An Introduction to Groundwater Issues at Mine Sites

Produced by:

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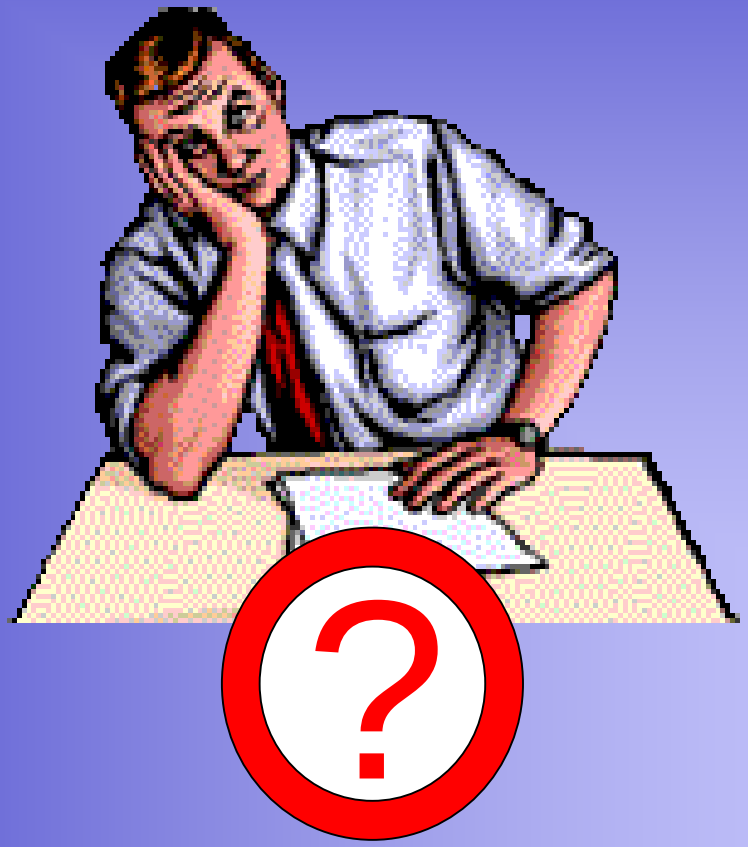
Topic 5:
Measurements and Estimations



Measurements and Estimations in the Laboratory

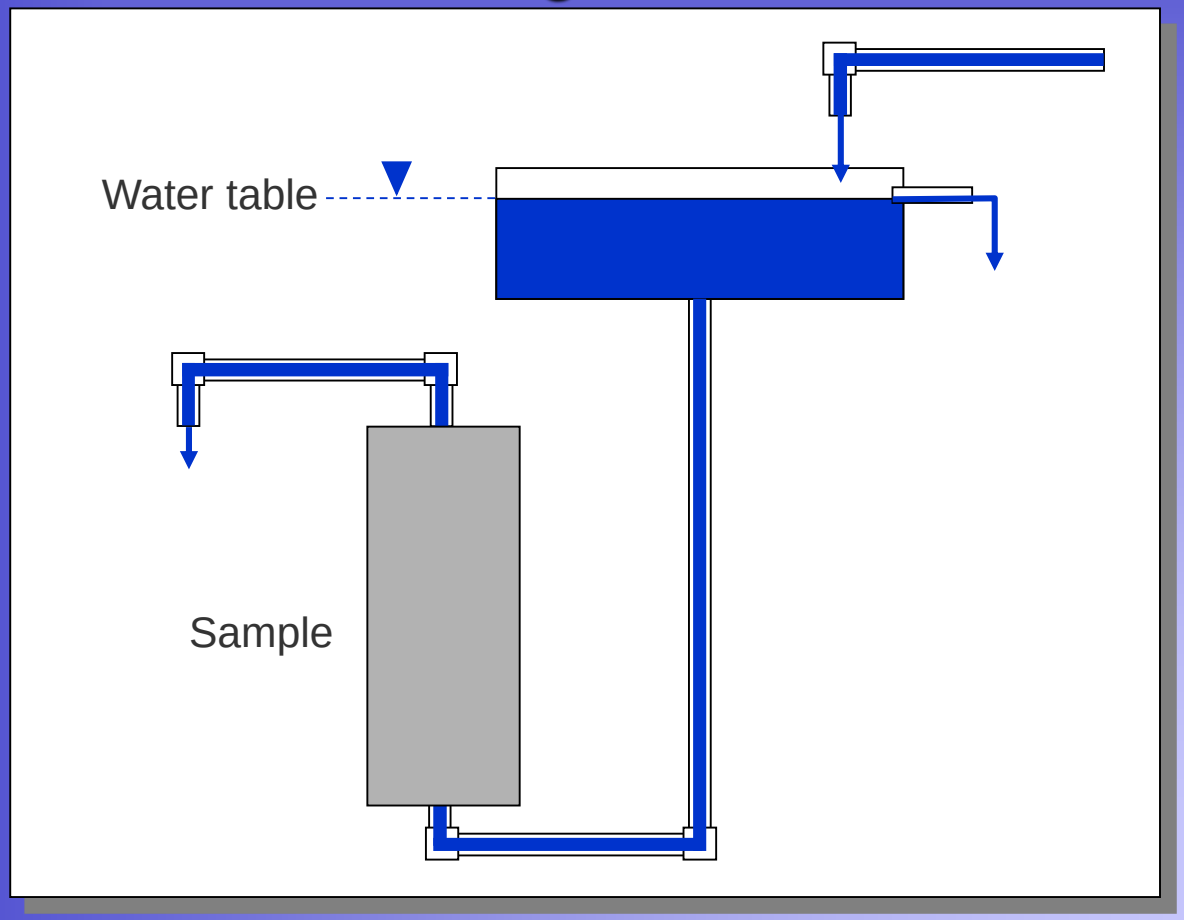
- Hydraulic conductivity
- Porosity
- Moisture content
- Drainage curves

Measurements and Estimations in the Field

- Water levels / pore pressure
- Hydraulic conductivity (single well pump test)
- Moisture content

