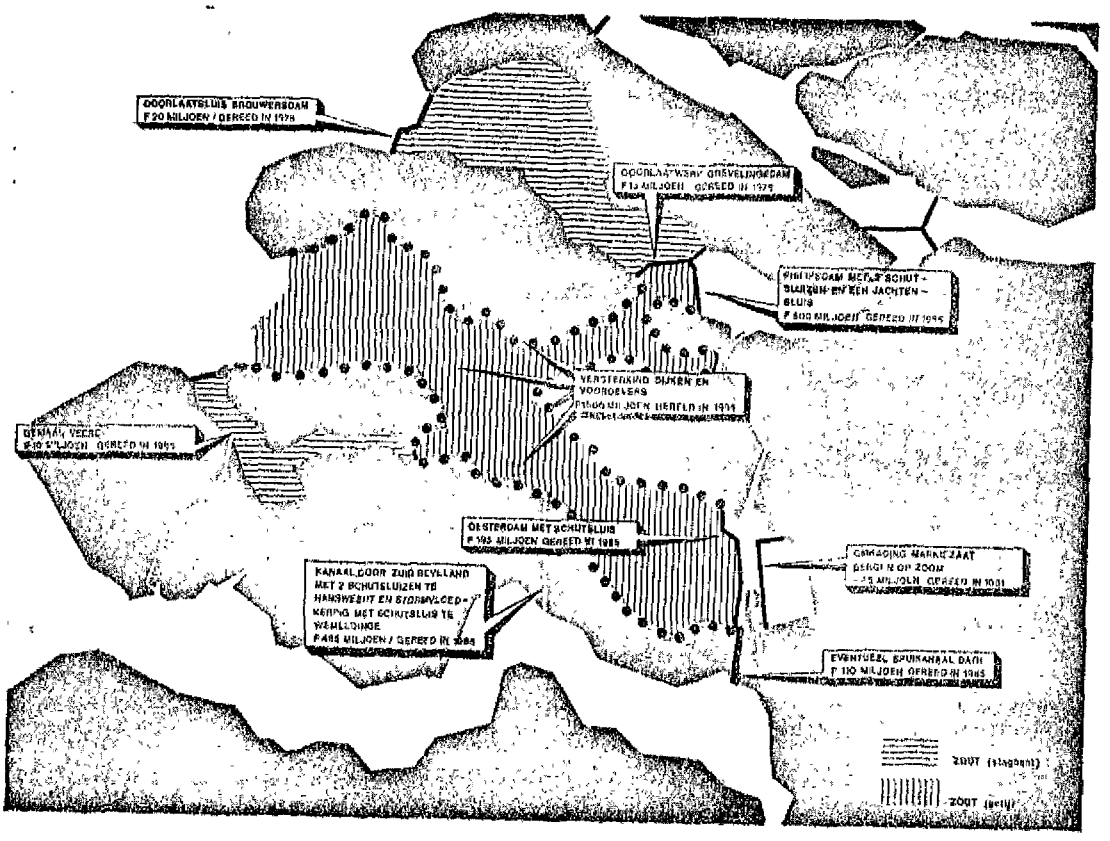


Figure 8. Survey of costs A3.

3.1. SAFETY.

Introduction.

The works at the mouth of the Easternscheldt have as an ultimate goal to provide safety to a large part of Zeeland as promised in the Delta Act. Safety, however, has rather a relative meaning. One can only approach it by speculating which safety measures have to be taken; in other words by making a mental picture of a possible calamity. Then it appears to what extent one undergoes a calamity as a disaster. This highly depends upon the personal involvement. Experiences from the past play a role: has one personally been subjected once upon a time to such a calamity or seen it from nearby? Also the economic interest might tip the scales: the inundation of a small polder might stir the inhabitant of higher grounds less than he who sees his immediate surroundings being distroyed. Expressed in risk-analytical terms: we must determine whether the risk is to be considered as a micro-meso or macro-risk. In general one can say that in case of major flood-disasters our population is involved in an almost emotional way even inundations without loss of human life make a deep impact. A clear-cut example were the floods of Tuindorp-Oostzaan. Though there were no victims the incident was seen and experienced as a national disaster. Some important risks of floods are:

- loss of human life
- groups of people losing hearth and home: the "sans-abris"
- loss of cultural and environmental values.
- (social)-economic chaos
- material loss both direct and indirectly.

Apart from those there are other less noticeable immediate effects: for example a lack of confidence of safe-feeling. The latter could be regarded as a significant lack of well-being.

In our country great importance is being attached to the safe-guarding against floods.

For this protection, however, certain standards have to be taken into consideration: for example, what degree of safety should be pursued and what is society prepared to pay for it?

"Safety of the Delta-area".

In former times in our country the dimensions of the water-retaining structures were based on experience: the standard was the highest water-level known from the past. With the report of the Delta Committee a completely different approach was made: the height of the water-retaining structures of the North Sea was based on a theoretically established and not yet occurred water-level at Hoek van Holland: N.A.P. + 5 m. This figure is called the basic level. Water-levels higher than the basic level may occur namely with a chance of 1/10000 time per year. Colloquially now one says that the basic-level has a chance of being exceeded 1/10000 time a year.
The dikes are designed to retain the so-called "design-level". This theoretical level equals the basic-level for central-Holland and thus the chance of it being exceeded is 1/10000 time a year. For the Delta-area a theoretical level is being maintained which is 30 cm lower than the basic-level and which has a chance of being exceeded 1/4000 time per year. There seems little enough chance of it. One has to bear in mind, however, that this chance of exceeding could present itself every year, a person has therefore during his life-time - say 80 years - a chance of 80 x 1/4000 times or 1 in 50 that he may experience a storm which can cause such a high-water-level!
The Delta Committee has investigated by means of econometrical calculations in how far it is economically justified to take the theoretical level as a basis for improvement of the water-retaining structures. Notwithstanding the many uncertainties in the calculation it appeared that the design-levels could be

considered as economically justified. The method of calculating (24) developped by the Committee is still being applied, recently by the Committee Oosterschelde. The chances of exceeding indicated by the Delta Committee are being called for convenience's sake the "Delta-standard". According to the Delta-Act our country is protected either by the enclosing dams in the Delta-area or by heightening of the existing primary water-retaining structures in accordance with the Delta-standard.

The measure of safeguarding of a certain area does not depend solely upon the height of the primary water-retaining structure. Often this problem is unjustly simplified to this aspect alone. In reality it is a combination of a great number of factors of which the most important are:

- the height of the primary water-retaining structure
- the quality of the primary water-retaining structure
- the condition of the sub-soil.
- the length of the primary water-retaining structure
- the alignment of the primary water-retaining structure
- the foreland
- the secondary water-retaining structures
- the size of the polder involved
- the depth of the particular polder
- the possibility of heightening at a later date.

These factors will be further discussed in the next paragraph.

Furthermore, one has to bear in mind that also other causes than high water-levels alone can lead to a breaching of the dikes. For example the indirect cause of the inundation of Tuindorp-Oostzaan probably was a busted water-pipe. One may not therefore accept without further thought that two areas which are both protected by a "Delta-dike" have an equal chance of being flooded and also not that this chance coincides with the Delta-standard.

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* Page 30. This is a simplification, based on statistics; the chance is in fact somewhat smaller.

The Delta Committee has signalled this already. The Committee highly values the presence of secondary retaining structures. The Committee based it's advice for the Delta standard for the south-western part of the country unequivocally on the presence of secondary water retaining structures:"For the south-western part of the country which is divided into small areas, each one individually protected by primary water retaining structures, design-levels have been fixed which have a 2,5 times bigger chance of being exceeded than the locally accepted basic levels" (25). The Committee also offered some recommendations for the construction and maintenance of a system of secondary water-retaining structures although the primary water-retaining structure needs attention in the first place. A similar recommendation is made by the Technical Advisory Committee for the water-retaining structures in it's report "The Secondary Water-retaining structures in the Netherlands"(26)
Thus in fact the *Delta Act regulates* only one aspect of the safeguarding against floods: the construction of adequate primary water-retaining structures, by building enclosing dams in the south-western part of the country and by heightening dikes elsewhere. The chance of floods in our country is-on the one hand higher than could be expected with regards to the theoretical height of primary water-retaining structures - because other causes than the decisive storm-surge may lead to a breach of dikes - on the other hand the chance of floods might be lower than expected owing to the existance of secondary retaining structures. How effective the safeguarding might be is difficult to say.

In any case one is striving to make the protection as adequate as possible. The Delegated States of North-Holland, South-Holland and Utrecht have formulated this effort in such a way that a good safe-guarding has to meet at least one of the three following conditions:

a. Flooding must, according to human standards be impossible because of a high formation of dunes with sufficient width or if a fortified narrow formation of dunes is protecting the country;

b) A possible breach should not immediately cause a flooding of the area itself because a secondary retaining structure of sufficient strength and at a proper distance is situated from the primary water-retaining structure.

c) In case of a possible breach no spill-way in the dike may develop; the dike should therefore be concealed on the outer-side with a high foreland of sufficient width or with a strong low over-flow structure behind it.

A protection that meets one of those criteria is regarded as an optimal protection. Behind the enclosing dams in the south-west of the Netherlands, as laid down in the Delta Act, there are water-areas of a large size. The low-lying polder-land is being protected by former primary water-retaining structures. It is therefore highly improbable that the polders lying along-side the Delta-lakes would be flooded in case of a breach of a Delta-dam. The Delta Act provides these polders therefore with an"optimal protection."
Summarizing, the following can be established:

a. In our country floods are considered disastrous. In their disrupting results this kind of disasters are difficult to compare with other social risks. A comparison with earthquakes or violence of war has the closest resemblance. Great significance therefore is being attached to an adequate safeguarding against floods.

b. The Delta Act provides the construction or the improvement of a system of primary water-retaining structures with quantifiable chances of breaching: the Delta standard.

c. The actual safeguarding of a certain area cannot without further ado be deducted from the Delta-standard. For this the area has to considered in its totality.

d. The endeavour is aimed at "optimal safety".

e. The Delta Act holds in prospect "optimal safety" for the areas around the Easternscheldt.

If one would want to introduce for the Easternscheldt-area the somewhat confusing term "Delta-Security" then the safeguarding for this area would imply the construction of a dam (provided with or without a storm-surge barrier) at the mouth of the Easternscheldt.

The system of security.

In the former paragraph it has been explained that the safety of a certain area is not exclusively determined by the height of the primary water-retaining structure, but that one has to talk of a system of safeguarding composed of a great number of elements. The elements that play an important role in the security of the Easternscheldt-area will be discussed successively now. Also attention will be paid to the specific problem of dike slides.

a. The height of the primary water-retaining structure.

In many cases a breaching of the dike starts with overflowing or overtopping water. Due to this the landward slope of the dike soaks through which may result in slides. Thus the height of the crown of the dike is the principal criterion in designing a dike. It is not true that a dike cannot bear any water on the landward slope; some wave overtopping need not be dangerous. More or less due to the lack of anything better a so-called 2% criterion is used; a criterion of the design which stipulates that 2% of the decisive waves may overtop the dike. This criterion is somewhat gross; one dike may well be able to withstand a higher wave-overtopping than another. An exact and optimal determination for the height of the dike is as yet not possible. No more is it possible to determine exactly the remainder of the design; one has to start from great extrapolations. Ultimately the decisive wave-overtopping which establishes the design-level is a factor which hides many unknowns. All together the determination of the height of a dike remains a difficult task, which in itself militates against attribution of an absolute value to the numerical value of the safety provided by the dike.

b. The quality of the primary water-retaining structure.

The quality of the retaining structure depends on many factors; such as the profile, i.e. the width and the gradient of the slopes, and the width of the banquettes, the revetment and the turf, the material with which the dike has been built,

and the presence of alien components such as sluices, buildings and retaining walls. The foundation is also important; a dike is never better than the foundation on which it rests. The modern techniques enable us to rebuild already existing and qualitatively not very good dikes and turn them into water-retaining structures of full value again. However, a completely new dike which need not be a compromise between existing interests and demands for retaining water will harbour fewer uncertainties.

c. The length of the primary water-retaining structure.

The foregoing has shown that there is no such thing as absolute certainty about the retaining-power of a retaining-structure; inaccuracy in the theories and weak spots in the water-retaining structures still entail certain risks. It is evident that these risks are fewer with a short water-retaining structure than with a long one; the extent of the risk is directly proportional to the length of the water-retaining structure. For that reason one has endeavoured in our country since a long time already to shorten the coast-line to be protected. Another important factor in favour of a short dike is the maintenance; a water-retaining structure requires continuous inspection, maintenance and surveillance.

d. Alignment of the primary water-retaining structure.

A dike is being attacked most strongly when the wind hits the dike perpendicularly. A straight dike therefore offers a better protection than a tortuous one, because with a tortuous dike the chance of the wind hitting it somewhere perpendicularly is greater. In this respect a dike around a bowl-shaped basin is the most unfavourable: practically every wind-direction might be aimed unfavourably at some section of the dike. An alignment with many sharp angles could also be called unfavourable; especially at re-entrant angles the water will be tilted extra high. The tortuous coast-line of North-Beveland is a fair example of an unfavourable alignment.

e. Secondary water-retaining structures.

Secondary water-retaining structures can add considerably to the safety of an area. To this end the retaining structures have to meet with certain demands. The most important requirement is that the secondary water-retaining structure is stiuated at a certain distance from the primary water-retaining structure. Behind the primary water-retaining structure there should be an area that would need a certain period of time to fill up when a dike breach occurs, so that the secondary structure only has to retain the water when the high tide is already subsiding again. Intersecting dikes cannot be regarded as secondary water-retaining structure; they are not meant to be. As a rule one tries to construct a secondary water-retaining structure which can retain water at a level that corresponds with the so-called "border"-level: that is a water-level that has a chance of being exceeded 1/2 time per year.

f. The possibility of heightening dikes later on.

In the course of the years the height of the dike decreases due to natural wear and tear, settlement of the dike's body and settlement of the foundation. In the long run the fact that the sea-level rises with respect to our country also plays a role. For this so-called relative rise of the sea-level a standard of 20 cm/per century is maintained as a rule. Furthermore one should bear in mind that the chance of occurrence of the design-levels has been based on the storms that took place in the past. If climatic changes would occur which would manifest themselves by a higher frequency of storm-floods in the North Sea area then the design-levels would have to be adjusted. Though new dikes are being constructed with a certain excess-height one has to take into account that in the future, this need for heightening of dikes might present itself again. Dikes that can easily be heightened in the future offer an additional safety in the long run.

g. Bank and dike slides.

Various areas along the Easternscheldt are "sensitive to slides". Two conditions have to be met with if slides occur: the bottom must consist of loosely packed layers of sand and the bank has to be steep. One can distinguish three kinds of slides: slab-slides, bank-slides and dike-slides. Though slab- and bank-slides indirectly might also endanger the water-retaining structure, the dike-slides are of course the most dangerous. Most of the times slides will occur at low water-levels; this is why it is often assumed that this phenomenon is not so dangerous.
This is not wholly correct, however. Especially dike-slides during the stormy season (October through March) are exceedingly disagreeable. It is highly conceivable that a storm-flood occurs even before the damaged dike can be repaired. Then a breach of the dike is unavoidable. By the Provincial Waterstaat of Zeeland has been calculated that there is a chance that such a calamity can happen 1/60 time per year. Thus, this is considerably higher than the chance of occurrence of the storm-flood of 1953.
That the phenomenon of bank- and dike-slides happens much more frequently along the Easternscheldt than along the Westernscheldt is probably due to morphological developments in the Easternscheldt. Since a long period of time the basin has had the tendency to deepen and widen.(it is a so-called erosive basin). Time and time again man had to give up land here; a process that is still continuing up to this day.

Comparison of the alternatives in the final stage.

In the foregoing a qualitative view has been given about the various components which determine the safety of the country. With the three alternatives the security can be obtained in a different way; this is shown in fig. 9 regarding the area in front of the compartmentation dams and in fig. 10 with regard to the area behind them. The alternatives will be compared as far as the aspect of safety is concerned on the following points:

- the measure of safety
- the quality of the primary water-retaining structure
- the length and the alignment of the primary water-retaining structure
- subsequent dike-heightening
- dike-slides

A closed off Easternscheldt, (D4)

- Measure of safety

The closing dam causes all present primary water-retaining structures to become secondary ones. Between the secondary water-retaining structures and the new primary water-retaining structure a big lake is situated which acts as a buffer-zone. The measure of safety complies with the fixed standard; the Delta Act will be met.

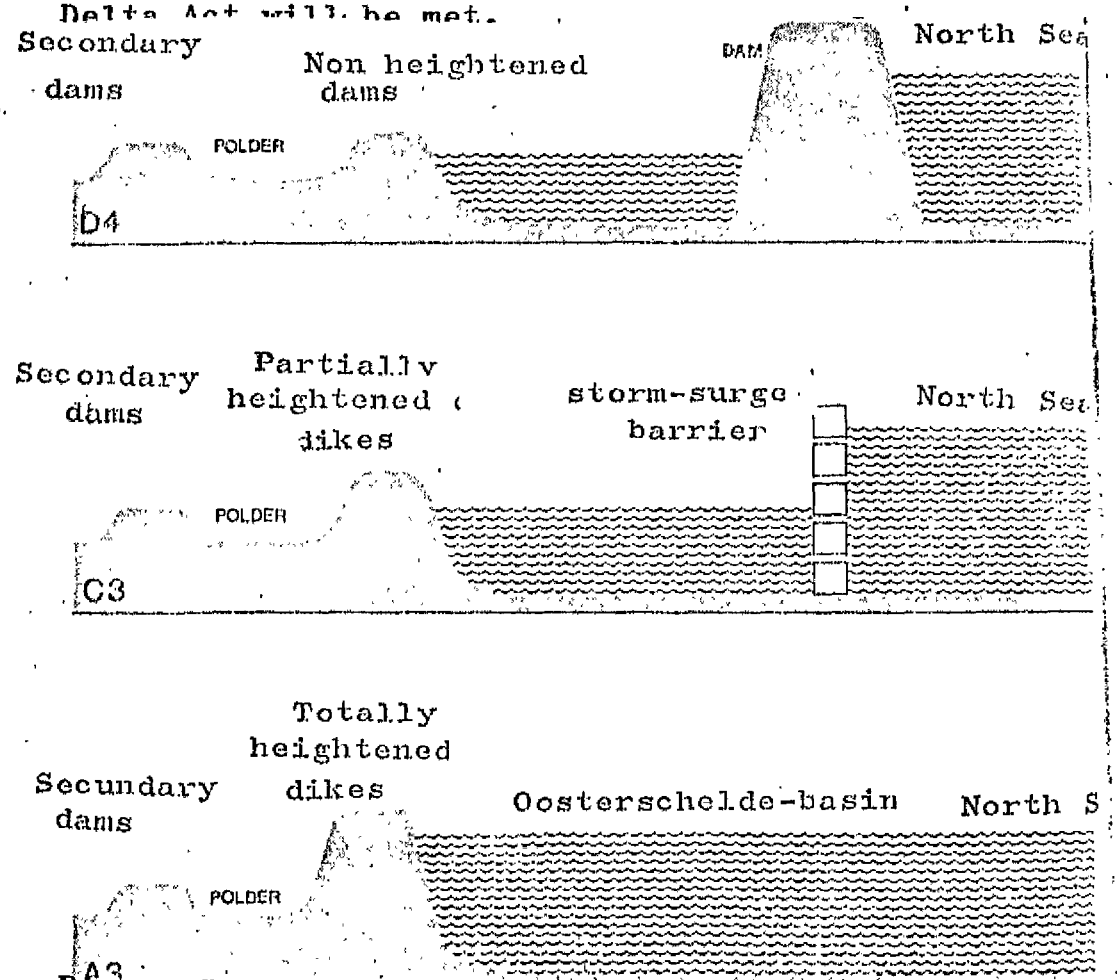


Figure 9: area in front of compartmentation dams-

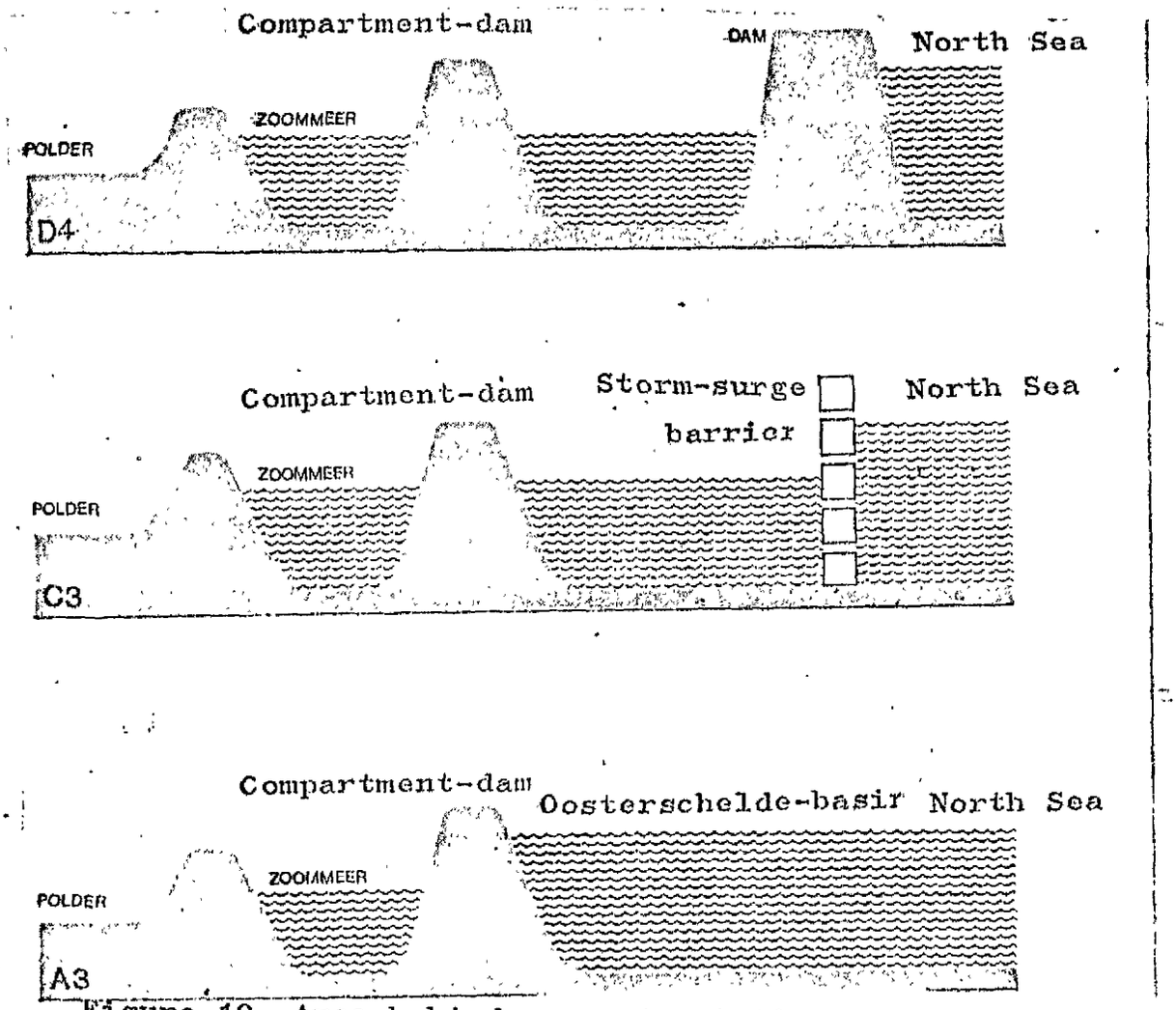


Figure 10. Area behind compartmentation dams.

- Quality of the primary water-retaining structure
  Without any restriction the quality of the Delta-dams can be said to be of a high standard. There is no need for fear of hidden deficiencies.
- The length and the alignment of the primary water-retaining structure.
  With the closing dam the present coast-line will be shortened from 245 km to 9 km, extremely short in comparison with the protected area.
- Subsequent heightening of dikes.
  Future heigthening of the Delta-dams can be done without great interventions.
- Dike-slides
  The danger of bank- and dike-slides has been warded off.

