1. The Netherlands and Water

Water has always played a central part in Dutch history. On one hand it brought wealth to the Netherlands through trade and fishery; on the other hand it brought a number of losses through the many floods. To date water has remained important for the Netherlands. From a geographical point of view, the Netherlands are placed in a very favorable position; at the sea and in the delta (a triangular section of land at the mouth of a river) of four large rivers.

The Dutch surface area has almost doubled through centuries of “impoldering” (area drained and prepared for agriculture) lakes and parts of the sea. As a result of this impoldering almost 40 percent of the land lies below sea level. Areas include large parts of the highly populated and the economically important west, with cities such as Amsterdam and Rotterdam. To keep these areas dry, superfluous water is continuously pumped out of the polders. Furthermore, the Netherlands is protected from floods through a combination of levees, dunes, dams and barriers. After the last big flood of 1953, people decided to build the Delta Works; one of the largest built flood protection and water management projects in the world.
2. The North Sea flood of 1953

On the night of February 1st 1953, a combination of a spring tide and the associated North-Western storm on the North Sea led to a major natural disaster affecting the United Kingdom, Belgium and the Netherlands. In total 2,167 people were killed, of which 1,835 were from the Netherlands. This disaster has had a large influence on the way the Netherlands protects itself against the sea, today, and in the future.

2.1 Refuges, Levees and Polders

In the past, floods in the Netherlands occurred much more frequently. Herewith, sometimes thousands of people died. To protect themselves from the sea, people began to build refuges; the so called ‘vlietbergen’ or ‘terpen’ mounds. As the size of these mounds started to grow, small villages were built on top these hills. To connect the villages, people constructed small levees between them, through what polders arose. Thanks to the construction of levees and wind driven mills to keep the polders dry, the Netherlands grew larger, piece by piece.

2.2 Weakened levees

It already became clear that the levees were not tall enough to keep out high water levels, in the years before the North Sea flood of 1953. The total length of the levees was too long and they were weakened by both a lack of maintenance and through damage caused during the Second World War. A plan for structural improvement of the levees and the shortening of the coastline came arduously into action and so only a few small projects were actually carried out. By the end of January 1953, the Delta Commission presented the first report documenting the plans for the disconnection of the bigger sea arms for the protection from the sea. However, only a few days later, the inevitable happened.

2.3 Meteorological cause of the Watersnoodramp

The poor condition of many of the levees in the delta area became painfully apparent on the morning of the first of February 1953. On the 30th of January in the South of Iceland, a storm field with a huge depression behind it arose. It came from the North-West in the direction of the Netherlands and dropped large amounts of water in the direction of the strait of Calais. This narrow passage served as a funnel, propelling the water more and more, while the water levels gradually rose. The situation worsened under the influence of a hurricane that formed on the edge of Scotland. In some places in the Netherlands the water already started to stream over the levees. On the night of the 31st of January the storm became stronger above the North Sea, and the coastal areas saw wind speeds of force 10 on the Beaufort scale. In addition, the storm was combined with the spring tide, whereby under the influence of the position of the sun and the moon, the water rose much higher then it usually would.
The highest water level was reached at 03.24 a.m. that morning: 4.55 meters above the N.A.P. The levees were not designed to withstand these high levels and the first levees failed before the highest level was reached. In total 89 levees were destroyed.

2.4 Devastating power of the sea
Many people woke up frightened by the water that night. Houses collapsed due to the power of the streaming water and the raging storm. The severity of the situation in the affected area was however not yet visible to the outside world. The situation worsened when it became high-tide again later in the afternoon of the first of February. This flood took the most lives. Due to the fact that most of the levees were already destroyed, the water rose in the polder to an even higher level. Many of the houses that had survived the first flood were destroyed in the second. For many, help came too late.

2.5 Aid
Due to the flooded transport links, it was a long time before the rescue operations could begin. The severity of the situation only became clear on Monday the second of February. Inhabitants from the affected areas were evacuated and goods and sand bags were dropped via airplanes. A large aid program began, from within and far outside the Netherlands.

