First experimental and simulation results of bank-side extraction well field tests to influence water exchanges in the hyporheic zone

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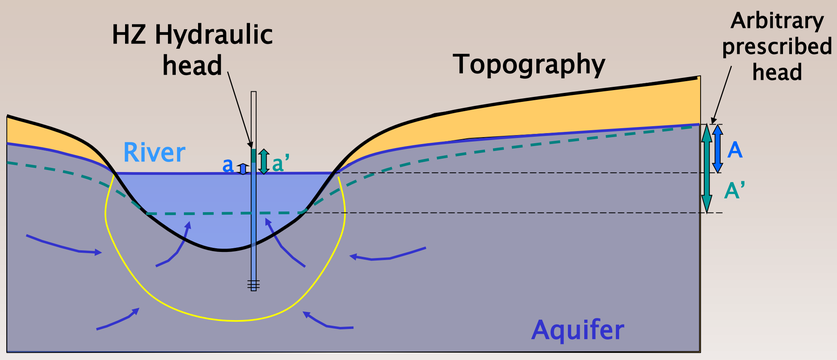
Introduction

Hyporheic zone (HZ)

- Exchanges between the ground and river waters
- Biogeochemical processes controlled by the exchanges
- Influence of hydraulic conditions on exchanges



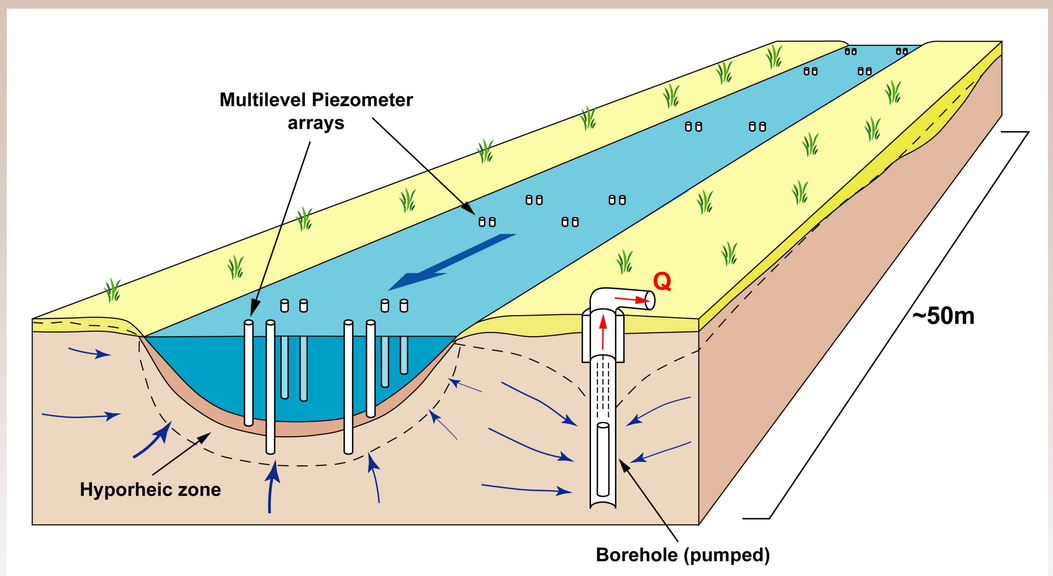
- Hypothesis: stable head as a boundary condition in the aquifer
- If river level decreases → HZ hydraulic head increases (**A** to **A'** → **a** to **a'**)

Problematic

- What is the sensitivity of the HZ hydraulic head to river level variations?
- Can a long-term pumping test control the surface-ground water exchanges?

Method: coupled field test/modelling approach

- 10 m wide, 20cm-2m deep river (mean discharge ~2 m^3/s)
- Well 5 m adjacent to the river, 16 m deep
- Heads and quality monitoring in the riverbed



