IAH-Meeting
„The Interaction between Surface Water and Groundwater “
14. September 2006

Quantitative aspects of stormwater infiltration

Geological-Palaeontological Institute and Museum
Division of Applied Geology
Corrensstr. 24
48149 Münster

Westfälische
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Münster

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Urban water balance

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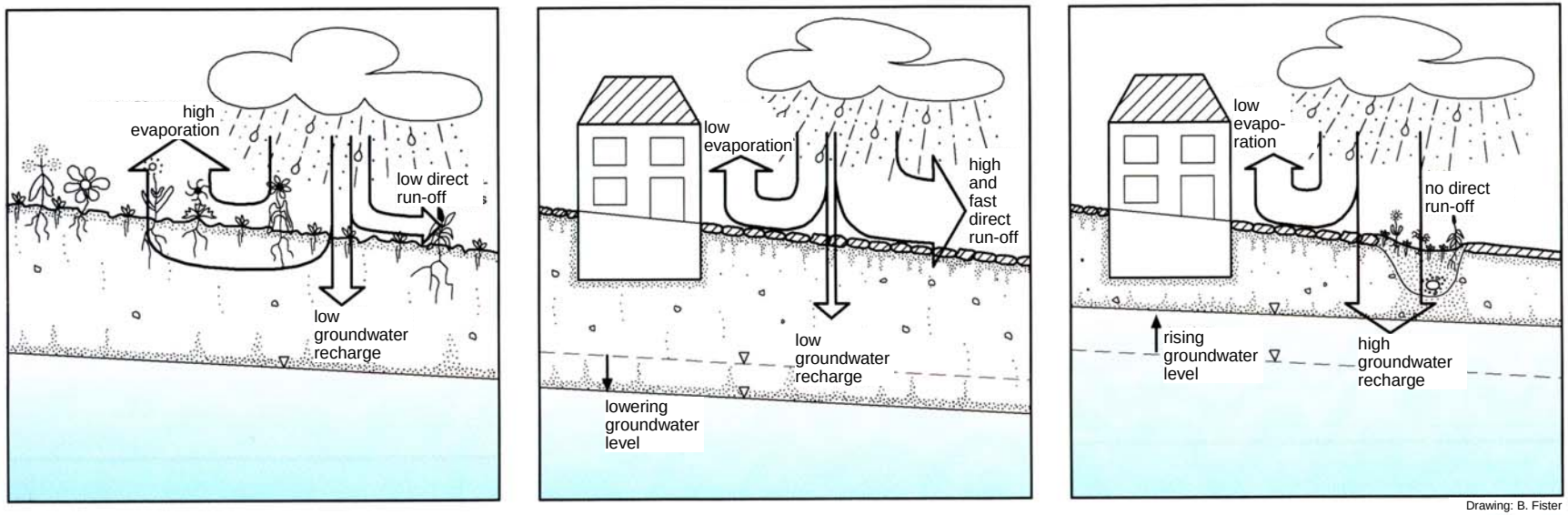

(after GEIGER & DREISEITL 2001)

Urban water balance

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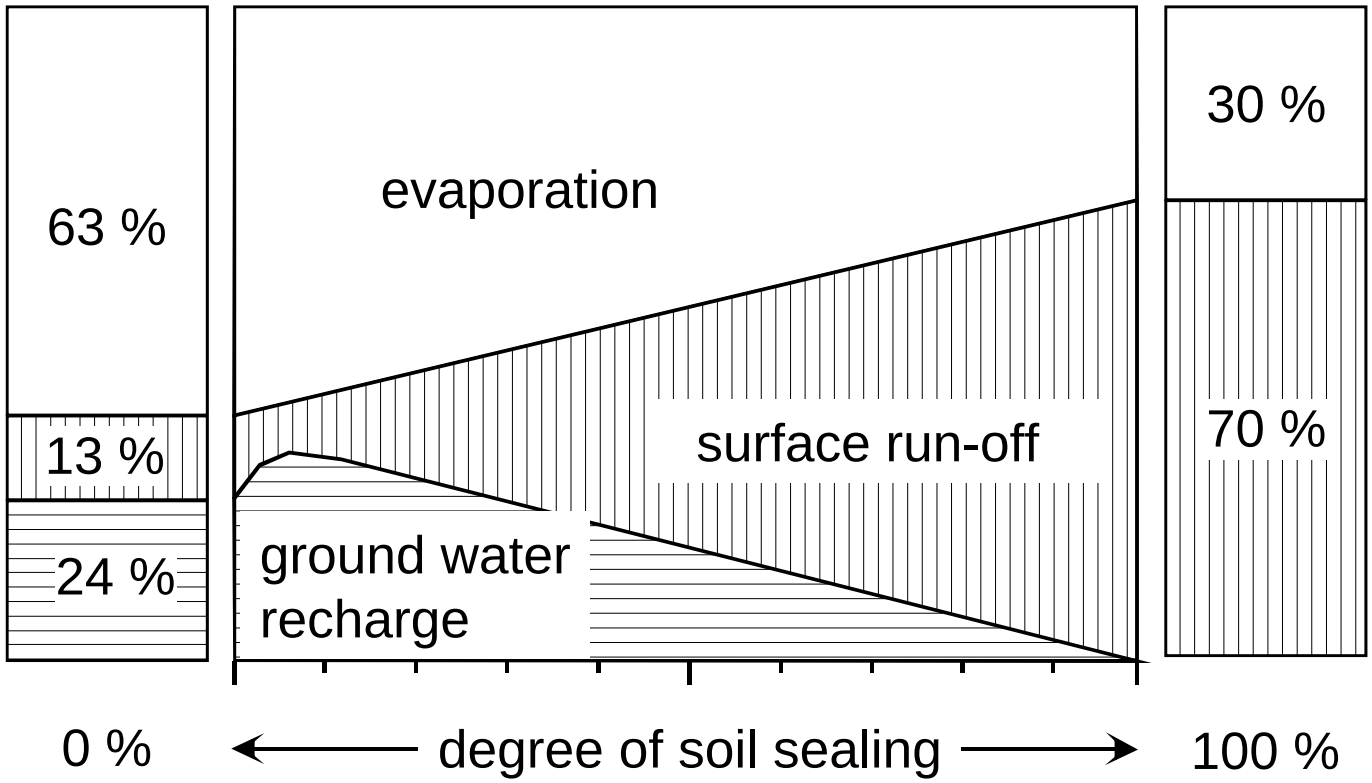
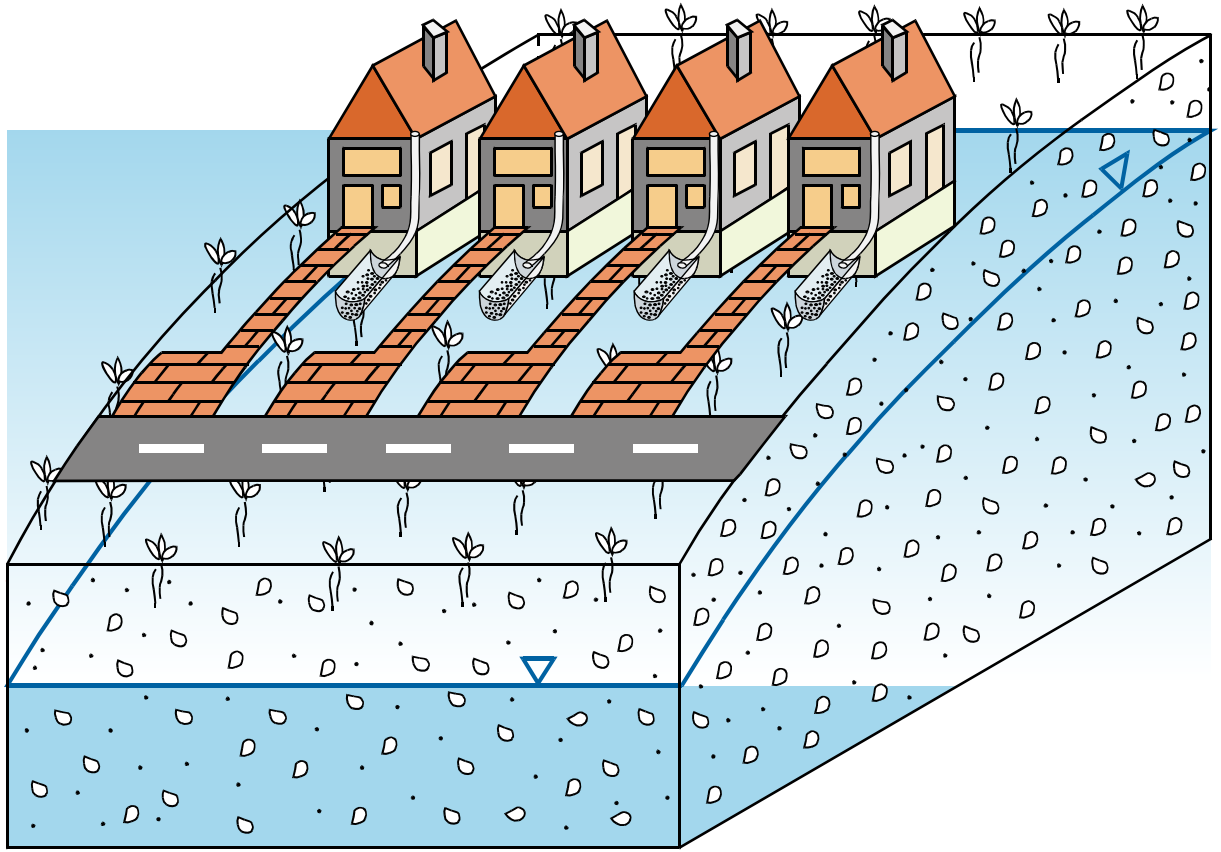
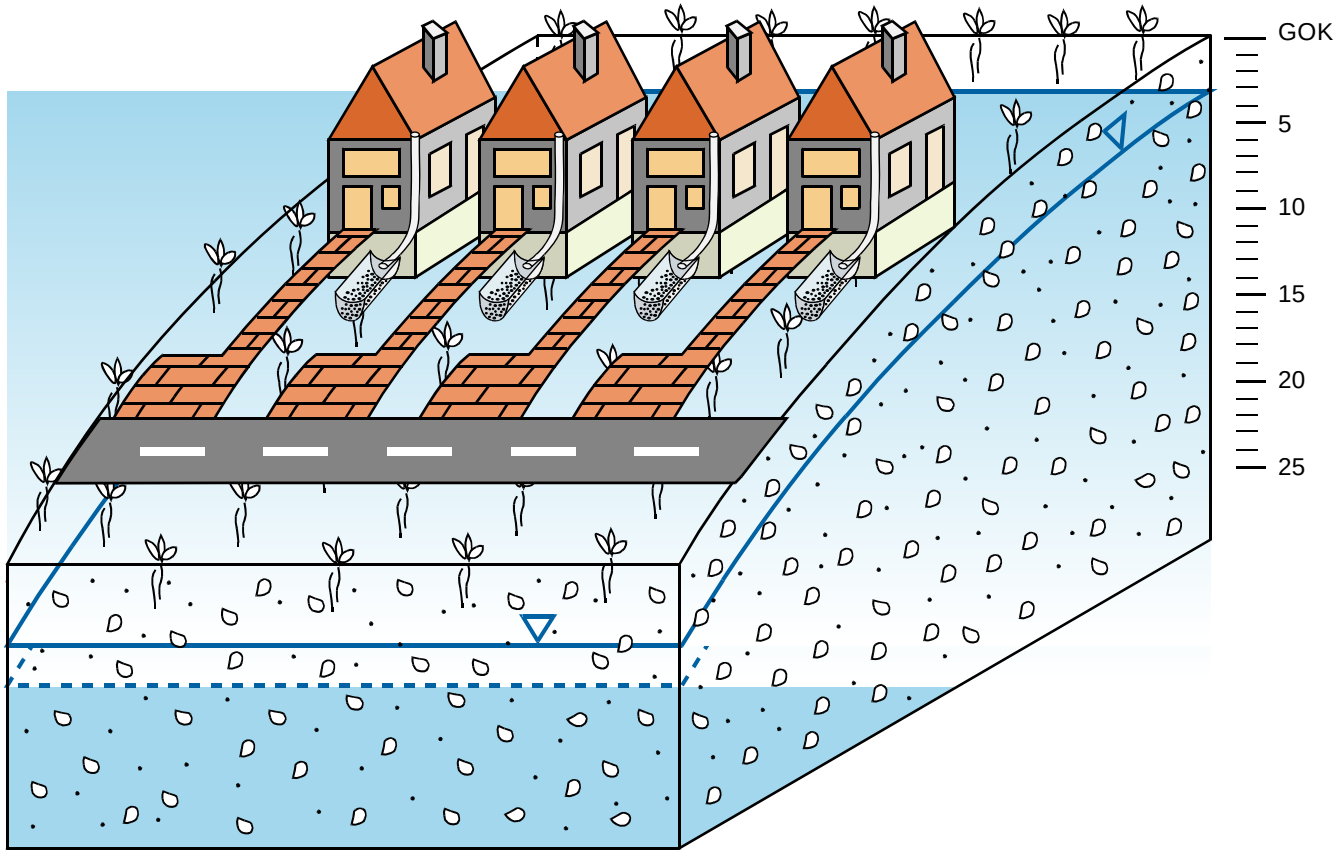


