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HWRS 431
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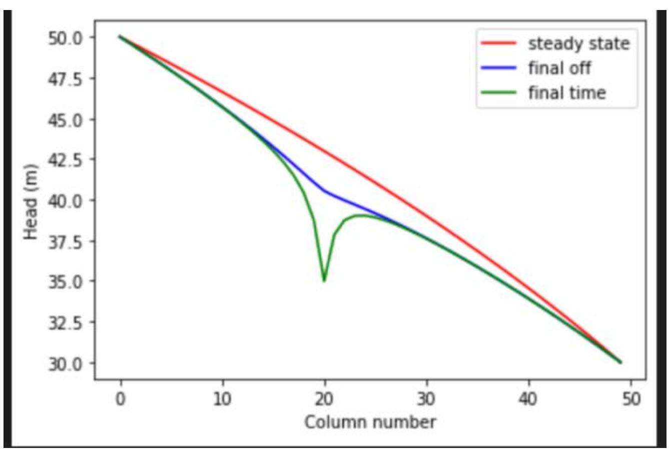
The Challenge Questions_Final

a)The gradient is not uniform for the initial steady state conditions - discuss the influences of recharge and the unconfined condition on this nonlinearity

Since the gradient (dh/dl) is not uniform for the initial steady state conditions, the recharge adds more water as the head drops from pumping being turned on, so the graph shows a bulge where the water from recharge is being added.

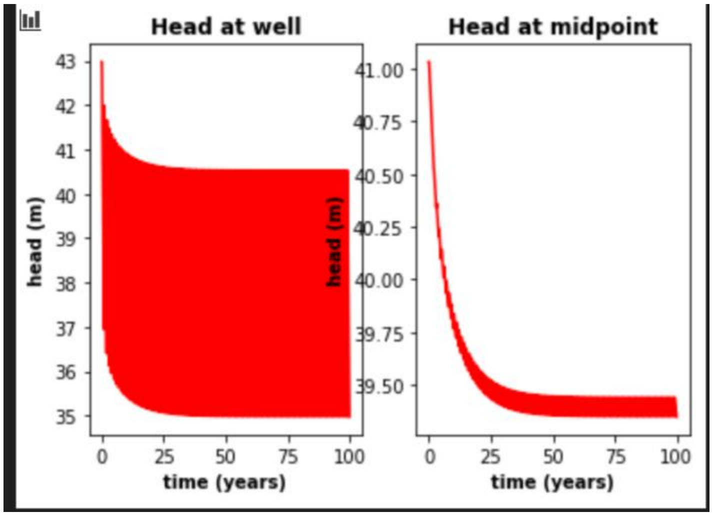
This is nonlinear because this is an unconfined aquifer and MODFLOW models this as reducing the thickness value, so the model has to make up for it by increasing the head gradient to reduce the transmissivity. There is also an accumulation of volume from the recharge, so the head is changing. The steady state line would be linear if we were modeling a confined aquifer without any recharge.



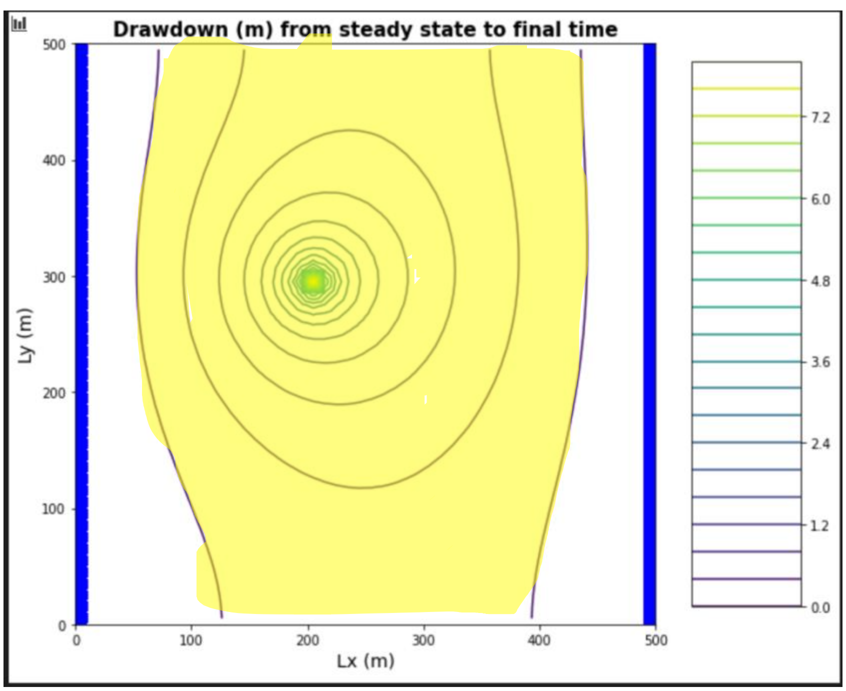
b) Determine if the system has reached steady state - consider a point at the well and another at the center of the domain.

