Zurich/Sihl Case Study Switzerland

WSL Swiss Federal Research Institute

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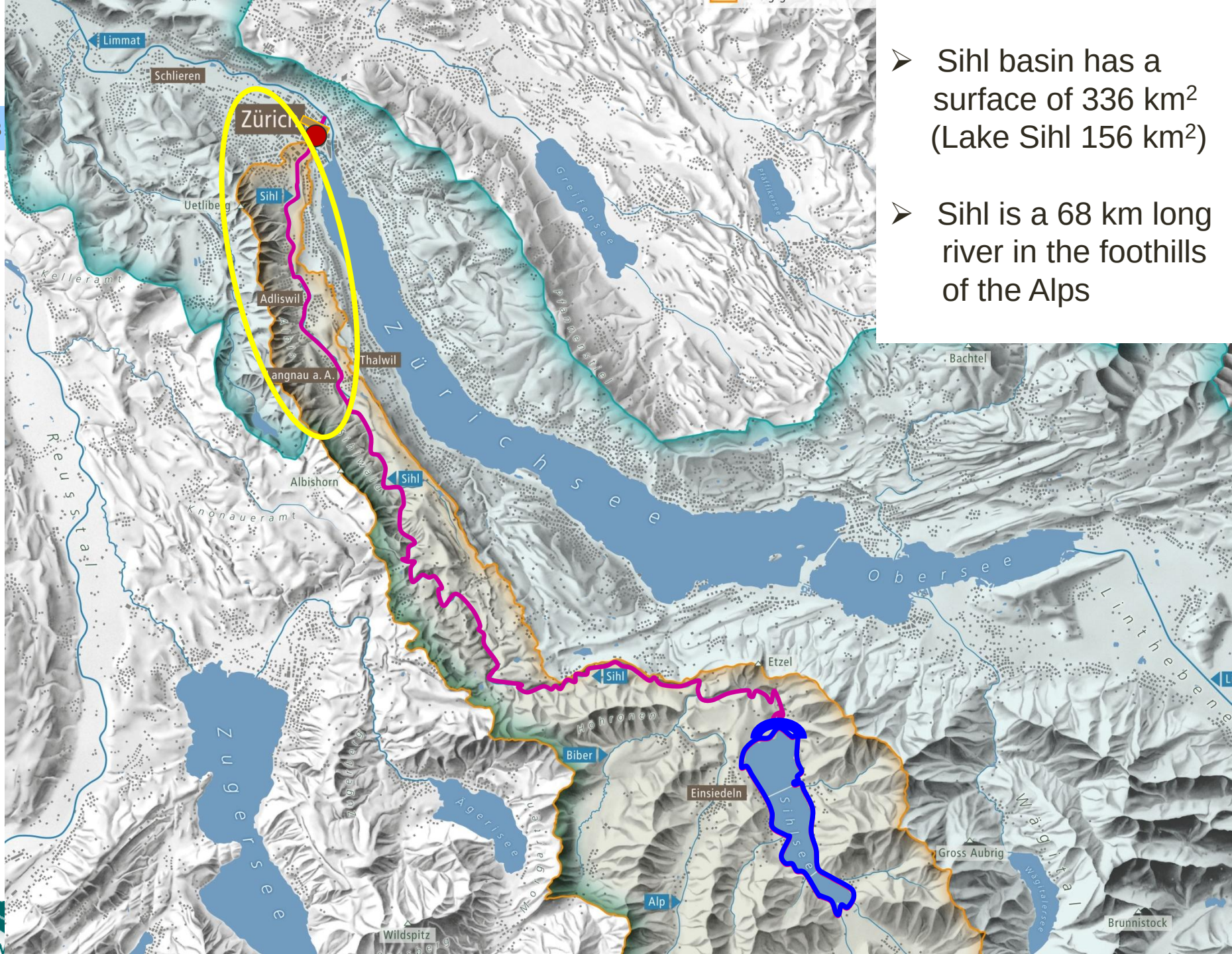
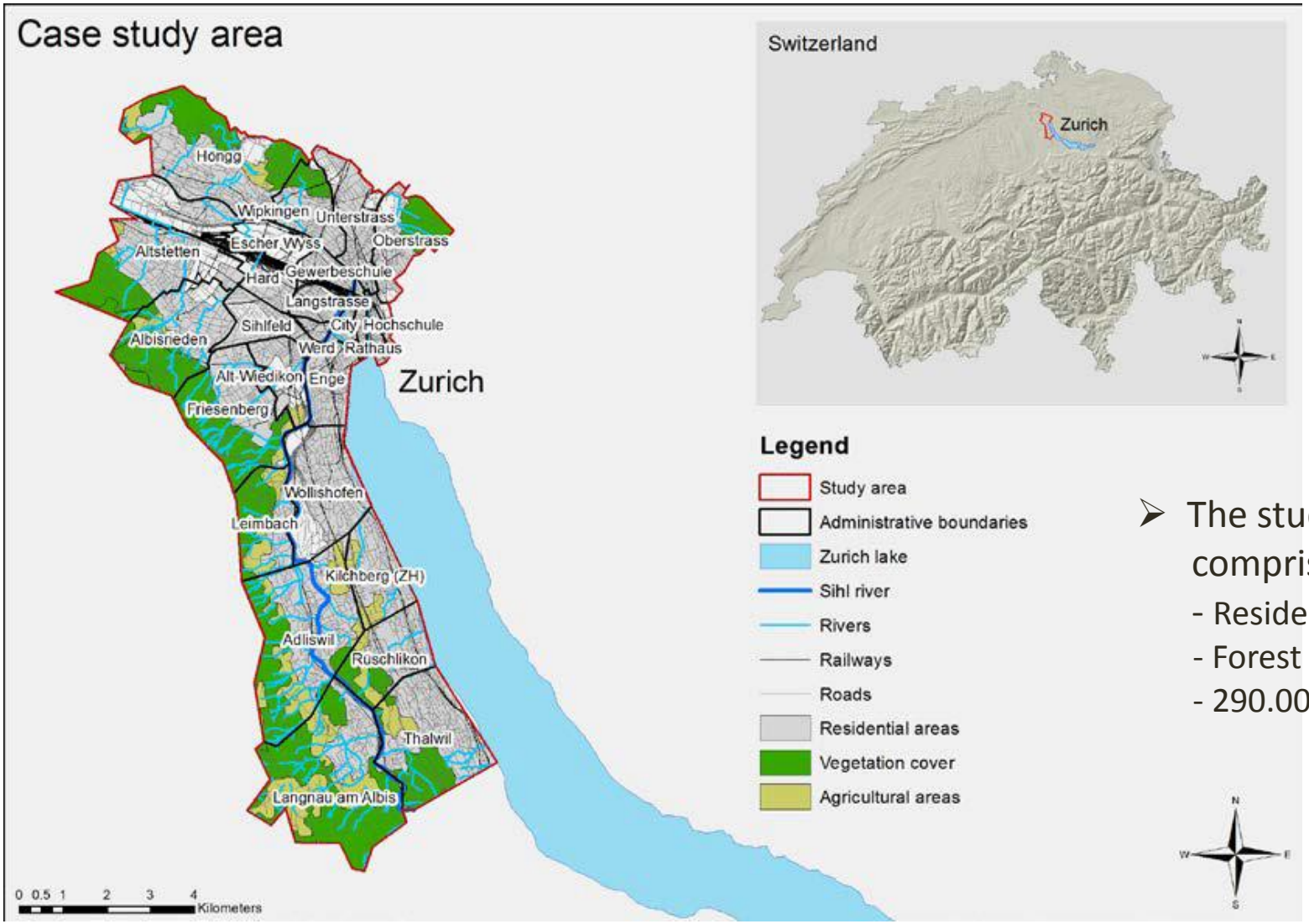
Sihl Case Study



- Sihl basin has a surface of 336 km^2 (Lake Sihl 156 km^2)
- Sihl is a 68 km long river in the foothills of the Alps

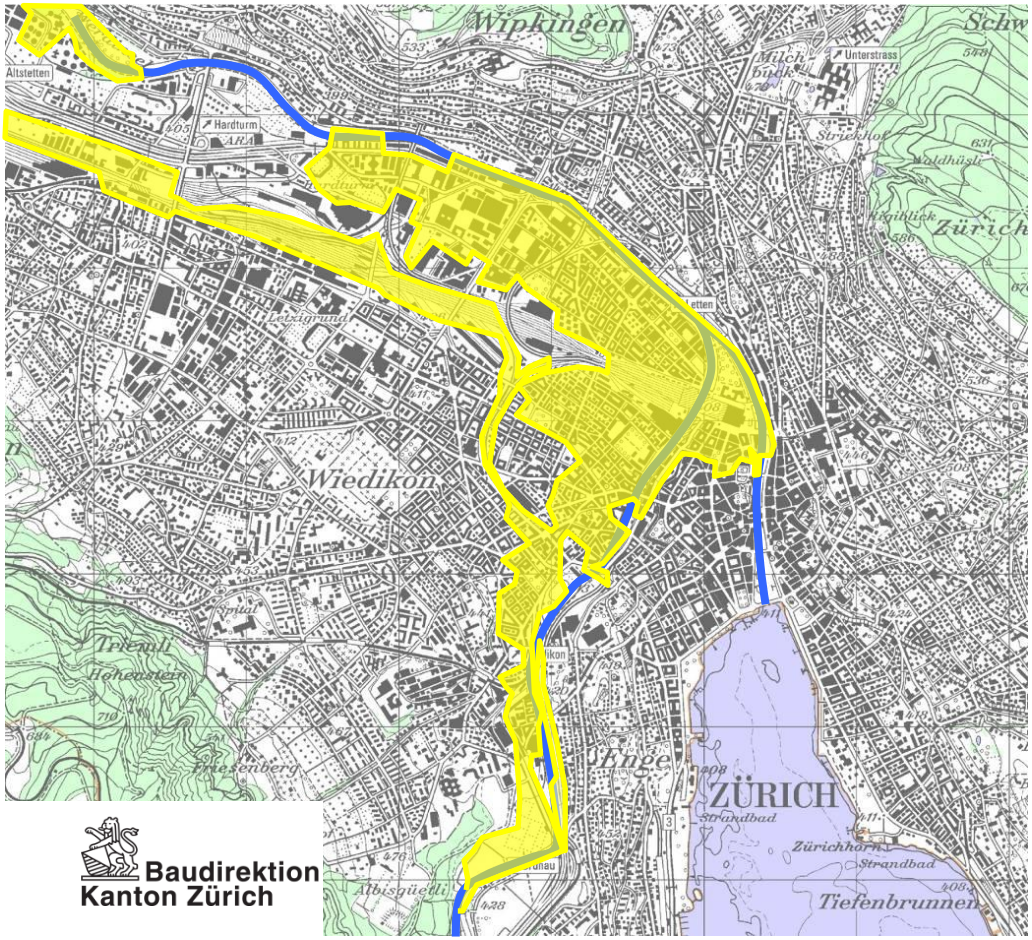
Sihl Case Study



- The study area comprises 78 km²
  - Residential area: 41 km²
  - Forest area: 20 km²
  - 290.000 residents

Sihl Case Study

Estimation of Building Department Canton Zurich; 500 years return period



- Up to 3‘600 buildings affected, hundreds of special buildings
- 4–5 km^2 flooded area
- Material damage 4.5 bn €
- Main station damage: about 400 mn €
- Fatalities possible
- Indirect damages due to interruption of infrastructure

