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

Mid-term Examination – Tuesday March 13th, 2012 – 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: _____

Include extra sheets, as needed, and return entire packet

Question	Points	Score
1	100	
2	100	
3	100	
Total	300	

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, $F = -D * \frac{\partial C}{\partial x}$

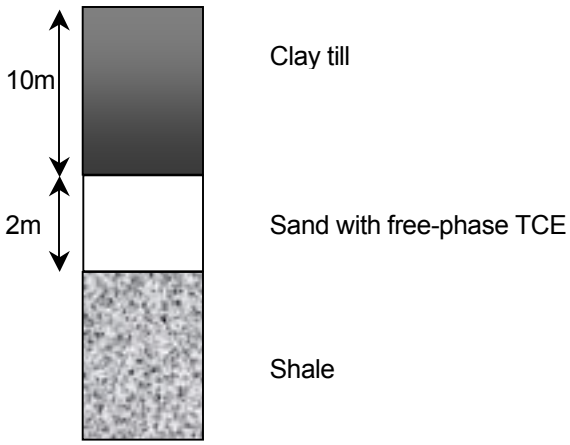
8. Critical ganglion height, h_{min}

9. Pore volumes, t_R

10. Natural gradient tracer test.

Question 2

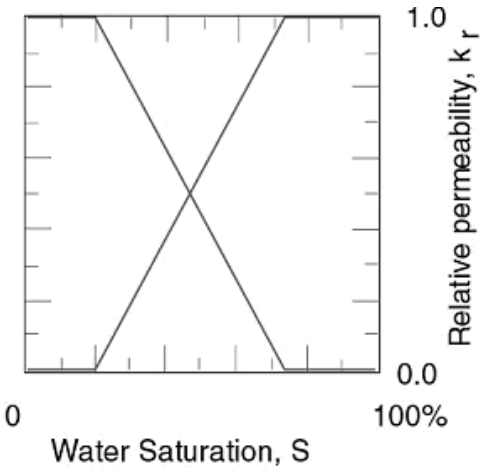
Free-phase TCE has been detected in a sand aquifer that was thought to be protected by 10 meters of clay till, as illustrated. The water-table is at the ground surface. The sand aquifer is underlain by shale.



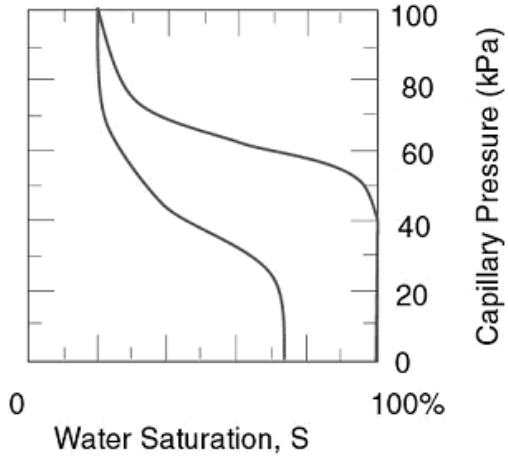
The capillary pressure versus saturation and relative permeability versus saturation curves are available for the underlying sand.

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%.

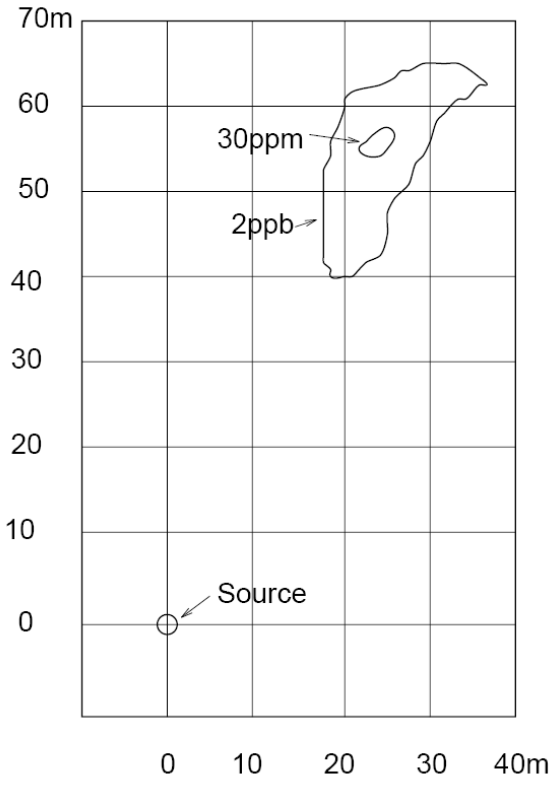
5. How far will the plume travel in 10 years if transport is both near-conservative and you assume advection dominated?

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

For the figure, showing the plume resulting from pulse injection of chloride tracer in well graded sands at the Borden aquifer, determine the following. (Use the shape of the plume after 647 days as shown.)

Note: $M = c_o V$; $c = \frac{M}{8(\pi t)^{3/2}\sqrt{D_x D_y D_z}} \exp[-\frac{X^2}{4D_x t} - \frac{Y^2}{4D_y t} - \frac{Z^2}{4D_z t}]$.



1. The longitudinal dispersivity, D_L.

2. The coefficient of longitudinal hydrodynamic dispersion, a_L.

3. The transverse dispersivity, D_T.

4. How far downgradient from the source will the center of mass of the plume be 10 years after the initial injection?

5. What will be the peak concentration of the plume after 10 years if the peak concentration after 647 days is 30 ppm?

6. What is the approximate volume of fluid comprising the plume, if the porosity of the aquifer is 0.3? Use the area of a rectangle to approximate the area of an ellipse.

7. What is the mass of chloride comprising the plume?