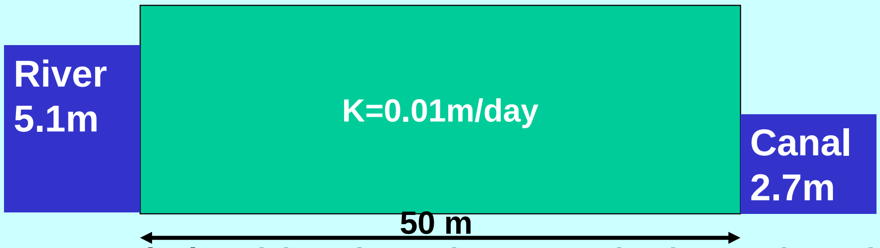
A canal parallels a river 50 m to its west. The maximum ground surface elevation between them is 6 meters. Both the river and the canal fully penetrate an aquifer having a hydraulic conductivity of 0.01 m/day. Precipitation is 0.5 m/year, evapotranspiration is 0.4 m/year. The river is 5.1 m deep while the canal is 2.7 m deep.

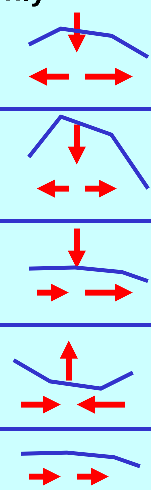


Group 1 Calculate d, h_{max}, $h_{x=12.5}$, $h_{x=37.5}$, q at the river, and q at the canal. Sketch a diagram illustrating the shape of the water table and indicating the discharges.
Group 2 do the same except, $K = 1 \times 10^{-4}$ m/day
Group 3 do the same except, $K = 1 \times 10^{0}$ m/day
Group 4 do the same except, ET = 0.55 m/year and K = 0.01 m/day
Group 5 do the same except, ET = 0.5 m/year and K = 0.01 m/day

Meters and Days	d	h_{max}	$h_{x=12.5}$	$h_{x=37.5}$	qriv	qcan
Group 1 K=0.01 w=0.000274	18.17	5.92	5.85	4.98	-0.00498	+0.00872
Group 2 $K=1 \times 10^{-4}$ w=0.000274	24.93	41.58	36.13	36.00	-0.00683	+0.00687
Group 3 $K=1 \times 10^{0}$ w=0.000274	-658.28	12.03	4.63	3.48	+0.18035	+0.19405
Group 4 K=0.01 w= -0.000137	38.66	(min) 2.35	3.86	2.36	+0.00530	-0.00155
Group 5 K=0.01 w=0.0	-infinity	infinity	4.62	3.46	+0.00187	+0.00187

Group 5: q same as using Dupuit approx dh/dx with avg h for b

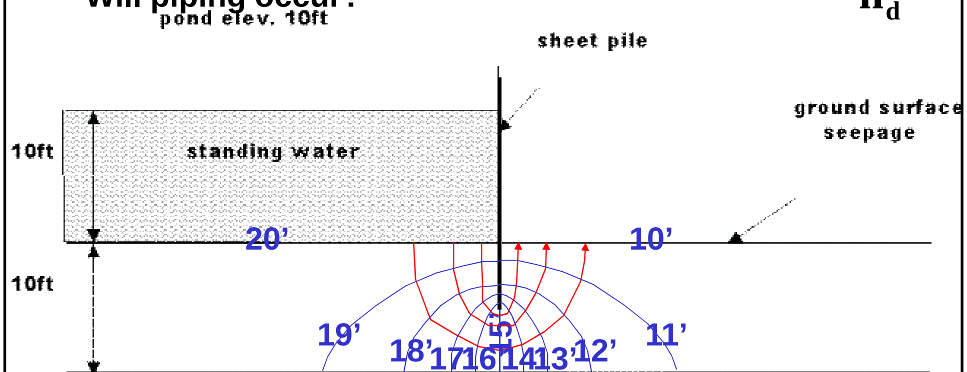
	Meters and Days d	qriv	qcan	Arrows Conceptual Only
Group 1 K=0.01 Recharge=0.0137	18.17	-0.00498	+0.00872 = 0.0137	
Group 2 $K=1x10^{-4}$ Recharge=0.0137	24.93	-0.00683	+0.00687 = 0.0137	
Group 3 $K=1x10^{0}$ Recharge=0.0137	-658.28	+0.18035	+0.19405 = 0.0137	
Group 4 K=0.01 Discharge=0.00685	38.66	+0.00530	-0.00155 = 0.00685	
Group 5 K=0.01 w=0.0	-infinity	+0.00187	+0.00187 = 0	



Group 5: q same as using Dupuit approx dh/dx with avg h for b

What is the flux under the sheet pile wall if K=2ft/day? Will piping occur?

$$Q = q_A n_f = KH\frac{n_f}{n_d}$$



$Q = KH(n_f/n_d)$ = 2 ft/d 10ft 4/10 = ~ 8 ft^3/day

Using: γ_t = 0.7 (165 lb/ft^3) + 0.3 (62.4 lb/ft^3) = (134 lb/ft^3)

$$i_{critical} = \frac{134\ lb/ft^3 - 62.4\ lb/ft^3}{62.4\ lb/ft^3} = 1.15$$

gradient is ~1.0 at the critical location, so it looks OK

What could change that? How could you correct it?

