

## Coastal management in the Netherlands for the past 2000 years

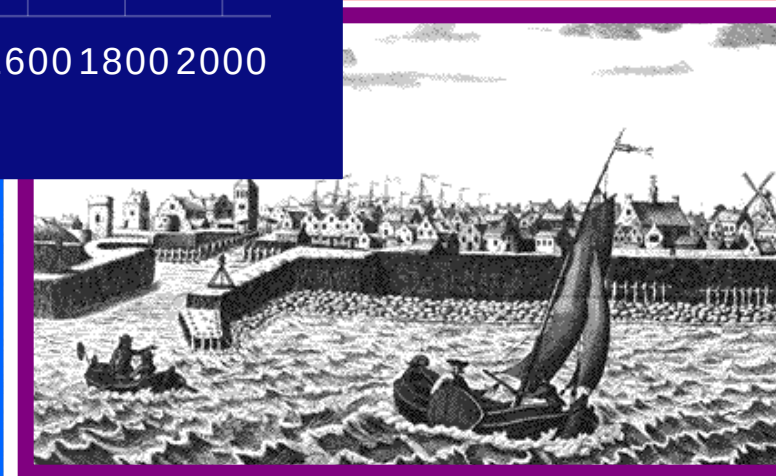
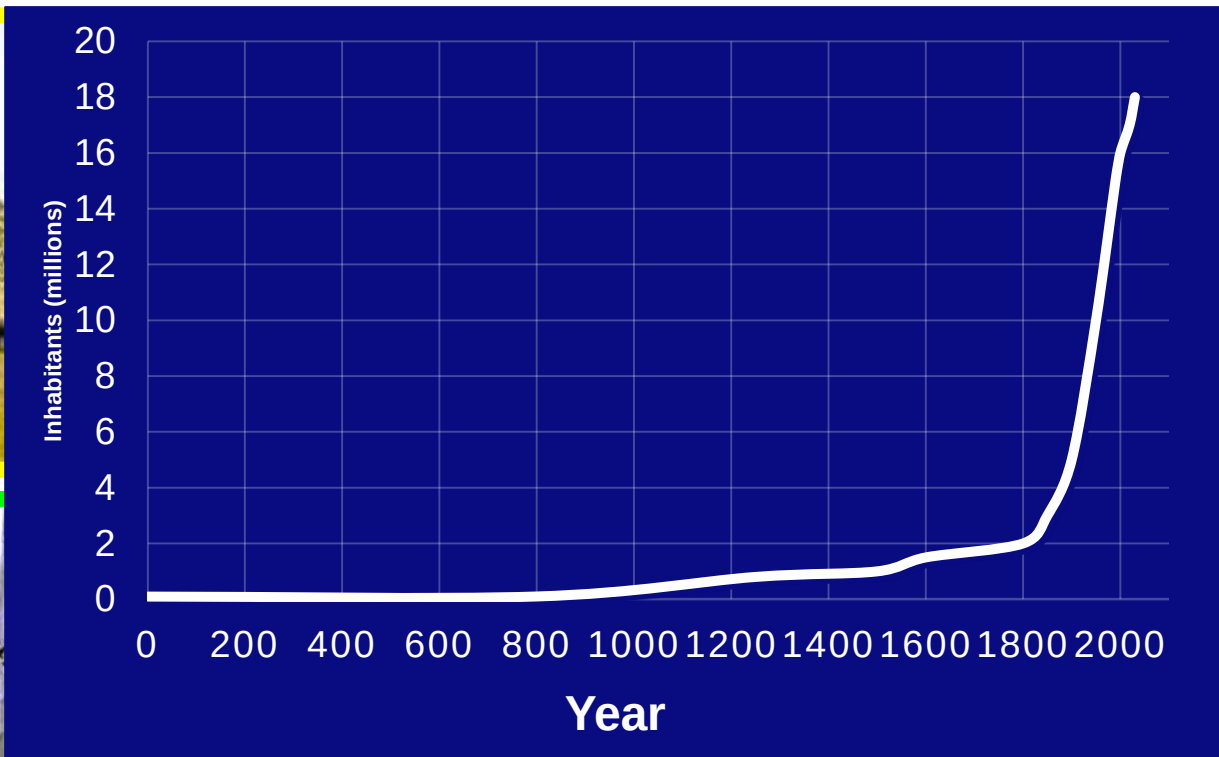
Dr Albert P. Oost

0

800

1250

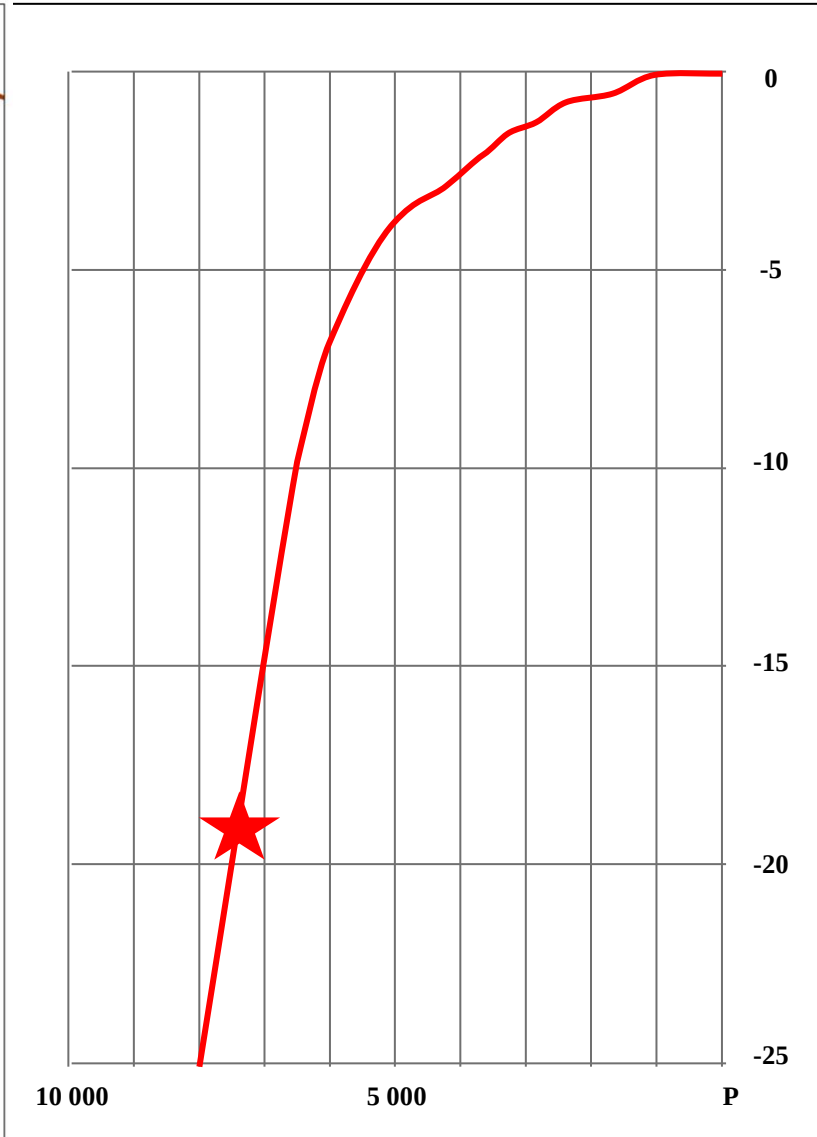
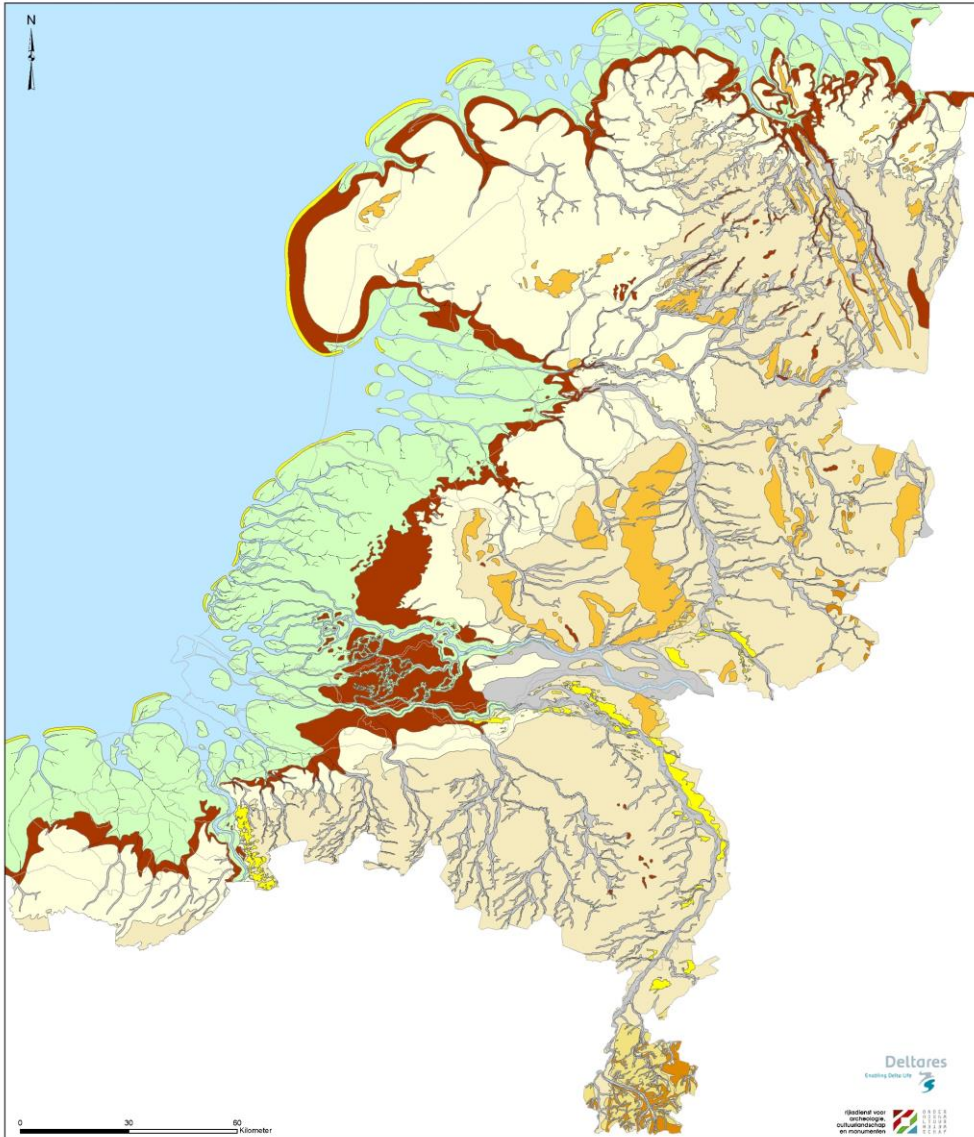
1600 1800 2000



Deltares



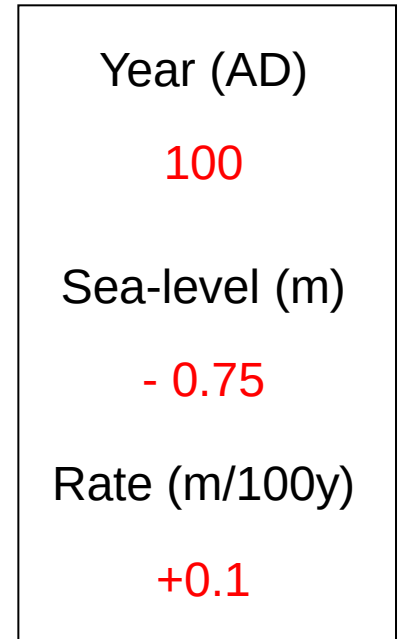
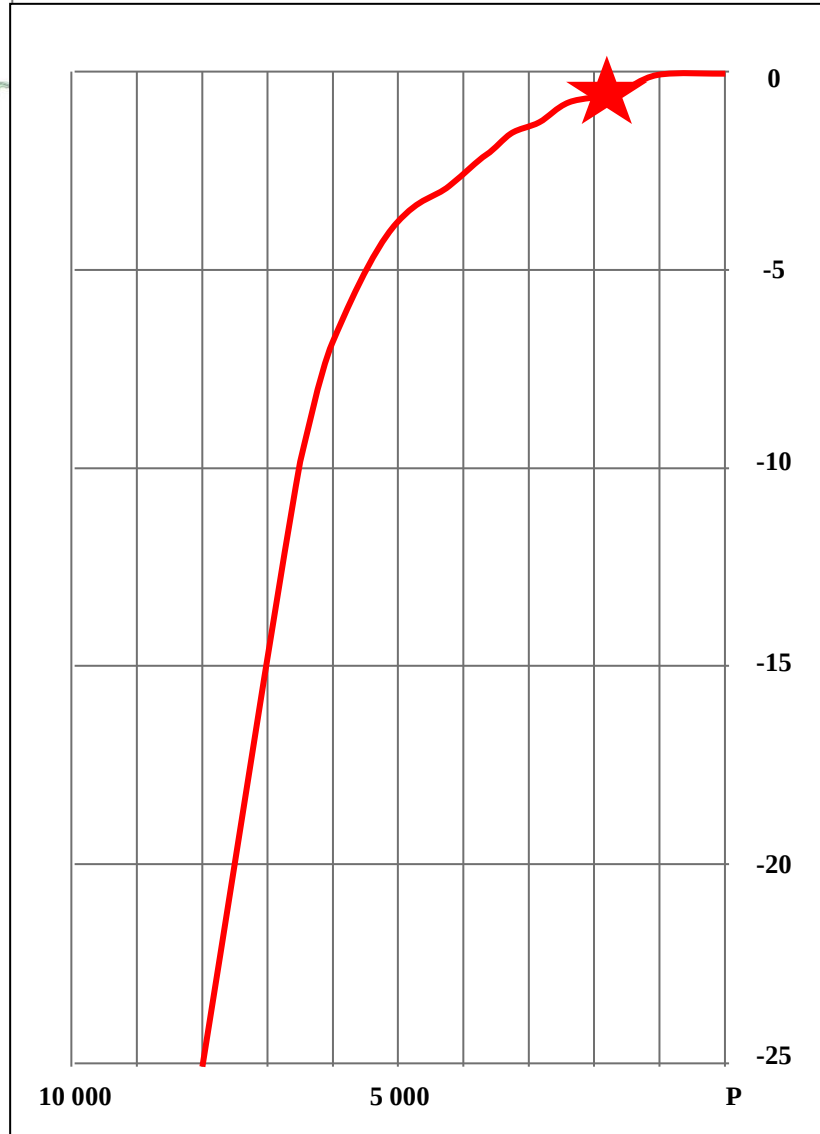
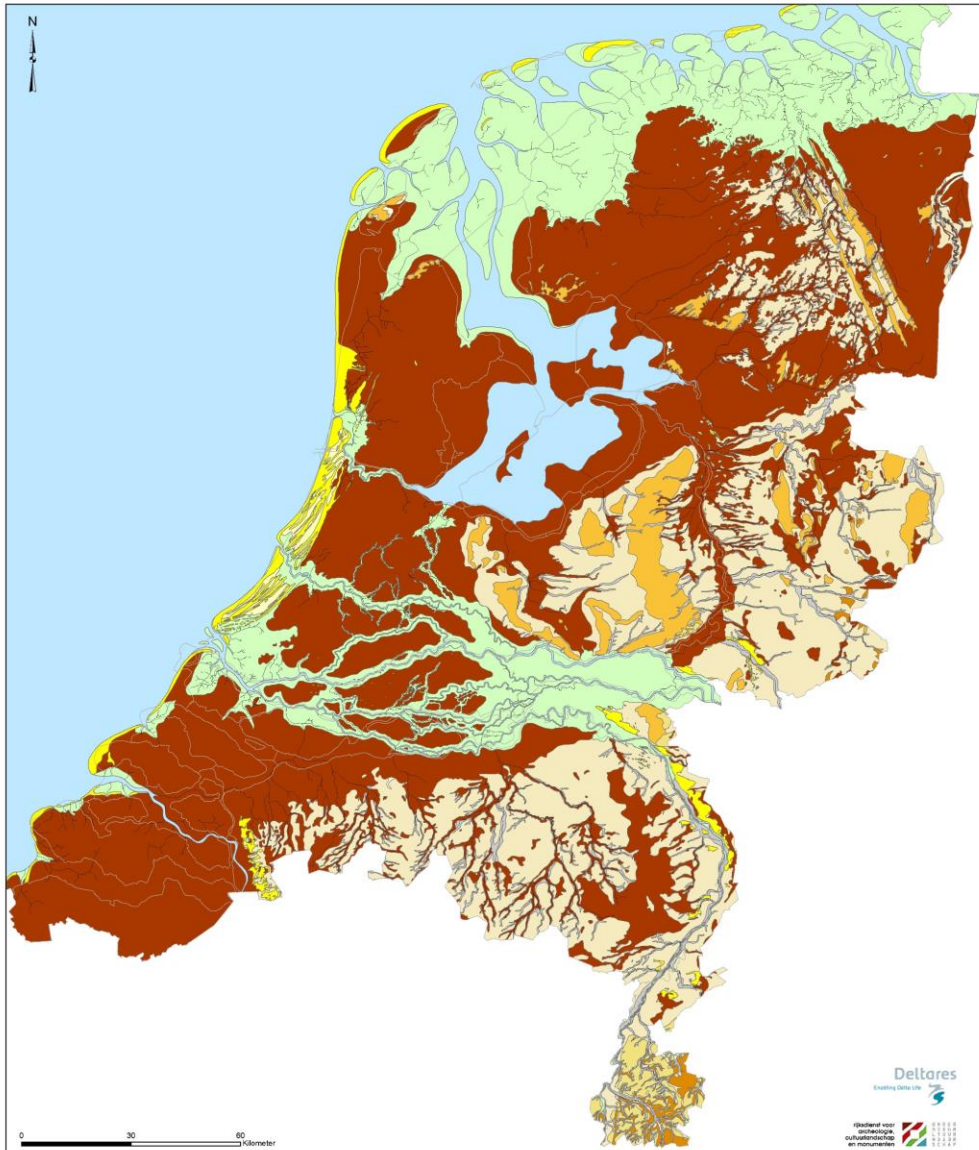
# Geological history of The Netherlands



|               |
|---------------|
| Year (BC)     |
| 5500          |
| Sea-level (m) |
| - 19          |
| SLR (m/100y)  |
| 1             |

