Ministerie van Verkeer en Waterstaat

Rijkswaterstaat

Hydra-Models

A way to assess the influence of climate change and river programs on future dike heights and the probability of dike failure.

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18 april 2005

Contents

Probabilistic versus deterministic approach

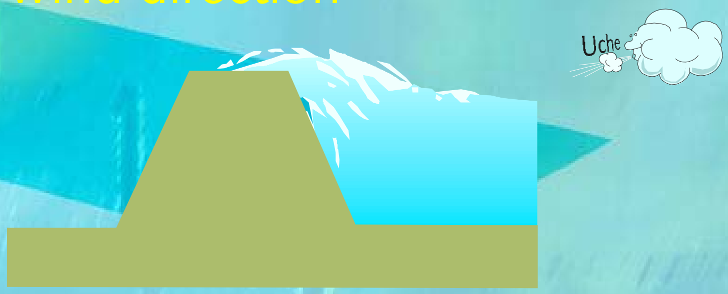
Deterministic

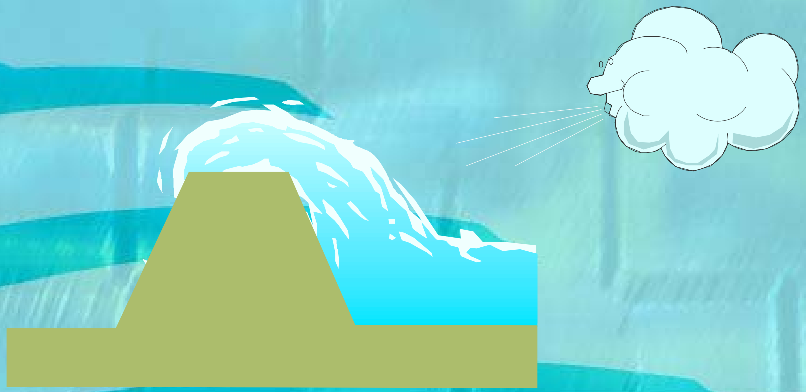
a design water level,

a design wind speed and wind direction

Probabilistic

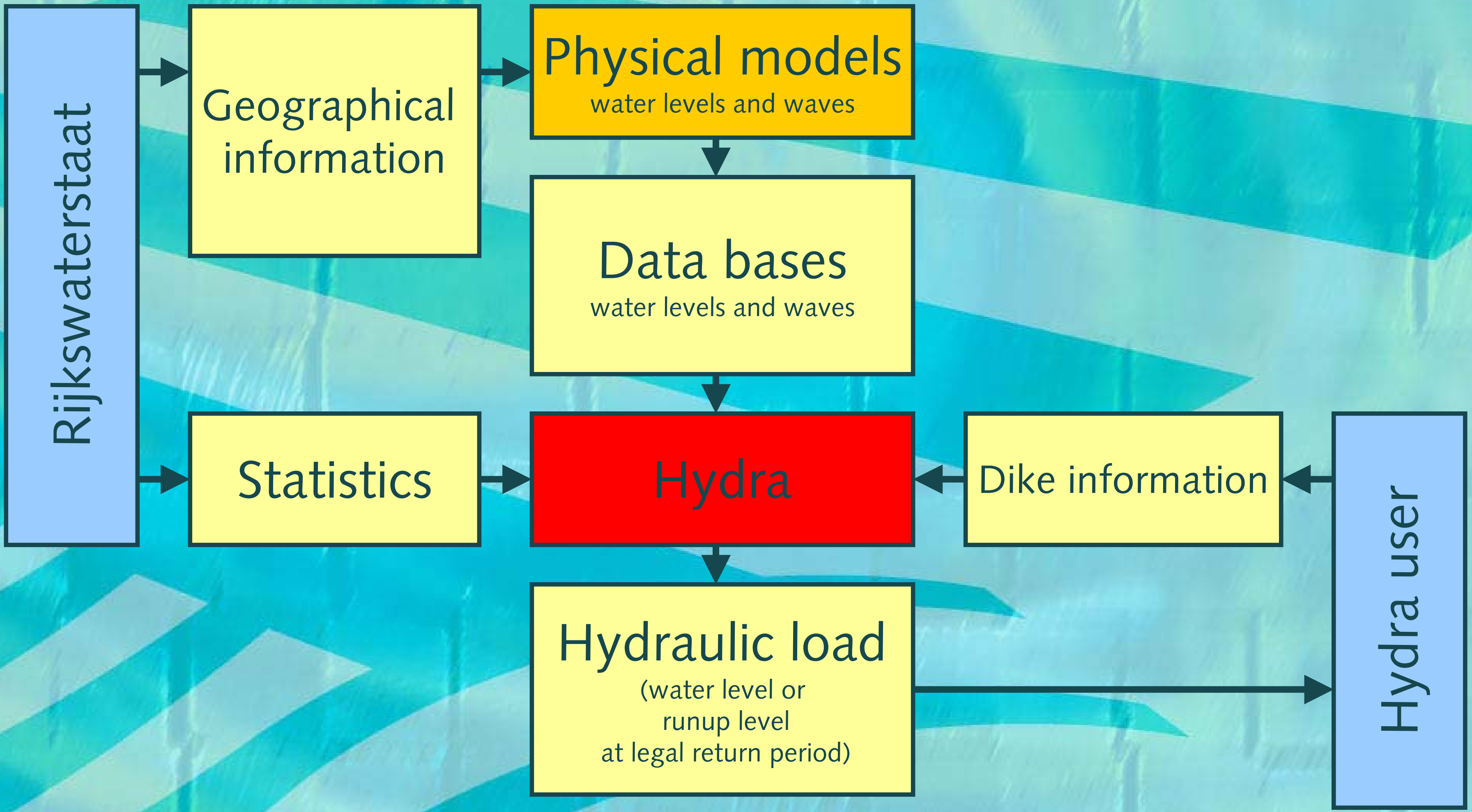
Infinite number of combinations of water levels, wind speed and wind direction



