THE PENNSYLVANIA STATE UNIVERSITY
DEPARTMENT OF ENERGY AND MINERAL ENGINEERING
GEOEE 408 CONTAMINANT HYDROLOGY

Mid-term Examination – Tuesday March 2nd, 2010 – 75 minutes
Answer all three questions.

For water (in contact with air): $\sigma = 7.3 \times 10^{-2}$ *N/m*; γ=9.8 kN/m^3; $\mu = 1.12 \times 10^{-3}$ *N.s/m*^{2}
For TCE (in contact with water): $\sigma = 3.5 \times 10^{-2}$ *N/m*; γ=15.6 kN/m^3; $\mu = 0.96 \times 10^{-3}$ *N.s/m*^{2}

Name: _____

Question	Points	Score
1	100	
2	120	
3	80	
Total	300	

Include extra sheets, as needed, and return entire packet

Question 1

Define the following terms, and identify the units [MLT] of the quantity, where relevant. Be as specific and as exhaustive in your definitions as possible.

1. Intrinsic permeability, *k*

2. Capillary pressure, p_c

3. Effective diffusion coefficient, D*

4. Conservative transport

5. Brooks-Corey parameters, p_b and λ

6. Advective velocity, v_a

7. Fick's law, $F = -D * \frac{\partial C}{\partial x}$

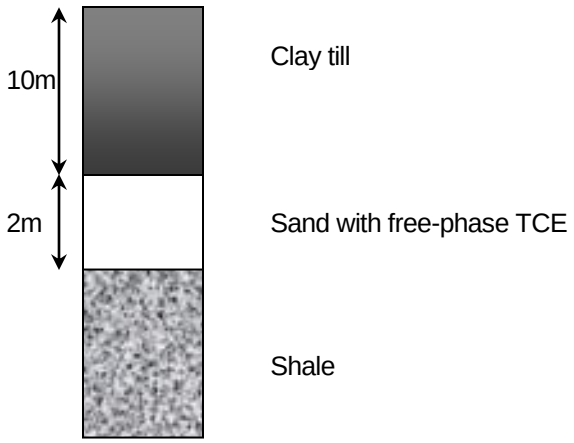
8. Critical ganglion height, h_{min}

9. Pore volumes, t_R

10. Natural gradient tracer test.

Question 2

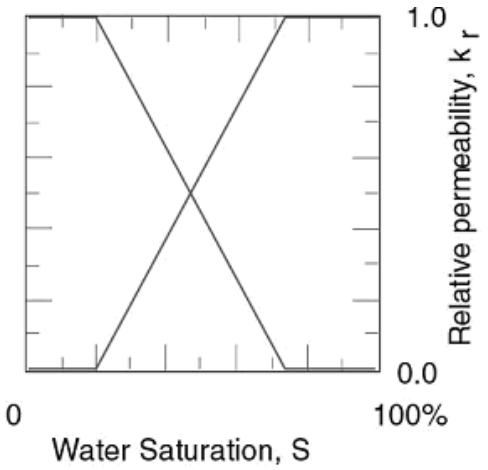
Free-phase TCE has been detected in a sand aquifer that was thought to be protected by 10 meters of clay till, as illustrated. The water-table is at the ground surface. The sand aquifer is underlain by shale.



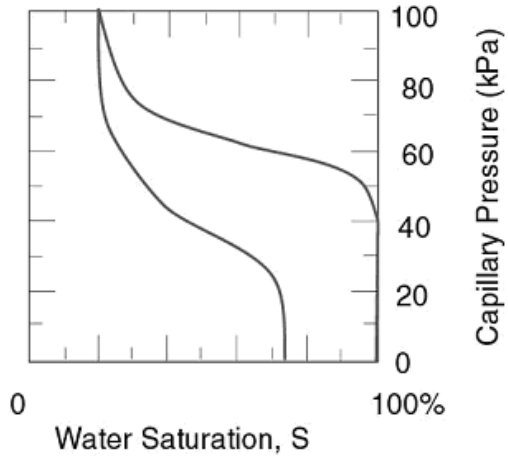
The capillary pressure versus saturation and relative permeability versus saturation curves are available for the underlying sand.

Determine the following:

1. If you assume the clay till to be unfractured, with a porosity of 20%, evaluate the minimum matrix permeability at its base if the free-phase TCE has managed to cross it. [Leverett curve gives $J=0.3$ at $S_w=99.999\%$]



2. How does this magnitude of permeability compare with values you expect for clay? Correspondingly, what does this say about the likely presence or absence of fractures in the clay?



3. If TCE may be present only up to the ground surface, what is the range of maximum saturations that may be present in the sand? i.e. at the top and base of the aquifer.

4. If the horizontal hydraulic gradient is 1 in 100 in the sand aquifer, what is the average horizontal advective velocity, if the hydraulic conductivity of the sand is $K=10^{-5}$ m/d, and its porosity 30%.

5. How far will the plume travel in 10 years if transport is both near-conservative and you assume advection dominated?

6. Based on your knowledge of the fidelity of plume length predictions for Peclet numbers less than 10, do you expect your prediction of the plume length to underestimate, closely estimate, or overestimate the true length? [In this do not assume that the main dispersive process is mechanical dispersion.] Explain your reasoning.

Question 3

A dissolved plume of Trichlorobenzene (TCB) is detected in sands and gravel present at the site of a semiconductor plant. The form of the plume is as shown in the figure, where isopleths are in ppb. You have been retained to determine the source of the plume. Assume the aqueous TCB component is conservative.

1. A potential source for the plume, is a pulse spill of TCB that occurred 10 years previously. Is it possible to suggest the possible coordinates of the source? State your assumptions. If not, what additional data are needed?
2. The regional hydraulic head gradient is measured as as 0.01. Hydraulic conductivity of the material is 10^{-3} cm/s and mean porosity is 25%. Are you able to estimate the coordinates of the source?
3. Where will the center of mass of the plume be in a futher 5 years?
4. If you wished to have greater constraint on both the source location and where the plume will be in 5 years time, what information would you desire?