Urban water balance without storm water infiltration.
Percentage of average annual precipitation
of Bergkirchen, Germany (from MEIßNER 2001).

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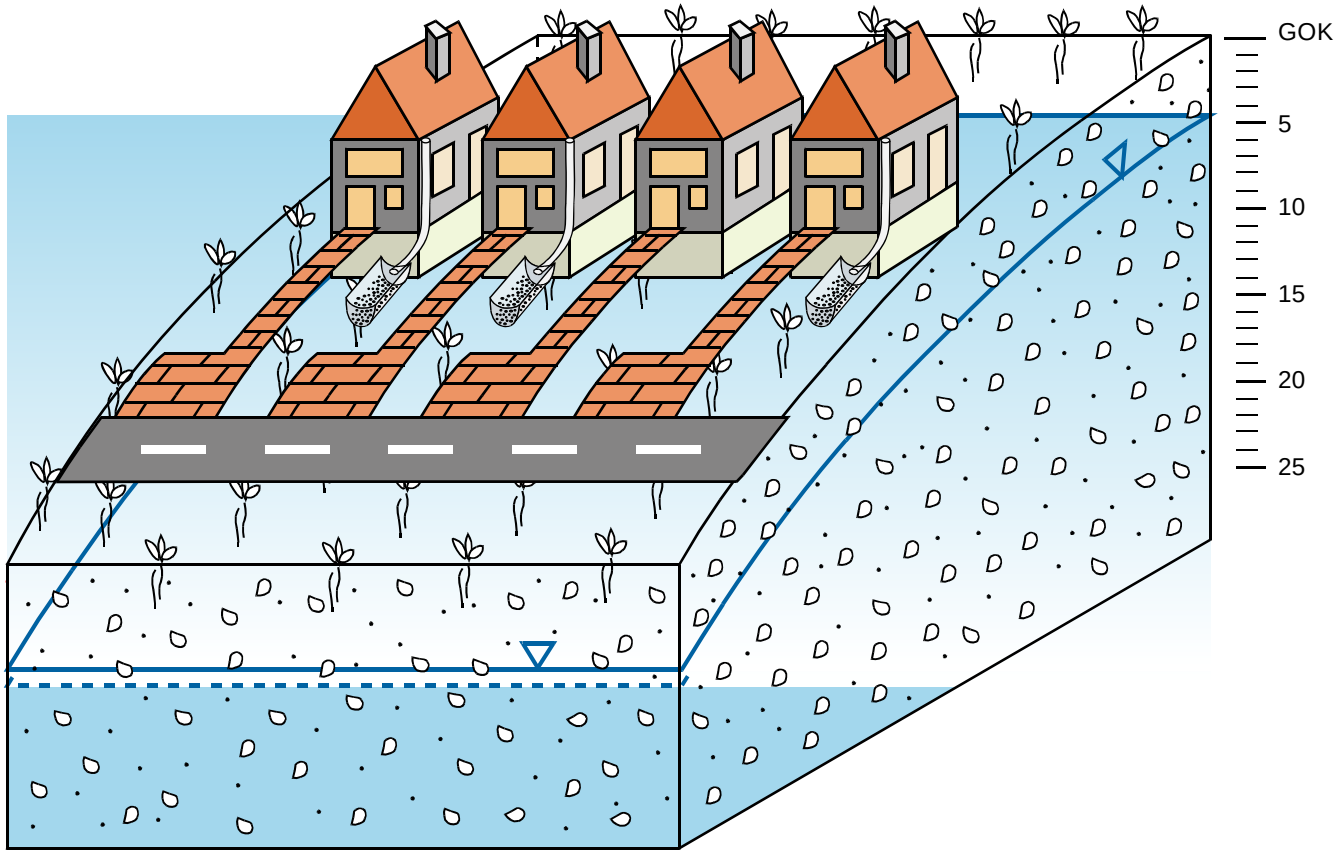
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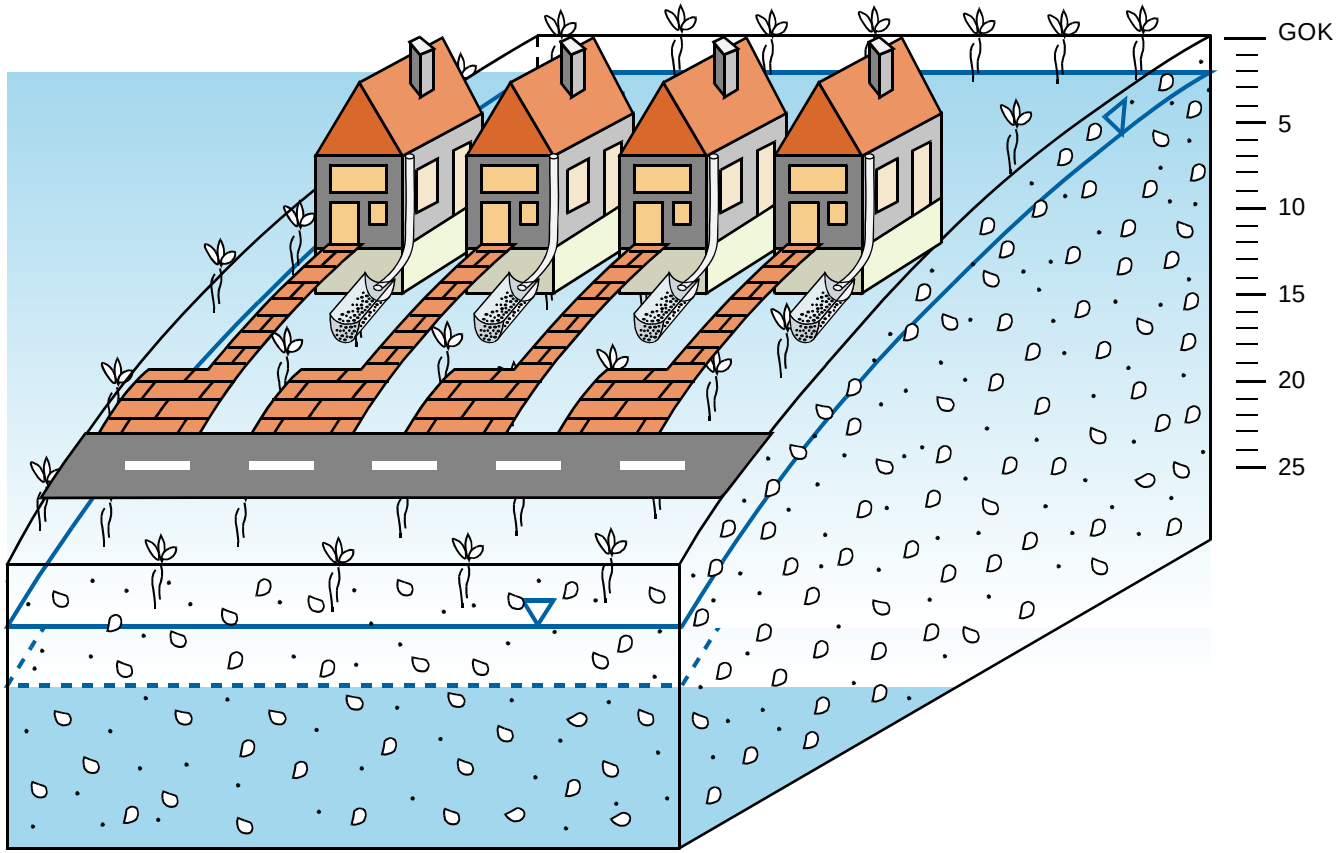