Storm-surge barrier, C3.

- Measure of safety

The situation in C3 reminds one of the storm-surge barrier in the Hollandsche IJssel. Assuming that the storm-surge barrier in case of a storm-surge will be closed in time, the measure of safety equals that of D4. The existing dikes, however, will require a little more care than with D4, but on the other hand with C3 we may start with "1/500 dikes".

- Quality of the primary water-retaining structure.

The quality of the storm-surge barrier will correspond with that of other great hydrological structures.

- Subsequent dike-heightening.

The retaining height of the storm-surge barrier is exclusively based on the design-level.The wave-overtoppping is not detremental to the stability of the water-retaining structure. Future adaptations of the construction to the relative rise of the sea-level for example will not be simple to realise, but in view of the foregoing it will not be so urgent either. One has to assume that possible necessary adaptations will be executed as part of a total overhaul or replacement of the by then old structures.

- Dike-slides.

How the morphological development of the Easternscheldt basin will be is as yet difficult to predict. Though a further erosion of the banks will go more slowly as a result of decreasing flow-velocity, the danger of dike-slides, though considerably less, will not disappear completely, because the shifting of channels has to be taken into account. Calamities, however, can be avoided, because one has the possibility to close the storm-surge barrier.

Open Easternscheldt, A3.

- Measure of safety

Over a length of 145 km the height of the primary water-retaining structure will have to be adjusted to the design-level with a chance of exceeding of 1/4000 time a year.

The plan (6) herefore developed by the Province of Zeeland has been sufficiently illustrated in all its aspects to allow for a fundamental policy-decision, which the Cabinet did in November, 1974. However, a number of important data for an elaboration of the plan are still lacking, especially the design-level for the dikes.

Very recent studies have shown that the exceeding of high storm-surge levels in an estuary as the Easternscheldt may occur more often than was assumed in the past. More insight in particular has been obtained in the behaviour of the wind under extreme circumstances and its influence on the water-levels of the basin of the Easternscheldt. This affects the design-levels to be used. The estimates concerning the wind used until now appear to be on the low side, both with regard to the duration and the velocity. As a result both higher water-levels and higher waves might occur under "Delta-storm" conditions. According to the most recent views this study could lead to a not inconsiderable rise of the design-levels, especially in the eastern part of the basin, where the order of magnitude might easily reach a few meters of dike-height.

In appendix II this problem will be further elaborated. With great certainty, however, it can be said already that the height of the dikes in the "plan Zeeland" is too low especially in the eastern part of the basin. The Provincial Waterstaat stated this already in a recently published actualisation of the Plan (6).

In order to offer security to as many areas as possible around the Easternscheldt, a safety that at least is comparable to what is being required by the Delta Act, the forming of a system of secondary water-retaining structures will be necessary. However, this cannot be realised everywhere. For the area in front of the compartmentation dams no "optimal safety" as in D4 will be possible. The purpose of the Delta Act will not be met.

- Quality of the primary water-retaining structure.

With modern techniques it is possible to heighten the existing water-retaining structures in order to form appropriate "Delta-retaining structures". Quality-wise these retaining structures fall short of the dams, because locally the sub-soil is very poor as the old dikes which serve as a foundation may have unknown weak spots. Also the already existing interests have to be taken into consideration (such as constructions). Due to this fact the chance of a breach of the primary water-retaining structure may well be higher than 1/4000 time per year.

- Lenght and alignment of the primary water-retaining structure.

The coast-line will be shortened from 245 km to 145 km. Because of this part of the old dikes will then be situated behind the compartmentation dams. Though the heightened water-retaining structures will become more straight than before, the alignment as a whole will yet remain tortuous.

- Subsequent heightening of dikes.

In principle subsequent heightening will be possible, but one will probably encounter the same problems as with the present heightening.

- Dike-slides.

Because of the construction of the compartmentation dams, the Philipsdam and the Oesterdam, the tidal-volume at the mouth of the Easternscheldt will decrease by 10 to 15%, so that it will become equal again to the volume of before the closure of the Volkerak. This will influence the morphology. The increased removal of sediment of the basin that started after 1969, will again decrease and the soil-management will become more balanced. As yet it will be difficult to indicate to what degree the construction of the dams will change the erosive character of the Easternscheldt. Even if an equilibrium would develop as far as the total balance of sediment is concerned -

which means that the total volume of the Easternscheldt does not change- then one still has to bear in mind that this is a dynamic equilibrium. Internal shifting of sediment resulting in diversion of channels will continue. Owing to the construction of the compartmentation dams shifts of phases in the tide will occur between the various main channels. As a result the hydraulic system will change. The nature of the expected changes has as yet not been sufficiently studied. A realistic prognosis regarding possible diversion of channels is not yet feasable, because physically the process is still intransparent.
An extensive surveillance-system by means of frequent sounding which can signalize in time the diversion of the channels will be necessary. This holds both for the diversion of channels near the banks, through which loss of stability of banks and dikes could be initiated as well as at the Easternscheldt-bridge where impermissable scouring could occur around the piers.
The danger of bank- and dike-slides therefore remains. About the extent of it, however, nothing can be said.
In order to curb the danger as much as possible extensive rubble-layers will be necessary. It should be noted, however, that a rubble-layer does not prevent a dike-slide, but restricts more or less continuing erosion.

Comparison of alternatives in the transitional period.

The risks in the period that an alternative is being executed is, among other things, determined by the initial phase, the sequence and the time-schedule of the individual activities and the duration (of the execution) of the works.
For a better understanding of the situation we repeat here once more the main issues from the time-schedules of chapter 2:

C3: the storm-surge caisson dams will be completed in 1985. The partial heightening of all Easternscheldt-dikes up to the chance of being exceeded 1/500 per year will be finished in 1980; the storm-surge caisson dam and the compartmentation dams in 1985.

D4: the partial heightening of the dikes will be halted immediately after the decision, the Easternscheldt will be closed in 1980.

A3: the partial dike-heightening on the west-side of the compartmentation dams will be halted immediately after the decision, the compartmentation dams will be completed in 1985. The integral enlargement and heightening of the Easternscheldt-dike requires three years of preparation and takes 15 years of construction.

Based on these time-schedules the chances of being exceeded can be calculated for those areas which are not yet properly protected during the transitional period. Due to the fact that during this period the dike-heightening takes place, that chance is not the same at all places; in the extreme case it might vary from polder to polder. In order to make the calculations possible on the basis of information and resources available at the moment, some assumptions will have to be made about the contribution of already heightened dike-sections to the protection of the whole area. The experience with heightening of dikes shows that vulnerable sections require the longest time of preparation. In many cases the dike not only functions as a water-retaining structure but serves other interests as well, which in the past also led to arrears in maintenance and adjustment.

We therefore start in this Note with the assumption that the chances of floods remain the same for the whole area, until all dikes are brought up to the required height. In this way there is no need to include the problems with regard to an outline of priorities for the execution in this Note. That this consitutes a problem is shown by the heightening of the dikes along the Westernscheldt, where now, 23 years after the flood disasters, half of the dikes are completed. At the same time one should bear in mind that a considerable part of this half was prepared and executed in a period of time where preservation

of scenery and nature was not as much in the general lime-light as it is to-day. A drawback of this, though for the rest highly appreciable, increased interest in scenic, natural scientific and cultural historical values, is, however, that it takes a lot of time before a plan is accepted by all interested parties, especially where it concerns valuable areas and cities. In this respect one should think of the time and efforts it cost to arrive at solutions; for example the river-land and the Alblasserwaard. In order to complete A3 in a period of 18 years accelerated procedures will certainly be needed (see also par. 3.7). If we view a specific period then the total chance of flooding is equal to the sum of the chances of flooding for each year. The actual chances of exceeding for the dikes along the Eastern-scheldt is different from one dike-reach to another. Along the Volkerak for example it is not less than 1/100 time per year, while for Schouwen-Duiveland, west of the Easternscheldt bridge it will probably be 1/300 times. Although Committee Easternscheldt in it's calculations used an average value of 1/100 times (9) now a figure of 1/200 times is considered being more realistic. With emphasis it is stated, however, that it concerns here an average value for the whole basin. In view of the previously described recent findings with regard to high water-levels at the back of the basin, this average may only be used for a broad estimate of the chances of exceeding in the transitional period.

The chance for the alternatives are as follows:

C3: 1976-1980 5 x 1/200
    1981-1985 5 x 1/500 } = 3,5 %

D4: 1976-1980 5 x 1/200 = 2,5 %

A3: 1976-1994 18 x 1/200 = 9%

In the area that will be created behind the compartmentation dams in A3 a partial heightening of dikes will be

executed between 1976 and 1980. As the compartmentation dams will be closed in 1985 the calculated chances of floods in this area should be fixed at least at 3,5%. Starting from the more real actual chances of topping the existing dikes there one arrives at 5%. During the transitional period D4 therefore has the smallest and A3 the biggest chances of floods. The difference between both these alternatives is a factor of $3\frac{1}{2}$; with C3 the chance is somewhat bigger than with D4.

Instead of the chances of floods one could also use the conception of expected damages from diasters - expressed for example in destroyed values -. The damage due to the disaster would then have to be established separately for each polder, in order to arrive at a total picture. Unfortunately such a detailed calculation has not yet been realized. In chapter IV though, there are some calculations made on different bases with regard to contribution of already heightened dikes to the protection during the transitional period.
With a simplified approach, though, one can get an impression of the risk (chance x damage) one runs with the alternatives during the transitional period. Assuming that the destroyable values in the area around the Easternscheldt at this moment would be approximately 10 billion guilders, then D4, based on the abovementioned calculations will show a total risk during the transitional period of approx. 210 million guilders. With C3 the risk amounts to 260 million guilders and with A3, 450 million guilders. For more accurate figures a more detailed analysis is necessary based on the individual polders.

The Committee Easternscheldt has made calculations with regard to the expected damage in a number of alternatives. From those a "gain in safety" followed, which varied from hfl. 1,9 billion for a completely closed off Easternscheldt to hfl. 1,4 billion for an open one with heightening of dikes. (pricelevel 1973). The difference in gains with

with the two alternatives corresponds reasonably well with the difference in risk with D4 and A3. In all these surveys the possible loss of human life, the costs of social chaos, the loss of labour-opportunity and damage to the environment as a result of flood disasters have been left out of consideration.

Side-effects as a result of changed water-movement.

The construction of a storm-surge barrier at the mouth of the Easternscheldt will reduce the tidal volume and with that the flow-velocities in the channels; the transport-capacity of the tide will decrease. The sea-ward growth of the submerged delta, which is now a result of the dominating erosion in the Easternscheldt basin, will diminish and the net-transport will probably turn in reverse direction. In the Eastern part of the pre-delta along the coast, sedimentation will mainly take place in the channels. On the outer-side the erosion might begin to dominate, as a result of which the sea-ward side of the pre-delta will get a somewhat steeper gradient. The direction of the tide-channels will be mainly East-West.

With D4 the process of sedimentation as a result of the disappearing tidal flows will accelerate more than with C3. In the area around the mouth some circular-flow might develop, in the same way as in the Haringvliet and the Brouwershavense Gat.

With A3 the tidal volume at the mouth of the Eastern-scheldt will decrease by about 10%. In the areas at the mouth which were deepened after closure of the Volkerak, some sedimentation will take place again. At the same time some shifting of the channels might occur. In view of the fact, however, that the changes of the tidal volume is relatively small, it is expected that the influence of alterations in the hydrographical pattern on the behaviour of the coast will also be little.

At the present situation there is some erosion of the beach at the western side of Schouwen.

The average retrogression before the start of the Delta-works and even now amounted to a few meters - maximum about 5 meters - per year. The very wide dune-area there is the reason that no extensive provisions were needed. Therefore up till to-day only stake-screens have been placed in order to keep the "retrogression" within bounds. On Walcheren the deterioration of the coast is relatively light; due to the limitedness of the dune-area already a long time ago extensive protective measures had to be taken.
According to present views it seems possible with all alternatives for the time being to protect the heads of the island with limited supplementary sand-layers. In view of the fact that a new pattern of equilibrium will be created, here and there erosion but elsewhere also sedimentation will take place. The costs for this protection of the coast are shown in paragraph 3.7.

At the moment there is - under normal circumstances - only little exchange of water and silt between the mouth-areas of the Eastern- and Westernscheldt. From bi-dimensional calculations of the tide the conclusion was drawn that a construction in the mouth of the Easternscheldt has practically no effect upon the water-movement in the mouth of the Westernscheldt.The influence of the closure of the Easternscheldt on the water-levels in the Westernscheldt amounts to a few centimeters only, which have been already negotiated in the plan for enlargement of the Westernscheldt-dikes. The silt-intrusion of the Westernscheldt will probably not be influenced to a large extent by any of the alternatives. The silt that settles down in the Westernscheldt is mainly brought in along the French-Belgian coast and originates from the eroded layers of clay and silty sands in the mouth-area. Dependant upon the measure of reduction of the tidal movement in the Easternscheldt the perpendicular water-movement on the coast will decrease.

As a result the water-movement parallel with the coast becomes more important for the transport of silt. And consequently the exchange of water and silt between the mouth-area of the Easternscheldt and the North Sea area will also decline. In view of the fact that the silt-content increases towards the coast, this might lead to an increase of the silt-content at the mouth of the Easternscheldt. With D4 the silt-transport vanishes into the Easternscheldt. As a result the silt-content in front of of the mouth might increase. The consequences of C3 for the expected alteration of the silt-content in front of the mouth of the Easternscheldt are still being studied.

Scorechart safety

	C3	D4	A3
year when complete safety is reached	1985	1980	1994
length primary water-retaining structure (km)	9	9	145
quality primary water-retaining structure	+	+	-
dike- and shoreslides	-	0	--
optimal protection at the final stage	yes	yes	no
total odds on floods during transition period (%)	3,5	2,5	9
total risk during transition period (million guilders)	260	210	450
possibility for future heightening	-	+	--

3.2. ENVIRONMENT.

One of the needs in the society of the south-western part of the Netherlands is a better protection of the country against floods. This protection cannot be obtained without radical changes in the environment on the border of land and water and in the water itself. These changes vary per alternative, but with each of the three alternatives they are of considerable magnitude.

Changes in an area, also great changes, do not necessarily include a depreciation. The Easternscheldt for example obtained through human intervention such as the closure of the Kreekrak and the Volkerak a greater natural value now than before. It is necessary, however, to know beforehand what changes are brought about as a result of an intervention and what these alterations will signify for the natural system. The necessity to study thoroughly beforehand the ecological effects of the three alternatives originates from the concern about the living conditions and the natural and scenic values, but also from the conviction that within the system itself a lot of information is stored, which could be of great importance for mankind, all the more so if this system becomes rarer in our country or in Europe.
With all the alternatives efforts are being made to affect the environment as little as possible. With alternative D4 the historically developed dike-scenery will be maintained but the tide will disappear. With alternative A3 the tide remains, but the intersections and the scenery along the banks will be affected.
With C3 efforts were made to seek a compromise in which the tide, be it limited, will be maintained and the scenic interventions in the bank-zones are limited to a minimum. After each intervention the ecology will adapt itself again to the new situation, so that ultimately a new system develops with it's own characteristics.
It is impossible to give an objective evaluation of the environments which will be created by the various alternatives. How, for example, would one give an objective answer to the question whether a wetland-area is better

or more beautiful than for example the surroundings of the Naarder lake? Each person will give his own answer to that question, depending on his views and preferences. For that reason the score-charts with some environmental aspects of the alternatives only indicate the changes with regards to the present situation, without any evaluation. It was established though, that with each one of the alternatives the Easternscheldt-area will keep it's great nature values.
At the discussions of the alterations in the environment with C3, D4 and A3 not only the Easternscheldt has been viewed. The various basins in the Delta-area, do not stand alone; they affect each other. In the following survey the assumption that all necessary measures will be taken to achieve in the basins an as stable as possible environment, was used as scenario. This is also in the interest of the many diverging functions which they will have to fulfil for example for the shipping and fisheries. The possibilities that these basins have from the point of view of environment, will be used in the best possible manner. The selection of the scenario is based on the view that the creation of a properly functioning biological system constitues the best way to make or keep the basins suitable for as many functions as possible with the least possible managerial efforts. This, moreover, has the advantage that as much as possible is left to nature.

Of the consequences of the alternatives on the environment the following will be viewed:
- the biocenis in the water;
- the intertide-area, the vegetated mud-flats and shores;
- nature areas behind the dikes;
- the Delta-area as a whole;
- the Zoomlake;
- the Westernscheldt;

In the analysis of the changes in the environment an ecological model was used. The basis for this model is a so-called food-web, that is an outline in which is

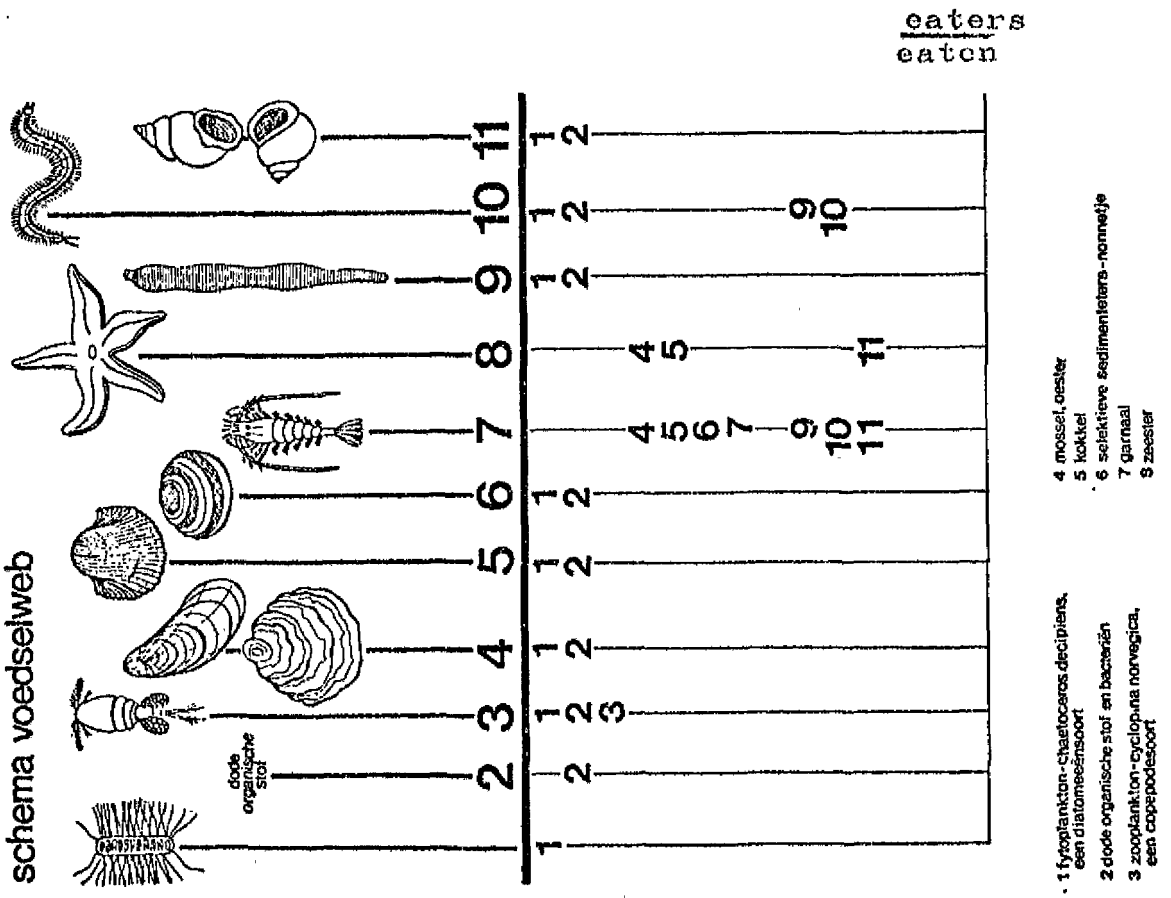
indicated which nutrients the various species of organisms need and how these organisms in their turn serve again as food to others; in other words how the nutrients circulate within the biocenis. Thus plankton serves as food for fish, which in turn are eaten by birds (fig.11) The more plankton in the water the more and the bigger the fish and the more birds can feed in the area.
Food can be introduced in an area in two ways. It can be produced in the area itself for example by algae which produce organic cel-material from sunlight and nutrients, which again are consumed by higher organisms; the organic food however, can also come into the area with the seawater. Thus, the food in the basin before the closure of the Grevelingen originated for one part from self-production and for the other from the sea.
In the ecological model the complete transfer of nutrients from one organism to the other is copied.
The quantity of nutrients which a certain group of organisms represents in the basin, is indicated by a specific magnitude, the "biomass". This is the dry weight of the organically formed cel-material of all individuals in this group of organisms together.
The ecological model used is new and moreover not all necessary data are available. The results, should therefore be viewed with caution. The model was tested though on the data of the Grevelingen. There the results of this model appeared to correspond reasonably well with the reality. For the time being it has been assumed therefore that the results of the model constitute a fair reflection of the future developments in the salt-water basins.

The biocenis in the water.

Of great importance for the biocenis is the quality of the water; that depends on the content of various nutrients,

Fig. 6 Food chains in the open Oosterscheldo.

1. fytoplankton-chaetoceros decipiens, a species of diatomea
2. dead organic matter and bacteria
3. zooplankton-cyclopina norvegica, a species of copepodoa
4. mussel, oyster
6. cockle
6. selective deposit eaters, - smew
7. shrimp
8. starfish
9. deposit-eaters, lugworm
10 omnivorous - nereis diversicolor
11 mudsnail, periwinkle
12 plankton eating fish
13 zoobenthos eating fash - plaice
14 fisheating fish - cod
15 plant eating fish - lesser grey mullet
16 fish eating birds - grebe
17 herbivorous birds - brent goose
18 zoobenthos eating birds - oyster catcher.



Figuur 11. schema

as well as on the salinity. With A3 the quality of the water in the tidal area is expected not to deviate too much from the one in the present Easternscheldt. The influence of polder discharges will be negligeable and only at the locks in the compartmentation dams some influence will be noticeable from the adjacent Zoomlake. Due to the enormous exchange of water with the North Sea, as a result of tidal movements, this will not affect the quality of the water in the tidal area. With C3 the influence of fresh-water at the locks in the Philipsdam might be felt a little more than with A3. The content of nutrients, nitrogen in particular, will increase in the Krammer, the Zijpe, the Mastgat and the basin of the Easternscheldt. Nitrogen is a nutrient which in all salt-water basins of the Delta area is completely used by algae in spring and in summer. This element constitutes as such a limiting factor in the production of algae, an increase of the nitrogen content means a greater growth of algae. It is not expected, however, that C3 will produce undesirable consequences for the biocenis.
The salinity of the water in C3 as well as in D4 and A3 will have to be at least 15,5 gr.Cl^-/1 in order to let the salt-biocenis function in an optimal manner. A drop below this value to a minimum of 13,5 gr. Cl^-/1 would be permissable if of very short duration.
For the preservation of this halophile vegetation such as we find in the Krabbenkreek, a salinity of 13 gr. Cl^-/1 is sufficient. It is expected that the required salinity in all alternatives can be realised. The level of nutrients as well as the salinity of the salt-water lakes, that is the Easternscheldt in D4; the Grevelingen and the Veerse Meer in C3, D4 and A3 , can to a certain extent be regulated with the aid of the sluices in the dams. The lakes can be flushed as often as need be with seawater. Broad calculations have shown that this is an adequate way to keep the quality of the water in the lakes at the desired level.

The abundance of species in the biocenis in the water will not change with A3 and probably not too much with C3 in comparison with the actual situation. It is expected that with D4 the number of species of organisms in the water will be smaller than in a tidal area. In Table 7 a broad estimate has been given about the size of this phenomenon.

Table 7. Percentage of number of species in the salt-water lake of D4 with respect to the actual situation.

Organisms	Percentage
Phyto-plankton	100
Algae	80
Zoo-plankton	80
Benthic animals	50
Fishes	25
Salt-waterfowl	100

The intertidal area, the vegetated mud-flats and the shores.

