



Rijkswaterstaat
Ministry of Infrastructure and the
Environment

Flood Risk and Water Management in the Netherlands

A 2012 update

Water. Wegen. Werken. Rijkswaterstaat.





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Robert Slomp

July, 9th, 2012

Summary

As in most countries legislation for flood risk management and crisis management in the Netherlands was driven by disasters. European Directives increasingly influence our legislation, consequently we apply experiences from other countries for our legislation. The Floods Directive was an initiative of France and The Netherlands. The goal of this Directive is to have integrated flood risk management plans, covering flood alerts, spatial planning, flood defenses and response and rescue services.

Flood Management in the Netherlands has been successful the last 60 years because of adaptive changes in our organizational, legal and financial tools and institutions. Flood Risk Management and Water Management are integrated in the Netherlands. Flood defenses only last if there is adequate funding for maintenance and regular overhauls. By combining daily water management and flood risk management, the same people are involved who have a detailed knowledge of their water systems and flood defenses.

However crisis communication between water managers and crisis managers from the emergency services is still an important issue for improvement. The Katrina 2005 flood in New Orleans was a wakeup call for the Netherlands. Even though the Netherlands has very high flood defense safety standards a disaster is still possible. This process, communication between different departments and agencies, received a boost with the TMO national disaster exercise in 2008 "Water Proof".

This report describes the Dutch context of flood risk management, the institutions, disasters which influenced our flood risk policy and disaster management, our flood protection standards for flood defenses, flood risk management, financial issues, large projects, urban planning and the choice not to insure against flood risk, the influence of European legislation and finally specific issues concerning our disaster management and response. Some current and unresolved issues are also covered, financing the next round of major overhaul of flood defenses 2015-2023, preparing our flood risk management for 2050 and 2100 and finally "conflicts" when applying different European Directives concerning flood risk and nature conservation.

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Preface

Learning from other countries is important, while analyzing flood risk. Since Flood Risk Management evolves over the years, current descriptions are easily out of date. I have given an update on legislation, organizational and policy changes, these in fact are more important than the large-scale reconstruction projects. Without clear mandates, long term maintenance, specialized personnel and adequate funding every improvement after a disaster will deteriorate. This is a lesson we have learned over the centuries. I have tried to summarize four current books on flood risk and water management in the Netherlands:

- *Water Governance, The Dutch Regional water Authority Model, 2010, "Unie van Waterschappen",*
- *Water in the Netherlands, managing checks and balances, 2004 Pieter HUISMAN,*
- *Fundamentals on Water Defenses, Guidelines for Water Defenses, 1998, Technical Advisory Committee on Water Defenses',*
- *Water Management in the Netherlands, Rijkswaterstaat, Geo Arnold et al, 2010*

This book is a description of process, which started over 1000 years ago. About 1000 years ago monks drained marshes and transformed them into agricultural land. People lived on man-made mounds in the marshes. This process of cultivating the marshes, sea level rise, and large storm surges between 1000 and 1200 brought people together. The first "water boards" were formed around 1200. These democratic institutions preceded the current centralized state by a number of centuries.

Adapting legislation, the organizational and financial structures to the needs of society is a permanent process. This means this book is out of the date the moment it is published. Every society has its own choices to make. Our society has a number of valuable examples both successes and literally fatal errors. Understanding what is at stake is the first step. Deciding on how to protect what is at stake is the next step. A democratic and transparent decision process is necessary for the adequate allocation of funds.

Because we have not had large floods in the Netherlands for more than 60 years we try to systematically analyze large flood events in other countries, some recent examples are:

Hurricane Katrina, New Orleans 2005 [Kok et al, 2007]
Storm Xynthia, France 2010 [Kolen and Slomp et al, 2010]
River Flooding in Bangkok, Thailand, 2011, [ENW, 2011]
The Tsunami and Fukushima, Japan, 2011, [HKV, 2012, in preparation]

This book was first written in French as background information for a French Senate hearing on Flood Risk Management Policy, May 29th 2012.

Robert Slomp, Rijkswaterstaat, Waterdienst

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1 Introduction

The Dutch flood management policy did not succeed because of large-scale flood defence reconstruction projects. The real reasons of the success are the changes in legislation, organizational structures and policy. Without organizations with clear mandates and proper funding, reconstruction and maintenance is not carried out. This is why I will focus on these issues.

I will start with facts and figures, large disasters which drove our flood risk and disaster management policy, then I will proceed with other subjects: flood protection our main policy, the decision not to implement insurance policies for flood risk, our organizational structure, responsibilities, financial issues, the current set of flood protection standards, the large reconstruction projects, EU legislation and civil protection issues.

As in most countries the legislation on flood risk and crisis management was driven by disasters. The influence of European legislation is also visible in our Flood Risk, Water Management and Disaster Management legislation. Flood risk protection issues sometimes conflict with European Directives on nature conservation, e.g. the Habitat and Bird Directives. This is still an issue that has to be resolved.

Flood Risk Management and Water Management are integrated in the Netherlands. Flood defenses only last if there is adequate funding for maintenance and regular and systematic overhauls. By combining both tasks daily water management and flood risk management, the same people can be involved who have a detailed knowledge of their water systems and flood defenses.

Adequate funding remains an important issue for the future, especially in a changing society and climate. This is one of the main reasons for the nomination and appointment of a Delta Commissioner in 2010, the preparation of a new delta program and new legislation in 2011¹.

Crisis communication between water managers and crisis managers from the emergency services is still an important issue for improvement. This process received renewed attention after the Katrina Flood in New Orleans in 2005. After this wake-up-call, the Dutch Cabinet installed a Taskforce on Flood Management to strengthen response and recovery. The Taskforce ended their mandate with the national disaster exercise "Waterproof" in 2008.

1 http://wetten.overheid.nl/BWBR0030836/geldigheidsdatum_06-07-2012

2 Some background information on the Netherlands and the influence of past disasters

2.1 Facts and figures

About 60% of the Netherlands is flood prone (figure 1, see next page). Flood hazard in the Netherlands is caused by floods on the two major Rivers Rhine and Meuse, storm on the North Sea, storm on the large lakes, or the combination of storm and floods in the deltas of the Rhine and Meuse. Almost 26% of the Netherlands lies below sea level [PBL, 2010]. Two thirds of Gross Domestic Product of the Netherlands is produced in 55% of the land surface area which is also flood prone. In theory the damages in case of a flood are large, 400 billion euro's just for the protected area 14, the south of Holland, of figure 27a (see page 39). Flood simulations show a smaller area is inundated in case of a flood, figure 59 (see page 83) shows a flood event with a return period of 100 000 years and a maximum damage of 120 billion euro's. For each flood prone area legal flood protection standards for areas behind major (primary) flood defenses have been set, see figure 27a and 27b.

About 100 000 people of the almost 17 millions inhabitants of the Netherlands live outside flood defenses, see figures 1 (yellow area) and 29. We can distinguish five major areas according to [Rijkswaterstaat, 2011]:

- In fluvial areas: along the Meuse River (4 000 people) and along the Rhine River (5 000 people);
- In the Rhine-Meuse estuary (60 000 people); this is mainly around the large cities or harbors of Rotterdam, Dordrecht, Sliedrecht and Papendrecht;
- On the dunes of the Frisian islands and the coastal cities of Holland and Zeeland (15 000 people)
- In and around the large lakes Marken and IJssel (5 000 people).

People living in these areas cannot rely on legally set flood protection standards². In recent years they can rely on adapted houses, which are often built above the legally set flood levels. Houses from the 15th and 16th centuries have been built a lot lower. In principle all inhabitants have access³ to current knowledge about the probability of flood events in these areas, which can cause inundation, destruction of homes and/or dune failure due to wave action. Often they have chosen for houses outside the protected zones because of the view, the proximity to waterways, cheaper building sites (along the Meuse) and/or the charm of a 15th or 16th century town (e.g. Dordrecht). After a generation the population tends to forget they are at risk. Also many new inhabitants to these areas are not always aware of the risk. The city of Dordrecht sends a letter each year to all the 15 000 people living outside of the protected area. However, only a few communities inform their population explicitly on the potential flood risk. In January 2011 at Dordrecht a street was flooded twice in one single week (this street has a return period for flooding of 10 years), a number of storm events coincided with a river flood, which is not unusual.

2 People living in these areas can rely on the current flood risk management policy, extra sand in front of the beaches ("Kustlijnzorg" along the coast) which reduces dune erosion, the storm surge barrier at Rotterdam closes if a 2.9 m above mean sea level is predicted at Dordrecht and a 3 m water level at Rotterdam to reduce flooding the Rhine-Meuse estuary.

3 The EU flood risk Directive requires publishing information about flood risk as well.



Figure 1: An overview of the flood prone parts of the Netherlands, [Plan Bureau voor de Leefomgeving, PBL, 2010]

Legend of figure 1:

Dark blue: below sea level 26% of the Netherlands

Light blue: flood prone and above sea level 29% of the Netherlands.

Yellow: Non protected areas 3% of the Netherlands (note some of these areas have been raised above the flood levels and average dike height)

Purple: Non protected areas and partially protected area's along the Meuse River, 1% of the Netherlands (current safety standards correspond to a return period of 50 years, in 2015 the safety standards will correspond to a return period of 250 years)

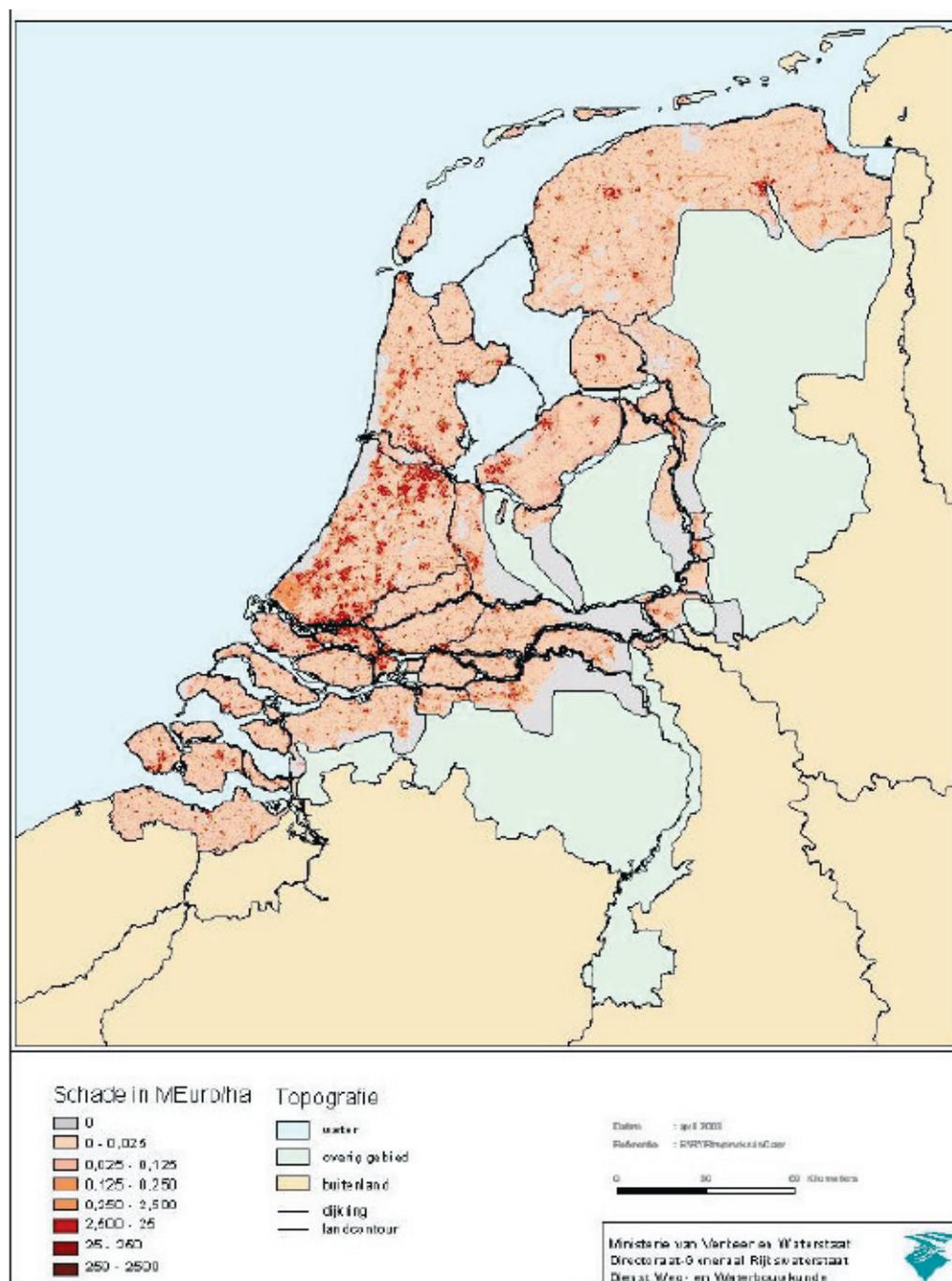


Figure 2: Maximum flood damages in billions of Euros, [Rijkswaterstaat 2003]. Note: Figure 59, shows a single flood scenario.

2.2 The influence of past disasters

The last flood in 1953 was caused by a storm surge. Flood Risk Policy changed significantly on account of this flood. Scientific methods were formally introduced. The Delta Committee, assigned to analyze the flood and find solutions for the future, developed a Cost-benefit-analysis [van Dantzig, 1956] and set new standards for dike reconstruction. The flood also changed the way prediction of floods was carried

out and the way flood alerts were communicated. Many techniques and methods existed before the year 1953; the flood provided the opportunity to formally introduce these as new policy tools.

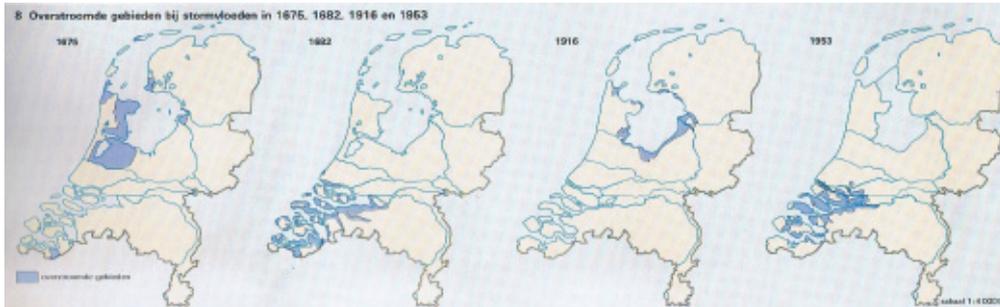


Figure 3: Four important and infamous storm surges for the Netherlands: 1675, 1682, 1916, and 1953.



Figure 4: Four important and infamous river floods in the Netherlands: 1820, 1876, 1871, 1926, [van der Ham, 2004]

The ice dam/ ice flow flood⁴ of 1871 has been enlarged; otherwise figures 3 and 4 (approximately) have the same scale.

2.2.1 Devastating storm surges

The storm surge of 1916 was the tipping point for the implementation of the “Zuiderzee” project prepared by Engineer Lely. The plan consisted of the construction of a 32 km long barrier dam and 5 polders of agricultural land⁵ of about 40 000 ha each. The dam reconnected the areas of Friesland and western Friesland which were separated in the storm surges of 1219 and 1287 see [Rijkswaterstaat, 2008a] and [Duin, R.H.A. van and Kaste, G. de, 1990]. This barrier dam is called the “Afsluitdijk”⁶. Engineer Lely prepared the plans for a private organization

4 The enlarged figure is about floods caused by ice dams in the “Land van Maas en Waal” and “de Bommelerwaard” in 1781. There are 4 ice dams. Each ice dam can cause multiple breaches [Van der Ham, 2004].

5 In 1980 the Netherlands decided not to build the last polder the Markerwaard because of ecological and environmental reasons. Amsterdam, Lelystad and Almere have started a number of housing projects in Lake Marken. The area IJburg in Amsterdam is partly finished.

6 <http://en.wikipedia.org/wiki/Afsluitdijk>

financed by the towns around the “Zuiderzee”. He was able to implement the plans as the minister of public works and water management. The project was finished in 1970 with the construction of the polder of Southern Flevoland. The Second World War and the flood in 1953 in the south-western Netherlands significantly delayed the project. People, building equipment and finances were needed elsewhere.

The 1953 storm surge was a flood with more than 2000 fatalities in Belgium, England and the Netherlands. 1853 people died in the Netherlands. Even though the Netherlands had not yet recuperated from the recession of the nineteen thirties and the Second World War and thus less funds were available for water management, many preventable errors were made.



Figure 5: A dike breach in Zeeland in 1953, source: SVSD, Jan Kroos 2010

The large number of fatalities was caused by a number of reasons:

- Flood warnings were not understood or not received
- Responsibilities in flood risk management were not clear
- Maintenance of flood defenses was poor
- Funding for major and minor repairs was insufficient due to an insufficient tax base, organizations were too small.

The 1953 flood was the main reason for the Delta Works⁷, prepared by the Delta Commission. The first storm surge barrier was constructed in 1958 in the river “Hollandse IJssel” near the city of Rotterdam. The Delta plan was finished in 1986 with the construction of the Eastern Scheldt Storm surge barrier. Note: In 1997 a new storm surge barrier, the “Maeslant” barrier was built near Rotterdam closing off the last of the Rhine Branches to the sea. The Western Scheldt remains open since the access to the port of Antwerp depends on this water way⁸.

7 http://en.wikipedia.org/wiki/Delta_Works

8 When the Southern and Northern Netherlands were legally separated in 1839, the Southern Netherlands (Belgium) received the right of “corridors” to the Rhine, the North Sea and Germany <https://zoek.officielebekendmakingen.nl/trb-2008-190.html>



Figure 6: The delta plan consisted of 4 main barriers and 6 secondary barriers in the Rhine, Meuse and Scheldt Estuaries.

2.2.2

Devastating river floods

Between 1800 and 1900 the fluvial areas in the Netherlands were often flooded. Ice dams in thawing rivers were the main cause of flooding. Ice dams impeded the flow of the river, this caused the dikes to be overtopped and breached. The number of ice dams diminished significantly since regulation works in the Rhine and Meuse rivers for shipping and the construction of power plants in Germany and the Netherlands. The power plants heat up the river, significantly. Since many power plants are being relocated to coastal areas, due to the increased number of low discharges in summer the reoccurrence of ice dams should not be ruled out.



Figure 7: An impression of a flood caused by an ice dam, which happens when a frozen river thaws and ice flows create dams. The ice dam itself, further downstream, is not visible.

The 1926 flood was the last large river flood, see figure 8. After the flood most dikes were raised and reinforced. Dikes were both breached in the Netherlands and Germany.

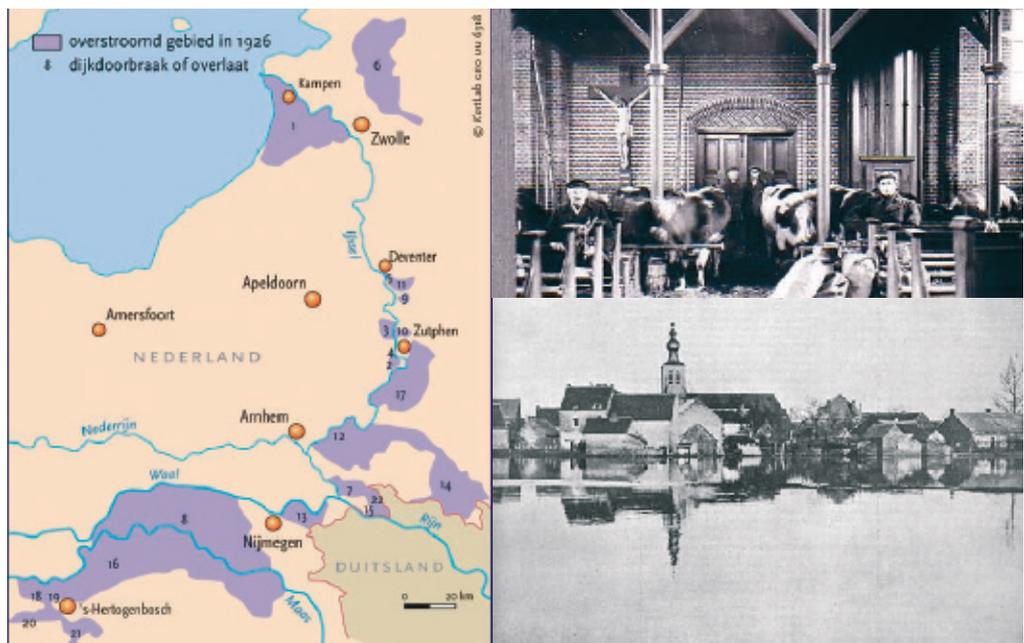


Figure 8: The area flooded in 1926, cows in the church at Kekerdom [Roth et al, 2006]

Along the Meuse River in Gelderland and Brabant the height of the dikes is often still the height after the 1926 reinforcements. The Delta Plan Large Rivers (DGR) project of 1996 to 2001 mainly increased the width of the dikes.

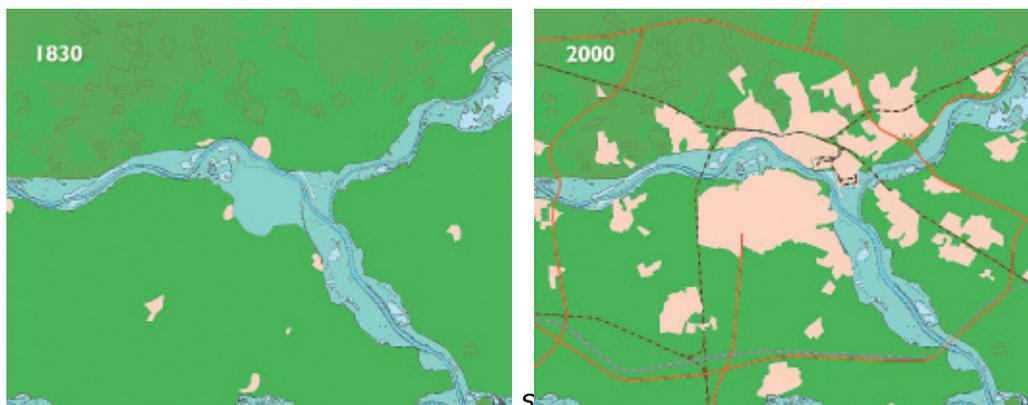


Figure 9: Reduction of the area of the flood plain at Arnhem between 1830 and 2000. More space was available to the river Rhine in 1926 than in 1995

In 1993 and 1995 the Meuse valley flooded, see figure 10. No dikes failed along the Rhine or Meuse rivers. 250 000 people were evacuated in 1995 along the Rhine branches "Nederrijn" and "Waal", between Arnhem en Nijmegen, when the inner part of dike at Ochten, near Nijmegen failed due to saturation. The city centers of Nijmegen and Arnhem were not evacuated since they both lie on a glacial pressure ridge.



Figure 10: The approximate size of the Meuse flood plain in 1995

Figure 10 shows the Meuse valley and the un-protected flood plain, which was flooded in 1993 and 1995. Compared to 1926 and 1953 a relative small part of the Netherlands was flooded. In total in 1993 about 170 km² of flood plain were inundated. Damages in 1993 along the Meuse River exceeded 100 million Euros,

about 8000 people were affected. Despite higher water levels in 1995 the damages were lower along the Meuse than in 1993, since people were prepared. Total damages in 1995 (400 million Euros) were higher due to the evacuation cost [Kolen, B. et al 2012].

2.3 “Multi-layer safety” for Flood Risk Management

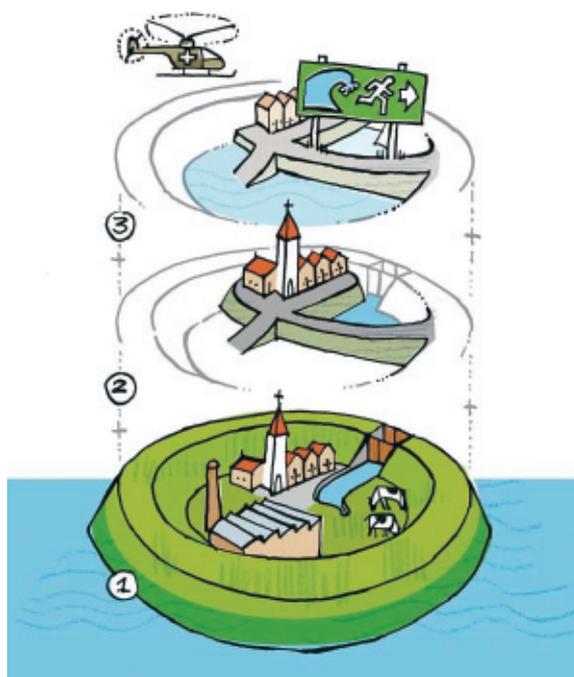


Figure 11: “Multi-layer safety concept” for Flood Risk Management

For the analysis of flood risk management measures it is useful to use the “Multi-layer safety concept”. Flood risk management can be separated into three layers: (see figure 11):

- (3) Flood alerts, evacuation, response and recovery (civil protection issues) most of these issues are organizational, some issues like identifying, checking, repairing/restoring and signaling evacuation routes are physical measures.
- (2) Spatial planning issues, reducing the impact of flooding through spatial planning measures, not building in flood prone unprotected areas, or through building codes (adapting houses to regular flooding, raised houses or floating houses)
- (1) flood protection, Flood defenses to reduce the probability of failure of flood defenses

Since 1953 the Netherlands have privileged flood protection. This choice has found its way in legal standards for flood defenses. A number of publications illustrate / confirm why this choice has been made, the annual risk assessment of 2008 [BZK, 2008a], [Kok, 2005], and [Jongejan R.B., S.N. Jonkman, J.K. Vrijling].

