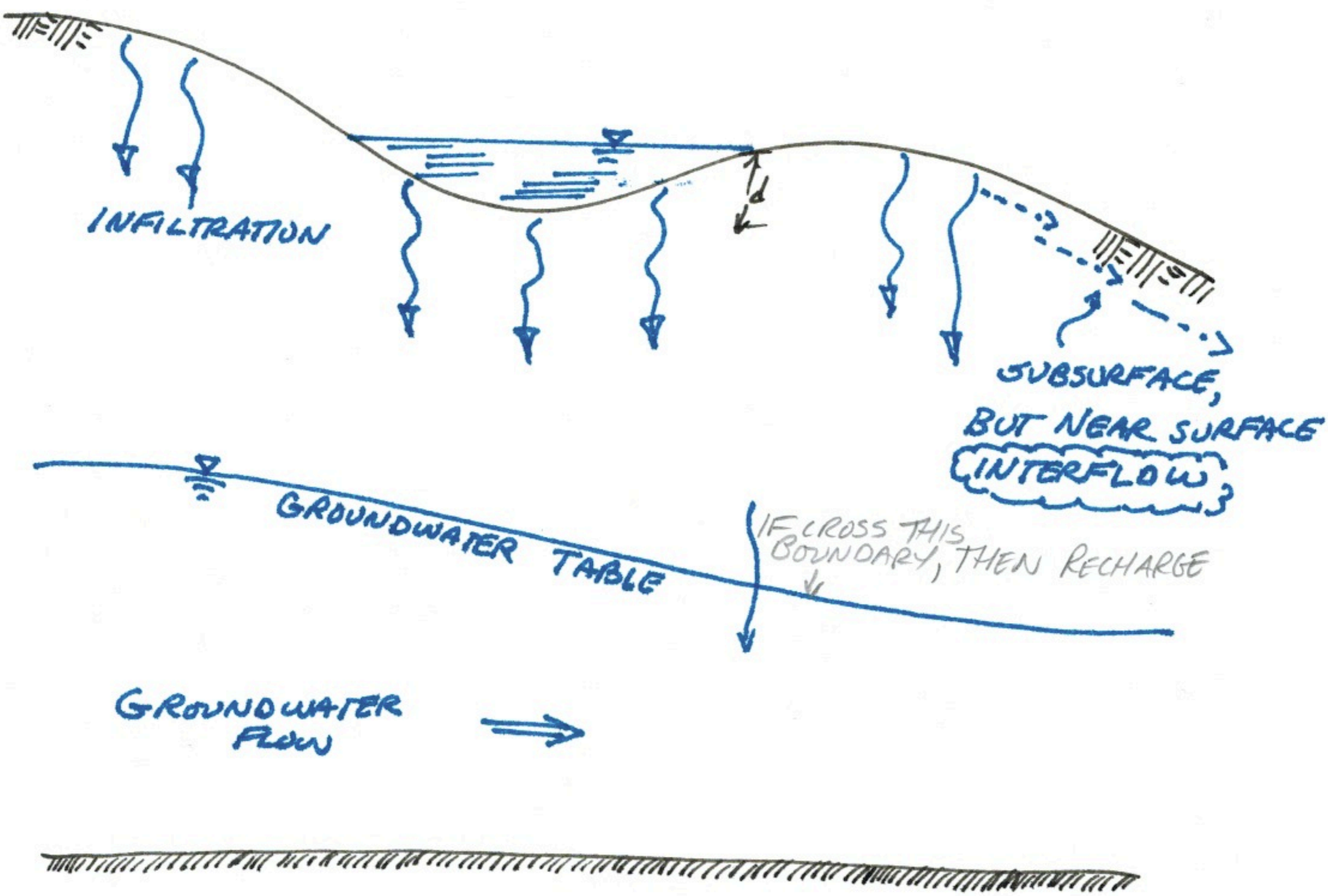
Infiltration

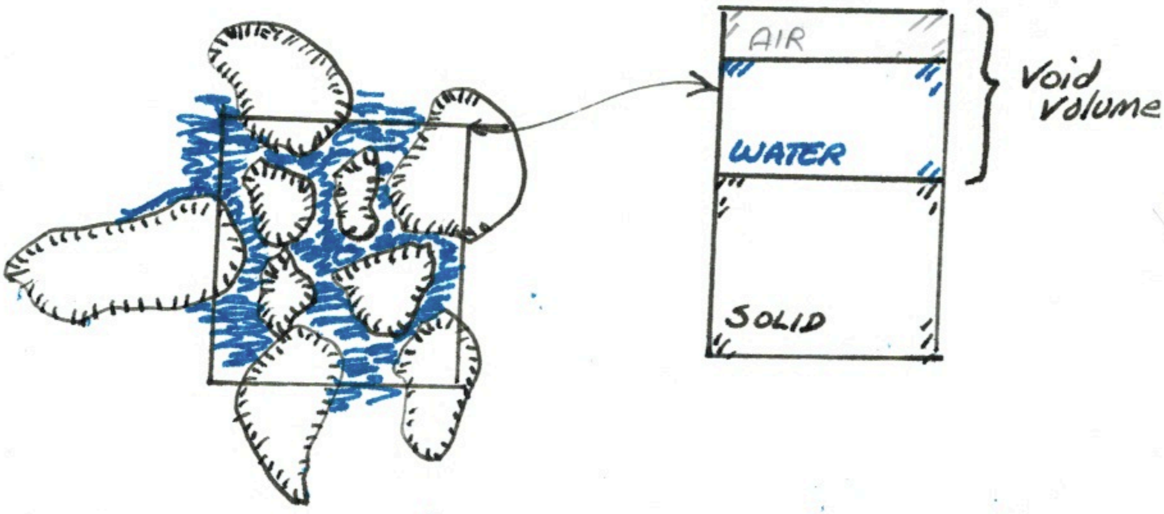
pg 266–267

- Water soaks into ground through
  - pore space
  - cracks



- Rate controlled by
  - soil properties
  - ponded depth (d) where fitting

Porosity