The intertidal area comprises now about 17000 ha. With construction of the compartmentation dams according to A3, this area will diminish by 28% or 4700 ha. With C3, due to the reduction of the vertical tide, it decreases even more namely 8500 ha, that is half of the present area. With D4 there is no intertidal area at all; the shores will get a different character. The intertidal area is an important feeding ground for birds, fish and shrimps. A reduction of the area is the cause that the biomass and the number of organisms in the intertidal area is proportionally reduced.

With C3, however, another phenomenon appears that partly prevents the reduction of the biomass. In C3 the settlement of sand and silt will increase all over the basin and as such more organic material attached to the silt will be added to the bottom. This material constitutes a source of food for many kinds of organisms.
On the shallow flats the settled silt will be whirled around and carried away by the action of the waves. Nevertheless the organic elements will be available to the benthic animals in the meantime. In the deeper parts all the sunken silt will be permanently settled because it will no longer be removed by waves or flows. Here also the benthic animals can benefit from the organic material and increase in numbers. Then also the number of shrimps and crabs will increase and the fish that use the benthic animals for food and consequently the fish-eating fish and birds. These effects can be estimated by this ecological model. In Table 8 a few results of this ecological model have been indicated, not exclusively for the intertidal area, but for the whole Easternscheldt basin.

Table 8. Proportional changes in the biomass (in tons of dry weight) in the salt-water basins in comparison with the actual situation in the Easternscheldt.

	Present situation (in tons)=100%	C3 %	D4 %	A3 %
Phyto-plankton, algae and eelgrass	8900	60	30	70
Zoo-plankton	600	45	1	75
Mussels, oysters, cockles	12000	75	20	75
Other benthic animals	4800	270	10	75
Fish	2290	135	15	75
Salt-waterfowl	11	100	35	100

The decrease of the biomass in A3 is mainly caused by a reduction of the intertidal area owing to the construction of the compartmentation dams. With C3 the reduction of the tidal area affects in particular the plankton. The remaining groups of organisms benefit with C3 from the sharply increased biomass of the benthic animals due to the sedimentation. In D4 the decline is caused by the disappearance of the intertidal area.

The vegetated mud-flats comprise at the moment an area of approx. 1450 ha., including the whole of the Easternscheldt area and the adjacent tidal waters Keeten and Volkerak. With C3 and A3 about 900 ha. (i.e. 60%) of that area will be situated behind the compartmentation dams. From the remaining 550 ha. still another part will disappear owing to a heightening of dikes, in particular on the south-west coast of Tholen, in the Krabbenkreek, along the north coast of St.Philipsland and in the basin of the Easternscheldt near Krabbendijke. With A3 even a larger part will disappear than with C3, because the heightening of dikes in A3 is more extensive. The vegetated mud-flats will mainly fall victim to smaller or larger poldering which could be necessary to obtain a smoother dike-alignment. Although each area in itself does not necessarily represent a very great value, together they constitute, however, an important facet of the present Easternscheldt. Due to the lack of sheltered angles in the new dike-alignment one should not count on the creation of such small new vegetated mud-flats.
With A3 no significant changes are being expected in the salt-water character of the remaining vegetated mud-flats. With C3, as a result of the reduction of the tide, the existing vegetated mud-flats will be so high above the average high-water level that they will practically get complete fresh-water aspects. As a result the vegetation will change its character. For the major part one may expect the same species of plants which are now found at the former mud-flats in the Grevelingen. The

number of species increases from about 75 to 120, because also species less sensitive to saline water will get a chance. There will be more and other species of birds, mammifers and insects on the drier and fresh-water vegetated mud-flats; their number will also increase. In C3 the vegetated mud-flats retain a considerable nature value. With D4 these mud-flats will disappear as a type of scenery. Owing to the disappearance of the tide the foreshores and shoals have in D4 a totally different character than the vegetated mud-flats and shoals in C3 and A3. The scenery gets a totally different look. This is caused by a de-salting, maturing of the bottom, changes in the ground-water regime and the inherent occurrence of drifting of drift-prone grounds and the adaptation of the flora and the fauna to the new circumstances. The developments in the Braakman, the Veerse Meer and the Grevelingen show that on the shores and shoals of salt-water lakes very interesting and valuable nature areas can develop. The former vegetated mud-flats and shoal areas with their pattern of creeks, ridges, basins and inclining planes show various courses of development; in the long run a great variety of biocenes will be the result. Ultimately rough landscapes could develop with forests and brush-wood and a flora and fauna rich in species.

The dike-enlargements in A3 and C3 will also have consequences for the biocenes on the rubble-layers of the shore revetment-works. Due to necessary adjustments of the submerged slope, the organisms now living on the rubble-layers will suffer seriously. In particular the rarer species might quite easily disappear for good. If the new rubble-layers are sufficiently coarse one may expect that a new colonisation will develop before long. Then the biocenis will be able to recuperate itself for the greater part.

Nature areas behind the dikes.

Along the Easternscheldt one finds many intersections, old closed off creeek areas and "karrevelden", these are areas which are excavated. Some of them are so close behind the dike that they are under the influence of salt seepage and harbour a halophile vegetation. In all alternatives the salt-seepage will remain at its present level. Enlargement of the dikes in A3 and to a less extent in C3, could have great effect on the intersections. Intersections are mostly found in those places where the tide-channels run very close to the dike. Together they embrace an area of approx. 450 ha. With the alignment of dikes as outlines by the Prov. Waterstaat of Zeeland (6) the intersections on North- and South-Beveland will disappear completely (fig.12). On Schouwen-Duiveland some intersections will remain partly unimpaired due to their greater distance from the flow-channel at the outer side of the dike. All in all not more than 50% of the area of intersections will remain intact with A3. With C3 the losses will be less. Also the "karrevelden" at the innerside of the dike and other low-lying salt areas are being affected by the dike-enlargement. It concerns here the Schelphoek and a few "karrevelden" on Schouwen-Duiveland and a lower part in the Vlietpolder on North-Beveland.
With D4 no dike-enlargement will be necessary; the present landscape of dikes and the fused village-nuclei will be maintained. The intersections at the innerside of the dikes will keep their present condition.

The Zoomlake.

In C3 and A3 the Zoomlake consists of the present Volkerak and the Verdronken Land of the Marquisate of Bergen op Zoom, connected with each other by the Scheldt-Rhine link. In total this lake covers an area of approx. 8000 ha. D-4 also includes the Verdronken Land in the Zoomlake; the lake then measures approx. 18000 ha. The quality of the water in the Zoomlake is determined by the level of nutrients. How the quality of the water will be, depends upon the load of nutrients coming from the Hollands Diep,

by side-long discharges of polders, or by water flowing from Western-Brabant. If the concentration of nutrients, especially phosphate, becomes too high excessive growth of alagae will occur, which is undesirable for many reasons (see appendix I). It is extremely difficult to find the right criteria which could indicate when the growth of algae is to be considered as injurious. Still the best thing to do is to draw a comparison with other great lakes (see table 9.) On the basis of this comparison it may be assumed that with C3, D4 as well as with A3 a "sometimes cumbersome" growth of algae might develop in the Zoommeer. All the more so because great parts of the Zoomlake consist of shallow areas, where the growth of algae develops more easily. Although, measures against an excessive growth of algae are possible, they offer no certainty of success. These measures are: purification of the lateral discharges into the lake and the de-phosphating of the intake-water. A more radical measure would be sub-compartmentation of the Zoomlake. With C3 and A3 this is done by embankment of the Marquisate of Bergen op Zoom.

Table 9. Total-phosphate contents and qualification of algae growth for a number of large Dutch lakes.

	Total content phosphate (mg-l)	Qualification algae growth
Eemmeer*	0,70	cumbersome
Gooimeer	0,51	cumbersome
Veluwemeer	0,44	cumbersome
Drontermeer	0,41	sometimes cumbersome
Brielse meer	0,30	cumbersome
IJsselmeer	0,21	sometimes cumbersome
Zoommeer	0,15 - 0,20	

* meer = lake

The Marquisate of Bergen op Zoom

With D4 moreover, the Verdronken Land of South-Beveland can be embanked; this possibility will be dealt with in the sensitivity-analysis.
With all the alternatives the fresh-water lakes will receive a bigger or smaller salt-load via the navigation locks. In D4 it is possible to maintain the chloride content of the Zoomlake at approx. 0,25 gr. Cl^-/1, but with C3 and A3 one has to reckon with an average chloride-content in the southern part of the Zoomlake of approx. 0,3 to 0,4 gr. Cl^-/1 with occasional maxima of 0,8 gr.Cl^-/1. In the embanked Marquisate of Bergen op Zoom probably lower chloride contents could be realised.
Chloride-contents higher than 0,4 gr. Cl^-/1 will be detrimental to the organisms in the water as well as to those at the shores. In C3 and A3 with chloride-contents higher than 0.4 gr. Cl^-/1 the biocenis will clearly contain less species of organisms than with D4.

The shores of these fresh-water lakes need special attention because with respect to the present situation, they will undergo a drastic change. Under water, along the shores and on the adjacent higher grounds a great variety of vegetation could develop. This vegetation is also important as a biotope for fishes and birds. The shoals eastwards of the Philipsdam, under fresh-water circumstances will start to fulfil a function comparable to the one of the important bird-area at the Ventjagers-shoals.
In a fresh-water lake these will become valuable regions. The quality of the biocenis depends to a great extent on a good quality of the water and an as small as possible variation of levels. Sub-compartmentation of the Marquisate of Bergen op Zoom and the Verdronken Land of South-Beveland could lead to a better control of these fringe-conditions which are so important for the biocenis. The differentation in bottom, hydrology and geomorphology of the shores and higher parts of the Zoomlake justifies high expectations for the future as far as the quality of the new landscape is concerned.

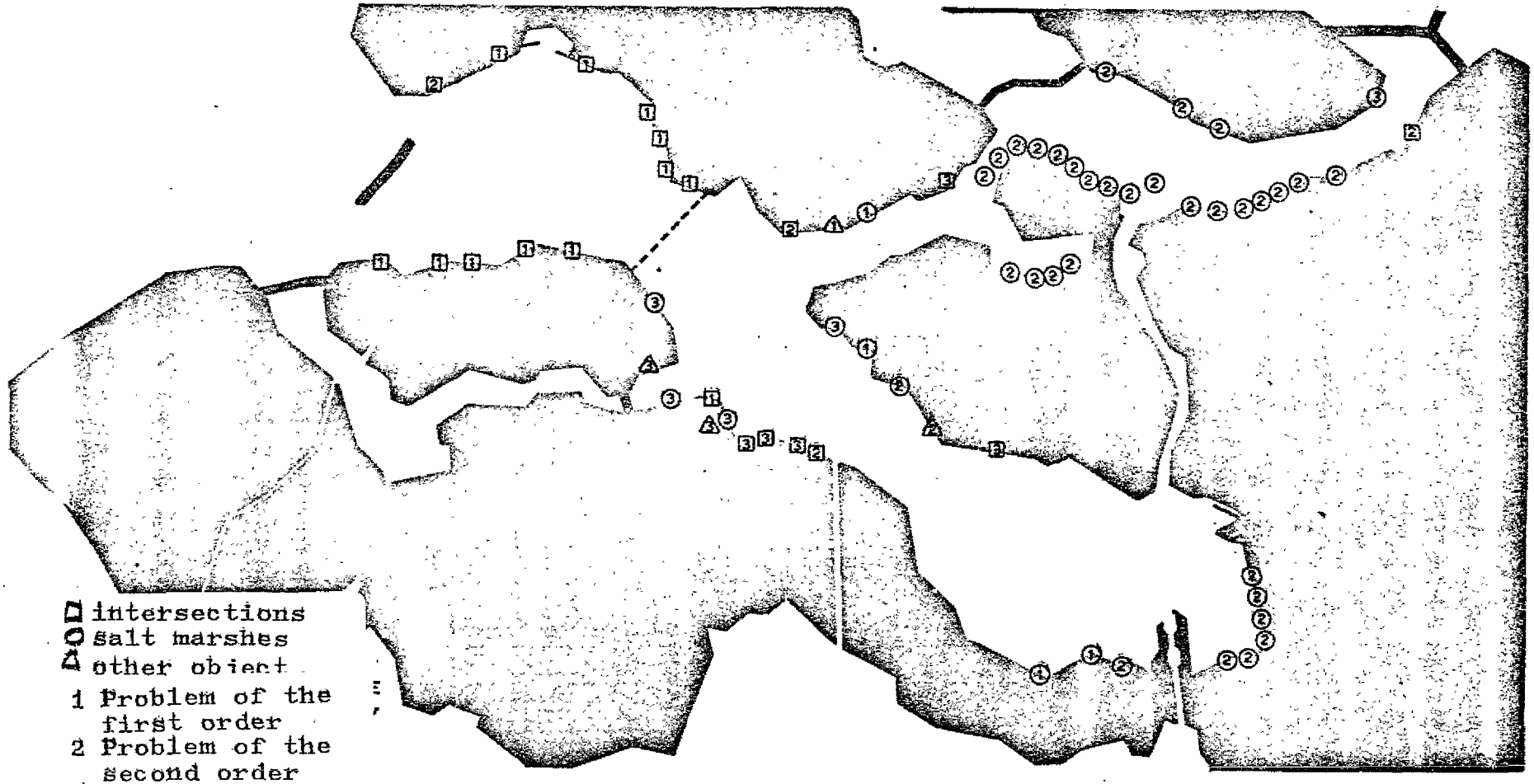


Figure 12 nature areas behind the dikes and outside the dikes

After sub-compartmentation areas could even develop there with the character of the present Naarderlake.

The Westernscheldt.

The fresh-water Zoomlake will discharge an additional fresh-water load on the Westernscheldt: a rest-flow from the salinity combatting system at the navigation locks and possibly flushed excess fresh-water from the Zoomlake. This fresh-water load is still enlarged in D4 by the navigation lock with a salinity combatting system at Hansweert. This lock and the one in the Scheldt-Rhine link supply each about 20 m^3/sec. of fresh-water.

The estuarial character of the Westernscheldt determines the nature value of this area. Shifts and changes in the chloride-gradient as a result of the fresh-water discharges could have consequences for the biocenis. With that in view it is important to know in how far an increase of the fresh-water flow into the Westernscheldt affects the chloride-contents at the mouth of the Westernscheldt and on the vegetated mud-flats. The additional quantities of fresh-water of 20 to 40 m^3/sec. are of great influence, considering that the average discharge of fresh-water from the Scheldt amounts to 70 m^3/sec.

A decrease of the salinity will diminish the saline character of the vegetated mud-flats of the Verdronken Land van Saeftinge. At the same time the number of organisms per species of the marine biocenis on the Hooge Platen at the mouth of the Westernscheldt could diminish as a result of decreased chloride-content.

The shoals at the mouth of the Westernscheldt and especially at the Hooge Platen are of great importance to waterfowl as feeding and resting area. With an additional 60 m^3/sec. of fresh-water the critical limit of fresh-water for various species of animals lies even west of the Hooge Platen, which affects the natural scientific significance of the Westernscheldt in a negative sense. With each alternative there is the

possibility that now and then higher fresh-water loads might occur. It is true that after the chloride-content - due to a diminishing fresh-water flow - will have increased again. Re-colonisation of the area by organisms will take place but the temporary shortfalls mean a decline in the foodsupply for the birds and therefore will affect the bird-population. In the present situation such temporary disturbances also occur, namely with high discharges from the Scheldt, but with C3, A3 and especially D4, these disturbances will occur with a higher frequency. Toploads that coincide with natural high discharges from the Scheldt are as such not judged in a negative way.
For the preservation of the biocenis in the Westernscheldt D4 is more unfavourable than C3 and A3, because of the higher permanent fresh-water load.

The Foredelta.

The Foredelta comprises the area at the mouth of the estuary outside the coastline. It is intersected by deep tide-channels, which are separated from each other by shoals. From an environmental point of view this area is characterised by a not-unimportant production of plankton, wurms and testacea which serve as food for shrimps, fishes and birds. The abundance of the species of fish in the foredelta is big, bigger than for example in the basin of the Easternscheldt. The foredelta is also a spawning-ground and nursery for fish and shrimp, but in this respect of less import than the present Easternscheldt. Also a small number of bird species are to be found there; the number of these species, however, is high. These are, in particular the various species of sea-ducks that feed on the foredelta. For these species the area is of great importance.
D4 affects the biocenis of the foredelta in a positive way. Shoaling of the area will result in more attainable food for among others the birds. With C3 and A3 there

will only be small changes with respect to the present situation. In C3 and D4 the construction of works offers a firms basis for various organisms, such as sponges, coelesterata, tunicata, enchinoderms and crustacea, which are now also to be found in the rubble-layers along the dikes of the Easternscheldt and which form an important part of the biocenis there.
With D4 the biocenis of the foredelta will become richer still, if in the long run the creation of areas of salt-water lagoons with mud-sedimentation and new beaches becomes possible. If the latter takes place on a big scale, very important areas could develop here for the environment as already has been indicated in "The colours of the South-West Netherlands" (29).

The whole Delta-region.

The effects of the Delta-works on the biological values of the whole Delta-region are three-fold; a great part of the Delta-region will practically be cut off from river-water; tidal areas will be transformed into areas with stagnant water and a number of areas which originally were saline areas, are or will become fresh-water areas. Originally, there were in the Delta-region only tidal areas with salt-, brackish- or fresh-water. Due to the construction of the Volkerakdam the influence of the river-discharges on the Easternscheldt became considerably less. Under the influence of the Deltaworks stagnant basins were added, with fresh- as well as brackish- and salt-water. As a result thereof many tide-bound species of animals and plants disappeared from the stagnant areas, while other species could still hold their own, only in much smaller numbers. For mobile species such as birds, a refuge was still possible to the remaining tidal basins, as a result of which the number of these species increased in those localities.
Other species though, were able to increase their number in the new situation. Also new species established themselves because the changed situation offered new

opportunities. This goes in particular for the fresh-water bound species, which also got a chance in the salt-water basins on the higher parts which remained permanently above water since the closure. In Table 10 the aforementioned has been further quantified. In this Table are not included the lower landplants such as fungi, lichens and lower terrestrial animals such as wurms, spiders and insects.

Table 10. Numder of species of organisms in the whole Delta-region (exclusive of the Westernscheldt.)

	Situation 1950	Situation 1976	C3-A3	D4
Phyto-plankton	400	500	500	400
Zoo-plankton	85	125	125	100
Phyto-benthic organisms	400	450	450	350
Zoo-benthic organisms	1200	1300	1300	700
Higher plants outside the dikes (fresh-water)	150	700	800	900
Higher plants outside the dikes (salt-water)	75	75	75	90
Fish and octopi	75	70	100	50
Birds	100	200	200	200
Reptiles, amphibians ands mammifers	20	30	40	40
Total	2505	3450	3590	2830

As a result of the already executed Delta works and the creation of new basins the abundance in species has been increased in the Delta area as a whole. In this respect the Delta works have a positive result. It appears at the same time that with C3 and A3 only the number of species of the higher plants in the shore-zone will increase.

For the rest. however, there are but a few changes. With D4, it is true that the number of species is smaller than at present but larger than before the Delta works. The Table indicates that from an environmental point of view, the Delta-region will remain a very important area, whatever alternative one might choose.
The preceding considerations have been summarised in score-charts. In these score-charts only the extent of changes with respect to the present situation is indicated and no evaluation is expressed about the environment in the various alternatives.

Score-chart environment.

	Present* situation	C3	D4	A3
Areas (ha)				
Area under tidal influence (dike to dike)	45000	35000	0	35000
Intertidal area	17000	8500	0	12000
Vegetated mud-flats	1450	550	0	550
Intersections	450	450	450	225
Mud-flats and desiccated shore-lands				
Maintenance saline character of mud-flats		-	--	h
Abundance halophile plants		+	+	h
Abundance of other plants		+	++	+
Abundance of birds (Species)		+	+	+
Number of birds		+	++	+
Intertidal area				
Abundance of species of plants		h	--	h
Abundance of species of animals		h	--	h
Biomass in salt part	tons of dry material (100%)	%	%	%
Phyto-plankton, sea-weed, eelgrass	8900	60	30	70
Zoo-plankton	600	45	1	75
Mussels, oysters, cockles	12000	75	20	75
Other zoo-benthos	4800	270	10	75
Fish	2290	135	15	75
Marine birds	11	100	35	100
Water				
Types of salt water		h	--	h
Intersections and other nature areas inside the dikes		-	h	--

* the absence of changes with regard to the present situation has been indicated with an "h"

Score chart environment (continued)

	Present* situation	C3	D4	A3
Westernscheldt				
Effects of the fresh water load from the Zoom lake		-	--	-
Foredelta				
Effects on the biocenis		h	+	h
Number of species of organisms in the whole Delta-area (excluding Westernscheldt)				
Phyto-plankton	500	500	400	500
Zoo-plankton	125	125	100	125
Phyto-benthos	450	450	350	450
Zoo-benthos	1300	1300	700	1300
"Higher" plants outside dike (fresh)	900	800	900	800
"Higher" plants outside dike (salt)	75	75	90	75
Fish and octopus	70	100	50	100
Birds	200	200	200	200
Reptiles, amphibians and mammals	30	40	40	40
Total	3450	3590	2830	3590

3.3. Professional Fishing.

Introduction.

In this paragraph we shall try to make an estimate of the damage the various alternatives will cause to professional fishing and the results thereof for the national economy. The proceeds from fishing dependant on the Easternscheldt amount to about 10% of the value of the total Dutch supply. The importance of the Easternscheldt via à vis the pattern of the fishing of Zeeland is very great (17). Moreover, the indirect consequences for for example commerce and the canning-industry within the fisheries-sector could be considerable. And that might cause certain effects for other industries.

It should, though, be put first and foremost, that the consequences of the alternatives should not be viewed from an economic point of view only. On the other hand a quantitative insight in the economic consequences might clarify the problem of selection. It is, for the rest very difficult to obtain a quantitative insight, in the first place, because only little is known about the fish-population and their ecological conditions of existance; for that reason the basis for the estimates which are required for the economic analysis are sometimes uncertain. In the second place because good statistical material only exists about the supply; figures about the activities of trade, the canning-industry and consumption are very incomplete.

The estimates of this analysis therefore will have to be viewed with some reserves.

The following industries have been analysed: mussel-, oysters- and cockle-fishery, the lobster trade and the coastal and North Sea fishery.

Not analysed are: the local fishery in the Easternscheldt on periwinkles, whelks, lobsters, North Sea-crabs, shrimps, young herring, eel, flounder, sea-pike, lesser grey mullet, etc., etc., and the fresh-water fishery. With the exception of the eel-fishery, the proceeds of these types of fishery

are relatively small. The situation of the salt-water fishery on eel will not change with any of the alternatives.
As a starting point for the analysis of the influence of the alternatives, first the present situation of each of the types of fisheries has been described. On the basis of ecological insights estimates have been made about the possible production of testacean and fish with each of the viewed alternatives. Changes in production can have important economic and social consequences for the fishing-industry.
At the evaluation two norms have been used for the significance of one activity; the added value and the labour-opportunity. The added value - that is the proceeds of the production minus purchases from other enterprises - is one of the norms to establish the role of an activity in the economy. Another one is the labour opportunity which is being expressed in man/year, because in this case it concerns persons who are not fully employed during the whole year. In addition to the changes in added value per year the effect on the national economy is also being indicated.

As scenario the thesis has been used that the circumstances for the mussel-culture in the Waddensea remains adequate and that production there might even be increased. It has been further assumed that the situation will continue in which workers once they become unemployed will have great difficulty finding a job elsewhere.

The mussel-industry.

In this type of enterprise we distinguish four kinds of economic activities e.i. the culture, the storage and revitalisation, trade and the canning-industry. The Dutch mussels are being cultivated for 70% in the Waddensea and for about 30% in the Easternscheldt (19).
They are being fished with ships off the culture grounds and brought to Yerseke where the cultivators sell their produce to merchants at the auction. The merchants take care of the revitalisation and storage of the mussels. This process is necessary to give the mussel the opportunity

to get rid of sand and silt and to recuperate from the physiological shock due to the fishing and transportation. This takes between 2 to 4 weeks. After revitalisation about 4,5 million kg are being sold on the home market as fresh mussels, about 50 million kg are being exported and about 15 million kg, sometimes hardly revitalized, are being used in the canning-industry.