A PLAN VIEW FLOW NET BY CONTOURING USING FIELD HEADS AND DRAWING FLOW LINES PERPENDICULAR: can't assume constant K or b

assuming no inflow from above or below, we can evaluate relative T:

$$Q = A_A V_1 = A_B V_2$$

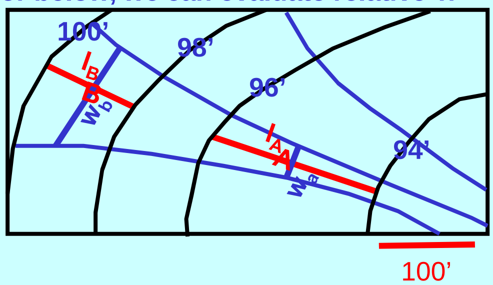
$$A_A K_A \frac{\Delta h}{l_A} = A_B K_B \frac{\Delta h}{l_B}$$

$$\frac{A_A K_A}{l_A} = \frac{A_B K_B}{l_B} \qquad \frac{K_A}{K_B} = \frac{A_B l_A}{A_A l_B}$$

$$A = wb \quad (b = \text{aquifer thickness})$$

$$\frac{K_A}{K_B} = \frac{w_B b_B l_A}{w_A b_A l_B}$$

$$\frac{K_A b_A}{K_B b_B} = \frac{w_B l_A}{w_A l_B} = \frac{T_A}{T_B}$$



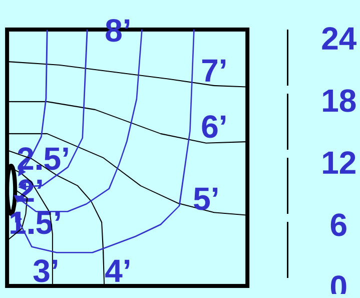
"Irregularities" in "Natural" flow nets

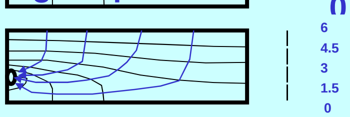
- varying K
- varying flow thickness
- recharge/discharge
- vertical components of flow

Nature's flow nets provide clues to geohydrologic conditions

A longer narrower shape indicates higher T, a shorter wider shape, low T

The pond elevation is 8m, ground surface is 6m, the drain is at 2m (1.5 to 2.5), bedrock is at 0m, K_x is 16m/day, and K_z is 1m/day.





$$x' = x \qquad z' = \frac{z\sqrt{K_x}}{\sqrt{K_z}}$$

~ 5 flow tubes and 6 head drops

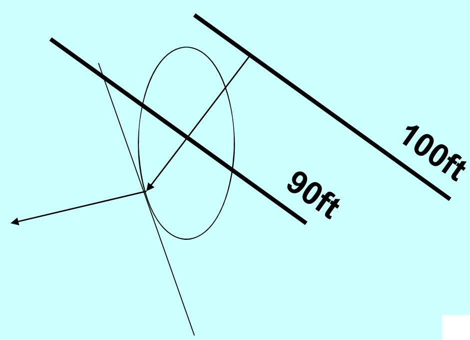
If the pond elevation is 8m, ground surface at 6m, the drain at 2m, bedrock at 0m and K_x is 16m/day and K_z is 1m/day , what is the flow at the drain? **Recall:**

$$K' = \sqrt{K_x K_z}$$

$$Q = q_A n_f = KH \frac{n_f}{n_d}$$

Q = 4 m/day 6 m 5/6 = ~ 20m^3/day per m

$try \text{ it for } K_x = 16\ ft/day \quad and \quad K_z = 4\ ft/day$



1 - Draw an INVERSE K ellipse for semi-axes $\frac{1}{\sqrt{K_x}}$ and $\frac{1}{\sqrt{K_z}}$
2 - Draw the direction of the hydraulic gradient through the center of the ellipse and note where it intercepts the ellipse
3 - Draw the tangent to the ellipse at this point
4 - Flow direction is perpendicular to this line

Explore the Flow Net Software at

http://inside.mines.edu/~epoeter/_GW/09FlowNets/topodrive/index.html

Before leaving class use the software to simulate a regional system with similar boundary conditions as one of those presented by Toth Freeze or Witherspoon but different heterogeneity

Submit in the homework box WITH YOUR NAME ON IT:

An image of your system showing the flow pattern
(make it the active window then ALT PrintScreen then paste on MSWord)
and 2 paragraphs as follows

1st paragraph:
describing the system boundary conditions and properties

2nd paragraph
describing why the flow moves as shown in the image