

Problem 1:

Porosity enhancement mechanisms and processes:

- Fracturing
- Chemical Dissolution

Porosity reduction mechanisms and processes:

- Compaction
- Pressure Solution
- Cementation
- Mineral Replacement
- Chemical Precipitation, e.g., recrystallization

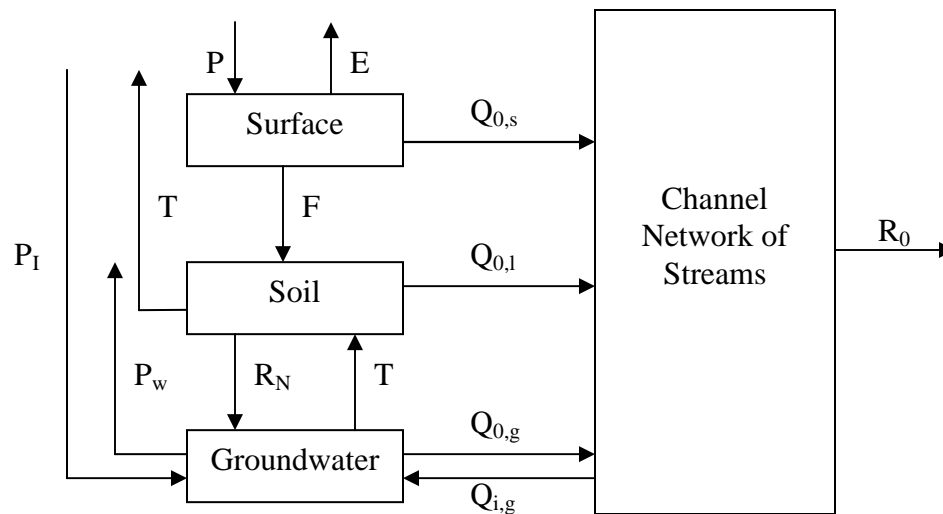
Problem 2:

Primary Porosity – Interstitial pore space formed at the same time a rock or soil is created and is relatively more homogenous.

Secondary porosity – porosity created by fracturing and/or chemical dissolution and is relatively less homogeneous. Secondary porosity is in most cases small in magnitude than primary porosity.

Problem 3:

Elements of basin hydrologic cycle with artificial groundwater injection and withdrawal:



Definition of flux terms:

Q = recharge from or discharge to surface streams;

Subscripts 0, i, s, l and g = outflow from surface/subsurface components, inflow to subsurface components, surface component, soil component, and groundwater component, respectively;

F = infiltration;
 T = transpiration;
 P = precipitation;
 E = evaporation;
 R_N = recharge to groundwater
 P_W = groundwater withdrawal;
 P_I = artificial groundwater injection;
 R_0 = basin runoff.

The hydrologic equation may be written as:

$$\begin{aligned} \text{Basin: } P - E - T - P_W + P_I - R_0 &= \Delta S \\ \text{Groundwater: } R_N - T - P_W + P_I - Q_{0,g} + Q_i &= \Delta S \end{aligned}$$

Where ΔS is change of storage.

Problem 4:

Equation (1.3) in the textbook suggests that groundwater recession curves may be represented by

$$Q = Q_0 e^{-kt} \quad (1.3)$$

The total stream discharge contributed by groundwater recession (base flow) between time t_0 and t is the integration of equation (1.3) over the period $t - t_0$, or

$$V = \int_{t_0}^t Q dt = \int_{t_0}^t Q_0 e^{-kt} dt = -\frac{Q_0}{k} e^{-kt} \Big|_{t_0}^t = \frac{Q_0}{k} (e^{-kt_0} - e^{-kt}) \quad (a1)$$

Let $t_0 = 0$, equation (a1) becomes

$$V = \frac{Q_0}{k} (1 - e^{-kt}) \quad (a2)$$

As t approaches infinity, we have the total potential groundwater discharge as

$$V = \frac{Q_0}{k} \quad (a3)$$

because $e^{-kt} \rightarrow 0$ as $t \rightarrow \infty$.

After using equation (1.3) to obtain the recession constant k , read the time of the end of the recession line from the hydrograph, t , one has the remain storage of groundwater as equation (a3) minus equation (a2) or

$$V_s = V_{pt} - V = \frac{Q_0}{k} - \frac{Q_0}{k}(1 - e^{-kt}) = \frac{Q_0}{k} e^{-kt} \quad (\text{a4})$$

Assuming the above k is the constant obtained from the first recession curve, or using k_1 in the place of k , one has the remaining storage before the storm as

$$V_s = \frac{Q_0}{k_1} e^{-k_1 t} \quad (\text{a5})$$

Using equation (1.3) again to obtain the recession constant of the next base flow period, or k_2 , one has the total potential groundwater discharge at the end of the storm as

$$V_{pt}' = \frac{Q_0'}{k_2} \quad (\text{a6})$$

where Q_0' is the beginning stream flow rate of the second groundwater recession period. The total groundwater recharge is the difference between (a6) and (a5), or

$$V_r = V_{pt}' - V_s = \frac{Q_0'}{k_2} - \frac{Q_0}{k_1} e^{-k_1 t} \quad (\text{a6})$$

For your homework problem 4 in Homework 1, I read from the hydrograph the following values:

$$\begin{aligned} Q_0 &= 10 \text{ cfs} \\ Q &= 8 \text{ cfs} \\ t = 9.5 \text{ h} &= 34200 \text{ s} \quad \rightarrow \quad k_1 = 6.52467 \times 10^{-6} \text{ 1/s} \\ Q_0' &= 53 \text{ cfs} \\ Q' &= 25 \text{ cfs} \\ t = 30 \text{ h} &= 108000 \text{ s} \quad \rightarrow \quad k_2 = 6.95756 \times 10^{-6} \text{ 1/s} \end{aligned}$$

Plugging in the numbers above, we have

$$V_r = \frac{53}{6.95756 \times 10^{-6}} - \frac{10}{6.5246 \times 10^{-6}} e^{-6.52467 \times 10^{-6} \times 34200} = 7617617 \text{ ft}^3$$

Problem 5:

1. Recharge = 0
2. Change of GW storage = 0
3. Precipitation = Evapotranspiration + Runoff
4. The hydrologic system is steady because of long term (38 years).
5. The evapotranspiration rate reported is real and estimated, not potential.

Problem 6:

Setting the net storage on the R.H.S. equal to zero, one may rearrange the hydrologic budget equation to:

$$\{\text{recharge due to precipitation}\} + \{\text{recharge from stream}\} - \{\text{discharge due to evapotranspiration}\} = \{\text{discharge due to pumping for domestic water use}\}$$

The solutions are listed in this table:

Time (year)	Recharge (precipitation) m ³	Recharge (stream) m ³	Discharge (evapotranspiration) m ³	Max. Pumping (m ³)
1	3.00E+07	1.00E+06	9.00E+06	2.20E+07
2	2.80E+07	2.00E+06	5.00E+06	2.50E+07
3	2.50E+07	3.00E+06	3.00E+06	2.50E+07
4	3.50E+07	4.00E+06	1.00E+06	3.80E+07
5	3.50E+07	4.00E+06	2.00E+06	3.70E+07
6	3.50E+07	4.00E+06	4.00E+06	3.50E+07