

# One-dimensional Darcy flow in a confined system

December 31, 2016

This example shows the steps needed to create and run a one-dimensional hydraulic model of a confined aquifer with a single pumping location. The assumption is that all the conditions are uniform over the horizontal axis, perpendicular to the main direction of flow. Note that the example is solely for instructional purposes and does not represent a real-world problem.

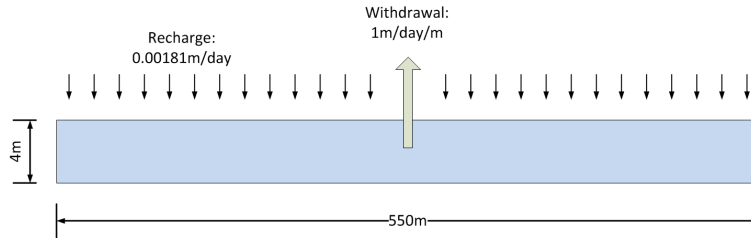


Figure 1: The schematic of the 1-D confined aquifer model

It is assumed that a withdrawal of  $1\text{m/day/m}$  occurs at the center of the aquifer and that a constant recharge of  $0.00181\text{m/d}$  occurs over the entire duration of the simulation (1000days). We will discretize the aquifer into 11 blocks so each block will have an area of  $50\text{m} \times 1\text{m}$ . The aquifer's porosity is assumed to be 0.35 and its thickness is assumed to be 4m. The aquifer's hydraulic conductivity is  $1\text{m/day}$ . Figure 1 shows the schematic of the model. A no-flow boundary condition is assumed at the two boundaries of the aquifer. The steps needed to construct the model are presented below.

- Start GIFMod
- **Create a single Darcy block:**

From the top ribbon click on the Darcy icon . Set the following properties:

- Bottom area:  $50\text{m}^2$ .
- Initial moisture content:  $0.35$  (assuming the initial hydraulic head is zero)
- Saturated moisture content:  $0.35$
- Saturated hydraulic conductivity:  $1\text{m/day}$
- Precipitation: *Yes* (allows introducing recharge using the precipitation feature)
- Storage coefficient *under Specific Storage*:  $0.01\text{m}^{-1}$

- Bottom elevation:  $-4m$  (this sets the datum on the interface between the confined aquifer and the top confining layer.)
- Depth:  $4m$

Leave the rest of the properties unchanged. Default values will be used.

- **Create an array of blocks:**

In this step we create an array of the Darcy block created in the previous step. The array will be composed of 11 blocks.

- Right-click on the Darcy block created in the previous step and select **Make array of blocks** from the drop-down menu.
- Select the **Horizontal 2D array** option and enter the number 11 in the text box labeled **Number of columns**.
- For the **Horizontal distance between cell grids**, enter 50m.
- Click on **Ok** button.

The array should appear on your screen as shown in Figure 2.

- **Setting the properties of the connectors:**

When an array of blocks are created GIFMod automatically connects the blocks sequentially and assigns some of the relevant properties from the blocks to the connectors. For example in this case the values of saturated hydraulic conductivity from the initial block are assigned to the connectors. Also the length of the connectors is assigned based on the horizontal distance indicated in the array dialog. However, some other properties of the connectors still need to be assigned. In this case the only property that needs to be specified for the connectors is **Interface/cross sectional area**.

- select each connector and from the **Properties** window set the interface area to  $4m^2$  (i.e. 4m thickness  $\times$  1m horizontal depth in the axis perpendicular to the screen).

- **Adding recharge:**

The recharge will be added using the precipitation feature of the program. First a text file containing the precipitation data should be created. The duration of the simulation is assumed to be 1000 days starting from day zero until day 1000.