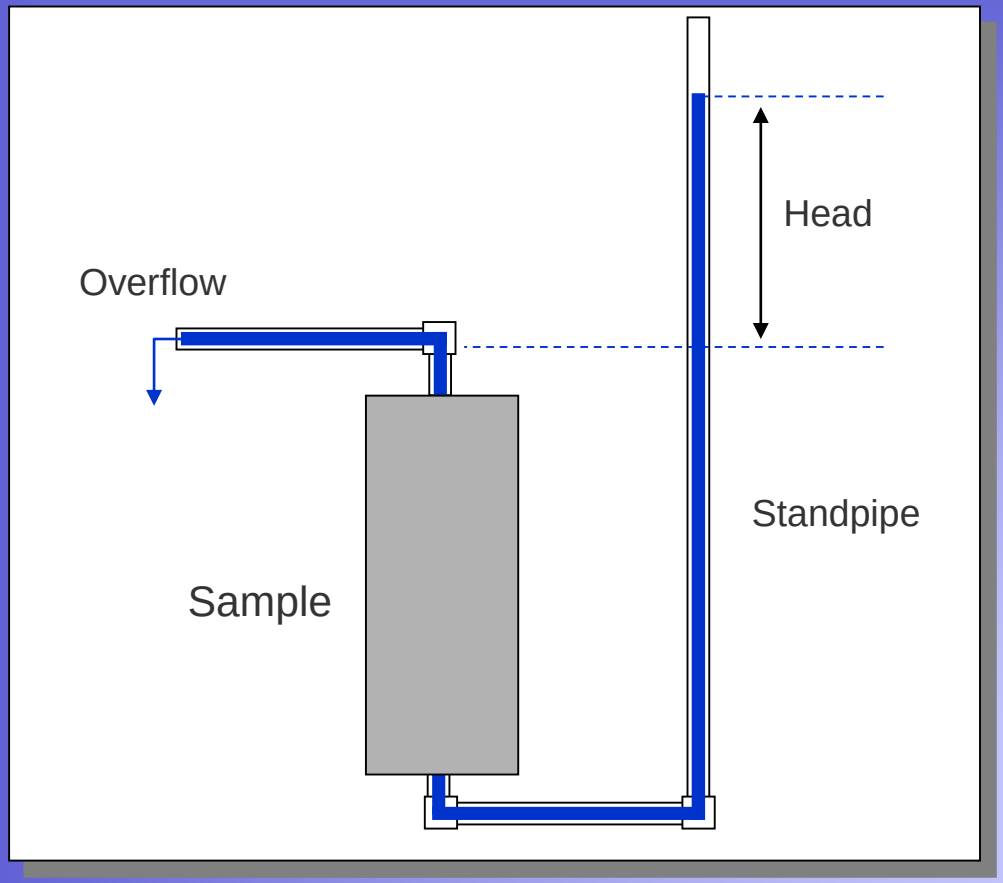
Laboratory: Hydraulic Conductivity

Constant Head Testing



Laboratory: Hydraulic Conductivity

Falling Head Testing



Laboratory: Porosity Measurements

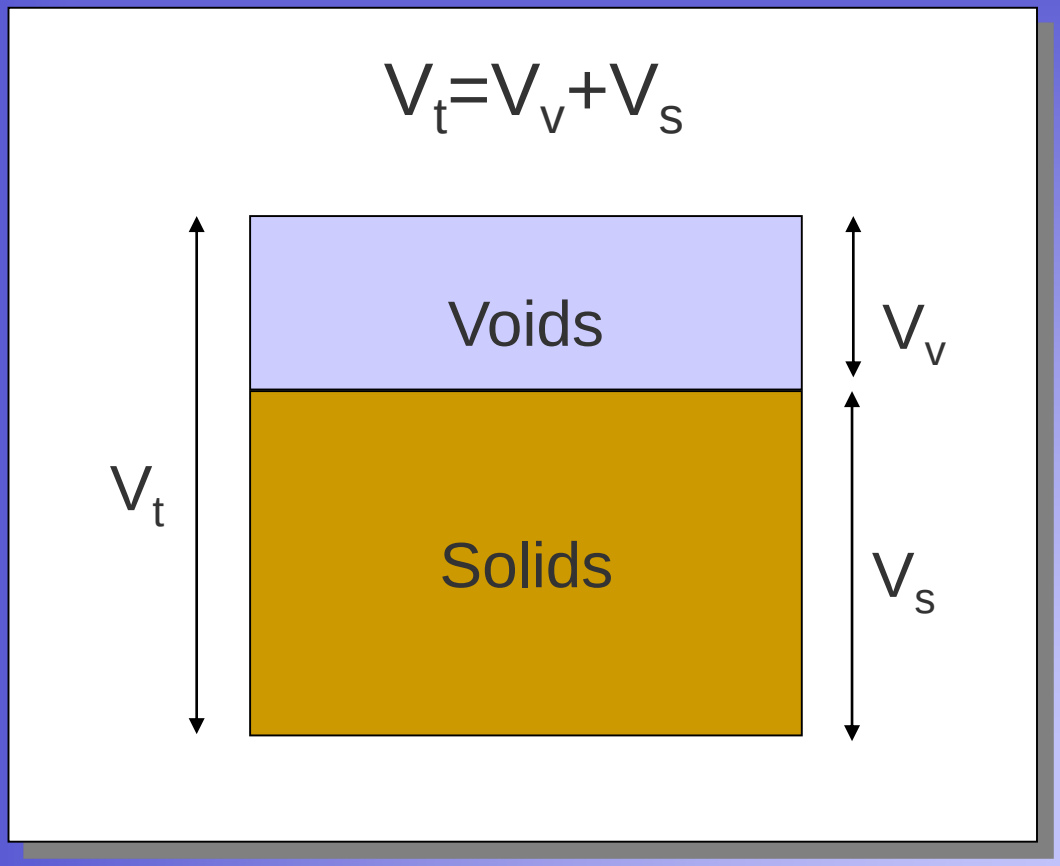
- Porosity

  $n = V_v / V_t$
- Solids Density

  (ρ_s)=Mass Solids / V_s where $V_s = V_t * (1-n)$
- Bulk Density

  (ρ_b)=Mass Solids/ V_t

Laboratory: Porosity Measurements



Laboratory: Moisture Content

- $\theta = V_w / V_t$

