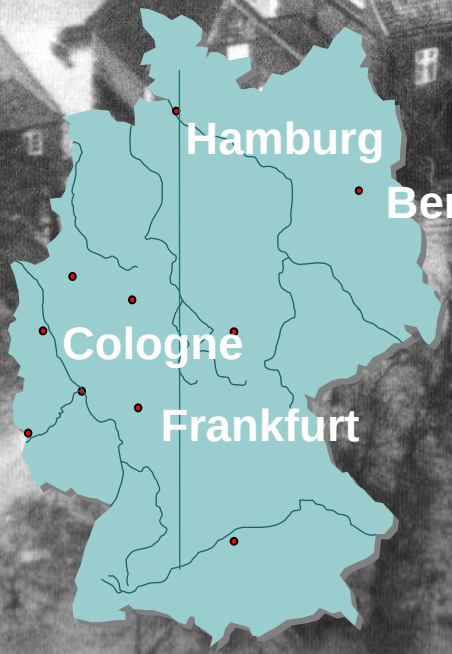
Risk management of extreme flood events

4th International Symposium on Flood Defence
Managing Flood Risk, Reliability and Vulnerability
Toronto, 06.-08.05.2008

Making Coastal Cities Flood Resilient in the Era of Climate Change



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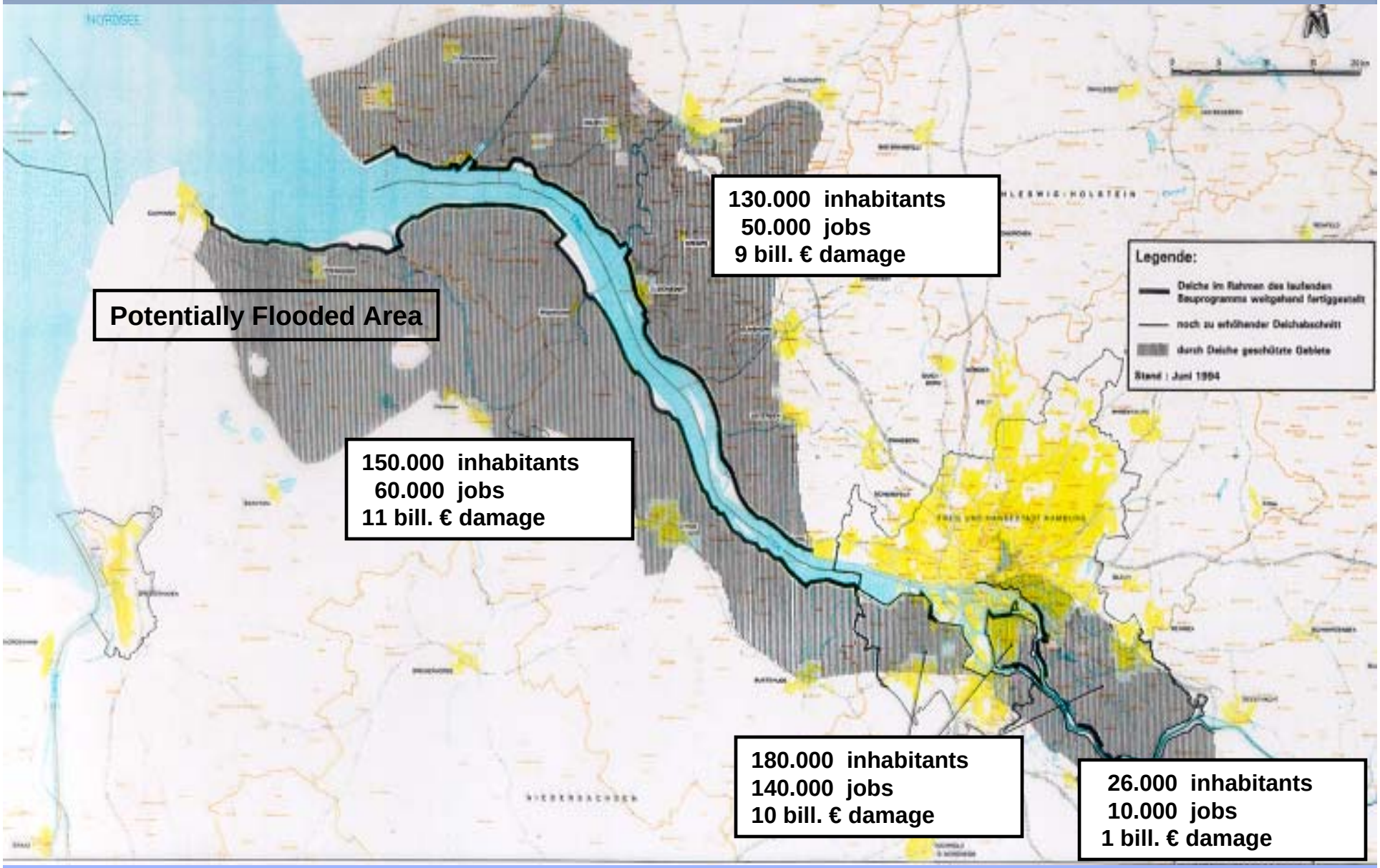
Technische Universität Hamburg-Harburg

Outline

1. *Present Practice of Coastal Flood Risk Management – Elbe Estuary*
2. *Impact of Climate Change on the Marine Hydrology of the North Sea*
3. *Concept for the Development of a Flood Resilient City*
4. *Cascading Flood Compartment Method (CFC) as part of a Flood Resilience Strategy*
5. *Application and Assessment of the CFC-method to the City of Hamburg*
6. *Conclusion*

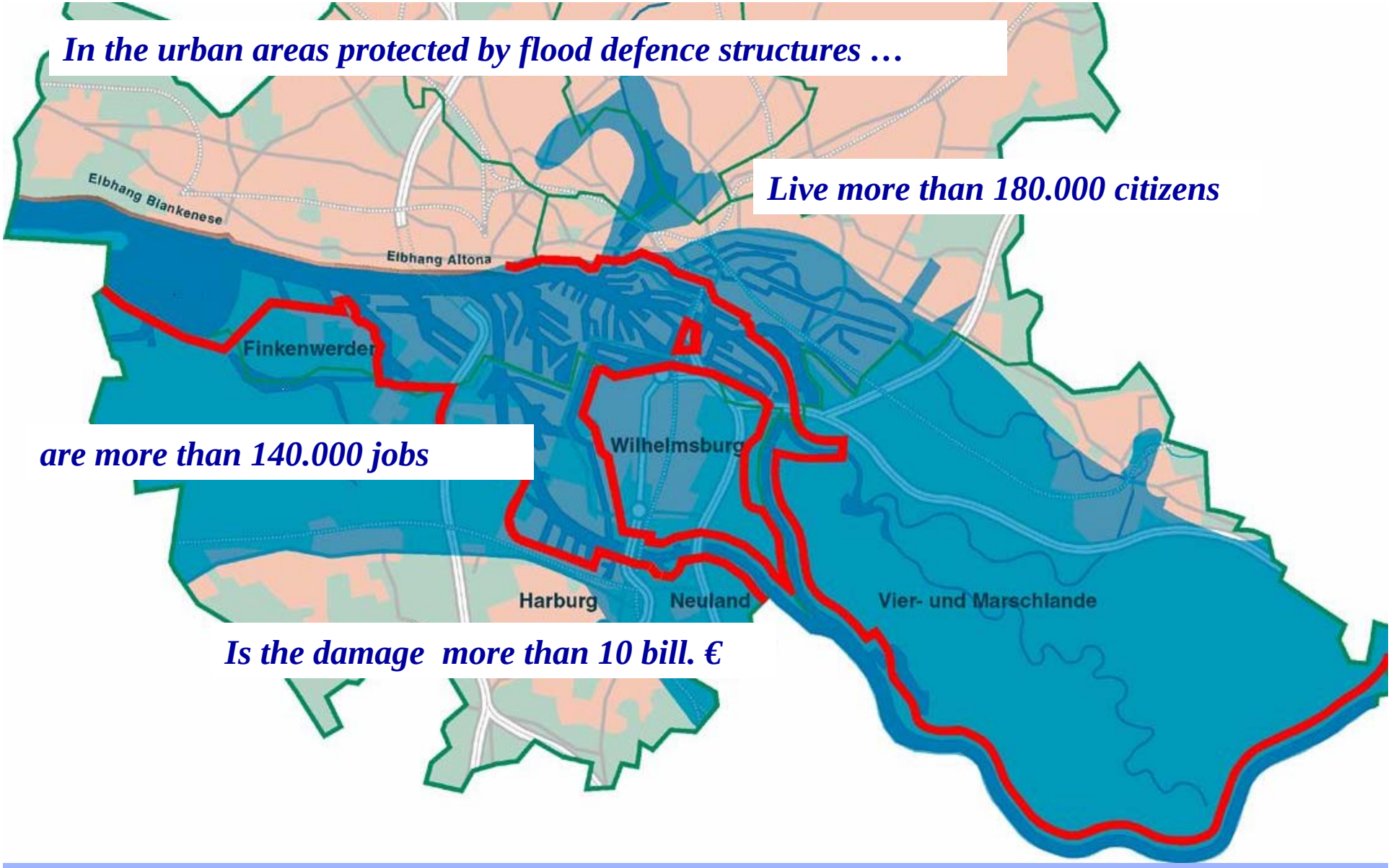
WASSERBAU
River and Coastal Engineering

Present Practice of Coastal Flood Risk Management
Flood Risk Through Storm Surges –Elbe Estuary



Present Practice of Coastal Flood Risk Management
Flood Risk Management through Hydraulic Structures

In the urban areas protected by flood defence structures …

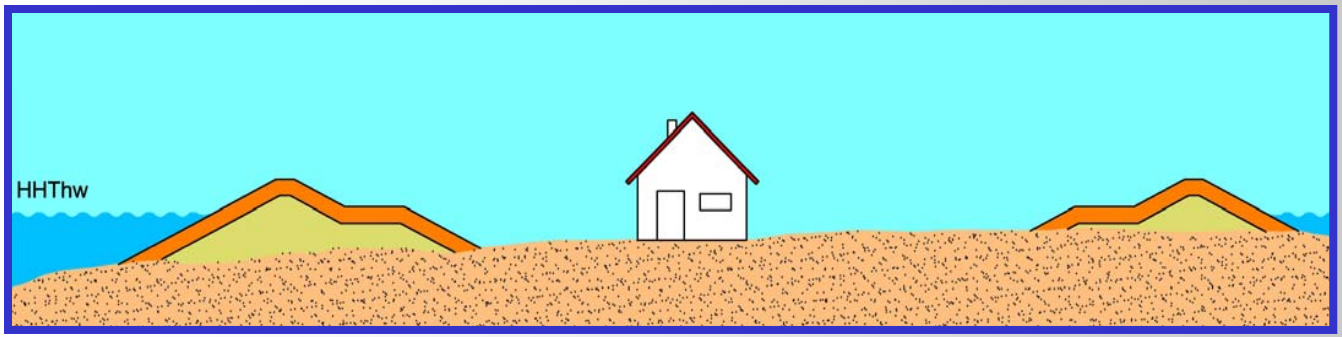


Live more than 180.000 citizens

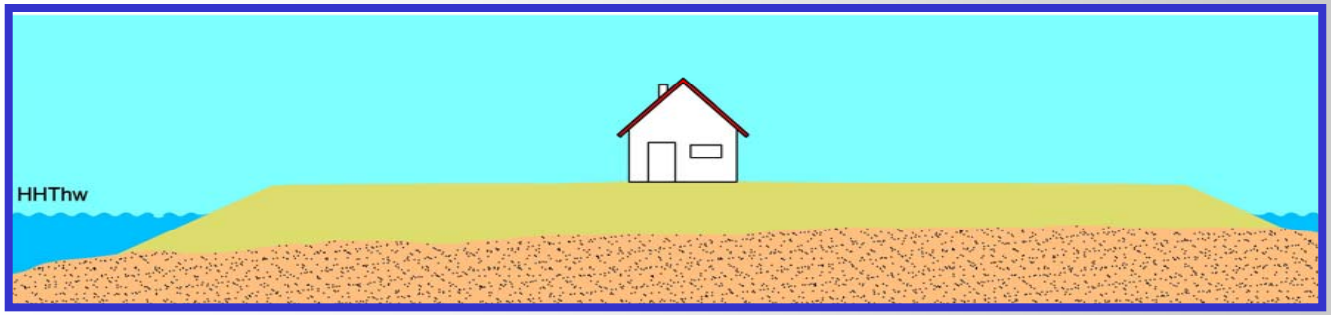
are more than 140.000 jobs

Is the damage more than 10 bill. €

Present Practice of Coastal Flood Risk Management
Flood Risk Management through Hydraulic Structures



Dike/Polder

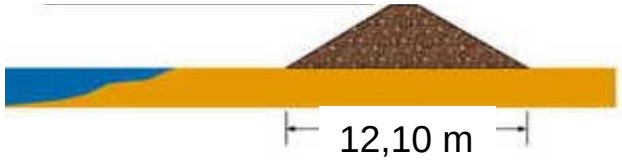


Land Fill
(Living Mounds)

Present Practice of Coastal Flood Risk Management
Hamburg's flood defence strategy rising the Dikes

