Rijkswaterstaat
Ministry of Infrastructure and Water Management

Storm Surge Barriers
in the Netherlands & I-STORM

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I-STORM
INTERNATIONAL NETWORK FOR STORM SURGE BARRIERS

Content of presentation

1. Personal introduction & introduction to Rijkswaterstaat

- *It's organisation and tasks*

2. The Netherlands

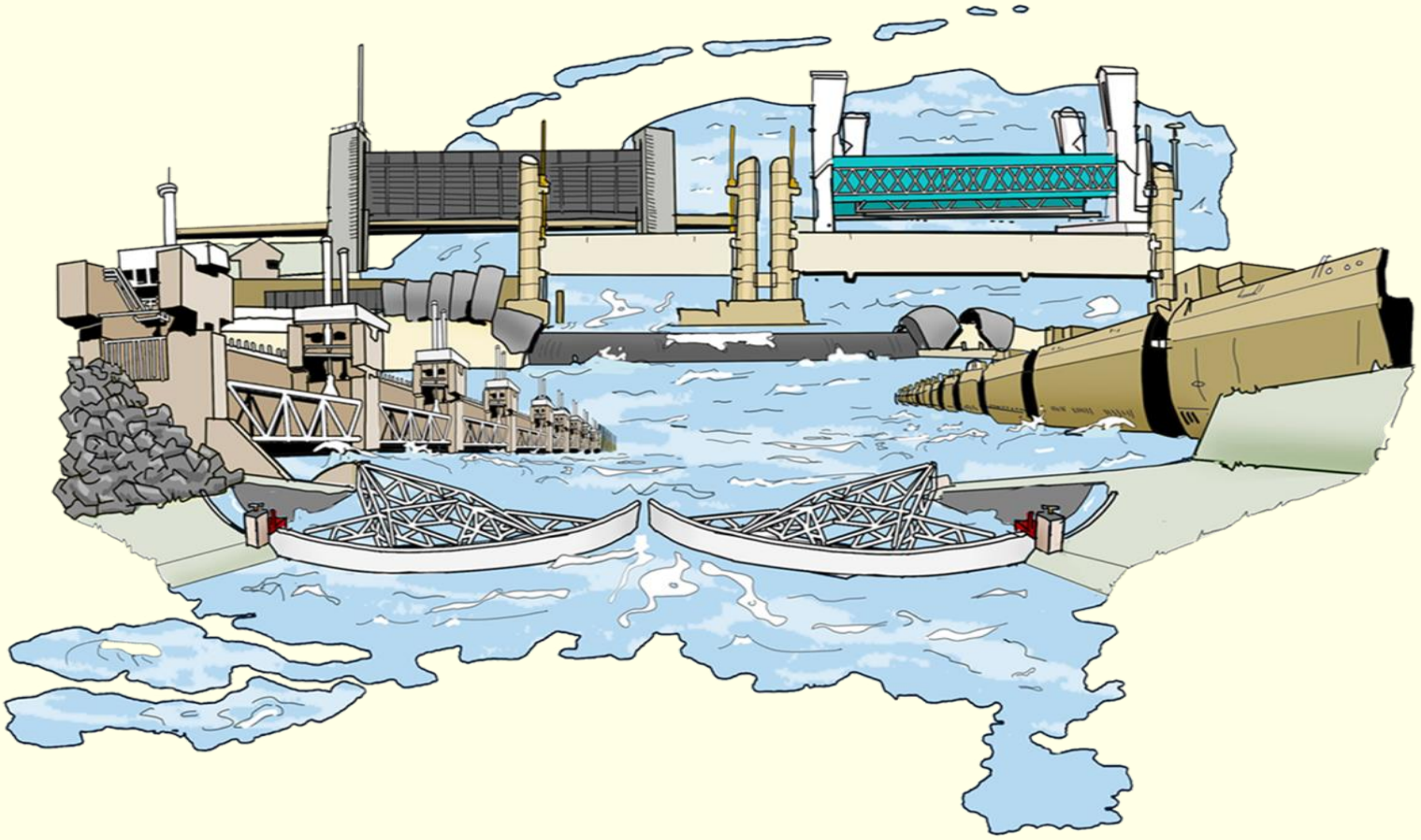
- *History of flooding, recovery & consequences*

3. Storm surge barriers in the Netherlands

- *An overview and impression*
- *Lessons Learned*
- *Closure of Maeslant Barrier*

4. I-STORM

- *Examples of sharing scarce knowledge and expertise*



What we have in common

Galveston, after Ike in 2008

New Orleans, after Katrina in 2005

London, 1953

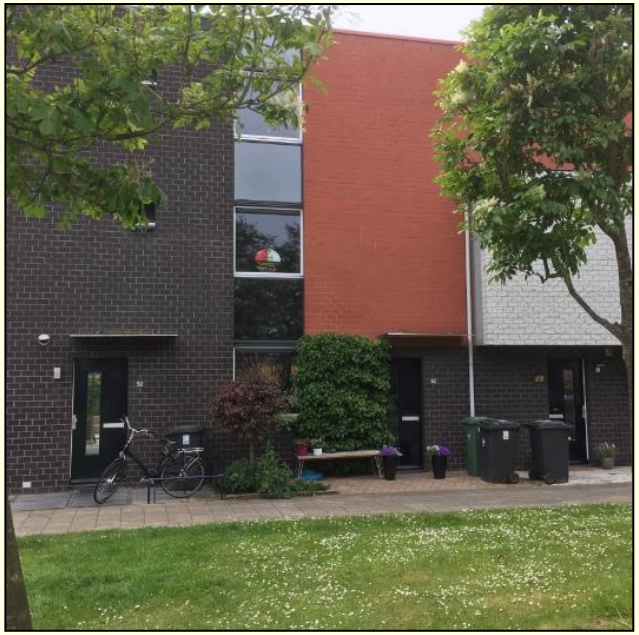
Netherlands, 1953

What we have in common

Storm surge pole, Ribe Harbour

My home

Let me take you on my bike . . . .
on a personal journey
of experiences regarding
Storm Surge Barriers



- 4m under mean see level

Marc Walraven, M.Sc.

- Formerly District Manager and responsible for management and operations Rotterdam storm surge barriers
- Senior advisor Storm Surge Barriers (Ministry of Infrastructure and Water Management, the Netherlands)
- Leader Operations Team Maeslant Barrier
- Co-founder and Member of Delivery Board I-STORM network

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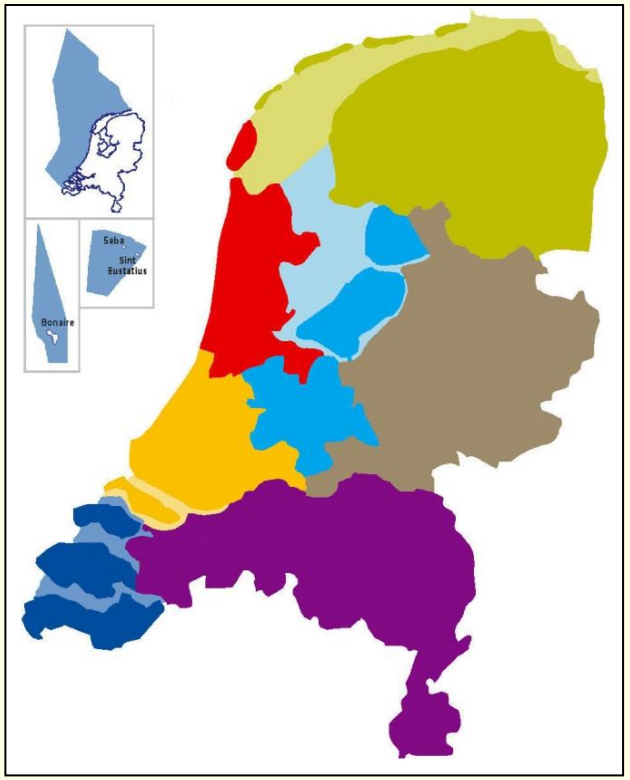
Introduction to Rijkswaterstaat

- Rijkswaterstaat was founded in 1798 to take control of public works and water management in the Batavian Republic (1795-1801)
- Rijkswaterstaat now is the executive organisation of the ministry of Infrastructure and Water Management
- It's mission:
  - protection against floods
  - sufficient and clean water
  - a smooth and safe flow of transport on the national highways and the main waterways
  - reliable and useful information
  - a sustainable environment
- Around 8.500 employees
- 7 Regional and 6 central departments



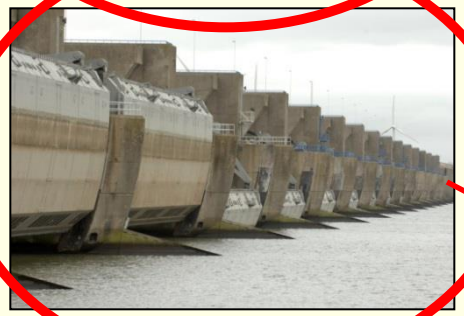
Introduction to Rijkswaterstaat

Rijkswaterstaat – it's water related assets:

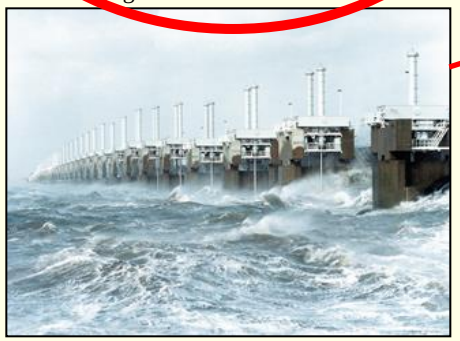
- 90,310 km² of surface water
- 35 kilometres of dunes
- 201 kilometres of dikes and dams
- 10 weirs
- Afsluitdijk and Houtribdijk (two dikes)
- **And 6 Storm Surge Barriers**

Dutch Storm Surge Barriers

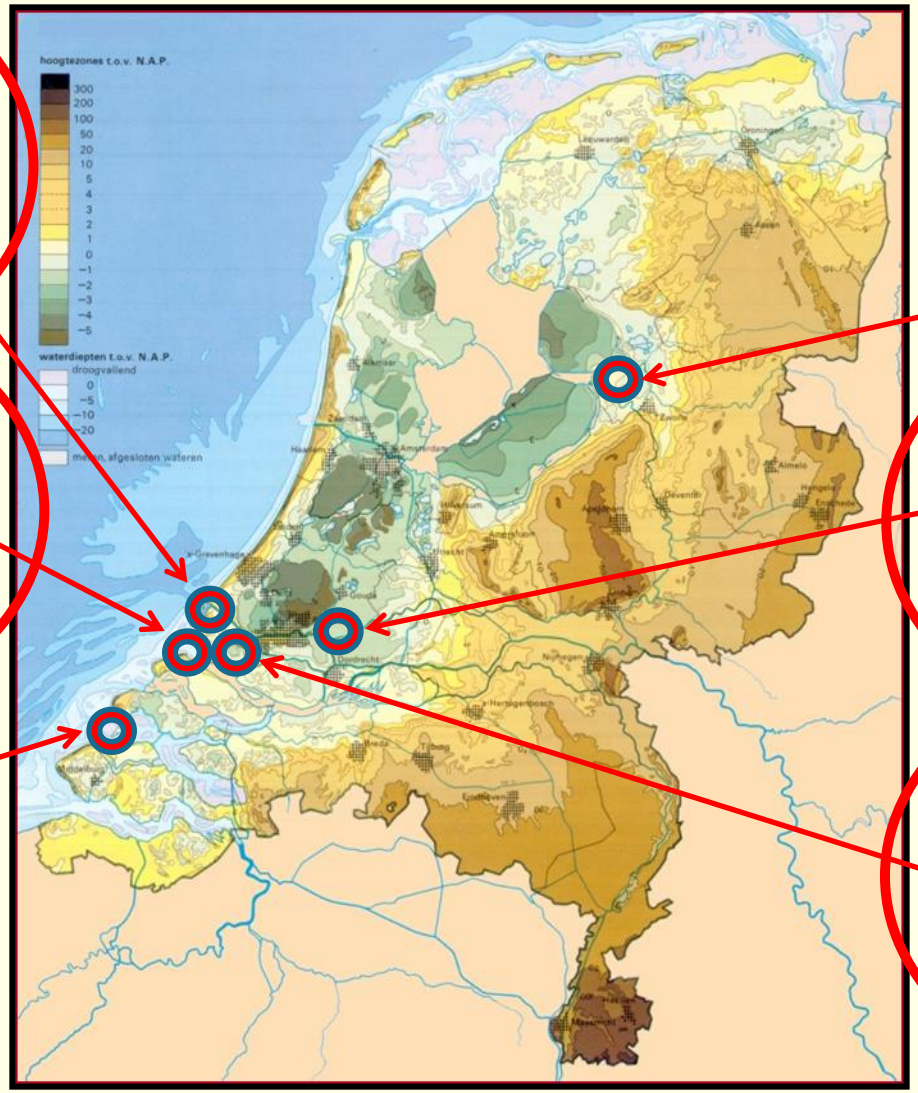
Maeslant Barrier - 1997

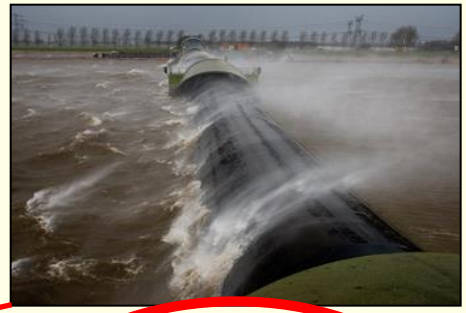


Haringvliet Sluices / Barrier - 1970



Eastern Scheldt Barrier - 1985





Ramspol Barrier - 2002

Hollandse Ijssel Barrier - 1958

Hartel Barrier - 1996

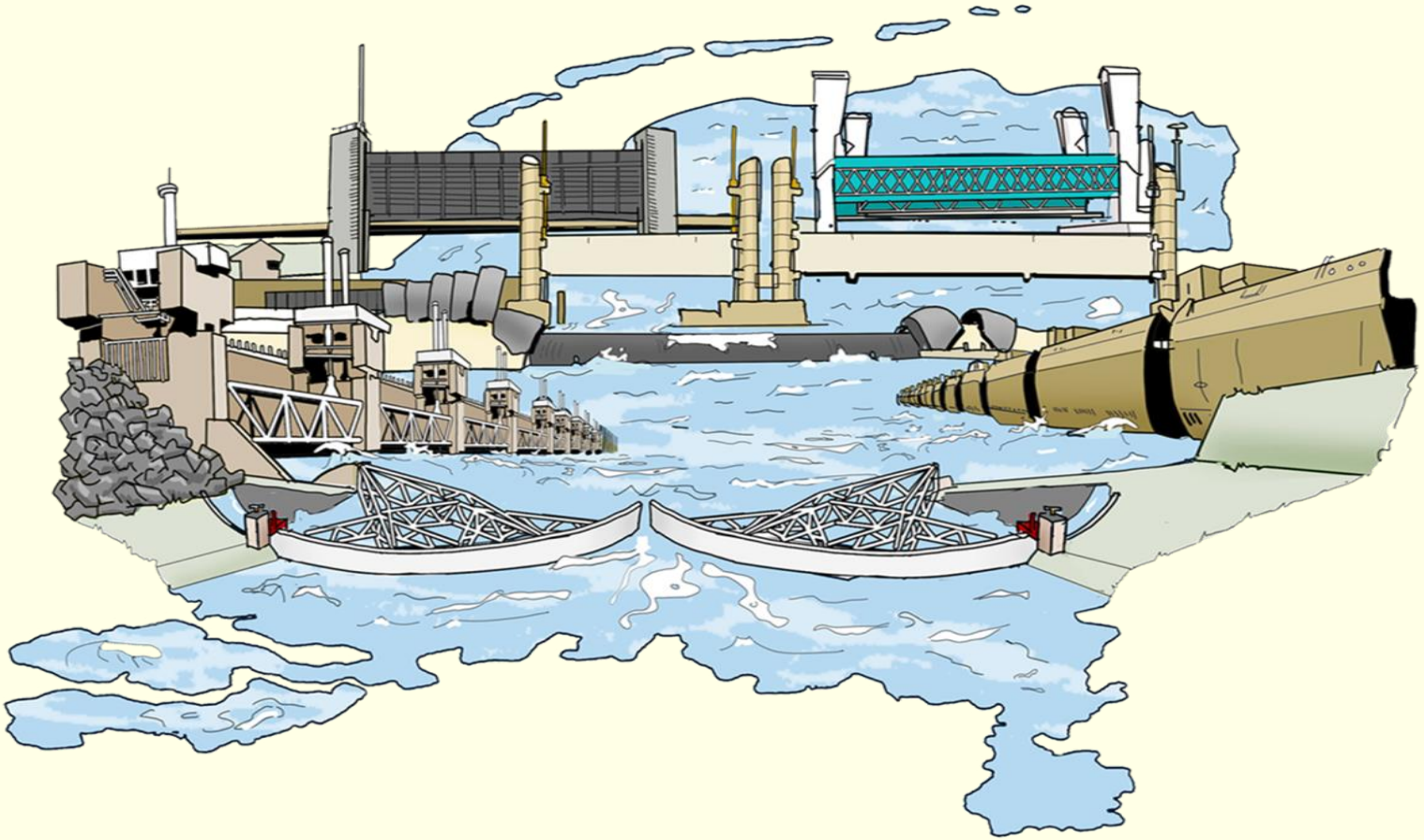
Personal perspective

2004 – 2019 major characteristics

- Out of 8.500 RWS personnel about 250 working on Storm Surge Barriers
- Three major reorganisations and financial restrictions
- Shifting policy regarding in house maintenance vs outsourcing
- Some major technical surprises and challenges
- Challenges regarding knowledge and expertise