-weigh sample of known Volume

-Dry in oven

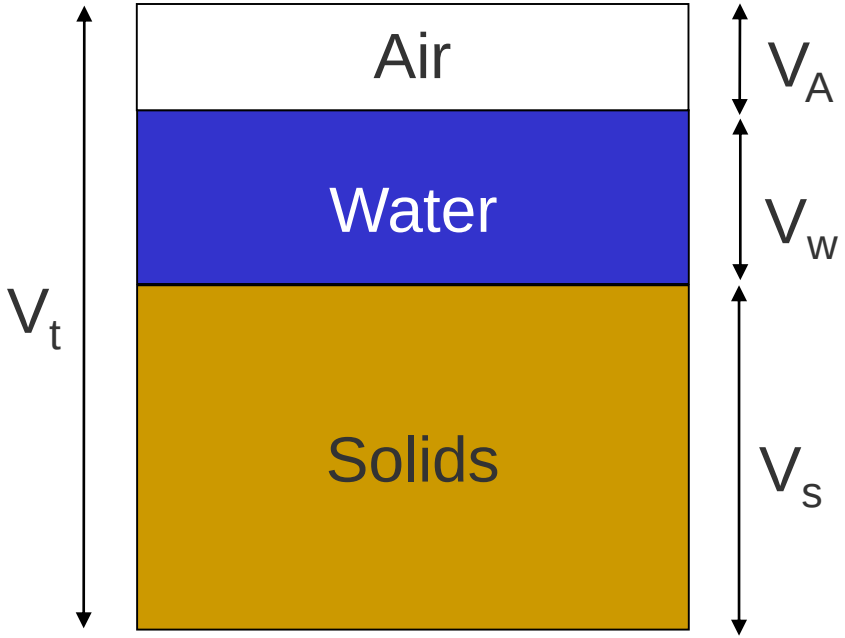
-weigh dry sample

V_w = Mass of water

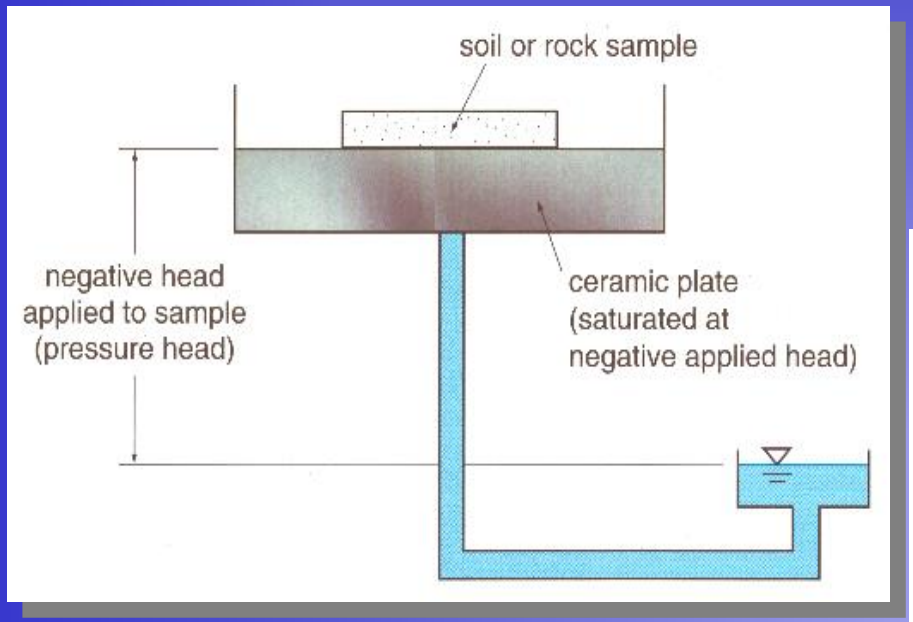
Laboratory: Moisture Content

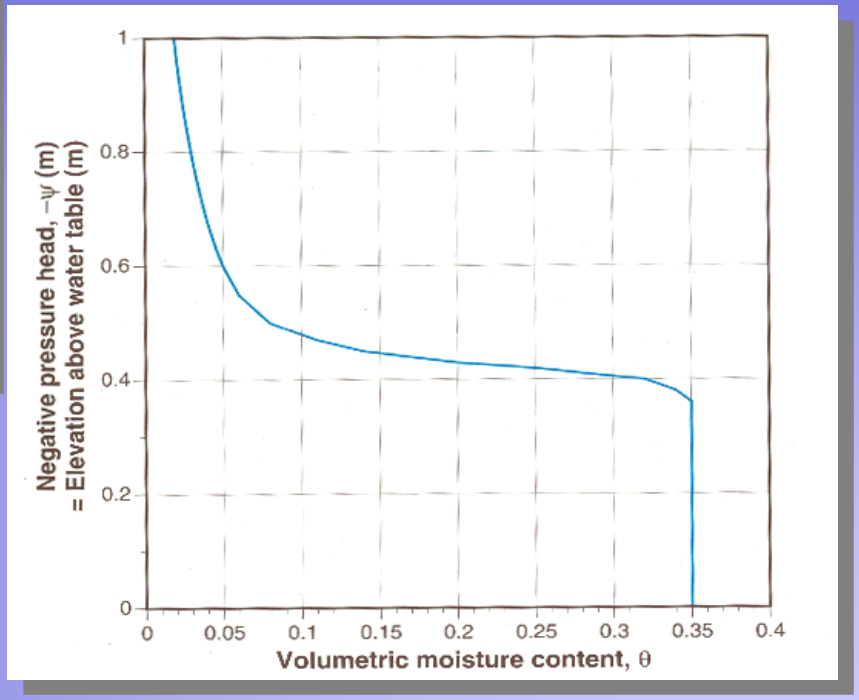
$$V_t = V_w + V_s + V_A$$

$$V_v = V_A + V_w$$



Laboratory: Drainage Curves





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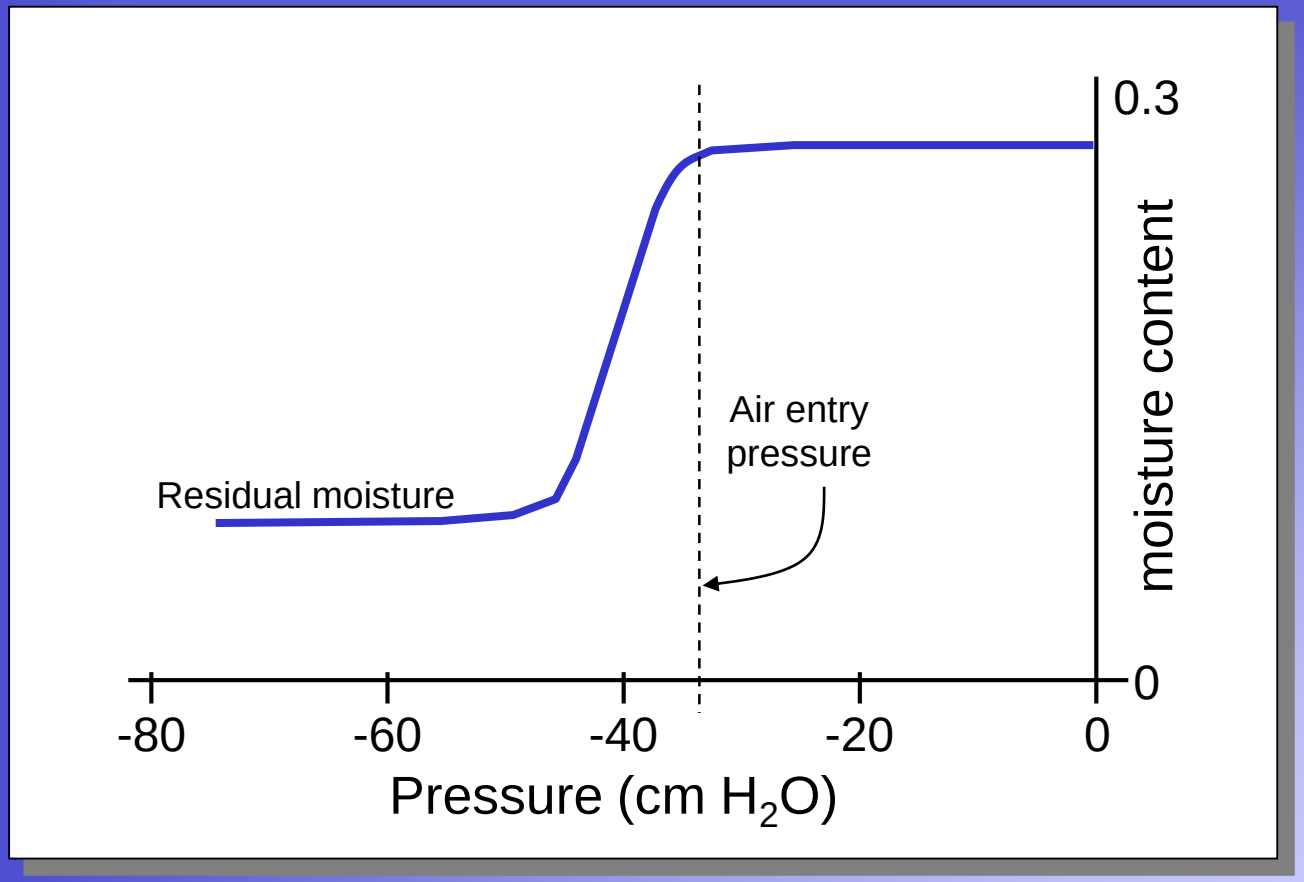
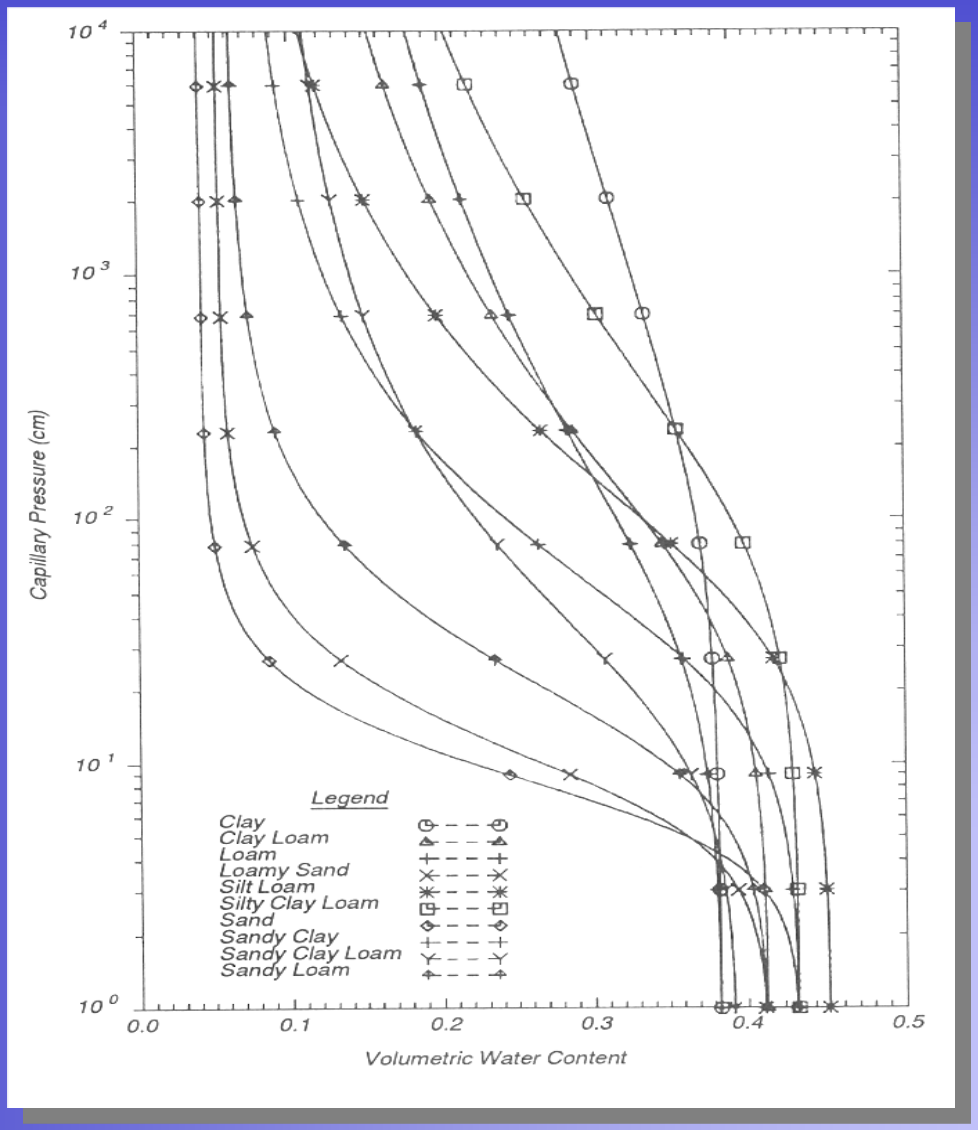