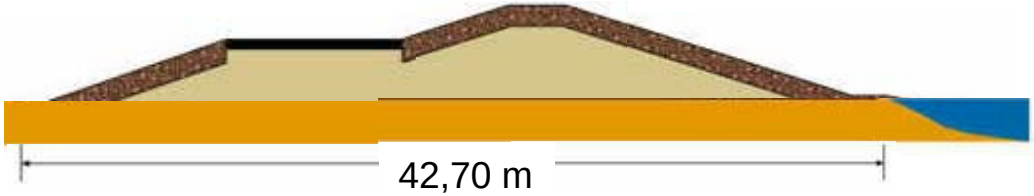
Dykes before 1962

Crest hight 5,70 m aboveSL



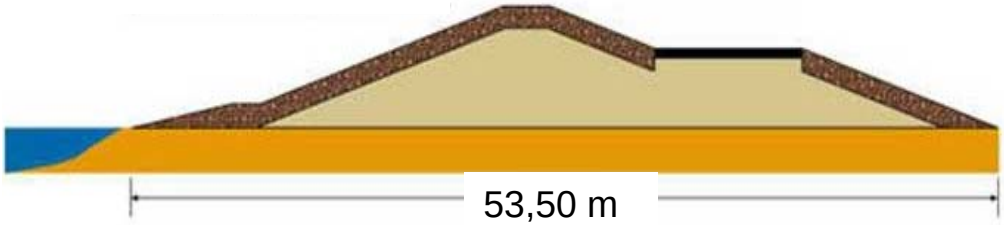
Dykes after 1962

Crest hight 7,20 m above SL



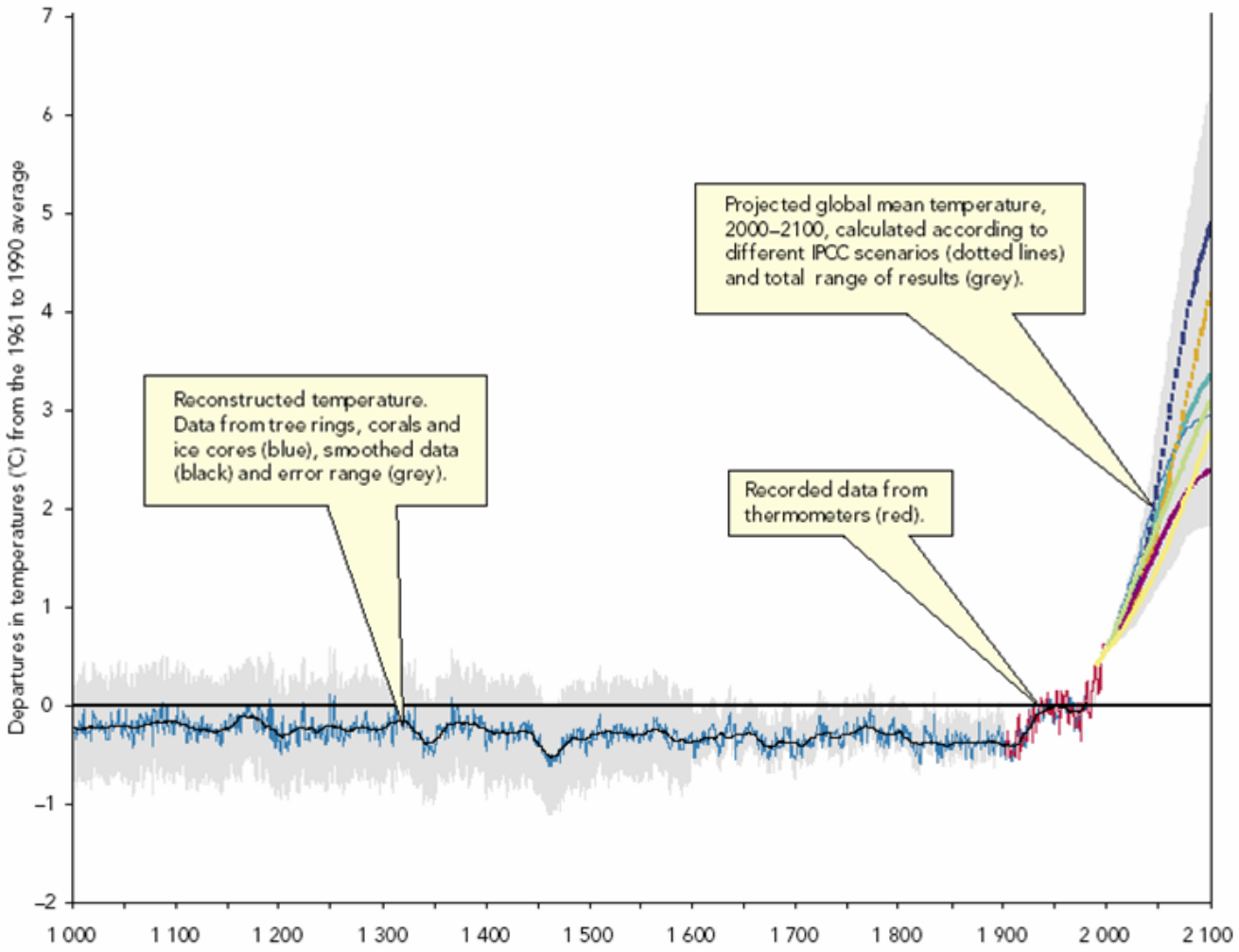
Present dyke profile

Crest hight 8,0 m to 8,50 m above SL



Present Practice of Coastal Flood Risk Management
Raising of Flood Defence Walls - Where to go?

Impact of Climate Change on the Marine Hydrology of North Sea
Higher Temperatures



Source: Mann *et al.*, 1999 (last 1 000 years); IPCC, 2001a (projection for the next 100 years).

Impact of Climate Change on the Marine Hydrology of North Sea
Melting Ice

Source: H. Bäsemann, 2004.

Impact of Climate Change on the Marine Hydrology of North Sea
More Storms

Impact of Climate Change on the Marine Hydrology of North Sea
Rising Sea Level

Scenario study for German North Sea Coastline

Predicted Rise of Storm Surge for 2070-2100

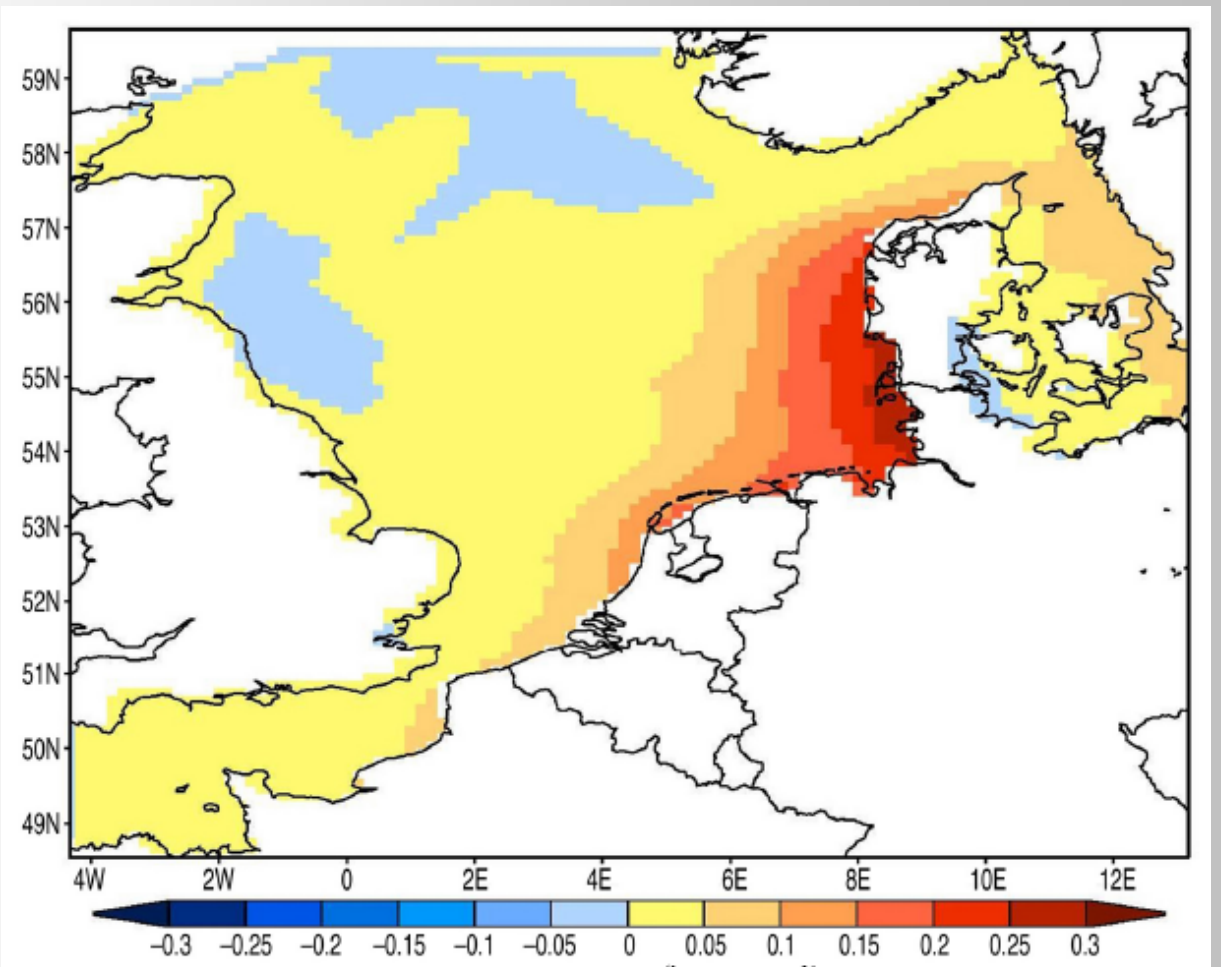
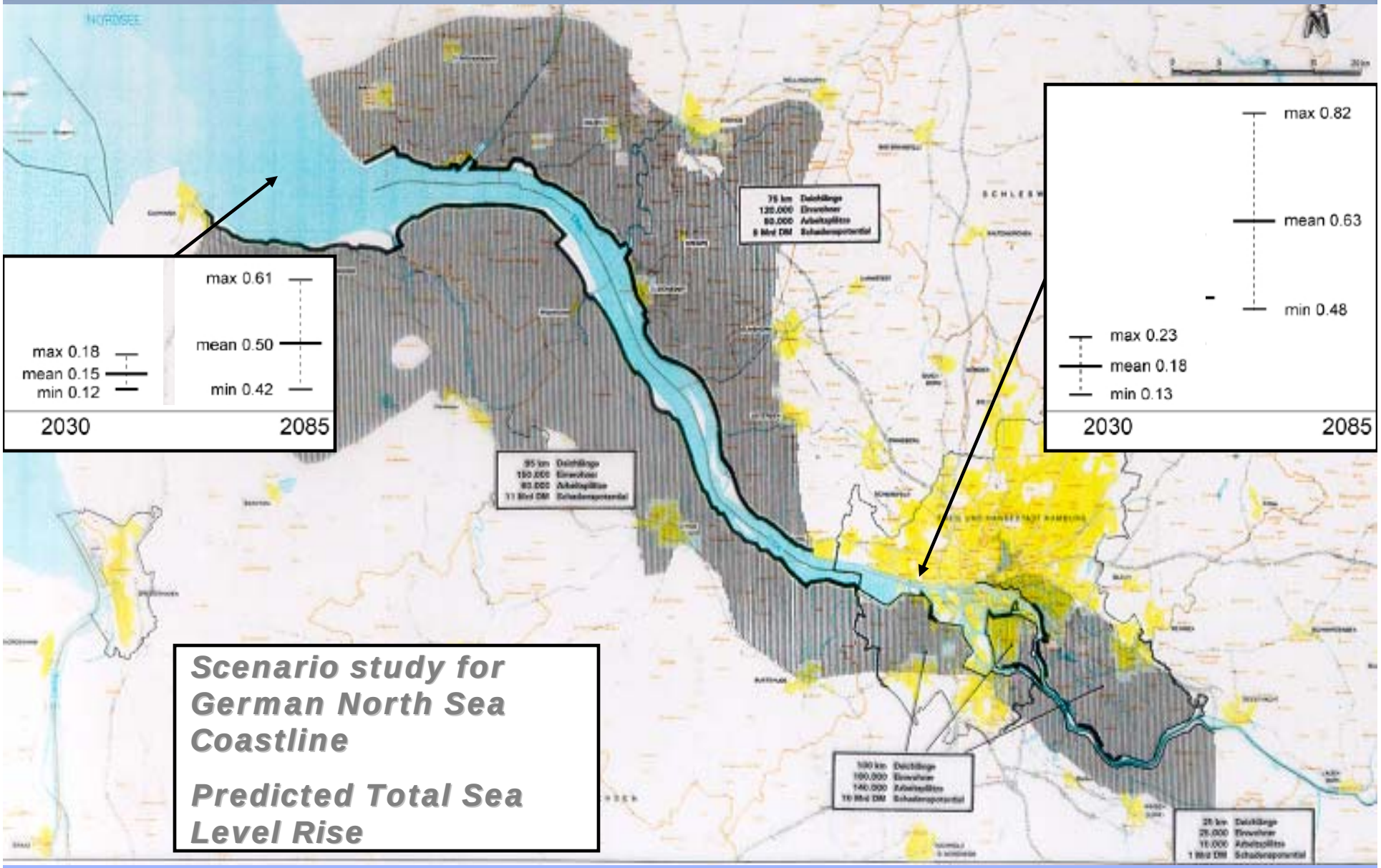
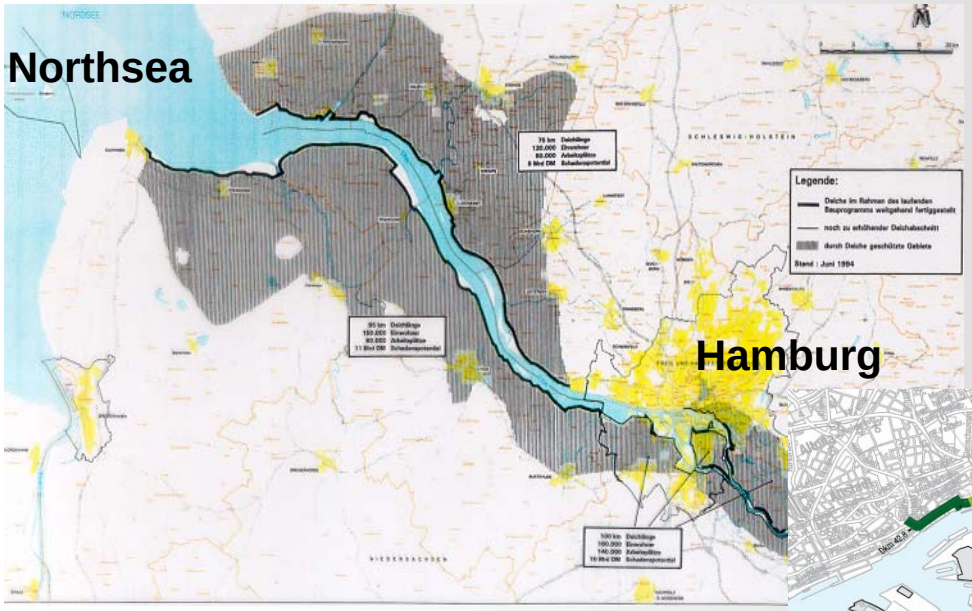