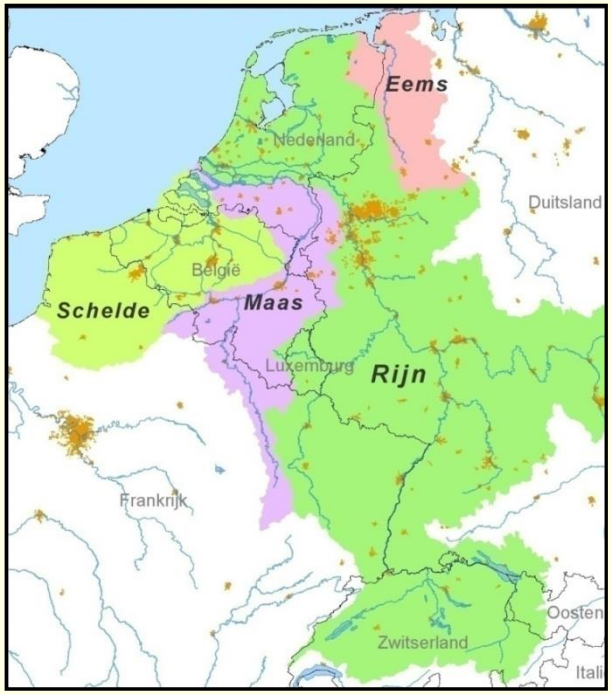
These issues will return in my story of experiences to share today with you

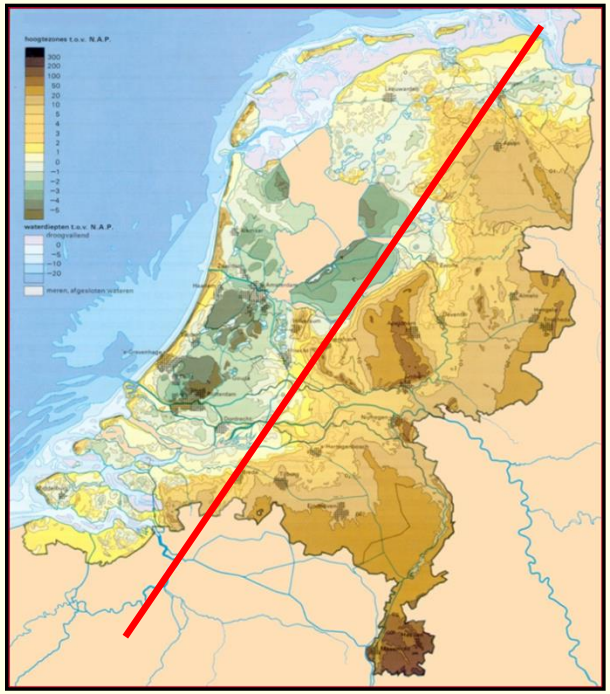
History of flooding and challenges



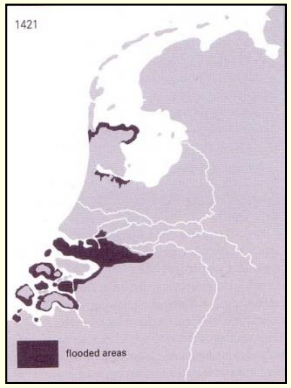
The Netherlands

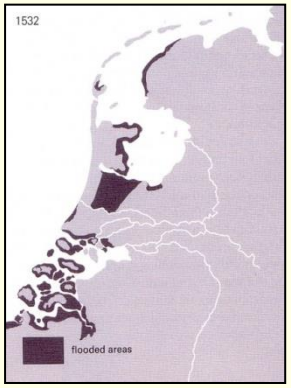
- About 45% of the Dutch borders are coastal
- Over 55% of the country is in floodplain (sea and river)
- Three European rivers discharge into the North Sea

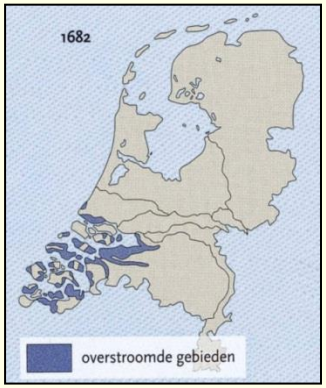


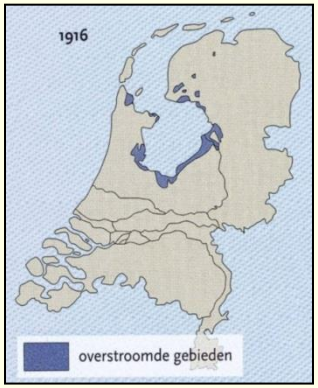


Storm surges through the ages





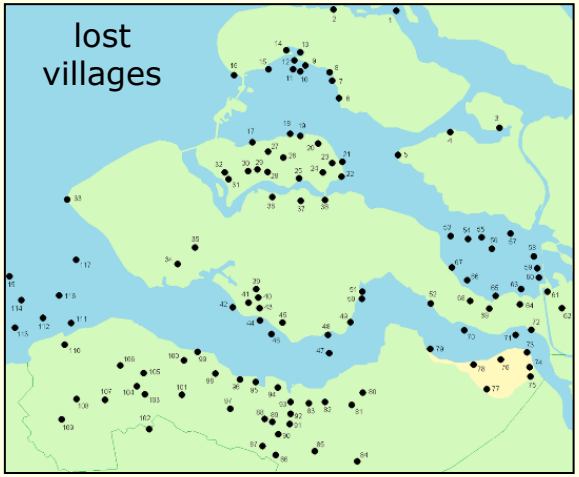




Early ages: swamps, regular flooding, houses and farms on mounds

- Major flooding in 1421 and 1570, thousands of deaths. Causing wetland areas, part of which are nowadays major nature preserves (so called 'Biesbosch')!

- Since 1500, growing wealth and the advent of the windmill enabled land reclamation, protected by dikes. Still regular flooding continued:
  25 major floods between 1500 and 1953!
  Floods always led to new protection measures.



20th Century's Floods in the Netherlands

1916 - North

1953 - Southwest

1993/1995 - Center

1916

Flood of 1916

1916 Flood (North)

- Structural solutions with dams
- 'Afsluitdijk' dam to create IJssel Lake

Flood of 1916

1927-1932

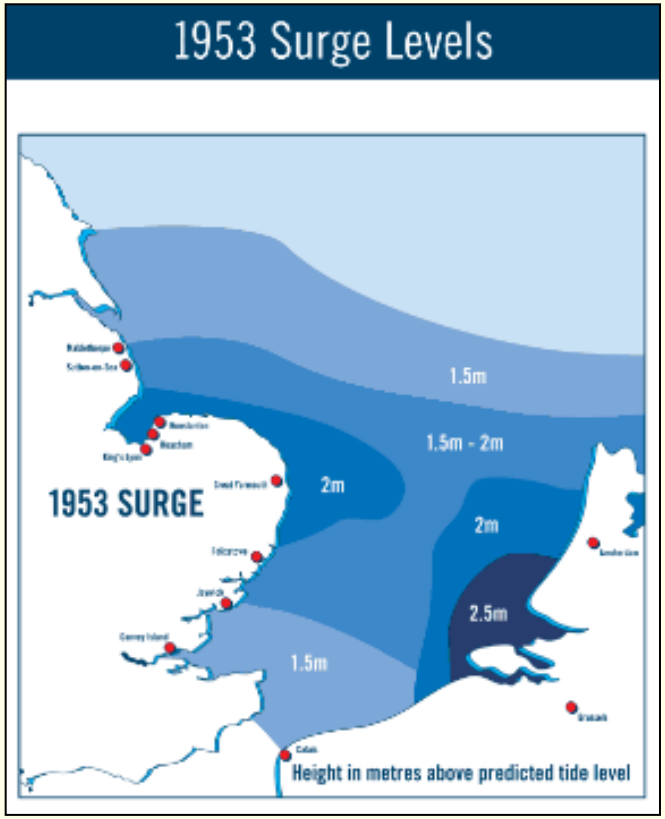
Flood of 1916 – Catalyst for land reclamation

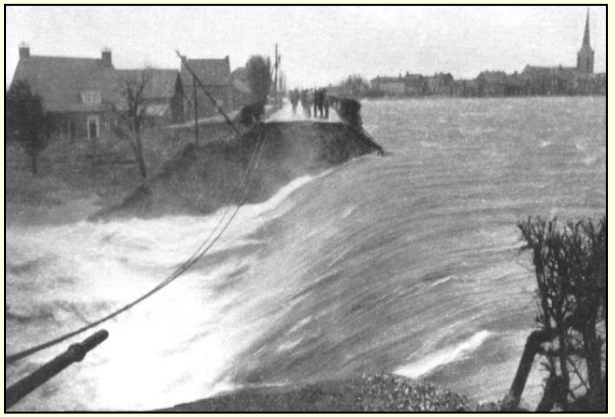
1953

Flood of 1953

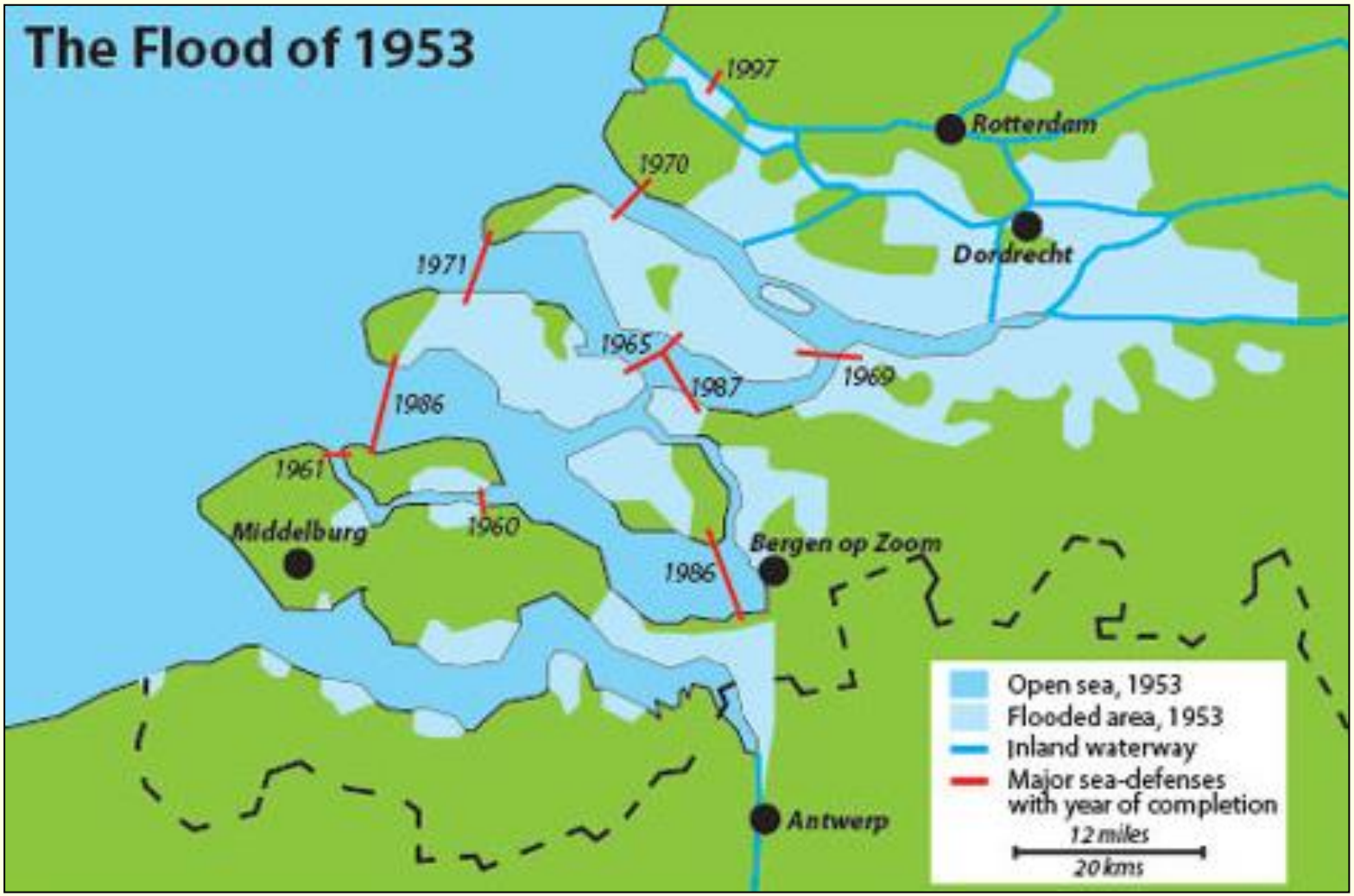
1953 flood disaster (South-West)

- Structural solutions with dams and storm surge barriers (Delta Works)

