Ministerie van Verkeer en Waterstaat

Flood Risk and Safety in the Netherlands (FLORIS)
→ *the method*

Tsukuba, October 1st 2009

Durk Riedstra
Rijkswaterstaat,
Centre for Water Management

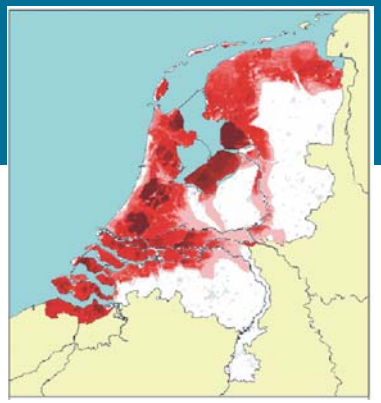
Presentation

- Introduction
  - Current protection standards
  - 2nd Delta Committee → new risk based safety standards?

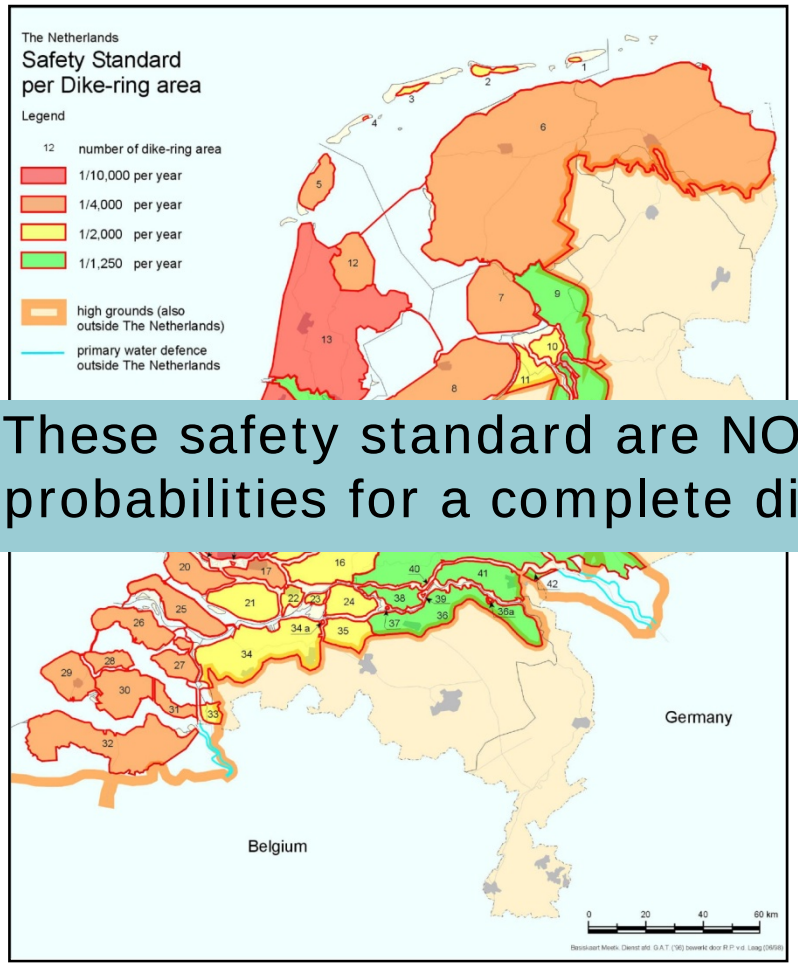
- The FLORIS project
  - Method
  - Results for two dike ring areas (river & sea)
  - Impact of risk reduction measures

- Time schedule new risk based approach

Flooding in the past



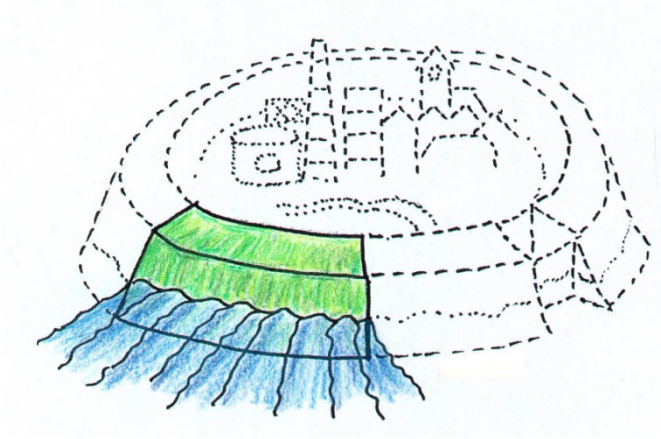
1st Delta Committee ('60s)



- These safety standard are NOT flood probabilities for a complete dike ring area

2nd Delta Committee (2008)

Current approach



'60s
exceedance frequency
overflow & wave overtopping
dike ring section
cost-benefit analysis

2nd Delta Committee (2008)

The new protection standards based should be based on:

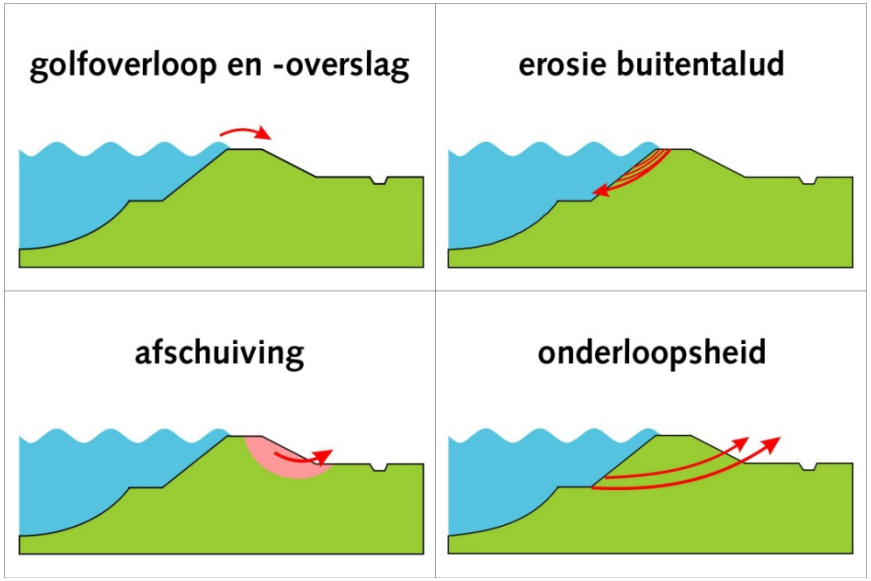
- Basic level of protection for every citizen
  → Individual risk
- Risk aversion against many casualties
  → Societal risk
- Cost-benefit analyses

