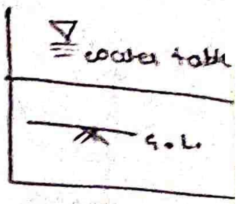
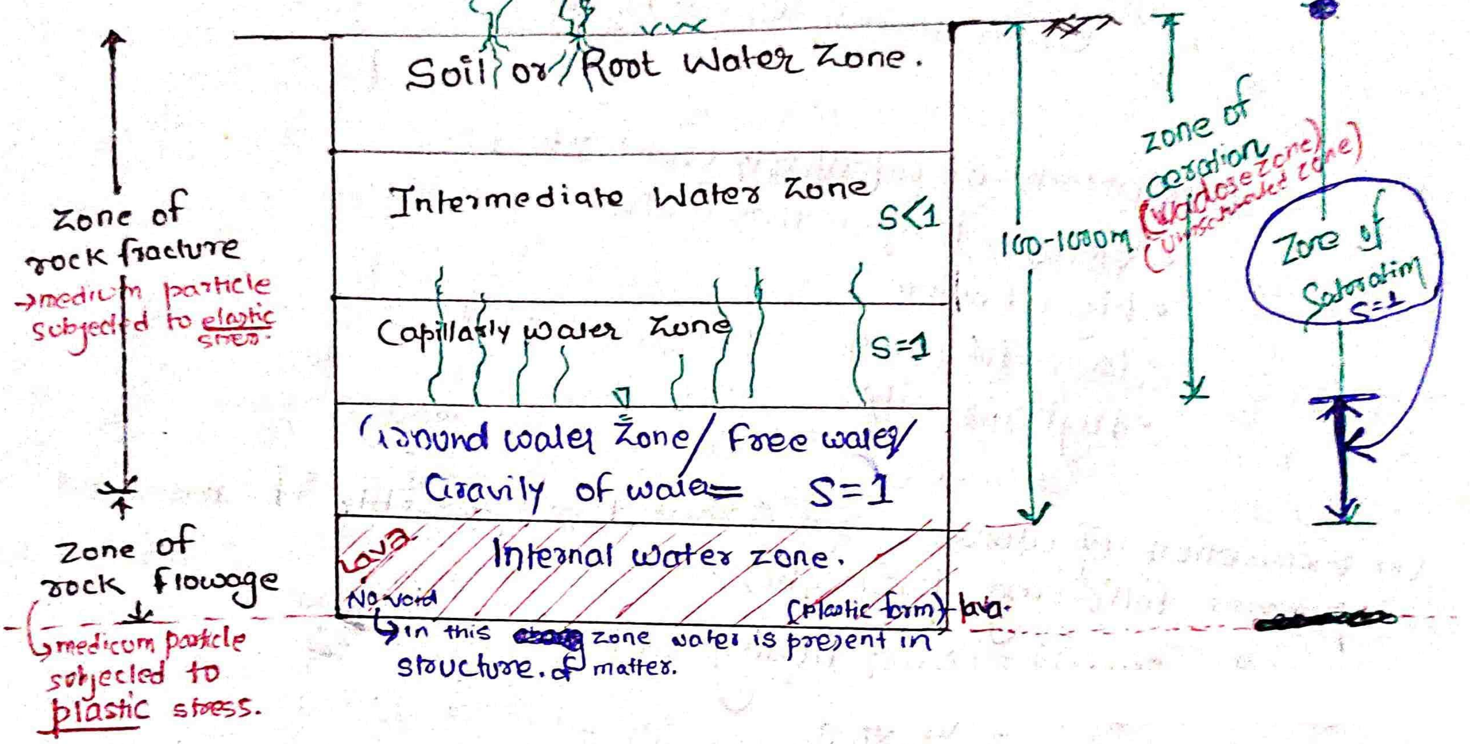
Imarshy – दलदल Area

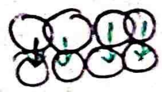


SOURCE OF WATER

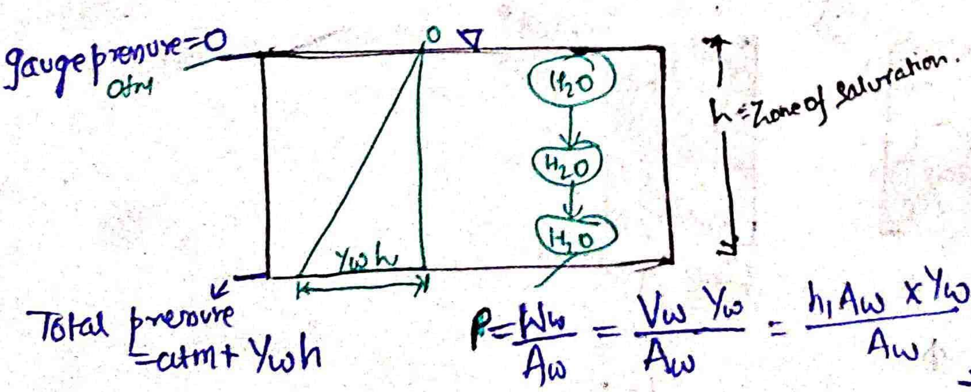
SOURCE → Surface
→ Subsurface (ground water). – SOO
→ Rain/precipitation.

1.) With regard to extraction/presence of water in ground.





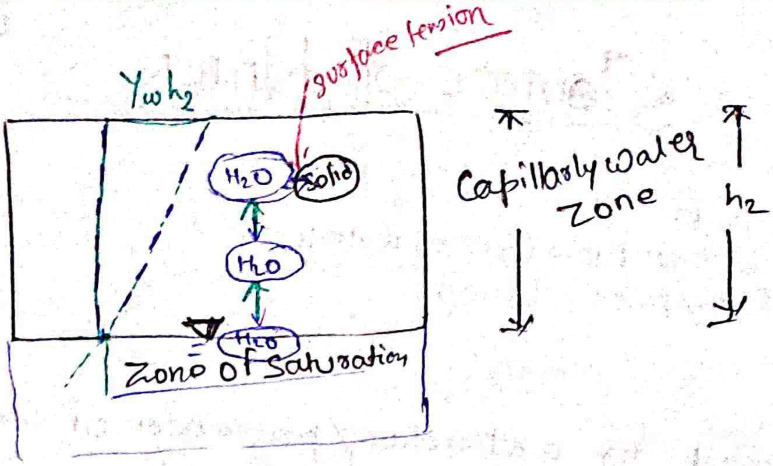
*Soil transfer its weight through soil grains not water.



$$P = \frac{W_w}{A_w} = \frac{V_w\,\gamma_w}{A_w} = \frac{h_1 A_w \times \gamma_w}{A_w} = \gamma_w h$$

→ hydrostatic pressure (compression)

→ Pressure head = h



~~+ve~~

-ve	+ve = tension
+ve	-ve = Compression

Surface tension = $W_w = h_2 \gamma_w$

~~Every~~ Property of capillarly water :-

- Viscosity is higher than water
- higer boiling "
- lower freezing "
- higher density "

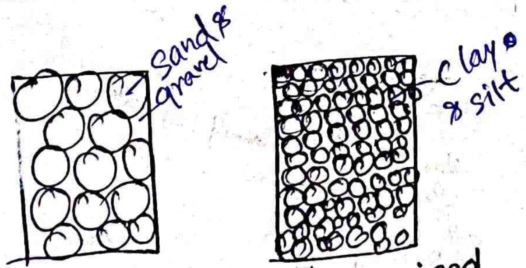
(ii) Extraction of water from Ground is possible if medium possess following properties:-

(a) Porosity (η) = water hoding capacity $\propto$ voids.

$$= \frac{V_v}{V} \times 100$$

d = size of particle.

$$\boxed{\eta \propto V_v \propto \frac{1}{d}}$$



	Coarse	Fine grained
Size of voids →	↑	↓
Volume of 1 void →	↑	↓
no. of voids →	↓	↑
	↓	↑

Total volume of void = $n \times V_{v_i}$

Ground Water Development.
With regards to the existence of water below the Earth crust.
It is divided into following zone.

(i) Zone of rock flowage:-

→ It is the zone in which medium particles are being subjected to permanent deformation due to the application of plastic stress over them. NO VOIDS.

→ Water in this zone is present only inside the structure of medium particles thereby it is termed as internal water zone. Structural water.

→ Thickness of this zone extends upto several kms. below the earth crust.

→ This zone is no. of egg use. as water can't be derived by it by any means.

→

(2) Zone of Rock fracture:

It is the zone in which medium particles are being subjected to elastic stresses hence water is available in the voids of this zone extraction. of water which depends upon the properties of the medium.

→ Thickness of this zone is the range of 100 - 1000m below the earth crust

This zone is further divided into:-
(3) Zone of saturation & zone of aeration.

Ground / free / Gravity of water zone:-
Ground → because it found in ground.
free → free to more.
Gravity → only weight of water act.

(4)

Note:-

Note:-

(i) if we have choice to extract water from capillary ground then our first choice would be ground water zone because in this water is free but in capillary zone water is held by soil so more energy is required to extract water from this zone.

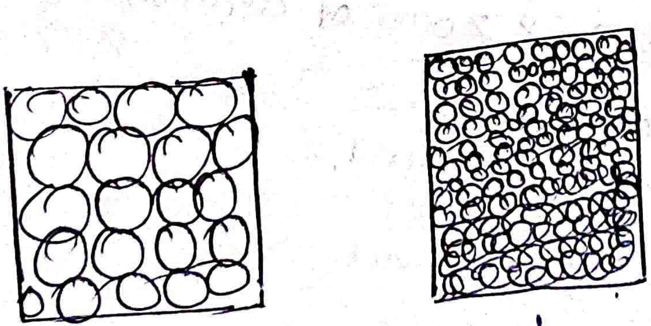
(ii) If we have the choice in ~~blue~~ between intermediate water zone and capillarly zone then our first choice will be capillarly because there more water is available where as in intermediate zone voids are ~~porous~~ probability filled with water so here will be lack of water.