$$\text{porosity} = \frac{\text{volume voids}}{\text{total volume}} = n$$

Geologic materials have porosity ranging from ~0 to 0.5

Moisture content

Ratio of water to total volume is called moisture content, θ

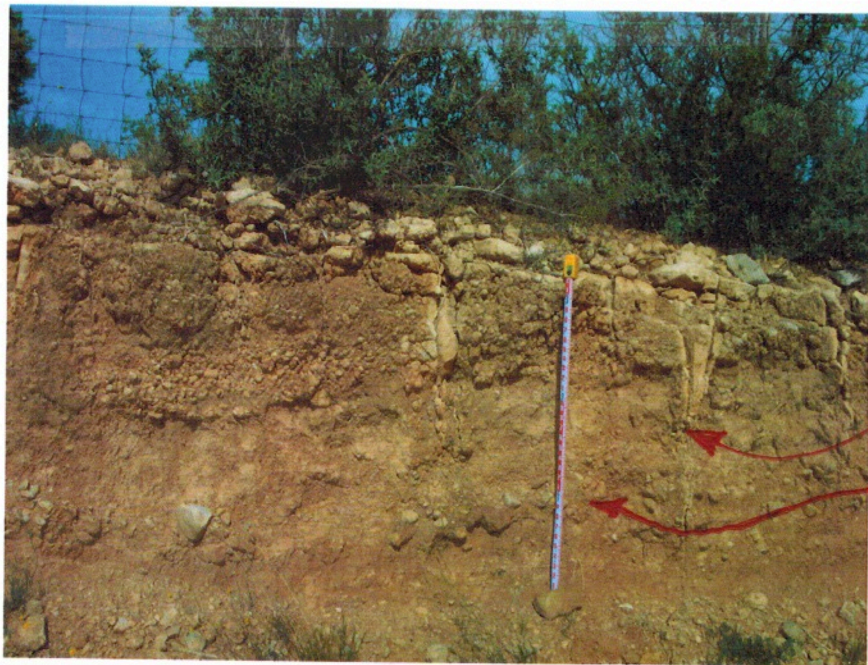
Moisture content ranges from 0 to n for a particular soil.