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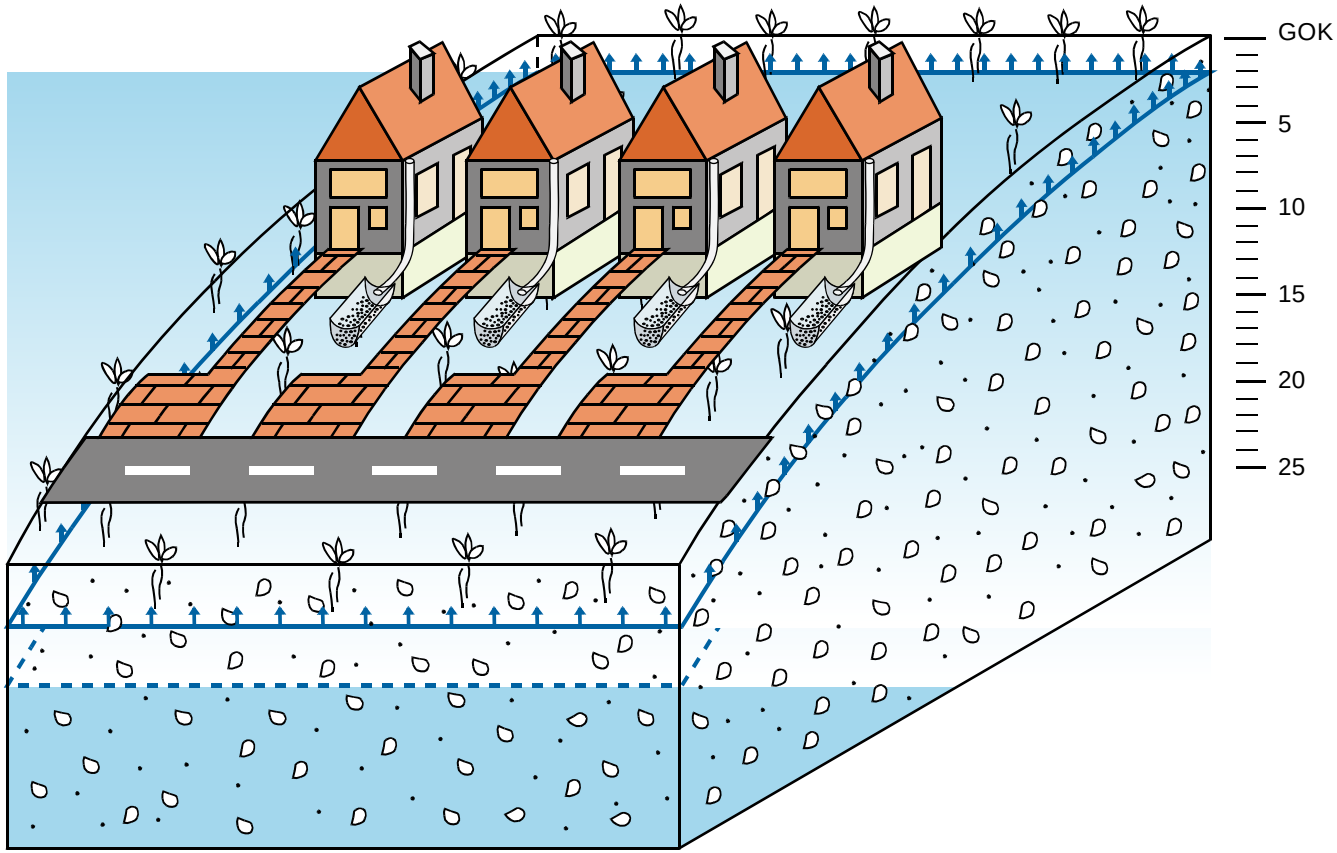
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Hydraulic conductivity

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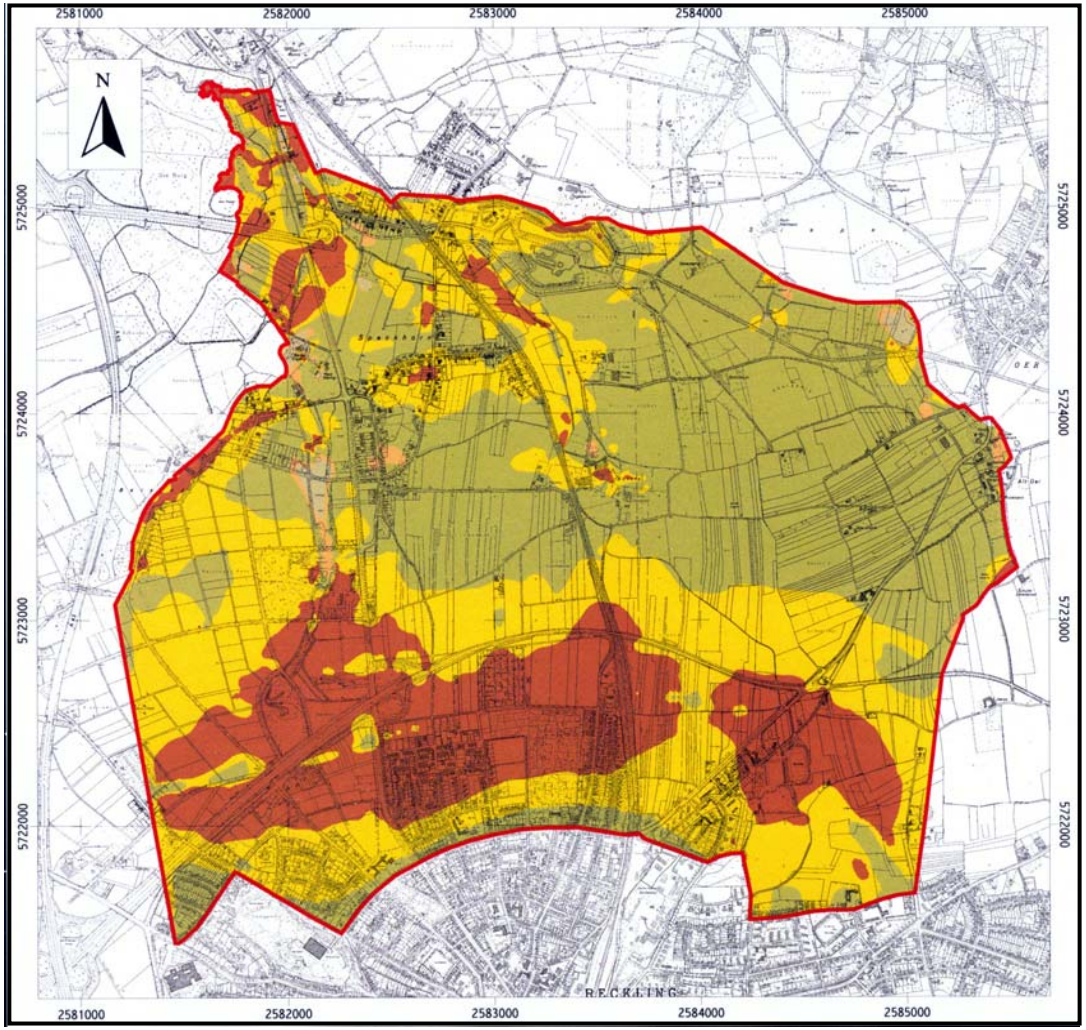

legend

investigation area

hydraulic conductivity (m/s)

