Technology Fact Sheet

Water resources model - Groundwater flow modeling with MODFLOW and related programs[i]

1) Introduction

Computer model that can simulate groundwater flow in the aquifer system continues growing significantly, not only in the two-dimensional but three dimensional scale. The computer model can now be run using a personal computer, so the user model is easier to operate for research. One of the most popular computer models used by researchers is the MODFLOW ground water problems. Groundwater Flow Model module of finite-difference (MODFLOW) was developed by the U.S. Geological Survey (USGS). MODFLOW is a computer program to simulate the general features of the groundwater system (McDonald and Harbaugh, 1988; Harbaugh and McDonald, 1996).

MODFLOW program is built in the early 1980s, the current model continues to evolve which is equipped with a new package and program development related to ground water used in the study. MODFLOW program popularity as a computer program that can be used to simulate ground water is the most widely used program in the world for the simulation of groundwater flow.

2) Technical requirement

MODFLOW is designed to simulate aquifer systems in which (1) saturated-flow conditions exist, (2) Darcy's Law applies, (3) the density of ground water is constant, and (4) the principal directions of horizontal hydraulic conductivity or transmissivity do not vary within the system. These conditions are met for many aquifer systems for which there is an interest in analysis of ground-water flow and contaminant movement. For these systems, MODFLOW can simulate a wide variety of hydrologic features and processes. Steady-state and transient flow can be simulated in unconfined aquifers, confined aquifers, and confining units. A variety of features and processes such as rivers, streams, drains, springs, reservoirs, wells, evapotranspiration, and recharge from precipitation and irrigation also can be simulated. At least four different solution methods have been implemented for solving the finite-difference equations that MODFLOW constructs. The availability of different solution approaches allows model users to select the most efficient method for their problem.

A) Application of MODFLOW

MODFLOW simulates ground-water flow in aquifer systems using the finite-difference method. In this method, an aquifer system is divided into rectangular blocks by a grid. The grid of blocks is organized by rows, columns, and layers, and each block is commonly called a "cell." The output of this MODFLOW model can be realized in addition to numerical data, the image can also be visualized. Visual display output from MODFLOW model in the computer, as if to give an overview of the real conditions. Visual appearance of natural objects imitated in the computer model can bring all parties to take appropriate action.

B) Model Input

For each cell within the volume of the aquifer system, the user must specify aquifer properties. Also, the user specifies information relating to wells, rivers, and other inflow and

outflow features for cells corresponding to the location of the features. For example, if the interaction between a river and an aquifer system is simulated, then for each cell traversed by the river, input information includes layer, row, and column indices; river stage; and hydraulic properties of the river bed.

3) Status of technology and its future market potential

Modeling technology has become a very important tool in the study. As a tool in research, technology has many advantages: 1). Provide quick and efficient results. 2). As a tool to predict groundwater flow conditions in the aquifer system in the future. 3). Can be used to improve the situation in the future, by using a design scenario. 4). Inspire more extensive research in the future.

The ability of researchers in Indonesia to master the modeling technology is very possible that needs to be supported by hardware and software. If the hardware and software is available on the market in Indonesia is the modeling technology will be more interesting to learn.

The market potential associated with the modeling technology widely opens, considering that Indonesia is an archipelago, so that each region has different hydrological characteristics as well. This condition causes the computer modeling market primarily related to groundwater flow in the aquifer system is promising potency in the future.

4) Contribution of the technology to protection of the environment

Simulation modeling technology of water resource is intended to have better knowledge about the potential water in the storage of the ground and then to optimize its usage. By optimizing the use of available water it is automatically the water resource is protected meaning the protection of environment. The output of the model is for planning purposes in optimizing the usage of stored water hence it is maintaining the environment.

5) Climate

Groundwater modeling technology application is actually derived from existing water scarcity as a result of climate change impact. Therefore it is very important to have this projection model on water resource in order to better manage the available water. The climate parameters such as rainfall and temperature are basic inputs to the program of groundwater modelling. The results of groundwater flow predictions obtained with the computer model is a very important sources of information for administrator for making development plan. Thus, stakeholders are benefitted from the outputs generated by this computer model.

6) Financial requirements and cost

To be able to develop and apply computer models of groundwater flow, it requires substantial funds. Substantial funds are allocated to: 1). the cost of procurement of hardware (computers and their supporters) and software (software licenses). 2) The cost for the procurement of data (through surveys and the purchase of secondary data). 3). Salaries and wages for researchers.

[i] **This fact sheet has been extracted from TNA Report - Adaption for Indonesia. You can access the complete report from the TNA project website http://tech-action.org/**