# Lecture 13b – Groundwater flow

Learning Outcomes

- Be able to describe and explain the differences between aquitards, unconfined aquifers, confined aquifers, and advantages/disadvantages of wells dug into either

- **Be able to explain how and why groundwater moves and draw flowlines on a cross-section of a drainage basin**

- Be able to describe and explain what occurs when the water table intersects with the ground surface and what geologic arrangements might lead to springs occurring

- Be able to draw/describe/explain/carry out simple calculations related to the freshwater/saltwater interface near the ocean

Groundwater Flow

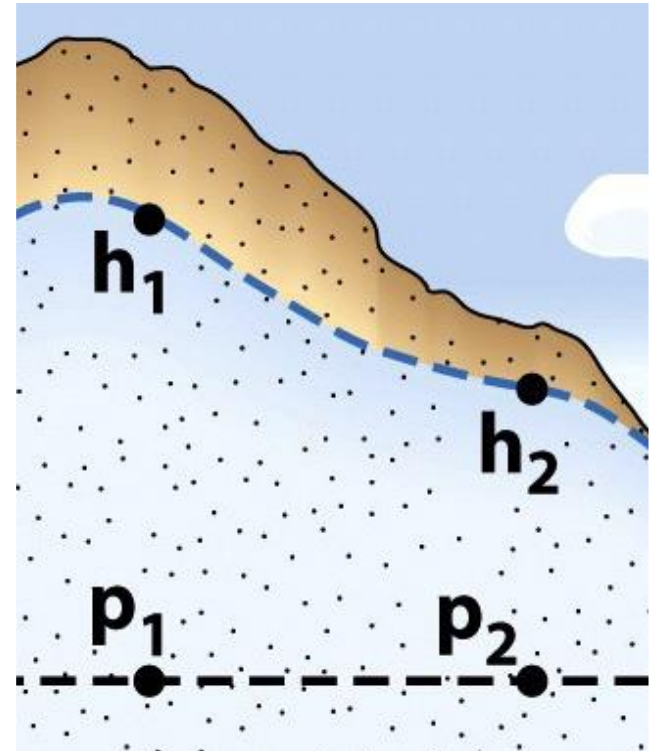Which direction would water flow between the two lower points?

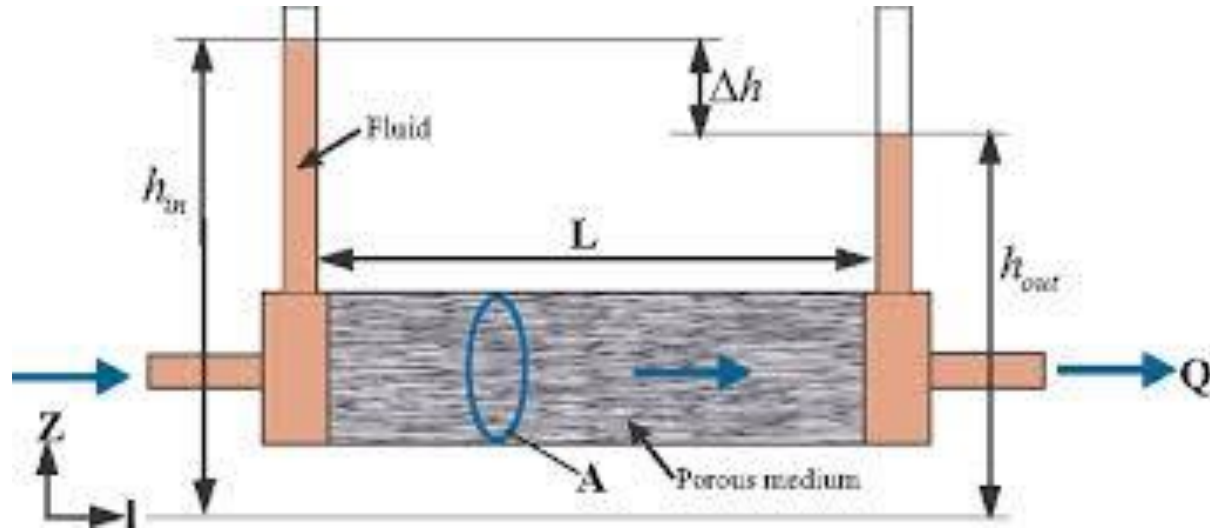a) Left to right
b) Right to left
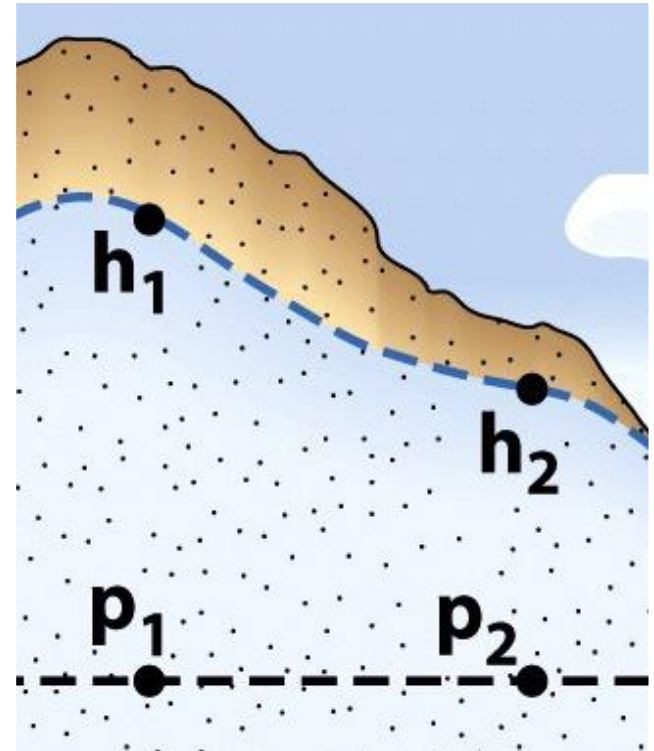
Groundwater Flow

