Hydraulic load interdependencies: a case study on a regional flood defense system in the Netherlands

Stephan Rikkert, Matthijs Kok

s.j.h.rikkert@tudelft.nl

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Flood defences in the Netherlands

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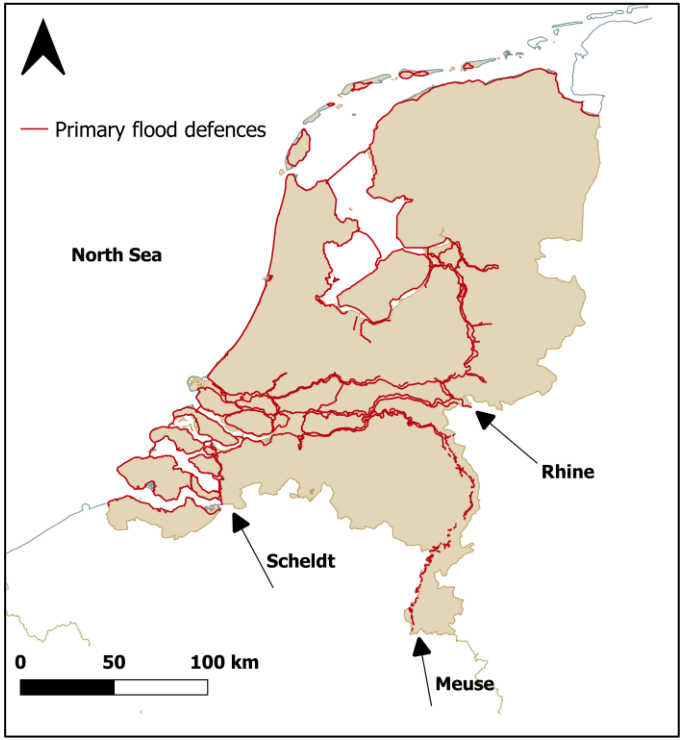
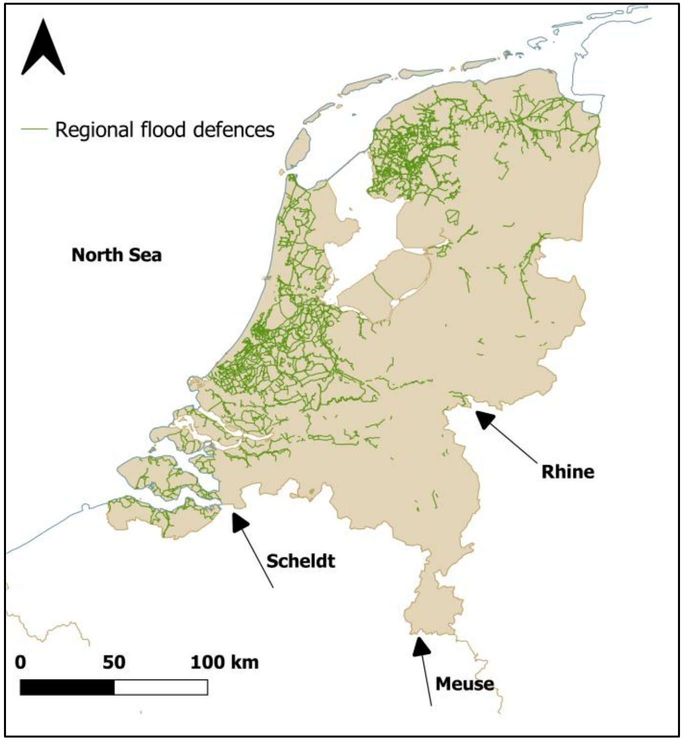
±3.400 km: primary



±11.500 km: regional



Polder canals

Approximately 80% of regional flood defences consists of polder canal levees (in Dutch: boezemkaden): >8,000 km

(https://beeldbank.rws.nl, Rijkswaterstaat / Rob van der Laag)

(https://beeldbank.rws.nl, Rijkswaterstaat / HHRS)

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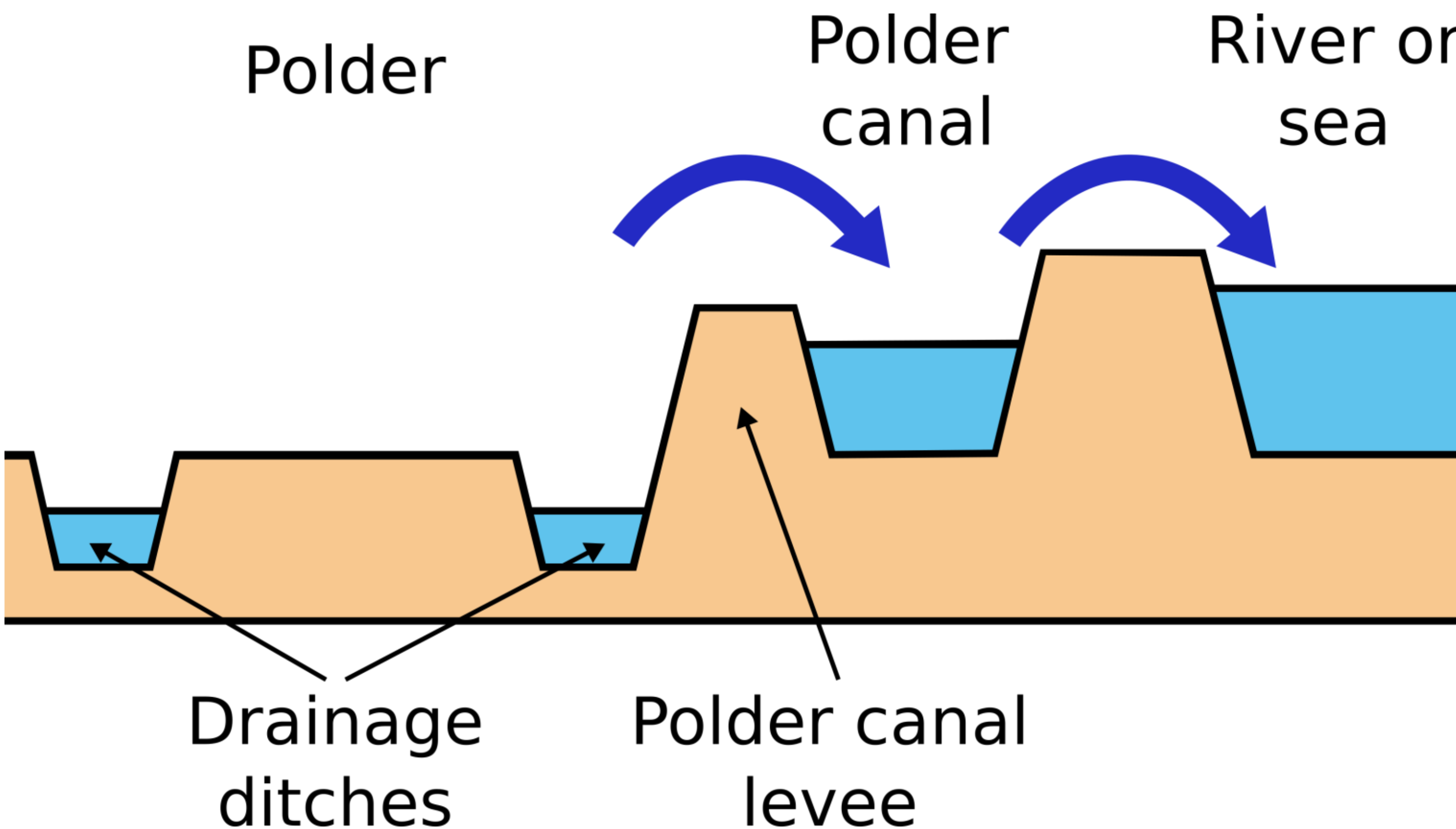
Polder canals