(11) Permeability/Hydraulic Conductivity (K)

→ Permeability is the ability of the medium to permit the flow of voids fluid though it's interconnecting voids it may be defined as per Darcy's law.

$$K = f(\text{friction}) \propto \frac{1}{f}$$

* Friction ~~depends~~ act upon on contact area. but in soil it act on surface area.



dia of particle	↑	↓
Surface area	↑	↓
no. of particle	↑	↑
Total surface area = n.SA	↓	↓
Permeability	↑	

* Water is only extracted from coarse site, fine sand.

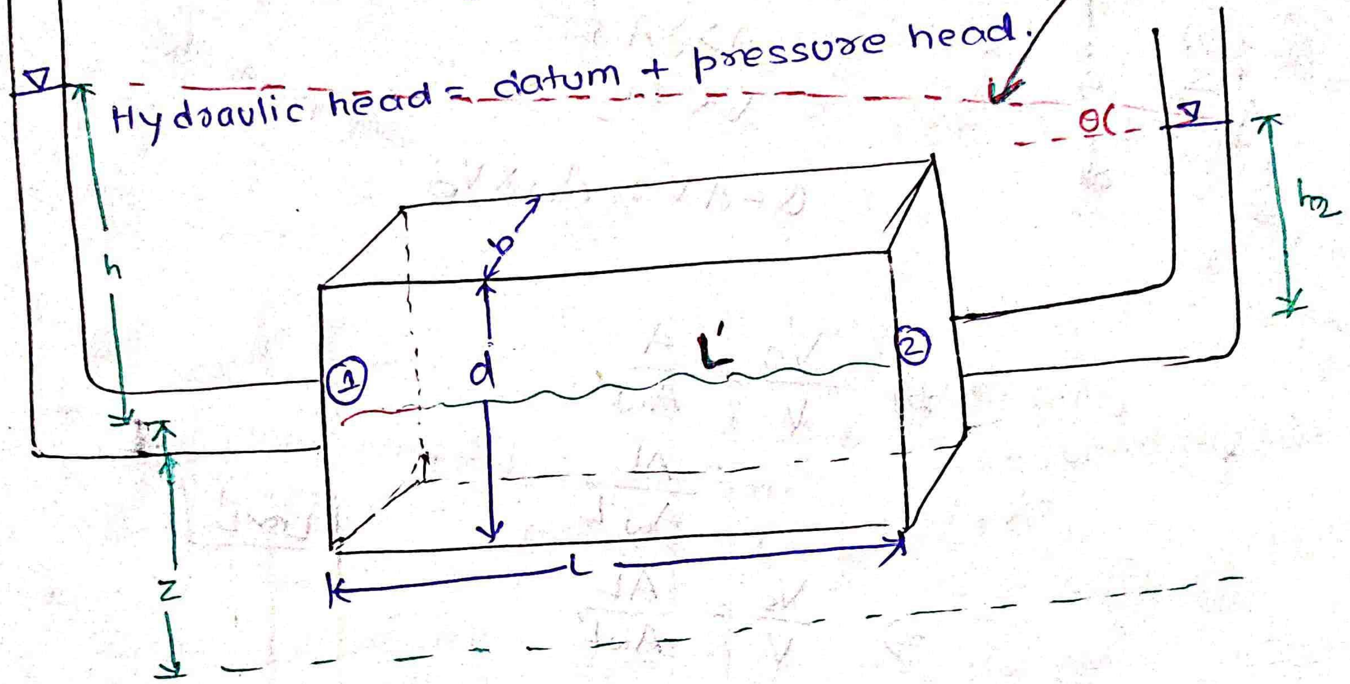
Darcy's law

Assumption :- $S = 1$ and laminar flow.

$V \propto i$

i = hydraulic gradient.

$= \dfrac{\text{hydraulic head loss}}{\text{length of flow}}$



$(L' > L)$

$$i = \frac{(z+h_1) - (z+h_2)}{L'} = \frac{h_1 - h_2}{L'}$$

Hydraulic gradient line,

$$\tan\theta = \frac{h_L}{L}$$

Assume $L' = L$

$$i = \frac{h_L}{L'} \approx \frac{h_L}{L}$$

$$V = Ki$$

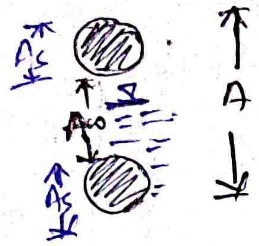
$$Q = VA$$

$Q = KiA$

if $i = 1$

$Q = KA$

$$K = \frac{Q}{A} \ (m/sec) = \frac{m^3}{sec\text{-}m^2}$$



$A >> A_w$

$V << V_s$

$Q = AV = A_w \times V_s$ — seepage velocity

$$\Rightarrow \frac{V_s}{V} = \frac{A}{A_w}$$

$$= \frac{AL}{A_w L}$$

$\boxed{L \approx L'}$

$$\Rightarrow \frac{V_s}{V} = \frac{AL}{A_w L'}$$

$$\Rightarrow \frac{V_s}{V} = \frac{V}{V_w}$$

$$= \frac{V}{V_v} \cdot \frac{V_v}{V_w}$$

$$\frac{V_s}{V} = \frac{1}{\left(\frac{V_v}{V}\right)\left(\frac{V_w}{V_v}\right)}$$

$$\boxed{V_s = \frac{V}{\eta S}}$$

$\Rightarrow$ if $S = 1$

$$\boxed{V_s = \frac{V}{\eta}}$$

$0 < S \leq 1$

$0 < \eta < 1$

$$\therefore \boxed{V_s > V}$$

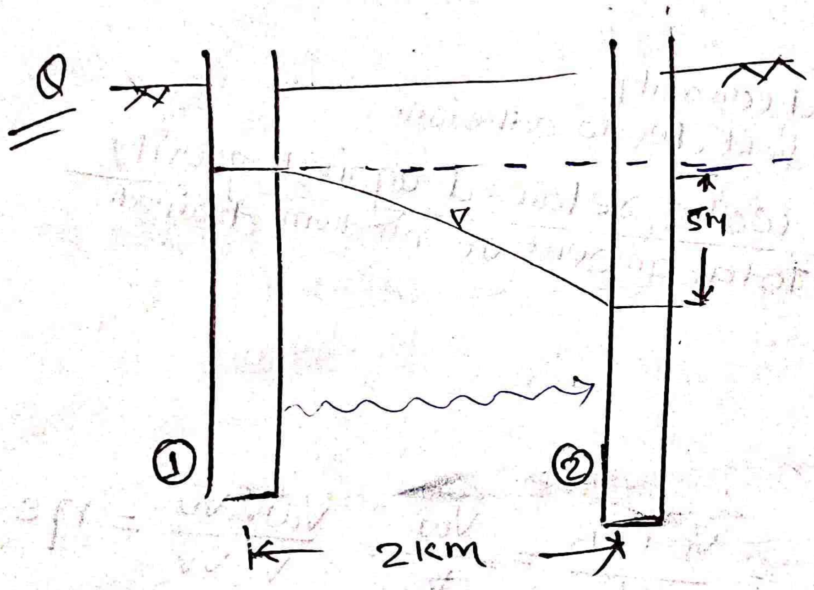
Transmissibility

→ Rate of flow through medium per unit width under unit hydraulic gradient

$$\boxed{T = \frac{Q}{b}} = m^3/m/sec$$

$$K = \frac{Q}{bd}$$

$$K = \frac{T}{d} \Rightarrow \boxed{T = Kd} = m^3/m/sec.$$



$\eta = 0.35$

$K = 300 m/day$

$t = ?$

$$\text{time of travel} = \frac{\text{distance} \approx 2km}{V_s}$$

$$= \frac{2000m}{\frac{V}{n}}$$

$$= \frac{2000 \times \eta}{V}$$

$$= \frac{2000 \times 0.35}{Ki} \qquad i = \frac{h_L}{L \approx 2000m}$$

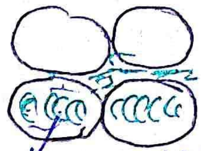
$$= \frac{2000 \times 0.35}{300 \times \frac{5}{2000}} = 933.3 \text{ days} = 2.55 \text{ years}.$$

[specific - per unit quantity (m or V)]

→ Even if the medium is porus and permeable, we can't withdrawl all water. because certain amount of water will be retained over surface of medium particle because of physical force of attraction between water molecule and particle. and this water retained inside the medium particle this water is called adsorbed water.

(iii) Specific Yield (Y_s) — per unit quantity.

$$Y_s = \frac{\text{Amount of water drained by gravity.}}{\text{Amount of medium drained.}}$$



$$Y_s = \frac{V_w}{V} \times 100.$$

Specific Retention / field capacity.

