Unit 8:
Flood risk assessment
Case Study Gleisdorf

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River room agenda Alpenraum

This project has received European Regional Development Funding through the INTERREG IIIB Community Initiative

Alpine Space

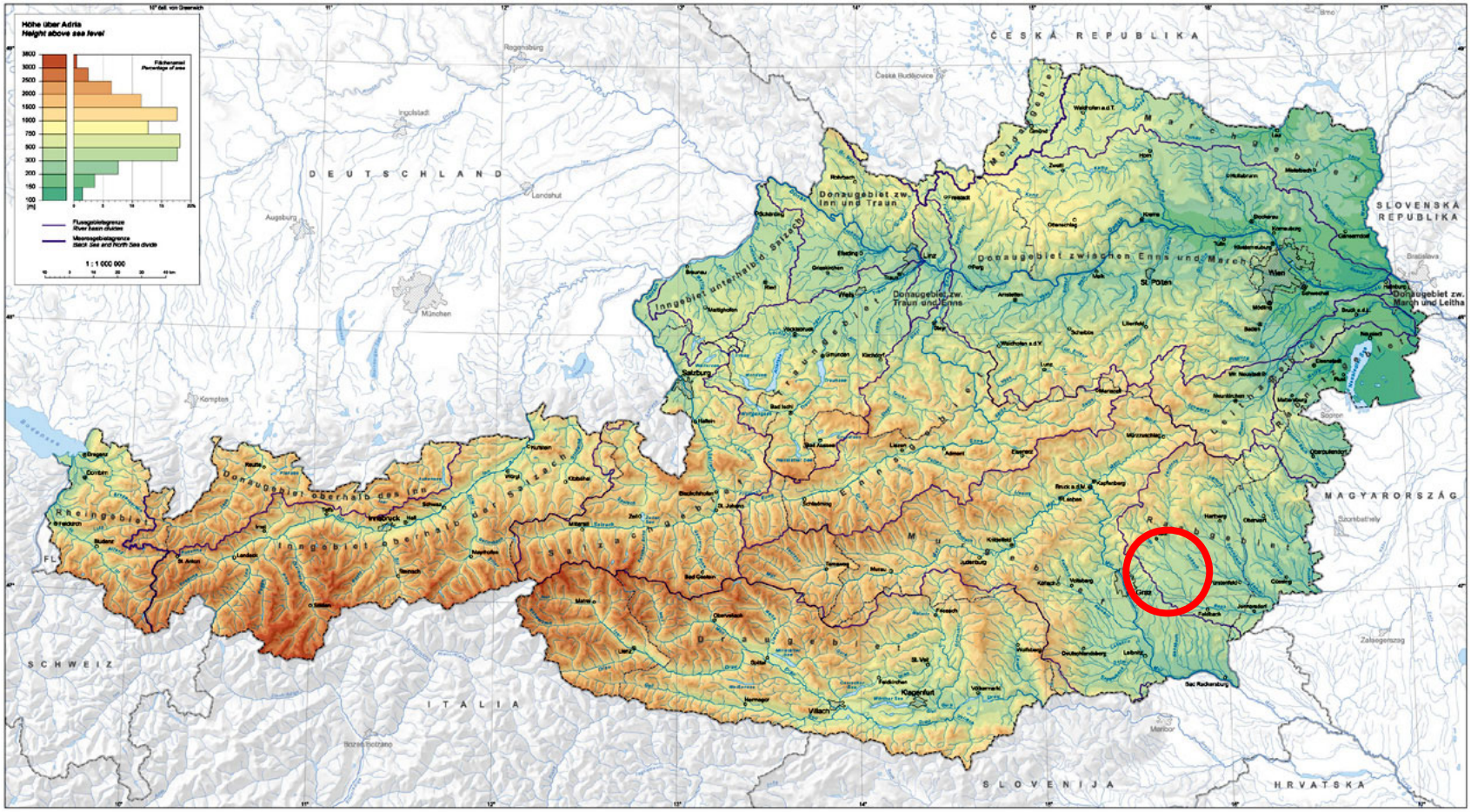
Interreg III B

What did we discuss so far ?

- Identification of a hazardous event X
- Fitting a pdf to observations f(X)
- Principles of damage assessment D(X)

- Now an example

The region of Gleisdorf



Development in the Region

Flood protection project 97-99

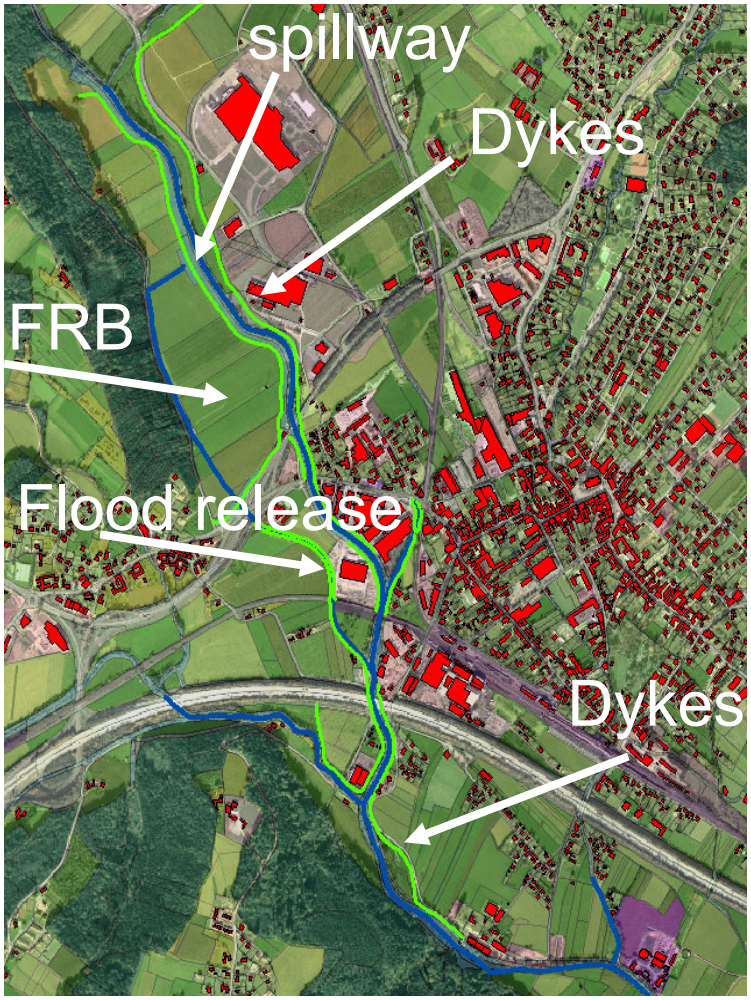
In the late 1990-ties a flood protection scheme for the city of Gleisdorf weas planned and completed in 1999.

The city is now protected against a 100-years flood event

Just after the construction works the former flood plain was intensively used

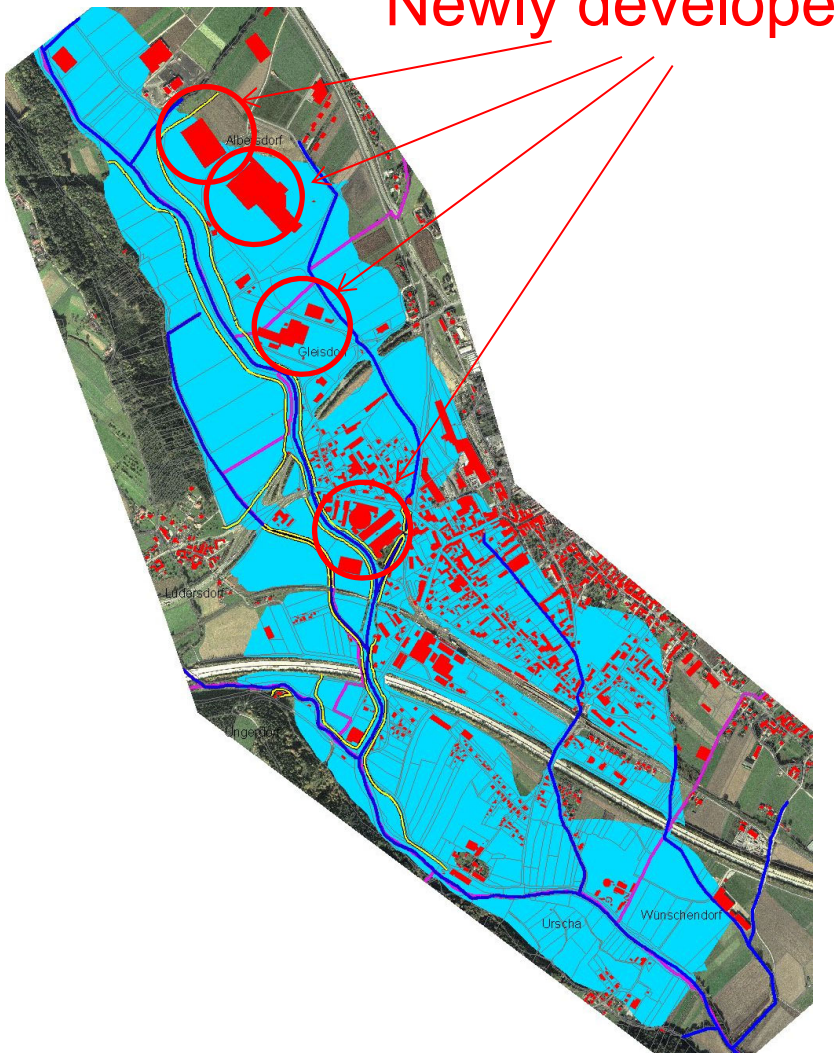
Several companies built their factories there

The damage potential is now much higher than before



Inundation area before 1999

Newly developed firms



The goal was a protection level of HQ_{100}

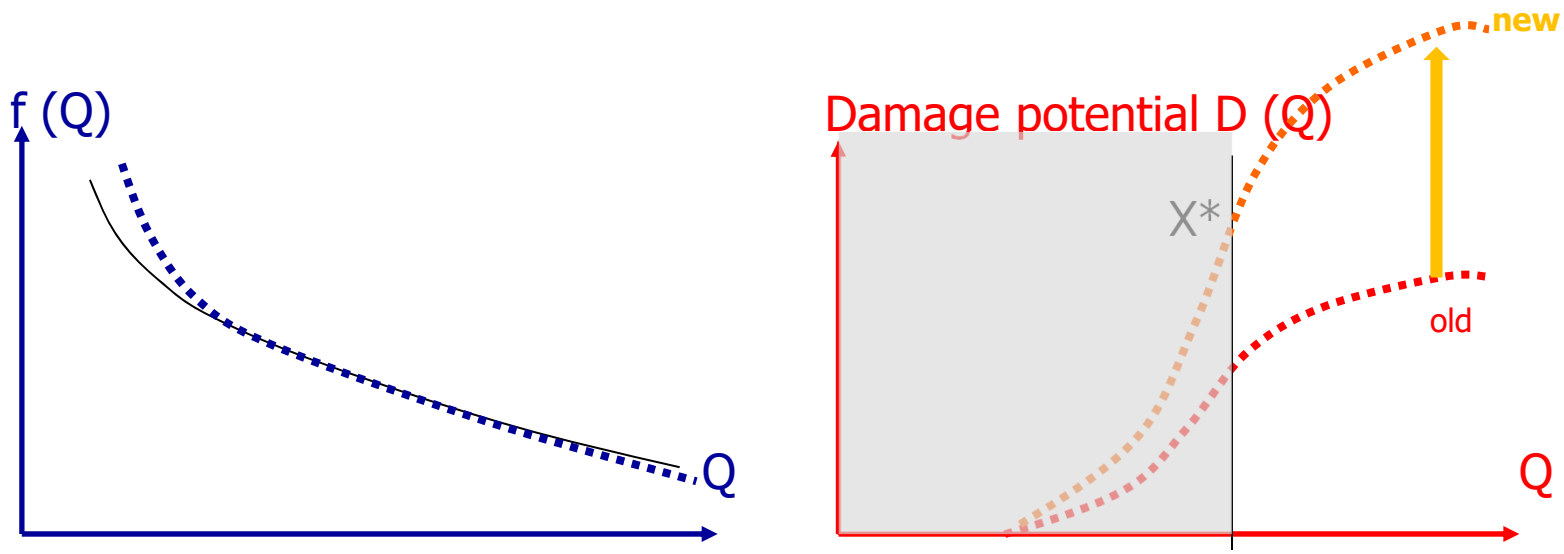
Protection of 233 objects and 130 hectares