- $1 \cdot 10^{-6}$ - $5 \cdot 10^{-6}$
- $5 \cdot 10^{-6}$ - $1 \cdot 10^{-5}$
- $1 \cdot 10^{-5}$ - $5 \cdot 10^{-5}$
- $5 \cdot 10^{-5}$ - $1 \cdot 10^{-4}$
- $1 \cdot 10^{-4}$ - $2 \cdot 10^{-4}$

Depth to ground water

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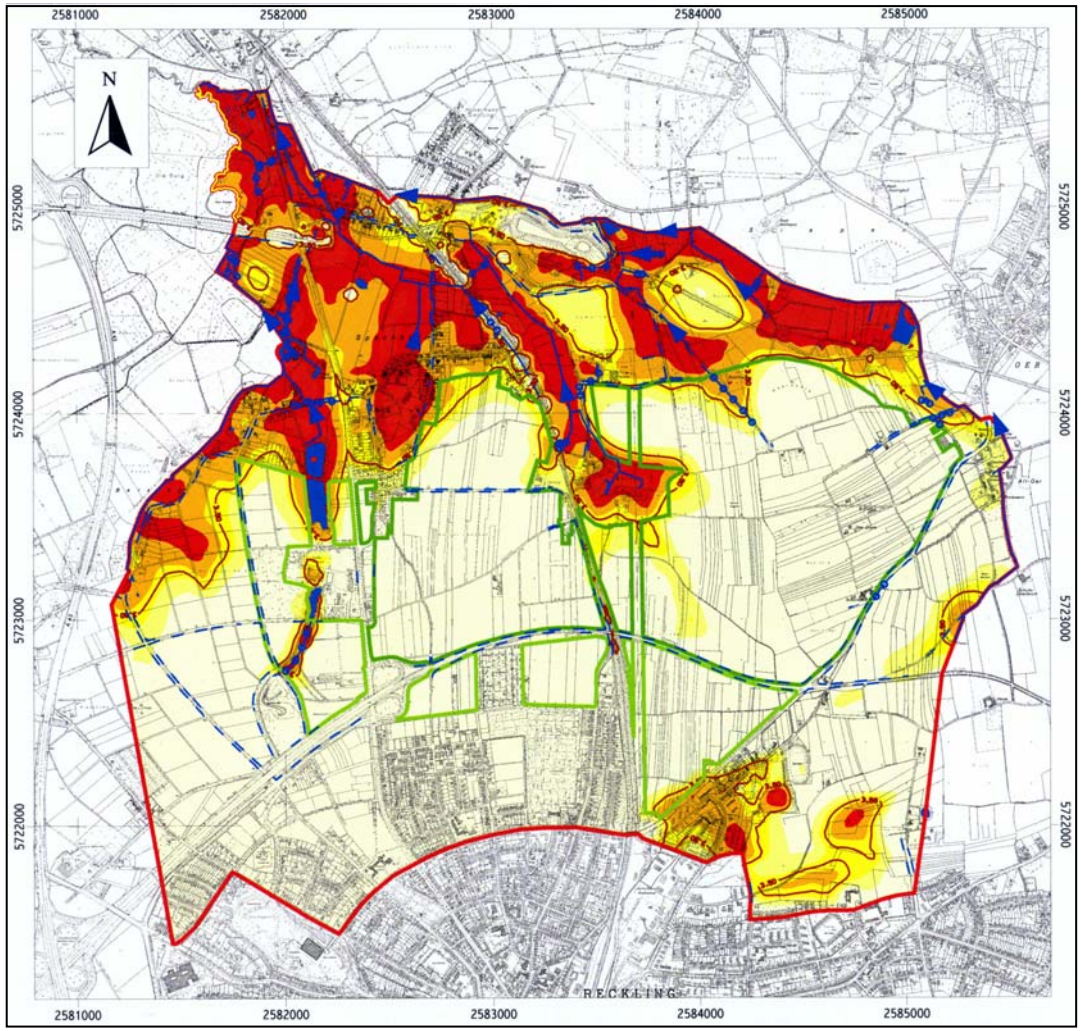

legend

- investigation area

water courses
- standing water
- running water
- dry
- pond

development area
- medium development
- dense development

depth to water table (m)
- < 0
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- 3,5

Scenarios of simulation

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scenarios	assumptions			
	dimension of develop-ment areas	degree of soil sealing	degree of infiltration depression/ditch (80% / 20%)	precipitation year
initial state	none	0%	0%	2001
1	small	medium	100%	2001
2	medium	medium	100%	2001
3		dense		
4		medium / dense		
5a	medium	medium / dense	75%	2001
5b			50%	
6a	none	0%	0%	1997 (dry)
6b	medium	medium / dense	100%	
7a	none	0%	0%	1998 (wet)
7b	medium	medium / dense	100%	
8	medium	medium / dense	100%	nonstationary

Investigation flow chart

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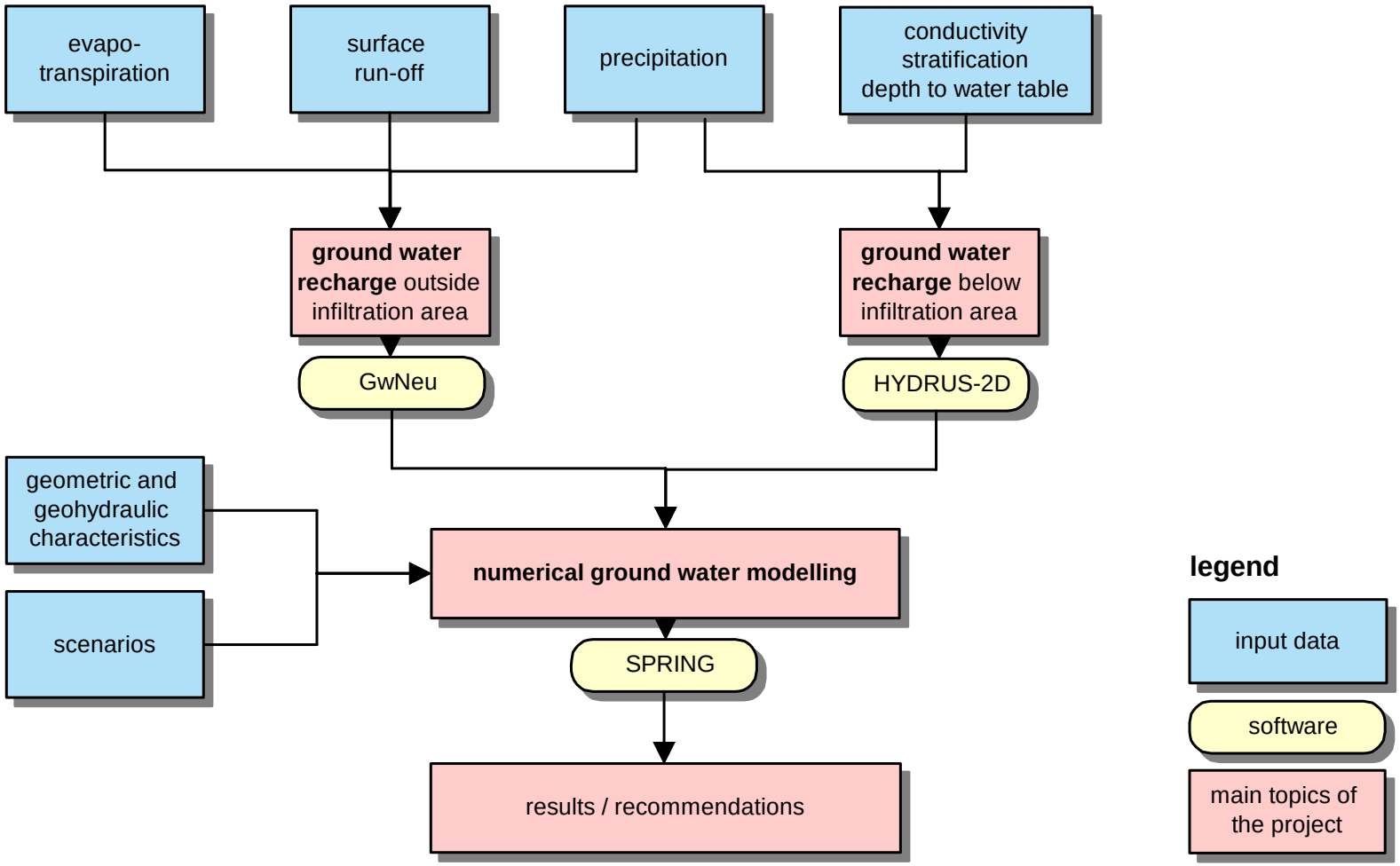