2.4 Flood forecasting and flood alerts

After the 1953 flood the way flood alert systems were made public was overhauled. A system with a paid distribution and telegrams was changed into a public system, with clearer messages, phone calls and telegrams to confirm the message. Since 1980 the telegrams were replaced by phone-calls. Confirmations and detailed information for some services (e.g. WDIJ page 25) were sent by faxes and later on by emails.

The Delta works in the Scheldt region and the increase of the shipping to the Rotterdam Harbor were the reason to set up regional Hydro-Meteo centers and putting meteorologists and "tidal hydrologists" from different organizations in one building. The national warning service SVSD is still separated from the Hydro-Meteo centers and is responsible for publication and communication of the actual storm surge alerts.

Storm surges and river floods can be forecast a number of days ahead, for other more rapid meteorological phenomena other services are provided. "Seiche" warnings by the Hydro-Meteo centers are computer generated and sent by email to water boards (regional water authorities) and Rijkswaterstaat in coastal areas. "Seiches" are long waves (about 20 minutes), caused by meteorological phenomena like troughs, cold front passages or convection cells [de Jong, 2004]. Warnings for high precipitation events are sent to water boards (regional water authorities) by the meteorological service KNMI.

Storm surge Flood and River Flood Warning Services,

The Water Management Centre of Rijkswaterstaat in Lelystad is responsible for sending out the storm surge and flood warnings and matching the different input from the regional centers.

The North Sea

- "SVSD", storm surge warnings service since 1921
 - Storm surge warnings consist of predicted maximum water levels and a general description of the expected wind and tide and the moment of the expected maxima. Also the 10 minute water level-forecasts are computed and distributed.
 - Since 2012 wave action is also forecasted in an experimental setup. In the long term this is to facilitate the forecasting:
 - Of dune erosion on account of water levels and waves.
 - Of wave run-up and wave overtopping for dikes.

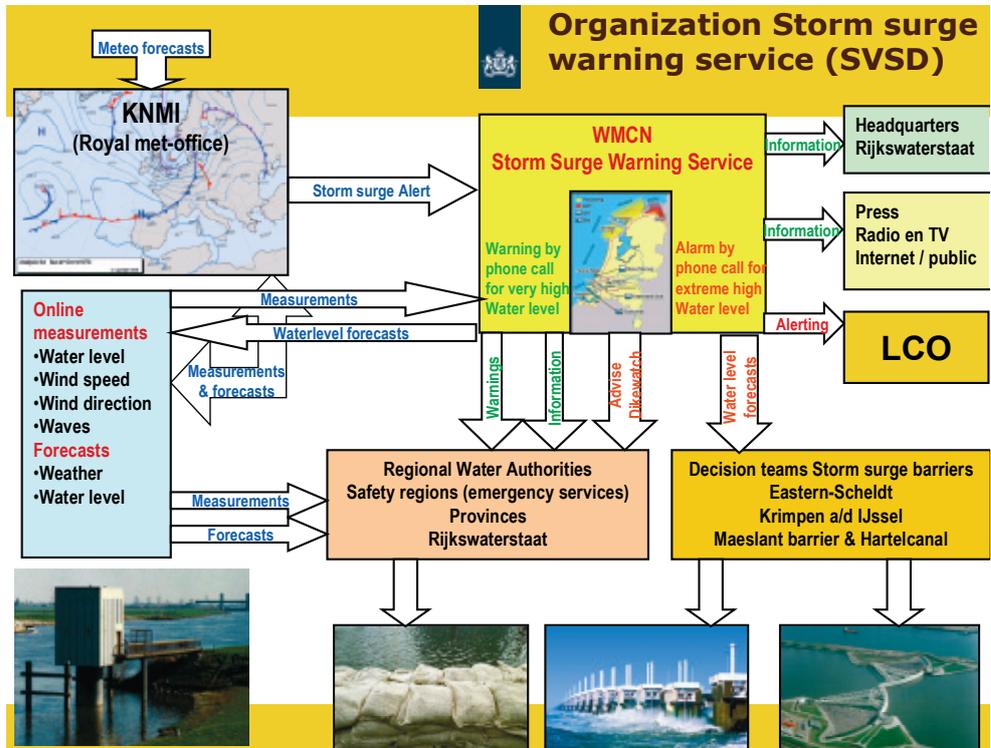


Figure 12: Organization of the Storm Surge Warning Service, SVSD, Jan Kroos, 2012

The Rivers, Rhine, Meuse and Vecht flood warning services

- "Hoogwatergroep",

- The flood warning at the Dutch borders for the Rhine River (at Lobith) and for the Meuse River (at Borgharen and recently Sint Pieter)

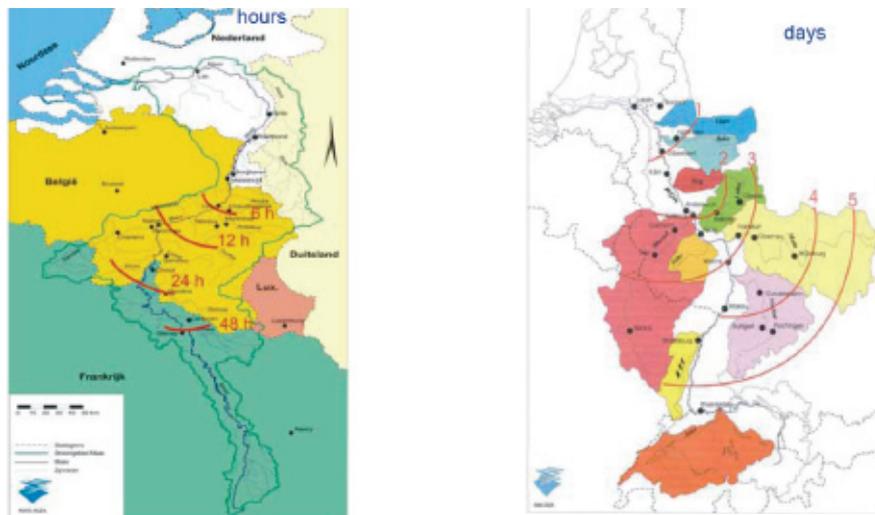


Figure 13: Lead time for the Meuse and Rhine Rivers at Borgharen and Lobith, [Sprokkereef, 2010]



Figure 14a: The names of the Dutch water systems (in Dutch).

- Regional Centers for river branches at Maastricht, Arnhem and Rotterdam:
 - Maastricht: for the Meuse River, the predicted maximum water levels and the moment of the maximum water levels
 - Arnhem: for the Rhine River and the three Rhine branches (“Waal”, “IJssel”, “Nederrijn/Lek”) the predicted maximum water levels and the moment of the maximum water levels
 - Rotterdam: Flood warnings and storm surge warnings combined for the Rhine-Meuse Estuary. The predicted maximum water levels and the moment of the maximum water levels

- A river flood warning service for the “Vecht” (see figure 14). This service is currently provided by the regional centre at Arnhem. In the future it will be provided by a common service, which is being developed with the water boards (regional water authorities) and Rijkswaterstaat. Since the river originates in Germany, the Germans are also involved in the development of the new flood-forecasting model.



Figure 14b: The IJssel and Vecht river delta; the Vecht is the eastern river, the IJssel the western river, Lakes Zwarte and Ketel "Zwarte Meer" and "Ketelmeer" are parts of the Lake IJssel water system

Marken and IJssel and the delta's of the IJssel and Vecht

- The "WDIJ" provides a number of services since 1985⁹
- A storm-surge warning for the lakes Marken and IJssel, and the smaller lakes Gooi/Eem Lake, Ketel Lake, Zwarte Lake. The service provides general information on the storm, predicted water levels at each dike section, wave run-up height and wave overtopping volumes.
- Flood warnings and storm surge warnings combined for the "IJssel" and "Vecht" estuaries. The service provides general information on the storm and provides predicted water levels at each dike section.

The following actions (figure 15 to figure 22) are carried out to make a flood alert¹⁰ for the WDIJ:

9 A large number of dikes in 1985 did not meet the standards. After major repairs DGR (from 2001 to 2005) and HWBP I (from 2001 to 2005) the flood warning service was continued at the request of the water boards.

10 The dispatch which is sent to the waterboards is not included in the figures.



Figure 15: Meteorological measurements are collected on a planetary scale at automated metrological stations: An example of local measurements, local wind speeds, source "KNMI"

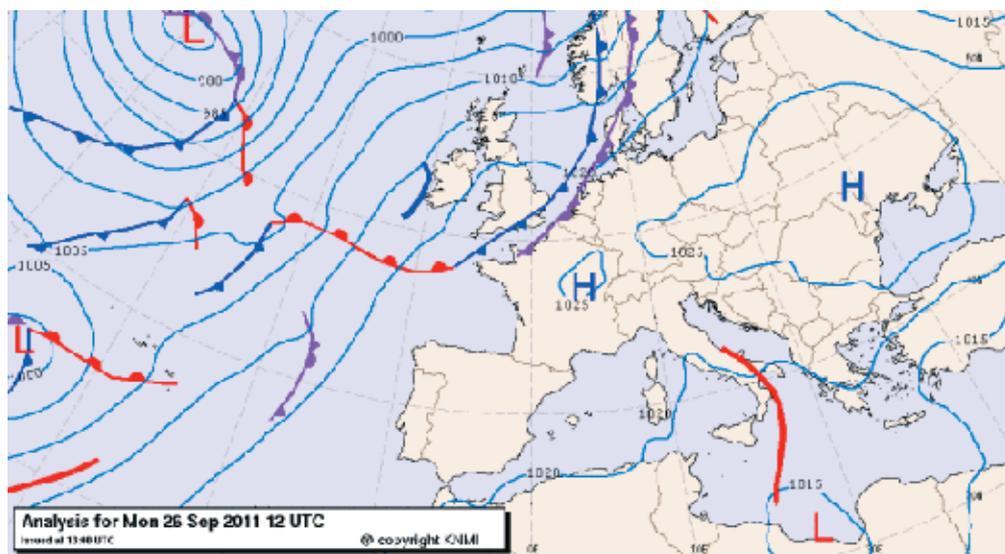


Figure 16: At Reading in England the global meteorological situation is calculated, information for Europe is provided to the Dutch Meteorological Institute "KNMI"

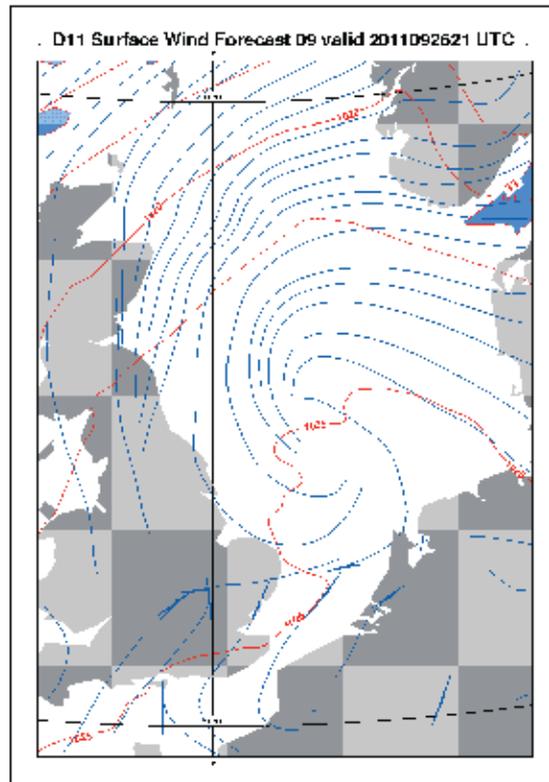


Figure 17: Meteorological Forecast for the North Seas, source KNMI" HIRLAM (high resolution limited area model) 50kmx50km

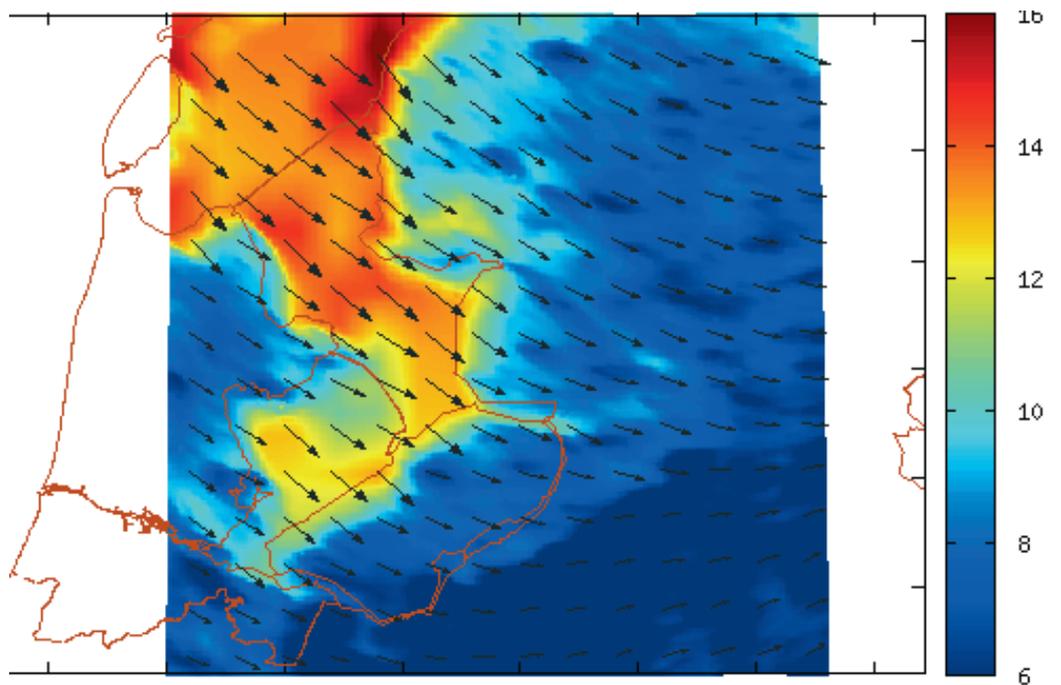


Figure 18: Wind forecast for the lake IJssel area, KNMI, HARMONIE MODEL, 2.5 x 2.5 km (Hirlam Aladin Regional Meso-scale Operational NWP in Europe)

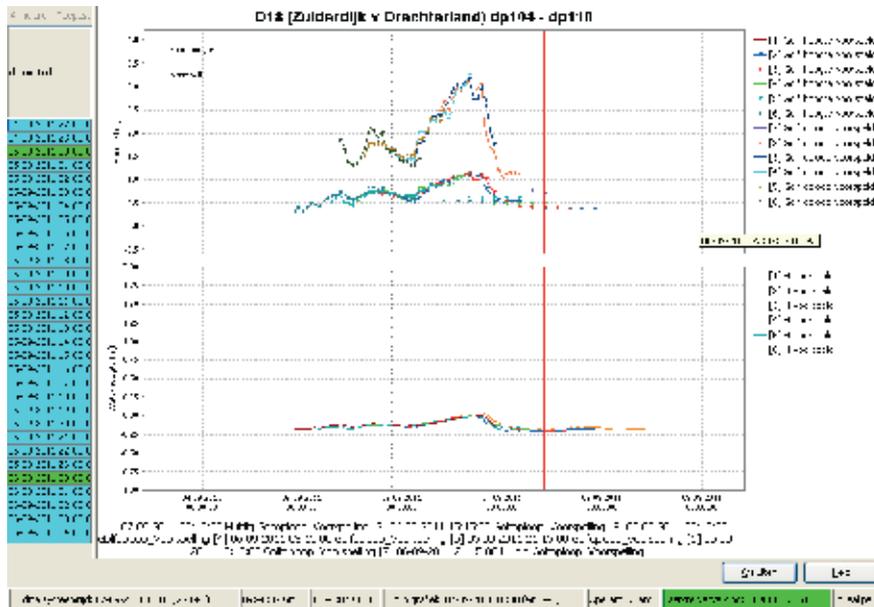


Figure 21: Prediction of water levels and wave run up on the dike, WDIJ, System FEWS (Flood Early Warning System), Deltares. The horizontal red dotted lines are the alarm level and crest level.

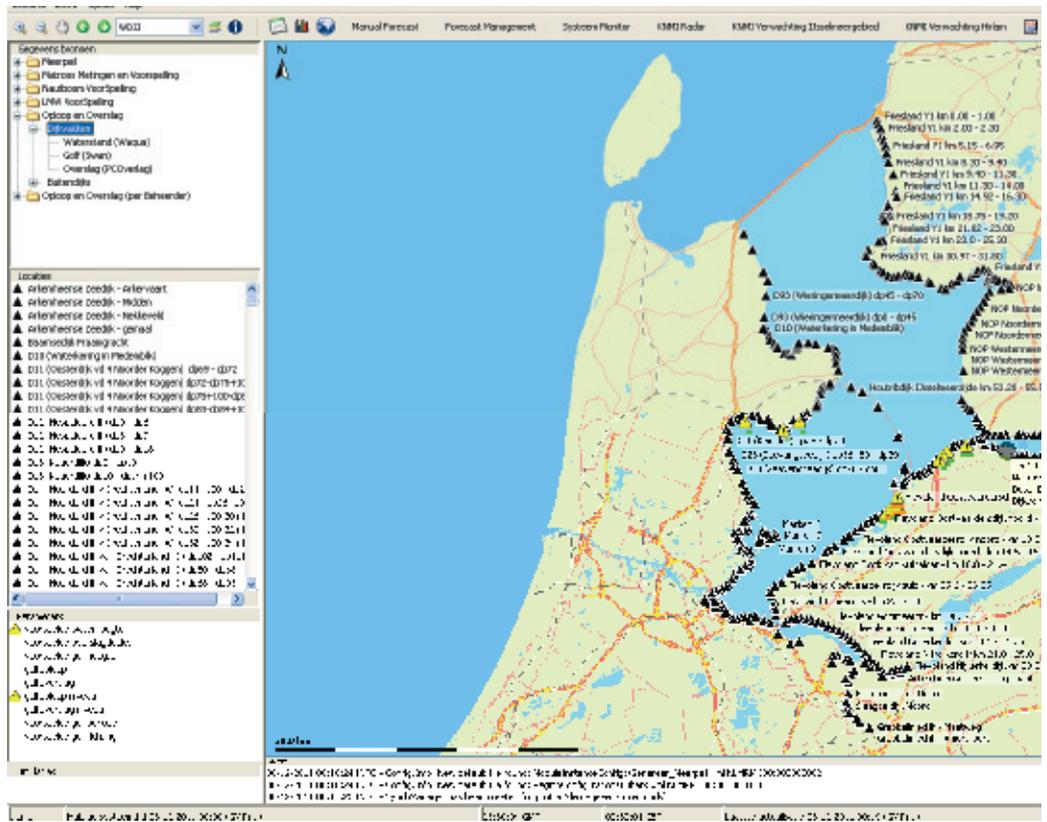


Figure 22: Overview of flood warnings, an example, December 2011, WDIJ FEWS, (Flood Early Warning System, Deltares)

2.5 Crisis Management and Disaster Relief

In the last decade of the 20th century the Netherlands were confronted with a few large incidents which influenced crisis management and disaster relief, response and recovery:

- An El Al airliner crashed into an apartment building in Amsterdam in 1992.
- The evacuation of 250 000 people in 1995 on account of saturated dikes (see paragraph 2.2).
- Water logging in 1998 in "Delfland" (the region in between the Hague and Rotterdam), North Eastern Flevoland and the province of Groningen, due to excessive rainfall
- A fire works factory exploded in "Enschede" in 2000
- A flash fire in a discothèque at "Volendam" in 2000 due to the abundance of non fire-proofed Christmas decorations.

These incidents had legislative consequences: a law on major accidents and catastrophes "Wet Rampen en Zware Ongevallen" and a law merging the emergency services into 25 territorial units "Wet op de veiligheids regio's", Safety Regions Act.

The El Al Boeing 747 crash into an apartment building caused more than 43 deaths, including 4 crewmembers and 26 wounded. The exact number of casualties could not be determined because of unregistered immigrants.

The Enschede explosion caused 23 deaths (including 4 fire men) and 950 wounded; it destroyed 42 hectares of houses and businesses. Firemen assisted from a 100 km radius in the Netherlands and Germany.

The Volendam fire caused 14 deaths, 241 wounded out of which 200 people were severely burned. Many of the casualties were teenagers¹¹. The incident overwhelmed the health capacity in the Netherlands for treating the severely burned victims. Patients had to be evacuated to Belgium because the specialized hospitals in the Netherlands lacked capacity.



Figure 23: Apartment building after being hit by a Boeing 747 Amsterdam "Bijlmer", October 4th, 1992.

¹¹ The young teenagers should not have been in a discothèque due to their age. That however is another societal problem, not covered in this document.

The role of the mayors responsible for the safety regions, the territorial units of emergency services and public health services, was redefined as well as the role of the safety regions themselves. Professionals now provide the coordination; many of the professionals are volunteers¹². The coordination by provincial authorities was replaced by national coordination. This responsibility is provided at the national level by the Coordinator for Counterterrorism and Security of the Ministry of Security and Justice. The Coordinator has an executive mandate and is in direct contact with the prime minister and other relevant ministers.

In 2007, France and Switzerland set up a European group, which elaborated a handbook on flood risk mapping "Excimap". The European commission has recommended the use of the "Handbook on good practices for flood mapping in Europe".

The Netherlands asked the "Excimap" participants to contribute to the: "Atlas of Flood Maps, Examples from 19 European Countries, USA and Japan"

In 2009 the European commission issued a guideline (non binding) on a common method to determine risk and for risk mapping (see weblinks, page 101). The risk maps, both for flooding and for other risks, are available on a website www.risicokaart.nl. This website is maintained by the provincial governments. Both professionals and the public have access to the website. However professionals from the Crisis Management and Emergency Services have access to additional information and at a more detailed level.

2.5.1 *Disaster Warning to the population by the emergency services*

Air raid sirens are used to alert the population. The local radio and television networks inform the inhabitants. The local radio and television networks are provided an annual fee for this service. The Ministry of Security and Justice regularly informs the public in public information campaigns on different risks. The web site www.crisis.nl informs the public during and before a crisis.



Figure 24: Air raid siren, used to warn the population in case of a disaster.

12 Note volunteer firemen receive the same arduous training as full time professionals.

Using the cell broadcasting system "NL Alert" all mobile phones in a specific geographic area can be reached. From 2012 onwards every mobile phone user can receive an NL alert, www.NLalert.nl, source [Ministry of Security and Justice, 2011]. The mobile phone user will have to change the settings of his phone to receive these messages. Three pilot areas will receive the system in 2012.

2.5.2

"Safety Region" regroup municipal emergency services

Twenty-five "safety regions", territorial emergency units regroup the municipal emergency services and the public health authorities.