2.6 Recovery of the struck areas
Minister Drees announced on the 4th of February 1953, in the Second Chamber, that the recovery of the levees would receive the highest priority. Additionally, the government started the Delta-commission, led by the director-general of the Department of Waterways and Public Works, Mr. Maris. Meanwhile, volunteers and levee workers worked hard to close the holes in the levees as effectively as possible. Where the holes were too large they were closed with so called unity caissons. The area was officially declared dry at the end of 1953.
The consequences of the flood were catastrophic.

- 1,835 people died as a result of the disaster
- 200,000 cattle drowned
- 200,000 hectares of soil flooded
- 3,000 houses and 300 farms were destroyed
- 40,000 houses and 3,000 farms were damaged
- 72,000 people were evacuated
- 91 km of levees were heavily damaged in Zuid-Holland with holes of up to 1 km
- 10 km of levees were heavily damaged in Noord-Brabant
- 38 km of levees were heavily damaged in Zeeland with holes of up to 3.5 km
3. The Delta Works

3.1 The Delta Commission

The Delta commission was initiated twenty days after the North Sea flood, on the 21st of February 1953. This commission gave advice on improving safety. This was a challenging task, as the Nieuwe Waterweg and Westerschelde had to stay open for economical concerns of the Rotterdam and Antwerpen harbor. The Delta commission finally gave five counsels which resulted in the Delta plan, on the 18th of October 1955. The plan would be carried out for 25 years whereby the costs were devised for an estimated 1.5 to 2 billion Dutch guilders (approximately 680 to 900 million Euros). To ensure the high quality building of the dams, the Delta law was accepted in 1959. As, the diverse parts of the Delta Works could not be completed simultaneously, the Department of Waterways and Public Works chose to follow a logical order: from small to large and from simple to complicated. The Department of Waterways and Public Works also took into account that protection from storm floods should be gained as soon as possible.
3.2 The dams

3.2.1 Caissons

The building of dams in the gullies was extremely problematic, due to the fast speed of the fluxing water. The sand and the stones which should shape the dam were washed away. Therefore a new technique was devised: Phoenix unity caissons. These are prefabricated hollow concrete boxes, which could be placed adjacent to each other in the water gully. In this way they could group together and form a dam. During transportation to the gully the caisson was temporarily blocked with wooden boards. Once at the destination the caissons were submerged and the wooden boards were removed. This way, all the caissons ended up next to each other, and became part of the permanent works. The dam initially had an open disposition whereby the sea water ebb and floodtide could almost flow back and forth through the hollow caissons unhindered. Once in place, the top part of the caisson was filled up with sand and gravel. Stones and sand were also added to the base of the caissons before gates embedded in the caissons were closed. Through lowering the gates, the sea arm was closed, and the dam could be completed. The Veersegaatdam and parts of the Grevelingendam, Volkerakdam, and Brouwersdam were completed using this technique.
3.2.2 Funicular railway
For some parts of the dams the caissons turned out not to be the best method for closing the gully. Hence, a revolutionary technique was used. Via a funicular railway, large concrete blocks, weighing about 2.5 tons each, were dumped into the water. A gondola was built that could carry 15 tons of material. With the help of pincers, the concrete blocks could be hung under the cabin. After dumping the huge concrete blocks into the sea, the dam was filled up with sand, so no water could flow through any longer. This technique was applied to the Grevelingendam, Haringvlietdam and Brouwersdam.

3.3 From salty to fresh
Where at first the sea water streamed in and out unhindered, the sea water was now sealed up behind the dams. The tide disappeared and the salt water turned fresh. This had major consequences for the nature. Saltwater fish and plants died and birds went away. Particular parts of the country which were originally always flooded were now dry. Other parts that were normally dry at ebb were now continuously under water.