Ground water recharge

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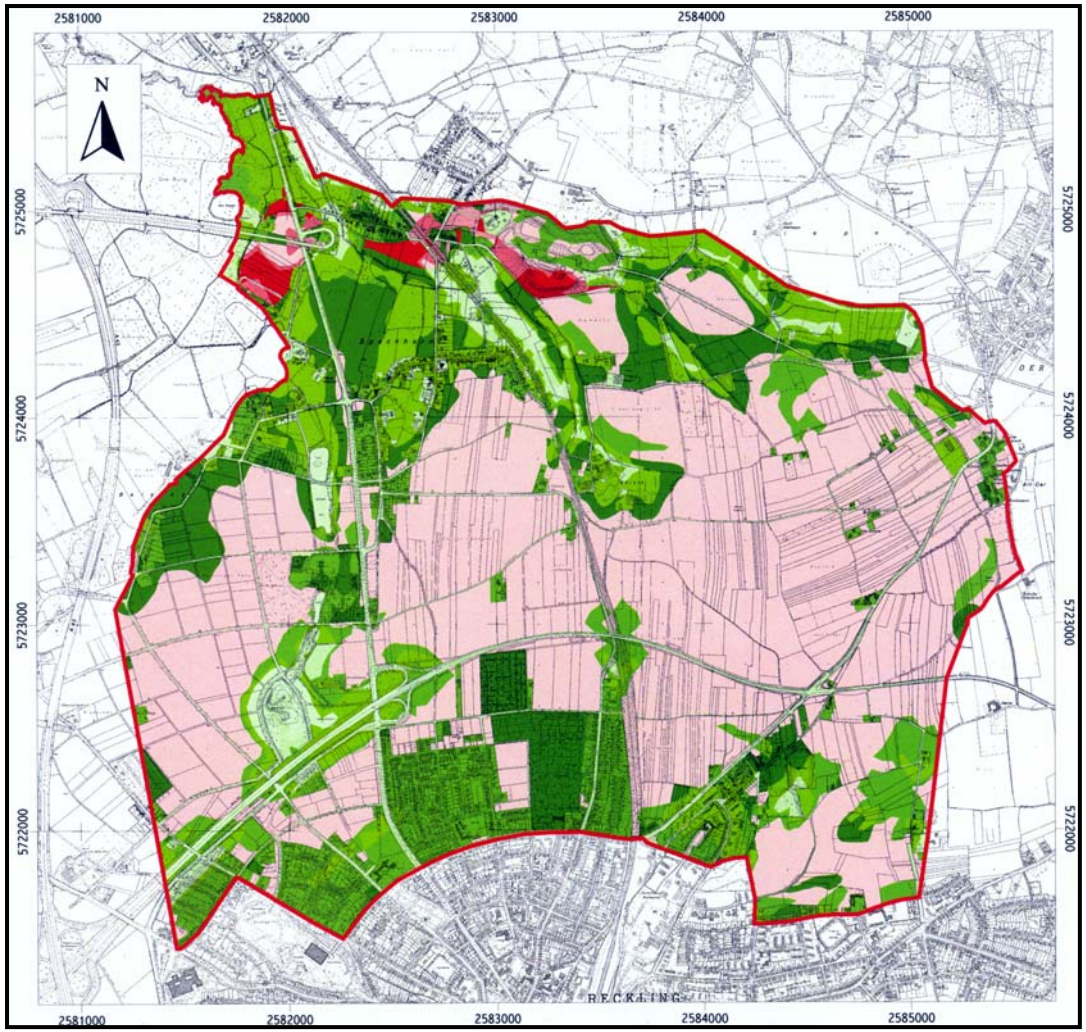

legend

investigation area

low ground water recharge (mm/a)

- 0 - 50
- 50 - 100
- 101 - 150
- 151 - 200
- 201 - 250

high ground water recharge (mm/a)

- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550

initial state

Ground water recharge

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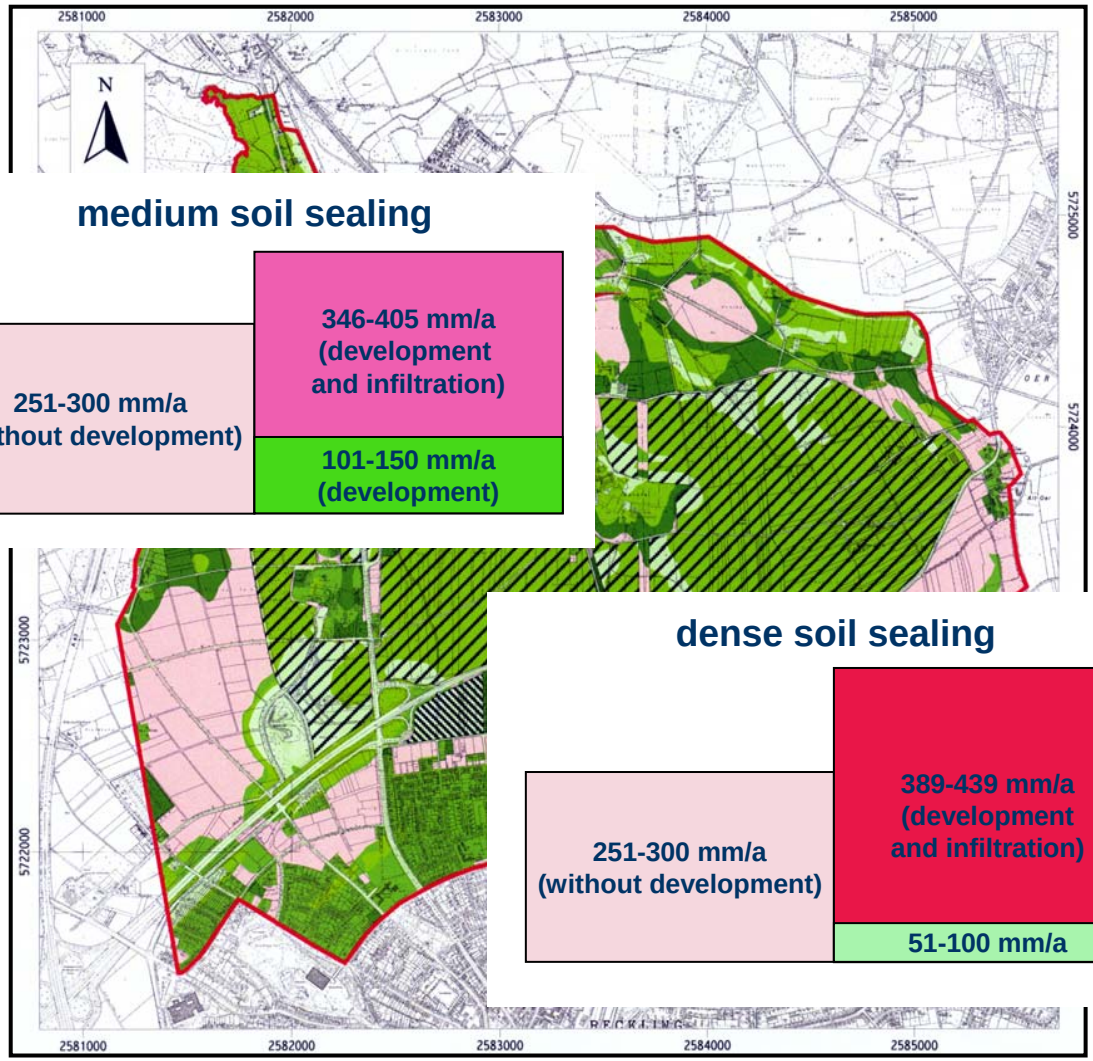

legend

investigation area

low ground water recharge (mm/a)
- 0 - 50
- 50 - 100
- 101 - 150
- 151 - 200
- 201 - 250

high ground water recharge (mm/a)
- 251 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550

ground water recharge below infiltration area (mm/a)
- 245
- 339

with development and infiltration

(after GÖBEL et al.: J.Hydrol.299(2004) 267-283)

Scenarions and results

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scenarios	assumptions				results for development area			
	dimension of developement areas	degree of soil sealing	degree of infiltration depression/ditch (80% / 20%)	precipitation year	ground water recharge			maximum of differences in water level
					outside infiltration area	below infiltration area	total	
				mm/a	mm/a	mm/a	mm/a	m
Ausgangs-zustand	none	0%	0%	799	221	0	221	0
1	small	medium	100%	799	178	58	236	+ 1,08
2	medium	medium	100%	799	165	78	243	+ 1,76
3		dense			150	108	258	+ 2,89
4		medium / dense			163	82	245	+ 2,34
5a	medium	medium / dense	75%	799	163 [1]	61	224	+ 0,83
5b			50%		163 [1]	41	207	- 1,32
6a	none	0%	0%	625	109	0	109	0 / - 7.00*
6b	medium	medium / dense	100%		87	63	150	+ 4,40 / - 4,38*
7a	none	0%	0%	917	278	0	278	0 / + 3,77*
7b	medium	medium / dense	100%		208	86	294	+ 1,28 / + 4,72*
8	medium	medium / dense	100%	instationary	n.p.	n.p.	n.p.	0.6
remarks:		n.p.: non presentable [1]: iterative calculation of ground water recharge *: difference to scenario 6a or 7a / difference to initial state						

