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HWRS 582 – HW4 Discussion

The Challenge

1. The well is located at [0,10,15] in the starter code and it is withdrawing water at a rate of -8 m3/day (note, the rate is negative to indicate water being removed from the domain). You need to move the well to the center of the domain [0,12,12] and change the rate to -10 m3/day.

2. For the initial well location, plot the total flow into the left (constant head = 20) and out of the right (constant head = 10) boundaries. (The code, as provided, makes this plot for you.)

    - Explain why the values are not constant along the boundary (relate to the definition of a Type I boundary).
        1. For a Type-1 boundary, which is what we have created, heads along the boundaries are constant, but that does not mean that flux is. The pumping well creates a change in head in the middle of the domain, which causes the flows to adjust.

    - Explain the shapes of the flow distributions and why they are not the same for the left (inflow) and right (outflow) boundaries.
        1. The pumping well decreases head locally. It is in the middle of the domain, so if flow is from left to right, then it's creating a stronger gradient for the left half of the domain, which creates more flow. For the right half, the overall gradient becomes less strong, which means flow is less. For both left and right, because well is at the center of the domain, these effects are most pronounced in the middle rows of the domain.

    - You are still modeling stead state conditions? So, what is supplying water to the well?
        1. The domain is supplying water to the well. It's still steady state, because for the domain as a whole, Qin = Qout, but now Qout isn't just the right side of the domain. A portion is leaving from the right side and a portion is leaving out of the well.

3. Plot series of the flow left-to-right along a vertical line that passes through the center of the well [:,12]

    - How do you interpret the flow along this transect? (Hint, also look at the flow along a transect just upgradient from the well [:,11]).
        1. Immediately upgradient of the well, the flow is highest, because of the strong head gradient created between the left boundary and the pumping well. Q is measured on the right face of a cell. If the well is in column 12, then the flow at column 12 is the low peak, because the right face of column 12 would have a low head gradient between column 12 and the right boundary.

4. Then, look at the plot of equipotentials (i.e. the constant head lines, this is the last plot in the example) and flow vectors. Describe how water flows through the domain. To aid in your description, draw a line through all of the flow vectors that terminate in the well. This approximates the capture zone of the well. Use this to refine your description of the flow system, being as specific as possible about where water that ends up being extracted by the well originates on the inflow boundary.

    - Kinks in the head contours are most pronounced between Ly = 1000-1500 and Lx = 1000-1500, although one can still see that head contours at the top and bottom of the domain are still not completely straight. Flow vectors show left-to-right flow for almost everywhere except the immediate vicinity of the well. The flow vectors especially make it seems like almost all of the water that gets pumped out of the well originated from between Ly=1000 and Ly=1500.

5. Then, look at the plan view drawdown plot.

    - Why aren't the drawdown contours circles? Either explain why this is correct, or fix the plot.
        1. Most of the drawdown contours are circles, if the chart is scaled appropriately. If the chart were squeezed horizontally, so 2500m in the x direction took up the same space on a computer monitor as 2500m in the y direction, then they'd look like circles. The outermost drawdown contour would be a circle if the domain of the model were larger, but the spatial confines of the model create that shape, since I believe the top and bottom boundaries are "no flow" boundaries. If this question isn't about x-y scaling issues, then I believe the answer would be because as explained in question 4, the strongest head gradient and highest flows come from the middle rows, which creates the oblong shape.
    - Why are the drawdown contours not equally spaced?
        1. The solution for confined drawdown, the Thiem equation, involves the natural log of the ratio between two radii, which is not linear.

6. Move the well to [0,5,5]. Use all plots necessary to describe fully how water is flowing through the domain with the well in this location. Be sure to include the drawdown plot in your discussion - compare this plot to the equipotentials and flow vectors.

    - The left boundary has increased flow towards the "top", because the well is now much closer to it. As you go "down" the y axis, the left flow boundary flattens out and becomes pretty steady. The right boundary is steady all the way across, because the well is now so far away from it, that it has very little influence on flow at the boundary. Just like in the original well location, flow immediately left of the well is highest, and flow immediately right of the well is lowest. The drawdown plot is more irregular, because the well's circle of influence is overlapping more with the spatial boundaries of the model.

Glossary Questions

1. What are equipotentials? How do we create them from MODFLOW Models?
    1. They are lines of equal potential. Or lines of equal head. They are created by calculating the head at the node of each cell, choosing some sort of spacing (e.g., 1m intervals), and then connecting lines of equal head, interpolating when necessary.

2. What are flowlines? (BONUS thought experiment: How can you impose a no flow boundary based on symmetry? Give it a shot to explain WHY this works in a couple of sentences.)
    1. Flowlines are lines that show the direction flow. One could create a no-flow boundary by creating a "mirror well" that would have the same properties as the original well. If it were symmetrically placed in the model, then there would be a line made where water couldn't cross, because water on either side of the boundary would be sucked into, or at least diverted by the well of that respective side.

3. What are flownets? And how does a flownet vary from a map of equipotentials with flow lines drawn on it?
    1. Flownet lines are tangent to flow along streamlines. Equipotential lines are perpendicular to streamlines. This creates "boxes" of flow, which one can then use to calculate total flow in the aquifer.

4. Define the concept of 'capture' in a way that a non-expert might understand? (e.g. think about our homework problem, if the right boundary represented a stream, what would the impact of the well be on the stream?)
    1. If the right boundary were a stream, then the well pumping in the middle of the aquifer would cause the stream to receive less water from aquifer, lowering the stream level. This is because the pumping well is capturing some of the water that would have otherwise gone into the stream.