## HW6\_Transpire\_Portillo.md

## **Transpire**

Sembrar semillas hasta que crecen los raices

constant heads of 15 and 5, respectively.

Using ET package in MODFLOW

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A flopy code is provided that recreates the 3D homogeneous box model with constant head boundary conditions. The aquifer is now

defined as unconfined. Use this to explore the combined impacts of recharge, ET, and pumping on an unconfined aquifer. The model that is provided is set up for a homogeneous medium. There is a well located at [0,15,15], but it is not being pumped. The background recharge rate is zero. There is a region of localized recharge in [6:10, 6:10] - in python terms - with a recharge rate of 5e-4 m/day. ET occurs over the entire domain at a rate of 5e-5 m/day and an extinction depth of 3 m. The left and right boundaries have

For the initial boundary head values and recharge and ET rates, establish the flow across the boundary versus y-distance along the left (15 m) and right (5 m) boundaries. Plot the equipotentials and flow vectors in plan view and outline (hand draw) the area that would be affected by recharge (i.e. if it were contaminated). Also show a contour plot of the steady state ET flux in plan view. No well is currently pumping.

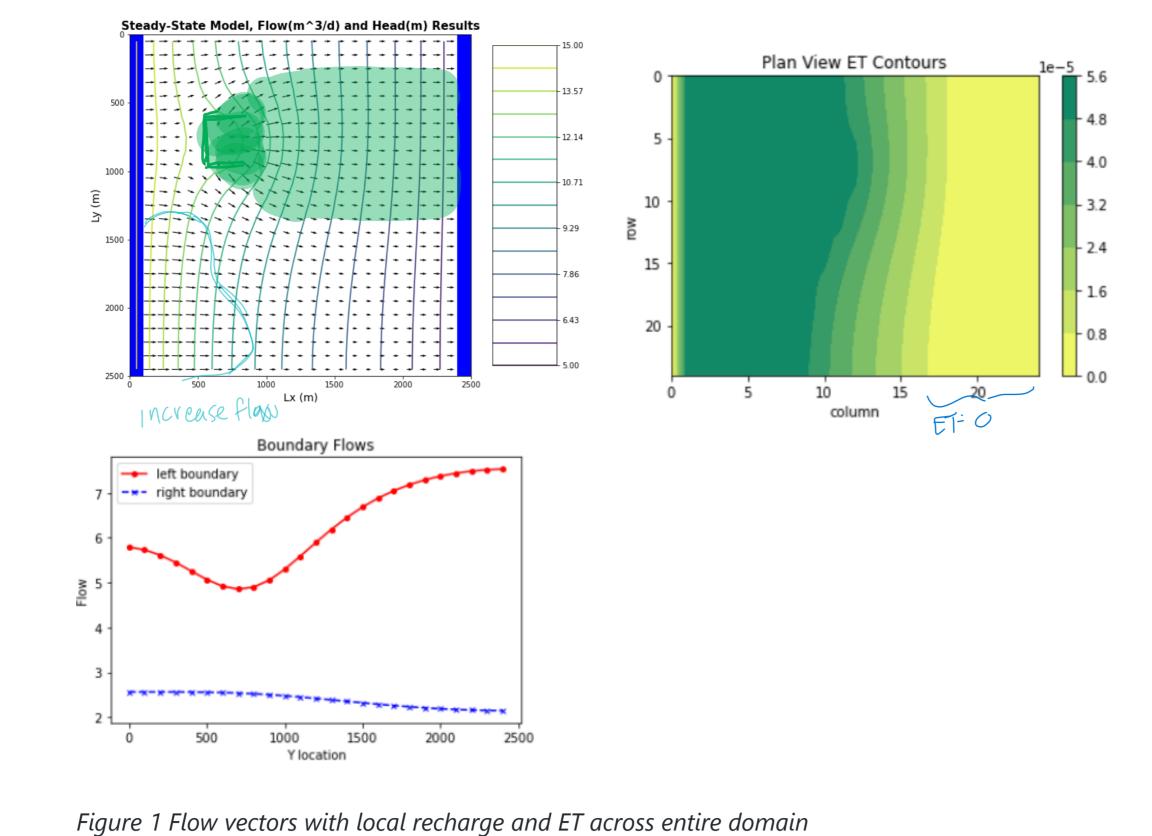


Figure 2 ET flux contours across the domain

Figure 3 Flow along left and right boundaries

Change the extinction depth. What impacts does this have?