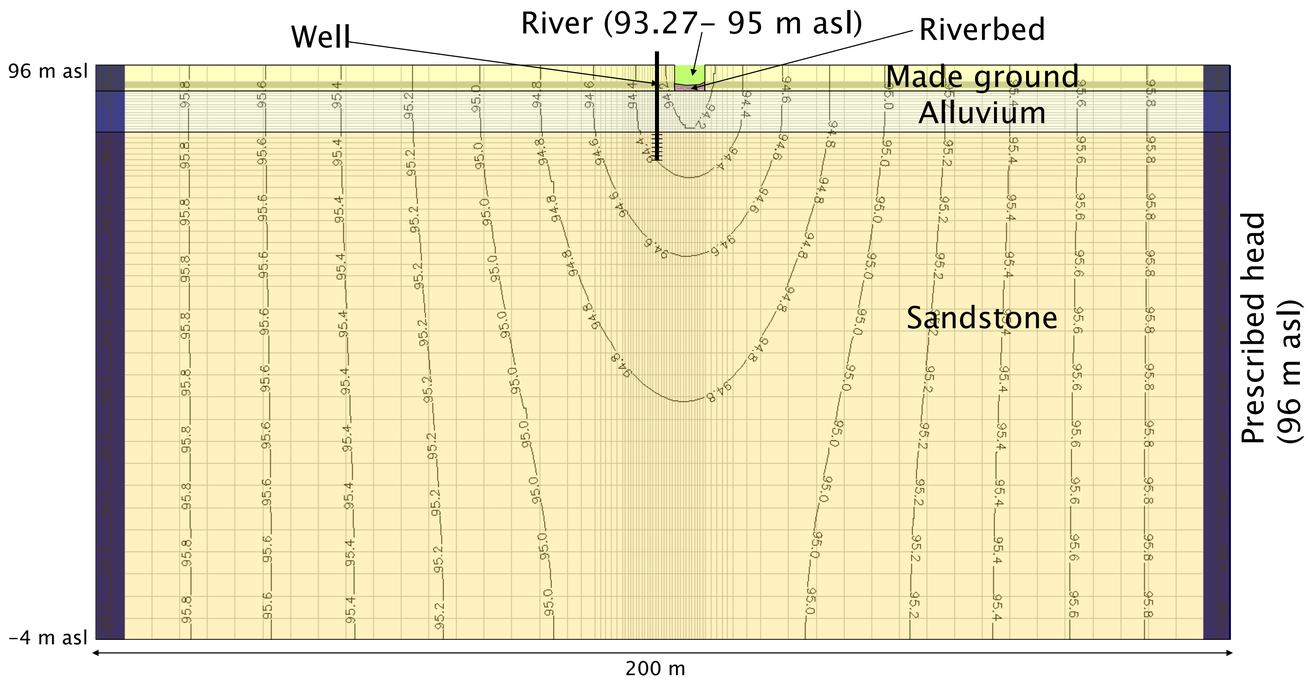
Test site:

- Urbanised reach of the River Tame, Birmingham (UK)
- Alluvial-drift deposits overlying ~100m of Permo-Triassic sandstone