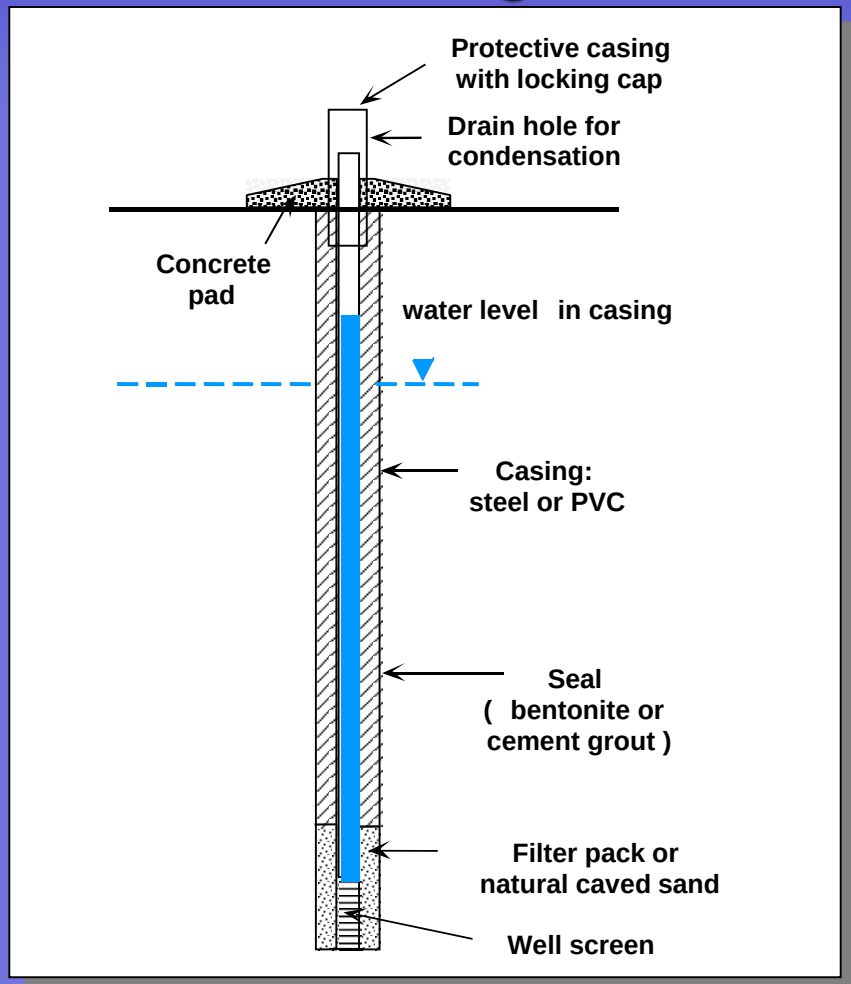
Laboratory: Drainage Curves



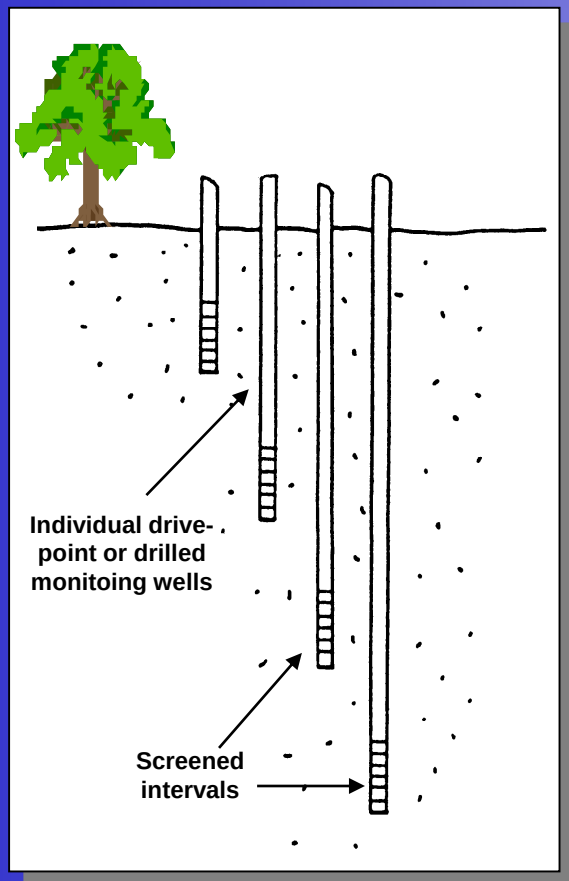
Field Measurements: Piezometers

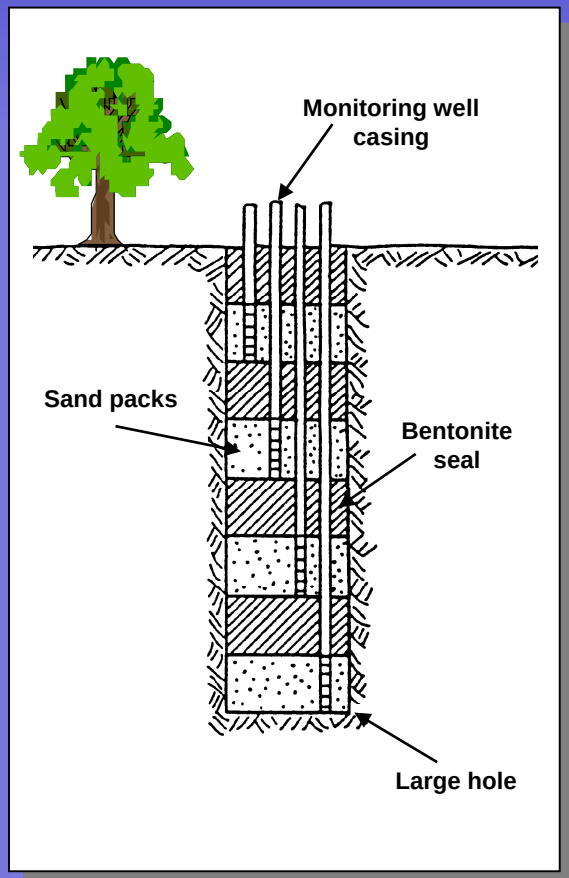
Monitoring Wells and Drilling Methods

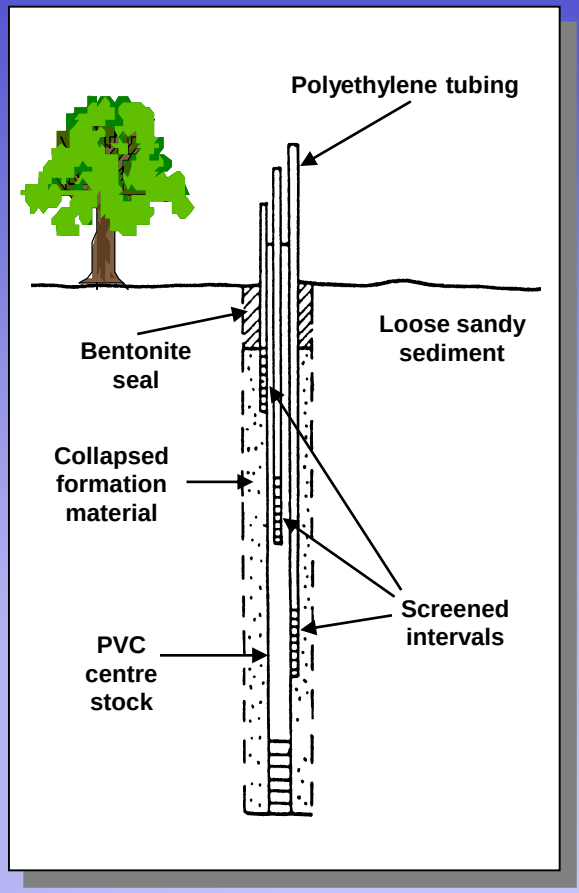
Well Types



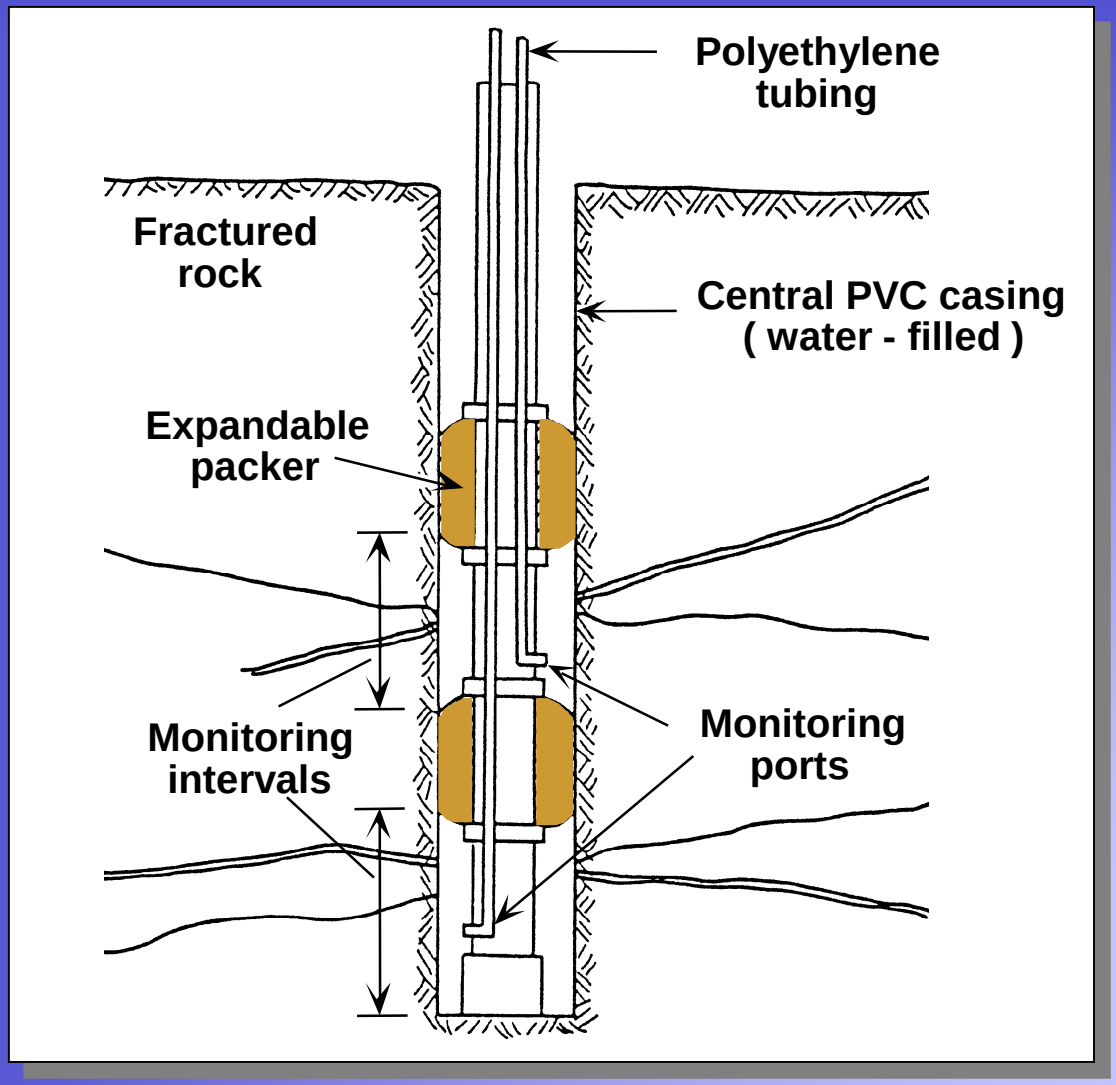
Approaches to Measuring Vertical Gradients (Profiles)







