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HWRS 482
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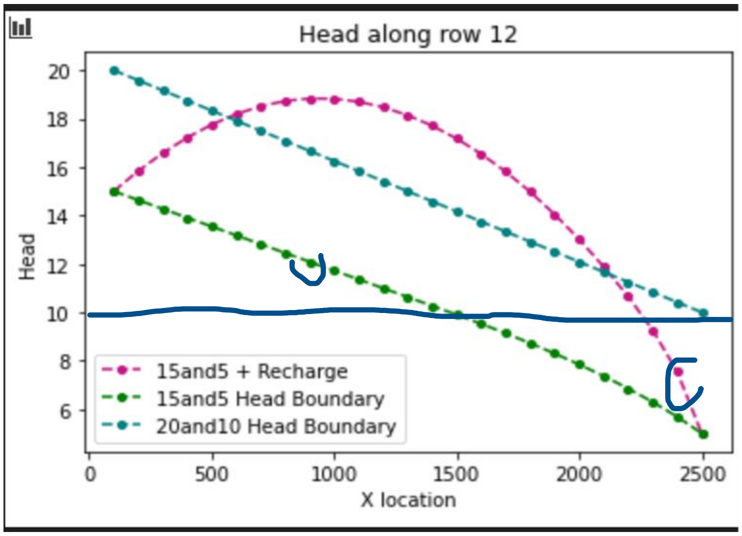
The Challenge

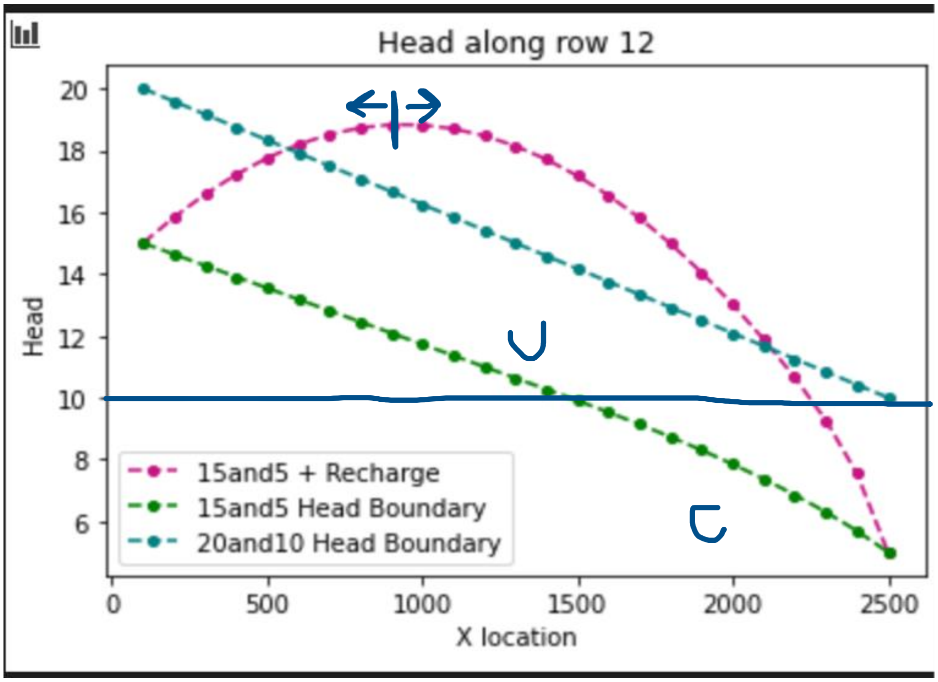
1. Now reduce the boundary heads to 15 m and 5 m. Compare this result and explain any observed differences. The overall gradient is the same, as is the K of the medium ... is the flow the same for both boundary conditions? Why or why not?

   The aquifer thickness is 10 m, the flow would be decreased and the green graph with head boundaries of 15 m and 5 m becomes unconfined past the 10 m line. The gradient becomes shallower as it reaches the thickness level of 10 m, which means it takes more energy for water to flow, so then flow decreases. The piezometric surface becomes less than 10 m, so the saturated thickness decreases and flow becomes more difficult. The equipotential surface is above the top of the aquifer and then after 10 m, the water level is within the aquifer, so part of the aquifer is not contributing to the flow. At the 10 m thickness line, that is where the aquifer goes from unconfined to confined. A higher gradient means a more decreased aquifer thickness, so the gradient becomes steeper at the end of the green graph. It takes more energy at the bottom of the green graph to go through the saturated thickness, so there has to be less energy used at the top. Because the overall head loss is the same, and the part near the right boundary is desaturated, we know that it has to have less flow through the unconfined than the confined.



2. Now add recharge at a constant rate of 1e-4 m/day over the entire top boundary. Explain the head transect and boundary flows. Is flow in this system 2D or 3D? Is it represented as 2D or 3D? Explain what you mean by your answers.