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Levee failures

Tuindorp Oostzaan, 1960
Cause: unknown, most likely ruptured water pipe

Wilnis, 2003
Cause: drying of a peat dike

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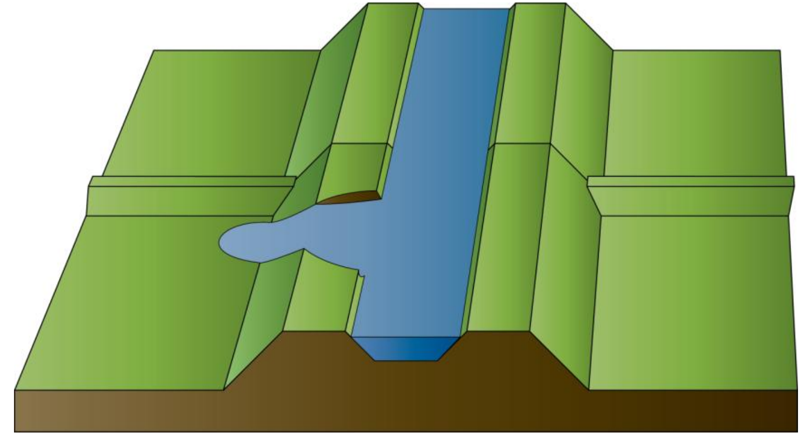
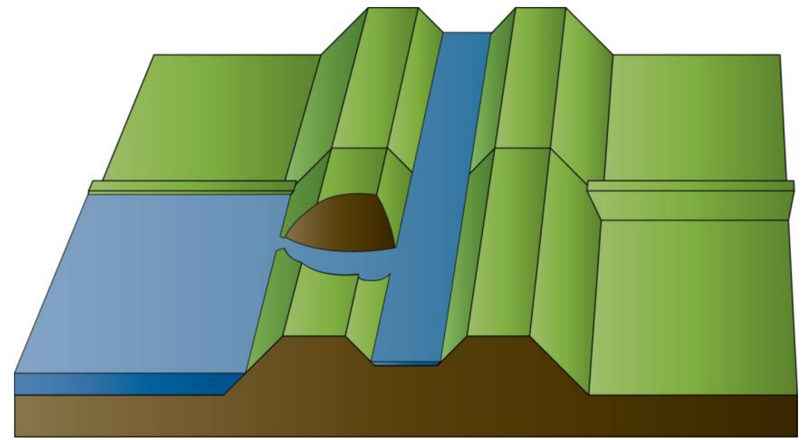
Description	Schematic representation
Phase 1 • Hydraulic load larger than levee resistance; • Breach starts growing	
Phase 2 • Breach has grown; • Adjacent polder fills with water; • Canal water level drops; • ‘Surviving’ levees ‘relieved’.	

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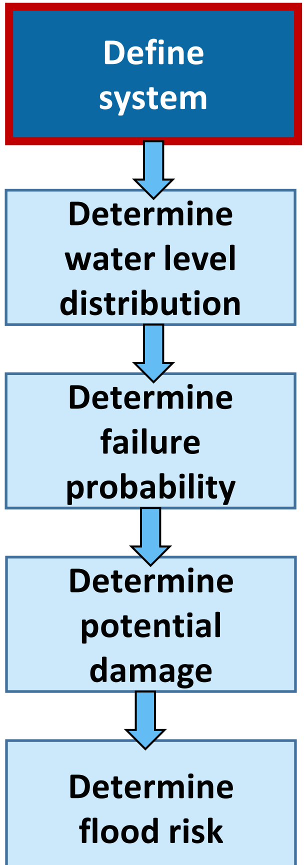
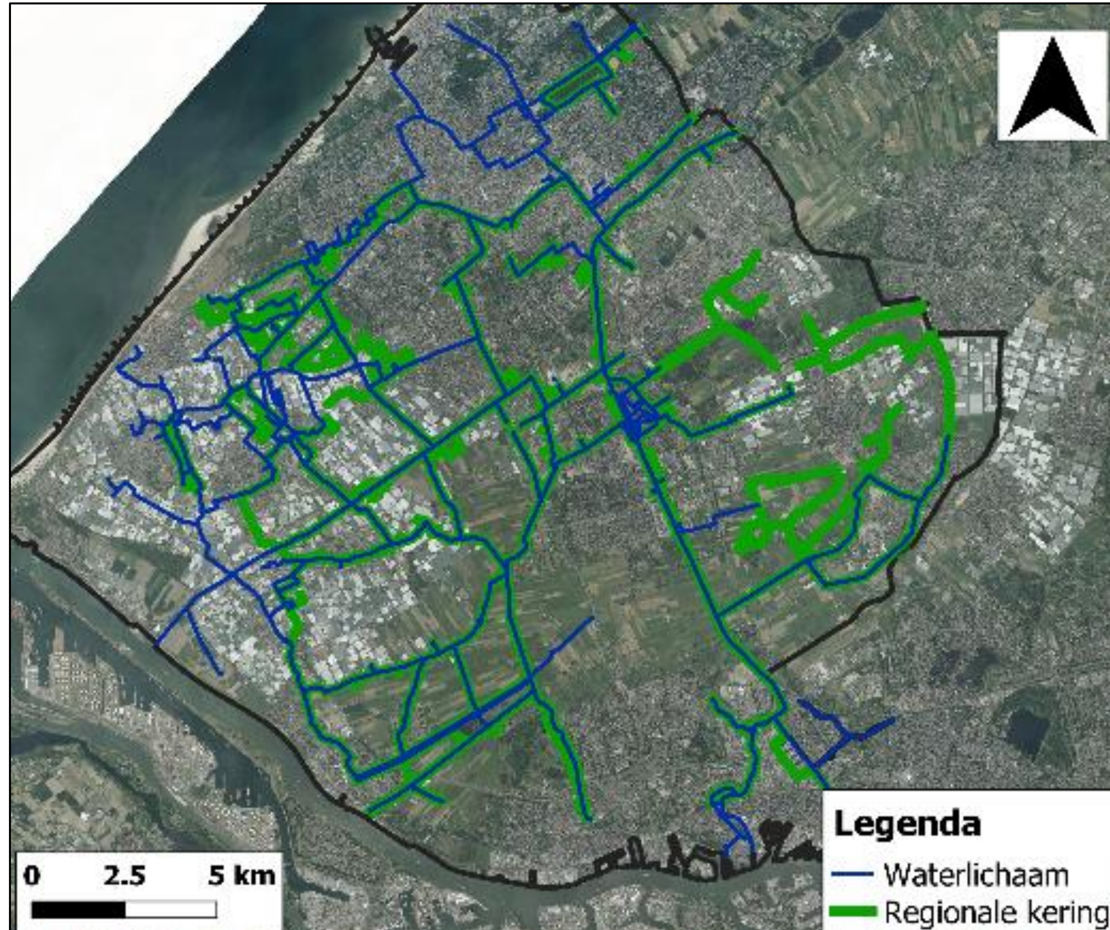
Objective

