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AND PROTECTION**

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**FLOODING RISKS OF FLOODPLAIN AREAS IN THE NETHERLANDS**

Discussion paper transmitted by the Government of the Netherlands \*/

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## **SUMMARY**

The Dutch floodplain areas are attractive for many reasons. The most important functions for the floodplain areas are discharge of water ice and sediments. Developments in the floodplains for industry, recreation, living added all kind of other interests to the natural river functions. These developments were allowed as long as the natural riverine functions of the floodplains weren't hampered. Potential flooding risks of industry, housing and recreation weren't considered. The floods of 1993 and 1995 have illustrated the primary function of the floodplain areas, and made clear that flooding risks in the floodplain areas could be significant. This has led to a change in policy. For the further development of this new policy on the floodplain areas an investigation is carried out.

## **1. INTRODUCTION**

### **Development of floodplains**

The first inhabitants of the river areas in the Netherlands settled around 1700 B.C. The meandering river area was surrounded by lower and higher grounds. The higher grounds were the most popular parts for settling. In the following decades the possibilities for further development were restricted due to inundations.

Around 800 A.D. the riverlands became more densely inhabited. The inhabitants started to protect their properties against flooding. Initially small embankments and walls, later on dikes were built along the rivers.

Around 1300 A.D. the dikes were closed in a circle, a so called dike ring, in order to protect the inner area (polder) against flooding. This was not very successful, referring to the numerous dike breaches in these years. Nevertheless the construction of dikes marked the separation between polders (protected areas) and the flood plains (unprotected areas).

After the flood disaster in the winter of 1860-1861, the necessity of flood protection became significantly clear, and plans were developed to protect the river area by controlling the course of the river and strengthening the dikes. Starting point for determining the dike height was the highest known river discharge and associated water height. In 1926 in Lobith this assumption proved questionable when the river Rhine discharged 13.000 m<sup>3</sup>/s causing severe problems for the protection of the hinterland. Several polders were flooded due to breaches in the dikes.

Years later it became apparent that developments and settlements had taken place within the floodplains, which resulted in damages whenever the floodplains were inundated.

In 1980 questions were asked in the Dutch House of Commons by members of parliament Wisseling en Materman about the inundations and damages in the floodplains.

"Is the Minister aware that the inundation of the rivers caused damages of 35 million guilders in the province of Gelderland, for agriculture alone? Is it true that the probability of flooding will grow in the next years? What is the cause of this increase?"

Around Christmas 1993 both the Meuse and the Rhine exhibited top water discharges. In 1995 the rivers flooded again. The inhabitants and users of the floodplains became strongly aware of possibility of inundation.

Again questions were posed on how to deal with inhabitants of the floodplains. How, and whether, the damages should be compensated by the government. How permissions for activities in the floodplains should be limited.

In this presentation on the flooding risks of floodplains, an investigation is presented on the flooding risks of the Dutch floodplains. Instead of the protected areas, the polders, this paper discusses the risks of the unprotected areas, the floodplains. The definition of a floodplain is defined and the present Dutch policy on floodplains is discussed first. Secondly the investigation which is now being performed by the Ministry of Transport, Public Works and Water Management (TPWWM) will be explained. Finally the recent studies on floodplains and flooding risks, used for the investigation are discussed.

## 2. DEFINITION AND USE OF FLOODPLAINS

A floodplain is defined as an area along a river which is not sufficiently (according to law) protected by dikes. It may be an area outside the river dikes, where 'outside' should be interpreted from the viewpoint of protected land, or an area without protection of dikes. Areas with protection by low embankments, e.g. those along the Meuse in the Dutch province of Limburg are also considered to be floodplains.

The floodplains in the Netherlands are very important for river management during periods of high riverdischarges. The inundation of the winterbed reduces the backwater effects compared to the situation of constriction of the river due to buildings on the floodplains. The storage of the winterbed affects the water level in downstream areas.

The floodplains of the Dutch rivers are attractive for many reasons, like industry, recreation. Priorities must be set in order to achieve the goal of a sustainable river management. The natural river functions such as discharge of water, sediment and ice are paramount. The functions shipping, agriculture, nature, landscape have to be balanced.

Unprotected areas, floodplains, can be found along the rivers and the sea. For instance, along the Rhine and the Meuse, housing and industrial areas can be

found. Along the sea, the Maasvlakte near the Rotterdam port, is an example of an unprotected, floodplain, area although the risks of this area will not be as high as the word 'unprotected' suggests. Along the Ysselake, floodplain areas can be found as well.