Instrument for water safety policy: FLORIS

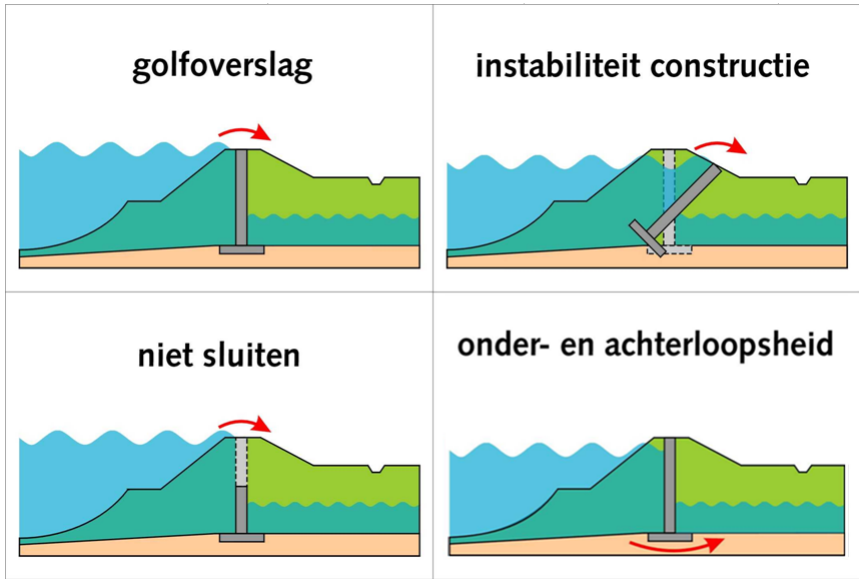
→ www.deltacommissie.com

Failure mechanisms FLORIS

dikes

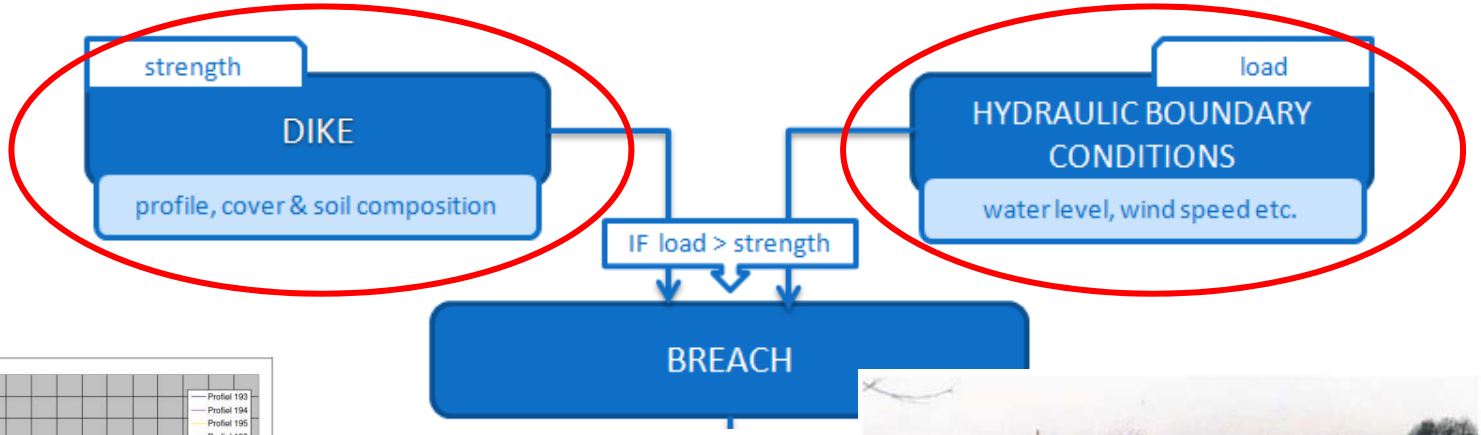


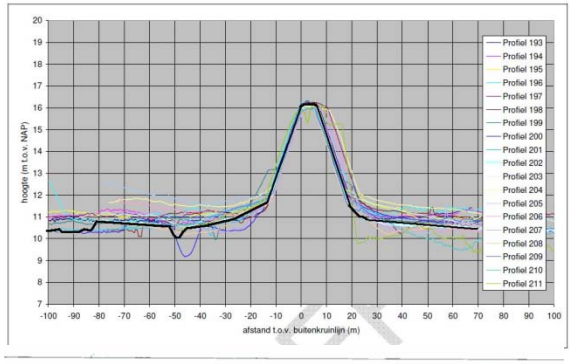
hydraulic structures

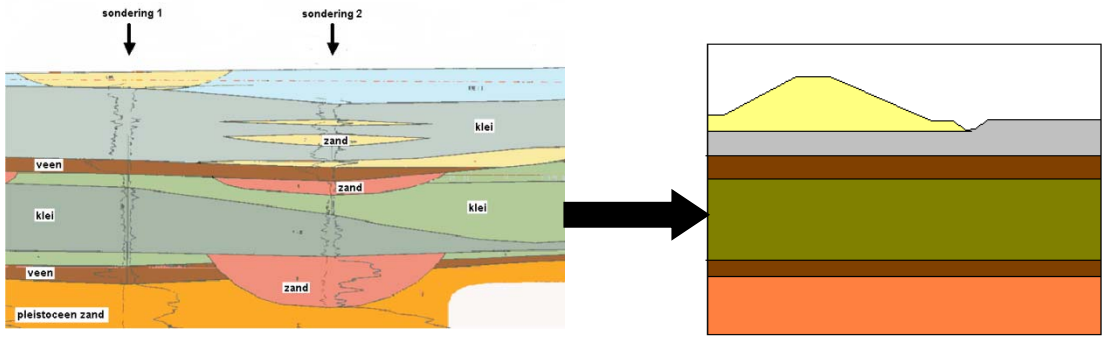


dunes

Method


strength
DIKE
profile, cover & soil composition
load
HYDRAULIC BOUNDARY CONDITIONS
water level, wind speed etc.
IF load > strength
BREACH


hoogte (m t.o.v. NAP)
afstand t.o.v. buitenkruinlijn (m)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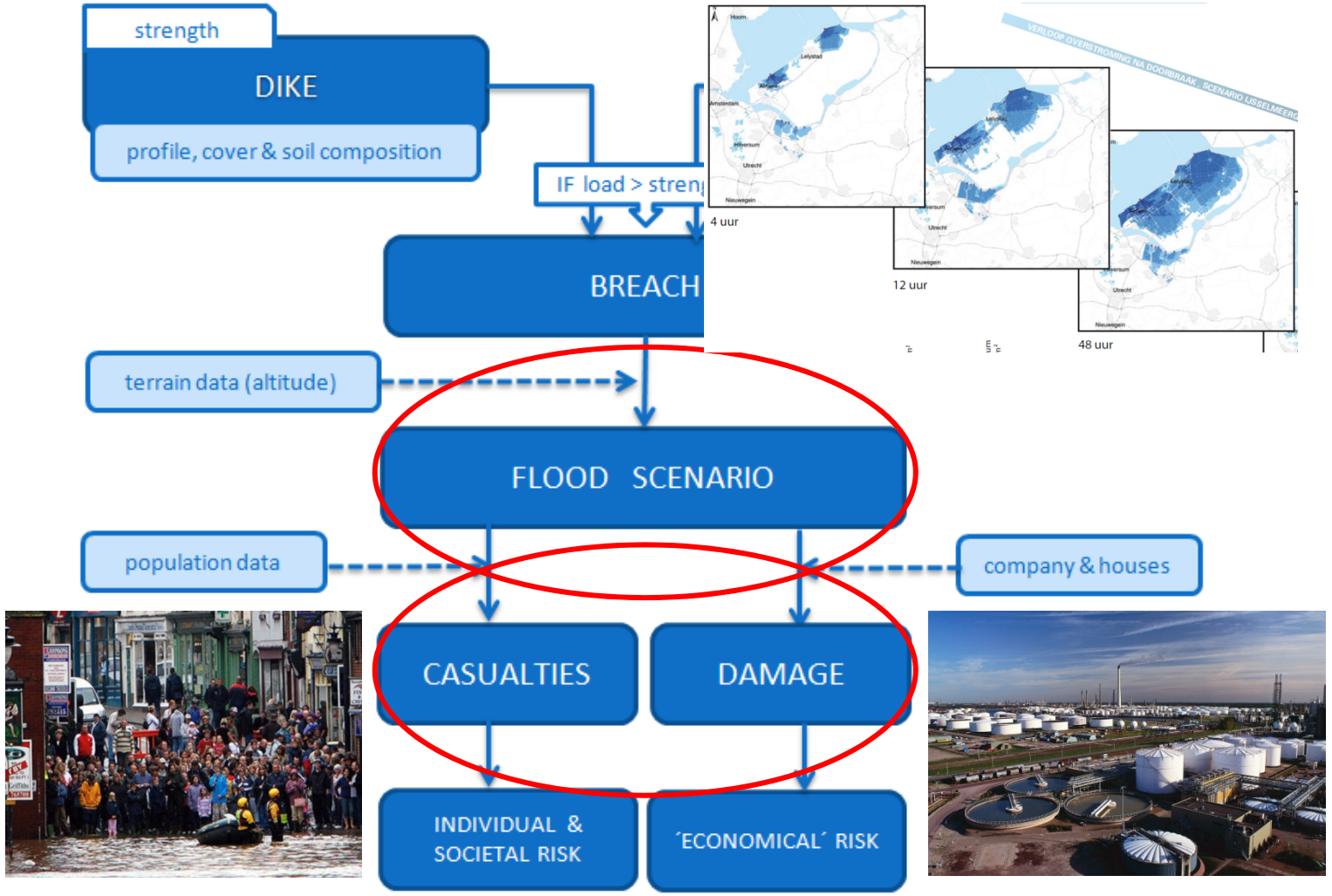
Method