Develop a method to include hydraulic load interdependency in flood safety assessments for regional flood defense systems

Method





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Method

Define system

Determine water level distribution

Determine failure probability

Determine potential damage

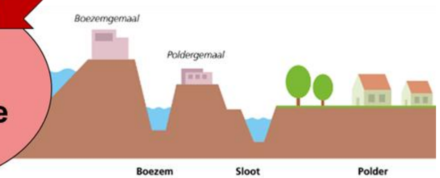
Determine flood risk

Rainfall (and wind)

Initial conditions system

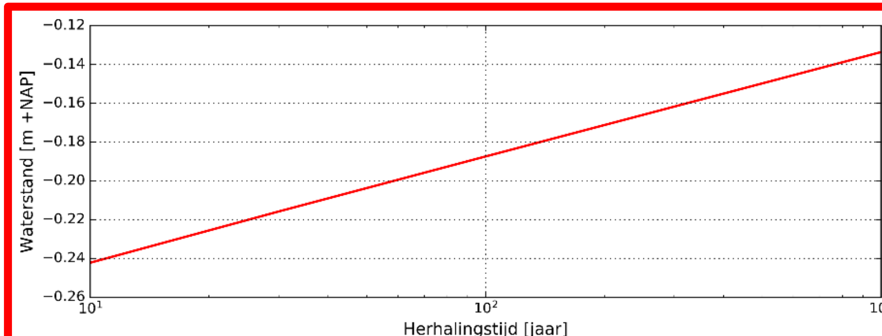
Available storage capacity

System response



Water level

Exceedance frequency curve



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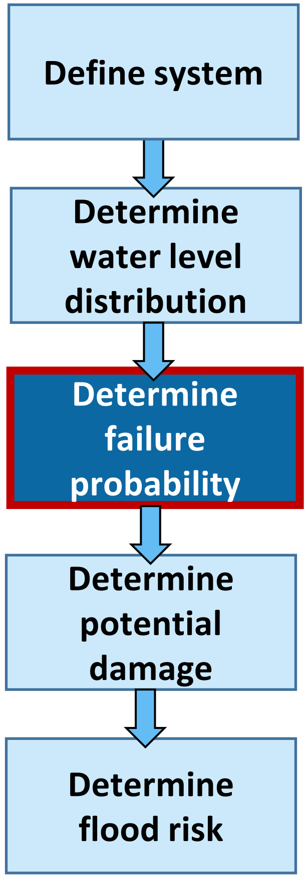
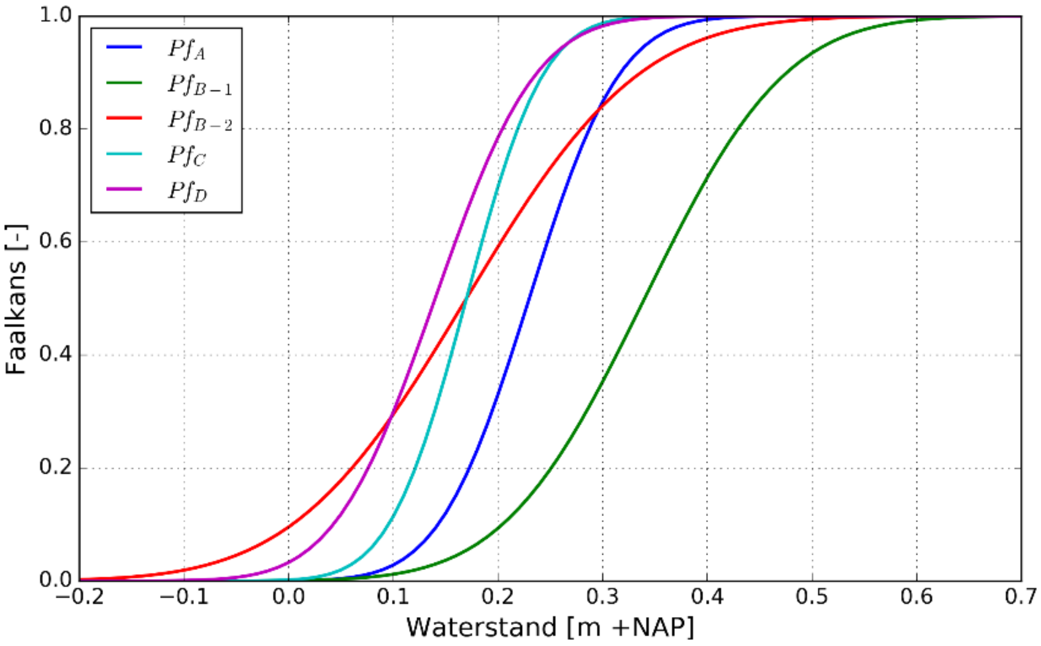