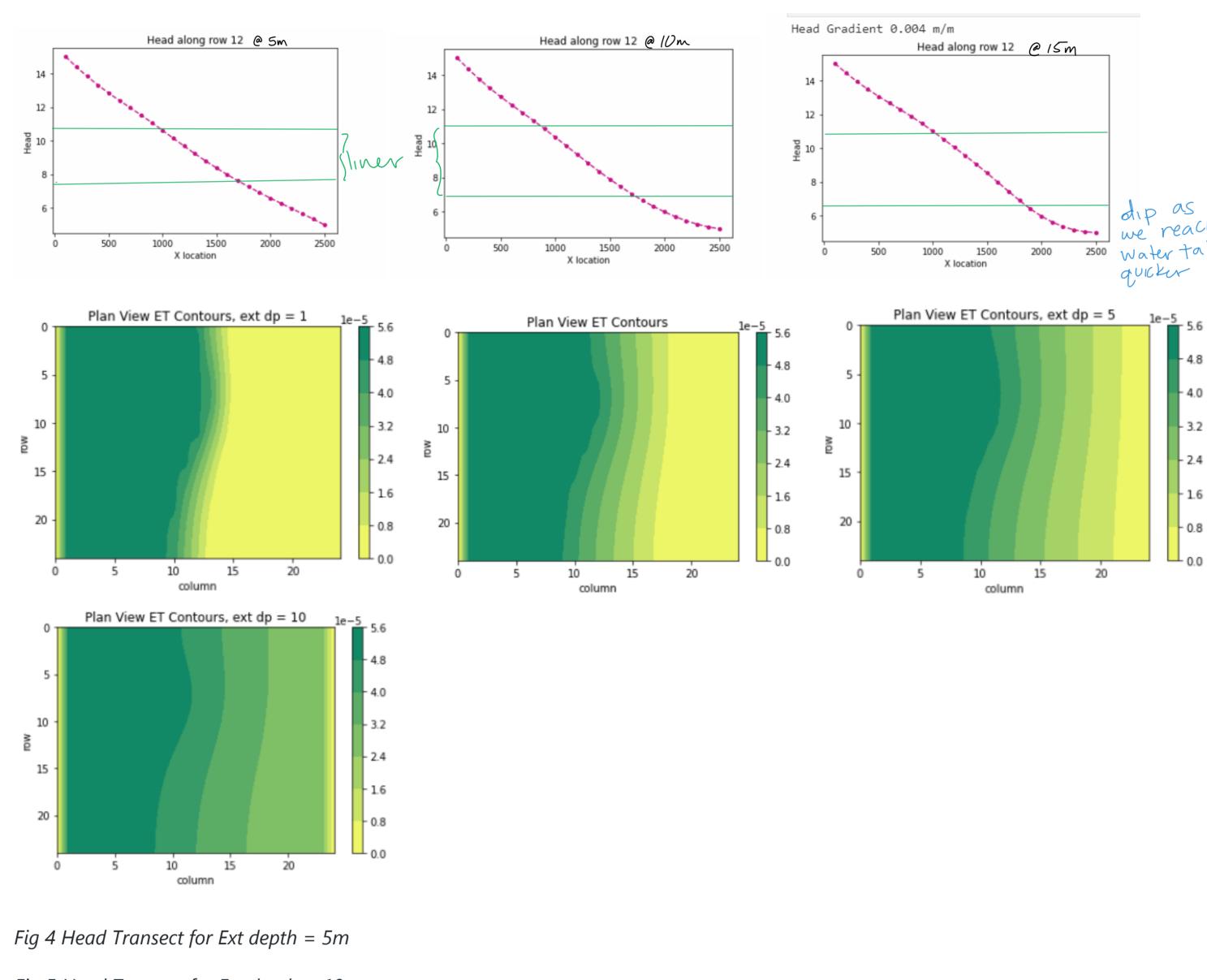


Fig 5 Head Transect for Ext depth = 10m

Fig 6 Head Transect for Ext depth = 15m

Fig 7 ET flux for ext depth = 1m

Fig 8 ET flux for ext depth = 3m Fig 9 ET flux for ext depth = 5m

Fig 10 ET flux for ext depth = 10m Immediately we notice how MODFLOW linearizes ET. As the extinction depth increases, we can see the rate of ET also increases across the

'drowning' our plants and transpiration cannot occur. Below explains why this is so. Explain, conceptually, how MODFLOW is representing ET. How does this compare to your intuitive understanding of ET in the real world

domain. Anything above 10, however, doesn't converge. This is becasue anything below out saturated thickness or water table, we are