The average annual production, proceeds, added value and labour opportunity have been indicated in Table 11.

Table 11. Data on mussel-industry, averages over the period 1970-1974 (20).

Activity	Production (mln kg per year)	Proceeds (mln gld. per year)	Addedvalue (mln guild. per year)	Labour opportuni (man-year per year)
Culture	90	24	14	400
Revitalisation	90	47	19	150
Trade	70			
Canning-industry	2,5	14,3	4	150
Total		85,3	37	700

Mussels, as typical inhabitants of estuaries, can stand sharply changing and extreme circumstances. This makes the mussel, together with its rapid growth, delicious taste and endurance against transportation, an excellent animal to cultivate. We know from experience, however, that the salinaty should not fluctuate too much and that the average salinity should not be too low. The limit for the spreading lies at an average chlorinity of 10 gr. Cl^-/l.

Mussels filter plankton and dead organic material from the water. This should be available in sufficient quantities in order to maintain the great number of animals in the growing-grounds. At these growing-grounds the maximum flow-velocity is 0,50 - 0,75 m/sec. Lower and higher velocities are possible and mussels live also in stagnant water, but a profitable culture will probably not be possible.

Mussels, by nature, exist mainly on the lower parts of sandy shoals if there is little wave-action. The growing-grounds are almost all permanently submerged, because that guarantees a continuous food-intake. The peculiar character of the Dutch mussel-industry with only one trade-centre at Yerseke and two production-areas - Waddensea and Easternscheldt - makes it necessary that the mussels produced in the North are being stored in the South. The mussels are being harvested on the growing-grounds with cornets and during the operation they swallow sand which has to "be brought up" later. The mussels have also been weakened by the two days transportation by boat and it is essential that they recuperate in order to be exported alive over great distances and without loss of quality.
Storage, removal of sand and recuperation all take place simultaneously during the so-called "revitalisation"-period. This takes place in the basin of the Easternscheldt at Yerseke, where the circumstances are favourable; clear water, a hard and clean bottom close to the most important export-areas: Belgium and France. The flow-velocities at Yerseke are already so low (0,3 - 0,5 m/sec.) that sedimentation of silt should take place. This hardly occurs, however, because the wind creates waves in this shallow water which causes great turbulence. Fig. B shows the position of the mussel-banks in the Easternscheldt.

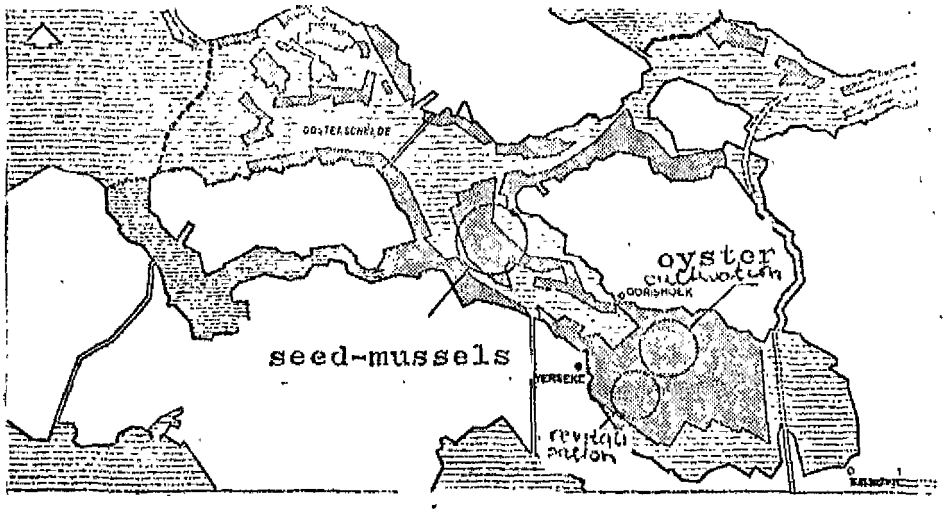


Figure 13. Location of mussel- and oyster beds in the Easternscheldt.

The consequences of A3 for the mussel-culture appear to be negligible. With C3, owing to a reduction of the flow-velocities, less fresh-water will flow over many of the culture-grounds. It is not impossible that new culture-grounds can be found, where flow-velocities are sufficiently high. For the time being, we assume, however, that with C3 mussel-cultivation will remain feasable in the same manner. This seems reasonable because a temporary set-back in the cultivation need not have a negative effect on the total Dutch cultivation; there is, at the moment a surplus-production of cultivated mussels. In the period 1970 to 1974 this amounted to 25 million kilo per year. The surplus-production is not apparent in for example, the statistics of the Central Bureau of Statistics. The factual mussel-production was higher in the last few years than the 90 million kg. mentioned in the statistics; the surplus was sold to the "musselfund" against the lowest prices at the auctions. These mussels are not being destroyed but sold back to the cultivators at the end of the season and a smaller part to traders. The next season they will be offered again as fresh mussels. All in all this means that C3 does not necessarily have to cause economic effects on the cultivation of mussels.

With D4 the cultivation of mussels in a stagnant salt-water basin is in principle feasable, this contrary to what had been believed up till now. In March, 1976 a great quantity of seed-mussels of good quality was harvested from the Grevelingen. But because the input of organic material from the sea is declining sharply cultivation will probably not be remunerative. Even other production methods, such as "suspended cultures" and cultivation in eutrophic ponds will probably not be worthwhile, due to the relatively high labour costs. It is being assumed that with D4 the mussel cultivation in the Easternscheldt is not a paying proposition. With this alternative one should therefore reckon with a reduction of 30% of the total Dutch production. In view of the fact that the storage and revitalisation can continue in a normal way, the cultivation in the Waddensea can go on or even be expanded. The actual production there

is not very high and it is being limited to the western part; only 50% of the allotted banks are being used. However, the expansion of the cultivation in the Waddensea might conflict with the interests of the shrimp-fishery. It is also possible that the intensifying will cause a small increase of production costs.

During the storage and revitalisation process the mussels "spit out" silt and sand. The silt has to be removed because otherwise the revitalisation process would become impossible. Now, the flow-velocities are so low already in the present situation that, without the influence of the winds, sedimentation of silt would take place. With A3 this hardly changes but with C3 the maximum velocities of 0,3 - 0,5 m/sec. will be reduced one more by half. This does not imply an automatic increase of sedimentation. In the first place because with the frequent harvesting of the mussels silt is being stirred up which is then carried away by the flow of the water. In the second place because also in stagnant basins the bottom can be deficient in silt due to the wave-action in shallow water. It is therefore uncertain if revitalisation in a natural way can be continued or not. This requires further research. For the time being we assume that with C3 revitalisation in a natural way remains possible. Alternative possibilities of revitalisation are being discussed in chapter IV.

With D4 an artifical basin for revitalisation has been included in the estimate of the costs (5). In view of the present surplus-production only a small expansion of the cultivation in the Waddensea would be sufficient to maintain the total Dutch sales at 90 million kilo's level. We assume that this expansion will not cause any problems.

The foregoing implies that with C3 as well as with D4 the cultivation and revitalisation will continue in a normal way. There is, therefore no reason to assume that trade and canning-industry will suffer damage, so that we may conclude that none of the alternatives will produce economic effects for the mussel-industry. Added value and labour opportunity remain unchanged.

Oyster farming.

From an economic point of view the oyster culture is the most important after the mussel-industry. The actual oyster farming consists of 10 big enterprises with a total annual turnover of 14,9 million guilders (exports and sales on the home market). This industry offers labour opportunity to about 70 people. It is, however, very difficult to obtain a clear picture of the labour opportunity in the branch of the testacean type of animals. Some oyster farms are (partly) combined with mussel enterprises ; a number of firms also trade in lobsters. In the oyster farms there is quite a high percentage of seasonal labour, who out of season, November and December, also work in the mussel industries.

The activities of the oyster farms can be split in cultivation and trade. There are no oyster farms though, that specialize either in trade or in cultivation only. Because trade as well as cultivation are being handled by the same enterprise and owing to the fact that there are no data available to obtain a clear picture of each separate activity, the effects of the alternatives are only analysed for the oyster culture as a whole.

It is made even more difficult to obtain an insight about the effects for the oyster culture, because it is not clear how big the share is of own production in the total turnover. The turnover consists mainly of exports (in the period 1970-1974 about 1,2 million kilo's) amounting to approx. 14,3 million guilders (21). Sales on the home market amount to approx. 50.000 kilo with a value of 0,6 million guilders (prices of end 1975).

In order to calculate the added value the purchases at other farms have to be deducted from the total proceeds of 14,9 million guilders. Imports averaged 1,6 million kilo's per year, amounting to 8,6 million guilders (18). In any case the added value is less than 6,3 million guilders per year. Under the influence of purchases from third parties this amount could be even lower. The conclusion is that only a small part of the traded oysters have been grown in Zeeland itself.

In the first place the value of imports is so high that these cannot consist of seed-oysters only, but consist for a great part too of almost adult oysters of 2 to 3 years old or mature animals of 3 to 5 years old. Secondly, if all sold oysters, roughly 17 million aniuals would have been grown in the Easternscheldt from the beginning of the breeding-phase, then that would have required 170 man/year. This estimate has been based on the Report of the Committee Easternscheldt where it states: "in a well-run oyster farm working with mussels and the growing of oysters for breeding and comsumption the production per man/year amounts to approx. 100.000 consumption oysters (9)" Regarding the present labour opportunity - about 70 man/year including trade - one may state that the majory of the farmed oysters has not been started from the breeding phase. And if at the same time, one takes into consideration that a part of the 70 labour places is being maintained by typical trade-activities, the conclusion can be drawn that the production of original Zeeland oysters is small.

In former years the import of oysters was incidental. But in the winter of 1962-1963 the frost destroyed nearly the whole oyster population. After passing the Delta Act it was calculated that all 211 oyster farms would sustain damages as a result of the closure of the Easternscheldt. After 1963 the Government offered compensation to all 211 growers on the basis of the liquidation value according to the "Damage to oyster growers Act". In spite of the compensation the oyster farms were free to continue their activities "till the closure". The impression exists that the present level of production is not at its maximum. In May, 1976 the compensation for all 211 growers will be settled. Then an amount of 45 million guilders as liquidation value will have been paid out to the oyster growers. The fact remains, however, that the losses in added value in the future will have to be considered as national economic losses.

Oysters are far more sensitive to environmental conditions than mussels. The salinity should be at least 13 gr Cl^-/l. The flow-velocities required for the cultures vary per age-group. Young oysters are being kept at places where the velocities are low; while growing older they are being transplanted to places with higher velocities. In order to spawn oysters need a temperature of 18°C or higher. At very low temperatures as happened in the winter of 1962/63 they die; in that year the oyster culture in Zeeland was practically wiped out. Oysters, especially young ones, also perish if they find themselves in places where settlement of silt takes place. All this causes the oyster farming to be restricted to the basin of the Easternscheldt where the conditions for oysters are favourable. The oyster beds have been indicated in figure ...

With A3 the effects on the oyster culture appear to be negligible, except for the necessary shifting of installations, etc. as a result of the dike-heightening.

The reduced tide with C3 will lead to a decrease of the flow-velocity, an increase of sedimentation and a reduction of the quantity of floating organic material. Sedimentation is deleterious to oyster beds, because contrary to mussels oysters cannot live on muddy bottoms. Reduction of the flow-velocity causes the oysters to absorb less food. On the other hand the quantity of nutrients (phyto-plankton) will augment because of the increased clarity of the water. We assume that, although the production capacity might diminish, the present sales will remain the same. Moreover, if one assumes, as is the case now, that part of the traded oysters are being imported completely or almost mature for consumption, then also with C3 no damage to the oyster culture is to be expected.

With D4 the whole oyster culture will be lost. By changing to other techniques and locations the damage could be somewhat reduced. (See chapter IV), but further research will be required. Starting from the hypotheses that oyster farms depend on the Easternscheldt for their total turnover, this

This will lead to a loss of 6,3 million guilders in added value and to a loss of labour opportunity of 70 man/year.

Cockle fishery.

Cockle fishery not only takes place in the Easternscheldt, but also in the Waddensea. Cockle fishing proves to be very lucrative; and during recent years this branch of the fishing-industry expanded considerably.
In 1972 the supply from the Easternscheldt amounted to about 1,2 million kilo but in 1975 already 7 million kilo were harvested. In 1974 the export value was 8 million guilders and in 1975 it amounted to hfl. 14 million at prices of hfl. 2 per kilo.
The harvesting was done so rigourously in 1975, that economically collectable populations will probably not be found any more in 1976. Only in 1977 and 1978 harvesting will become interesting again. This does not mean though, that cockles as a species are being threatened. They are numerous, and of all the animal species occurring in the Easternscheldt they have the biggest total biomass. The distribution of cockles lies at a salinity of 13 gr. $Cl^-/4$. Cockles will occur at the lower parts of the shoals, below NAP. The heaviest concentrations in the Easternscheldt in 1975 occurred at Neeltje Jansplaat. The density is not only determined by the growing conditions at the locations, but in particular by the hydrological conditions that determine the degree of"fixation"of the young animals.
Cockles are being harvested with special dredge-nets or even with suction dredgers, which by the way, is deleterious to the rest of the biocenis.
A rational level of harvesting is being estimated at 2 million kilo's per year. This would mean proceeds amounting to approx. 5,6 million guilders, an added value of 2,4 million guilders and a labour opportunity of 30 man/year.
With A3 no change is being expected.
With C3 the area where cockles might be found will be reduced by 40% but due to the fact that the regions with the highest

density of cockles are all situated west of the compartmentation dams, the collectable populations will diminish with less than 40%. Due to the reduction of the flow-velocities the quantity of cockles might be affected in an unfavourable way. Cockle fishery will further become more difficult as a result of the tide-reduction. Now already harvesting has to take place during the short periods of high tide. If the height of the tide decreases, the margin as far as the draught is concerned will diminish and consequently the period available for harvesting. One and the other might be the reason that the cockle fishery will become less lucrative. Based also on calculations with models as mentioned in par. 3.2, we assume that the total decline will be about 25%, which means a loss in added value of about 0,6 million guilders and 7 man/year of labour opportunity.

As far as D4 is concerned the results of the models and the experience with the Grevelingen indicate that the cockle population will be a lot less numerous. Besides the hydrographic pattern will change in such a way that regions which are interesting for fishing, will disappear. Since a remunerative exploitation will not be feasable any longer, the total added value of 2,4 million guilders will be lost and as a result the loss of 30 man/year labour opportunity.

Lobster trade.

Yerseke is the centre of an international lobster trade. After being imported, mainly from Great Brittain and Norway, the lobsters are being stored in artificial basins with circulating seawater. Most "lobster-parks" are covered. During this stay in the "parks" for a few weeks up to a few months at the most, no growth or improvement of quality occurs. Apart from lobsters, also langousts are being traded. Although data about the sales on the home market are not available, it is estimated at 2,1 million guilders per year, against an export value of 6,7 million guilders. The added value of the lobster trade will amount to 2,4 million guilders at the most.

As long as sea-water of good quality will be available for the basins, the lobster trade will not encounter any problems. A3 and C3, therefore will not have deleterious consequences for the added value and the labour opportunity. With a stagnant salt-lake as in D4, one can no longer profit from the tide for the "refreshing" of water in the"parks." May be we should start making use of pumps, which could lead to somewhat higher costs. If the lobster-parks will have to be moved, new investments will be required. We assume that in the long run, this will not have ill-effects on the added value and the labour opportunity.

Coastal and North Sea fishery.

The Easternscheldt has the function of a "nursery" for species of fish which are being caught in the North Sea. It concerns in particular sole, plaice and shrimps. In recent years the populations of sole and plaice dropped sharply as a result of over-fishing; the Government has therefore imposed a hauling-limit. As yet, little is known about the significance of the Easternscheldt as a "nursery"; recent research though indicates that the significance is less than was accepted. In any case, it does not seem probable that with C3 the function as "nursery" will be affected. The results of the models even indicate an increase.

Uncertain is the effect of the sill of the storm-surge barrier; especially bottom-fish will have to conquer great differences indepth in a short period of time when crossing this sill, which might cause some damage. It is not certain whether D4 will have any effect on the fishing of sole and plaice. The shrimp fishery, that's for sure, will certainly be affected. To avoid being too optimistic, we copy the estimates of the Committee Eastern-scheldt. On the basis of the Zeeland supply in 1972 this means a decrease of the added value of 3 million guilders (price-level end 1975) per year and a loss of labour opportunity of 60 man/year.

Table 12 gives a summary of direct effects of the alternatives on the various branches of industry.

Table 12. Direct effects on the fishing-industry.

	C3		D4		A3
	added value million gld. yearly	labour oppor-tunity	added value million gld. yearly	labour oppor-tunity	
Mussel culture	0	0	0	0	0
Oyster culture	0	0	-6,3	-70	0
Cockle fishery	-0,6	-7	-2.4	-30	0
Lobster trade	0	0	0	0	0
Coastal and Sea-fishery	0	0	-3,0	-60	0
Total	-0,6	-7	-11,7	-160	0

Consequences for the National Economy.

The consequences for the national economy consist of national-economic losses of added value of the fishing-industry and the effects thereof on other related branches of industry. From the "input-output" data of the Central Bureau of Statistics one may deduce that the indirect effects for the fisheries correspond to about 60% of the direct effects. In order to find the total effect of the alternatives the amounts have to be multiplied by 1,6. Thus, the total loss of added value with D4 will amount to 18,7 million guilders per year.

To compare: the annual added value of the whole Dutch fishing industry amounts to more than 200 million guilders.

In order to determine the cash-value of the national economic losses, we have to capitalise with 10%, according to the guidelines of the (C.O.B.A.) Committee for Policy Analysis. In this way the total loss with D4 amounts to 187 million guilders and 10 million guilders with C3.

As indicated in the introduction a scenario is being used whereby the future contribution to the national product of people becoming unemployed has been fixed at nil. (Zero). The real losses as such could be lower than the amounts mentioned earlier.

A significant difference between the calculation in this Report and those of the Committee Easternscheldt is the construction of a mussel-revitalisation place with D4. Because of this the mussel-industry could be preserved with limited costs.

The Committee Easternscheldt furthermore assumes that people who lost their job will be able to find employment elsewhere after retraining which proves that the Committee has a more optimistic outlook than we show in this Note.

The score-chart with the effects of the alternatives on the fishing-industry has been shown on the next page.

The national-economic losses amount to more than 180 million guilders with D4 and to 10 million guilders with C3; with A3 no losses are to be expected.

In Chapter IV the results are being shown in case some theories will be changed.

Score-chart Fisheries.

	C3	D4	A3
Cash value of future loss for the commercial fishery (million glds.)	6	117	0
Annual loss of employment in the fisheries (man/year)	7	160	0
Cash value of total national-economic loss (million guilders)	10	187	0

3.4. Watermanagement.

In this paragraph, we shall give an idea of the watermanagerial consequences of the alternatives, particularly with regard to the fresh-water Zoomlake, that will be created behind the compartmentation dams. Although, a fresh-water Zoomlake will be created with all the alternatives, there are as yet watermanagerial differences, as a result of, among other things, the differences in salt-loads.
It has been assumed that on the Zoomlake an almost constant level will be maintained. As mentioned already in chapter II for level control, flushing and de-salting a discharge-medium into the Westernscheldt with a capacity of 100 m3/sec. will be required for all alternatives.
With C3 and A3 this will be a scouring-channel which discharges the fresh-water into the Westernscheldt near Bath.
With D4 a scouring-sluice has been included in the plans for improvement of the Canal through South-Beveland. The effects of the fresh-water discharges on the aquatic environment of the Westernscheldt have been dealt with in par. 3.2.
In the next pages we shall discuss the following subjects:

- the control of salinity of the Zoomlake;
- the possibility to supply the adjacent agricultural and horticultural areas with fresh-water from the Zoomlake.
- the possibilities of supply of drinking- and industrial water in the southern Deltabasin;
- the southern Deltabasin in relation to the national watermanagement.

Control of the salinity of the Zoomlake.

Firstly, one should determine which degree of salinity one wishes to accept in the Zoomlake. In the Indicative Muli-year Program 1975-1979, 0,2 gr. Cl^-/l is mentioned as a provisional limit and 0,15 gr. Cl^-/l as a target value. (16).

In the Netherlands a degree of 0,3 gr. Cl^-/l is considered a maximum for the time being. For a proper development of the flora and the fauna this standard should also be applied in a fresh-water basin.

The de-salting of the Zoomlake could in principle start immediately after closure of the compartmentation dams by taking in fresh-water from the rivers via the inlet-sluice in the Volkerakdam and by discharging brackish-water into the Westernscheldt with an average flushing of 100 m^3/sec.

The de-salting of the Zoomlake with C3 and A3 will roughly take 6 to 12 months; with D4 - due to the greater volume of the Zoomlake - it will take 12 to 18 months.

After de-salting of the Zoomlake the salinity will increase every now and again by brackish discharges from the polders especially those from Tholen, which carry an average of 2 kg Cl^-/sec - and by salt-intrusion via the navigation locks. Increasing salinity can be countered not only by limitation of those salt-loads but also by additional flushing with fresh-water from the rivers. The salt-loads entering via the navigation locks with the various alternatives have been indicated in tables 3 and 6 of chapter II.

In Table 13 the separate chloride content of the Volkerak-section and the southern part of the Zoomlake are being indicated respectively with and without additional flushing of 100 m^3/sec.

Table 13. Chloride content Zoommeer (in gr. Cl^-/l

	C3	D4	A3
without flushing			
flushing: Volkerak	0,3-0,6	0,15-0,3	0,3-0,7
southernpart	0,5-1,2	0,3 -0,5	0,6-1,3
with additional flushing: Volkerak	0,15-0,5	0,1-0,35	0,2-0,6
southern part (100 m3/sec.)	0,2 -0,5	0,2-0,35	0,25-0,6

From this Table we can see that an additional flushing of 100 m3/sec. in particular with C3 and A3 causes a considerable decline of the salinity of the Zoomlake.

Fresh-water supply for agriculture and horticulture.

The interest of agri- and horticulture are in principle served with a fresh-water supply from an eventual fresh-water basin. The water to be taken in serves to flush the polder-waters as well as to maintain the level of those polder-waters. Flushing is a medium to keep the salinity low. Replenishment is necessary to bring the water, that has been withdrawn from the polders due to evaporation, vegetatiou, drainage and sprinkling, back to its proper level.

The effects of the alternatives on agri- and horticulture can be measured by the higher yields as a result of the additional supply of fresh-water. We speak of a quantitative effect when the higher yield is a result of the countering of droughts and of a qualitative effect when it is the result of a reduction of the degree of salinity. The scope of these effects will be determined by the size of the area which has to be served by the Zoomlake and the total demand for water in that area (13).

The area to be serviced by the Zoomlake consists with C3 and A3 of St. Philipsland and Tholen and part of Western Brabant. With D4 there are also possibilities for fresh-water supply to the eastern part of South-Beveland.

The quantitative effects prove to be considerable: for the major part though, they will be compensated by the costs which are connected with the measures to be taken, such as: production costs, transportation costs and the costs in the Public Rights' sector.

The qualitative effects can be determined roughly with the aid of the estimated higher proceeds of the auction-supplies on the islands of Tholen and of St. Philipsland. We expect an increase of the added value of approx.

4,5 million guilders per year. With D4 this increase will be really feasible as a result of the chloride content to be attained. With C3 and A3 this will be less because of the higher degree of salinity of the Zoomlake. One should also bear in mind that the transition from the present situation to a situation with completely de-salted arable grounds will take many decades.

Immediately after the de-salting of the Zoomlake it will already be possible to draw drinking water for cattle and sprinkling water for fruit trees from the ditches. Exploitation will thus become cheaper and that in itself is a small additional advantage.

Supply of drinking and industrial water.

In the future the drinking and industrial water-supply in Zeeland will become ever more dependant on surface-water, because reserves of ground-water are falling short.