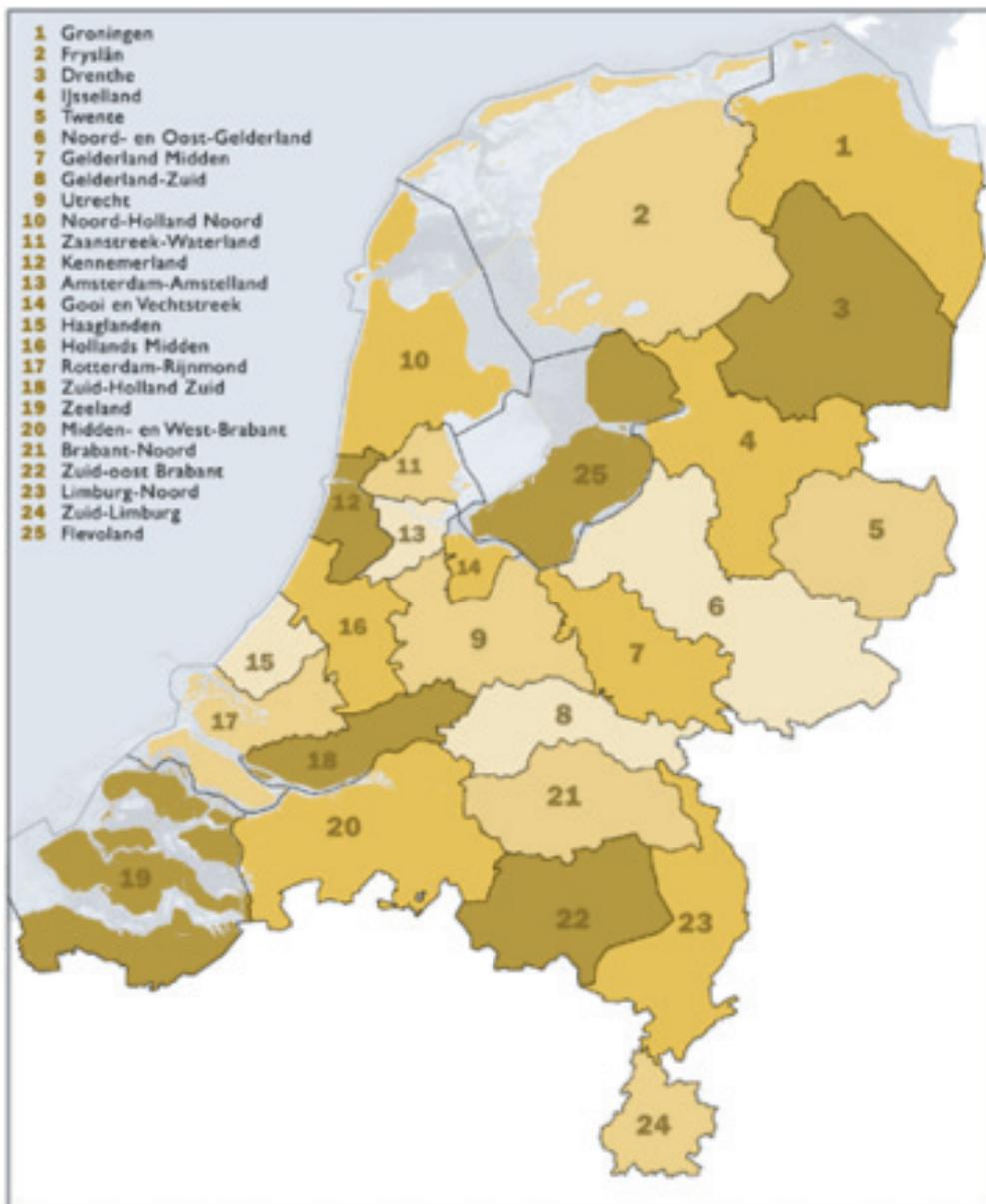


Figure 25: The "safety regions", these overlap with the 25 police regions

The mayor of the largest town or city is the president of the safety region; the mayor is also the head of the police region. The geographical boundaries of the "safety regions" are based on the borders of the existing 25 police regions. This "safety region" regroups the emergency services (fire and rescue brigades, ambulances and police services) and the public health authorities.

Each safety region has liaison officers for communication with:

- Rijkswaterstaat (for the highways, major water ways and the large navigation channels)
- The water boards (regional water authorities) for the dikes and minor water ways
- The army (often a reserve officer).

2.5.3

Escalating/devolving responsibilities during a crisis

How the different safety regions interact with other authorities during a crisis is described in [Province of North Holland et al, 2012]. This description of roles and responsibilities has been made for large incidents and disasters in the Netherlands. The analyses of a disaster type is always prepared by a specific sector, the "functional chain", in the case of this report the national and regional water authorities which are responsible for flood risk management. The "functional chain" is responsible for the flow of information to other authorities. Information to the public always passes through the local authorities responsible for public safety (the mayor) or the national authorities responsible for public safety (Minister of Security and Justice).

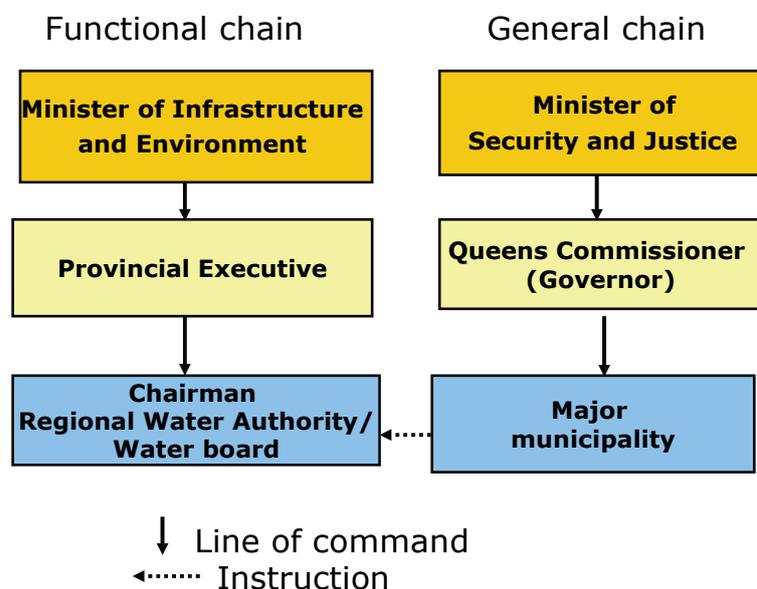


Table 1: Line of command during a storm surge or river flood [BZK, 2007]

If a disaster or crisis happens in only in one municipality, the local mayor is responsible. If a disaster extends to more than one municipality, the coordinating mayor of the territorial safety region is immediately also responsible, with decisive powers. Since the safety region and police region overlap, this coordinating mayor is

also the head of the police region. Only when the five national interests¹³ are threatened the Ministry of Safety and Justice steps in to coordinate. The provincial governors can help the minister in this task as his or her eyes on the ground. "On site" the operational commanders of the fire- and rescue brigades remain in charge.

Extra units of emergency services to assist can be provided by the safety region, other safety regions, and the army or EU member states. The LOCC, National Organization for Crisis Coordination, on a national level is the linking pin for coordinating operational capacity and advises the government in case of conflicting demands for operational capacity.

In extreme situations the Dutch Cabinet can install temporary laws on account of a disaster, deliver the order to evacuate or commandeer housing, equipment or personnel.

2.5.4 *Monitoring and dike inspection during floods and storm surges*

The roles, responsibilities and operating procedures for flood control are described in [Ministry of Transport, Public Works and Water management, 2010].

During floods and storm surges, professionals often aided by trained volunteers monitor all flood defenses permanently. The number of volunteers is usually very high when temporary flood defenses have to be built up. Temporary flood defenses are common where roads and railroads cross flood-defenses or are built up on boulevards along rivers. The temporary flood defenses are tested each year. Depending on the flood forecast temporary flood defenses can also be built up for dikes which have not passed the yearly visual inspections or the 5 yearly dike assessments. Each water board has prepared for these scenarios.



Figure 26: 1995 along the Rhine

¹³ The five national interests are: Physical Security, Economical Security, Environmental Security, Social and Political Security and Territorial Security.

3 Institutions and instruments

3.1 Institutions

As in most European countries different ministries cover flood management issues. In the Netherlands the Ministry of Infrastructure and Environment is responsible for spatial planning and flood protection. How waterways, lakes and the Sea are managed is also their responsibility. The Ministry of Security and Justice is responsible for emergency services and civil protection issues. The Ministry of Security and Justice is responsible for the annual national risk assessment.

There are four levels of government, the European and national state level, and two lower levels, which consist of 12 Provinces and about 400 municipalities.

The 12 provinces are responsible for spatial planning and they determine which areas will be nature, urban or industrial. They have a role in flood protection e.g. setting the standards for secondary dike systems and construction permits for large infrastructure projects like dikes. This will be covered in this chapter. They are also responsible for transport; this means provincial roads and waterways, public transport in the province not covered by the municipalities and the national railway.

The provinces have an elected council, a board chosen by the council members and a nominated "president" a state commissioner.

The 400 municipalities are responsible through the Spatial Planning Act for local spatial planning, land use plan, "Bestemmingsplan", and building permits. The municipalities have an elected council, a board chosen by the council members and a nominated¹⁴ "president", a mayor.

On the same level, at par with the municipalities are 25 water boards, regional water authorities. Their sole purpose is water management and flood protection. They are responsible for the quality of surface water in all minor waterways and therefore also for sewage treatment.

The Regional Water Authorities have an elected council, a board chosen by the council members and a nominated¹⁵ "president", the "Dijkgraaf".

For disaster management, the emergency services and public health authorities have been regrouped into 25 "safety regions". The mayor of the most important municipality and head of the police region¹⁶ is the "president" of this safety region.

The National Coordination Council (NCC), of the Ministry of Security and Justice is responsible for the national coordination in case of a disaster. Each Ministry has its own Departmental Crisis Coordination Centre (DCC). Logistical support and

¹⁴ The council proposes a candidate who is nominated by the National Government.

¹⁵ The council proposes a candidate who is nominated by the National Government. This function and a noble title, a count, have existed for more than 800 years.

¹⁶ The size and number of police regions may change in the near future. Legislation introducing a national police force is being prepared.

coordination is provided by the LOCC, National Organization for Crisis Coordination. Liaison officers of the Emergency Services and of the Army are based permanently at the LOCC.

Rijkswaterstaat, an Agency responsible for Public works, Transport and Water Management is the National Water Authority. Rijkswaterstaat was founded in 1798 to cope with repetitive and devastating fluvial flooding. Rijkswaterstaat is responsible for the North Sea, the large lakes, Estuaries, the major rivers and navigation channels.

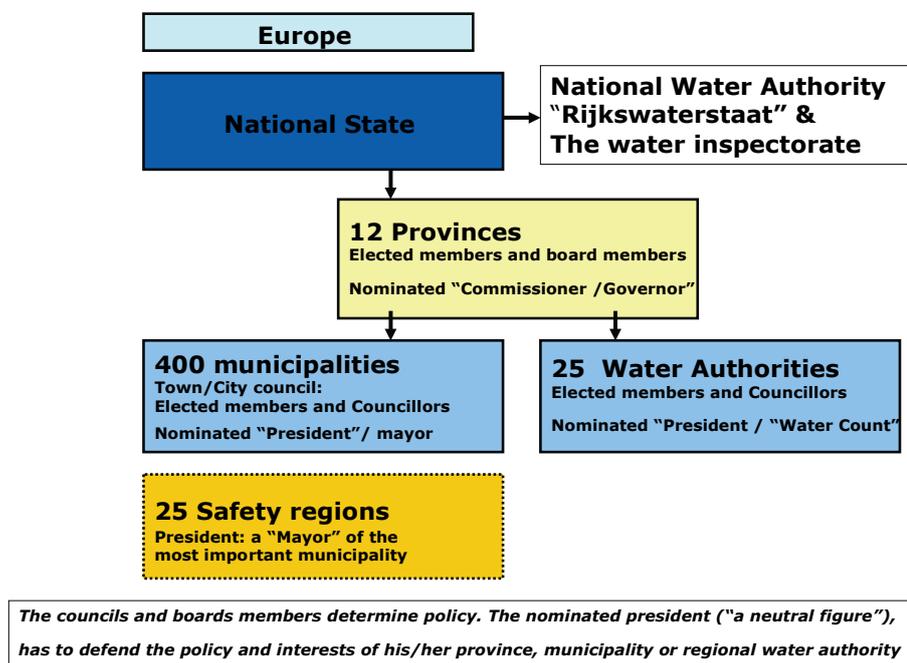


Table 2: Current organizations in the Netherlands

From 2001 on, policy, inspection and management were separated within state organizations. The water inspection, a part of the Ministry of Infrastructure and Environment is responsible for controls in the whole water sector, water management, water quality, and flood protection.

Experts from universities, research institutes and the private sector advise the Ministry of Infrastructure and Environment on flood protection issues. This technical committee, the "Expertise Netwerk Water"¹⁷ reviews all changes in policy or in technical manuals.

17 <http://www.enwinfo.nl/asp/uk.asp?documentID=110> All technical manuals are available in English. Rules and regulations are available in English on the governmental website. <http://www.helpdeskwater.nl/algemene-onderdelen/serviceblok/english/>

	Prevention	Protection	Preparation	Response	Recovery
Legislation	Spatial Planning Act (SPA)	Water Act (WA)	Safety Regions Act (SRA)		
	Provinces Act Municipalities Act	Water Boards (regional water authorities) Act	Municipalities Act "Gemeente Wet"		Disaster Compensation Act "WTS"
Administrative level	Ministry of Infrastructure and Environment		Ministry of Security and Justice		
State	National Water Plan accent on protection (WA), also zoning (SPA)				
	National Spatial Strategy (SPA)				
		National Flood protection program (WA)			
			National floods crisis plan and large-scale evacuations (SRA)		
Provinces	Provincial Water Plan (WA), zoning (urban, nature, industry, agriculture) (SPA)				
Water Boards (regional water authorities)	Water Management Plan (WA)		Flood Disaster Management Plan (WA)		
Safety regions			Crisis Coordination Plan (SRA), Disaster Management plan (SRA)		
Municipalities	Land use plan (SPA)				

Table 3: Flood risk management instruments in the Netherlands, regrouped according to administrative levels and policy fields [Alphen, J. et al, 2011]

The different policy tools for flood risk management (in table 3) for each administrative level are covered in more detail in paragraph 2.5, chapter 5 (Spatial planning), chapter 6 (European Floods Directive) and chapter 7 (Disaster Management, "Preparation").

The Provinces Act, Municipalities Act and Water Boards (regional water authorities) Act cover the responsibilities of each organization, financing and electoral issues. These acts will not be covered in detail in this document.

3.2 Flood Risk policy is based on Flood Risk Assessment of 1953-1960

After the 1953 flood scientific methods received a formal place in flood protection issues. The "Zuiderzee" project started after the 1916 floods is an example that scientific methods were widely accepted by the engineers, technicians and scientists, designing and building at that time. E.g. Physicist and Nobel prize winner Lorentz provided a mathematical model for tidal calculations. From 1960 onwards, scientific analysis was formally used to inform policy. This was a major change.

The Delta Commission, "Deltacommissie", a committee made up of scientists and politicians was instrumental to this policy change. The policy of rebuilding dikes about half meter (to 1 meter) higher than the last observed flood levels was abandoned¹⁸. Formal safety standards were introduced after a risk analysis. This process of formal safety standards on a national scale was finalized in 1996 with the Act on Flood Defenses [see MNP, 2004]

The Delta Commission determined the levels of acceptable risk. A Cost-benefit-analysis [van Dantzig, 1956] was carried out for dike ring 14 (see figure 27a). A dike ring is an enclosed (see figure 28) continuous line of flood defenses composed of dikes, dunes, structures and high ground. Major parts of Rotterdam, The Hague and Amsterdam and minor parts of Utrecht lie in dike ring 14; this agglomeration of cities is called the "Randstad". Flood risk with a return period of 100 000 years was considered to be acceptable for this area. For political and practical reasons this was linked to a return period for design water levels of 10 000 years. Please note the units differ. For less populated areas of the Northern and South Western Coast lower return periods for design water levels were considered to be acceptable (4000 years). On average dike heights along the estuaries of the Scheldt, Rhine and Meuse were raised by a number of meters, especially where no storm surge barriers or dams were built (e.g. the Western Scheldt).

For the areas along major rivers other state commissions "Committees Becht and Boertien" determined acceptable safety standards. A return period of 1250 years for design water levels was considered acceptable along rivers and 2000 years for estuaries protected by storm surge barriers or dams against the sea.

The 150 kilometers of new dikes built along the river Meuse in the years 1995 and 1996 received a safety level corresponding to a return period of 50 years for design water levels in 1996 which was to be raised to 250 years through river enlargement works. About 20 000 people live behind approximately 40 small dike rings along the Meuse River.

18 http://www.dbnl.org/tekst/vier004trac01_01/ Dike construction manual from around 1600, reprint in 1920. Andries Vierlingh 1507 - 1578 (estimation)

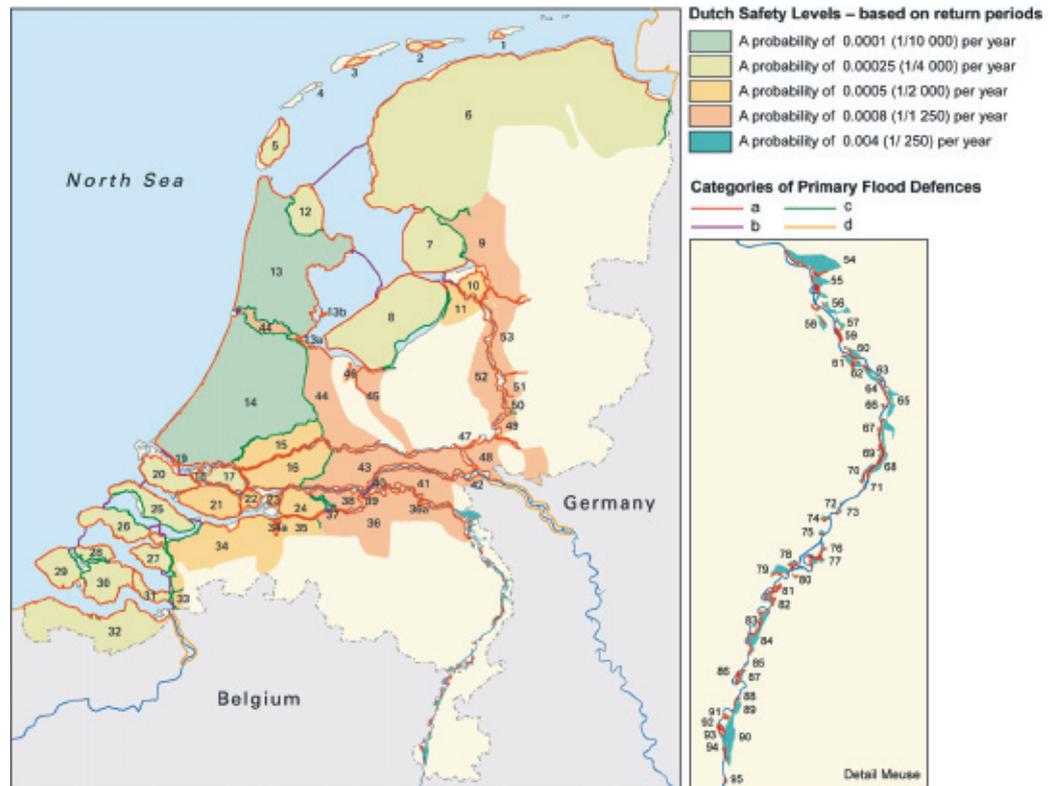


Figure 27a: Flood protection standards for primary flood defenses, Flood Defense Act “Wet op de waterkering 1996”, Figure 27b: Flood protection standards for primary flood defenses along the Meuse River in the provinces of Limburg and the North of Brabant, “Water Act”, “Waterwet, 2009”.

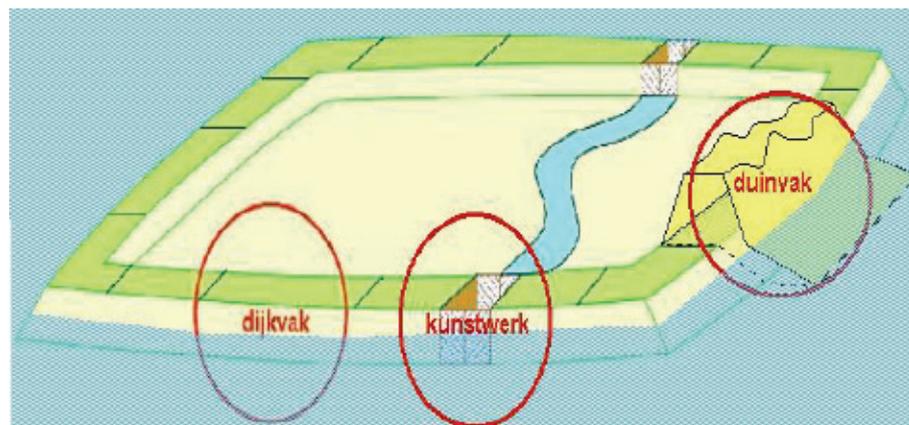


Figure 28: An enclosed continuous line of flood defenses composed of dike sections “dijkvak”, dune sections “duinvak”, structures “kunstwerk”, and high ground (not shown).

The minimum level of the probability of failure for the exceedance of design water levels in figure 27a is set between 0.01% (a return period of 10 000 years) and 0.08% per annum (a return period of 1 250 years). The minimum level of the probability of failure in figure 27b is set at 0.4% per annum (a return period of 250 years).

Please note: the 95 flood protection zones (figure 27a and 27b) are protected by an enclosed (see figure 28) continuous line of flood defenses composed of dikes, dunes, structures and high ground. Preferably there is only one organization responsible for the management of each "Dike Ring", the regional Water Authority¹⁹. After 50 years of mergers of Water Boards, only three dike rings have more than one organization responsible: number 6 (Friesland and Groningen), number 14 (the South of Holland) and number 44 (along the Amsterdam Rhine Canal and the North Sea Canal).

There are four categories of primary flood defenses.

- a. Primary flood defenses protecting dike rings along rivers, lakes and the sea, which are a major hazard
- b. Barrier dams and additional infrastructure, these are continuous lines of flood defenses connecting dike rings.
- c. Primary flood defenses protecting dike rings along rivers, canals lakes which are a minor hazard or dikes separating two area's with different safety standards (e.g. 1250 and 2000 years as return periods)
- d. Primary flood defenses partially protecting Dutch dike rings but which lie in Belgium or Germany and which are formally outside of Dutch control.

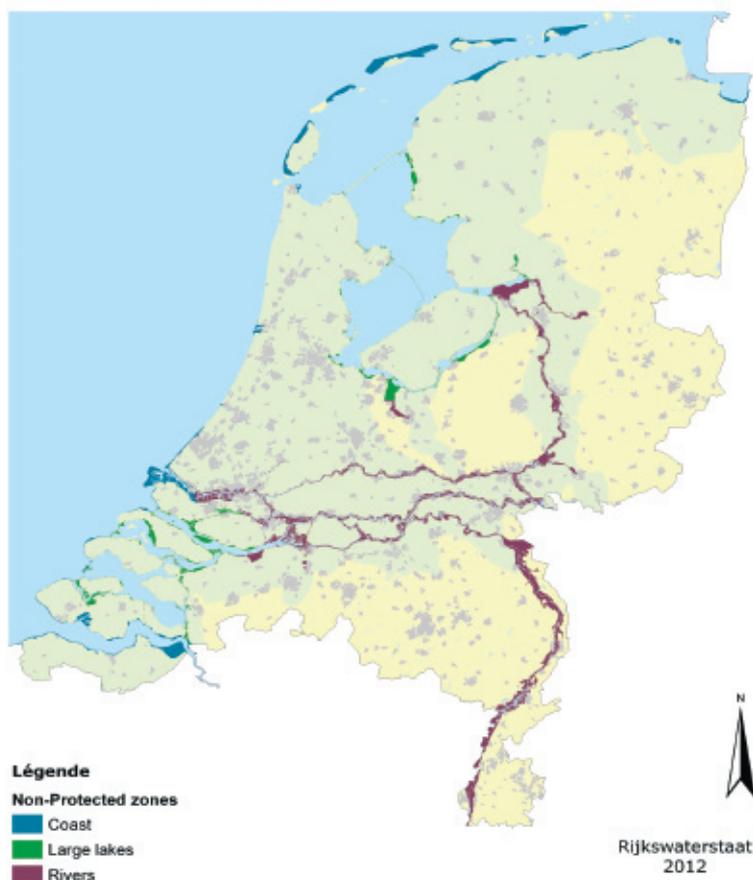


Figure 29: Areas without formal safety standards against floods.

19 Please note: the inverse is no problem, one water board can manage more than one dike ring.

Please Note: Urban and industrial zones are often built on artificially raised mounds. If these areas have been built recently they are often higher than the surrounding dikes or higher than the 1 in 10 000 year flood level (Port of Rotterdam). In towns which date back to the 15th or 16th century like Dordrecht large parts of city are built at lower levels. These areas are more at risk.

3.3 Regular Dike assessments and reports to Parliament

In 1993 and 1995 both the Rhine and Meuse rivers had very large discharges, with return periods of in between 50 years and 100 years. The Meuse valley, without real flood protection, filled up and the river flooded a number of towns and villages. About 8 000 people were affected along the Meuse River. In 1995 the discharges were even higher. At "Ochten" near Nijmegen the dikes were saturated. This caused a preventive evacuation of 250 000 people. The polders in between the cities of Arnhem, Nijmegen in the East and Gorinchem in the West were evacuated.

This situation made it easy for the government to pass the Act on Flood Defenses²⁰. This law set formal Flood protection standards for the whole of the Netherlands. Every 5 years all flood defenses had to be assessed. The Ministry of Infrastructure and Environment has to provide Hydraulic Boundary Conditions (up to date, information on water levels and waves, including observed climate change), a set of formal up to date flood defense assessment rules, "VTV" to assess all flood defenses. All 3600 km (see figure 27a) of primary dams, dikes, dunes and structures have to be assessed by the water boards (regional water authorities) and Rijkswaterstaat. The provinces²¹ are responsible for the inspection of the assessment process. Since 2005 the Water Inspectorate reassembles the provincial reports into a national report for Parliament. Parliament formally receives the report and votes on a budget for major reconstruction works²².

The assessment rules are given in "Het Voorschrift Toetsen op Veiligheid" and the Hydraulic Boundary Conditions in "Het Randvoorwaardenboek". Both books are accompanied by a number of computer programs²³.