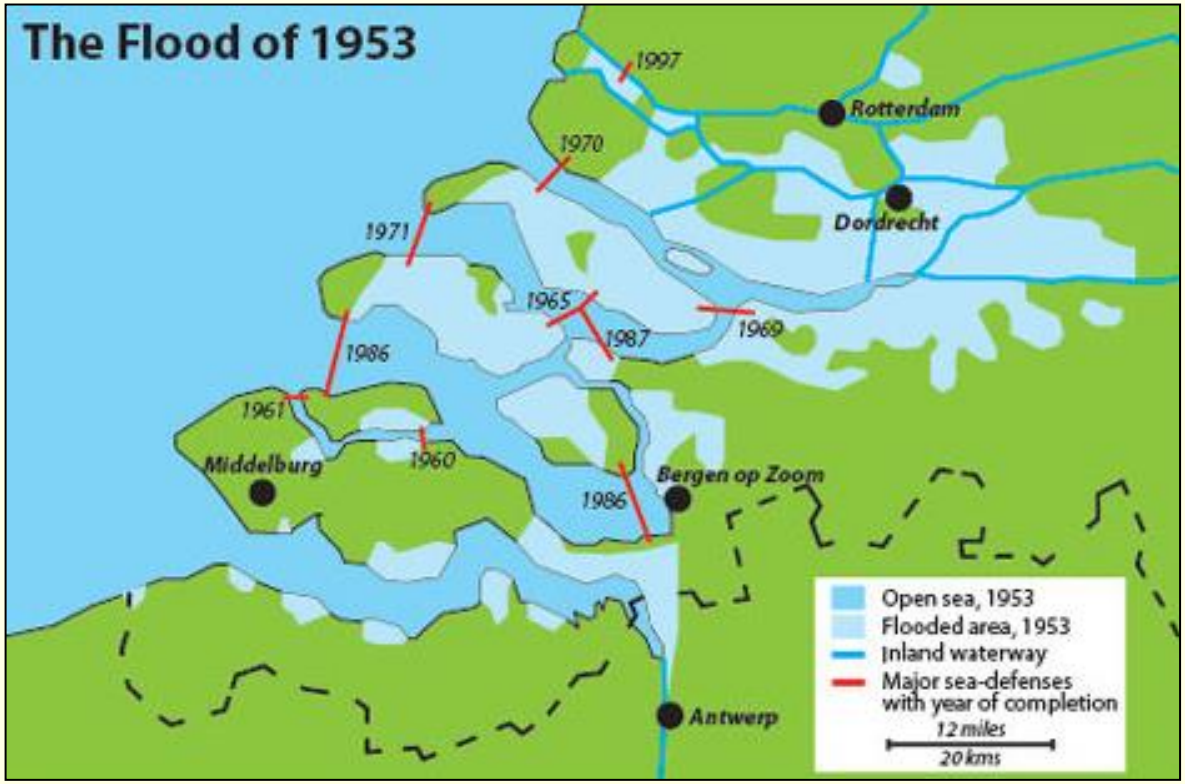




Flood of 1953
Start of the Delta Works

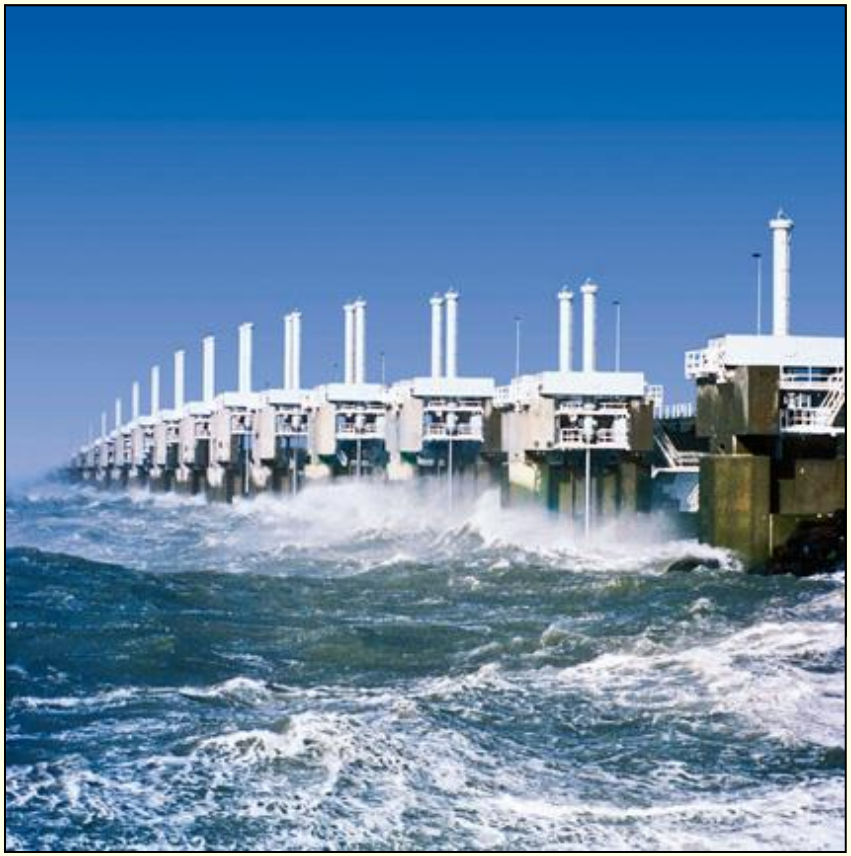


Flood of 1953
Start of the Delta Works



- 1836 inhabitants died
- 100.000 inhabitants lost there houses and their belongings
- Ten thousands of cattle drowned
- Political statement 'this never again'
- Start of Delta Commission – Delta Act

Flood of 1953
Start of the Delta Works



Starting point of Delta Works

- Closing estuaries off from sea
- Shortened coastline with 2/3
- Raising dikes
- Ports of Rotterdam and Antwerp stay open
- Delta Act ready in 1957
- Investment of M€ 15
- Consist of closed dams, sluices and storm surge barriers

1993/1995

Floods of 1993/1995

1993/1995 river flooding (Center)

- Evacuation of 200.000 people
- Start of spatial solutions (Room for the river / Meuse Projects)

Floods of 1993/1995
Catalyst for Room for the River

Starting point for 'Room for the River' principle

Effects of these Floods

- Every flood got it's response with dikes, storm surge barriers and 'room for the river' projects

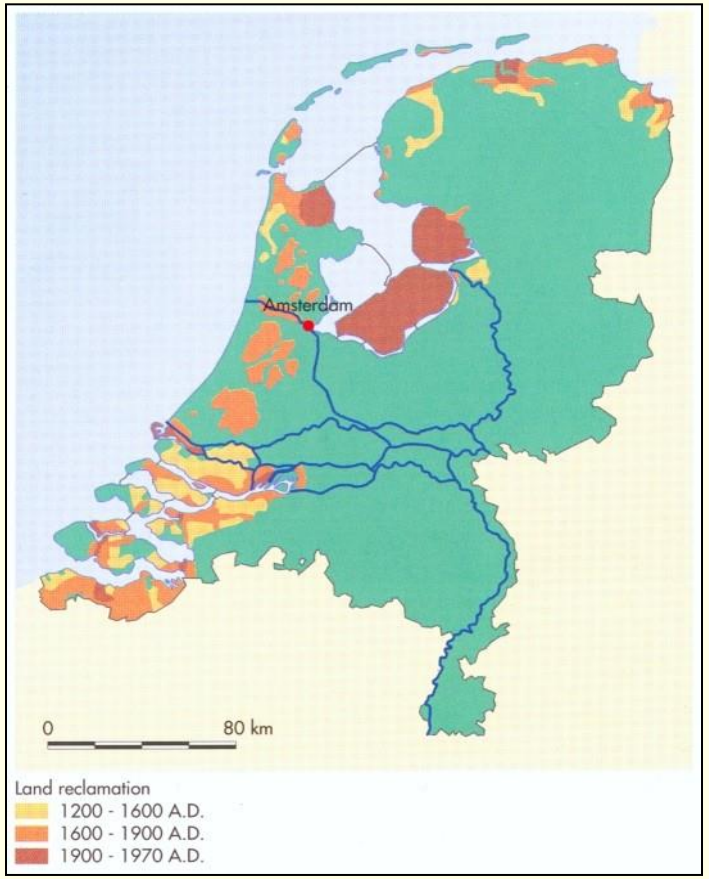
- And, apart from the disasterous effects, every flood brought new opportunities as well:
  - fresh water reservoirs and new land/cities
  - innovations such as movable storm surge barriers
  - new policies regarding river space
  - integral design for multipurpose use
  - . . . .

And last but not least

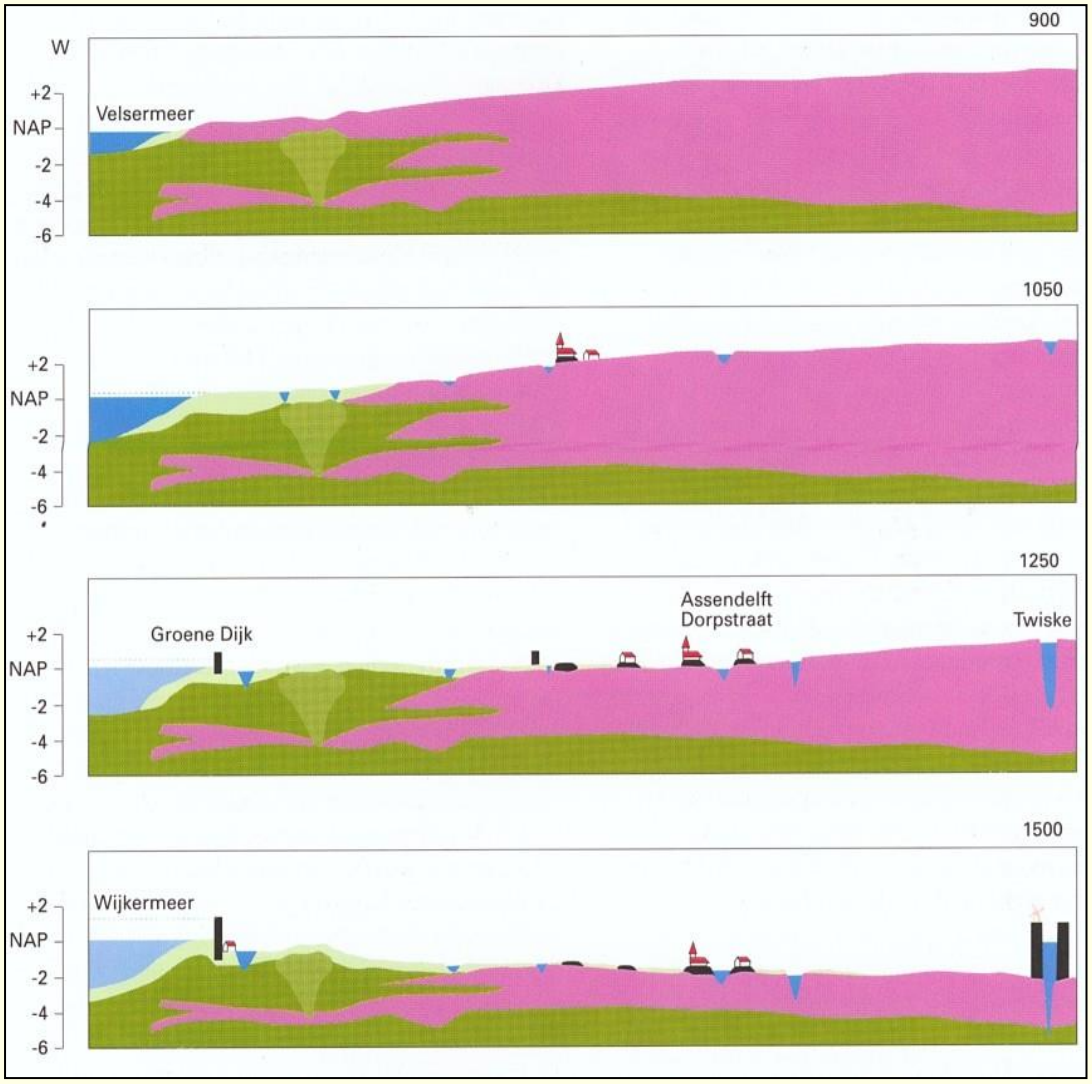
- More integrated approach to water management

"Water follows function":
Land reclamation, levees and drainage created the country

- If we want to live on the bottom of the sea, we create a polder
- If we want to have agriculture in extremely wet areas, we drain the soil
- If we want to have agriculture in saline areas, we bring in fresh water



