

MODFLOW

What is MODFLOW? What is a MODFLOW package (provide at least 2 examples)? What are the inputs to a MODFLOW model?

MODFLOW is a command-line program and represents a computer simulation of a groundwater flow developed in Fortran 66 computer language. MODFLOW is a finite-difference groundwater model where flow is simulated using a block-centered finite-difference approach (Harbaugh, 2005).

The structure of MODFLOW includes main program and packages. There are 3 main MODFLOW packages. Packages dealing with groundwater flow are **hydrologic packages**: 1) hydrologic and internal flow package (flow between cells); and 2) stress package (recharge, well, river, etc.). These packages are made to deal with the specific features of the hydrogeological system. Another package is a **solver package** (multiple solution methods) that represent the work of the program together with hydrologic package. The third is the **basic package** which is in charge for controlling the program.

| Package Name | Abbreviation | Package Category |
|-----------------------------------|--------------|---------------------|
| Basic | BAS | Program Control |
| Block-Centered Flow | BCF | Hydrologic/Internal |
| Layer-Property Flow | LPF | Hydrologic/Internal |
| Horizontal Flow Barrier | HFB | Hydrologic/Internal |
| Well | WEL | Hydrologic/Stress |
| Recharge | RCH | Hydrologic/Stress |
| River | RIV | Hydrologic/Stress |
| General-Head Boundary | GHB | Hydrologic/Stress |
| Drain | DRN | Hydrologic/Stress |
| Evapotranspiration | EVT | Hydrologic/Stress |
| Strongly Implicit Procedure | SIP | Solver |
| Preconditioned Conjugate Gradient | PCG | Solver |
| Direct Solution | DE4 | Solver |

Figure 1. Packages for simulation of the groundwater flow (taken from Harbaugh, 2005)

Inputs to a MODFLOW model are files/packages with specific features of a hydrologic system that will be simulated.

HEAD GRADIENTS AND K

What is the relationship between head gradients and hydraulic conductivity in steady state systems?

According to the Darcy's law, hydraulic conductivity is the constant that defines the proportionate relationship between flux and gradient. Hydraulic gradient always decreases in the direction of water flow.

GRID CELLS

What is a model node? A model cell? Use a simple diagram to show the relationship between heads defined at nodes and properties defined in cells.

Model node is a point at the center of a cell at which head is to be calculated, whilst **model cell** is a block of a grid where rows, columns, and layers are described.

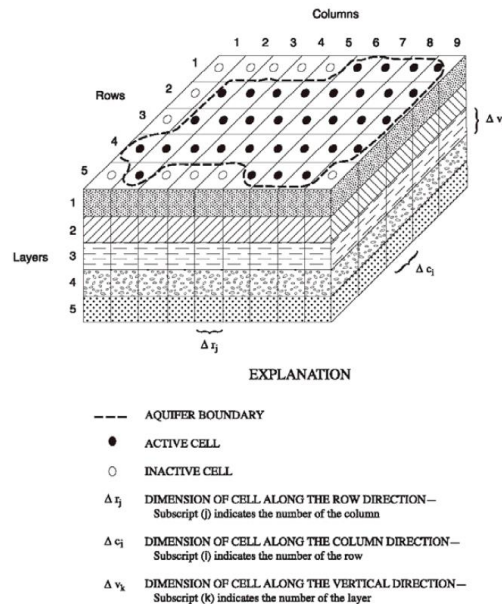


Figure 2. 3D model of aquifer system (taken from Harbaugh, 2005)

BOUNDARY CONDITIONS

What is the difference between Type I and Type II boundary conditions and under what conditions might you use each? Provide at least 2 examples for locations where we might use Type I or Type II boundaries to represent a feature in the real world.

Boundary conditions are physical characteristics of a groundwater system (Reilly, 2001). Boundaries are characterized by a constant rate of flow into or out of the aquifer. Type I of boundary condition, in this case represent the constant head (specified head), and Type II is a constant flow (specified flux). These boundaries can be used in steady state conditions. Streams, lakes, constant recharge, or topography can be applied as a boundary.

References:

Harbaugh, A.W., 2005, MODFLOW-2005, The U.S. Geological Survey modular ground-water model—the Ground-Water Flow Process: U.S. Geological Survey Techniques and Methods 6-A16, variously p.

Reilly, T, 2001: System and Boundary Conceptualization in Ground-Water Flow Simulation. Techniques of Water-Resources Investigations of the U.S. Geological Survey Book 3, Applications of Hydraulics Chapter B8