Investigation of the Hyporheic Zone via bankside extraction well field tests: Concept, design and site conditions

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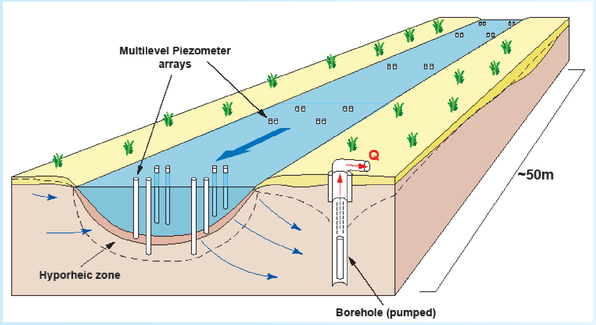
Research concept

The hyporheic zone represents an important system for water self purification that may mitigate the impact of urban groundwater contaminant plumes on receiving water courses due to natural attenuation. Our research involves the use of bank-side extraction well field tests that will perturb the natural groundwater – surface-water exchanges in a controlled manner. The transport of solutes/contaminants naturally present and injected tracers will be monitored under natural conditions and during tests conducted over several months. Such tests will allow controlled perturbation of the geochemical gradients and hence examination of hyporheic zone natural attenuation capacity and controlling processes at the field-scale. The adjustment of flows due to the extraction will lead to the residence times across the hyporheic zone varying from test to test.



We report herein on :

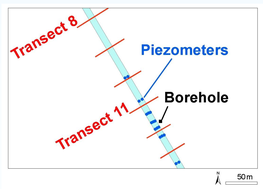
- **preliminary geochemical characterisation** of the hyporheic zone under natural flow conditions to establish natural attenuation controls.
- **preliminary numerical simulations** of the test design to investigate sensitivity of groundwater – surface water interactions to extraction rate, well location, river stage, and geological heterogeneity.

Test site

The test site is located on an urbanised reach of the River Tame, Birmingham (UK) that receives groundwater baseflow from the Permo-Triassic Sandstone aquifer. The site is being established over 2006-07 with extraction tests scheduled for 2007-08.

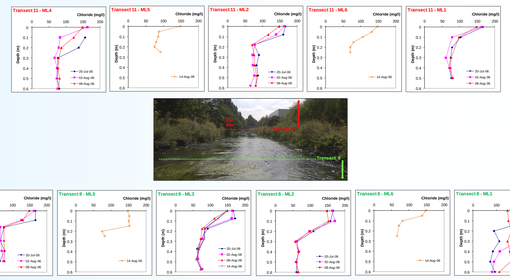
Field data: Hyporheic zone water quality under natural flow conditions

Preliminary Water quality and hydraulic head data have been collected using mini-drivepoint piezometer and multilevel samplers (Rivett et al., in subm. *QJEGH*) from the proposed experiment test site reach.



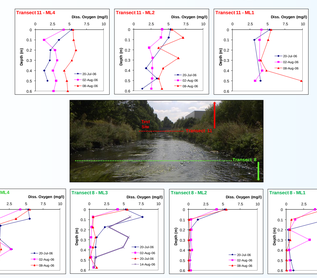
Data presented below are taken from two transects spaced about 150 m apart; the location of the proposed extraction test is close to transect 11. Sampling was under relatively low river flow conditions with occasional influenced of sporadic low to medium intensity rainfall events. Heads indicated groundwater was largely effluent. The data illustrate significant chemical quality variation with depth through the hyporheic zone, laterally across river transects and longitudinally along the reach suggesting complex temporal and spatial behaviour under these natural flow conditions.