Land surface (HSURF) Rsxd = 0Sxd

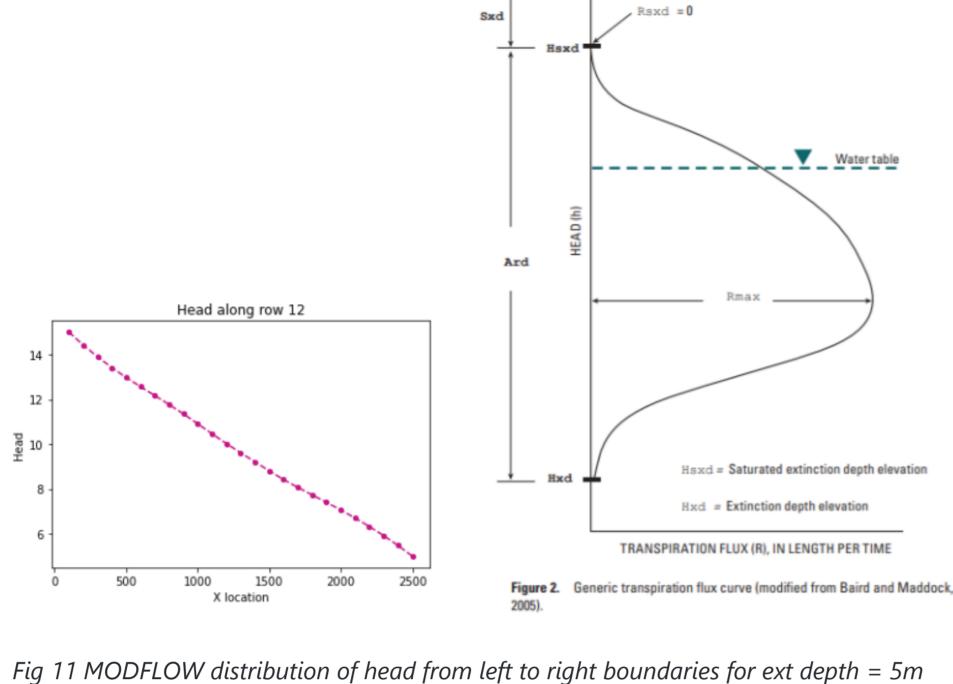


Fig 12 Interpretation of Transpiration flux with depth below surface https://pubs.usgs.gov/tm/tm6a39/pdf/tm6a39.pdf\* Evaporation from subsurface occurs above the water table where there is enough energy to "pull" water up from the ground. Max potential

evaporation is at the ground surface and decreases with depth - harder to evaporate deeper because the temperature is lower and requires more energy. Soil is very humid (~99 relative humidity in most cases). Deeper in the soil, there is essentially no evaporation, it

assumes extinction depth and transpiration rate is linear with extinction depth. So we set a transpiration rate for plants, set an extinction depth, and below that there is no transpiration. Output values from MODFLOW depend on model resolution (the number of grid cells and its respective thickness), but we only get to pick one number for the input. We know this is not physically true as seen in Figure 12. There are other varuables affect oot uptake that MODFLOW ignores. The root uptake depends on water pressure - degree of wetness or dryness in the surropunding soil. Now start the well pumping, extracting 20 m3/day. How does the well change the zone that is affected by the recharge area? How does it affect the ET map? Write a mass balance for the well - how much water is coming from a boundary? How much is originating as recharge? How do you account for the impact of ET on this mass balance? At steady state, what are the effects of 'capture' by the well?

drops off very sharply at the water table. This is in real life - however, MODFLOW just assumes it decreases linearly with depth. MODFLOW