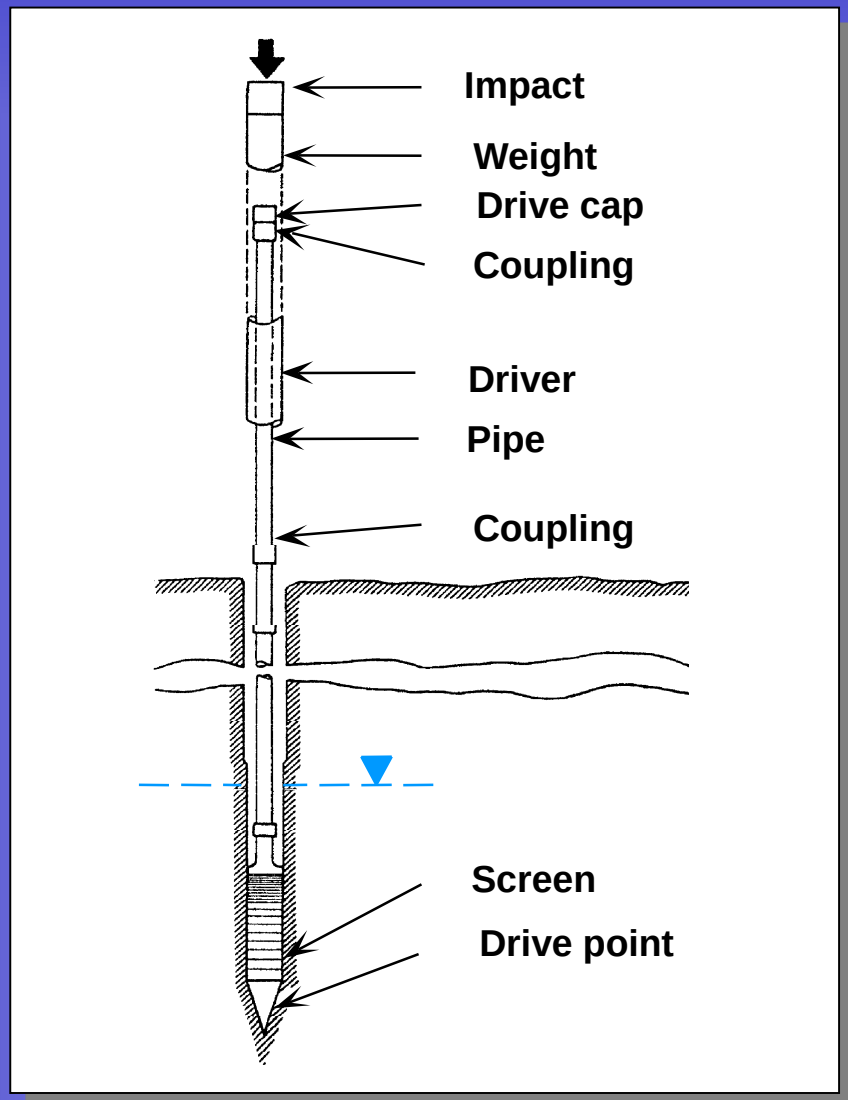
Wells in Fractured Rock



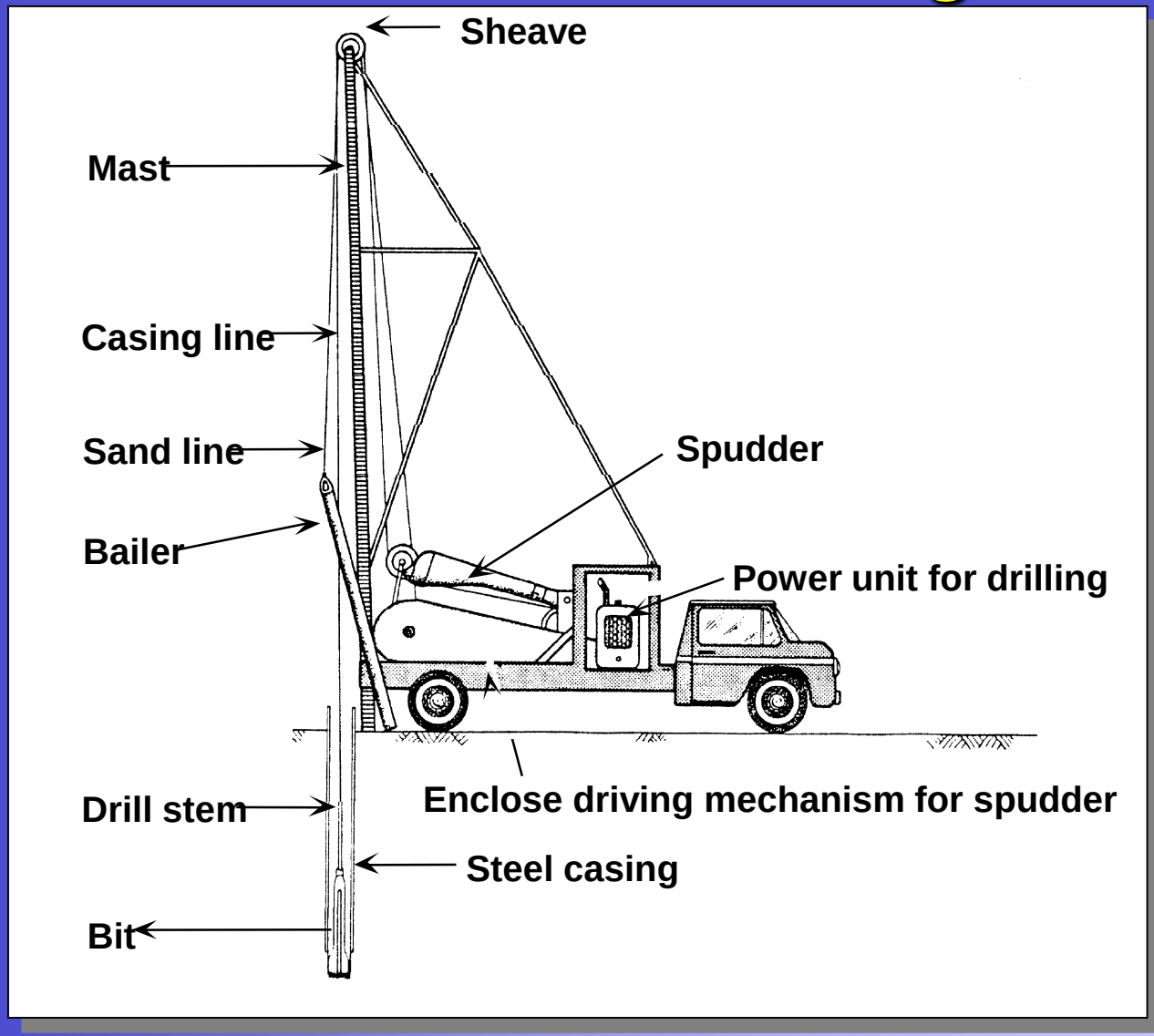
Drilling Methods

- Drive point
- Cable tool
- Mud rotary
- Air rotary
- Diamond bit
- Auger (hollow or solid stem)

