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River/Groundwater Interaction Dynamics in the Upper Motueka Catchment: Progress Report

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River/Groundwater Interaction Dynamics in the Upper Motueka Catchment: Progress Report

Motueka Integrated Catchment Management (Motueka ICM) Programme Report Series

by

Mike Stewart[1], Joseph Thomas[2], Tim Davie[3]

[1]GNS Science/Aquifer Dynamics Ltd, PO Box 30368, Lower Hutt
[2]Tasman District Council, Private Bag 4, Richmond
[3]Landcare Research, PO Box 40, Lincoln
NEW ZEALAND

Cover Photo: Surface water ponding and ephemeral streams across the alluvial terraces adjacent to Motupiko River, Korere. These water sources normally infiltrate into groundwater before reaching the river.
(Photo John Payne, August 2006)

PREFACE

An ongoing report series, covering components of the Motueka Integrated Catchment Management (ICM) Programme, has been initiated in order to present preliminary research findings directly to key stakeholders. The intention is that the data, with brief interpretation, can be used by managers, environmental groups and users of resources to address specific questions that may require urgent attention or may fall outside the scope of ICM research objectives.

We anticipate that providing access to environmental data will foster a collaborative problem-solving approach through the sharing of both ICM and privately collected information. Where appropriate, the information will also be presented to stakeholders through follow-up meetings designed to encourage feedback, discussion and coordination of research objectives.

Introduction

The Upper Motueka valley contains a sizeable portion of fertile river terrace land suitable for irrigated agriculture. Improved understanding of the interaction between the river and groundwaters in the area will contribute to improved management of the water resources. The information will also provide a conceptual framework to assist development of computational models which can be used to investigate a variety of land use and water allocation scenarios.

Methods

Samples were collected for tritium, oxygen-18 and chemical measurements from locations shown in Figure 1. (NEEDS FIGURE 1).
Timing of sampling? i.e. Feb, Aug and October, why the range (presumably to get as many points on the curve as possible)

Results

The results of the measurements are given in Table 1. The table contains Mg, SiO_2 and $\delta^{18}O$ concentrations as well as the tritium concentrations. The tritium values have been used to estimate the mean residence times using the smoothing of the natural variation of tritium in the rainfall when it goes underground. The derived mean residence times (MRTs) are given along with the goodness-of-fit of the simulations to the data in the last two columns.

To determine the MRTs, simulations based on flow models were fitted to the data. The exponential piston flow model (EPM) was used for the simulations. This assumes that the system can be approximated by a well-mixed (exponential) section followed by a non-mixed (piston flow) section. The parameter f (the exponential section volume divided by the total volume) is used to specify the model. An f value of 100% was used to derive the MRT values in Table 1.

The Motueka River was sampled at two locations. At Gorge, it has a short MRT (about 1 month). The goodness-of-fit is poor, but this is more a reflection of the limits of the data (i.e. the monthly sampling of the rainfall does not allow accurate estimation of very short timescales). It is relatively clear, however, that the indicated MRT is very short.

Further down the valley, upstream of the confluence with the Wangapeka River, the river has a MRT of 2-4 months. The variation of the goodness-of-fit indicator (sd) with MRT for different values of f in the EPM is shown in Fig. 2a. The smaller the value of sd, the better the fit. f=1.0 has a best-fit (lowest sd) at about MRT=2 months, but produces reasonably good fits between 2 and 4 months. f=0.9 has a similar shape, but f=0.8 has a sharp minimum near 2 months. Based on this and the other results, an f value of 100% is used to evaluate the MRTs in Table 1. (An f value of 100% (when you say 100% do you mean f=1.0?) was also found to be the best for simulating the $\delta^{18}O$ values given in Stewart et al. (2005.) Three simulations using the EPM model with f=1.0 are given in Fig.2b, along with the Motueka River data and monthly tritium concentrations in bulk rainfall (dotted line; data from Kaitoke adjusted by a scale factor (1.2) to correct for altitude and latitude differences between Kaitoke and Motueka).

Table 1. Tritium and $\delta^{18}O$ values of sampled features in the Upper Motueka Valley. Estimated ages are based on tritium concentrations.

Feature	Date	Mg mg/L	SiO_2 mg/L	$\delta^{18}O$ (‰)	Tritium (TU)	MRT[1] (mths)	SD[2] (TU)
Motueka R @ gorge	14/02/05	8.7	10	-8.0	2.17 ± 0.07	1	0.16
	4/08/05				2.11 ± 0.05		
Higgins bore	14/02/05	16	21	-7.6	2.35 ± 0.06	4	0.07
	4/08/05				1.87 ± 0.06		
Campbells bore	14/02/05	10	15	-7.5	2.11 ± 0.06	13	0.10
	14/02/05				2.06 ± 0.06		
Hinetai Spring @ source	12/10/04	14	16	-6.9	2.07 ± 0.05	14	0.04
	14/02/05	12	19	-7.0	2.10 ± 0.06		
	4/08/05				1.94 ± 0.05		
Motueka River u/s Wangapeka	12/10/04	4.6	13	-7.4	2.27 ± 0.05	2-4	0.07
	14/02/05	6.9	11	-7.5	2.32 ± 0.06		
	4/08/05				2.07 ± 0.06		
Quinneys bore	14/02/05	1.4	11	-7.0	2.39 ± 0.07	2	0.06
	4/08/05				2.10 ± 0.08		
Crimps bore	14/02/05	2.9	11	-6.9	2.47 ± 0.08	2	0.06
Roadside spring	12/10/04	3.5	16	-6.8	2.33 ± 0.05	2	0.14
	31/08/05				2.22 ± 0.05		
	21/12/05				2.30 ± 0.05		
Quinneys Spring	31/08/05	3.5	16	-6.8	2.07 ± 0.05	20	0.05
	21/12/05				2.05 ± 0.05		

[1]MRT is the mean residence time based on the exponential piston flow (EPM) model with f=1.
[2]Standard deviation of the difference between the simulation and the data (used as a measure of the goodness-of-fit).