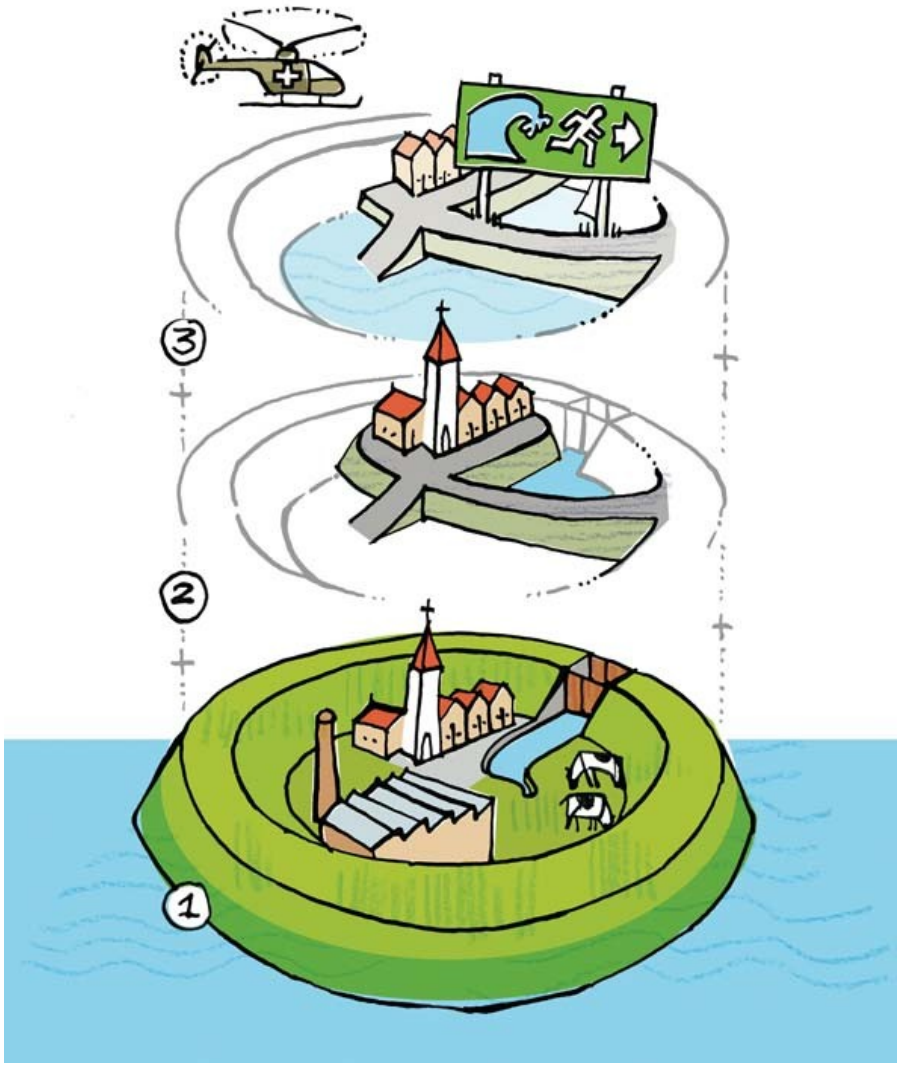

strength
DIKE
profile, cover & soil composition
IF load > stren
BREACH
terrain data (altitude)
FLOOD SCENARIO
population data
company & houses
CASUALTIES
DAMAGE
INDIVIDUAL & SOCIETAL RISK
´ECONOMICAL´ RISK
4 uur
12 uur
48 uur

Risk reduction

Preparation / response
(emergency response)

Pro-action
(spatial planning)

Prevention



Method - Failure frequency

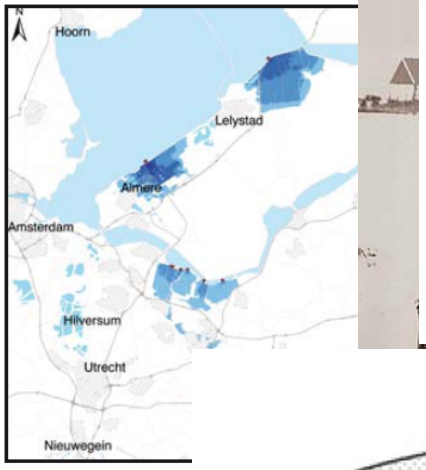
- FAILURE: Limited state condition = STRENGTH – LOAD < 0
  - Formulas for each failure mechanisms
    - → Stochastic distribution (inherent en knowlegde uncertainties)
    - → Failure frequency per mechanism per dike ring (section)

failure probabily per dike ring area

	failure mechanism			**all**
dike section	overflow	instability inner slope	piping	**mechanism**
1	4,2E-04	1,0E-06	n.a.	**4,2E-04**
2	3,7E-06	n.a.	2,8E-04	**2,8E-04**
3	2,3E-04	n.a.	1,9E-04	**4,2E-04**
…	…	…	…	**…**
total dike ring				**3,3E-03**

Method – Consequences (loss of life)

- Flood simulation
- Evacuation
  - warning, re
  - traffic mod
- Mortality funct
- → Deterministic r



4 uur

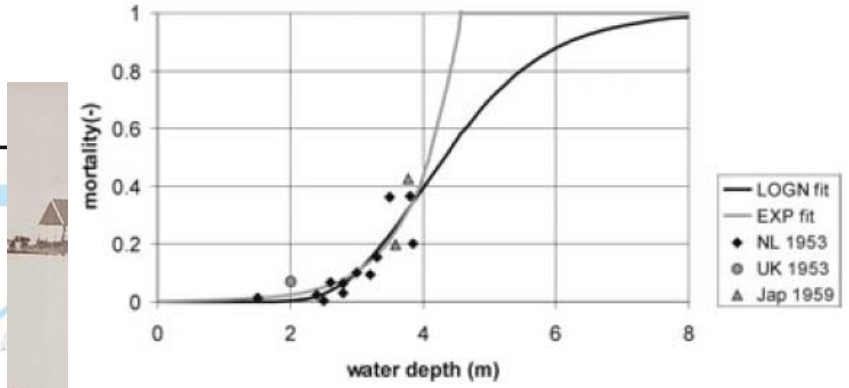
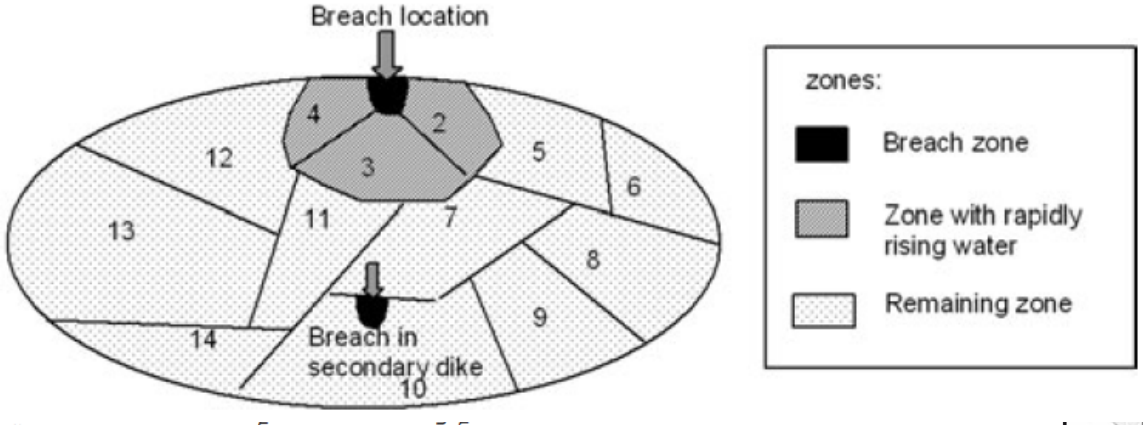
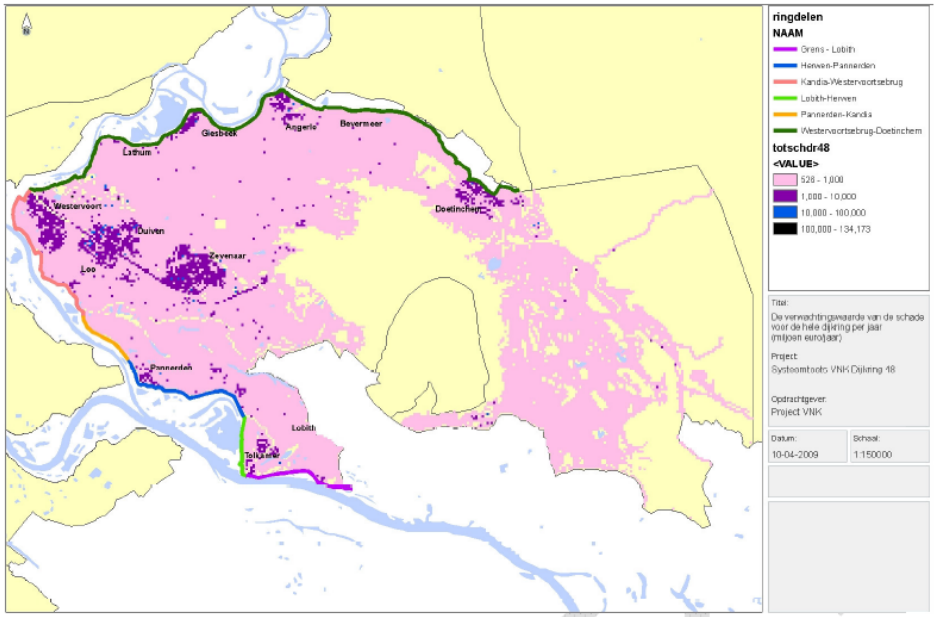


Fig. 6. Mortality function and observations for the zone with rapidly rising waters.(3)