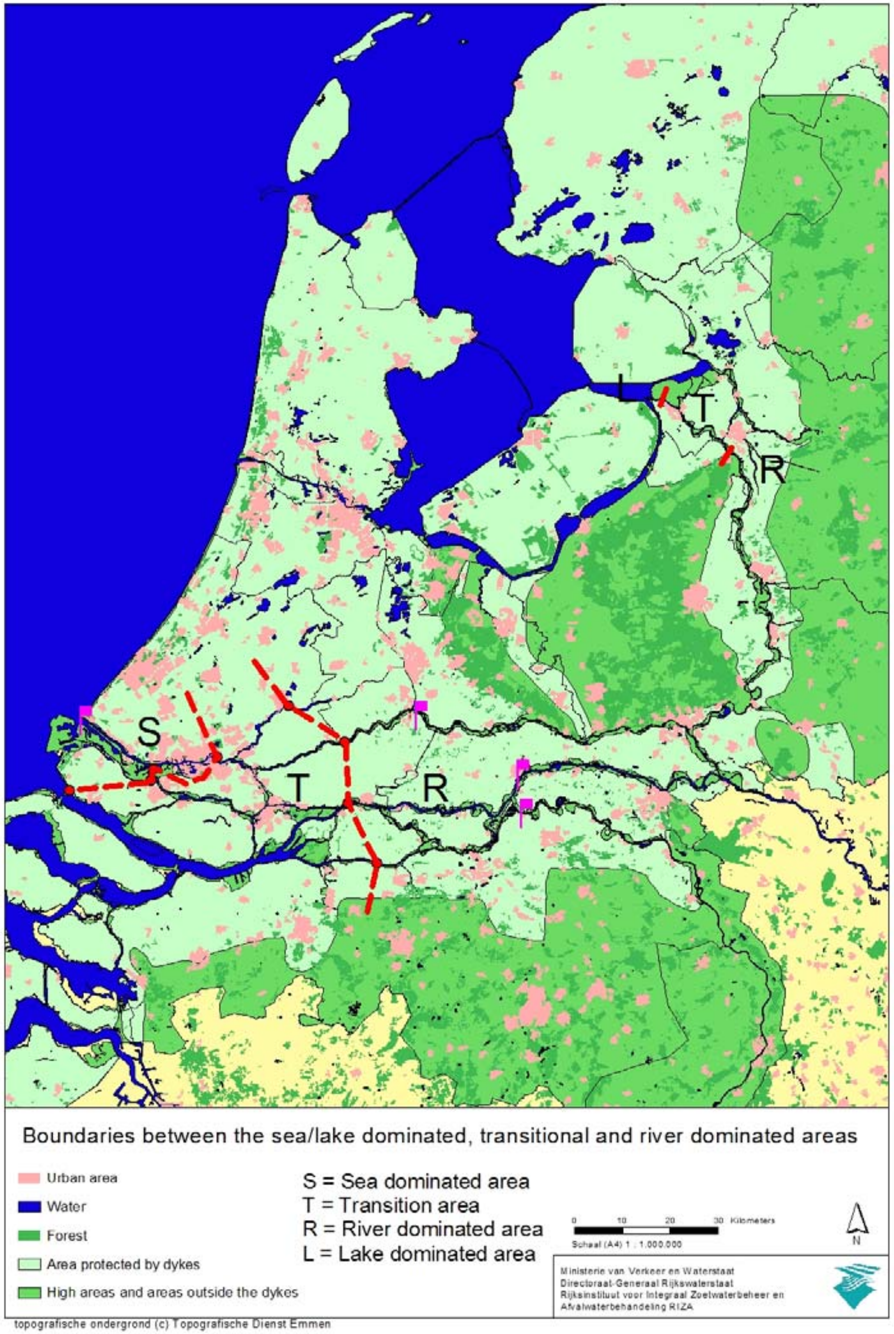


What are Hydra-models?

A method to weigh possible physical events (water levels and waves)



