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The impact of structural streambed heterogeneity on groundwater - surface water exchange fluxes and nitrogen metabolism within the hyporheic zone

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This study investigates the impact of physical riverbed conditions on the dynamic exchange fluxes across the groundwater - surface water interface as well as on transport and metabolism of nitrogen species within the hyporheic zone. The investigation focus on stream reaches of the River Leith in Cumbria, UK. The complex spatial pattern of physical riverbed characteristics were examined by 42 sediment cores which were taken during base flow conditions in summer 2006 along characteristic pool-riffle sequences and cross sections including mid stream islands and sandbanks. Eighty seven piezometers were installed in nested arrays at several transects and cross sections. Pressure head differences between the piezometers of different depths and the river have been recorded in order to observe the temporal and spatial dynamics of exchange fluxes along the groundwater - surface waters interface. In order to investigate the impact of physical riverbed conditions on the temporal and spatial pattern of redox sensitive nitrogen species within the hyporheic zone the sediment cores have been analysed for nitrate and ammonia concentrations in 5 cm steps. Stream water and pore water sampled in the piezometers have been analysed for nitrogen species at fortnightly time steps corresponding with the hydraulic head observations. Additionally three nested arrays of 50 shallow sediment cores along characteristic features as mud banks and bare or reed covered islands were analysed for their nitrate and ammonia concentrations in order to quantify the potential effect of these geomorphic structures. The analyses of the hydraulic head gradients between the piezometers and the river detected complex spatial pattern and some significant temporal dynamics of fluxes along the groundwater - surface water interface. Generally the groundwater is con-

tributing to the river with variable intensities but also stream reaches which are gaining and loosing groundwater at opposite sites of a cross section were identified. The pore water nitrate concentrations correlate with physical streambed characteristics as transmissivities and the resulting intensities of exchange fluxes and flow directions as well with the chemical characteristics of the sediment material. The vertical distribution of nitrate within the analysed profiles is mainly characterised by a decrease of nitrate concentrations with depth. In the riffle section high concentrations of up to 8 mg/l could be found in shallow top gravel layers on top of in-situ sandstone, low concentrations in some anoxic, organic rich and peat layers. Low nitrate concentrations within the sediment strongly corresponds with the amount of organic carbon as a reductive agent and the existence of anoxic conditions which promote denitrification. Within pools generally higher nitrate concentrations than in riffles were detected (up to 50 mg/l). A typical longitudinal pattern of a pool - riffle - pool sequence was characterised by high nitrate concentrations in the pools, low nitrate concentrations in the beginning of a riffle (which we attribute to natural attenuation processes) and a subsequent increase towards the end of the riffle.