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

Final Examination
1 hour 15 minutes
May 4th, 2001

Name: _____

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 in your definitions as possible. Where relevant, include any equations or figures to explain the term.

1. Distribution coefficient, k_d.

2. Ground penetrating radar (GPR).

3. Split-spoon sampler.

4. Cassagrande or standpipe piezometer.

5. Soil washing processes (*in situ*)

6. Relative permeability, k_r.

7. Capillary pressure, p_c.

8. Henry's law coefficient, H'.

9. Steam Enhanced Extraction (SEE).

10. Darcy's law.

Question 2

Free product TCE and TCB are present in the subsurface at the Smithville site. These components are suspected to be present in free phase form in the limestone aquifer that underlies a cap of fractured clay till. Under the aquifer is a potential capillary barrier of shale. A few thousand litres of DNAPL have been spilled. The water table is at the surface.

1. Describe an appropriate (direct) site investigation for this site to:

   (a) Evaluate geology and hydrogeology.

   (b) Determine the extent of NAPL (free product) and dissolved product contamination.

   (c) Determine the potential for continued migration within the groundwater zone.

   Use note form, if you wish, to itemize your choices and explain their relevance.

2. The bulk hydraulic conductivity, of the fractured limestone aquifer is of the order of $10^{-2}\ cm/s$, and the matrix conductivity is very low, of the order of $10^{-10}\ cm/s$, with a porosity of 13%. The overlaying till is fractured and has a matrix porosity of 25%, and a bulk saturated conductivity of $10^{-4}\ cm/s$, and an intact matrix conductivity of 10^{-6}.

   Identify, and describe the operating principles of <u>two</u> remedial techniques that may be applied to this site to remove or contain the bedrock source NAPLS. For each of these two applicable techniques, identify three factors that make the technique particularly applicable to the site. Use note form to answer if you wish.

Question 3

TCE has been spilled into the vadose zone in a sand aquifer. The aquifer has a porosity of 25%. From samples recovered from the aquifer, the total mass of TCE is 76 g in a sample of 1 liter volume - this includes soil and water in the pores. The pores are filled with water and free-phase TCE, in the absence of air. The density of TCE is $1500\ kg/m^3$. Given that the Henry's law coefficient is $H = 0.4$, the aqueous solubility is $1100\ mg/L$, solid sorption is only on organic carbon, present at $f_{oc} = 1\%$, $k_{oc} = 110 L/kg$, and the specific gravity of quartz is 2.7, evaluate the following:

1. Evaluate the amount of TCE that is held in aqueous form?
2. Evlauate the amount of TCE that is held in solid form?
3. Evaluate the amount of TCE that is present in free phase? What is the saturation of TCE in the aquifer?
4. Based on the proportions identified in the aqueous, solid, and free phase states, how would this guide your selection of remedial method? i.e. What would you want to get rid of first?