Hydra's



* 1998 –1999

  Hydra-M, for the IJssel lake area

- 2001

  Hydra-B

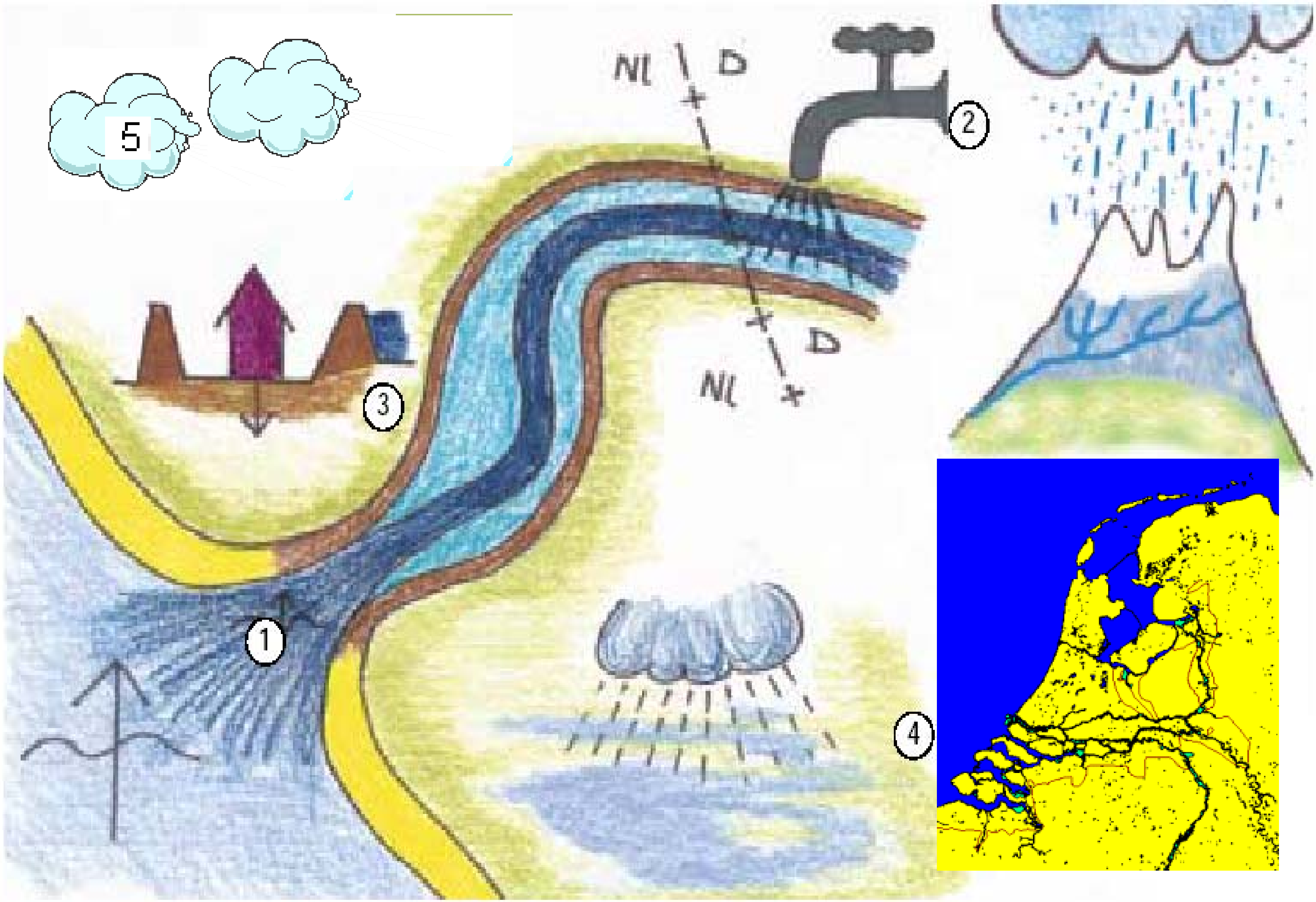
  for the Rhine and Meuse Estuaries

  extended in 2004 to the borders with Germany and Belgium