But, drainage means soil subsidence



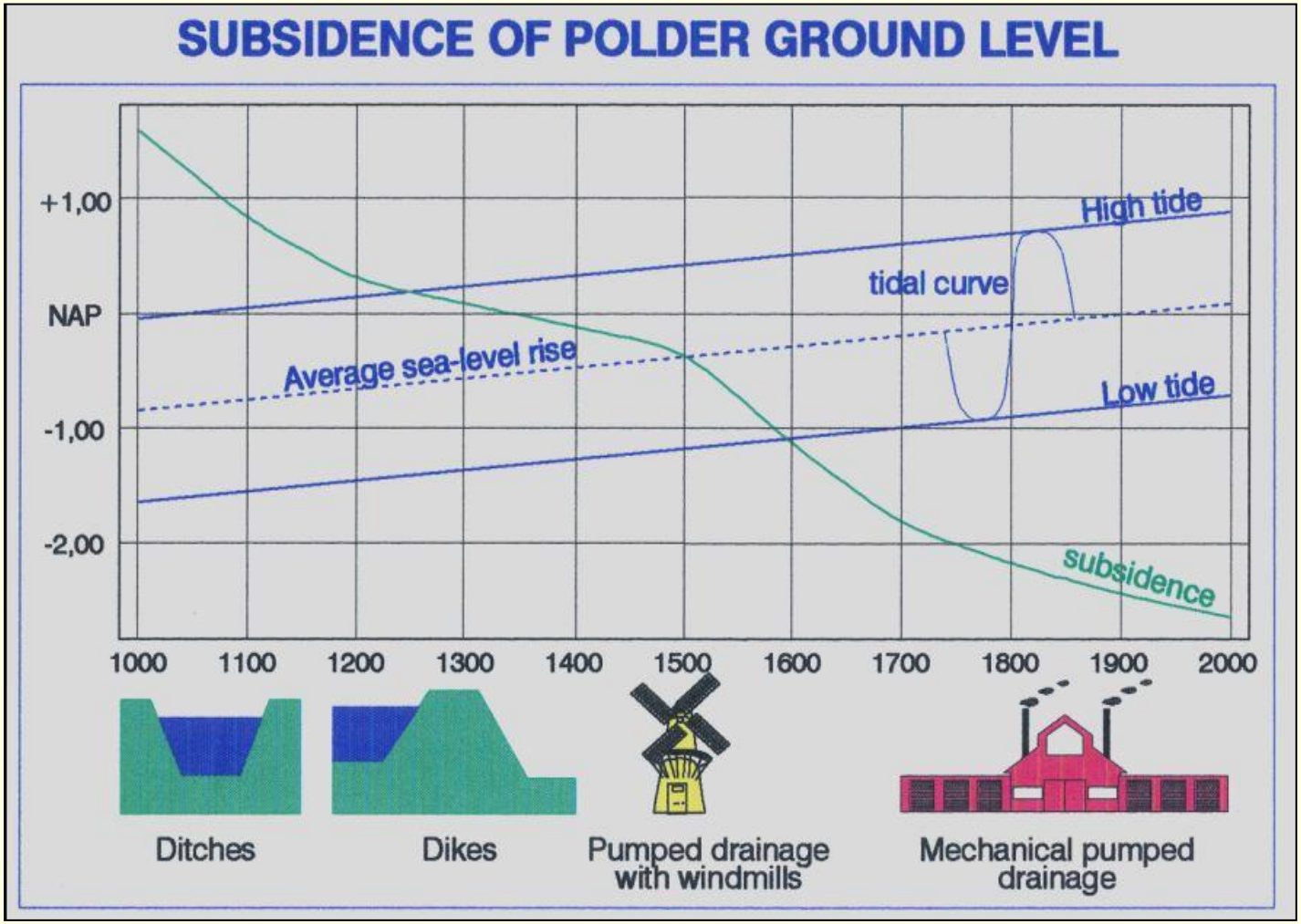
900

1050

1250

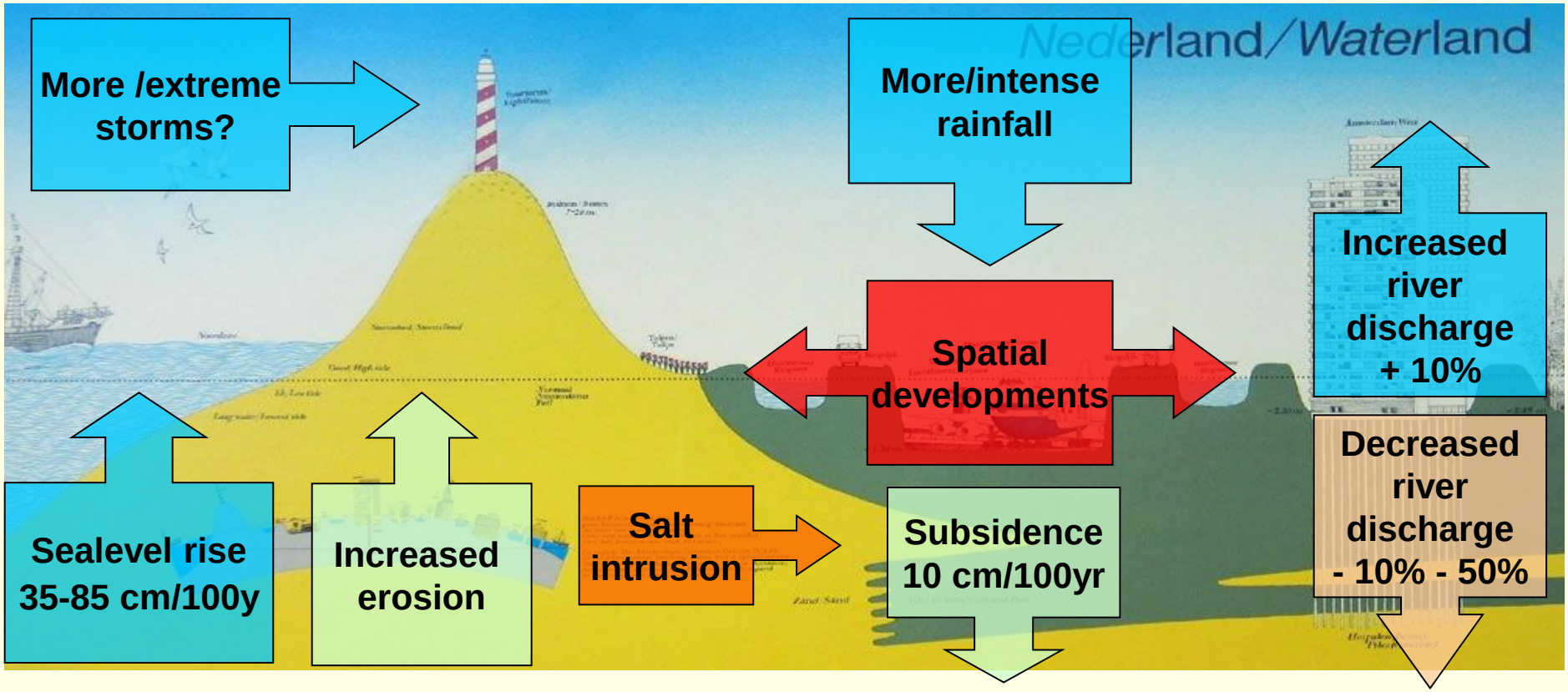
1500

Imbalance of soil subsidence and sea level rise

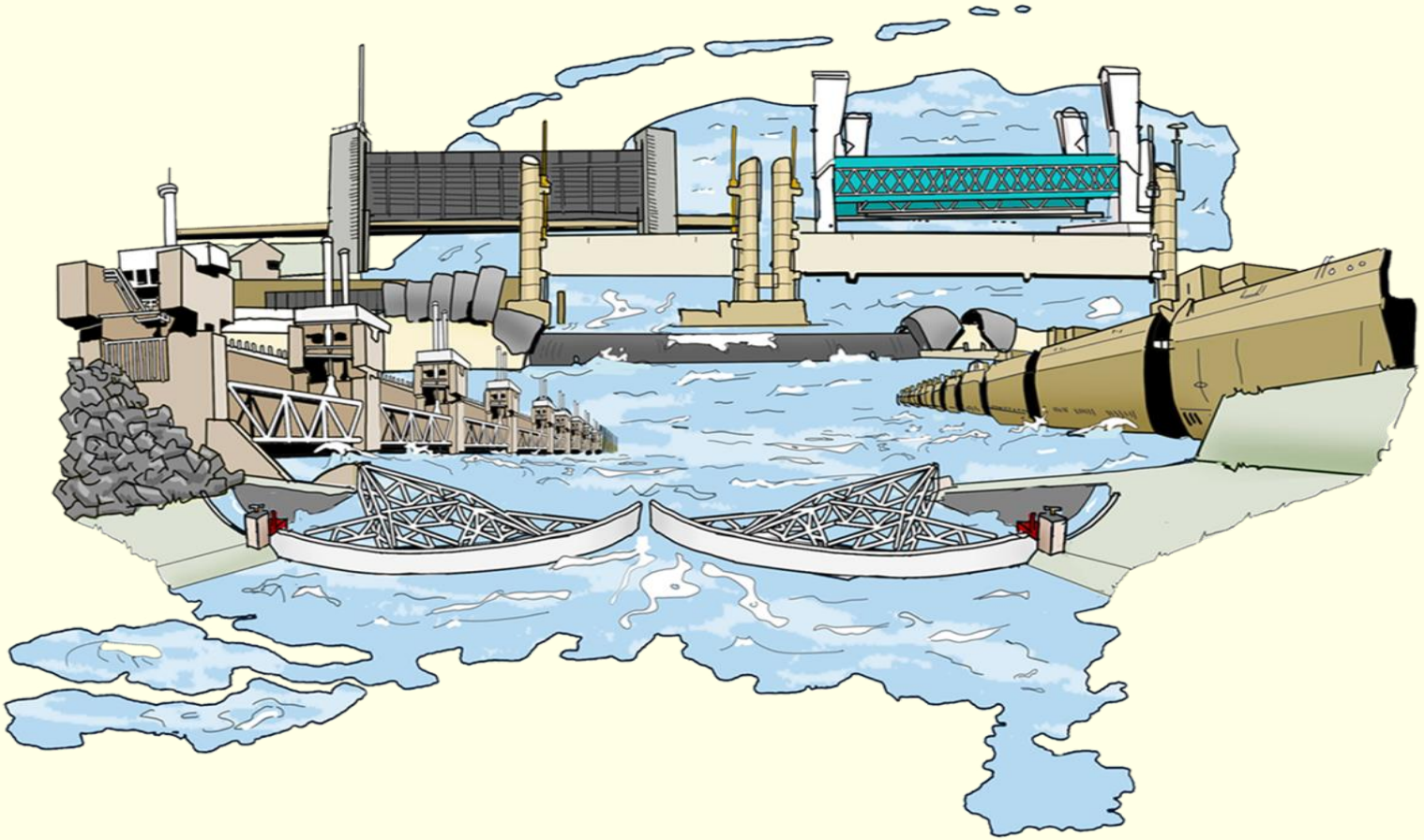


Delta under pressure: Future challenges

And flooding is not the only challenge



Overview of Dutch Storm Surge Barriers

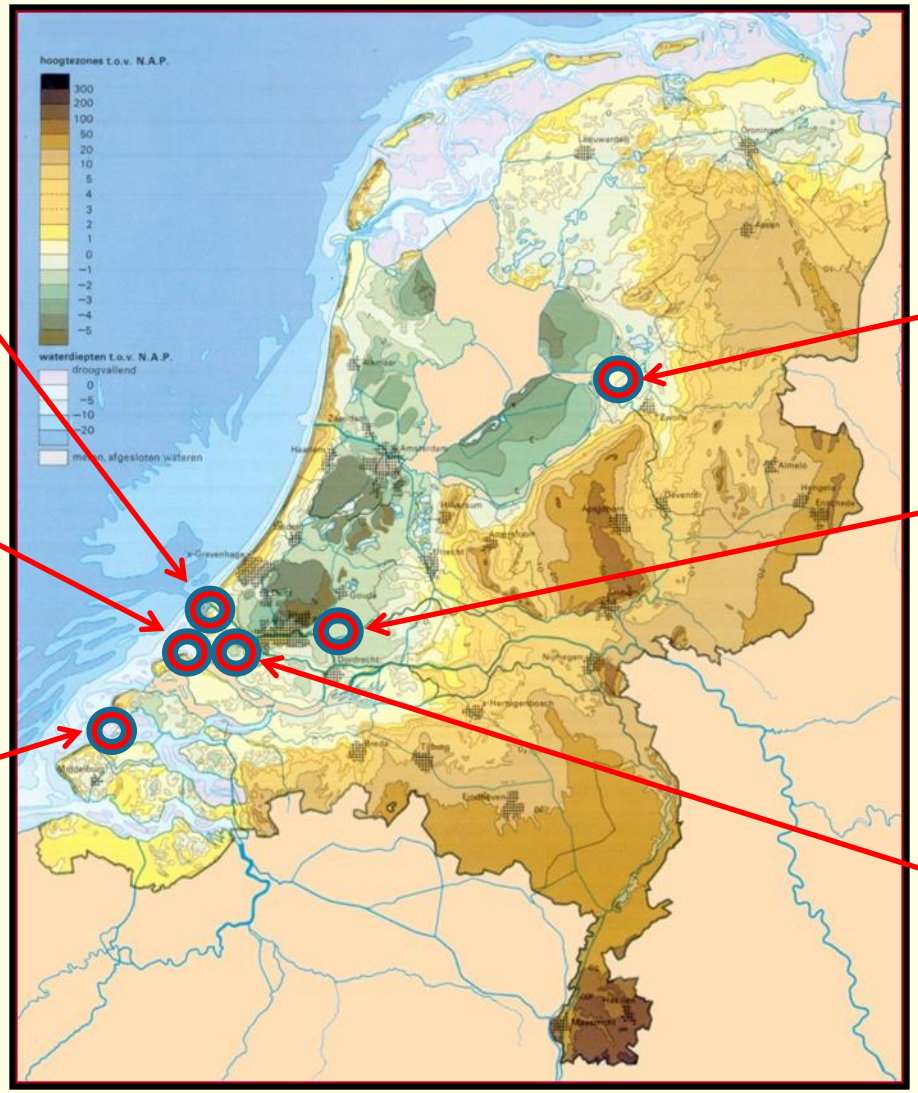


Storm Surge Barriers in the Netherlands

Maeslant Barrier - 1997

Haringvliet Sluices / Barrier - 1970

Eastern Scheldt Barrier - 1985



Ramspol Barrier - 2002

Hollandse IJssel Barrier - 1958

Hartel Barrier - 1996

Hollandse IJssel Barrier

Lowest point of the Netherlands: -6,74 m

1958

1st of Delta Works

2 vertical lift gates

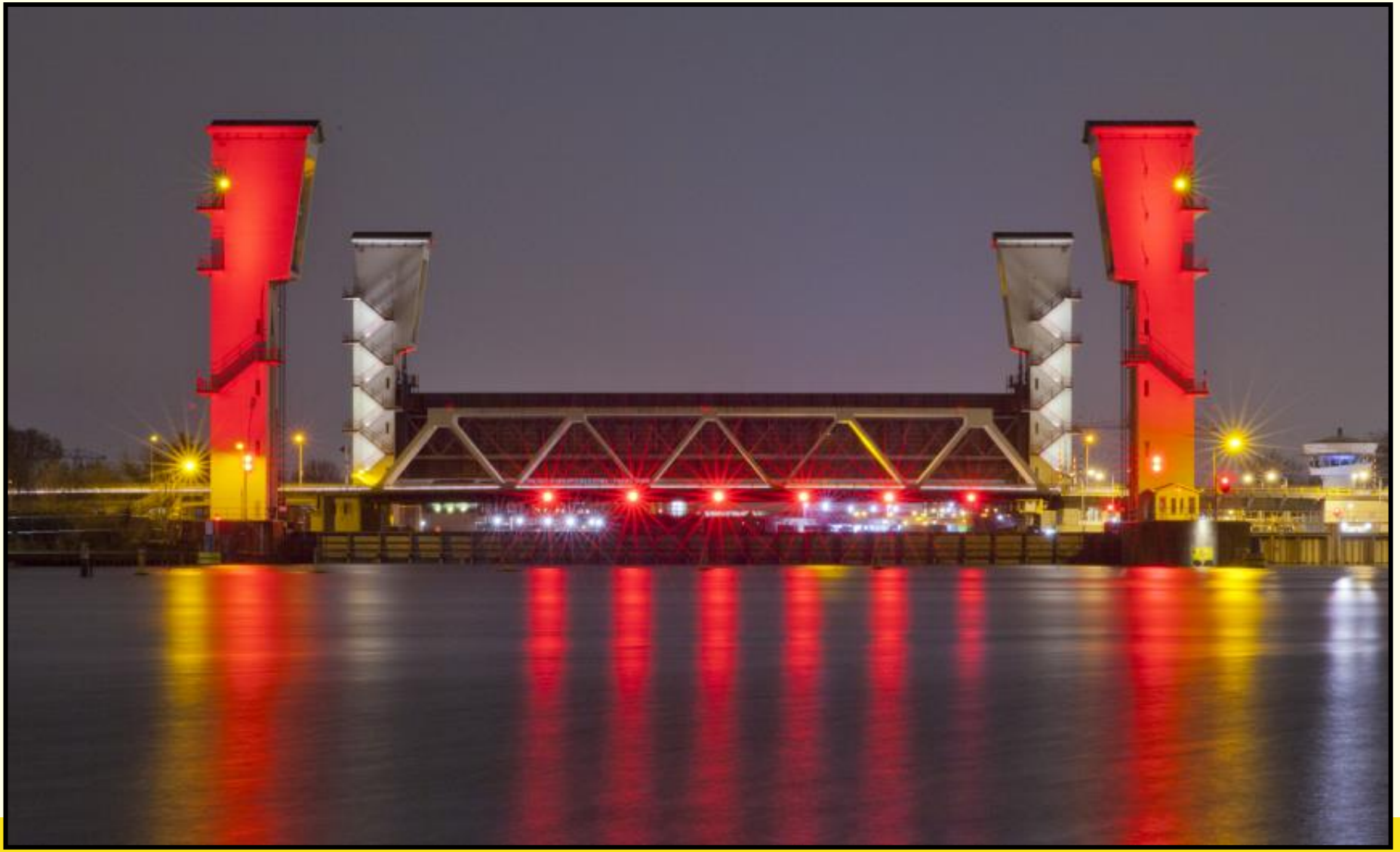
1 sluice

80 m width

Hollandse IJssel Barrier

Situated in inabited area provides also a chance to emphasize consiousness regarding water safety

Hollandse IJssel Barrier



Haringvlietsluices

1971

17*2 gates

1 sluice

60 m width per gate

‘water tap’ of Europe

(since 2019)

Haringvlietsluices


Stroming en vistrek van de rivieren tot de Noordzee
Trekroutes van verschillende vissoorten in relatie tot het Kierbesluit
Noordzee
zout
brak
zoet
Effect van de kier op vissen die van de rivier naar de zee en andersom trekken om te paaien
fint
driedoornige
spiering
Van zout naar zoet water