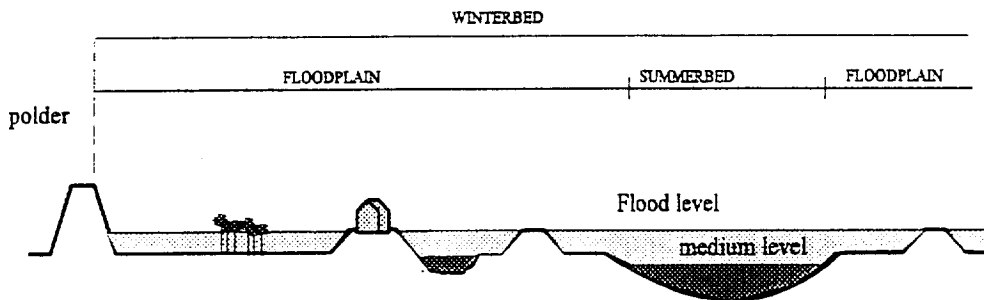


Fig. 1 Floodplain areas.

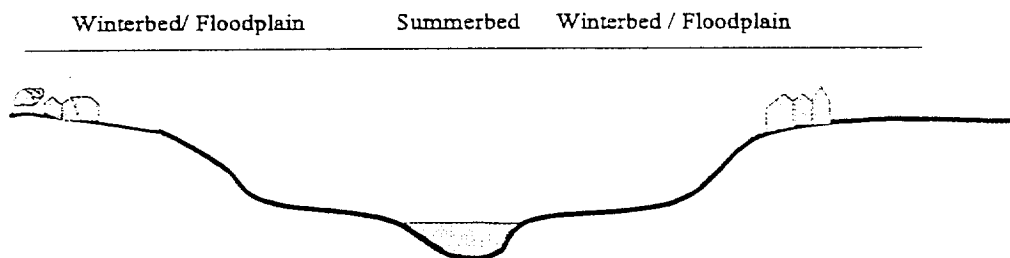


Figure 2. Unprotected areas along the Meuse.

### 3. POLICY ON THE DUTCH FLOODPLAINS

The flood of 1993 have caused significant damages along the unprotected section of the Meuse. People wondered why the Ministry of Transport, Public Works and Water Management, in charge of the rivers, had permitted the plans and buildings in the area along the Meuse.

According to the Dutch River Act the Ministry can give a 'declaration of no objection', if the plans do not influence the storage or water discharge of the river. In some places in the river area activities or buildings will not interfere the storage or discharge of the river water. In these areas activities cannot be stopped by the Ministry of Transport, Public Works and Water Management. People planning to live, recreate or use the land for industrial or agricultural activities have to take the (possible) flooding risks into account.

Following the floods of 1993 and 1995 a 'no regret' policy has been issued by the Ministry of Transport, Public Works and Water Management<sup>1</sup>. This policy is more strict with regard to the use of the floodplains of the large rivers. The objective of this Line of Policy is reached by adhering to the following aspects:

- Maintaining the available space in the floodplain. This space will remain available to accommodate future higher river discharges. It can only be used for activities which are inextricably tied to with the river.
- Creating additional space. The discharge capacity of the river has to be enlarged by widening and extending the floodplain, in combination with the reinstatement of a natural habitat. Developments which hamper current and future possibilities for extension of the floodplain will not be allowed.
- Maintaining the protective level at a minimum of waterlevels occurring at a rate of once per 1250 years. Damage control can be achieved by requiring this minimum protective level for all activities admitted in the flood plain<sup>2</sup>.

Discussing the responsibilities of the public authorities on the flooding risk in the floodplains different arguments arise:

- It is the responsibility of the inhabitants and farmers and industrials to be aware of the risks of flooding; this means that taking precautionary measures or compensating damage is not the responsibility of the Dutch government.
- Although it is understandable that the Dutch government supplied generous financial aid after the flooding in December of 1993 and 1995, this should be an exception to the rule. Continuously compensating damage prevents the desired self-regulation of the behaviour of inhabitants and industrials towards avoiding risks.
- Municipals weigh the short term profits (developments in the winterbed) against the long term profits (annoyance of flooding). In case the short term profits have been chosen, the damage due to flooding are is no more the responsibility of the society.
- Equal protection of all inhabitants and industries in the country is the responsibility of the public authority.  
Because the Dutch protection level for flooding exist, depending on regional density, potential flooding level and economical importance, the area along the Meuse should have a certain protection level as well.
- As 'Safety against flooding' is one of the central tasks of the Ministry of TPWWM, the floodplains should have their attention as well.
- A comparison of protection levels bases on flooding risks is crucial for a consistent safety policy for the Ministry of TPWWM.