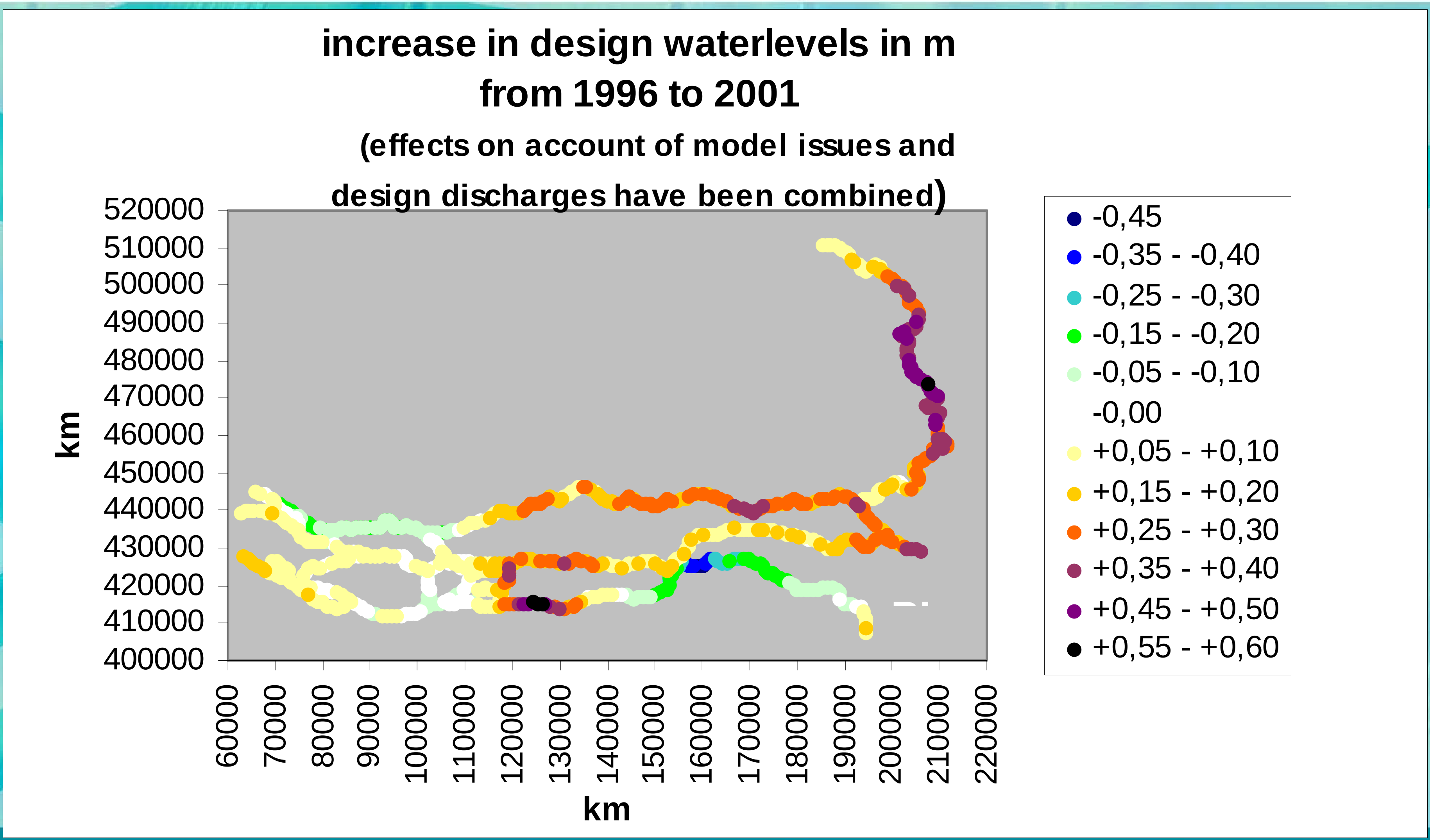
- 2006

  Hydra VIJ for the Vecht and IJssel delta area

Climate change and soil subsidence



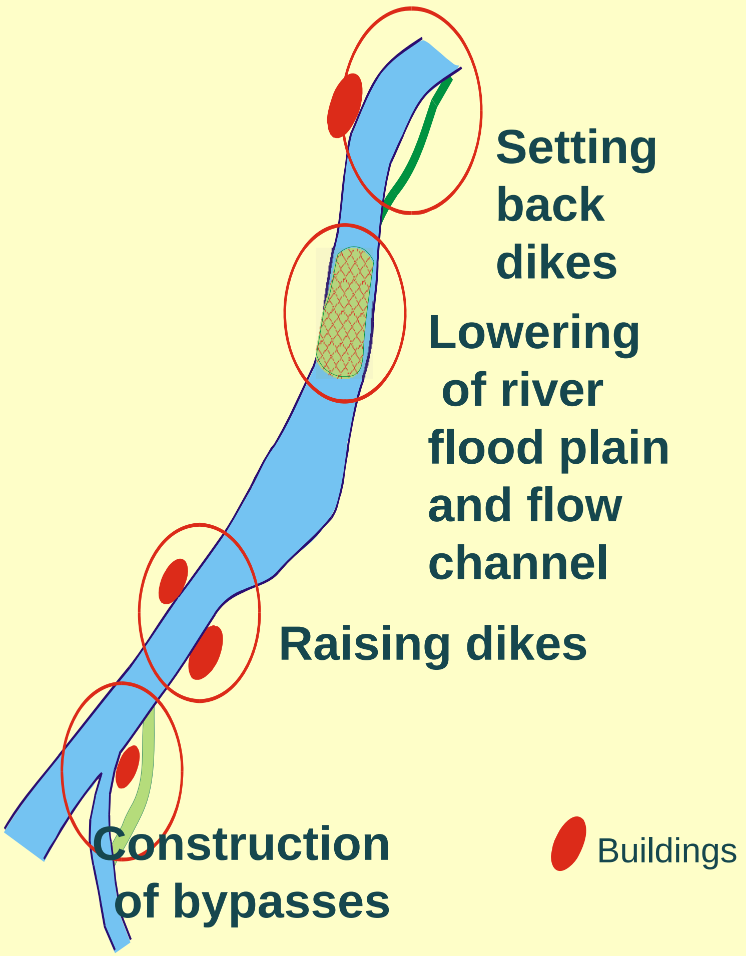
Room for the River objective: to deminish the increase in design water levels