- Hydraulic head, potential energy driving flow, is due to…
  - Elevation above sea level
  - Pressure exerted by weight of overlying water

  (Given that pores are now completely saturated we can ignore tension – yay! Pressure is only positive.)

Review: Darcy's Law

Darcy's Law

$$Q = -KA \frac{\Delta h}{L}$$

Q = discharge/flowrate (volume/time)
K = hydraulic conductivity (length/time)
Δh = energy head/hydraulic head
L = flowpath length
A = cross-section area

$$q = \frac{Q}{A} = -K \frac{\Delta h}{L}$$

q = specific discharge

Saturated Hydraulic Conductivity (K_{sat})

- Function of:
1. Fluid properties
   a) Viscosity
   b) Density
2. Structure of pore space
   a) Roughness of grains
   b) Tortuosity of flowpaths
3. Configuration of fluid in the pore space
   a) Saturation

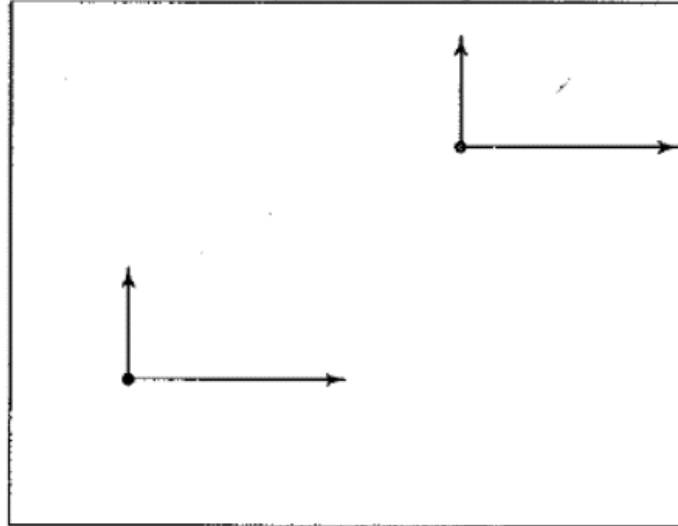*Note: Permeability is a property of the material itself so is part of hydraulic conductivity.*
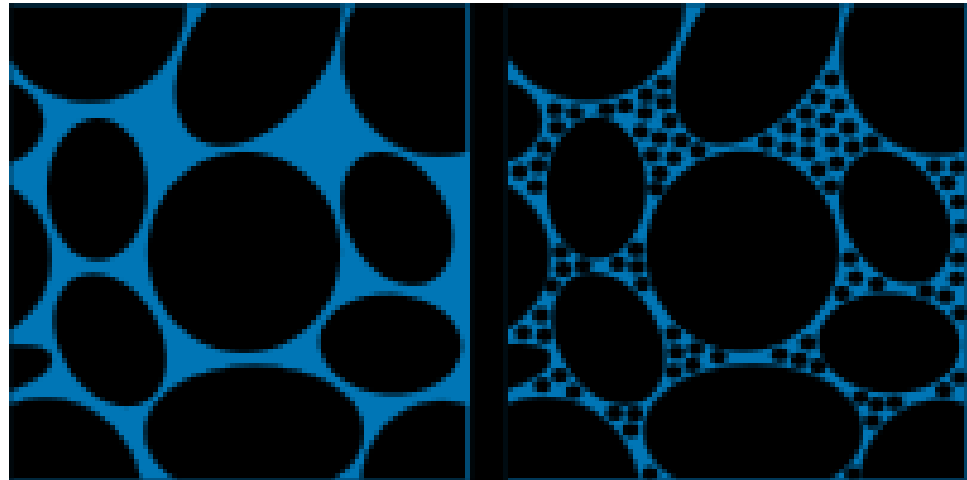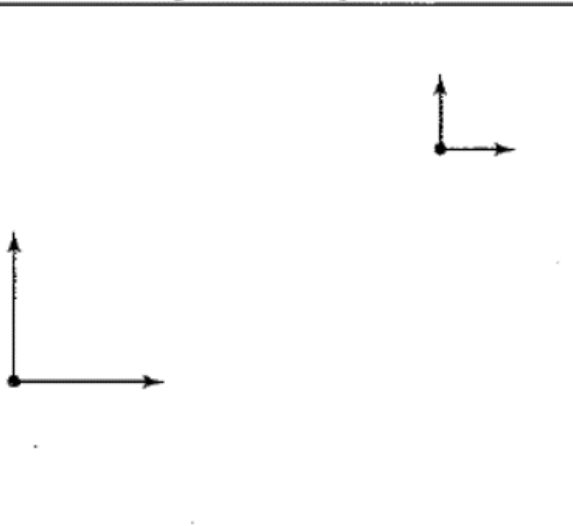
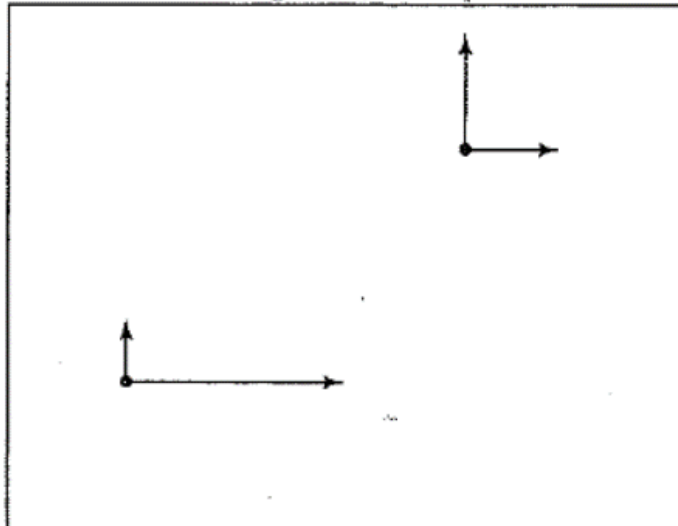# Saturated hydraulic conductivity (K_{sat})

Homogeneous, isotropic
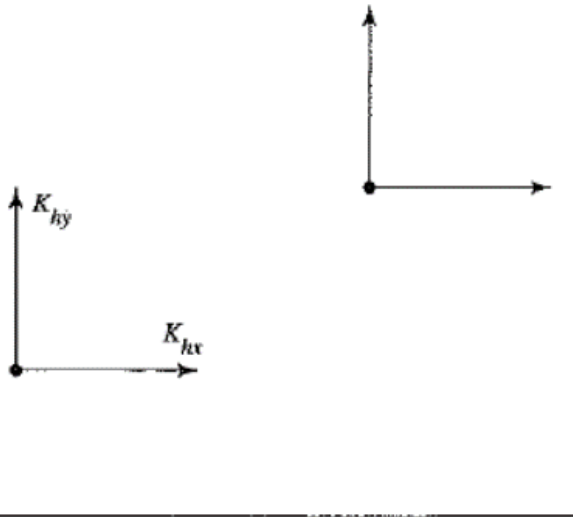
Homogeneous, anisotropic