The water retained in field due to adhesion.

$$Y_R = \frac{\text{Amount of water retained against gravity}}{\text{Total amount of medium drained.}}$$

$$= \frac{V_R}{V} \times 100.$$

$$Y_s + Y_R = \frac{V_D}{V} + \frac{V_R}{V} = \frac{V_D + V_R}{V} = \frac{V_w}{V} = \frac{V_w}{V} \cdot \frac{V_v}{V_v} = \eta S$$

$$\boxed{Y_s + Y_R = \eta S}$$

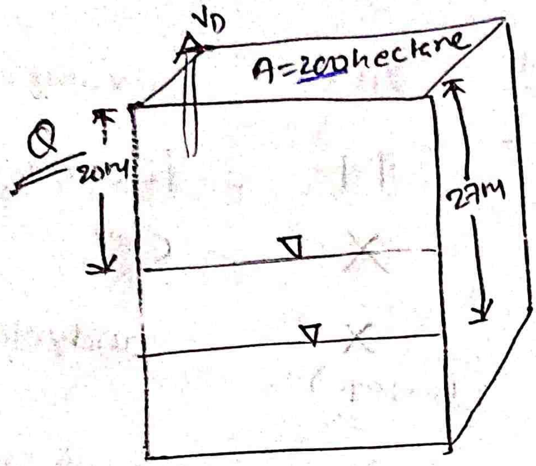
if $S = 1$

$$\boxed{Y_s + Y_R = \eta}$$

$Y_S = f[d]$ $[d\uparrow \rightarrow SSA\downarrow \rightarrow f\downarrow \rightarrow Y_S\uparrow]$

$Y_R = f[d]$ $[d\uparrow \rightarrow SSA\downarrow \rightarrow Y_R\downarrow]$

Clay, silt → retention ↑ yeid ↓
Sand, gravel → retention ↓ yield ↑



change in ground water storage due to pumping
$\eta = 0.4$, $Y_R = 0.15$.

Nature of change = decreasing.

V_D

$Y_S = \frac{V_D}{V}$

$V_D = Y_S V$

$V_D = (\eta - Y_R) \times V$

$= (0.4 - 0.15) \times 7 \times 200$

$= 350$ hectare-meter.

$Y_S + Y_R = \eta$

$Y_S = (0.4 - Y_R)$

$hec = 10^4 m^2$

If due to rain 500 hectare-m

300 hac-m → 7m ↑

50 hac-m → 1m ↑

500 hac-m → 10 m ↑

350 - 7
50 - 1

New water table = 27 - 10 = 17 m from top.

$\eta = 0.4 = \frac{V_V}{V} = \frac{V_w}{V}$

$= V_w = \eta \times V$

$= 0.4 \times 200 \times 7$

$= 560$ hectare-m

DIFFERENT TYPES OF GEOLOGICAL FORMATION

1) **AQuifer:** Aquifer are those geological formation which are highly porous and its permeable. hence, they give high yield.
eg. fine sand, coarse sand.

	Porosity (n)	Permeability (k)	Yield	example
1.) AQUIFER	↑↑	↑↑	↑↑	fine sand, coarse silt
2.) AQUICLUDE	↑↑↑	↓↓↓	X	clay
3.) AQUITARD	↑↑	↓↓	X (seepage)	-sandy clay
4.) AQUIFUSE	X (voids zero)	X	X	Granite stone

Types of Aquifer :-

1) Unconfined Aquifer / Non-artesian / water table aquifer.
(ii) Confined aquifer / Artesian.
(iii) Perched aquifer.

② **Aquiclude:-** These are type of geological formation which are high porus but impermeable hence water can't be drained through it eg. clay.

③ **Aquitard:** These are type of formation which are porous (but less as compare to aquiclude) and less permeable hence water does not flow through them but instead it seeps. (seepage) eg. sandy clay.

④ **Aquifuse:-** These are formation which are neither porous nor permeable.
eg. granite rock.

Types of Aquifer:-

(i) Unconfined/ Water Table Aquifer/ Non-artesian.

→ No confining pressure.
→ No artificial pressure.
→ Top zone of saturation is water table level.
→ These are type of saturation aquifer in which G.W.T. marks the upper limit of saturation.
→ Water in these aquifer is subjected to pressure not greater that hydrostatic pressure.

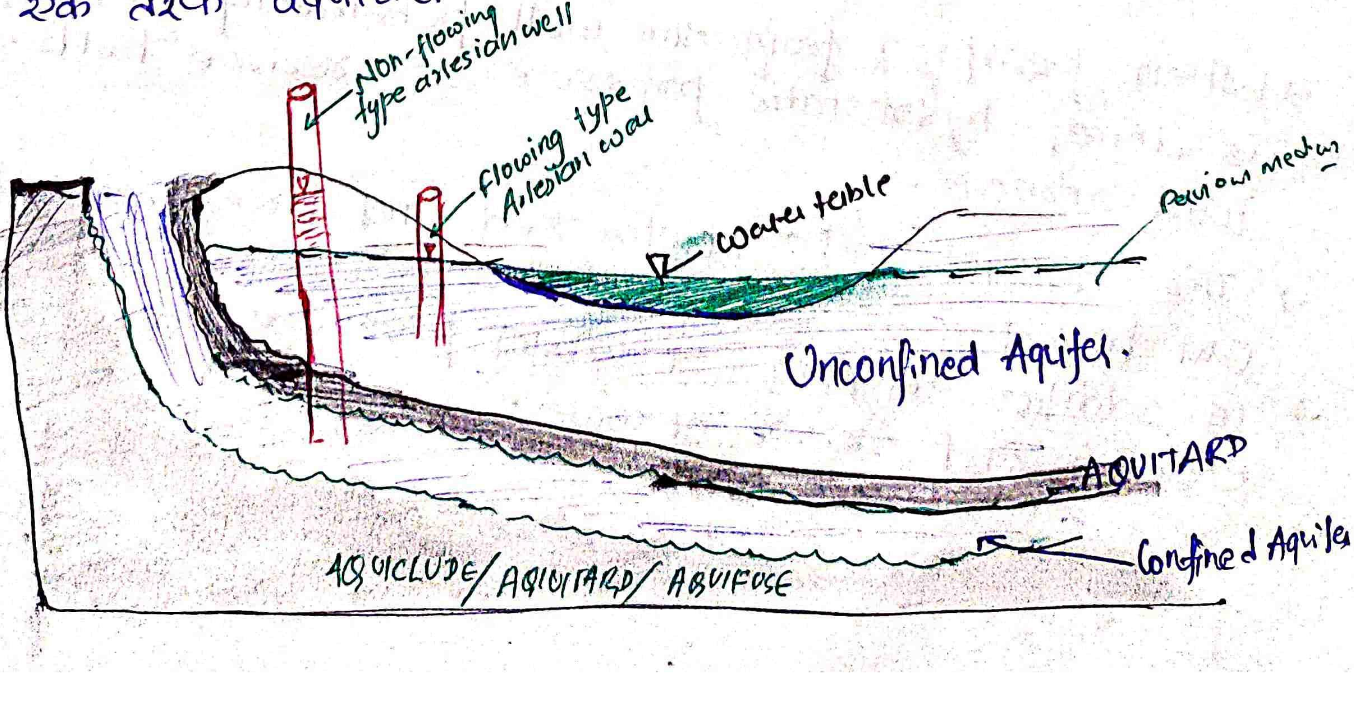
(ii) Confined Artesian Aquifer:

→ Confining pressure.
→ These are the type of aquifer which are formed when a pervious medium is found to exist in between two compeoneable layer.
→ Water in these aquifer are subjected to pressure greater than Hydrostatic pressure.

(iii) Perched aquifer.

Sometimes an impermeable layer is found to exist in a pervious medium, above the G.W.T. carrying the saturated soil mass that can also be used as source of water and is termed as perched aquifer.

Semi. confined:- Confined aquifer. के दोनों तरफ ~~aquitard~~. या एक तरफ aquitard आ जाये. जिससे water leak हो जाता है।



Storativity / specific storage / co-efficient of storage (s)

$$S = \frac{\cancel{V_w}\ \cancel{\text{(by any means)}}}{V}$$

$$S = \frac{\text{Volume of water drained from medium (By any means)}}{\text{Volume of medium drained (SA} \times \text{drop in water table / Piezometric head)}}$$

$$Y_s = \frac{V_{wa}}{V}$$

(i) For unconfined aquifer

$$Y_s = S$$

(ii) For confined aquifer.

$$Y_s \neq S$$

→ In case of confined aquifer water is drained because of = compression of aquifer + Expansion of water

→ In confined aquifer, the hydrostatic within the partially supports the overburden, while remaining is supported by the soil structure of aquifer.

→ When pumping from the well penetrating this aquifer is done, hydrostatic pressure is reduce bulb aquifer load increase.

→ The aquifer gets compressed and forces some water out from it.

→ In addition lowering of water pressure cause small expansion and release of water.

Hence in this case storage co-efficient is defined as volume of water release from the aquifer from full aquifer height and unit cross-sectional area, when pizometric surface decline by unity.

Storage of Cofficient for confined aquifer:-

$$S = \gamma_w H(\alpha + \eta\beta)$$
$$= \gamma_w H \left\{ \frac{1}{E_s} + \eta \frac{1}{E_w} \right\}$$

γ_w = unit weight of water

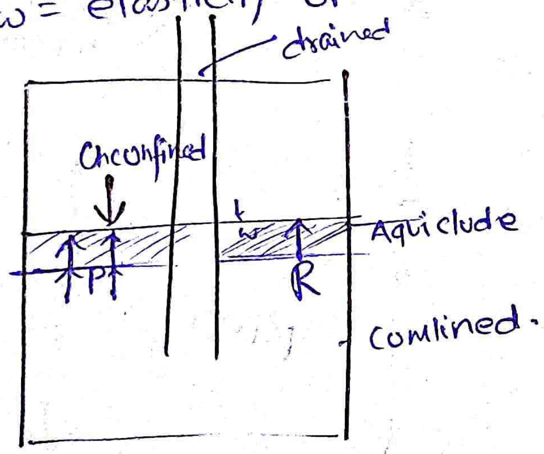
H = confined aquifer thickness m.

α = Compressibility of the aquifer $= \frac{1}{E_s}$

E_s = Elasticity of aquifer.

