Quantification of stormwater retention capacity and groundwater quality as ecosystem services in urban environments

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Case study: single-house residential area

- municipal growth in Lower Saxony occurs to a large extend in the form of suburban single-house residential development
- case study in a single-house residential area near Brunswick, Lower Saxony
- changes in stormwater retention capacity and groundwater quality as ecosystem services for 3 development scenarios are addressed

Scenarios	(1) built according to plan	(2) status quo 2016	(3) draft urbanized quarter
Total area [m²]	61,450	61,450	80,453
Living space [%]	15	16	19
Average number of floors [-]	2	2	5
Impervious area [%]	32	35	31
Semi-pervious area [%]	5	15	25
Pervious area [%]	63	50	44

Fig. 1: Percentages of living space, pervious, impervious and semi-pervious areas of the three scenarios as well as the average number of floors per residential building. Living space refers to the area covered by residential buildings (without garages).

Model setup

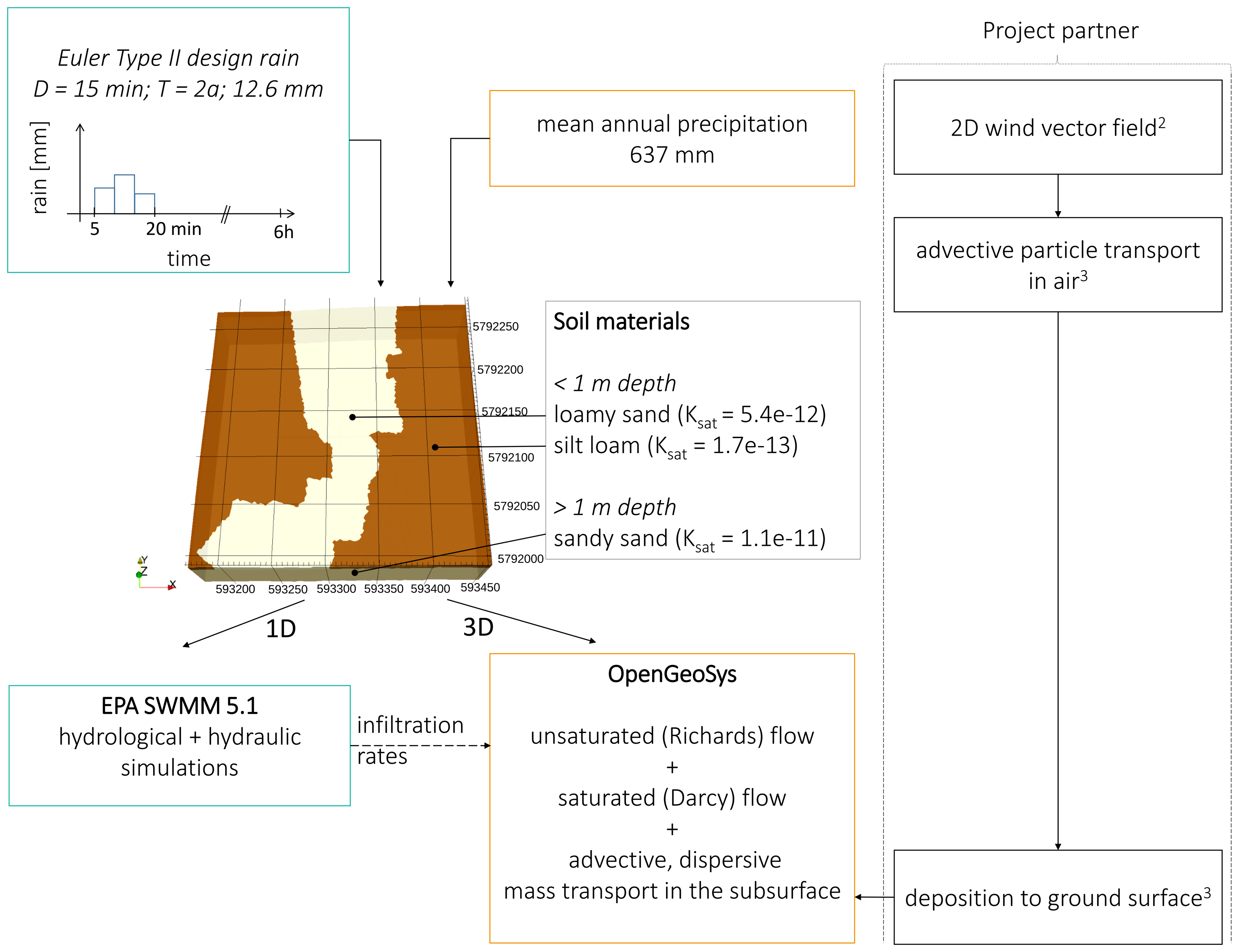

Fig. 2: Scheme of model setup. Coupling between SWMM and OGS is possible via infiltration source terms but not implemented yet.