Vos, 2008

0 800 1250 1600 1800 2000



Vos, 2008

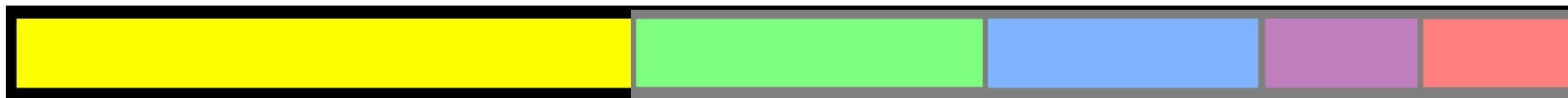


0

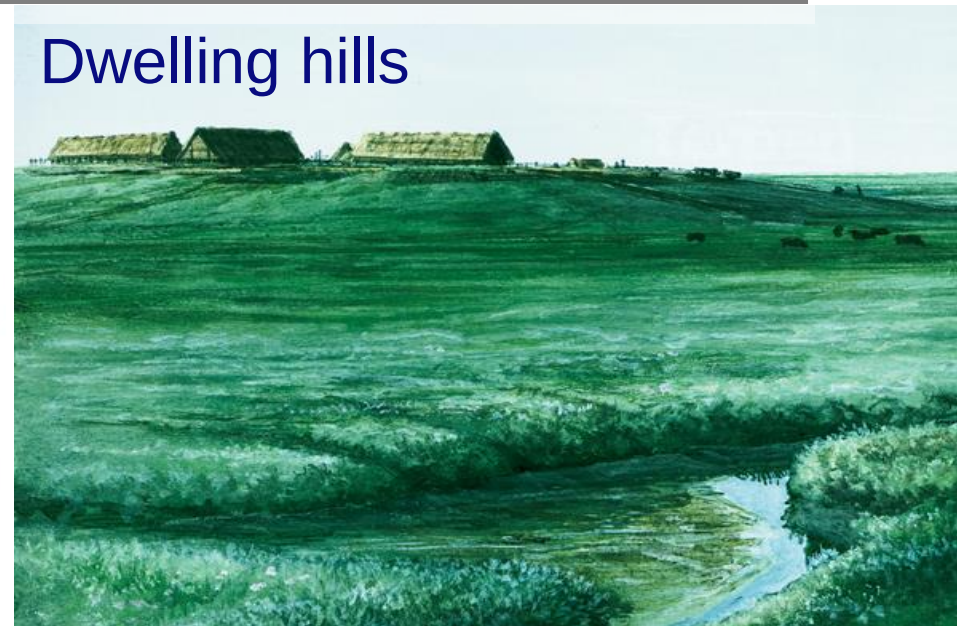
800

1250

1600 1800 2000



Dwelling hills



*There this miserable race  
occupies elevated patches of  
ground or platforms built up by  
hand above the level of the  
highest tide experienced...*

Deltares

Pliny, Hist. Nat. XVI





0 800 1250 1600 1800 2000



Dams in tidal creeks  
Culvert with anti-flood valve



Dwelling hills and dikes!



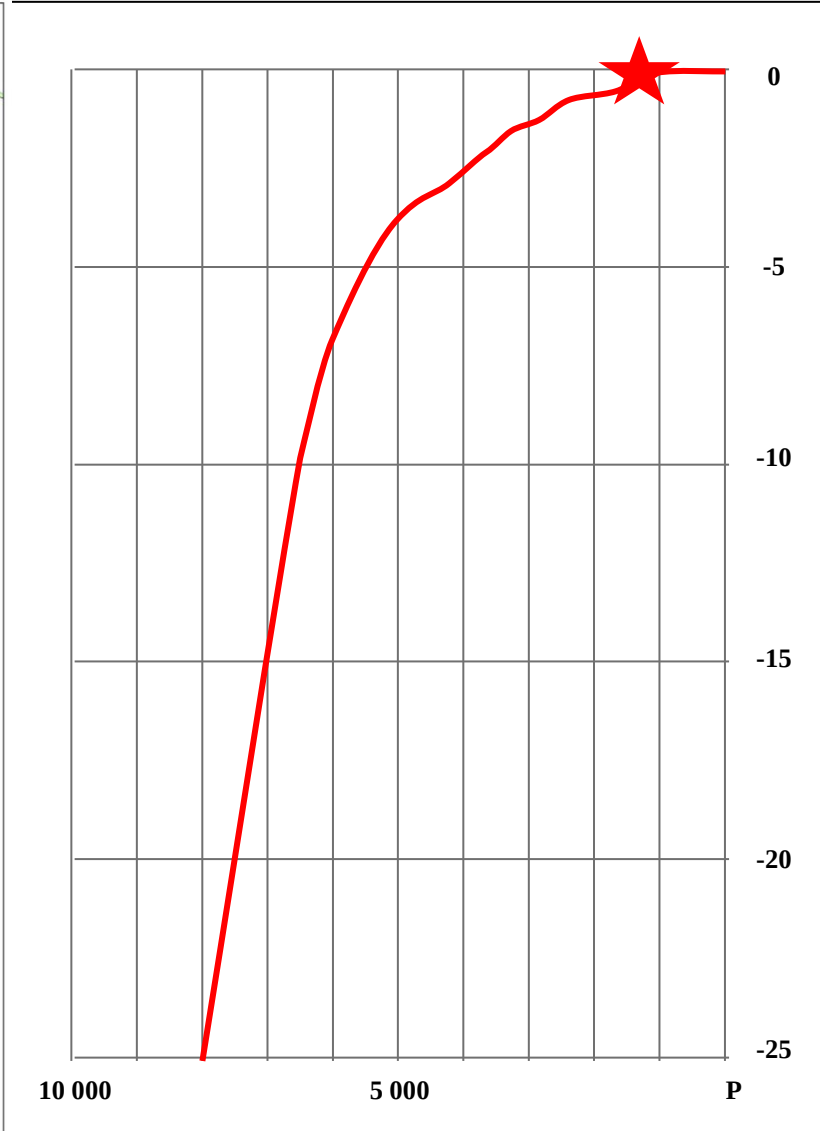
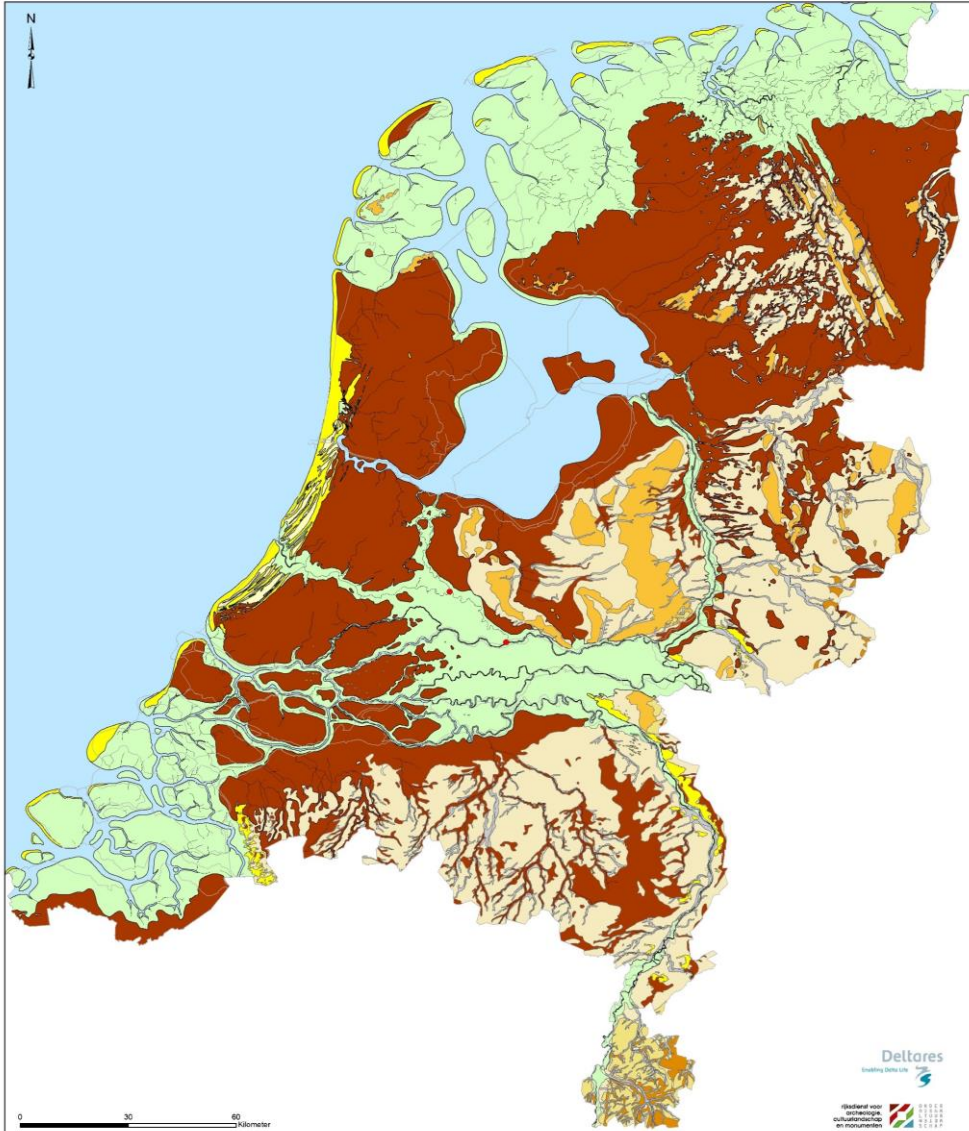
+0.9-1.1m  
middle marsh

+0.1-0.2m  
lower marsh



800

1250



Year (AD)

800

Sea-level (m)

- 0.2

Rate (m/100y)

+0.0

Vos, 2008

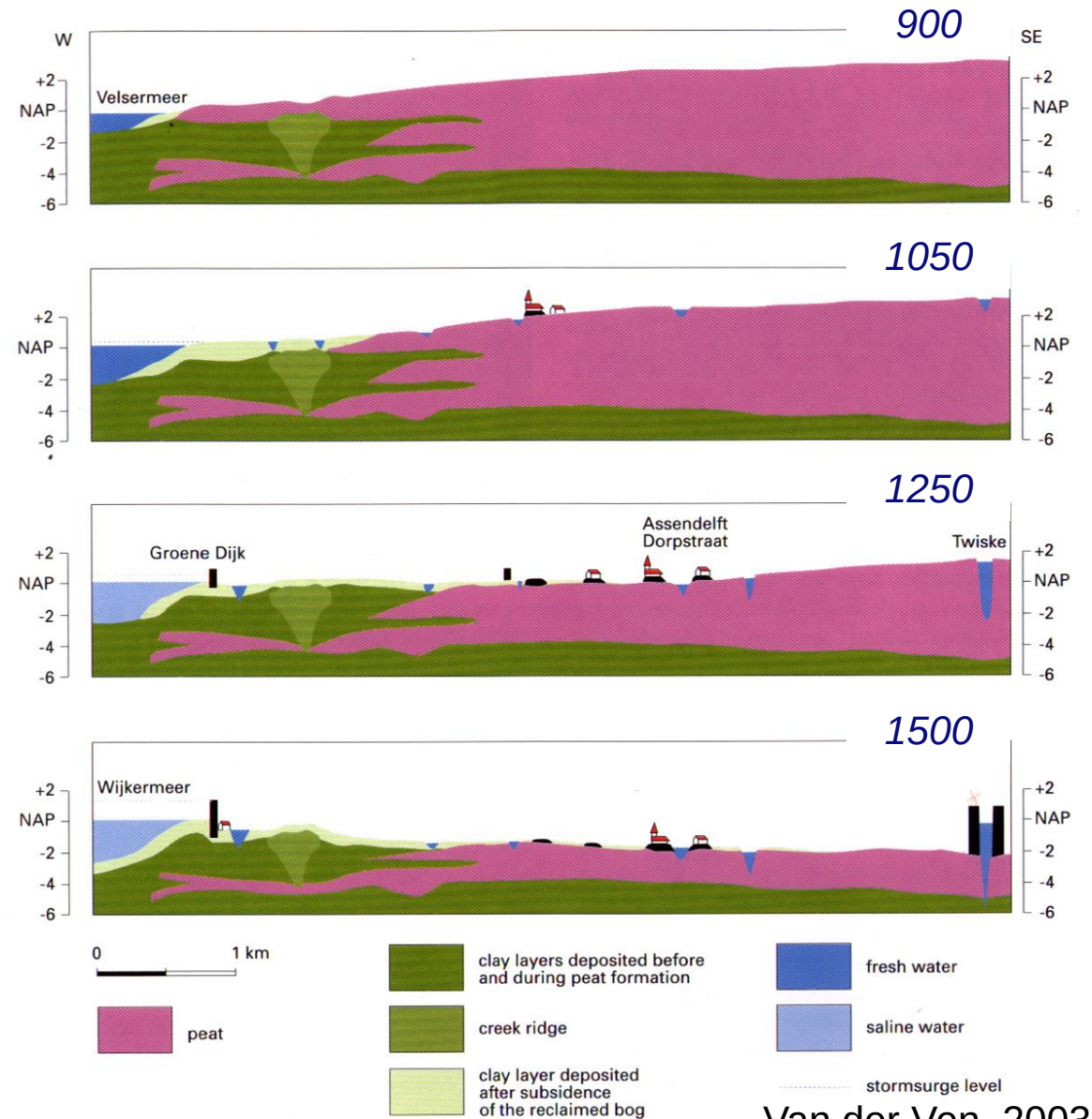


800

1250



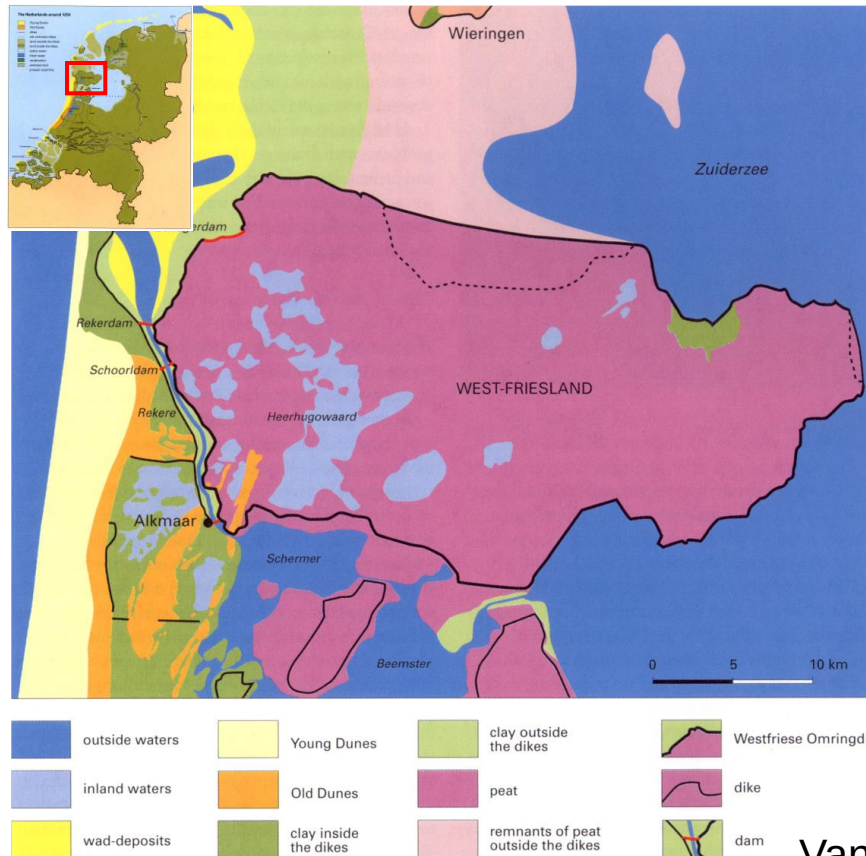
*Subsidence due to  
agriculture of peat-areas*





800

1250



## Local water authorities

Van der Ven, 2003

*That we, Frisians, have to found a stronghold against the sea,  
a golden hoop which lies around all of Friesland, of which  
every dike-measure shall be equal to the other...*

**Deltares**

Rustinger Law, 12th century

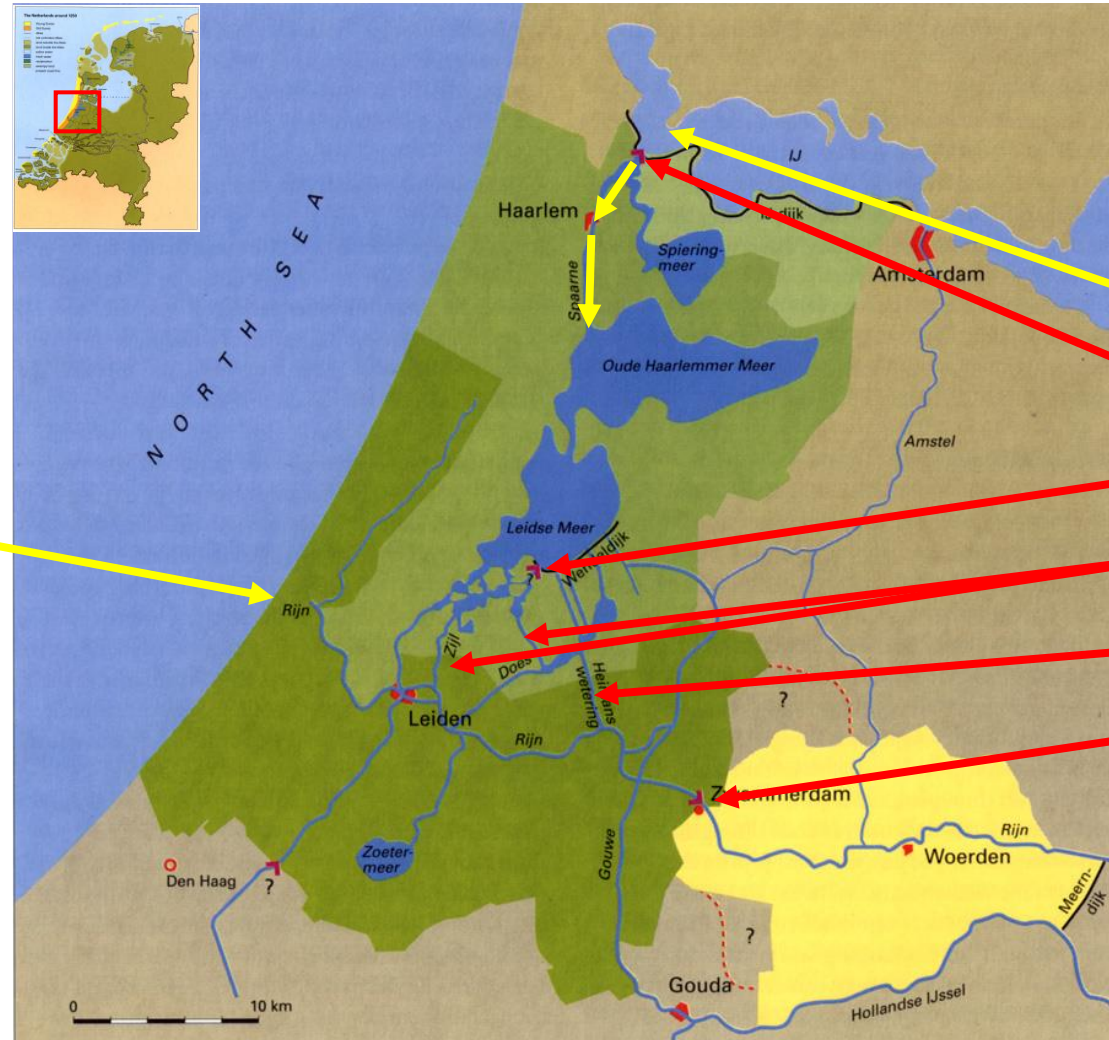
800

1250



Water-boards:  
Regional judicial &  
administrative districts  
*Hoogheemraadschap*  
*Rijnland*

