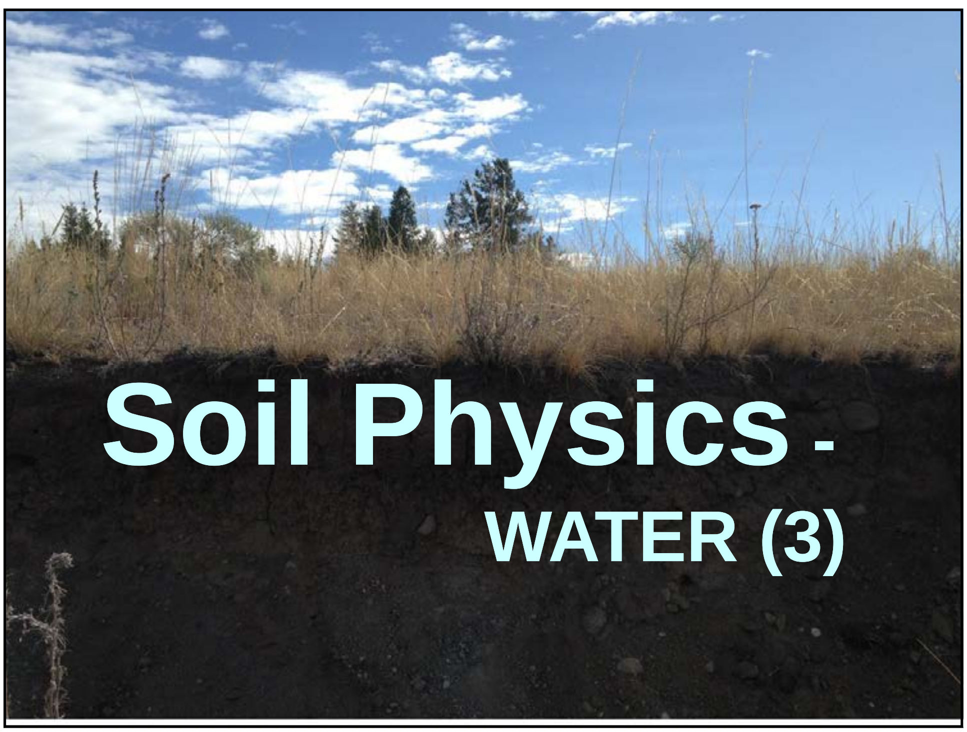

APBI 200
SOIL COMPONENTS


Soil Physics -
WATER (3)

Lecture outline

A. Inferring the direction of water flow

B. Water potential gradient

C. Soil hydraulic conductivity

D. Summary

Types of water movement within the soil

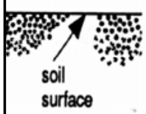
- Saturated flow
- Unsaturated flow
- Vapor movement