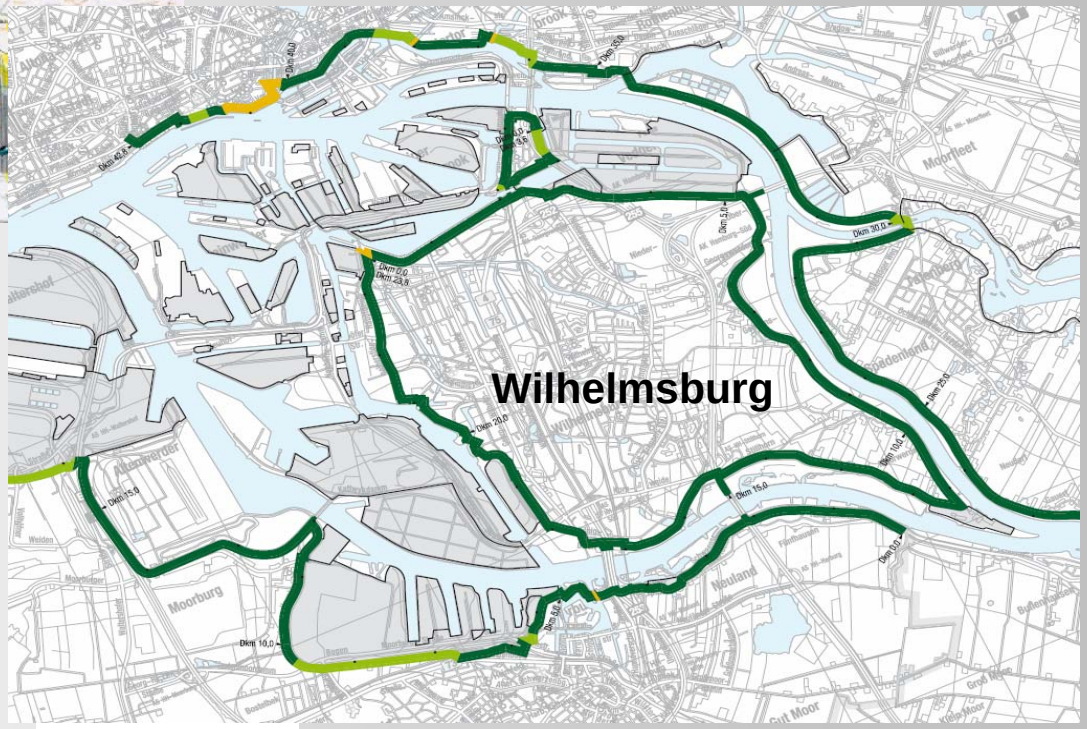
Figure 4-1: Changes of the inter-annual mean of the 99.5th percentile[36] of storm surge heights in metres, projected for 2070–2100 in the A2 scenario, as simulated by TRIMGEO as response to CLM winds. Courtesy of Katja Woth.

Impact of Climate Change on the Marine Hydrology of North Sea
Rising Sea Level

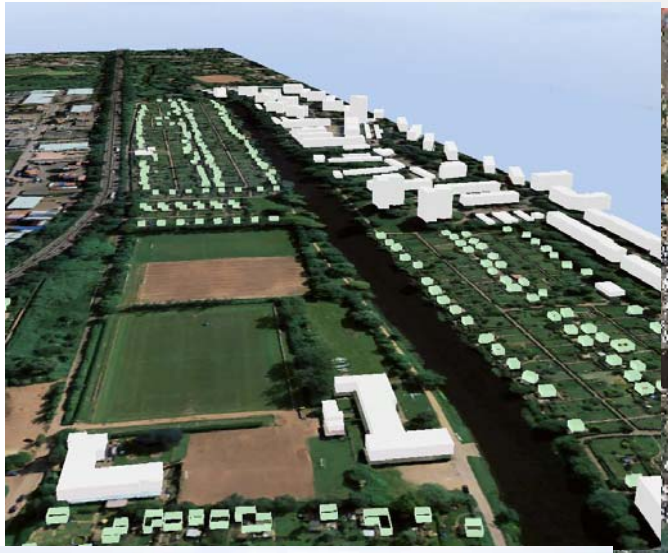


Impact of Climate Change on the Marine Hydrology of North Sea
Impact Study on Elbe Island Wilhelmsburg/Hamburg



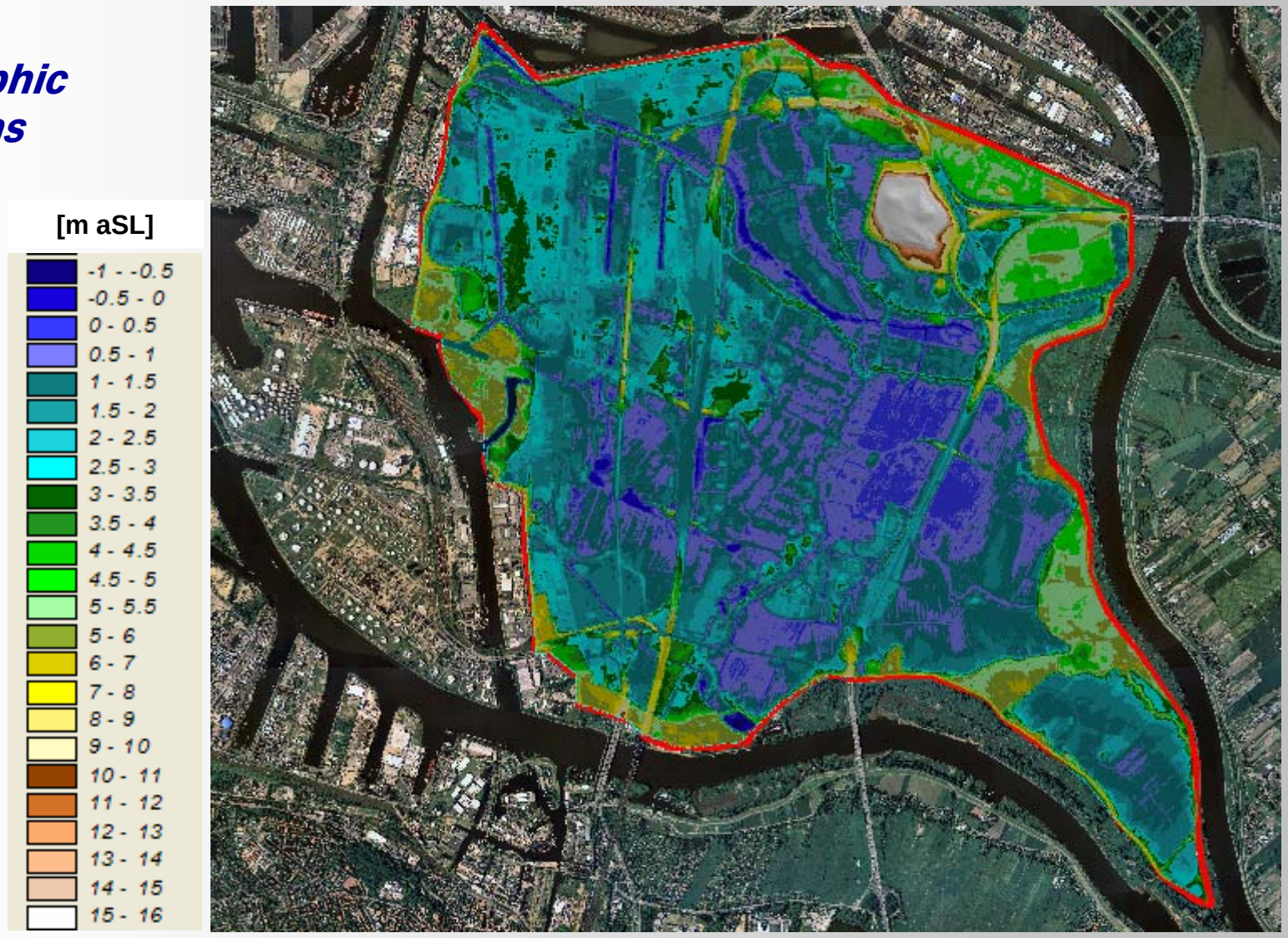


Impact of Climate Change on the Marine Hydrology of North Sea
Elbe-Island Wilhelmsburg - Centre of Urban Development



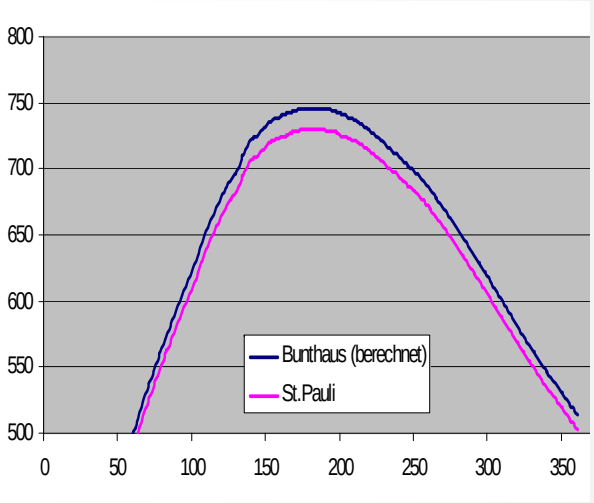
Elbe-Island Wilhelmsburg - Topography

Topographic conditions

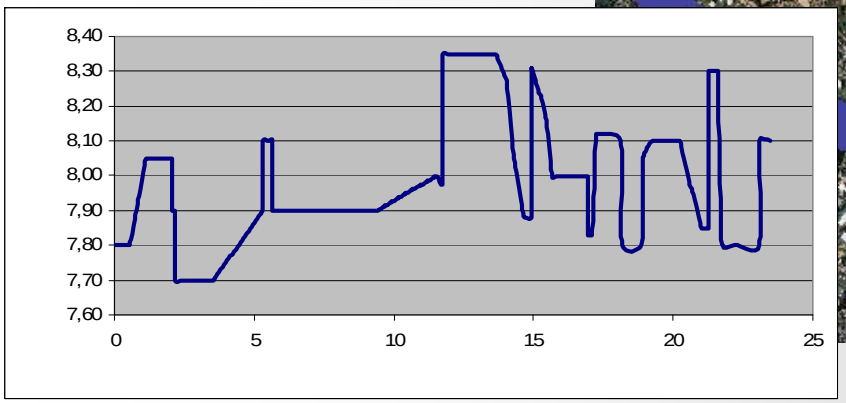


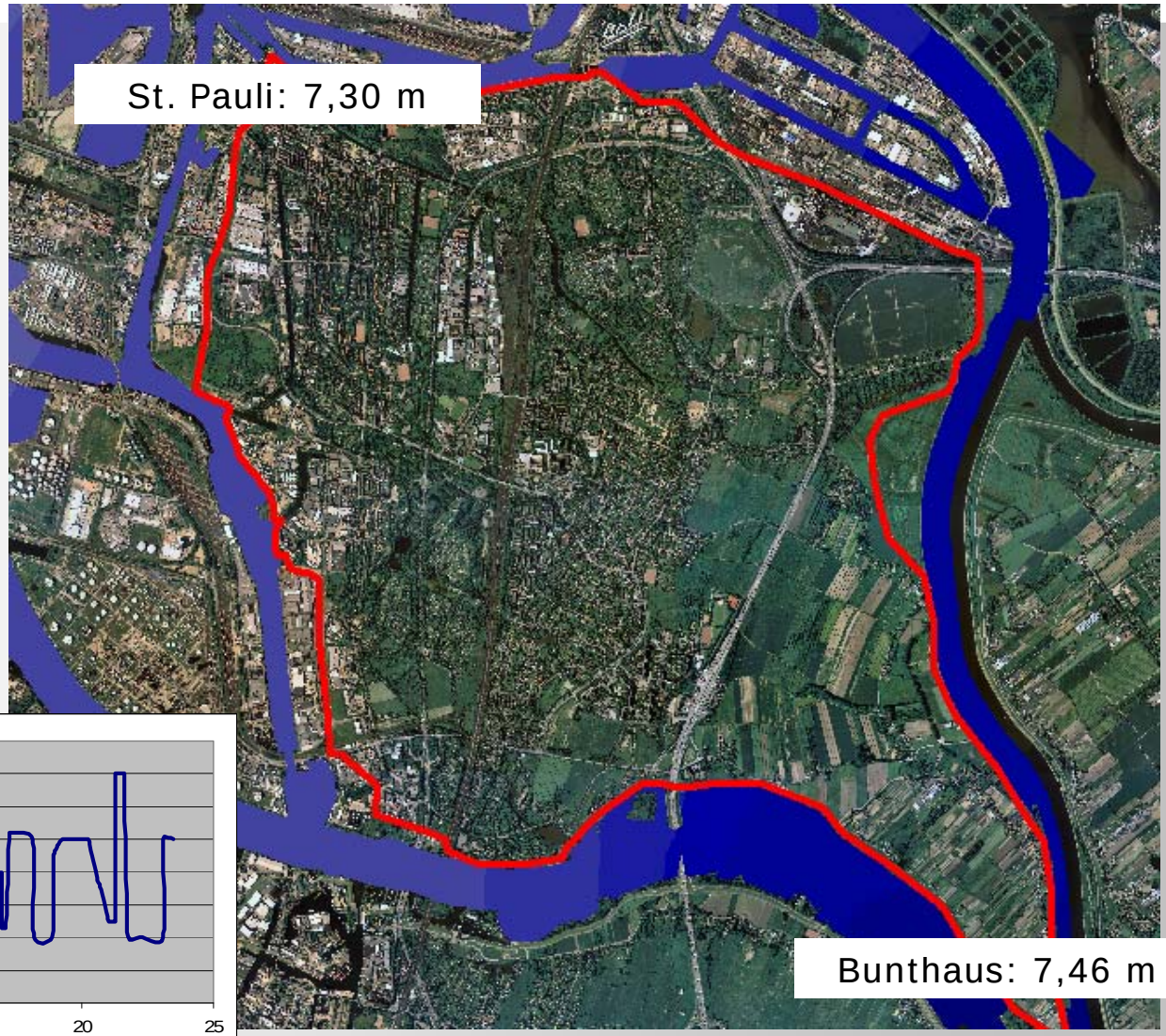
Impact of Climate Change on the Marine Hydrology of North Sea Elbe-Island Wilhelmsburg - Levee System