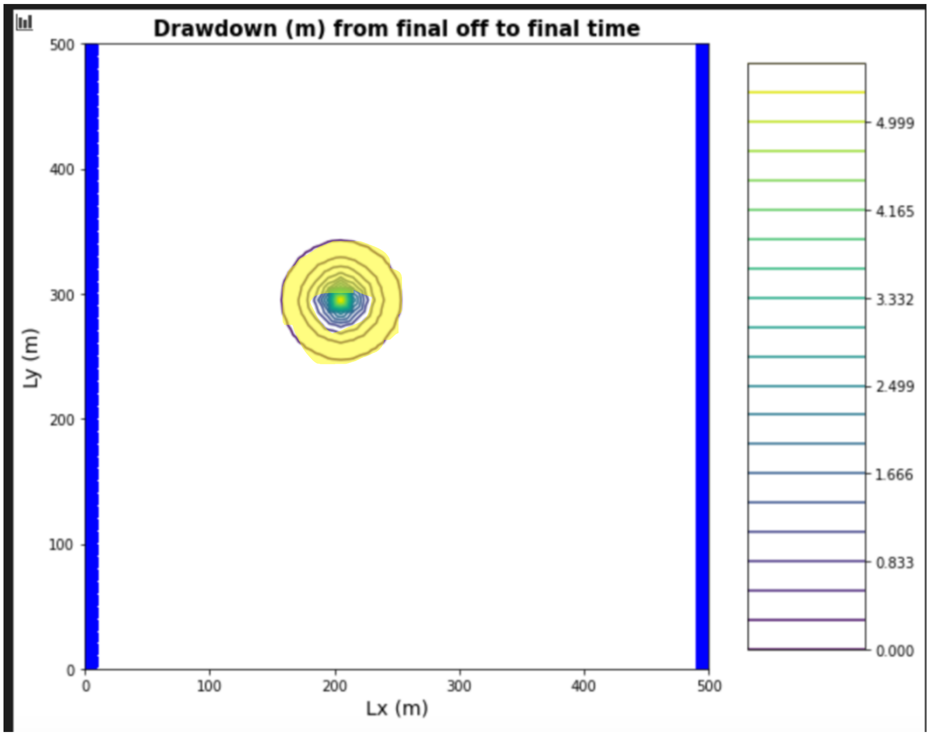
I think the well has reached steady state by the end of 100 years because the head values are not changing with time, so I think it is safe to assume a steady state condition.

The system has reached steady state at the well around 60 years and has also reached steady state at the midpoint by around the same time. These values would be hard to tell from the graph since it is difficult to see when the slope levels out at zero, which would be steady state.



c) Find the zone of influence of the well defined in two ways: - Based on the drawdown from the initial steady state to the end of simulation time (end of final no-pumping stress period). - Based on the drawdown from the end of the last pump-on stress period to the end of simulation time.





I have highlighted the zone of influence on each diagram, which show that there is a significantly less zone of influence from the final off to final time compared to the steady state to final time diagram.

d) How long does it take a point at the center of the domain to reach steady state. At that point, explain how you could divide the domain into a steady and transient part and solve each separately.