Eastern Scheldt Barrier

1986

62 gates

1 sluice

42 m width per gate

2 islands

Eastern Scheldt Barrier

Maeslant Barrier

1997

2 gates

no sluice

360m width in total

Maeslant Barrier

Hartel Barrier

1997

2 gates

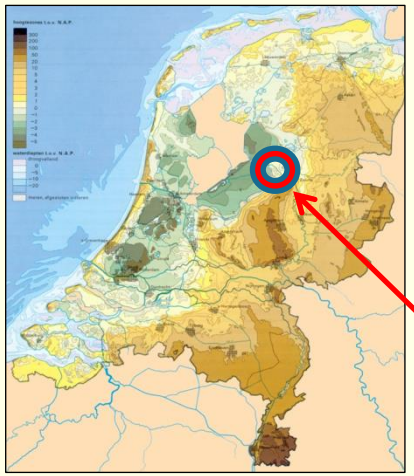
1 sluice

98 and 49 m width

per gate

Hartel Barrier

Ramspol Barrier



2002

3 gates

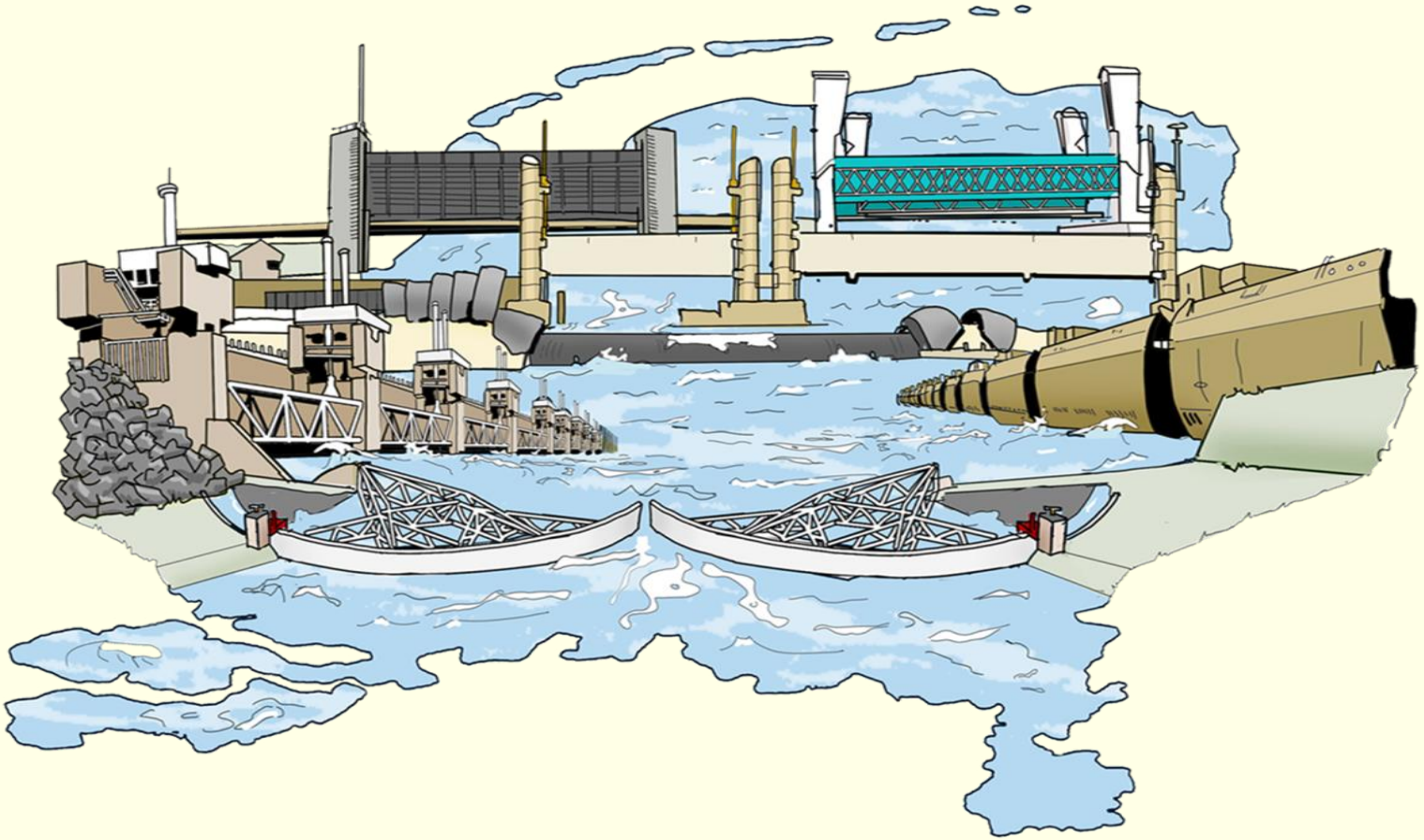
Inflatable dam

no sluice

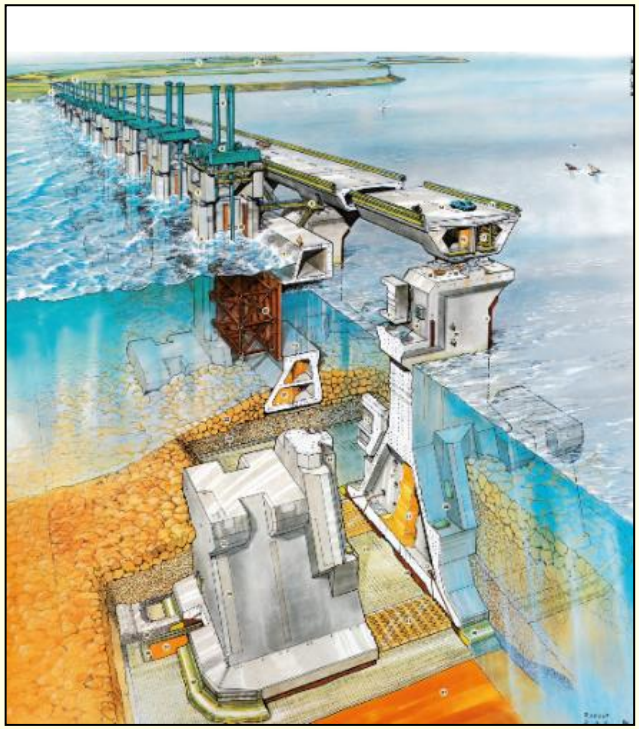
80 m width per gate

Ramspol Barrier

Sharing experiences & Lessons Learned

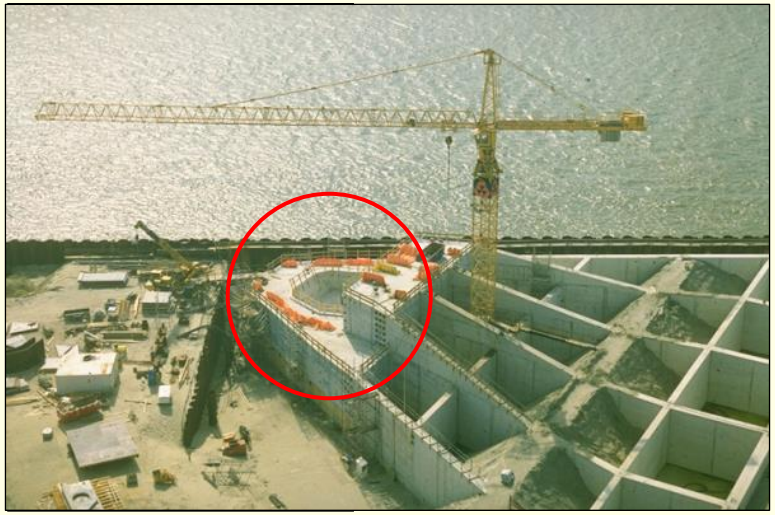


It al starts with the celebrating of the works



It al starts with the celebrating of the works

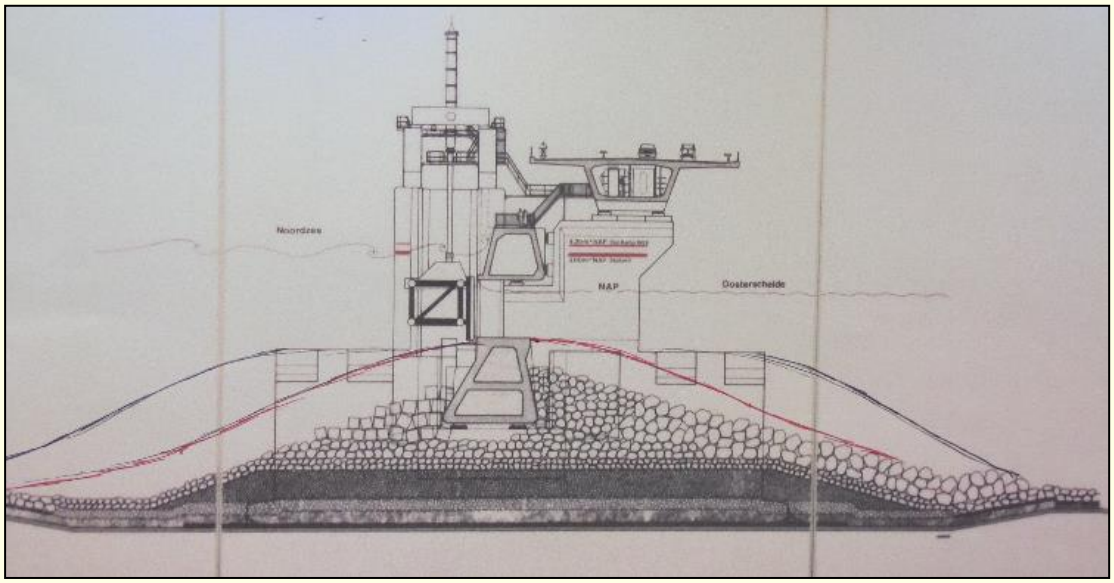
Then the challenge begins
Example 1 – Ball Joint



- The ball joint: a steel ball rotating in a steel hollow. Designed to be ‘maintenance friendly’
- Technical problem: Unexpected rapidly wear of the coating of the steel hollow
- Additional environmental problem: New laws blocked the use of specialized coating
- Short term: Additional maintenance turned out to be no permanent solution
- Longer term: Alteration of design (2-4 million euro’s)

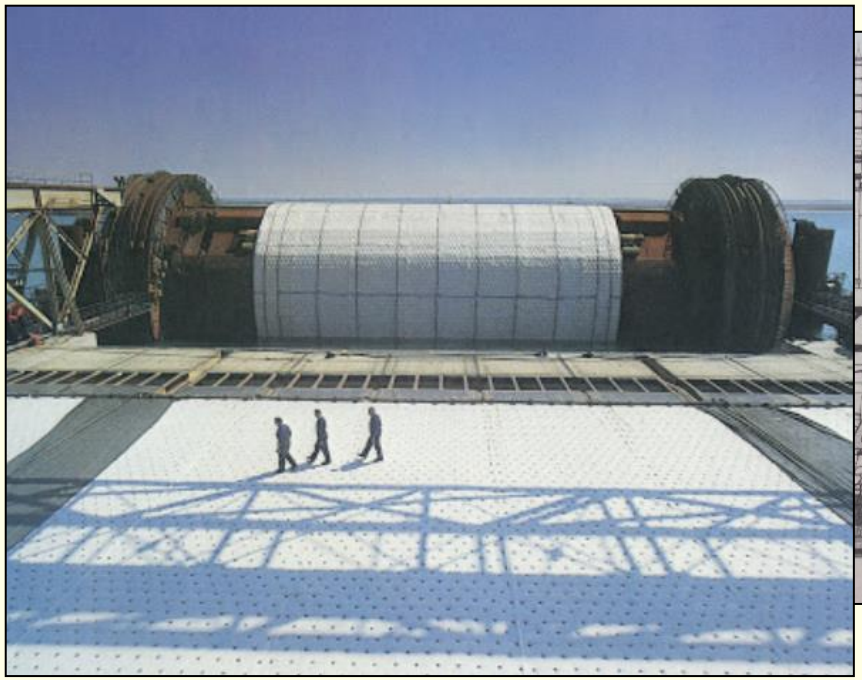
Then the challenge begins
Example 1 – Ball Joint

Example 2 – Scour holes Eastern Scheldt Barrier



- Early 2012 scour holed ‘discovered’
- Repair time with rock armour from 2012 - 2015

Example 2 – Scour holes Eastern Scheldt Barrier



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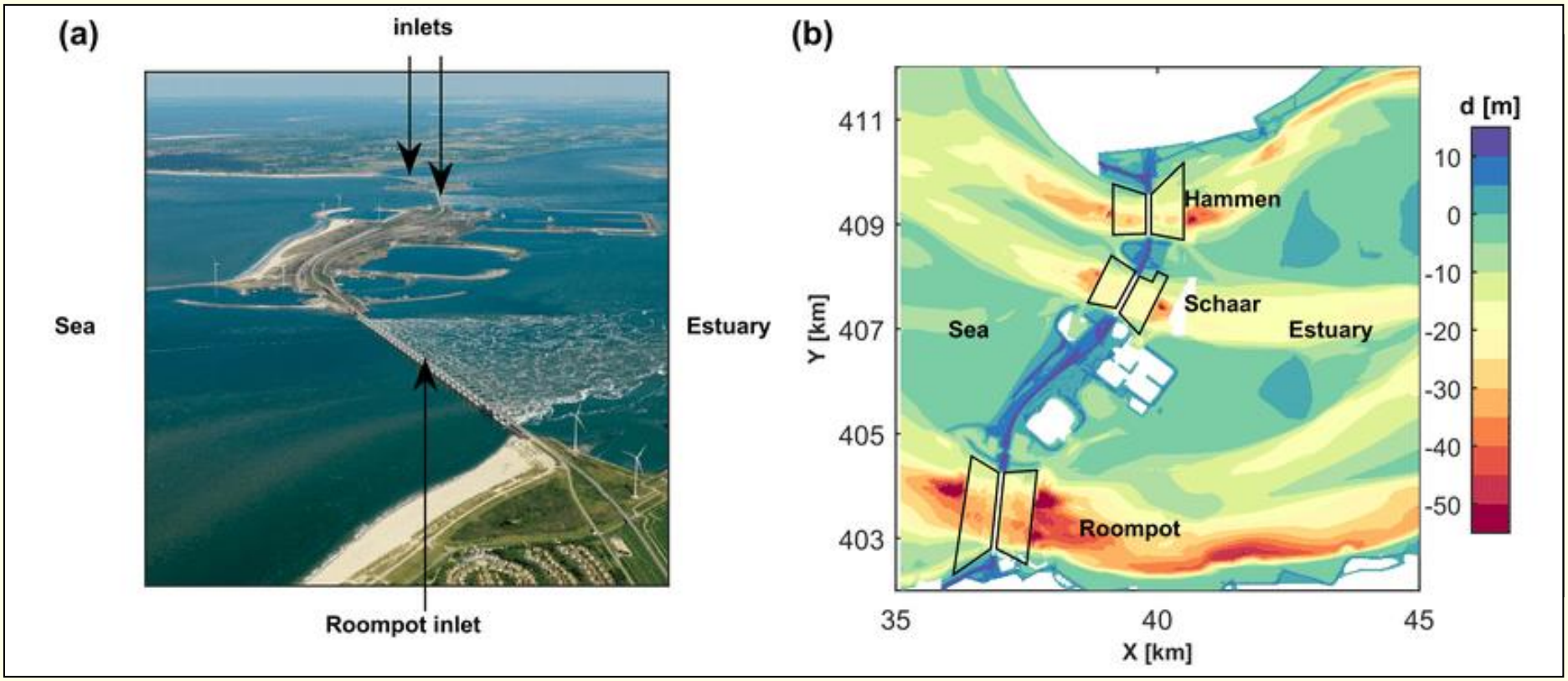
Example 2 – Scour holes Eastern Scheldt Barrier



- Early 2012 scour holed ‘discovered’
- Repair time with rock armour from 2012 - 2015