Design flood of the levees

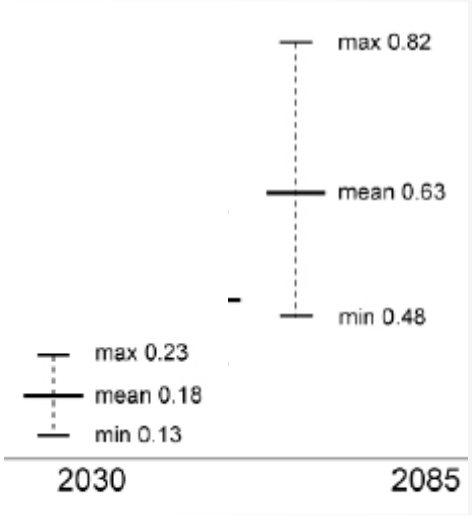


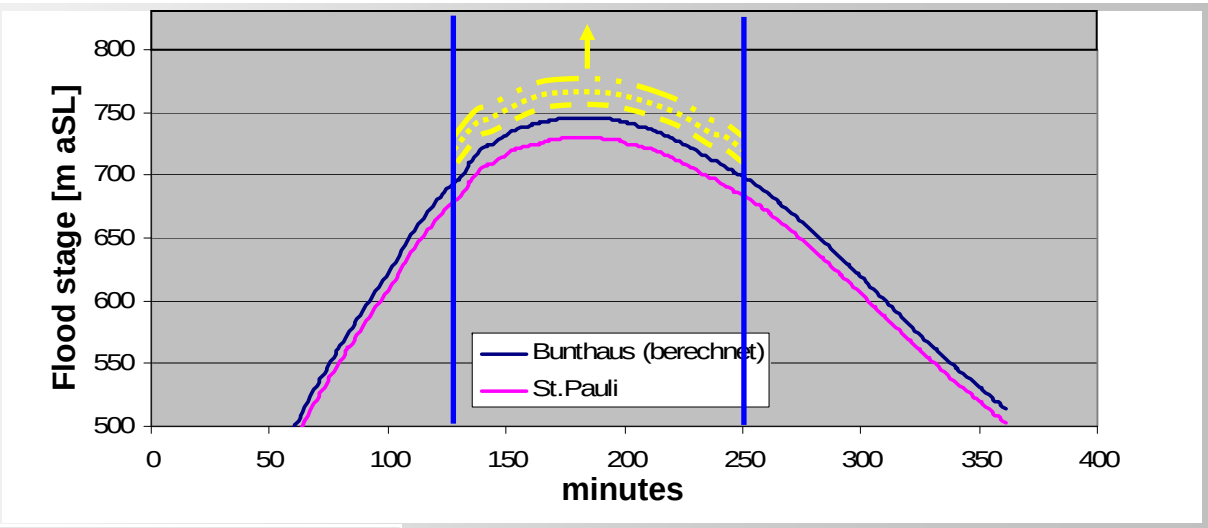
Crest height of the levees

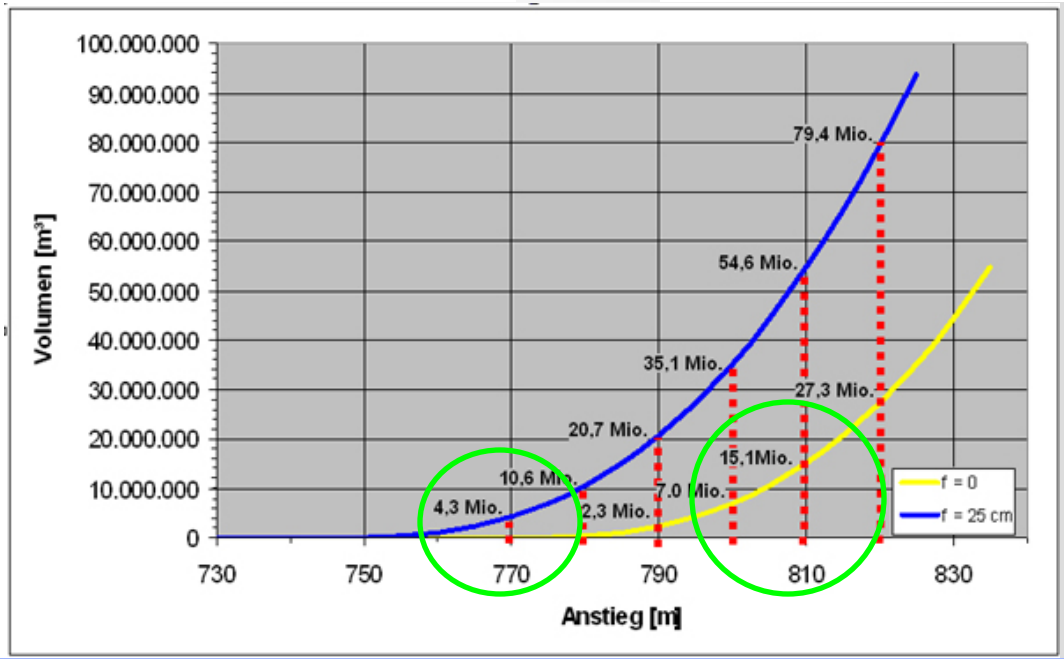




Impact of Climate Change on the Marine Hydrology of North Sea
Scenario Study for Wilhelmsburg