The discussion on the policy of the floodplains is not finished. The recent floods of 1993 en 1995 has brought the topic back on the agenda. For the discussion an overview of the Dutch floodplains is needed. It was after the floods of 1993 en 1995, that a policy on the floodplains was needed urgent. This paper presents the investigation executed to support the discussion on the policy of the Dutch floodplains.

#### 4. INTRODUCTION TO THE INVESTIGATION

Three Engineering Divisions of the Directorate General of Public Works and Water management an investigation is carried out on the floodplains in order to support the (future) policy on the floodplains.

The purpose of the study is to give insight in the problems that arise with floodplain areas. The question is how many floodplains there are in the Netherlands. How serious is the flooding risk in the flood plains? How can the flooding risk be influenced. Which influencing measures can be taken by government and other authorities?

For this insight an inventory of the areas and their flooding risks is needed. Also a guideline of the possible measurements in order to reduce the flooding risks has to be drawn up. Another important aspect in this study is insight in the acceptance of the flooding risks by society.

### **Investigation**

The plans for the investigation on the Dutch floodplains can be divided in three major parts.

- Geographical information of the Dutch floodplains. (e.g. situation, level, area, landuse)
- Assessment of the flooding risks of the Dutch floodplains, using the results of a set of case studies.  
Risk assessment will be based on using the results of recent studies.  
Special attention for:
  - Social effects of flooding and public acceptance.
  - Damage to cultural aspects.
  - Damage and danger due to dispersed materials (in industrial areas) by flooding.
- Measures to influence the flooding risks.  
The flooding risks can be influenced by limiting the (probability of) damage as a result of high water levels. Examples of such measures are: effective prediction and warning systems, building regulations and services. In addition much attention will have to be paid to inform and making the people in the river area aware of the consequences of living in flood-prone areas.

The investigation is executed by three Divisions of the Directorate- General of Public Works and Water Management of the Ministry of Transport, Public Works and Watermanagement. The first results are expected at the end of 1997.

The results of the investigation will be used to support the discussion on the Dutch policy on the floodplains.

In figure 3 the different parts of the investigation are presented in a scheme. The middle part of the scheme, the development of a GIS-application, resulting in the presentation is the principal line.

The case studies for Dordrecht, Maasvlakte II en Limburg will be used to improve the damage model. The damage model is on the financial damages due to floods.

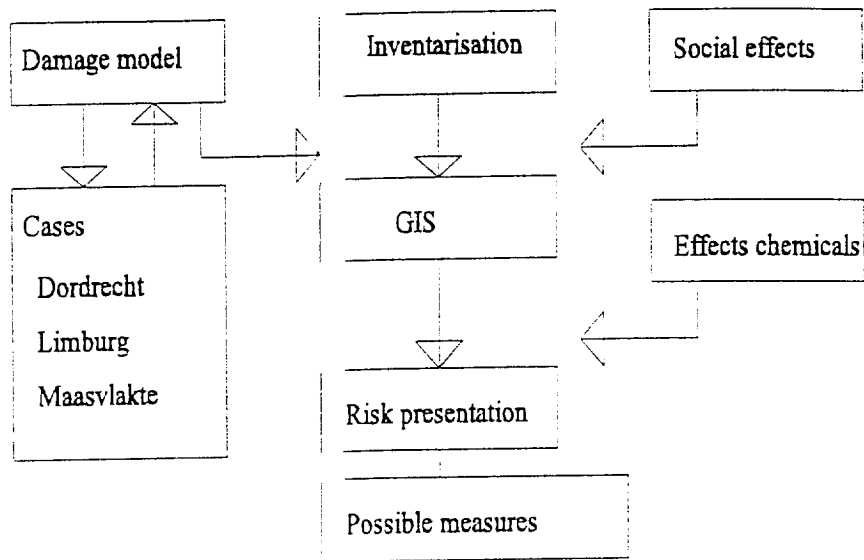


Fig 3. Schematic plan of the investigation.