β = Compressibility of water $= \frac{1}{E_w}$

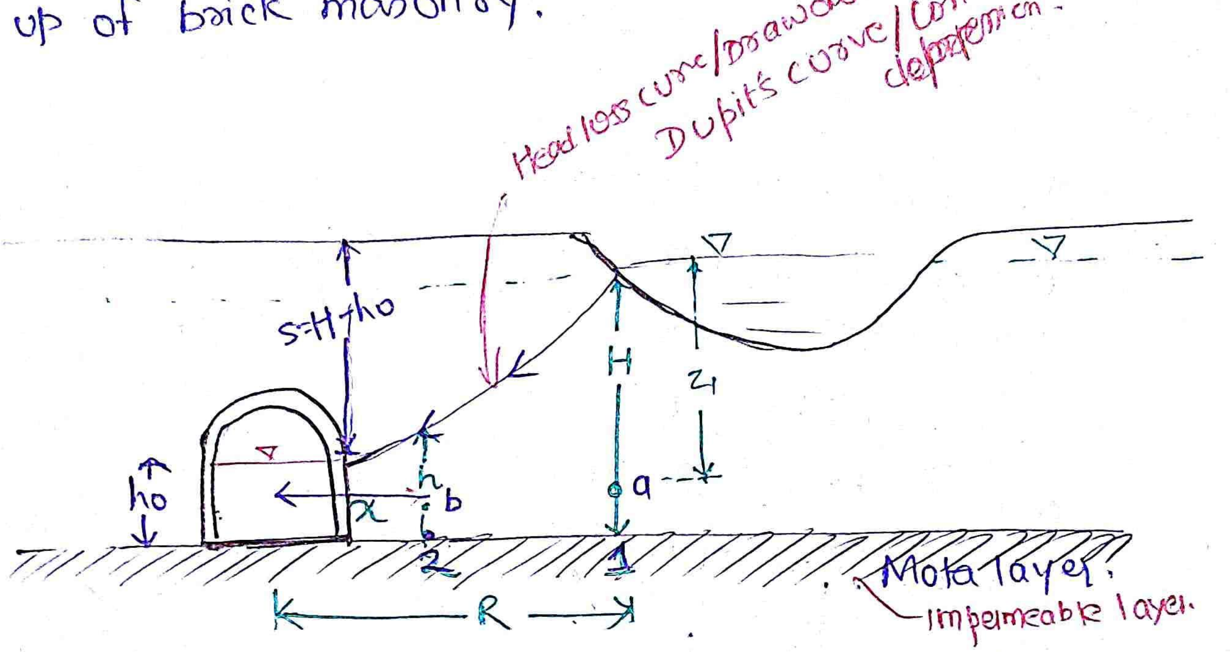
E_w = elasticity of water.

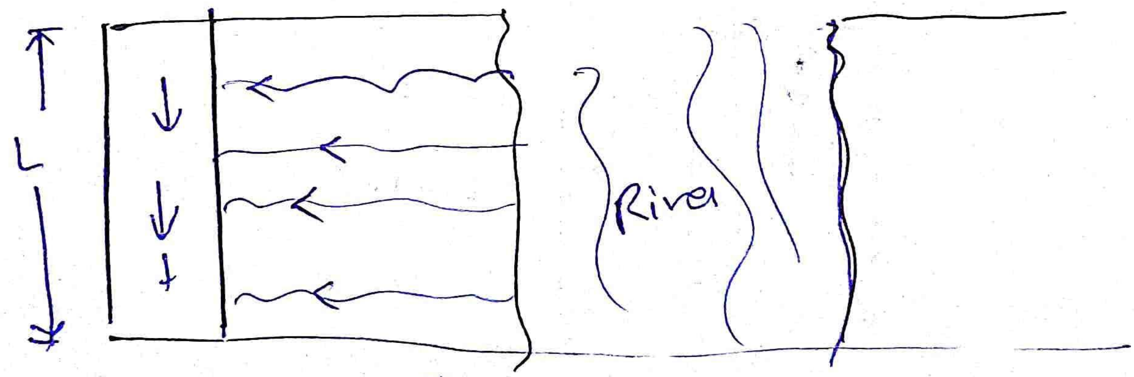


Different forms of Extraction of Ground Water:

1.) Infiltration Gallery

Infiltration gallery are generally horizontal tunnel constructed at shallow depth of 3-6mt along the bank of the river in water bearing structure through which the water is utilized by seepage from surface which is generally made up of brick masonry.



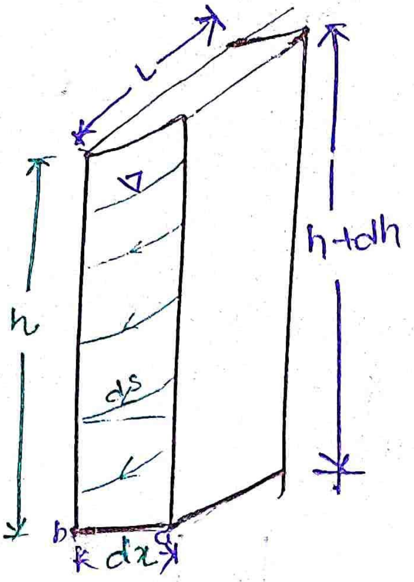


Plan

H = Height of the water in the river/ or high of original water table.

h_o = height of water in ~~the steer~~ gallery

R = radius of influence ≃ 300m.



$$q_x = q_x \times V_x$$
$$= (h \cdot L) \cdot K i_x$$

$$q_x = h L . K \frac{dh}{ds}$$

$ds > dx$
if θ is small, $\sin\theta \simeq \tan\theta$.

$$ds = dx$$

$$\therefore q_x = h L K \left(\frac{dh}{dx}\right)$$

Assume $dh = ds$
$\sin\theta = \frac{dh}{ds}$, $\tan\theta = \frac{dh}{dx}$

$\tan\theta = \frac{1}{300}$
$\theta = 0.19^\circ$

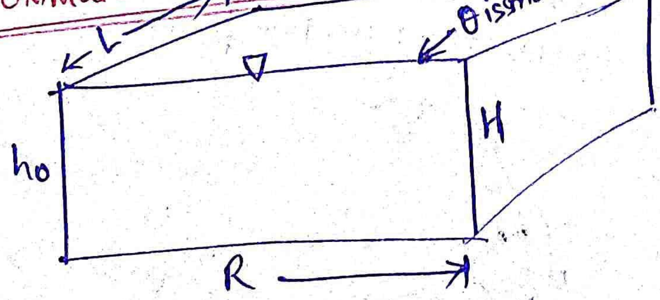
$$Q = \int q_x = \int h L K \frac{dh}{dx}$$

$$\int_{x=0}^{x=R} Q\, dx = \int_{h=h_o}^{h=H} h L K\, dh$$

$$Q[x]_0^R = L K \left[\frac{h^2}{2}\right]_0^H$$

$$\boxed{Q = \frac{KL(H^2 - h_o^2)}{2R}}$$

Approximate Method

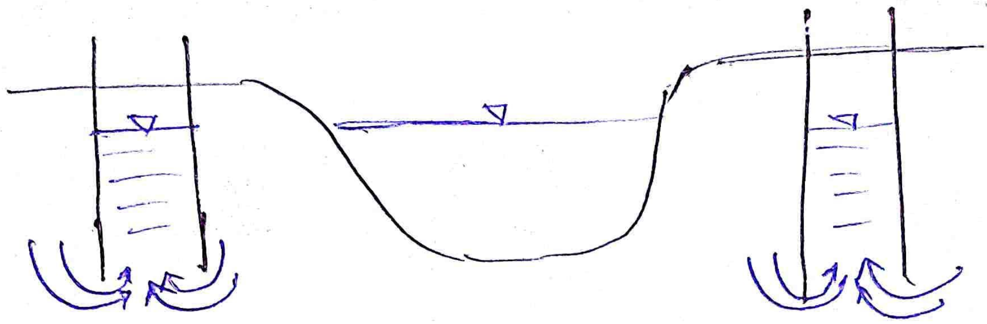


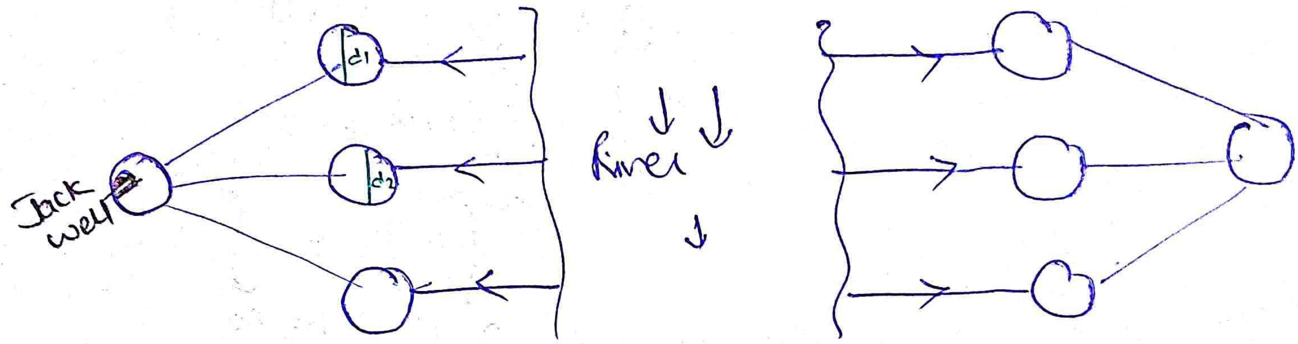
$$Q = A_{vg} \times V_{avg}^{ki}$$
$$= \left(\frac{HL + h_o L}{2}\right) \frac{K(H - h_o)}{R} = \frac{KL(H^2 - h_o^2)}{2R}.$$

② Infiltration well.

Infiltration wells are shallow discontinous constructed along the bank of the river through which the water is utilised by seepage from bottom.

→ Several such infiltration wells are connected through a common well known as Jack well. from where water being pumped into the treatment plant.



