Infiltration:

Engineering Hydrology
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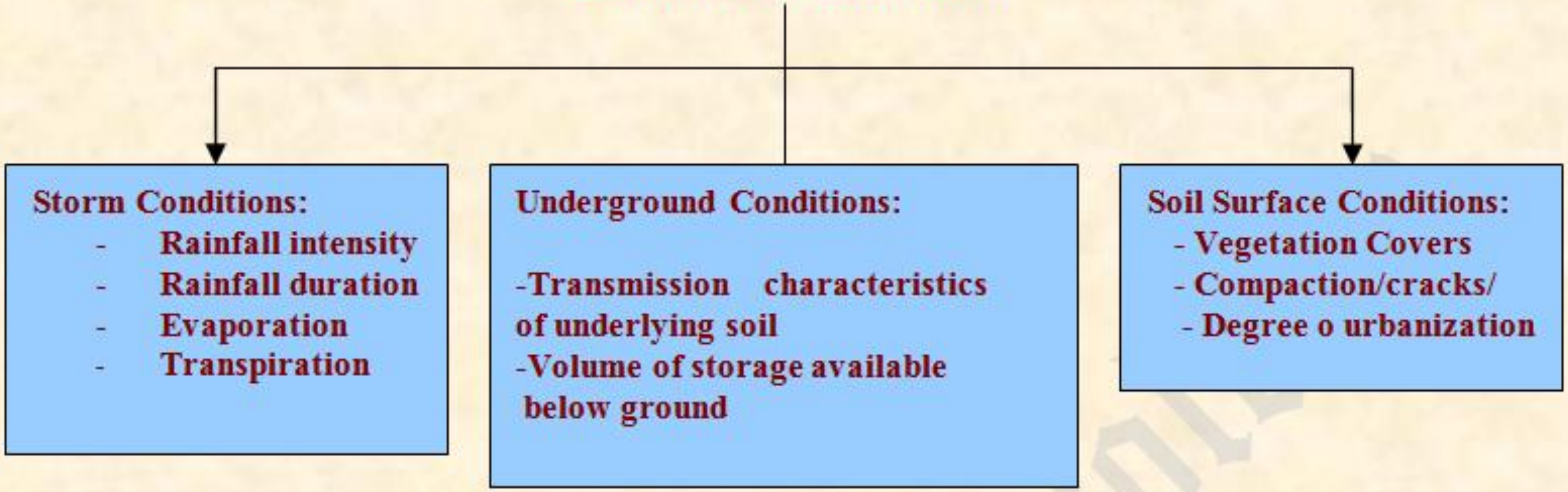
Infiltration:

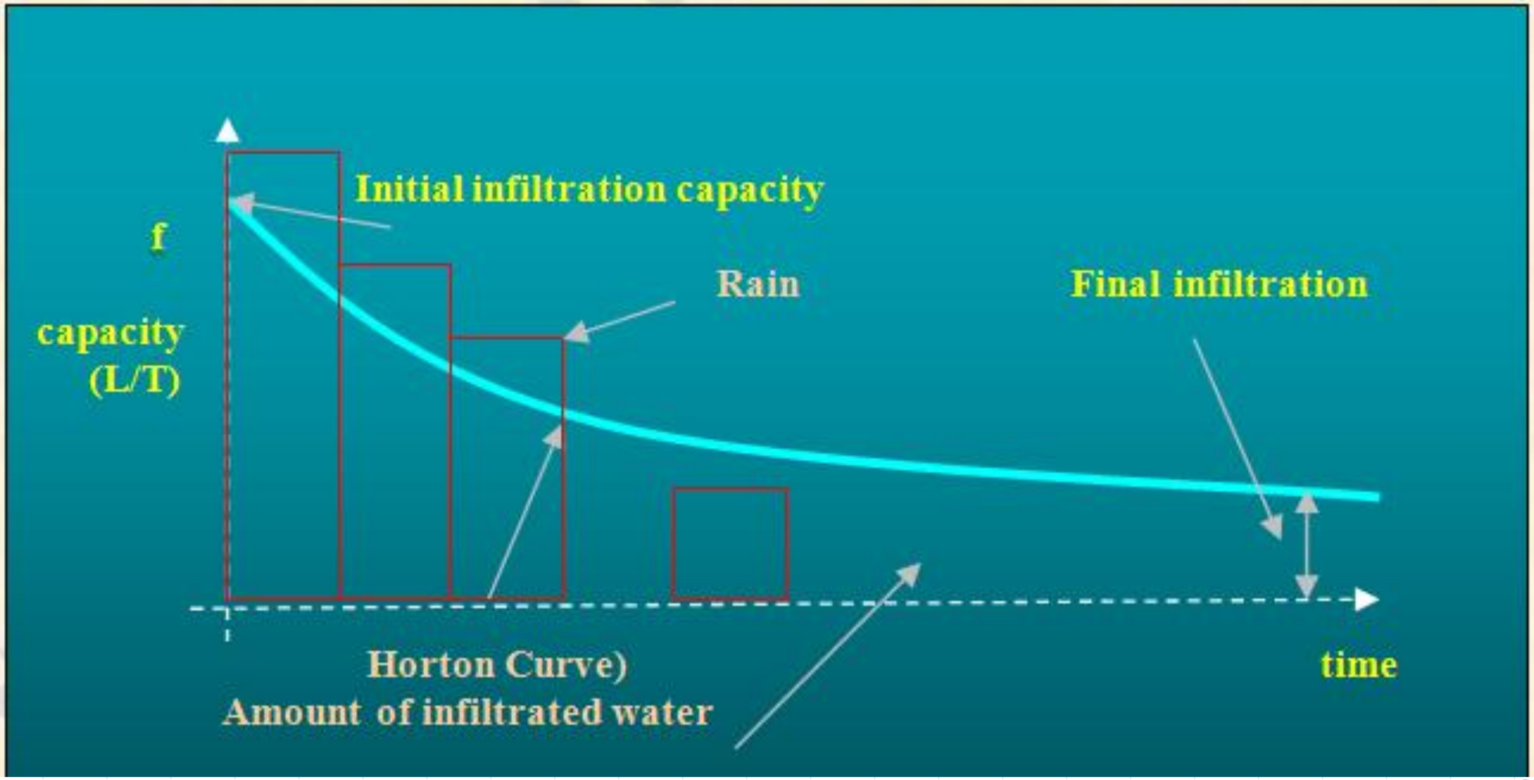
Infiltration is the process by which water is moved from the surface to subsurface replenishing soil and recharging aquifers.

Elements of Infiltration



Infiltration Capacity:

Infiltration capacity is an aspect of infiltration that is associated with soil. It is defined as the maximum amount of water per unit time that can be absorbed under given conditions. The greater the infiltration capacity of soil, the greater amount of water that can be infiltrated.



Horton Infiltration Formula:

K: Constant depending on soil & surface & cover conditions, t is time

$$f = f_\infty + (f_0 - f_\infty)\, e^{-Kt}$$

f_0: Initial infiltration capacity (L/T)

f_∞: Final infiltration capacity (equilibrium capacity)