20 The Flood Defense Act had been in preparation for about 10 years.

21 From 2012 onwards the provinces will no longer have a role in the assessment of the primary flood defenses (of figure 27a).

22 From 2012 onward the Regional Water Authorities (the Water Boards) will finance 50% of reconstruction works. A new law is being prepared (see chapter 4.5)

23 All manuals and computer programs are available on: <http://www.helpdeskwater.nl/>. Note Hydra-B, for dike height assessment in the Rhine and Meuse Estuaries has English Language features and an English language manual. The other books VTV and HR are not translated into English, since they have limited (5 or 6 year) validity. They are also too specific and tailor-made for the Netherlands for translation.

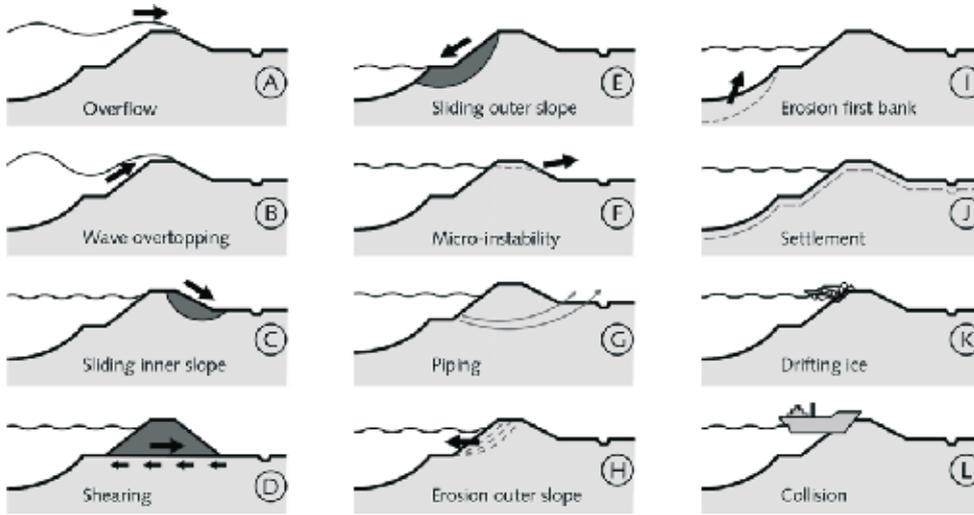


Figure 30a: A summary of the flood defenses Assessment rules for dikes, [TAW, 1998]

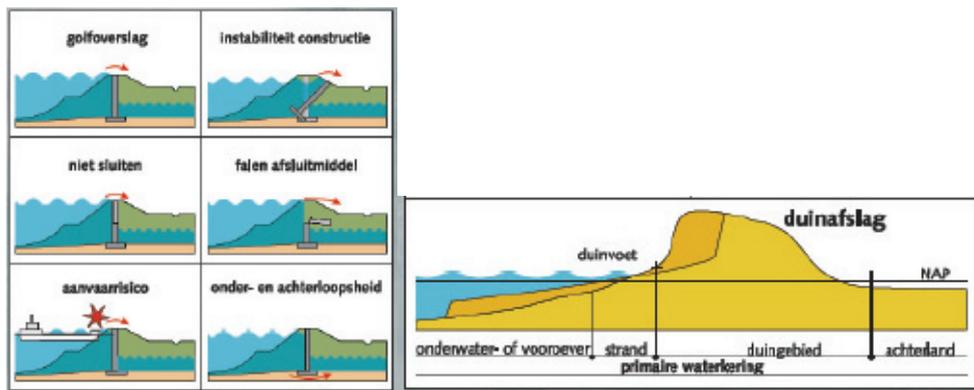


Figure 30b: A summary of the flood defenses Assessment rules for structures and dunes, [TAW, 1998]

3.4 Management of Waterways and Flood Defenses

Since the 13th century water boards have built and maintained flood defenses. The water boards are responsible for the 95 dike rings. There used to be about 2500 Water Boards in 1950, now they have been merged into 25 regional water authorities. The borders of the regional water authorities more or less correspond to secondary or primary river basins. They are responsible for all flood protection issues, major and minor drainage and irrigation channels, water quality in surface waters and sewage treatment. They consist of local authorities, which are independent and democratically run. They set rules for water bodies and flood defenses and they set taxes for all the beneficiaries of their services. The tax rate and voting rights are set according to the value of ones property. Recently the inhabitants have at least 50% of the total voting rights. Industry and Agriculture have significant voting rights.

Since 1798, a precursor to the development of a centralized state, rivers and coasts are managed by the state organization "Rijkswaterstaat", the National Water

Authority. Rijkswaterstaat manages two types of flood plains, see figure 31. The top figure shows the flood plain between the dikes. The bottom figure shows the area that can be flooded when a discharge with a return period of 1250 years occurs.

Farmers usually own the flood plain. Over the years nature conservation organizations and the state government have bought up a large part of the flood plain. Rijkswaterstaat needs the land to carry out projects to improve the conveyance capacity of the rivers. After the project and the landscaping the land is mostly handed over to nature conservation groups to maintain. These organizations can be private "Natuurmonumenten", state controlled "Staatsbosbeheer", the Forestry service or controlled by provinces "provinciale landschappen". The riverbed and banks always belong to the state. The flood plain is also a "Natura 2000" designated area. As the land is not very valuable, it floods regularly and cattle are kept in barns more often, farmers are using the land less intensively. Both changes in use of the flood plain (less cattle and more nature) promotes the existence of scrubs and trees on the former grazing grounds, and obstructs the flow of the river. The formal boundaries of the river and flood plain are shown in figure 34.

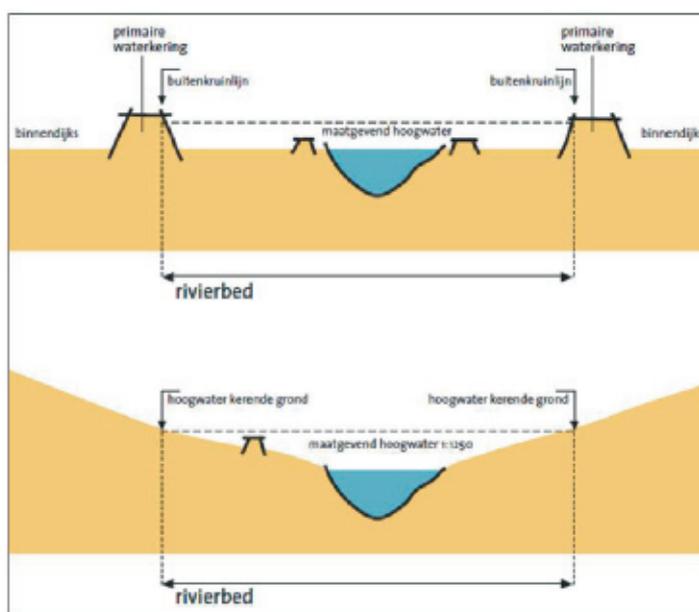


Figure 31: The river and flood plain are managed by Rijkswaterstaat, top figure flood plain in between the dikes, bottom figure flood plain in between a theoretical limit set by the water levels which correspond with a 1250 year return period.

The dune (see figure 32) is managed by the water board; the shore from the level 20 m below mean sea level up to the beach is maintained by Rijkswaterstaat (see figure 33). The left red mark in figure 32 shows the predicted line of dune failure after a storm with a return period of 10 000 years, the right red figure shows the same spot but after 200 years of sea level rise. NAP is the mean sea level.

Every house constructed to the seaward side of the red lines (in the orange zone, figure 32) is at risk; in a large storm the dunes will be eroded by wave action²⁴. The water board usually owns the dunes. Water services companies also often own the dunes behind the red lines; they use the dunes for bank infiltration, to purify the water. In urban areas, the houses and the dunes are often owned by private citizens or companies (e.g. hotels).

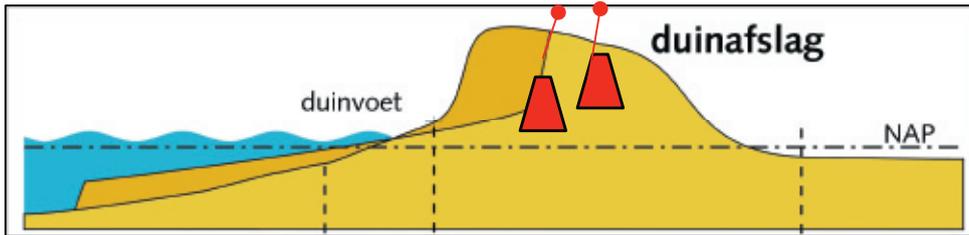


Figure 32: Protected coastal zones for flood defenses.

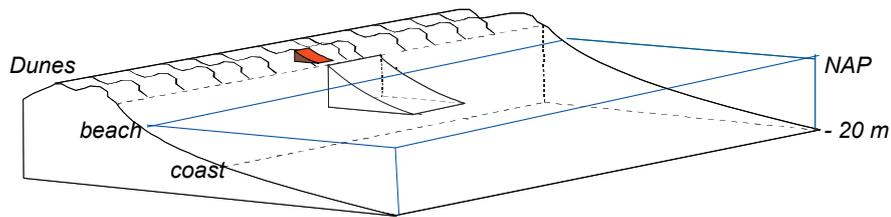


Figure 33: Flood risk protection zone for dunes, NAP is the mean sea level.

²⁴ Rijkswaterstaat has published maps for houses at risk with return periods of 10, 50, 100, 1000 years for storms. These maps with coastal erosion figures have no legal value. They cannot be compared to the map in figure 27a and 27b. The inhabitants have to be informed of their risk, see the Flood Risk Directive. This is the reason they are published. In the case of a dune failure and the collapse of a house, the house is not insured. Since this will concern a few hundred houses up to a few thousand it will probably be considered as a natural catastrophe and be covered by the law on financial compensation after a disaster, "Wet tegemoetkoming Schade, WTS". Note: This compensation is never 100% and often around 60%.



Figure 34: Zones with specific rules for rivers, the flood plain and the dune coast regarding flood defenses.

Rijkswaterstaat is the National Water Authority²⁵. The Regional Water Authorities (water boards) and Rijkswaterstaat are jointly responsible for the flood protection and flood control of water ways. Rijkswaterstaat is also responsible for:

- Communicating flood alerts (in close cooperation with the meteorological institute “KNMI”)
- Organizing scientific research in the field of flood risk and flood protection measures
- Preparing the assessment rules and hydraulic boundary conditions.

3.5 Ownership of flood defenses

Before 1953, different organizations could be responsible for one dike ring or even one dike section (see figure 28). Rijkswaterstaat, a number of the 2500 water boards, the municipalities, provinces, private people and private organizations could

²⁵ Rijkswaterstaat is also responsible for the main navigational waterways and highways in the Netherlands.

all be owners. Now the 3 500 km of primary flood defenses protecting the dike rings are solely in the care of the water boards (regional water authorities) (see figure 27a and 27b). All but three dike rings (figure 27) are managed by a single water board. There is one other exception; Rijkswaterstaat manages the large shipping locks, which sometimes are also part of dike rings e.g. in dike rings 44 “Kromme Rijn” and 43 “Betuwe, Tieler- en Culumbergerwaarden”.



Figure 35: The current 25 water boards (regional water authorities)²⁶

26 Note: Water boards (regional water authorities) Vallei en Eem and Veluwe will merge in 2012 or 2013. Reest en Wieden and Velt en Vecht will merge in 2013 or 2014.

Note: the 25 water boards (regional water authorities) do not overlap with the safety regions (figure 25)



Figure 36: (In yellow) secondary flood defense system, 15 000 km, the safety standards have been set by the provinces [Inspectie Water 2011], Provincial boundaries are given in black.

The system of secondary flood protection is 15 000 km long (see figure 36). The secondary dikes and structures, and the 55 000 km (see figure 38) of minor waterways (lakes, ponds, streams, large irrigation and drainage ditches) are managed by the water boards. Most of the secondary flood defenses and waterways belong to the water boards (regional water authorities). But many of the secondary dikes and minor waterways are privately owned or belong to a municipality or province. Usually the fact that water boards (regional water authorities) are responsible for maintenance and that the ownership is private does not pose many problems²⁷. Water boards (regional water authorities) also own and maintain 360 sewage treatment plants. In some provinces, like South-Holland they also maintain roads and navigational waterways. Many of the roads maintained by the water boards (regional water authorities) are on the dikes. In total they maintain about total 7500 km of roads. Through roads however on dikes are often maintained by municipalities or provinces. This means a close cooperation is necessary, to ensure the integrity of the dike.

²⁷ There are two type of maintenance:

- By the owners, where the Water boards (regional water authorities) inspect the maintenance
- By the water board itself (even if the land has other owners).

If an owner does not carry out maintenance in ditches or on private dikes the Water Board will carry out the maintenance and send a bill.

Rijkswaterstaat manages:

- 65 250 km² of large lakes and the North Sea, see figure 37
- 44 kilometers of dunes
- 325 kilometers of dams (the largest is 33 km long) and dikes (major flood defenses cat a, paragraph 3.2)
- 2 706 kilometers of riverbanks
- 16 large navigation locks
- 4 storm surge barriers

The ownership of all state owned land, buildings or objects is managed by the "Dienst Domeinen" of the Ministry of Finance (for land and objects) and by the "Rijksgebouwendienst" of the Ministry of Interior (for buildings).



Figure 37: National waterways and water systems managed by Rijkswaterstaat



Figure 38: All waterways and water systems fall under the European Water Framework Directive

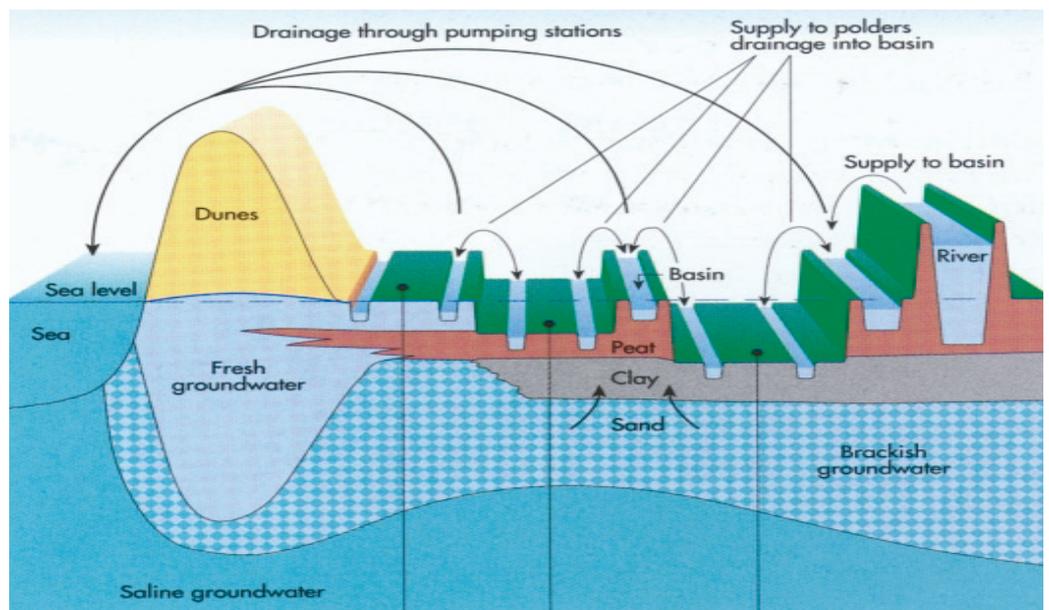


Figure 39: A view of how water systems interact in the western part of the Netherlands

Water boards (regional water authorities) are responsible for maintenance and reinforcement projects

The water boards (regional water authorities) are solely responsible for the reconstruction projects. They have to make the plan and design. Their financial plans and designs are submitted to the Ministry of Infrastructure and Environment for approval. Rijkswaterstaat, Waterdienst in the HWBP-II project, does this assessment. Consultants who aid the water boards (regional water authorities) often prepare designs and plans. The designs have to be sober and efficient. They have to meet the flood defense goals, a new defense with a design period of 50 years (for dikes) or 100 years for structures. Other goals e.g. nature preservation and landscaping have to be covered by other funding. Private companies carry out the actual reconstruction work. Water boards (regional water authorities) are also responsible for the technical controls during the construction. Since this is not their normal flood defense manager's role, during the planning and construction phase water boards (regional water authorities) can borrow experts from Rijkswaterstaat or hire consultants²⁸.

From 2012 onwards the Water Inspection is responsible for evaluating the dike assessment process by Rijkswaterstaat and the water boards (regional water authorities). From 1996 up to 2005 provinces used to be responsible for the inspection of the dike assessment process. From 2005 until 2011 the inspection was responsible for the verification of the inspection process by the provinces. These are random, spot checks²⁹. In practice the water boards (regional water authorities) are almost solely responsible for all technical issues. They can ask for assistance from Rijkswaterstaat, research institutes or from private consultants.

The provinces give the permit for dike reconstruction, as this still is a spatial planning issue. A dike has many functions.

3.8 Paying for Water Management

How water management is financed in the Netherlands is described in "Water Governance"³⁰. The roles of each organization and especially the water boards (regional water authorities) are covered as well. I have just summarized the figures and roles.

28 The number of experts capable of managing large scale infrastructural projects is limited. Successfully managing port extensions, the construction of a new railway, a highway, a new tramway, metro line, a storm surge barrier or large dike relocation project is a specialized job.

29 The technical checks are usually done when a design is considered by HWBP-II for funding.

30 Internet link: <http://english.uvw.nl/publications.html>

Organization	Millions of €	%	Main task
National Government	1070	21	The Ministry for the development of water and spatial planning policy. Rijkswaterstaat is responsible for <ul style="list-style-type: none"> • Lake, River and Coastal management, • Maintenance and reconstruction of dams and structures, large navigational waterways, inspection
Provinces ³¹	230	4	Spatial planning, water management planning on a regional level Maintenance of provincial navigational waterways, Inspection, Permits for dike reconstruction
Water boards "Regional Water Authorities"	2600	50	Management of 55 000 km waterways, 18000 km of dikes, 360 sewage treatment plants
Municipalities ³²	1300	25	Sewer systems and some local water ways
Total:	5200	100	

Table 4: Financing water management in 2010

Water Management issues, which have to be financed are covered by three European Directives:

- Water Framework Directive
- Flood Risk Management Directive
- Marine Strategy Framework Directive

National taxes cover the state tasks. In 1960 the "Delta committee" considered that 1% of Gross National Product could be spent on flood defenses³³. For large-scale flood defense projects there is a national solidarity. Maintenance is covered by regional solidarity.

The tax principle for water boards (regional water authorities) is based on the direct benefit principle: interest, taxation, voting right/ the right to decide.

³¹ Provinces are entitled to claim charges for ground water extraction.

³² The Municipalities act covers taxation to cover for costs engaged for water related responsibilities. The most important water related responsibility is the sewage system.

³³ In 1960 about 1% of GDP was spent on flood defenses when both the Delta Plan and "Zuiderzee" project were underway. As our economy grew, the percentage for flood protection has diminished to about 0.2% of GDP (1 billion/600 billion=0.0017).

Four types of stakeholders have to be represented in the council according to the "Water Boards (regional water authorities) Act":

- The residents or inhabitants of the area
- (Farmers) the owners of real estate consisting of open land which does not constitute a natural reserve
- Owners of natural reserves
- Businesses /industry

Since residents pay the largest share, they have a majority in the council.

A resume of the tax principles is given in "Water Governance"

- a) Direct benefit principle, you pay more if you own more, since you pay more you have more voting rights, everyone pays their share!
- b) The polluter pays; this is also the principle of the Water Framework Directive.
- c) The solidarity principle, water boards (regional water authorities) are large enough for cities to "subsidize" sparsely populated rural area's
- d) The cost-recovery principle, it is not a commercial enterprise
- e) The legality principle, all principles are legally embedded in law "the Water Act 2009" and the "Water Boards (regional water authorities) Act"

The water boards (regional water authorities) are self-financing (except for the large dike reconstruction projects, also see above). The annual tax to cover maintenance costs for waterways and flood protection measures is about 63 € per household³⁴ and 53 € per hectare of farmland or nature. If you live below sea level you will probably receive a separate line on your bill for pumping costs. If you live outside of the areas protected by the dikes, you will only pay for the maintenance of the 55 000 km of waterways maintained by the water boards (regional water authorities) (all minor and major water ways figure 38). The bill for sewage treatment is around 200 € per household per year. Paying for the maintenance of flood protection measures is not very expensive compared to other essential expenses.

3.9 Full time jobs involved in Water Management

It is difficult to properly calculate the number of people involved in water management. Most organizations, other than water boards, are responsible for additional tasks as well.

Organizations	Number of full time jobs	Sources
Water boards (regional water authorities)	10 500	"Water Governance"
Rijkswaterstaat	2 000	Estimation by the author
Provinces	200	Estimation by the author
Municipalities	1 000	Estimation by the author
Research institutes	3 000	Estimation by the author
Universities	500	Estimation by the author
Total "public" sector	15 200	

Table 5: Number of "public sector" full time jobs in water management

34 This figure, an example, is based on the average value of a house about 200 000 €

For example an organization like Rijkswaterstaat has about 9000 full time jobs. About 2000 people are employed in water management issues (navigation, water quality and flood protection). Most employees work on highways, in policy, operation, maintenance and construction.

According to the [National Water Partnership, NWP, 2011], there are about 80 000 full time jobs in the water management sector (including flood protection) and the "delta technology" sector. In the water management sector there are about 35 000 to 40 000 full time jobs and who work for about 1500 employers. The delta technologies sector is focused on the technology you need to live in a delta (foundation techniques, construction techniques, architecture, essential services) water is often the integrating factor see figure 19. There are about 35 000 to 40 000 full time jobs for about 450 employers. In both sectors many consultants are self-employed, a large number of people focus on niche markets where they can have a large influence through their expertise. Determining the exact number of jobs or the budget in flood risk management is impossible as flood risk management and water management are intertwined.

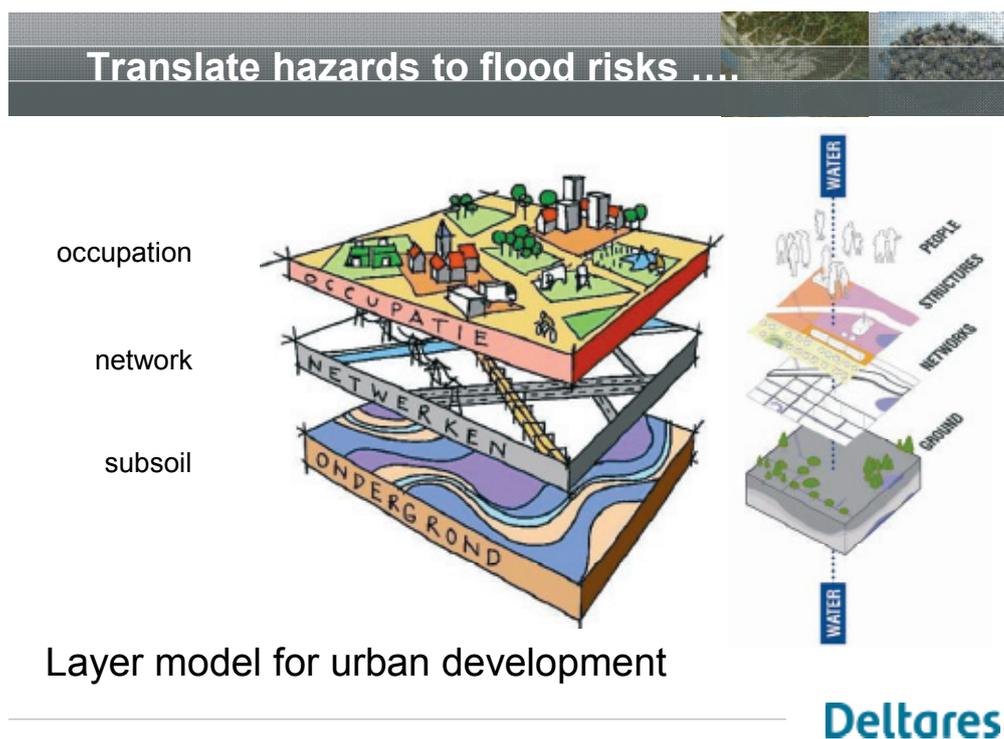


Figure 40: "Delta technology", [van der Ven, Dr. Ir. F, 2012]

4 Dike reinforcement projects and the Delta Program

4.1 The two large projects of the 20th century

The 20th century was dominated by two large long-term projects: The “Zuiderzee project (1920-1980)” and “The “Delta works” (1953-1986)”. Both were covered in chapter two. The 1953 flood delayed the “Zuiderzee” project, since personnel, material and finances were needed in the Rhine, Meuse and Scheldt Estuaries.



Figure 41: The Zuiderzee project in 1891 by Engineer Lely, [Duin, R.H.A. van and Kaste, G. de, 1990]



Figure 42: Eastern Scheldt storm surge barrier, built in 1986. Figure 6 shows the whole project

Between 1970 and 1980 just before both projects were finished local people employed in the area (fishermen) and nature conservationists protested against the way both projects were carried out.