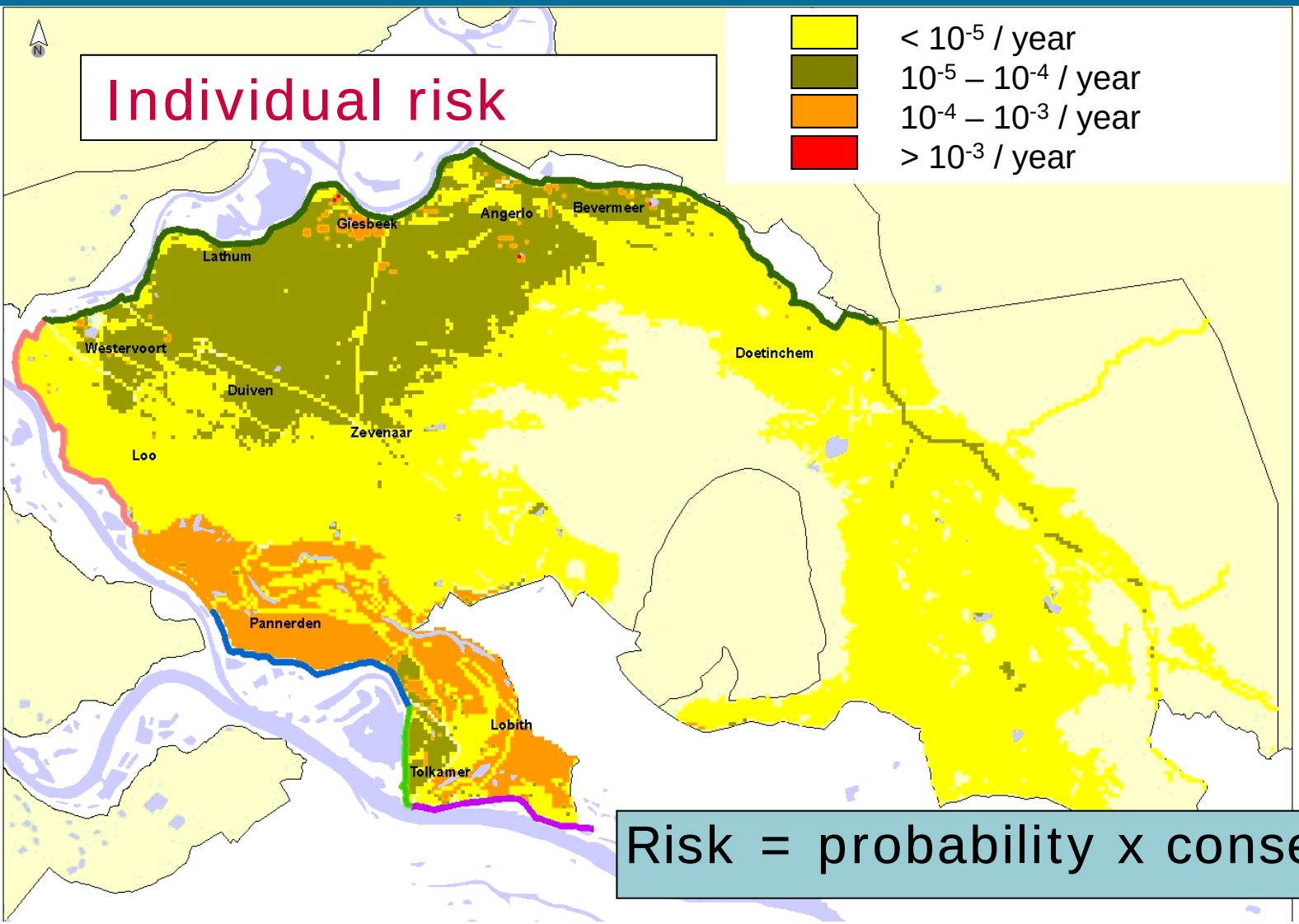
Method – Consequences (economical damage)



Figuur 6.1: Verdeling verwachtingswaarde totale schade

- Flood simulation
  - maximum water level
- 'Economic value'
  - Type of industry
  - Density of houses
  - Loss of life (!)
    → € 6 million / casualty
- Indirect costs

Individual risk



Risk = probability x consequences

Societal risk

Fig. 13. FN curve indicating the effects of two types of measures.

Ministerie van Verkeer en Waterstaat

Flood Risk and Safety in the Netherlands (FLORIS)
→ *first results*

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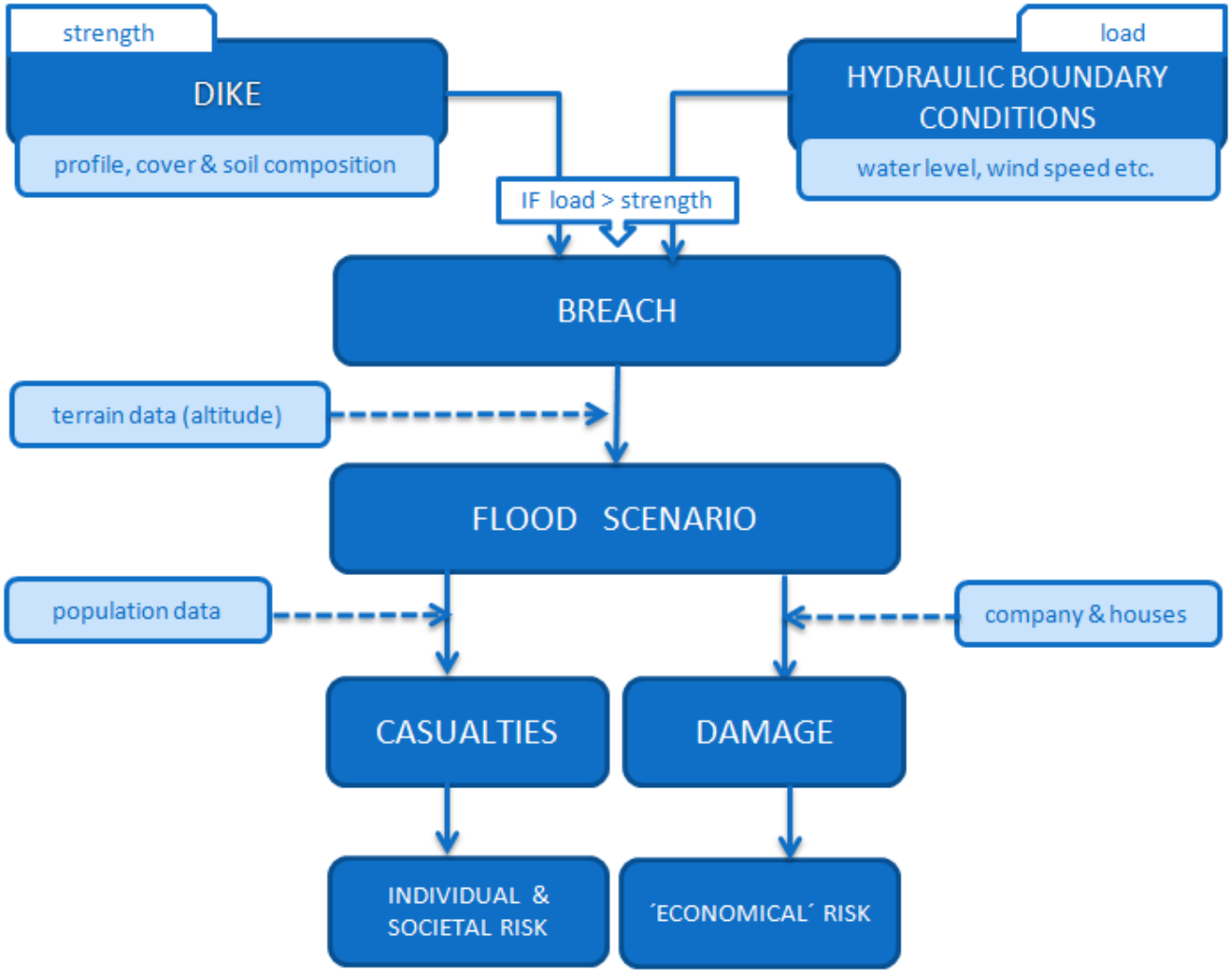
Method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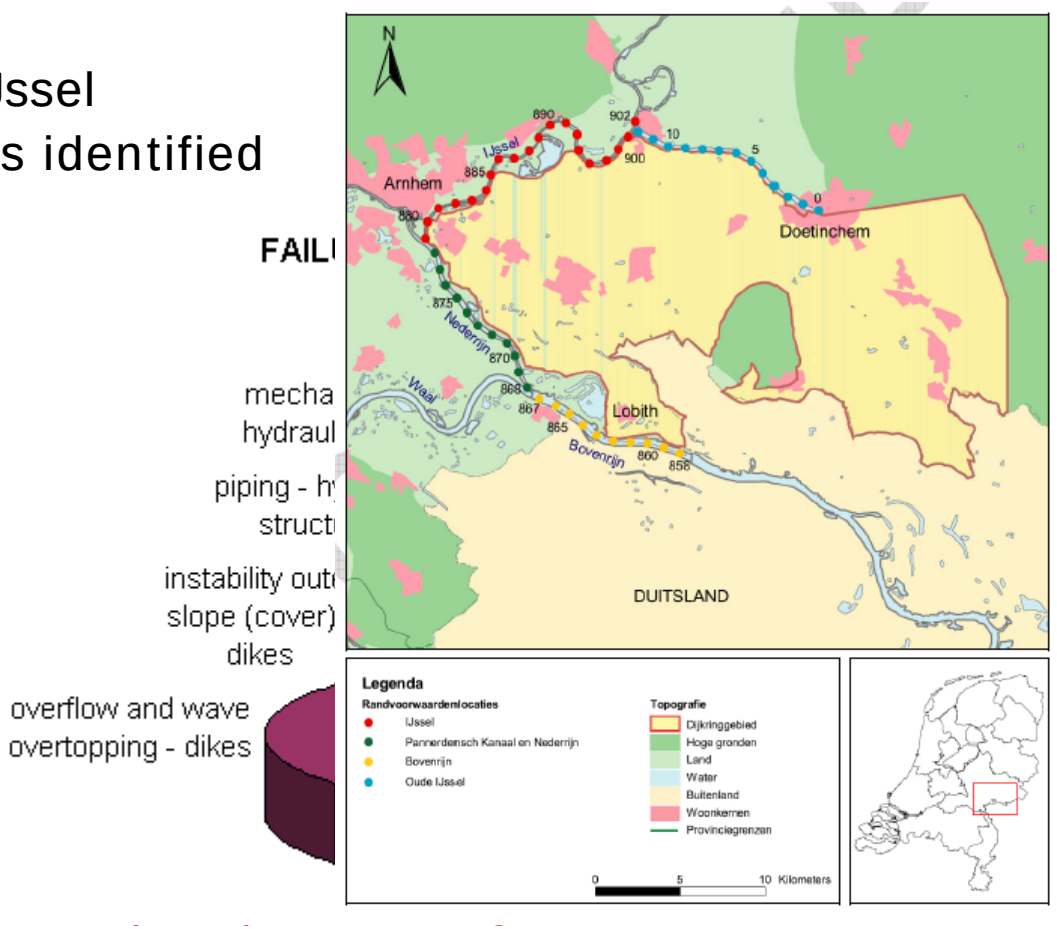
CASUALTIES
DAMAGE
INDIVIDUAL & SOCIETAL RISK
´ECONOMICAL´ RISK