Closure Rhine: 1150-1175



Flooding: 1165-1250

Sluices: 1248

Sluices: 1226

Channels: ca. 1165

Channels: 1202/04

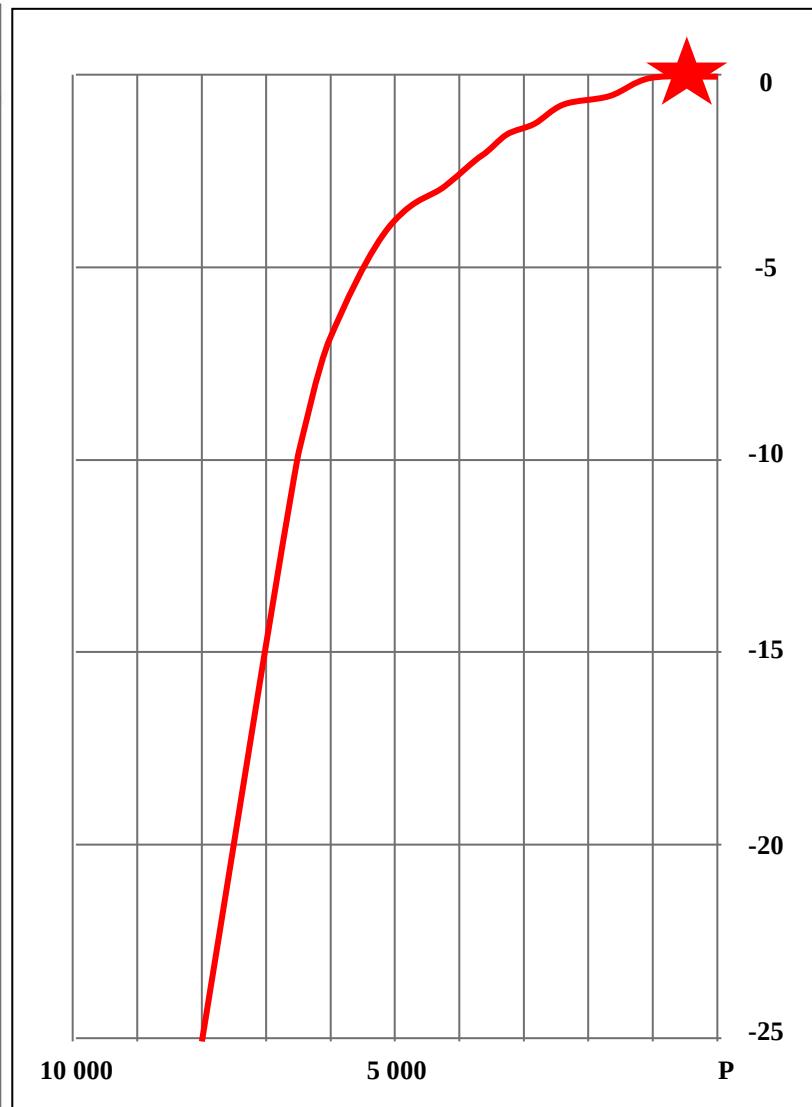
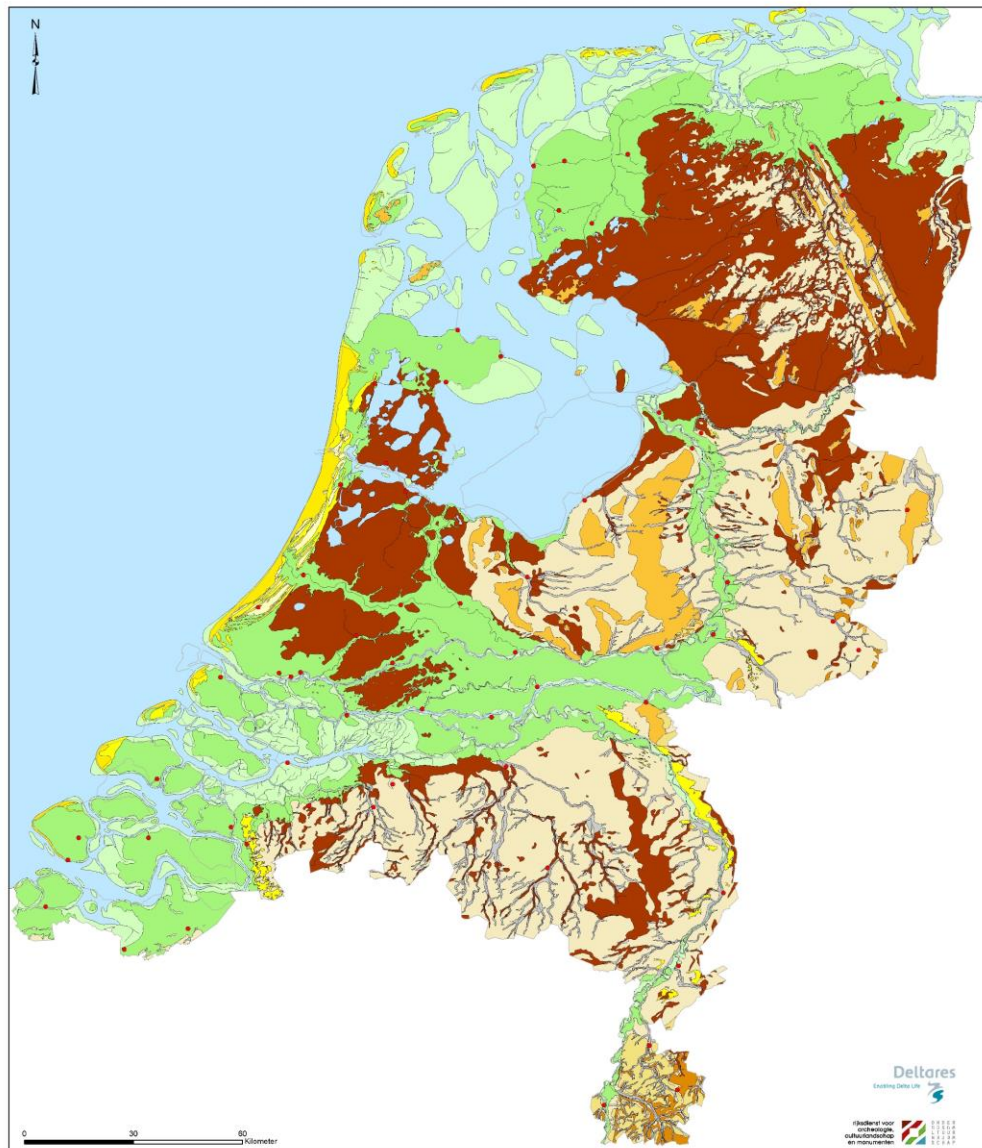
Dammed: <1165; 1202

Van der Ven, 2003



1250

1600



Year (AD)

1500

Sea-level (m)

- 0

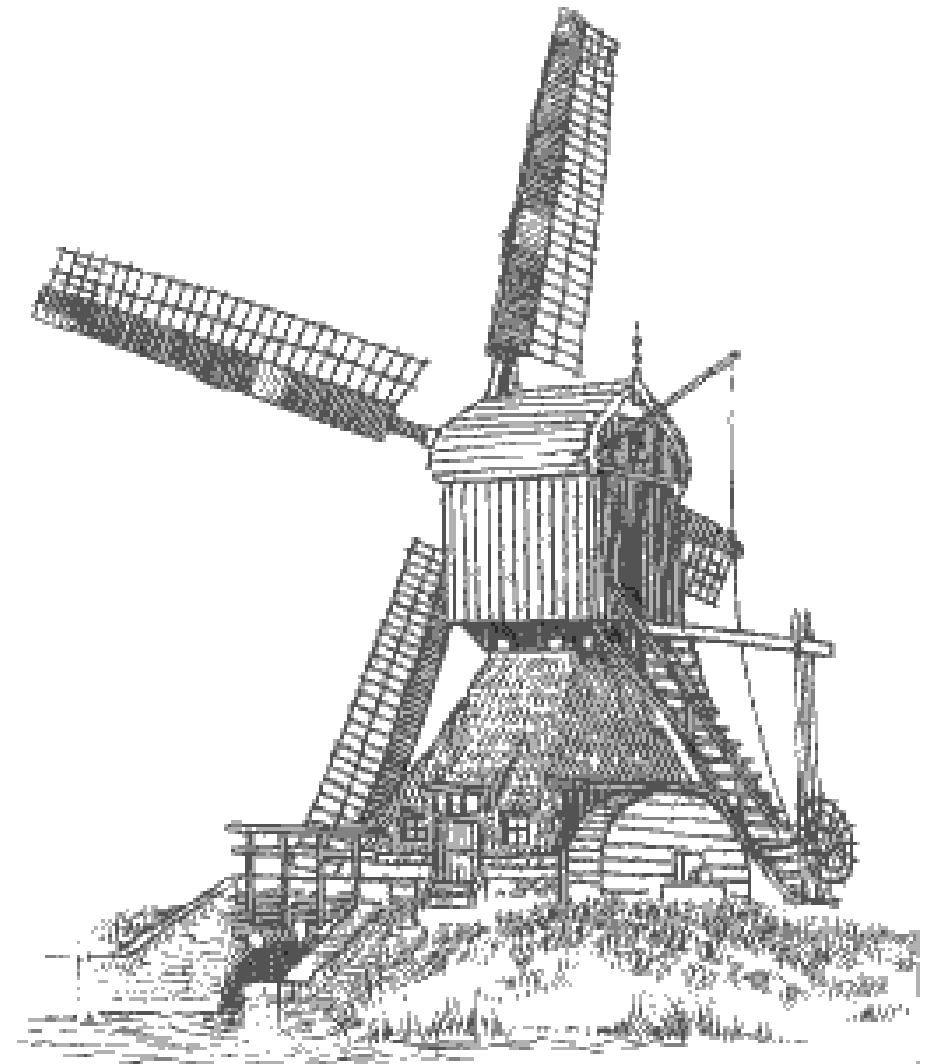
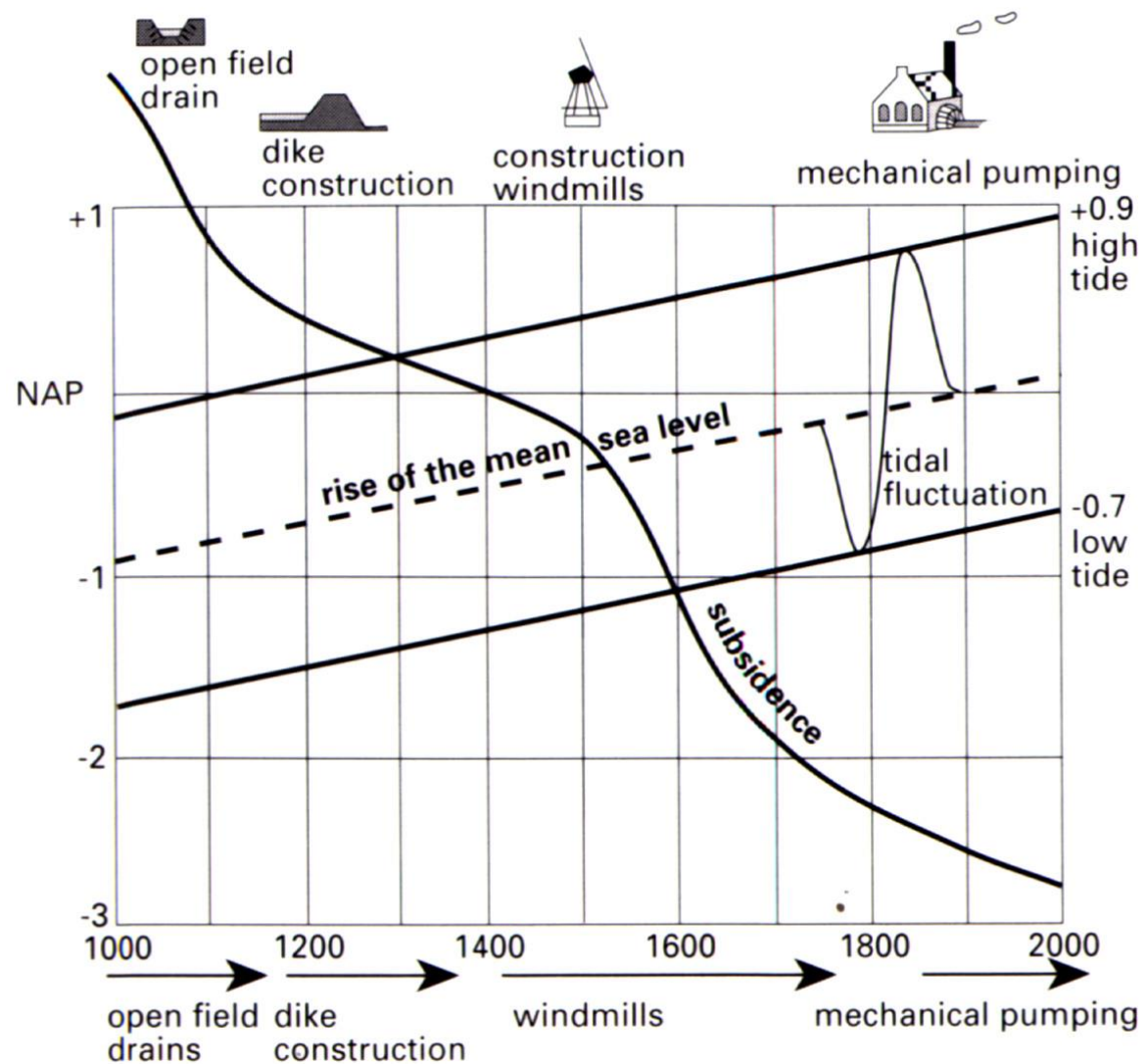
Rate (m/100y)

+0.0

Vos, 2008

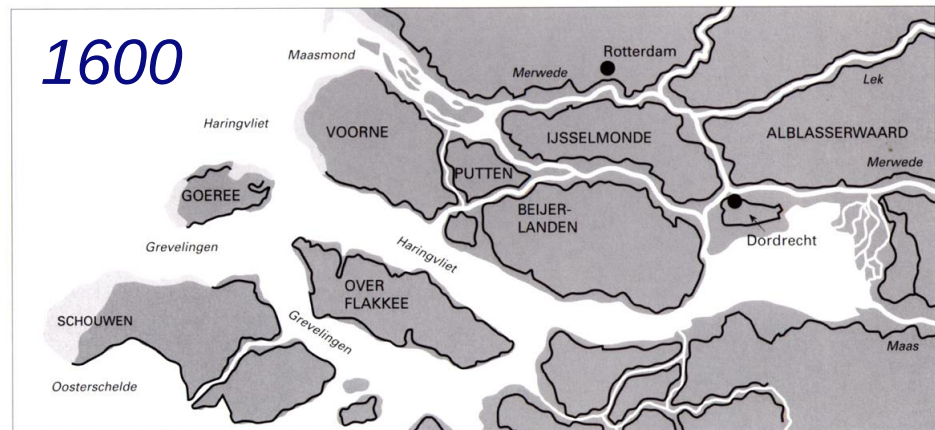
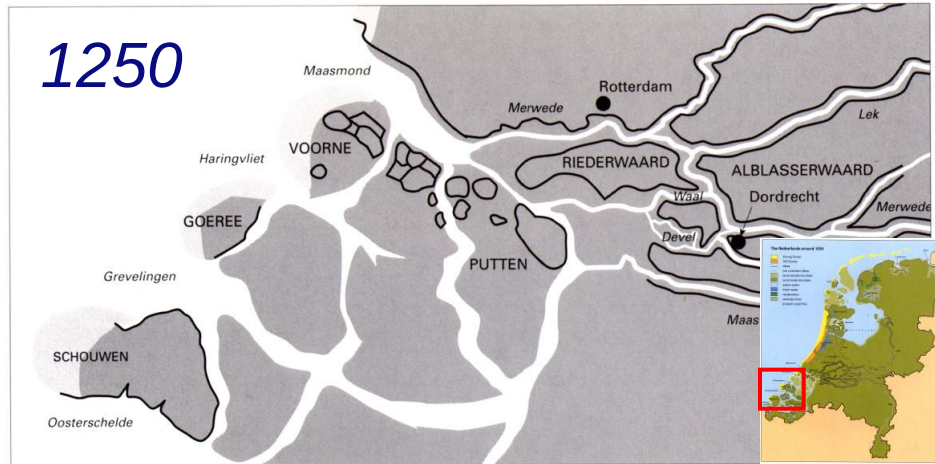
1250

