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Groundwater Dynamics and Sources from Age Tracers, Isotopes, and Hydrochemistry: An example from the Heretaunga Plains, New Zealand

Uwe Morgenstern, Rob van der Raaij, John Begg, Mike Stewart, Chris Daughney, and Mike Toews
GNS Science, Hydrogeology, Lower Hutt, New Zealand (u.morgenstern@gns.cri.nz)

Understanding of groundwater recharge sources, and flow pathways and rates is key to sustainable management of aquifers including preservation of drinking water security and integrity of the aquifers and surface waters that receive inflows from groundwater. Time series and multi-tracer data is used to understand the dynamics of the groundwater from recharge to discharge, and processes that control the hydrochemical properties (quality) of the groundwater.

Age tracer and isotope data (tritium, CFCs, SF6, 2H, 18O) are available from c. 160 ground- and surface water sites across the Heretaunga Plains, at the east coast of the North island of New Zealand. Historic and recent tritium and SF6 data show that the groundwater abstracted from wells often has a complex age distribution, confirmed by a 3D geologic model that captures the complex structure of the aquifer system with well screens intersecting multiple layers of a heterogeneous aquifer. Binary mixing models produced excellent matches to the measured multi-age-tracer time-series data.

Hydrochemistry data provide context for the main drivers of hydrochemistry and recharge source, including oxic rivers and river-recharged groundwaters with low nutrient concentrations, association with limestone or carbonate geology, oxic rainfall-recharged groundwaters with moderate land-use impact and anoxic groundwater with chemistry typical of natural conditions.

The age tracers indicate that groundwater in most of the wells within the Holocene unconfined gravel fans of the main rivers are relatively young with mean residence time (MRT) 0 – 10 years, and from the area of the main water loss from the river towards the coast the groundwater within the confined aquifer becomes progressively older, with MRT between 20–40 years southwest of Napier. Further toward the coast, the groundwater becomes significantly older with MRT 40–80 years, and close to the coast the water is even older, indicating sluggish flow at this part of the aquifer. More vigorous groundwater flow in the confined aquifer toward the coast is indicated further south in the centre of the Plains – with a tongue of very young groundwater with MRT < 5 years extending nearly half way towards the coast. The groundwater ages imply horizontal flow rates of > 5 km/y near the gravel fans, decreasing to 0.05 km/y towards the coast.

The recharge source indicators (Ar, N2, 2H, 18O, nitrate, excess-nitrogen, and CFCs) indicate two areas of aquifer recharge from the main river – one of them being the tongue of young groundwaters. It is likely that this represents a buried paleo river channel that is still hydraulically connected to the river enabling fast seaward flow of water lost from the river. The tracer data indicate that not all major rivers contribute water to the main aquifer, despite presence of losing stretches in these rivers.

Age, gas, and isotope tracer data have provided details on large-scale groundwater processes that are not obtainable by other hydrologic methods.