RESULTS - 'RIVER' dike ring

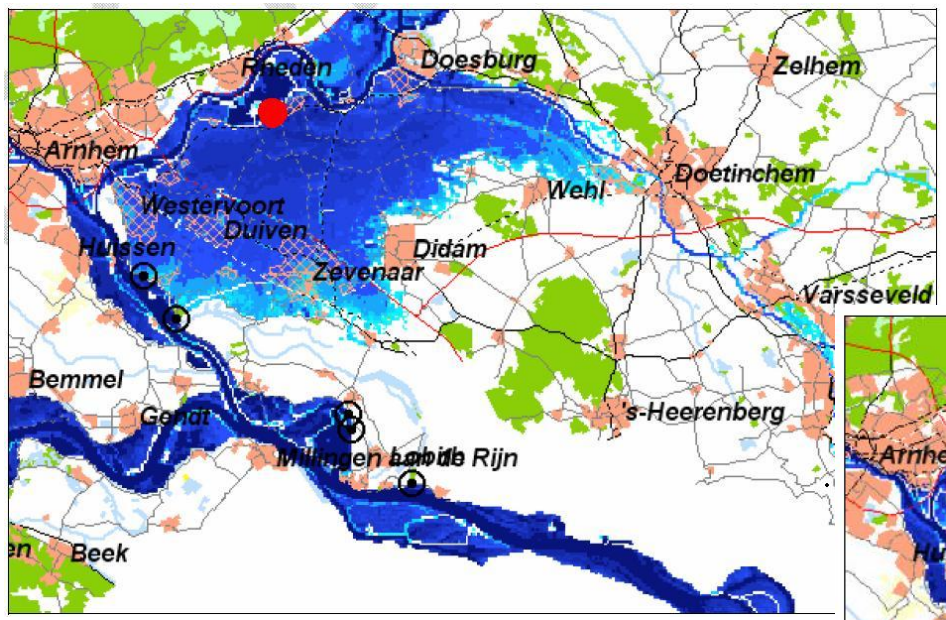
- Along the river Rhine & IJssel
- 6 different flood scenario's identified
  - No multiple breaches

dike ring section	probability [per year]	dominant f
48 - 1	2,92E-04	overflow ar
48 - 2	5,95E-05	
48 - 3	2,55E-04	
48 - 4	6,57E-05	
48 - 5	3,16E-04	
48 - 6	7,72E-04	overflow ar
total	**1,76E-03**	