As scenario a prognosis up to the year 2000 has been used, taken from the Structural Outline Drinking and Industrial Water-supply (15). That shows that in the period 1990-2000 a shortage of fresh-water is to be expected. The estimated demand in the year 2000 for the whole of Zeeland and Goeree Overflakkee - approx. 120 million m3 - exceeds the available quantity of ground- and surface-water, 96 million m3, by an ample margin. In the Structural Outline it is being proposed, with regard to the national water-supply, to reserve two storage basins, one with a capacity of 100 million m3/year in the eastern part of the Grevelingen and another with a capacity of 150 million m3/year near St. Philipsland.

Apart from that one could consider the construction of a pipe-line with a capacity of about 40 million m3/year from the storage basins in the Biesbosch.

On the other hand measures could be taken which would make it possible to use reserves from the IJssellake in dry periods on behalf of the south-western part of the Netherlands.

Apart from the available quantities of fresh-water from the northern Delta basin, it will also be necessary to make an estimate of the quantity of fresh-water required in the southern Delta basin. The quantities of fresh-water which in summertime would have to withdrawn from the northern Delta-basin to maintain an almost constant level of the Zoomlake, have been indicated in the following Table. Additional flushing has been competely left out of consideration. In wintertime evaporation is negligible.

Table 14. Estimate of quantities of fresh-water to be replenished in summertime (m3/sec.)

	C3	D4	A3
Max. evaporation	5	10	5
Fresh-water withdrawals	0 à 5	5	0 à 5
Fresh-water losses at navigation-locks (without regain or replenishment)	42	45	47
Total	50	60	55

The quantities which are required for additional flushing are strongly dependant on the target values for the chloride-content of the Zoomlake with the various alternatives. If, for example, in autumn one should wish to permit in the Volkerak-section of the Zoomlake a chloride-content of 0,4 gr. Cl^-/l, then no additional flushing would be required with D4. With C3 and A3, however this chloride-content even with an additional flushing of 100 m3/sec. would be exceeded. The reason is among other things, that the water to be let in from the

Moreover, in the period under consideration we shall in the first place have to meet the fresh-water requirements already existing in the Netherlands.
With these starting-points in mind we have calculated which quantities in the period 1933-1969 could have been withdrawn from the northern Delta region via the Volkerak inlet-sluice; without diminishing the minimal discharge required for countering the salinity on the Nieuwe Waterweg. In the following table the periods have been indicated in which less than 100 m3/sec and even 0 m3/sec. would have been available:

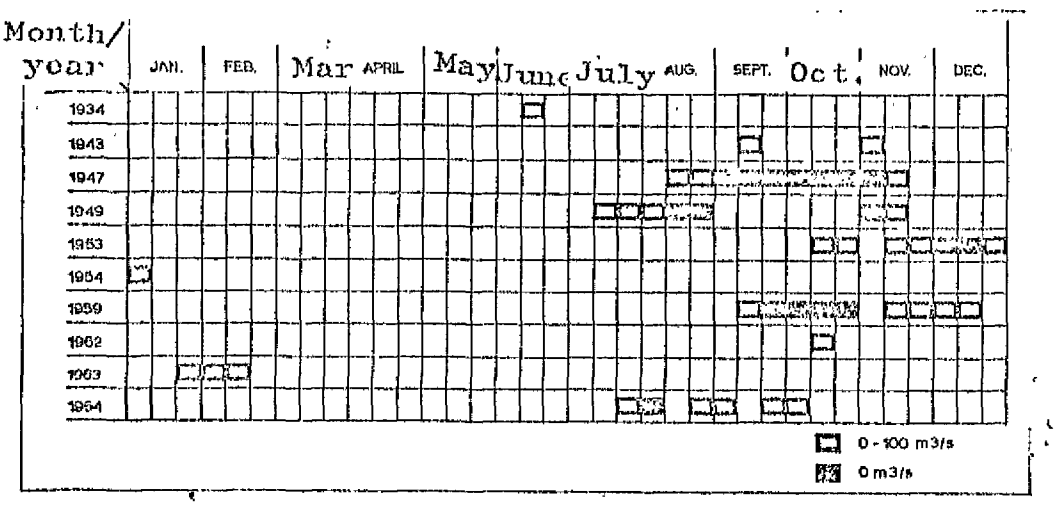


Figure 14. Availability of fresh-water for southern Delta-basin in the period 1933-1969.

From these results it appears that the chances of water-shortage in the total water-balance are highest in the autumns of dry years. Moreover, one has to take into account an increase of the water-demand in the future also elsewhere in the country; the discharge via the Nederrijn (Lower Rhine), Lek and Waal will be lower than in the period of 1933-1969, which means that our calculationsshow too favourable a picture.

C3, D4 and A3 imply a salt-water Grevelingenlake. One and another would mean that in the eastern part of this lake a fresh-water section would have to be separated from the rest of the lake, within which a storage basin could be created. Due to the fact that the degree of salinity in the Volkerak is lower with D4 than with C3 and A3, the possibilities for the projected storage basins are greater with the first mentioned alternative. With all alternatives it will be possible to construct a second pipe-line from the storage basins in the Biesbosch.

Inter-relation with the national watermanagement.

With all viewed alternatives the salt-infiltration into the Haringvliet-basins via the Volkerak-locks will come to an end after the de-salting of the Zoomlake. With C3 and A3 this will be the case in 1986 and with D4 in 1981. When the salt-loads at the Volkerak-locks have disappeared then only those quantities of fresh-water will be of interest which the southern Delta area needs for the national watermanagement in periods of drought.

In order to determine how much fresh-water the northern Delta region could supply in a certain period a calculation was made starting from the following theory. Under normal tidal conditions a minimum of 625 m3/sec. of fresh-water will have to be discharged via the Nieuwe Waterweg. A discharge of less than the above-mentioned minimum will not only cause an increase of the salinity of the Hollandse IJssel, but could probably also lead to incidental intrusion of sea-salt up to the Volkerak-locks. Neither is such a "backward increase of salinity" in the interest of the southern Delta area, because there one wishes to take in water from the Hollands Diep. Maintenance of a minimum discharge of surface-water via the Nieuwe Waterweg to curb the increase of salinity is therefore in the interest of the whole Delta region.

has a relatively high chloride-content when the Rhine-discharge is low. The demand or appeal that the southern Delta area makes on the national water-balance, is therefore strongly dependant on the required standards for the chloride-content of the Zoomlake, in particular when the river-discharges are low. One could consider to limit the consumption of fresh-water at the navigation-locks by "regaining (or replenishing)" the fresh-water. The fresh-water consumption at the navigation-locks would in this way be more or less cut in halve; the chloride-content, though, in the Zoomlake will increase.

If, with all alternatives the same standards would be applied for the chloride-content, then the "regaining" of fresh-water with D4 could start sooner than with C3 or A3. In designing the navigation-locks at fresh-water/salt-water separations, one aims at a further optimalisation of the salinity-countering system of the Kreekrak-locks in order to limit the salt-/fresh-water exchange as much as possible.

Score-chart watermanagement

	C3	D4	A3
chlorinity Zoom lake without extra flushing			
Volkerak section	0,3-0,6	0,15-0,3	0,3-07
southern section	0,5-1,2	0,3-0,5	0,6-1,3
chlorinity Zoom lake with additional flushing			
Volkerak section	0,15-0,5	0,1-0,35	0,2-0,6
southern section	0,2-0,5	0,2-0,35	0,25-0,6
possible expansion of the drinking- and industrial water-supply	+	++	+
claim on the national balance with maximum chlorinity 0,5 g Cl^-/l in dry periods (m3/s)	150	60	>155

3.5. SHIPPING.

In this paragraph we shall indicate how the alternatives C3, D4 and A3 affect the traffic via the inland shipping-routes. There are three thoroughfares in the southern part of the Delta-region, i.e. via the Scheldt-Rhine connection, the Canal through South-Beveland and the route from Flushing via Kats to the Volkerak.

With inland shipping is meant the commercial shipping with vessels between 150 and approx. 10.000 tons.

One criterion for the extent in which the alternatives will affect the aforementioned traffic flows are the annual total costs of the transportation of merchandise per inland-ship through Zeeland, from the Volkerak onwards. These costs should not be viewed in an absolute sense.

The judging of the alternatives is primarily based on the differences in costs with one or with the other alternatives. The annual costs have been capitalized so that the differences in costs can be compared with other consequences - for exemple fisheries - expressed in money. With inland shipping the added value does not provide a usable measure for an analysis of the effects of the alternatives.

As a scenario for the traffic flows existing prognoses for inland shipping have been used, which among other things, are based on the national and international economic developments. Only the direct effects have been taken into consideration at the establishment of the total costs. The costs of the passages at the Volkerak-sluices have not been included. Apart from the capitalized costs also the number of sluice-passages and the presence or absence of so-called separation of functions - i.e. separation between recreational and commercial shipping - have been reviewed.

Traffic flows.

Fig. 14 gives a picture of the traffic flows in million

tons loading capacity/year, which will pass through the southern part of the Delta-region in 1980, resp. with C3 and A3.

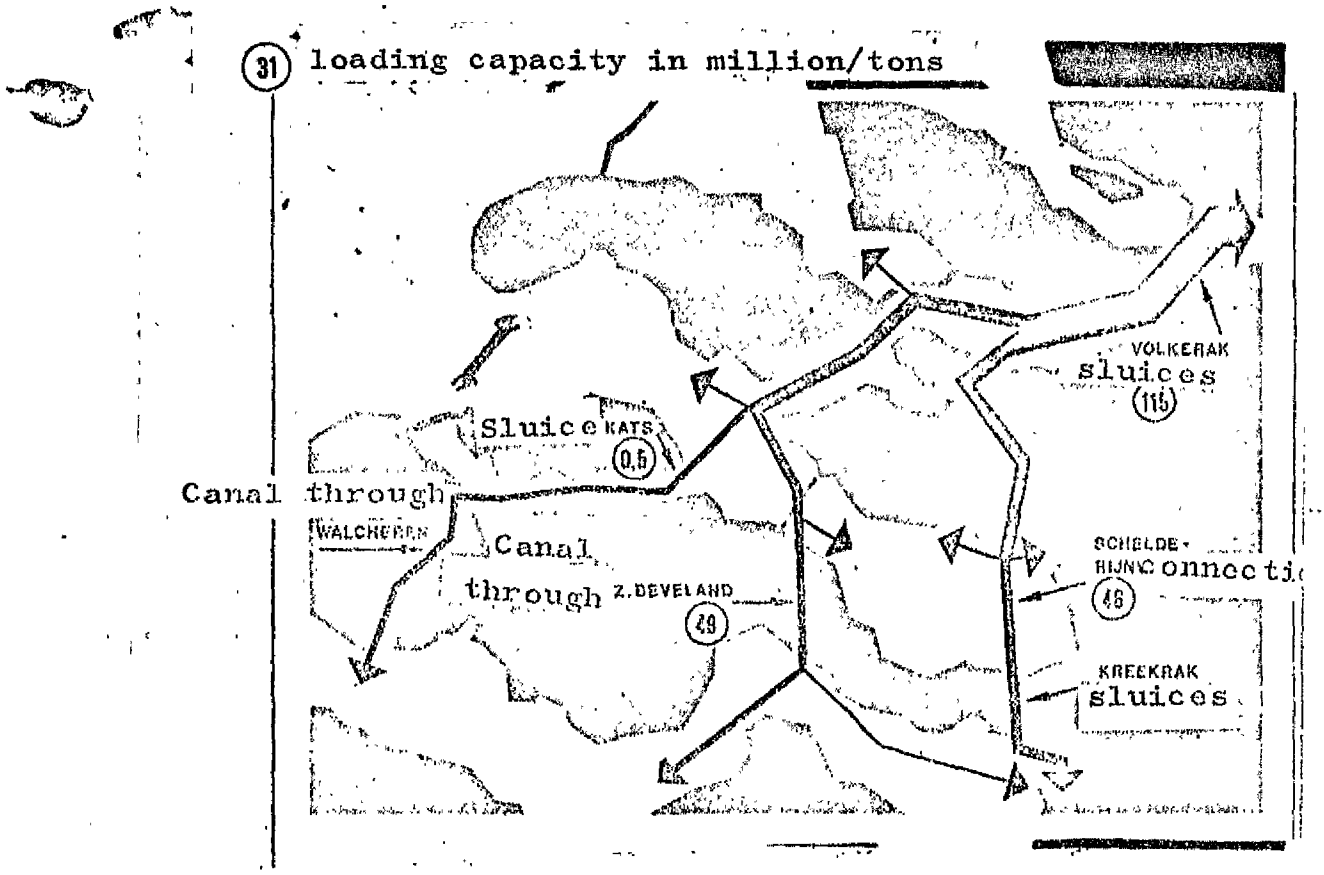


Figure 14. Traffic flows with C3 and A3.

With D4 the through-going traffic will be directed from the Canal through South-Beveland via the Eendracht-section of the Scheldt-Rhine connection. With D4 the Canal through South-Beveland will be brought in an open link with the Zoomlake via a new canal-mouth immediately east of the Wemeldinge dam.
Fig. 15 gives a picture of the traffic flows which will pass through the southern Delta-region in 1980.

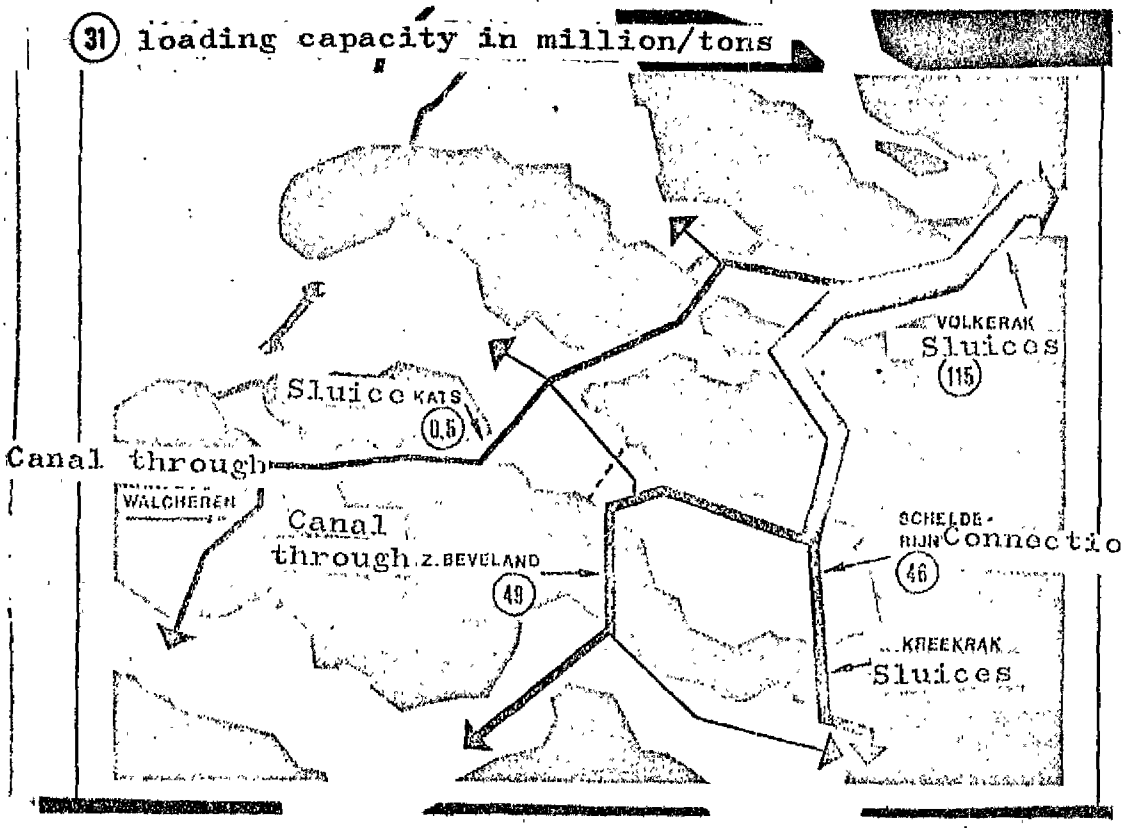


Figure 15. Traffic flows with D4

The Eendracht-section of the Scheldt-Rhine connection has sufficient possibilities to absorb the traffic-volume of these two shipping-routes. For the "high"-shipping between the Westernscheldt and the Volkerak, which cannot pass under the fixed bridges across the Eendracht - it concerns in this case one to two hundred units per year - the route via the Canal through Walcheren, the Veerse lake and the Philipsdam remains available.

Besides, special transports can follow the route via the Canal through South-Beveland, the Wemeldinge dam and the Philipsdam. With D4 the through-going shipping will encounter only <u>one</u> sluice between the Western-scheldt and the Volkerak, namely the one at Hansweert.

Due to the fact that the main shipping-routes are directed outside the salt water lakes, a clear separation of functions emerges between recreational and commercial shipping. One of the consequences is, however, that no alternative route with adequate lock-capacity will be available for the through-traffic via the Canal through South-Beveland and the Scheldt-Rhine connection in case calamities would cause congestion in the Eendracht.
With D4 the route between the Canal through Walcheren/ Veerse lake and the Volkerak will pass completely through tide-free waters. The number of sluices in this route between the Westernscheldt and the Volkerak will increase from three - at Flushing, Veere and Kats - to four; also the Philipsdam must then be passed via a sluice. In order to keep the Easternscheldt region west of the Philips- and Wemeldinge dam within reach of floating cranes with a capacity up to 400 tons - for example for the salvaging of wrecks - a through-passage of 21 meter in the Philipsdam will be necessary. The port of Bergen op Zoom can only be reached by coastal shipping coming from the Western-scheldt by the one sluice at Hansweert.

Changes in costs.

As far as shipping is concerned the differences between the various alternatives finds expression in the number of sluices, the length of the routes, the tides and the flows. Due to differences in these factors, differences will show too in the travelling time and subsequently in the transportation costs of merchandise by inland shipping. It was assumed that these costs will be passed on to the enterprises that receive the goods.These enterprises in turn will calculate these transportation costs in the prices of their products. In order to obtain an impression of the consequences for the Dutch economy the analysis has been restricted to the effects on Dutch enterprises only.

For each type of vessel the navigation costs are known for a specific route once the travelling time and length of the route are given. This means that the costs per

vessel for each of the three routes and per alternative can be figured out. The scenario gives an estimate - until the year 2000 - of the number of vessels on each route, specified per size of the ship. Multiplication of the number of ships with the costs per vessel provides us with the total annual costs of the inland shipping for each of the routes. Adding up the routes gives the total costs of C3, D4 and A3. One should, however, take into account that the costs of inland shipping will be chargeable to both Dutch and foreign enterprises. Only 27% of the total costs is chargeable to Dutch firms and 73% to foreign firms. Table 15 shows the total annual costs for the Dutch enterprises with C3, D4 and A3, specified in the four phases of construction.

Table 15. Annual costs for Dutch enterprises (in million guilders, price level 1976).

Period	C3	D4	A3
1976 - 1980	13	13	13
1981 - 1985	15,5	15	15,5
1986 - 1990	17,7	16	18,3
1991 - 1999	20,5	19,7	21

From this table one can deduce that after 1980 the costs with D4 will be somewhat lower than with C3 and A3. The differences, however, amount to less than 0,1 percent of the total production costs of each of the separate forms of enterprise. As a rate of the costs of transportation per inland ship the differences for some forms of enterprise could, however, add up to 10%.

Table 16. Capitalized costs for Dutch enterprises. (In million guilders, price level end 1975)

	C3	D4	A3
Capitalized costs	172	166	174

The figures shown in the score-chart concern exclusively the costs for Dutch enterprises. It proves that the differences are actually extremely small.

Score-chart inland shipping.

	C3	D4	A3
Capitalized costs (in million guilders)	172	166	174
Separation of function	no	yes	no
Alternative routes	yes	no	yes
number of sluice-passages between the Westernscheldt and Hollands Diep for:			
- Scheldt-Rhine connection	2	2	2
- Canal through South Beveland	3	2	3
- Canal through Walcheren	5	4-5	5

3.6. RECREATION AND TOWN AND COUNTRY PLANNING.

In this paragraph the effects of the alternatives for recreation in the central Delta-area will be analysed.

Recreation.

As far as the recreation is concerned the alternatives show differences in the usable length of beaches and shores, the number of fish, the number of berths for pleasure-craft and the tides. The most important form of recreation in the Delta-area is the beach- and shore-recreation, angling or fishing and aquatic sports. The town and country planning policy for the central Delta-area plays also a role in the question as to what extent one wants to utilize the recreational possibilities of the Easternscheldt. As a scenario for the analysis of the effects of the alternatives a non-investment-policy has been taken as a basis. In the sensitivity-analysis the effects of a supposedly stimulating policy for recreation have also been viewed.
In the selected scenario, in which the Easternscheldt-region will not be open for intensive out-door recreation, the following assumptions have been made:

- no investments will be made for recreational facilities, neither by the Government nor by the private sector;
- there will be no expansion of approach-routes to the central Delta-area.

Such a scenario corresponds with the main lines of the present town and country planning-policy for the development of the south-western part of the Netherlands. In this so-called "horse shoe" conception (12) the Easternscheldt must remain a quiet nature area. The coastal areas, the surroundings of the Veerse Meer and, to a lesser degree the Grevelingenbasin are destined for intensive recreation. In this respect it should be noted, that in order to keep the Easternscheldt quiet, certain, at this point as yet unidentifiable investments will have to be made to canalize the recreation-throng.

In this scenario, the alternatives affect the forms of recreation in the following way. With C3 and A3 almost nothing changes except for sportfishing, because with C3 the number of fish will decrease more than with A3. With D4 far greater changes will occur. The usable shore-length will increase with approx. 17 km; at the sea-side of the dam an additional beach-length of 8 km can arise in due course. The number of marine fish will probably decrease by 90%; at the same time the number of species will somewhat diminish. For pleasure-craft an additional 150 berths will become available, because part of the commercial fishing-fleet will disappear. Because of the absence of tides the waters will become more attractive for small pleasure-boats and for fishing from small crafts. In Table 17 the decisive factors for those three alternatives are being shown.

Table 17. Decisive factors for the recreation.

	C3	D4	A3
Increase in length of shore and beach	0	25	0
Decrease of fish-population in %	40	90	25
Increase of number of berths for boats	0	150	0
Tides	yes	no	yes

There are, however, two reasons why, in spite of the changes with D4, no increase of recreation in the central part of the Delta is to be expected. The visit of day-trippers on warm summer days will be limited by the capacity of the approach-routes. Besides, an increase of the visits of tourists (on week-ends or during the holiday-season) is hardly possible without additional investments in accomodation, such as hotels, camping- and caravan-sites and small summer cottages. Changes in the recreational use of the Easternscheldt can therefore only occur by changes in the spreading-pattern of the tourists within the central Delta-area.

These changes might occur with D4, because part of the visitors of the beaches of Schouwen, Walcheren and to a lesser degree of Goeree, will head for the beach of the Easternscheldt. This will also be the case for the recreation-seekers of the shores and the aquatic sportsmen. Sea-faring yachts will probably take refuge in harbours outside the Easternscheldt; the smaller vessels can then take their places. The effect of D4 on sportsfishing and the spreading thereof is uncertain. In case the alternatives should not bring about a change in the recreational use of the central Delta-area as a whole, there will be no net advantages or disadvantages for the catering enterprises such as snackbars, restaurants, shops, hotels, camping-sites, etc., etc. It is obvious that changes in the spending-pattern of recreation-seekers in the Easternscheldt will cause changes of the spending in other areas in the Delta.
In order to arrive at a reasonable estimate about the recreative use of the Easternscheldt - at present on a summerday approx. 150.000 persons - it is assumed that the visits to beaches and shores will spread out evenly within the Delta-area over the available number of kilometers of beaches and shores, and that the number of aquatic sportsmen will increase in proportion to the available number of berths. The effects of the alternatives on the recreational use are being indicated in the score-charts. In view of the "horse shoe" conception, D4 is considered less attractive than the two other alternatives.

Town and country planning.

