Groundwater age and transit time in the Lake Rotorua catchment, New Zealand

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Lake Rotorua is a cultural icon and a focus of tourism in New Zealand. The lake's water quality has been declining over the past 40 years, due to nutrient inputs that reach the lake via the groundwater system. Improved management of land use within the Lake Rotorua catchment requires a better ability to predict the spatial and temporal variations of water age, and from this to predict current and future nutrient inflows to the lake.

This study combines the two main methods currently available for determination of water age: numerical groundwater models and hydrological tracers. A steady-state finite element groundwater flow model was developed for the Lake Rotorua catchment and then calibrated with PEST to match observed groundwater levels and stream base flows. The model was also calibrated to measurements of water age in streams and wells, as determined from fitting the exponential-piston flow model (EPM) to time-series measurements of tritium concentration. A Laplace transform of the transit time differential equation was used to account for advection and dispersion of "age mass". This allows determination of the distribution of water age at each point in the model domain, and hence a more meaningful comparison to the EPM.

Results show that simulated travel time from the land surface through the aquifer system and into Lake Rotorua varies from a few years to more than 200 years, depending on location. Notable from a management perspective is that rainfall recharge to the aquifer system far from the lake can still reach the lake quickly where groundwater emerges into a river that then flows rapidly to the lake.

The results of this study have important ramifications for understanding and controlling nutrient inflows to Lake Rotorua with full consideration of time lags associated with transport of nutrients through the groundwater system. This study also illustrates that the numerical modelling and tracer methods for determination of water age are highly complementary, and merging them retains their individual strengths while overcoming weaknesses that exist when they are used in isolation.