- Flood probability dike ring a
  - Exceedance frequency 1

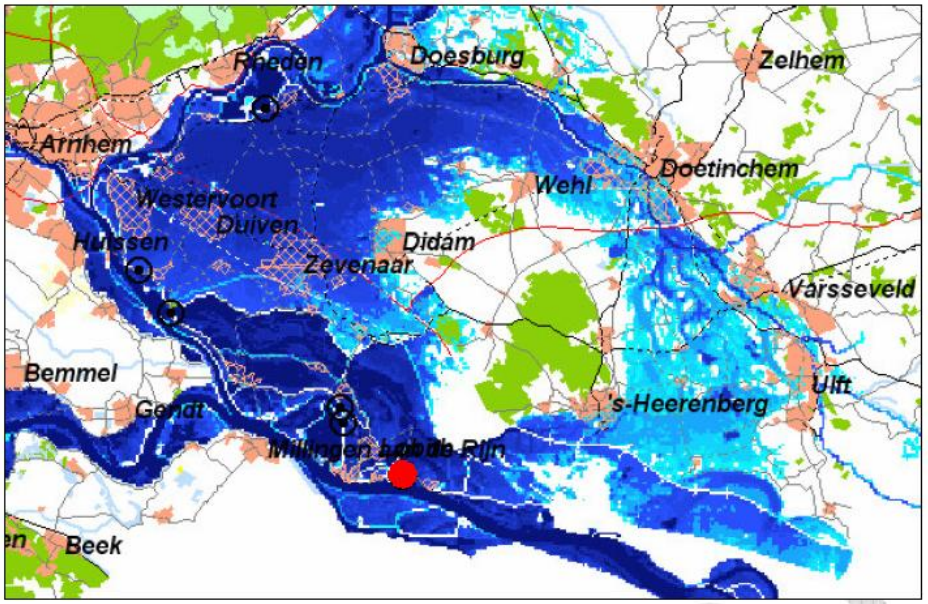


Flood simulations

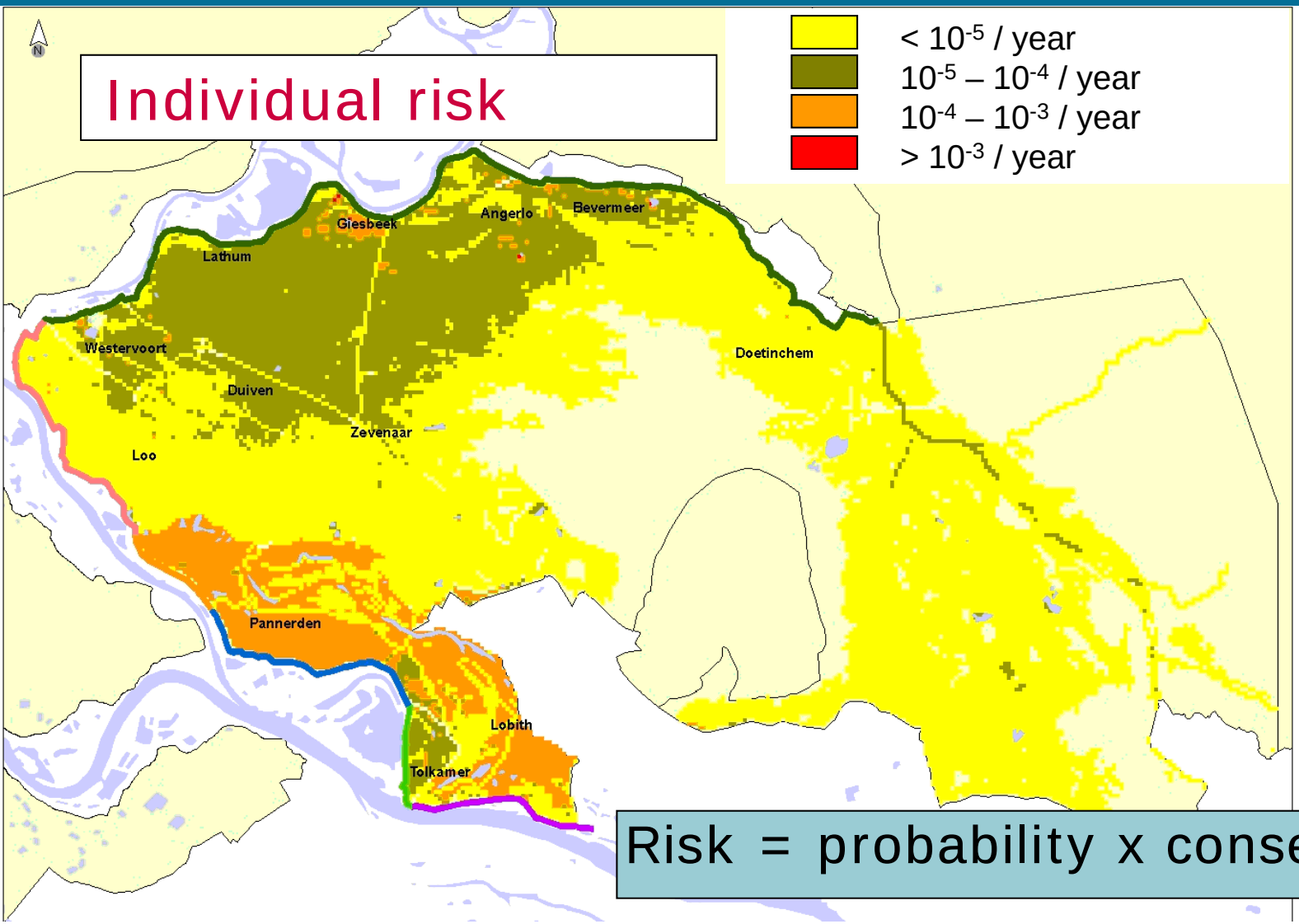


Breach section 6 (north):
20-370 casualties;
damage: € 3,5 billion

Breach section 1 (south):
60-1000 casualties; damage: € 6 billion

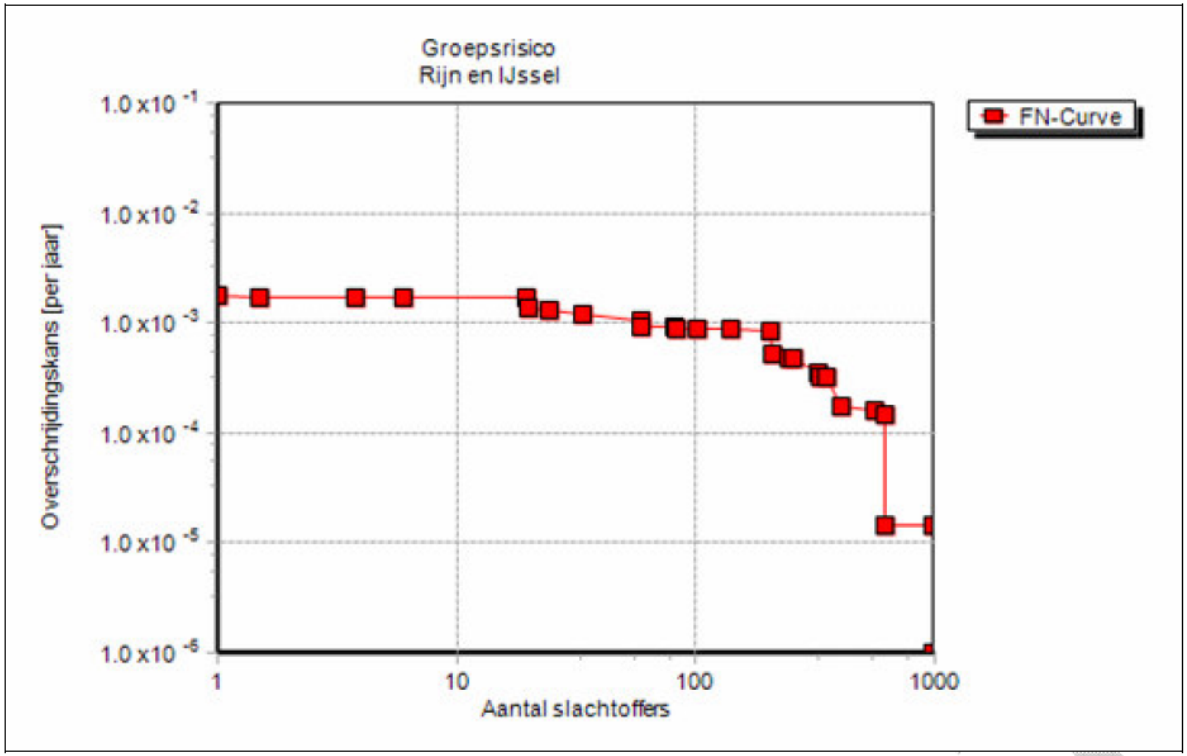


Individual risk



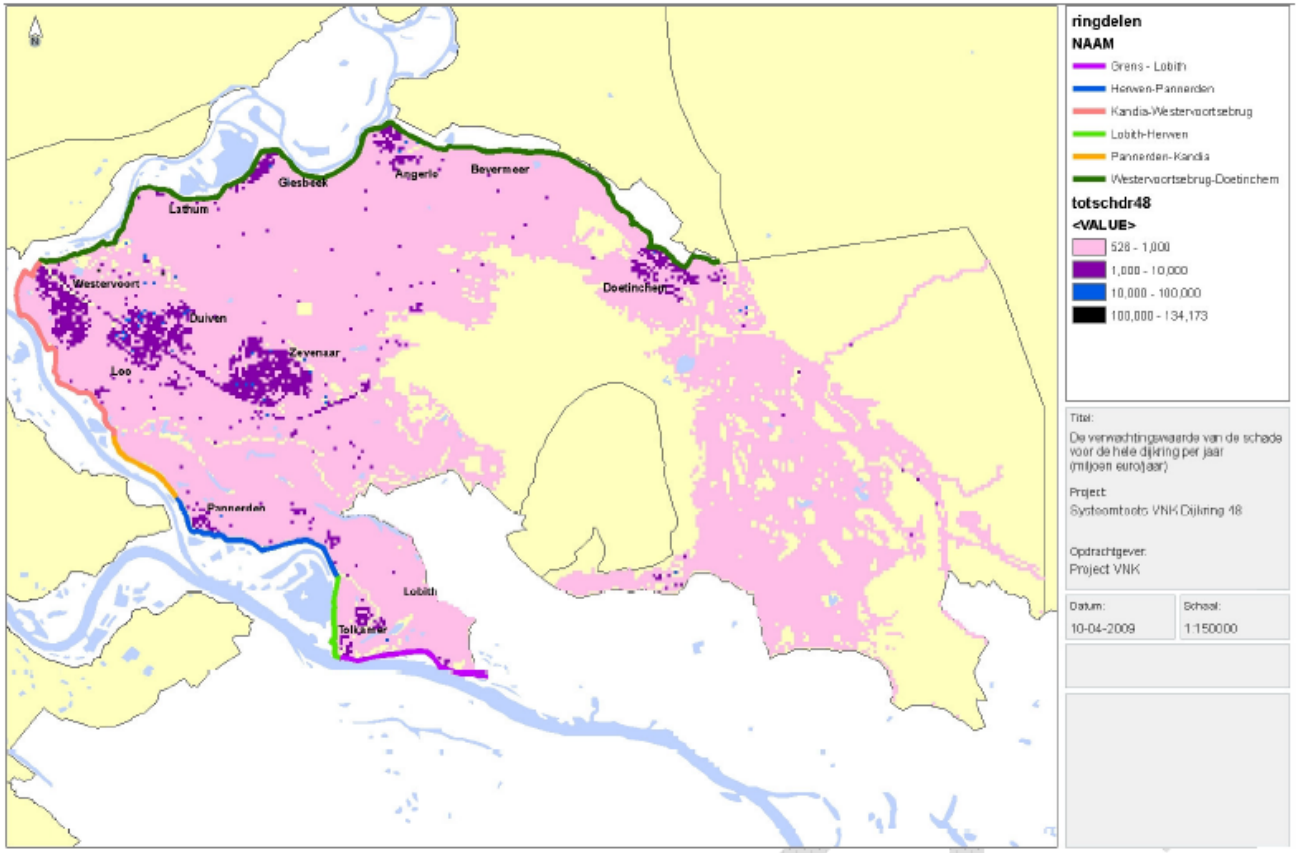
Risk = probability x consequences

Societal Risk



- Probability of >10 casualties: 2 x 10^{-3}/year
- Probability of >100 casualties: 1 x 10^{-3}/year
- Probability of >1000 casualties: 1,5 x 10^{-5}/year

Economical damage

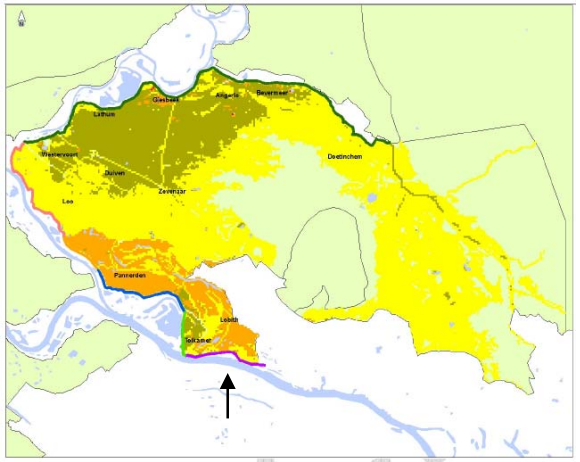


Figuur 6.1: Verdeling verwachtingswaarde totale schade

Risk reduction 1: Impact of higher dikes?