1600





# Most regional water-boards created before 1550



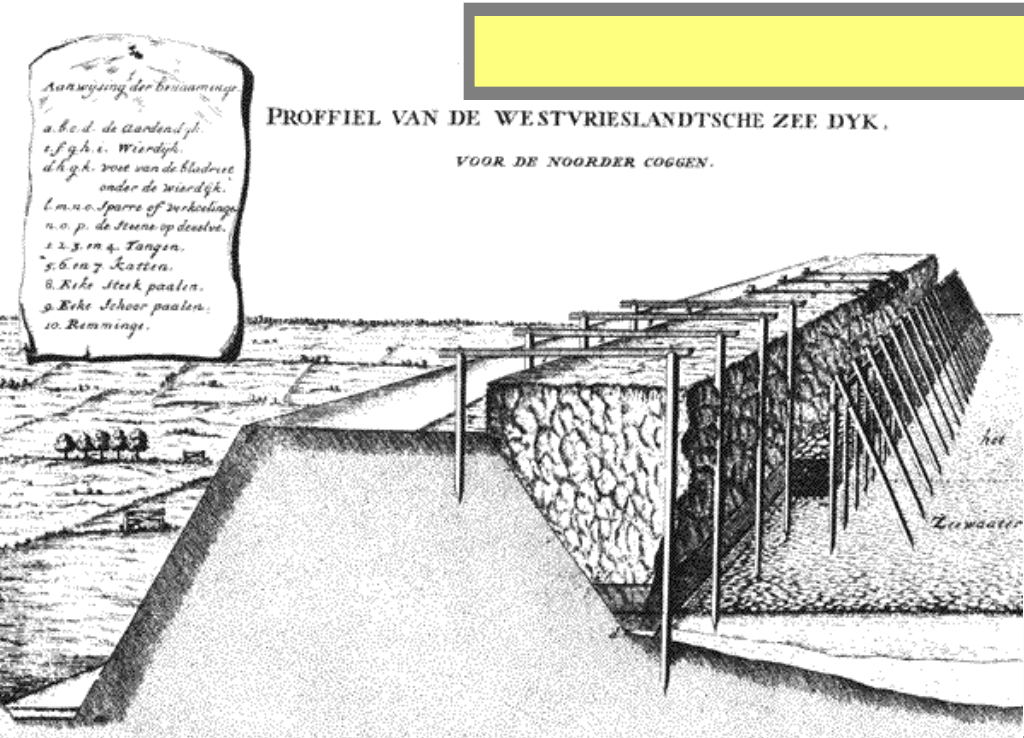
**Deltares**



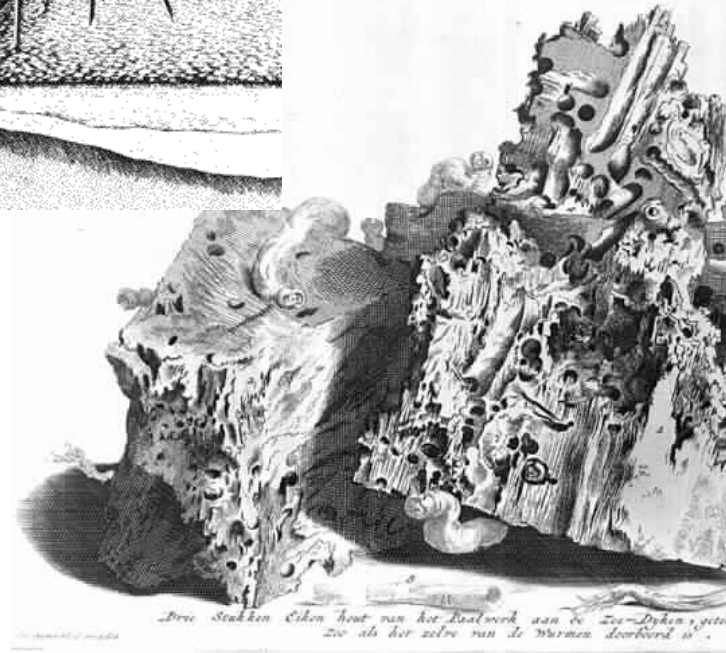
Van der Ven, 2003



1600 1800

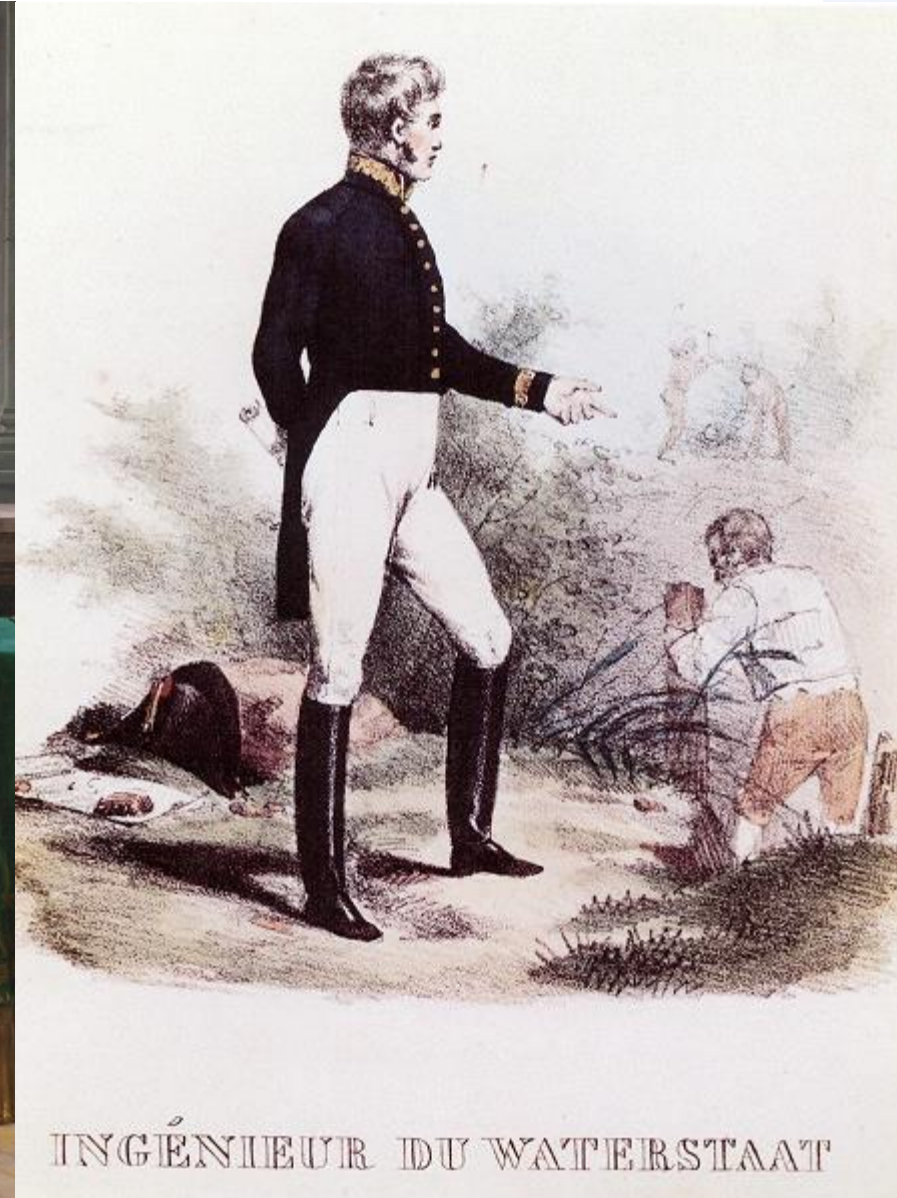
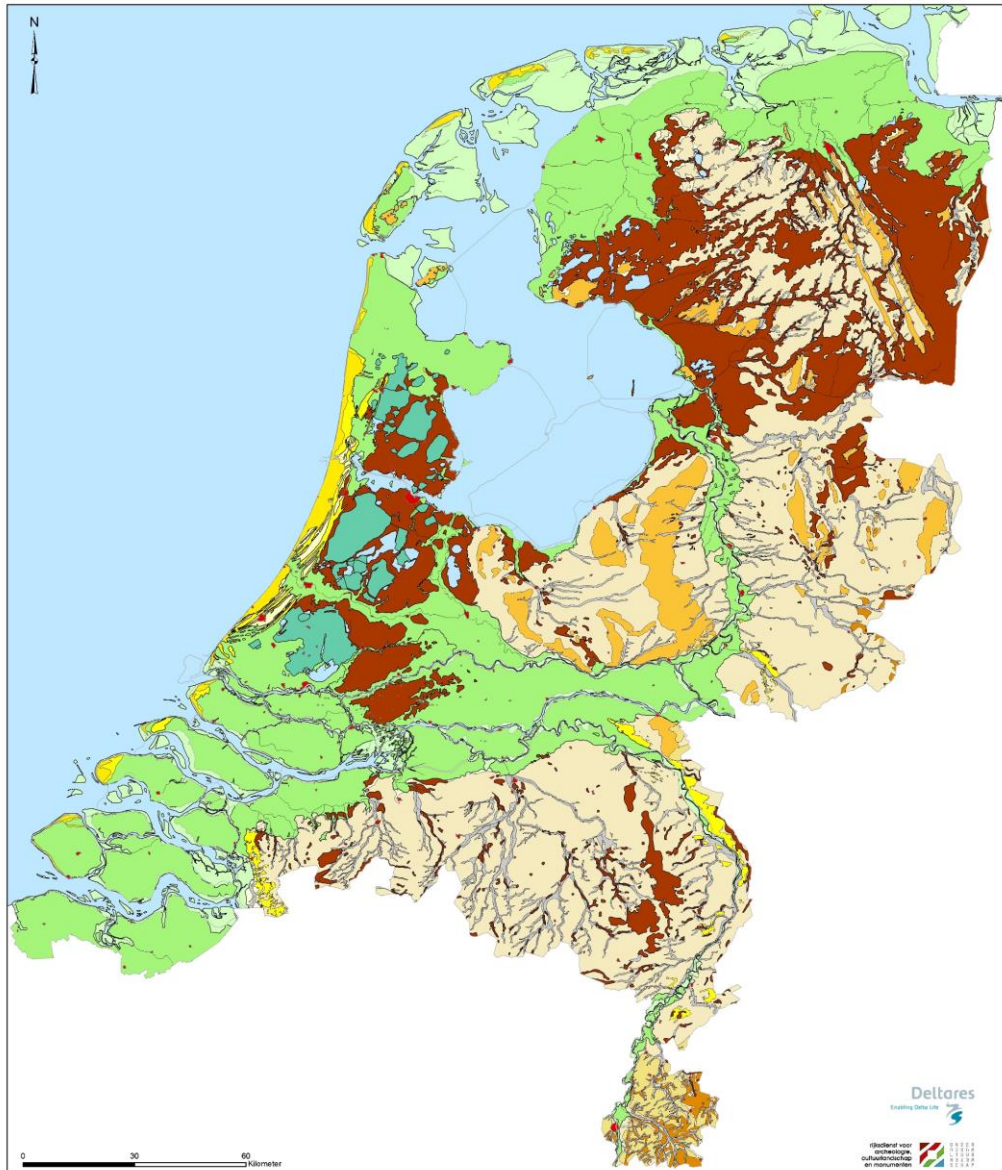


1732-34: Shipworm  
(*Teredo navalis* & *Psiloteredo megotara*)





1600 1800





1800 2000



1891



Cornelis Lely



Deltares

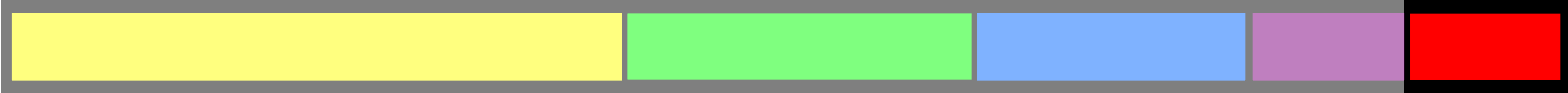


1800 2000

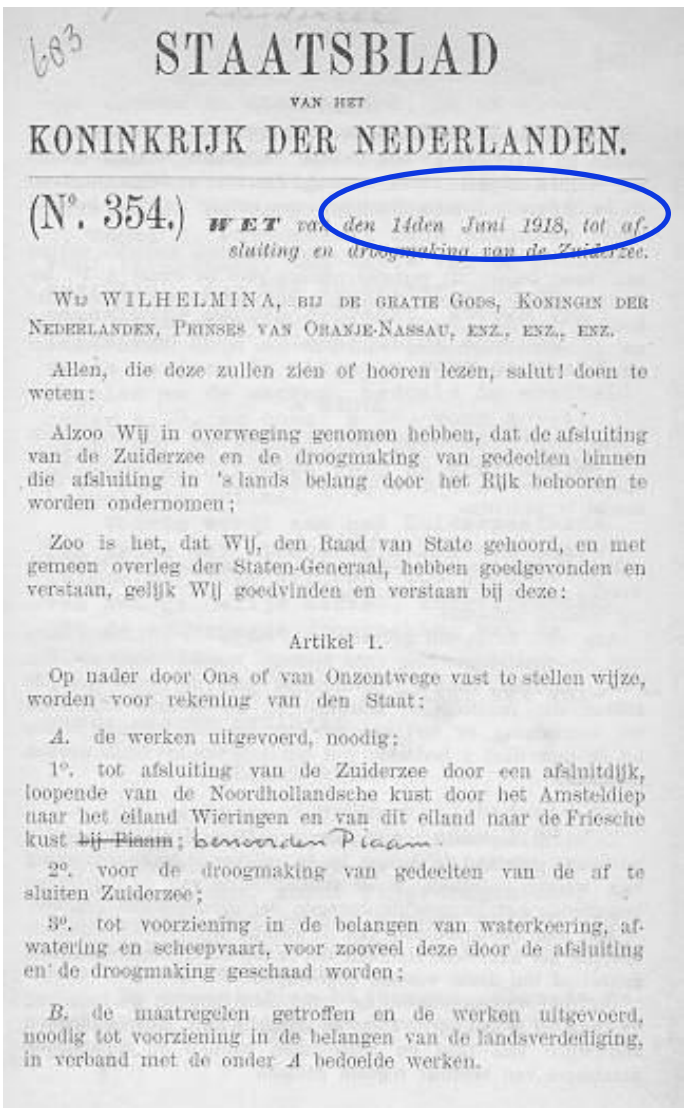


1916: storm surge floods the Zuiderzee area





1918





1800 2000



1932: Zuiderzee enclosure (Afsluitdijk)



Deltares







1953



1835 dead; 72.000 evacuated;  
500 km dike damaged; 2000 km<sup>2</sup> flooded

Deltan





Deltaplan



Deltar

# Two-fold approach:

## 1) Standarized safety for flooding

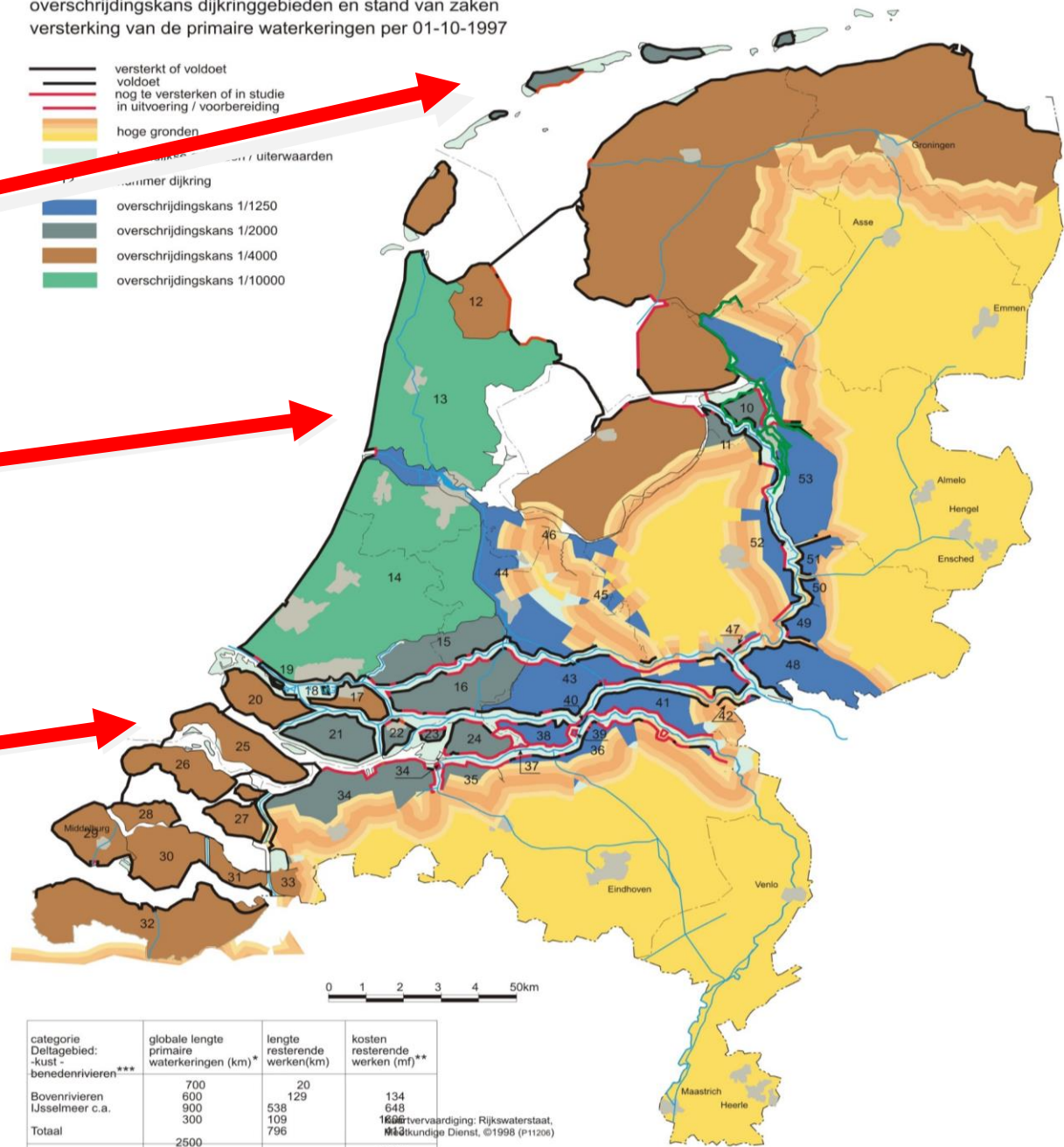
1 : 2000

1 : 10.000

1 : 4000

overschrijdingskans dijkkringgebieden en stand van zaken  
versterking van de primaire waterkeringen per 01-10-1997

- versterkt of voldoet
- voldoet
- nog te versterken of in studie
- in uitvoering / voorbereiding
- hoge gronden
- uitwaarden
- uiterwaarden
- overstroomingsgebied
- overschrijdingskans 1/1250
- overschrijdingskans 1/2000
- overschrijdingskans 1/4000
- overschrijdingskans 1/10000



| categorie                                       | globale lengte<br>primaire<br>waterkeringen (km) * | lengte<br>resterende<br>werken(km) | kosten<br>resterende<br>werken (mfl) ** |
|-------------------------------------------------|----------------------------------------------------|------------------------------------|-----------------------------------------|
| Deltagebied:<br>- kust -<br>benedenrivieren *** | 700                                                | 20                                 | 134                                     |
| Bovenrivieren                                   | 600                                                | 129                                | 648                                     |
| IJsselmeer c.a.                                 | 900                                                | 538                                | 109                                     |
| Totaal                                          | 300                                                | 796                                | 796                                     |
|                                                 | 2500                                               |                                    | 2801                                    |