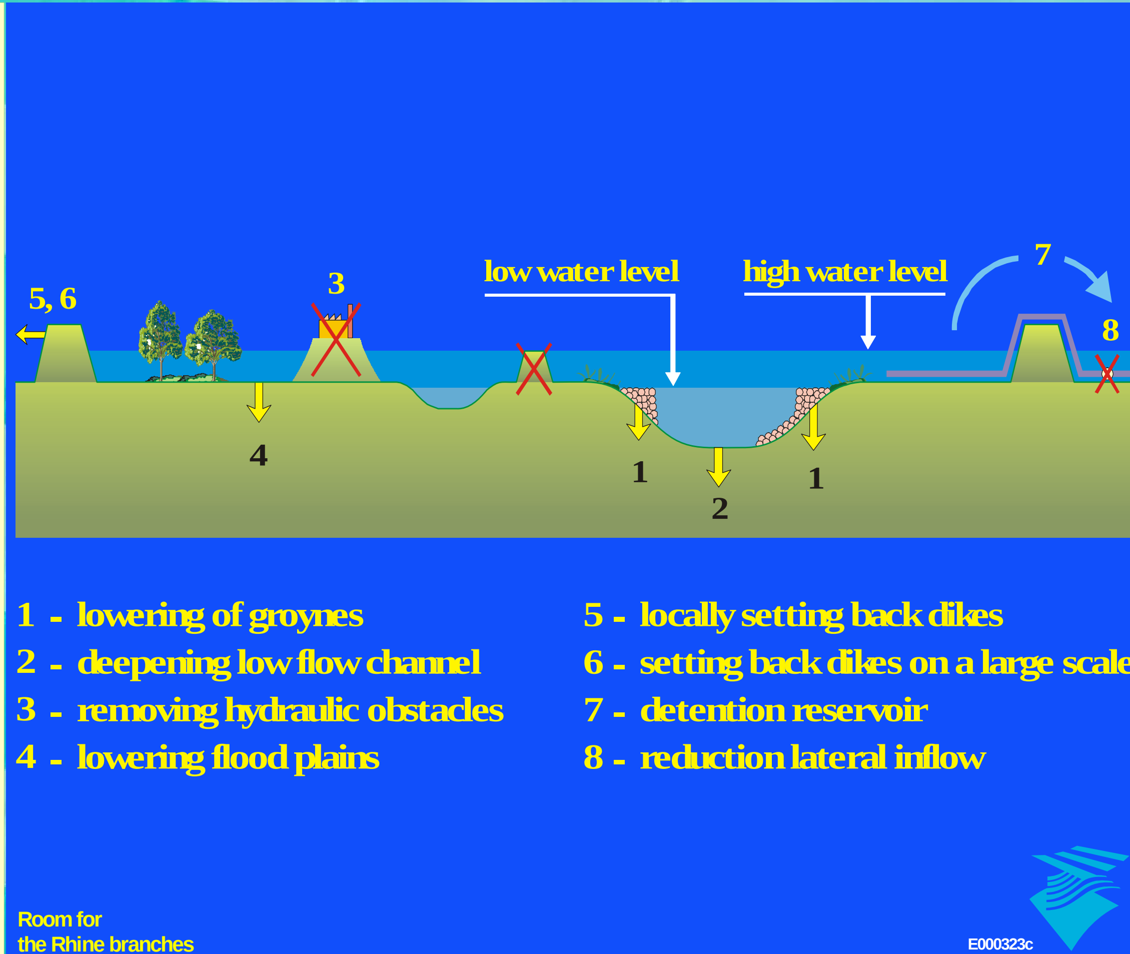


Little space and more damage potential each year

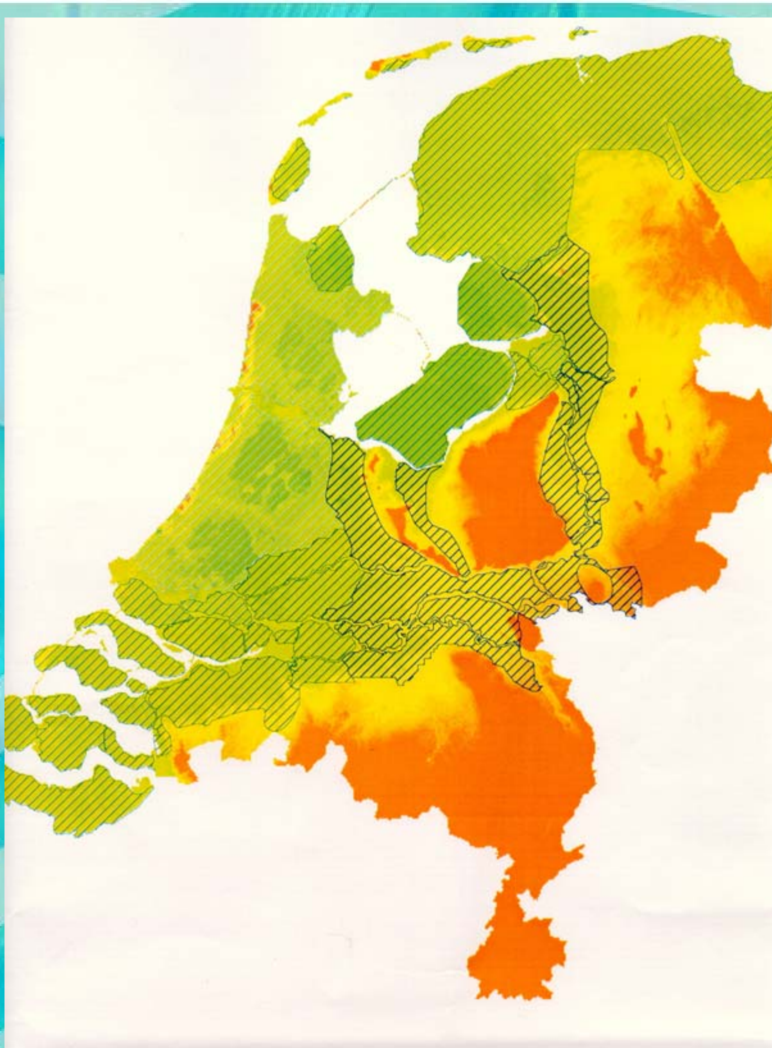
Arnhem, 1830 Arnhem, 2000

Measures


Setting back dikes
Lowering of river flood plain and flow channel
Raising dikes
Construction of bypasses
Buildings


5, 6
3
low water level
high water level
7
8
4
1
2
1
1 - lowering of groynes
2 - deepening low flow channel
3 - removing hydraulic obstacles
4 - lowering flood plains
5 - locally setting back dikes
6 - setting back dikes on a large scale
7 - detention reservoir
8 - reduction lateral inflow
Room for the Rhine branches
E000323c

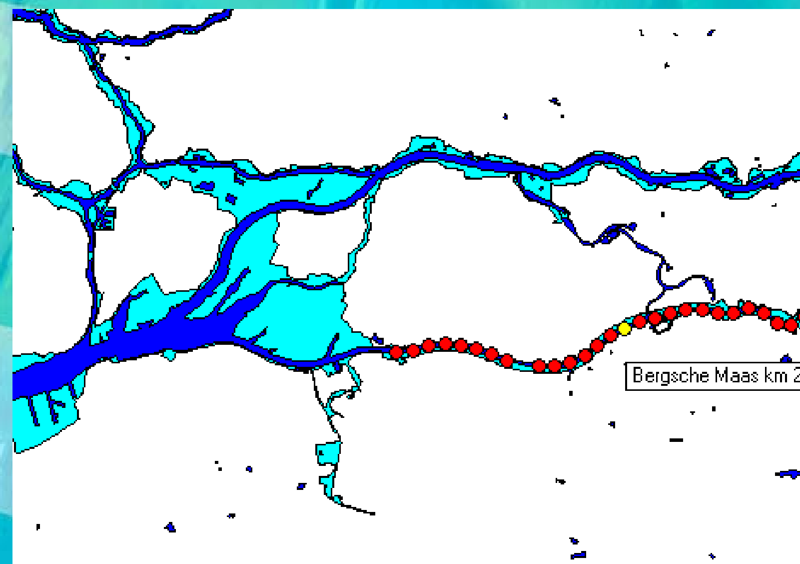
Meuse Works – mainly improvement of the 40 new dikes and lowering of the flow channel



Climate change, the influence on dike heights

1) **Extra storm surge and sea level rise:
an effect of 60-70% in the lower Rhine and Meuse reaches**

The influence on design water levels of a 60 cm sea level rise	
location	meters
Bergse Maas km 231	0,10
Bergse Maas km 235	0,12
Bergse Maas km 240	0,16
Bergse Maas km 245	0,23
Bergse Maas km 246	0,25
Bergsche Maas 247	0,37
Bergsche Maas 251	0,50
Hollandsch Diep km 980	0,40