Table 1: Different damage types due to floods.<sup>3</sup>

Damages	Monetary	Non-monetary		
Primary direct	man-made capital	humans	ecosystems	historic monuments
indirect	interruptions of production			
induced	emergency costs			
Secondary	supply bottlenecks reductions in demands			

The geographical information on the floodplains in the Netherlands, will be the input for the (simplified) damage model in the GIS application, in order to determine the financial flooding risk for the floodplains.

The results of the investigation on the social effects, the danger of dispersed chemicals have to be add to the damage model.

#### Recent studies on floodplain management and flooding risk

Recently investigations have been executed on floodplain management and/or flooding risk analyses. A short review of the most important studies, in relation to the investigation on the Dutch floodplains will be presented.

#### Boertien I

The Boertien-I research started in July 1992, testing the starting-points for the Dutch river dike reinforcements. The Boertien-I study investigates the effects of the chosen level of protection against flooding (the safety standard) and the possible strategic options with respect to decision making regarding dike reinforcement plans complying that protection level.

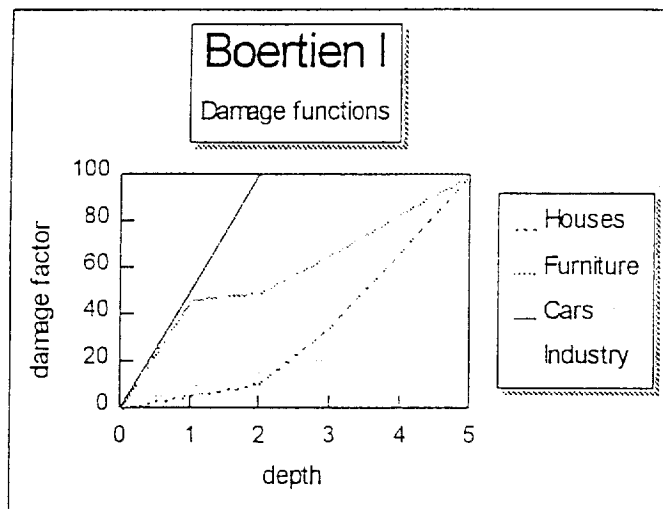


Figure 4 Damage functions for different land use types

The study makes use of the methods developed by TAW. The Technical Advisory Committee for Water Retaining Structures advises the Dutch Ministry of Transport, Public Works and Water Management.

In the Boertien-I study for different land use types damages functions area used, for housing, agriculture and industry (fig 5). The damage factors represent the percentage of the value of the aspect. The damage factors are in the used functions not dependent of stream velocity or rising velocities of the water level. Referring to table 1 the man made capital and the interruptions of production are included.

#### Boertien II

In December 1993, around Christmas, the Dutch Meuse flooded after a period of heavy rainfall in the Meuse discharge area. The total damage caused was about 254 million Dutch guilders, about 8000 people had to evacuate<sup>4</sup>. After this Meuse flood, the Dutch government gave Delft Hydraulics the assignment to investigate the flood and established the Commission Boertien-II to coordinate the research. In cooperation with a lot of institutes, universities, companies, and public agencies Delft Hydraulics investigated various aspects of the flood in the Meuse valley.

Part of the Boertien-II study is the development of the Meuse Damage Model. This model is aimed at assessing flood damage for the analysis of individual technical measures and strategies on a regional scale. It determines the net present value of flood damage for different strategies and the number of victims. Other parts of the study determine the costs of measures and strategies and analyze the uncertainties of the avoided losses. The damage types in the Boertien-II method are man made capital and humans (table 1).

#### IVR, Integrated flood protection Rhine

The development of the decision support system on integrated flood protection for the Rhine<sup>5</sup> recently, can be used to set priorities in order to achieve the goal of sustainable river management.

Tools are developed to quantify the effect of increased drainage and flood



plain development on flood levels (given a certain discharge). Also the effect of water retaining reservoirs can be quantified<sup>2</sup>. Results show that lowering and widening of the flood plain are the most effective measures for accommodating peak discharges in the future. Additional measures like shortening and lowering groynes, guidebunds, lowering dams in the flood plain, creating more flow channels can be applied locally. This will require a further policy with regard to physical planning and river management.