\* primaire waterkeringen die direct buitenwater keren (als in zwart/rood aangegeven op de kaart)



Two-fold approach:

1) Standardized safety for flooding

Weak links: Hondsbossche & Pettemer Zeewering

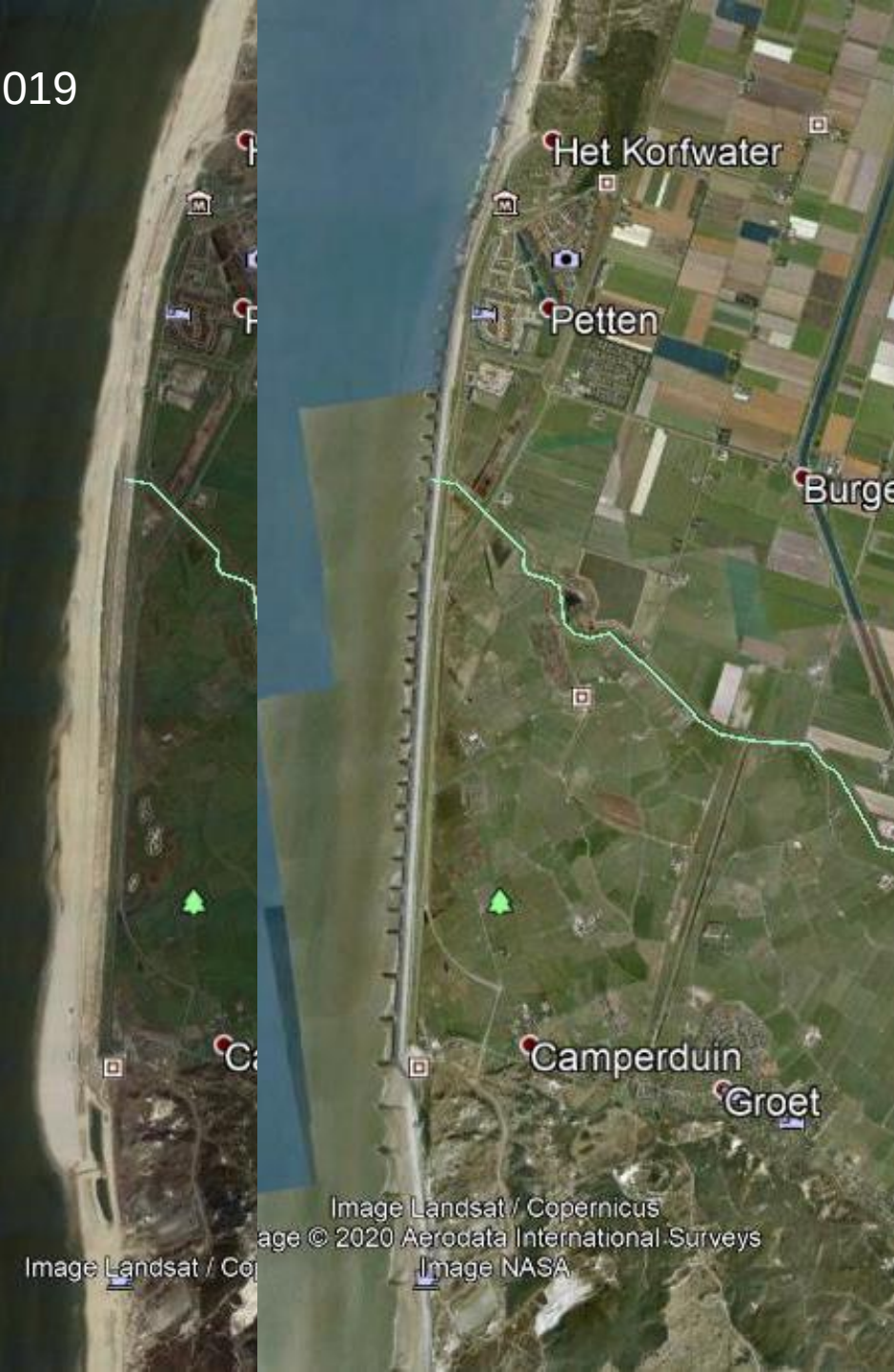
→ 2014-2015: 5.5 km, 250 m of dunes & beaches

In total:  $40 \cdot 10^6 \text{ m}^3$  sand



Deltares

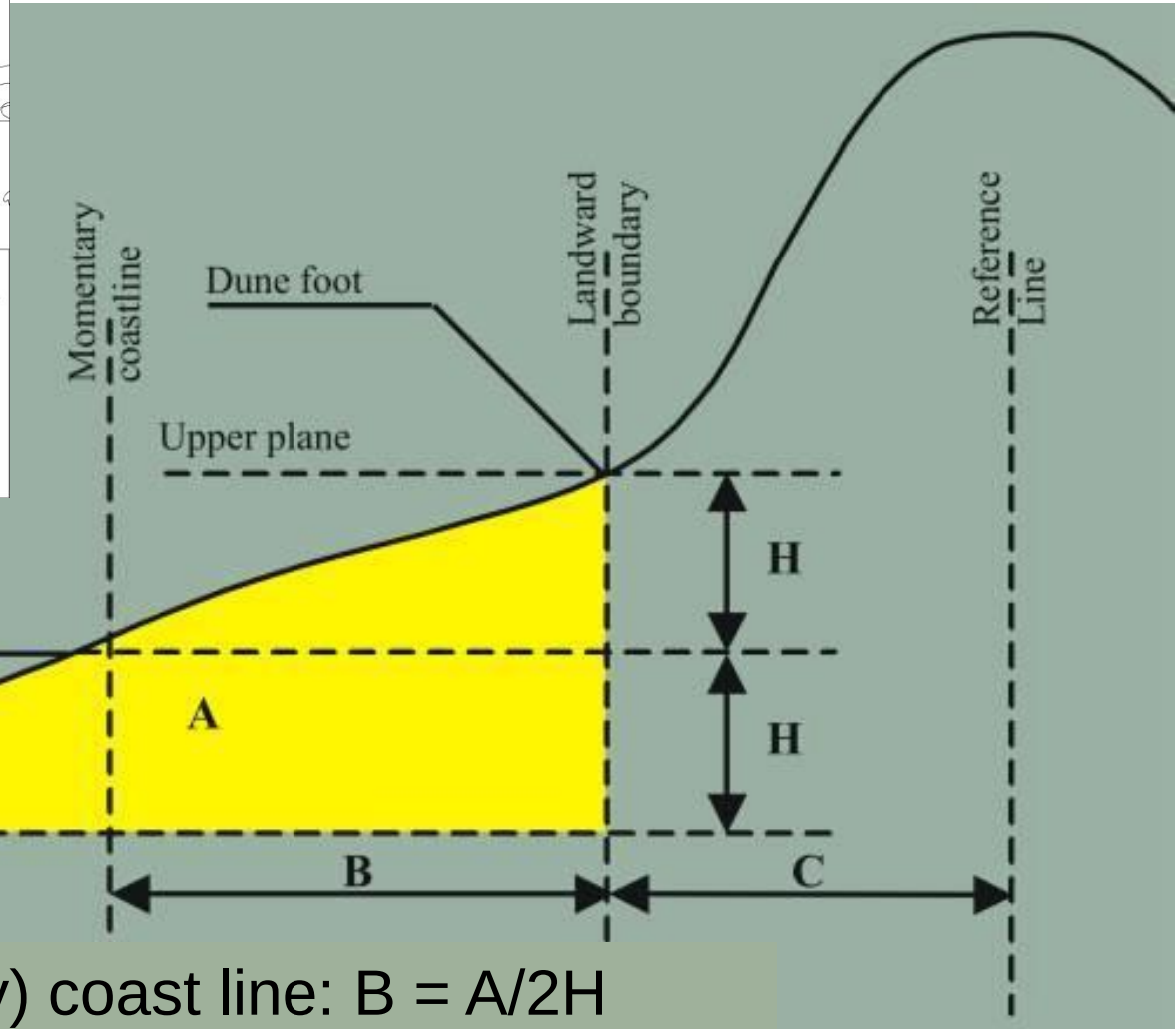
2019



Two-fold approach:

- 1) Standardized safety for flooding
- 2) Maintaining the coast

1<sup>st</sup> Coastal Policy Document, 1990:  
*Maintain coast line on its position  
without disturbing natural dynamics*

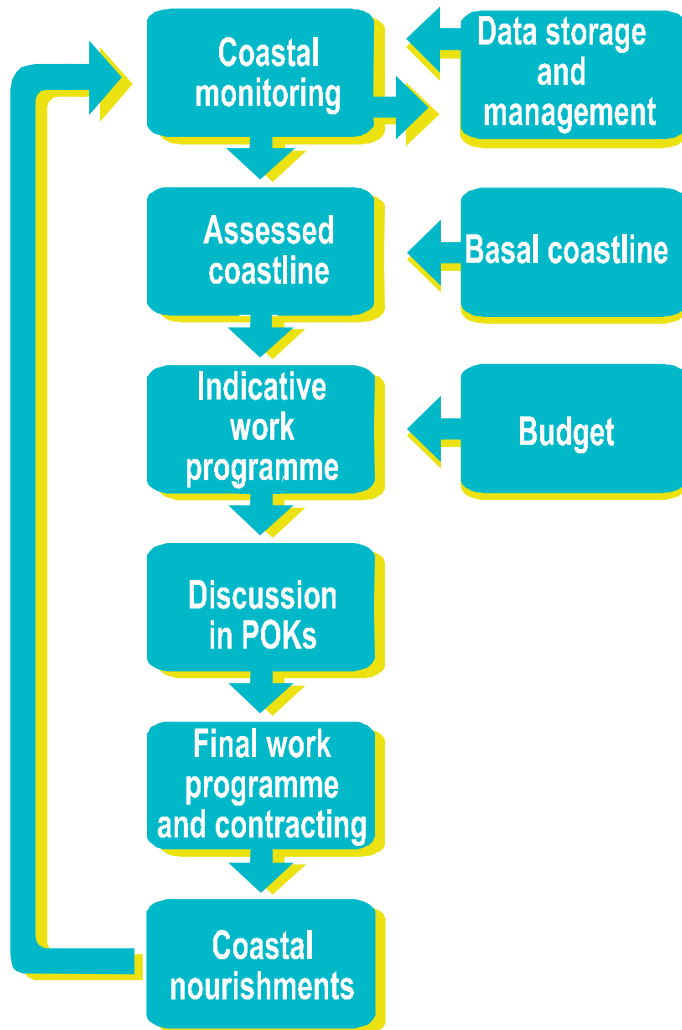


Deltares

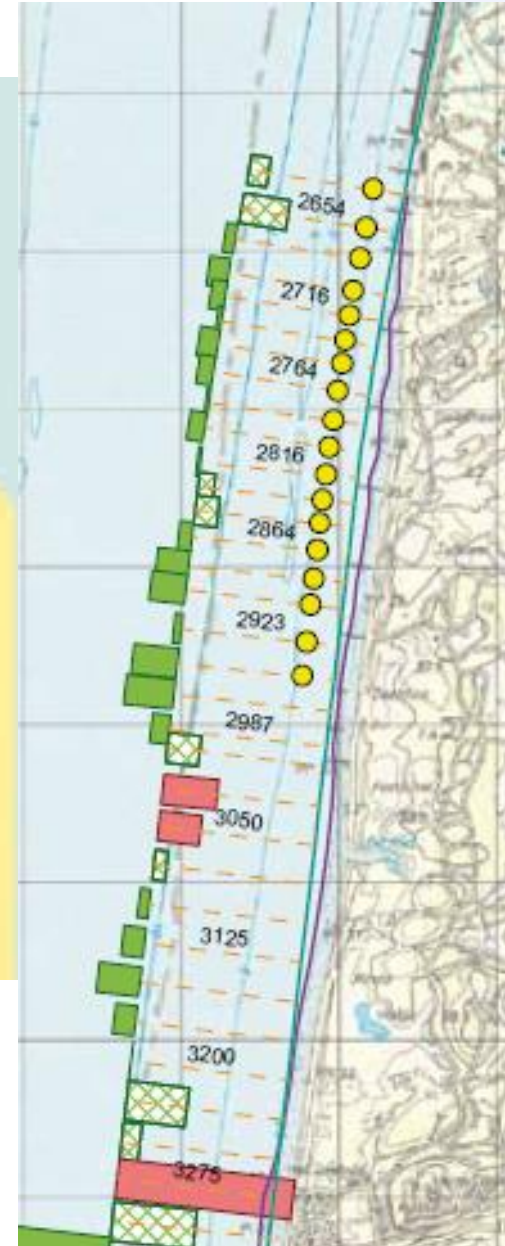
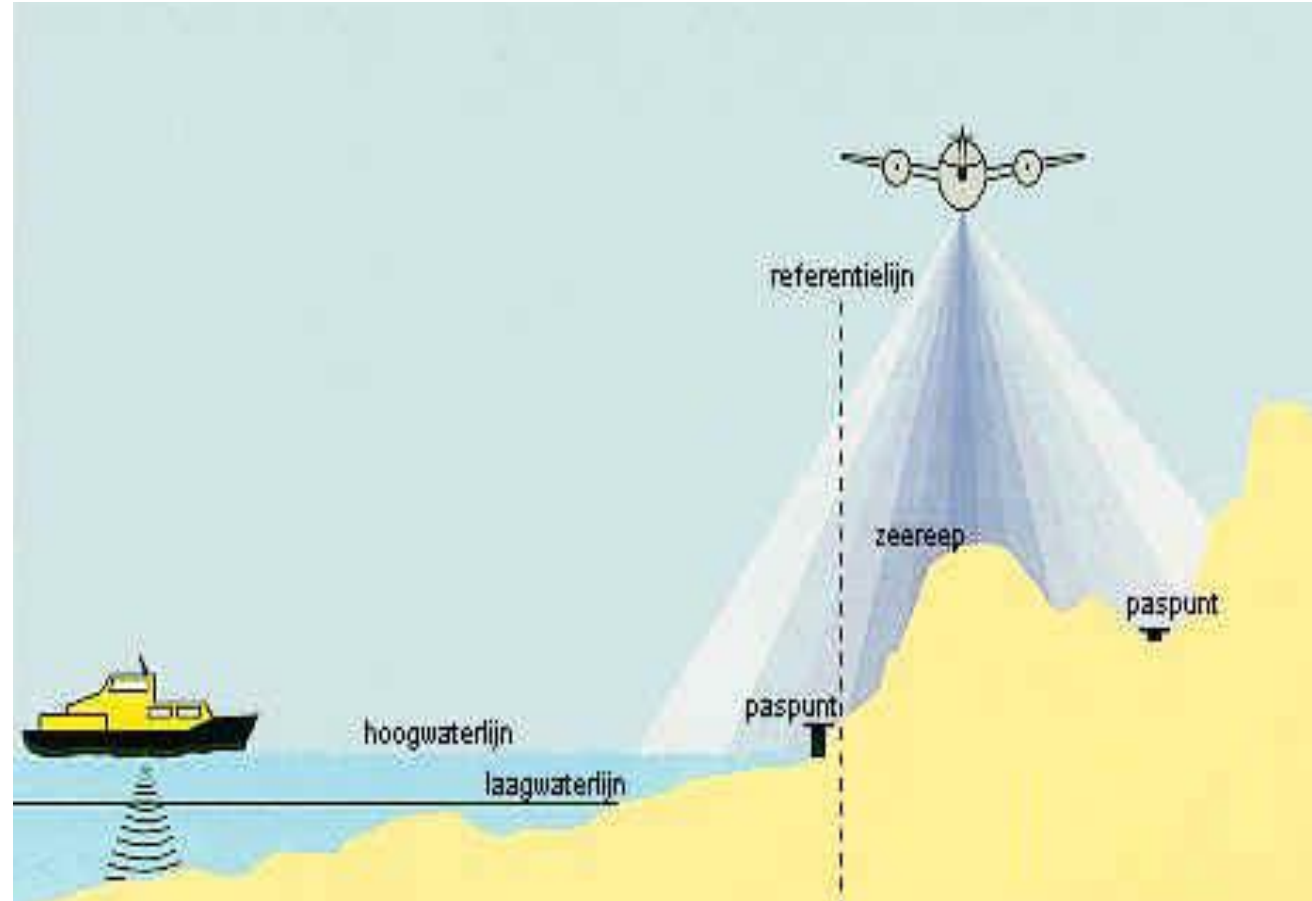
(momentary) coast line:  $B = A/2H$