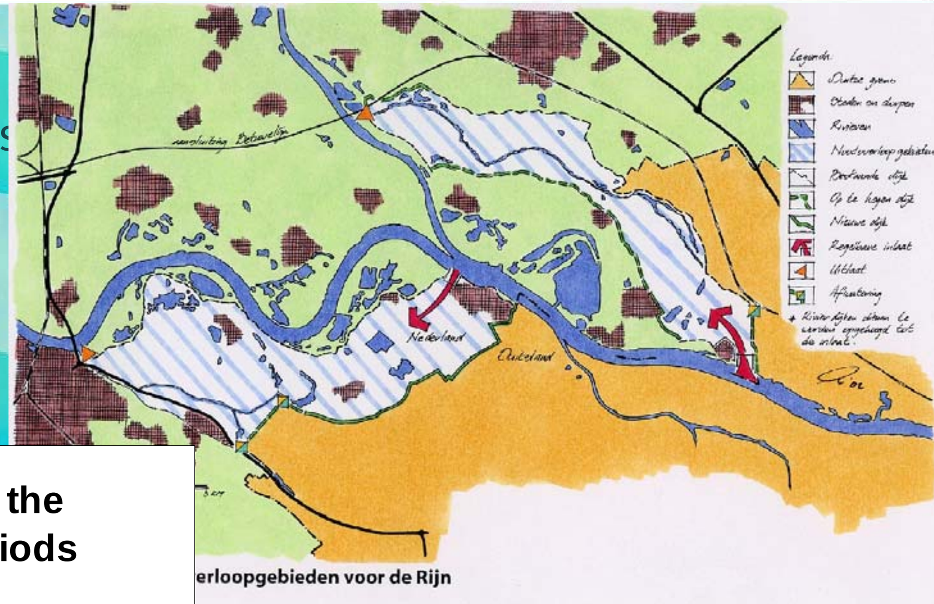


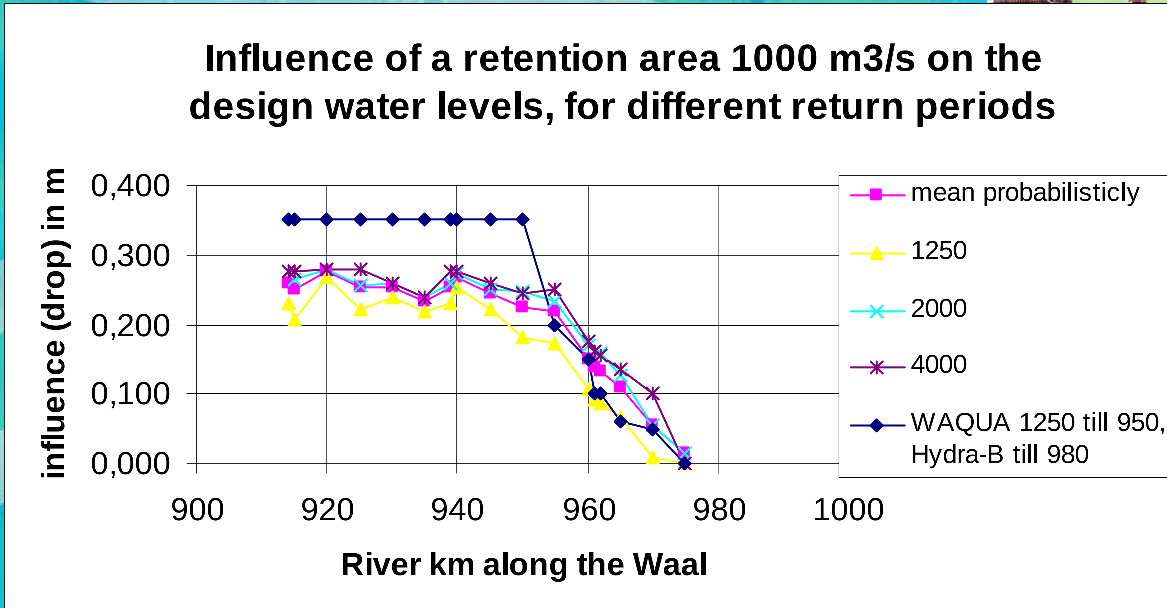
**2) Higher design discharges, main branches and tributaries
a 0,60 to 0,80 m increase from the main branches**

**3) 10% higher wind speeds and more westerly winds
10% increase?**

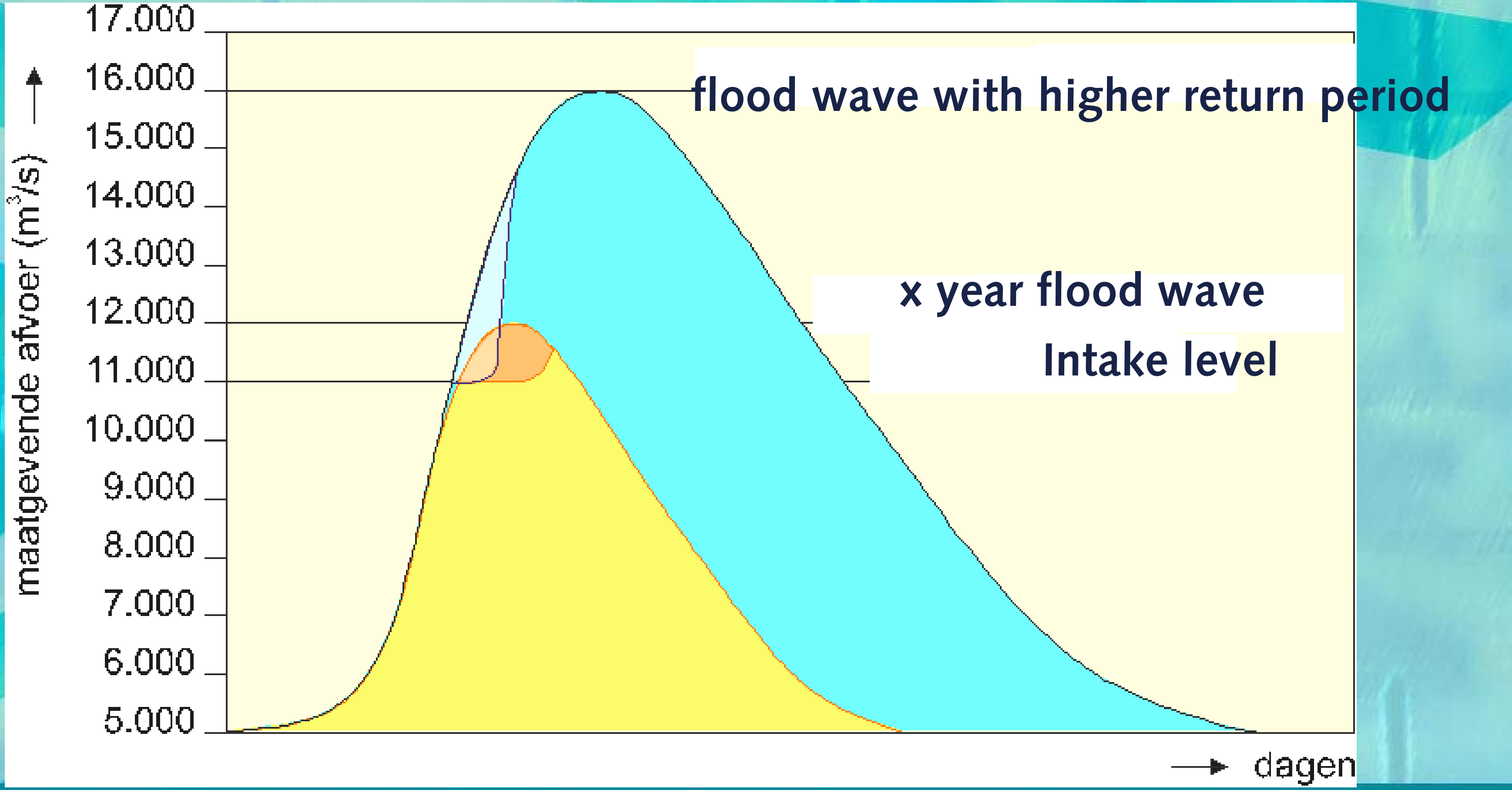
Flood retention on the Rhine

1000 m^3/s flood retention is a drop of
30 -35 cm on the Waal in design water levels
Probabilisticly this is only 20 – 25 cm