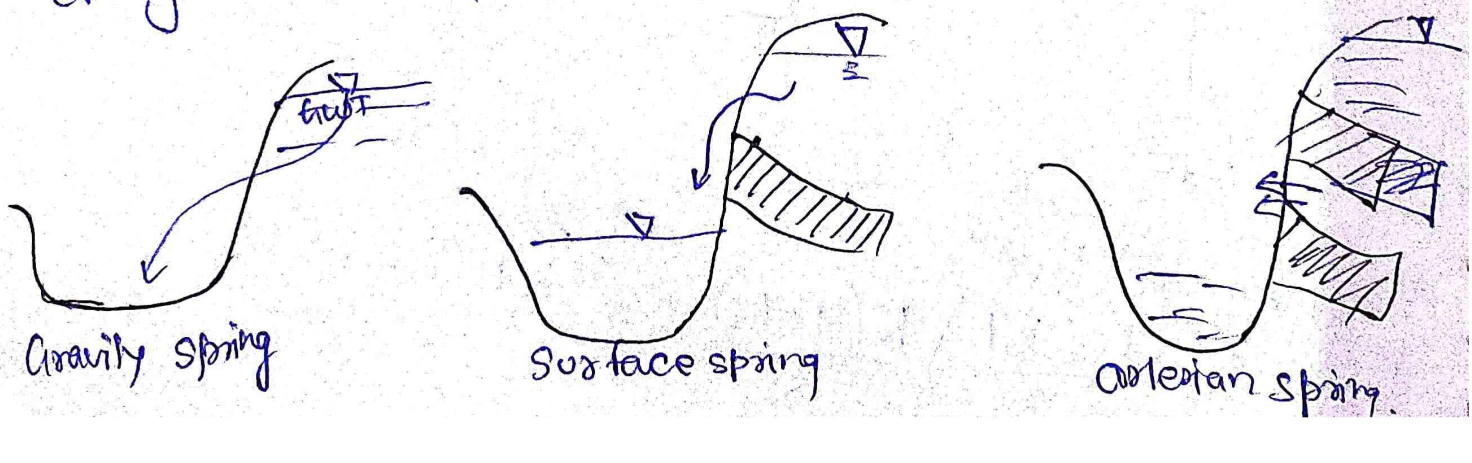


$l = (d_1 + d_2 + d_3) \ldots d_n)$

3) Springs.

Natural out of flow of ground water over the ground surface is teamed as spring.

→ only artesian spring are considerd as the potential source of ground water {since water flow under pressure}.



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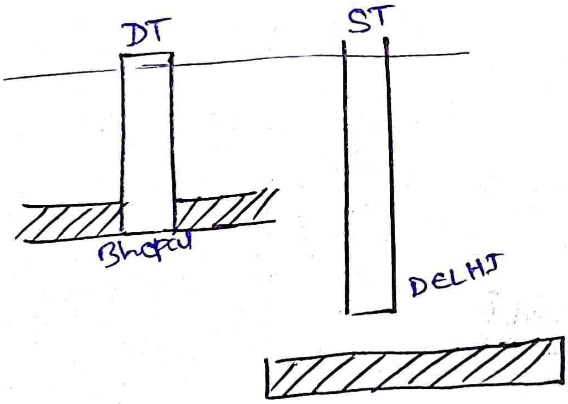
WELLS

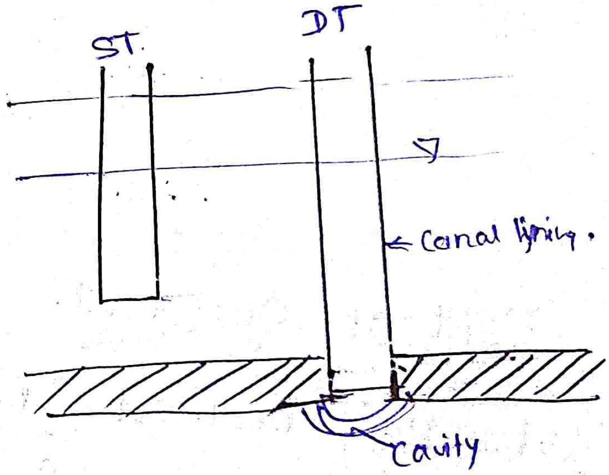
- OPEN
  - SHALLOW
  - DEEP
- TUBE
  - CAVITY
  - SCREEN
    - STRAINER
    - GRAVEL PACK

	OW (2-5)m	TW (20cm)
Dia -	↑	↓
depth -	↓	↑
Discharge -	↓↓	↑↑↑

SHALLOW WELL :- are those which derive water from upper water bearing strata.

DEEP WELL : derive water from lower water bearing strata.





	ST	DT
Quality	Poor	better.
Quantity	less	More.

Open Well

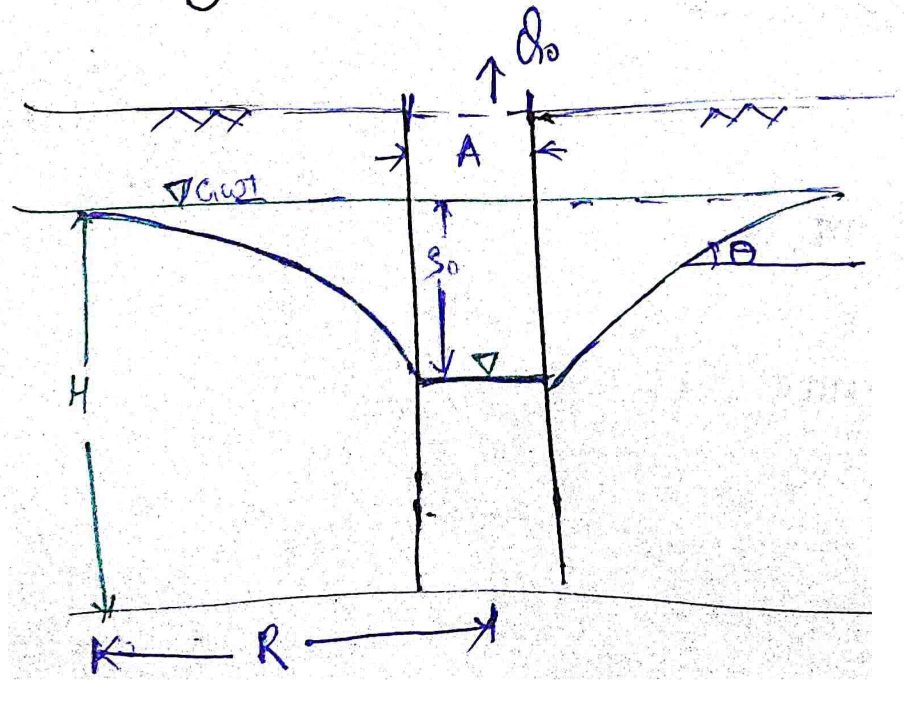
Shallow type open wells are those which utilize water from upper water bearing strata. that is liable to be Contaminated to higer extent.

→ Discharge from the shallow well is also very limited as if the discharge through those walls is increased criticau velocity & settling velocity of medium particle may also lead to the removal of medium particle particle along with the flowing water and if this process continuous it may also lead to the sinking of the well into the medium.

→ However this process is not observed in deep type wells as they derive their support from the lower impermeable layer but cravity is formed at the bottom of these wells due to the removal of the medium particle along with following water.

Yield of Open well.

(1) Pumping method {field test}



[V_0, t_0 + S_0]
Volume time depression.

v = velocity. $\boxed{S_0 = H - h_0}$

$$Q_0 = \frac{V_0}{t_0} \quad \text{—(i)}$$

$$Q_0 = A v$$

$$Q_0 = A K i$$

$$= A K \frac{S_0}{R}$$

$$Q_0 = \frac{K}{R} A S_0$$

$$\boxed{\frac{K}{R} = C \cong \text{constant}}$$

$$Q_0 = C A S_0$$

$$\boxed{C = \frac{Q_0}{A S_0}}$$ = C = Specific capacity of open well ($m^3/m^2/m$/sec or sec^{-1})

$m^3/m^2/m$

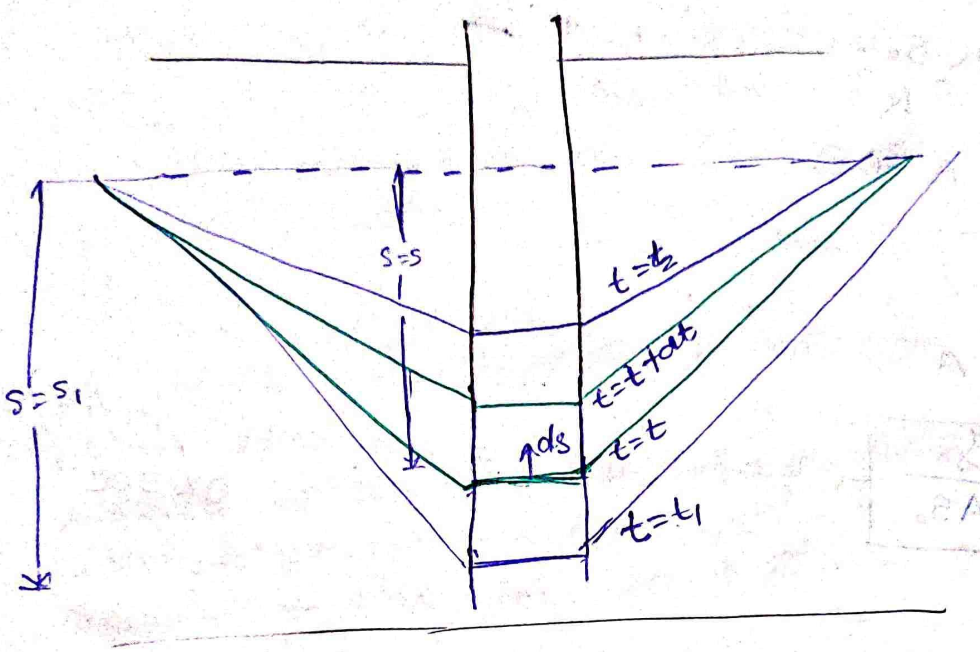
$$\boxed{\begin{aligned} Q &= C A S \\ Q &= \left(\frac{Q_0}{A S_0}\right) A S \end{aligned}}$$

Drawback: Not use for unsteady state.