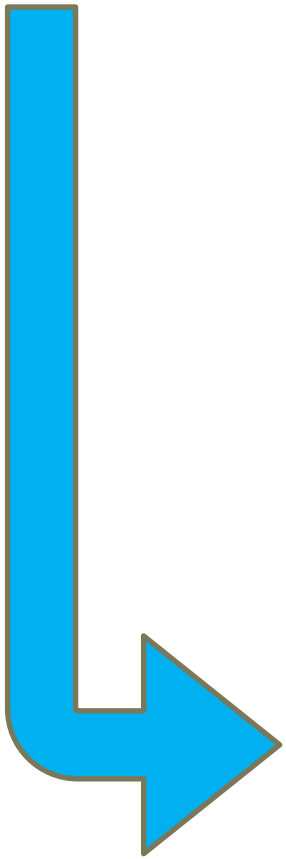
Sihl Case Study

Estimation of Building Department Canton Zurich; 500 years return period

Sihl Case Study

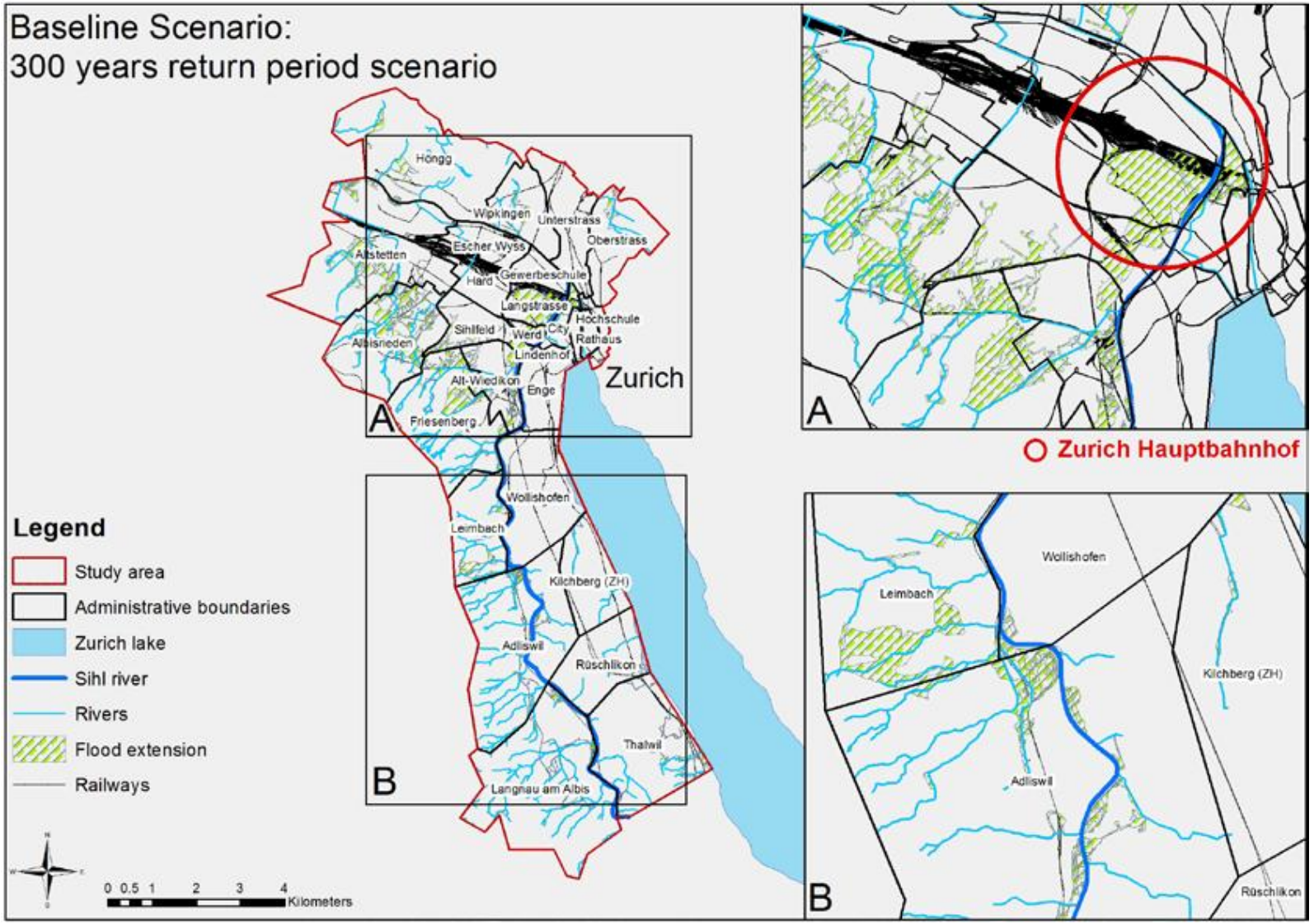
River Sihl crossing underneath Zurich main station

RRA methodology



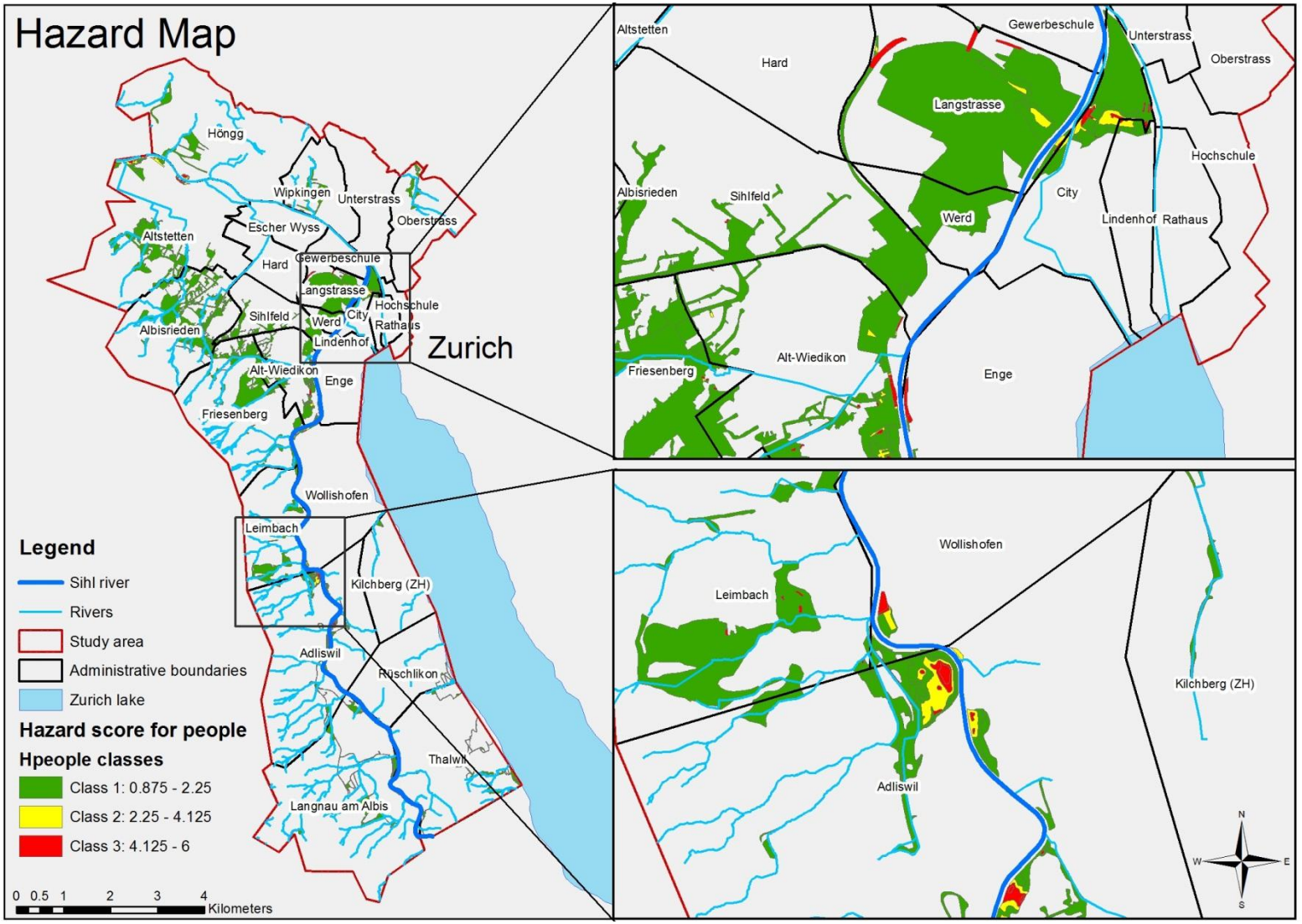
- **Flood hazard assessment** → Identify flood metrics as flow velocity, water depth, flood extension
- **Exposure assessment** → Identify localisation of the receptors potentially affected by flood event
- **Susceptibility assessment** → Evaluate degree to which receptors could be affected by flood event based on physical/ environmental site-specific information
- **Risk assessment** → Define risk index that allows to identify and classify areas, receptors and hotspots at risk