The plan for the last polder in between Amsterdam and Enkhuizen, the "Markerwaard" of the "Zuiderzee" project was abandoned (see figure 41).

With the Delta plan, around 1970, the "Grevelingen" an Estuary of the Rhine had become an ecologically dead lake. The same ecological disaster was going to happen to the Eastern Scheldt. In the end a compromise was found by building a storm surge barrier instead of a closed dam. The ecological problem of the "Grevelingen" has not been addressed properly yet. There are plans to reconnect the lake to the sea. Adequate funding is still however an issue. The tidal movement will reintroduce shellfish and other sea life, the current lack of consistent spatial planning rules provides a constraint, see chapter 5.

4.2 Delta Plan for the Large Rivers "DGR" 1996-2001

After the high discharges of 1993 and 1995 most flood defenses along the main rivers had to be reinforced. This project took about 6 years from 1996-2001. Parliament adopted the plan in 1996 and made funding available. The plan was called "Delta plan Large Rivers" in Dutch "Delta plan Grote Rivieren, DGR". Almost 1000 kilometers of river dikes were reinforced and 150 km of new dikes were built along the Meuse River. 20 000 people received additional protection this way.



Figure 43 Widening and heightening of a dike

4.3 First and Second large reconstruction projects, "HWBP", 2001-2006 and 2006-2015

The first national dike assessment program mostly identified areas with insufficient dike height or dike revetments. The projects of the HWBP I program were largely finishing touches to the Delta Plan Large Rivers and fine tuning of the Delta Works and "Zuiderzee" projects.

- Also the dikes built and maintained by Rijkswaterstaat, the RIJP "Zuiderzeeproject" and Delta Works had to be formally handed over to the water boards (regional water authorities). All dikes, which were handed over, first had to meet the formal standards of 1996. The water boards (regional water authorities) accepting the dikes had to formally accept all the reconstruction plans before they were carried out.
- In Zeeland the existing dike revetments (against wave action) made during the Delta program proved to be insufficient for a 1 in 4000 year storm.
- Since one of the polders of the "Zuiderzeeproject" was no longer being built, some of the dikes along the new lake Marken were too low and lacked proper revetments.
- Furthermore, the 1 in 4000 year storm surges and wave action along the Lake IJssel and Lake Ketel coasts were calculated to be higher. Wave buoys were already recording 1 in 4000 year wave periods. Dikes had to be redesigned.

Rijkswaterstaat and the water boards (regional water authorities) set up two offices to carry out both large projects: "Bureau Zeeweringen" in Zeeland and "Bureau Dijkversterkingen IJsselmeerdijken" in Flevoland (dissolved in 2005). Setting up temporary offices for a project staffed by different organisations (provinces, water boards (regional water authorities) or Rijkswaterstaat) is an efficient way of running complex projects. In this way technical, financial and legal issues can be addressed efficiently. "Bureau Zeeweringen" combines research, dike assessment techniques, reconstruction of dike revetments and innovations in the Eastern and Western Scheldt Estuaries. Rijkswaterstaat and the different water boards (regional water authorities) have participated as equal partners since 1997³⁵. It will be dissolved in 2013. This is the way the Delta Works used to work, combining research, assessment, design and construction in one project.

35 <http://www.zeeweringen.nl/overons/organisatie/>

The second flood defense assessment program “2001-2006” led to the HWBP-II reconstruction program. This program has received funding from parliament of around 3,2 billion Euros [Rijkswaterstaat, 2011b]. The program will be finished in 2015.



Figure 44: Repairing a drainage culvert using sheet piling

Figure 45: HWBP measures

4.4 Space or Room for the River Projects, “Ruimte voor de Rivier” and “Maaswerken” 2001-2015

After the 1995 floods, all flood defenses along the Rhine and Meuse Rivers were assessed and if necessary restored so they met the safety standards set in the 1996 Flood Defense Act. But because of the higher discharges the Hydraulic Boundary conditions (water levels and waves) in the Rhine and Meuse River increased. To compensate for this increase in water levels by the higher discharges a paradigm shift was introduced. Instead of raising the dikes after the DGR project in 2001, the conveyance capacity of the river would be increased through a number of measures (see figures 46 and 47).

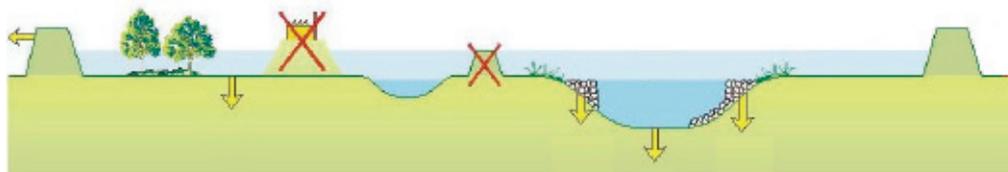


Figure 46: Measures to increase the conveyance capacity: Enlargement of the flood plain (laying back dikes), lowering the flood plain, removing obstacles, secondary channels, “removing summer dikes”, lowering the groins (which focus the flow of the river during low discharges).

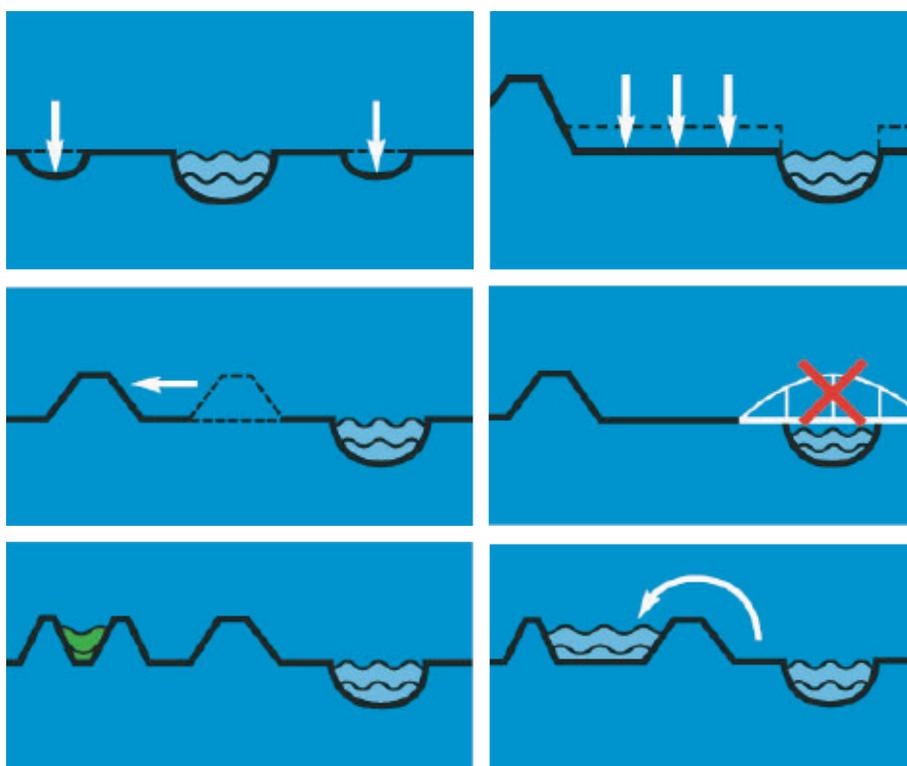


Figure 47: Different measures to enlarge the conveyance capacity of the river [Beekmans, 2002]; side channels, lowering of the flood plain, dike relocation, removing obstacles, a bypass, an emergency flood storage area,

The Room for the River Project has a national budget of about 2.2 billion Euros. The main purpose of the project is lowering the design water levels; the second major goal was improving the landscape along the river. The 40 (now 37) projects needed to accommodate the higher design discharges over the three Rhine branches and their estuaries, including the estuary of the Meuse. The decision was made after a lengthy process of public participation. All ideas from the public and from provinces, water boards (regional water authorities) and nature organizations were evaluated using the same set of rules. This was facilitated by a tool the “planning kit” the concept was developed by Wim Silva, Jos Dijkman and Arthur Kors, [Kors, A.G., 2002], see figure 48.

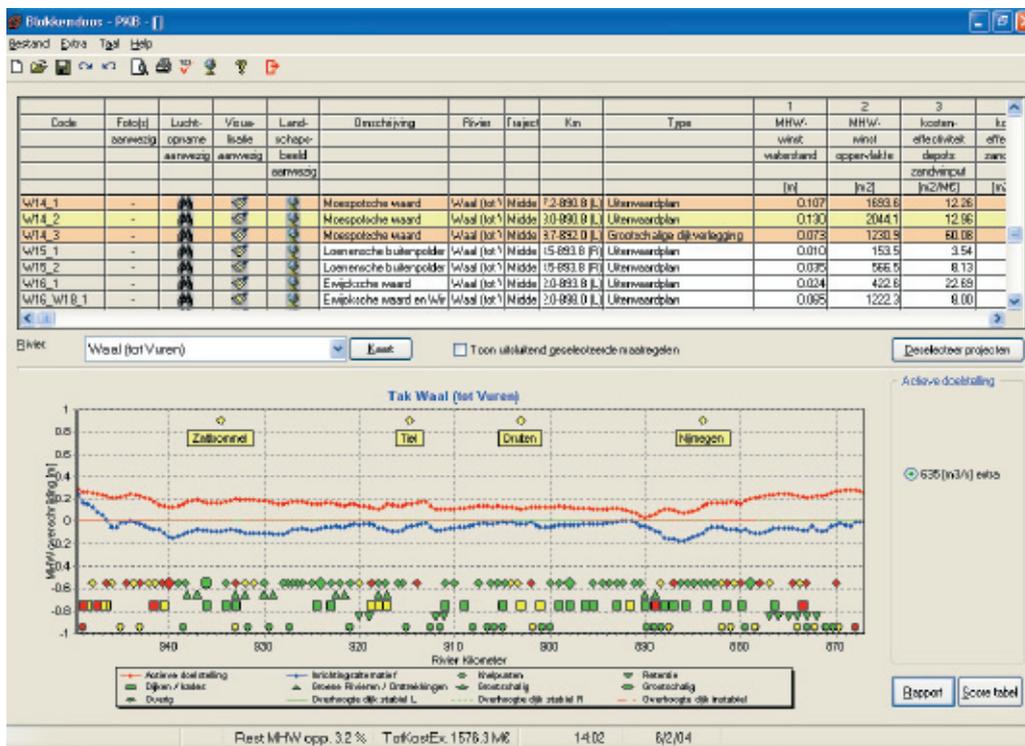


Figure 48: Planning kit³⁶ for the Room for the River Project [Kors, 2002]

The purpose of the planning kit is to find optimal strategy per river branch for measures to lower the design water levels. The planning kit shows the target water level "red line" which has to be lowered over the whole branch of the river, on average 30 cm. Different measures can be chosen (see figures 46 and 47), the effect of the measures in water levels is shown in the blue line. A draft of each plan can be shown and also aerial pictures. The price of the measure, and the number of houses, which have to be removed, is mentioned. Using the planning kit made it possible to take difficult decisions, like the removal of 50 houses at Lent (a part of Nijmegen). It was transparent; not removing 50 houses at Lent could mean more measures elsewhere and consequently the removal of more houses. Both houses of parliament were convinced of the Room for the River program using this tool and made the funding available through a Key Planning Decision, accompanied by a law. They were also convinced by a Cost-Benefit Analysis [Eijgenraam, 2003] carried out by the Central Planning Bureau, an independent bureau, which formally belongs to the Ministry of Economy, Agriculture and Innovation.

Each project in the program is carried out by municipalities (at Nijmegen), water boards (regional water authorities) (Zutphen), Provinces ("Overdiepse" Polder), or Rijkswaterstaat (Hondsbroekse Pleij). The lead partner depends on the main focus of the project. The focus of the project can be spatial planning, flood safety or urban development. At Nijmegen a side channel and a city island are made, including 3 new bridges, the city is the lead partner. River works are done by Rijkswaterstaat.

36 Blokendoos Ruimte voor de Rivier, adapted for use in secondary schools
http://www.edugis.nl/index.php?Itemid=221&id=236&option=com_content&task=view

At Zutphen it mostly consists of laying back the dikes; the waterboard is the lead partner. At Hondsbroekse Pleij, the bifurcation point, a weir was built to influence the amount of water going to the IJssel and Nederrijn rivers; Rijkswaterstaat is the lead partner, [Rijkswaterstaat, 2007b]. Rijkswaterstaat supervises all the projects. The focus by Rijkswaterstaat is on legal, technical and financial issues. The project goals have to be met, within the allocated time and budget.



Figure 49: The construction of a side channel, "Blauwe Kamer Wageningen"

The "Maaswerken", Meuse Works project is more of a mix of the Delta Plan for the Large Rivers, Room for the Rivers and the improvement of navigation on the Meuse River and its canal system. The conveyance capacity is increased by the same type of measures as the Room for the River Project (see figure 46 and 47). Except for one issue, selling the extracted gravel and sand mainly finances the project. Over the last 60 years the gravel companies have left immense scars in the landscape by leaving deep extraction pits. Now they have to landscape the area after mining for sand and gravel. They also have to mine where the extra conveyance capacity is needed for now or for the future. This means they do not always get the best sand or gravel. Accommodating climate change is an additional goal if the projects are economically feasible. Most of the planning phase was paid for by state funds, as are additional dike reinforcement/heightening projects and the navigational projects. In total the project costs about 1 billion Euros, and it will take up to 2020 to complete, since it depends on how much sand and gravel are sold every year. Its progress depends on the state of the economy.

4.5

Third or new reconstruction program, "nHWBP" 2011-2023

After the third flood defense assessment period which started in 2006 and ended in 2012, the third reconstruction program was formed. This project is estimated to cost

about in between 5 and 8.5 billion Euros. There are a number of reasons why each program needs more money. New and stricter dike assessment rules, higher hydraulic boundary conditions (water levels and waves), more data on the actual dikes, but also some organizational issues. Flood defense reconstruction since 1996 has been financed by the state at 100% (even the 15% planning costs). The water boards (regional water authorities) solely finance flood defense assessment. Flood assessment costs are only a fraction of the reconstruction costs, even if laser altimetry and soil surveys are carried out. The water boards (regional water authorities) have proposed to change the economic drivers of the assessment and reconstruction programs. From 2015 onwards the water boards (regional water authorities) will finance 50% of the reconstruction costs. The dike assessment period however will be changed to every 12 years³⁷. These changes still have to pass through parliament and are expected to do so in 2012. Since these are major changes the program is called "new HWBP" or "nHWBP".



Figure 50: Flood Defenses in need of repair or with ongoing repair

³⁷ How the 12 yearly assessment period will be carried out is not known. However it will start in 2017. In principle it may be a permanent assessment with an annual report to parliament, or it may be a phased assessment with only a number of areas assessed each year. This will probably be decided when the law on the new financial proposal for the nHWBP is brought to parliament.

4.6 **Future climate change and uncertainties**

Taking into account future climate change was introduced by the Room for the River project in 2003 and formalized for flood defense reconstruction programs in a number of new design manuals. These design manuals e.g. for Rivers [ENW, Leidraad Rivieren, 2009] formally introduced future climate change in the design of flood defenses. In all previous designs, e.g. Eastern Scheldt Storm surge Barrier or "Maeslant" Storm surge Barrier only the observed climate change, 20 cm of sea level rise per century was accounted for. The manual also introduced a general 30 cm uncertainty surcharge in water levels and waves. These are additional reasons why the nHWBP program budget rose significantly.

This principle of accommodating future climate change as introduced by the Room for the River project had smaller impact. If a measure is proposed somewhere, a check has to be carried out. One has to verify if the measure is still efficient after a period of climate change. This is to ensure that dikes are not laid back twice in twenty to fifty years. So in some projects like Lent (at Nijmegen) and Veesen Wapenveld (near Deventer) the plan was adapted to accommodate for future climate change.

In principle the IPCC scenarios are used. These have been adapted in 2001 for use in the Netherlands by the meteorological institute KNMI. In 2009 three scenarios for flood defense design were formally given, the middle scenario is used for the actual design. 60 cm of sea level rise per century is taken into account and about 20% higher river discharges. The design discharges are expected to rise from 16 000 m³/s on the Rhine at Lobith to 18 000 m³/s in the next century.

In 2006 new climate scenarios were published by the KNMI. These are not yet used in the design of new Flood Defenses. Only policy studies use the new scenarios. 80 cm of sea level rise per century is the largest change. Even though rainfall events and discharges increase significantly, the effects on the design discharges on the Rhine and Meuse rivers are limited. Flooding will occur in Germany and Belgium when the design discharges increase. Design discharges will only change if major flood defense programs or conveyance capacity programs for the river are carried out in Germany and Belgium.

4.7 **The New Delta Program 2010-2015, preparing water management policy for 2050 & 2100**

4.7.1 *A description of the program*

A large scale policy review has been started up. For the first time the driver for flood risk management reform is not a past disaster. Is the Netherlands making the right choices for 2050 and 2100 if economic growth and climate change are considered? This is very similar to the way the "Room for the rivers" program evaluates their choices (see paragraph 4.6). We currently have an adaptive strategy, is this sufficient?

There are 7 regional and 3 national “sub-programs”:

- The Coast: “Kust”
- The Scheldt Estuary: “Zuid Westelijke Delta”
- The sea around the Frisian Islands: “Waddenzee”
- The major rivers Rhine and Meuse: “Rivieren”
- The Rhine-Meuse Estuary: “Rijnmond Drechtsteden”
- The Large Lakes and surrounding rivers: “IJsselmeergebied”;

The national “sub-programs”

- National Risk Assessment “Veiligheid”
- Water Management “Zoetwater”, water supply for irrigation, drinking water, flushing canals and rivers against salt intrusion and drainage.
- Urbanization and Spatial Planning “Nieuwbouw en Herstructurering”

A national Commissioner was nominated by the Government to manage the Delta Program. The Commissioner's mandate has been prepared in a specific law. He has a budget and staff. He has a coordinating role in preparing projects with municipalities, provinces, water boards (regional water authorities), state agencies and the different ministries. His mandate allows him a seat at the weekly Cabinet meeting (with all the Ministers) if his dossier is discussed.



Figure 51: Houses built near the dike, after a number of dike reconstruction programs

Each regional or national sub-program has its own director, research budget and staff. The staff is composed of supporting staff and national or regional specialists from the municipalities, provinces, water boards (regional water authorities), state agencies and the different ministries {Economic Affairs, Agriculture and Innovation (EL en I) and Infrastructure and Environment (I en M)}.

A national coherent program will be presented in 2015. Projects will commence from 2020 and onwards. There are two major questions to be answered:

- Which policy options are available for 2050 and 2100 to cope with water management issues and flood risk management?
- Are the correct issues being addressed in the ongoing projects?

These have been translated into 5 major decisions:

- New standards for flood defenses
- The way the large lakes will be managed
- The future of the Rhine-Meuse Estuary
- Water Supply
- Spatial Planning issues

4.7.2 *An update of the flood risk assessment of 1956*

Before 2011 a formal Cost-benefit-analysis for flood risk on a national scale was never carried out. In 1956, the Delta Committee published a Cost-benefit-analysis of dike ring 14 (see figure 27a), the most densely populated part of the Netherlands, [van Dantzig, D. 1956]. Between 1970 and 1995 three committees "Becht, Boertien I and Boertien II" analyzed a number of dike rings (of figure 27a and 27b) along major rivers.

In 1956 it was evident that something had to be done. However how much had to be done was a major issue. At this moment 2012, the major question is: are we "underinsured" / not protected enough, and if this is not the issue at the moment, when will we be underinsured? The question is when to intervene and how much? The "van Dantzig" model was adapted by Eijgenraam, in [Eijgenraam, 2003], [Eijgenraam, C.J.J. 2006], in [Eijgenraam, C.J.J. 2007] and in [Brekelmans, R.C.M., C.J.J. Eijgenraam, D. den Hertog, C. Roos, 2012]. The Cost-benefit-analysis itself was carried out by Kind in [Kind, 2011] from Deltares³⁸. Deltares is an institute, which focuses on flood risk management issues, water management issues and delta technology (see paragraph 3.9)

The Cost-benefit-analysis aim is to find the optimum between the cost of flood defense reinforcement and the cost of damages due to flooding (figure 52). The driving forces are economic growth, which increases flood damages and climate change, which increases the probability of flooding and thus the cost of measures to compensate for increased damages due to both issues.

³⁸ <http://www.rijksoverheid.nl/documenten-en-publicaties/rapporten/2011/11/29/maatschappelijke-kosten-batenanalyse-waterveiligheid-21e-eeuw.html> additional information and information on the authors can be found at the following website:
<http://www.deltares.nl/nl/expertise/100417/veiligheid-en-risico-s/1402630>

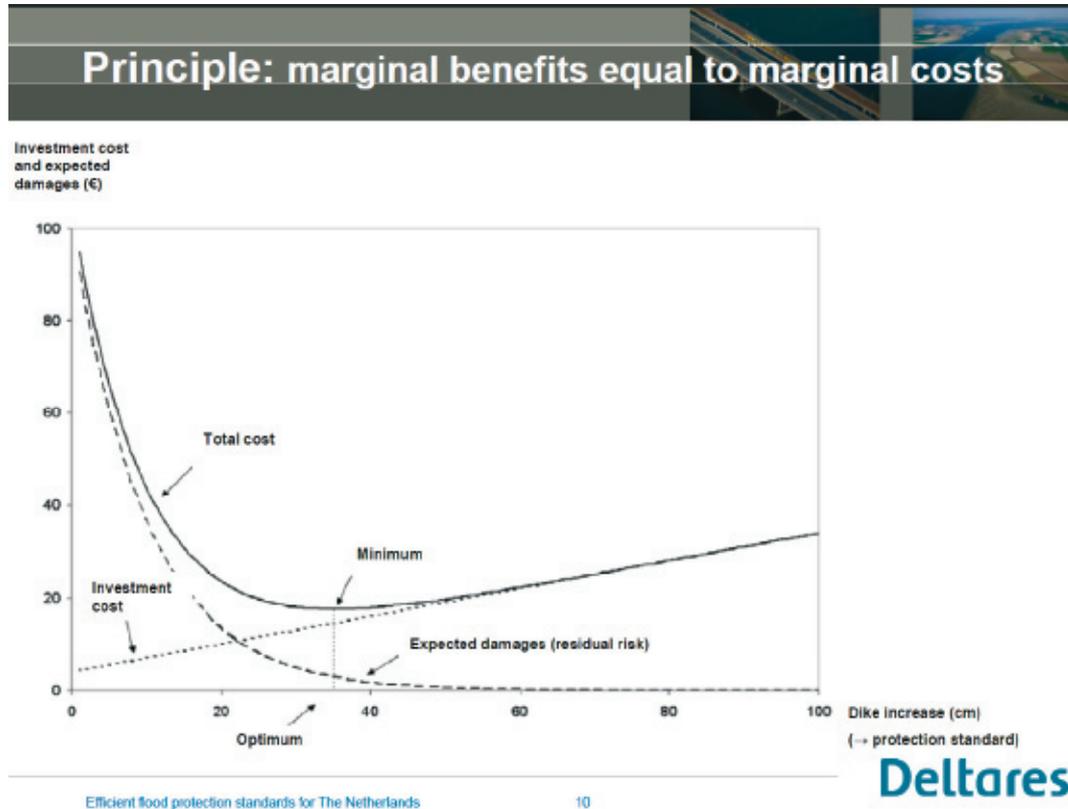


Figure 52: Cost-benefit-analysis, Jarl Kind, Deltares



Figure 53: Economically efficient flood probabilities for dike ring sections in the Netherlands

The optimal Flood protection standards for dike ring sections [Kind, J, 2011] show a number of issues:

- There is a large variation in optimal standards for flood defenses
- Determining optimal standards per water system instead of per dike ring would economically be preferable
- If you compare the map to figure 27a and 27b, the dike ring section in the transitional zone in between the Estuary of the Rhine and Meuse and the major Rivers Rhine and Meuse seems underinsured.
- Due to economic growth, the legal flood protection standards will be stricter (higher return periods)

However a number of issues have to be addressed before new legal flood protection standards can be set. These issues are possible societal and political constraints:

- Flood protection standards have to be explainable to the general public; a maximum of 5 categories seems acceptable.
- Flood protection standards should not vary too much between areas with comparable general characteristics; comparable urban or rural areas along a river or lake should have the same safety standard. A differentiation between urban and rural areas along the same river is still an ongoing discussion.
- In 2009 the Secretary of State Mrs. Huizinga determined no flood protection standards would be lowered.
- The definition of probability of failure has changed since van [Dantzig, 1957]³⁹

To solve these issues a public participation process has been started in the regional programs.

A cost benefit analysis is an economic way of looking at the problem. There are however two other important issues: Societal Risk and Individual Risk⁴⁰:

- How many fatalities are acceptable when a major flood occurs?
- What is the acceptable probability of dying due to floods at a given place in the Netherlands $1 \cdot 10^{-5}$ or $1 \cdot 10^{-6}$ per year? The last figure, individual risk, a probability of $1 \cdot 10^{-6}$ per year, is used for determining zoning around industrial complexes.