Results - scenario 4

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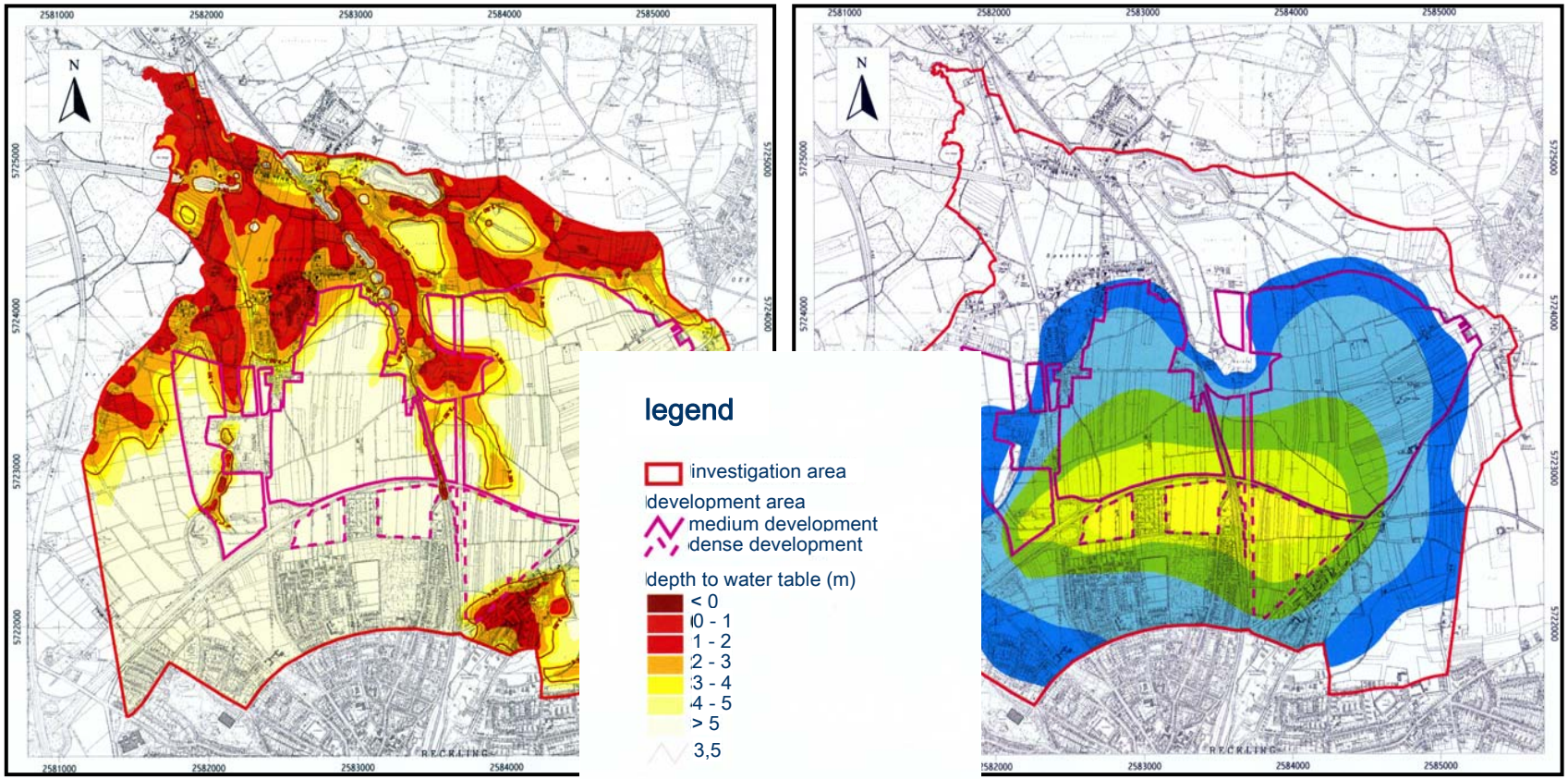

Scenarions and results

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scenarios	assumptions				results for development area			
	dimension of developement areas	degree of soil sealing	degree of infiltration depression/ditch (80% / 20%)	precipitation year	ground water recharge			maximum of differences in water level
					outside infiltration area	below infiltration area	total	
				mm/a	mm/a	mm/a	mm/a	m
Ausgangs-zustand	none	0%	0%	799	221	0	221	0
1	small	medium	100%	799	178	58	236	+ 1,08
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3		dense			150	108	258	+ 2,89
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5a	medium	medium / dense	75%	799	163 [1]	61	224	+ 0,83
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6a	none	0%	0%	625	109	0	109	0 / - 7.00*
6b	medium	medium / dense	100%		87	63	150	+ 4,40 / - 4,38*
7a	none	0%	0%	917	278	0	278	0 / + 3,77*
7b	medium	medium / dense	100%		208	86	294	+ 1,28 / + 4,72*
8	medium	medium / dense	100%	instationary	n.p.	n.p.	n.p.	0.6
remarks:		n.p.: non presentable [1]: iterative calculation of ground water recharge *: difference to scenario 6a or 7a / difference to initial state						

Results - scenario 5a

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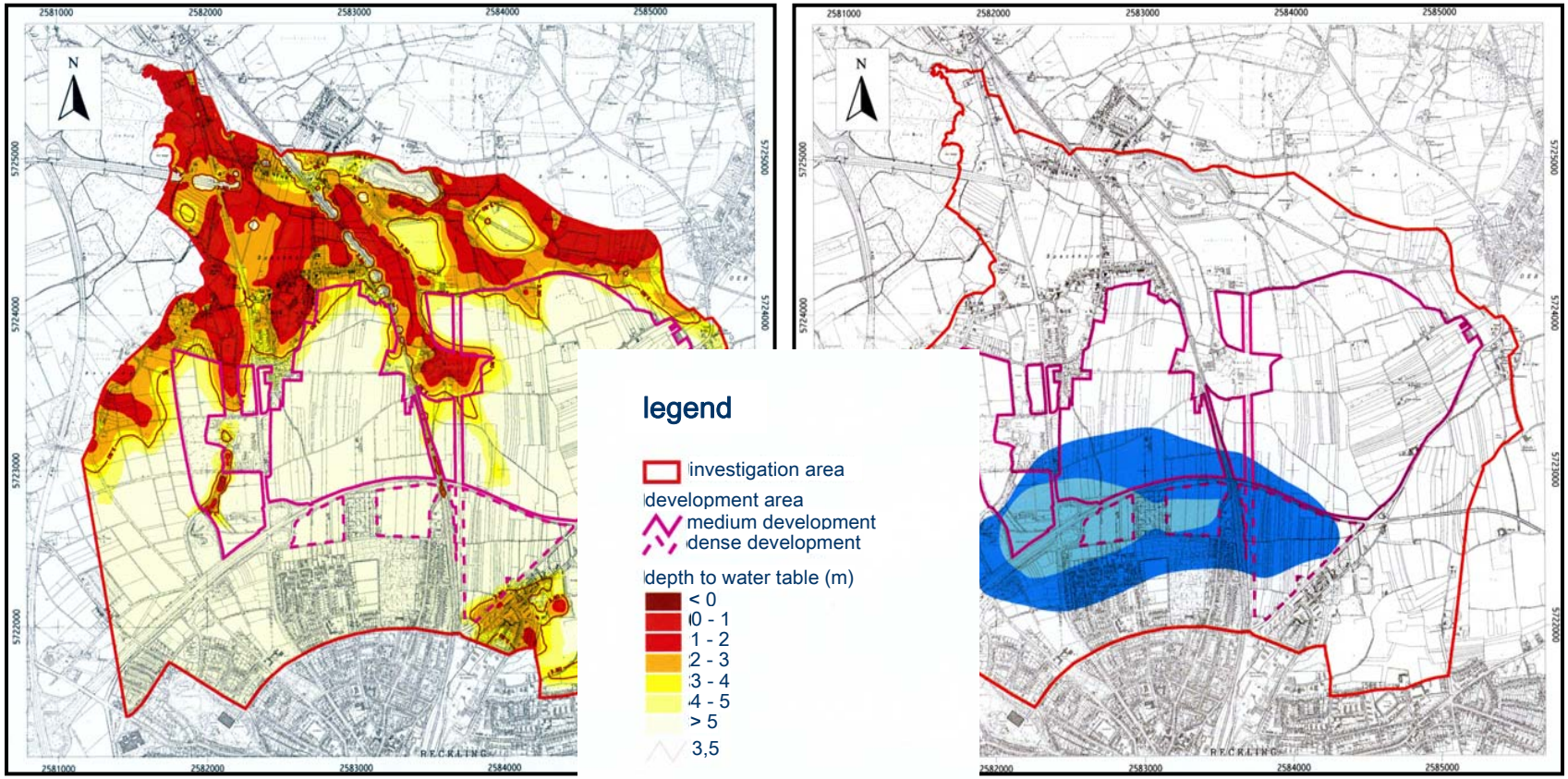