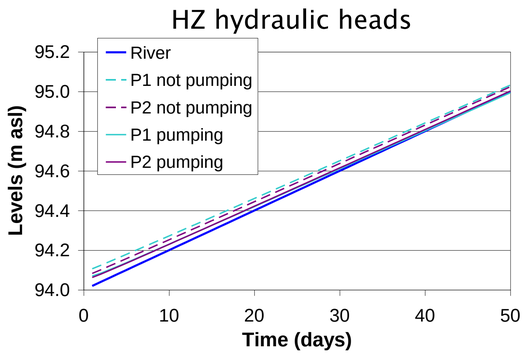
Results

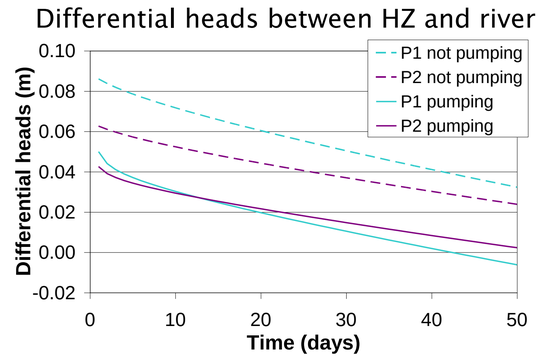
Model geometry

Simulated hydraulic heads in cross-section view under natural flow regime



Unrealistic simulation of HZ heads under a linear increase of the river level

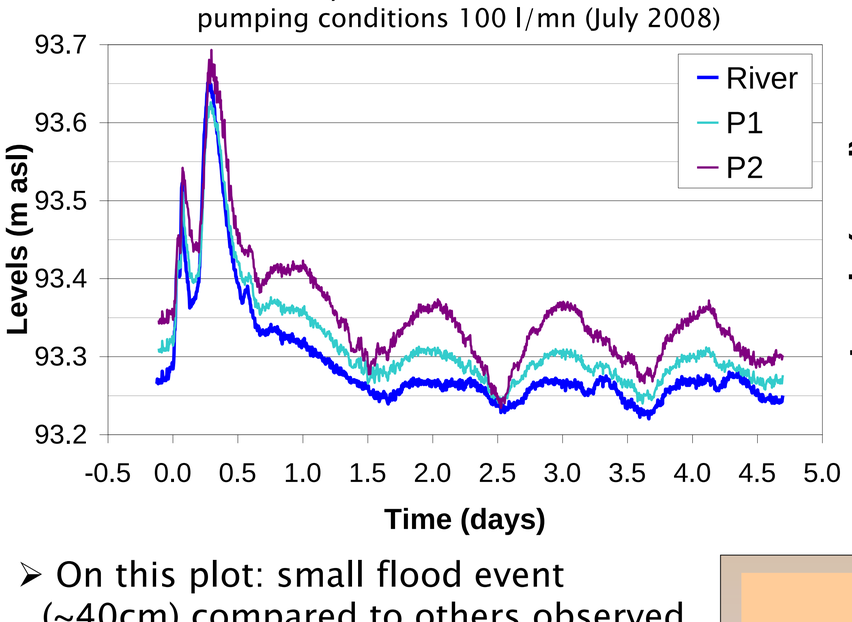


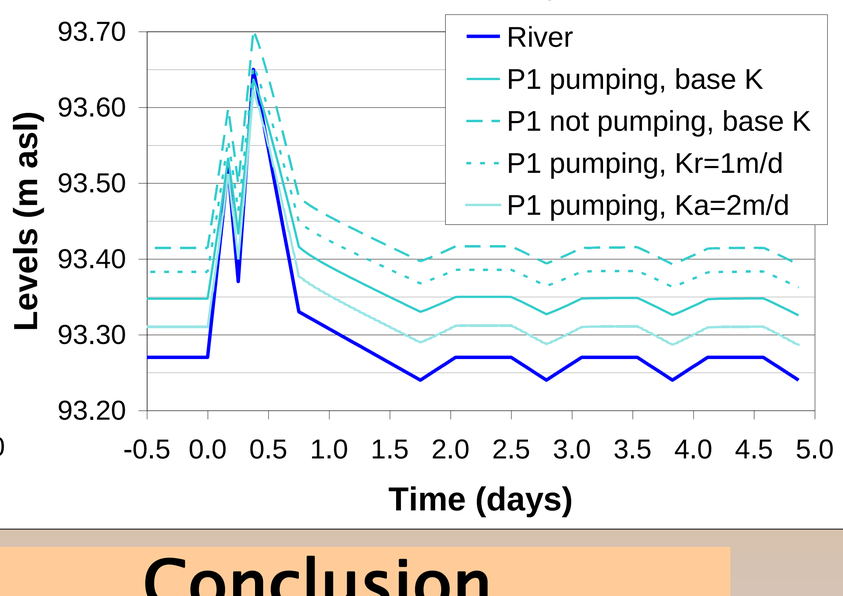


- High control of the river level on HZ hydraulic heads
- Differential heads between HZ and river decrease when river level increases
- Various slopes for differential head decrease in piezometers: higher slope for piezometer closer to the river bench (P1)
- Pumping impact (80 l/mn): shifting of the differential head but same slope

Measurements and realistic simulation inspired from the same river level variations

Base hydraulic conductivities:
Kr=2m/d (Riverbed)
Kg=5m/d (Made ground)
Ka=5m/d (Alluvium)
Ks=1m/d (Sandstone)





- Impact of pumping (100 l/mn)
  → decrease of HZ hydraulic head ~6cm
- Decrease in Kr (half value)
  → increase of HZ head ~3cm
- Decrease in Ka (~half value)
  → decrease of HZ head ~4cm

- On this plot: small flood event (~40cm) compared to others observed (increase of river level up to 2m)
- Daily variations (3cm) observed in the river → influence on HZ heads

Conclusion

- High sensitivity of HZ heads to three factors:
  - River level (major during flood events)
  - Aquifer conditions (higher influence at low river levels)
  - K heterogeneities

Perspectives

- Calibrate the spatial K heterogeneities
- Take into account the chemical parameters
- Analyse the temperature variations within the riverbed

Hyporheic Hydrology, Birmingham, 17th December 2008.