Raab: Qmax = 200 m^3/s

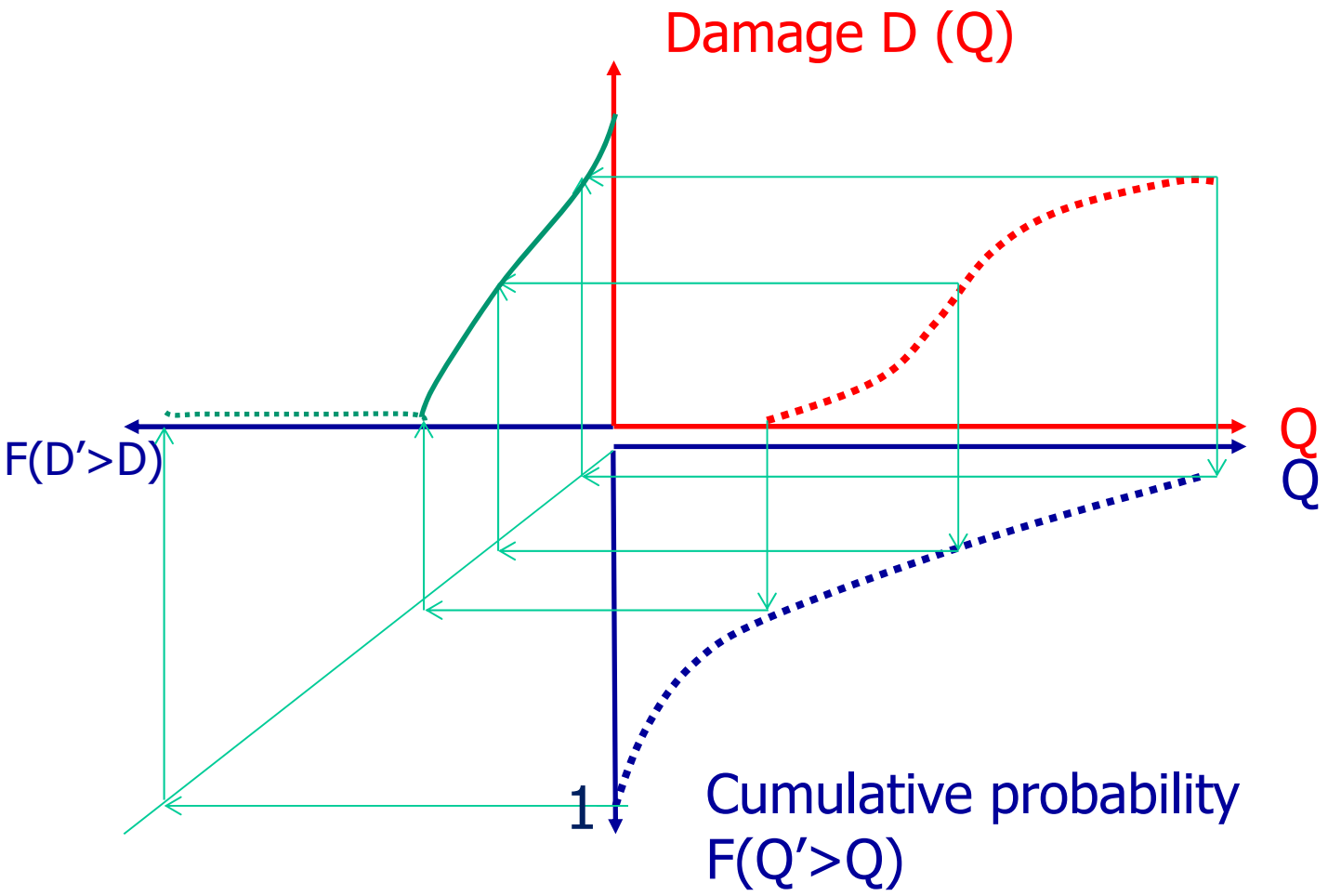
Rabnitz: Qmax = 40 m^3/s

Risk is changing with time

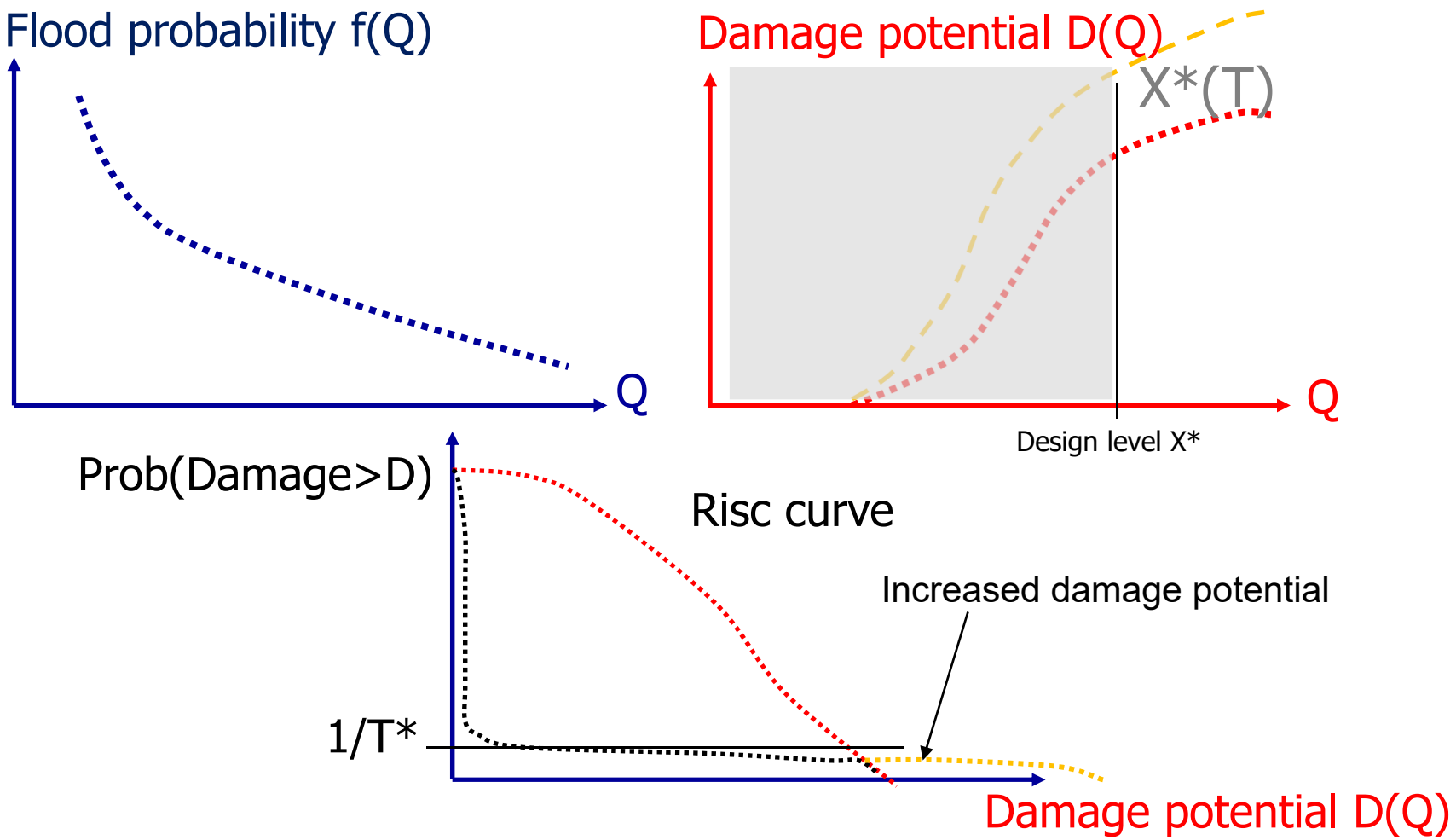
- What happens when land use changes (e.g. population density increases)



Risc curves



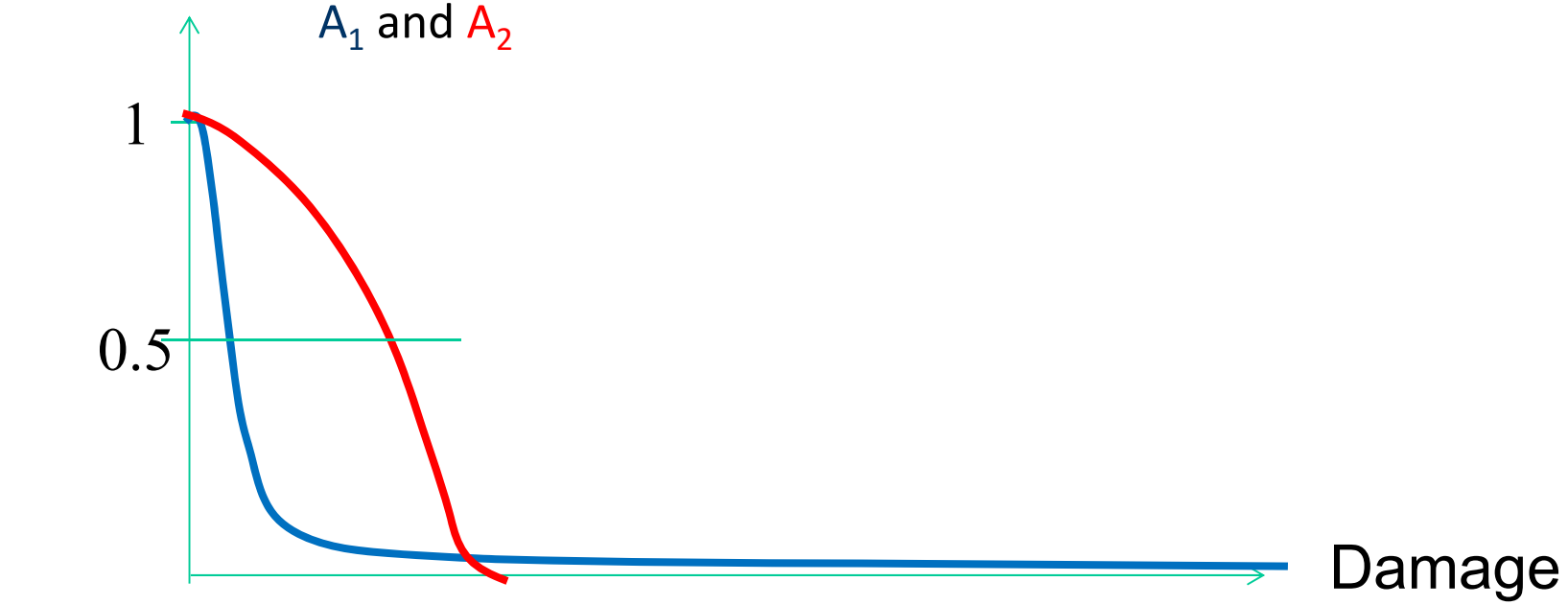
Risk curves


Flood probability f(Q)
Q
Damage potential D(Q)
X*(T)
Q
Design level X*
Prob(Damage>D)
Risc curve
Increased damage potential
1/T*
Damage potential D(Q)