Sihl Case Study



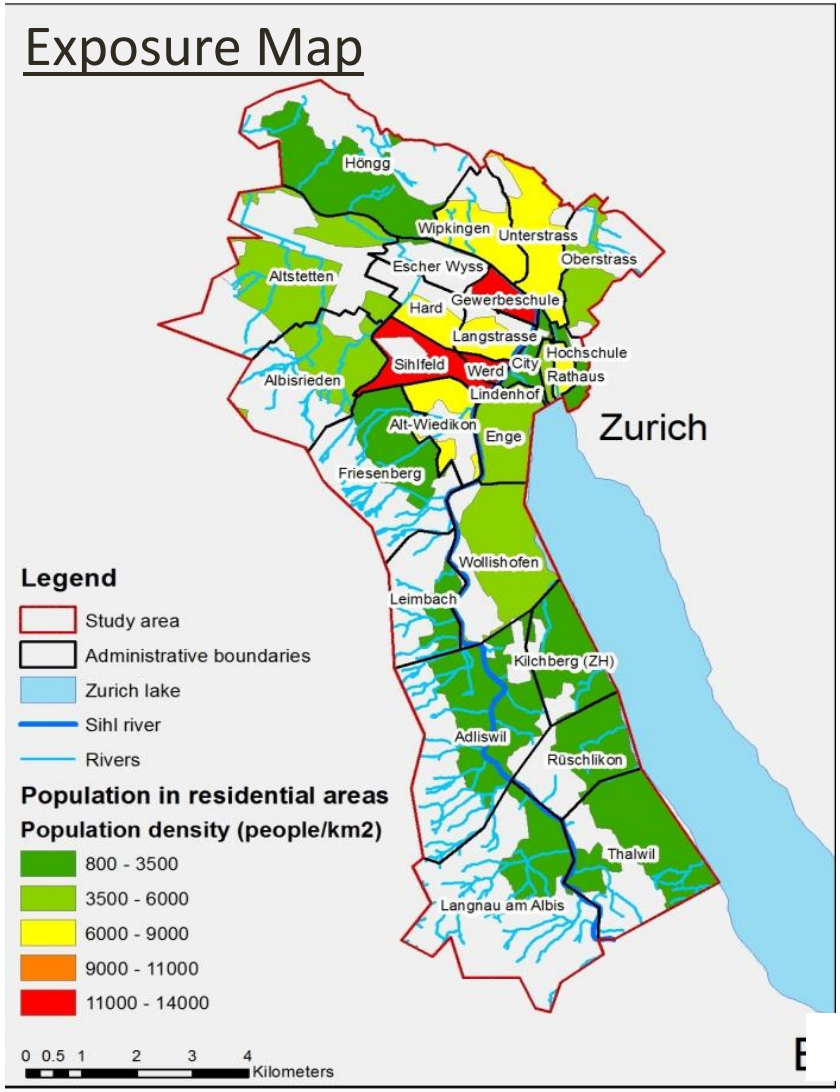
Receptor: people

Flood hazard assessment



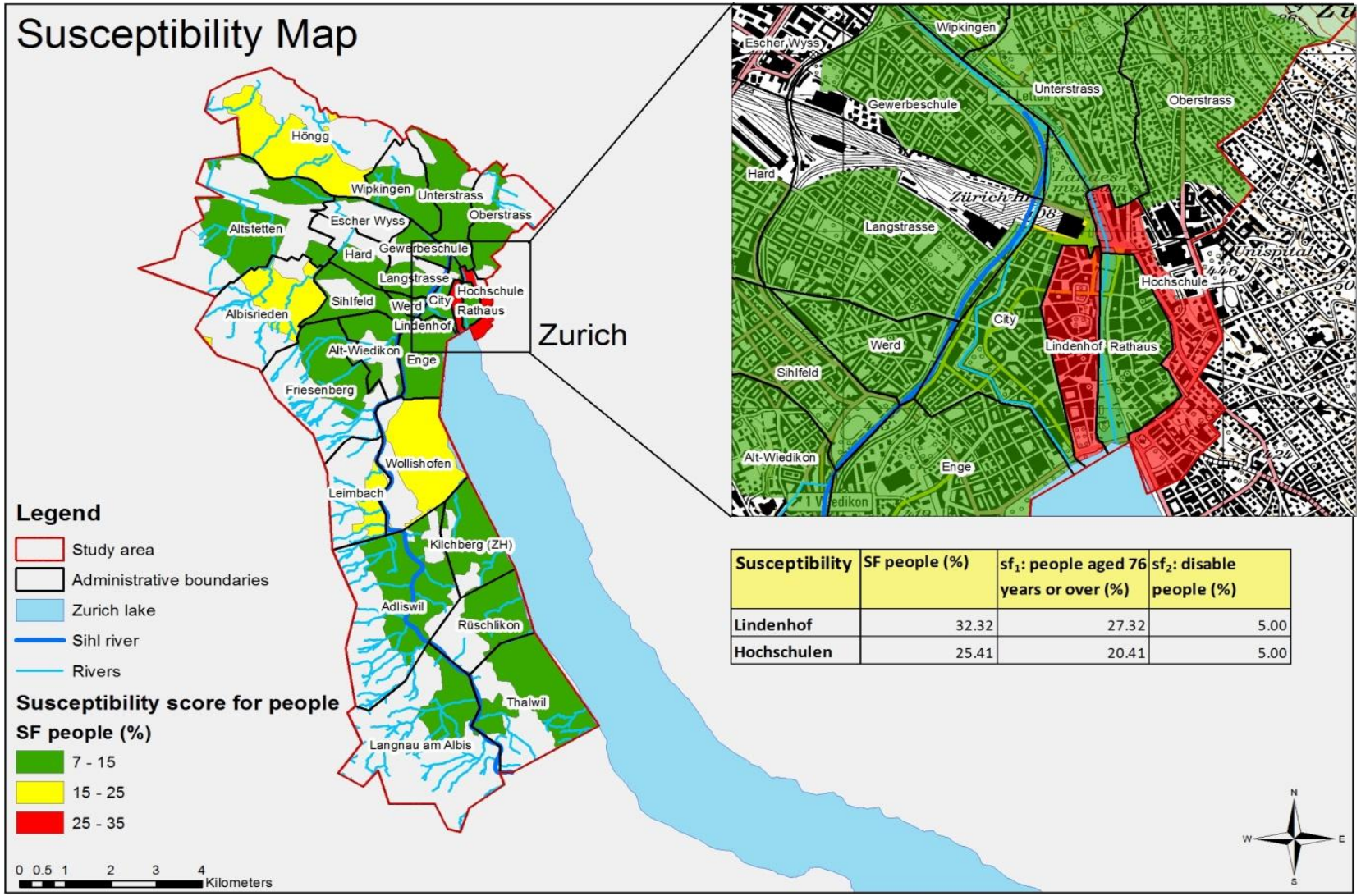
Receptor: people

Exposure assessment



Receptor: people

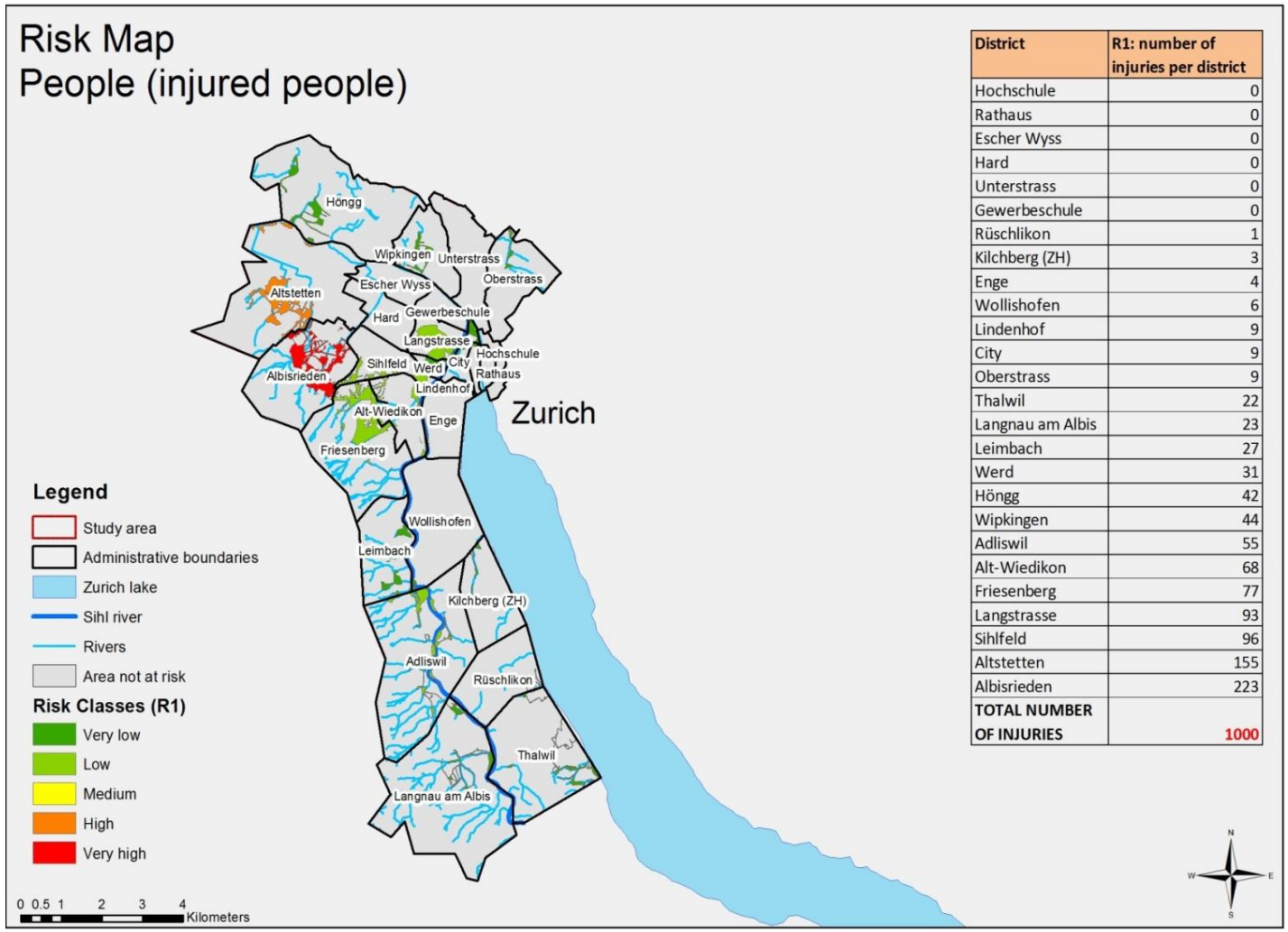
Susceptibility assessment



Susceptibility	SF people (%)	sf_1: people aged 76 years or over (%)	sf_2: disable people (%)
Lindenhof	32.32	27.32	5.00
Hochschulen	25.41	20.41	5.00

Receptor: people

Risk assessment

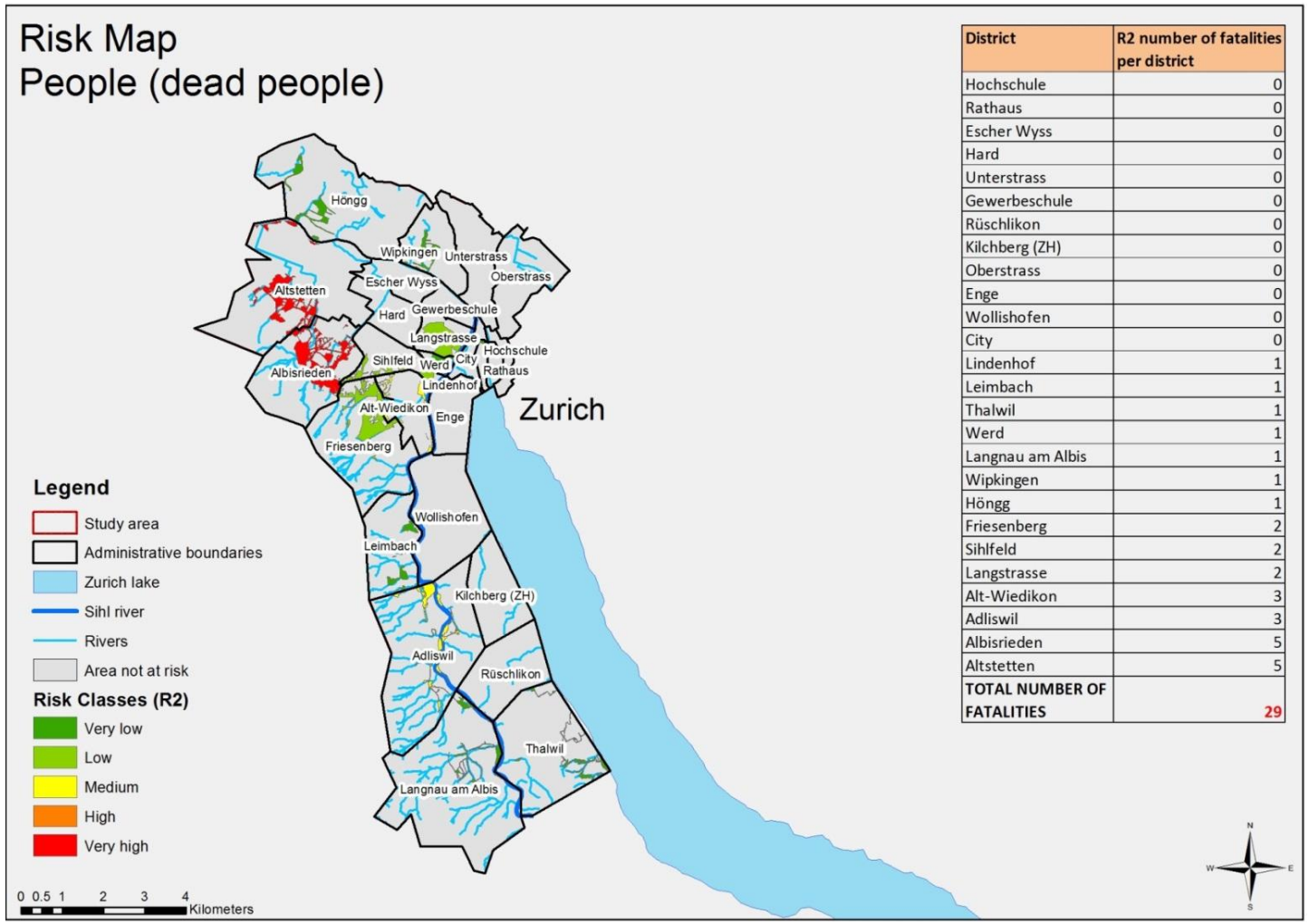


District	R1: number of injuries per district
Hochschule	0
Rathaus	0
Escher Wyss	0
Hard	0
Unterstrass	0
Gewerbeschule	0
Rüschlikon	1
Kilchberg (ZH)	3
Enge	4
Wollishofen	6
Lindenhof	9
City	9
Oberstrass	9
Thalwil	22
Langnau am Albis	23
Leimbach	27
Werd	31
Höngg	42
Wipkingen	44
Adliswil	55
Alt-Wiedikon	68
Friesenberg	77
Langstrasse	93
Sihlfeld	96
Altstetten	155
Albisrieden	223
TOTAL NUMBER OF INJURIES	**1000**