# The proces



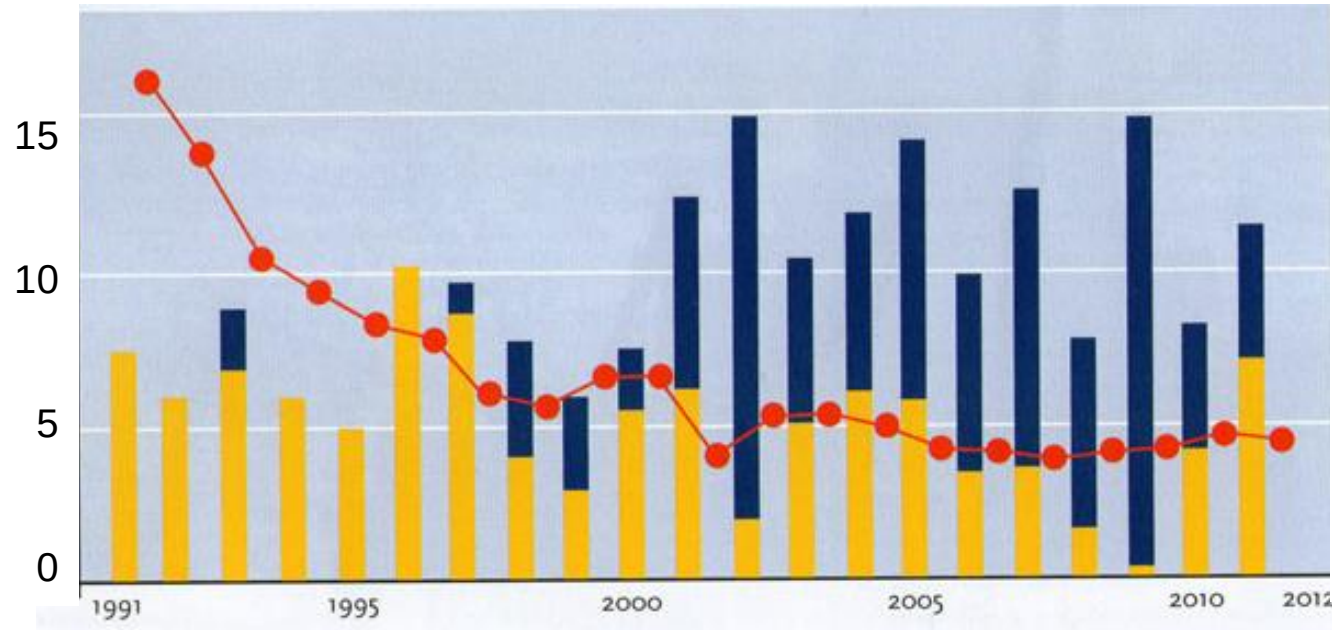
Deltares



## From beach to upper shoreface, and beyond...



Beach



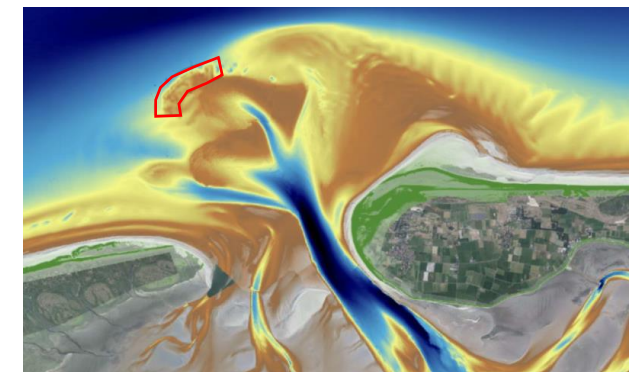
Upper shoreface



Channel wall



Sand Motor  
Mega-nourishment

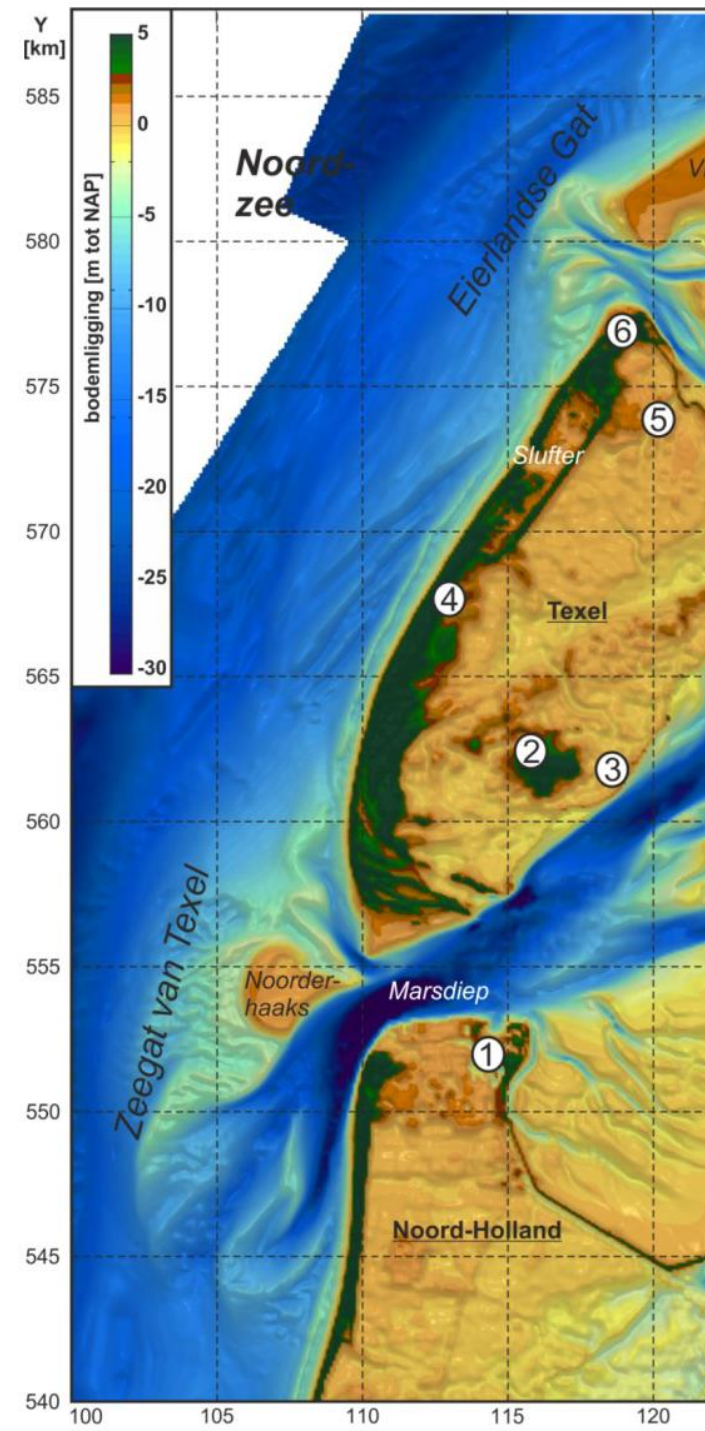
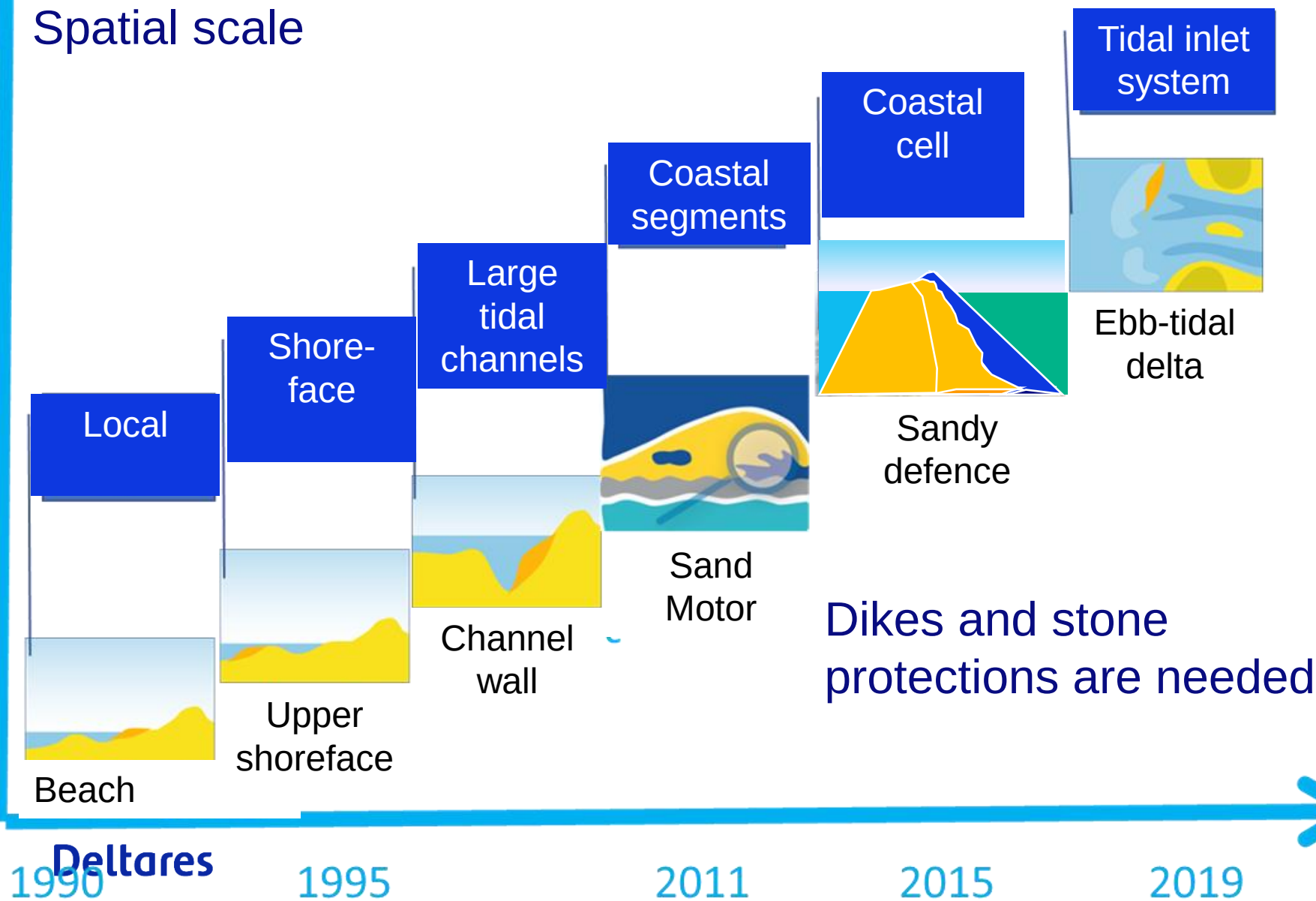


Ebb-tidal delta



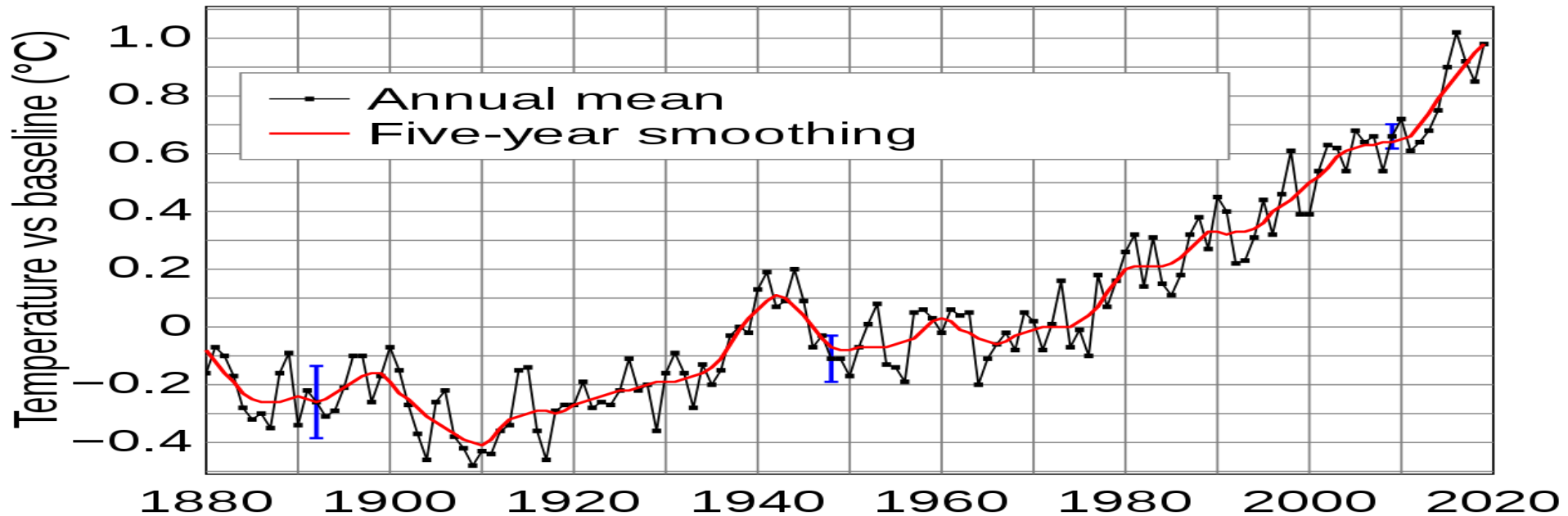
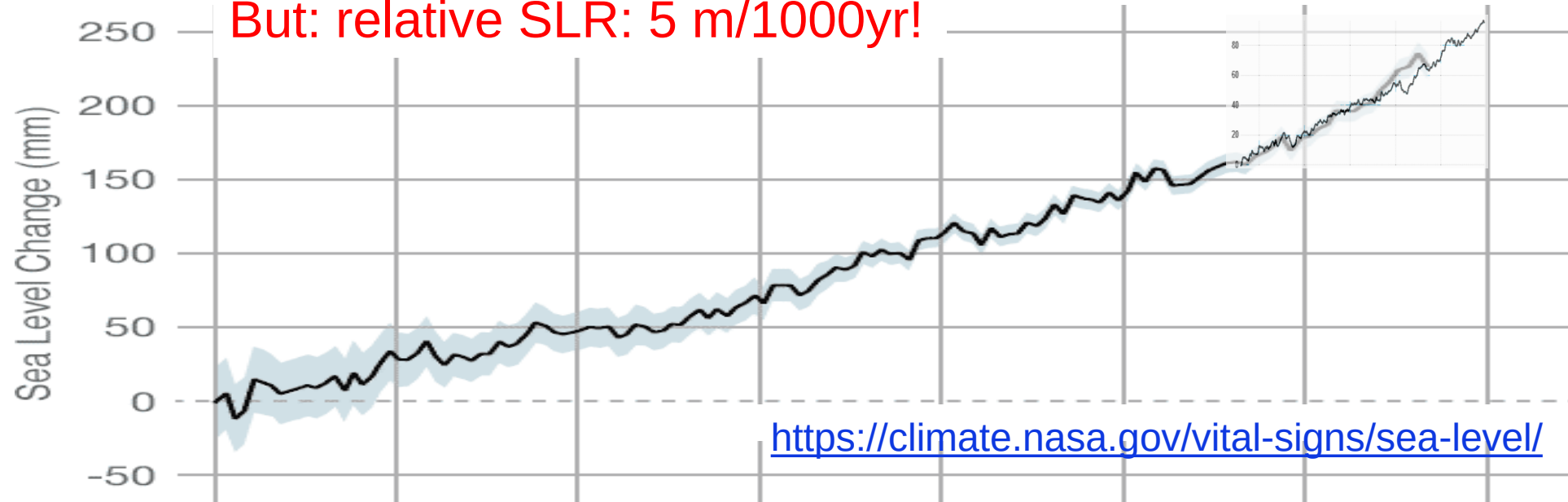
Shift to a ever larger dynamic maintenance  
*Soft where possible, hard where needed*

Spatial scale



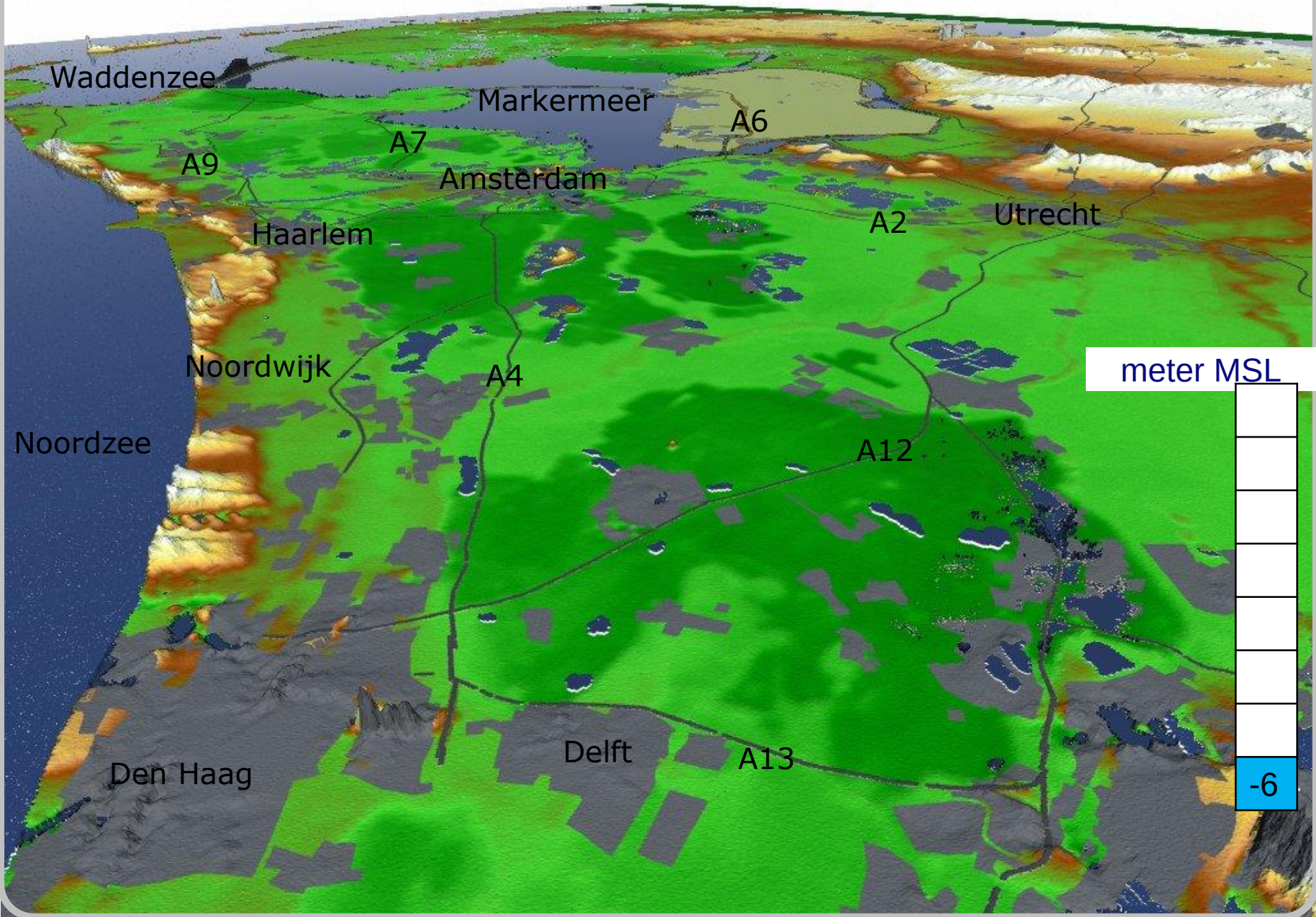
So, what about sea-level rise? → NL: only 0.17 m/100y

But: relative SLR: 5 m/1000yr!