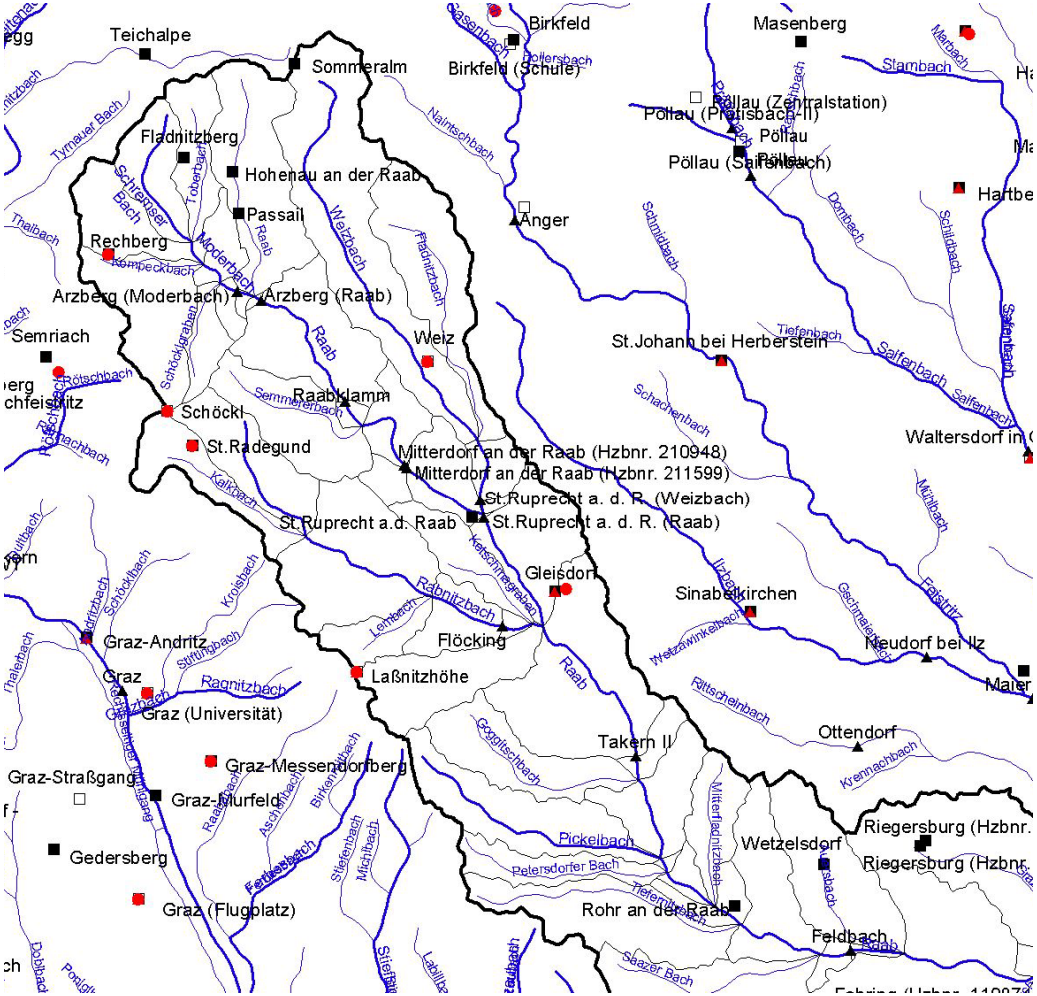
Comparison of different risk curves

- Comparison of two hazards with quite different consequences
- A1 very low probability of occurrence but extreme consequences
- A2 high probability of occurrence but lower consequences
- E.g. A1 nuclear power station and A2 thermal power station

A1 has a low mean value but highly skewed
A2 has a higher mean but an upper limit



Simulation of the load (hazard)

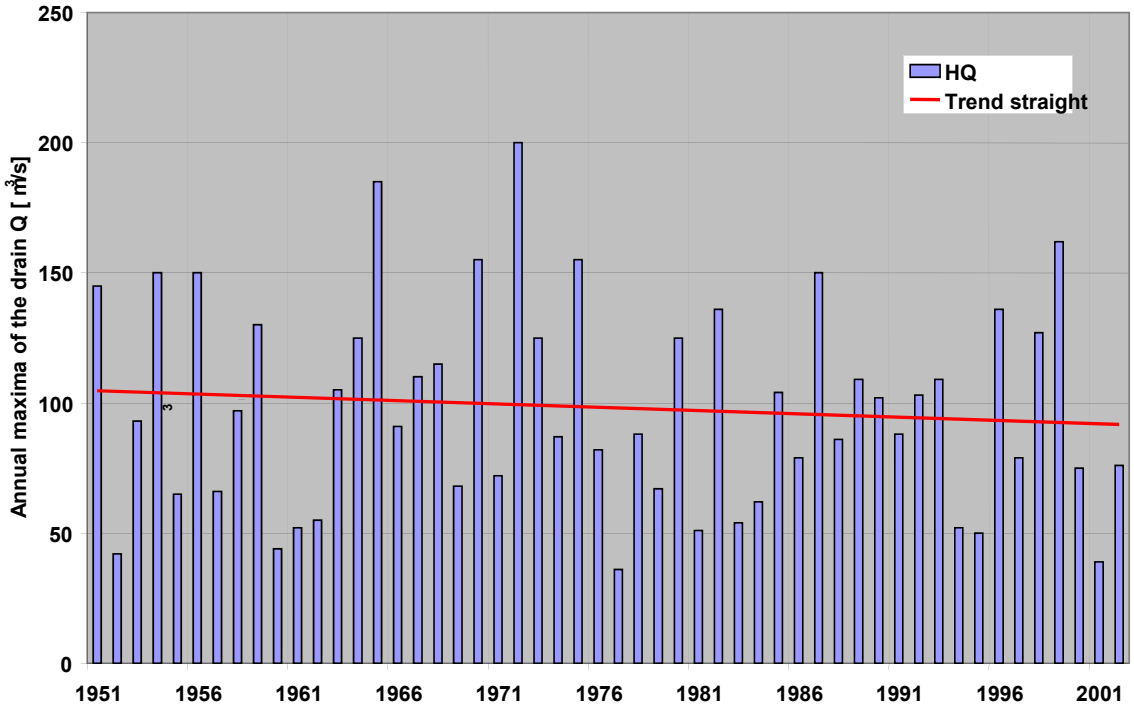


The hazard is the flood event in Gleisdorf which is generated by intensive rainfall over the catchment

Not only the flood peak but also the shape of the flood event is relevant (reservoir capacity!!)

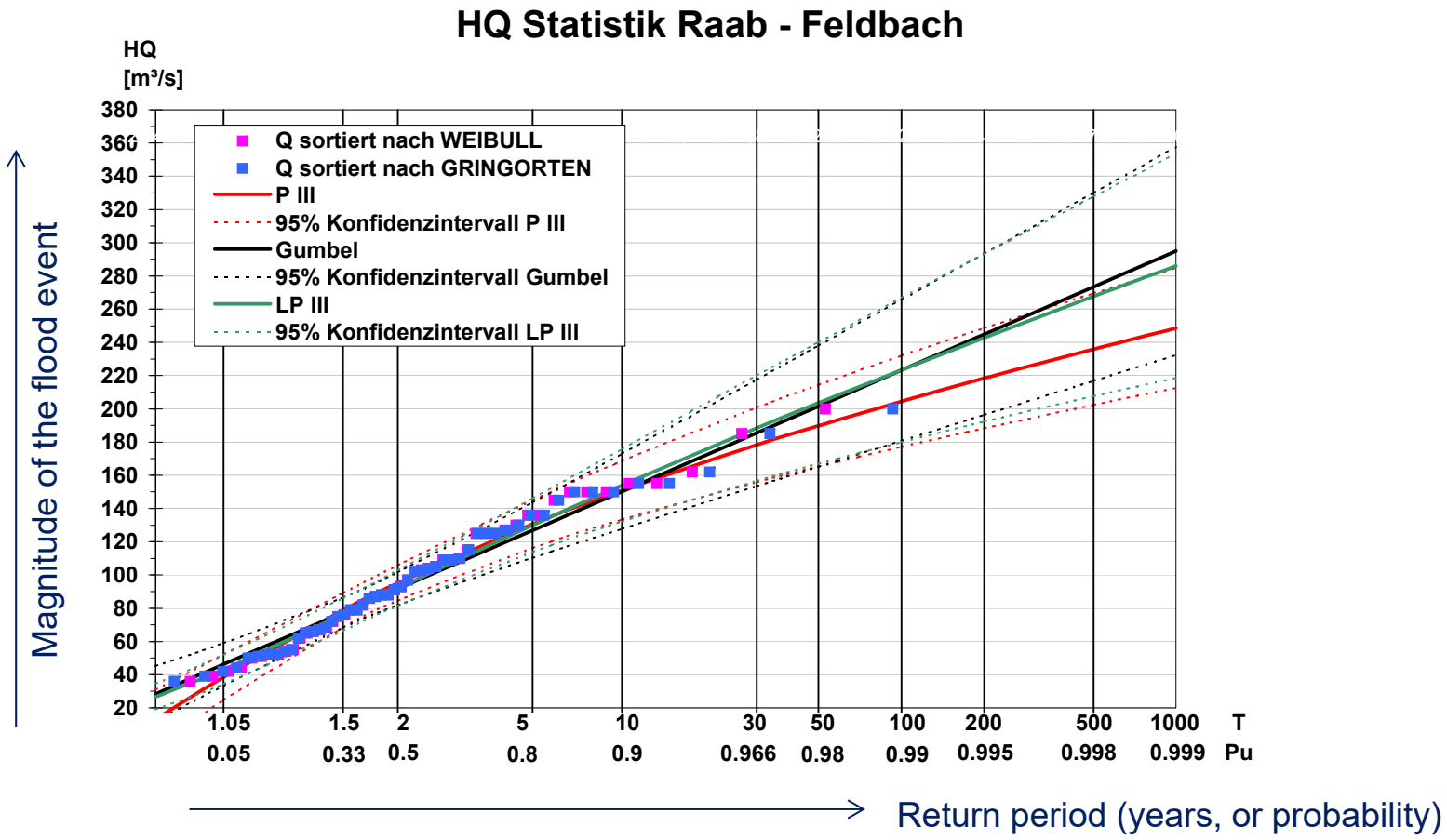
Given the rainfall statistics numerous flood events can be generated by the help of hydrologic models

