Solutions

CE6361 Groundwater Hydrology , HW#8, Fall 1993 Due: ________________

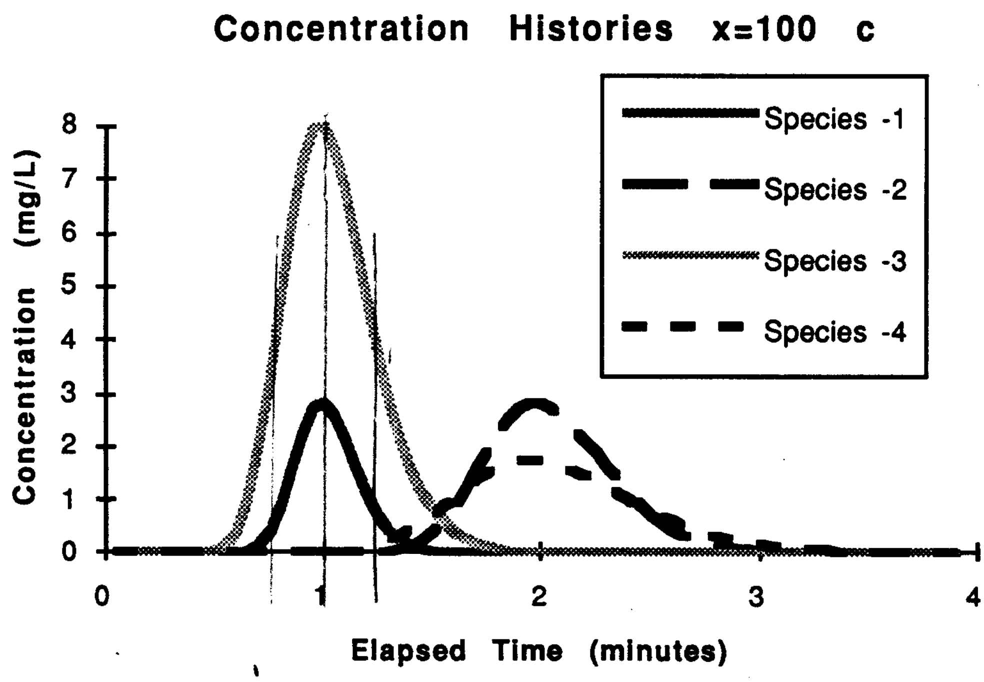
1) Consider the concentration histories shown below. All species were introduced as a slug at t=0 minutes, at x=0 cm along the aquifer material. Species 1 is known to be a conservative species.

(a) What is the specific discharge of the porous medium shown if the porosity is thirty percent?

(b) Assuming linear, instantaneous, equilibrium adsorbtion isotherms for species, what are the distribution coefficients for species 2, 3, and 4, if the solids density is 2.97 g/cc (grams per cubic centimeter)?

(c) Estimate the dispersion coefficent for species 3.

(d) Predict the concentration history for species at x=50 cm.



2) A rectangular excavation was cut into the surface clay for a sewer pipe and backfilled with sand. The hydraulic conductivity of the sand is 20.0 ft/day. The hydraulic gradient in the sand is 0.1. The longitudinal dispersivity of the sand is 10 ft/day. The sewer leaks and introduces a steady stream of contaminated water at a concentration of 100 mg/L into the sand at the access shaft shown at time t=0 days. What is the concentration 100 feet away in the sand near the school yard after 6, 16, 25, and 75 days? The retardation of the contaminant is 2.