Risk Classes (R1)	Number of injuries
Very low	1 - 50
Low	50 - 100
Medium	100 - 150
High	150 - 200
Very high	200 - 250

Receptor: people

Risk assessment



District	R2 number of fatalities per district
Hochschule	0
Rathaus	0
Escher Wyss	0
Hard	0
Unterstrass	0
Gewerbeschule	0
Rüschlikon	0
Kilchberg (ZH)	0
Oberstrass	0
Enge	0
Wollishofen	0
City	0
Lindenhof	1
Leimbach	1
Thalwil	1
Werd	1
Langnau am Albis	1
Wipkingen	1
Höngg	1
Friesenberg	2
Sihlfeld	2
Langstrasse	2
Alt-Wiedikon	3
Adliswil	3
Albisrieden	5
Altstetten	5
TOTAL NUMBER OF FATALITIES	29

Risk Classes (R2)	Number of fatalities
Very low	1
Low	2
Medium	3
High	4
Very high	5

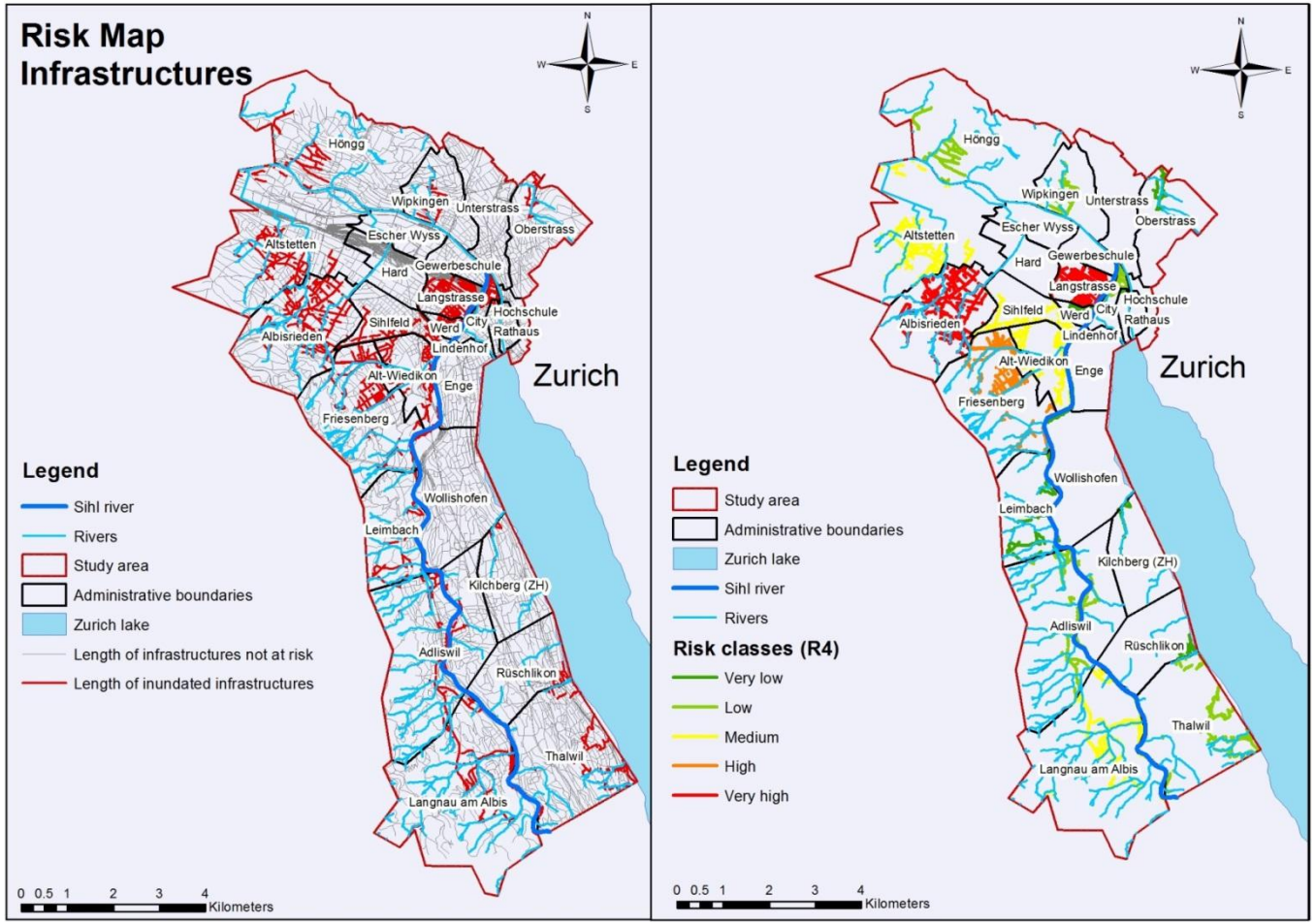
Receptor: people

Risk assessment

- Total population in the study area: 290.000
- About 1.000 injured people (0.35 %)
- About 30 fatalities (0.01%)

Receptor: infrastructures

Risk assessment



- Total length of infrastructures at risk: **210** km (55 km railways, 155 km roads/pathways (14% of total length of infrastructures within the study area)

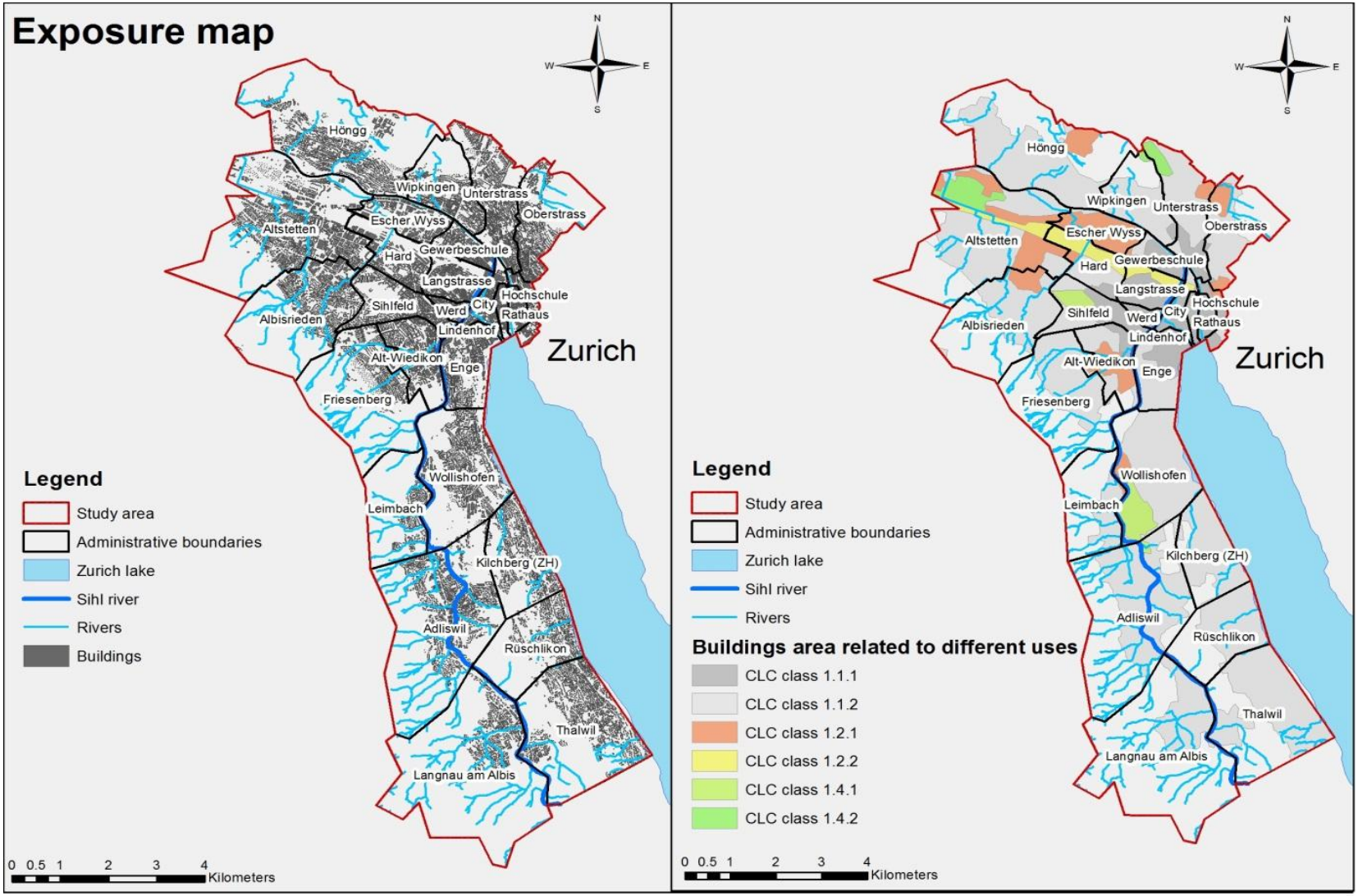
Receptor: buildings

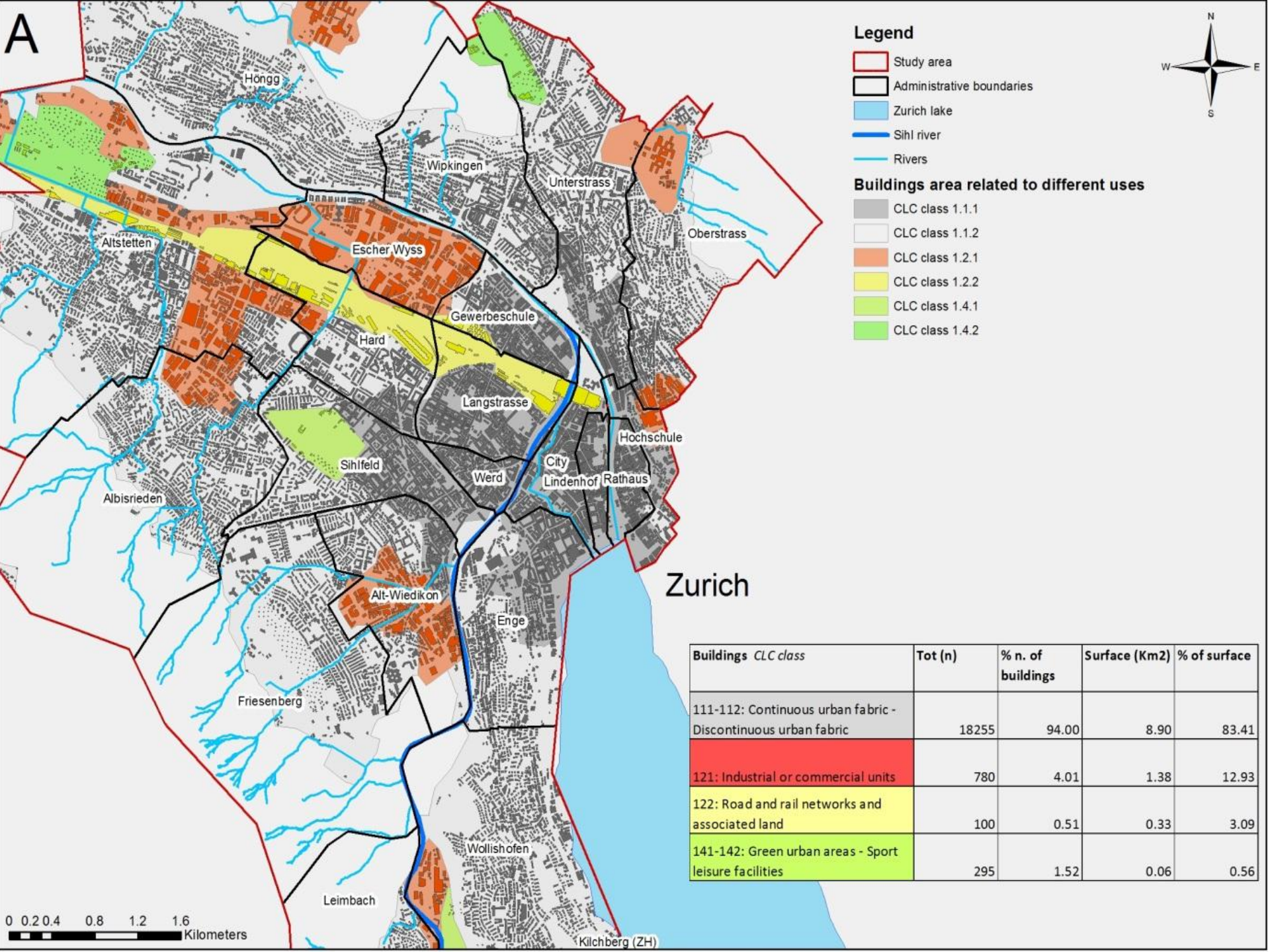
Hazard assessment

Flood hazard threshold	Building-related risk class	Definition
v ≤ 2 or v x d ≤ 3	**Inundation**	**Damage similar to that caused by a natural low-velocity river flood. No immediate structural damage.**
v > 2 and 3 < v x d ≤ 7	Partial damage	Moderate structural damage, i.e. windows and doors knocked out. Little damage to the major structural elements of the building.
otherwise	Total destruction	Total structural collapse or major damage to the structure necessitating demolition and rebuilding.

