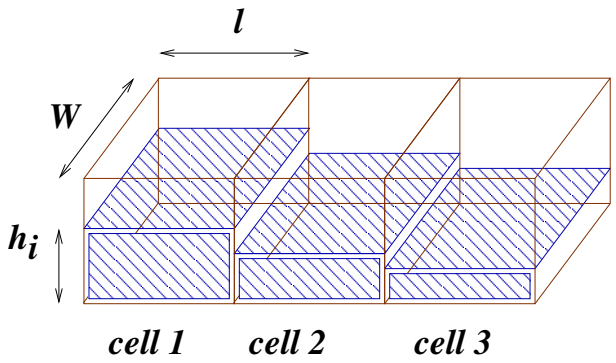
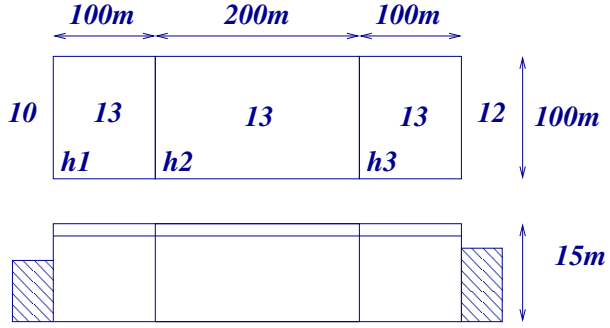
TD 603- Tutorial 4

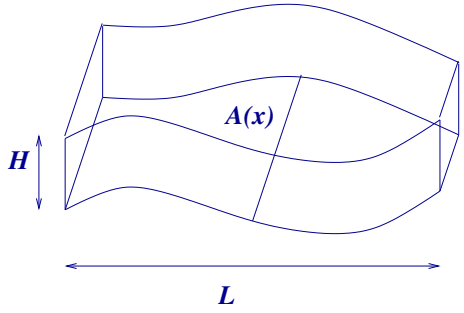
1. Consider the 3 cell system with unknown heads h_1, h_2 and h_3. Let $h_0 = H_0$ and $h_4 = h_4$ be fixed and known. Write the three unsaturated conservation equations for each cell. Note that while considering cell c_i, if we assume all variables but the particular cell variable h_i as fixed, then we get a quadratic equation for h_i in terms of the others, and which is easily solved. We will propose a method to solve such non-linear equations. Let (h_1, h_2, h_3) be a current guess for the solution. Pick a cell, say $i = 1$. Solve for h_1' assuming all other cell values as known. Repeat this a few hundred times and check if this converges.



2. Consider the gymkhana ground of length 400m and width 100m as shown, and as divided into 3 subparts. Assume that the soil thickness is 15m. Suppose that either ends are held at heads 5m below ground and 3m below ground. Also suppose that, to begin with, the heads are constant at 2m below ground level. Assuming that the soil thickness is 15m, $K = 1m/d$ and $S_y = 0.05$, simulate and plot the head values with time. Experiment with various values of Δt. Suppose that the soil-thickness were $L + 15$, instead of 15, how would it affect the rate of convergence?



3. Consider a tube of length L and cross-section width $A(x)$ which is a function of x, where $0 \leq x \leq L$. The thickness of this tube is H. If either ends of the tube are held at $H_1 < H$ and $H_2 < H$, find the intermediate values of saturated thickness $h(x)$ at distance x. Solve this when $A(x) = 3 - x$ and $0 \leq x \leq 2$. Use this to estimate the cone of depression of a well.



4. Consider a small regional watershed as shown below. There are two rain-guages RG1 and RG2, four observation wells OB1-OB4 and a V-notch at the exit of the watershed. The rain-gauges give us daily rainfall readings, while the observation wells are read monthly. The V-notch gives us weekly discharge in cu.m./week.

   There are three types of land-use, viz., wasteland, only *kharif*, which begins in November and *kharif+rabbi*. *Kharif* begins in June and requires about 200mm of additional water, while *rabbi* requires 450mm.

   The well locations are as follows:

Well	Elevation	Aquifer Thickness	S_y	K (in m/day)
OB1	275m	25m	0.05	1.1
OB2	285m	15m	0.03	1.1
OB3	265m	20m	0.05	2.1
OB4	250m	30m	0.12	3.5

   Observations at wells and rain-gauges are as follows:

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
OB1 (m.bgl)	5	7	8	10	12	5	2	2	3	4	4	5
OB2 (m.bgl)	6	7	8	9	10	7	4	2	2	3	4	5
OB3 (m.bgl)	5	6	9	11	10	4	2	2	2	3	4	5
OB4 (m.bgl)	5	6	7	8	9	4	3	3	3	4	4	5
RG1 (mm)	0	0	20	20	40	160	200	160	90	30	0	0
RG2 (mm)	0	0	20	10	30	150	180	160	80	20	0	0

   (a) Estimate the amount of groundwater stored in the region as a function of time.