Analysis of the flood series



Flood series Feldbach

Flood frequency estimates



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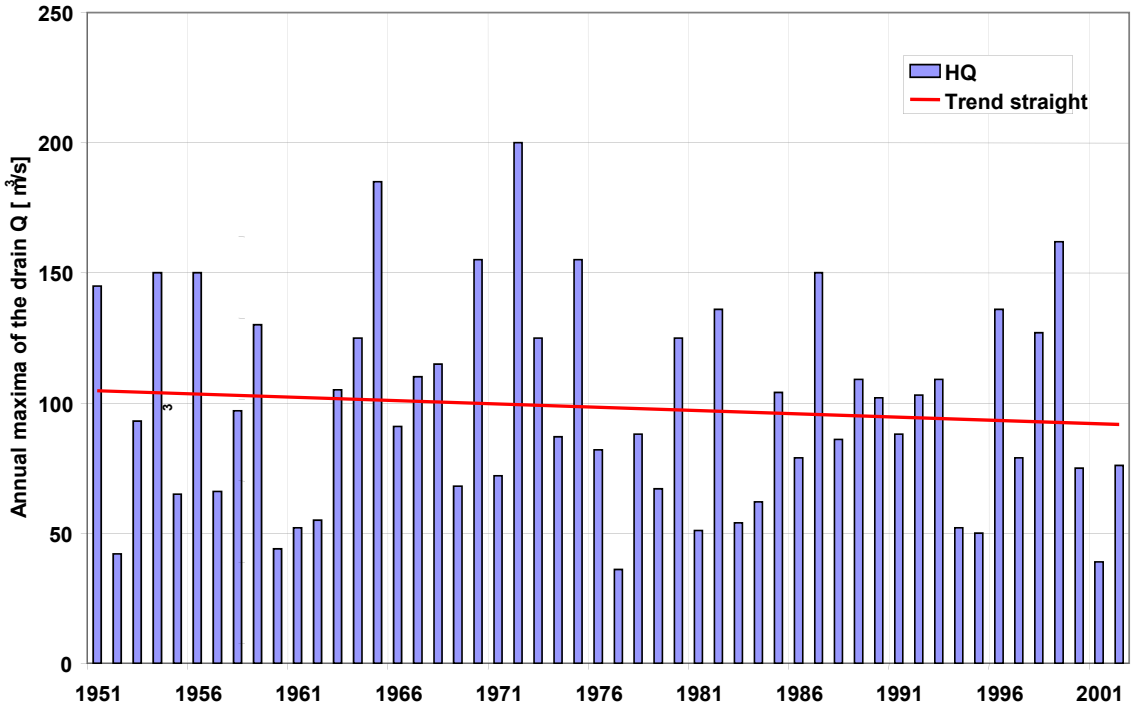

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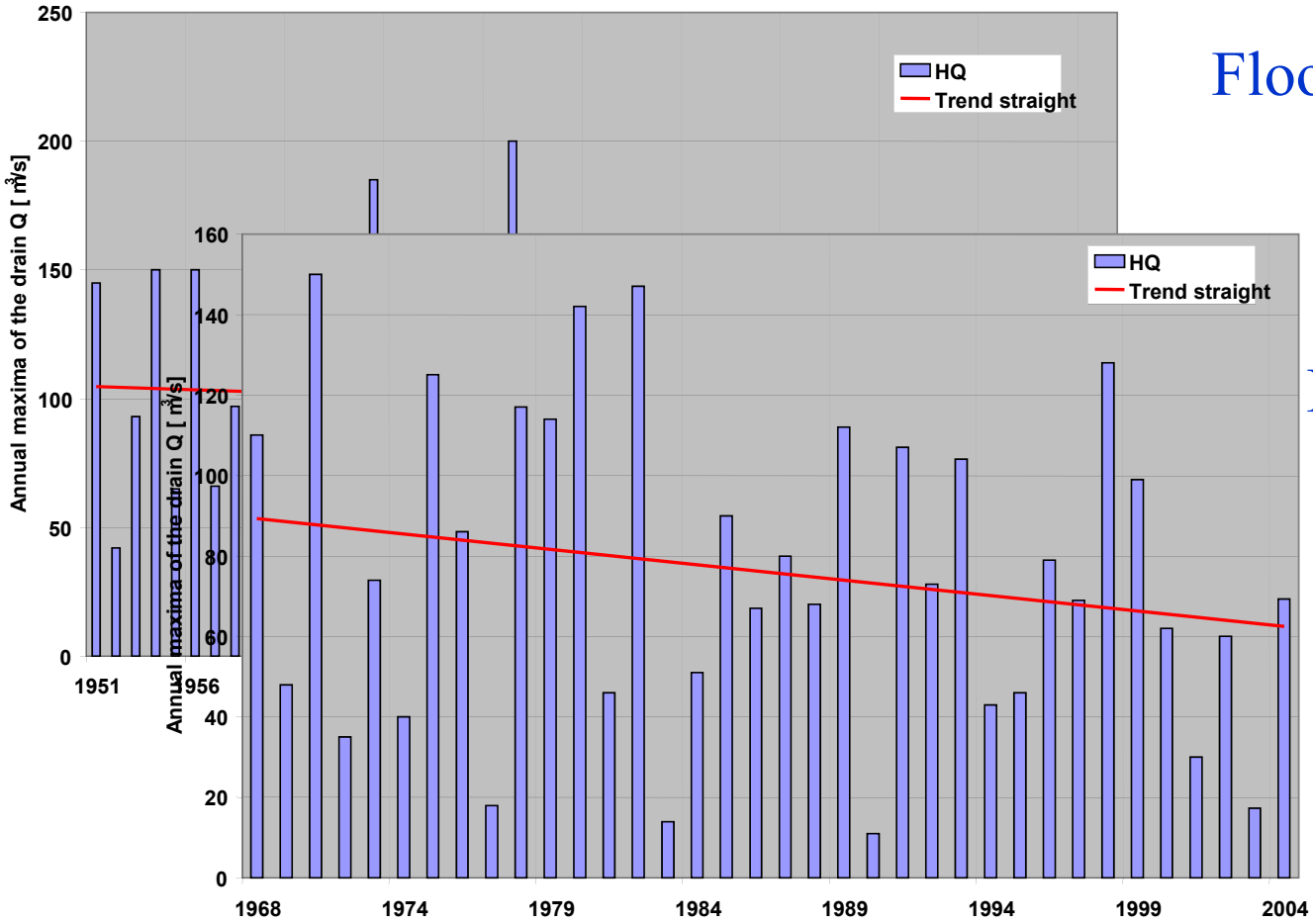
Analysis of the flood series