Fig 14 Head transect for ext depth = 3 Fig 15 Head transect for ext depth = 5

Head along row 12

12

Head along row 12

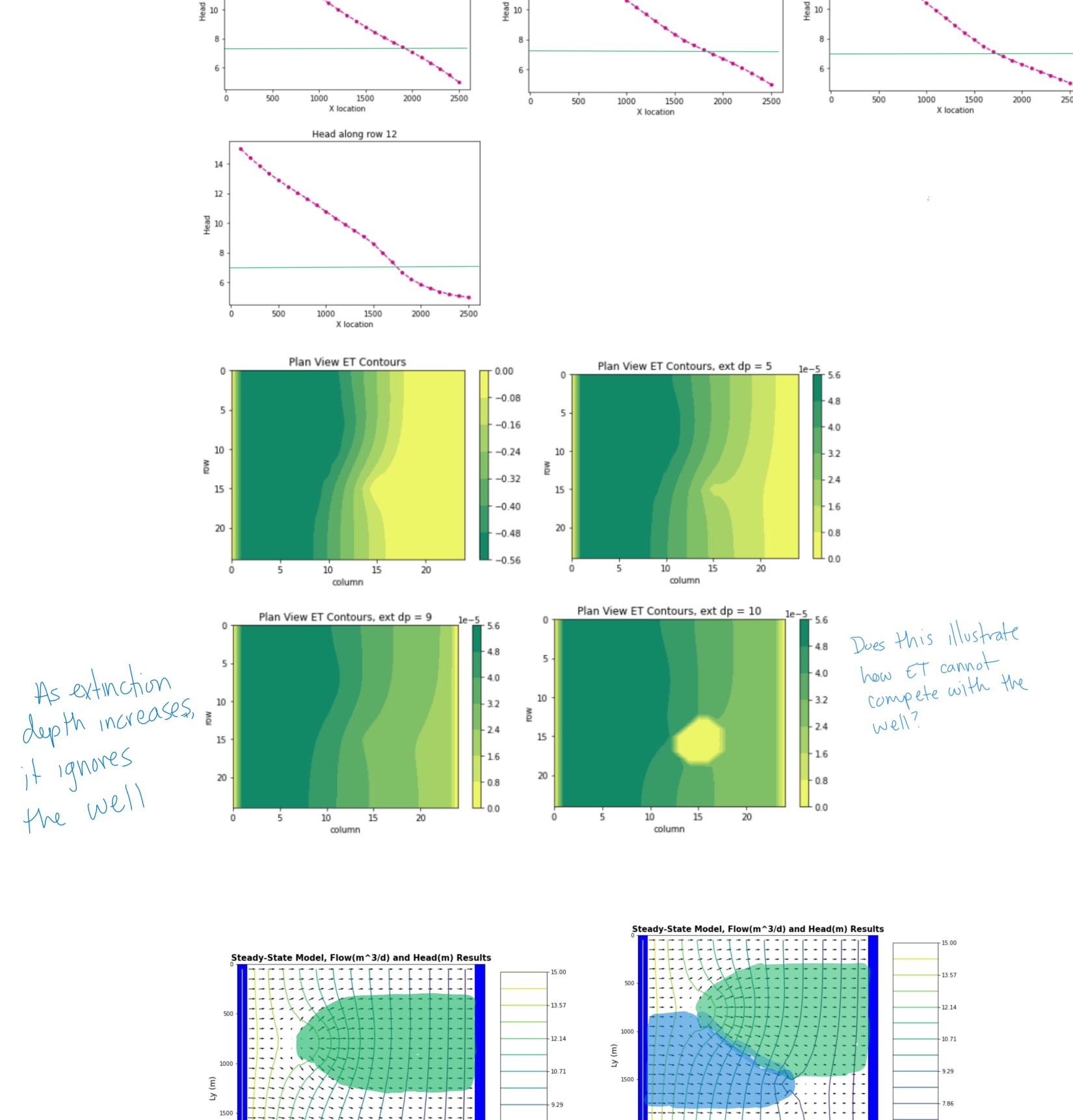
12

Fig 16 Head transect for ext depth = 10

Fig 13 Head transect for ext depth = 1

Fig 17 ET flux with well for ext depth = 3 Fig 18 ET flux with well for ext depth = 5

Fig 19 ET flux with well for ext depth = 9 Fig 20 ET flux with well for ext depth = 10 Head along row 12