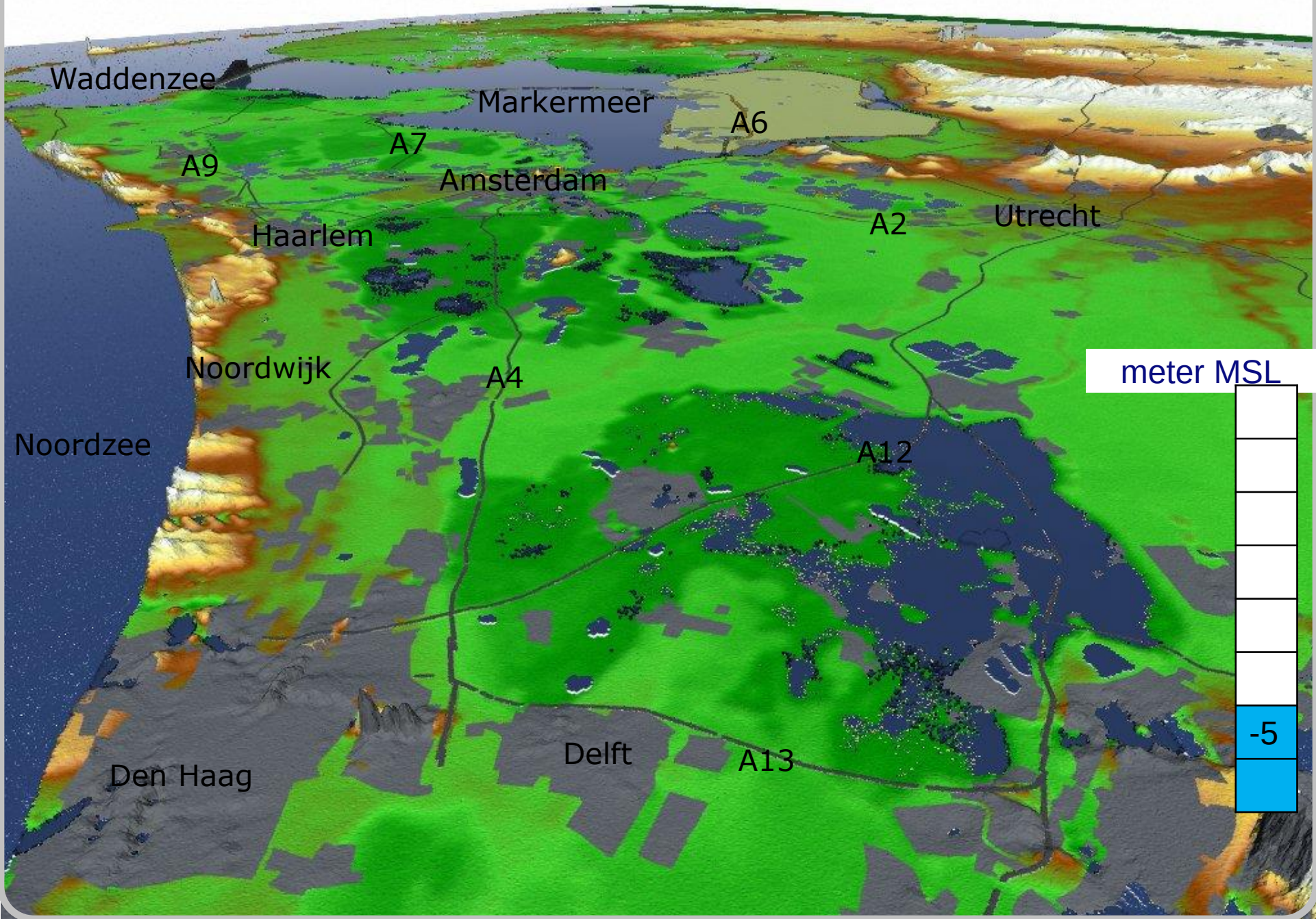


# Flooded at MSL -6.0 m



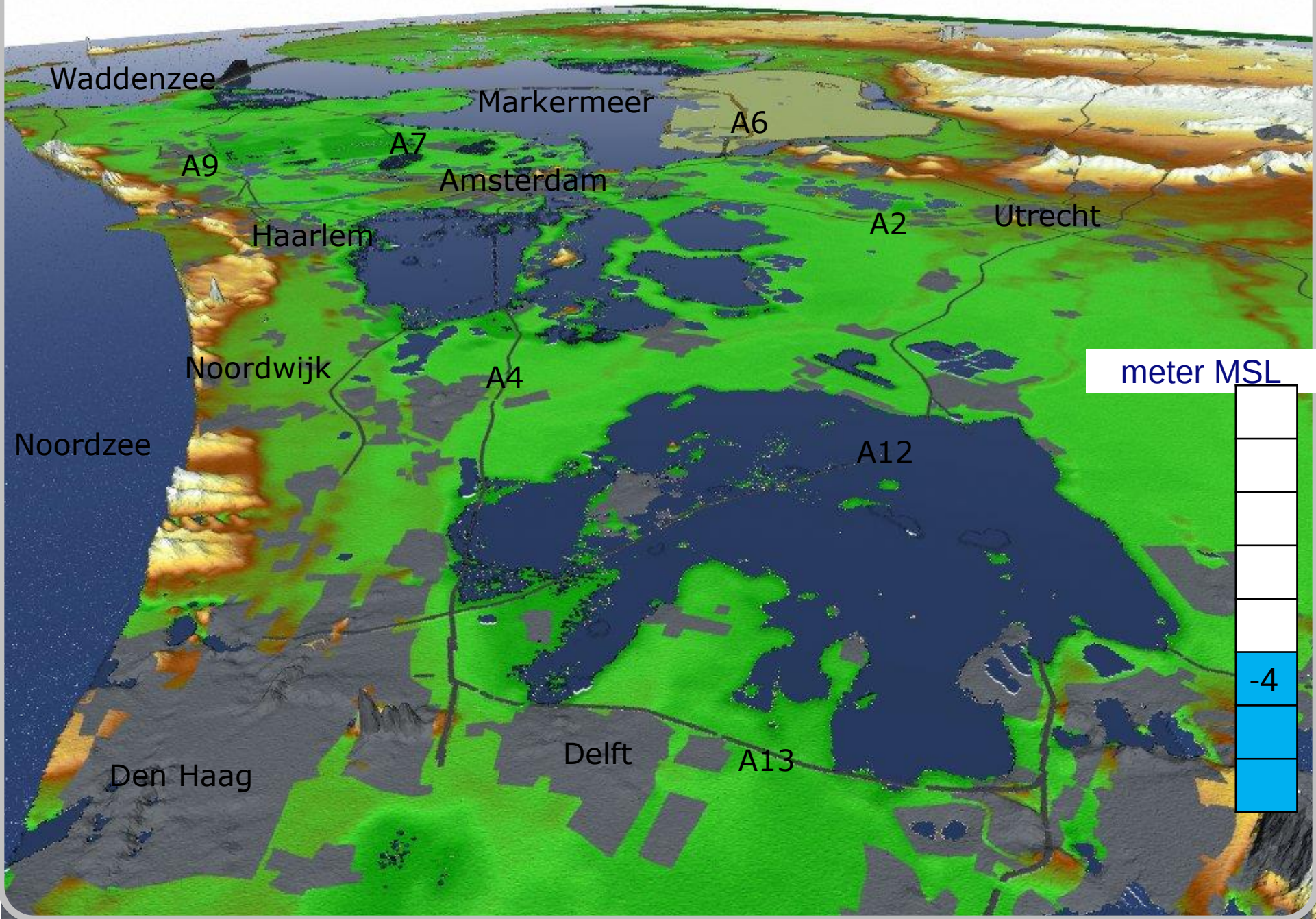


# Flooded at MSL -5.0 m



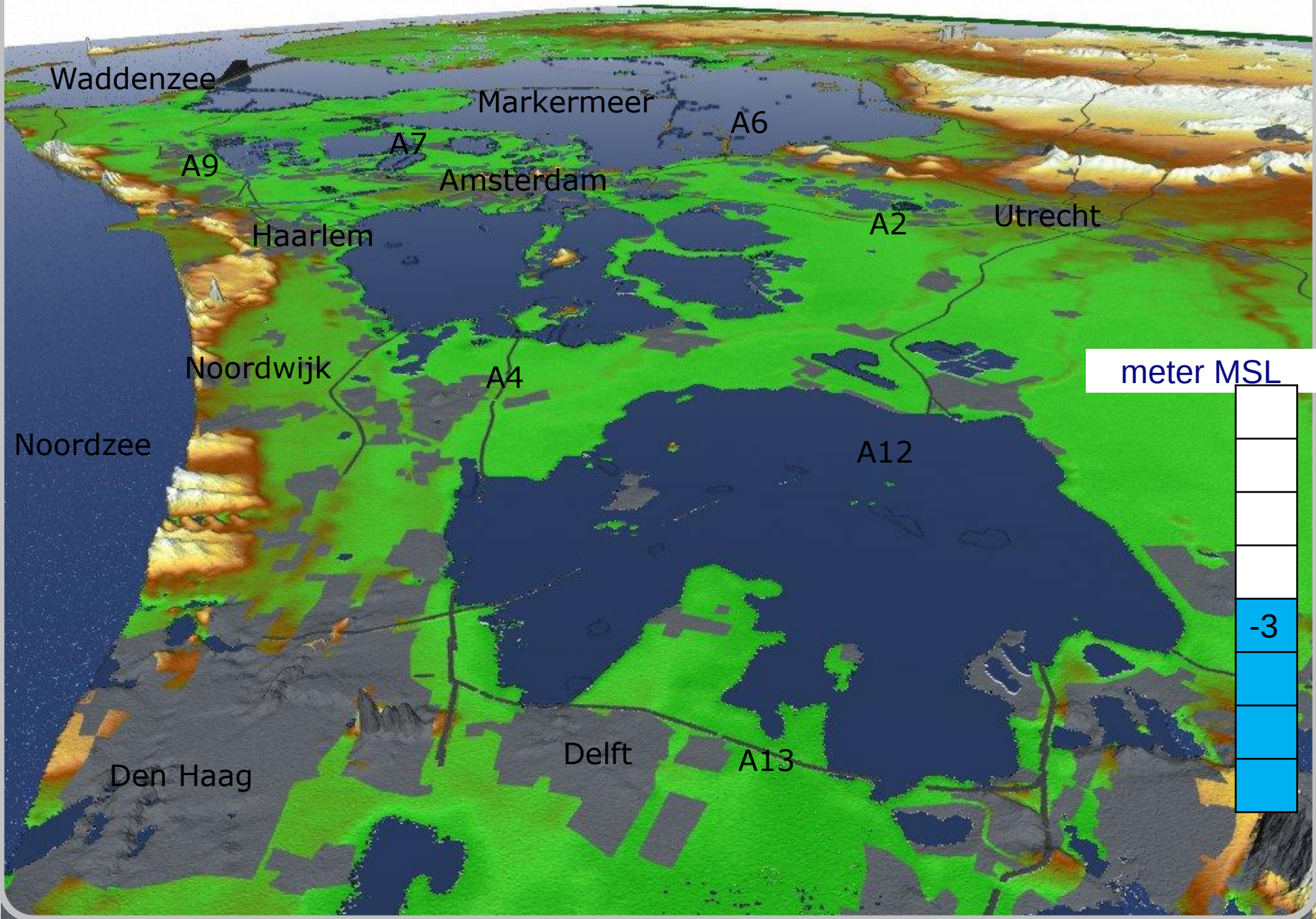


# Flooded at MSL -4.0 m



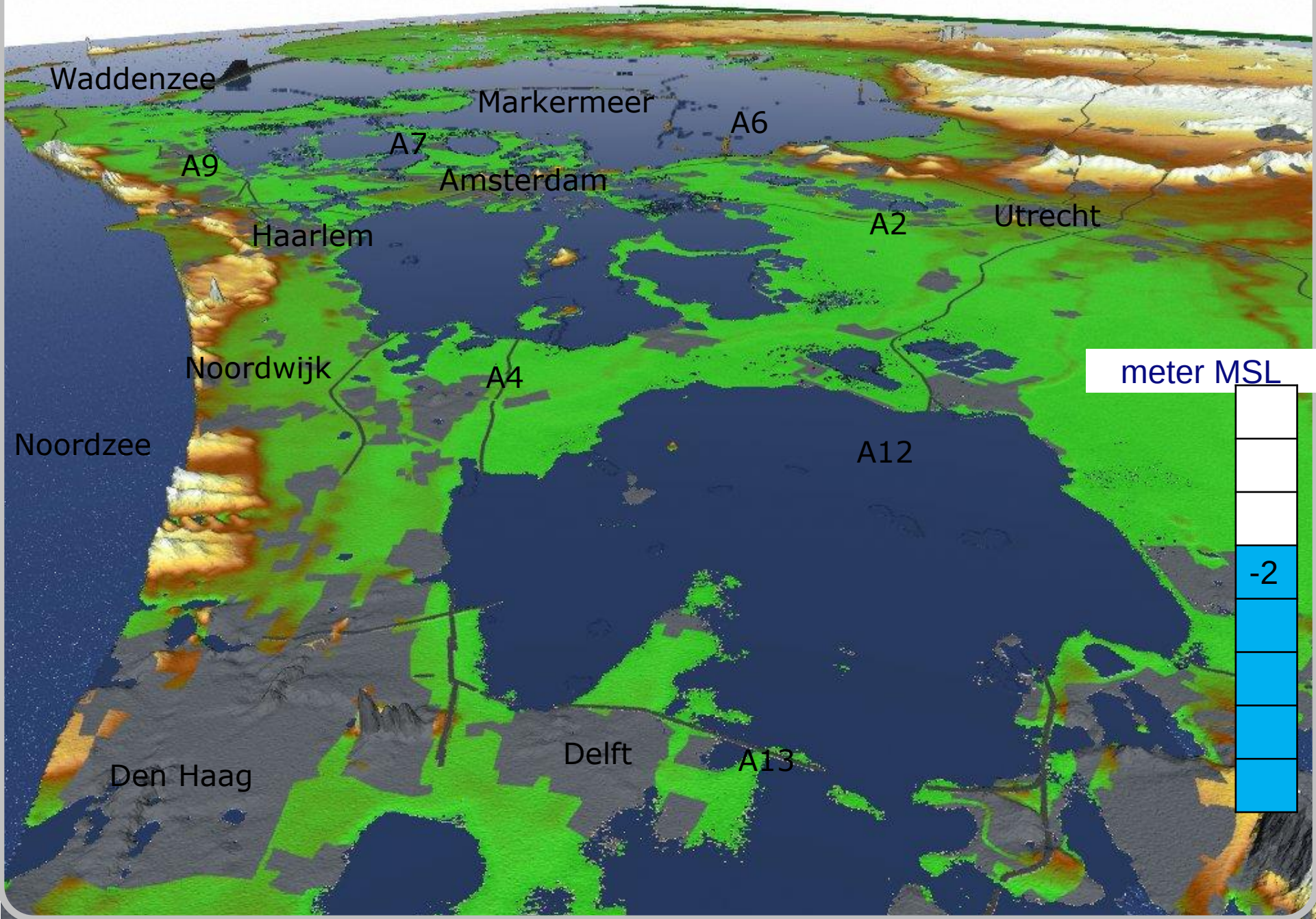


# Flooded at MSL -3.0 m



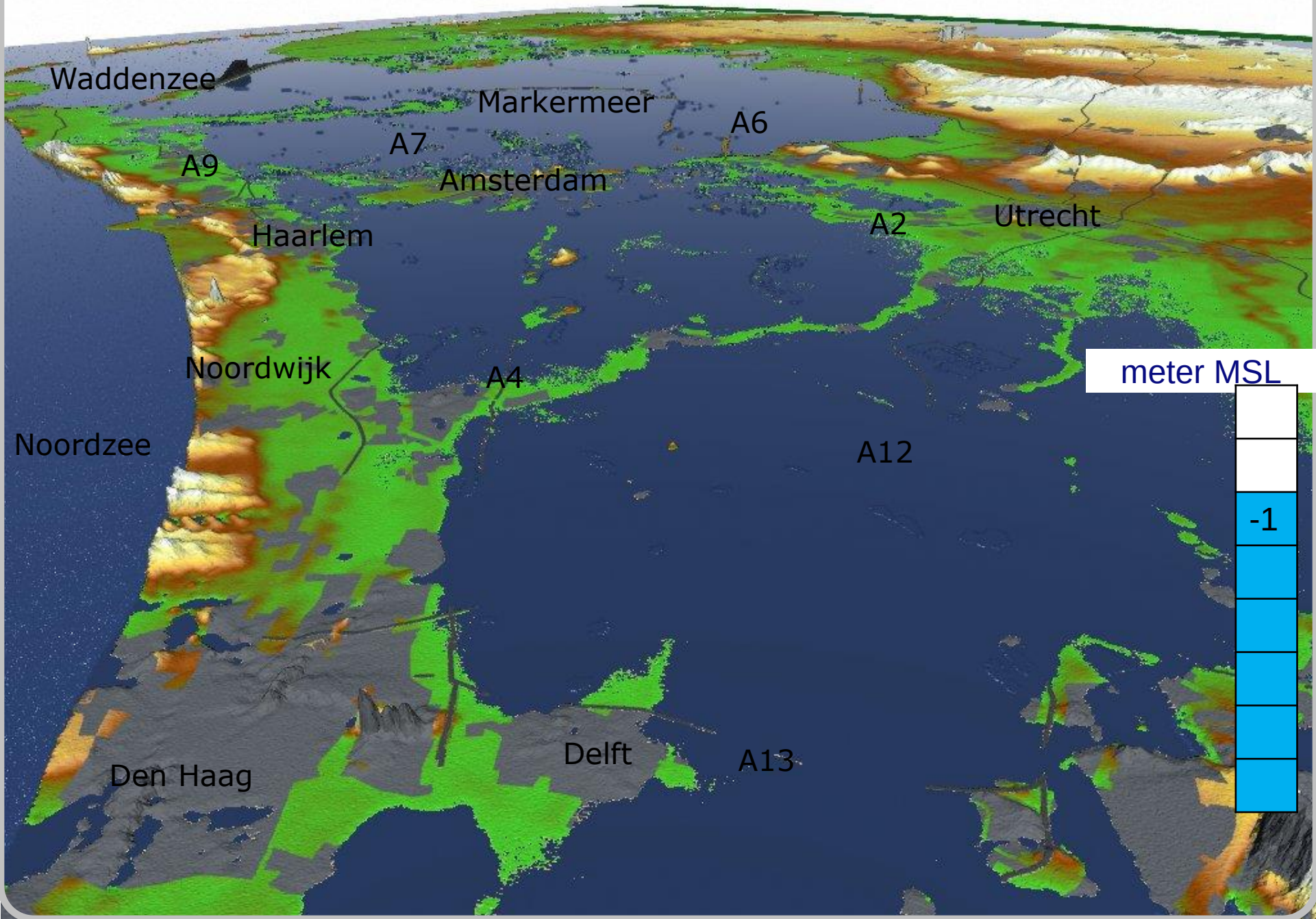


# Flooded at MSL -2.0 m



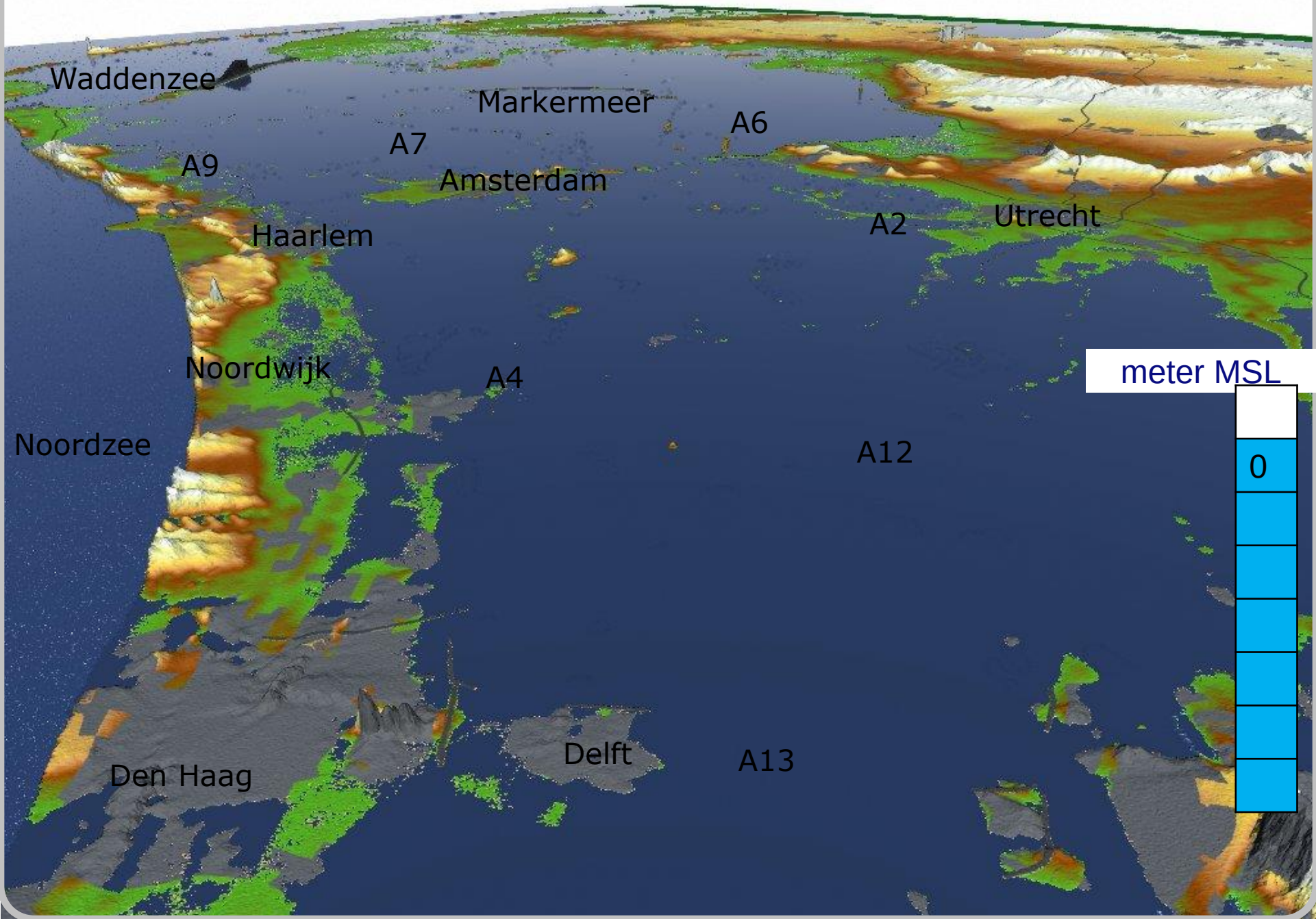


# Flooded at MSL -1.0 m





# Flooded at MSL

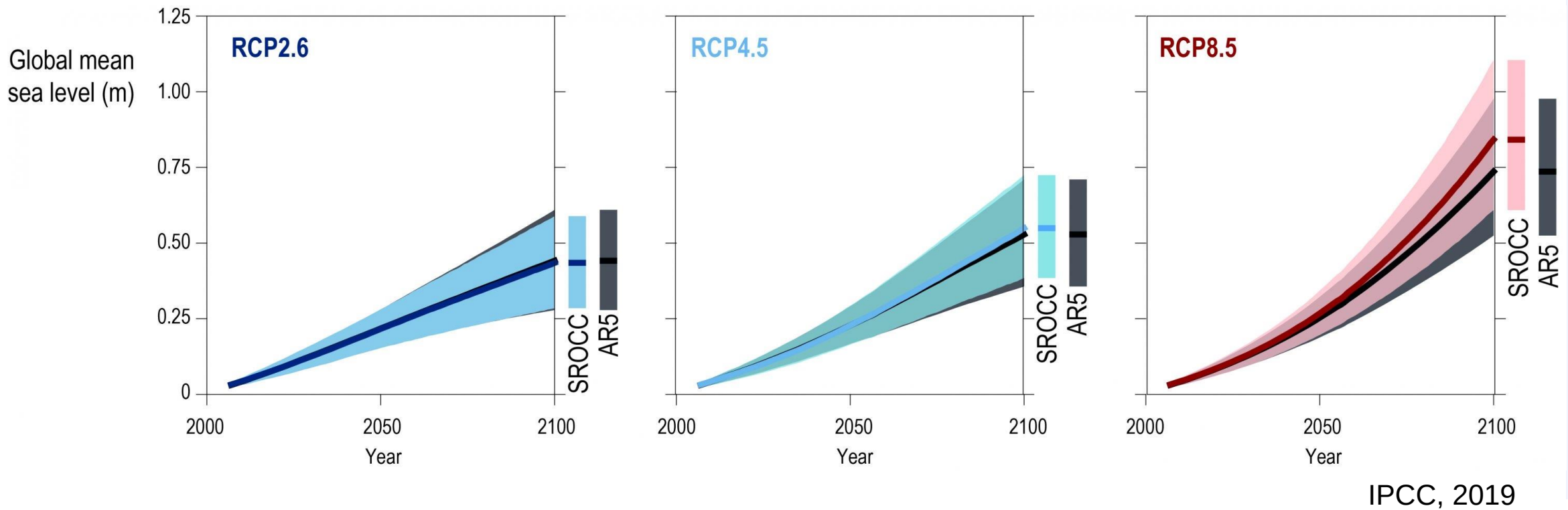


Flooded at MSL +1.0 m = ca. MHW





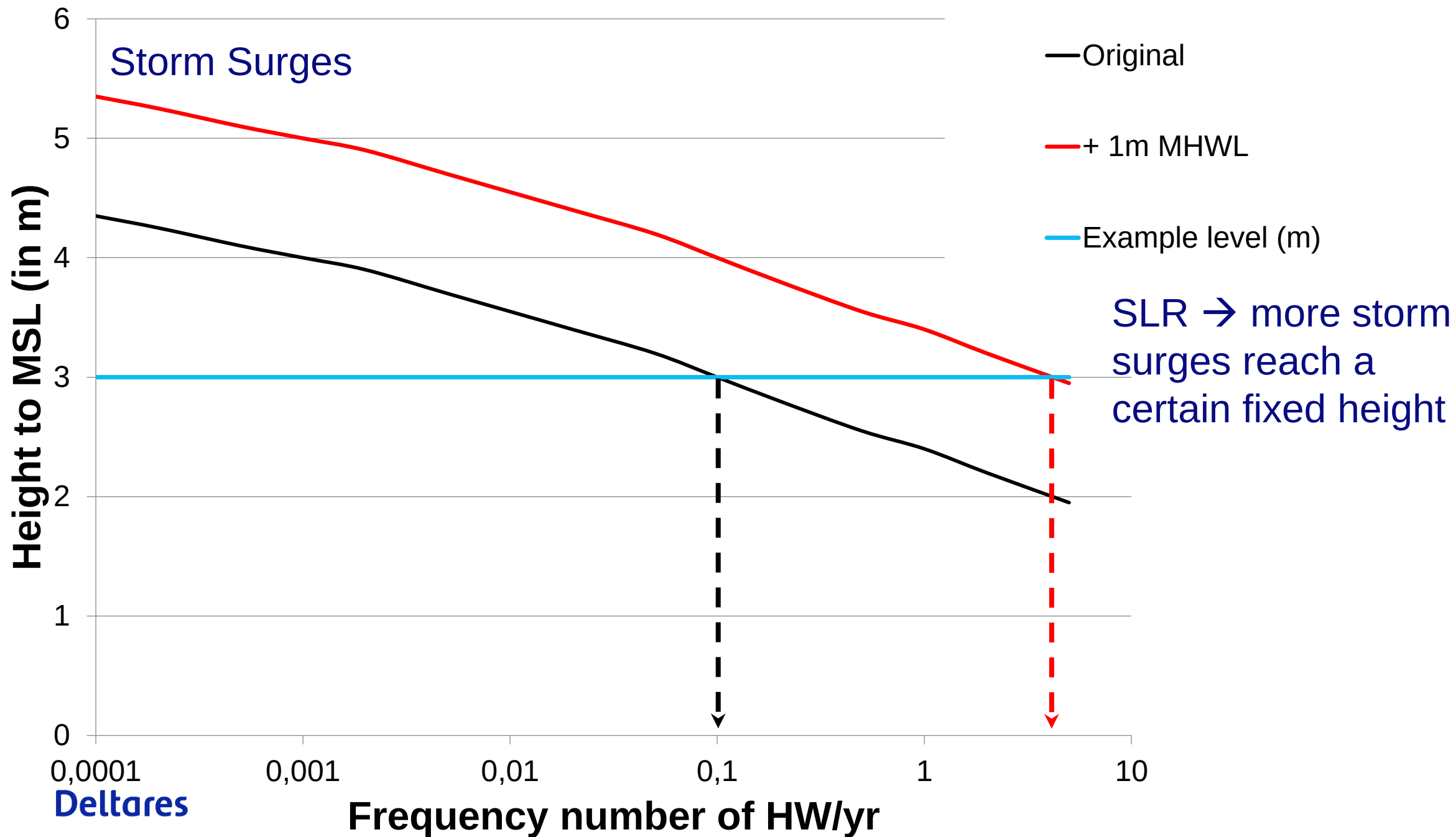
Sea-level rise will not stop at 2100 → meters more to come...  
Not a question if, but when...



*GMSL 2100 relative to 1986–2005:*

- RCP2.6: 0.43 m (0.29-0.59 m)
  - RCP8.5: 0.84 m (0.61-1.10 m)