If saturated, then $\theta = n$

Figure 4.14. Photograph of feature in limestone showing obvious signs of large-scale water intake. Photograph taken by the author, US 277 in Schleicher County, Texas.

Preferential flowpaths

Figure 4.15. Photograph of a preferential flow feature in alluvium showing obvious signs of large-scale water intake over time. Photograph taken by the author, Tom Green County, Texas.



Hydraulic conductivity. Different in these two close to each other places

Figure 4.16. [Photograph of a preferential flow feature in alluvium showing obvious signs of large-scale water intake over time, Tom Green County, Texas.

Some features large

K=?

K=?

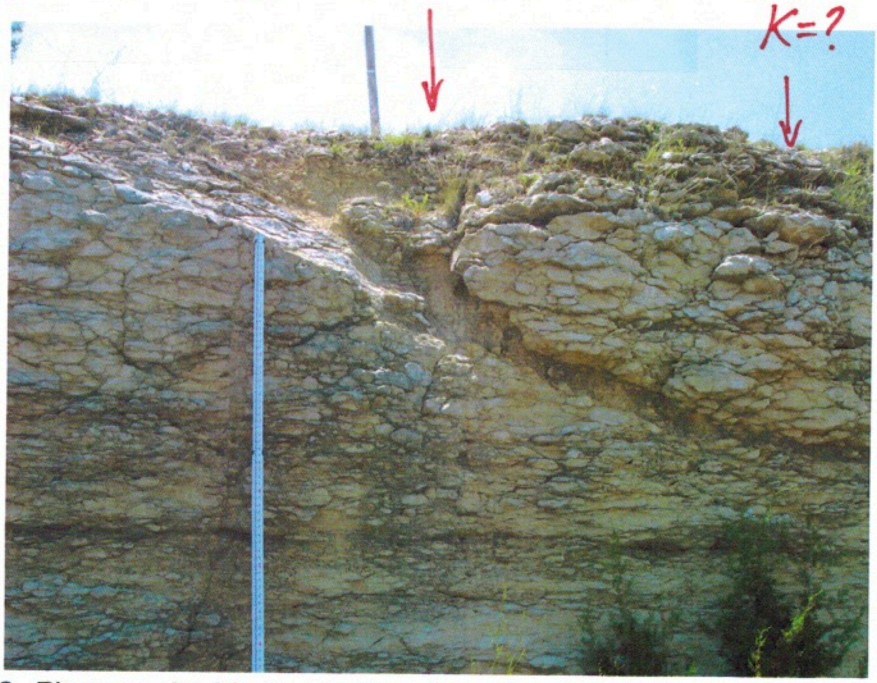
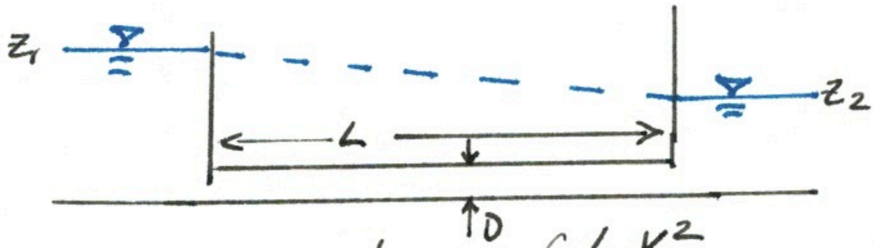


Figure 4.13. Photograph of feature in limestone showing obvious signs of large-scale water intake. Photograph taken by the author on US 277 in Schleicher County, Texas.