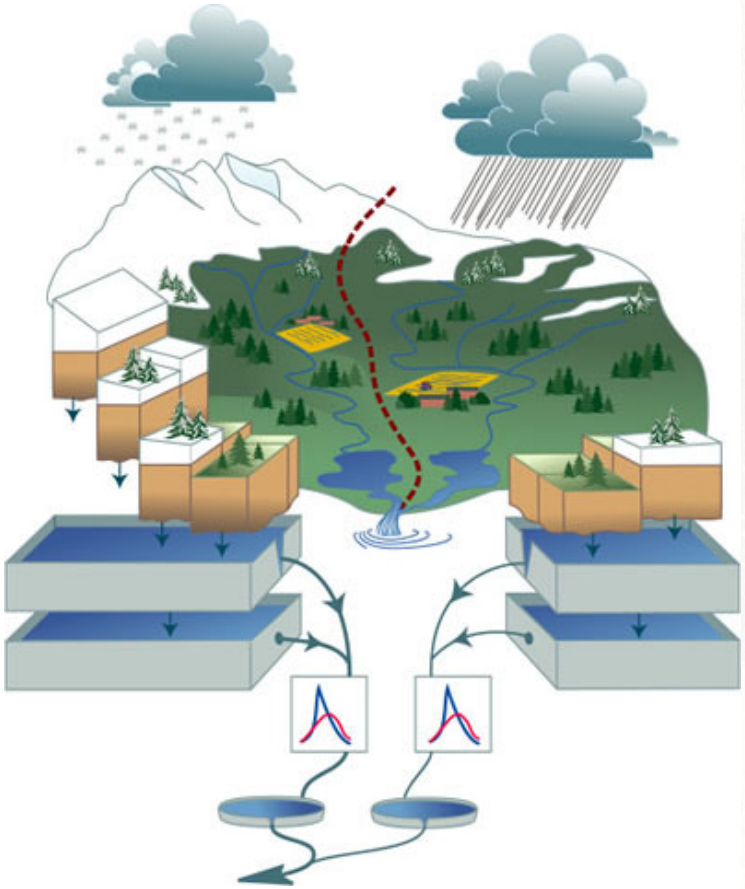
Flood series Feldbach

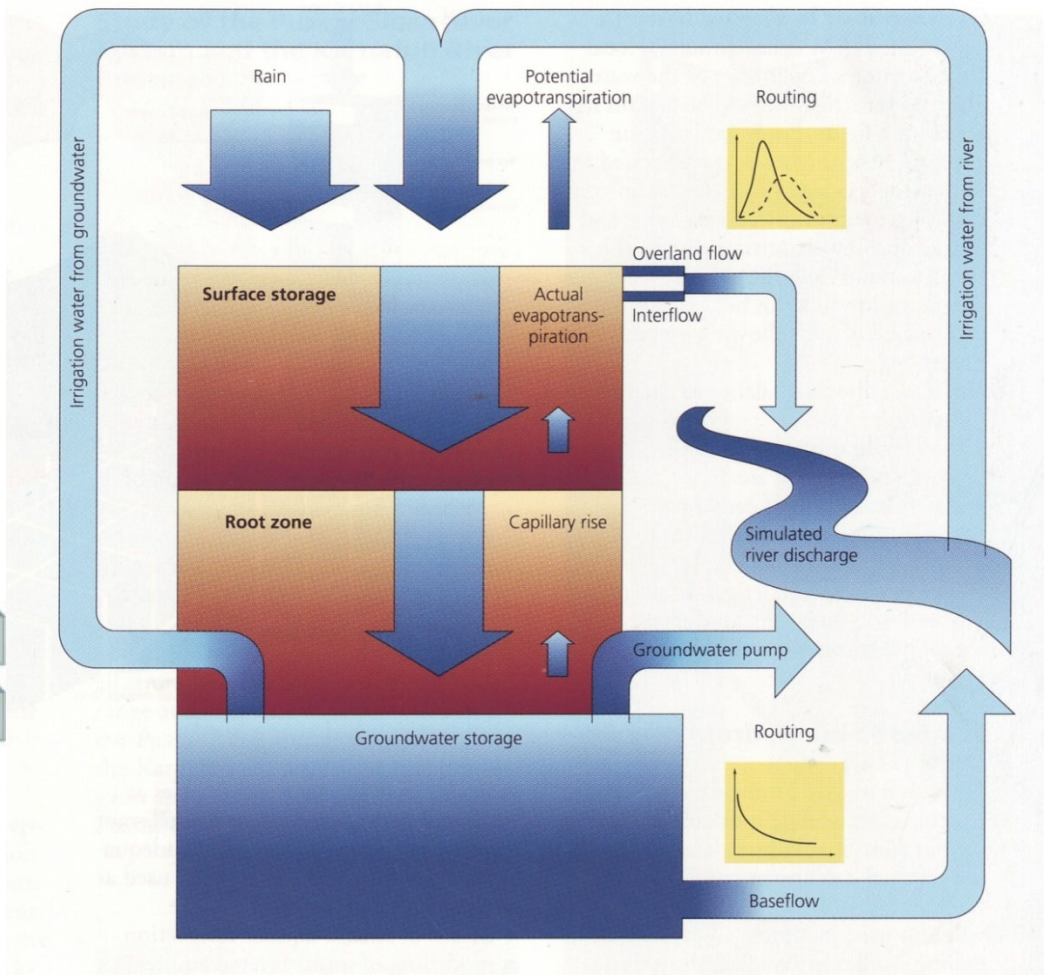
Flood series Takern

Generation of flood scenarios

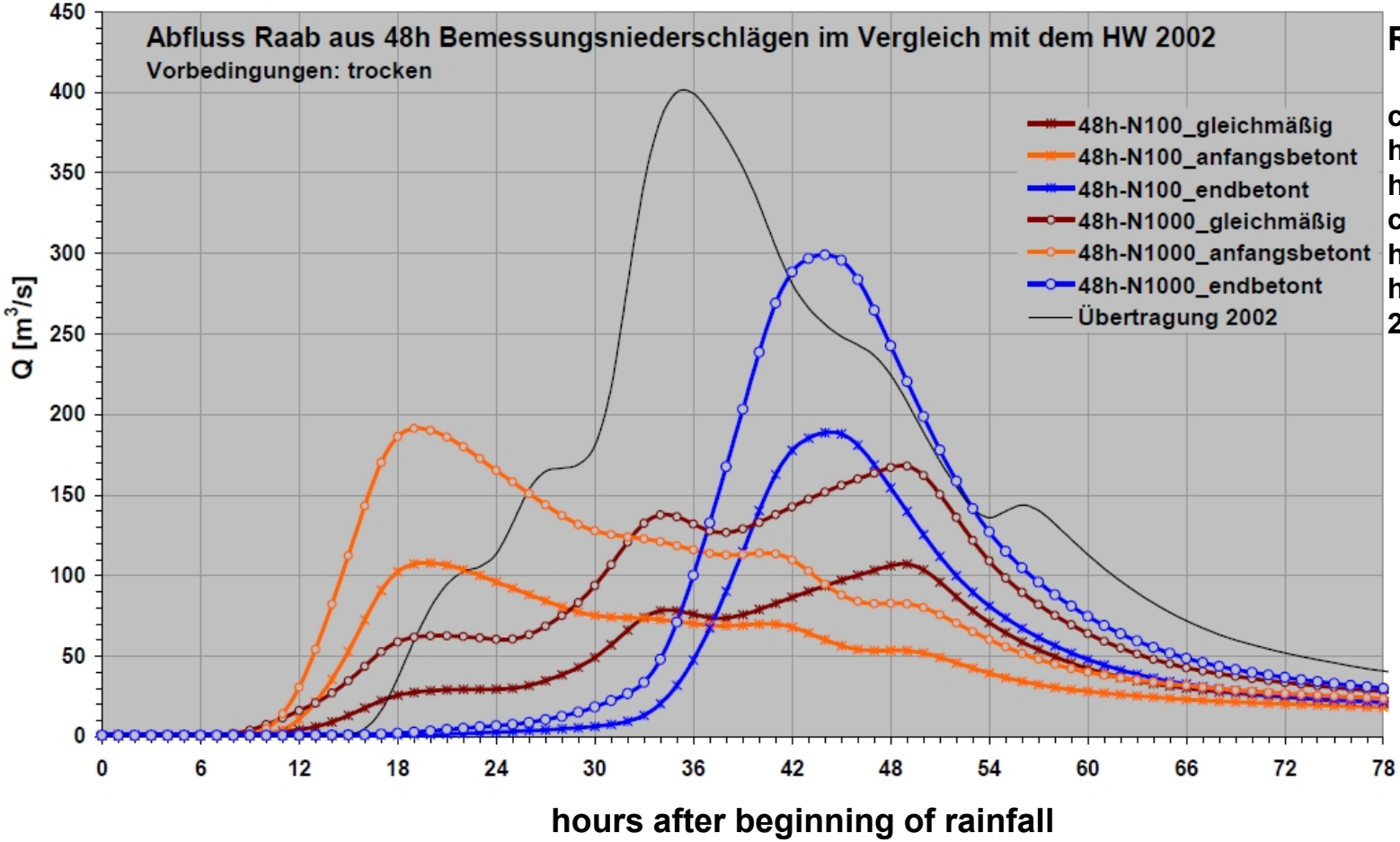
- The flood risk directive (EU-2007/60/EC) requires at least 3 different flood events to be analysed.
- In Austria HQ_{30}, HQ_{100}, HQ_{300}
- Given the rainfall statistics numerous flood events can be generated by the help of hydrologic models
- Here: estimation of critical loads (e.g HQ_{30}, HQ_{100}, HQ_{300}, HQ_{1000}, HQ_{5000})

Rainfall-runoff models





Generation of different critical flood events



Rainfall intensity is

constant over time
high at the beginning
high at the end
constant over time
high at the beginning
high at the end
2002 flood simulated

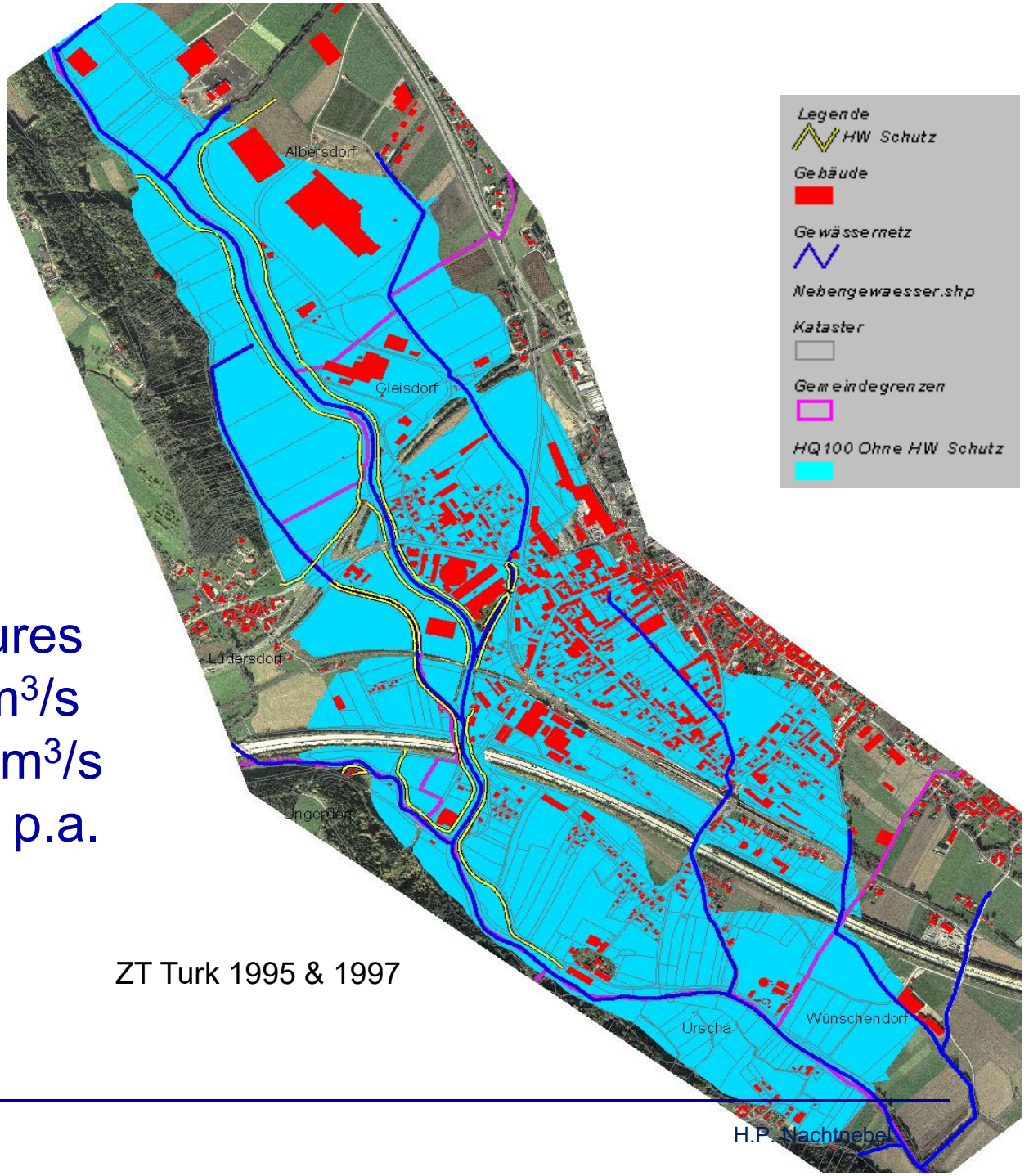
Scenario 1

Flood area before implementation of flood control structures

Raab: Q_{max} = 200 m^3/s

Rabnitz: Q_{max} = 40 m^3/s

probability: ~1/100 p.a.



ZT Turk 1995 & 1997

Scenario 2

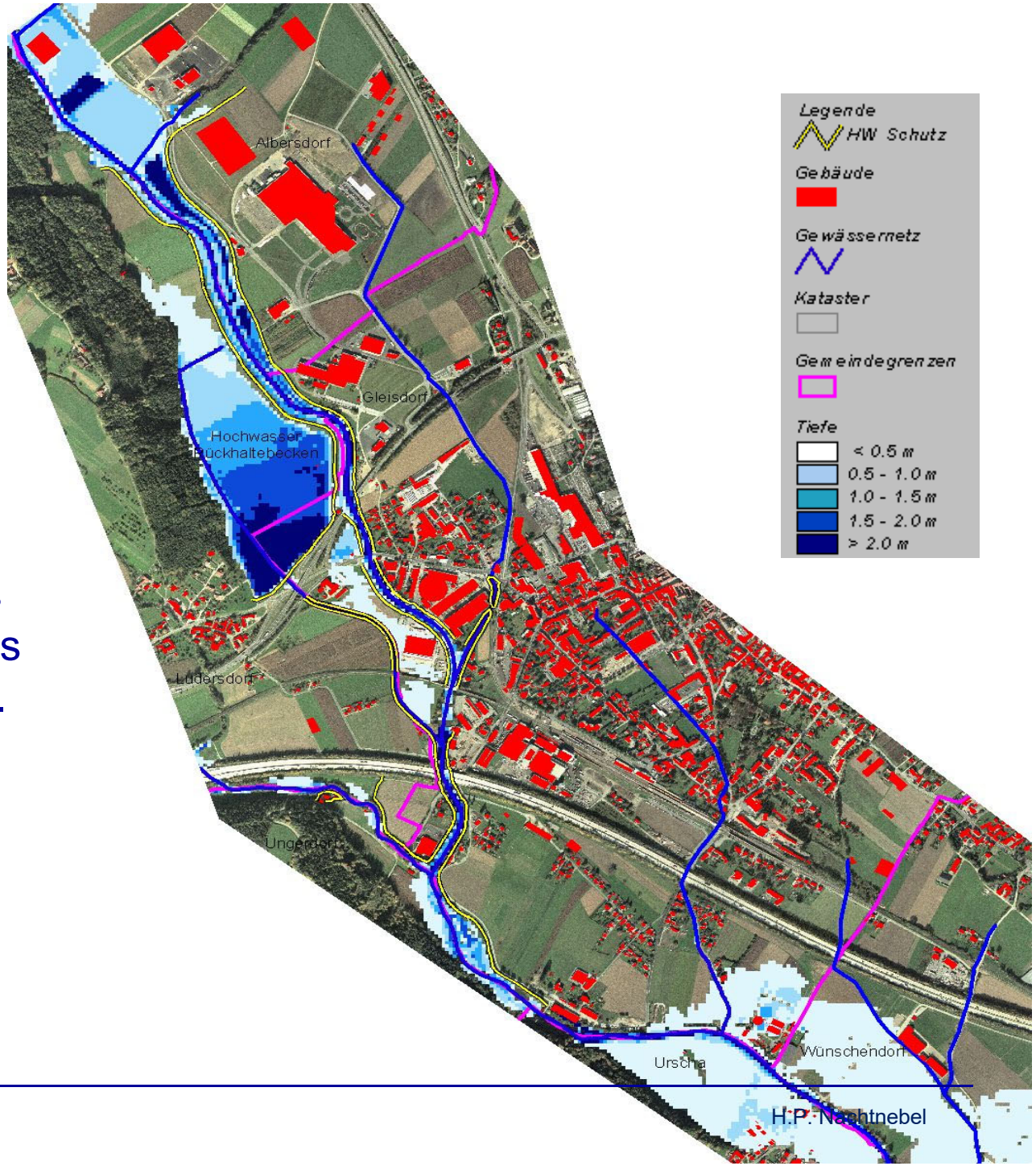
Flood areas,

Depths

Raab: Q_{max} = 200 m^3/s

Rabnitz: Q_{max} = 40 m^3/s

probability: ~1/100 p.a.



