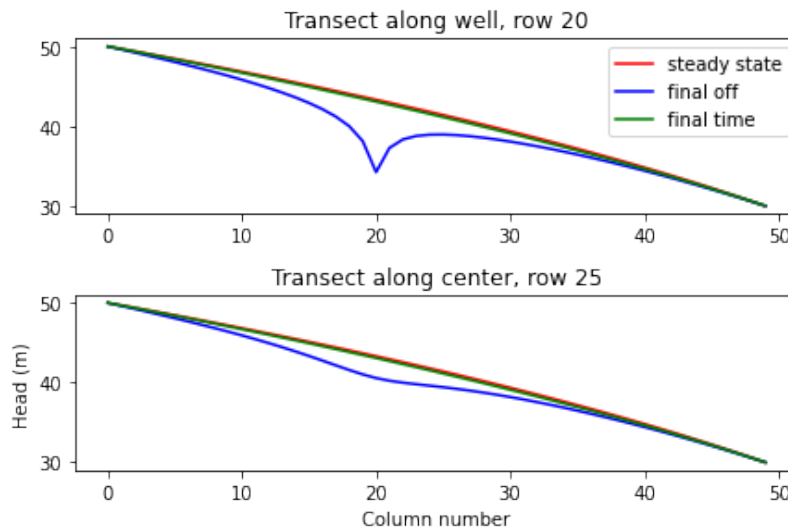


## HW8 Transient

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

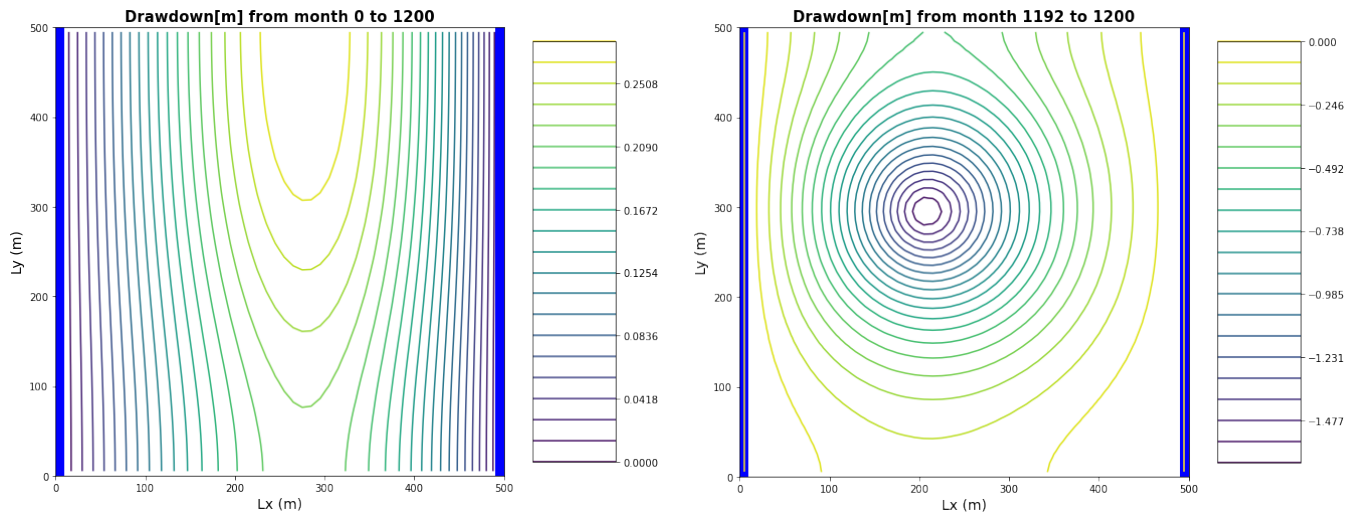
The gradient is not uniform for the initial steady state conditions because the aquifer is unconfined which means that the cross-sectional flux plane of each grid cell dependent on the heads of the two cells in the direction of flow. The gradient is also dependent on the area of the flux plane; it is this source of interdependency between variables and the state of the system that creates the nonlinearity seen in the steady state curve. Furthermore, the recharge parameters can contribute to the gradient by influencing the rate of change in the head values and this effect is felt largely by end of the system after the gradient has moved through the majority of the domain.

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



The system has essentially returned to steady state. In the above figure, it is clear that the steady state (red) and the final time (green) curves have aligned almost perfectly.

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.



Above are two images depicting the difference of water levels between two stress periods. In the left plot, there is higher water level in the steady state than in the final period that has mounded up near the top half of the domain, just downgradient from the well. This is to be expected because it suggests that after 100 years, the system is not quite at steady state.

In the image on the right, there is a large area of influence that spans across the entire domain. This graph shows the difference in water level between the final pumping stress period and the final time when the simulation ends.

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 takes 8 years for the system to achieve steady state. By creating an array of head values for each step in the transient system, I was able to find the sum of every 12 elements in the array and print out these 100 values. It was clear to see that after the first seven years, the rest of years were at steady state. The number of periods could be reduced to 14—instead of 200—that would be solved as a transient state and the remaining periods would be solved at a steady state system.

```
# Add up every 12 step head values to find head sum for each year in order to see
when the sum stops changing.
np.add.reduceat(trans_head_arr, np.arange(0, len(trans_head_arr), 12))
```

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

I'm not sure how to answer this question considering the head times series at the middle of the domain experienced a 3-month period of pumping and a 9-month period of shut off. This resulted in an initial drop in head and a subsequent recovery. No amount of constant pumping rate could have resulted in an initial drop followed by a recovery. I've pasted the observed steady state 12-month pattern that I saw repeated from years 8-100.

40.60895538 40.00204849 39.61199951 40.31495285 40.75571823 41.01025772  
41.17313766 41.28748322 41.3731842 41.44033051 41.49454117 41.53918076

*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?*

Same problem as above. I'm not sure what is being asked for by these questions.

*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 captured by the well are the recharge as well as the volumetric flux coming from the left-boundary.

*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 could be considered a large plume that starts along the left-boundary but a significant portion of the well capture zone also comes from the recharge around it. It's different from the capture zone we've used in the course this far because we haven't included how recharge contributes to the capture zone.