### Damage modelling

The damage model used for the study is based on recent studies as discussed before. The University of Twente is investigating the cause of the difference in total damage during the floods in Limburg in 1993 and 1995. The Boertien II study will be used for the damage modelling. The investigation can be used to quantify the uncertainties in the damage functions used in the Boertien II model. The results of this investigation will be used to improve the damage model.

The damage model will at first focus on financial damages, to man made capital, and interruptions of productions. Separate investigations focus on non-monetary damages, like humans or social damages and damages to historic monuments.

The damage model uses functions for different aspects. Compared to the Boertien I study the functions are more in detail on the different aspects. At first the damage functions are related with flooding levels only. The damage model will be used for the case studies first.

### Case studies

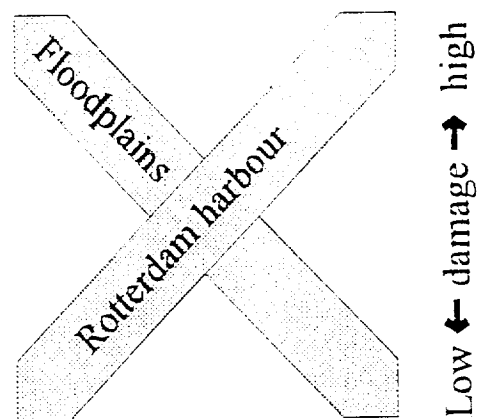
#### Dordrecht.

The Storm Surge Barrier in the Nieuwe Waterweg in the southern part of the province of South Holland, is the final part of the Deltaproject. In October 1997 the Storm Surge Barrier will be operational in case of heavy storm surges.

The decision on the water level for closing the water barrier caused a discussion on the risks for the industry versus the inhabitants on the floodplains in Dordrecht.

The storm surge barrier will be closed at high water levels on the North Sea, in order to protect the southern part of the province from flooding.

When the barrier is closed ships can no more pass the Nieuwe Waterweg, the activities in the Rotterdam harbour will be idle. From the point of view of the harbour activities a high closure level for the storm surge barrier is favourably. The inhabitants of the floodplain areas in Rotterdam and Dordrecht, want the barrier to be closed as often as possible, in order not to be flooded that often



Seldom ← Closure → Often

Figure 5 Optimum for floodplain areas versus Rotterdam harbour

#### Maasvlakte

The Maasvlakte, a raised site in the mouth of the Nieuwe Waterweg in the

south of Holland, is an non protect industrial area for it is not protected according to the safety standards.

The Maasvlakte and the plans for another raise site, the second Maasvlakte are interesting areas for a flooding risk assessment. The areas can be flooded from the sea side.

As the Maasvlakte areas are used for industrial purposes as chemical works, flooding of these areas can cause release of chemicals. The consequences of chemical releases can become enormously for the Maasvlakte area and the surrounding areas.

#### Limburg

In 1993 and 1995 the inhabitants of the floodplain areas along the Meuse in Limburg had to deal with high flood discharges and resulting flooding. In the Boertien II study, possible strategies and measures to reduce the water discharges in the Meuse are proposed. After the flooding of 1995, part of the Boertien strategy, the construction of levees around the villages quickly was realised. At the moment plans are being prepared to fulfill the total advised Boertien strategy, lowering the summerbed of the Meuse.

Limburg is interesting for a flooding risk assessment in order to investigate the social impact of flooding and flooding risks. The results and the expertise from the Boertien II study will be used for the risk assessment in the case study.

### 5. CONCLUSIONS

Discussing the policy on the floodplains in the Netherlands some conclusions can be made.

For the polders, the protected areas in the Netherlands, the attention for flood protection has always been awake. The legally prescribed safety level is accepted by society. For the unprotected areas the safety level is not prescribed by law.

The former 'No objection policy', originated from the water discharge function of the river, didn't prevent new developments in the floodplain areas sufficiently. Nevertheless the floods in 1993 and 1995 caused significant damages in the unprotected area along the river Meuse. The compensation of the damages in the floodplains due to these floods lead to discussions on developments in the floodplains.

As a different policy was needed, the 'no regret policy' prevents developments in the floodplain areas more strictly. The floodplain can only be used for activities which are inextricably tied to the river. Compensation measures for the river functions have to be taken in case of new developments.

In order to develop a future policy research is now being executed.

The investigation is divided in three parts:

- An inventory of the floodplain areas.
- A potential damages assessment.
- Possible measures.

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