Receptor: buildings

Exposure assessment

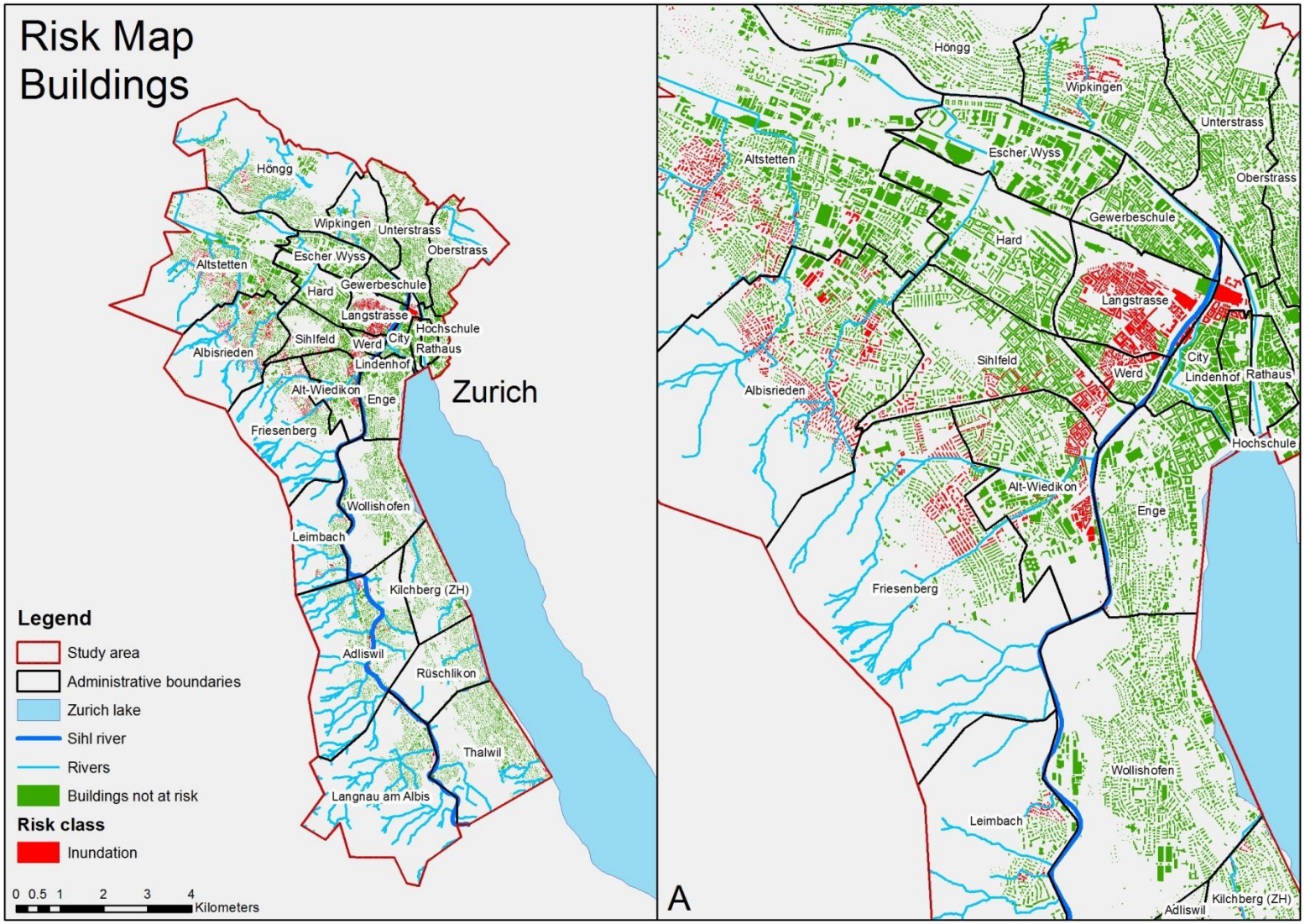




Buildings *CLC class*	Tot (n)	% n. of buildings	Surface (Km2)	% of surface
111-112: Continuous urban fabric - Discontinuous urban fabric	18255	94.00	8.90	83.41
121: Industrial or commercial units	780	4.01	1.38	12.93
122: Road and rail networks and associated land	100	0.51	0.33	3.09
141-142: Green urban areas - Sport leisure facilities	295	1.52	0.06	0.56

Receptor: buildings

Risk assessment



Receptor: buildings

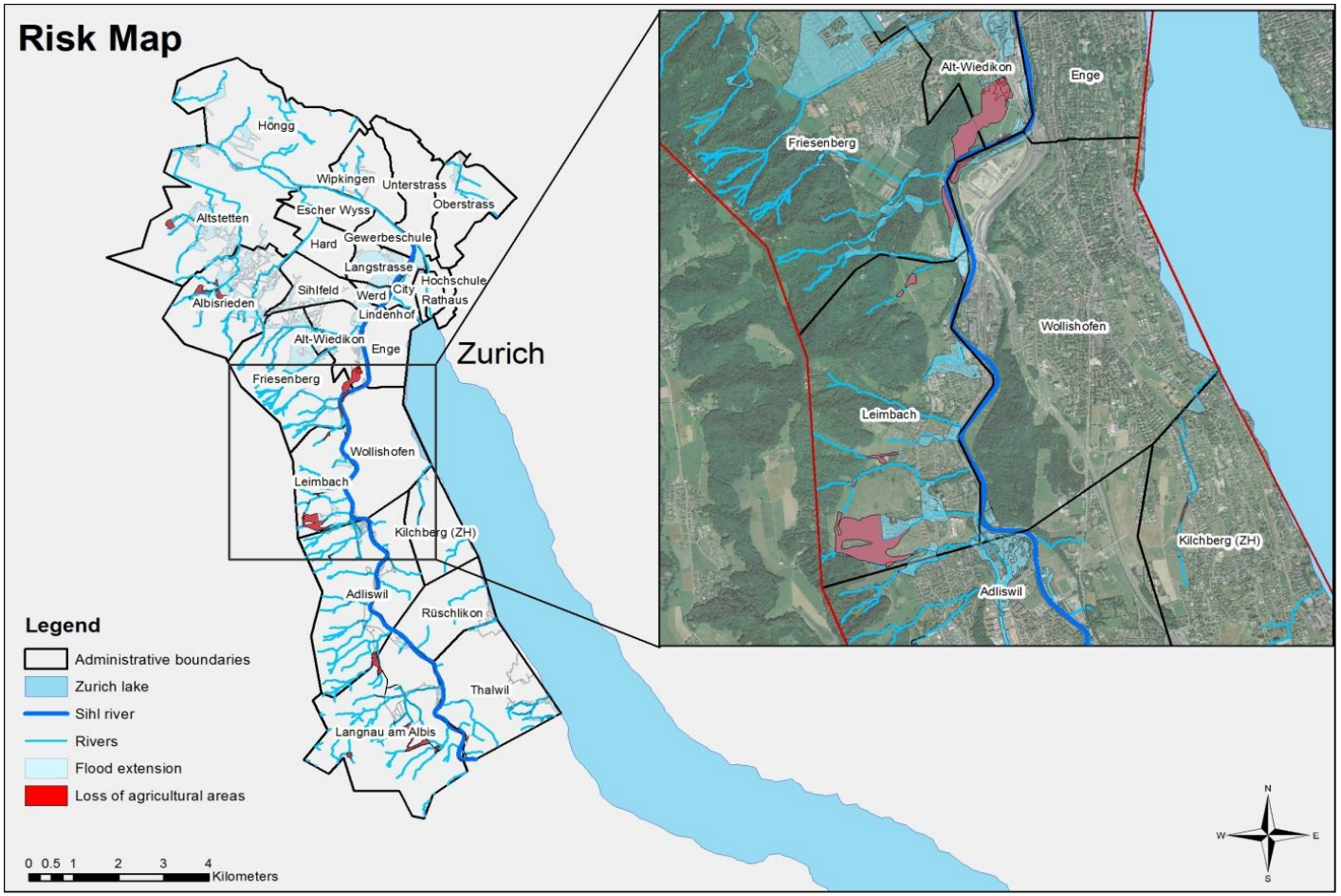
Risk assessment

- Buildings at risk: **3.267**
  (17 % of total number of buildings within the study area)

- Surface at risk: **2.2** km^2
  (20 % of total surface covered by buildings within the study area)

Receptor: agriculture

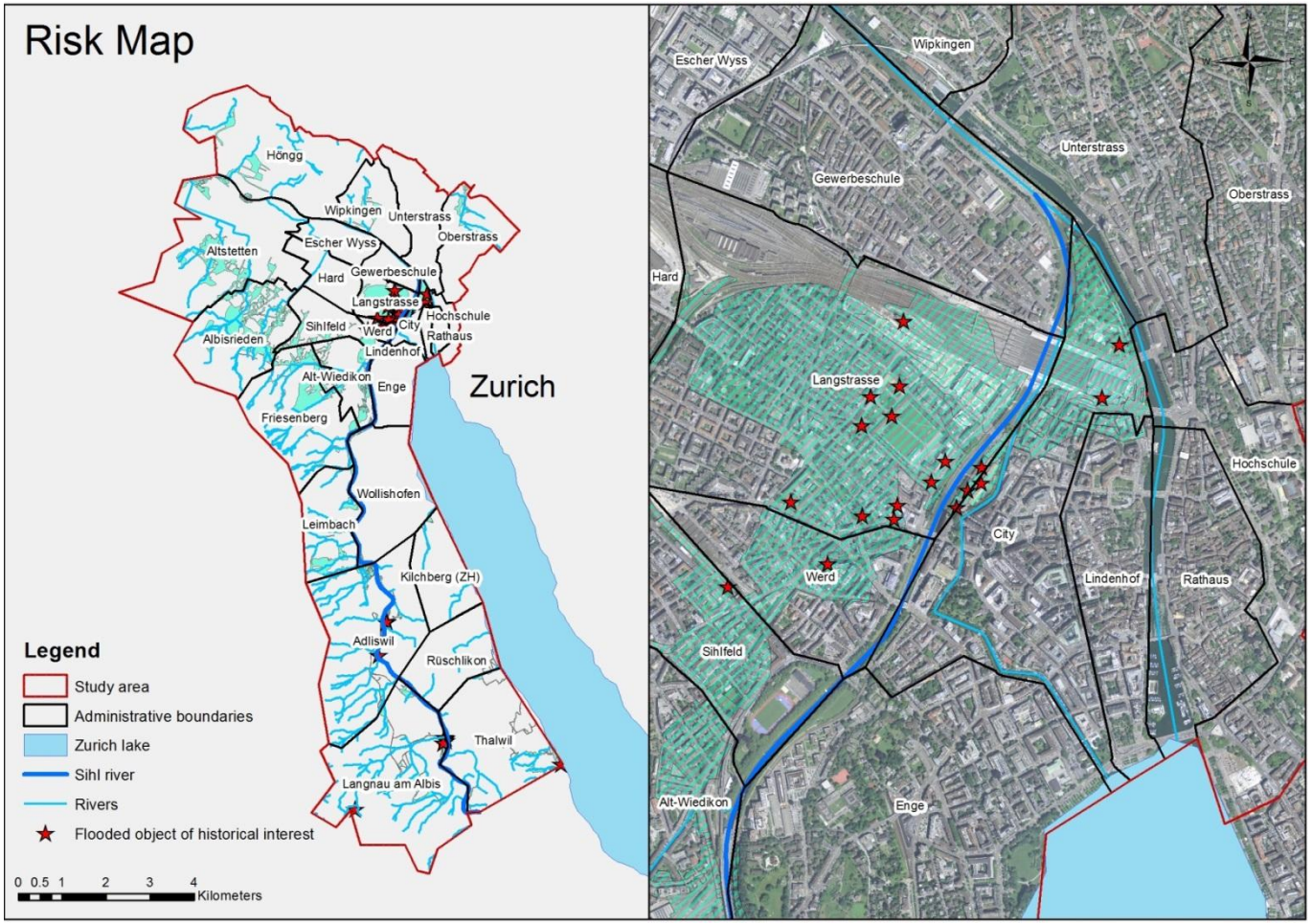
Risk assessment



- Loss of agricultural areas: **0.6** km^2
  (8 % of total agricultural areas within the study area)