Scenarions and results

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scenarios	assumptions				results for development area			
	dimension of developement areas	degree of soil sealing	degree of infiltration depression/ditch (80% / 20%)	precipitation year	ground water recharge			maximum of differences in water level
					outside infiltration area	below infiltration area	total	
				mm/a	mm/a	mm/a	mm/a	m
Ausgangs-zustand	none	0%	0%	799	221	0	221	0
1	small	medium	100%	799	178	58	236	+ 1,08
2	medium	medium	100%	799	165	78	243	+ 1,76
3		dense			150	108	258	+ 2,89
4		medium / dense			163	82	245	+ 2,34
5a	medium	medium / dense	75%	799	163 [1]	61	224	+ 0,83
5b			50%		163 [1]	41	207	- 1,32
6a	none	0%	0%	625	109	0	109	0 / - 7.00*
6b	medium	medium / dense	100%		87	63	150	+ 4,40 / - 4,38*
7a	none	0%	0%	917	278	0	278	0 / + 3,77*
7b	medium	medium / dense	100%		208	86	294	+ 1,28 / + 4,72*
8	medium	medium / dense	100%	instationary	n.p.	n.p.	n.p.	0.6
remarks:		n.p.: non presentable [1]: iterative calculation of ground water recharge *: difference to scenario 6a or 7a / difference to initial state						

Results - scenario 7a

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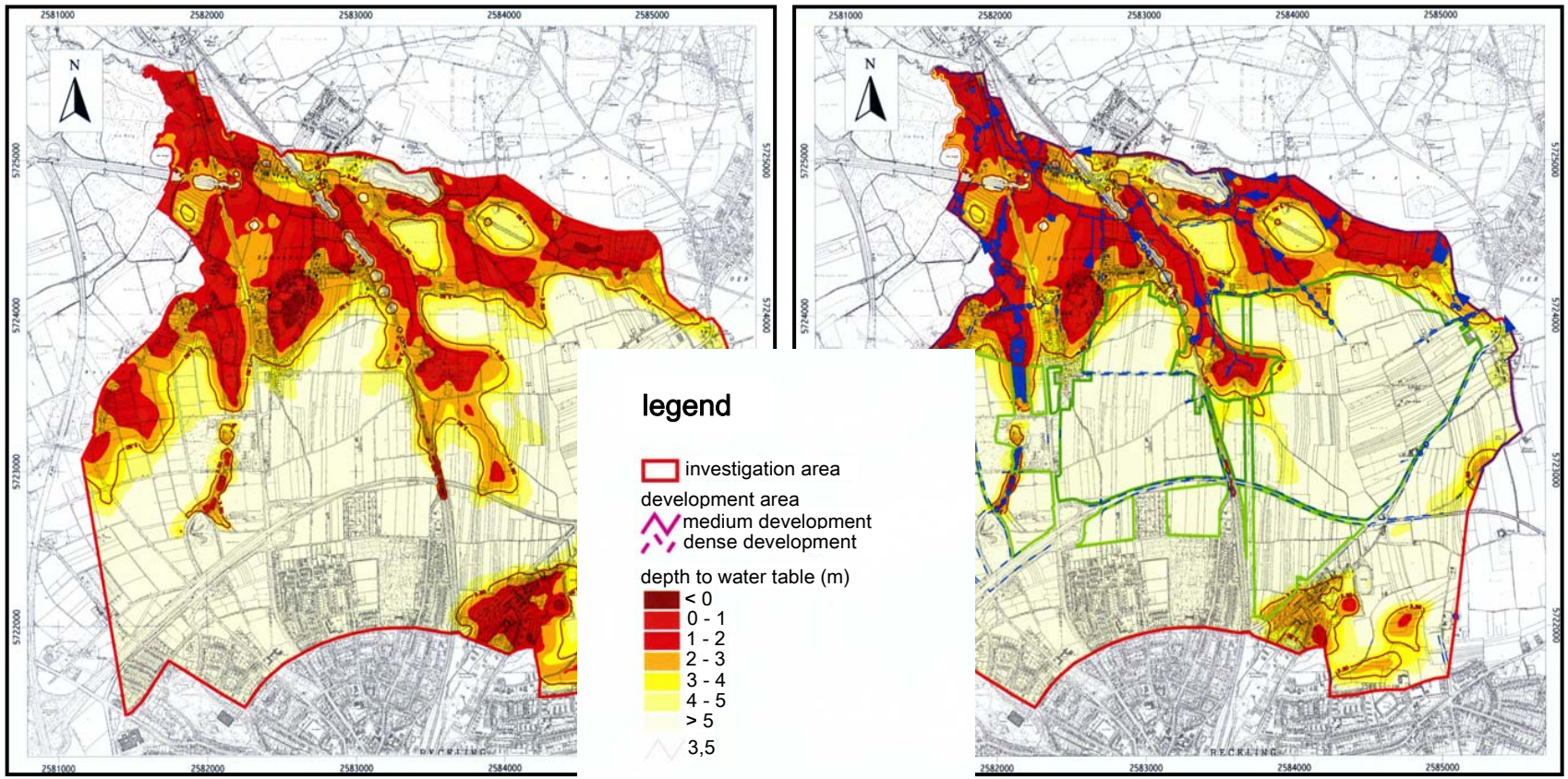

Results - scenario 7b

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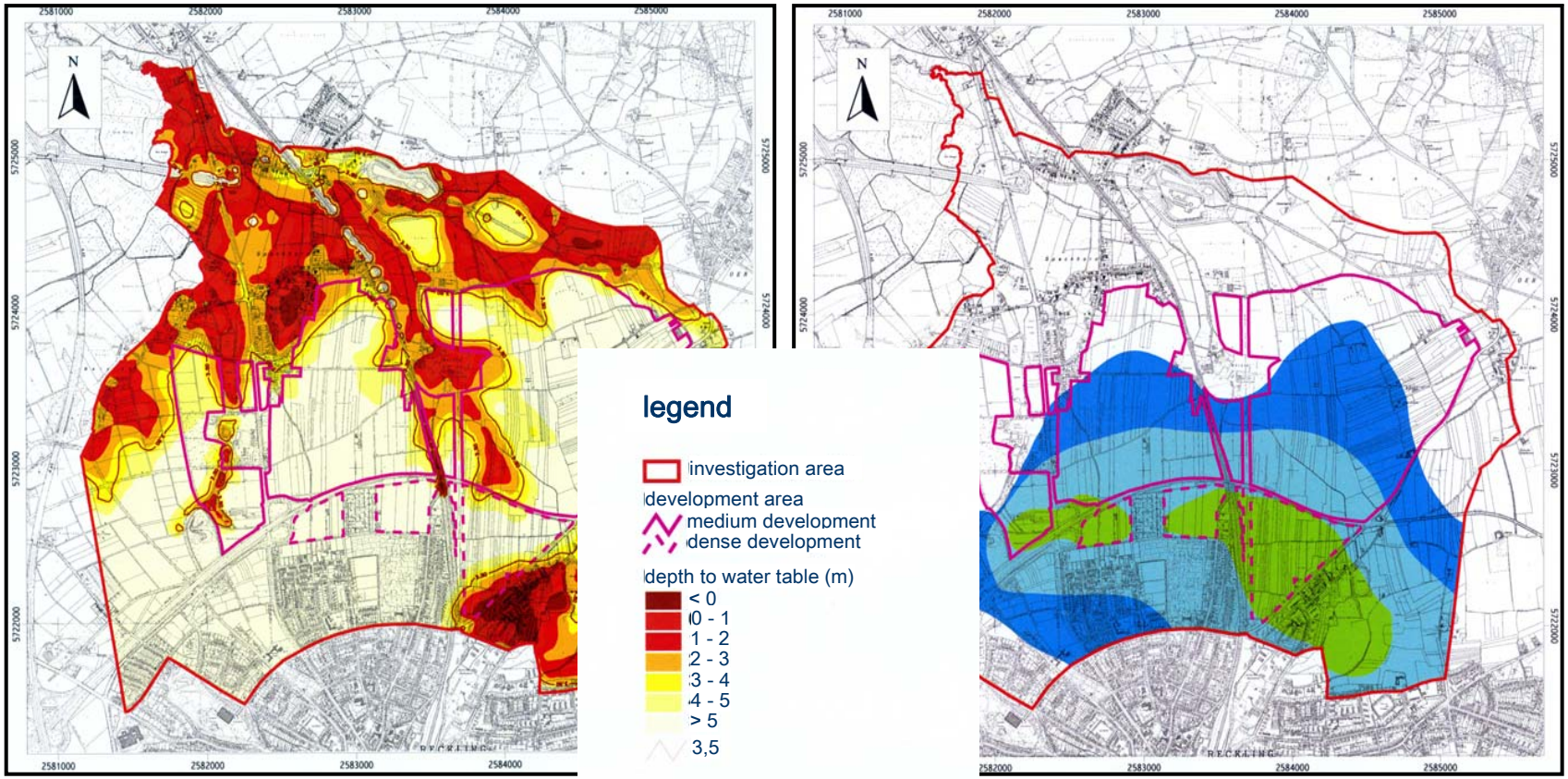

