DYNAMIC 3-D FINITE-ELEMENT RIVER-AQUIFER INTERACTION MODELLING IN THE UPPER MOTUEKA CATCHMENT

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The Upper Motueka catchment is an area of 887 km^2 of fertile river terraces suitable for irrigated agriculture. There has been an increasing demand for irrigation water, especially from groundwater, in this catchment since the 1990s. The Upper Motueka catchment includes a shallow unconfined alluvial aquifer located on Quaternary river terrace formations and modern river deposits. The river terraces are composed of five different Quaternary gravel formations. There are (from the oldest to the youngest): the Moutere Gravel, Manuka Gravel, Tophouse Gravel, Speargrass Gravel and modern river Gravel formations. The Quaternary gravels are underlain by the Moutere Gravel Formation throughout the whole study area.

The extraction of more groundwater for irrigation during the summer period has caused lower groundwater levels and consequently decreases in the baseflow of rivers due to strong shallow aquifer-river interaction in this area. In order to manage the water resources in this region, the development of an efficient groundwater flow model is required to understand the effect of groundwater abstraction on river flow and groundwater level. The purpose of the study is to understand dynamic interactions between the shallow aquifer and the surface water systems by developing a dynamic 3-D finite-element groundwater-river interaction model. In this study FEFLOW, which is an adaptive finite-element groundwater modelling system, is used. The model is developed at a daily time step in the period of 01/07/2001 to 30/06/2002.

The Motueka groundwater flow model focuses on the area within the boundary running from 3 km downstream of the Motueka River - Tadmor River confluence to 3 km up the Tadmor River from the confluence, to approximately 8 km upstream of Kohatu on the Motueka River, and to approximately 15 km up the Motupiko River from its confluence with the Motueka River (Figure 1). The aquifer domain is discretized using 6-node triangular finite-element with 29299 nodes and 30386 finite element mesh (Figure 2). The aquifer thickness varied between 9-12 m in the lower part and average 8 m in the upper part within the model domain.

The following dynamic models are developed to represent the Upper Motueka river-aquifer interaction model:

- Groundwater abstraction model
- Rainfall recharge model
- Hill slope recharge model
- Side river model
- River model

There are total of 39 groundwater pumping wells identified in the model domain (Figure 2). The dynamic groundwater abstraction models at 39 sites are developed using a '4th kind' boundary condition in the model. The daily rainfall recharge model is also developed, using a water balance model, as a function of soil permeability, land use, precipitation, evapotranspiration, for the non-irrigated and the irrigated fields in each of three different zones (Figure 3).

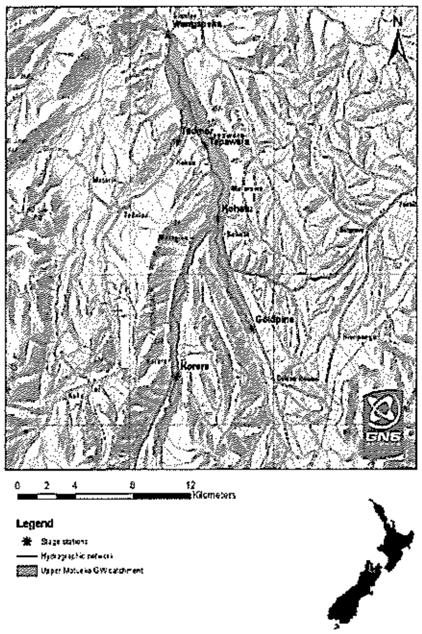

Figure 1. The Upper Motueka groundwater catchment (red) with six river stage recording sites.

Figure 2. Finite-element structure of the model with the river model. Groundwater abstraction wells and eight hillslope recharge zones are also displayed.

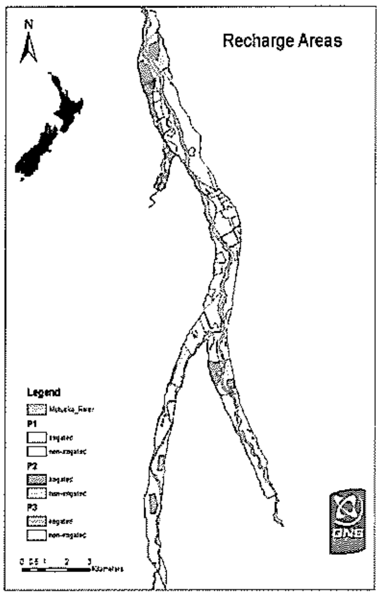

Figure 3. Six different recharge zones.

The river system in the model domain is composed of three rivers: Motueka River, Motupiko River and Tadmor River. They are implemented using a '3rd kind' boundary condition, also referred to as the *Cauchy's boundary*, that represents leakage from surface bodies where the exchanges of water between aquifer and surface water depends on the head differences between surface water and groundwater. The river stages are recorded in six river gauging stations (Figure 1). The Akima inter/extrapolation technique based on the cubic transfer function has been applied for calculating the dynamic river stage change at all river nodal points in the river model where the observed data are not available.

The four small streams coming from the hills are identified as side river recharge sources that would influence river flow. These four side river recharge systems are implemented using a '3rd kind' boundary condition in the model. The eight potential hill-slope aquifer recharge zones have been identified by Landcare in the Upper Motueka catchment (Figure 2). This hill-slope recharge is not significant compared to rainfall recharge and river recharge to the aquifer. However recharge from hill-slopes influences the total water budget in the model domain. The transient hill-slope recharge model is developed at eight sites in the model domain.

The model has been run for the period of 01/07/2001 to 30/06/2002 with a daily time step. The model was calibrated to achieve a best fit between the observed and predicted head distribution at 3 groundwater monitoring sites (Quinney Bush, Crimps, and Hyatts). The current range of hydraulic conductivities used in the model are from 1×10^{-4} to 10^{-5} m/s. These are rather low values for gravel formations in the area and they will be adjusted to achieve the better calibration result in the next project step.

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