Discharge constant

(ii) RECUPERATION TEST

As it is difficult to maintain constant level (steady state) of water in well recuperation test is being performed in order to find the specific capacity of the well in which level of water recuperated in the well well in a given time is noted in order to find it's yield.



Volume of water recuperated in well in time 'dt'.

$$dv = -Q\,dt = +A\,ds$$ (+ increasing) (- decreasing)

$$-CAS\,dt = A\,ds$$

$$C\,dt = -\frac{ds}{S}$$

$$C\int_{t=t_1}^{t=t_2} dt = -\int_{S=S_1}^{S=S_2} \frac{ds}{S}$$

$$C\left[t\right]_{t_1}^{t_2} = \left|\ln S\right|_{S_2}^{S_1}$$

$$C(t_2-t_1) = \ln\left(S_1/S_2\right)$$

let $t_1 - t_2 = t$

$$C = \frac{\ln(S_1/S_2)}{t} = \frac{2.303\log_{10}(S_1/S_2)}{t}$$

$(m^3/m^2/m/sec)$

As change in S

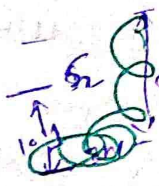
I	II
10	10
8	12
2	2

(1liter $= 10^{-3} m^3$

$Q' = CAS'$

$= \left(\dfrac{2.303 \log_{10}(S_1/S_2)}{t} \right) AS'$

Q During a recupiration test water is pumped upto 3m and it recuperated by 1.1m in 90 minutes. find the size of well to yield 10 liters/second under depression head of 2.5m.



$S_1 = 3m$

$S_2 - S_1 = 1.1$

$S = 3 - 1.1 = 1.9$

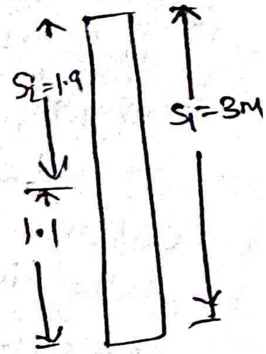
$t = 90 min$

$Q' = 10$ liters/second

$= 10 \times 10^{-4}/s \; m^3/s$

$Q' = \left(\dfrac{2.303 \log_{10}(S_1/S_2)}{t} \right) AS'$

$10 \times 10^{-3} = \dfrac{2.303 \log_{10}\left(\frac{3}{3-1.1}\right)}{90 \times 60} \times \frac{\pi}{4} \times d^2 \times 2.5$



$d^2 = 60.20$

$d = 7.75$

Q Water is pumped from a fine sand aquifer region at a rate of 12 lit/s find size of the well to give the required yield. at the draw down of 2m take $\frac{C'}{A} = 0.06 m^3/hr\text{-}m^2\text{-}m$.

1/ specific capacity $= C$

$Q = 12$ lit/s $= 12 \times 10^{-3} m^3/s$

$Q' = CAS'$

$12 \times 10^{-3} = \dfrac{0.06}{60 \times 60} \times \dfrac{\pi d^2}{4} \times 2m$

$d = 21.4m$.

TUBE WELL

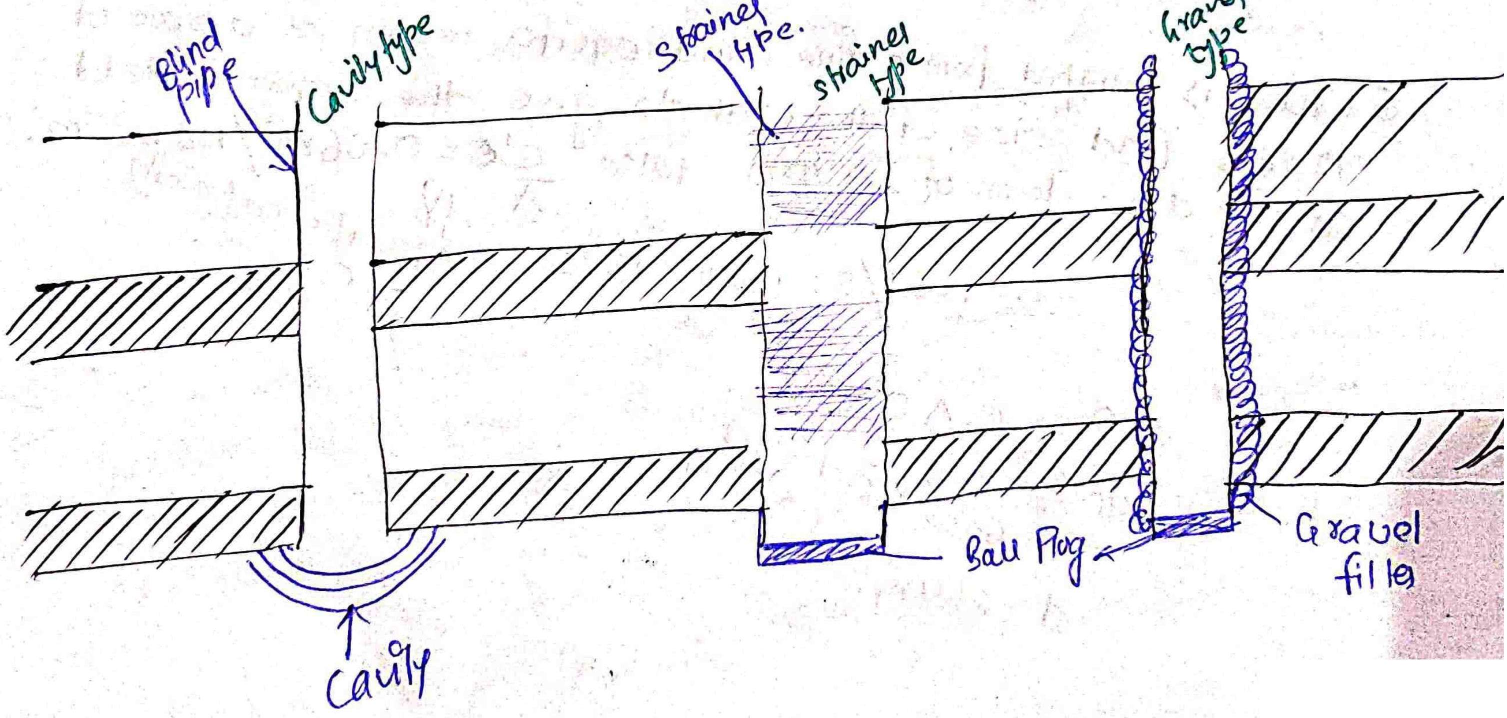
Discharge from the open well is limited in the range of 5-10 lit/sec whenever discharge from tube well extends upto 200-220 lit/sec as they derive their water from depth of 70-300 m.

→ Gravity type tube well are those tube well which utilize the water from the bottom.

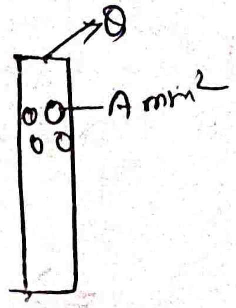
→ whereas screen type tube well are those which utilise water from the surface.

→ In order to prevent the entery of the medium particles into the well along with the flowing water screens are used & gravel pack type tube well.

capacity of well will reduce if medium particles will inters into the screen type well not in cavity type since there is no option of sedimentary of particles in cavity type.



Q what is the strainer length required for a tube well giving a discharge of 8L/s? Assume permissible entrance velocity of ~~20m~~ 2cm/s. It is desired to have the strainer of slot 20mm X 0.2mm with no. of slots per cm of the strainer as 100.



$Q = A_s \times V$

$A = \frac{Q}{V} = \frac{8\times10^{-3}}{2\times10^{-2}}$

$A_s = 0.4 m^2$

$A_s = n A_{s1}$

$0.4 = L \times 10^4 \times (20 \times 0.2) 10^{-6}$

$L = 10M$

1 cm = 100
1 m = 100×100

Yield of Tube Well

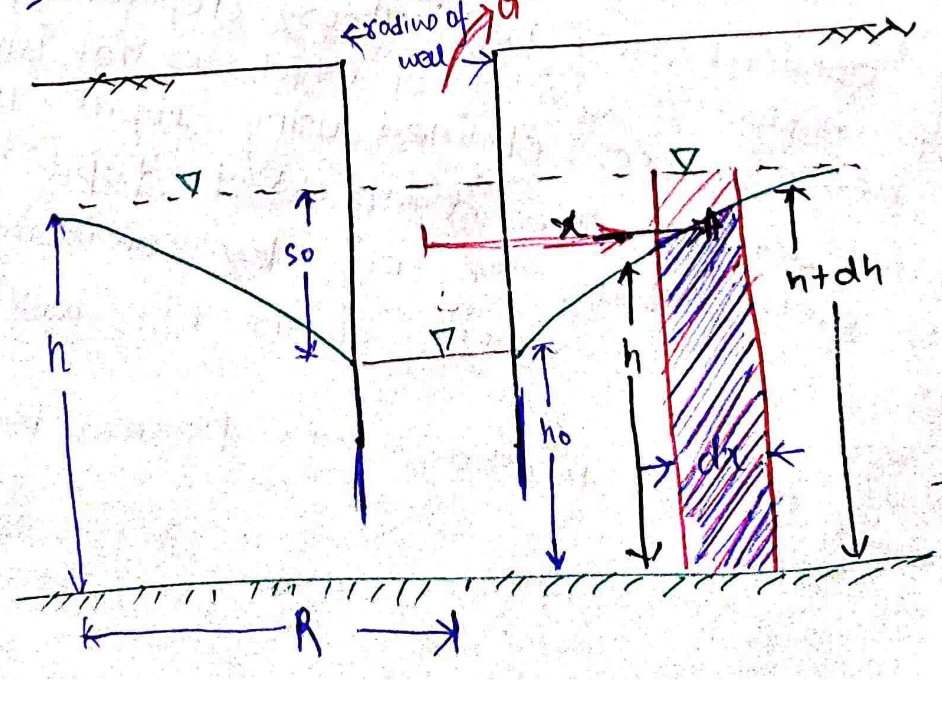
(1) DUPIT'S theory
(2) Themi's theory.