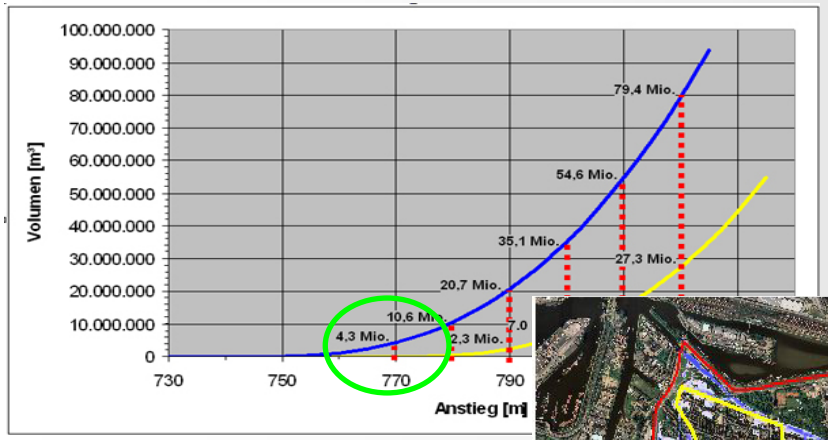




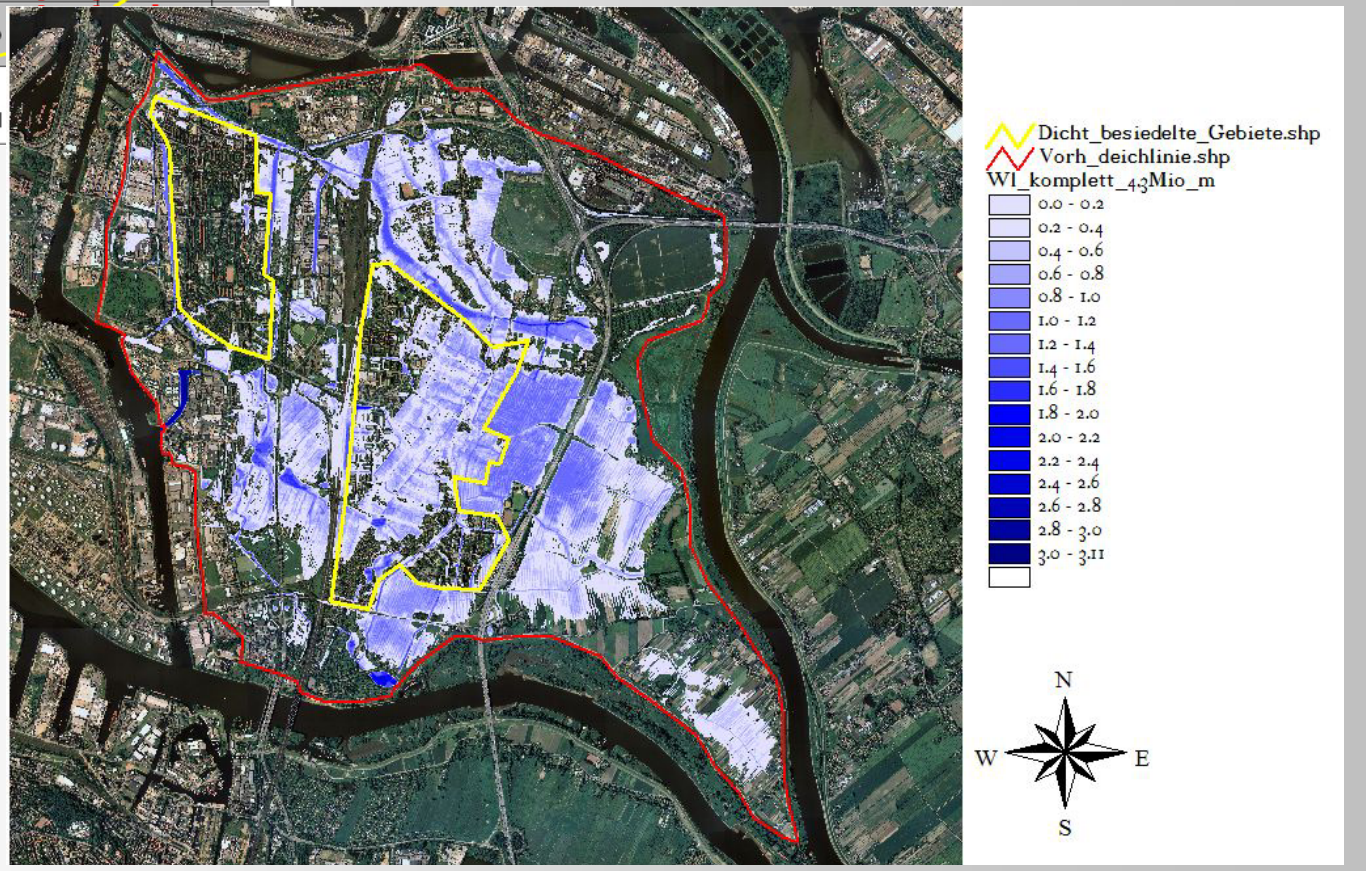
Flooding begins when water stage is

f = 0 at crest height

f = 25 25 cm below crest height



Design Flood in 2030



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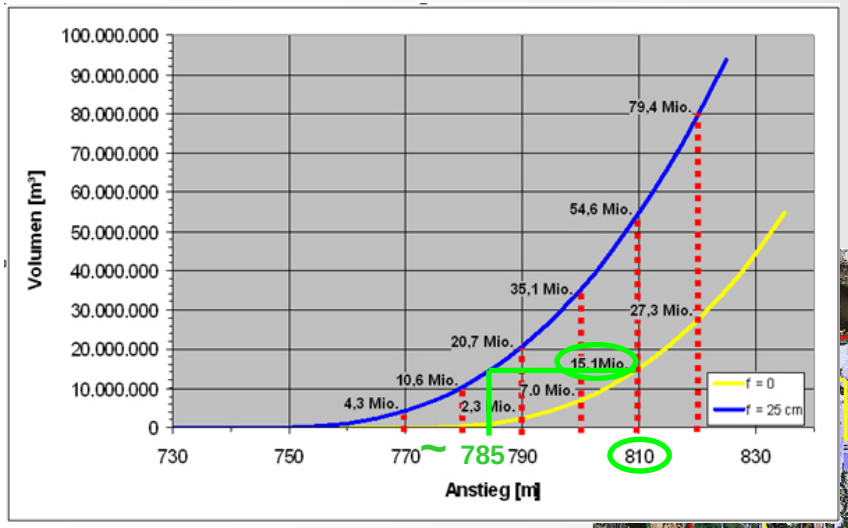
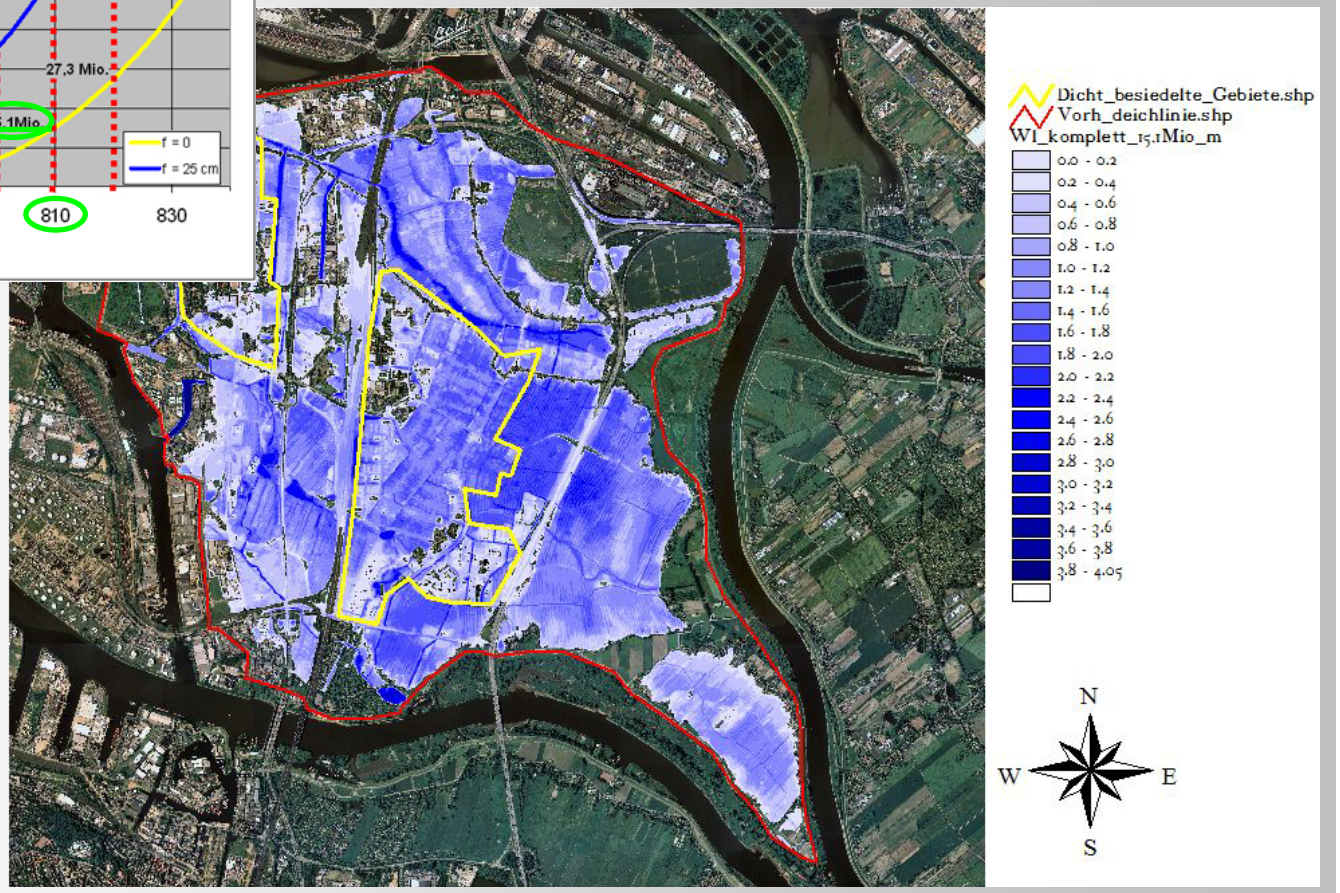
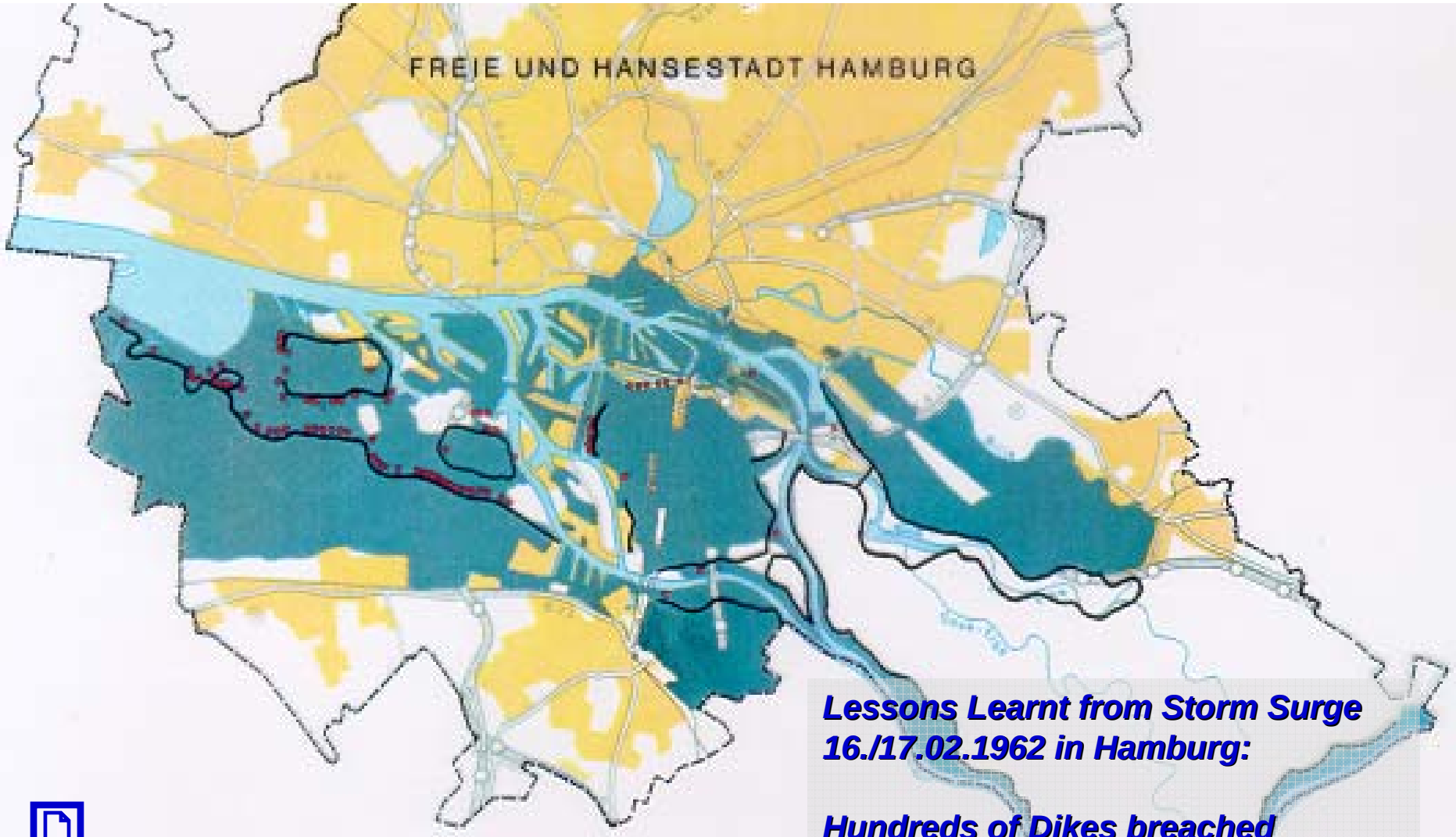
Impact of Climate Change on the Marine Hydrology of North Sea
Scenario Study for Wilhelmsburg



Design Flood in 2085



Critical Review of Present Practice Levee-Effect



Lessons Learnt from Storm Surge 16./17.02.1962 in Hamburg:

Hundreds of Dikes breached
Instantaneous Flooding of wide parts of the City

Critical Review of Present Practice Levee-Effect

Impact of Climate Change on the Marine Hydrology of North Sea

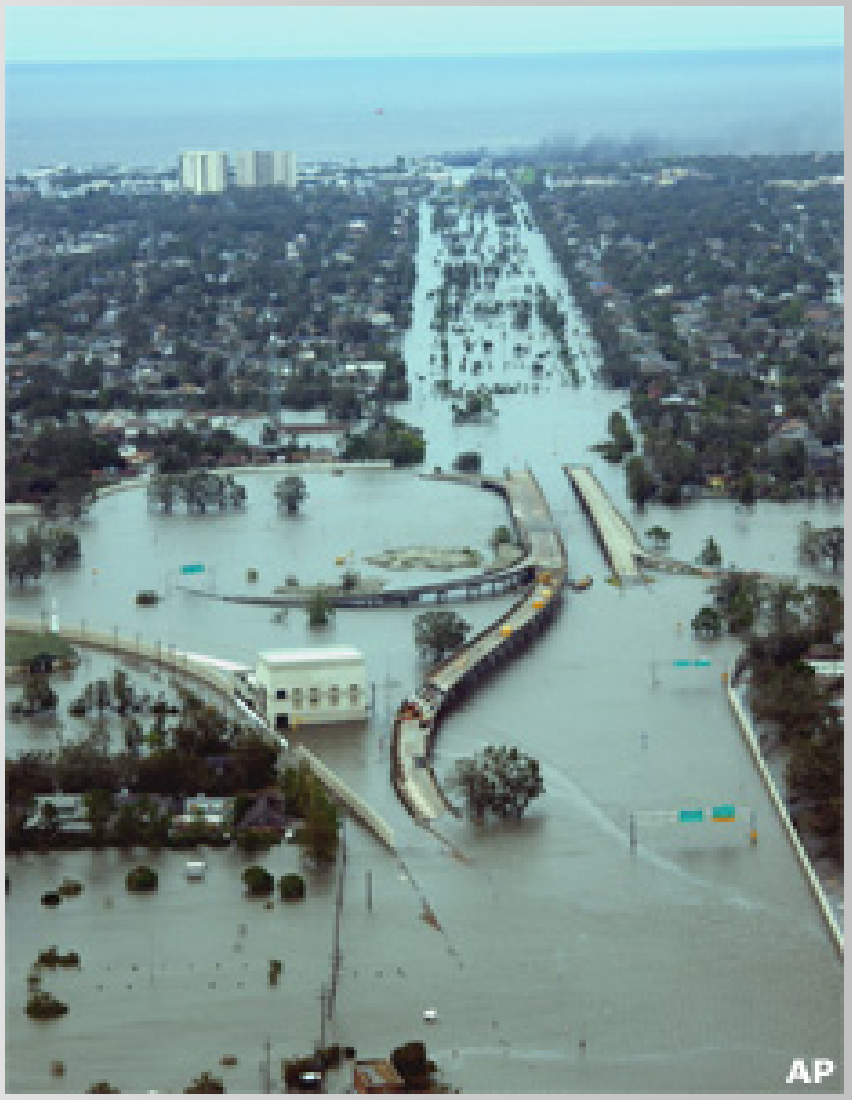
Consequence of insufficient resiliency

Lessons Learnt from Storm Surge 16./17.02.1962 in Hamburg:

People had to leave because of no water, no electricity and no heating

Empty Districts are threatened by burglary

Impact of Climate Change on the Marine Hydrology of North Sea
Consequence of insufficient resiliency



Lessons Learnt from Katrina and Elbe-Flood:

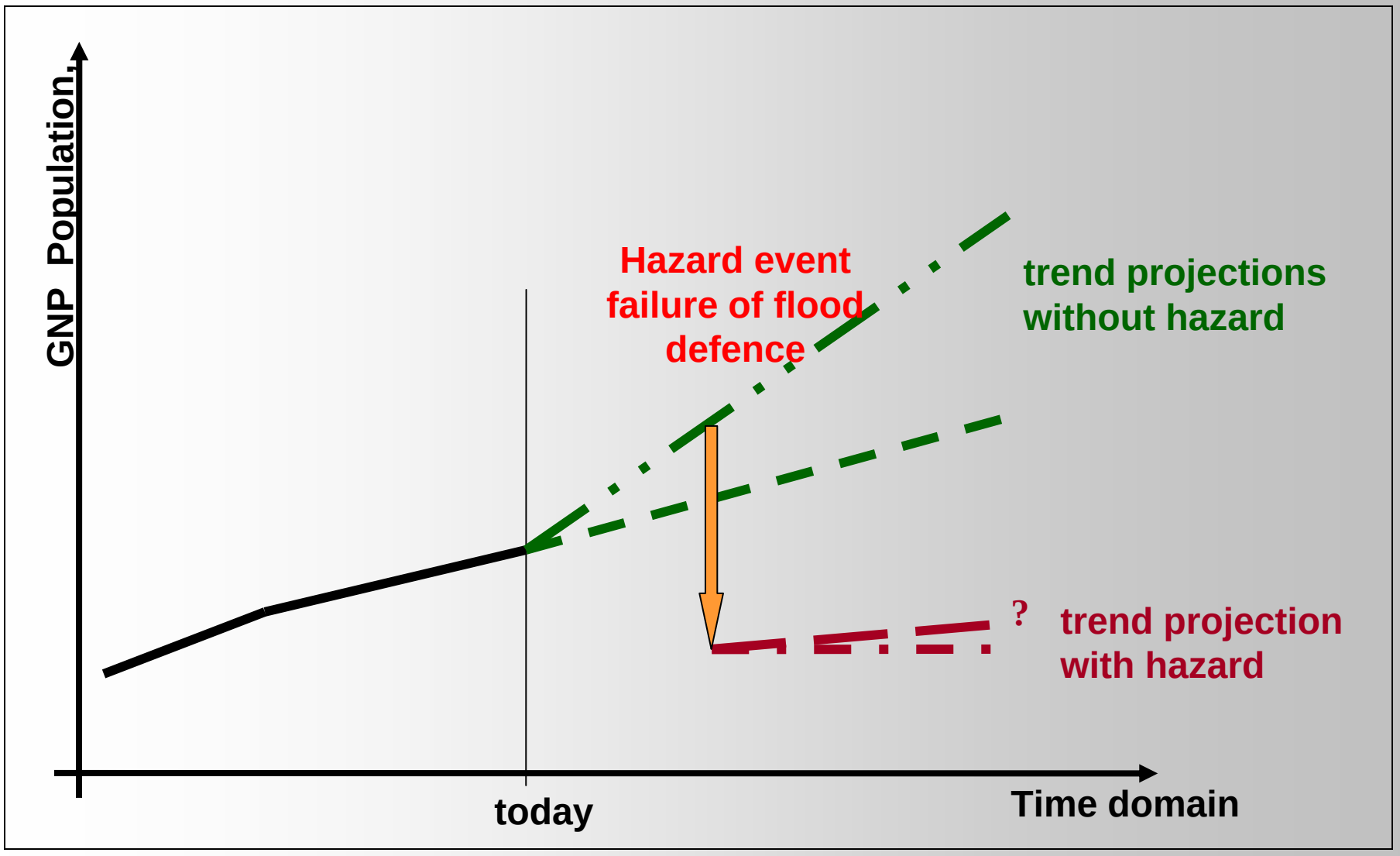
Logistic and technical requirements for safe evacuation of a large number of citiziens are nearly not to fulfill

Impact of Climate Change on the Marine Hydrology of North Sea
Consequence of insufficient resiliency

Lessons Learnt from Katrina and Elbe-Flood:

Escape Ways are blocked
People do not want to leave

Consequence of insufficient resiliency



Concept for the Development of a Flood Resilient City

Integration of

risk awareness, preparedness, hazard response and recovery

to a safety chain - the 4A's (Ashley et al, 2007)

Not a fixed set of tangible measures, but a process of transfer

Focus on Flood Preparedness

FRM	Type of measure	NS Responses	Effect
Capacity building of human resources A1: Awareness of flood risk	**Information**	Emergent	Stakeholders perform effectively
	Inundation Maps		
	Flood Risk maps		
	Info material (brochures)		
	Education - Communication	Emergent	
	Face-to-face learning		
	Web-based learning		
	Training		
	Collaborative platforms		
Land use control A2: Avoidance of the risk where possible	**Spatial Planning**	Emergent	Adaptation of land use to flood risk
	Flood risk adapted land use		
	Building regulations		
	Building codes		
	Zoning ordinances		
Flood preparedness A3: Alleviation of the effects of the flood	**Flood Resistant buildings**	Emergent	Minimization of exposure
	Wet-proofing		
	Floatable buildings		
	Dry-proofing		
	Cascading flood compartment	Emergent	
	Erosion resistant dikes		
	System of inner abatement lines		
Contingency measures A4: Assistance in the event of difficulties	**Financial Preparedness**	Emergent	Support of recovery
	Insurance of residual risk		
	Reserve funds		
	Emergency Response:	Traditional	
	Evacuation and rescue plans		
	Hazard forc. & warning service.		
	Control emergency operations	Traditional	
	Providence of emergency response staff	Traditional	
	Emergency infrastructure	Traditional	
	Allocation of temporary containment structures (dismountable flood barriers, sandbags, pumps)		
	Telecommunications network		
	Transportat. & evacuation facilities		
	Recovery: Disaster recovery plans	Emergent	