Fragility curves



Failure probability P_f as a function of the water level

Method

Define system

↓

Determine water level distribution

↓

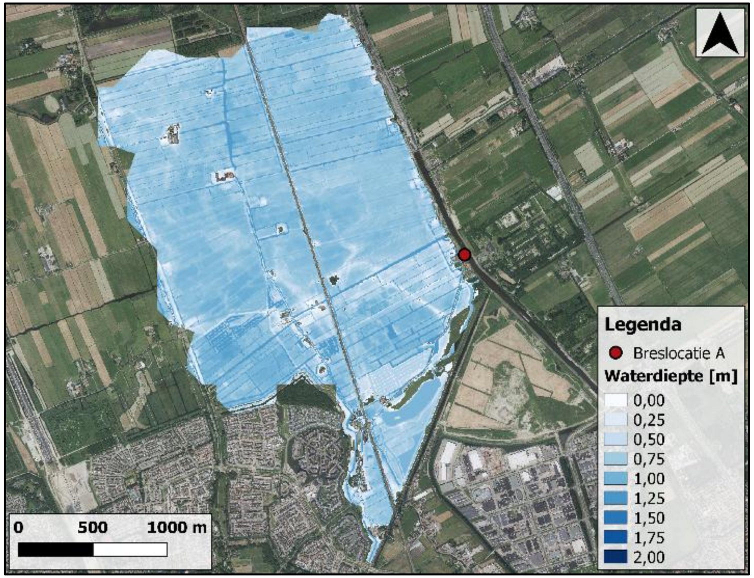
Determine failure probability

↓

Determine potential damage

↓

Determine flood risk



Inundation maps

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Damage model

↓

Damage

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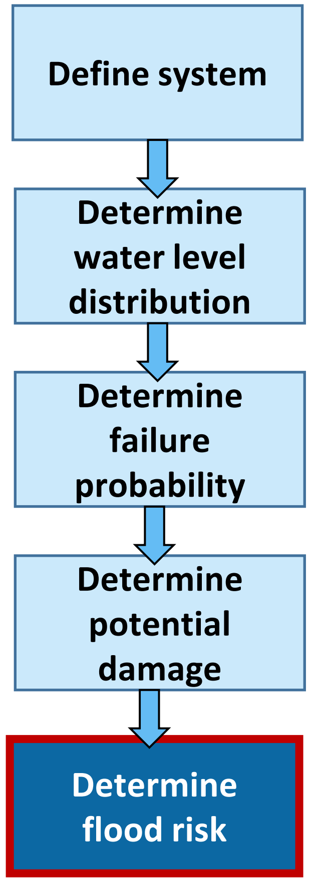
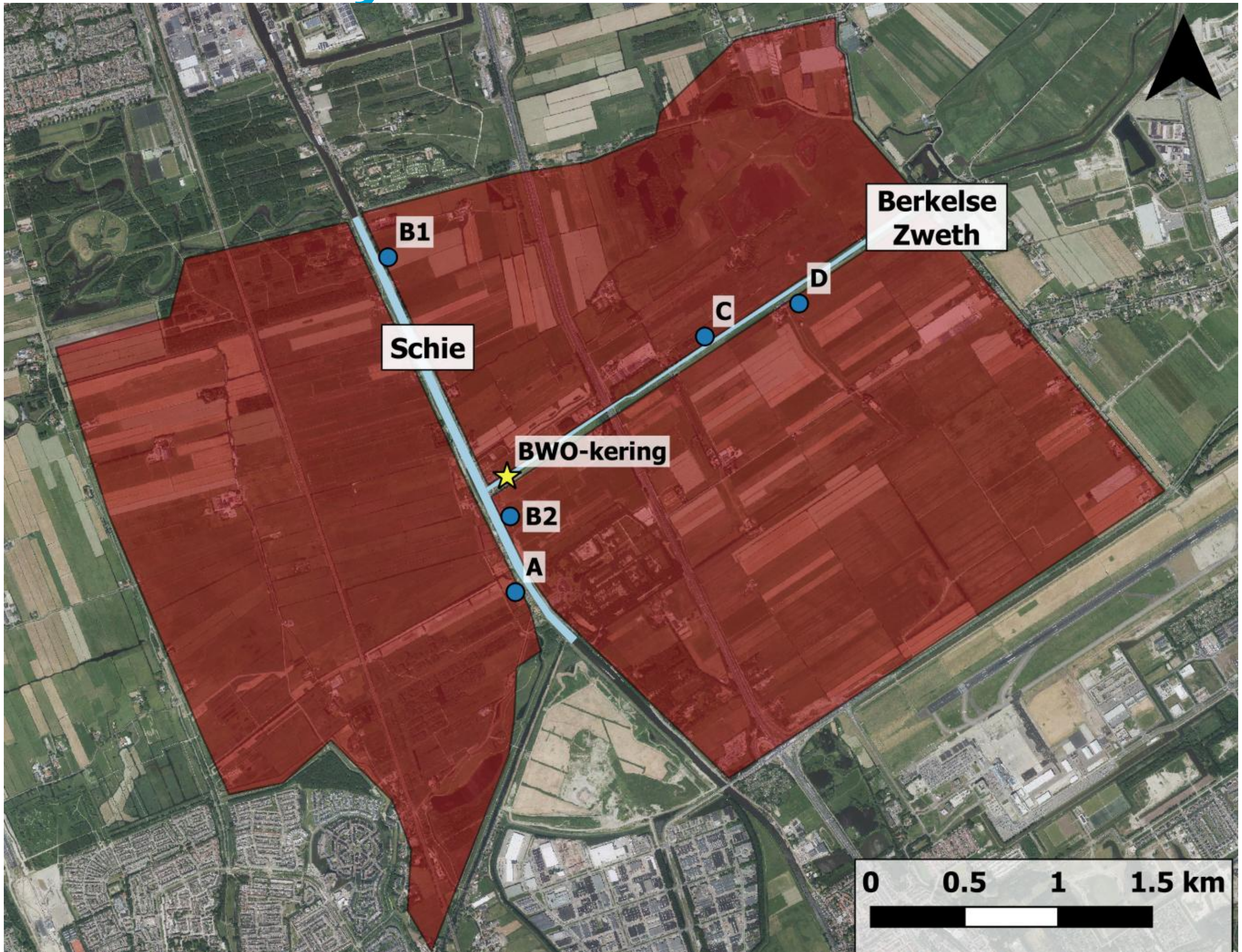
Method