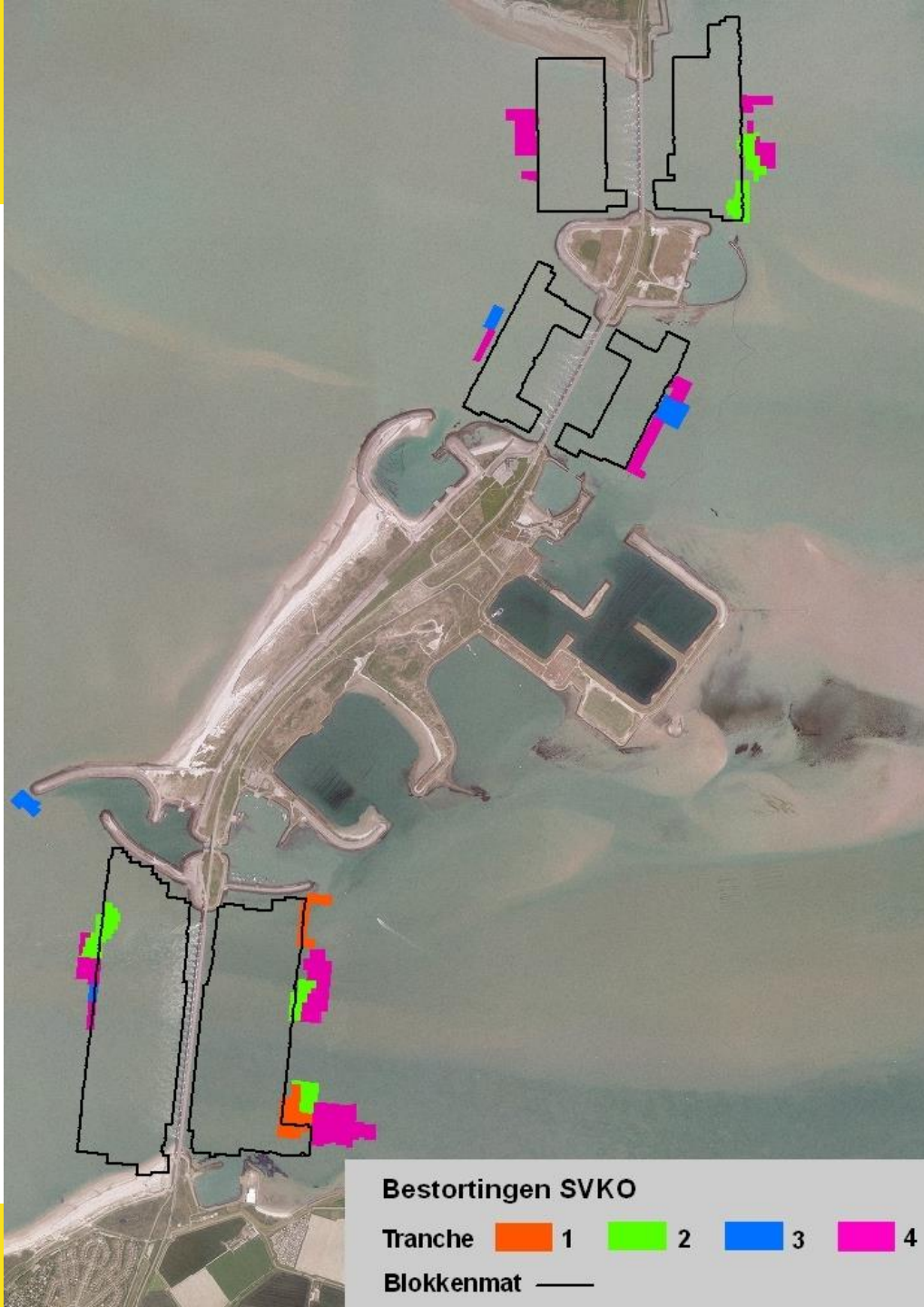
Example 2 – Scour holes
Placing rock armour

Tranche 1:
May 2012 until June 2012
Ca. 115.000 tons armour
[M€ 3,6]

Tranche 2:
Nov until Jan 2013
Ca. 345.000 tons armour
[M€ 9]

Tranche 3:
Nov 2013 until Jan 2014
Ca. 150.000 tons armour
[M€ 4,7]

Tranche 4:
July 2014 until March 2015
Ca. 700.000 tons armour
[M€ 20]



Example 3 – Butterfly valve pipeline

- During ‘after storm season inspections’ one butterfly valve pipeline was found to have almost failed because of corrosion
- Other pipelines could only be inspected by removing it’s sleeve
- Removing a sleeve meant replacement of pipeline
- Unplanned replacement was needed within 3 months for 3 km of pipeline serving 60 valves

Example 4 – Frontpage news

SPORTWERELD Russen rekenen op Guus Hiddink

Prijs: € 1,00

AD Rotterdams Dagblad

www.ad.nl

vrijdag 3 maart 2006

Sportwereld 16 pagina's uitneembaar

Van Basten wordt strenger

ENTERTAINMENT

Lost Op elkaars lip op een eiland

ZONDAG 5 MAART GEOPEND

En de winnaar is... Links en rechts strijden over armoede Pagina 2 & 3

Rotterdam Dichtbij 16 pagina's regionieuws uitneembaar

Hollands Glorie?

Campus voor kansarme Rotterdamse jeugd

Consul bemoeit zich met Marokkaanse ouders

Maatregelen moeten gezag politie vergroten

Veel fouten in Maeslantkering

JEROEN DE VREEDE

Het weer

Example 4 – Less automation, more staff & skills

Shifting emphasis on Risk Based Asset Management and Organisation

- Debate on reliability. Explicit and quantitative proof of reliability was required
- Improvement of quantitative risk based asset management
- Technical improvements applied
- Rediscovery of positive impact human involvement (if specifically trained) in improving reliability
- Expanding and profesionalizing operational teams

Typical characteristics of Storm Surge Barriers

- Mostly unique design / a kind of prototype
- Sub systems designed for other use then in a storm surge barrier
- Low frequency of use
- Full test is difficult (shipping, required water levels)
- High reliability requirements
- Low chance on failure, extreme high risk
- Governmental organisations fully responsible
- Operations team and trained staff has a crucial role in achieving level of reliability – knowledge and experience are crucial

Design & lifetime points of attention

- **Environmental pressure changed the final design of Delta Works**
  - From closing estuaries towards keeping more open estuaries
    - Eastern Scheldt partly open (originally designed as a dam)
    - Maeslant and Ramspol Barrier fully open
    - Haringvlietsluices just shortly opened more for fish migration
  - With impact on complexity of O&M
- **New characteristics introduce higher complexity**
  - Reliance on complex prediction-, decision- and control systems mklop0p
  - High reliability and availability requirements
  - Reliability based requirements demands reliability based maintenance and operations
- **Last moment changes in design – be alert, often**
  - With focus on reduction building costs
  - Cheaper design alternatives often not as good thought through
  - Challenging and more expensive for O&M

Technical points of attention

- Computing systems appeared not to be that reliable as they were considered before, human involvement contributes more to reliability than originally was thought of

- Most components are developed to operate constantly under severe circumstances. A barrier operates once in every year or even once in 10 years. This requires specific (not by manufacturer) developed maintenance program

- The unicity and specific characteristics of each barrier constrain the value that the industry can add with short term contracts

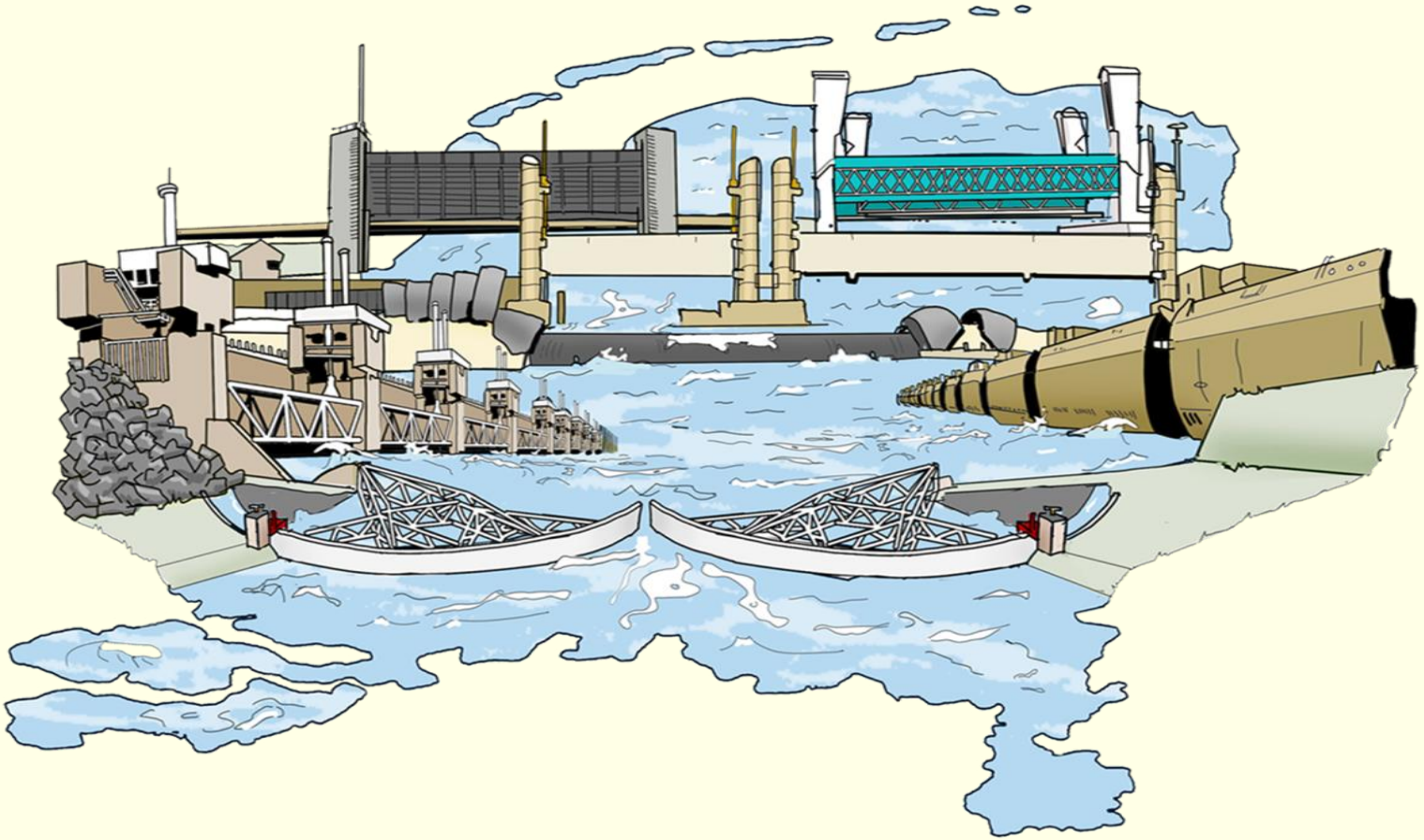
Organisational points of attention

- The unicity of design and construction in combination with low frequent operational use constrain the number of people that have the expertise of the barrier's characteristics
- Life time existence of a barrier is up to or more than 100 years, but regulations, policy and organizations change frequently with mostly unpredictable but significant influence
- Development, construction and building attract common interest, but maintenance and operations define reliability