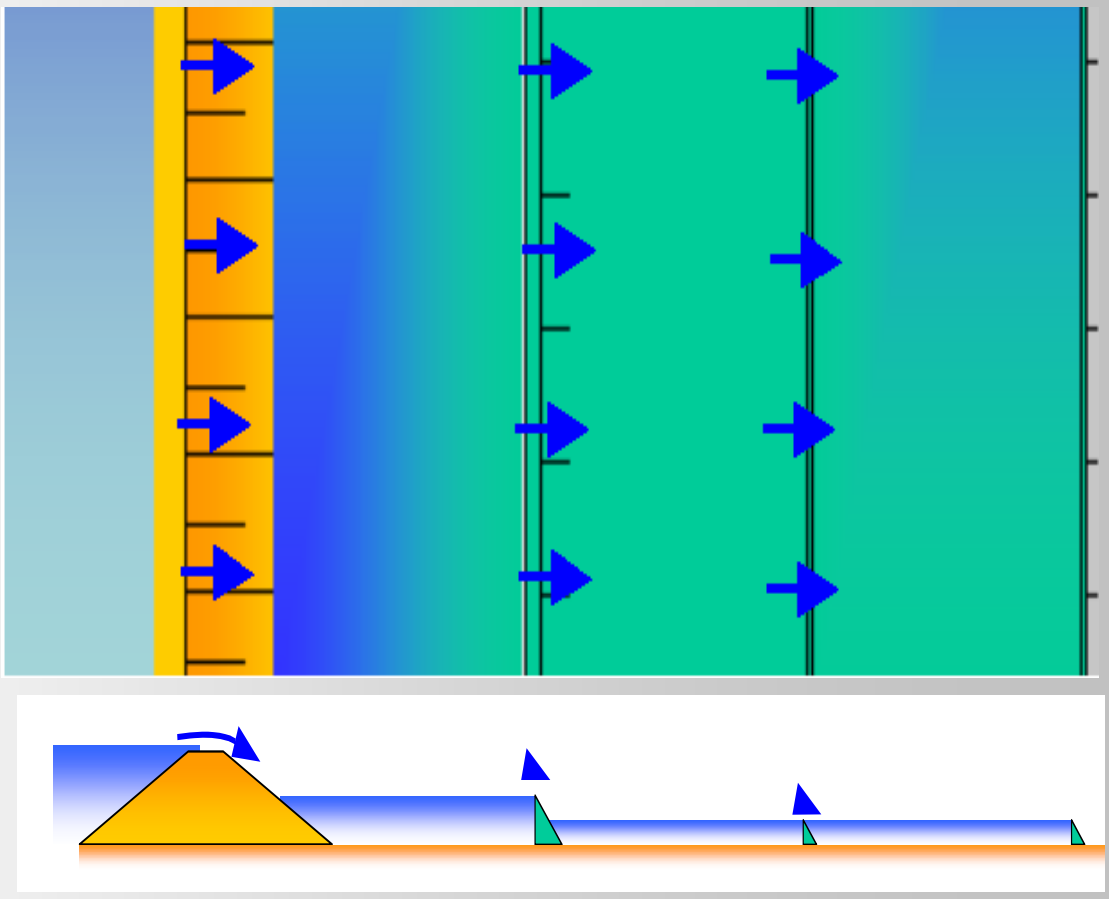
Cascading Flood Compartment Method (CFC) as Part of a Flood Resilience Strategy

Failure Response strategy

To contain the flood migration in case of levee overtopping

with the objective

- ***to gain time for emergency response***
- ***to reduce the consequences of flooding of the Hinterland***



Cascading Flood Compartment Method (CFC)
Guidelines for the design of the compartments levees

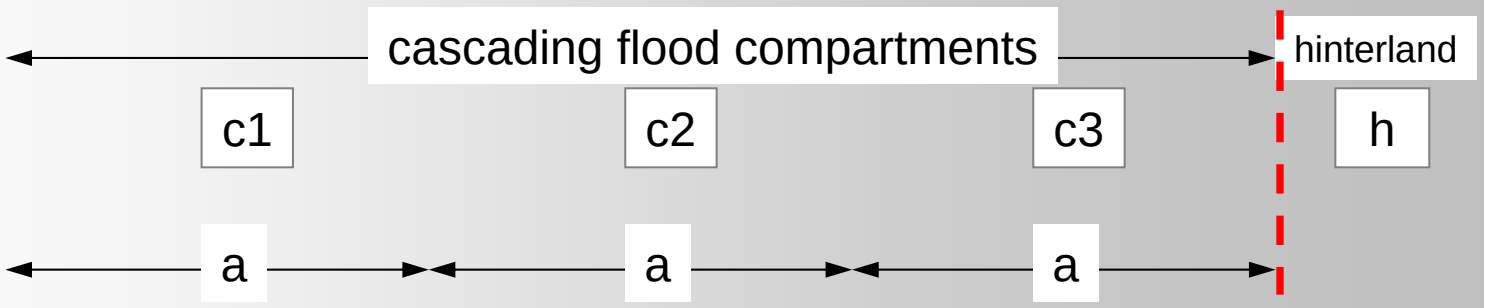
Basic Concept: Hazard Response and not Flood Defense!

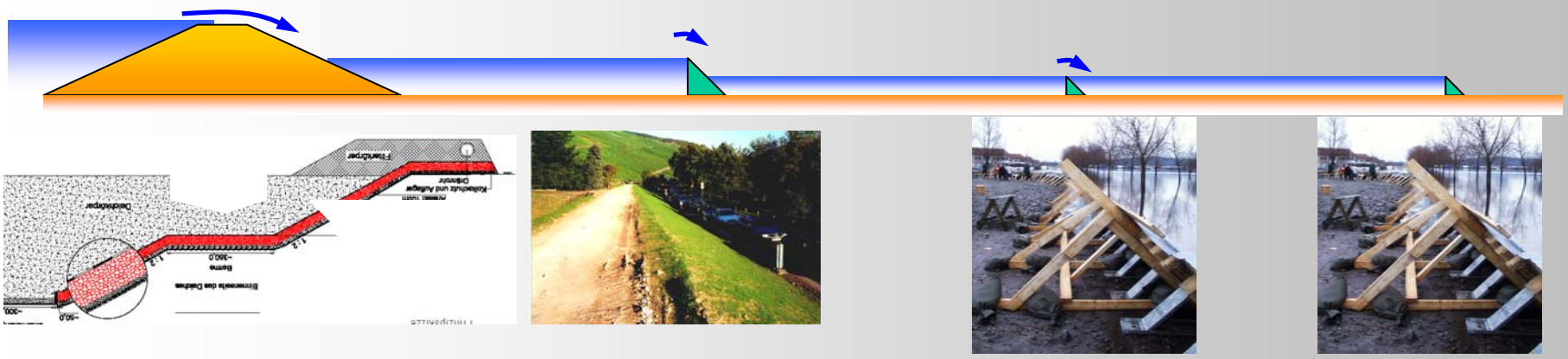
Less robustness of the compartment levees is possible

Compartment levees are considerably lower than main levee

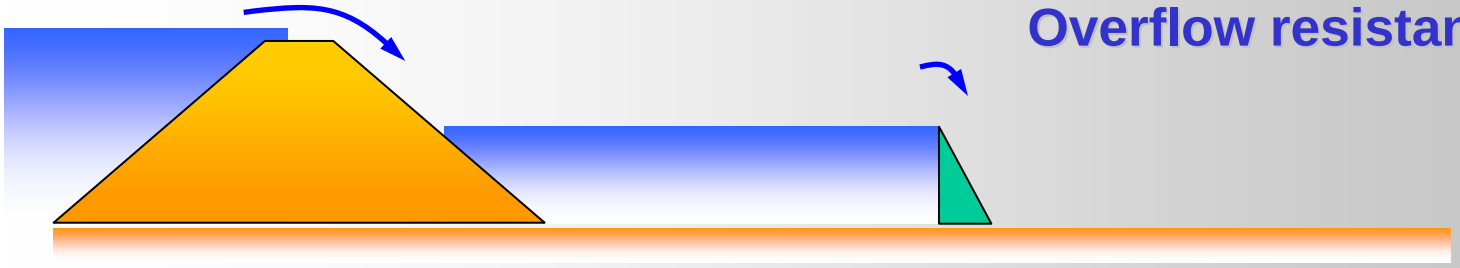
2nd and 3rd compartment lines: intensive use of dismountable walls

Main levee must be resistant to overflow





Overflow resistant main levee



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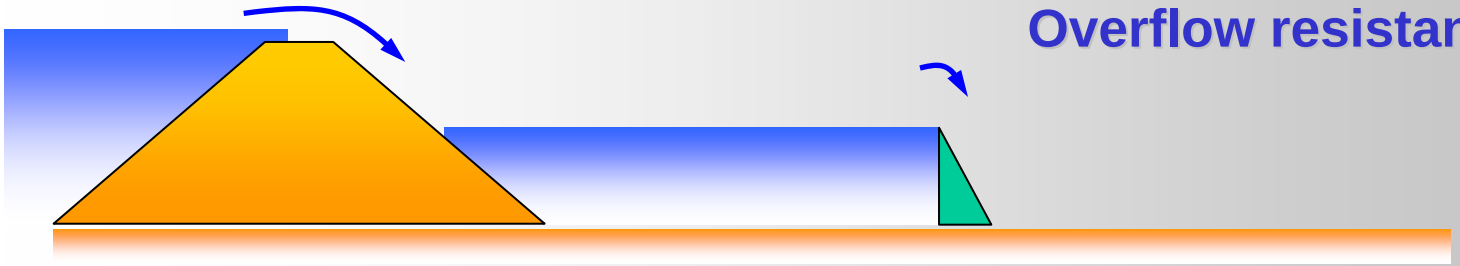
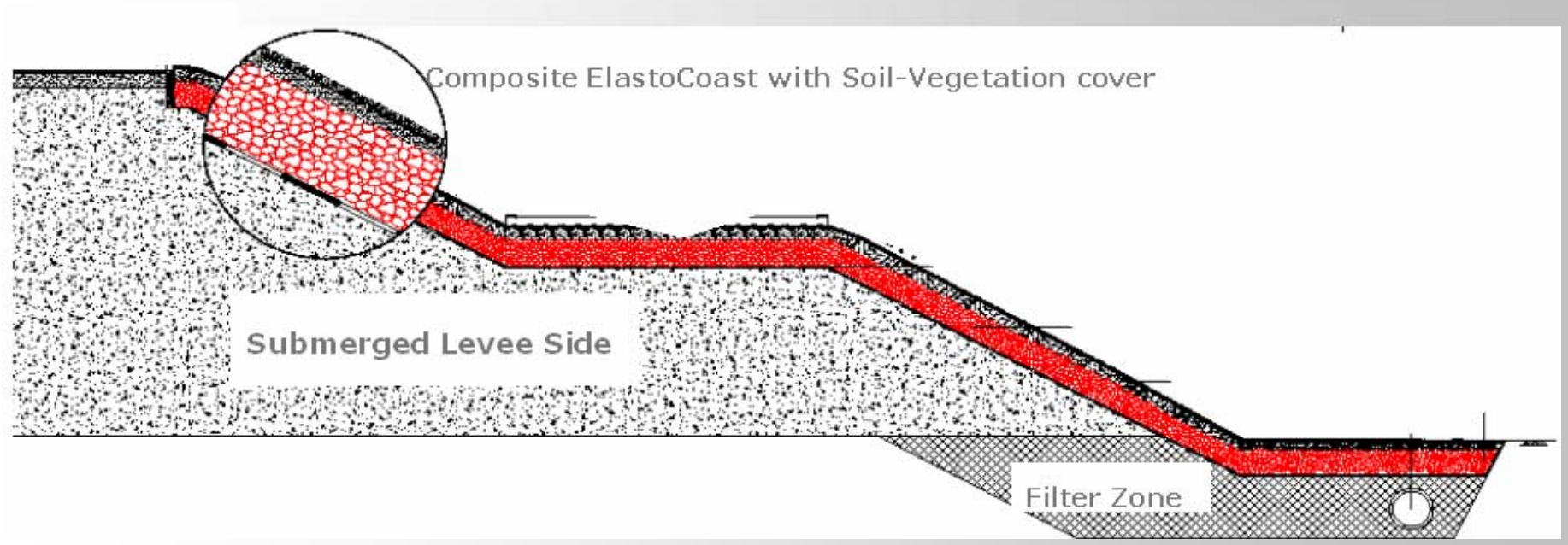
Cascading Flood Compartment Method (CFC)
Guidelines for the design of the compartments levees

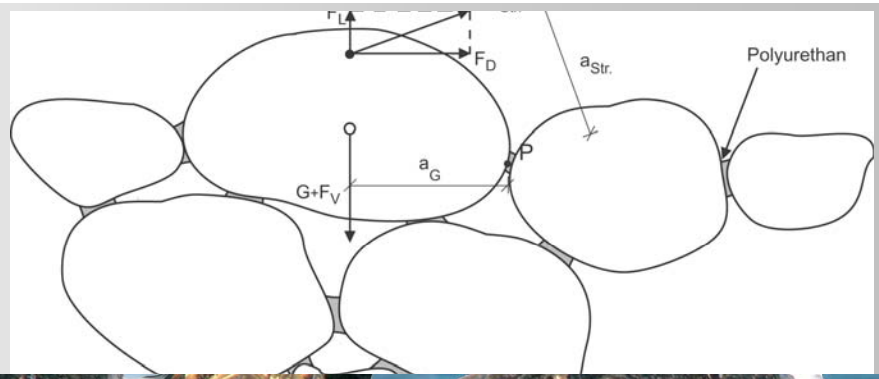


Overflow resistant main levee



Cascading Flood Compartment Method (CFC)
Guidelines for the design of the compartments levees