3.4 Oosterschelde dam becomes a ‘kering’
Originally it was planned to dam the Oosterschelde. This meant that the water behind the dam would slowly turn to fresh water. Resistance quickly arose against this interference, as the unique salt water environment in the Oosterschelde would be the next ‘victim’ of the extra safety regulations. In 1976 people came up with an alternative: the Oosterschelde dam would become a barrier, where the doors would only be closed under extreme weather conditions. This way, the unique saltwater environment, the mussel and oyster cultivation and the working of the tides would remain natural. The storm surge barrier with a total length of 3 km would consist of 65 prefabricated concrete pillars, in between which 62 steel slides would be installed.
The soil on which the barrier would initially be placed was too weak. To strengthen the soil, a number of proceedings were carried out, for example, the placement of gravel filled synthetic mats, on which the pillars were placed.

The pillars were the most important elements of the dam. Each pillar is between 30.25 and 38.75 meters high and weighs 18,000 tons. The placement of the pillars was precision work and could only take place when the flux was as small as possible, that is, at the turn of the tide. The pillars were heightened with pieces between which the barrier gates subsequently would be assembled.

The Oosterscheldekeuring became the largest barrier in the world. The costs of a barrier were considerably higher than those of a dam: 2.5 billion Euros were needed to complete the barrier. The Oosterscheldekeuring received a celebratory opening, by Queen Beatrix, on the 4th of October 1986.

3.5 Measlandtkening
At first, people thought that with the Oosterscheldekeuring, the Delta Works were complete. However, the enhancement of the levees along the Nieuwe Waterweg would not sufficiently protect the surrounding areas, including Rotterdam. Therefore the Ministry of Waterways and Public Works organised a competition for the construction of a storm surge barrier. This barrier would be placed in the Nieuwe Waterweg. Due to the fact that this waterway is the main route into the harbor of Rotterdam, the barrier was not allowed to block the shipping route; and only in exceptional cases should the barrier be able to be closed. The winning design consisted of two curved steel doors that would be submerged to the bottom of the waterway on a threshold.

Maeslantkering is the only storm surge barrier in the world with such large movable parts; the storm surge barrier doors are both 240 meters long. Under normal weather conditions the two doors are fully open, stored away in a dock alongside the water. This allows ships access to the harbor of Rotterdam without any inconvenience. At storm tide the storm surge barrier doors are closed. The round shape of the doors ensures it can resist the power of the water during the storm. On Saturday the 10th of May 1997 the official opening of the storm surge barrier Nieuwe Waterweg at the Hoek van Holland took place. Thanks to this storm surge barrier, one million people are protected from the sea.

3.6 Importance of the Delta Works
Finally, the Delta Works were complete. However, the massive project cost more than the expected 680-900 million Euros. Altogether the Delta Works cost nearly 5 billion Euros. On top of the diminution of the total length of the sea averting levees by 700 km, the Delta Works have many more advantages. Firstly, the freshwater supply for agriculture is much better regulated. Additionally, the entire water management within the Delta area has been improved. The installation of the Delta Works has
been beneficial for the mobility and the inland waterways. Finally, the Delta Works influenced developments in the fields of economics, recreation and nature. Some nature areas were irrecoverably affected, but in other places nature values have been created or maintained.

The Delta Works are a global model for technological development whereby the safety of humans and nature play the central part. Thereby, the Netherlands have widened its look on safety and water. The Delta Works compose an unique compromise between safety, economy, recreation and nature.

Nonetheless, the accomplishment of the Delta Works does not mean a remission of consideration for water management in the Netherlands. The Netherlands face new challenges. Climate changes ask for a fundamental reflection on a permanent livable design of the Netherlands, for future generations.

Also, dried land turning brackish, land subsidence, and demands on water quality and ecology ask for new treatments. To care for these challenges responsibly the Netherlands will in the future invest in an enduring delta system, in change for socially acceptable expenses.
4. New water management in the Netherlands

In the Netherlands, dealing with water is a continuous struggle that has shaped the country’s culture and the way the Dutch perceive the world around them. As a result, the Dutch have turned the threat of living in a complex delta region into a series of opportunities, constantly innovating to produce new solutions and products that contribute to Dutch Delta Technology. Dutch Delta Technology is the Dutch integrated approach which enables living in delta areas. Besides the traditional, core disciplines water management and hydraulic engineering, it encompasses many fields of expertise such as spatial planning and ecology which add up to innovative solutions.