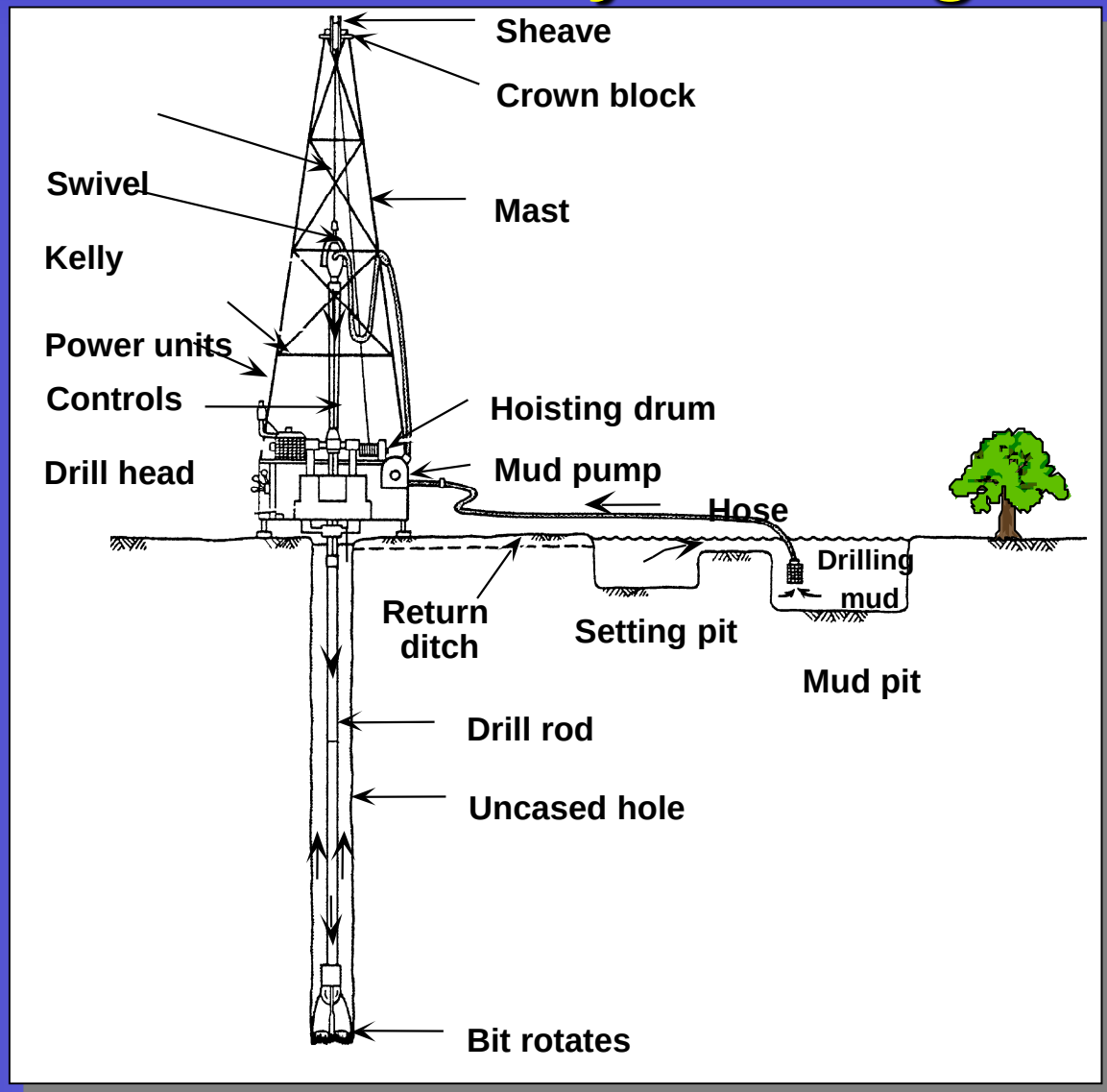
Drive Point Wells



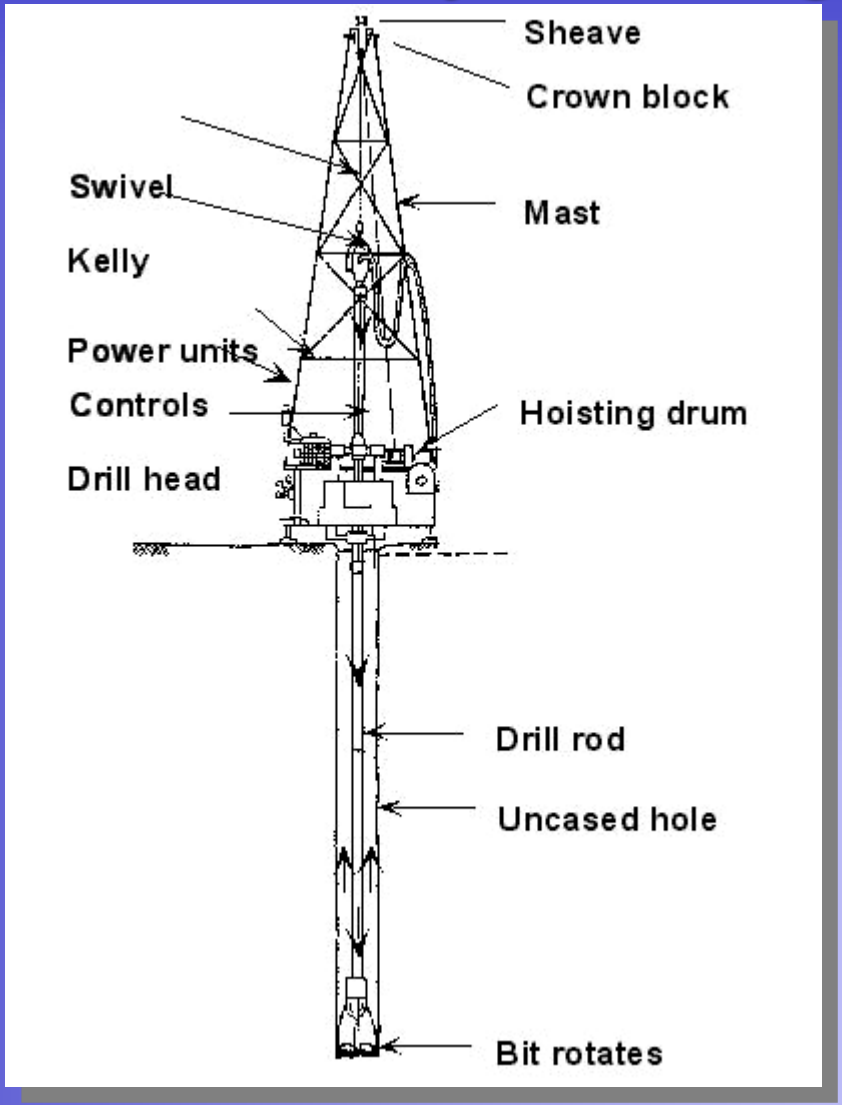
Cable Tool Drilling



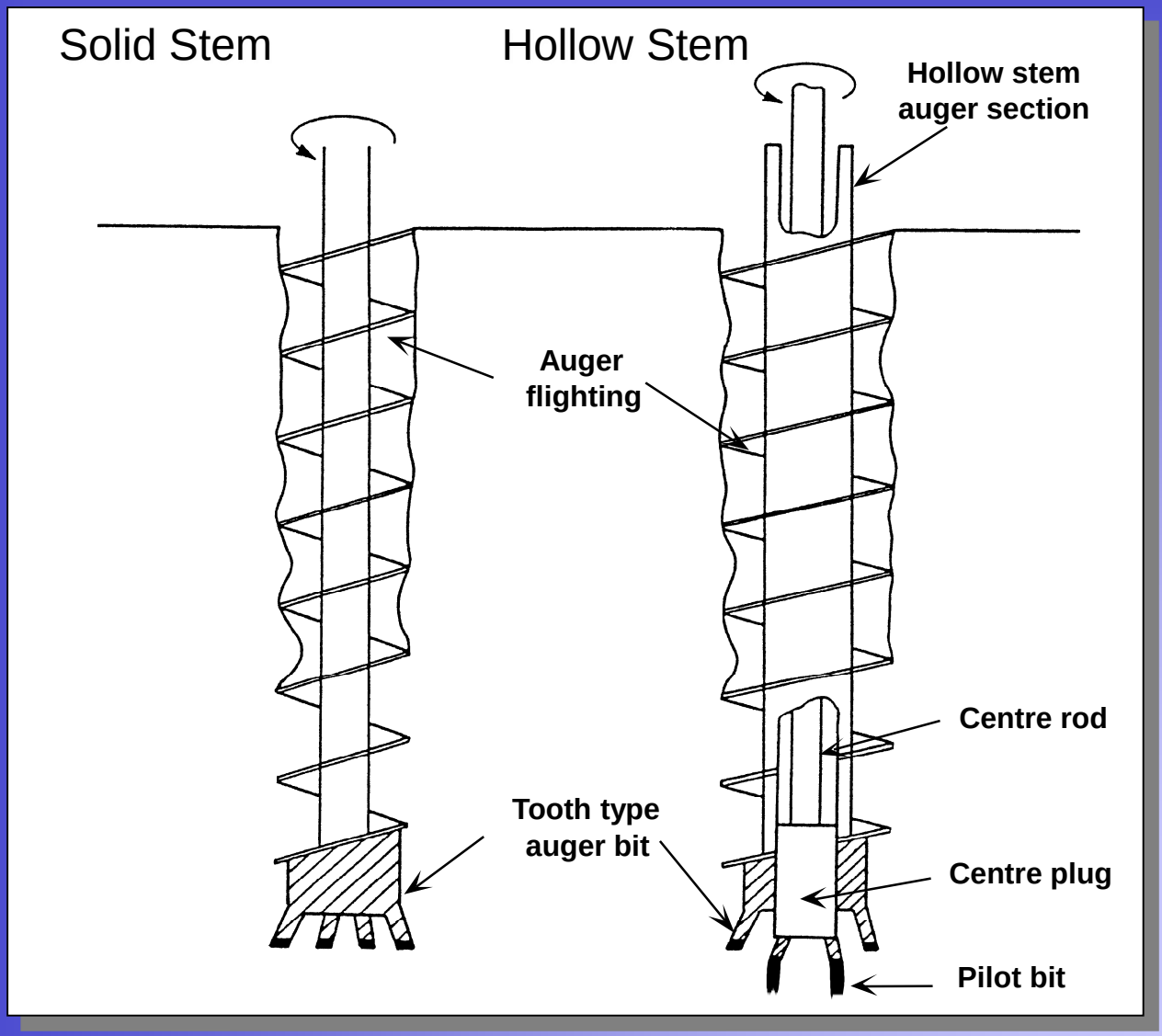
Mud Rotary Drilling



Air Rotary Drilling