Ecosystem services

- surface sealing and pollution reduce the capacity of local ecosystems to provide ecosystem services for human well-being
- in the project a criteria catalogue is developed to assess different aspects of these scenarios and to conclude on ecosystem services or disservices

Stormwater retention capacity

Tab. 1: Preliminary water balance for the three scenarios. Simulations were conducted in EPA SWMM 5.1. For all simulations an Euler-Type II 15-minute precipitation event of two years return period is applied. Results are shown after 6h of simulation time.

Scenarios	(1) built according to plan	(2) status quo 2016	(3) draft urbanized quarter
Infiltration [% of precipitation]	67.3	58.1	67.9
Surface runoff [% of precipitation]	30.6	39.1	29.2
Storage [% of precipitation]	2.3	3.1	3.0
Continuity error [% of precipitation]	0.3	0.3	0.2

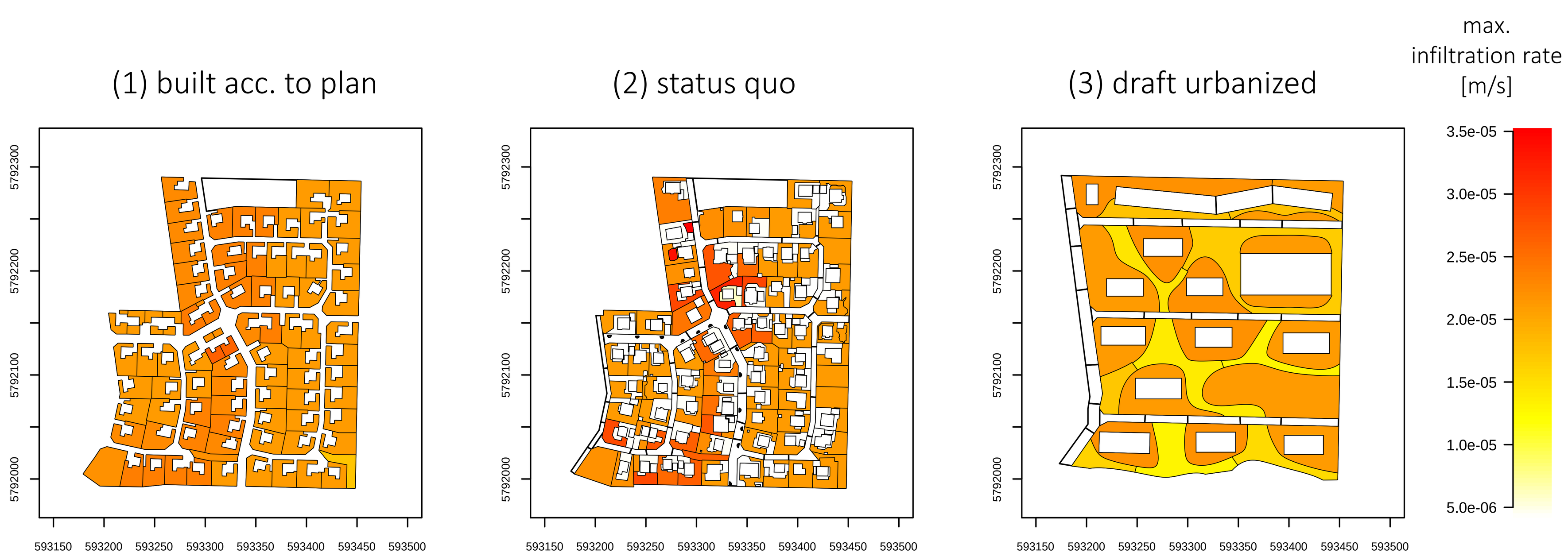

Fig. 3: Maximum infiltration rates at pervious surfaces (garden, park and gravel areas). Simulation remarks: scenario (1): 12-25% of parks are impervious pathways; scenario (2): 20% of sealed surfaces are permeable; scenario (3): 50% of pathways are permeable.