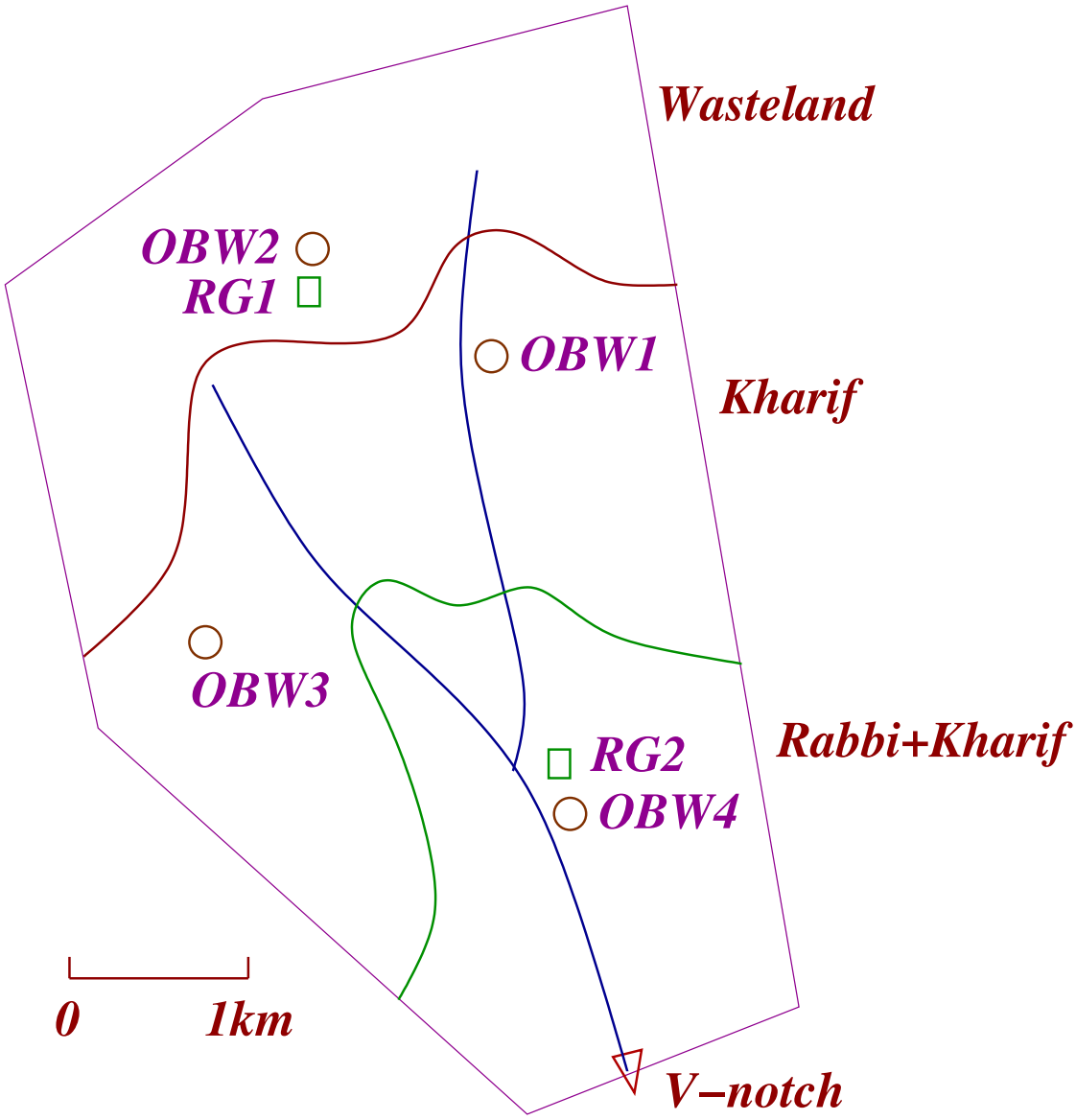
   (b) Based on this and the rainfall, estimate the amount of water which is discharged out of the watershed.

   (c) Estimate the total water requirement. Is the cropping pattern sustainable based purely on groundwater?

   (d) Estimate the groundwater flow from the upper to the middle reaches and from the middle to the lower reaches.

   (e) Plot an estimate of the V-notch flow data. Suggest locations of additional flow meters and conjecture the flows at that time.

   (f) There is a plan to make some reservoirs in the watershed to augment the water in the system. What amount of water do you think should be stored and where do you think the reservoirs should be located? Do the flow-meter readings matter in the design of the reservoirs?


Wasteland
OBW2
RG1
OBW1
Kharif
OBW3
RG2
OBW4
Rabbi+Kharif
0
1km
V–notch