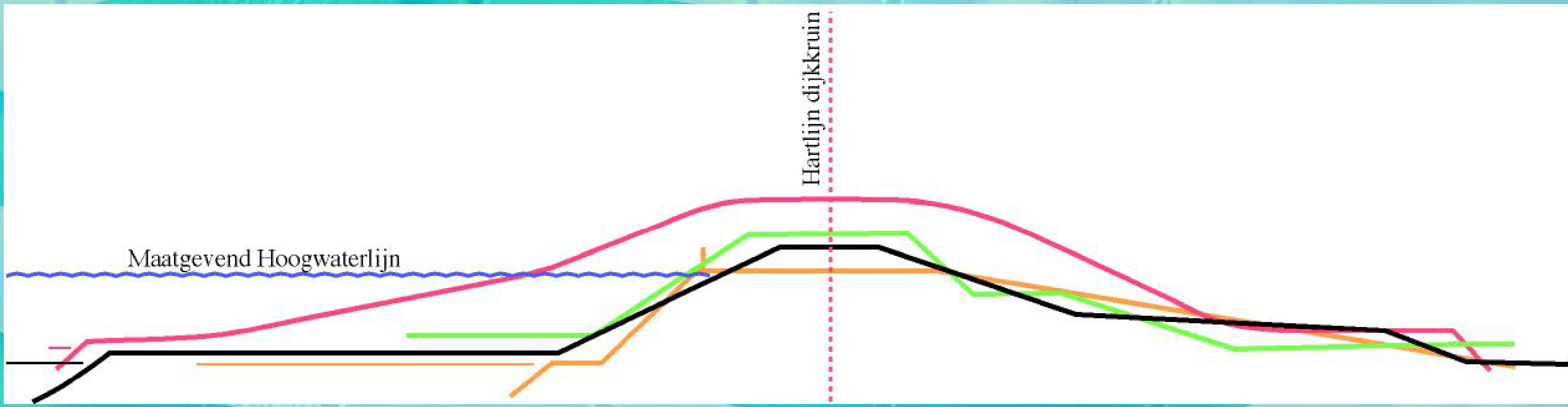
Flood retention only takes a bite out of the flood wave



Flood retention on the Rhine

Effect on dike heights

Dikes have been built in all sizes, forms and heights



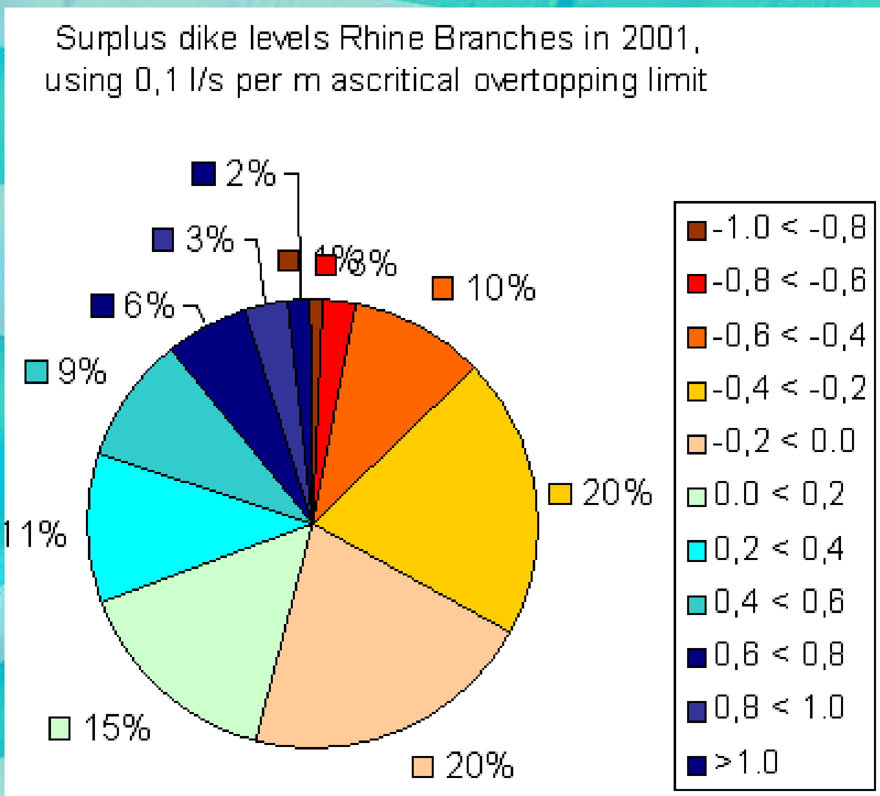
Rhine Branches 600 km dike, 6000 cross sections