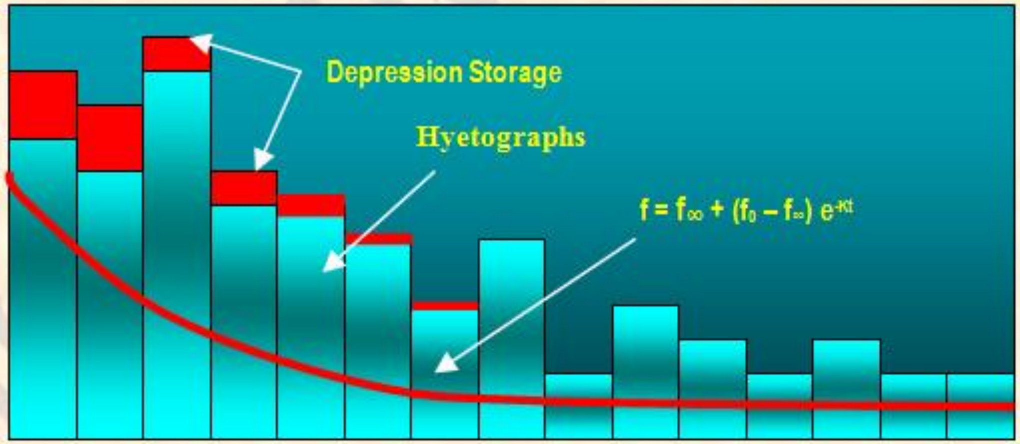
f: Infiltration capacity at a given time t

The assumption inherent is that water is "ponded" and, therefore, it is a potential infiltration curve
Horton equation requires evaluation of f_0, f_∞ and K .which can be derived from infiltration tests

Observations:

- *If rainfall intensity exceeds the infiltration capacity, the infiltration capacity decreases exponentially.*

- *The area under the curve is the volume of infiltration. However, the actual infiltration rate is equal the infiltration capacity **f** only when rain intensity, less the rate of retention, equals or exceeds **f** (see figure below).*



- *The value of **f** is maximum (= f_0) at the beginning of the storm. This becomes constant (=f_∞) as the soil becomes saturated.*

- The value of f is maximum ($= f_0$) at the beginning of the storm. This becomes constant ($=f_\infty$) as the soil becomes saturated.

- When rain intensity at any given time is less than the infiltration capacity, adjustments to the infiltration capacity curve must be made.

- Infiltration capacity depends on soil type (porosity and pore-size distribution are being the most important parameters), moisture content, organic matter, vegetative cover, season and soil content of organic matter (organic content enhances infiltration because it increases porosity).The values of f_0 and k can be calculated by observing the variation of infiltration with time, plotting f vs. t and selecting two points from the graph. The two values can then be determined from Horton equation.

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Example:

Given initial infiltration capacity of 60 cm/day and time constant, k of 0.4 hr^{-1}. Derive infiltration capacity vs. time curve if the equilibrium capacity is 10 cm/day. Estimate the total infiltrated water in m^3 for the first 10 hours for a 100 km^2 watershed.

Solution:

Horton curve: $f = f_\infty + (f_0 - f_\infty)\, e^{-Kt}$ substituting,

$$f = 10 + (50)\, e^{-0.4t}$$

Integrating,

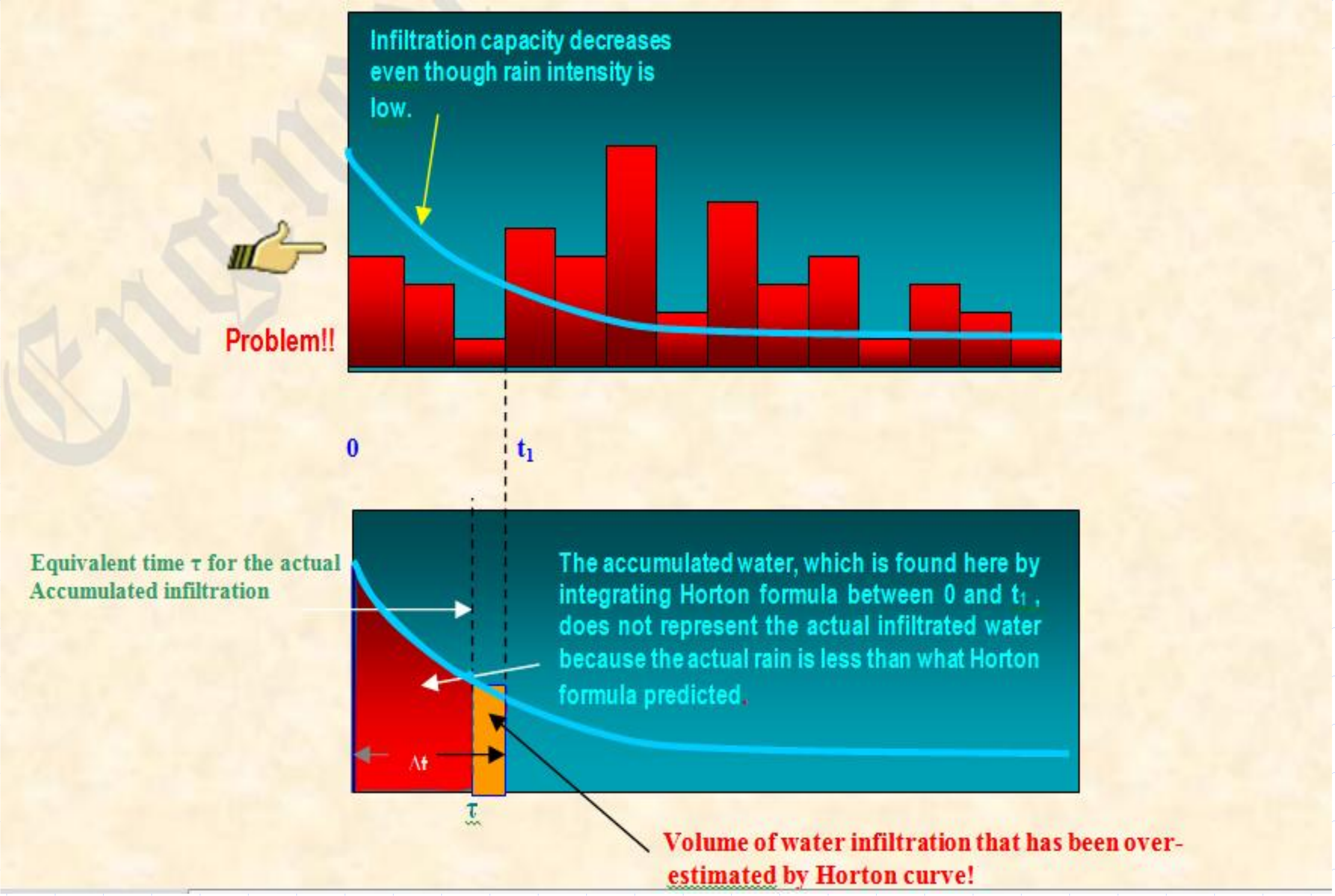
$V = \int [10 + 50\, e^{-0.4t}]\, dt$

$V = [10t - (50)e^{-0.4t} \,|_{0 \text{ to } 10} = [(10)(10) - 50e^{-4}] + 50 = 100 - 0.916 + 50] = 149.1$ cm

Volume in = (149.1 / 100 cm/m)100 km) (1000 m/km)^2 = $\underline{1.491 \times 10^8\ m^3}$

Correction of Horton Formula:

It is often the case that the intensity of rain is much smaller than the values of initial infiltration capacity f_0 and the equilibrium capacity f_c of the soil. Since the Horton's formula assumes that the intensity of rain is always larger than the infiltration capacities of the soil, solving the equation for f as function of time only, would show continuous decrease in f even if the rain intensities are very low and much less than the soil capacity (see figure)


Infiltration capacity decreases even though rain intensity is low.
Problem!!
0
t1
Equivalent time τ for the actual Accumulated infiltration
The accumulated water, which is found here by integrating Horton formula between 0 and t1 , does not represent the actual infiltrated water because the actual rain is less than what Horton formula predicted.
Δt
τ
Volume of water infiltration that has been over-estimated by Horton curve!