The 2005 Boxing Day Tsunami and the Fukushima disaster show that you have to think through the unimaginable. Are 1000, 10 000 or 100 000 fatalities acceptable (see figure 54)?

Only if society has set a standard for both issues can you think about taking the most efficient measures for both issues. Using the multi-layer safety concept (of paragraph 2.3), the two problems can be tackled.

When one looks at figure 54 first the probability of large numbers of fatalities is dominated by the upper river areas (light blue) and then by the Rhine-Meuse Estuary (red). For the upper river areas the time needed for evacuations is only 2 to 3 days, this time is available, since acceptable flood alerts are available at least 3 to 4 days ahead. In 1995 250 000 people were evacuated from these areas. So in theory it is feasible to evacuate. The 10% to 20% of the people remaining in the area, who refuse to comply with the order to evacuate, may pose a problem. I will cover this issue later in chapter 7.

39 Note: the probabilities of flood risk for the elaboration of figures 27 and 53 have been determined with completely different methods. As mentioned before the flood protection levels of figure 27 were based on a mix of political and practical choices. The probability of flooding (for the elaboration of figure 53) was determined using Hydra-models available on the Helpdesk water website, the prescribed tools for dike assessment. But a number of changes were made. The current dike assessment tools are not completely consistent and they are focused on design water levels, dike height and dike revetments. Dike strength is not considered e.g. piping and slope stability, this is covered by the flood defense assessment rules, "VTV" see paragraph 3.3. A group of experts modified the probabilities using information from the Hydra-models and the Florisk II project. In this way a dike strength and independence in the probability of hydraulic loads on a dike ring were corrected.

40 <http://www.rijksoverheid.nl/documenten-en-publicaties/rapporten/2011/11/29/analyse-van-slachtofferrisico-s-waterveiligheid-21e-eeuw.html> (in Dutch)

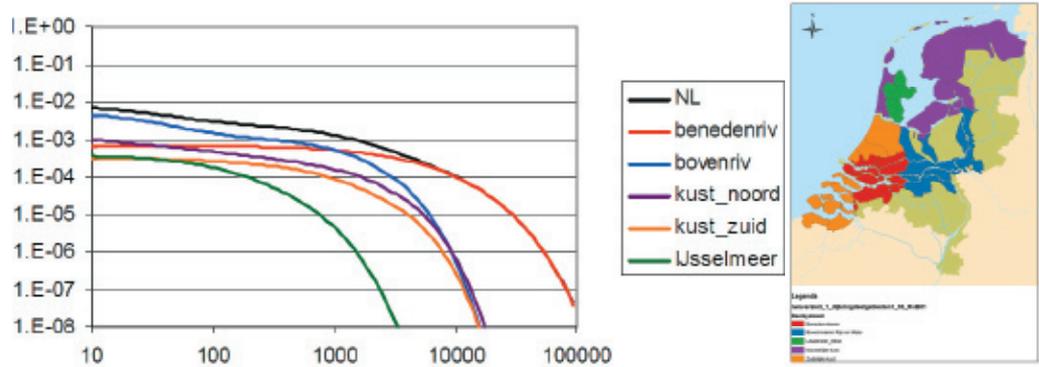


Figure 54: Societal risk, the number of fatalities for different scenario's, different return periods and geographic regions. The black line is the line for the whole of the Netherlands.

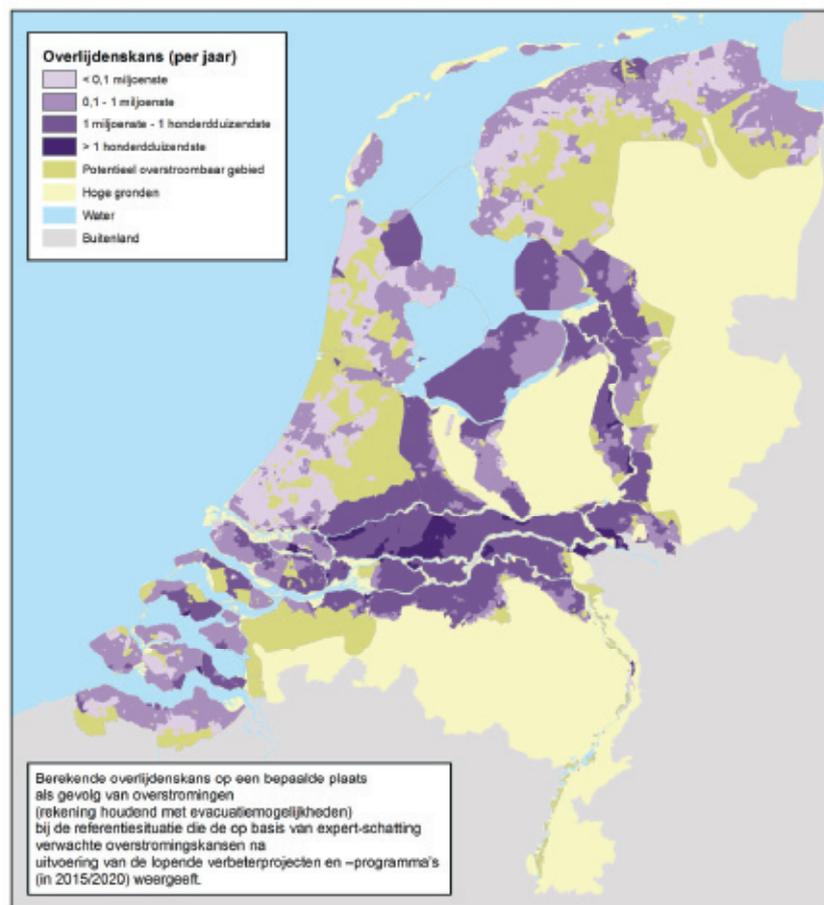


Figure 55: Individual flood risk per annum

For the Rhine-Meuse Estuary, the time needed for evacuation is about 3 days or more, during a storm (beaufort 10 or 12) it is impossible to travel, and sufficiently reliable flood alerts are only available 1 to 2 days before the storm hits, [BZK, 2008a and b]. Increased flood protection seems the only feasible solution.

Secondly if you look at figure 55, the darkest spots with a probability higher than $1 \cdot 10^{-5}$ almost all these areas are in the river areas along the Rhine and Meuse. In principle you can evacuate in these areas, the lead time is sufficient.

For the darkest spots in the Estuaries and the coast it can be possible to reduce individual flood risk if there are few inhabitants. Removing housing or replacing houses with flood proofed housing is feasible. Economically removing or replacing the existing housing is not a feasible measure for densely populated areas. Dividing dike ring into smaller units with less potential damage is not economically feasible either [Rijkswaterstaat, 2008b].

The new flood protection standards will be discussed from 2012 until 2015, and then they will be included in a new law. From 2017 up to 2023 the safety assessment period will use these new flood protection standards.

4.7.3

Public Participation

Both the flood risk analysis and the water management analysis have to be accepted by the other partners, nature conservation organizations and the general public. The same organizations are also needed to evaluate the proposed solutions. This public participation process is essential. Rijkswaterstaat and the water boards (regional water authorities) have learned from mistakes made in the past. A number of manuals for professionals have been elaborated; one example is [Breman, et al, 2008].

Essential issues are:

- Identifying who needs to be involved
- There is no overall custom solution
- Setting clear goals to be achieved

There are three types of goals for public participation:

- Quality of the end result, by involving local knowledge
- Elaborating a common end result
- Democratic goals, the transparency of the government decisions and citizens should be able to influence policy

The Room for the River program is the most successful example of how it can be done. They focused on a simplified "flood defense safety objective", lowering design water levels. This was possible since all dikes had recently been reviewed and/or reinforced (in the DGR program). The focus was on elaborating a common end result, transparency and involving local knowledge. For such a large infrastructural project the number of court cases has been limited compared to highways and other types of large scale infrastructural projects. This has positively influenced the speed of the project and the total cost.

Just like the Room for the River a set of coherent evaluation instruments have to be given to all the sub-programs in the Delta-program. For this purpose the staff of the Delta-commissioner has published a list of indicators to be covered.

Rijkswaterstaat has developed a number of tools:

- The "Delta model"⁴¹ which has two major components
 - A tool "NHI" to evaluate water management issues (in the whole system of water ways see figure 38 except for the coast and open Estuaries)
 - A tool "Hydra-Zoet" in combination with "DAM" to evaluate the probability of flooding along major rivers and lakes
- Additional tools;
 - A tool Hydra-K to evaluate the probability of flooding along the coast and Scheldt Estuaries
 - KOSWAT, a tool to provide for the same cost base for each measure or solution
 - A consistent set of Flood Damage Scenarios
- The "Deltaportaal", a web application to show the results of the different programs in a transparent and coherent fashion. Every party concerned can propose their own solutions or measures. A coherent national program can only be elaborated if all the results are represented in a uniform and transparent way.

If the Room for the River program can be seen as an example, most probably a national Cost-benefit-analysis will be used to identify the most promising projects. The current Cost-benefit-analysis, which determined optimal safety standards for flood defenses, has been done with standard measures like dike heightening and dike reinforcement. Promising multi-functional measures still have to be evaluated.

41 <http://www.helpdeskwater.nl/onderwerpen/applicaties-modellen/deltamodel>

5 Spatial planning and Insurance

5.1 Spatial planning

Since 1996 all construction in the flood plain has been prohibited, for the Rhine and Meuse Rivers up to the Estuary and the city of Dordrecht. In 2009 this rule "Beleidslijn grote rivieren" was extended see figure 34. The Zwarte Water, Zwarte Lake and the enclosed estuaries of the Rhine and Meuse Rivers were included.

All buildings along lakeshores and the coast have to be raised on stilts or artificial mounds⁴² and/or flood proofed. Some experiments were carried out with floating houses at Rotterdam and Amsterdam. The most restrictive rules on spatial planning concern the shores and banks of waterways managed by Rijkswaterstaat⁴³ (figure 37). If houses are not built above the flood levels, frequent flood damage in these areas is expected in the near future.

42 Examples: Governmental Position Paper (in 1998/2000) on the building permit for the extension of Amsterdam (the suburb of IJburg) in Lake Marken and the decision of the Ministry of Public Works, Transport and Water Management on the extension of the industrial harbour of Harderwijk (in 2001/2002).

43 At Amsterdam in the old industrial harbor on islands where the ships of the East India Company were built, the Ministry of I en M set special building codes, since this part of the water ways is managed by Rijkswaterstaat. Every entrance of a building used as a home has to be higher than 1.20 m above mean sea level. If a shipping lock at IJmuiden fails the water levels will rise within a few hours, potentially trapping people in their sleep. Most houses have been built since 1990. There were a number of severe disputes with the architects. The architects claimed their artistic freedom was infringed.

Other examples are less positive. In many areas of coasts and banks of areas managed by Rijkswaterstaat artistic freedom of landscape planners and architects was more important than safety from flooding or even basic water management issues. Existing spatial planning rules were often not clear and mistakes were made. This lack of foresight is especially the case in the former parts of the Rhine, Meuse and Scheldt Estuaries, Lakes Grevelingen, Lake Volkerak-Zoom. Recreational and other houses have been built near the waters edge. Even relative small changes of the mean lake levels of 10 cm are impossible because of possible flood damage due to water logging e.g. in the Grevelingen lake. The public and professionals in the area, both the designers and the people responsible for permits, have to be more aware of the issues at stake. After 50 years of sea level rise and if pumping is not a viable option, the mean lake levels have to be raised. Small sea level rises will immediately cause problems for draining the water from the lakes and also for the buildings around the lake. Even reintroducing tidal movement to improve the water quality in the area has become difficult in some areas.

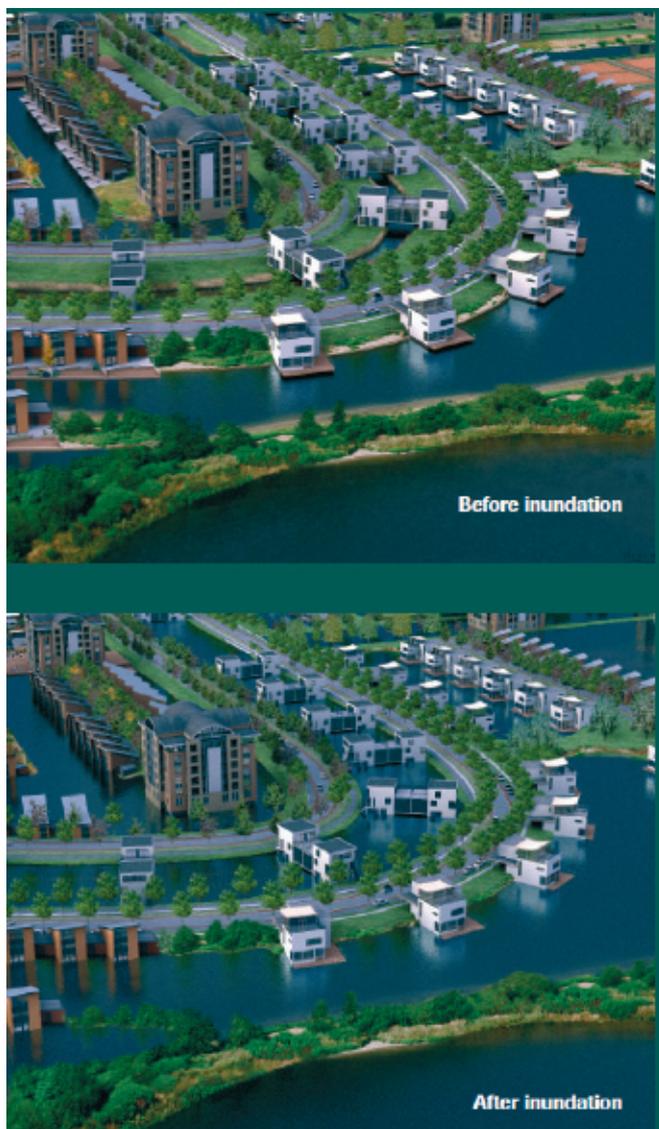


Figure 56: Floating Houses along rivers or lakes, Dura Vermeer, 2010

In 2009 legislation concerning spatial planning was introduced for the protected area (figure 27a). The water boards (regional water authorities) have to review all new urban developments concerning water management and flood risk management issues. However this “assessment”, the “water toets” is not binding⁴⁴.

In the Delta Program, in the subprogram Urbanisation and Spatial Planning, “Nieuwbouw en Herstructurering” (see paragraph 4.6) the current policy will be reviewed for protected and non-protected areas.

⁴⁴ Near the town of Gouda new urban developments in one of the lowest lying areas of the Netherlands and with one of the highest rates of soil subsidence will be carried out. Flood Risk was not really taken into account. However due to the assessment by the water boards (regional water authorities) some modifications of the plans were carried out for pluvial flooding and flooding by secondary flood defenses.

However for extreme rainfall events there are very clear rules. At least 6% of a new urban development has to be allocated for accommodating excess rainfall. This can be done through ponds, canals, and large ditches or in areas with low water tables wide dry ditches "wadis⁴⁵", where water can slowly infiltrate. New urban developments have separate systems for the removal of sewage and access rainfall.

During the projects "DGR" and Room for the Rivers (paragraph 4.2 and 4.4) many houses have been and will be demolished. At one location, during the DGR project 1996-2001, at IJsselmonde, near Rotterdam, 1000 houses were demolished. The dike had to be reconstructed. A large number of people were allowed to return to homes rebuilt near the dike or on a raised platform in front of the dike after the reconstruction.

5.2 The policy not to have flood insurance

It is not possible to get flood insurance for your home or business in the Netherlands. This is national policy. The insurance companies were only willing to provide insurance in the Netherlands if the Dutch Government provided the reinsurance policy. The risk was considered too high for global players in the reinsurance market. Paying for flood protection through national and local taxation is 50% cheaper than individual insurance policies per household, [Kok, 2005]. Furthermore high flood protection standards are provided by taxation for maintenance and reconstruction projects.

However if a disaster occurs there is a reimbursement policy, the "WTS, Wet tegemoetkoming schade". A percentage of the occurred damages are paid. Private sector insurance agents employed by the national government determine the actual damages at each household or business. The reimbursement rate is a "political decision". The Ministry of finance does the payments after a disaster. There is no national damage fund. This is a policy decision; government buildings, infrastructure and vehicles are not insured against fire or accidents either. [Kok, 2005] notes that it is feasible for insurance companies to provide insurance for the secondary dike system (figure 36) without assistance from the state.

Normal home insurance covers fire, theft, etc but also leaking pipes, sewage spills and flooding from local rainfall events (e.g. a single street).

45 https://www.ruimtelijkeplannen.enschede.nl/NL.IMRO.0153.20092210-0003/tb_NL.IMRO.0153.20092210-0003_5.pdf



Figure 57: Coastal Flood Defenses in an Urban Environment, Noordwijk, Arcadis 2010

6 The European Floods Directive

6.1 European Floods Directive

The European Floods Directive, issued November 23rd 2007, requires hazard maps and "risk maps"⁴⁶ showing potential damage, and flood risk management plans to be produced. The Directive was implemented into national law, in the Water Act of 2009 and accompanied by a number of legal instruments summarized in the Water Decree, "Waterbesluit"⁴⁷

The current Dutch Flood Risk policy has been implemented through the Act on Flood Defenses of 1996. The flood risk management policy, which has been developed over a 50-year period, favors flood protection measures. The policy has been formalized in a document [The National Water Plan⁴⁸] and different regional plans. No major changes in policy are expected on account of the Floods Directive. Also no organizational changes will be made on account of the Directive. However there are two "slight" but in fact significant changes:

- The flood risk management policy is a shared responsibility of both the Ministry of Security and Justice and the Ministry of Infrastructure and the Environment and has to be reported in a single document. The goal of this Directive is to have integrated flood risk management plans, covering all layers (figure 11) from flood forecasts, to flood alerts, spatial planning, flood defenses and response and rescue services.
- Flood risk management along rivers should be based on international river basin management and the principle of solidarity, so cooperation between neighboring countries is essential. Especially in the analysis of the case of river flooding and future climate change. Over the last years many projects have been initiated, two examples are the Meuse and Rhine Action Plans.

The Netherlands decided to produce the flood risk and hazard maps and flood risk management plans before December 2009. According to article 13 -1-b of the Directive, this offers the possibility of not conducting the "preliminary flood risk

46 Note: Risk maps as shown in figures 53, 54 and 55 (chapter 4) are not required.

47 The Water Act formalizes the regulations and flood protection standards for regional waterways and flood defenses (figure 36).

- Water Authorities have to meet chemical and ecological quality objectives.
- Water Authorities can conclude water agreements and administrative arrangements with other authorities (e.g. municipalities) on water management.
- All Water Authorities have to draw up ledgers for water ways; these indicate physical characteristics, management borders and the protected zones.
- Project plans are needed for infrastructural changes (new flood defenses, realignment of rivers and/or dikes etc)
- Maintenance of water ways and flood defenses not belonging to water authorities has been regulated. Owners are obliged to allow people on their property to carry out these activities; this is called the right to consent.
- The concept of general regulations was introduced, to reduce the number of rules. This clarifies in advance what is permitted and what not.
- There are only two Water Authorities, the state and the regional water authorities (Water Boards). Provinces and Municipalities are not water authorities, although they have some water management tasks.
- The right for regional authorities, provinces and municipalities to levy taxes, is fixed by law, for details see chapter 3.

48 This document describes integrated water management policy. The plan has been prepared by the Ministry Infrastructure and Environment together with the Ministry of Economic Affairs, Agriculture and Innovation. [http://www.helpdeskwater.nl/algemene-onderdelen/structuur-pagina/zoeken-site/@28444/waterbesluit-\(dec/](http://www.helpdeskwater.nl/algemene-onderdelen/structuur-pagina/zoeken-site/@28444/waterbesluit-(dec/)

assessment". In fact, this assessment had already been carried out directly after the 1953 floods – leading to the first Delta Plan. The Dutch hazard zones and potential damages have been identified and are the basis for policy since 1960 (paragraph 3.2).

In November/December 2011, the Netherlands identified which objectives they wish to focus on in reporting to the EU.

- The zones protected by the 3600 km of primary flood defenses (figure 27), with formal legal safety standards set by the National Government
- The zones protected by 15 000 km of secondary flood defenses (figure 36) with formal legal safety standards set by the Provinces
- The zones along coasts, large lakes and rivers not protected by flood defenses (figure 29). Note many recent urban and industrial areas have been built above the design flood levels for the primary flood defenses.
- Transnational water courses, without flood defenses where Germany or Belgium have decided to elaborate a river basin flood risk management plan

It took 40 years to implement the current flood risk management policy in the Netherlands. The major characteristics are:

- Flood alerts and flood forecasts, which are understood by the public and by the different water boards (regional water authorities) and understood by emergency services responsible for response and rescue.
- Legislation, to determine roles of each partner and a sound financial structure
- Organizational changes, a concentration of tasks, less organizations are involved each year; experts remain available in the field.
- A regular review of flood defenses
- A major repair/ reconstruction of all flood defenses (this took 40 years)
- The inclusion of environmental issues⁴⁹ and spatial planning (since 1975/1980)
- A renewed cooperation between response and rescue services and flood risk managers

⁴⁹ Since 1975 environmental issues have become important. Dikes are no longer realigned and reconstructed with major consequences for houses on the dikes and the environment, an issue addressed by the general public from 1980 onwards. Houses on dikes and dike alignments date back hundreds of years. Fishermen and nature conservationists obliged Rijkswaterstaat to redesign the dam in the Eastern Scheldt into a storm surge barrier (Eastern Scheldt Project, 1986). Fishermen and nature conservationists also obliged the Government not to build the last polder in Lake Marken (1980). The committees Boertien I (in 1993) and Boertien II (in 1995) proposed changes for the river dike reconstruction program, which had stalled in the 1980's due to local resistance. Rijkswaterstaat decided in 2001 that the room for the rivers second main goal (second to lowering design water levels) would be to improve the landscape.

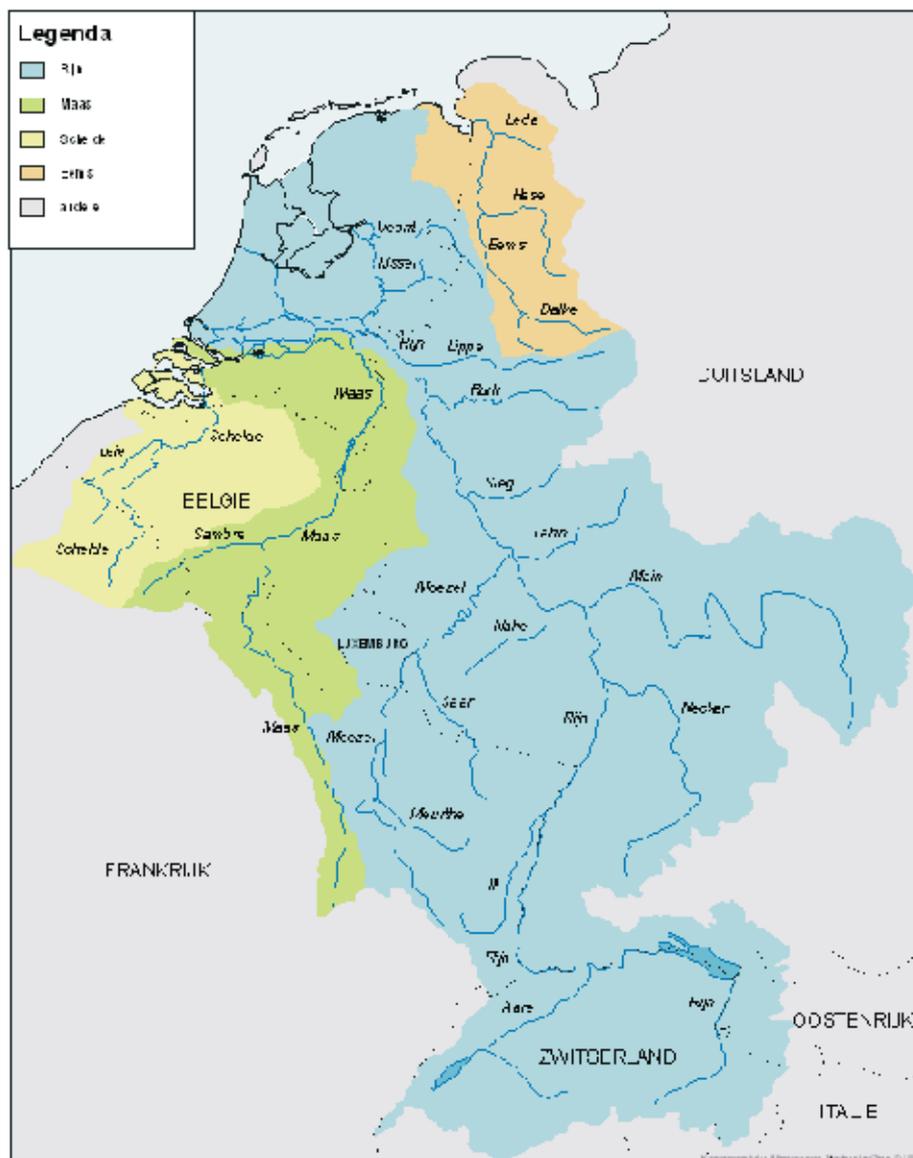


Figure 58: The four international river basins in the Netherlands, Rhine, Meuse, Scheldt and Eems. Note: Since the Netherlands is a Delta, along Meuse River, the coast and in the estuaries the presented borders between river basins have been chosen pragmatically.