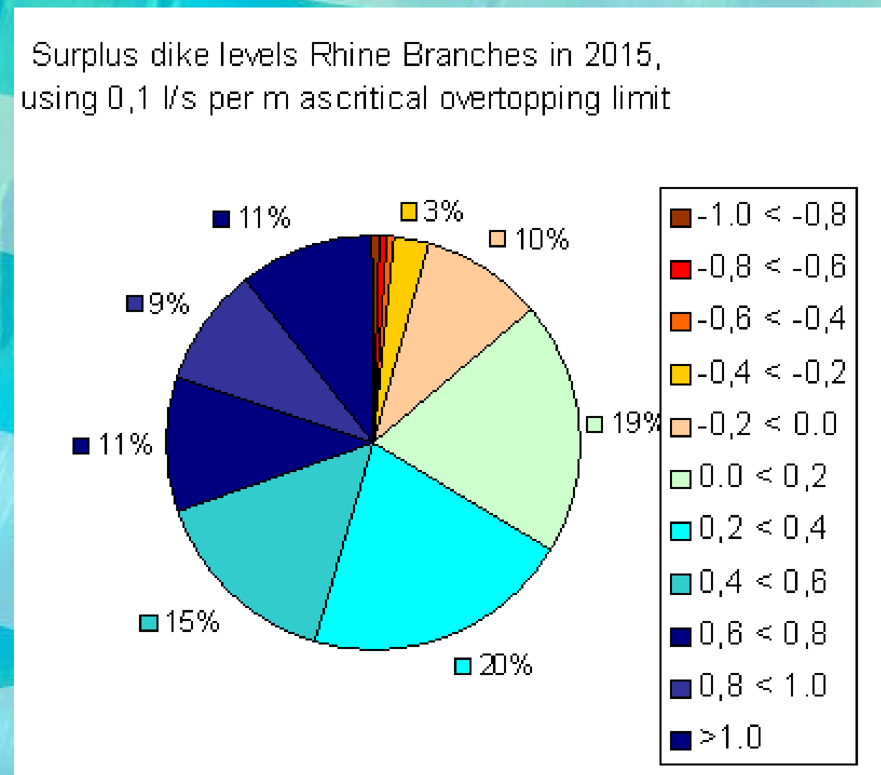
Meuse 200 km dike, 2000 cross sections

All dikes are modeled as:

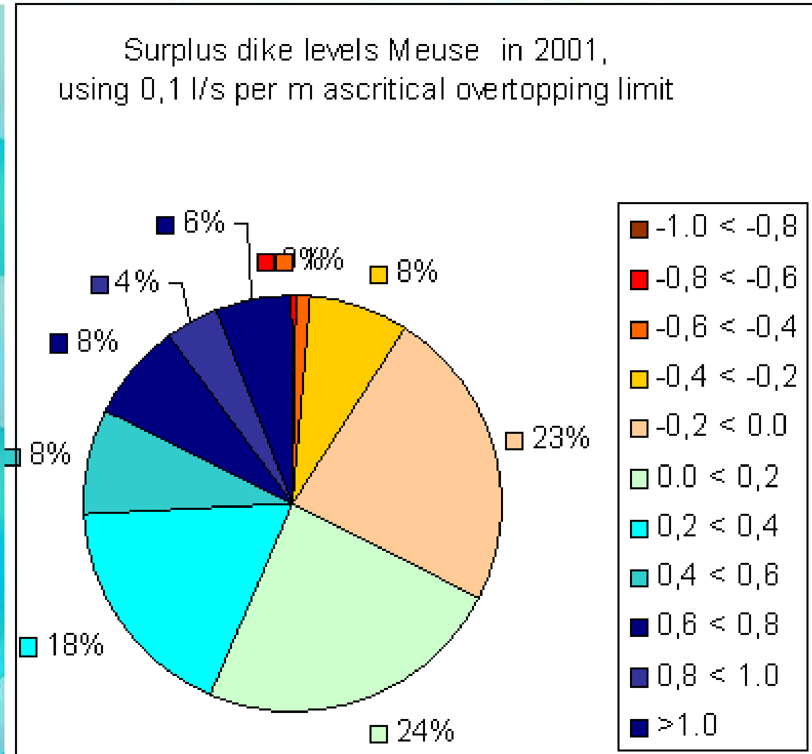
a 1 in 3 outer slope
the actual outer crest level
the dike perpendicular line from GIS, filtered for 100 m sections

Surplus dike heights before and after Room for the River





Surplus dike heights before and after Meuse Works



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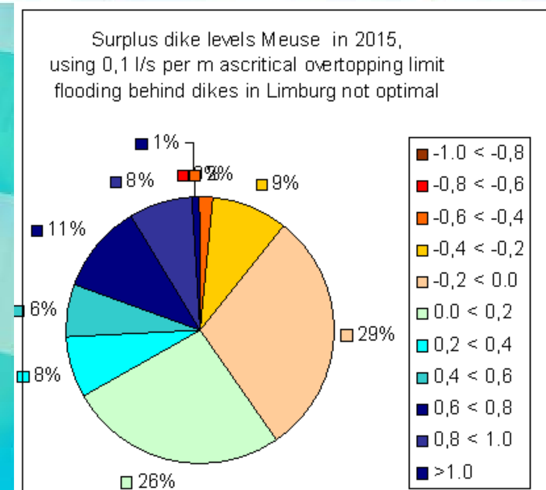
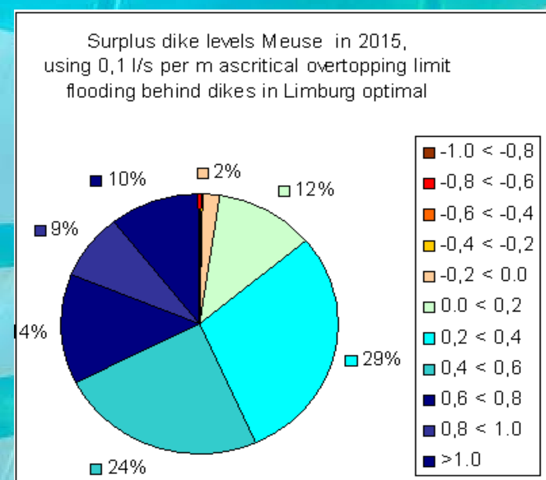


1

Neglible flooding of upper reaches Km 3 to 150/170



2

Perfect flooding of upper reaches Km 3 to 150/170

Probability of dike failure dike ring 43

probability of dike failure, dike ring 43				
scenario	dike heights	critical overtopping limit	max discharge Rhine	probability
Actual 2001	current design practice	1 l/s per m	18 000 m^3/	1/600
Actual 2001	actual dikes	1 l/s per m	18 000 m^3/	1/200
After RvdR 2015	current design practice	1 l/s per m	18 000 m^3/	1/1100
After RvdR 2015	actual dikes	1 l/s per m	18 000 m^3/	1/1200
After RvdR 2015	actual dikes	50 l/s per m	18 000 m^3/	1/5000
After RvdR 2015	actual dikes	1 l/s per m	16000 m3/	1/1400