LAB 4 FOR 1.106
Transport in Porous Media
October 15, 2003, To Be Determined

Objective: Use a tracer study to estimate the dispersion coefficient, pore velocity and porosity of a sediment column.

Background:
Material carried by a fluid flowing through a porous medium is dispersed by several processes; e.g. a) molecular diffusion, b) mechanical dispersion, c) stagnation in pore spaces, and e) spatial variation in hydraulic conductivity. In this lab you will observe dispersion in a porous media by observing its effect on a slug of tracer, M, released into a column of soil. The concentration of tracer at the end of the column is given by the 1-D advection-dispersion equation. The tracer travels at the mean pore velocity, $\bar{v}$ such that the arrival time of the peak is $L/\bar{v}$. In this lab you will use conductivity as a surrogate for concentration, and assume that there is a linear relationship between the concentration and conductivity, here *C*. Then, correcting for the background conductivity, C_B, the observed conductivity, C_O, should be,

$$C_O - C_B = [C_{max} - C_B] \exp\left[-\frac{\left(L - \bar{v}t\right)^2}{4Dt}\right]$$

Here, C_{max} is the maximum observed conductivity, D is the dispersion coefficient, and L is the length of the column between the injection port and the measurement position.

Pre-Laboratory Activity:
Prepare an EXCEL spread sheet that plots $C_O(t)$ based on the above equation. Allow the variables C_{max}, L, $\bar{v}$, and D to be adjusted with ease to produce new $C_O(t)$ curves. Using the following test values plot $C_O(t)$ versus t for t = 1 to 20 seconds at 0.5 second intervals. Show that the peak arrival time and the duration of the peak are correctly reproduced on the graph. [See Chapter 3, Instantaneous Point Source in web notes].
You will hand in a copy of this graph at the beginning of class.

Test Values: $D = 0.1\ cm^2s^{-1}$, $L = 10$ cm, $C_B = 5$, $C_{max} = 40$ and $\bar{v} = 1\ cms^{-1}$.

Outline for Lab Report
1. Record the experimental set-up and procedure in sufficient detail that you could recreate the experiment ten years hence.
2. Describe the analyses used to estimate the dispersion coefficient, D, the mean pore velocity, $\bar{v}$, and the effective porosity, n_e.
3. Table of observed conductivity and a plot comparing observations to 'best fit'
4. Clearly state your estimates for D, $\bar{v}$, and n_e, with uncertainty.
5. Discussion points:
   5.1 How do you know that turbulent diffusion is not contributing?
   5.2 Describe the processes that determine the observed spread of tracer.

This lab was developed by H. Nepf, and J. MacFarlane Parsons Laboratory, MIT