Challenge Answers:

1. The flux shows that the models are at steady state conditions (ignoring time discretization) as when the model converges, the flux remains constant with depth (flow in = flow out and is constant across all cells).

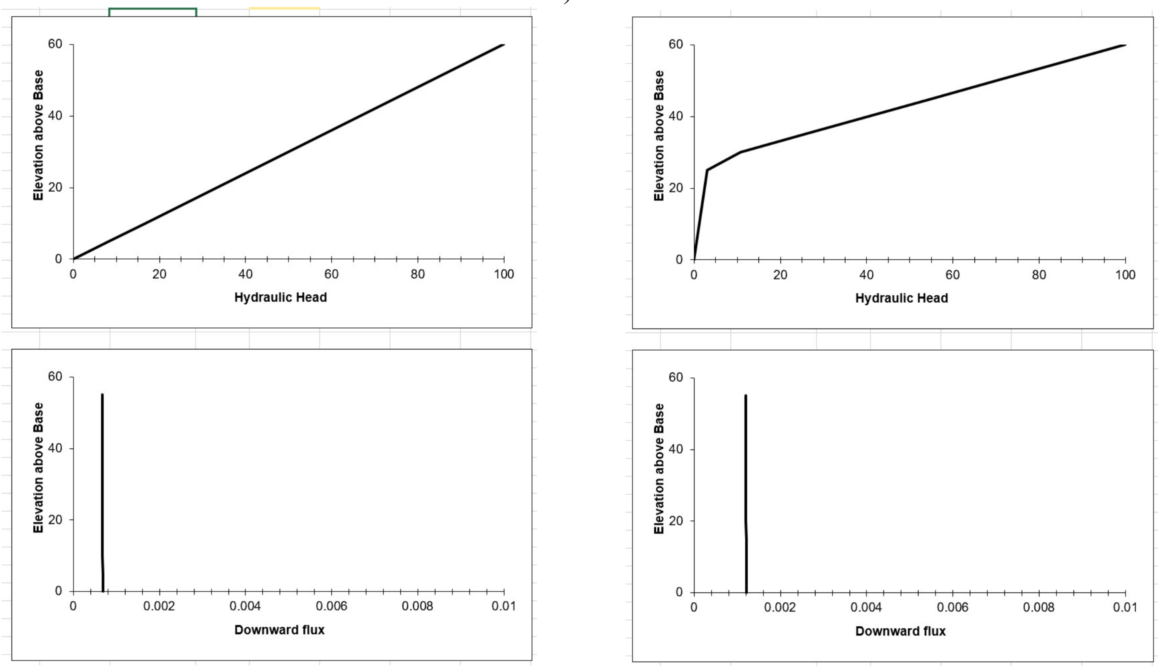

Figure 1: Homogenous Model outputs on the left and the equal thickness layer Heterogenous Model outputs on the right; both models show that the flux within each column remains constant with depth, displaying that each has reached a steady-state equilibrium in their respective columns.

2. The modeled flux for the homogenous and heterogenous models were both equal to the direct calculation of flux using the harmonic mean hydraulic conductivity (K_{eq}). The calculation for flux (q) uses the following equations:

$$q = K_{eq}\frac{dh}{dL}; dh = (h_{top} - h_{bottom}), dL = (z_{top} - z_{bottom})$$

where dh/dL is the change in head over the change of length within the column.

Direct solution for flux

	K	num cells
zone 1	0.0004	12
zone 2	0.01	0
zone 3	0.0001	0
Keq	0.0004	
q	0.000667	

z	K zone cell	K cell	H	q
60	1	0.0004	100	
55	1	0.0004	91.66667	0.000667
50	1	0.0004	83.33333	0.000667
45	1	0.0004	75	0.000667
40	1	0.0004	66.66667	0.000667
35	1	0.0004	58.33333	0.000667
30	1	0.0004	50	0.000667
25	1	0.0004	41.66667	0.000667
20	1	0.0004	33.33333	0.000667
15	1	0.0004	25	0.000667
10	1	0.0004	16.66667	0.000667
5	1	0.0004	8.333333	0.000667
0	1	0.0004	0	0.000667

Direct solution for flux

	K	num cells
zone 1	0.0004	6.5
zone 2	0.01	5.5
zone 3	0.0001	0
Keq	0.000714	
q	0.00119	

z	K zone cell	K cell	H	q
60	1	0.0004	100	
55	1	0.0004	85.11905	0.00119
50	1	0.0004	70.2381	0.00119
45	1	0.0004	55.35714	0.00119
40	1	0.0004	40.47619	0.00119
35	1	0.0004	25.59524	0.00119
30	1	0.0004	10.71429	0.00119
25	2	0.01	2.976191	0.00119
20	2	0.01	2.380952	0.00119
15	2	0.01	1.785714	0.00119
10	2	0.01	1.190476	0.00119
5	2	0.01	0.595238	0.00119
0	2	0.01	0	0.00119

Figure 2: Direct solutions for the homogenous (left) and heterogenous (right) models. Both of the directly solved fluxes (q in the bold outlined box) are equal to the fluxes between each cell of their respective models.

3. The K_{eq} is closer to the lowest K of the heterogenous model due to energy conservation laws. When water passes through layers with a low K, it uses more energy to move through the system, resulting in less energy to flow through the remainder of the system. This is seen as a rapid head change in the low K upper layer, and then a gradual change to the 0 m head boundary at the base of the column within the high (relatively speaking) K lower layer. (Refer back to Figure 1’s head w/ depth graphs).