K_{hy}

K_{hx}

Heterogeneous, isotropic

Heterogeneous, anisotropic

To make our life easier we usually assume that K_{sat} is homogeneous and isotropic but that it often not true at all!!
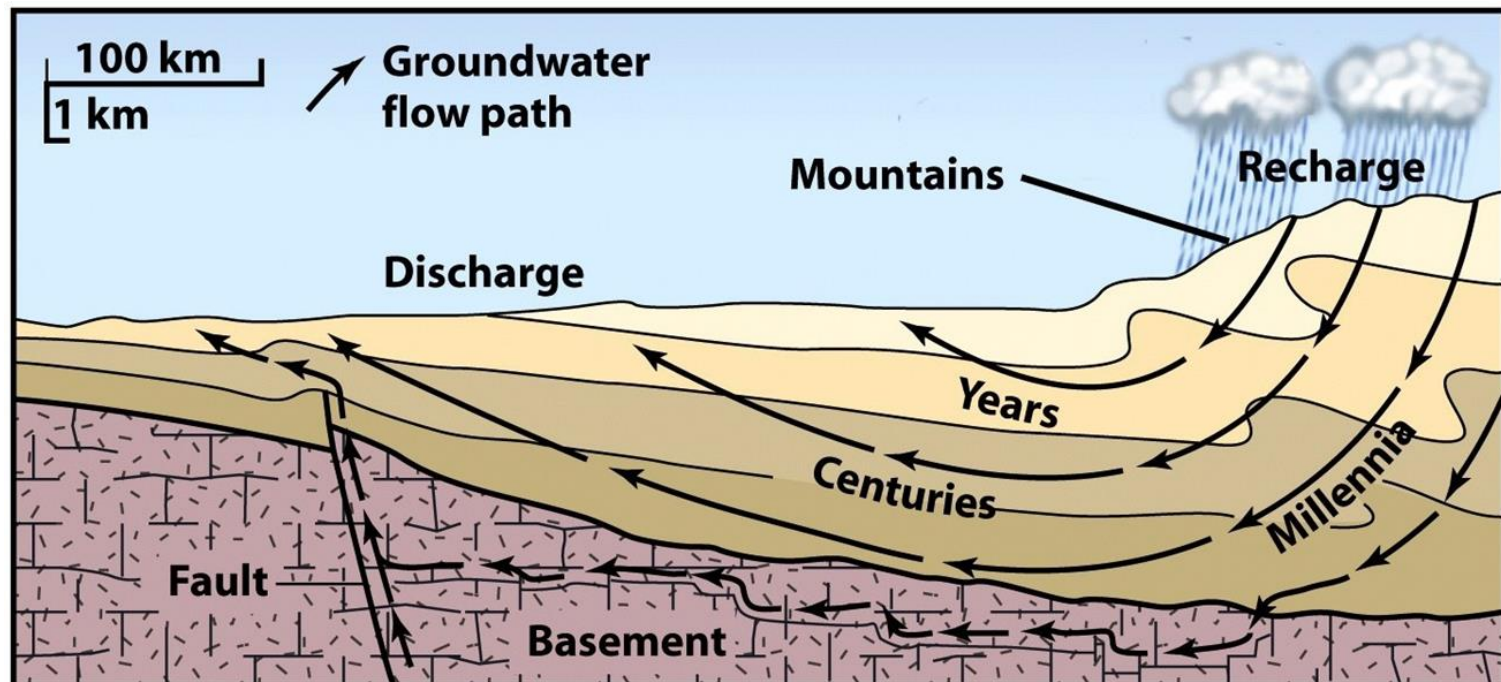
Groundwater Flow

