List ALL assumptions used (some critical assumptions will be necessary for these problems)

1. [4 pts] A surface spill of 50 gallons pure PCE and TCE mix (50% each) occurs on the ground surface. The ground is bare sandy loam, the season is rainy with some site run-off and some infiltration. Soil permeability (k-horiz) calculated from a liquid constant-head permeameter test is 1 darcy (assume vertical permeability 80% of the horizontal permeability, therefore 0.8 darcy). The total porosity of the aquifer (both above and below water table) is 0.3. The typical water saturation in the vadose zone is 20%. The groundwater table varies seasonally between 15’ to 18’ below ground level. The hydraulic gradient (dh/dl) is 0.001 m water head/m horizontal distance. At 30 ft below ground level is a bedrock formation. The average temperature of the subsurface varies from 5°C to 15°C. Given the following information, estimate:

Both TCE and PCE are DNAPLs and will migrate down into the subsurface. The total mass of each compound spilled which must be accounted for is:

- \(25 \text{ gallons PCE} \times 3.785 \text{ L/gal} \times 1.63 \text{ kg/L} = 154.24 \text{ kg PCE}\)
- \(25 \text{ gallons TCE} \times 3.785 \text{ L/gal} \times 1.46 \text{ kg/L} = 138.15 \text{ kg TCE}\)

(assuming that at the ground surface at the time of the spill the NAPLs were 25°C).

When the material is spilled on the surface, the immediate fate will be:
- Some volatilization from the pure compound to the air
  speed of volatilization will depend on temperature, surface area, wind speed
  in addition, the “equilibrium” vapor pressure and H of the compounds
- Some will “run-off” over the ground surface dissolved in the rainwater
  speed of “dissolution” into rain runoff dependent on temperature, rainfall time and quantity, water characteristics, water:NAPL interfacial area, ...
  in addition, the equilibrium solubility of the compounds
- Some of the compounds will dissolve into the rainwater and infiltrate into the subsurface
- Some of the compounds will sorb to the surface soil
- Some pure DNAPL will penetrate into the soil
  penetration will depend on temperature, viscosity of NAPL, density of NAPL, pore structure of the soil, ...
  and of this DNAPL some will remain trapped as ganglia in the unsaturated zone,
  some of the compounds will sorb to the soil, DNAPL will eventually migrate to the water table, saturated zone, and bedrock
  * Some of the compounds may be transformed
    primary process likely anaerobic degradation of PCE and TCE, but will only occur in an anaerobic zone in the subsurface (therefore, unlikely to be significant biotransformation on the surface or in the vadose zone)

For this case, the “equilibrium” partitioning behavior of the compounds is less critical than the rate of partitioning.

a. what will be the concentration of compounds in the subsurface 1 month after the spill? (2 pts)

in this case, let’s first determine the vertical penetration “NAPL conductivity”
K-pce = k * \rho * g / \mu = 0.8 \times 10^{-8} \text{ cm}^2 \times 1.63 \text{ g/cm}^3 \times 981 \text{ cm/s}^2 / 0.009 \text{ g/cm-s} \\
= 0.00142 \text{ cm/s} = 122.8 \text{ cm/d} => 3684 \text{ cm/month} = 36.84 \text{ m/mo}

if “surface spread” area of spill was

b. what will be the concentration of compounds in the subsurface 1 year after the spill?
(2 pts)

Consider: fate and partitioning between different phases and concentration in each phase

2. [1 pt] If a mixture of CACs (methanes, ethanes, and ethenes) had historically been dumped in an unlined pit, what would be the three PRIMARY risk pathways (remember: pathway consists of source, release, travel, receptor, exposure) Justify your response as necessary