Risk = probability x consequences

Case study Delfland



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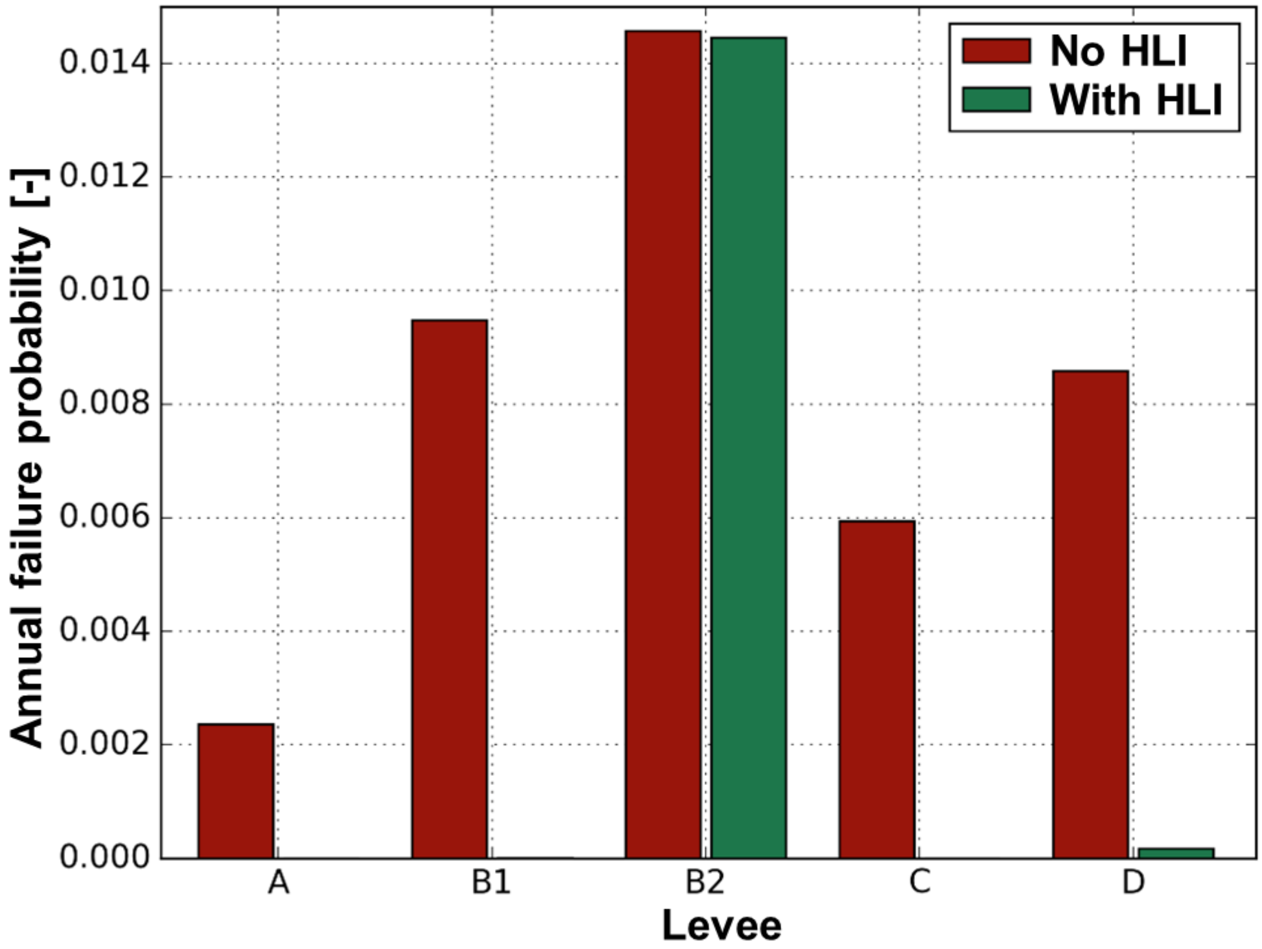
Case study Delfland



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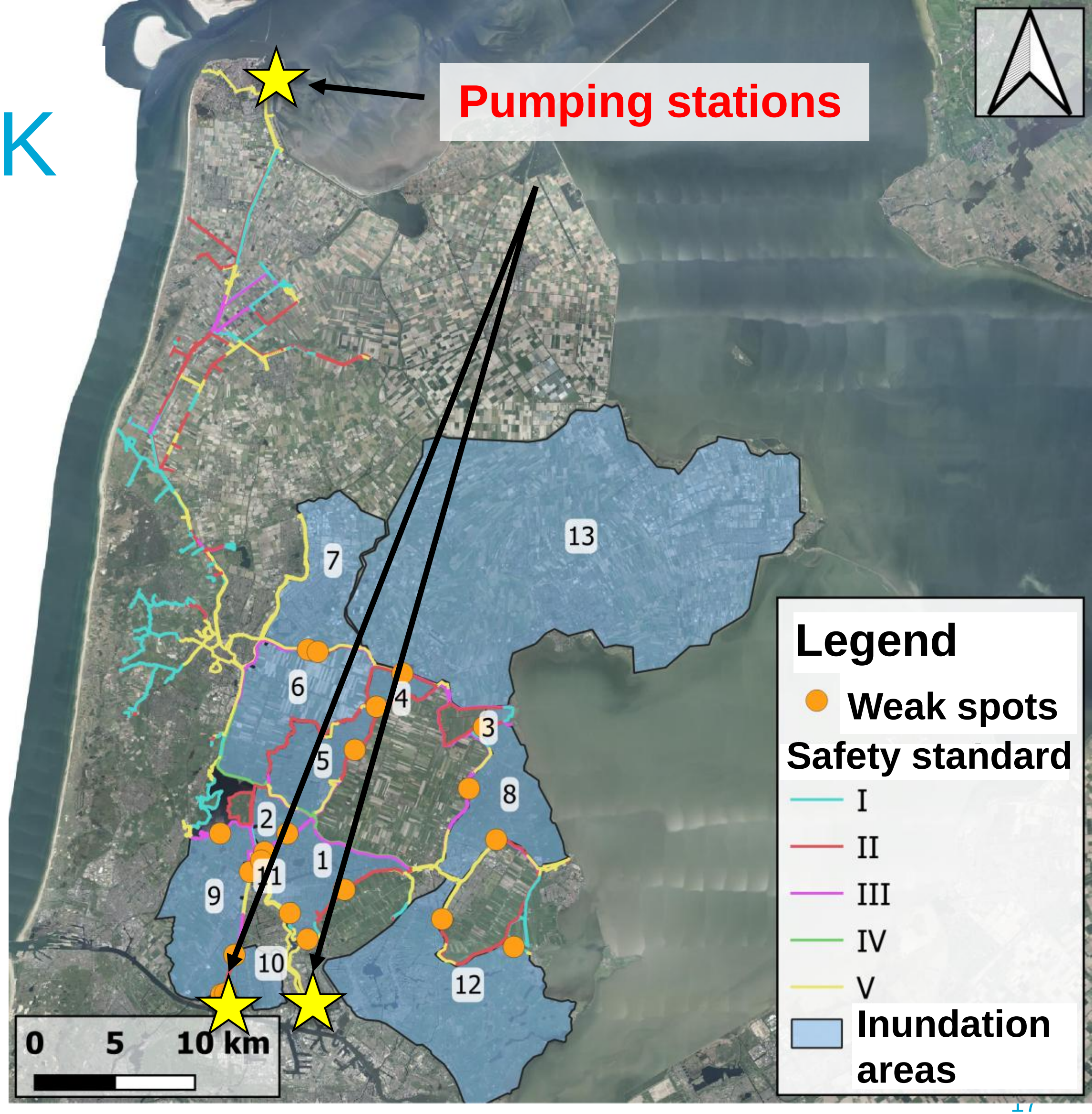
Case study HHNK