As a methafor

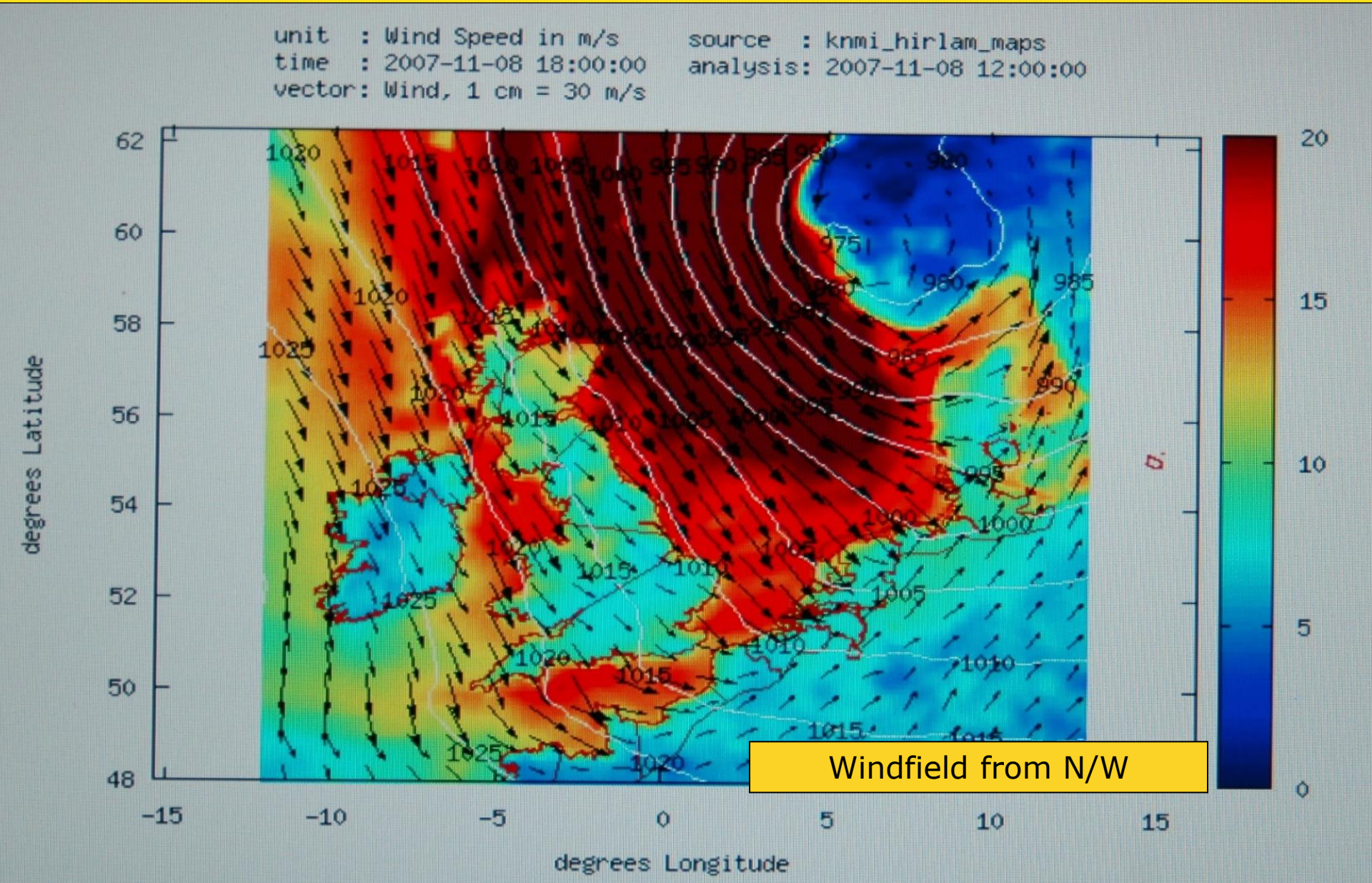
Barrier as a sleeping giant

Operational closure



Closures

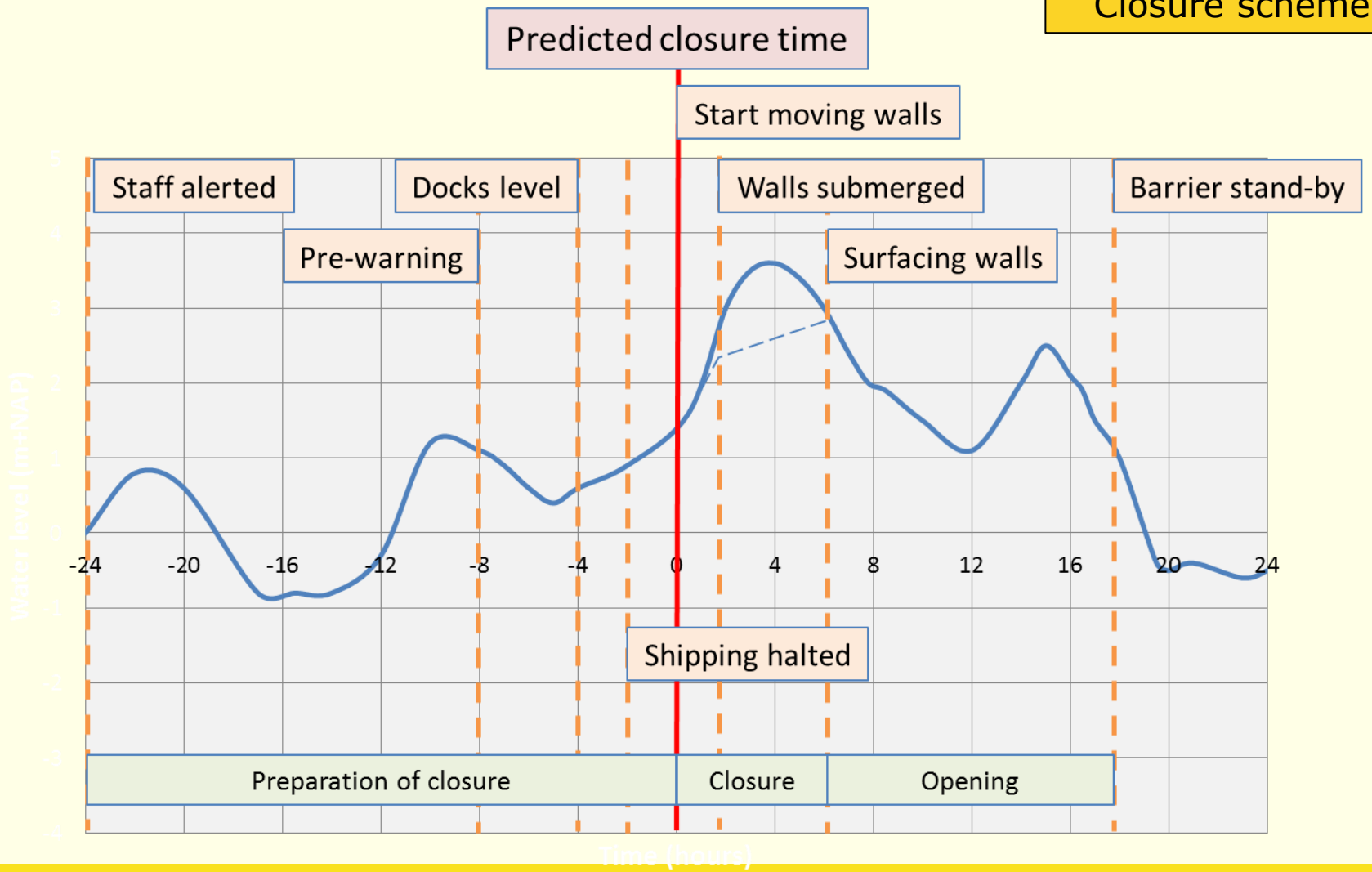
Northwestern Storm



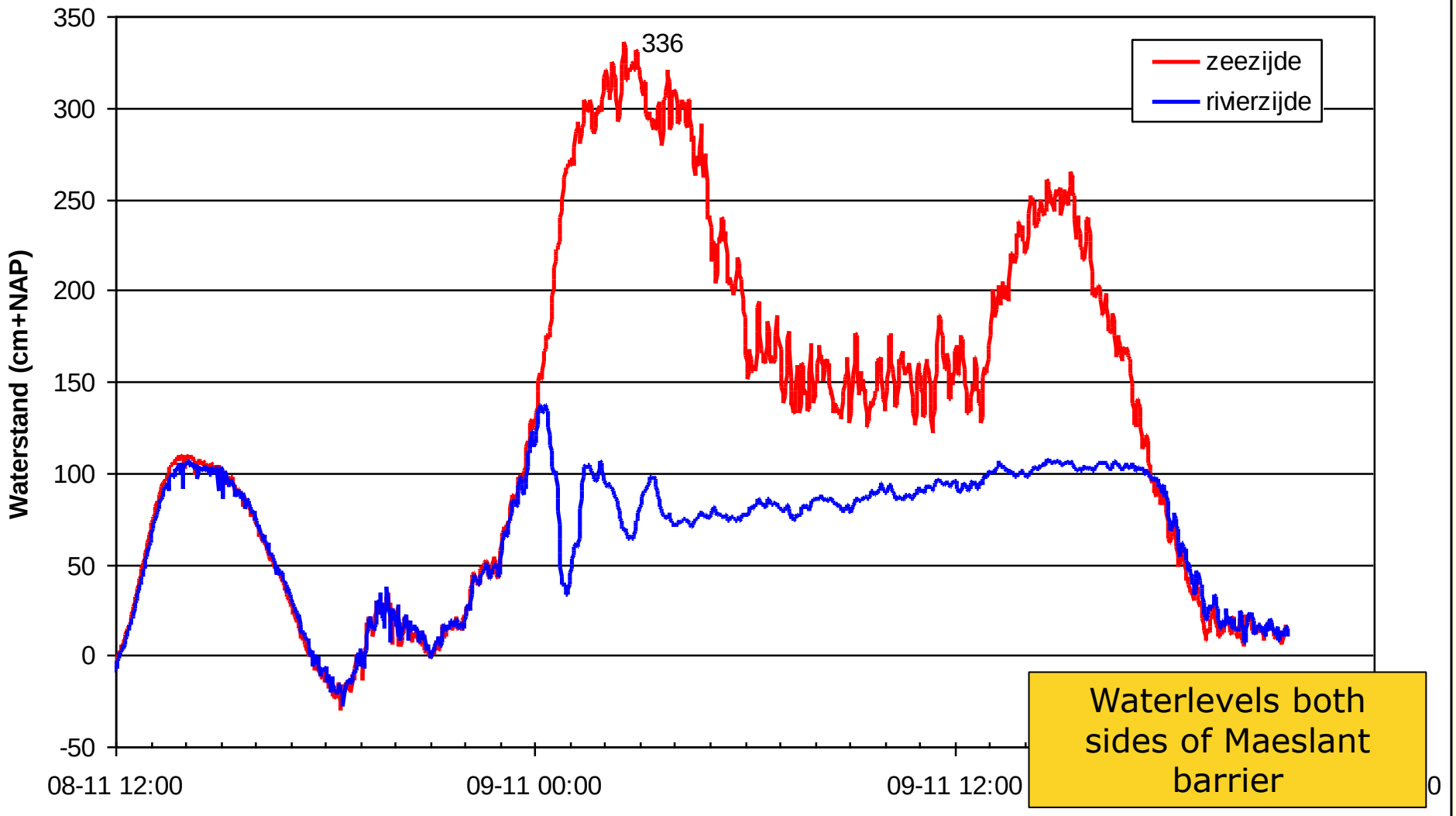
Closures

The Maeslant Barrier Closure Procedure

Closure scheme



The Maeslant Barrier closure effect



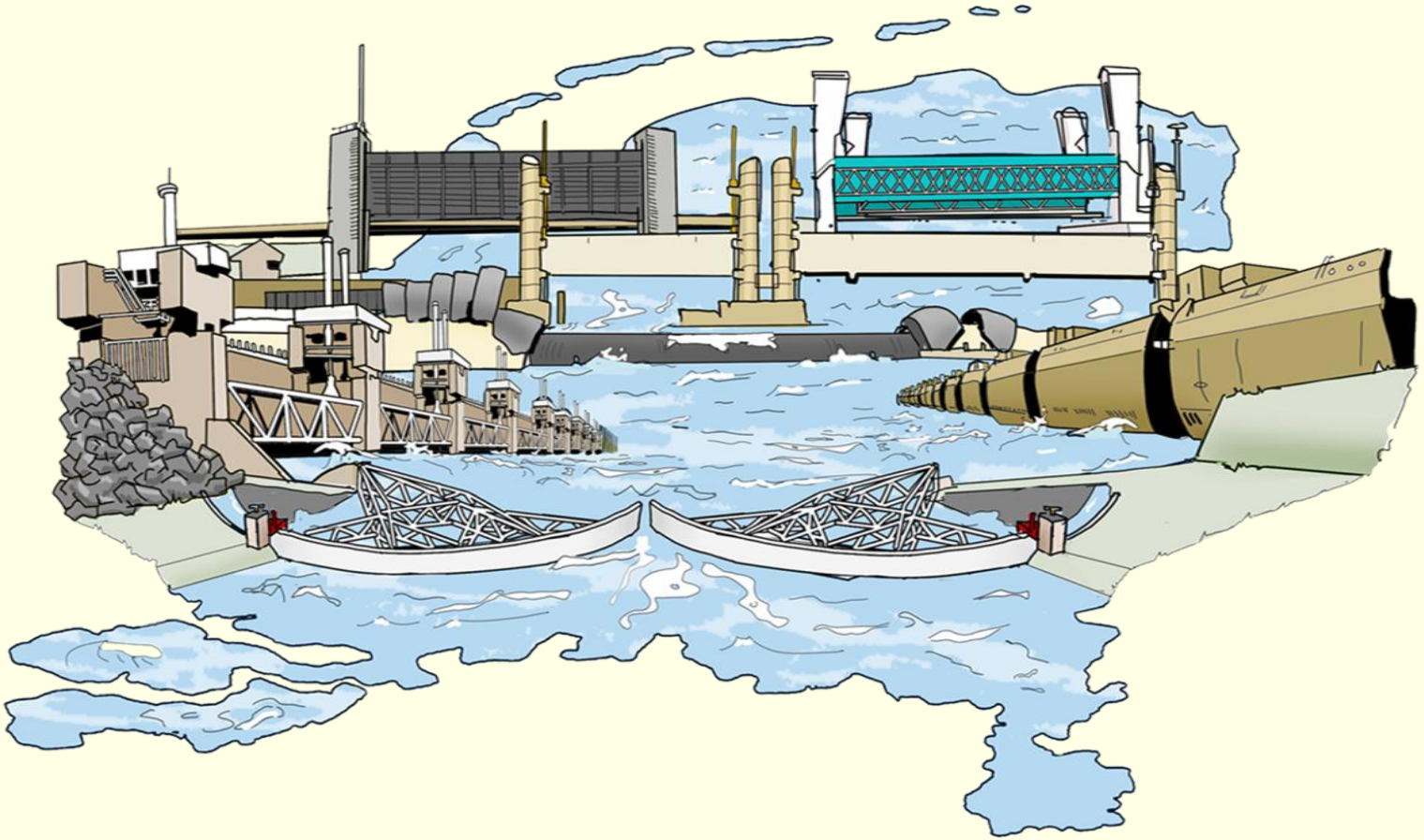
Waterlevels both sides of Maeslant barrier

Ships leave port of Rotterdam

Public and media attention

View at closed barrier
from operations room

I-STORM



I-STORM

International Network of Storm Surge Barriers

Start I-STORM in 2006

About I-STORM

An international knowledge sharing network

- To better protect people, places and property from flooding
- For Storm Surge Barriers (SSB) professionals around the world
- Sharing knowledge and experience to improve management, maintenance and operations of SSBs
- Established in 2006

What we do

Members share their knowledge and experience to:

- Improve operation, management and performance
- Develop standards
- Peer review
- Inform concept, design and construction of new barriers
- Optimise SSBs performance within Flood Risk Systems
- Understand impacts of sea level rise on SSBs
- Collaborate on research and development

I-STORM

I-STORM

We’re not about right or wrongs

Different countries have different history and policies
which logically leads to different priorities and solutions
whether an existing operation or just in design
everyone has something to contribute

Members of I-STORM share knowledge and experiences
to learn from each other
today and in the future

Who we are
the core members

- Environment Agency (EA), England

- Rijkswaterstaat (RWS), the Netherlands

Venice Water Authority

- Venice Water Authority (VWA) and Consorzio Venezia Nuova (CVN), Italy

- US Army Corps of Engineers (USACE), United States of America

New Orleans (USA)

New Orleans (USA)

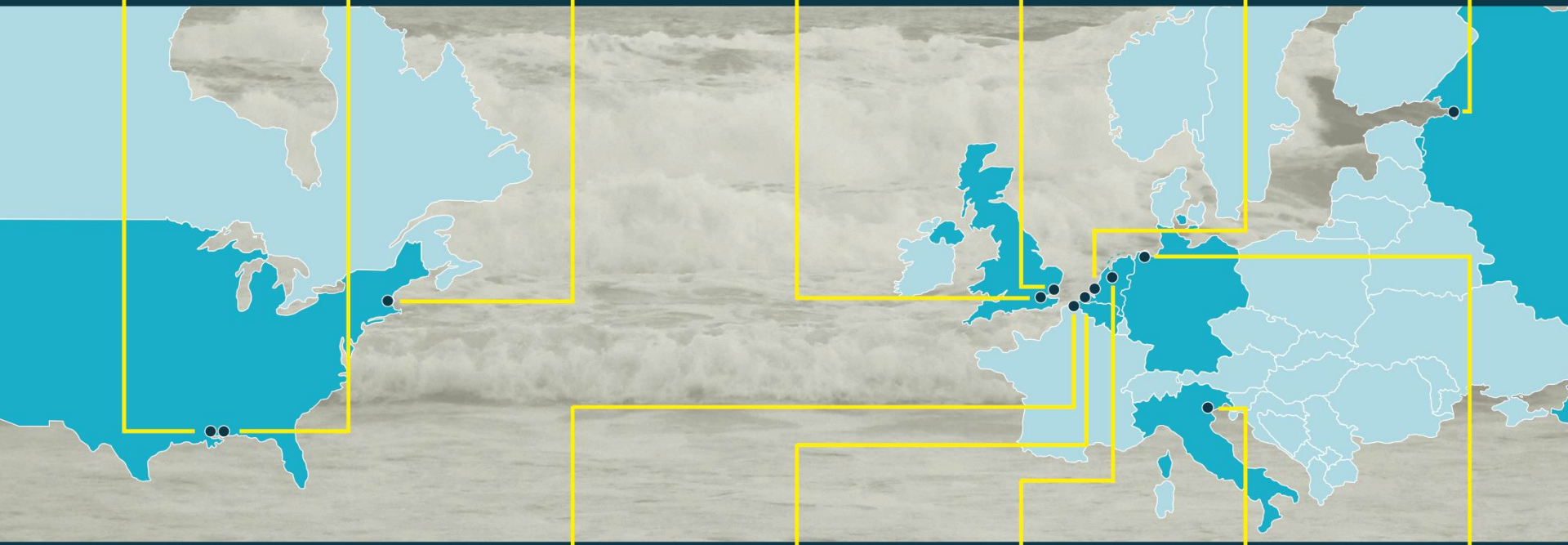
New Bedford Boston (USA)

Thames Barrier (UK)

Barking Barrier (UK)

Maeslant Barrier (NL)

St. Petersburg Barrier (RUS)



Belgium Barrier (BE)

Eastern Scheldt Barrier (NL)

Inflatable Dam at Ramspol (NL)

Venice Barrier (IT)

Ems Barrier (GE)

under construction

Governance

Strategic Board

- **Chair**: Willy Dekker, RWS
- Tom Smith, USACE
- Andrew Pearce, EA
- Roberto Linetti, VWA

Strategic Board

- Provides governance of the network.
- Sets strategic direction and objectives.
- Reviews effectiveness of I-STORM's work.

Delivery Board

- **Chair**: Andy Batchelor, EA
- John Winkelman, USACE
- Giovanni Zarotti, CVN
- Marc Walraven, RWS

Delivery Board

- Maintains technical focus of I-STORM's work.
- Develops future work programme and proposals for the Strategic Board

Membership types

Core

For organisations with large publicly owned SSBs that help run the network.