According to the advice of the Rijksplanologische Commissie (30) none of the alternatives is in conflict with the "horse shoe" conception for the south-western part of the Netherlands. In this case the urbanisation is thought to be concentrated in the northern Delta-area, along the axis Rotterdam-Antwerp and along the Scheldt-basin. The alternatives with the Oesterdam (Oysterdam) (C3 and A3),

meet more with the required objectives than with those of the Wemeldinge dam (D4).
The roadconnections to be built over the compartmentation dams have not been incorporated in the National Road Plan 1968. The roads on the Philipsdam could fulfil a function for the regional and recreational traffic. A road via the Wemeldinge dam (D4) would suit the community of Tholen and of the Province of Zeeland somewhat better than one via the Oysterdam (C3 and A3). Two-lane roads on the compartmentation dams would meet with the requirements to fulfil these functions.

With the alternatives under review the possibilities for a so-called Reimerswaalplan, i.e. a great-scale harbour and industrial area in the eastern part of the Easternscheldt will remain technically feasable. It should be noted, however, that a Reimerswaalplan is inconsistent with the objectives of the Government which formed the basis for the selection of alternative C3, namely to maintain in the major part of the Eastern-scheldt the present environment as much as possible.

In the design-Structural-outline Electricity Supply (31) a provision is made for the possible establishment of a Powerplant near St. Philipsland and/or Tholen, because of the available cooling facilities. The viewed alternatives show a strong limitation of these cooling facilities. Only by linking the Philipsdam with St. Philipsland as far as possible to the East, a limited cooling-circuit around St. Philipsland will remain possible. At the same time possible cooling-facilities in the Volkerak might be examined.

Score-chart recreation and town and country planning.

	C3	D4	A3
Increase of beach- and shore-tourists (%)	0	30	0
Increase of aquatic sportsmen (%)	0	20	0
Increase of number of berths of pleasure-crafts	0	150	0
Possibilities of cooling-circuits	-	-	-

3.7. PROCEDURES, COSTS AND ASPECTS OF EXECUTION.

In this paragraph we shall deal with the procedures that play a role in the various alternatives as well as with some of the bottle-necks.For each alternative the costs, itemized according to the most important components will begiven from January 1st, 1976 onward. At the same time the trend of the expenditures in the course of time will be shown. Finally, some of the bottle-necks concerning the planning for the execution of the works will be indicated for each alternative.

"Voice-in" and other procedures.

For all alternatives it holds that the preparation should be made in accordance with the requirements of the various legal regulations. From experience we know that it is difficult to indicate in advance how much time this will take. This goes in particular for alternative A3, where the time needed for the integral heightening of the dikes strongly depends on the course of the democratic "voice-in" process. For a number of usual procedures with the construction of hydraulic engineering works (such as preparing the specifications, inviting of tenders, advisory procedures of the Raad voor de Waterstaat) (Council of Dept. of hydraulic engineering works) one can say that in general these activities require a more or less fixed period of time.

With all alternatives one should, in connection with certain components of the works, for example the compartmentation dams, count with consultations and legal procedures due to land utilisation plans and the acquisition of sites.

The following table gives a summary of the expropriation of sites and buildings for each of the three alternatives.

Table 18 Size of the areas and number of buildings to expropriated.

	C3	D4	A3
Areas (ha)	430	300	742
Number of buildings	230	200	330

Apart from the aforementioned procedures a number of considerable problems emerge with A3. As a basis for A3, with respect to the integral heightening of the dikes, it was specified that the period of preparation should be 3 years, while the execution would take 15 years. This is based on the time-schedule in the plan of the Provinciale Waterstaat of Zeeland (6). The Committee Easternscheldt maintains in it's report a period of 15 to 20 years. In order to be able to maintain this time-schedule one shall have to count anyway with an accelleration of the procedures with regard to the present course of affairs at the execution of the heightening of dikes within the framework of the Delta-act.
Such an accelleration makes high demands upon the planning, coordination and in particular upon synchronisation of the works with the Government authorities, the provincial authorities, the local councils and polderdistricts. (waterschappen). In case one should wish to shorten the total time of execution to a considerable extent, without changing the existing legislation and procedures, this would, in fact, only be possible if interested parties, interest groups and victims would waive their rights of "voice-in" and their statutory rights of appeal. The question might arise in how far within our legislature one can expect - with the execution of works such as those - the parties concerned to waive these, so highly valued rights.
Furthermore, one should ask oneself with whom that kind of agreements would have to be made. Finally, one could argue about the question whether - in case such agreements could already be reached now - the interest groups or victims which could come forward in a couple of years, will consider themselves equally committed to those agreements. The views on those matters evoluate rather quickly.
For a summary of the existing statutory regulations which concern the preparation and execution of works to improve the existing water-retaining structures along an open

Easternscheldt we refer to appendix II and annexis.

Costs.

In this paragraph we shall deal with the costs of all the works associated with the decision about the future of the Easternscheldt-basin. All expenditures made or to be made after January 1st, 1976, which are connected with the components of the alternatives mentioned in chapter 2 are therefore being budgeted. In this way one gets an impression of the expenditures still to be made at the selection of a certain alternative. All amounts of money are based on the pricelevel of end 1975. As it has been accepted that not all effects of the alternatives will be put under the same denominator, the annual costs of construction have not been discounted. Thus one keeps a clear insight into the actual costs of construction. For the sake of completeness the total costs of construction for each alternative will also be given in a discounted form in the score-chart.

Not mentioned are the probably necessary costs with all alternatives for improvement of the water-quality, such as dephosphating of the inlet-water into the Zoom lake, the diversion of polderdischarges and the purification of polluted waste-waterdischarges. The necessity and the scope of these activities will have to appear from further examination of the quality of the water.

The total estimated costs per alternative have been reproduced in Table 19. The item "research" includes: hydrological, ground-mechanical and ecological research. Included in all estimates are the T.A.V. and the general costs. On each "column" of the Table a short explanation will be given.

C3.

The estimate of the costs has been based among others on the Finalreport Storm-surge caisson barrier Easternscheldt (10) and the Report of the Committee Compartmentation Easternscheldt (2). The costs for partial heightening of the dikes are based on the experience gained sofar. As in these studies no indication has been

found that the protection of the coast would cost more in one alternative than in the other, those costs have been estimated to be equal in all alternatives.
The total costs for C3 are estimated at fl. 4645 million with a single water-retaining structure and at fl. 5145 million with a double water-retaining structure.

D4.

Sub-compartmentation of the Zoom lake is not, as it would be with C3 and A3 - necessary for execution-technical reasons. Closer studies will have to show if it should be necessary for waterquality-reasons. The costs of the compartmentationdams are lower with D4 than with C3, due to the fact that the closure can take place in stagnant waters. The costs of the improvement of the Canal through South-Beveland are higher with D4 than with C3 due to the fact that a new lock-complex with a salt/fresh water combatting system will have to be built at Hansweert.
The costs of the mussel-"revitalisation" facility are based on the Final Report of the Stuurgroep Project Kunstmatige Mosselverwaterplaatsen (5), with some adjustments though, because with D4 a salt/fresh water combatting system - as was first assumed (5) - will not be required.
The costs presented for partial dike-heightening and for the storm-surge barrier refer to works already given out in contract in 1976. Total costs for D4 are estimated at 2135 million guilders.

A3.

The costs for reinforcing the dikes of the Easternscheldt are estimated on the basis of an updated report of the Provincial Waterstaat of Zeeland (6), adjusted for the building of the Philipsdam and the Oysterdam and indexed on the price-level of end 1975. (See also appendix II.)
Although no studies have been made about the magnitude of the works as mentioned in (6), we are under the impression though, that in view of the applicability of new techniques, especially as far as the construction of protections for the foreshores is concerned, the costs

for this component might possibly turn out to be lower. On the other hand the costs for the dike-heightening might be higher than estimated in (6) as a result of new insights about the expected high water levels at the end of the basin, higer sand and clay prices and additional measures in view of the condition of the soil.

The costs for partial dike-heightening concern - as with D4 - an amount of money for works already given out in contract in 1976 and also 25 million guilders for the area east of the compartmentationdams. As for the costs of the storm-surge barrier the same is valid as for D4. The costs for the compartmentationdams are somewhat higher than with C3, because the dams and locks will have to be executed as primary water-retaining structures and because the sills of the sluices will have to be 1 meter lower. The costs for the improvement of the Canal through South-Beveland are higher than with C3 because near Wemeldinge probably a storm-surge barrier and a lock will become necessary.
The total costs for A3 are estimated at 3620 million guilders.

In Table 19 the estimated costs for each alternative are conveniently arranged. The differences with the figures in the Final Report Storm-Surge Barrier - Easternscheldt (10) are a result of the fact that in the latter cost made in the period January 1st, 1974 - January 1st, 1976 have been included.
In the present policy analysis only the expenditures to be effected after January 1st, 1976 have been included.

Table 19 Total estimated costs as of January 1st, 1976. (in million guilders, price-level end 1975).

	C3	D4	A3
1. Primary dam.			
Storm-surge barrier single structure	2.340	15*	15*
Unforeseen	250	-	-
Easternscheldt dam	-	600	-
sluice Noordland	-	65	-
salvage works mouth of the Easternscheldt	-	-	50
2. Compartmentation			
Philipsdam	175	65	185
Oysterdam	130	-	140
Wemeldinge dam	-	100	-
navigation locks	340	120	370
ring-embankment Marquisate of Bergen op Zoom	45	-	45
Discharge medium Zoom lake	110	25	110
3. Canal through South-Beveland	375	445	485
4. Enlargement of dikes.			
Partial heightening of dikes	170	35*	60
Heightening of dikes 1/4000	-	-	655
Protection of foreshores	70	30	580
Secundary water-retaining structures	-	-	240
Slopes	20	20	60
5. Coast protection	150	150	150
6. Works i.b.o. watermanagement			
Sluice in Brouwersdam	20*	20*	20*
Sluice Grevelingen dam	15	15	15
Pumpingstation Veere	10	10	10
7. Adjustment constructions			
Discharges	55	55	40
Ports, wharfs, etc.	45	30	110
	4.320	1.800	3.340

	C3	D4	A3
Amount carried forward	4.320	1.800	3.340
8. Mussel-storage and revitalisation-place	-	120	-
9. Research	325	215	280
Total	4.645	2.135	3.620

* current obligations

For a proper budgeting it is not only important to know the total construction costs but also the spreading of the costs over the years. Fig. 16 shows the annual expenses as a function of time. For all alternatives the peak lies in 1980. With C3, with a single retaining structure this amounts to fl. 690 million; for D4 fl. 420 million and for A3 to fl. 410 million. These amounts correspond with resp. 0,80%, 0,54% and 0,53% of the Government's Budget for 1976. (fl. 78.000 million).

Further, also very important are the costs for maintenance in the various alterations. It is very difficult to make a reasonable budget of these costs at this stage, but a broad estimate is, however, possible. The annual expenses for management and exploitation (including personnel) for all components mentioned in Table 19 are estimated for C3 at fl. 25 million; for D4 at fl. 10 million and for A3 at fl. 15 million. The expenses for maintenance are only necessary after completion of an alternative; in view of the fact that this point of time is different for the various alternatives, this has been taken into consideration with the discounting.

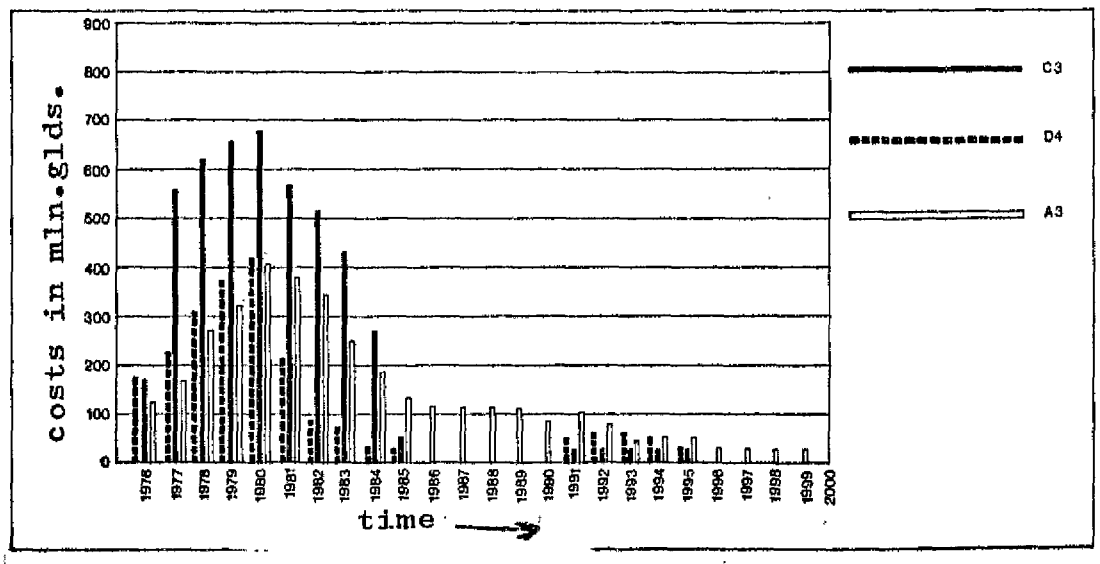
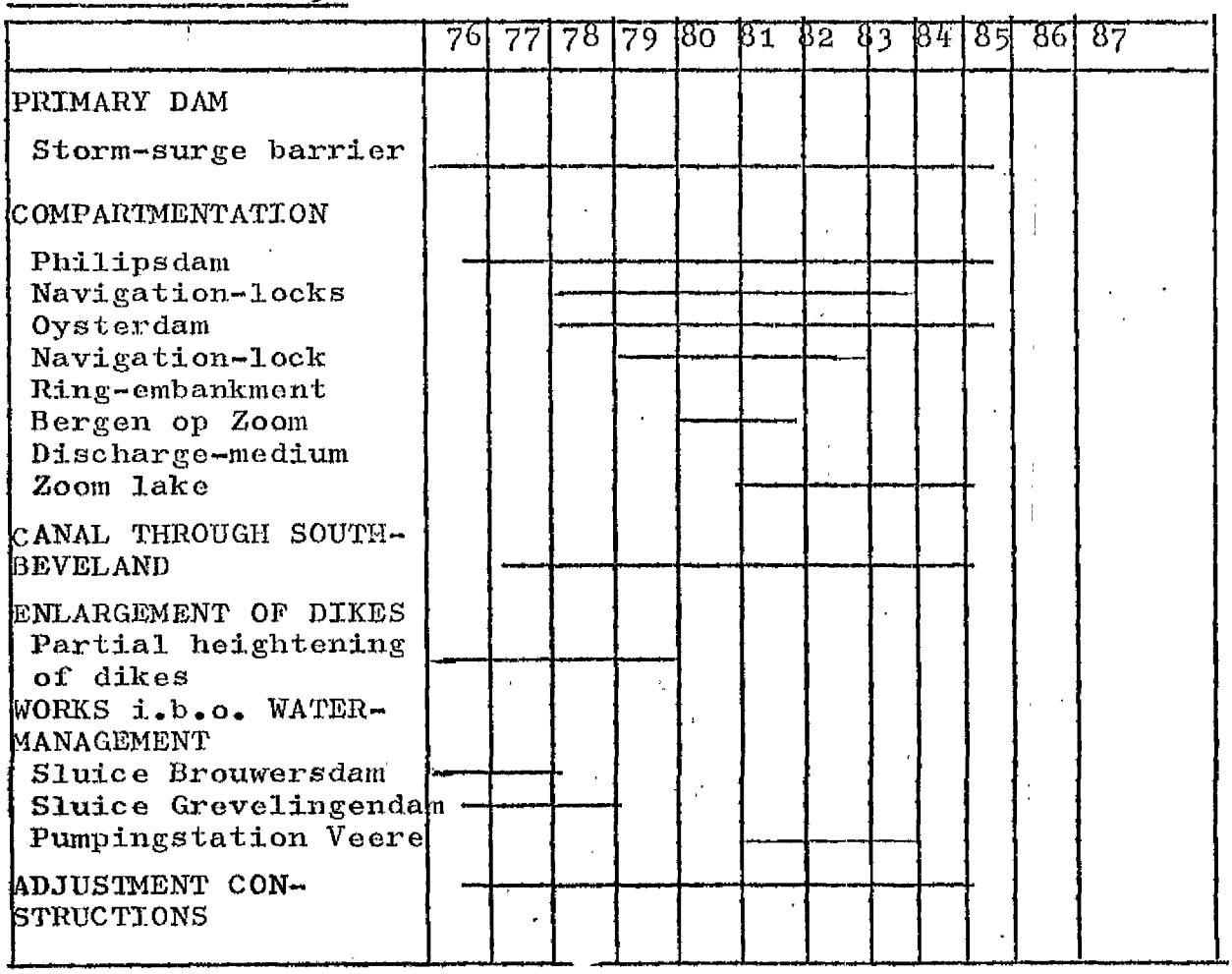


Fig. 16 annual expenses as a function of time.

Aspects of Execution.

In the case of C3 the compartmentationdams would practically have to be completed simultaneously with the storm surge barrier in accordance with the promise given by the Minister of Transportation and Public Works to the House of Parliament.(37) Closure of the compartmentationdams one or two years prior to the primary water-retaining structures would cause higher storm-surge levels directly west of these dams. On the other hand the closure of the compartmentationsdams one or more years after reducing the tide, would temporarily increase the salinity of the northern part of the Delta-basin. The time-schedule shown below meets with the conditions that: the storm-surge barrier and the compartmentationdams can both be closed in 1985, provided that in 1976 the construction of the Philipsdam is started where the huge lock-complex must be built that will be decisive for the time-schedule.

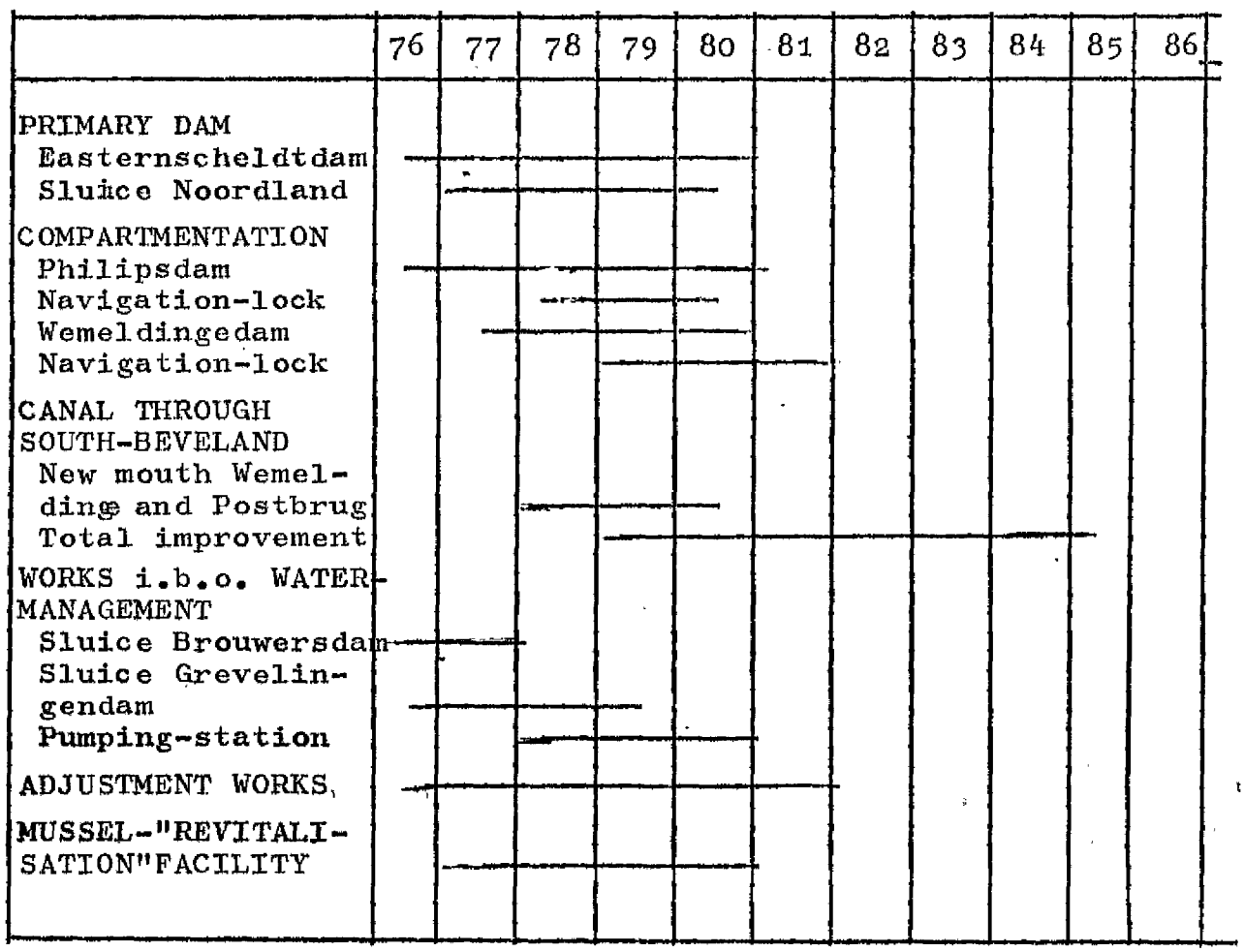
Time-schedule C3.



In 1985 the improvement of the Canal through South-Beveland should also be completed in order not to have to increase the number of locks via this route. Therefore it will be necessary to start the expropriation-procedures for the Canal through South-Beveland in 1976 and in particular for the lock-complex in Hansweert-East. The discharge-medium in the Zoomlake should also be put into service in 1985 in order to make the discharge of water from this lake possible.

With D4 the compartmentation dams should also be completed at the same time as the closure of the Easternscheldt. That is also necessary in order to avoid that the closed off saline area of the Easternscheldt will become brackish by fresh water infiltration via the Volkerak locks and the Brabant shores. The time-schedule for the execution of D4 is shown below.

Time-schedule D4.