Water board Hollands Noorderkwartier

Schermerboezem

> 660 km of levees



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Water level drop

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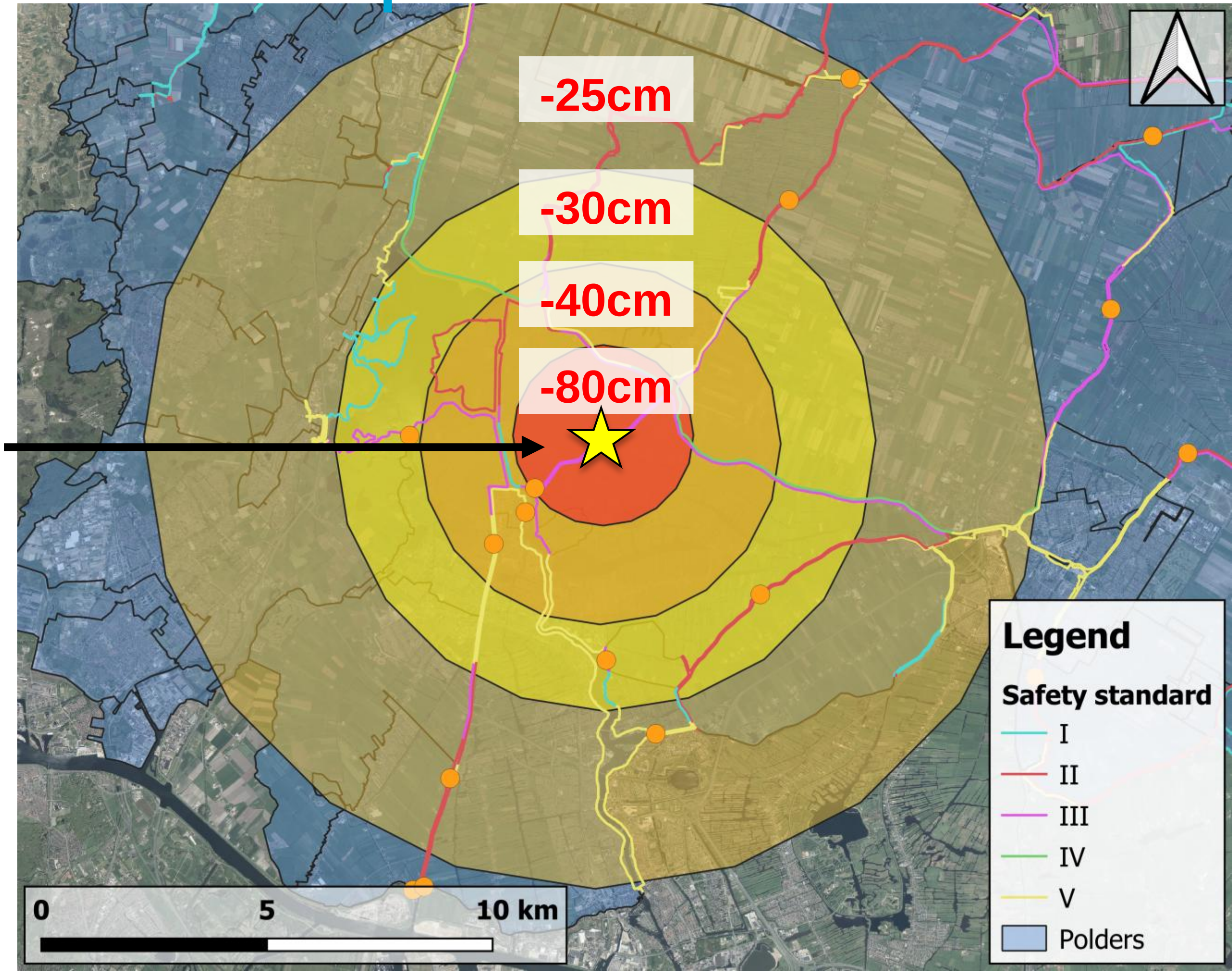
Levee breach



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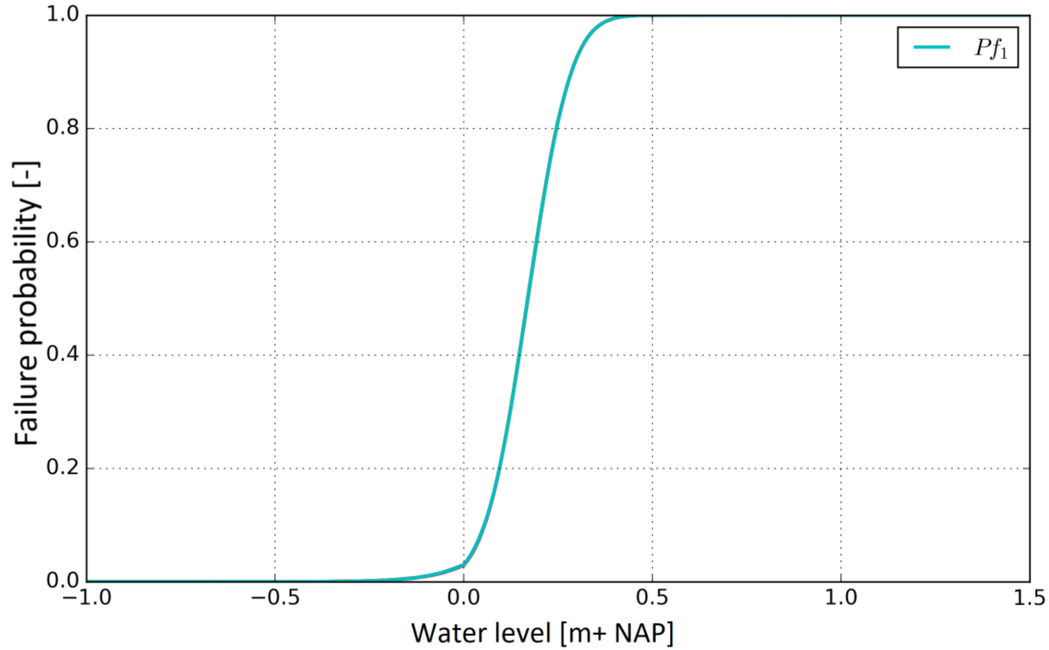
Fragility curves

Failure probability as a function of the water level



BUT… water level hardly varies!