Chloride



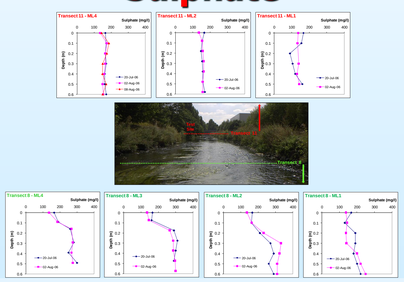
- Chloride is elevated in the surface water due to upstream sources; it hence provides a good indicator of surface water – groundwater mixing. The conservative chloride front in some profiles is relatively stable invading 15-20 cm into the riverbed. More temporally dynamic fronts invade further and present in a turbulent riffle zone.

Dissolved oxygen



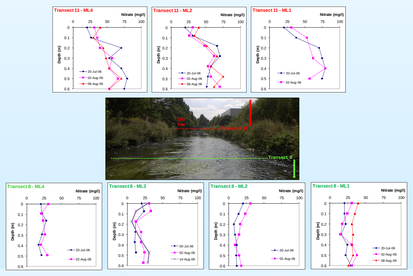
- Dissolved oxygen (DO) profiles in Transect 11 were aerobic, typically at 2-6 mg/l, with some evidence of decreasing concentrations with depth. Transect 8 was more variable. Depletion to very low levels was evident below 20cm depth, however, some transient increases occurred suggesting complex controlling processes.

Sulphate



- Sulphate was generally more elevated in discharging groundwater relative to the surface water, particularly for transect 8. That transect exhibited some inverse trends relative to chloride suggesting surface water dilution near the riverbed. Transect 11 sulphate was relatively uniform.

Nitrate



- Individual nitrate profiles were relatively stable with time and in Transect 11 exhibited lower values closer to the riverbed showing inverse behaviour to chloride, i.e. simple dilution may be occurring. Lower nitrate in Transect 8 show some evidence of mid-profile minima at 20-30 cm.

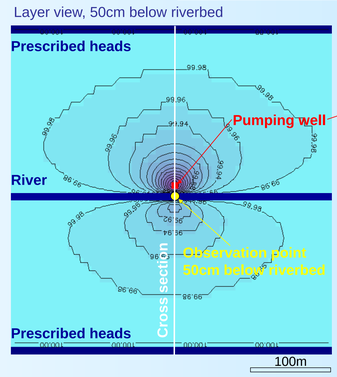
Modelling

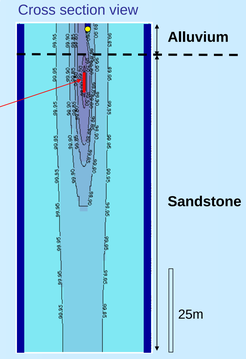
Changing heads in the riverbed are modelled in order to test the sensitivity of hydraulic parameters and pumping rates. The results will be compared to the field measurements during short pumping tests and will help to calibrate the aquifer properties. The aim of this preliminary model is to find the optimum pumping rate for long term pumping tests.

First simple model

- homogeneous hydraulic conductivity K = 1 m/d
- pumping discharge = 50 m^3/d

Head results





Sensitivity tests

- Increased K in alluvium by 10 times (K=10m/d)

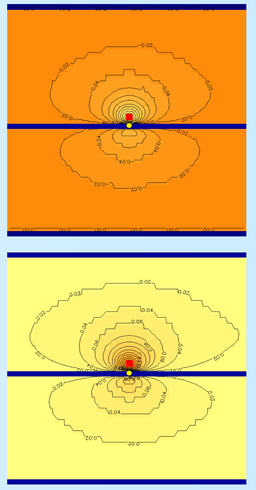
→ Reduced drawdown around the pumping: head at obs' point increased by 0.012%

- Doubled discharge (=100 m^3/d)

→ Increased drawdown around the pumping: head at obs' point decreased by 0.015%

→ Second case more sensitive than first

Head differences at 50cm below the riverbed



Future Work

A more detailed network of multilevel samplers is about to be installed local to the test site to further evaluate the baseline condition and further model sensitivity runs are in progress. The extraction well and infrastructure is about to be installed with extraction tests scheduled to start late summer 2007.