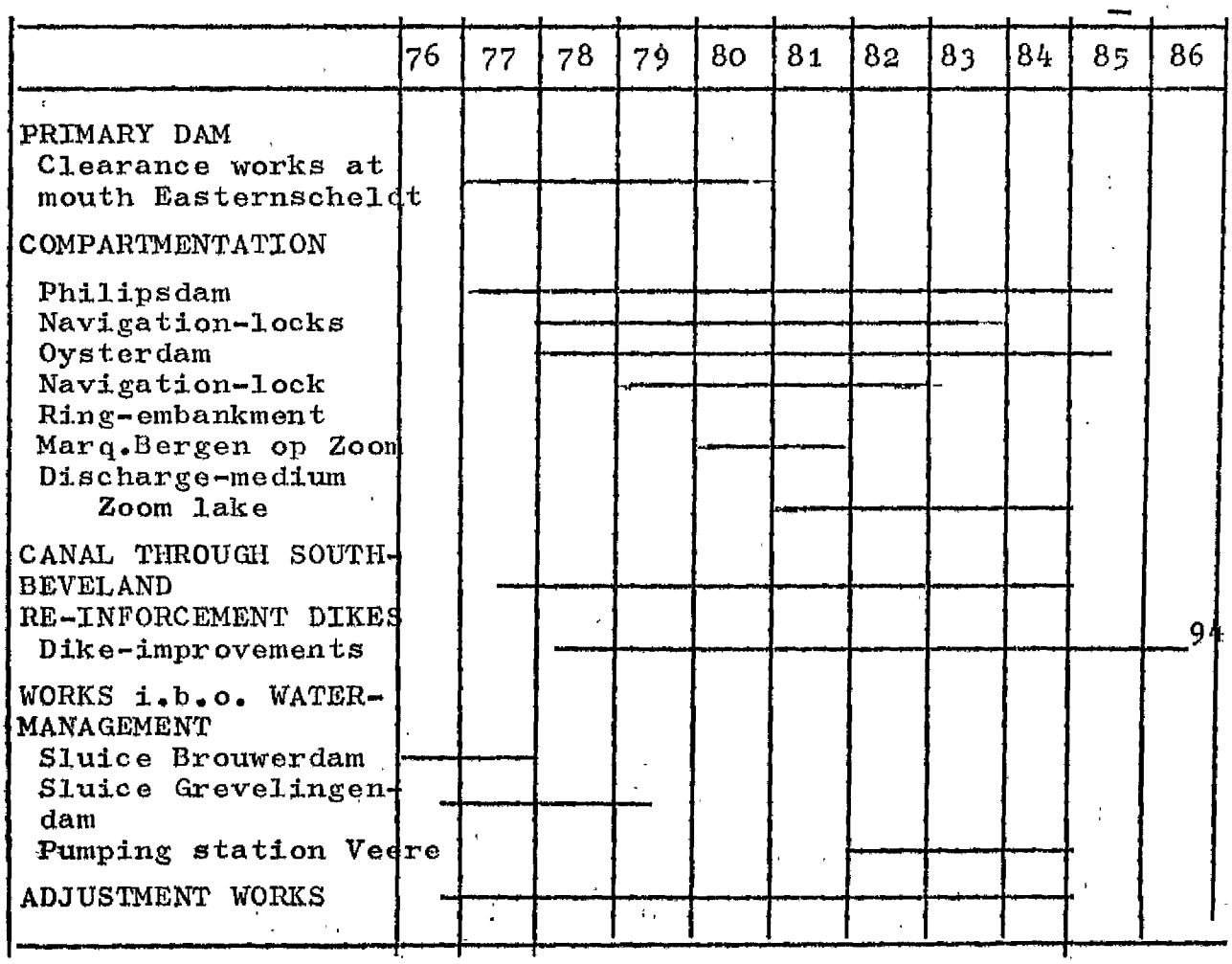
The closure of both the Easternscheldt and the compartmentation dams in 1980 will only be feasable if already in June, 1976, the decision for D4 will be made. Continuation of the works at the Easternscheldt dam and the construction of the Philipsdam should be started in 1976. The time for the construction of the Philipsdam is much shorter with D4 than with C3; in the first place because there will be smaller locks, but also because with C3 the closure will take place with tidal motion and with D4 in practically stagnant water. As already mentioned in chapter II the new mouth of the Canal through South-Beveland at Wemeldinge should be completed by 1980 and the western lock at Hansweert should be converted into a scouring-sluice; this for reasons of shipping as well as management. The new mouth at Wemeldinge can only be dredged when the tide of the Easternscheldt has disappeared. It is not quite necessary that the lock in the Wemeldingedam will be completed at the closure of the compartmentation dams, because the "high" shipping can for some time still make use of the existing locks at Wemeldinge. With A3 it has been assumed that both the Philipsdam and the Oysterdam will be closed in 1985; as with C3, the construction of the Philipsdam should be started in 1976 and of the Oysterdam in 1978. The improvement of the Canal through South-Beveland and the discharge-system of the Zoom lake should, as with C3, be completed in 1985. The time-schedule for the execution of A3 can be found on page 116.

After closure of the compartmentation dams the area east of these dams will be adequately protected against storm-floods. On the western side of the compartmentation dams, however, higher storm-flood-levels will arise, in particular in the vicinity of the Philips- and Oysterdam. In the priority plans for the enlargement of the dikes one should take this into consideration. If during the execution of the works it turns out that the enlargement of the primary dikes directly west of the compartmentation dams cannot be completed in 1985, one could still consider to keep the closure-gaps in the Philips- and Oysterdam open for some more time.

That will of course require some additional protection of the shores and bottom near the closure-gaps. In that case one will choose for a later protection of the area east of the compartmentation dams in the interest of the protection of the western area.

Finally an observation should be made about the winning of sand. In the report of the Province of Zeeland it has been assumed that the sand needed for the enlargement of the dikes can be obtained from the Easternscheldt itself. It looks now, hoever, as if part of the required quantity of sand will have to be obtained from other places. This will of course affect the cost of the enlargement of the dikes.

Time-schedule A3.



Score-chart procedures and costs.

	C3	D4	A3
in accordance with the Delta-Act	yes	yes	no
area to be expropriated (ha)	430	300	742
number of buildings to be expropriated	230	200	330
total building-costs as of January 1st, 1976 (million guilders)	4645	2135	3620
ditto, discounted with 10% (million guilders)	3180	1485	2025
building-costs in peak-year (million glds.)	690	420	410
annual maintenance-costs (million guilders)	25	10	15
maintenance-costs discounted with 10% (million guilders)	110	70	30

3.8. EMPLOYMENT AND ECONOMY.

In this paragraph a broad estimate is being made about the possible effects of the alternatives on the employment; both direct and indirect effects will be viewed. We shall also go briefly into the effects on the national product and the trade balance. The effects of the financing of the alternatives are not included in this review.

Employment.

The expenditures for the alternatives have a direct effect on the turnover of the construction firms connected with the execution of the plans and on the direct employment that results thereof in Zeeland, western North-Brabant and southern South-Holland. This direct employment can be deduced from the distribution of the expenditures over the years as indicated in paragraph 3.7. Based on the wage-component in the various categories of expenditures - groundwork, concrete, steel, etc. - an estimate has been made of the employment-opportunity in man/years. The figure includes the employment-opportunity at the construction site itself, as well as the acessory enterprises, for example construction-workshops, which will supply the steel parts for the locks (see Table 20.) It also shows that C3 offers the highest rate of employment and D4 the lowest. A proportional distribution of the abovementiond man/years over the various sectors has broadly been indicated in Table 21.

Table 20 Direct employment in man/years.

Year	C3	D4	A3
1976	1290	920	620
1977	2730	1200	790
1978	3410	1730	1560
1979	3690	2090	1980
1980	3580	2420	2360
1981	3260	1260	2240
1982	3370	650	2140
1983	3080	560	1440
1984	1720	160	790
1985	200	100	530
1986	10	10	420
1987	10	10	420
1988	10	10	420
1989	10	10	420
1990	10	10	390
1991	50	170	400
1992	50	190	310
1993	50	190	190
1994	50	180	190
1995	10	50	190
1996	-	-	60
1997	-	-	60
1998	-	-	60
1999	-	-	60
2000	-	-	60
Total	26590	11920	18100

Table 21. Proportional distribution of direct employment according to categories of expenditures

sector	C3	D4	A3
Ground-hydraulic works	23	37	51
Concrete construction	21	18	15
Metal construction	47	29	25
Research	9	16	9

This Table shows that with C3 employment is stimulated mostly in the metal sector, while with D4 and A3 employment is primarily stimulated in the sectors ground-works and hydraulic engineering constructions. This is due to the considerable amount of steelconstructions and auxiliary tools which are required for the storm-surge barrier. In order to obtain insight in possible bottle-necks in the supply of personnel, the increase of employment should be compared with the situation on the regional labour-market. The registered male labour-reserves (including additional and social labour projects: for Zeeland 8% and for Brabant 2%) amount in the sectors concerned to approx. 17.000 men for Zeeland and North-Brabant combined. (33).

Table 22. Registered male labour-reserves 1975.

Sector	Zeeland	North-Brabant
ground-, road and hydraulic engineering construction	295	1960
buildings and utility-construction	290	9600
metal	310	4900
	895	16460

The total consequences for the employment consist, apart from the effects already mentioned above, also from the effects of demand that develops in other enterprises as a result of the increased turnover. For the calculation of the total consequences a model of the Dutch economy has been used that was developed on the basis of the "input-output" tables of 1972 from the Central Bureau of Statistics. The model shows that the total employment effect with a single water retaining structure amounts to approx. 35.000 man/years with C3, 155.000 man/years with D4 and 235.000 man/years with A3.
Apart from that C3 in particular produces some side-effects. The Netherlands have an international reputation in the field of hydraulic engineering. Recent orders from abroad, viz. France, Germany, Great-Britain , Algeria, South-Africa

be
Saudi Arabia would inconceivable without the experience gained in the Netherlands itself. The level of the Dutch knowledge about hydraulic engineering works will advance gradually as a result of the construction of the storm-surge barrier in the Easternscheldt. The annual turnover in foreign orders in the road- and hydraulic engineering construction on a medium-long term is estimated at 3 to 4 billion guilders of which approx. 1,5 billion guilders will be spent in the Netherlands. If this turnover would increase by approx. 20% as a result of the "know-how" gained with the construction of the storm-surge barrier in the Netherlands - and this is only a conservative estimate - it means a profit in added value of approx. 100 million guilders a year and employment for at least 1.000 men. These figures are of course speculative, but they do give an impression of the order of magnitude of the possible effects.

National Economy.

With the aid of the earlier mentioned model the effect has been calculated of each alternative on the national economy and the balance of trade. As scenario in this case use was made of a situation which is based on the general prognoses for the future from the Provisional Scientific Council for Government Policy. (32). It turns out that a change in the national product and the imports caused by an alternative amount to an average of 0,2% during a couple of years. The additional imports of stones lie well above this average and amount to max. 6% with C3, 2% with D4 and 3% with A3.
In the score-chart are shown: the direct and total employment and the employment in the "peak-year", viz. the year in which an effect reaches it's highest value.

Score-chart employment.

	C3	D4	A3
direct employment total (man/years)	26590	11920	18100
total employment (man/years)	34600	15500	23500
employment in "peak-year" (man/years	4800	3150	3100

Chapter IV

SENSITIVITY ANALYSIS.

4.1. INTRODUCTION.

In chapter II three alternatives have been outlined the consequences of which in the various fields have been indicated in chapter III. In chapter II a number of assumptions have been made for each alternative. It is possible, however, that different assumptions lead to essentially different hypotheses; in other words, that the order on the score-chart will change for a specific effect. The same holds for the assumptions and the scenarios which are used in chapter III. It will be useful to examine how the results change when one choses other starting-points. The combination of an alternative with assumptions and a scenario is called a variant. (variable) The variables for which in chapter III the consequences have been established, we call the "nil-variables. "

It should be noted, however, that this chapter only offers a limited sensitivity-analysis, because there was not enough time to analyse all the questions which arise at the examination of the score-charts. Particularly on the score of the safeguarding during the transitional period, an analysis based on the chance of flooding of separate polders could produce better insight and more accurate results. The results of this sensitivity-analysis are briefly summarized on pages 141 to 143.

The following variables are viewed in the next paragraphs:

Safety: · with C3 and A3 it is assumed that the already completed dikes will contribute to the safety and the protection during the transitional period.
· with A3 it is assumed that the period of execution can be shortened to 9 years c.q. can be stretched up to 23 years.
· with D4 it is assumed that the dikes will be partially heightened.

Environment: with C3 it is assumed that the storm-surge barrier has a flow-through area of 20.000 m3, so that the average tidal difference at Yerseke amounts to 3,1 meter.
with D4 it is assumed that a subcompartmentation of the Zoom lake will be executed.

Fisheries: with C3 it is assumed that due to sedimentation on the nursery beds the mussel- and oyster-production will decrease.
with D4 it is assumed that an increase of the mussel-industry in the Waddensea is not possible.
with D4 it is assumed that the revitalisation and storage of mussels is impossible and that the whole-mussel-industry must disappear.
with A3 it is assumed that the oyster-production can be doubled in 15 years.

Recreation: with D4 a recreation-stimulating policy will be assumed.

In those cases where it concerns a change in the alternative itself - for example partial dike-heightening with D4 -, it is also important to know what changes this will cause in the construction costs.

In general, assumptions in the calculation of the consequences of an alternative will not affect the construction-costs; for example the assumption concerning the sedimentation on the mussel- and oyster-beds does have economic consequences but does not affect the construction-costs.

4.2. SAFETY.

In chapter III consideration has been given to the chances of floods during the period that the heightening of dikes is in progress. It has been assumed that the odds of floods remain the same up to the moment that the dikes have reached the required height. This corresponds with line A in figure 17. The total odds equal the area under the line, a rectangle in this case. With a proper selection of priorities and the completion of certain areas the completed dikes could certainly contribute to the protection of the polders lieing further behind. To what extent will depend on the priorities and the duration of execution; for both cases we can only make a guess.

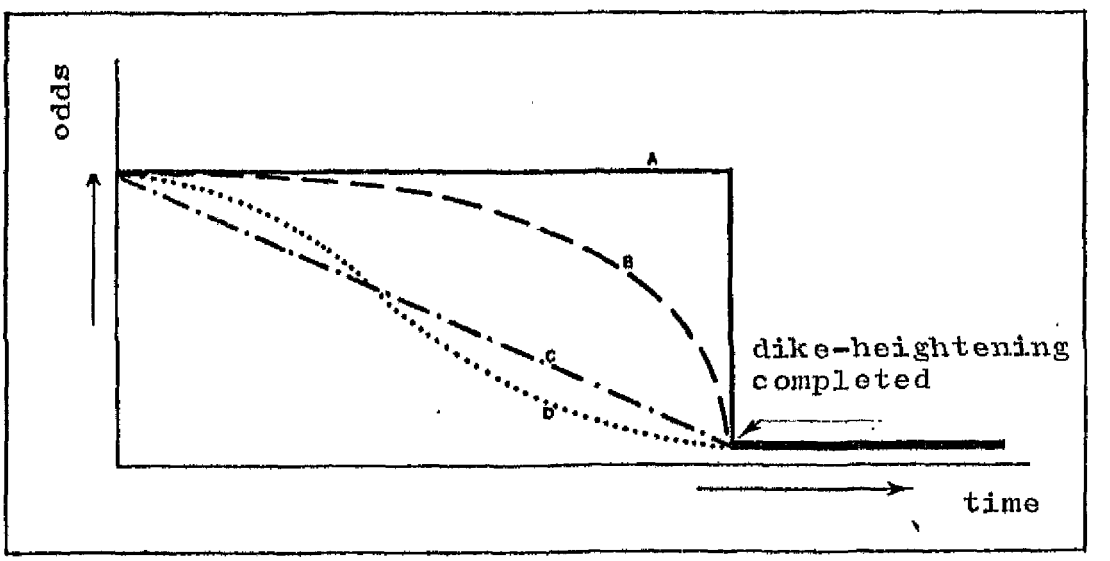


Figure 17. Tendency of odds of floods as function of time.

In order to determine as yet how sensitive the results are for the assumptions other - more optimistic - lines have been drawn in figure 17 for the chances of floods per year. It turns out that the speed with which the dikes are heightened does strongly diminish the chances of floods. For, the sooner one deviates from line A, the smaller the area becomes under the line. In our argumentation we have assumed up till now that the value of all polders to be protected is equally high. If one differentiates between polders than the sum-total of the risks could be considered in stead of the total odds. Not only the speed with which the dikes are being heightened is important, but also where one starts, i.e. the priority-plan. If one draws all consequences from this conclusion then, in principal a rapid heightening of the most important dike-sections is the best way to lower the total risks. The application of this criterion only, would lead to a preference of repeated heightening of the same dike-section until the desired height has been reached. Apart from the question whether the alignment of the dike permits such a procedure, this will lead to unacceptable technical problems in the execution and control. The nil-variables described in chapter III include the assumption that heightening of the dikes does not contribute to the safety until the work is completed. However, we might also assume that the dikes, as an average for the whole area, contribute to the safety for 50%. This means that in figure 17 the line C is maintained; the odds for floods per year drop linear with the time, if at least the priority schedule can properly be maintained, which is doubtful.

This assumption leads to variables with the following total odds for floods:

C3	1976-1980	$\frac{1}{2} \times 5 \times 1/200$	$= 2{,}25\%$
	1981-1985	$5 \times 1/500$	
D4	1976-1980	$5 \times 1/200$	$= 2{,}5\ \%$
A3	1976-1978	$3 \times 1/200$	$= 5{,}25\%$
	1979-1994	$\frac{1}{2} \times 15 \times 1/200$	

At the end of this paragraph one will find the score-chart relating to the safety on the basis of this changed assumption. Comparison with the nil-variables shows that C3 offers lower total odds and lower risks than D4. A3 still lags behind though now the difference has become smaller.

In the case of a complete closure of the Easternscheldt one could still diminish the chances of floods by expanding D4 with partial dike-heightening. In the period 1976-1980 the odds of flooding with D4 will become equal to those of C3. The costs of partial dike-heightening amount to approx. 135 million guilders.

One way to diminish the total chances of floods in the case of an open Easternscheldt is a rapid heightening of the dikes to the desired level. If one assumes with alternative A3 that all dikes will have been heightened by 1985, then that gives a sum-total of the odds of 10 x1/200 = 5%. One may not assume that in this short period a significant scheme of priorities could be maintained. It does mean though, that the costs with A3 in the peak-year will increase with at least 50 million guilders, because the expenditures for the heightening of dikes will be made over a shorter period. On the basis of this A3 variable the second score-chart shows a comparison with the nil-variable for C3 and D4.

In view of the problems expected with the construction of A3 within the 15 years mentioned in chapter III it would make sense to examine also what the odds of floods would be in case of a longer period of construction. If one assumes for A3 that all dikes are heightened by 1999 it seems reasonable to assume at the same time that a scheme of priorities can be maintained. The total costs for A3 will diminish in the peak-year with approx. 35 million guilders due to the fact that the peak will shift to the back. The sum-total of the chances of floods will be approx. 3 x 1/200 + 1/2 x 20 x 1/200 = 6,5%. On the basis of this A3 variable the third score-chart shows a comparison with the nil-variables C3 and D4.

Scorechart safety

Sensitivity-analysis: with C3 and A3 it has been assumed that already finished dikes contribute for 50% in the protection.

	C3*	D4	A3
year complete protection	1985(1985)	1980	1994(1994)
length primary water-retaining structure (km)	9(9)	9	145(145)
quality primary water-retaining structure	+(+)	+	-(-)
"optimal" safety	yes (yes)	yes	no (no)
dike- and shoreslides	- (-)	0	-- (--)
total odds in the transition period (%)	2,25(3,5)	2,5	5,25(9)
total risk in the transition period (million guilders)	160 (260)	210	295 (450)
possible future heightening	- (-)	+	-- (--)

*Between brackets the score for the nilvariable has been indicated

Score-chart safety

Sensitivity-analysis: the time to realize the heightening of dikes with A3 will be brought back to 9 years.

	C3	D4	A3 *	
year complete protection	1985	1980	1985	(1994)
lenght primary water-retaining structure (km)	9	9	145	(145)
quality primary water-retaining structure	+	+	-	(-)
"optimal" safety	yes	yes	no	(no)
dike- and shoreslides	-	0	--	(--)
total odds in the transition period (%)	3,5	2,5	5	(9)
total risk in the transition period (milion guilders)	260	210	340	(450)
possible future heightening	-	+	--	(--)
Expenditures in peak-year (in million guilders)	690	420	460	(410)

* Between bracksts the score for the nil-variable has been indicated.

Score-chart safety.

Sensitivity-analysis: the time to realize the heightening of the dikes with A3 will be stretched up to 23 years.

	C3	D4	A3*
year complete protection	1985	1980	1999 (1994)
length primary water-retaining structure (km)	9	9	145 (145)
quality primary water-retaining structure	+	+	- (-)
"optimal" safety	yes	yes	no (no)
dike- and shoreslides	-	0	-- (--)
total odds in the transition period (%)	3,5	2,5	6,5 (9)
total risk in the transition period (million guilders)	260	210	313 (450)
possibility future heightening	-	+	-- (--)
Expenditures in peak-year (million guilders)	690	420	375 (410)

*Between brackets the score for the nil-variable has been given.

4.3. ENVIRONMENT.

The alternative C3 has been described in chapter III with a storm-surge barrier with a flow-through gap of 20.000 m^2. An enlargement of this gap will reduce the tidal difference so that the impact on the environment will be somewhat limited. For that reason a design with a flow-through gap of 20.000 m^2 has also been considered in the Final Report Storm-surge barrier Easternscheldt (10). The average tidal range at Yerseke is then 3.1 meter. The additional costs for such a flow-through gap amount to 260 million guilders (with a single water-retaining structure). As a result of the lesser impact the then developed environment will differ less from the present one than in the case of the nil-variablesdescribed in chapter II. The superficies of the intertidal area will decrease less. The saline character of the vegetated mud-flats will decrease less than with the nil-variable; the abundance in species of plants and birds will continue to grow. The decrease of the biomass in the salt-water basin is less than with the nil-variable with the exception of the biomass of zoo-benthos and fishes. Calculations made with the aid of an ecological model indicate that with an average tidal range of 3,1 meter the influence of sedimentation is far less than with a lower tidal range. It appears that contrary to the nil-variable, the biomass for all organisms decreases in comparison with the present situation. As far as the number of species of organisms is concerned in the whole Delta area the difference between the two C3-variables are very small. It should be pointed out though that the results of the study with the ecological model for the time being are only of a purely indicative character.

In view of the fact that with D4 a subcompartmentation of the Zoom lake is not required for construction-technical reasons this is not included in the alternative as defined in chapter II. A possible sub-compartmentation consisting of a ringembankment of the Marquisate of

of Bergen op Zoom and ring-embankment of the Verdronken Land van South-Beveland has a positive effect upon the waterquality. Within the enclosed areas the quality of the water will be better and as a result thereof the number of species of organisms will increase. The costs of subcompartmentation amount to 45 million guilders for the Marquisate and 120 million for the Verdronken Land. In the following score-charts the effects of both variables are shown.

Score-chart Environment (cont).

Intersections and other nature areas inside the dikes	Present situation	C3*		D4	A3
		h	(-)	h	--
Total costs of building as of January 1st, 1976 (million guilders)		4895	(4645)	2135	3620

*between brackets the score of the nilvariable has been given

** the absence of changes with regard to the present situation has been indicated with an "h"

Score-chart Environment.

Sensitivity-analysis: effect of an average tidal-difference of 3,1 meter at Yerseke with C3.

	Present situation	** C3*		D4	A3
Areas (ha)					
area under tidal influence (dike to dike)	45000	35000	(35000)	0	35000
intertidal area	17000	11000	(8500)	0	12300
vegetated mud-flats	1450	550	(550)	0	550
intersections	450	450	(450)	450	225
Mud-flats and dessicated shore-lands					
Maintenance saline character of mud-flats		h	(-)	--	h
Abundance of species of halophile plants		h	(+)	+	h
Abundance of species of other plants		+	(+)	++	+
Abundance of species of birds		+	(+)	+	+
Number of birds		+	(+)	++	+
Intertidal area					
Abundance of species of plants		h	(h)	--	h
Abundance of species of animals		h	(h)	--	h
	tons of dry material	%		%	%
Biomass in salt part					
Phyto-plankton, algae eelgrass	8900	70	(60)	30	70
Zoo-plankton	600	75	(45)	1	75
Mussels, oysters, cockles	12000	75	(75)	20	75
Other zoo-benthos	4800	75	(270)	10	75
Fish	2290	75	(135)	15	75
Marine birds	11	100	(100)	35	100
Water					
Types of salt water		h	(h)	--	h

Score-chart Environment Westernscheldt, Fore-delta and the Total Delta-area (comparison with regard to the present situation)

Sensitivity-analysis: effect of an average tidal-difference of 3,1 meter at Yerseke with C3; effect of subcompartmentation of the Zoom lake with D4.

	Present situation	C3		D4*		A3
Westernscheldt						
Effects of the fresh-water load from the Zoom lake		-	(-)	--	(--)	-
Fore-delta						
Effects on the biocenis		h	(h)	+	(+)	h
Total Delta-area, number of species of organisms excluding the Westernscheldt						
Phyto-plankton	500	500	(500)	420	(400)	500
Zoo-plankton	125	125	(125)	110	(100)	125
Phyto-benthos	450	450	(450)	400	(350)	450
Zoo-benthos	1300	1300	(1300)	800	(700)	1300
"Higher" plants out-side the dikes (fresh)	700	800	(800)	960	(900)	800
"Higher" plants out-side the dikes (salt)	75	75	(75)	110	(90)	75
Fish and octopi	70	100	(100)	60	(50)	100
Birds	200	200	(200)	200	(200)	200
Reptiles, amphibians and mammals	30	40	(40)	45	(40)	40
Total	3450	3590	(3590)	3105	(2830)	3590
Total costs of building as of January 1st, 1976 (million guilders)		4895	(4645)	2300	(2135)	3620

*between brackets the score of the nilvariable has been given.