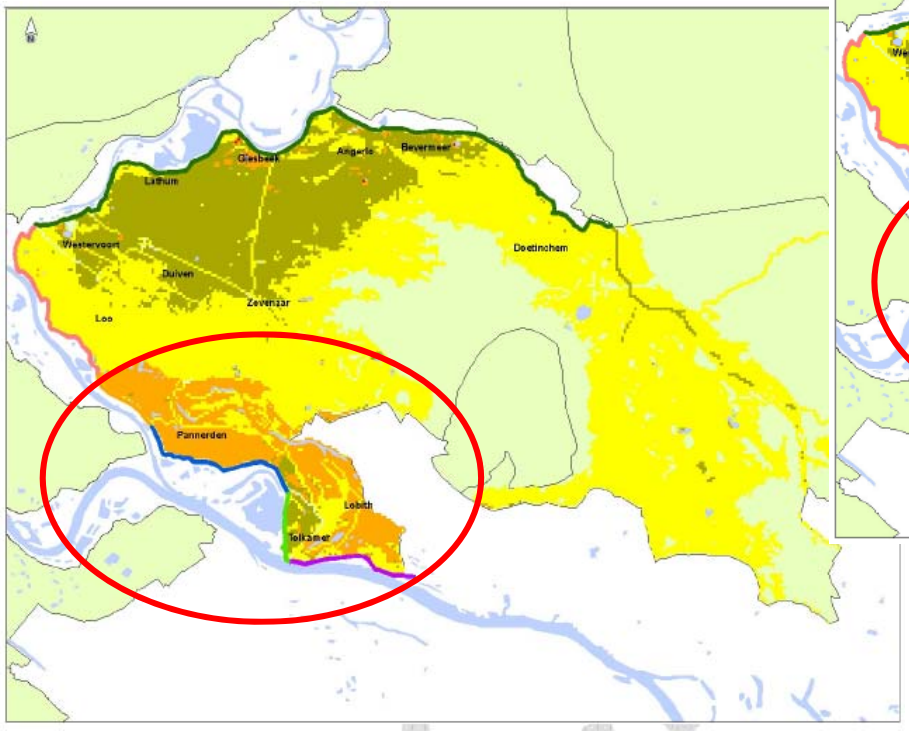
- A breach in section 1 results in:
  - almost complete dike ring area is flooded
  - many casualties & economical damage
  - overflow & wave overtopping dominant failure mechanism

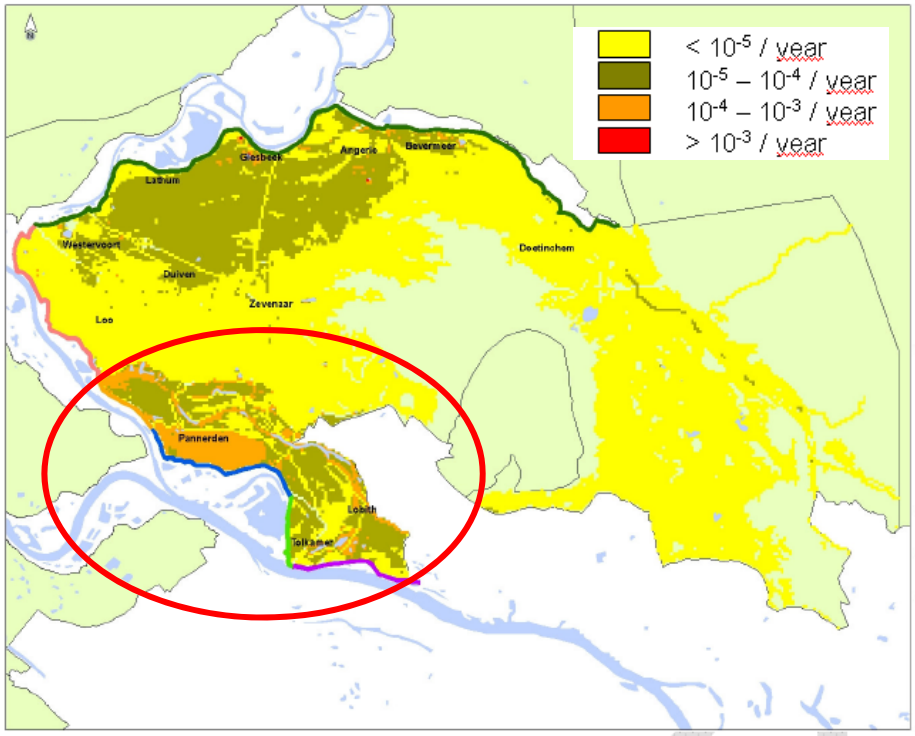
- What is the effect of higher dikes at section 1? (8% of the total dike ring length)