Auger Drilling

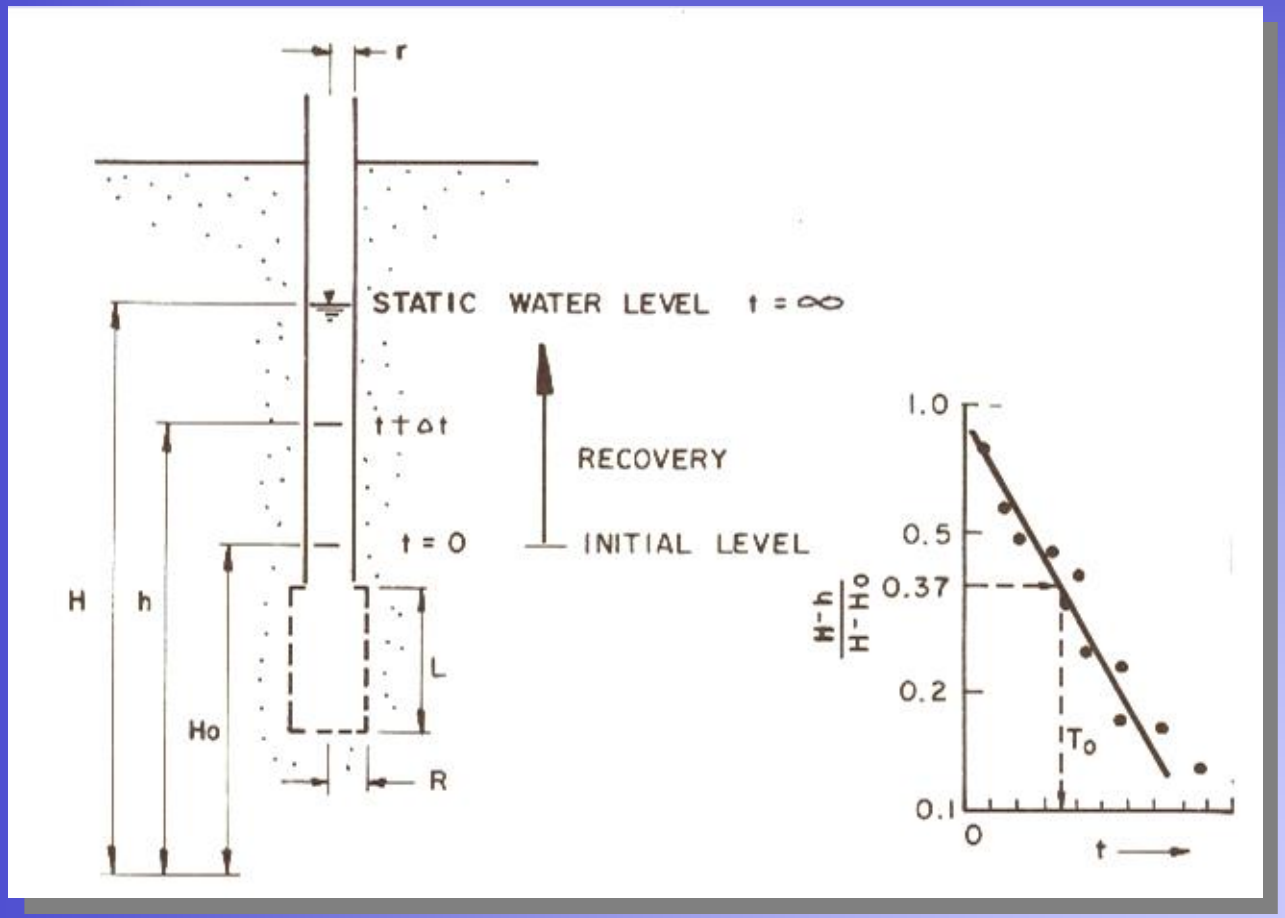


Installation of Wells Using Hollow Stem Auger

- Auger hole
- Pull out centre rod
- Insert well into auger
- Install sand/gravel pack
- Add sealant above sand pack