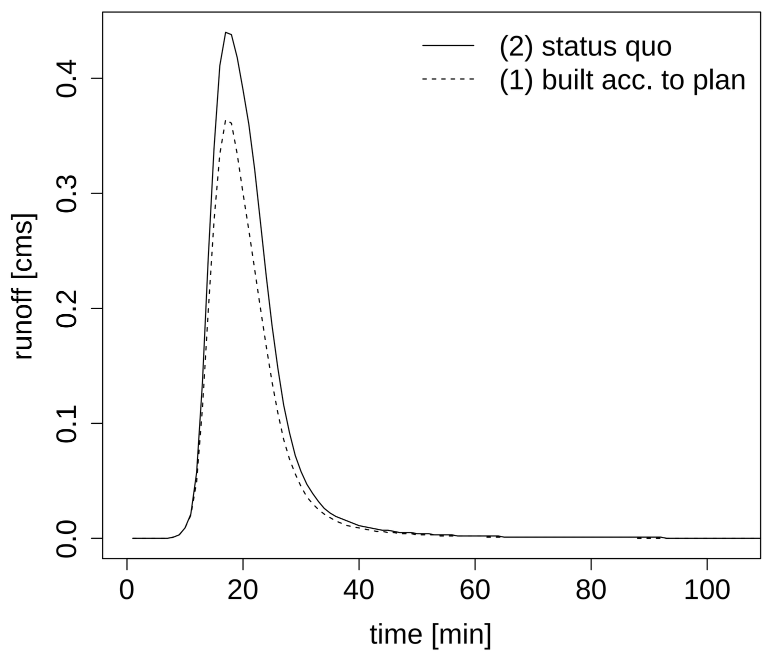

Fig. 4: Inflow at outfall node for single-house scenarios. Surface runoff from roofs and streets drains to the detention basin.

Summary & Outlook

- increased surface sealing results in increased surface runoff
  → infiltration capacity of small gardens might be reached immediately during heavy rain events
- to make scenario (3) comparable to (1) & (2) scales have to be revised
- nevertheless, in terms of reduced surface runoff per capita, scenario (3) is already the most sustainable scenario
- holistic approaches are needed to implement sustainable development strategies

Groundwater quality (in progress)

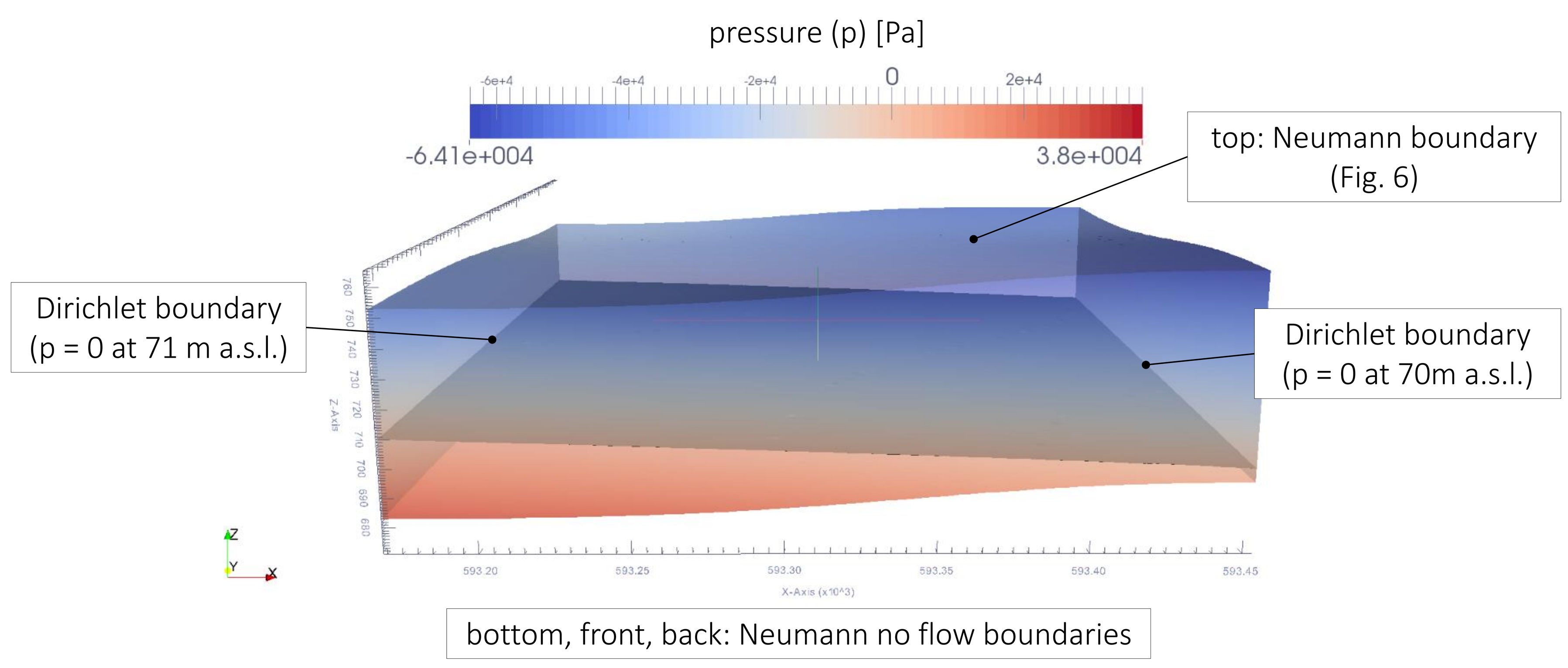

Fig. 5: Boundary conditions as well as pressure distribution at steady state (without source terms). Plane indicates groundwater level (pressure = 0).