Darcys Law (Quick Primer)



$$z_1 - z_2 = h_f = f\frac{L}{D}\frac{V^2}{2g} = \frac{8fLQ^2}{\pi^2 g D^5}$$ PIPE FLOW

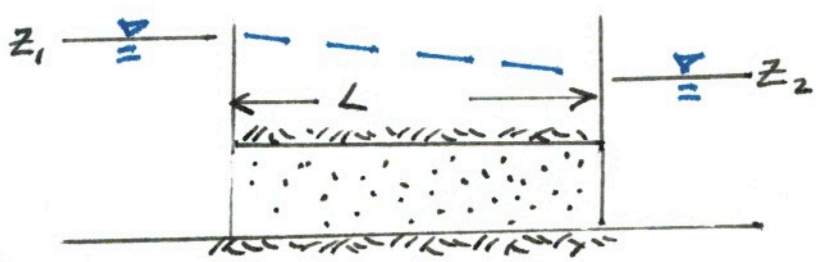
Relates Δz to Q and material properties

Slope of HGL

$$\frac{z_1 - z_2}{L} = \frac{8f|Q|Q}{\pi^2 g D^5}$$ let $$\frac{1}{K_p} = \frac{8f|Q|}{\pi^2 g D^5}$$

then
$$Q = \frac{\pi^2 g D^5}{8f|Q|} \cdot \frac{z_1 - z_2}{L} = K_p\left(\frac{z_1 - z_2}{L}\right)$$