Measuring Hydraulic Conductivity in the Field

Single Well Tests



Falling / Rising Head Tests Analysis

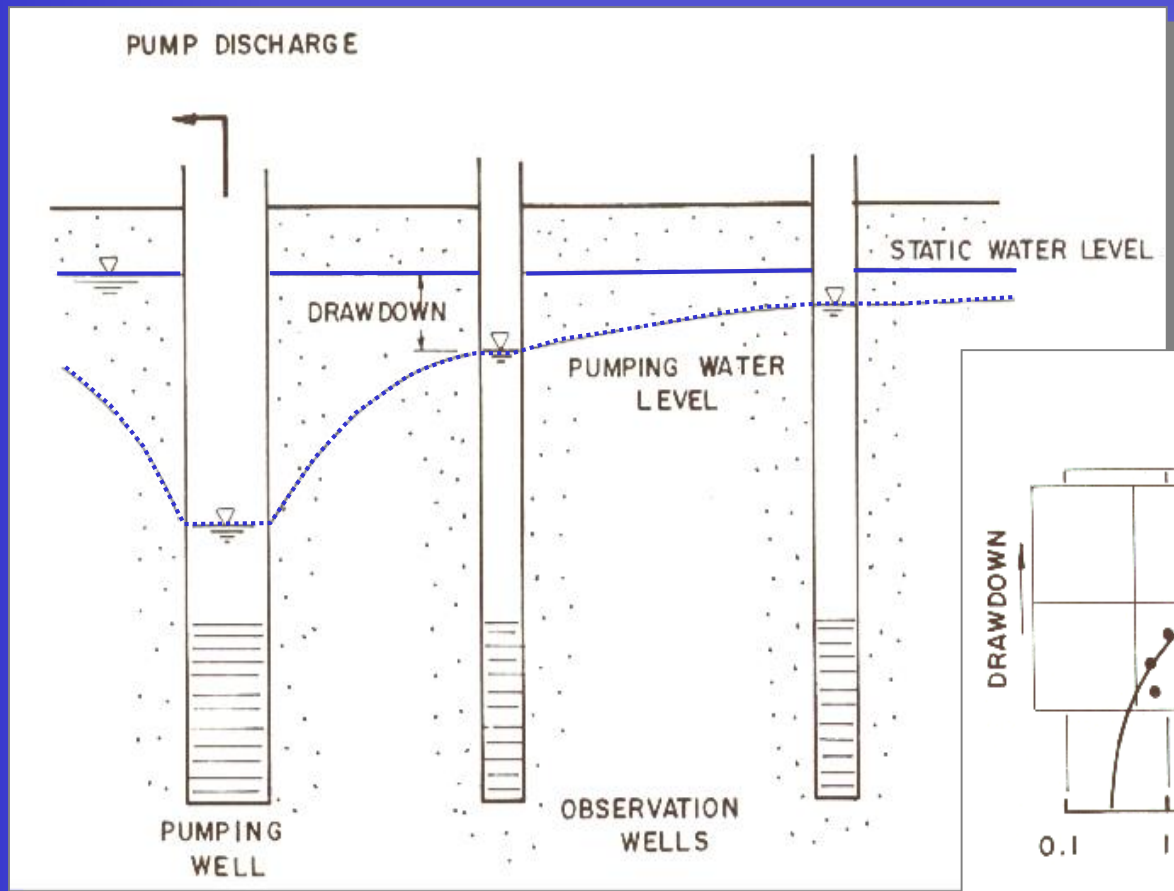
$$K = \frac{r^2 \ln(L/R)}{2LT_0}$$

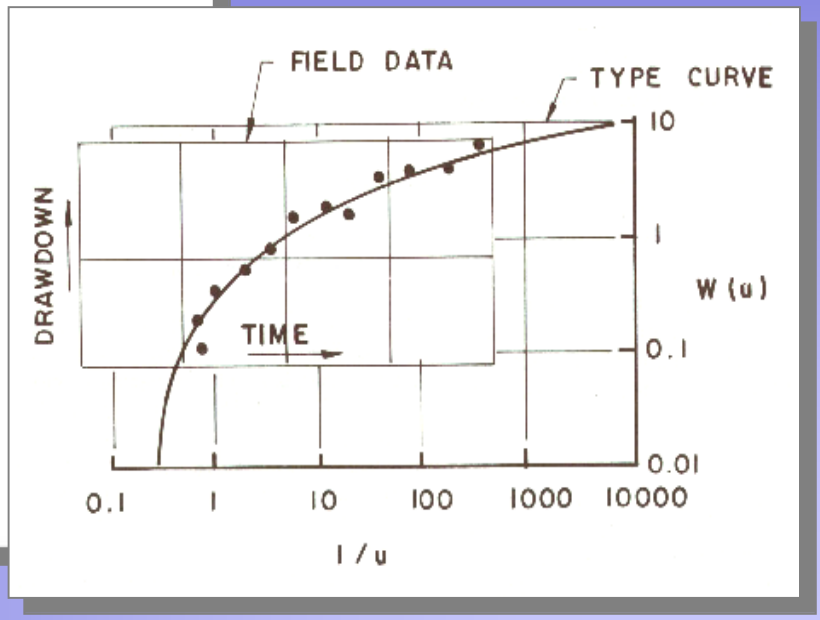
Where:

L and R refer to sand pack dimensions

and T_0 is the basic time lag (time to return to 37% of original head)

Pumping Test





Pumping Test Analysis

$$h_0 - h = \frac{Q}{4\pi T} W(u)$$

$$u = \frac{r^2 S}{4Tt}$$

T = k * b (thickness of aquifer)

S = Storativity (unitless)

r = radius of observation well

W(u) vs u value from tables

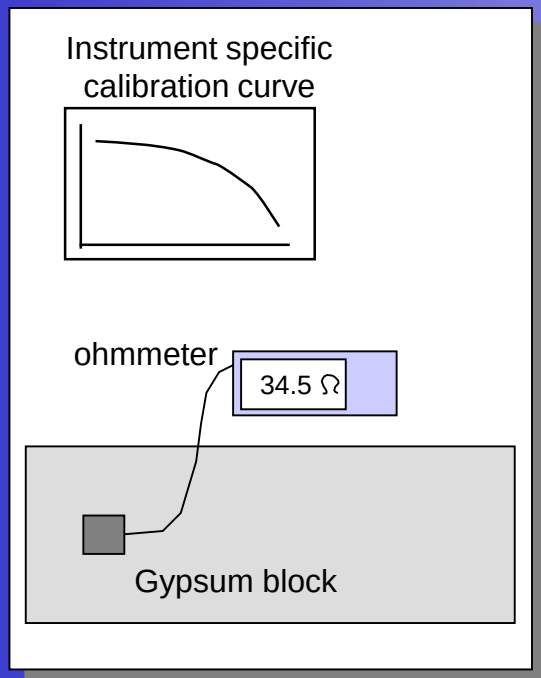
Advantages and Disadvantages of Single Well and Pumping Tests

	Advantages	Disadvantages
Single Well	• apply on any well •Simple •Fast (generally) •Low cost	• Small representative zone • well completion important
Pumping Test	• Large Representative zone • good for dewatering and resource evaluation • identify geologic boundaries / conditions	• Large Representative zone • good for dewatering and resource evaluation

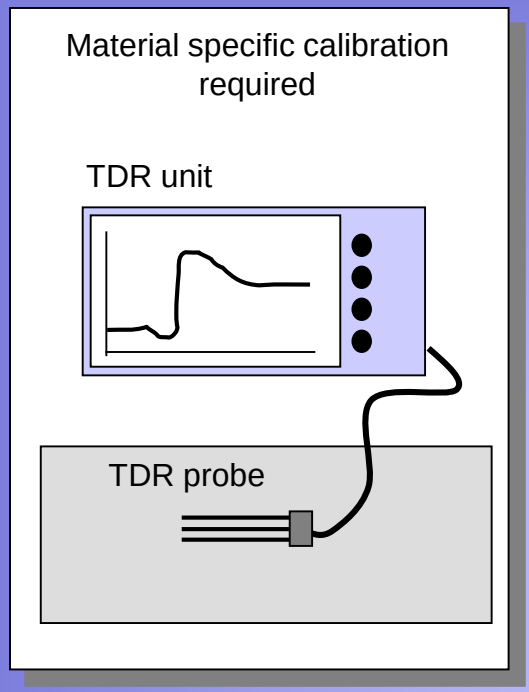
Moisture Content

- Sampling (In Situ)

Gypsum Blocks



TDR
Time Domain Reflectometry



ThetaProbe