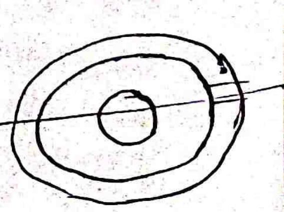
In ~~con~~ Unconfined Aquifer:-

Dupuit's theory:-

Assumption:-

(i) Medium is homogenious, isotropic, infinite.
(ii) Flow is radial, horizontal and laminar in the vicinity of the well.
(iii) for small elevation [water surface] $\sin\theta = \tan\theta$.





$$q_x = a_x V_x$$
$$= (2\pi x h) K \frac{dh}{dx}$$

$$Q = \int q_x = \int 2\pi x h \frac{dh}{dx}$$

$$\Rightarrow Q \int_{x=r_w}^{x=R} \frac{dx}{x} = \int_{h=h_0}^{h=H} 2\pi K h \, dh$$

$$\Rightarrow Q \left| \ln x \right|_{r_w}^{R} = 2\pi K \left| \frac{h^2}{2} \right|_{h_0}^{H}$$

$$\Rightarrow Q = \frac{2\pi K \left(\frac{H^2 - h_0^2}{2} \right)}{2.303 \log_{10}(R/R_w)}$$

$$\boxed{\Rightarrow Q = \frac{\pi K (H^2 - h_0^2)}{2.303 \log_{10}(R/R_w)}}$$

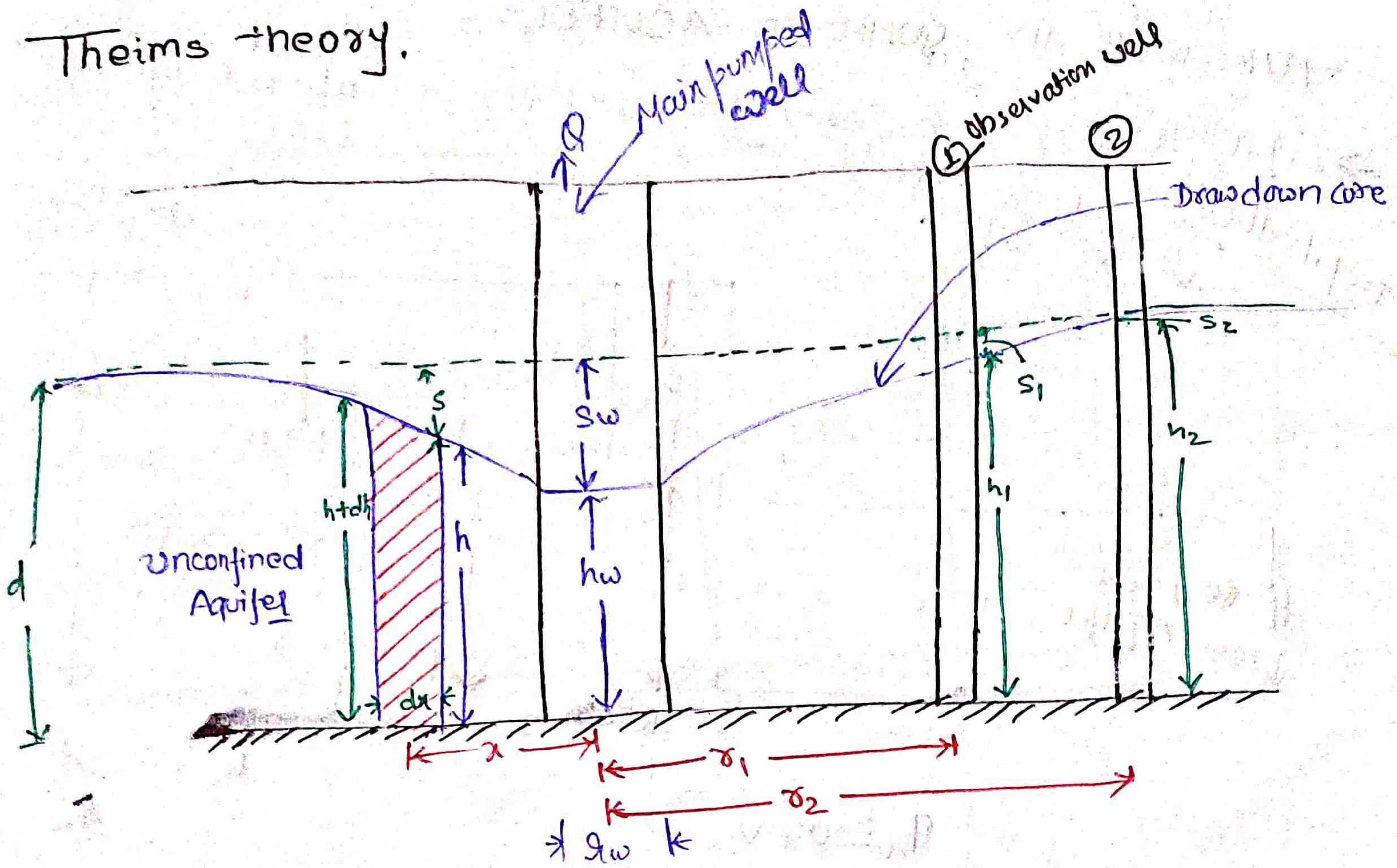
$R = 150 - 300\,m.$

Schidart eqⁿ = $\underset{(m)}{R} = 3000 \underset{(m)}{S} \sqrt{K}$ m/sec.

S = draw drawn due to correspo to constant discharge.

Note:- Discharge obtained using Dupit's theory depend upon radios radius of influence value of which is not known precisely hence resces obtained using Dupit's theory deviates from actual. This drawback of dupit's theory was further eliminated by Thiem's by considering two observation well in the vicinity of the test well to the drawback. corresponding a particle discharge beigs pumped from the test well.

Theims theory.



$$q_x = a_x \times V_x = (2\pi x h) K i_x$$

$$= (2\pi x h) K \cdot \frac{dh}{ds}$$

$(\sin\theta = \tan\theta)$
$\frac{dh}{ds} = \frac{dh}{dx}$

$$\Rightarrow q_x = (2\pi x h) K \cdot \frac{dh}{dx}$$

$$\Rightarrow Q = \int q x = \int 2\pi x h K \frac{dh}{dx}$$

$$\Rightarrow Q \int_{r_w}^{r_1} \frac{dx}{x} = 2\pi K \int_{h=h_w}^{h=h_1} h \, dh$$

$$\Rightarrow Q \left| \ln x \right|_{r_w}^{r_1} = 2\pi K \left[\frac{h^2}{2} \right]_{h_w}^{h_1}$$

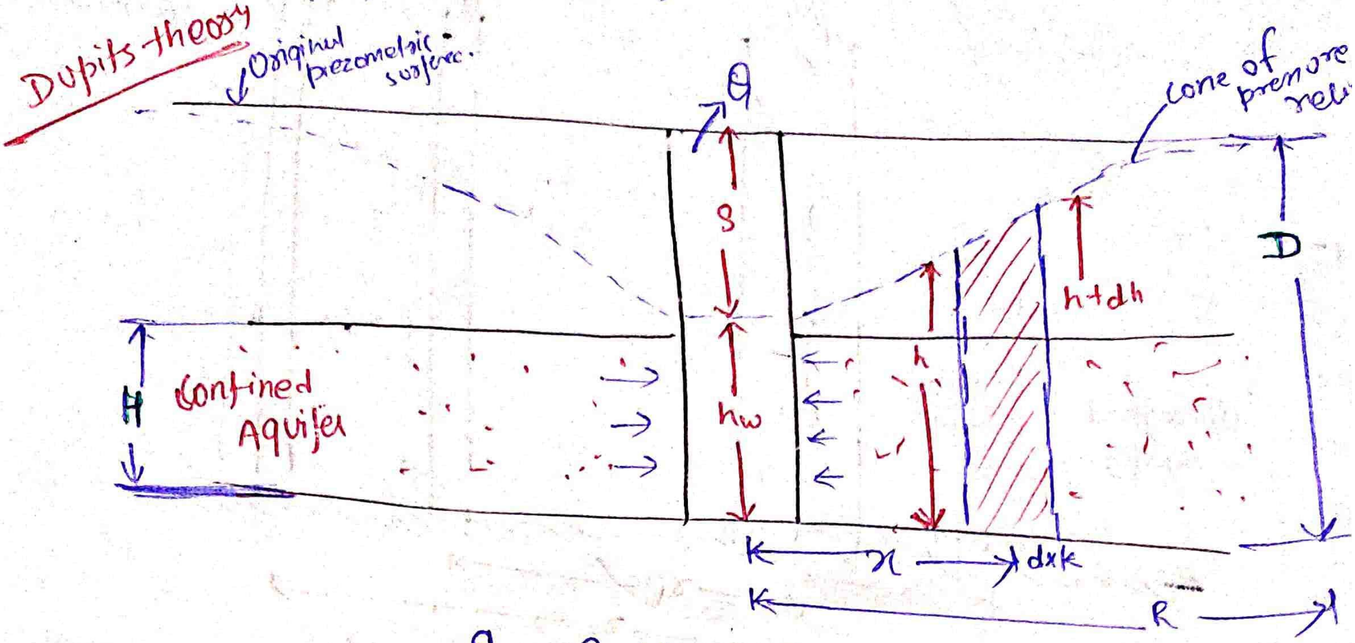
$$\Rightarrow \boxed{Q = \frac{\pi K [h_1^2 - h_w^2]}{2.303 \log_{10}\left(\frac{r_1}{r_w}\right)}}$$

or, $\boxed{Q = \frac{\pi K [h_2^2 - h_1^2]}{2.303 \log_{10}\left(\frac{r_2}{r_w}\right)}}$ or $\boxed{Q = \frac{\pi K [h_2^2 - h_1^2]}{2.303 \log_{10}\left(\frac{r_2}{r_1}\right)}}$