Construction technique ElastoCoast



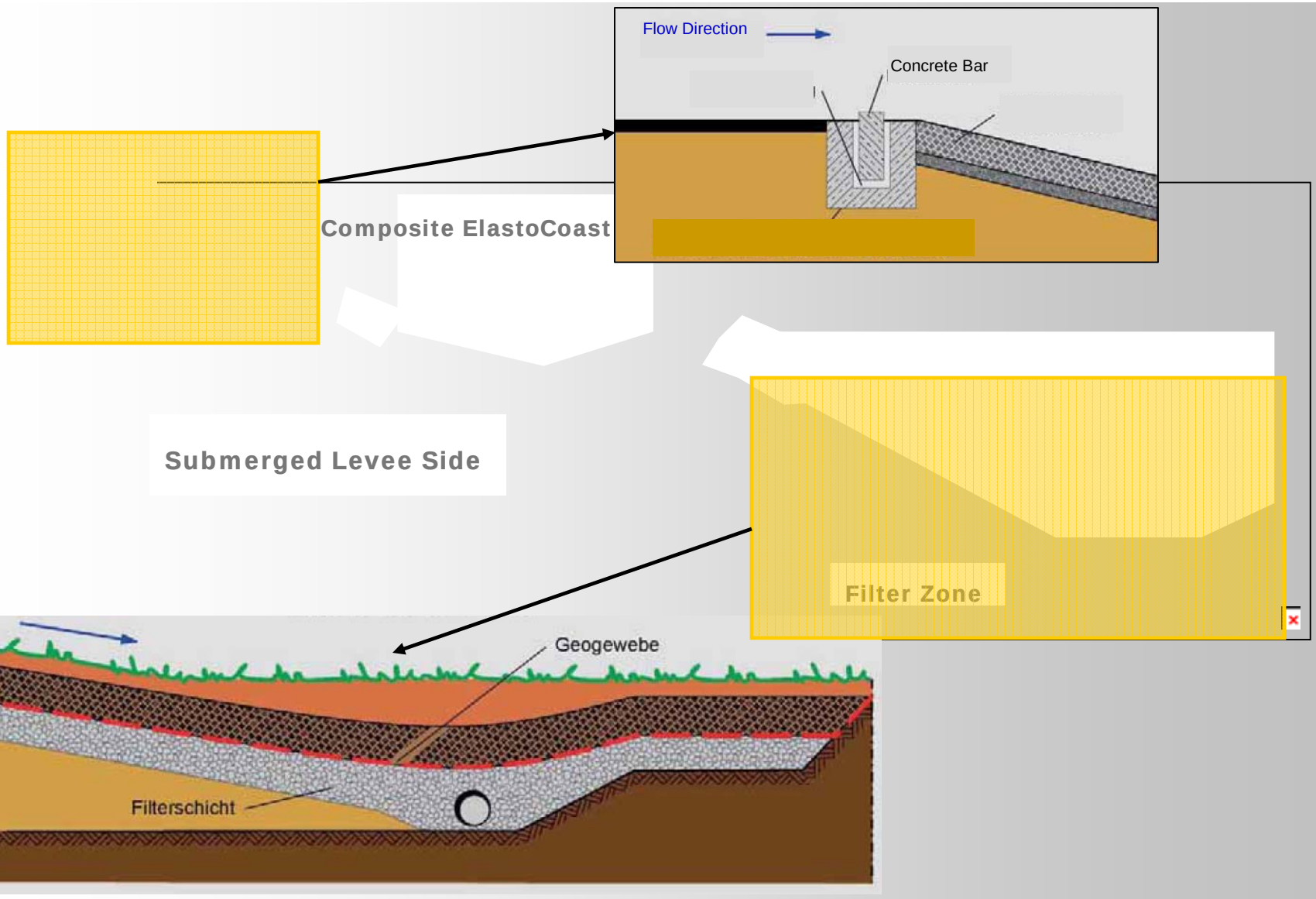
➔ ***Binding of stones with***

POLYURETHANE

➔ ***Composite***

Elastomeric Revetment

Cascading Flood Compartment Method (CFC)
Overflow Resistant Levee

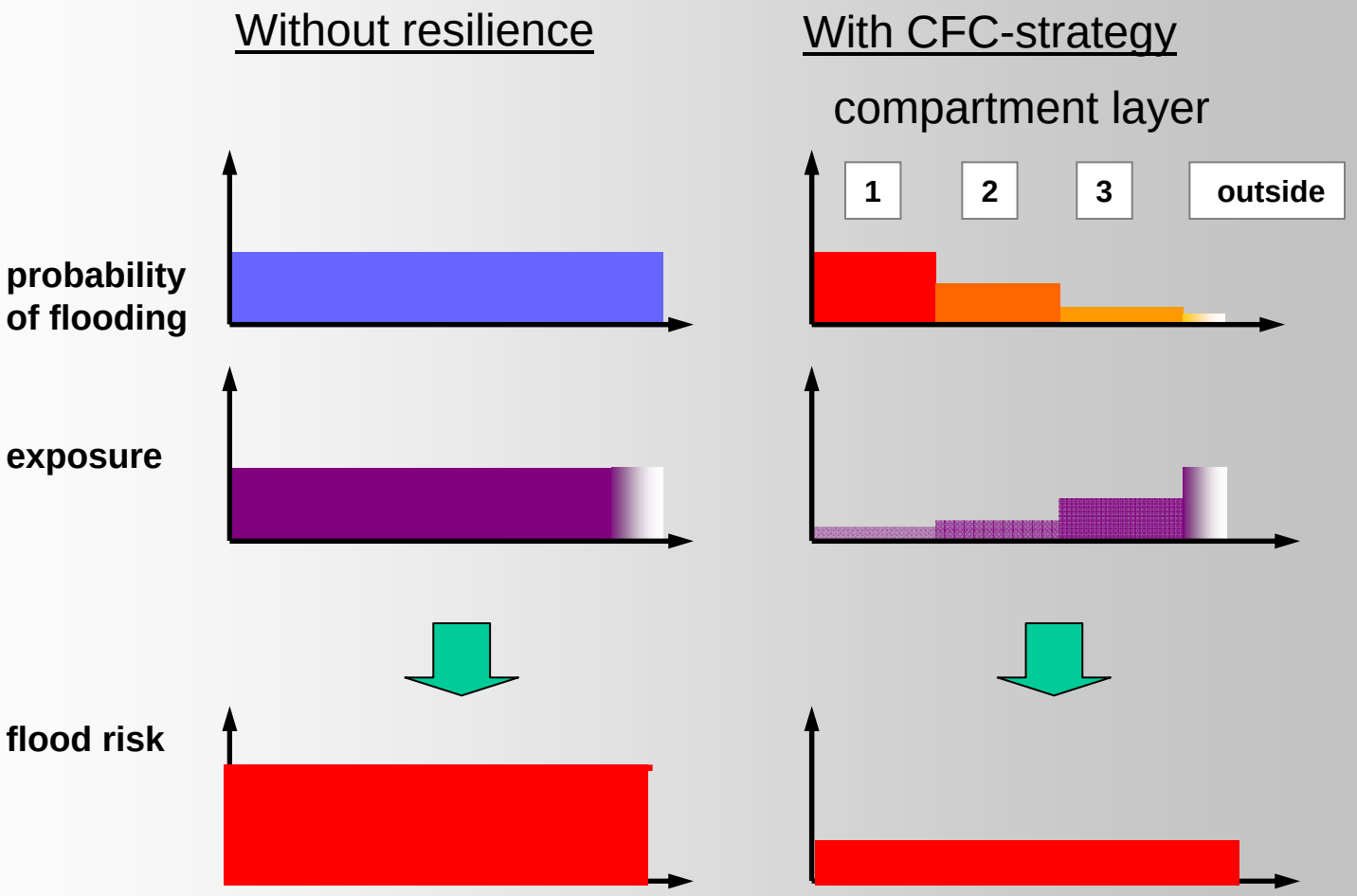


Cascading Flood Compartment Method (CFC)
Compartment Levees

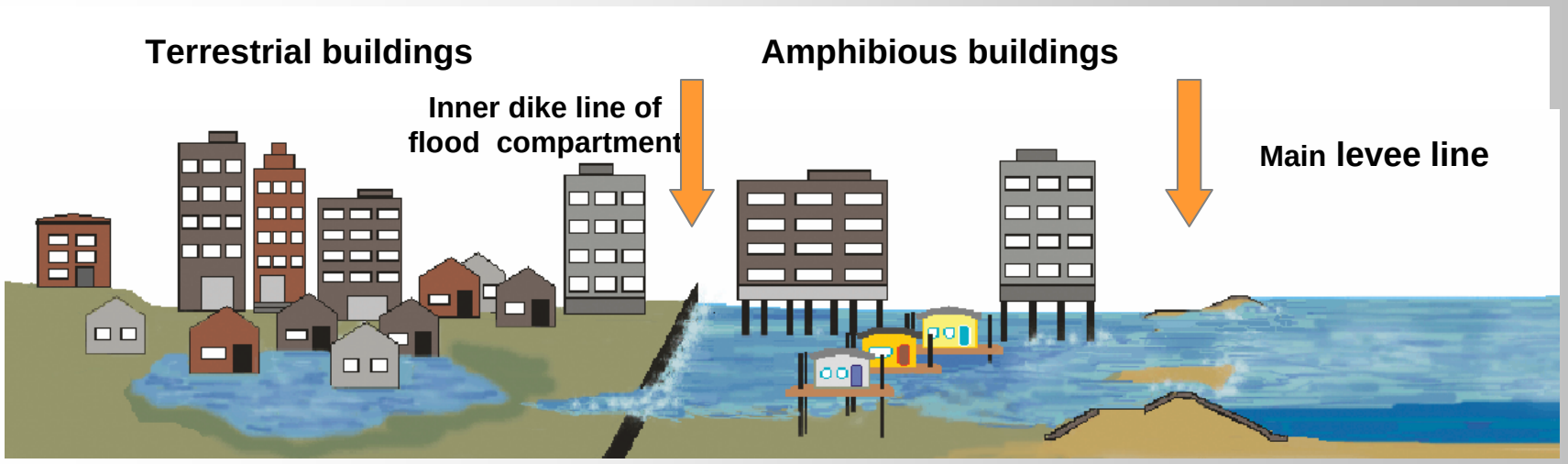
Making use of dismountable walls and gates to close gaps between houses and along roads and walls

Cascading Flood Compartment Method (CFC)
Necessary Adaptation of the Built Environment

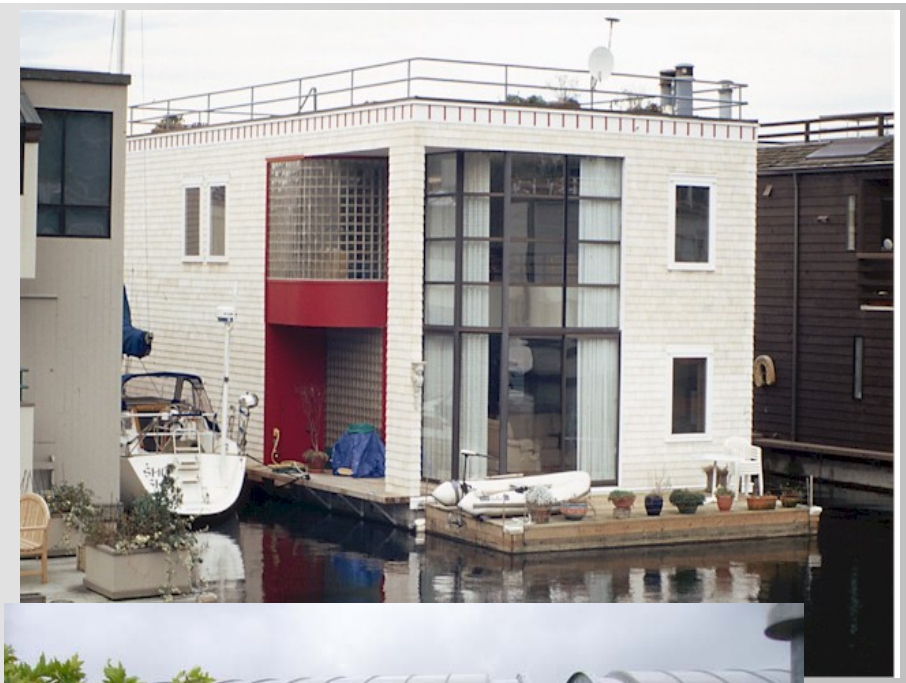
risk = probability times exposure



Cascading Flood Compartment Method (CFC)
Necessary Adaptation of the Built Environment



Cascading Flood Compartment Method (CFC)
1st Compartment – Floating Homes



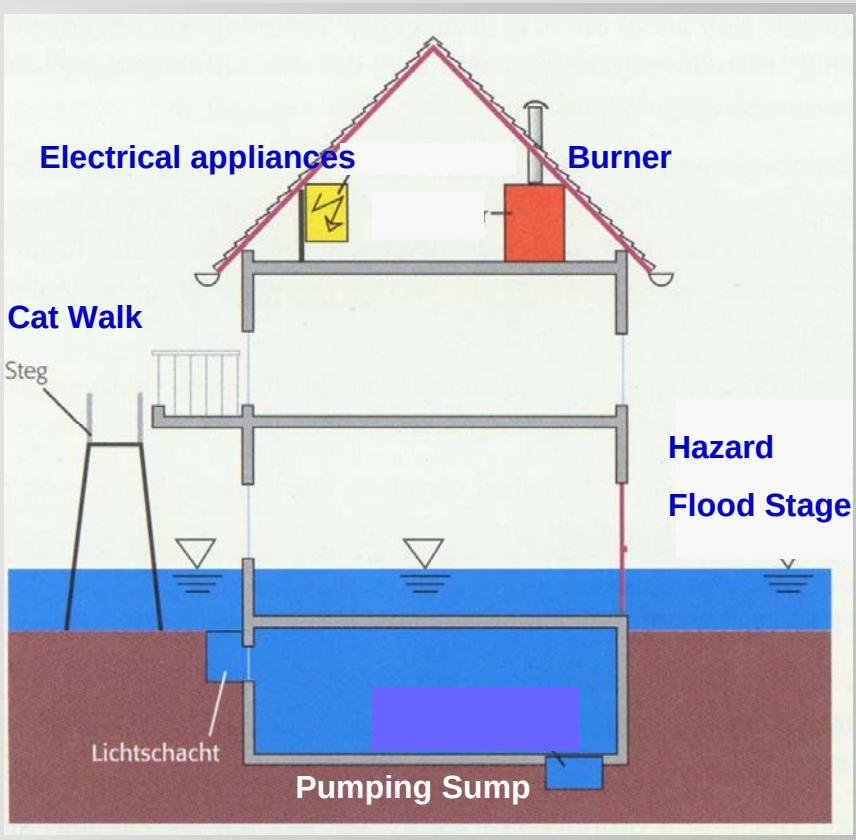
Cascading Flood Compartment Method (CFC)
1st Compartment – Amphibian Homes