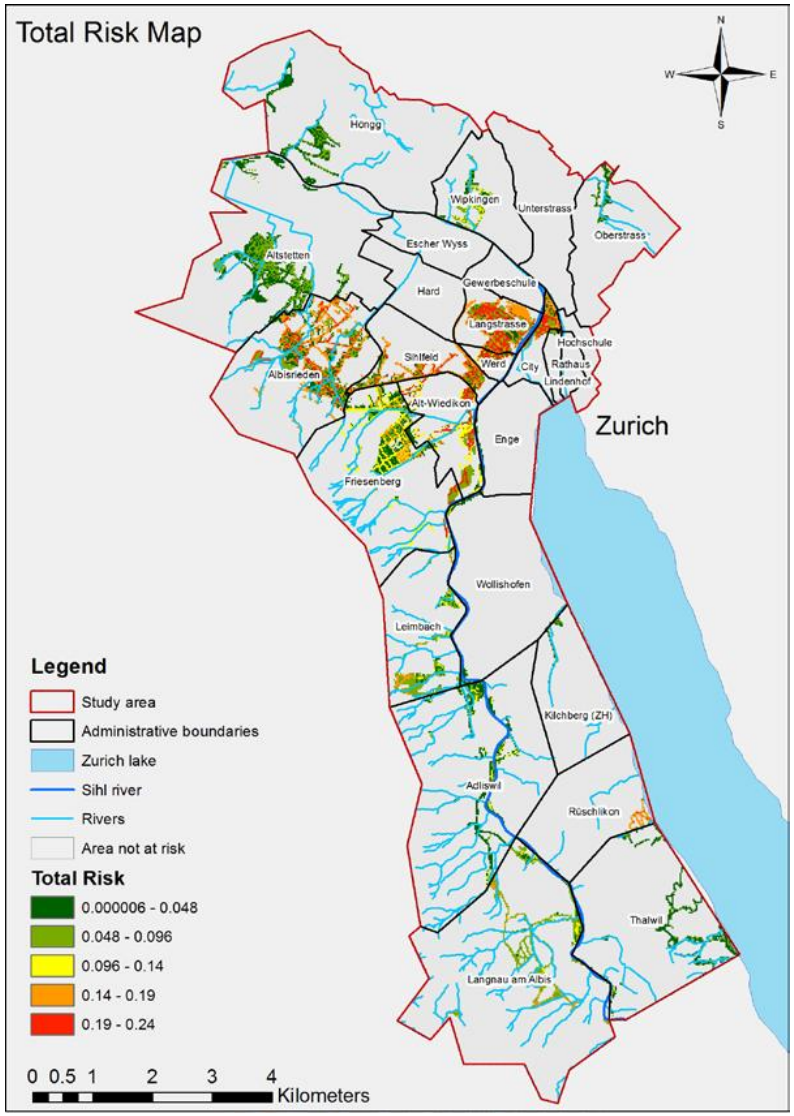
Receptor: cultural heritage

Risk assessment



- Flooded object of historical interest: **40**
  (10 % of all buildings of historical interest)

Total Risk Assessment

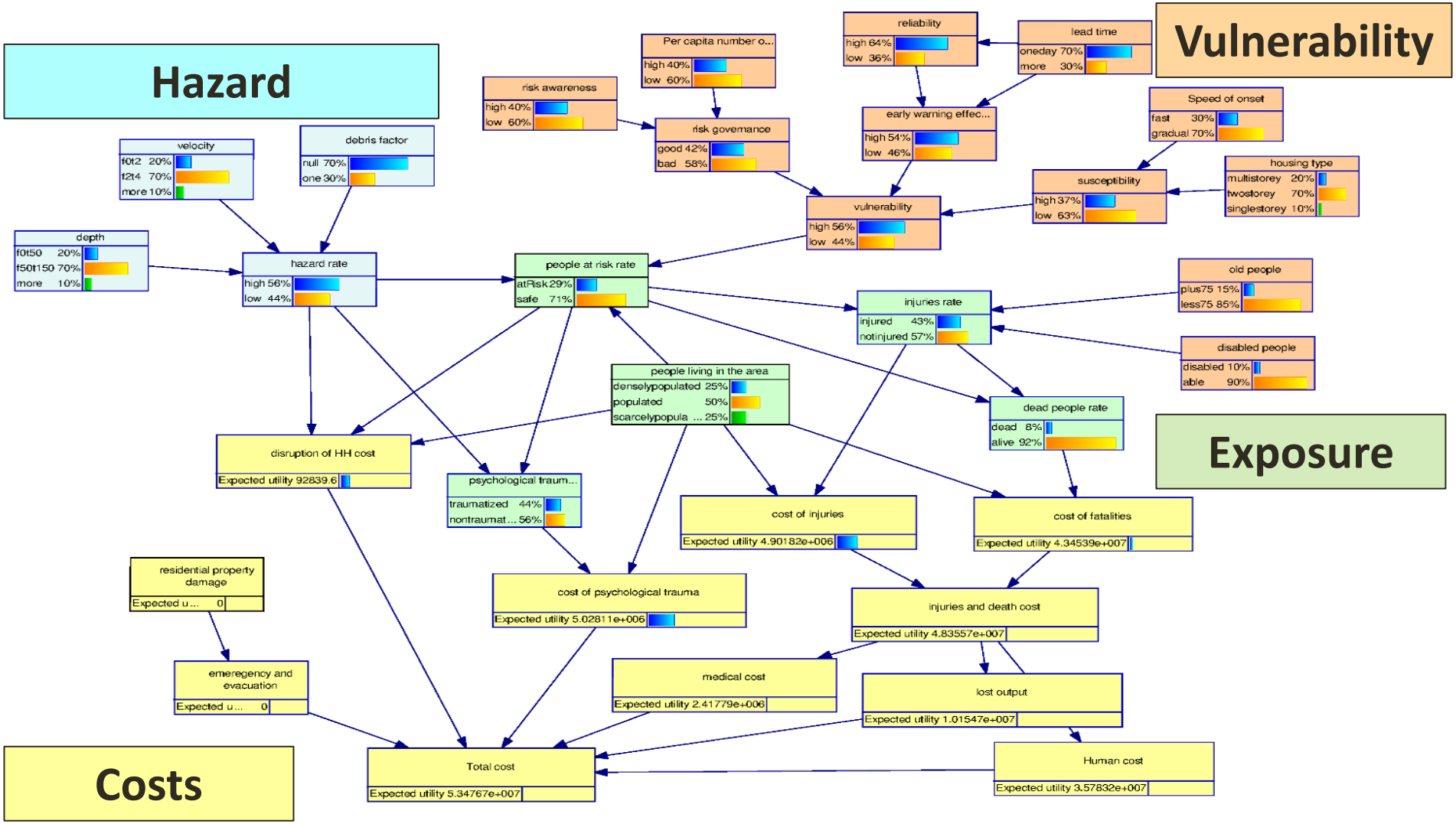


- High total risk index for city and main station confirms former analyses
- Other areas unexpectedly show a high total risk index

Receptor	Weight
Infrastructures	0.8
Buildings	0.6
People	0.4
Agriculture	0.2
Cultural Heritage	0.1
Natural /semi-natural systems	0

Outlook: Receptor people

SERRA based on Bayesian Network



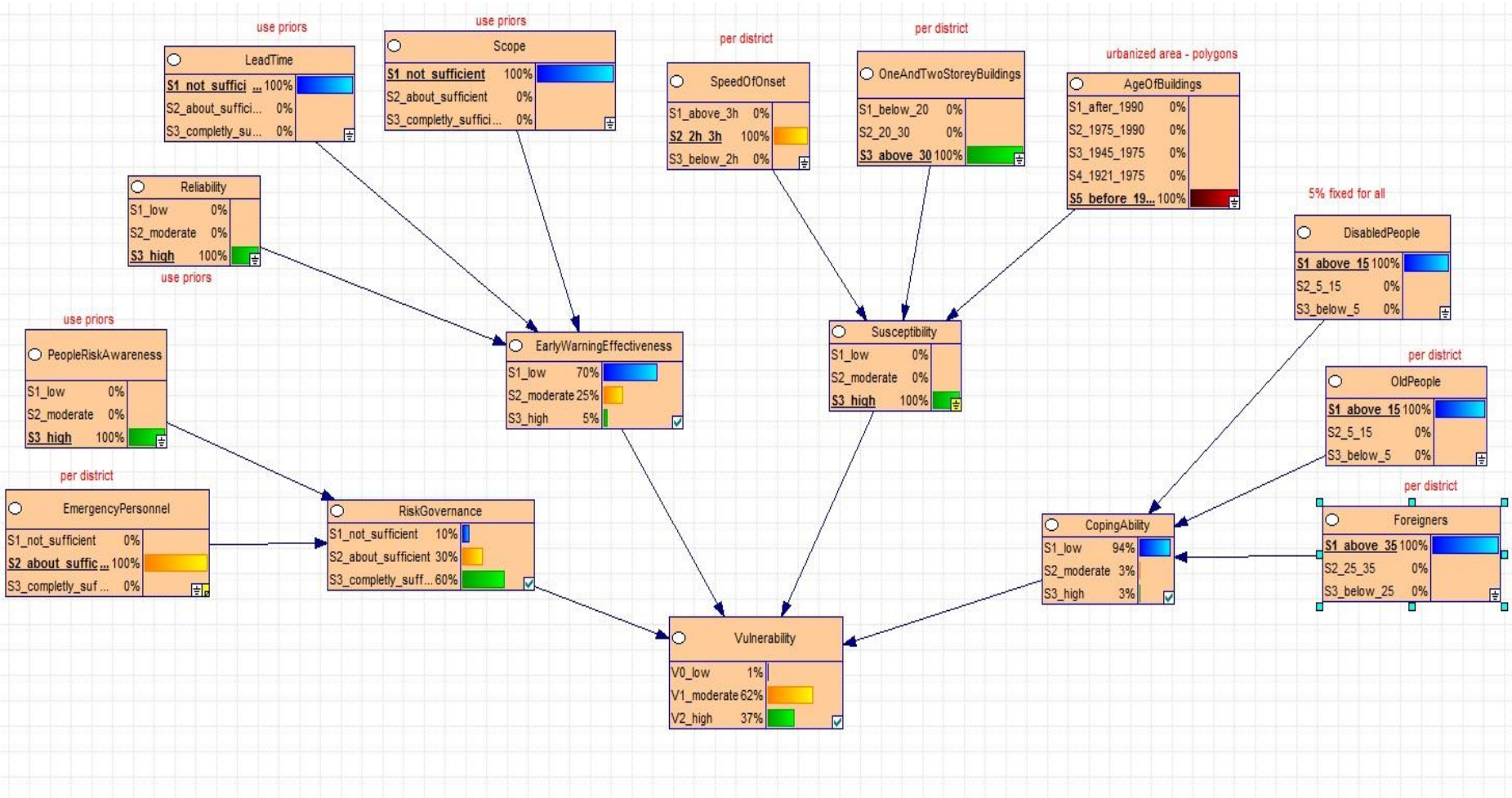
Outlook: Receptor people

SERRA based on Bayesian Network

- The networks contain probability distributions
- The probability distributions are based on the evidence given by the experts
- The automated procedure is called ‘learning’ and is meant to train the networks so that they can reproduce the opinion of the experts
- Different exposure scenarios possible (flood day/night)
- Comparative analysis with alternative scenario based on the improvement of the Early Warning System.