Now replace the pipe with a porous conduit

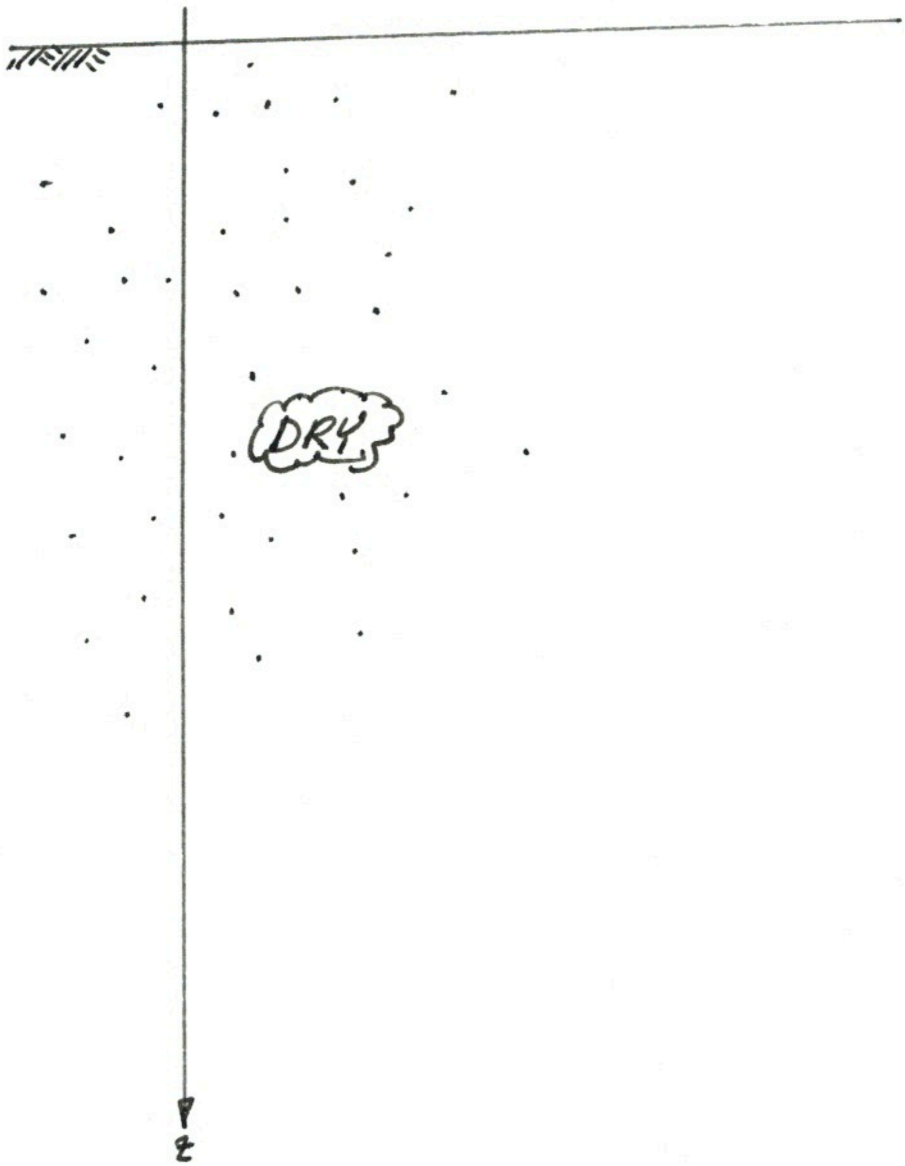


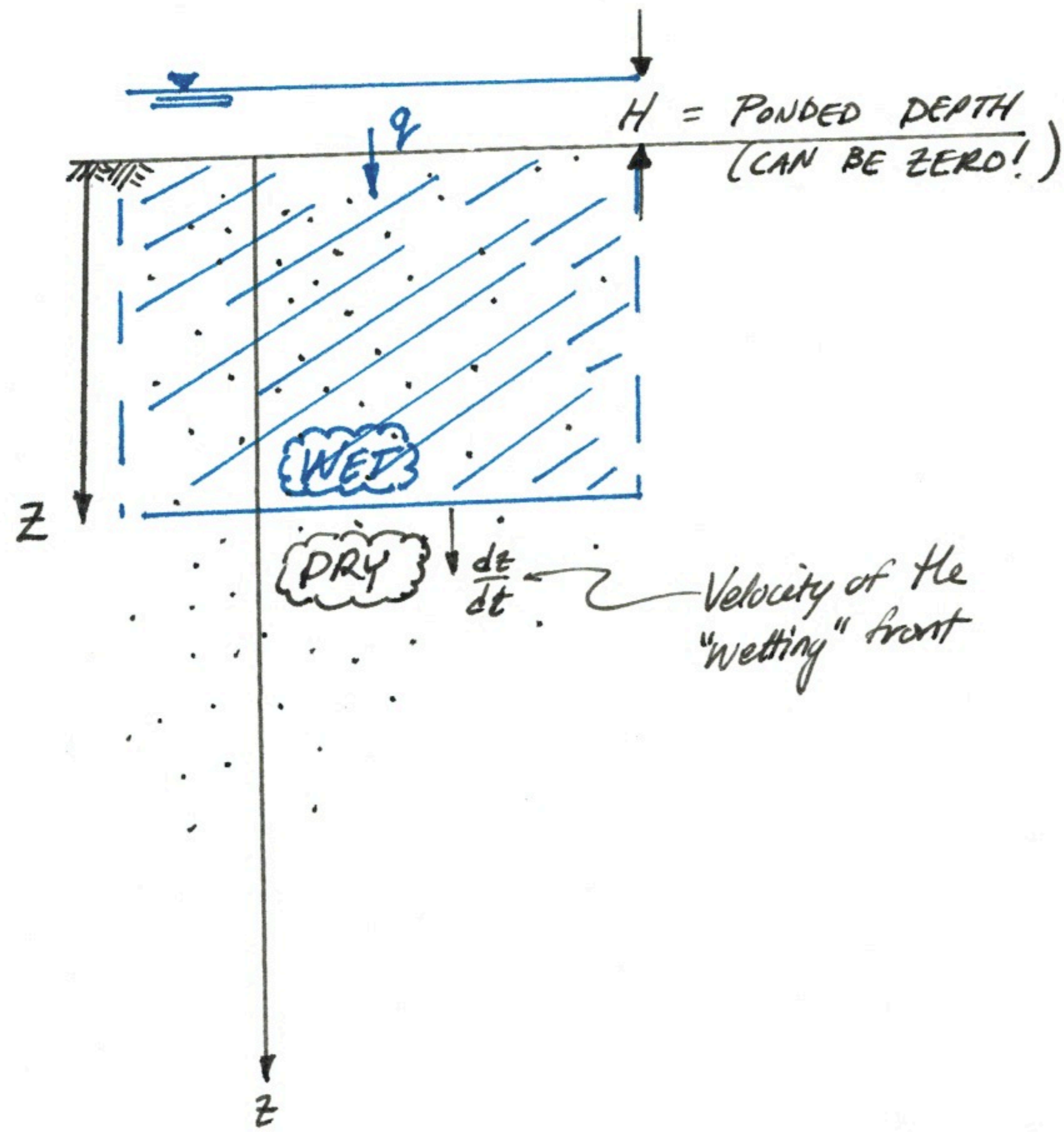
$$z_1 - z_2 = h_f = \frac{L}{KA}Q$$

then
$$Q = KA\left(\frac{z_1 - z_2}{L}\right)$$ Darcy's Law for porous media

K is called "hydraulic conductivity"

A is cross sectional area.


DRY
z


H = PONDED DEPTH
(CAN BE ZERO!)
q
WET
DRY
Z
$\frac{dz}{dt}$
Velocity of the "wetting" front
z

Consider the infiltrated volume

Area

Volume infiltrated $\quad \forall = \eta z A$

Speed of wetting front $\quad \dfrac{dz}{dt}$

Flow rate across surface $\quad \dfrac{d\forall}{dt} = Q = n \dfrac{dz}{dt} A$

Flow rate per unit area $\quad \dfrac{1}{A}\dfrac{d\forall}{dt} = \dfrac{Q}{A} = q = n\dfrac{dz}{dt}$

Now use Darcy's law to explain flow in the porous media (Chapter 6)

$$\frac{Q}{A} = K \, \frac{(H + h_c + z)}{z} \qquad h_c = \text{suction head}$$

$$\therefore \quad n\frac{dz}{dt} = K\left(\frac{H + h_c + z}{z}\right)$$

Seperate and integrate