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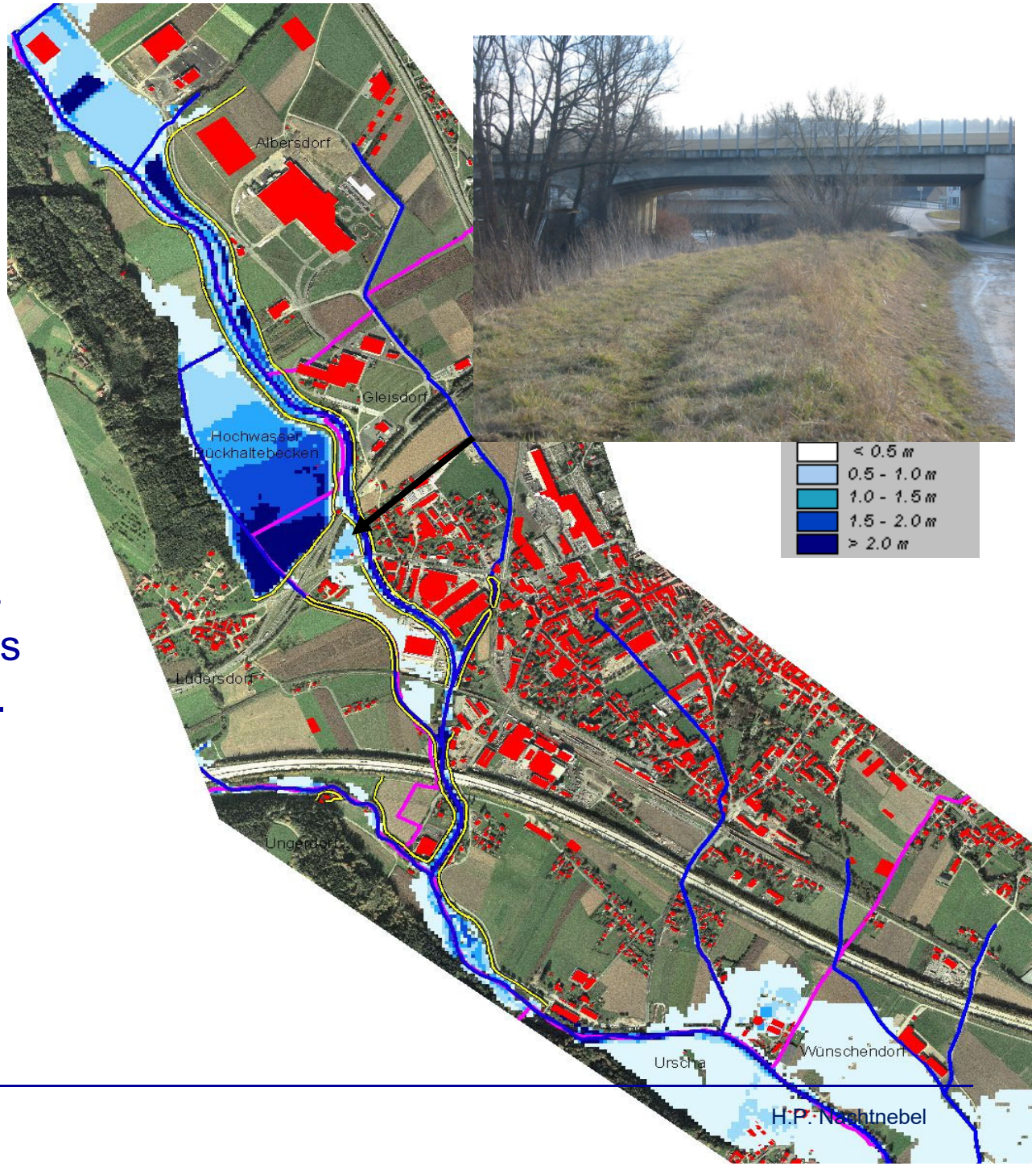
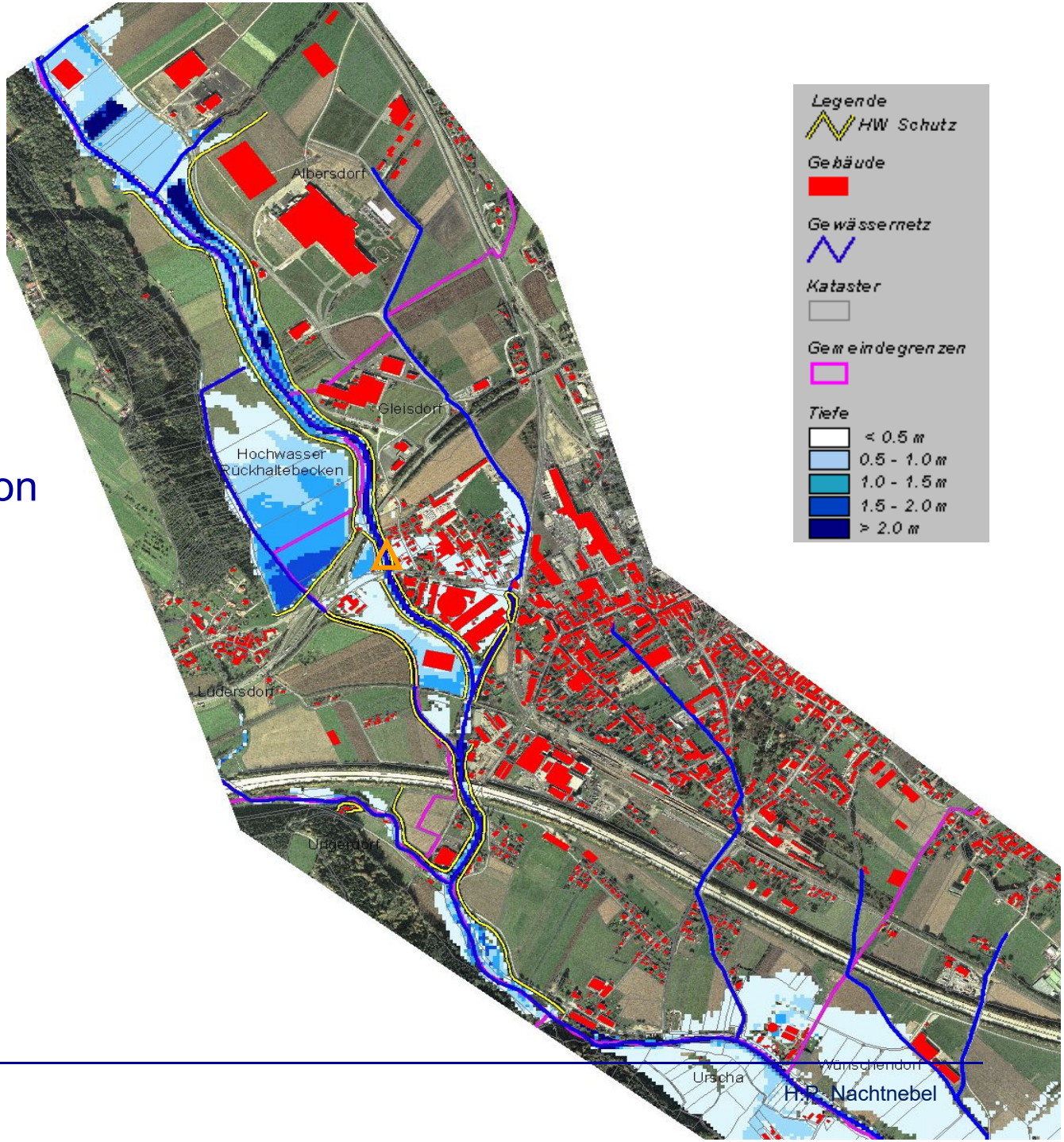