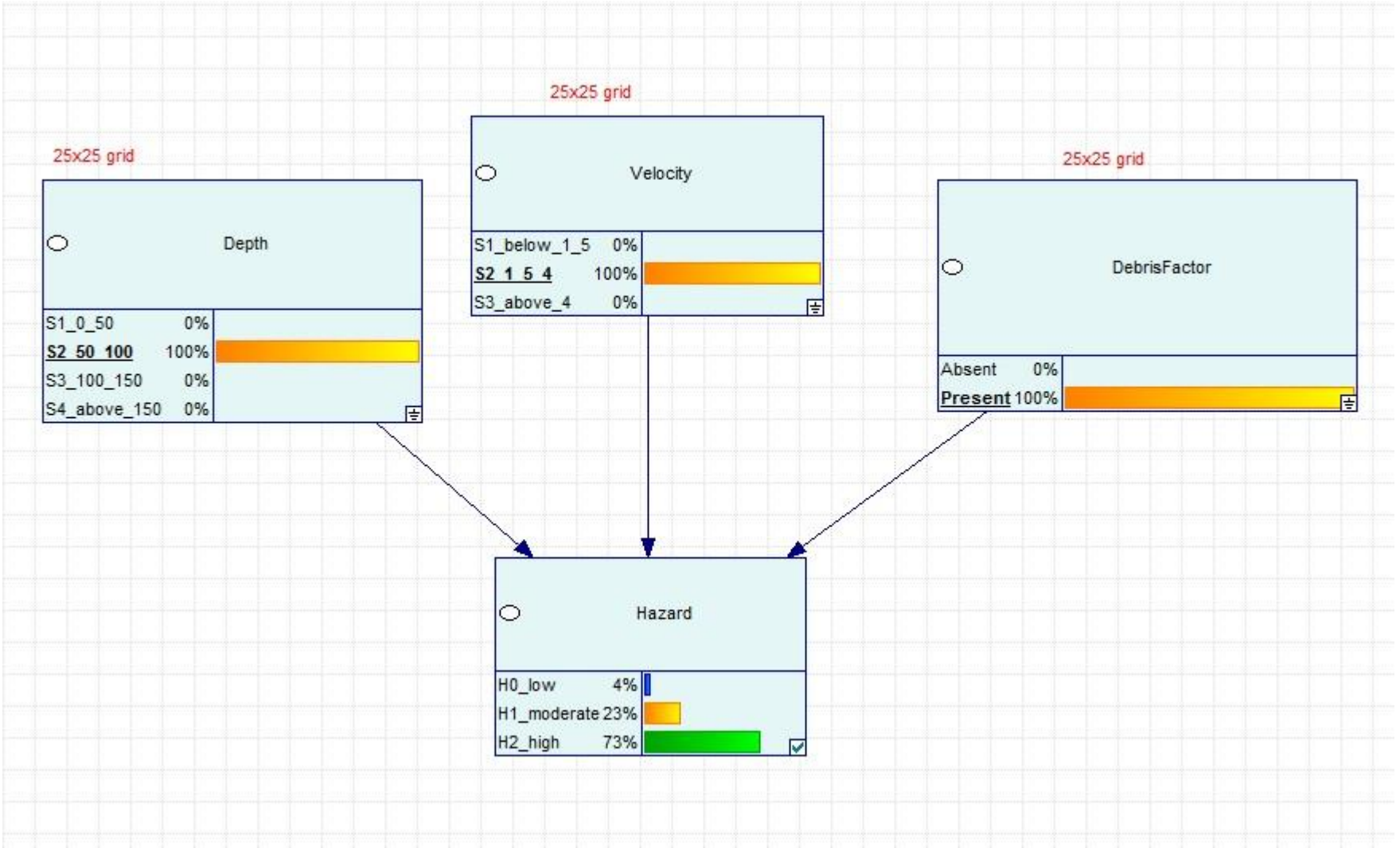
Outlook: Receptor people

SERRA based on Bayesian Network



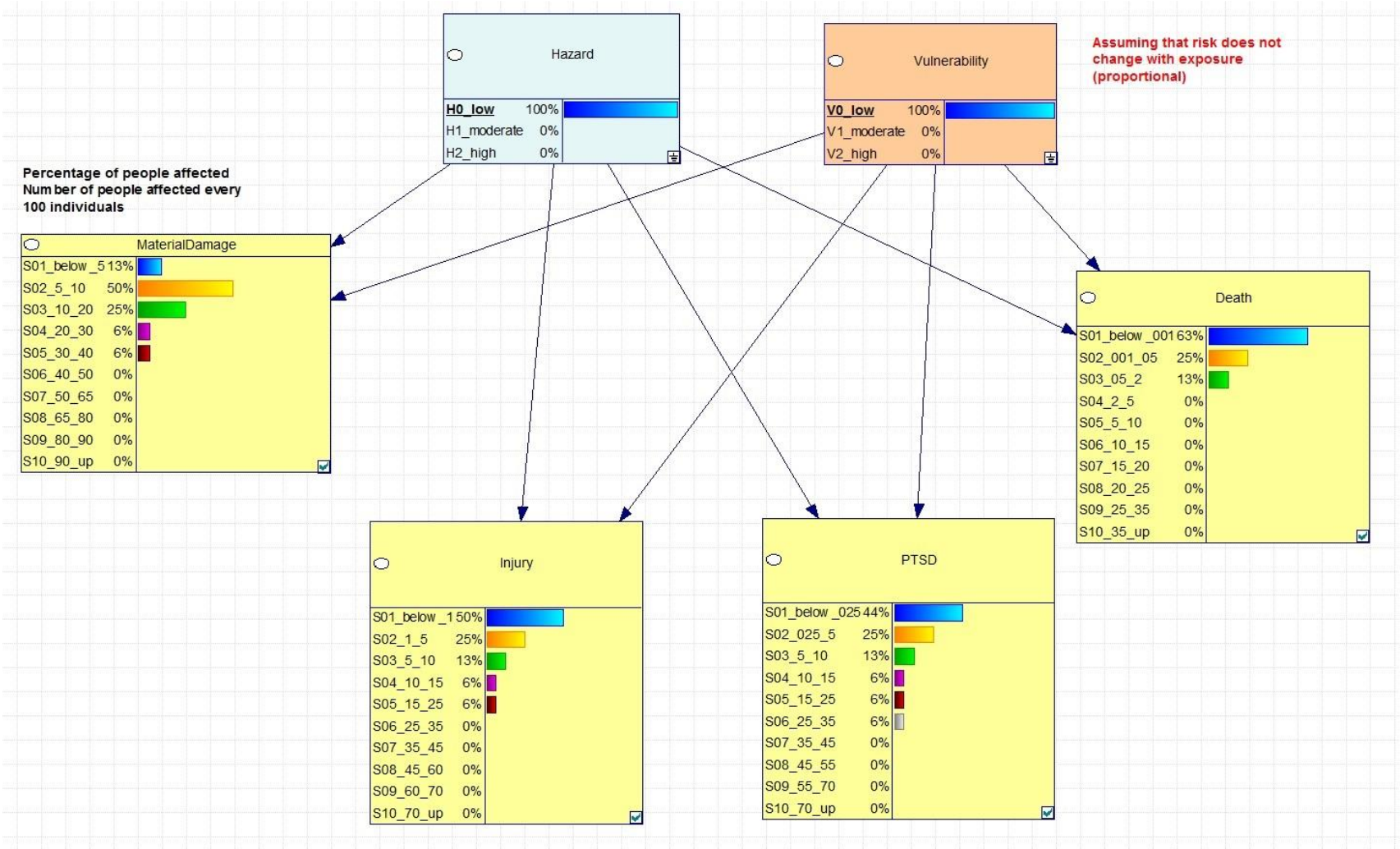
Outlook: Receptor people

SERRA based on Bayesian Network



Outlook: Receptor people

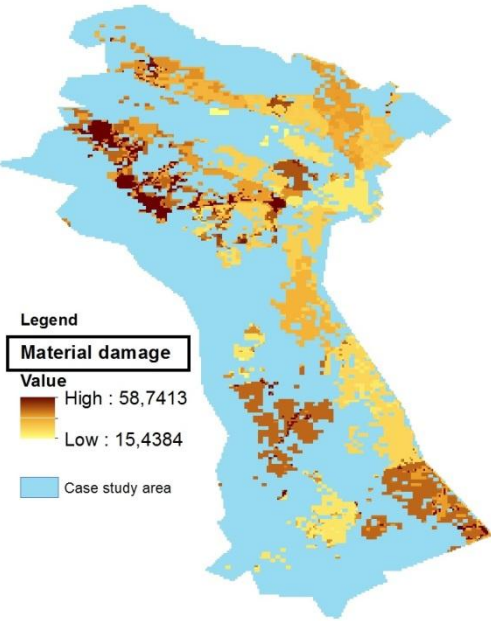
SERRA based on Bayesian Network

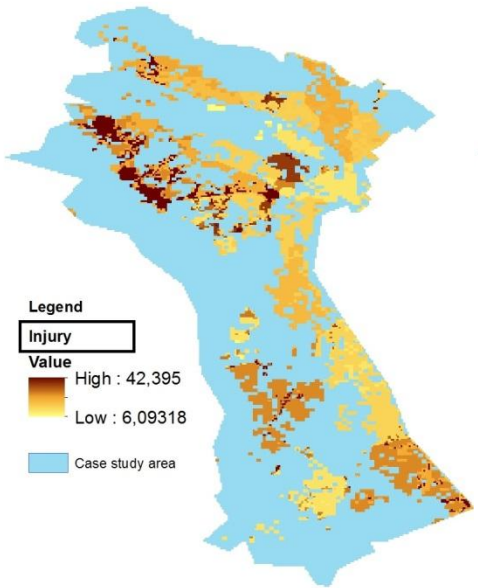


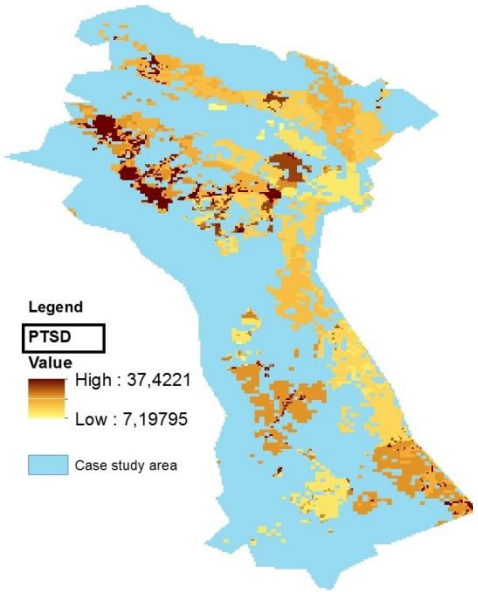
Outlook: Receptor people

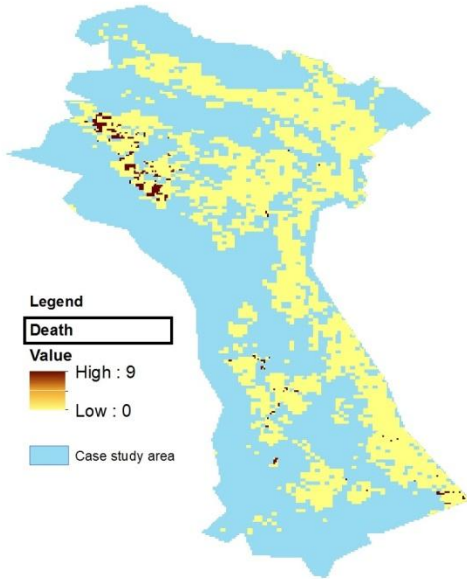
SERRA based on Bayesian Network

- Spatially explicit Bayesian Network
- Flood night hit (only damage to residential people)