Summary & Outlook.

- wind drift simulation and particle transport are preliminary (Fig. 6)
- coupling of SWMM and OGS via infiltration rates
- reduction of mass rates as ecosystem service

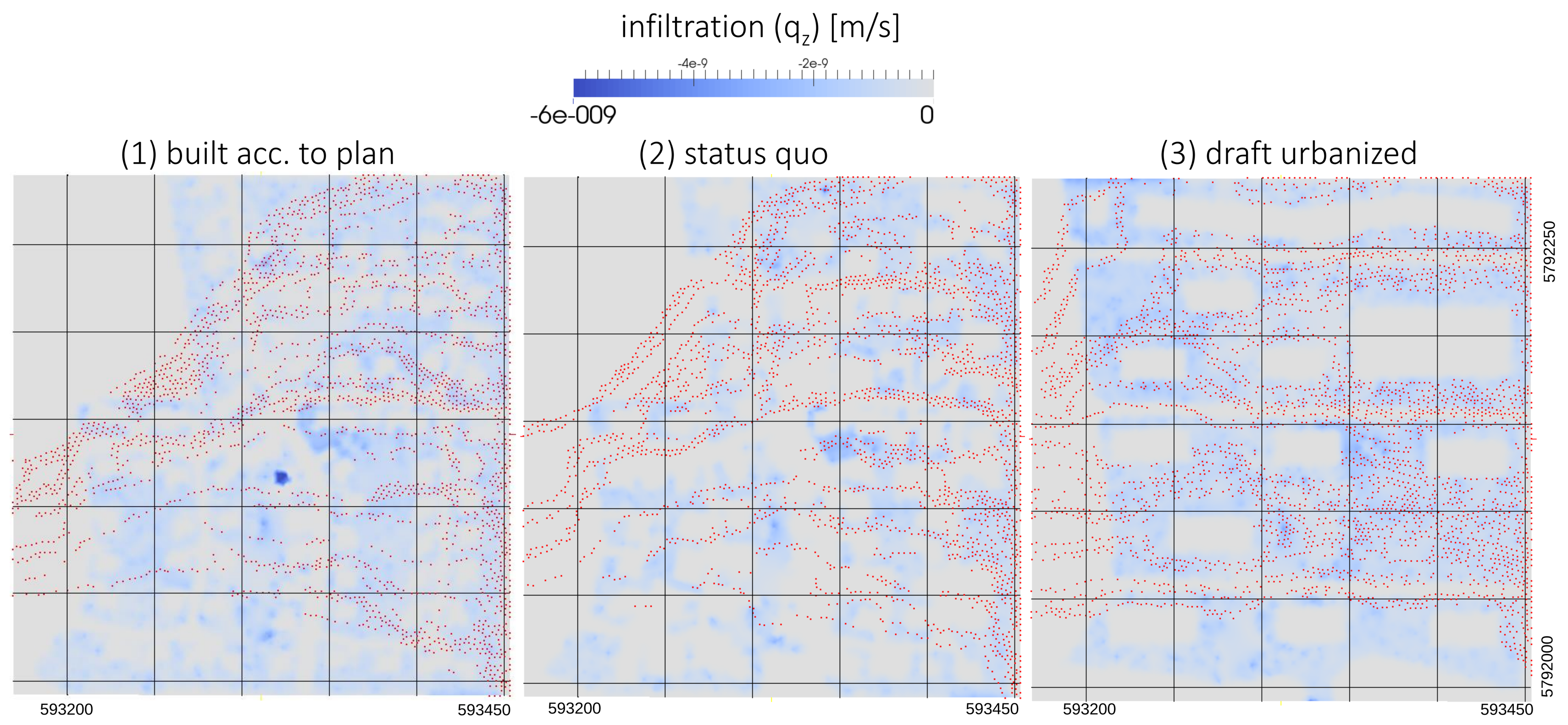

Fig. 6: Neumann source terms at upper boundary: infiltration of mean annual precipitation and particle positions (red dots) at ground surface.

[2]Wind drift simulations were performed by Laura Grunwald from the Institute of Geoecology of the University of Brunswick.
[3]Particle transport simulations were performed by Robert Sämann ICUD poster session: 5.15 (S5T13).

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