- (0.43-2.46 m: Slangen et al., 2014; Le Bars et al, 2017)

**Deltares**





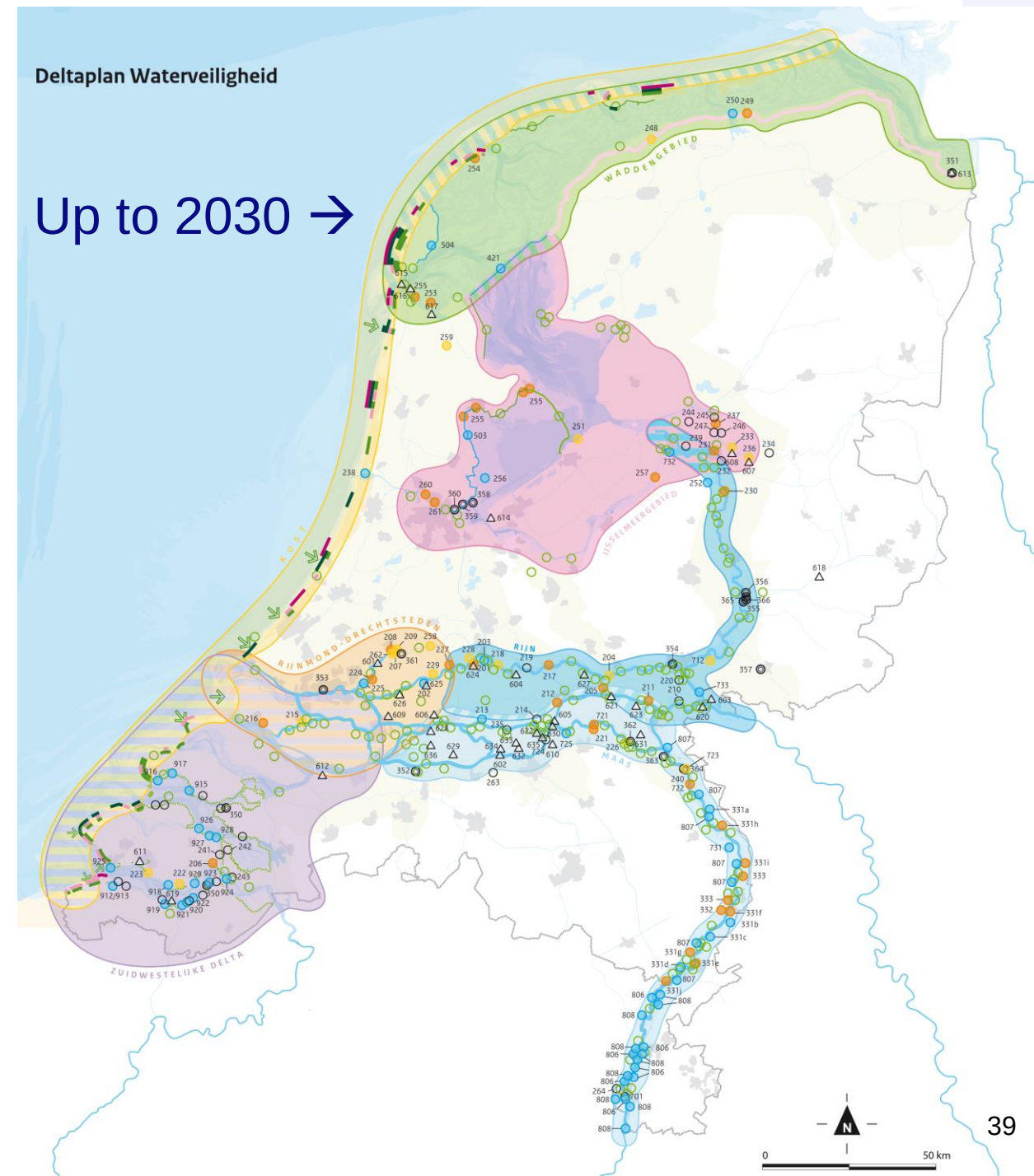
# How do the Dutch plan for the future?

2009: Delta Commissaris  
Deltawet special status, allocated budget

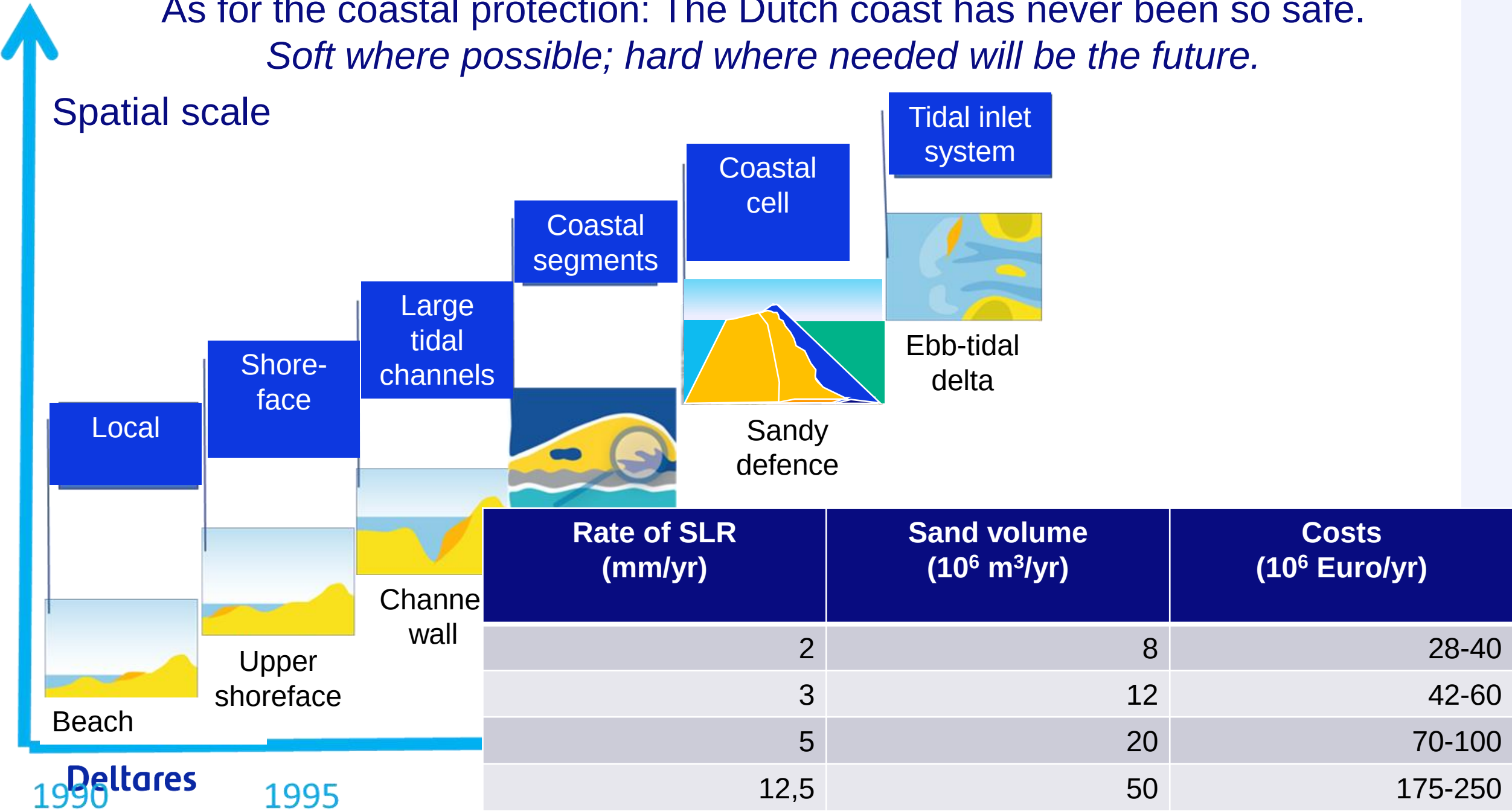
As a core value: **Allow for uncertainties.**

- Where actions are okay for each future scenario: carry out a.s.a.p.
- Where unsure: allow for flexible options (for instance adaptable dikes, or sand nourishments)
- Where possible: allow future generations to make their own decisions

Up to 2030 →



As for the coastal protection: The Dutch coast has never been so safe.  
*Soft where possible; hard where needed will be the future.*





# Contact

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