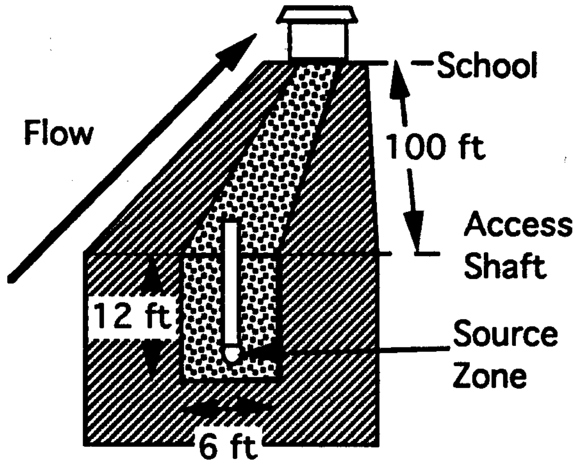
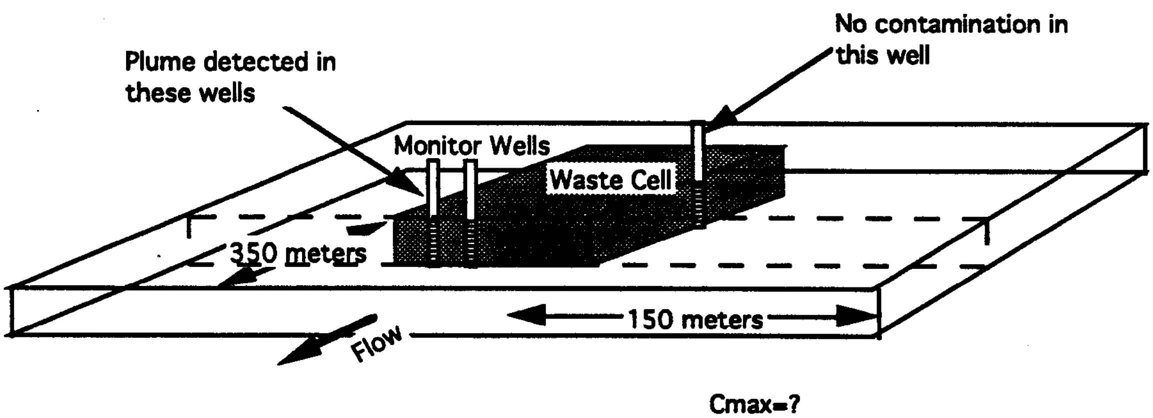


Figure 2. Diagram for problem 2.

3) An industrial waste facility is constructed in northern Harris county. The state requires a buffer zone between the waste trenches and the property boundary. Over 500 constituients are included in the waste, some with reasonably large distribution coefficients, and some that have nearly zero adsorbtion. A few years after construction, a plume is noticed by observation wells at the waste cell boundary. The maximum concentration occurs in a zone about 6 meters thick and 60 meters wide. Because of low permeability strata, the plume is only capable of lateral spreading, but not vertical spreading. Estimate the maximum concentration that might be expected (in terms of Co) once the plumes arrives along the edge of the compliance zone (symmetric about waste cell) that is depicted below. The longitudinal dispersion is 1E-02 square meters/second transverse dispersion is 1E-03 square meters/second and the pore velocity is 1E-03 meters/second.



1) ~~Species 1~~ conservative

$V_{s_1} = V_{water}$

$x = vt \qquad \frac{x}{t} = v$

$\frac{100cm}{1.0m} = 100 cm/min = 1 m/min$

$nv = q \qquad (0.3)(1 m/min) = \underline{\underline{0.3 m/min}}$

b) $R_2 = 2$ (peak takes 2x longer to travel 1m)

$R_4 = 2$

$R_3 = 1$

$R = 1 + \frac{1-n}{n} \varphi_s K_d$

$K_d = (\frac{R-1}{\varphi_s})(\frac{n}{1-n})$

$S_2, S_4; \ K_d = 0.144$

$S_3 \quad ; \ K_d = 0$

c) Various methods

- Use spreadsheet supplied with class to obtain D by trial and error

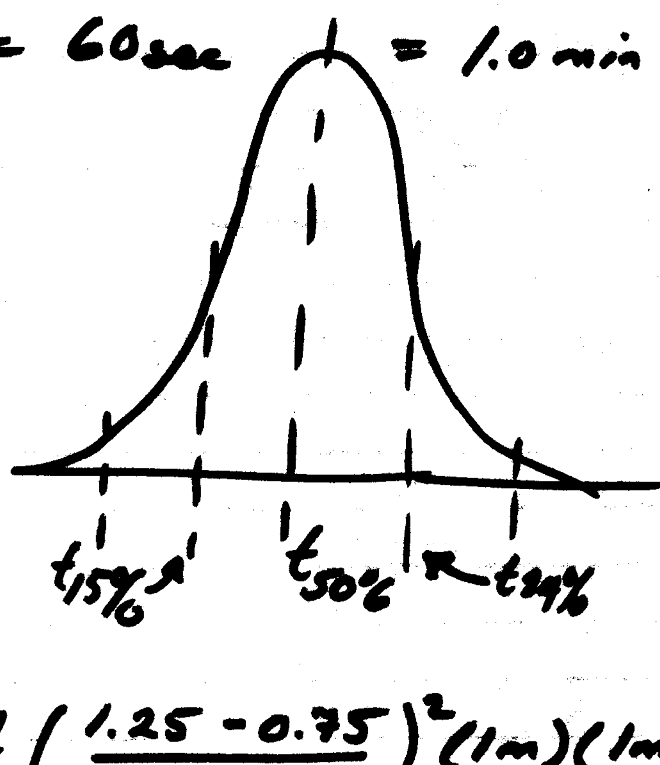
- Use breakthrough curve method (Beer 1972)