** the absence of changes with regard to the present situation has been indicated with an "h".

Chapter IV

SENSITIVITY ANALYSIS

4.4. FISHERIES.

As far as fisheries are concerned several hypotheses can be changed as well. For the mussel- and oyster-fisheries the three nil variables described in chapter 3 amount to:

C3: the retrogression of the mussel-culture has no direct effect on the added value of the mussel-industry because of the present over-production; retrogression in the production-capacity in the oyster-culture has no influence on the sales.

D4: expansion of the mussel-culture in the Waddensea is feasible without direct effects; continuation of the oyster-industry is impossible.

Now a few other variables will be viewed. Assuming the fact that with C3 the falling behind of the demand for mussels is only a very temporary affair than the decrease of the velocities of the currents on the culture beds will indeed have economic consequences. If one assumes that an increase of the mussel-culture in the Waddensea in the Waddensea is not possible a decrease of 50% of the culture in the Easternscheldt will result in a drop of 15% in the total production in the Netherlands. This implies a loss of 6,5 million guilders a year of added value and 105 man/year of labour opportunity. As far as the oyster-culture is concerned one may assume that with C3 the sedimentation will be so high, that the production will fall off with 10%. This leads to a loss of 0,6 million guilders a year of added value and of 7 man/years of labour opportunity.

With D4 one may assume that the mussel-culture can not be expanded in the Waddensea, because one wishes for example to avoid any conflicts with the shrimp-fishery. Further accepting the fact that the present over-production is only a temporary affair, than with D4 the Dutch mussel-output will decrease with 30%. This means a loss in added value of 13 million guilders a year and of 210 man/years of labour opportunity. In conclusion the new variables amount to:

C3: the Dutch mussel-output decreases with 15% due to deteriorating nursery-conditions in the Easternscheldt;

the oyster-production decreases with 10% due to sedimentation on the nursery-beds.

D4: the Dutch mussel-production decreases with 30% due to the impossibility to expand the culture in the Waddensea; continuation of oyster-farming is impossible.

With a threatening decrease of the oyster-culture a number of measures may still be considered. Apart from seeking alternative places for oyster-nurseries, one can also switch to other methods of"farming"such as:

a) hanging cultures of which literature provides us with a number of remunerative examples (34)*

b) oyster-culture in ponds with abundant nutrients, as practised in Belgium and France (35)*

c) oyster-culture in parts of an artificial mussel-"revitalisation" basin.

The traditional bottom-culture might also be practised in the Grevelingen as many oysters are being found there. However, all these possibilities require closer examination. As annexis one finds a scorechart with these new variables. It turns out that the sequence of the alternatives, due to changed assumptions, remains the same, but that the loss with C3 can be so high, that a closer study of the influence of the reduced tide on the mussel- and oystercultures appears highly desirable.

Finally another variable of D4 will be viewed; one in which no mussel-"revitalisation" place will be built. As yet another method of revitalisation is conceivable, f.e. in a "mussel-desanding ship," which, however, cannot serve as a storage room as is the case with the present "revitalisation" basins. It is still unknown whether the function of "revitalisation" can be fulfilled by those de-sanding ships. This function is important for trade, for life mussels are longer preservable and weakened mussels open their shells, lose weight and thus fetch lower prices. Those ships with a dual function would prevent loss of quality during transportation as is the case with the present usual dry transport. At the moment studies are being made of techniques to recover mussels sand-free and with less damage. The function of

"revitalisation" would then become less important. If, based on the Delta-indemnity-act, all 20 trading firms would be given such a ship, it would certainly be cheaper than the creation of a new mussel "revitalisation"

For the moment it has been assumed that this will not take place. With D4 the continuation of both the mussel- and oyster-industry will have become impossible. It is further assumed that the turnover of the oyster-industry with C3 will increase annually with 5% which means that a doubling of production will be reached in 15 years' time. An additional increase of production is impossible because the biological maximum will have been reached.

From the above the following variables result:

C3: the mussel-production decreases with 15%;
the oyster-production decreases with 10%;
the oyster-production could be doubled in 15 years' time.

D4: the continuation of the mussel- and oyster-industry will be impossible in the Netherlands; the oyster-production could be doubled in 15 years' time.

A3: the oyster-production will be doubled in 15 years' time.

On the next page one will find the scorechart with these variables. Against the loss with D4 stands a saving of 120 million guilders because the mussel-revitalisation basin will not be built. The size of the losses with D4 clearly shows the importance of the revitalisation-function; the desirability of a mussel-revitalisation facility has thus clearly been established.

Finally we wish to point out that all calculations in this Note are based on a disconto-rate of 10%. If one uses a scenario in which a lower percentage is assumed, then all capitalized values will become proportionally higher.

*Publications:

(35) Productivity of the Bassin de Chasse in Ostende.
P. - A.C. Burd. Nature, 1965 (101-103)

(34) Aquaculture. J.E. Bardach c.s. New York,
Wiley Interscience 1972.

Scorechart fisheries.

Sensitivity analysis: with C3 the mussel-production decreases with 15% and the oyser-production with 10%; with D4 the mussel-production decreases with 30%

	C3*		D4*		A3
cash value of the future losses for the commercial fisheries (mln guilders)	77	(6)	250	(117)	0
yearly losses in employment opportunity (man/years)	119	(7)	370	(160)	0
cash value of the national-economic losses (mln glds.)	133	(10)	395	(187)	0

Sensitivity analysis: with C3 the mussel-production decreases with 15% and the oyster-production with 10%; with D4 the oyster- and mussel-industries will disappear; with A3 the oyster-production will be doubled in 15 years' time.

	C3*		D*		A3
cash value of the future losses for the commercial fisheries (mln guilders)	89	(6)	616	(117)	0
yearly losses in employment-opportunity (man/years)	119	(7)	860	(160)	0
cash value of the national-economic losses (mln glds.)	142	(10)	986	(187)	0

total construction-costs as of January 1st, 1976 (mln guilders)	4635	(4645)	2015	(2135)	3620

* the score for the nil variable is given between the brackets.

Score-chart Recreation

Sensitivity-analysis: with D4 an recreation-stimulative policy has been assumed.

	C3	D4*		A3
Increase beach- and shore-length (km)	0	50	(25)	0
Increase number of berths aquatic sport	0	600	(150)	0
Increase tourists of beach and shores (%)	0	70	(30)	0
Increase of number of persons practising aquatic sports (%)	0	600	(20)	0
Investments	no	yes		no

* Between brackets the score for the nilvariable has been given.

4.5. RECREATION.

In chapter 2 the effects have been analysed of the alternatives for a few forms of recreation with a scenario which is based on a non-investment policy. However, as a closed off Easternscheldt will potentially be a very important recreation-area, it would make sense to examine what the effect would be of scenario which will be characterized by stimulation of the recreaction. In that case it is assumed that new investments in recreational provisions will be promoted and that the capacity of the approach-routes into the Central Delta-area will be expanded. About the character and magnitude of recreation-stimulative measures a great number of possibilities are conceivable. One could think of investments in a number of obvious projects for beach- and shore-recreation and aquatic sports. As a result one may expect greatly increased pressure from the residing tourists, who are less hampered by the existing road-capacity. The expansion of lodging-accomodations should, however, keep pace with the increasing number of lodgers. The question as to what extent day-trippers will make use of the created possibilities depends mainly on the size of the investments in the expansion of the road-capacity. We can state that one additional lane will increase the number of day-trippers by 25.000. Expansion of the road-capacity with four lanes would thus mean an increase of 100.000 day-trippers. It is assumed that a higher capacity will be fully used. The following score-chart shows the effect of a recreational use of the central Delta-area on the basis of the abovementioned measures. In this case one should take into account a government investment in the order of 100 million guilders. For the rest one will have to invest also in the case of a non-investment policy in order to arrange the area in such a way that recreation will be prevented in areas which from the viewpoint of natural environment are considered undesirable.

4.6. RESUMé.

Although no complete sensitivity-analysis could be made due to lack of time, we have examined on a number of issues whether changes in the assumptions would produce essentially changed results.

With regard to the safety during the transition period we started from the concept that a forced pace of dike-heightening with C3 and A3 will lead to a situation where the difficult issues from a planological point of view will be finished in the last instance and with that the safety will only be achieved too at the end of the construction period. In the sensitivity-analysis it has been assumed that, by executing the works in the order of priorities, posed by security, already during the dike-heightening important sections of the area will be protected. In assuming this, about the feasibility of which nothing can be said at this moment, the chance of floods during the construction period, which is four times bigger during dike-heightening than in the case of closure, will be reduced to 50%. The storm-surge barrier, as a result of the 1/500 dike-heightening becoming effective more quickly in the transition period, gets a smaller chance of floods than D4. It goes without saying that by expanding D4 with partial dike-heightening - costs 135 million guilders - this variable will have the lowest chances of floods also during the construction phase.

Further acceleration of dike-heightening whereby it has been assumed that execution in the proper sequence will not be possible, is of small value. A prolongation of dike--heightening with 5 years and a correct sequence of execution appears to be even more favourable than the original startingpoints. Also with changed assumptions the alternatives C3 and D4 still offer far better protection during the transition period than A3.

With regard to the environment two variables have been considered. In the first place the storm-surge barrier will be executed with a flow-through gap of 20.000 m^2 instead of 11.500 m^2. (additional costs 360 million guilders). The

tidal range at Yerseke will then be 3.1 meter, and the environment will deviate less from the present situation, although according to the results of the study with an ecological model, which for the time being should only be considered as an indication, the biomass will diminish due to a decreased sedimentation. Secondly, in alternative D4 (closure) a subcompartmentation in the Zoom lake at a cost of 165 million guilders has been provided. In this case the shallow parts in the basin of the Easternscheldt - the Marquisate of Bergen op Zoom and the Verdronken Land of South-Beveland - will be embanked, as a result of which the quality of the water in these places can be considerably improved. Due to these circumstances the number of species of organisms will increase and from an environmental point of view very interesting areas will develop there.

With respect to the mussel- and oyster-cultures it was assumed that with C3 (storm-surge barrier) the temporary retrogression of the mussel-culture will have no direct influence on the added value of the mussel-industry because of the present overproduction and thus a decline in the production capacity of the oyster-culture will not affect the turnover.

Under the assumption that expansion of the mussel-culture in the Waddensea will not be feasible and that also due to the lower flow-velocities because of the storm-surge barrier, the mussel-production will decrease with 15%, while on the other hand the oyster-production will decrease with 10% owing to sedimentation, the estimated capitalized national economic loss will increase from 10 million guilders to 135 million and the annual loss in labour-opportunity from 7 to 119 man/year.

Assuming that the sale of oysters in the next 15 years still could be doubled and that it is not possible to create an artificial mussel storage and revitalisation place, the capitalized national economic loss will increase to 986 million guilders at closure and the loss of labour-opportunity will rise to 860 man/years. This obviously only holds as long as no new methods of cultivation can be applied. In

the field of recreation the closed off Easternscheldt has the greatest possibilities; due to the enlargement of the beach-area on the one hand and on the other through the increased availability of berths for pleasure craft, In the scenario used in this case these possibilities are limited as a result of the non-investment policy and as such contrary to the "horse shoe" conception and thus considered unfavourable.

It should be noted, however, that in fact some provision will always be necessary to deviate the recreational pressure from shore-areas where, from an environmental point of view, silence is desired. In a changed scenario in which one wishes to utilize the potency of the Easternscheldt-basin as recreation-area, an investment of approx. 100 million guilders, mainly for doubling the capacity of the approach-routes, can multiply the possibilities of this area without repercussions - in view of the available space - for the natural environment.

The sensitivity-analysis does not give any cause to change the initially chosen starting points. It appears though that in case of the construction of the storm-surge barrier a closer study of the problems concerning the fishery is required so that necessary measures can be taken in time in order to limit the losses of the fisheries to a minimum. Besides, a study will be necessary to examine how the chances of floods during the construction phase could be reduced in the best possible way with the least possible interventions.

CHAPTER V.

Summary.

In this Note three alternatives are being placed side by side i.e.:

- At the mouth of the Easternscheldt a storm-surge barrier (which can be closed) will be built; the dikes along the basin will be slightly heightened locally (alternative C3).
- The Easternscheldt will be closed off by a dam according to the original Delta plan (alternative D4).
- The Easternscheldt remains open: the dikes along the basin will all be heightened at Delta-level according to the plans of the Provincial Waterstaat Zeeland (Provincial Water Control Board Zeeland) alternative A3.

Each one of these alternatives offers security and has, moreover, important consequences for a great number of fields such as environment, fishery, employment opportunity, etc., etc. Each alternative though, leads to part-problems which, individually have little to do with security, but which have influenced the decision policy.
In this Note efforts have been made to show in a concise and easy to survey manner the consequences of each of the three alternatives for a number of fields in order to contribute to a rational discussion and a well-considered judgement. To be able to pronounce upon the future consequences, assumptions have to be made with regard to the future. These assumptions have been mentioned explicitly, as much as possible and where ever possible the consequences have been quantified in relevant units, for example areas of tidal region, species of animals, number of labour places, guilders, etc., etc.
However, there are certain fields for which no quantitative units can be used; in that case efforts were made to indicate a certain order of priority. The quantification or order of priority mentioned above is not an evaluation. An evalutation, which in most cases is subjective, will be left to the eye of the beholder. The subjectivity is most evident in the field of environment. Here there is

no norm available for the measuring of values. On the one hand we have the present Easternscheldt with its vegetated and unvegetated mud-flats, on the other the closed off estuaries, such as the Veerse lake and the Grevelingen lake which with their growth of tangled brushwood present an extraordinary attractive landscape. Every one is considered to be able to evaluate the consequences of a chosen alternative. The most significant consequences have been summarised therefore in so-called "score-charts". In order to improve the synopsis the alternative with the highest score in a certain field has been indicated by a green square and the one with the lowest score by a red one. At a number of points the norm "money" has been introduced. One should bear in mind, however, that these amounts are not comparable without further preface. The cash-value of a certain effect for example, is far more inaccurate than the estimated costs of a specific structure. This is due to the uncertainty in relation to the future rates of discounts, the expected economic growth and the labour opportunity. Sums of money very often facilitate a comparison in one field but they are not always good measures for comparison between two fields.

Security.

The conception security is not quantifiable in every way; it is coupled with a personal norm of experience and it is not objectively measurable, although one usually feels one self safer as the risk one runs is smaller. In the score-charts five significant effects have been indicated. Closure of the Easternscheldtsoonest provides the desired protection with the least risks during the transitional period. The storm-surge barrier offers little additional risk but takes 5 years longer to be completed. An open Easternscheldt with integral heightening of the dikes will be ready much later - the assumption is 14 years later - than the closed off Easternscheldt

and the chances of floods during the transitional period are 4 times as big. In assuming a more optimistic view with regard to the priority plan for the execution of the heightening of the dikes this factor could drop to 2.

The Easternscheldt barrier reduces all other present primary barriers to secondary water retaining structures with a large lake as a buffer so that security will be optimal. The quality of the dam is very high and the danger of shore- and dike-slides has been warded off.

The storm-surge barrier can be built in the same quality as the other hydraulic engineering works. Also in this case one could speak of an optimal security although the present dikes require a little more care than with the preceding alternative.

An open Easternscheldt with heightened dikes according to the plans of the Province of Zeeland is in comparison with the other solutions less attractive even when the necessary corrections with regard to the higher design levels will be made. In the first place because the danger of shore- and dike-slides remains. In the second place because enlarged dikes are of a lesser quality than newly constructed ones. Moreover, a system of secondary water-retaining structures will still be necessary. The areas which will be situated behind the compartmentation dams will be optimally protected. The remaining part of the basin, however, does not meet with the Delta-standards. Although the coast-line will be shortened to 145 km, the alignment of the dikes will still remain tortuous; subsequent heightening of dikes will probably encounter the same problems as the heightening according to the plans of the Province of Zeeland.

Environment.

With each alternative big changes will take place in the environment of the Easternscheldt and the adjacent areas. These changes, however, are different with each alternative. In this Note these changes are being indicated

with respect to the actual situation, however, without evaluating the environment inherent in each alternative, because such an evaluation cannot be given objectively.

With an open Easternscheldt the actual biocenis with its abundance of species of organisms in the water and on the shores remains intact. This also holds for the foredelta. Due to the heightening of dikes the area of the intersections will be reduced by half, while also other nature areas behind and outside the dikes will disappear. The heightening of the dikes will impair the historically grown dike-landscape.
If a storm-surge barrier is built then the abundance of species in the salt tidal water will be equal to that in the Easternscheldt at present. Due to the fact that the highest parts of the vegetated mud-flats will loose their saline aspect the number of organisms on the shores will be higher than at present. The fordelta will hardly be affected.
With the closure of the Easternscheldt the number of species in the water will drop sharply because of the disappearance of the tide. On the shore-lands, however, due to the fact that the higher parts will become brackish and the remaining influence of the salinity on the lower parts, a greater variety of species of plants and animals will develop than there exists at present. The intersections and the dike-landscape will keep their present form. Due to sedimentation the foredelta will harbour more organisms and species in the future.

The embankment of the Marquisate of Bergen op Zoom and the Verdronken Land of South-Beveland has a favourable effect on the quality of the water and a number of organisms.
Which ever alternative will be chosen, the Easternscheldt will always have a great nature value; the character of the biocenis will correspond more with the present one if the Easternscheldt stays open or is closed with a storm-surge barrier than when completely closed.

Fishery.

Closure of the Easternscheldt has important consequences for the professional fishing, in particular for the culture of testacean. By building an artificial mussel storage and revitalisation basin immediately behind the Easternscheldt-dam, the mussel culture industry could be kept intact, even when the tide disappears, provided that expansion of the mussel culture in the Waddensea will be accepted.

The oyster culture will disappear completely when the closure is a fact, while coastal and sea fishery will be slightly affected due to the disappearance of the nursery-function of the Easternscheldt. The significance of this nursery-function is probably less than one always believed it to be. Also the cockle fishery will no longer be remunerative after the closure: for the rest, also with the construction of the storm-surge barrier this kind of fishery will diminish somewhat in size. The effect of sedimentation on the oyster-culture which will occur due to the reduction of the tide has to be still further examined.

The capitalised national economic losses in the field of professional fishery will amount to approximately (hfl) 190 million guilders in case of a closure of the Easternscheldt. If the abovementioned assumptions are changed (no mussel storage and revitalisation basin, doubling of oyster culture) these losses could run up to 990 million guilders).

Watermanagement.

The watermanagerial consequences concern chiefly the Zoomlake, which will be created behind the compartmentation dams. For control of the level, the flushing and the de-salination in all alternatives a discharge medium into the Westernscheldt will be required. In case of a closed Easternscheldt a scouring sluice is included in the improvement-plans for the Canal through South-Beveland; in all other cases a flushing channel at Bath will be required.

After de-salination of the Zoomlake the salinity can be limited by additional flushing. The lowest degree of salinity can be achieved when the Easternscheldt will be completely closed. The necessary quantities of flushing-water from the northern parts of the Delta-basin do not always seem to be available, also owing to an increasing demand for fresh-water in the rest of the Netherlands. The appeal by the southern part of the Delta-basin to the national stock of fresh-water depends strongly on the chloride content that is required for the Zoomlake.
The interests for agri- and horticulture will in principle be best served by the possibilities of fresh-water supply from the Zoomlake.
In this respect the differences between the alternatives are small. The possibilities for the creation of storage-basins are roughly the same.

Inland shipping.

Based on the prognoses about the traffic-flow of the inland navigation an estimate has been made of the navigation costs on the route through the southern part of the Delta-basin in the various alternatives. In that case the number of navigation locks between the Volkerak and the Westernscheldt in the three main-routes have been taken into account. The differences in costs are so small in those three alternatives that they do not play a role in the evaluation.
A separation of functions between yachting/boating and commercial shipping will be achieved by a closed Easternscheldt with compartmentation with the Wemeldingedam, while with C3 and A3 an alternative main-shipping route will be available in case of calamities in the Scheldt-Rhine connection.

Recreation and Town and Country Planning.

With respect to the possibilities of recreation in the Easternscheldt area the policy for town and country planning to be executed for the central Delta, also

plays a role. Starting from a non-investment policy the visit of day-trippers on warm days will be limited by the capacity of the approach-routes; the weekend and holiday visits will be restricted by the lodging facilities.
With the closure of the Easternscheldt the spreading pattern of the people seeking recreation will change. Within the horseshoe-conception one could consider this less desirable. On the other hand with a policy that is stimulating recreation by increasing the capacity of approach-routes and sleeping facilities a considerable increase of holiday-makers is to be expected.

Procedures, execution, expenditures and labour opportunity.

With all alternatives the preparation of the work will have to be made in accordance with the requirements of the various procedures prescribed by law. Experience has shown that it is difficult to indicate beforehand how much time this will take. This is, in particular, applicable to the integral heightening of the dikes, where the required time for preparation depends to a great extent on the democratic process of popular "participation" or "saying in the matter".
In this Note as well as in the plans of the Province of Zeeland it has been assumed that the time of preparation for integral heightening of dikes will be 3 years, while the execution will take 15 years. If one would desire a quick realisation without changing the existing legal procedures, then this could only be achieved if interested parties i.e. certain groups and victims would waive their right of a "say in the matter" and their legal rights of appeal. The question is in how far this could be expected from these groups in our present legal system.

In the other alternatives the procedures also play a role, although that is limited to a few issues of the total works.

The expenditures of the three alternatives have been calculated as of the 1st of January, 1976. This means that the investments made during the past two years have not been included; current commitments though have indeed been taken into account. All costs have been expressed in guilders of end 1975. The costs of the storm-surge barrier have been taken from the data of the concerning Final Report and the costs of the integral heightening of the dikes from the report of the Province of Zeeland. The amounts indicated in the score-chart apply to a storm-surge barrier with a single retaining structure. Construction-costs in the peak-year (1980) provide an impression of the significance of each alternative for the budget. In all respects the storm-surge barrier demands the highest expenditures; closure of the Easternscheldt the lowest.

Something similar holds for the total labour opportunity as a result of the execution of the works; there also the construction of the storm-surge barrier scores the maximum and the closure of the Easternscheldt the minimum. With the construction of the storm-surge barrier labour opportunity will be stimulated foremost in the metal-industry.

With the other alternatives the labour opportunity will mainly be stimulated in the ground and hydraulic engineering sector. In this context we should not leave unmentioned the improvement of the international competitive position of the Netherlands in the field of hydraulic engineering works, as a result of the increased know-how that attends the construction of a storm-surge barrier.

Summarized score-chart.

	C3	D4	A3
Safety			
year when complete safety is reached	1985	1980	1994
length primary water-retaining structure (km)	9	9	145
quality primary water-retaining structure	+	+	-
"optimal" retaining structure	yes	yes	no
odds on floods during transition period (%)	3,5	2,5	9
Environment *)			
Abundance of species in salt-water	h	-	h
Abundance of types of shores	+	++	h
Abundance of types Delta-area	+	-	+
Biomass in saline part	+	--	-
Effects on intersections, nature areas and dike-landscape	-	h	--
Commercial fisheries			
Annual loss employment-opportunity fisheries (man/year)	7	160	0
capatalized national-economic loss (million guilders)	10	187	0
Watermanagement			
max. salinity Zoom lake (g Cl^-/l) with additional flushing of 100 m3/s	0,5	0,35	0,6
demand on national watermanagement with max. salinity of Zoom lake (m3/s) 0,5 g Cl^-/l in dry periods	150	60	>155
Inland shipping			
Capitalized costs inland shipping (million guilders)	172	166	174
Recreation			
Increase tourists in Eastern-scheldt-area (%)	0	25	0
Procedures and costs			
In accordance with Delta-act	yes	yes	no
Area to be expropriated (ha)	430	300	750

	C3	D4	A3
Procedures and costs (cont.)			
Total costs of building as of January 1st, 1976 (million guilders)	4635	2135	3620
capitalized costs of building (million guilders)	3180	1485	2025
capitalized costs for maintenance (mill.glds.)	110	70	30
Employment			
Total effect on employment (man/year)	34600	15500	23500

* the absence of changes with regard to the present situation has been indicated with an " h"