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The Significance of Groundwater Modelling Practices for Resources Evaluation in Malaysia

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Groundwater modelling is normally carried out to estimate groundwater resources potential and to predict environmental impacts caused by groundwater abstraction as well as pollution migration in the chosen area. The results of simulation is normally able to characterise the groundwater conditions in the area and potentially enable to support technical decisions and policy making in planning for the sustainable groundwater resources development in the area. The model should enable the authorities to formulate optimal management strategies leading to a development and protection of the water resources of the area.

Groundwater models are conceptual descriptions, or approximations, that describe physical systems using mathematical equations and they are not exact descriptions of physical systems or processes. The applicability, or usefulness, of a model depends on how closely the mathematical equations approximate the physical system being modeled. For this reason, models that are based on a thorough understanding of the physical system and the assumptions embedded in the derivation of the mathematical equations produce better predictions. Some definitions of a model are:

"a model is a simplified representation of a complex system" or:

"*a model is any device that represents an approximation of a field situation*" (Anderson & Woessner, 1992).

Groundwater flow model can provide useful information on flow rates, drawdown and flow directions of the modelled area and hence allow for design of various remedial alternatives for hazardous waste sites. The flow model can also give information on the impact of resulting development. For managing the resource sustainably, the groundwater modelling was carried out in the area to:

- Improve the understanding of the modelled area (current or proposed abstraction area) and its surrounding regional groundwater flow system from the idealisation of the aquifer system in this area,
- Predict the potential migration of contaminant,
- Simulate systems for water supply, remediation and dewatering, and
- Predict the steady-state flow characteristics and the future regional changes caused by variable discharge of groundwater in the proposed abstraction area following extensive abstraction of groundwater from the multi-layered aquifers.

A contaminant transport model is necessary if information to assess the mechanisms of contaminant transport such as on concentration movement and reduction, mass fluxes and travel times are desired. It is used to:

- Estimate and track the possible migration pathway of groundwater contamination,
- Design and evaluate the design of hydraulic containment and pump-and-treat systems,
- Design and evaluate groundwater monitoring networks,
- Estimation of the possible fate and migration of contaminants for risk evaluation, or
- Assess the remediation work including: determining the effectiveness of hydraulic containment systems, estimating contaminant removal rate and cleanup time, evaluating the potential impact to downgradient receptors such surface water bodies or potable water supply wells, and predicting contaminant concentrations for natural attenuation remedies.

In Malaysia, the increased demand for the use of groundwater has resulted in significant advances in regional groundwater flow modelling. The modelling works have been driven by the demand to predict regional impacts of human inferences on groundwater systems and associated environment. The wide availability of powerful computers, user friendly modelling software (such as MODFLOW and MIKE SHE) and GIS stimulates an exponential growth of regional groundwater modelling in the country. The technology has made it possible to even understand rather complex processes of the hydrologic cycle by means of executing a *model* on the computer.

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