Water moves from

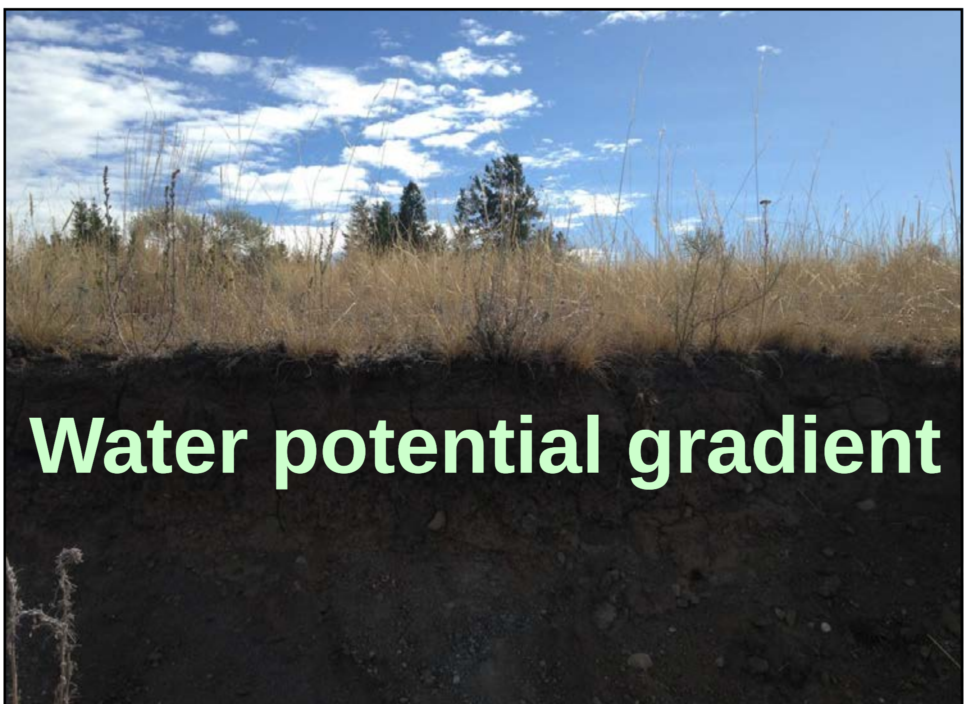
higher to

lower energy state

Water potentials and flow directions in a soil which is not at equilibrium



"Level"	Height on the *z*-axis (m)	Soil Water Tension (m)	Gravitational Potential (m)	Matric Potential (m	Total Water Potential (m)	Guessed Direction of Flow	"Level"
A	0	3.1					
B	–0.2	?					
C	–0.4	2.0					
D	–0.6	2.3					
E	–0.8	1.7					



Water potential gradient

is the change in water potential per unit distance along the axis of flow

$$\frac{\psi_C - \psi_D}{z_C - z_D} = \frac{(-2.4m) - (-2.9m)}{(-0.4m) - (-0.6m)} = \frac{0.5m}{0.2m} = 2.5m/m$$

Water potential gradient

$$\frac{d\psi}{dz}$$

Darcy's Law

- The rate at which water flows is directly proportional to the water potential gradient, and the proportionality factor is **hydraulic conductivity (*K*)**

$$q = -K\frac{d\psi}{dz}$$

q = water flux density [m/s]
K = hydraulic conductivity
dΨ/dz = water potential gradient

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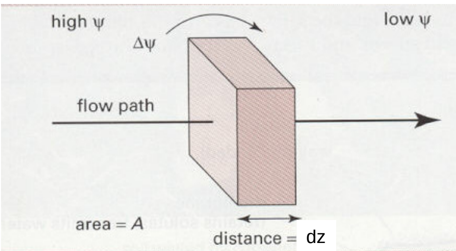
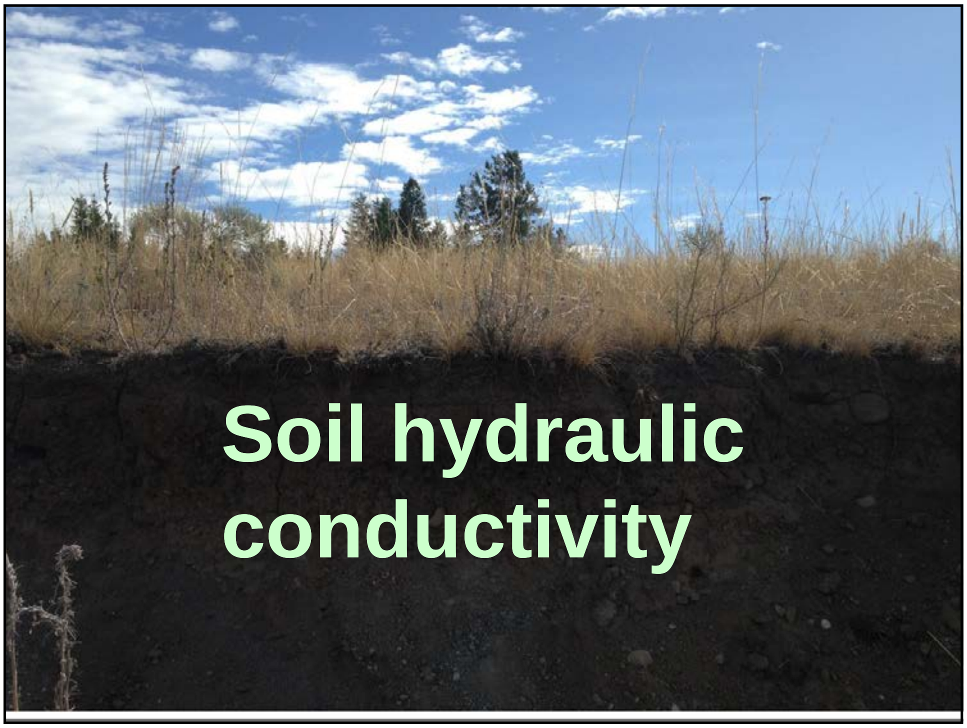