- Groundwater flows from areas of greater head (recharge areas) to areas to less head (discharge areas).
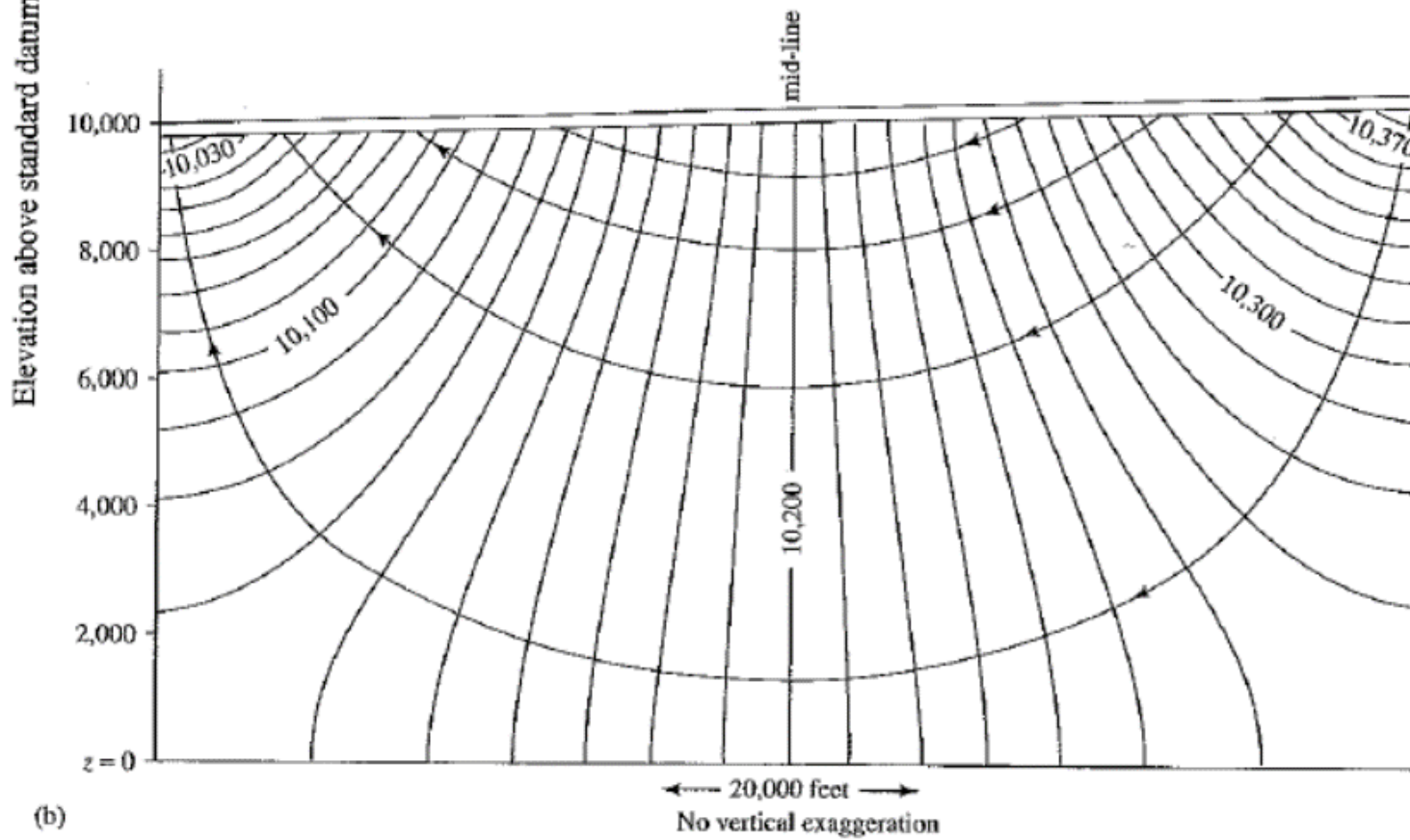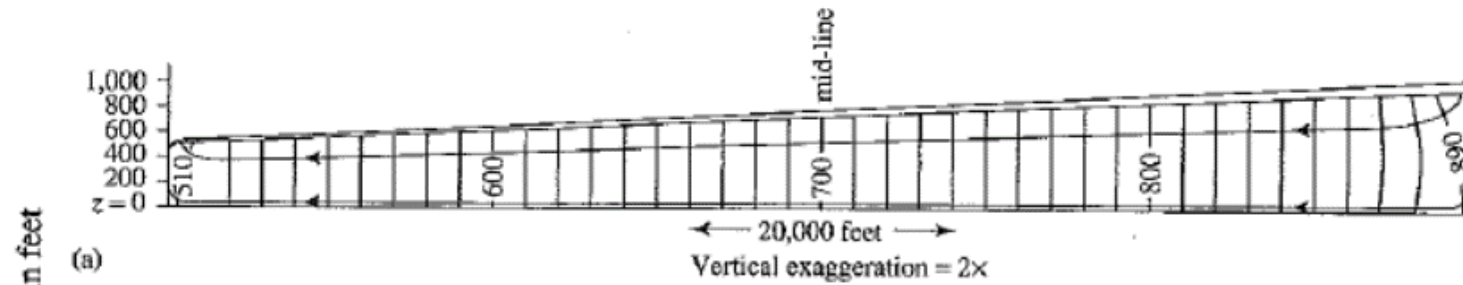
Recharge areas = groundwater flows away from water table

