Ground water modeling coupled with SVTA model and its application to Yasu River Basin

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1. Introduction

Preliminary study of ground water levels in the lower Yasu River basin indicates that some parts of the basin have experienced significant draw down in the ground water levels. Among the 10 sites where ground water was available during this study Otsukubo, station seems to be the most affected as shown in figure 1 below.

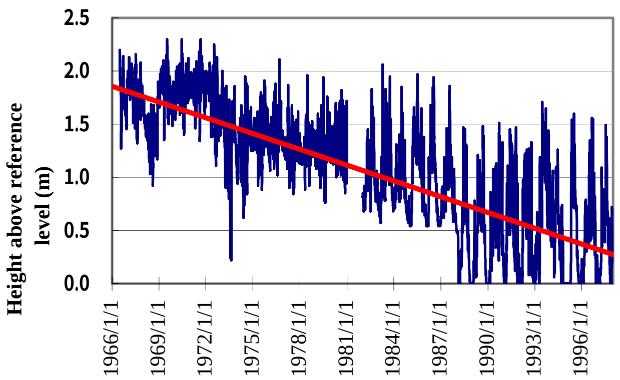

Figure 1: Water level trend at Otsukubo Ground Water Station in the lower part of Yasu Riber Basin

The objective of this study is to develop a suitable model for ground water movement and investigate possible causes for ground water depletion in the study area. The main assumption of the work is that land use changes among others have contributed to the change of water levels with different effects for different parts in the basin. In this study the Noilhan and Planton model is used to estimate ground water recharge. Since this model uses land use data, it can be used to study the effect of land use changes on groundwater resources when applied to estimate recharge.

2. Estimation of recharge

The estimation of recharge to ground water is done by utilizing the Noilhan and Planton model (1989). The model has been shown to have the ability to reproduce the components of surface energy balance over a wide variety of surface conditions. In this study the deep layer moisture W_2 is used to estimate ground water recharge as

$$I = K_s (W_2 / W_{sat})^{(2a+3)}$$

where I is groundwater recharge (L/T), K_s is saturated hydraulic conductivity (L/T), W_2 is the moisture content in the deep soil layer, W_{sat} is the saturated moisture content and a is an empirical coefficient referred to Clapp and Hornberger (1978)

3. Conceptual ground water model

It is assumed that the ground water reservoir in the study area can be represented by a single layer unconfined aquifer with two-dimensional flow. The Yanomune River, the Hayama River and the Lake Biwa form eastern, southern and northern constant head boundaries respectively. A mountain range on the southeastern part forms a no flow boundary between rivers Yanomune and Hayama (see Figure 2)

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4. Mathematical model

The governing equation applied to model groundwater flow in this case is the Boussinesq equation. When pumping and leakage term are introduced this equation can be stated as

$$\partial/\partial x(K_x b \partial h/\partial x) + \partial/\partial y(K_y b \partial h/\partial y) =$$
$$S\partial h/\partial t + q(x,y) \quad - K_z/2M(x,y)(2H_o - h_t - h_{t+1})$$

where K_x, K_y and K_z are permeabilities in X ,Y and Z directions [L/T], *b* is the saturated aquifer thickness [L] and q*(x,y)* is pumping or recharge rate (L^3/T). *M(x,y)* and $H_o(x,y)$ are the thickness and hydraulic head of the confining layer respectively.

5. Model application

The study area is located in the lower part of the Yasu River basin near Lake Biwa. The area has about 67 production wells with a total pumping load of 111778 ton/day and 10 observation wells. Initial conditions for groundwater model were estimated by Kriging technique utilizing observed water levels from the 10 observation wells. The ground water recharge is estimated prior to groundwater simulation.

6. Results and discussions

A test run for the ground water model was conducted. At the preliminary stage only the response to pumping is investigated. The result indicates that the model can simulate well the response to pumping. It is also seen that groundwater abstractions can play a major role in changing the direction of groundwater flow as seen in comparison of initial and final groundwater contours. This will in future with more realistic data give clue to how pumping in wells can affect the ground water levels over the study area. However more data is required to define the aquifer system in order to quantify water level changes.

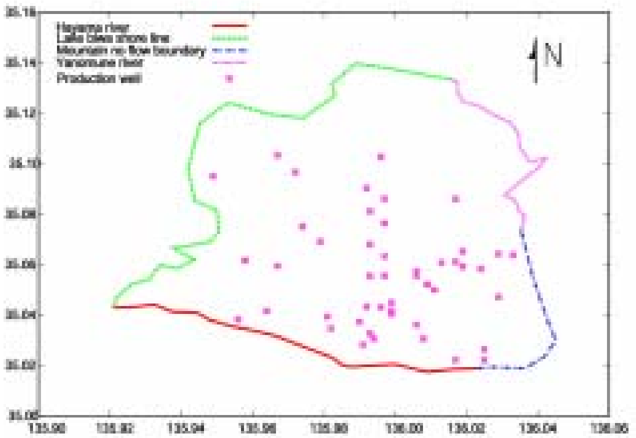

Figure 2 boundaries of study area

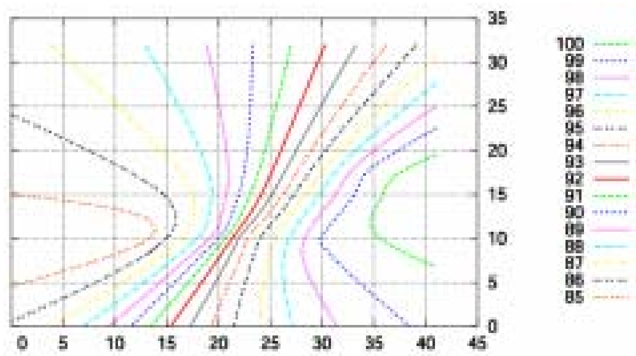

Figure 3 Initial ground water level contours

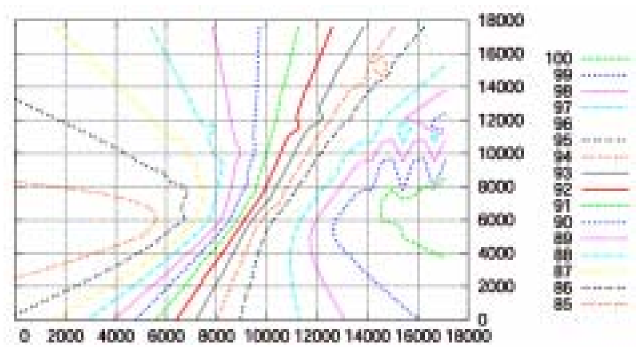

Figure 4 Ground water level contours after one-day simulation

References:

1) J. Noilhan and S. Planton 1988: simple parameterization of land surface processes for Meteorological models. *Mon. Wea. Rev.* **117**, 537-549.

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