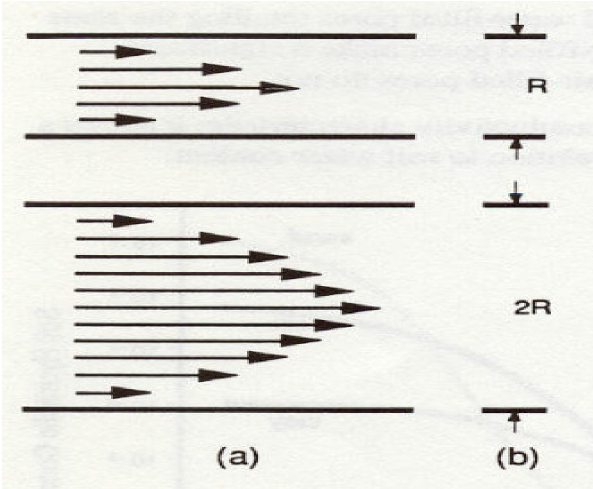
Water flux density (***q***) is the rate of water flow crossing the plane in unit time [m^3/m^2s = m/s].
The plane is always perpendicular to the axis of water flow.



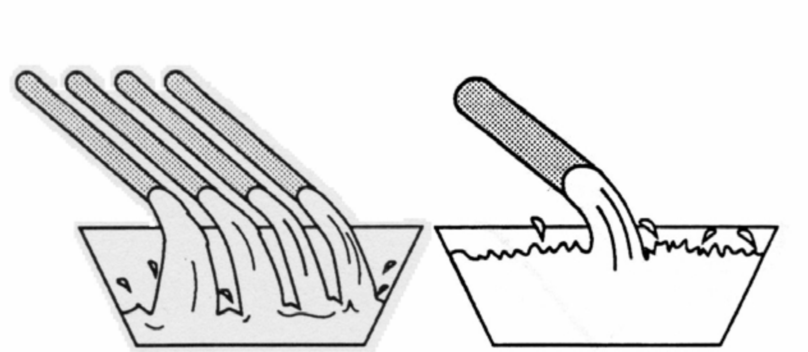
- **Conductivity** is a capability of a medium to transmit liquid

- Large water-filled pores are better water conductors than many small water-filled pores totaling the same cross section

Water flow through pipes of different sizes



One large pipe vs. 4 smaller pipes (totaling the same cross section)



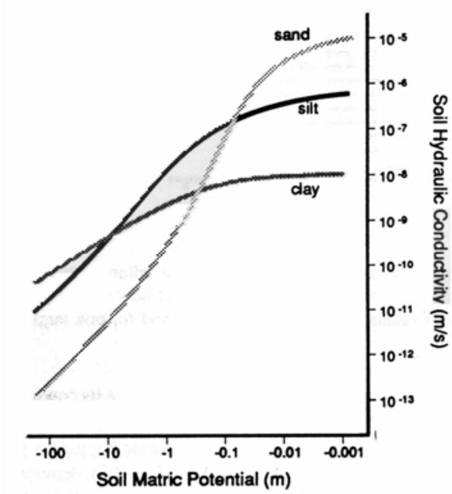
Remember:

One large water-filled pore makes a larger hydraulic conductivity contribution than many small water-filled pores totaling the same cross section

Water-filled vs. air-filled pores

- Water-filled pores make a significant contribution to hydraulic conductivity, while air-filled pores do not