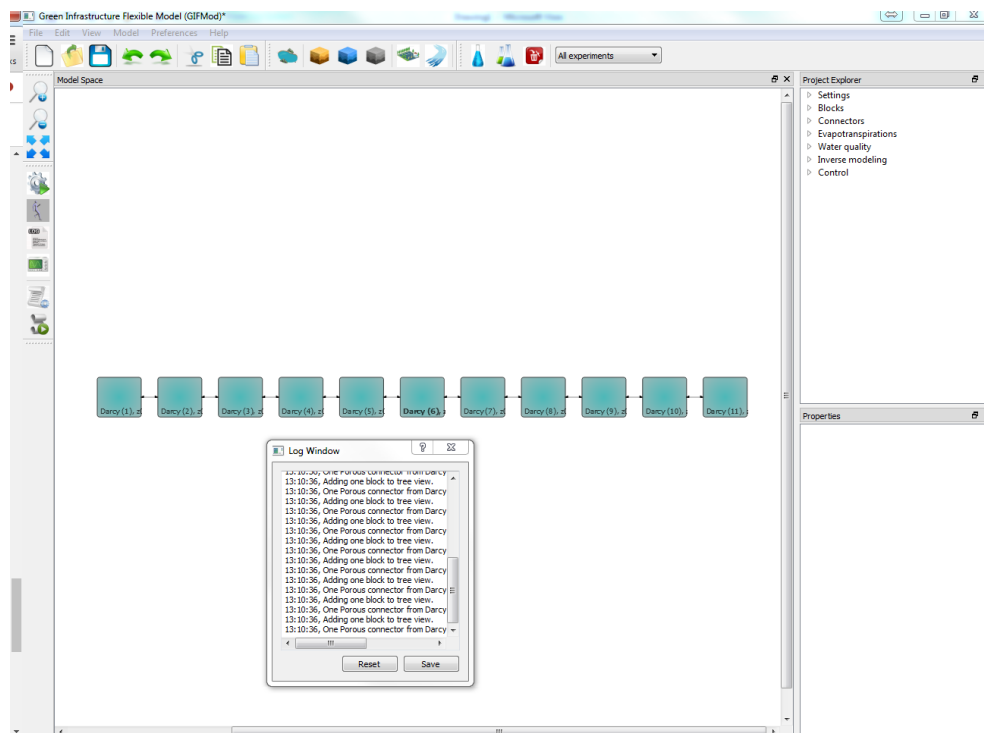



Figure 2: 1-D confined aquifer model representation in GIFMod

- The precipitation data file is a file containing three columns the first representing the start time of an event, the second representing the end time of an event and the third one the volume (in meters) of precipitation during the event period. The precipitation file for a uniform precipitation of 0.00181m/d will look like Figure 3. It should be noted that the time-intervals in the precipitation data file do not have to be uniform (or daily) but the daily intervals are used here for convenience. Save the text file as "precipitation.txt".
  - Choose the **Climate setting** item from the **Settings** menu in **Project explorer** and then click on the box in front of **Precipitation** and from the open dialog box that appear select "precipitation.txt" that was created in the previous step.
- **Adding withdrawal:**  
The pumping/withdrawal will occur on the middle block named "Darcy (6)".
    - The flow file contain a heading showing the nature of the quantity it represent in this case flow. This is the top most row of the file. Create a new text file. Type "names, flow" (without quotation marks) as the first row. This file will have two columns separated by comma. The first column is the time and the second is the flow rate in  $m^3/day$ . The file should look like figure 4. The negative rates indicate withdrawal. Save the file as "pumping.txt".
    - Click on the block labeled "Darcy (6)" and from the properties window find **Inflow time series** and select "pumping.txt".
- **Setting the duration of the simulation:**  
The duration of the simulation is from day zero to day 1000. From the **Project Explorer** select **Setting**→**Project settings**. From the property window fine right-click in the label **Simulation end time** and click on **Input Number**. Enter 1000 in the input box that appear.
- Save the project.
  - **Adding a recharge gage:**  
Here we just add a pond to keep track of cumulative precipitation.
    - From the top ribbon click on the pond button  to add a pond to the model.

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Figure 3: Precipitation data file for the 1-D confined aquifer model

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Figure 4: Pumping file for the 1-D confined aquifer example

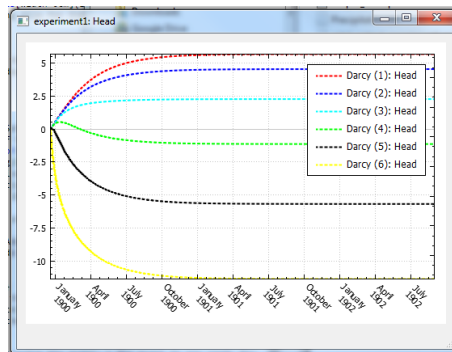



Figure 5: Temporal variation of hydraulic head in blocks Darcy (1)-(6) in the 1-D unconfined aquifer example

- Set the area of the pond to 1m.
- **Running the model:** The model is now ready for running. From the left hand ribbon click on the run button  and wait until the simulation ends.
- **Inspecting the results**
  - Right-click on blocks Darcy(1) to Darcy(6) and choose **Plot Hydraulic results**→**Plot head** from the drop-down menu. You can copy and paste all the graphs onto a single one and color each differently. The final results should look like figure 5.
  - Right-click on each of the connectors connecting blocks Darcy (1)-(6) and choose **Plot flow**. Copy all the curves into the same

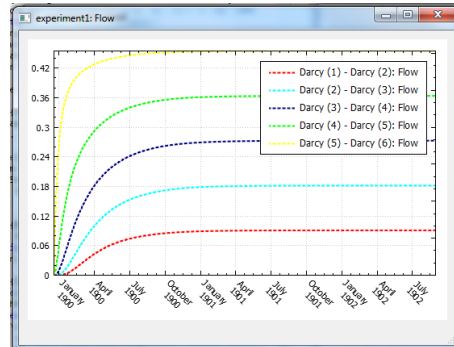


Figure 6: Temporal variation of flow rates in connectors connecting blocks Darcy (1)-(6) in the 1-D unconfined aquifer example

window and color each curve as you desire. The result should look like figure 6