6.2 New Legislation

An important issue in the Netherlands is to review existing laws and regulations while implementing EU Directives. At the moment two new laws are being prepared on Spatial Planning “Omgevingswet” and on Nature Conservation, “Natuur wet”.

6.2.1 A new integrated spatial planning act “Omgevingswet”

The Water Act (2009/2010) is a merger of existing legislation on water quality and flood defenses and incorporates the EU Floods Directive, Water Framework Directive and the Marine Strategy Framework Directive. About 7 acts on flood defenses were combined in the Water Act. In 2012 the Water Act and Spatial Planning Act will be combined in the integrated Spatial Planning Act “Omgevingswet”.

The public will notice this change directly. Private Citizens and businesses will have only “one stop” for all permits (e.g. building permits), at their municipality. This will significantly reduce the costs for all parties concerned. The municipality, provinces and the national government have to coordinate their actions.

6.2.2

Conflicts in legislation regarding Flood Risk and Nature Conservation

Nature Conservation law (“Flora- en Faunawet and Natuurbeschermingswet”) seems more important than the Water Act, “Waterwet, 2009” which covers flood protection measures.

Some conflicts occurred in a number of large flood defense reconstruction projects for coastal projects and fluvial projects (see chapter 4, “HWBP”). This concerns dike realignments (“Room for the Rivers and Meuse works”, maintenance projects⁵⁰ and the coastal defense “HWBP”, and sand (sediment deficiency) projects “Kustlijnzorg⁵¹”). The nature conservation laws incorporate the EU Directives on habitat and on birds.

Every large-scale project has to carry on a preliminary assessment (“voortoets”). If negative effects on the environment are foreseen, proposals have to be made to stop or limit the negative effects. If it is not possible to limit the negative effects on the environment, then a more detailed study has to be carried out. Alternatives for the project have to be considered. This is a common European practice [European Commission, 2011]. If there are no alternatives (or alternatives are too expensive), and it is clear that the project is of national importance, compensation has to be carried out.

This is often where discussions occur, is the project really of national importance, and is there really no affordable alternative? Managing such discussions is difficult. Discussions can bog down in the comparison of prices of alternatives. Rijkswaterstaat, the water boards (regional water authorities) or provinces are the driving forces behind the projects; the organizations for nature conservation are often critical of the proposals.

A common solution is to elaborate a solution together with the organizations for nature conservation by improving the natural habitats. This however is often only possible by extending the project area, to include the areas where the natural environment will be “improved”.

This cooperation which has existed for about 20 years between Rijkswaterstaat, the water boards (regional water authorities) or provinces and the organizations for nature conservation has been evaluated for the Rhine River by [Kurstjens, Gijs and Peter, Bart, 2012].

50 “Stroomlijn” Streamlining the river, a project which has to remove scrubs and trees from the flood plain which block river flows.

51 “Kustlijnzorg”, coastal zone management: since 1990. After an intensive study on coastal processes involving a multidisciplinary team, Rijkswaterstaat decided that natural processes that improve the dunes should be stimulated. The construction of dams in rivers and harbor jetties impedes the arrival of new sediment (sand) on the coast. This last process is artificially reproduced. Each year sand deposited by the Rhine and Meuse in the last 100 000 years is dredged far out in the North Sea and deposited just below the beach. The tidal action and the wind then reconstruct the dunes. The main harbor dams blocking the sediment flow along the coast are at “Zeebrugge” (Belgium), Rotterdam and IJmuiden (Amsterdam). Minor harbors are at Katwijk (Leiden) and Scheveningen (The Hague).

Enlarging the project area, which is legally allowed, is not always possible. This is especially not possible for maintenance projects e.g. sand nourishments of the beach and fore shore, "Kustlijnzorg", and removing scrubs and trees from the flood plain, "Stroomlijn". For maintenance it is harder to prove that it is of national importance and that it has to be done (now). There is no actual risk at hand, but the risk will evolve if the coastline or the flood plain is not managed. Alternatives to maintenance are often worse for the environment e.g. large scale dike (re-) construction projects. Many environmental groups understand the issues at stake.

Goals for natural habitats have been formalized in nature conservation management plans. Improving the existing nature with habitats that were lost in the last 50 years is almost impossible. Many river bends were closed off from the major rivers. Estuaries were often closed off from the sea, and the salt environment, brackish zones disappeared. Pastures and fields became monotonous with the introduction of mechanized agriculture.

A second issue is that if a protected species or habitat has been successfully introduced (e.g. beavers); this is not taken into account when a new project is considered.

An important issue is to change nature conservation into nature management. The laws protecting our natural environment are focused on conservation. But natural environments evolve and cannot be fixated, especially in a country like the Netherlands, where "nature" is often manmade. 90% of the waterways in the Netherlands are in fact man made; these water bodies could legally all be classified as heavily modified water bodies⁵².

"Nature" in the Netherlands is often the result of "maintenance"; this "maintenance" can be good or bad e.g. "desertification, by depletion of natural resources". The sand dunes and heather fields on the "Veluwe" are an example of the desertification process from 1700 to 1900. Without maintenance, a regular removal of trees, scrubs and the topsoil, the areas would become oak forests. Even in the U.S. the Yellowstone Park, the first National Park large errors were made by the park authorities⁵³. People forget that many parts of the U.S. were already a man made environment. Yellowstone had been developed as hunting ground, and was maintained by regular forest fires and hunting certain species. Without this maintenance by the "local population, the American Indians" the park degraded.

Changing the laws on Nature conservation to be more focused on Nature Management is something to tackle in a European setting. The first step is, understanding, how people over the centuries have influenced the natural environment. The second step is reintroducing "lost environments and species". If this succeeds, then it will be easier to find ways to fit in large-scale flood defense projects, necessary to protect the people living in our country.

⁵² If one considers the formal definitions from the Water Framework Directive.

⁵³ Playing God in Yellowstone: The Destruction of America's First National Park, Alston Chase and Community-based conservation, Wikipedia.

7 Disaster Management, “preparation”

7.1 National (annual) Risk Assessment (Nationale Risico beoordeling)

Every year the Ministry of Security and Justice⁵⁴ carries out a national risk assessment, see figure 61. The Ministry of Security and Justice is responsible for collecting indicators and scenarios from other ministries, provinces and research institutes. The Ministry integrates this data into a national analysis. In 2007 and in 2008 flood risk scenarios were provided for this analysis⁵⁵.

The probability of major flooding along the western coast is very low (about 1/10 000 per year to 1/100 000 per year), but the consequences are enormous and devastating for our society, see figures 59 and 61. The flood would have a national impact since especially the province of South of Holland, would be hit, with about 3.6 million inhabitants. This is more than the emergency services can handle. The maximum rescue capacity for a flooded city is about 40 000 people. In the annual report [BZK, 2008] the choice for flood protection measures for the coast is confirmed.

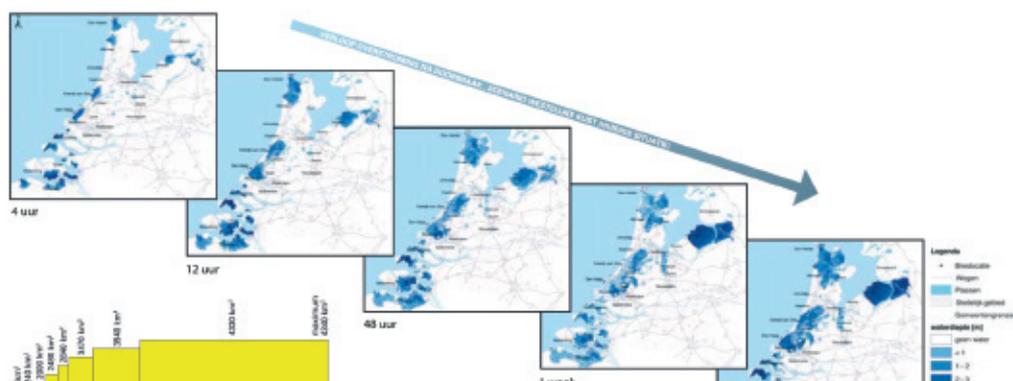


Figure 59: A flood scenario with a return period of about 100 000 years. The situation after a week is shown in the last figure on the right⁵⁶

⁵⁴ Before a Cabinets' decision (2010) to reorganize central government, it was the responsibility of the Minister of the Interior and Kingdom Relations to carry out this National Annual Risk Assessment.

⁵⁵ <http://www.rijksoverheid.nl/documenten-en-publicaties/rapporten/2009/10/21/scenario-s-nationale-risicobeoordeling-2008-2009.html> (in dutch, an English summary is available)

⁵⁶ <http://www.rijksoverheid.nl/bestanden/documenten-en-publicaties/rapporten/2008/06/16/rapport-capaciteitsplanning-ergst-denkbare-overstromingsscenario-s/capaciteitsplanningedoscenarios.pdf>

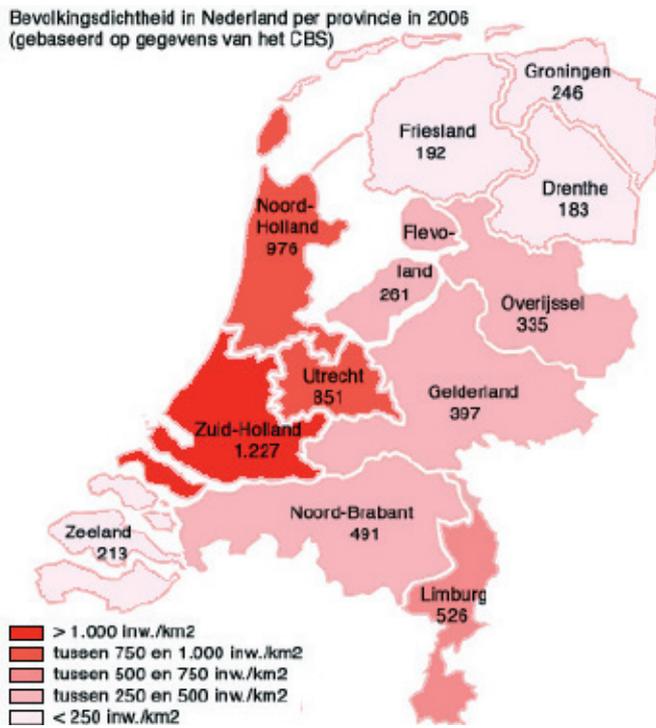


Figure 60: Population density per km2 per province (Central Bureau of Statistics)

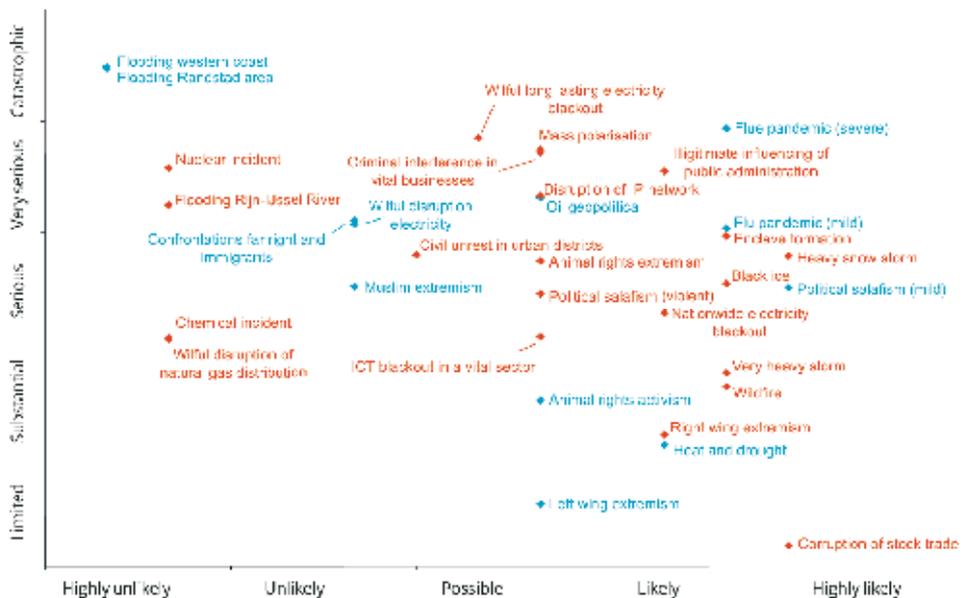


Figure 61: National Risk assessment 2008 the position of the scenario from figure 59 is the top left corner, very unlikely but with catastrophic consequences.

The diagram in figure 61 is the summary of the annual national risk assessment of 2008. Each type of risk is classified on two scales, the probability and the impact on the nation as a whole.

7.2 Multi Disciplinary Disaster Exercise "TMO", Waterproof

Since Katrina, 2005, in New Orleans, the Netherlands has rediscovered the fact that absolute safety does not exist. There is also a role in flood risk management for "civil protection issues" as evacuation, response and rescue. The last major flood incident was in 1995, 250 000 people were evacuated. Every organization has to organize professional training and exercises for their personnel. Cooperation between the two types of organizations is not often exercised.

In 2007 a major flood risk exercise was organized to bring both types of organizations together on a national scale. 15 000 professionals participated in the preparation (a two year period) and the exercise itself (which lasted a week). Exercises were held at different regional and national levels, the minister of interior and even the Cabinet participated for two days in the exercise. In September 2009 an international exercise was held, FLOODDEX.

The TMO, Waterproof exercise was focused on four issues:

- Collecting, processing, disseminating information,
- Decision making processes
- Crisis communication
- Cooperation between different governmental layers and in between the functional "flood control and water management" chain and general chain responsible for "public safety" (see table 1)

Both organizations emergency services and water managers use a different professional language. Identifying the others' organizational information needs before a crisis is essential. Knowing who is on the other side of the phone line before a crisis is also essential. This exercise has to be held every 5 years; in November 2012 the next exercise will be held, organized by the national and regional water authorities. This exercise has a steering committee called the "SMO". However, only some safety regions in certain areas of the North Sea coast in the South of Holland and Zeeland will be involved.

A number of tools were developed for the TMO Disaster Exercise: The concept of Worst Credible Floods and Capabilities Based Planning was applied to flood scenarios.

7.2.1 Worst Credible Floods

It is physically impossible to have a 1 in 10 000 year event in Zeeland and in the North at the same time. A deep depression over the "Wadden Sea" can cause problems for flood defenses Zeeland and Holland. A deep depression over Norway can cause problems for flood defenses in the "Wadden Sea" area. It is also very improbable to have a large storm event and a large discharge at the same time. A number of independent events for the Netherlands can be determined (see figure 62)

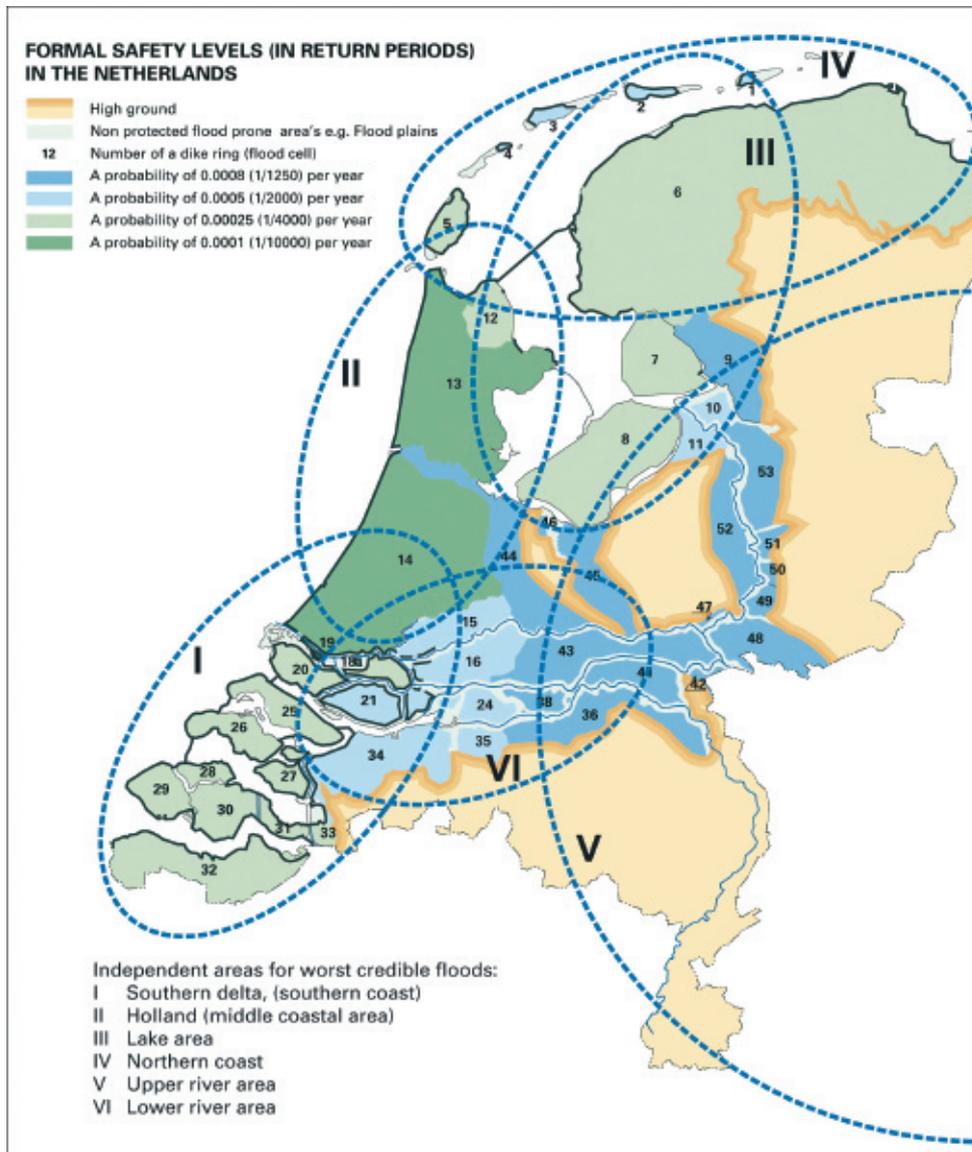


Figure 62: Worst Credible Floods and Safety standards for Flood Defenses (of 1996)

- Zone 1 Storm (\geq Beaufort⁵⁷ 12, >64 knots) in Zeeland en the South of Holland
- Zone 2 Storm (\geq Beaufort 12, >64 knots) the coast of Holland
- Zone 3 Storm ($>$ Beaufort 10 or 11) in het IJssel lake area, estuaries of the Vecht and IJssel
- Zone 4 Storm ($>$ Beaufort 12, >64 knots) in the Wadden sea area
- Zone 5 Discharge (discharge $>$ 4000 m³/s Meuse and $>$ 16000 m³/s Rhine river) en storm ($>$ Beaufort 6, 48-55 knots, to Beaufort 7, 28-33 knots) on the major rivers Rhine and Meuse
- Zone 6 Storm ($>$ Beaufort 10 or 11, 56-63 knots) and high discharges ($>$ 10 000 m³/s te Rhine and $>$ 3800 m³/s Meuse) for the Estuaries

International aspects

- Zone 1 means a storm, which affects The Netherlands, Belgium, England and the North Sea coast in France
- Zone 4 means a storm, which affects the Netherlands, Germany and parts of Denmark
- Zone 5 means discharges, which affect Germany, Belgium and Northern France (Meuse)

57 Beaufort wind scale, Developed in 1805 by Sir Francis Beaufort of England <http://www.spc.noaa.gov/faq/tornado/beaufort.html>

However the 1953 storm surge (NL, B, GB), the 1962 storm surge (Hamburg and Friesland NL), and the "Xynthia" storm in France (February 2010) show, that a coastal zone of 300 to 400 km can easily be affected by one storm [Kolen and Slomp et al, 2010]. So every disaster in the Netherlands for coasts or rivers is most probably also an international disaster.

The worst credible flood for the coast is determined by using a 100 000 year event (a 0.000001 probability) and a 10 000 year event (0.00001 a probability) for the rivers. Using water levels at higher return periods is a practical way to distinguish between floods. Even though a 1 in 100 000 year event is outside the bounds of the model. Along the coast and rivers a change in return period of a factor 10 is about 70 cm to 1 meter.

7.2.2 *Capability Based Planning*

Capability Based Planning as a tool was developed by the military for "war games". Essentially it is an important means of determining what your minimal needs are in case of a rare event and comparing these minimal needs to the maximum capacity emergency services can deliver. In this case the rare event was the worst credible flood and the current system of flood protection. If the needs cannot be met – a new strategy may be needed to reduce the number of potential fatalities.

The most essential tasks were determined first:

- Reducing the number of people to be evacuated
- Determining which areas suffer the most from flooding
- Evacuating the people who are not self-reliant from these area's
- Organizing traffic for the self-reliant

Results of the capability based planning exercise

For each worst credible flood simulation per region it was possible to reduce the number of fatalities to acceptable numbers. Except for one area, the south of Holland cannot be evacuated prior to the storm over the road. The window of opportunity for evacuation between the flood warning and the storm is too short. During the storm it will be impossible to evacuate. Once the storm trajectory is known there is less than 24 hours to evacuate. Even if the evacuation is decided with a 20% probability of the storm trajectory, evacuating 4.3 million people within 72 hours is almost impossible [BZK, 2008] and [Kolen and Helsloot, 2011]. Even a temporary evacuation to nearby higher ground is impossible because there are large groups of people who cannot evacuate on their own (0.5 million).

On the other hand, evacuating hundreds of thousands of people from a flooded area within three or four days after a flood is also impossible. The elderly, sick, and incarcerated are not independent or self-reliant. For this region, the south of Holland, increasing and maintaining the safety standards of the current flood defenses seems the only solution.

7.2.3 Results of the TMO "Waterproof exercise"

The TMO [TMO, 2009] "Waterproof exercise" showed there was a large difference between the twenty-five safety regions in the Netherlands. Some areas like the "safety regions" in the province Gelderland have held (international) flood exercises regularly for more than ten years. For other areas in the Netherlands this flood exercise was the first they had ever held. The safety region, which is responsible for the safety at "Schiphol" the National Airport, did not participate, because of other priorities.

One of the main purposes of the National Flood exercise was to have all levels of government involved and then to have the emergency services in the "safety regions" working together with the regional and national water authorities. Especially collecting, processing, disseminating information and the decision making processes were exercised together, as if it were a live situation. This part of the exercise was a success. People had prepared for months on their individual roles. They were free to focus on and practice on working together under pressure. This made it possible to identify and address issues in need of improvement. The government reacted in a policy statement⁵⁸.

Due to the "TMO" and the "Waterproof" exercise the government has focused on:

- Disaster communication, making people aware of the possibilities of disasters in their areas.
- The coordination and decision making process
- Making disaster response plans
- Improving the communication between regional and national water authorities
 - A national group for analyzing and flood alerts, 7 to 10 days before the event occurs (based at Rijkswaterstaat Lelystad). This group has staff from the meteorological office "KNMI", regional water authorities and the national water authorities.
 - Instruments (e.g. "Fliwas", "Infraweb") for rapid dissemination of information between the regional water authorities and the national water authorities

The first three issues have been addressed by the Ministry of Security and Justice:

- The campaign "Denk Vooruit" of paragraph 2.3
- A number of decrees which clarify the law on the "safety regions, and the national handbook on the decision making process during crisis "Nationaal Handboek Crisisbesluitvorming" [BZK, 2009]⁵⁹
- The elaboration of regional plans from 2010 to 2011 and two national plans: National Evacuation plan (see paragraph 7.4) and the National Crisis Plan⁶⁰. The National Crisis plan describes responsibilities of all involved for the preparation of the plans for safety regions and the operational process during a crisis. This is a more detailed account of devolved and central responsibilities, roles of each agency or organization and the communication process.

58 TMO+kabinetsreactie+juni+2009&hl=nl&gbv=2&gs_l=hp.12...968.13185.0.16263.57.15.0.42.2.0.94.952.15.15.0...0.0.tNCnqj28V_U&nfr=1&spell=&oq=TMO+kabinetsreactie+juni+2009

59 <http://www.nederlandalert.nl/overheid/a.-Nationaal-Handboek-Crisisbesluitvorming.pdf>

60 <https://www.nationaalcrisiscentrum.nl/document/ontwikkeling-nationaal-crisisplan>

The last issue has been addressed in the National Water Plan; it covers the integrated water management and flood risk management policy from 2009 until 2013. The multi layer flood risk strategy "Meerlaagsveiligheid" of paragraph 2.3 is an important issue. This has also been addressed in the Delta program, see paragraph 4.7. The multi layer flood risk strategy should be seen as an analytical tool, identifying and addressing missing links and issues in our flood management policy. It is not a new concept for flood risk management.