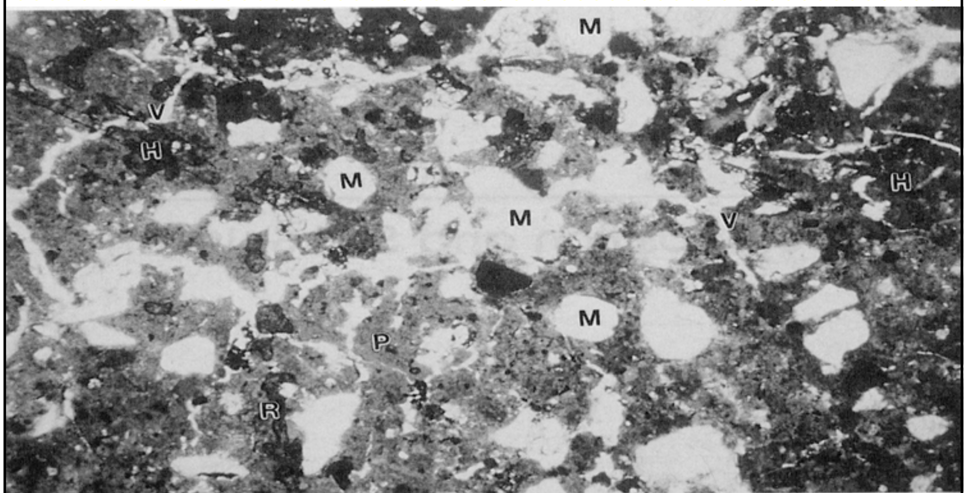
Hydraulic conductivity (K) in relation to matric potential (ψ_m)



Hydraulic conductivity is affected by:

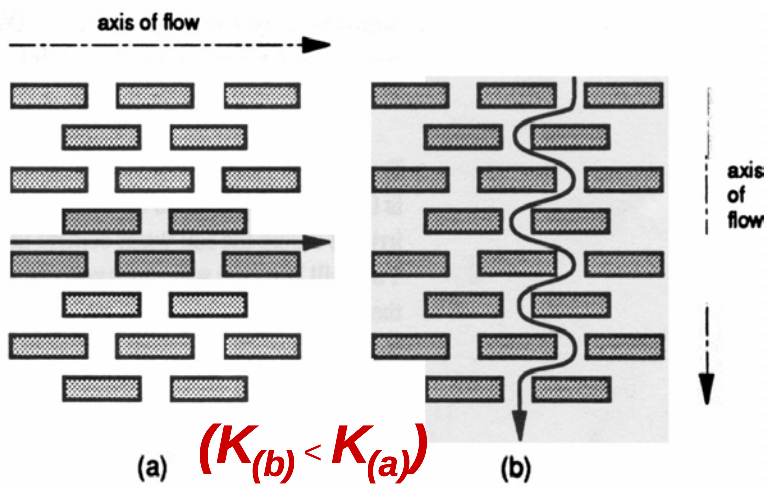
- **Soil porosity (*f*)**
- **Pore size**
- **Water content**
- **Tortuosity** (describes the non-straight nature of soil pores)

Spatial arrangement of soil components



M=primary minerals H=humus (organic matter) P=plasma (clay)
V=voids (pores) R=root fragments (organic matter)

Anisotropy - a medium has properties along one axis different to those along another axis



$(K_{(b)} < K_{(a)})$

Common principles for saturated and unsaturated soils

- Driving force for water flow is potential gradient (***d*Ψ/*dz***)
- Water flow takes place in direction of decreasing potential
- Rate of water flow (flux density) is proportional to potential gradient (***d*Ψ/*dz***)
- Rate of water flow is affected by geometry of soil pores (size, tortuosity)

Differences between saturated and unsaturated soils

- Driving force for water flow in saturated soils is submergence potential (Ψ_s)
- Driving force for water flow in unsaturated soils is matric potential (Ψ_m)
- Vapor movement occurs only in unsaturated soils

Differences between saturated and unsaturated soils - cont.

- ***K*** is at maximum in saturated soil, where all pores are water-filled
- In unsaturated soils some pores are air-filled and consequently ***K*** decreases
- Transition from saturated to unsaturated zone is usually characterized by a steep drop in ***K***