Discharge areas = groundwater flows towards the water table

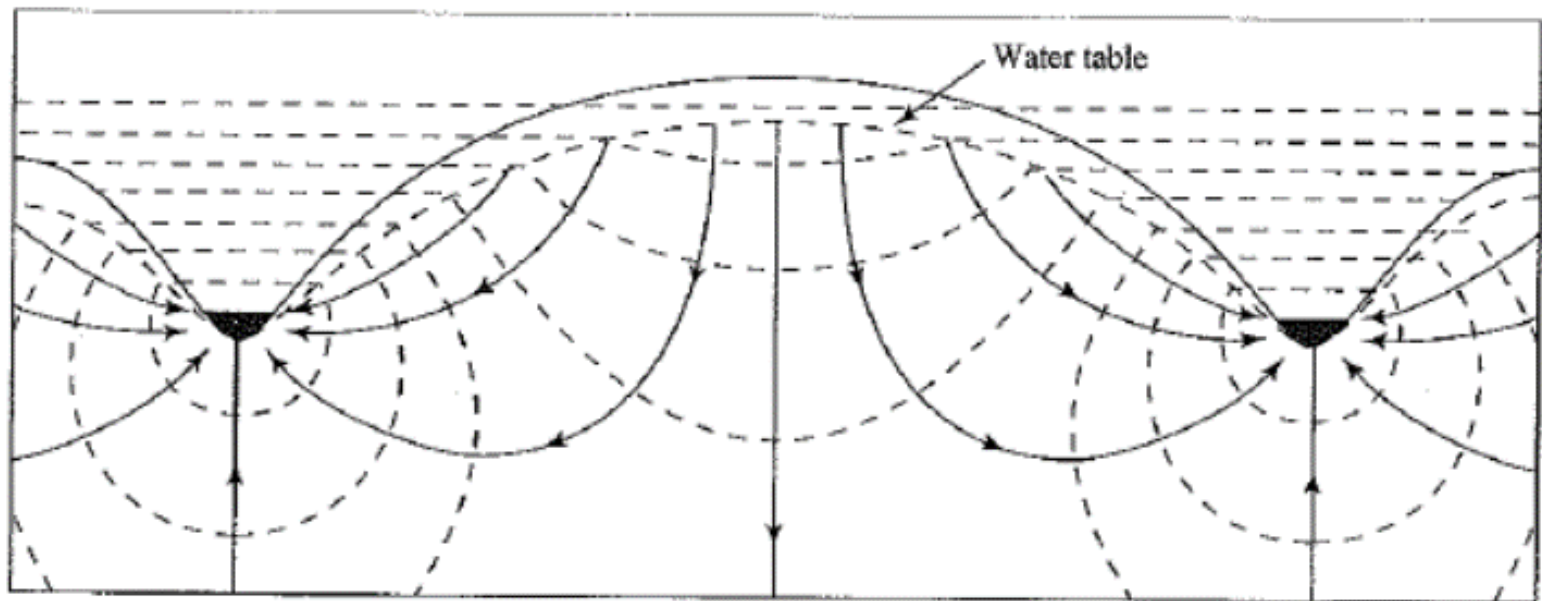Hinge line = line separating recharge and discharge areas

Groundwater Flowlines

Shallow aquifer
Flow = horizontal

Deep aquifer
Flow = more
        vertical

Water Table Topography

- Subdued replica of the surface topography
- Where is groundwater divide?
- What are we assuming here? When might the flows be different?

Water table

Water Table Topography