THE PENNSYLVANIA STATE UNIVERSITY
DEPARTMENT OF ENERGY AND GEO-ENVIRONMENTAL ENGINEERING
GEOEE 408 CHARACTERIZATION OF GROUNDWATER SYSTEMS

Mid-term Examination - Tuesday March 2nd, 1999 - 75 minutes
Answer all three questions.

Name: _____

SN: _____

Include extra sheets, as needed, and return entire packet.

Question	Points	Score
1	100	
2	100	
3	100	
Total	280	

Question 1

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

1. Advective velocity, v_x^a.

2. Effective saturation, S_e.

3. Bubbling pressure, P_b or P_{c0}.

4. van Genuchten relations.

5. Capillary rise, h_c.

6. Immiscible displacement.

7. Air sparging.

8. Mass concentration, c.

9. Ganglion length, h_{min}.

10. Coefficient of hydrodynamic dispersion, D_L.

Question 2

A spill of TCE occurs at the surface for the stratigraphy given in the figure. The profile includes laterally extensive and horizontally bedded sands and silts. An approximate capillary pressure curve is available for TCE penetration into the sand. Unit weight of TCE is $\gamma = 15.6kN/m^2$, and for water, $\gamma_w = 9.8kN/m^2$. The dynamic viscocities, μ of water and TCE are $1.12 \times 10^{-3} N.s/m^2$ and $0.96 \times 10^{-3} N.s/m^2$, respectively.

The capillary pressure relationship is defined for the silt units, as shown, and the piezometers measure pressures in the silt. Hydraulic conductivity magnitudes are available from pumping tests that yield $K_{silt} = 2.5 \times 10^{-5}\ cm/s$. The porosity of the sand is 31% and and for the silt 31%.

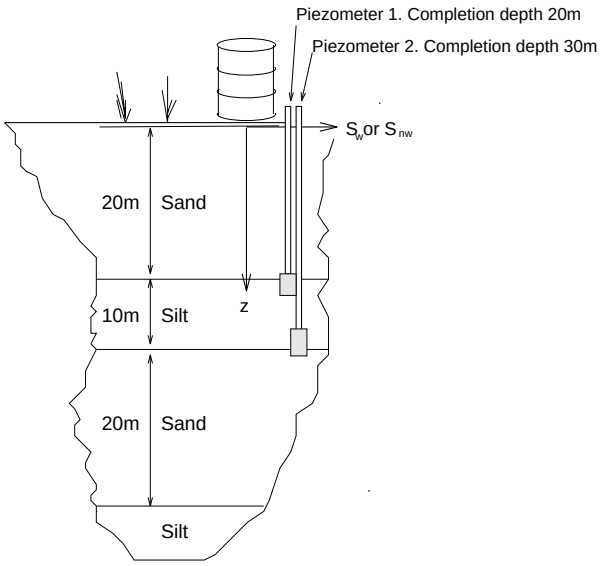
1. Water pressures are hydrostatic, with the water-table at the ground surface. Evaluate water pressures at the piezometer locations.

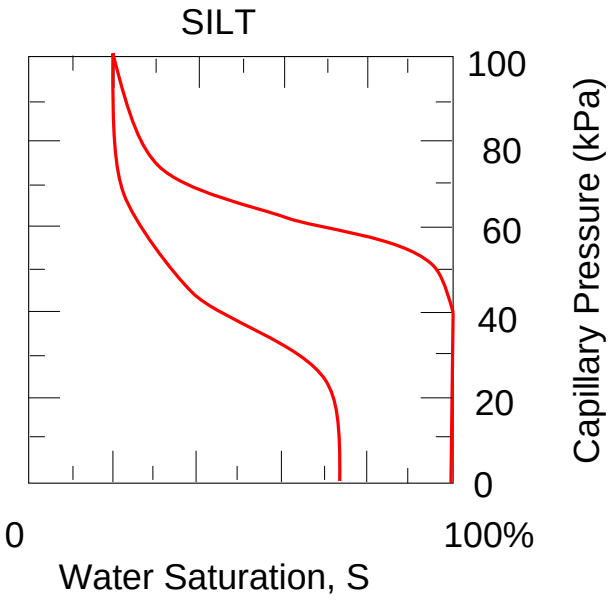
2. The piezometers measure TCE pressures in the silt layer. The TCE pressure in the upper piezometer is $280\ kN/m^2$, and $436\ kN/m^2$ in the lower piezometer. Determine the capillary pressures at the upper and lower piezometer locations. Are these positive or negative.

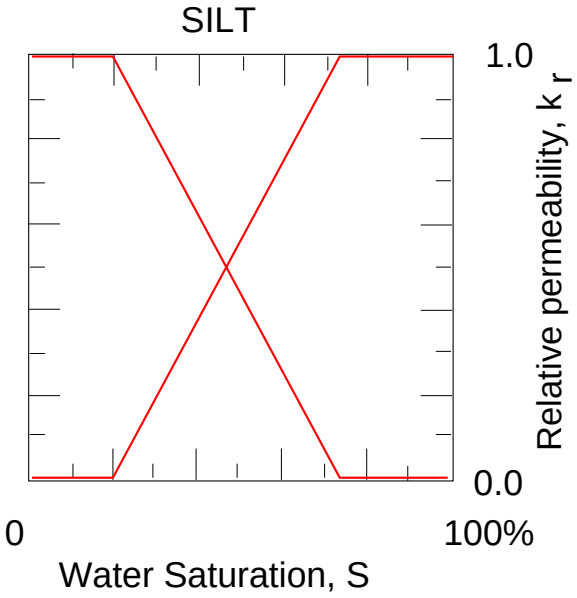
3. Evaluate the effective water and TCE saturations at the locations of each of the piezometers. Explain your rational for choice of drainage or imbibition curves.

4. What is permeability of the silt to TCE? State your assumptions.

5. What is the volumetric flow rate per plan area of flow?


Piezometer 1. Completion depth 20m
Piezometer 2. Completion depth 30m
S_w or S_{nw}
20m
Sand
10m
Silt
z
20m
Sand
Silt


SILT
100
80
60
40
20
0
Capillary Pressure (kPa)
0
100%
Water Saturation, S


SILT
1.0
0.0
Relative permeability, k_r
0
100%
Water Saturation, S

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 $K = 10^{-3}\ cm/s$, and mean porosity is $n = 25\%$. 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?