$$\frac{K}{n}\,dt = \frac{dz}{H + h_c + z} = \frac{H + h_c + z}{H + h_c + z}\,dz - \frac{H + h_c}{H + h_c + z}\,dz$$

$$\int \frac{K}{n} dt = \int \frac{H+h_c+z}{H+h_c+z} dz - \int \frac{H+h_c}{H+h_c+z} dz$$

$$\frac{K}{n} t + C = z - (H+h_c) \ln\left[(H+h_c+z)\right]$$

Evaluate the constant of integration $t=0, z=0$

Result is an infiltration equation that relates K (hydraulic conductivity)

A soil property that relates head loss to flow rate – like a "friction factor" in pipe flow.

Infiltration depth

$$z + (H+h_c) \ln\left[\frac{H+h_c}{H+h_c+z}\right] = \frac{K}{n} t$$

Infiltration Volume

$$I(t) = nz = n\left[\frac{K}{n} t - (H+h_c) \ln\left[\frac{H+h_c}{H+h_c+\frac{I(t)}{n}}\right]\right]$$

This is an Implicit Equation

Rearranged:

$$I(t) = Kt + (H+h_c) \ln\left[1 + \frac{I(t)}{(H+h_c)(n)}\right]$$

Compare to 7.4.24 in book, pg 273

Other infiltration models

Horton

ϕ-index (initial abstraction, constant loss)

Green Ampt (extension of piston flow)

CN method (not really an infiltration model)