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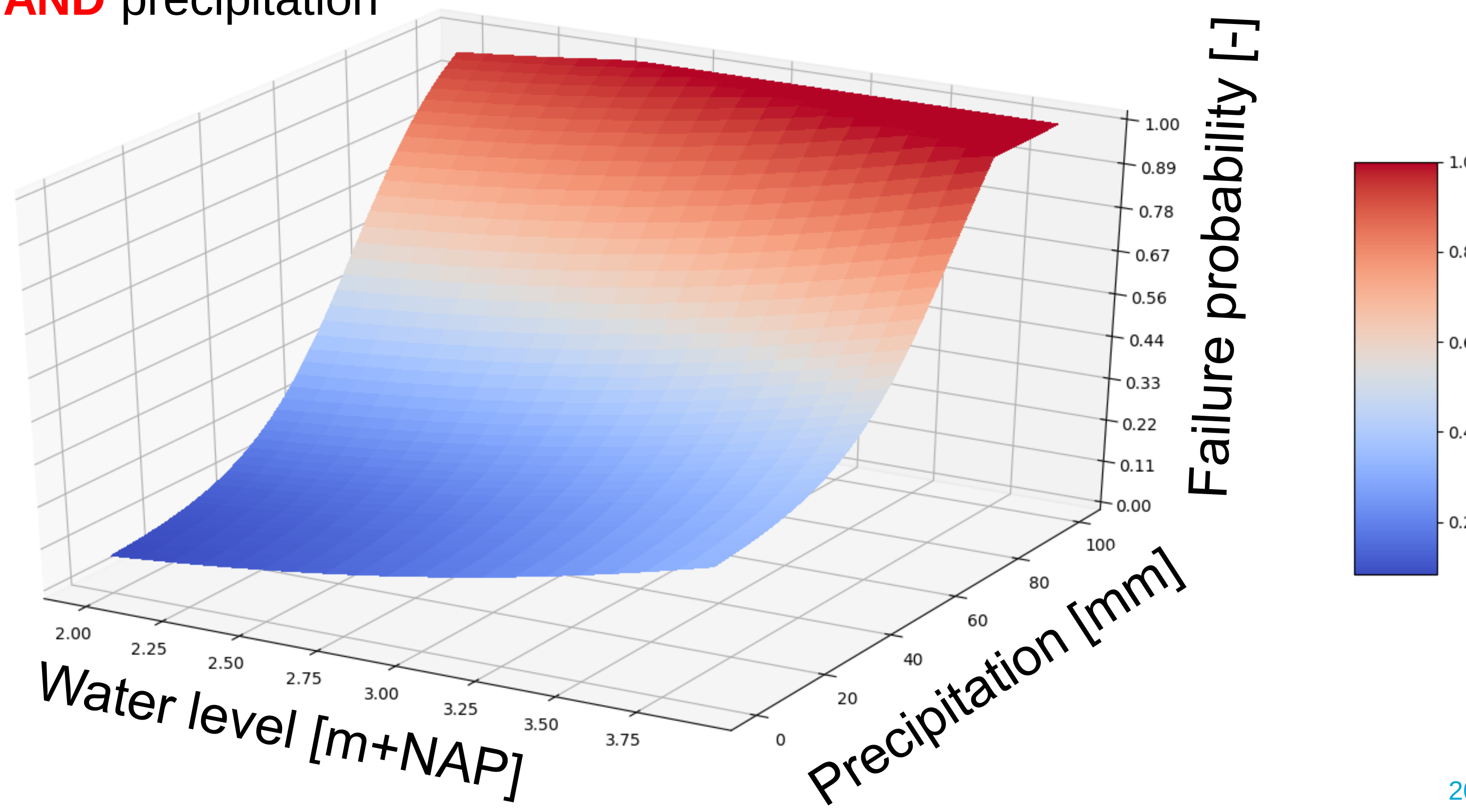
Fragility surface

Failure probability as a function of **BOTH** the water level **AND** precipitation



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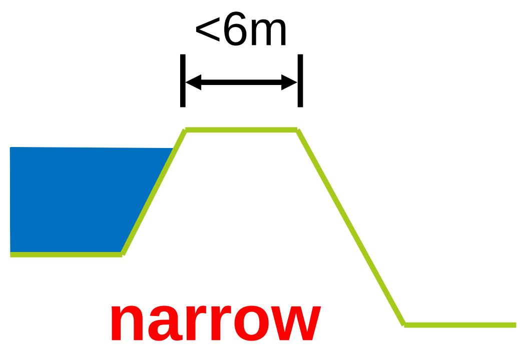
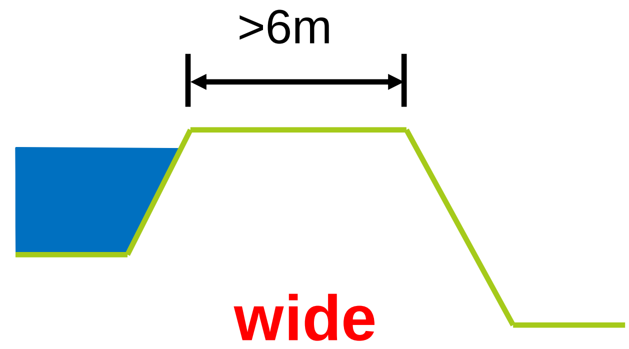
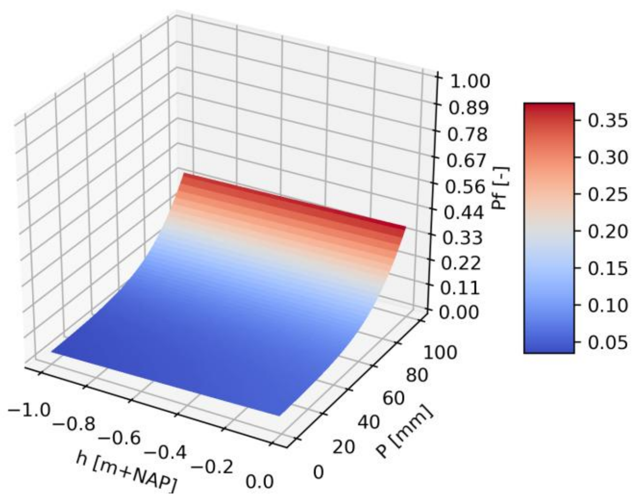
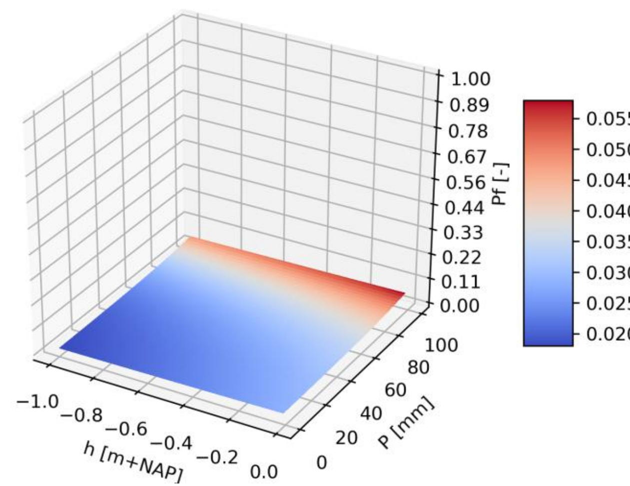
Fragility surface