Cascading Flood Compartment Method (CFC)
2nd Compartment – Dry-Proofing of Buildings

Cascading Flood Compartment Method (CFC)
2nd Compartment – Wet-Proofing of Buildings

Wet-Proofing Strategy
Move all supply elements to the top of the building

Provide temporary escape ways



Cascading Flood Compartment Method (CFC)
2nd Compartment – Dry- and Wet-Proofing

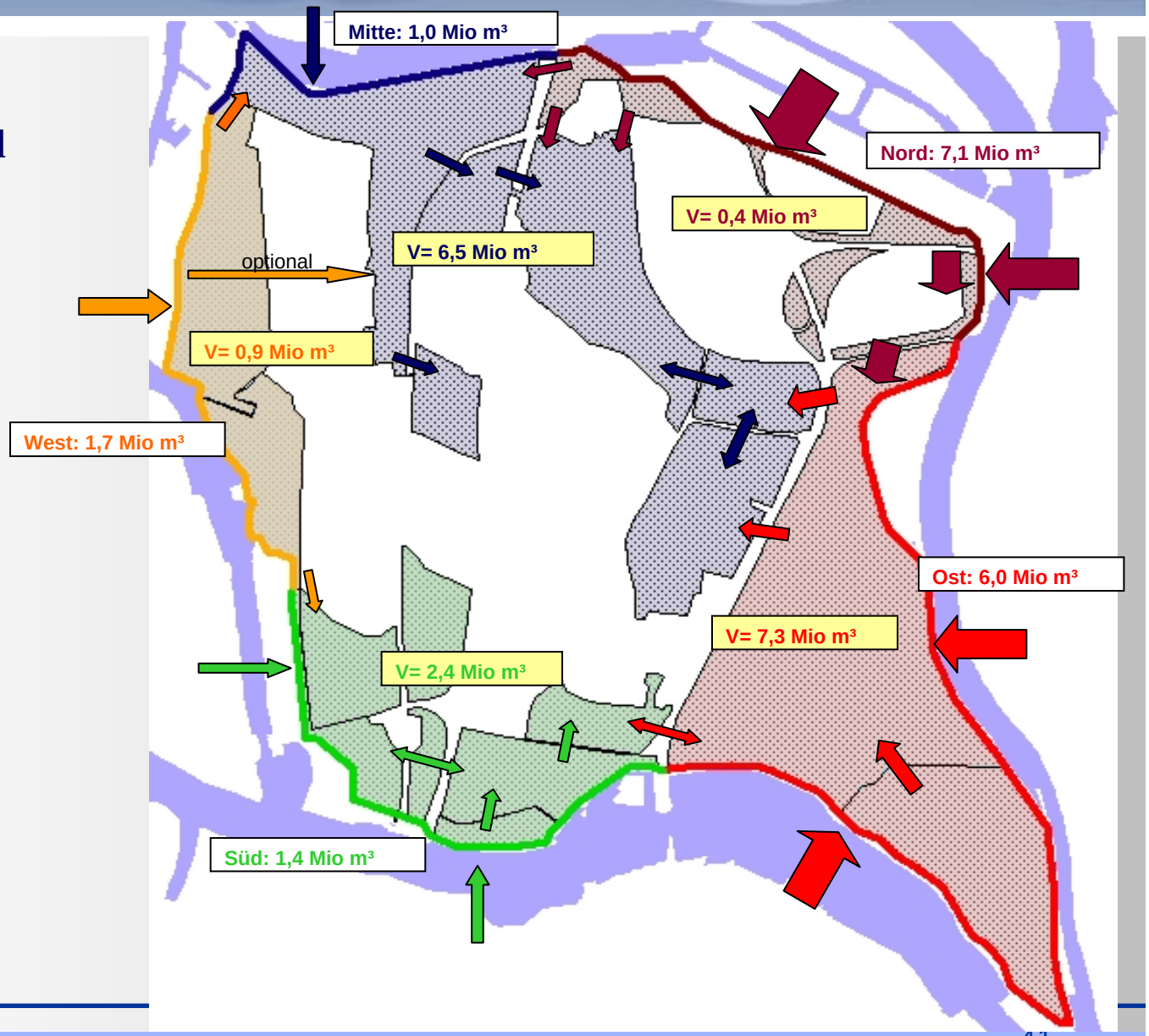
CFC-Strategy

No intensive use of 1st floor

Combination of mobile walls and cat walks

Application and Assessment of the CFC-method to City of Hamburg
Elbe-Island of Wilhelmsburg/Hamburg

Levees are arranged to a system of cascading flood compartments



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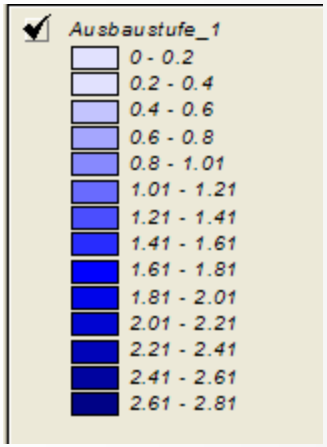
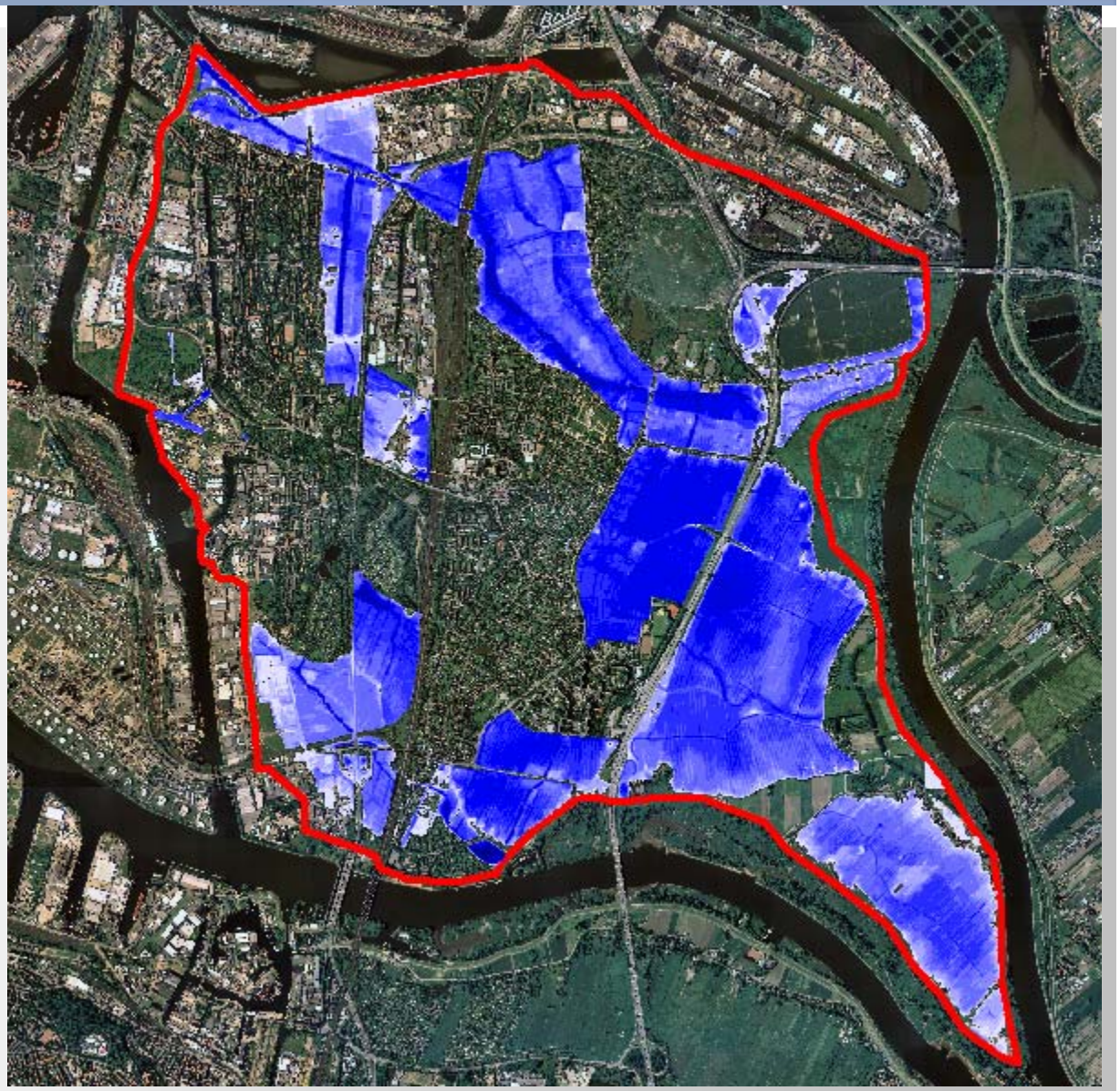
Application and Assessment of the CFC-method to City of Hamburg
Elbe-Island of Wilhelmsburg/Hamburg

Average water depth:
1,69 m

Total Storage capacity:
15,1 Mio m³





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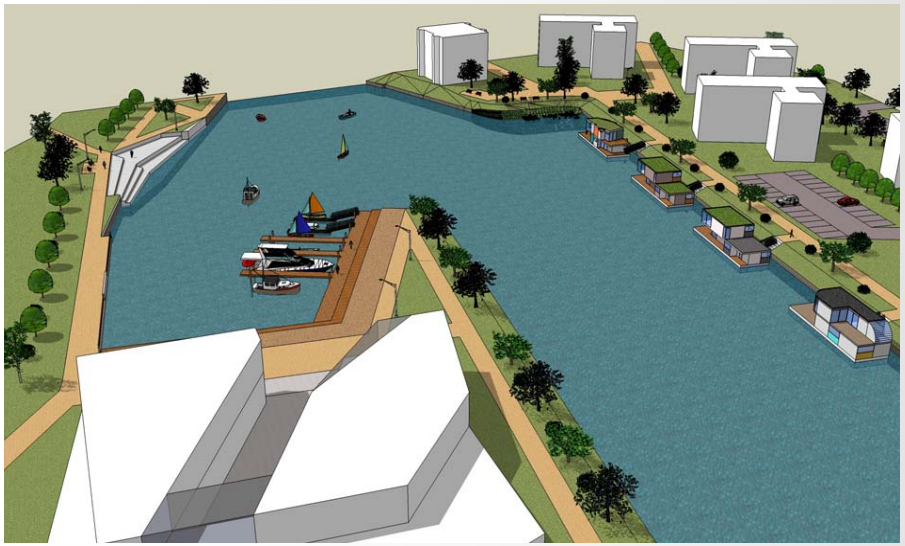
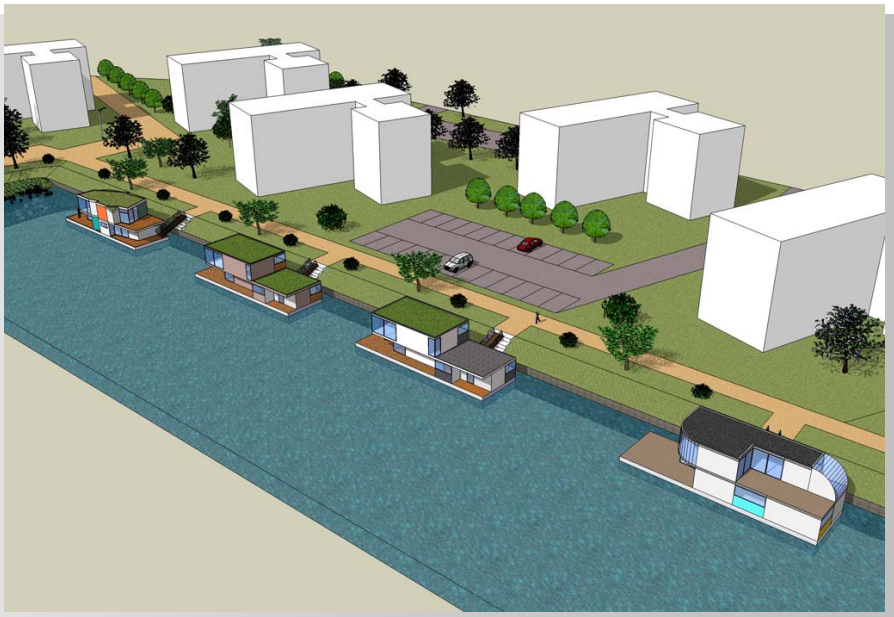
Application and Assessment of the CFC-method to City of Hamburg
Elbe-Island of Wilhelmsburg/Hamburg

Application and Assessment of the CFC-method to City of Hamburg
Elbe-Island of Wilhelmsburg/Hamburg





Application and Assessment of the CFC-method to City of Hamburg
Efficiency Analysis - Comparison of Costs

Conventional Method	Levee Rising by 80 cm	140 Million Euro
CFC-Strategy	Adaptation of Levees to overflow resistance	60 Million Euro
	Construction of compartment levees, Dry- and Wet-Proofing of Houses	30 Million Euro -
	Total Costs	90 Million Euro

Monetary Efficiency by 50 Million Euro!!

Conclusions

Climate Change requires a new flood risk policy behind the levees

The probability of flooding has to be taken into account

Transfer to flood resiliency requested: The safety chain concepts of the 4A's

CFC-Method should be part of this resilience stragegy

- ***They can compensate the rising risk due to climate change***
- ***They are cheaper than rising the levees***
- ***They keep alive the risk awareness at the residents***
- ***Create win-win situation by stimulating new forms of living at water***
- ***Flexible to adapt to changes of the climate projections***