4.1 Our experience

The Netherlands is not just a flat low-lying country. A substantial part of it has been reclaimed from the sea! If there were no levees, dunes or storm-surge barriers, 66% of the country, including cities like Amsterdam, The Hague and Rotterdam would flood on a regular basis. Moreover, this flooding would consume the high-earning areas, which account for up to 70% of the country’s GDP.

The Netherlands is also a country with a high population density (465 people per square kilometer). This, combined with an economy largely related to transport, navigation and ports, results in pressure on space and environment that has to be managed carefully. To do this, the Dutch plan by involving relevant stakeholders, to design sustainable engineering solutions and ‘smart’ infrastructures for complex settings.

4.2 Our challenge

The Netherlands is challenged by two impacts of climate change: rises in sea level and changing rainfall patterns. The latter resulting in more frequent and increased peak discharges, as well as local droughts and wet periods. Like many other delta areas, the Netherlands are also vulnerable to land subsid- ence. However, environmental challenges are not the only problems the delta areas have to face. Considerable pressure is also exerted by population growth and the associated rise in demand for space and resources such as drinking water. The Dutch will continue to live in their delta for centuries to come, and therefore keep producing innovative solutions to face delta challenges.

4.3 Our approach

To help address the problems it faces, the Netherlands relies on a highly developed institutional setting and detailed plans for sustainable water management.
When developing appropriate measures, the Dutch begin by ensuring that they thoroughly understand the water system they are dealing with. The Dutch are world leaders in terms of their knowledge of hydraulics, subsidence, salt-water intrusion, and aquatic ecology. And, they recognize the importance of integrating this understanding of natural systems with efforts to address the socio-economic aspects of systems at a larger scale (in river basins) and at a smaller scale (in urban areas).

4.4 Our action
Many projects are currently being implemented in the Netherlands to secure more ‘Room for Water’. For example, until recently it was standard policy to raise the crest levels of the levees to maintain the required level of flood protection. This centuries old policy was abandoned in 2000 in favor of ‘Room for the River’. In the new policy, river cross sections are widened by situating the levees further away from the river, or by lowering the river forelands. Care is taken not to affect valuable features of landscape, nature and cultural history. The approach aims at a balance between present and foreseeable future spatial requirements, keeping an open eye for every opportunity to enhance safety as well as the master landscaping and the improvement of overall environmental conditions.

4.5 Our vision
To treat the challenges of the future responsibly the Netherlands will continue with the development of innovative plans, products and services, which will be good for the situation in the Netherlands. Above that it may be of international use. We will accelerate the innovation-cycle through a better cooperation in authorities, knowledge institutions, market parties and social organizations; to bring together different assessment-fields of expertise. At the moment all its interesting development are visible, like risk-based design solutions, innovative levee and levee reinforcement and levee inspection techniques, flood warning systems, and expertise in multiple land-use. The Netherlands is a pilot project for innovative delta-solutions, enabling delta-life.
Information about this initiative

“Deltawerken Online - International Summaries” is an initiative of the Delta Works Online Foundation. It is our aim to translate the summaries into as many languages as possible to enable people to print, share and read information about the Delta Works and water management in the Netherlands in their own language.

A team of students and professionals worked in close collaboration with many volunteers to prepare the various translations, create the pdf-documents and integrate the translations into the website.

More language versions needed!
Translations of the summaries are submitted, corrected and maintained through the use of a Wiki. For the latest developments you can visit our wiki at:
http://www.deltaworks.org/wiki/

We encourage each and every person to submit a translation of our text into their own language through the wiki! We will make sure your text is incorporated into the pdfs and website!

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