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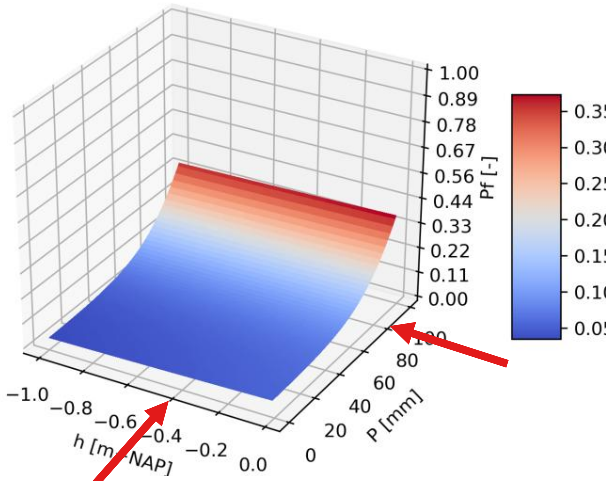
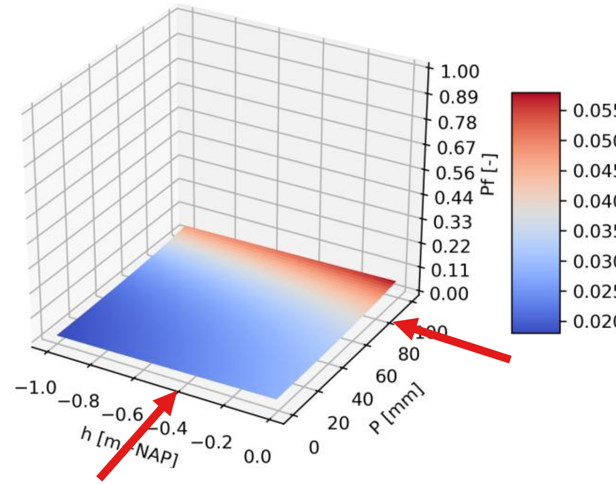
Results

Event:

- Water level: *-0.40 m+NAP*
- Precipitation: *80 mm in 24 hrs*

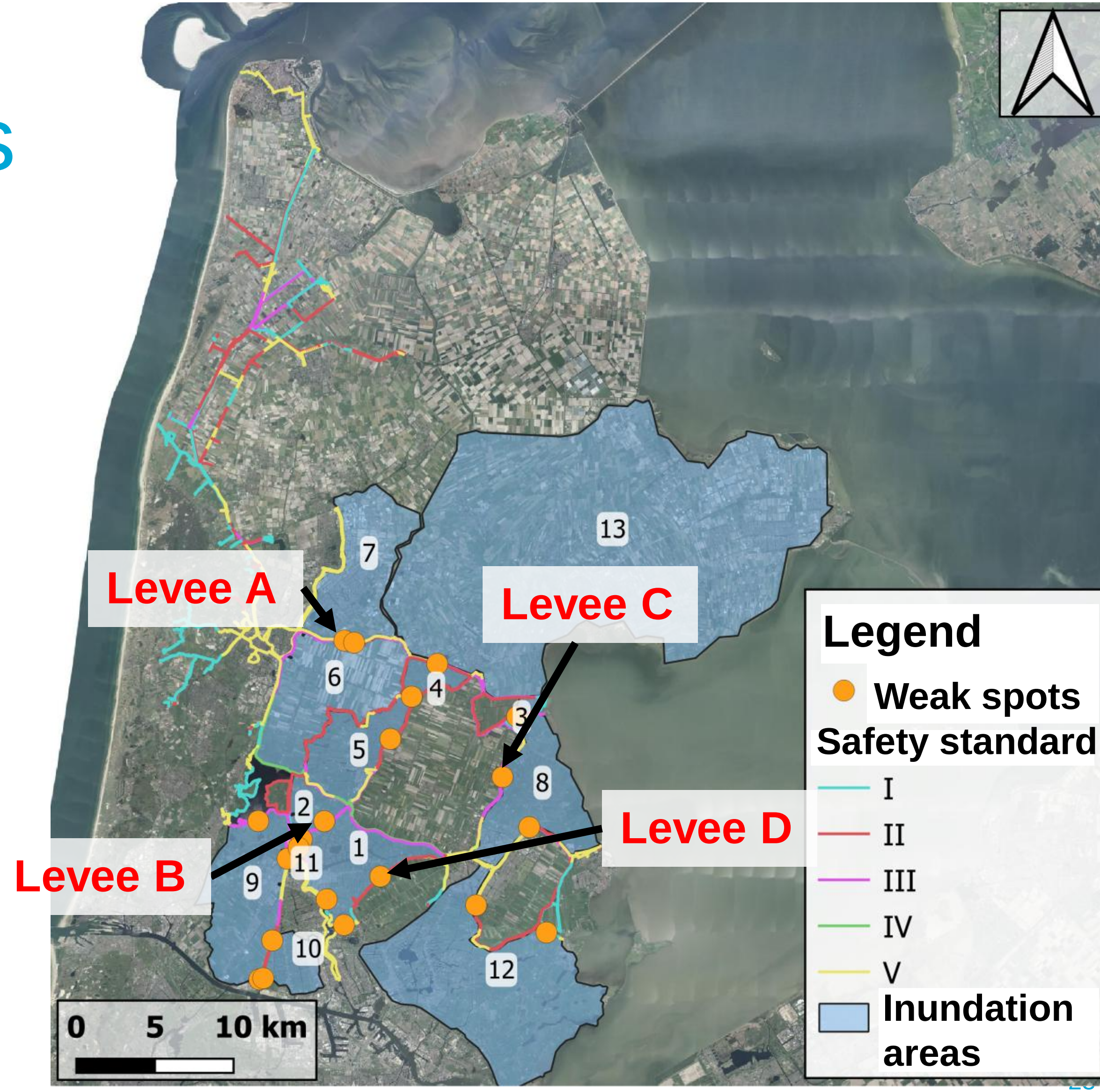




	Narrow dikes	Wide dikes
Conditional fail. prob. [-]	**0.1**	**0.033**

Results

	Pf [-]	
Levee	**No HLI**	**HLI**
A	0.033	0.027
B	0.1	0.056
C	0.1	0.066
D	0.1	0.054



Preliminary conclusions

- Levee breach affects hydraulic loads;
- Breach location matters;
- Not taking into account for hydraulic load interdependency leads to errors in risk assessment.

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