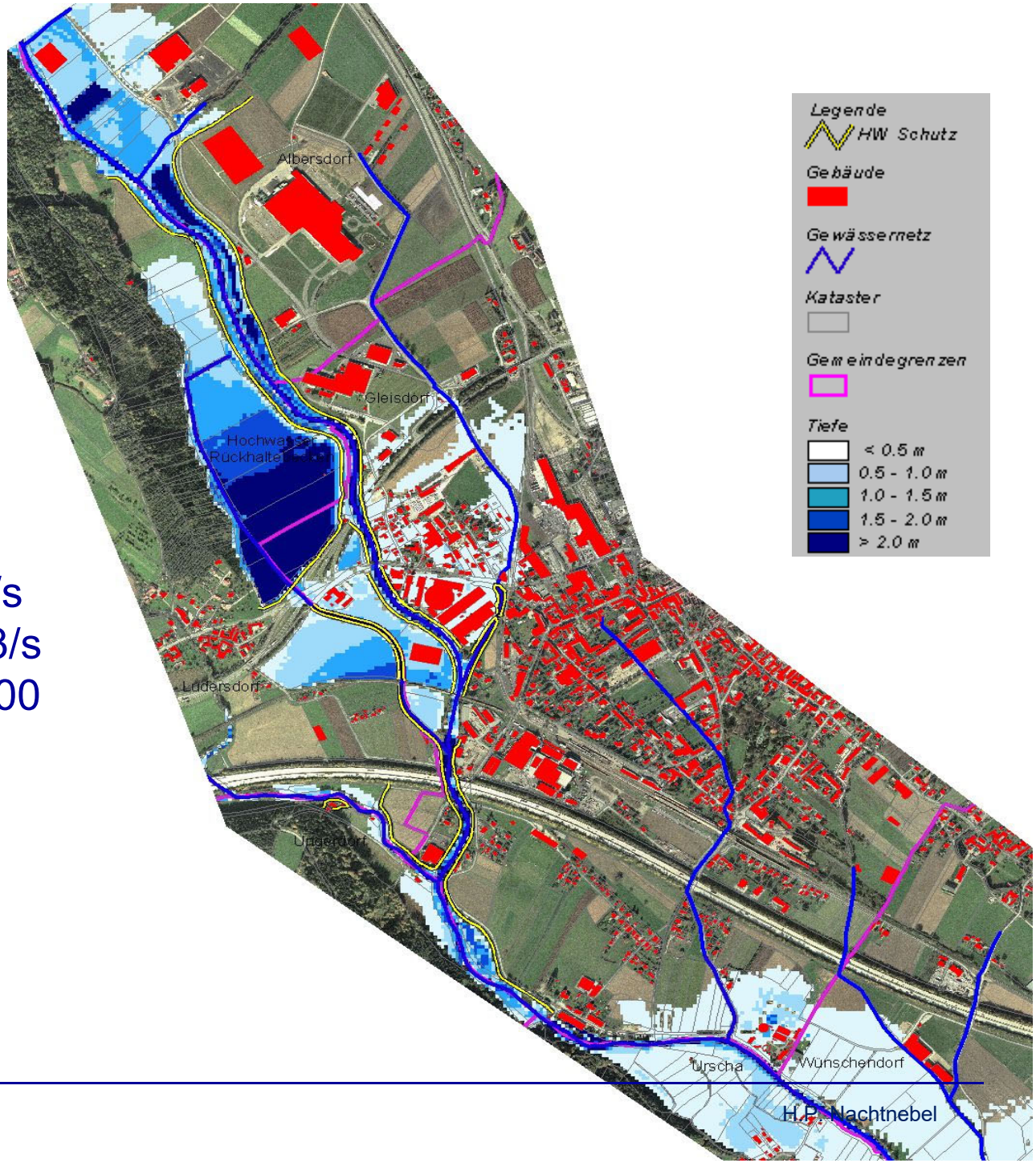
Scenario 3

Existing flood protection
Depth of inundation
log jam at the bridge



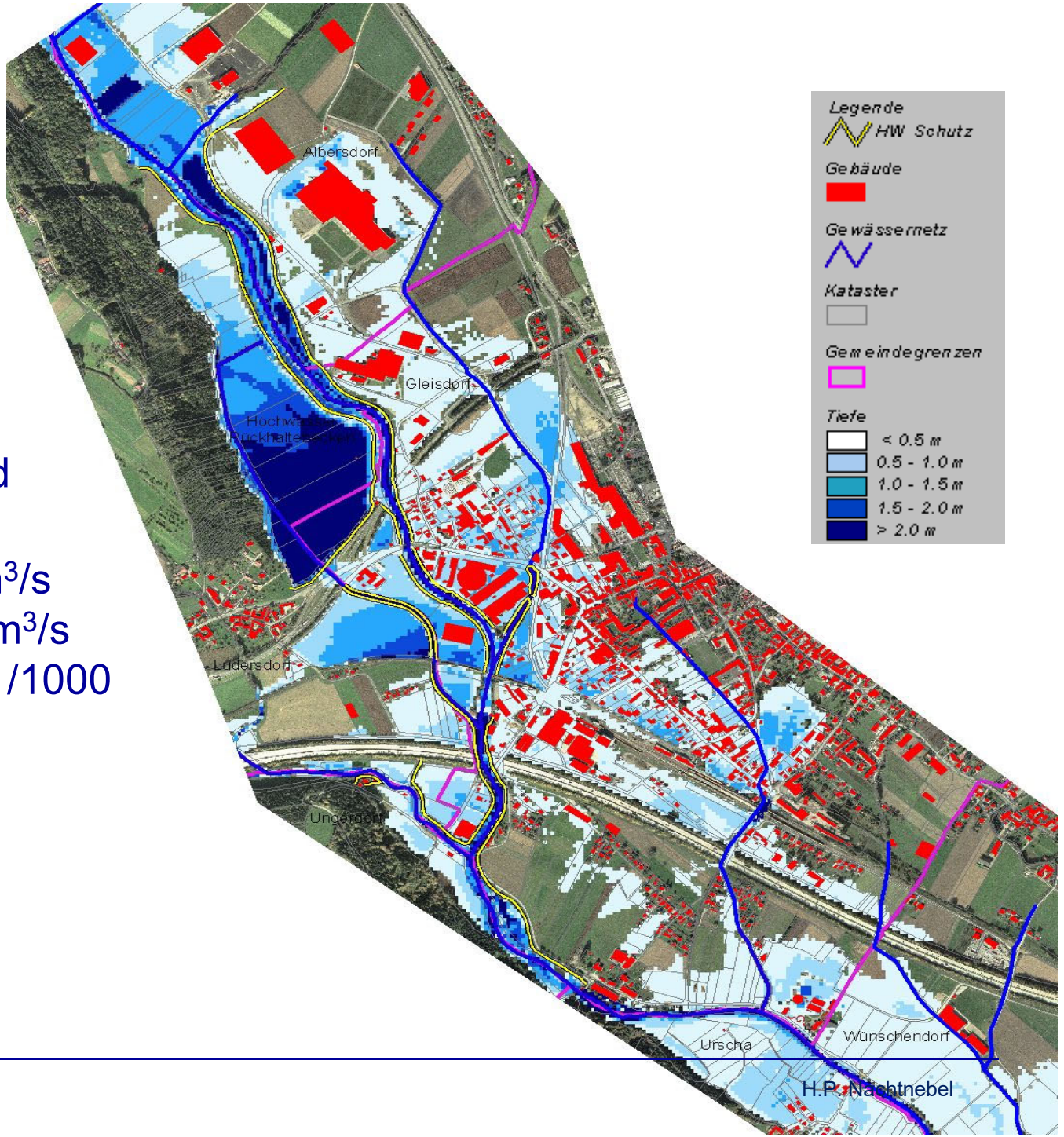
Scenario 4

inundation area and depth
Raab: Q_{max} = 245 m3/s
Rabnitz: Q_{max} = 56 m3/s
flood probability:~ 1/300



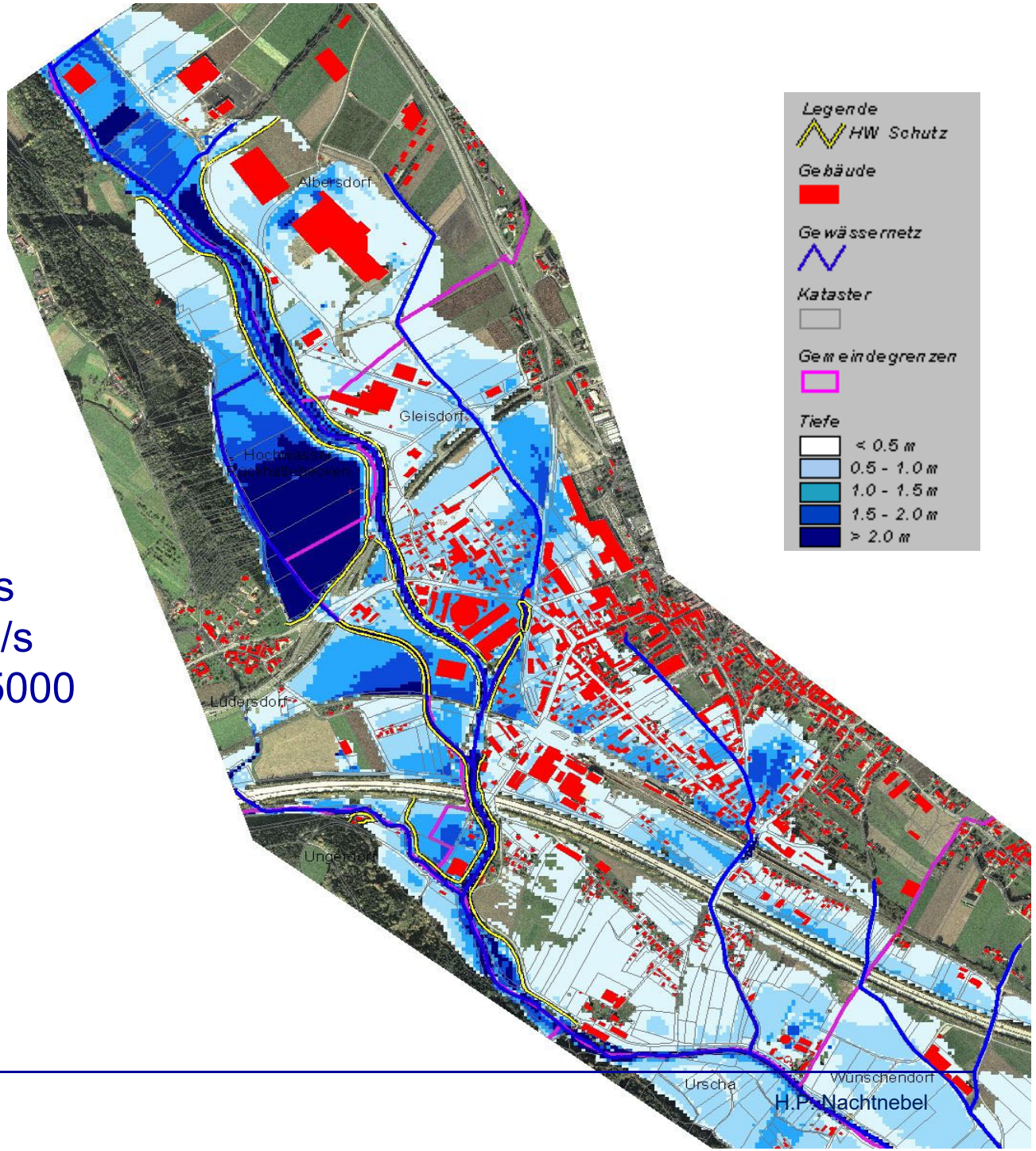
Scenario 5

Inundation area and depth
Raab: Q_{max} = 310 m^3/s
Rabnitz: Q_{max} = 82 m^3/s
flood probability: ~ 1/1000



Scenario 6

Inundation area and depth
Raab: Q_{max} = 400 m^3/s
Rabnitz: Q_{max} = 97 m^3/s
flood probability: ~ 1/5000



Impacts according to EU-FRD

- ‘flood risk’ combines the probability of a flood event and of the potential adverse consequences for human health, the environment, cultural heritage and economic activity (Directive 2007/60/EC).
- Conclusion: D(Q) is a vector $\vec{D}(Q)$

Classification of damages (vulnerability)

- Direct / Indirect damages
- Tangible / Intangible damages

From an insurance perspective

- insurable private damages
- damages of public property
- non-insurable damages

How to evaluate the potential damages

Typology of flood damages

(Messner et al. 2006, Penning-Rowsell et al. 2003, Smith and Ward 1998)

		Measurement	
		Tangible	Intangible
Form of damage	Direct	Physical damage to assets: Buildings Contents Infrastructure	Loss of life Health effects Loss of ecological goods
	Indirect	Loss of industrial production Traffic disruption Emergency costs	Inconvenience of post-flood recovery Increased vulnerability of survivors

Impact assessment domains

- Private sector
- Industrial sector
- Public sector

Impacts to people

Impact category	Indicator	Measurable quantity
humans	Physical health Psychological health	# of fatalities and injured people % of concerned population, # of evacuated people, restriction on energy, traffic, communication systems

Impacts on properties (€)

Impact category	Indicator	Measurable quantity
Private and public buidings	objects content	# of classified buildings, insured value, market value % of equipment
Industries, commercial sector	buidlings equipment stock production	# of objects, insured value, market value Damages of equipment, machinery Damages of material stock Duration of interrupted prodcution, income losses, Losses in market position
agriculture	Buildings Technical quipment Arable and stocks Production	# of buildings and damages Agricultural machinery Area of arable land and meadows Losses in stocks Harvesting losses, losses in life stock
forestry	forests Protective functions	Inundated forest area (ha) Losses in protective functions
hydraulic infrastructure	Protective structures Duration of losses of protective functions	Costs to re-establsh original state Risk due to non functioning structures

Societal impacts

Impact category	Indicator	Measurable quantity
Societal structures	Social services	Duration of non-functioning of social structures (supply chains, communication lines, service lines, education, health service, …
	Economic services	reduced investment, losses in competition
Cultural monuments	Objects	# and % of damages, uniqueness of monuments

Impacts on quality of life

Impact category	Indicator	Measurable quantity
Losses of daily environment	Typical scenery	# of destroyed typical objects
Well being	Subjective well being	Intensity and duration of unsetteldness
traffic	Type of transport Transport infrastruct. Transportation time	Means of transport (road, trains, public, private Damage costs to re-establish regular transport Losses in frequency of transport and increased transp. time
Emergency measures and post-recovery	Emergency actions Evacuation actions Recovery measures Concerned people	# and days of involved persons Volume of transported material Costs # of affected people

Environmental impacts

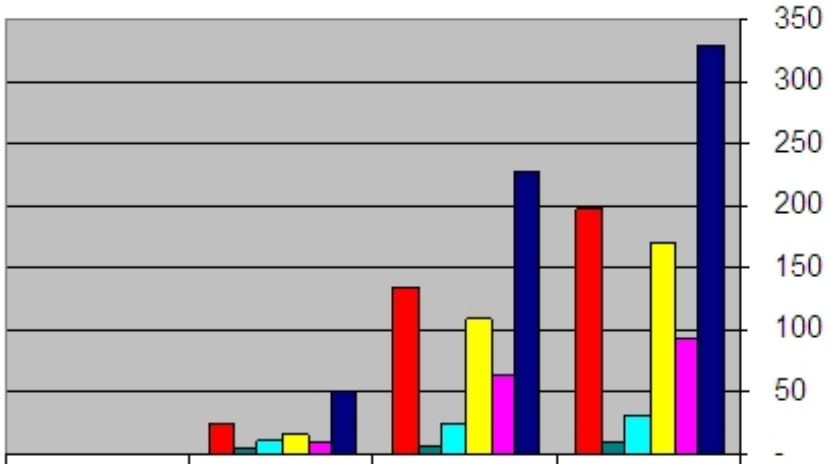
Impact category	Indicator	Measurable quantity
water	Quality	Level of water pollution
	Quantity	Volume of polluted water bodies
soil	Quality	Level of soil contamination
	Quantiy	Volume of polluted soils
air	Quality	Level of air pollution due to emissions
fauna	species	# of animals
	Population	% of population
flora	species	# of plant species
	Population	Damaged sensitive area