Since we added the recharge, we see an increase of flow and that is why there is more of a curve in the graph. This line of recharge also shows that the slope goes from positive to negative. The positive slope indicates that the water is flowing into the area (25 by 25 by 1) and a negative slope would indicate that there is more water coming in than there is space, so the water would be overflowing from the build-up of pressure from the water. The slope isn't constant for the pink line because although the transmissivity is constant, the flow is getting higher and higher as you go to the right because of the recharge. Everything is coming from the left and then whatever is coming from the recharge (collecting more water and becoming steeper and steeper). Higher gradient at the right boundary, transmissivity is the same, and there is negative slope. Flow is leaving the right boundary and shedding off of the middle by ponding in the middle and spilling over the area. At the point on the pink line where the slope turns from positive to negative, the flow goes in opposite directions and there is a groundwater divide/mound. The flow in this system would be 2D because the vertical flow doesn't matter for the system. Technically it is 3D but we can discount the vertical flow because it does not contribute to the system.



3. Now model a system with zero recharge except for a farm located in [6:10, 6:10] - in python terms. First, calculate the annual excess irrigation, in meters, that has been applied to the farm. Second, calculate the total irrigation rate on the farm that would be associated with this amount of excess irrigation. Finally, identify the area within the domain that might be subject to contamination if the recharge water was somehow tainted.

annual excess irrigation =m^2 *m/d= m^3/d *365 days = m^3

A= 10,000 m^2 *16 cells = 160,000 m^2

(160,000)(1e-4)(365) = 584 m^3

Total irrigation: 1.6 m^3/day?

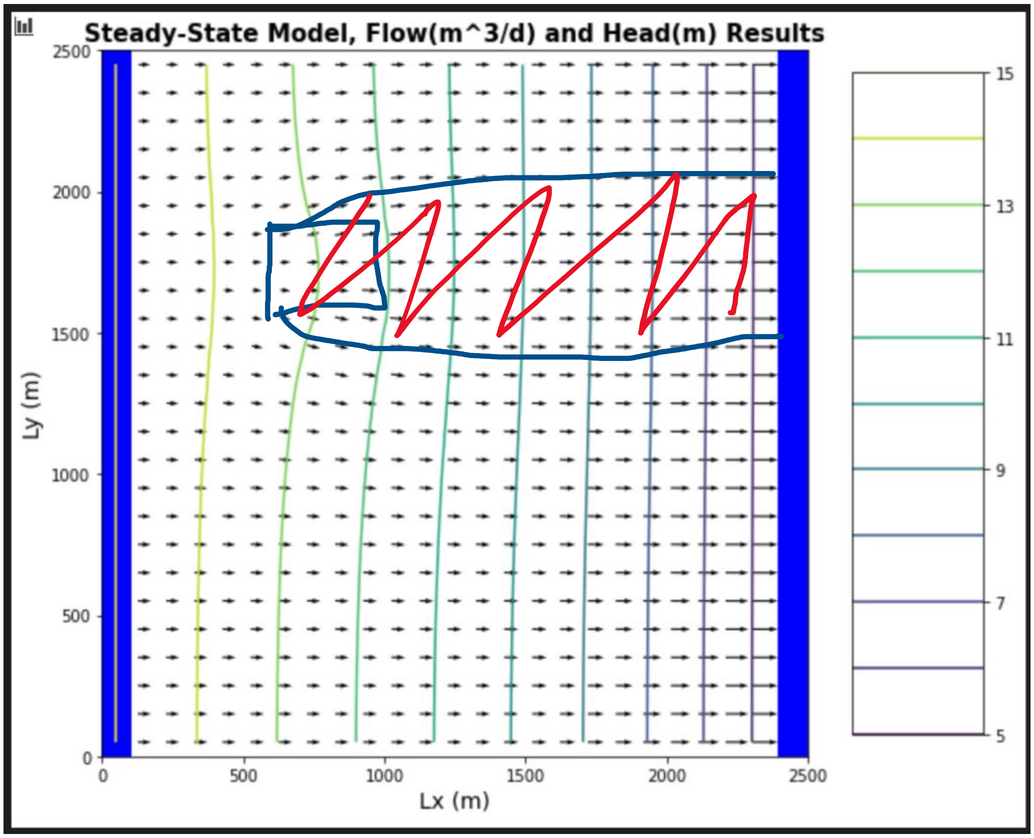
Crop water demand for cotton: 5-7 ml/hectare→ 0.6m of water per m^2 of land per crop (4 crops/year) → 2.4 m of water→ 0.0066 m/day

Q_ir = 0.0066

Q_t=Q_r +Q_ir

Q_t = 0.0001 + 0.0066 = 0.0067

This means that this is extremely efficient use of water under cotton, loss is 1 out of 66, mostly uses irrigation.



4. Lastly, start the well pumping at a rate of 8 m^3/day. Using one color, identify the capture zone of the well. Using a second color, show the area that might be contaminated by the irrigated farm fields. Comment on the impact of the well on the pattern of potential contamination.

The part I colored in with black, shows the area that would be contaminated from the irrigated farm fields. In order to calculate the actual impact from the contamination, we would need the area and the flux of the area. So, we can use a mass balance equation using Qin=Qout. We know that Qout is 8 m/day and then we have the flux in which is the recharge, 1e-4. We can extract the flow that comes out of the well using python and then we can solve for the flow coming from the farm fields by Q(well)=Q(left)+Q(farm). Then we can find the concentration which turns out to be around 0.2.

We can also look at the concentration vs time graph for a point on the flow graph. The concentration would be showing less than 1 because of the dilution of the water coming in from the left.