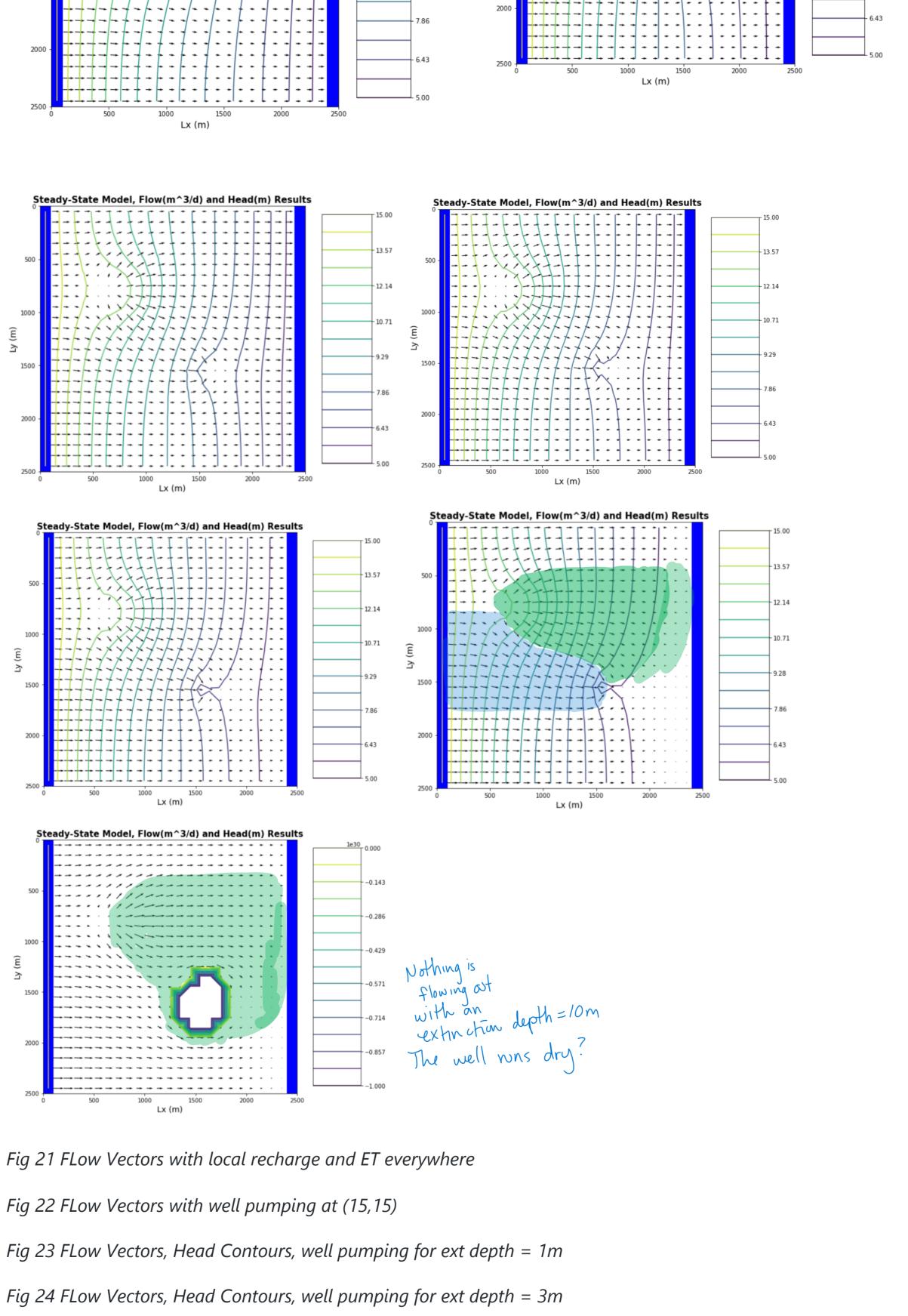


Fig 25 FLow Vectors, Head Contours, well pumping for ext depth = 5m

mass balance

Team partner: Jill

**Initial Discussions:** 

Fig 26 FLow Vectors, Head Contours, well pumping for ext depth = 9m Fig 27 FLow Vectors, Head Contours, well pumping for ext depth = 10m

 $\Delta S = Q_0 \mu t - Q_{in} = Q_{well} + Q_{ET} - (Q_{re} + Q_{bnd})$  $Q_well = 20$ #m^3/d

 $Delta S = Q_out - Q_{in} = Q_{well} + Q_{ET} - (Q_{re} + Q_{bndy})$ 

 $Q_bndy = 6.18$ sum flux from rows 9 to 17 over the left boundary #m^3/d # find Q\_re  $A_re = 400 * 400$ area of recharge #m^2 recharge = 5E-4 #m/d Q\_re = recharge \* (A\_re \*(1/4)) # assuming only 1/4 of the area is captured by the well # find Q\_Et # By mass balnce  $Q_ET = Q_re + Q_bndy - Q_well$ print(str(Q\_ET)+ ' m^3/d') 6.18 m<sup>3</sup>/d

Similarly, we can also pull ET values from the ET array starting from the left boundary until column 15 (where the well is located) and sum each column into a single row. This will represent all the ET left of the well. If we add this last array and normalize over the area of the

capture zone, we get Q\_ET = 8.23e-09 which is completely different than solved above. Why? This requires further investigation

Jill began with a comparative discussion of ET in the real world versus in MODFLOW. We discussed how MODFLOW interprets ET linearly as a function of head and is applied at the boundary/outside the domain. I explained how to plot the ET contours and how the model responded to a changing the extinction depth. We tried a myriad of values but

found that the model does not work for values less than one! This could be due to MODFLOW only taking in whole numbers or that it isn't possible to have an extinction depth in a fraction of a cell - in other words the model either has ET or doesn't. (I think)... Mass balance proved to be difficult to understand, as well the 'convertible cells' that MODFLOW changes in response to our inputs.