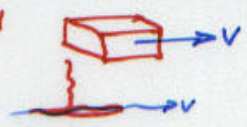
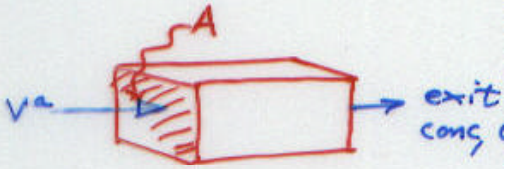
6.4.3 TIME REQUIRED FOR DISSOLUTION – two forms { Distributed, Pool }



a) Distributed throughout volume

- Slow dissolution rates
- Decreases with time due to reduction in contact area.



$$t = \frac{\text{Mass of NAPL}}{\text{Mass rate of removal}} = \frac{m}{V_i^a n_e C_w A}$$

V^a = advective velocity
n_e = effective porosity
A_i = c/s area of flow
m = NAPL mass
C_w = dissolved exit concentration

g.

$K = 10^{-3}$ cm/s
$i = 0.01$
$n_e = 0.3$

$$V^a = \frac{Ki}{n} = \frac{10^{-3}\,10^{-2}}{.3}$$

$= 3 \times 10^{-5}$ cm/s

$= 3$ cm/d $= .03$

of PCE $\rho = 1.63$ g/cm³

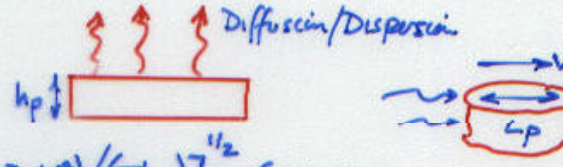
Solubility = 200 mg/L

Assume solubility @ 10% → 20 mg/L

$t =$ 744 years

Magnitudes consistent with persistent DNAPL contamination problems in 40s, 50s, 60s.

b) Residual Pool Sources



M_a = Surface area averaged mass transfer rate $(M/L^2/T)$

$$M_a = \left[(4 D_v V^a)/(\pi L_p)\right]^{1/2} C_{sat}\, n_e$$

D_v = coef of vertical dispersion
$= D^* + V^a \alpha_T$ (L^2/T)

V^a = average advective g/w velocity

L_p = pool length

n_e = effective porosity

C_{sat} = saturation concentration (solubility)
(may be 10% of this due to mass transfer rate effects)

Assuming pool area remains constant:

$$t_d = P_h \; n \; \rho_{nw} \; S_n / M_a$$

(Mass of NAPL per unit area; Mass rate of removal)

t_d = dissolution time

P_h = pool height

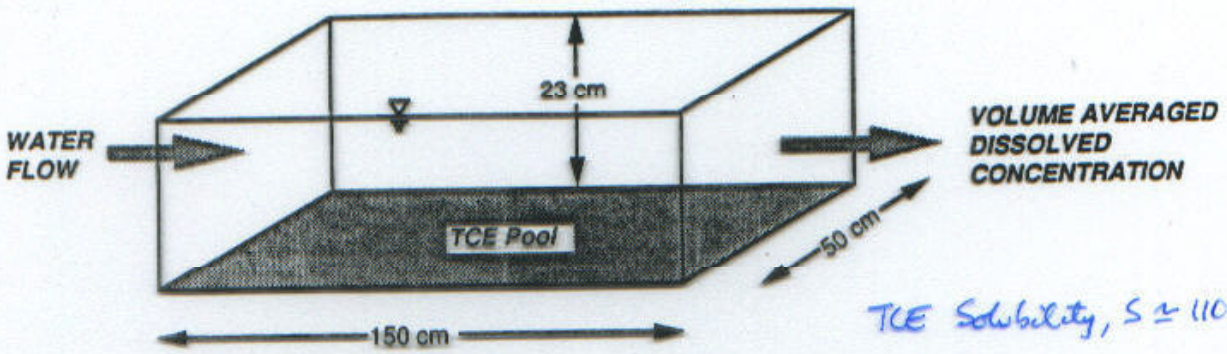
S_n = NAPL saturation

ρ_w = Density of NAPL

eg TCE in sand

Schwille experiment.

SCHWILLE POOL DISSOLUTION EXPERIMENT



TCE Solubility, S ≈ 1100 mg

From Schwille (1988)

RESULTS OF POOL DISSOLUTION EXPERIMENT:

Linear Velocity (m/day)	Concentration (mg/L)	Relative Concentration
1.1	90	8.2 %
2.3	67	6.1 %
2.3	87	7.9 %
4.5	73	6.6 %
6.8	77	7.0 %

Much lower than absolute solubility

CONCLUSION FROM POOL DISSOLUTION EXPERIMENT:

* Dissolved concentrations can be considerably less than saturation concentrations

→ Contact time of groundwater with solvent

→ Area of contact (Related to pool size).