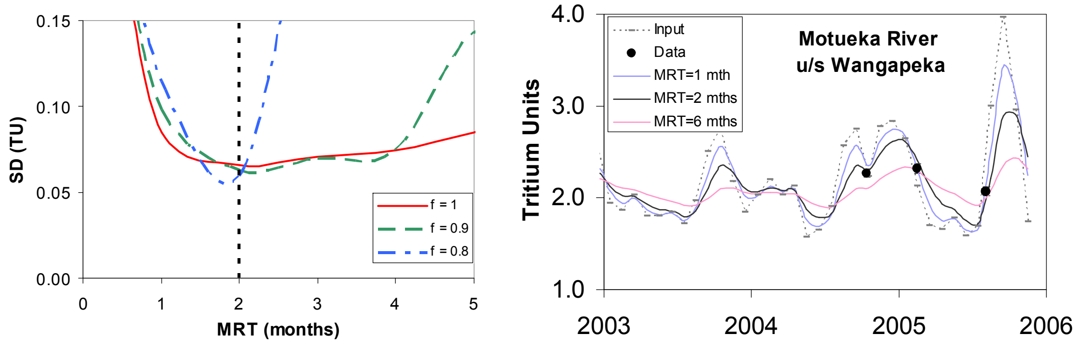

Figure 2: a) Variation of the goodness-of-fit (sd) with MRT for different values of f in the EPM model.
b) Tritium concentrations of monthly rainfall samples, Motueka River water samples and simulations using the EPM model (with f=1.0 and MRTs of 1, 2 and 6 months).

The Higgins (WWD4784) and Campbells (WWD4618) samples gave best-fit mean residence times of 4 and 13 months respectively with the EPM(f=1.0) model. These are similar to the results obtained using the variations in the $\delta^{18}O$ values (4 and 7 months, Stewart et al. 2005). They show a tendency for the groundwater to be older with distance from the river, and are consistent with the river being the major source of water in these bores (also shown by the mean $\delta^{18}O$ values).

Hinetai Spring discharges not far from the river above the confluence with Wangapeka River. The quality of fit (sd) for different values of f is shown in Fig. 3a. f=1.0 has a broad minimum, with the best fit at MRT=14 months. f=0.9 also has the best fit at MRT=14 months, but with a more uneven shape. f=0.8 has a similar shape, but with the minimum at 12 months and higher sd values (showing poorer fits).

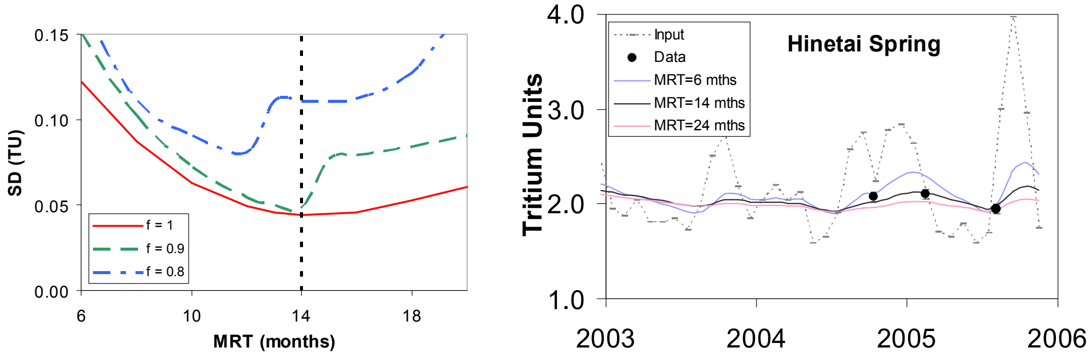

Figure 3: a) Variation of the goodness-of-fit (sd) with MRT for different values of f in the EPM model.
b) Tritium concentrations of monthly rainfall samples, Hinetai Spring water samples and simulations using the EPM model (with f=1.0 and MRTs of 6, 14 and 24 months).

Both Quinneys (WWD4615) and Crimps (WWD4616) bores had best-fit mean residence times of 2 months (i.e. very short). The MRT derived from the variation of the $\delta^{18}O$ values for Quinneys was also 2 months (Stewart et al. 2005). The earlier work showed that most of their water was sourced from the Motupiko River (88% for Quinneys).

Roadside Spring and Quinneys Spring have diverse mean residence times (2 and 20 months respectively). The roadside spring was immediately adjacent to a steep slope, suggesting the water was recently derived from this slope. Quinneys Spring appears to be derived from an old river channel, similar to Hinetai Spring.

Conclusions

The tritium and $\delta^{18}O$ values confirm the hypothesis that the groundwater is predominantly river derived. Mean residence times in the main stem river were 1-4 months. Shallow groundwater showed mean residence times of 2-14 months and water in spring fed streams ranged from 2-14 months.

References

Stewart, M.K., Cameron, S.C., Hong, T., Daughney, C.J., Tait, T., Thomas, J. 2005: Investigation of groundwater in the Upper Motueka River Catchment. *GNS Science Report 2003/32*. 47 p.