Estimation of the damages

- Detailed estimation considering each object
  - object (structure, infrastructure ...)
  - contents (equipment ...)
  - Induced damages
- General estimation based on empirical data
  - Population density
  - Density of objects
  - Standard cost functions
- Ex-post analysis of reported damages

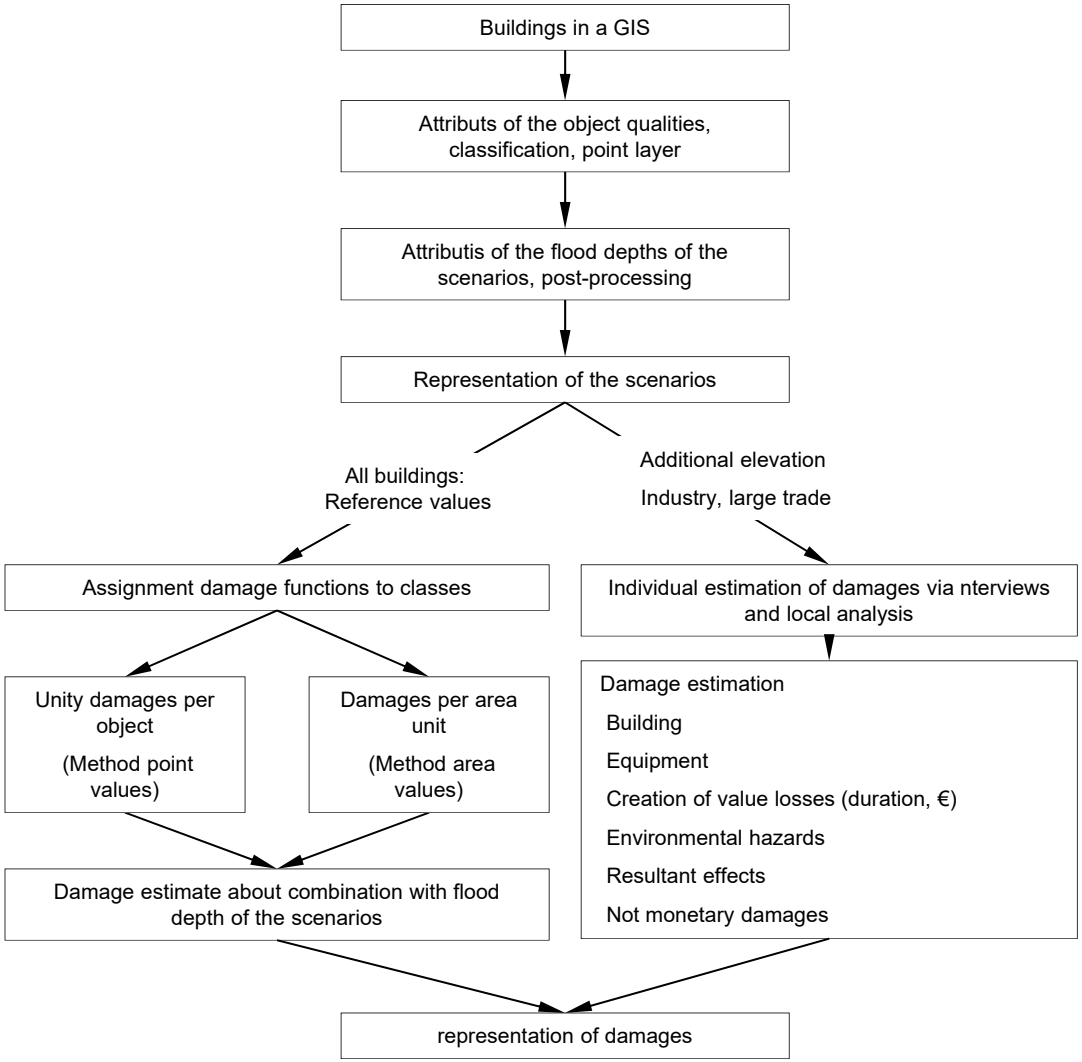
Exposition in different scenarios

of exposed objects



	Szenario 2	Szenario 4	Szenario 5	Szenario 6
total	1	49	228	330
Offices and commercial buildings	0	8	63	93
Garages and sheds	0	17	109	170
Industrial firms	0	11	24	31
Agricultural bldgs.	0	4	7	8
Residential blgds.	1	26	134	198

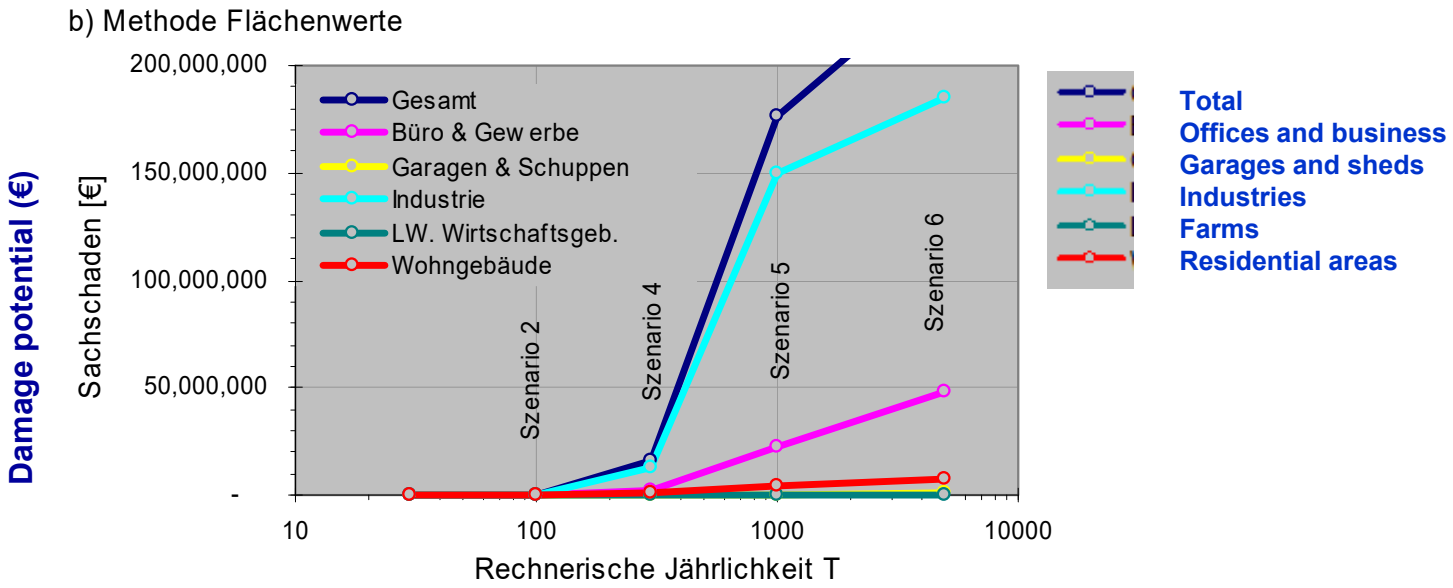
Damage potentials



Damage functions for private buildings in €

Classification of buildings BUWAL (1999) & BWG (2002)	Low intensity: inundation depth ≤ 0,5 m		Medium intensity: inundation depth > 0,5 m	
	a) Per building	b) Per square unit m^2	a) Per building	b) Per square unit
One- and two family houses	8.402	90	44.810	532
Multi-family houses	11.202	106	50.411	588
Commercial buildings	28.006	308	140.031	1.400
Industrial buildings	33.607	375	196.043	1.960
stables	2.801	62	22.405	294
Utility sheds	1.120	11	8.402	115

Cumulative damages in different scenarios (areal values in €)



Damage data for residential buildings, garages, agricultural buildings are comparable (lpoint and areal values)

It is difficult to estimate correctly the areas used for industrial and commercial activities.

Damage depends also on the production sector.

Damages of technical infrastructure

- Roads
- Energy supply systems
- Communication systems
- Water supply and sanitary systems

Highways	2.200 – 4.400 € / lfm		
	Terrain		
In € / lfm	Flat land	hilly	mountainous
Federal roads	600	950	1.350
Regional roads	450	900	1.200
Local roads	450	750	1.000
Acess roads (agri, forestry)	10	80	150
Bridges		880 – 1.100 € / m^2	
culverts		950 – 1.250 € / m^2	

Classification of damages of enterprises

Property damages

Building, heating systems, electric and electronic infrastructure.

Vehicles

Goods, products, stock levels

Operating equipments, EDP ...

Loss due to service interruption: losses in sales volume and profit

Location disadvantages

Environmental consequences

Damage potentials in industrial sectors:

Damage types
- damages of property
- losses in production
- competitional disadvantages
- subsequent damages

...

Analysis at the site
- Information (presentation, informative material, distribution of a questionnaire)
- Contacting technical managers
- Common inspection
- Damage estimation.

Estimation of damage potentials

Questionnaire

1st what can happen?

Einwirkungen	Mögliche Einwirkungen bitte ankreuzen & ausfüllen	
Überflutung, Beschädigung von	Büros	☐
	Lagerflächen	☐
	Produktionsflächen, Produktionseinrichtungen	☐
	Verkaufsflächen	☐
	Heizung	☐
	Klimaanlage, Lüftung, Strom	☐
	Fahrzeugen	☐
		☐
		☐
		☐
		☐
Freisetzung von	Öl	☐
	Chemischen Substanzen	☐
		☐
		☐
		☐
Weitere Folgewirkungen		☐
		☐
		☐
		☐

2nd description in monetary units

Schadensart	Hilfsgrößen		Schäden [€]
Gebäude	Wert (Versicherungssumme etc.) W_G		
	Schadensgrad S_G		
	Z.B. $W_G * S_G$		
Einrichtung, Anlagen, Betriebsmittel...	Wert (Versicherungssumme etc.) W_E		
	Schadensgrad S_E		
	Z.B. $W_E * S_E$		
Reinigung, Kontrolle, Instandsetzung, Austausch			
Weitere Schadenskosten			
Wertschöpfungs-Verluste	Geschätzte Dauer Betriebsunterbrechung		
	Umsatz (s. Bilanz) in Unterbrechungsdauer		
	Gewinn (s. Bilanz) in Unterbrechungsdauer		
	Alternativ		
Summe der Schadenskosten			

3rd mitigation

Gibt es Möglichkeiten zur Verbesserung? Bitte ankreuzen.

Ja	Nein	Thema nicht relevant
☐	☐	☐

Welche Vorsorgemaßnahmen kommen in Frage?

Damage potential in the industrial sector: Results from interviews

10 companies responded
among them the 4 largest ones:

- Management and insurance companies are interested
- one company: internal mitigation measures
- some of them have an insurance: property and losses in production
- sensible topic (losses when the companies vulnerability would be identified from outside)
- difficult to get reliable response from the companies

Summary and conclusions

- Flood risk analysis
- Flood risk assessment methodology for the city of Gleisdorf
- Generation of scenarios
- A methodology for the assessment of damages (consideration of national and international documents)
- Information of the public is also required

Thank you for your attention