Individual risk: 20-25% risk reduction

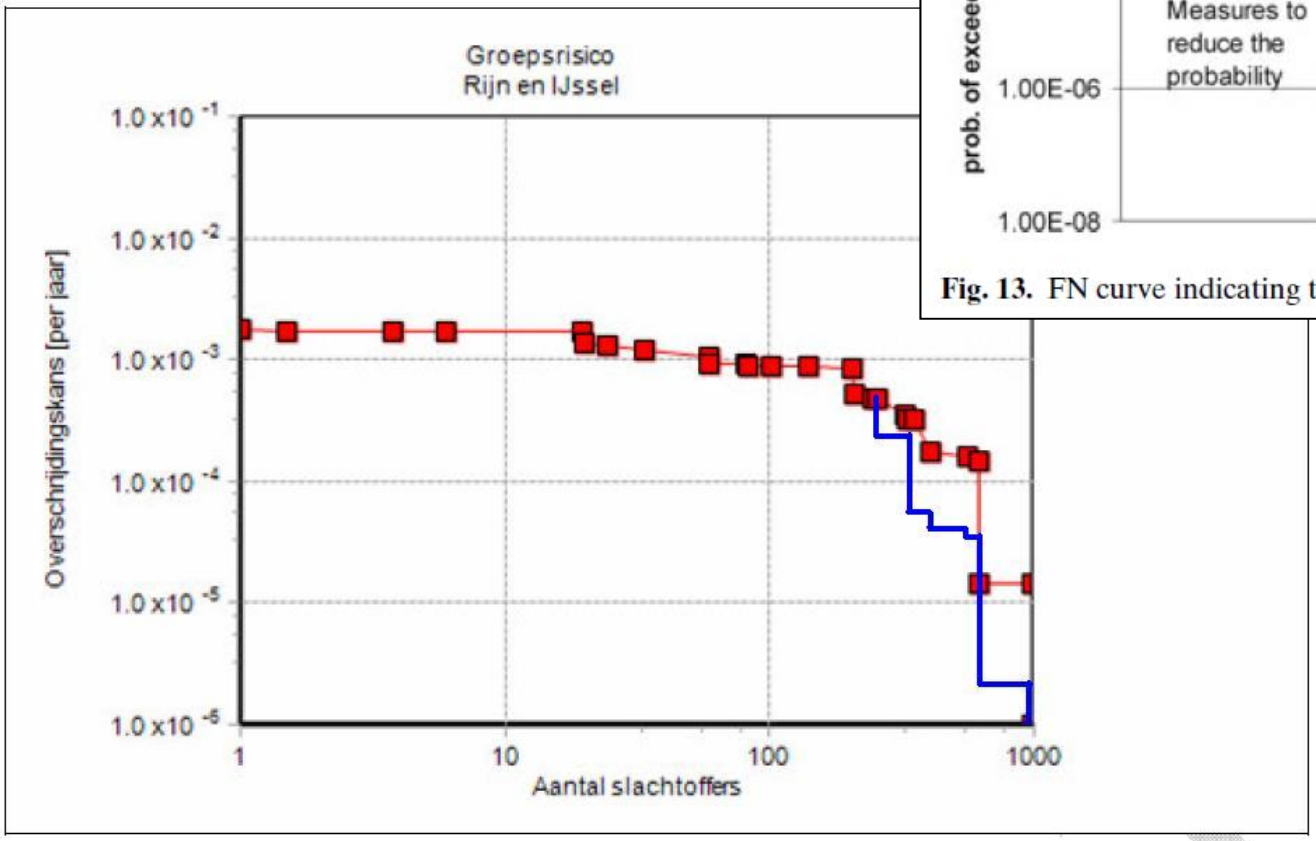
- Current situation





with higher dikes in section 1

Societal risk



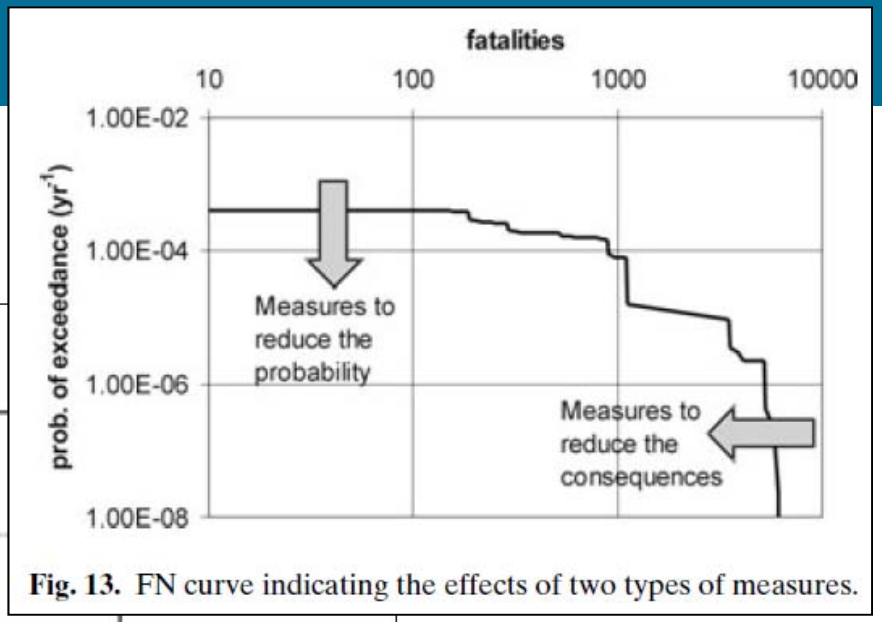
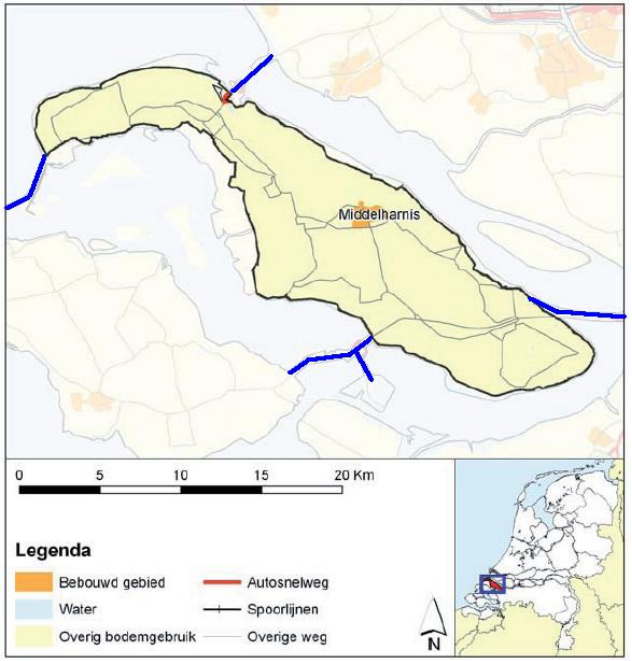
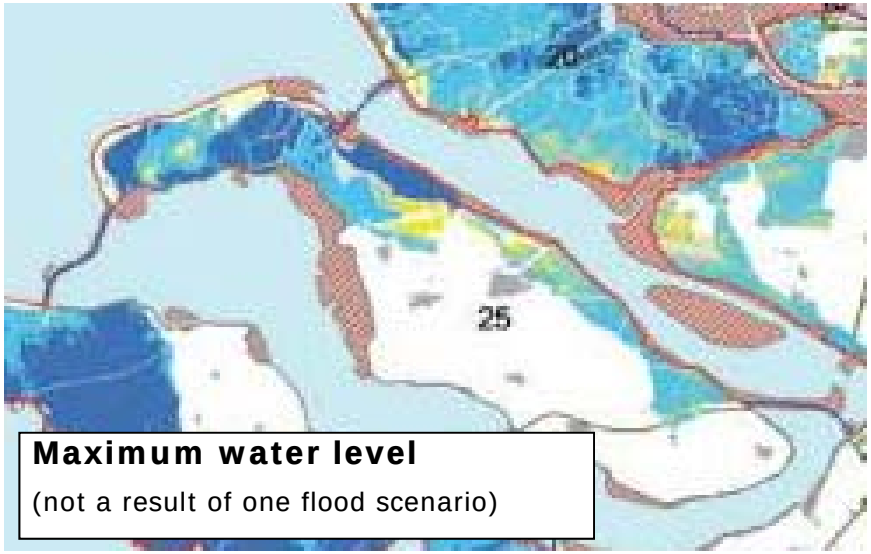


Fig. 13. FN curve indicating the effects of two types of measures.

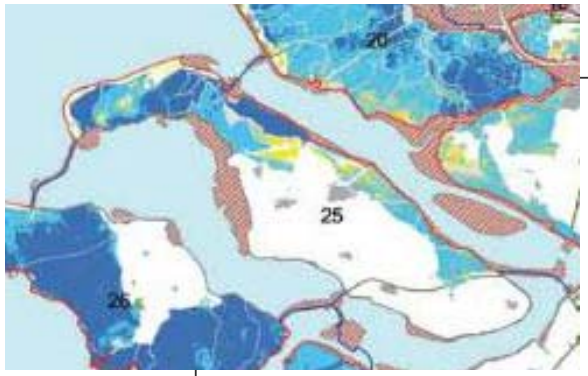
RESULTS - ‘SEA’ dike ring

- Partly along the North Sea (dunes)
- Mainly protected by dams
- 13 different flood scenario’s identified
  - multiple breaches are possible





Individual Risk



Risk reduction 2: Impact of measures against piping?

- Measure:
  → increase of the water level in the polder during high water

water level in the polder	level	probability of flooding	
		[per year]	[per year]
normal winter level	low	0,056	1/18
during high water (outside polder):	high	0,003	1/325

- Flood probability decreases with almost a factor 20!

- Flood probability = 1/325 per year
  - Exceedance frequency per dike *section* 1/4000 year

First conclusions FLORIS project

(after risk assessment of 3 dike ring areas)

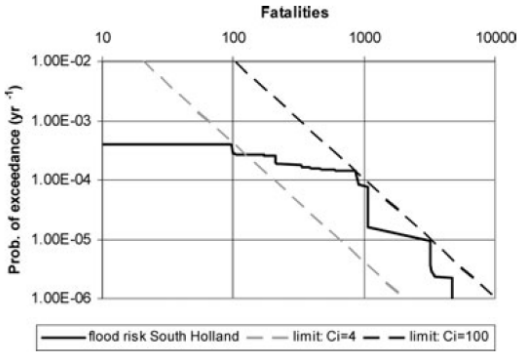
- The FLORIS method is a very useful tool to
  - determine the risk determining dike sections and failure mechanisms
  - Discriminate between more and less dangerous locations within a dike ring area

- High failure probabilities are found
  → defence system less safe than expected?
  → model too conservative (uncertainties)?

- Piping is a risk determining failure mechanism

Heading for new risk standards in 2011

- What should be the flood probability per dike ring and what will be the costs if:
  - Individual risk level of 10^{-5}/year is guaranteed?
  - and 10^{-6}/year?
  - An certain acceptable societal risk standard is proposed?
- And what will be the economic optimal flood probability per dike ring?



Time schedule

→ 2011: a new risk based approach should be presented

→ 2010: insight into costs of new risk based protection standards is necessary

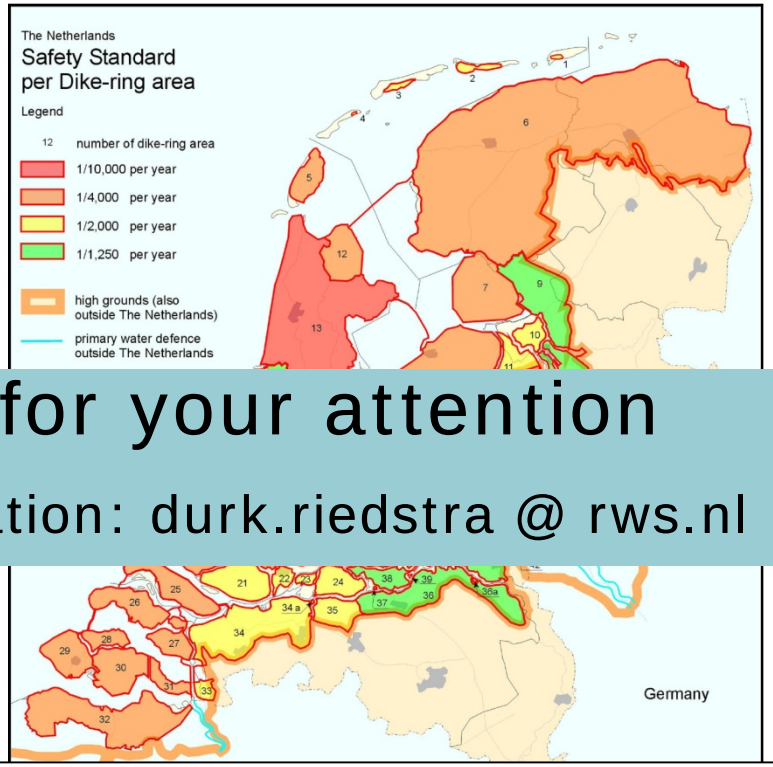
→ FLORIS not finished yet in 2011

- 2010: results of 6 more dike rings available
- 2011: 20 more dike rings …
- 2012: risk assessment of all 53 dike ring areas finished

→ new approach should be based on a ‘quick scan’

→ With input of only 9 FLORIS dike rings results …

To be continued …



Thanks for your attention

more information: durk.riedstra @ rws.nl

Special thanks to
- Harry Stefess & other FLORIS employees
- Ministery of Transport, Public Works and Water Management
- Water Board Union
- The 12 provences