Benefits

- ❑ *Participation in all I-STORM activities: international peer reviews, working groups, technical knowledge exchange visits.*
- ❑ *Representation on the Board.*
- ❑ *Invitation to Annual Meeting and workshops.*
- ❑ *Listing and access to I-STORM's member directory.*
- ❑ *Access to member forums and core member website area.*

Barrier

For individual publicly owned SSBs.

Benefits

- ❑ *Invitation to attend I-STORM annual meeting and all workshops.*
- ❑ *Participation in limited working groups and peer reviews by invitation.*
- ❑ *Listing and access to I-STORM member directory.*
- ❑ *Access to the member website and forums*

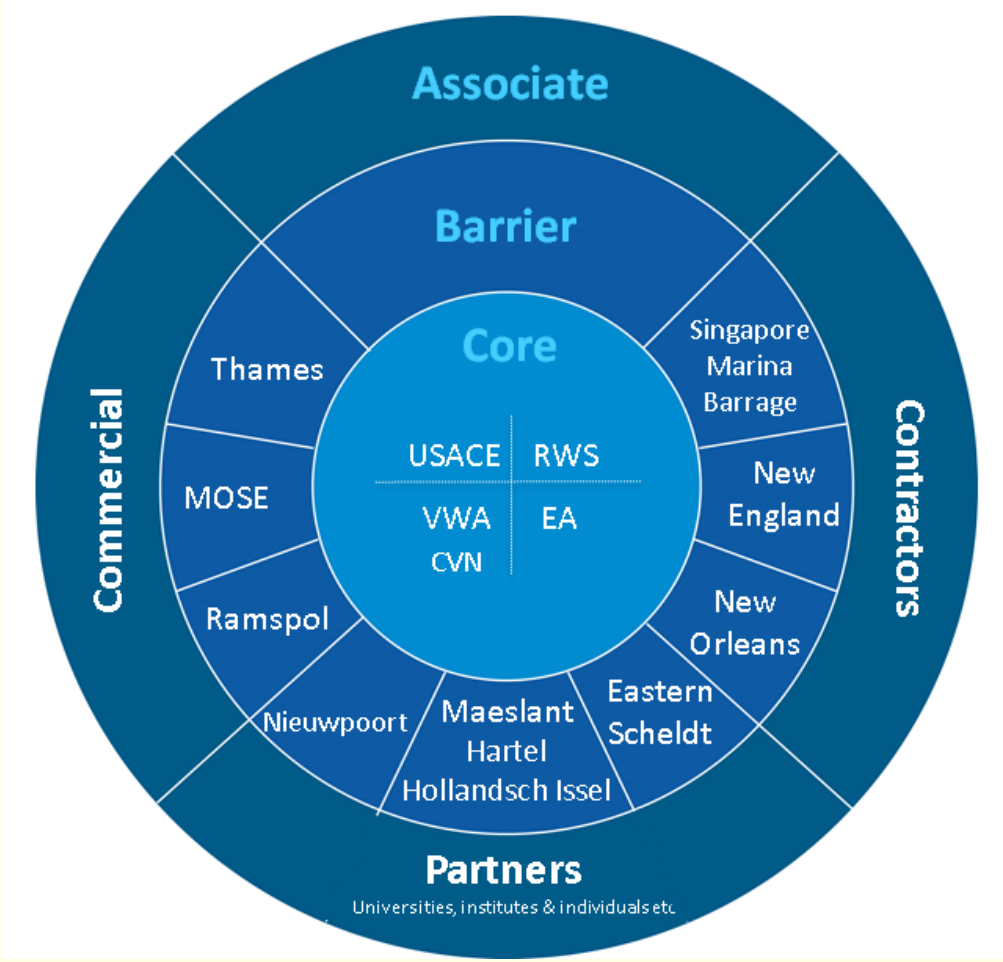
Associate

For those involved in SSB management, maintenance and design.

Benefits

- ❑ *Invitation to attend I-STORM annual meeting and some workshops.*
- ❑ *Invitation to participate in some working groups.*
- ❑ *Listing and access to I-STORM member directory.*
- ❑ *Access to the member website and forums.*

Membership Structure



How we share knowledge

- **Annual Conference:**
  presentations, site visits, worshops & program book
- **Knowledge exchange:**
  requests, site visits, shadowing, WebEx etc. on specific topics
- **Peer Reviews**
- **Varied approach:**
  newsletters, WebEx, I-STORM website, movies, case studies, reports & best practices guides
- **Translation**
- **Workstreams / Projects**

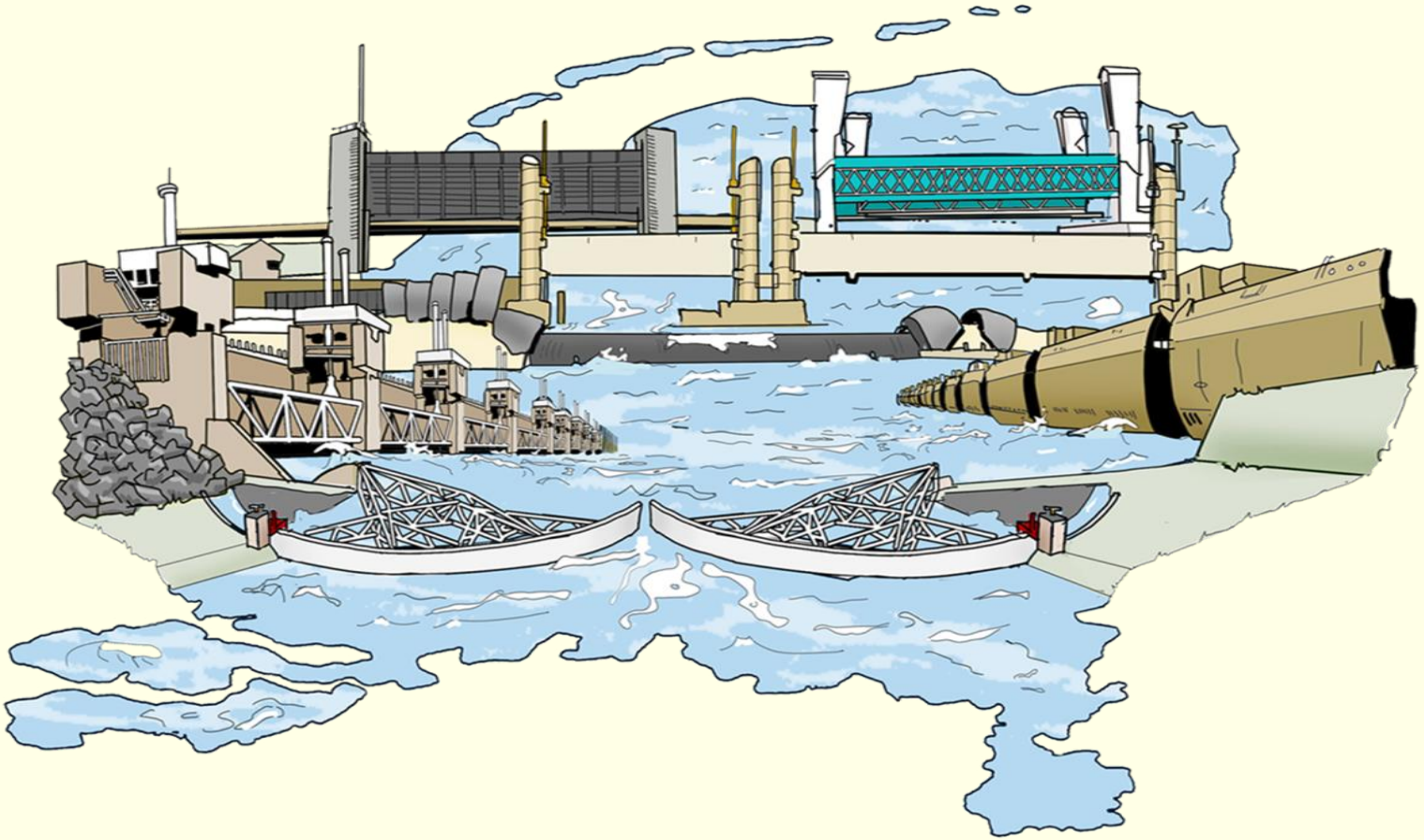


Peer Reviews

I-STORM
INTERNATIONAL NETWORK FOR STORM SURGE BARRIERS


THE PEER REVIEW
OF THE MAESLANT BARRIER
JUNE 2014

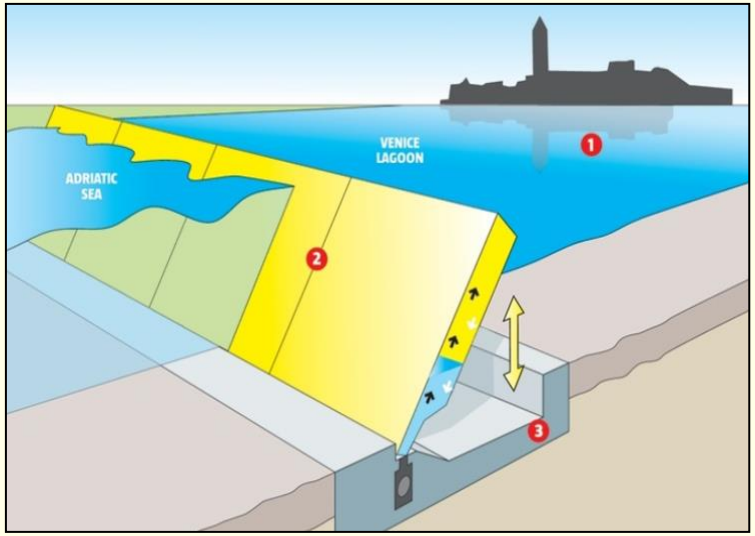
Recent activities

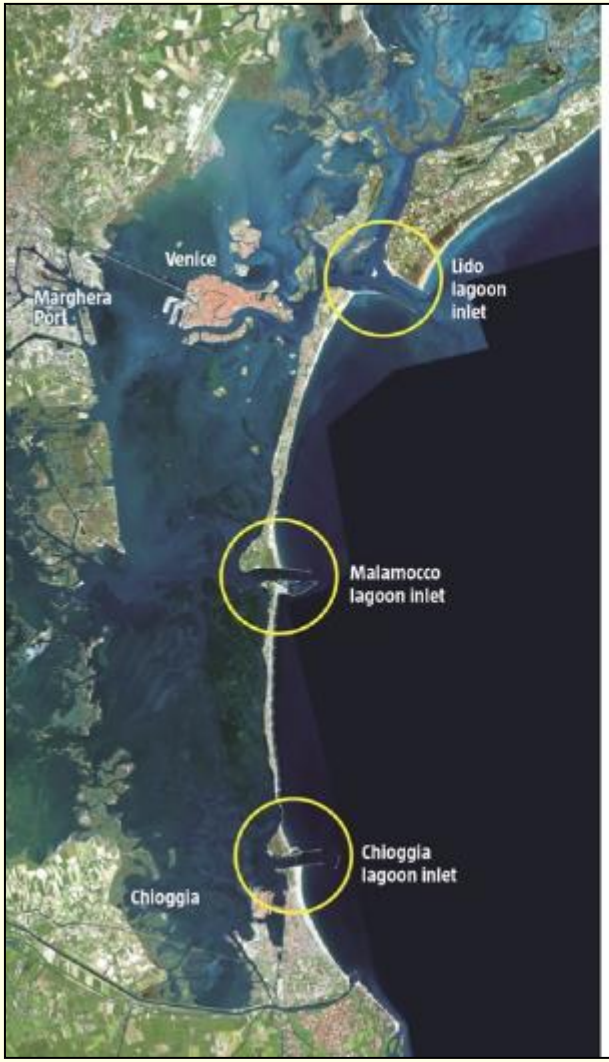


Most recent
Workshop Galveston

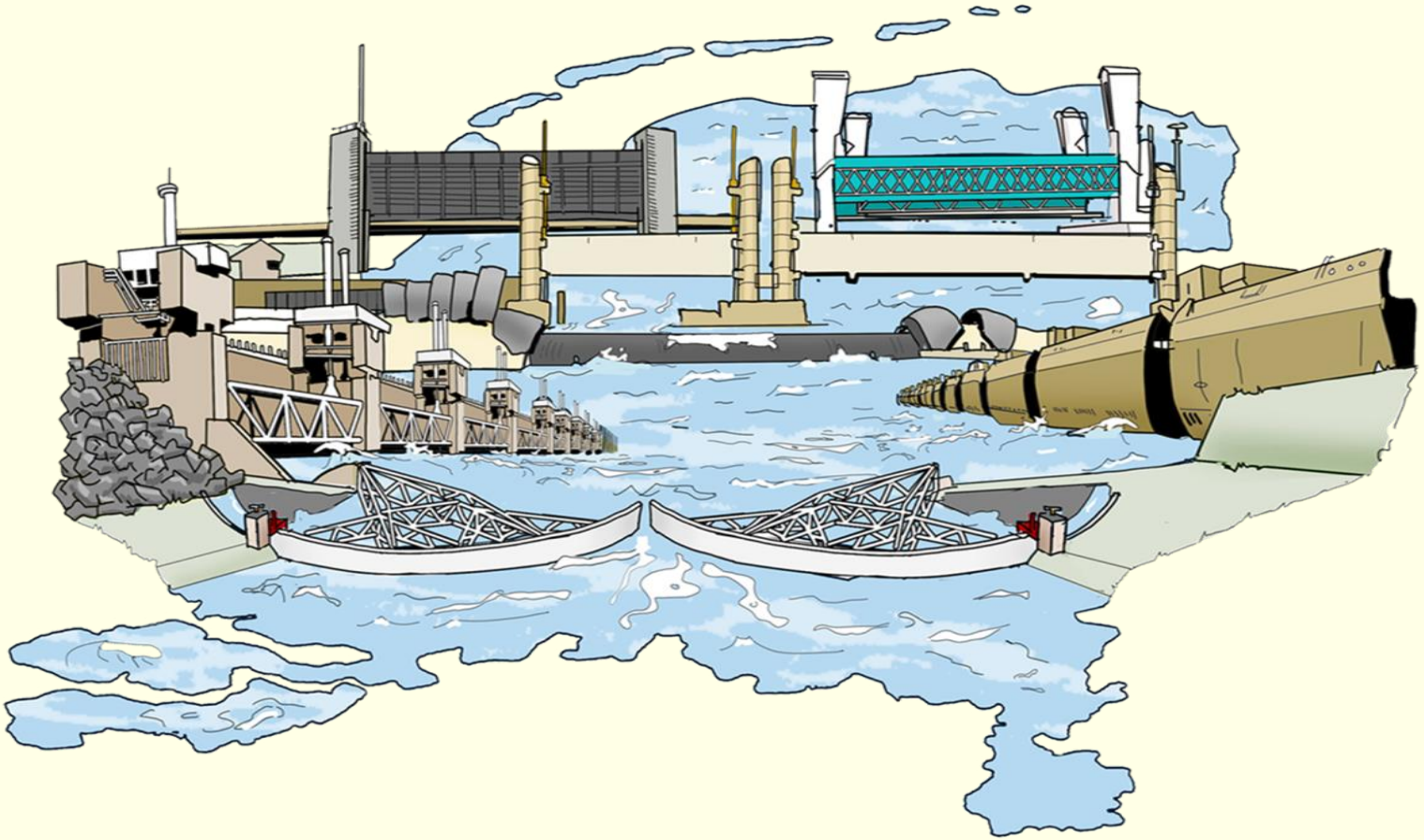
Today we're here in Denmark

Upcoming: Field trip and Operational Review Venice





Conclusion



Key note:

To prove that a storm surge barrier operates to its (legal) requirements, it has to achieve high standards for **maintenance**, **operations** and **organisation**

Therefore, pay special or equal attention to those aspects already in the phase of design and construction

I-STORM can be the community to learn, share and develop experiences with. We invite you to do so!


Thank you
Any questions?