~~$D_x = \frac{1}{2}\left(\frac{t_{84\%} - t_{16\%}}{2t_{50\%}}\right)^2 L v$~~

$t_{84\%} = 75\,\text{sec} = 1.25\,\text{min}$

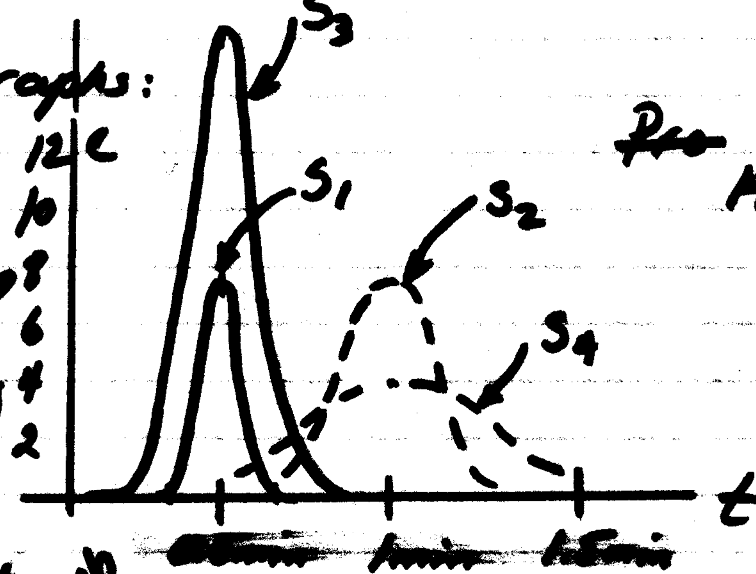
$t_{15\%} = 45\,\text{sec} = 0.75\,\text{min}$

$t_{50\%} = 60\,\text{sec} = 1.0\,\text{min}$



$$D \approx \frac{1}{2}\left(\frac{1.25 - 0.75}{2(1)}\right)^2 (1\,\text{m})(1\,\text{m/min}) = 0.031\,\frac{\text{m}^2}{\text{min}}$$

d) Graphs:



~~Pro~~ Histories should be <u>narrower</u> than histories on problem sheet

Peaks should be higher than peaks on graph on problem sheet

2) Assume $n_{sand} = 0.30$ (pg 26 - text)

$K = 20$ ft/d

$\alpha = 10$ ft/d

$C_0 = 100$ mg/L - continuous

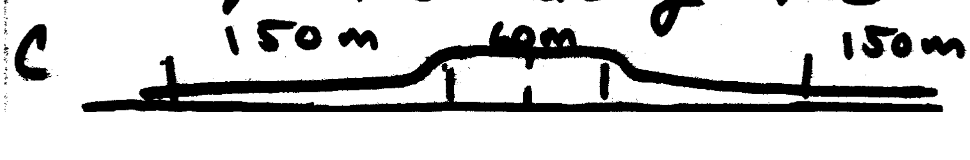
$\frac{\Delta h}{\Delta l} = 0.1$ $\quad L = 100$ ft $\quad R = 2.0$

$$C(L,t) = \frac{C_0}{2}\left[\operatorname{erfc}\left(\frac{L - V\frac{t}{R}}{2\sqrt{D\frac{t}{R}}}\right)_{(a)} + \exp\left(\frac{LV}{D}\right)\operatorname{erfc}\left(\frac{L + V\frac{t}{R}}{2\sqrt{D\frac{t}{R}}}\right)_{(b)}\right]$$

t/R	$2\sqrt{Dt/R}$	(a) $\frac{L-Vt/R}{2\sqrt{Dt/R}}$	(b) $\frac{L+Vt/R}{2\sqrt{Dt/R}}$	erfc(a)	erfc(b)	C(100, t)
3	28.27	2.83	4.24	0.000075	~0	0.003 mg/L
8	46.16	1.01	3.32	0.1573	~0	7.8 mg/L
12.5	57.7	0.29	3.17	0.671	~0	33.5 mg/L
37.5	99.94	-1.49	3.49	1.95	~0	97.5 mg/L

→ Note: Could also use the spreadsheet supplied with course.

3) Similar to problem 8, pg 673 in text. Should use one of equations in Ch. 17 and produce a profile along the boundary



✓ i.e. with #'s.