It would take about 25 years until it reaches steady state, which for this example would be at a head value around 40 meters. The transient part of the domain would be where there is a change in storage and where the in and out flow values are different and steady state is where there is no change in storage at any time or anywhere.

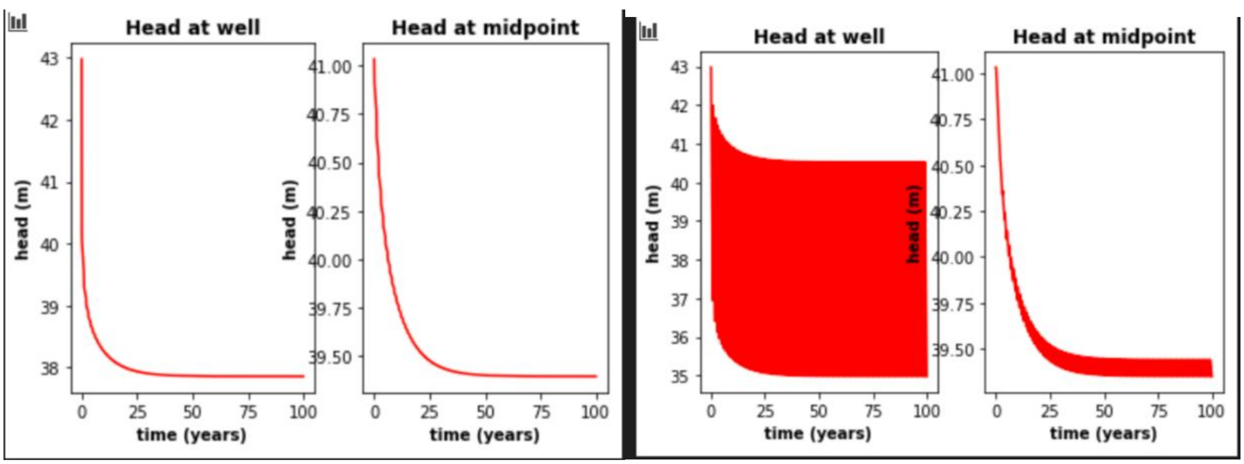
Based on my answer from part b, the model reaches steady state around 60 years. At that point we could divide the system into steady state and transient by looking at the capture zone of the well. Right around the well, it will be transient and anywhere outside of that zone will be modeling a steady state condition.

e) Find a constant pumping rate (same throughout the year) that matches the head time series at the middle of the domain.

I chose a constant pumping rate of -250 m/day by trying to match the curve of the initial graphs made with Q1 at 0 and Q2 at -500 m/day. To change the graphs in order to answer the question I changed the length of the steady state condition to 0 and played around with values while comparing the curves. (graphs in part f)

f) Find a constant pumping rate (same throughout the year) that matches the head time series at the well, leaving only a regular, repeating seasonal residual. Are the two pumping rates the same?

I did the same thing as part e but found that the value for Q that I chose was actually the same as part e. I think this makes sense because the midpoint and the well are so close in the domain of the problem that the Q values would be just about the same if not exact.



g) Discuss the sources of water captured by this well. If you're up for a challenge, calculate them for the final pump-on period!

The sources of water being captured would be the water from the recharge, the left, and also the water from the top and bottom.

The sources being captured by the well would be from storage from right around the well and recharge. The model and real life is cyclical, so the water is resupplied and then taken out every seasonally.

h) Discuss how you would define the capture zone of the well. How is it different than our definitions of capture zone so far in the course?

The capture zone of the well would be considerably smaller because of the area of water that is being captured. In order to find the volume of the water captured we could use the equation: $Q\Delta t = V*Sy$ = Volume of the water.

The capture zone will change over time because of the cyclical steady state patterns of supplying and taking out water. So, the capture zone will grow as there is a supply of water into the well and then it will shrink as there is not enough water. For the transient period, the system will only be transient at the well and the rest of the system will be modeled as steady state conditions. This is different from other capture zones we have talked about thus far is because usually they have just been steady state and do not change over time.