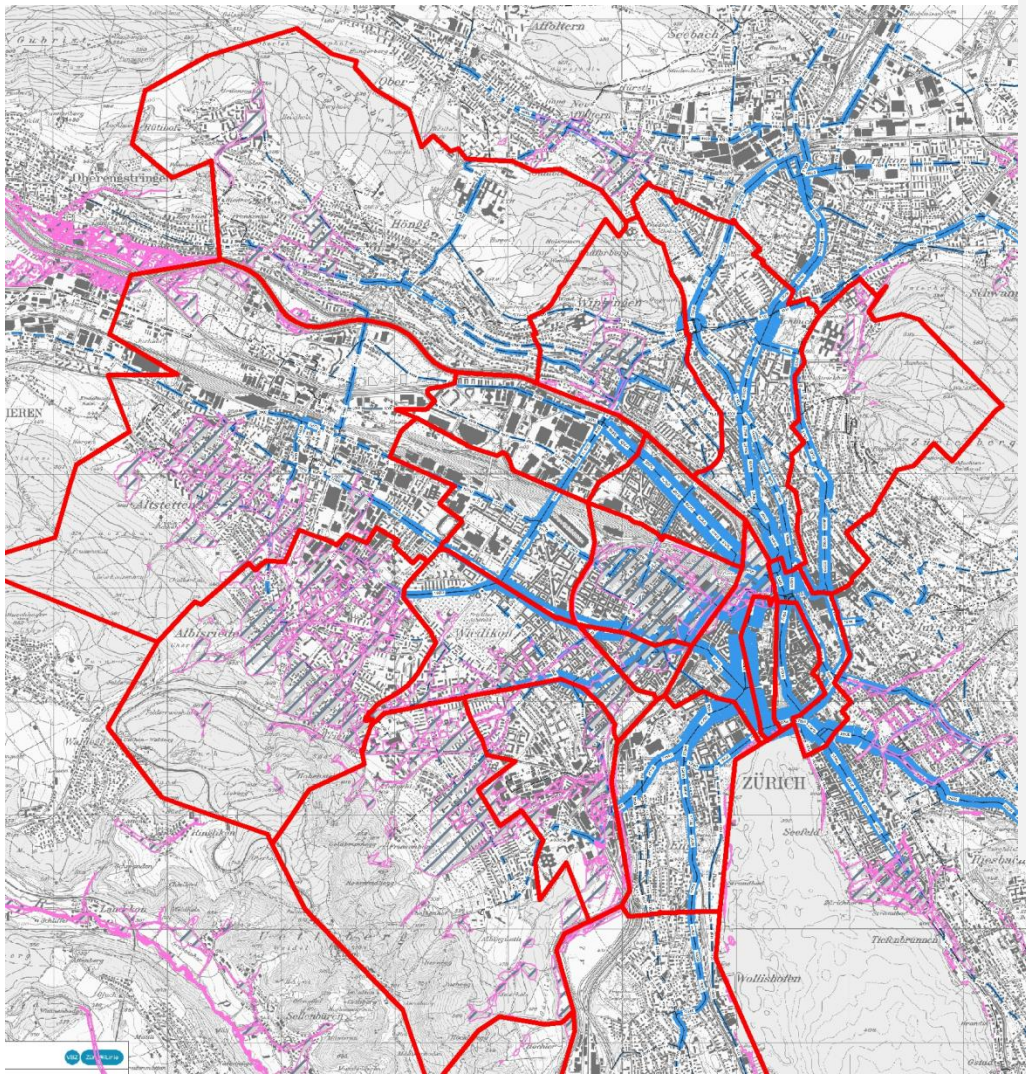






Outlook: Receptor infrastructures

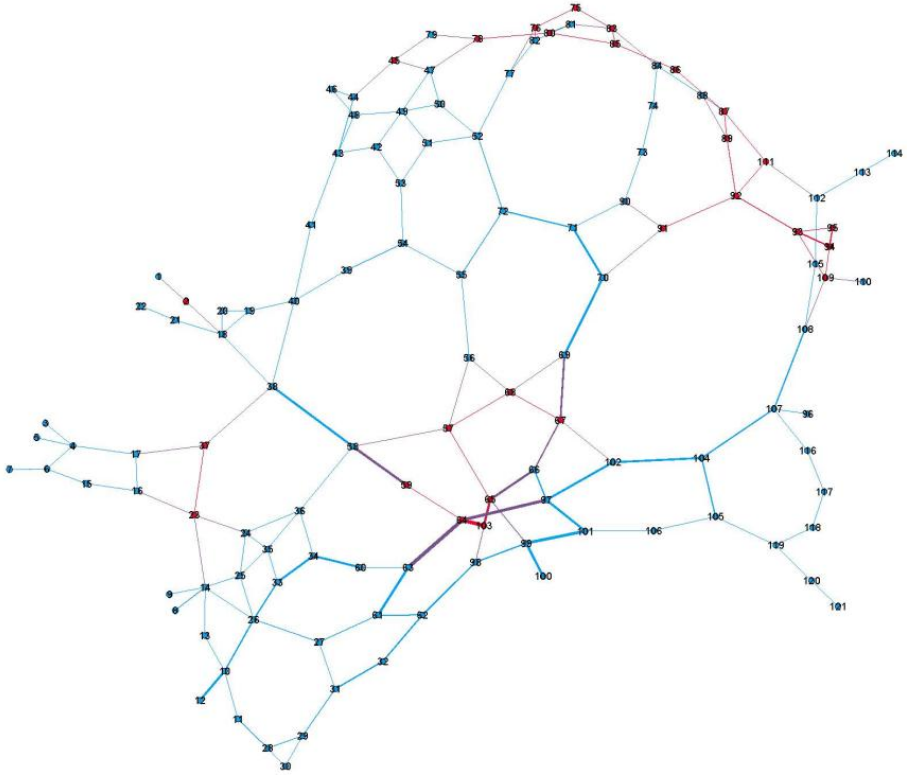
Tram network (blue)



- Average number of passengers travelling between tram stops
- Number all crossings
- Number of passengers travelling from one crossing to the next in a matrix
- Lay flood risk map over map with the tram network and mark all crossings that would be flooded

Outlook: Receptor infrastructures

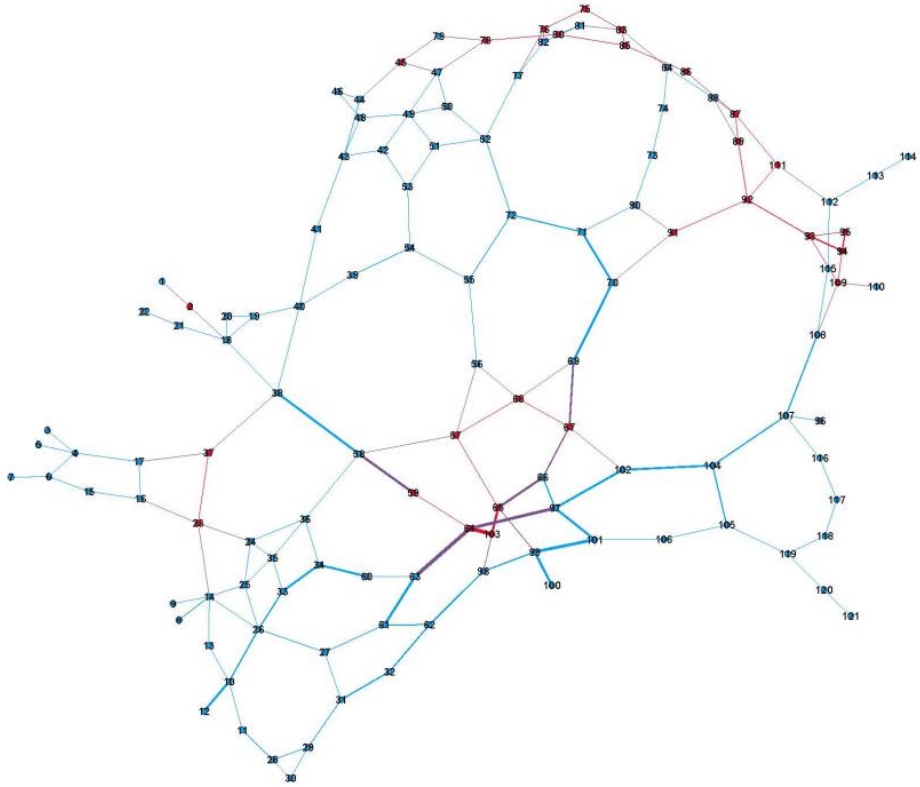
Tram network

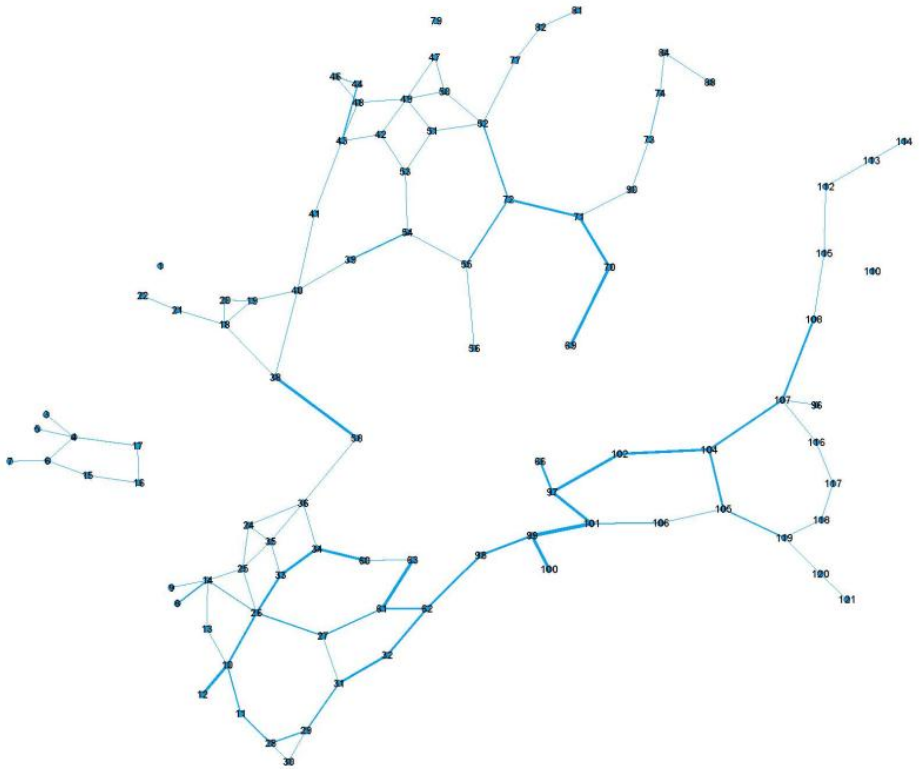


- Produce a network graph using the graph visualisation software Gephi, showing how all crossings are connected to each other.
- Vulnerable nodes are colored red.
- Use an R-script to produce the network under flooded conditions.

Outlook: Receptor infrastructures

Tram network





Problems Faced

- Missing velocity data
- Missing distinction between Sihl and small rivers
- Appropriateness of resident buildings for receptor people
- Impact of 300 or 500 years return period
- Impact of water depth/velocity on buildings
- Impact of weights

Sihl Case Study