Small coil Surface Nuclear Magnetic resonance for shallow resolution of rivers in New Zealand

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Braided river systems are one of the primary sources of recharge for aquifers in New Zealand. Yet knowledge of the subsurface hydrology is often limited, especially within riverbeds as monitoring equipment is vulnerable and often destroyed. Furthermore, many geophysical methods provide limited results in these highly resistive environments, especially at shallow depths (less than 10 m) where much of the relevant processes occur.

A recent field study in New Zealand investigated three braided river systems using surface nuclear magnetic resonance (SNMR). In total, 77 soundings were acquired in the braided rivers using the Apsu SNMR instrument with a small coil (20m x 20m). The recently developed steady state acquisition was used to map the three rivers yielding an average production rate of ~ 8 sites per day. The soundings are performed in dense grids in the riverbeds and on the berms. Each sounding was inverted separately for water contents, T2\*, and T2 using a blocky inversion. Preliminary single-site inversions are able to resolve the water bearing units but required looser vertical regularization than previously typical of larger loop setups. Soundings in close proximity were inverted by lateral constrained inversion (LCI) to help impose anticipated lateral continuity/consistency between neighboring sites. The LCI results enhance consistency amongst T2\* in the rivers, compared with single-site inversions. The resulting inversions are used to identify free water bearing layers in the riverbeds. A layer with low free water is identified beneath the aquifer in all three rivers, which act as a low permeability bound which is a significant control on the river hydrology. The SNMR results is well correlated to coring results where this low permeability layer is identified clearly in multiple cores. Grain size analyses indicate an increase of fines at the same depths as the lower free water unit. Furthermore, electrical resistivity tomography results identify boundaries consistent with the SNMR, where a minor decrease in resistivity at the low permeability bound is observed. In summary, SNMR is shown to be an effective tool for mapping the geometry of the upper water bearing and low-permeability layer throughout these braided rivers.