Scenarions and results

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scenarios	assumptions				results for development area			
	dimension of developement areas	degree of soil sealing	degree of infiltration depression/ditch (80% / 20%)	precipitation year	ground water recharge			maximum of differences in water level
					outside infiltration area	below infiltration area	total	
				mm/a	mm/a	mm/a	mm/a	m
Ausgangs-zustand	none	0%	0%	799	221	0	221	0
1	small	medium	100%	799	178	58	236	+ 1,08
2	medium	medium	100%	799	165	78	243	+ 1,76
3		dense			150	108	258	+ 2,89
4		medium / dense			163	82	245	+ 2,34
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6a	none	0%	0%	625	109	0	109	0 / - 7.00*
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7b	medium	medium / dense	100%		208	86	294	+ 1,28 / + 4,72*
8	medium	medium / dense	100%	instationary	n.p.	n.p.	n.p.	0.6
remarks:		n.p.: non presentable [1]: iterative calculation of ground water recharge *: difference to scenario 6a or 7a / difference to initial state						

Results - scenario 8

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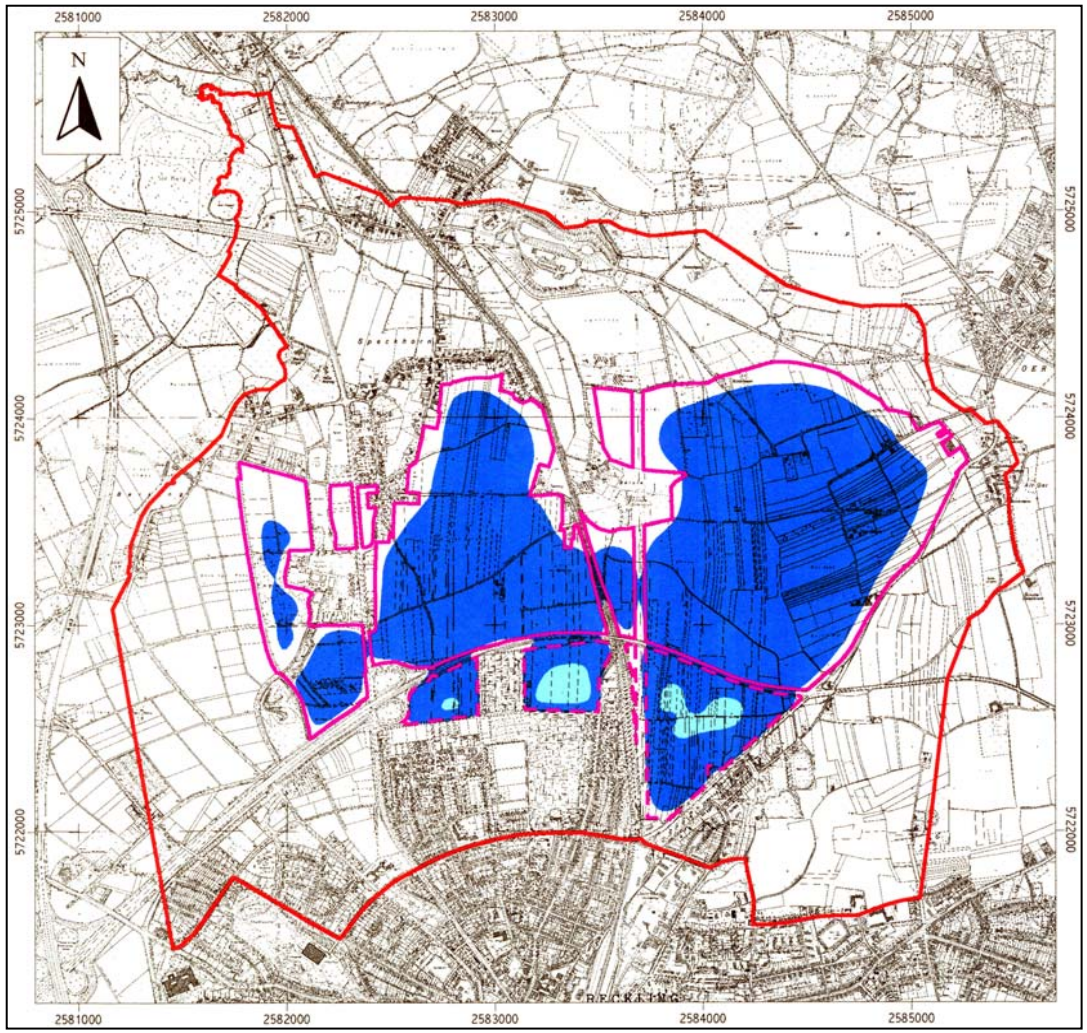

legend

- investigation area

development area
- medium development
- dense development

differences in ground water table (m)
increase of ground water table
- 0.25 - 0.5
- 0,5 - 1,0
- 1,0 - 1,5
- 1.5 - 2.0
- 2,0 - 2,5
- 2,5 - 3,0

Summary

- decrease of ground water recharge because of soil sealing
- increase of ground water recharge because of complete infiltration of storm water from roofs
- significant change of depth to water table in development areas
- insignificant change of depth to water table near close to receiving water courses
- extensive impact of infiltration
- relative stable ground water flow system
- increase of ground water outflow in receiving water courses
- impact of precipitation > degree of infiltration > degree of soil sealing > dimension of development areas

Conclusion

Problems due to:

- potencial conflict area within development area or its impact area
- infiltration > decrease of ground water recharge because of soil sealing
- natural low ground water recharge
  (e.g. in forest or high slop areas)
- hydraulic conductivity 10^{-5} m/s < k_f < 10^{-6} m/s
- reconstruction of sewer systems

Recommendations

- infiltration capability of the soil and depth to ground water
- hydrogeological situation
- extensive impact assessment
- function of receiving water courses and sewer system
- calculation of urban water balance
- ground water modelling
- ground water monitoring

Urban water balance calculation

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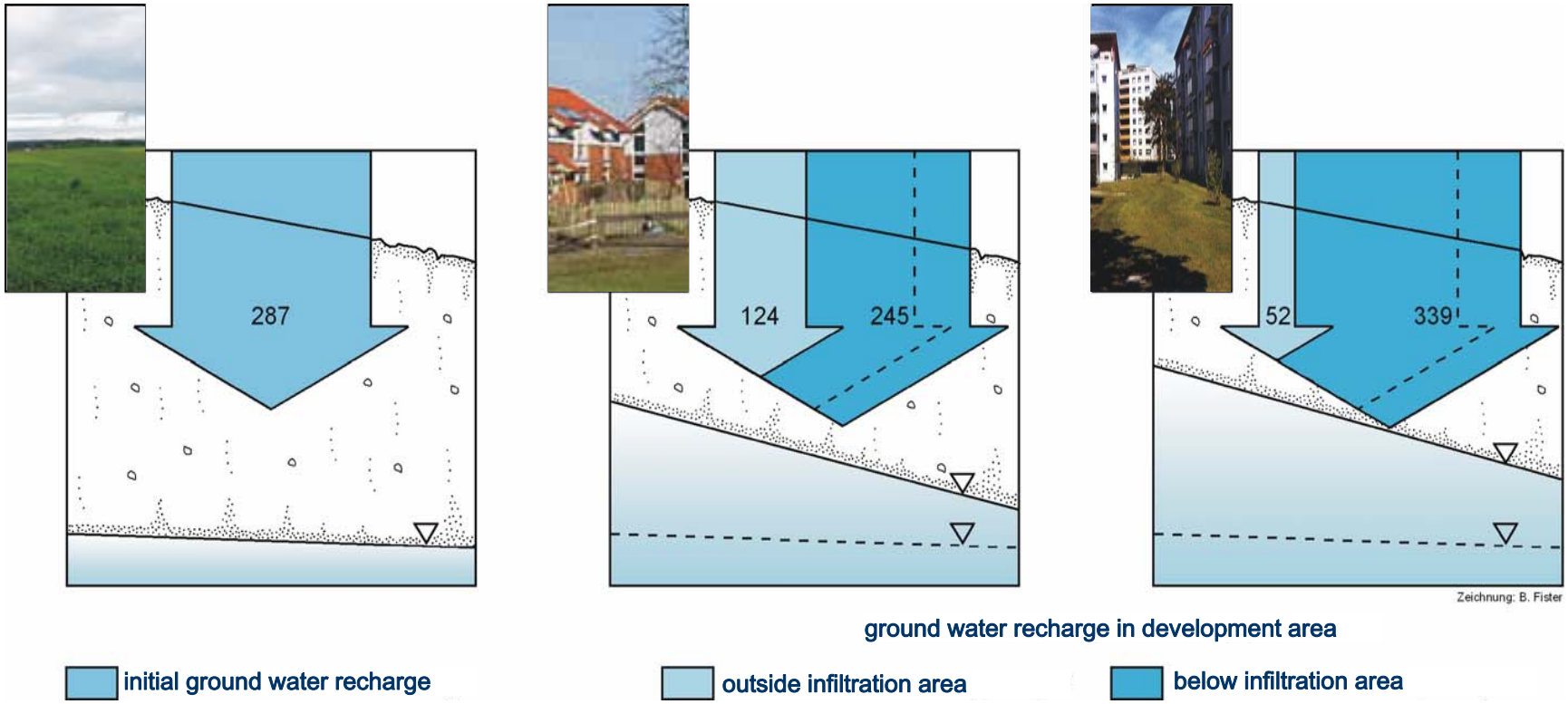

⇨ **infiltration of ca. 60% of storm water from roofs**

Acknowledgement

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DMT

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Any Questions?

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