**The challenge**

1. Chart, line chart

   Description automatically generatedFor 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).
     + A type 1 boundary condition is one where there is a constant head applied. The left and right boundary are not constant because there is flow leaving the system.
   * Explain the shapes of the flow distributions and why they are not the same for the left (inflow) and right (outflow) boundaries.
     + The inflow and outflow boundary are different because there is flow leaving the system from the well. The well pulls water toward it so the flow is quicker in the center, then past the well the flow has decreased because the water was pumped out. The right flow boundary has less flow and that missing flow was taken out from the system by the well.
     + The head gradient is increasing toward the well!
   * You are still modeling stead state conditions? So, what is supplying water to the well?
     + The water is coming from decompression of the soil matrix and slight expansion of the water. I don’t understand how long this could continue though…? After a certain point I think the well would stop working because the pressure would eventually begin to increase over time. Maybe that is what happens when the flow is -25?
2. Plot series of the flow left-to-right along a vertical line that passes through the center of the well [:,12]

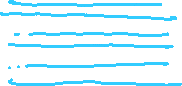
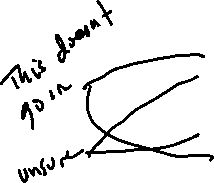
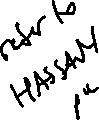
* How do you interpret the flow along this transect? (Hint, also look at the flow along a transect just upgradient from the well [:,11]).
* Chart

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* I see that at the center of the well the flow decreases but at the flow upgradient of the well increases in a mirror image of the center of the well. I interpret this as flow is increasing as it gets to the well because water is being sucked out, then at the center of the well the flow slows as the water is withdrawn…?

1. 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.

Chart

Description automatically generated



* Water that is far from the well is not affected by it. The water closest to the well is pulled into it or influenced by it. All of the extracted water originates from the rows nearest the well.

1. 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.
     + Because we have a constant head gradient of 20 on the left and 10 on the right, our system has flow in it. Therefore, I don’t think our contours would be perfect circles. I think it would be a perfect circle if our system was hydrostatic because the cone of depression would spread out evenly then.
   * Why are the drawdown contours not equally spaced?
     + The area experiencing drawdown is not the same the further away we get from the well. I think this is why our contour lines are not equally spaced.
2. 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.
   * + Because the well has moved location to the top left corner, so has the high flow area. The water is sucked in quicker at the pump increasing flow just before the well. Then after the well the flow decreases because there is less water. Area on our model that is further away from the well is less affected by it. Chart

       Description automatically generatedDiagram

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       Description automatically generated

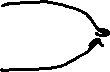
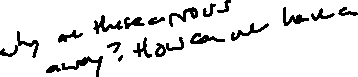
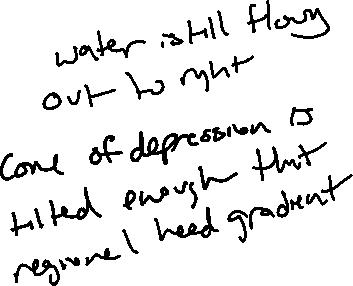


* + - The draw down circles have moved over to where the well is.



Chart, table

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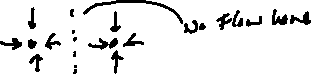


**BONUS** Before running the model, predict what you would happen to the inflow/outflow boundary fluxes if you reduced the pumping rate to -5 with the well located at [0,12,12]. Were you correct? If not, how were you wrong? Now predict what would happen if you increased the pumping rate to -20. Still correct? Now try -25. Uh oh, what happened??

* I was wrong, I thought the plan view drawdown would change but it didn’t. I don’t understand why it didn’t for either the -5 or the -20.
* I think the system couldn’t handle a pumping rate that high at -25 and all the water had been withdrawn from the system at that point.

## Glossary Questions

1. What are equipotentials? How do we create them from MODFLOW Models?
   * Equipotentials show places where the pressure head is the same.
   * We use matplotlib and plot out the head values along a column.
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.)
   * Flow lines show the direction of flow. They are vector quantities.
   * If we have equal and opposite system, this could make a no flow boundary?



1. What are flownets? And how does a flonet vary from a map of equipotentials with flow lines drawn on it?
   * Flowlines show where the water particle flows. Equipotential lines show area of high head. The combination of flowlines and equipotential lines create a flow net. Therefore, I think a flownet with a map of equipotential and flow lines are one and the same.

Equipotential lines

Flow Lines – flow lines and equipotential lines are spaces so that the grid cells they create mean something. We are not making flow nets. We make equipotential lines with flux lines ontop of then. We did not do anything with geometry to make them flownets.

1. 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?)
   * Capture is when water that would normally flow down its own watershed is diverted instead to another watershed.
   * If our right boundary was a stream I think that we would see some flow leaving the stream to go into the well.

“WOULD HAVE” is the key word

Captures water that would have gone somewhere else.

“paper water” – water that doesn’t really exist physically. It is actually just on paper

Cone of depression is relative to the gradient!! The stready state head model gradient picture.

At -25, the head pumping overcame the head gradient.

The model “breaks” after q = -21.

BC and K can’t change, and once the pumping became too much (above the BC).

Cant get enough flux into the cell to balance pumping rate. Cell goes dry, the cell has turned off.

* + In cell type properties. The model couldn’t balance the flux bc it had fixed k and fixed BC. No gradient to drive the flow.
  + Func of grid cells and how big model is and what BC are.