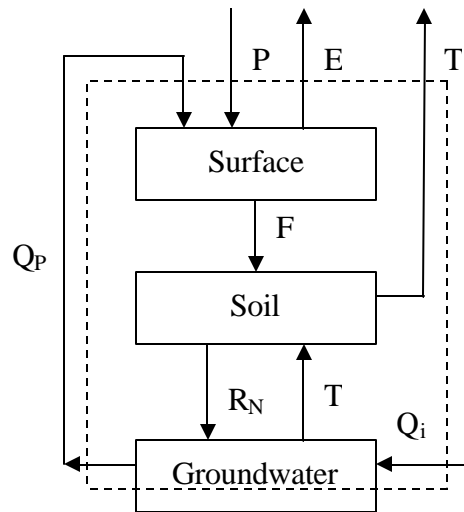


Mid-term 1 Solution Sheet

1. Soils No. 9 and 16 are the ones with the highest porosity because the soils are well sorted with large grain size. In contrast, soils No. 5 and No. 6 are the ones with lowest porosity because they are poorly sorted with fine grains filling the voids between large grains.
2. The major factors that affect solution enhancement of permeability of carbonate aquifer are the circulation patterns of groundwater. There must be (1) chemically aggressive groundwater recharge, (2) the rock units that actively transmit water through fractures, and (3) drainage of groundwater from the rocks.
3. The hydrologic cycle flow chart may be configured as follows:



The hydrologic equation may be formulated as:

$$P + Q_i + Q_p - E - T - Q_p = 0, \text{ or}$$

$$P + Q_i - E - T = 0$$

Considering only the processes at land surface, the hydrologic balance equation is

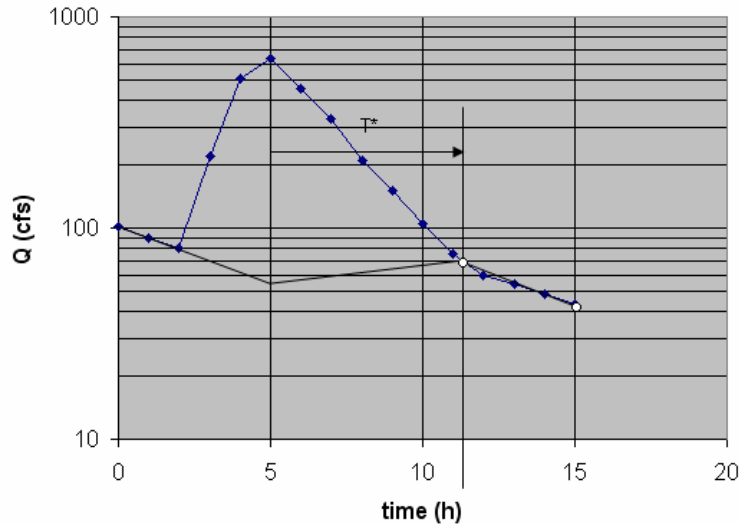
$$P + Q_p - E - T = F$$

or the amount of water infiltration back to the aquifer (including soil and groundwater). The total amount of annual precipitation is $P = 10,000 \text{ m}^2 \times 1,000 \text{ mm} \times 1/1000 \text{ m/mm} = 10,000 \text{ m}^3$. Therefore, we have $F = 10,000 + 2,000 - 10,000/0.85 = 240 \text{ m}^3$, with the evapotranspiration amount $E + T = P/0.85 = 11,760 \text{ m}^3$.

The amount of water the farmer draws from his neighbor's groundwater storage or surface stream is Q_i or

$$Q_i = E + T - P = 10,000/0.85 - 10,000 = 1,760 \text{ m}^3.$$

4. Because the drainage area = 0.0016 square mile, one has $T^* = 0.0016^{0.2} = 0.276$ days = 6.62 hours. One may thus determine the two recession period by the concave method and separate the hydrograph as indicated in the following figure:



From the hydrograph, one reads:

$Q_0 =$	102	cfs		
$Q =$	53	cfs		
$t =$	5	h =	18000	s
$k_1 =$	3.64×10^{-05}	1/s		
$Q'_0 =$	70	cfs		
$Q' =$	42	cfs		
$t =$	3.4	h =	12240	s
$k_2 =$	4.17×10^{-05}	1/s		

by using the equation

$$k = -\frac{\ln(Q/Q_0)}{t}$$

The groundwater recharge during the storm may thus be calculated by the following equation

$$V_r = V_{pt}' - V_s = \frac{Q'_0}{k_2} - \frac{Q_0}{k_1} e^{-k_1 t} \tag{a6}$$

or the total groundwater recharge is

$$V_r = \frac{70}{4.17 \times 10^{-5}} - \frac{102}{3.64 \times 10^{-5}} e^{-3.64 \times 10^{-5} \times 18000} = 220086 \text{ ft}^3$$

5. The capillary tube has two sections. Only when the capillary rise in the bottom section is higher than h_1 will there be capillary rise as a result of the top section. Therefore, the total capillary rise may be determined by the following two steps:
- Determine the capillary rise of the bottom section:

$$h_b = \frac{2s \cos \theta}{r g r_1}$$

If $h_b > h_1$, go to step b. Otherwise, the capillary rise is h_b .

- If the surface tension in the bottom section of the tube is high enough to pull the water to the top of the section, the smaller upper section will have enough force to pull the water column higher. In that case, the total height of the column is essentially

$$h_{ab} = \frac{2s \cos \theta}{r g r_2} \text{ if } h_{ab} < (h_1 + h_2), \text{ or}$$

$$h_{ab} = h_1 + h_2 \text{ if } h_{ab} > h_1 + h_2.$$

The relations are derived similarly as if there is only one tube of radius r_1 reaching below the water surface, because one may assume the shear stress between water molecules is negligible in comparison with surface tension and the adhesive force between water and the glass wall.

- With the above two relationships, one has

$$h_b = \frac{2 * 72.7 \text{ dynes/cm} * \cos 5^\circ}{1 \text{ g/cm}^3 * 981 \text{ cm/s}^2 * 0.18 \text{ cm}} = 8.20 \text{ mm} > 1.80 \text{ mm},$$

therefore, we need use the second equation above to determine the total capillary rise, or

$$h_{ab} = \frac{2 * 72.7 \text{ dynes/cm} * \cos 5^\circ}{1 \text{ g/cm}^3 * 981 \text{ cm/s}^2 * 0.01 \text{ cm}} = 147.65 \text{ mm} < (7 + 180) \text{ mm}.$$

Therefore, the total capillary rise is 147.65 mm.