7.3 **Communication between emergency services**

There are three "closed" communication systems for communication between emergency services and other state organizations:

- "C2000" A new mobile system, according to the latest European standard
- "NCV", a new fixed system for communication between all governmental, municipal, provincial offices, the communications centers of the emergency services and the utilities services.
- "Nafin", Netherlands Armed Forces Integrated Network

The emergency services (police, ambulances, and fire- and rescue services) have a mobile communication system C2000. This new system was introduced in 2001. It is no longer possible to listen in on the police channels on the radio. Since 2009 the number of ground stations has been increased to enhance the availability during a crisis. The antennas (ground stations) are connected to coordination centers by the "Nafin" (Netherlands Armed Forces Integrated Network) ground lines. The coordination centers host the emergency services call centers for the general public (112 in Europe).

The "NCV" an independent fixed telephone system that replaces an older system "Nationaal Noodnet", installed in 1991 with 6000 analogue telephones in all government offices (municipal, provincial, national), emergency services coordination centers, and utility services offices (public transport, water, gas and electricity). The system was for phone calls and faxes. The new system also allows electronic transfer of data.

Rijkswaterstaat and the water boards (regional water authorities) are not yet connected to mobile service C2000. However their offices are connected to the fixed phones of the NCV. As Rijkswaterstaat is often the first responder on waterways and highways, this is still considered to be a handicap. Professional mobile phones are used to communicate. In June 2012 all mobile phones at Rijkswaterstaat for personnel involved in accidents on rivers, the sea, and highways, flood alerts, water quality disasters have received roaming capabilities within the Netherlands. They are now independent of their normal provider.

If necessary the following networks can be connected to the C2000 system at a moments notice:

- The mobile communication systems of the "Marechaussee"⁶¹, formally they have tasks as military police and as the border police.
- The voluntary sea and lake rescue units <http://www.knrm.nl/>
- Foreign assistance from emergency services in neighbouring countries.

61 <http://www.defensie.nl/english/marechaussee>

For situation reports and other digital information sharing during a crisis there are two information networks:

- CEDRIC⁶² for the safety regions
- “Infraweb”, maintained by the national Water Authority, accessible to other organizations through internet

“Infraweb” has been used by Rijkswaterstaat the national Water Authority for chemical spills in rivers and incidents on major waterways since 2000. Since a chemical spill on a river travels from one area to the next, all relevant information has to be passed on from one area manager to the next.

7.4 Mass Evacuation strategy

In the National Risk Assessment of 2008 and in the TMO exercise Waterproof (2007) it was clear river area’s can be evacuated in time, densely populated areas along the sea coast cannot. Along the coastal areas the presented worst credible flood scenarios were considered so extreme that in many safety regions flood scenarios were no longer used in disaster planning, as was also the case before 2007. “The scenarios were numbing”. This happened even though scenarios with a lesser impact had also been provided. The Ministry of Security and Justice therefore decided to develop generic tools for effective planning and decision⁶³ making. One of these tools is the national evacuation strategy for all types of disasters [Ministry of Security and Justice, 2012]. In this way each safety region can prepare systematically for its own specific characteristics, based on the available capabilities. The most important issue is preparing tools and training the personnel who have to advise the decision makers.

Scenarios have to be prepared beforehand and thought through carefully. One has to be prepared at all times to deliver an assessment on a disaster /incident scenario and advice on proposed interventions, e.g. evacuation.

Making these assessments takes a lot of time. The different types of threats and response strategies have to be developed beforehand. In the end you need a short summary e.g. table 5.

Three Scenarios	Proposed interventions	Costs	Benefits
What has been predicted	e.g. - evacuation - the advice to stay inside -		
Worst Credible			
Scenario does not occur			

Table 5: example of what type of information is necessary for a decision maker on account of an incident/disaster.

62 <http://www.vr-rr.nl/smartsite.dws?id=1928>

63 [BZK, 2009] National Manual on Decision-making in crisis situations

A number of new issues are covered in this national evacuation strategy document:

- Responsibilities and Roles, escalating between the regional and national levels,
- Communicating clearly with the general public
 - About the scenario and what is at risk
 - About what the government can do and cannot do or provide
 - About what the public should do, to reduce the loss of life and living conditions
- Communication between different organizations involved

Note: Operational preparedness for different scenarios depends on the characteristics of each region,

If a major flood event occurs the general public will have to be self reliant or resilient for a number of days. This is due to the scale of the event. This was an assumption in the TMO2007 study, and now policy [BZK, 2008a]. This was a main part of the campaign on disaster preparedness "Denk Vooruit"⁶⁴. In large incidents the general public will also most probably be the first responders. This was also the case in the Netherlands. The emergency services will have to focus their efforts on reducing the number of fatalities. This means that if an evacuation order is given, the efforts of the emergency services will be focused on traffic control and on non self reliant groups. This also means people who do not comply with an evacuation order, will not forcibly be evicted. Resources for evacuating the unwilling simply are not available.

A number of organizational and legal issues have to be covered if the general public is to be involved more effectively in the response to disasters [Frerks, G. 2011]. Citizens are often first responders. They take initiatives, save and rescue disaster victims adequately. They are on the ground before professional responders have arrived. The emergency services are professionalized top-down institutions. Communication to the public is often reduced to a strict minimum. This reduces the effective use of the general public. This means a mind /paradigm shift is necessary in these organizations. Another issue is that the current disaster awareness campaigns do not seem to have reached the general public. Involving local community groups may be a solution e.g. the Red Cross, churches, other religious and local organizations. Furthermore, there are some legal issues which should or could be addressed. For example, who covers damages or destruction caused by first responders who are not professionals?

⁶⁴ <https://www.nationaalcrisiscentrum.nl/thema/risicocommunicatie/denk-vooruit-campagne>

8 Conclusions

The existence of the Netherlands and our living standards depend on an efficient flood risk management. This is one of the main reasons this dossier is not really a partisan issue in politics. As you can see from this book, our society and our climate are not static. Flood risk management policy, legislation and organizational structures have greatly evolved. This is a permanent process.

8.1 Organizational improvements

In the last fifty years large changes can be seen in the organizational structure. A number of issues and lessons are not only important to the Netherlands but also for other countries.

- The tasks of organizations evolve, as society and legislation becomes more complex solutions have to be found to cope with:
 - Spatial planning and urbanization;
 - Transport;
 - Risk management
 - Protection of the environment we live in
- There should be only one organization for a each governmental task, this is efficient, avoids mistakes and the public expects this
- Policy, Inspection, Management issues should be separated within an organization, for transparent discussion and deliberation.
- Society needs professionals to carry out these tasks
- Proper long term funding is essential
- Implementing the “one stop” policy. Citizens or businesses in need of a permit want to talk to one single “administration/authority” on a local municipal level for all matters concerning spatial planning, local building codes, environmental issues and nature conservation. The central state agencies, provinces and municipalities should organize this in a way that a citizen or business does not notice, there are different organizations working for them.

The need for adequate organizations, which can deliver on the complex issues for a modern society, reduced the number of municipalities from 1 200 (in 1850) to 400 and water boards (regional water authorities) from 2500 to 25 regional water authorities.

8.2 Legislation, necessary for organizational improvements

Large organizational changes, as described in the previous paragraph, can only be carried out successfully with adequate legislation. Every important law takes about 5 to 10 years to prepare, on average two to three governments. Organizational change is a long process.

European Directives are necessary and sometimes refreshing. Current legislation has to be reviewed. Are all issues properly addressed? Can issues be treated in a more efficient way? Are different laws inconsistent?

Is legislation explainable to an average citizen?

For flood risk management, and especially flood protection issues, adequate and long term funding is essential. One of the main issues is adequate local funding for maintenance and national solidarity for large-scale reconstruction. Since water boards (regional water authorities) have grown over the years, regional solidarity for large-scale reconstruction is now also a possibility.

There is a conflict of interest between flood risk management measures covered by the Water Act, "Waterwet", and the legislation for nature conservation. More flexibility on a national and European scale is needed to ensure protection against flooding (and life loss) and to ensure natural environments are not further degraded.

8.3 Spatial Planning and the voluntary lack of insurance policy

Commercial insurance policies without assistance from the state are not viable in the Netherlands for primary flood defenses. For secondary flood defenses however this is possible.

Building outside of flood defenses along the coast, along rivers and large lakes has been severely restricted, especially since 1996. Along the large lakes it is possible to build flood proof housing. Usually the new urban developments are raised above the flood levels and wave action is reduced through breakers.

Societal pressure, to reduce restrictions on urbanization in zones at risk from flooding, remains large. Society only has two solutions: adequate organizations capable of making difficult choices and adequate legislation. Every proposal, especially in urban environments, has to be evaluated carefully. For urban developments in all the protected areas, with 10 million inhabitants, a non-binding flood risk and water management assessment water "toets" or test is carried out by the water boards. In essence the Netherlands is still developing this relatively new spatial planning tool the "Water Test".

8.4 Management of Flood defenses

Three important Directives: The Floods Directive, Water Framework Directive and Marine Strategy Framework Directive have been transposed into national legislation. Measures have to be taken on a regional and local level.

The organizational structure has a number of specific characteristics:

- A single organization is responsible for flood risk management per "dike ring", a continuous line of flood defenses.
- The same organization, the regional water authority, is responsible per dike ring for flood defenses both primary and secondary, and for the waterways.
- A national water authority manages the waters outside of the protected areas.
- An independent organization is responsible for inspection of both water quality and the management of flood defenses.
- Because policy, inspection and management of flood defenses and waterways are separated transparent discussions are possible every time municipalities, provinces, water boards (regional water authorities) and the state launch new initiatives.

The process of improvement of flood defenses has a number of characteristics:

- A regular and compulsory (5 or 6 yearly) national assessment of flood defenses, with a report to parliament.
- Parliament has to vote a budget to cover the expenses of the reconstruction of flood defenses.
- The flood protection standards, hydraulic boundary conditions (water levels and waves), and flood defense assessment rules are a set by a central national authority. This makes the assessment results comparable.
- An adaptive strategy for flood defense assessment and reconstruction observed climate change is taken into account in the assessment process and predicted climate change in flood defense design.
- There are no strict rules for flood defense design; innovation is promoted. The designer has to prove his design is safe.

8.5 Predicting storm surges and river floods and communicating the right message

Flood alerts have improved since the 1953 disaster:

- The first issue is to put the meteorologists and hydrologists in a single building, to improve the quality and speed of flood alerts. If one has flash floods it may be important to regroup even more services in the same building e.g. response and recovery.
- Meteorology has progressed since 1953. These techniques are available on a global scale.
- Flood alerts have to be understood. They should provide explicit information for each user, so flood alerts have to cater to emergency and rescue services and especially also to the general public. The general public has to understand the scale of the problem and what they can do to reduce their own risk.

8.6 Crisis management

The role of emergency services is clearly defined. The local authorities manage local disasters. The mayor of a town is responsible. If more than one municipality is involved, the "safety region" is responsible. The mayor of the most important town (also the head of the police region) immediately receives decisive responsibility. These safety regions regroup the emergency services and the public health authorities. These safety regions have permanent liaison officers from the water boards, Rijkswaterstaat (manager of highways, major waterways) and the Ministry of defense. If the 5 national interests are threatened the minister of Security and Justice is responsible. The role of the provinces has been greatly reduced in disaster management. As a disaster grows in scale centralized authorities take over coordination and communication roles⁶⁵.

On the ground, in the disaster area, the operational incident manager, from the fire and rescue department is responsible.

⁶⁵ An industrial fire at "Moerdijk" in 2011 and large-scale soil, water and air contamination over a large part of the south-western Netherlands showed the "safety regions" use. The scale of the disaster overwhelmed the mayor of "Moerdijk". Within 24 hours the Mayor of Breda and the safety region seamlessly took over. In the follow-up the Mayor of "Moerdijk" chose to use an early retirement option and was replaced by a temporary mayor. The operational units and operational command on the ground were not hindered. A river flood during just days after this fire, caused for additional concerns on a national scale, agriculture in this region depends on a sufficient supply of fresh water from the Rhine and Meuse. This issue was managed adequately.

Even after reducing the number of municipalities from 1000 to 400, the size of municipalities remains relatively small. Disasters are often managed by the "safety regions".

8.7 Emergency Services, Crisis management teams and Water Authorities need to work together

Since Katrina in 2005 in New Orleans, the Netherlands has rediscovered the fact that absolute safety does not exist. There is also a role in flood risk management for "civil protection issues" as evacuation and rescue units. The last major flood incident was in 1995. The emergency services in the safety regions and the managers of flood defenses need to prepare together for major incidents. In 2007 a major flood risk exercise was organized to bring both types of organization together on a national scale. 15 000 professionals participated in the preparation (a two year period) and the exercise itself (which lasted a week). Both organizations use a different professional language. Identifying the others' organizational information needs before a crisis is essential. Knowing who is on the other side of the phone line before a crisis is also essential. This exercise has to be held every 5 years; in November 2012 the next exercise will be held.

Citizens are often the first responders. They are already on the ground when a disaster strikes. They act rationally, take initiatives, save and rescue disaster victims adequately. Their effectiveness can be improved if they are involved before disasters (through local community groups e.g. red cross, religious groups and other formal or informal institutions). A crisis communication which gives exact and timely information on the crisis and "options" for the population also improves the effectiveness of citizen "first responders".

8.8 Main References

These four books cover most water management issues in the Netherlands. Even if some issues are no longer valid, they give a good insight in how flood risk and water management in the Netherlands really works.

The organizational structure:

Water Governance, The Dutch Regional Water Authority Model

[Unie van Waterschappen, 2010]

Water Management in the Netherlands, Rijkswaterstaat,

[Geo Arnold et al, 2010]

How water management really works :

Water in the Netherlands, managing checks and balances,

[Pieter Huisman, 2004]

The philosophy behind water flood risk management in the Netherlands:

Fundamentals on Water Defenses, Guidelines for Water Defenses

[Technical Advisory Committee on Water Defenses, 1998]

9 References

- [Alphen, J. et al, 2011] Flood Risk Management Approaches, As being practiced in Japan, Netherlands, United Kingdom, IWR report no 2011-R-08, MLIT (Japan),USACE, Rijkswaterstaat (the Netherlands), Environment Agency (UK)
- [Arnold, G., 2010] Water Management in the Netherlands, Rijkswaterstaat, Geo Arnold et al, 2010 Arnold, G.;Bos, H.;Goud, R.; Kielen, N.;Luijn, F.
- [Beekmans, 2002] Powerpoint presentation, Rijkswaterstaat. 2002, Beekmans, C.
- [Brekelmans, R.C.M., C.J.J. Eijgenraam, D. den Hertog, C. Roos, 2012] Safe dike heights at minimal costs: the nonhomogeneous case, Accepted for publication in Operations Research.
- [Breman, et al, 2008], Participatie in Waterbeheer, Een vak apart, Breman, B.; Pleijte, M.; Ouboter, S.; Buijs, A. 2008
- [ten Brinke et al, 2010], W.B.M. ten Brinke, Kolen, B., Dollee, A., van Waveren, H., Wouters, C.A.H.: Contingency planning for large-scale floods in the Netherlands. Journal of Contingencies and Crisis Management, 18 1 (2010)
<http://onlinelibrary.wiley.com/doi/10.1111/j.1468-5973.2009.00594.x/abstract>
- [BZK, 2007] National High Water and Flooding, Emergency Response Plan Part 1: Policy Scenario, National Security Department, Ministry of Interior, January 2007.
- [BZK, 2008a] Ministry of Interior, Nationale Risicobeoordeling
- [BZK, 2008b] Ministry of Interior, Capaciteiten Analyse voor de taak [grootschalige overstrooming]
- [BZK, 2009] Ministry of Interior, National manual on decision-making in crisis situations (English), Note: update will be available in 2012 (in Dutch), Ministry of Security and Justice
- [van Dantzig, D. 1956] Economic decision problems for flood prevention, Econometrica 24: 276–287.
- [Duin, R.H.A. van and Kaste, G. de, 1990], The Pocket Guide to the Zuyder Zee Project by (200 pages) ISBN: 90-6914-012-8.
- [Eijgenraam, 2003], Economische criteria voor de hoogte van dijken, CPB Netherlands Bureau for Economic Policy Analysis, The Hague.
- [C.J.J. Eijgenraam. 2006] Optimal safety standards for dike ring areas. CPB Discussion Paper 62, CPB Netherlands Bureau for Economic Policy Analysis, The Hague.

[Eijgenraam, C.J.J., 2007]. From optimal to practical safety standards for dike-ring areas; "Water Science and Technology", volume 56, issue 4, pp. 113-124, (journal of the International Water Association). Also published as CPB Memorandum 213, CPB, Den Haag, January 7th, 2009.

[ENW, 2009], Leidraad Rivieren, 2009

[ENW, 2011] Post-flood field investigation in the Lower Chao Phraya River Basin 23-27 January 2012, Findings of the Thai –Dutch Reconnaissance Team.

[European Commission, 2011] EU Guidance on inland waterway development and management and Natural.

[Frerks, G. 2011] Citizens and Flooding in the Netherlands, Netherlands US Crises Research Network, NUWCREN, May 2011

[Huisman, Pieter 2004] Water in the Netherlands, managing checks and balances, Netherlands Hydrological Society, 2004

[Inspectie Water 2011] Regionale keringen, Aanwijzing en normering door provincies, 2 februari 2011, Ministry of Infrastructure and Environment,

[Jongejan R.B., S.N. Jonkman, J.K. Vrijling, 2012] The safety chain: A delusive concept, paru en Safety Science 2012 (pages 1299 -1303)

[de Jong, 2004] Origin and prediction of seiches in Rotterdam harbour basins, TU Delft 2004 <http://repository.tudelft.nl/view/ir/uuid%3Ad7ce7779-bf81-47b7-bc14-e01ce5e6856b/>

[Kind, J, 2011] Maatschappelijke kosten-batenanalyse Waterveiligheid 21e eeuw, 2011, Kind, J et al, Deltares.

[Kok, 2005] Een waterverzekering in Nederland: Mogelijkheid en wenselijkheid, Kok, M. HKV Lijn in Water, 2005.

[Kok et al, 2007], Twee jaar na Katrina, De catastrofale overstroming van New Orleans, Kok, Matthijs; van den Braak-Vermeij, Elmi; Kanning, Wim; Kolen, Bas; Thonus, Bart; Adams-Tonk, Aafke, TU Delft, HKV lijn in Water, 2007.

[Kolen B. and Helsloot, I. 2011] Time needed to evacuate the Netherlands in the event of large-scale flooding: strategies and consequences. Disasters: Journal of Disaster Studies, Policy & Management (Submitted)

[Kolen B. and Slomp et al, 2010] Learning form French Experiences with storm Xynthia, Damages after a flood, Kolen, Bas; Slomp, Robert; Balen, Wim van; Terpstra, Teun; Bottema, Marcel; Nieuwenhuis, Stefan, September 2010

[Kolen, B. et al 2012] Flood preparedness in The Netherlands a US perspective, Netherlands US Water Crisis Research Network (NUWCRen), Editors: Bas Kolen (HKV) | Saskia Hommes (Deltares) | Eric Huijskes (Deltares), 2012

[Kors, A.G., 2002], The DSS "Planning Kit" and its application in the Spankracht study, Kors, A.G. published in Lowland Technology.

[Kroos, Jan. 2012], PowerPoint presentation WMCN, Rijkswaterstaat

[Kurstjens, Gijs and Peter, Bart, 2012] Rijn in Beeld, Deel 1 Ecologische resultaten van 20 jaar natuurontwikkeling langs de Rijntakken, Deel 2: inrichting, beheer en beleid langs grote rivieren. Internet link: <http://rijninbeeld.nl/>

[MNP, 2004], Milieu- en Natuurplanbureau, ten Brinke, W.B.M. and Bannink, B.A., may 2004, Risico's in Bedijkte Termen, een evaluatie van het beleid inzake de veiligheid tegen overstromingen

[Ministry of Security and Justice, 2011] NL-Alert testrapport Datum 29 septembre 2011 <http://www.nederlandalert.nl>

[Ministry of Security and Justice, 2012] Strategie Groot Schalige Evacuatie, 2012.

[Ministry of Transport, Public Works and Watermanagement, 2010] Landelijk draaiboek hoogwater en overstromingen, Landelijke opschaling, informatievoorziening en afstemming voor de waterbeheerders en het ministerie van Verkeer en Waterstaat, Deel A, algemeen deel, sept 2010.

[NWP, 2011] Rapport concernant l'adaptation de l'enseignement au marché de l'emploi dans le secteur de la technologie de l'eau en France et aux Pays-Bas. - Analyse et solutions possibles

[PBL, 2010] Plan Bureau voor de Leefomgeving, Correctieformulering over overstromingsrisico, <http://www.pbl.nl/dossiers/klimaatverandering/content/correctie-formulering-over-overstromomgsrisico>

[Province of North Holland, 2012 et al] Bestuurlijke Netwerkkarten Crisisbeheersing, Provinces of North Holland, Overijssel, Flevoland and Gelderland, April 2012

[Rijkswaterstaat 2003] Mei 2003, Schade na een grootschalige overstroming DWW-2003-056, Stephanie Holterman, Martine Brinkhuis-Jak, Plony Cappendijk-de Bok, Koen Wouters

[Rijkswaterstaat, 2007] Brochure Risicokaarten, Rijkswaterstaat 2007.

[Rijkswaterstaat, 2007b] Rhine and Meuse, Two Rivers, Rijkswaterstaat 2007.

[Rijkswaterstaat, 2008a], Tom de Nijs (author) and Jan Al (editor); De Delta in Wording, Overzicht van het benedenrivierengebied door de eeuwen heen.

[Rijkswaterstaat, 2008b] Syntheserapport Compartimenteringsstudie Rijkswaterstaat Waterdienst, April 18th, 2008

[Rijkswaterstaat 2011] Definitiestudie Buitendijks in beeld MINISTERIE VAN INFRASTRUCTUUR EN MILIEU, April 7th, 2011, C03021.000064.0300

[Rijkswaterstaat, 2011b]. Basisrapportage Hoogwaterbeschermings-programma-2, juni 2011

[Roth et al, 2006] Een Noodverband tegen Hoog Water, Waterkennis, beleid en politiek rondom noodoverloopgebieden, Roth, Dik; Warner, Jeroen; Winnubst Madelinde, WUR

[Slomp, 2011] Tools for crisis management of floods, Slomp, R.M.;Kolen, B, Schaaf, Jaap van der, Montpellier Georisques 7, January 25th and 26th 2011

[Sprokkereef, 2010], Powerpoint presentation, WMCN, Rijkswaterstaat

[TAW, 1998] Technical Advisory Committee on water Defences, 1998 Fundamentals on Water Defences, Guidelines for Water Defences,

[TMO, 2009] Rapport Bevinden Task Force Management Overstromingen, 2009 <http://www.rijksoverheid.nl/documenten-en-publicaties/rapporten/2009/01/30/rapport-bevindingen-task-force-management-overstromingen.html>

[Unie van Waterschappen, 2010], Water Governance, The Dutch Regional water Authority Model,

[Van der Ham, 2004] Afleiden of opruimen, De strijd om de beste aanpak tegen het rivierbederf een beschouwing van 300 jaar rivierverbetering in het kader van de spankrachtstudie, Rijkswaterstaat RIZA, Dr Willem van der Ham.

[van der Ven, Dr. Ir. F, 2012] Water robust urban development TU Delft, Deltares.

Internet links :

Official website for information on Water Management and Flood Protection issues:
www.helpdeskwater.nl

Official website for crisis communication www.crisis.nl

"VNK-II, 2010", Floris II, internet link Rijkswaterstaat, www.helpdeskwater.nl
Research project Flood Risk (FLORIS II), determining the current flood risk
http://www.rijkswaterstaat.nl/water/veiligheid/bescherming_tegen_het_water/organisatie/veiligheid_nederland_in_kaart/

National Risk Maps (note: Hazard Maps): www.risicokaart.nl.
Official Rijkswaterstaat website in English: <http://www.rijkswaterstaat.nl/en/>
<http://www.ruimtevoorderivier.nl/meta-navigatie/english/>

"Wet op de Waterkering, 1996" Flood defence act (no longer valid)
"Wet op de Veiligheidsregio's, 2009", Safety region Act
http://www.eerstekamer.nl/behandeling/20090423/gewijzigd_voorstel_van_wet/f=/vi4zdr193pi2.pdf

"Water wet", Water Act 2009, http://wetten.overheid.nl/BWBR0025458/geldigheidsdatum_31-12-2009

"WTS", http://wetten.overheid.nl/BWBR0009637/geldigheidsdatum_23-06-2012

EU Risk Assessment and Mapping Guidelines
http://ec.europa.eu/echo/civil_protection/civil/pdfdocs/prevention/COMM_PDF_SEC_2010_1626_F_staff_working_document_en.pdf



Figure 63: "Dike Guard for flood defences", "dijkwacht" training commences at an early age, Kampen 2011, Source water board Groot Salland, Jan Put.



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