TUBE WELL in CONFINED AQUIFER :-

→ Dupit's theory was only proposed for unconfined aquifer

Dupits theory



$$q_x = a_x V_x$$

$$= 2\pi x H k i$$

$$= 2\pi x H k \frac{dh}{dx}$$

$$Q = \int q_x = \int 2\pi x H k \frac{dh}{dx}$$

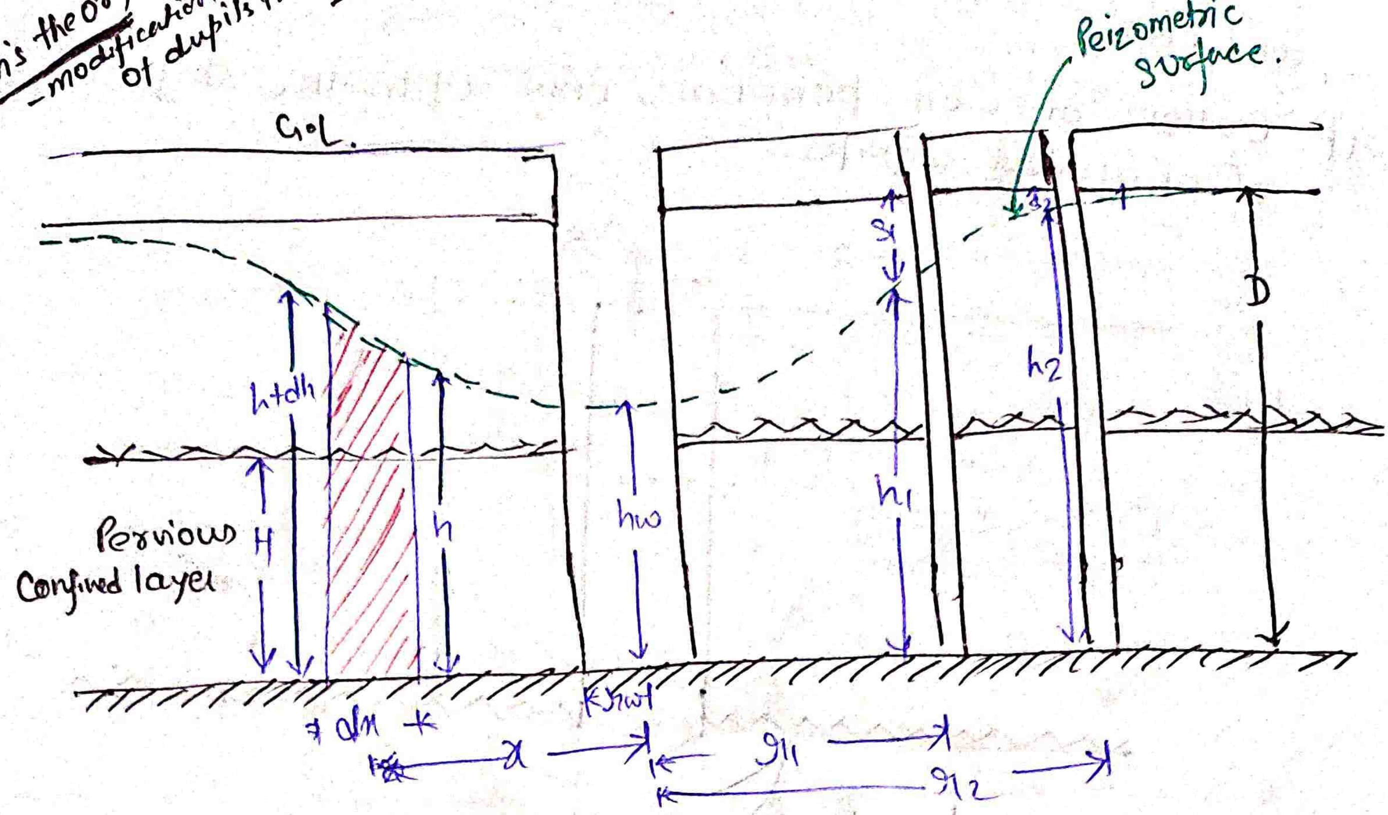
$$Q \int_{x=r_w}^{x=R} \frac{dx}{x} = 2\pi K H \int_{h=h_w}^{h=D} dh$$

$$Q \left| \ln x \right|_{r_w}^{R} = 2\pi K H \left[H \right]_{h_w}^{D}$$

$$\boxed{Q = \frac{2\pi K H (D - h_w)}{2.303 \log_{10}\left(\frac{R}{r_w}\right)}}$$

KH = transmissibili

Thiem's theory
– modification of dupit's theory.



$$q_x = a_x V_x$$
$$= (2\pi x H) K i_x$$
$$= (2\pi x H) K \frac{dh}{dx}$$

$$\Rightarrow Q = \int q_x = \int 2\pi x H K \frac{dh}{dx}.$$

$$\Rightarrow Q \int_{x=r_w}^{x=r_1} \frac{dx}{x} = 2\pi H K \int_{h=h_w}^{h_1} dh$$

$$\Rightarrow Q \left| \ln x \right|_{r_w}^{r_1} = 2\pi H K \left[H \right]_{h_w}^{h_1}$$

$$\Rightarrow \boxed{Q = \frac{2\pi H K [h_1 - h_w]}{2.303 \log_{10}\left(\frac{r_1}{r_w}\right)}}$$

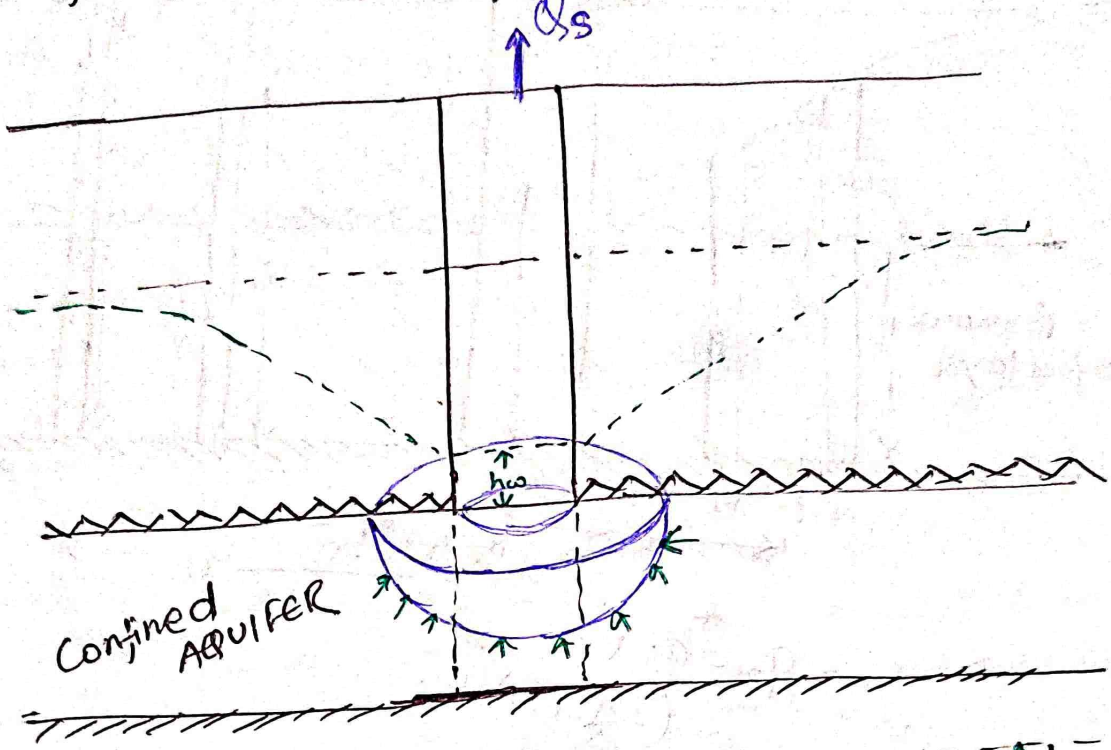
or,

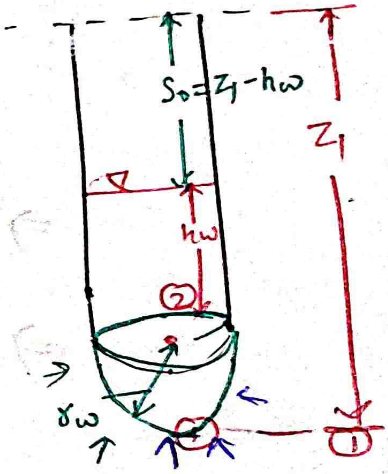
$$\boxed{Q = \frac{2\pi H K [h_2 - h_w]}{2.303 \log_{10}\left(\frac{r_2}{r_w}\right)}}$$

$$\boxed{Q = \frac{2\pi H K [h_2 - h_1]}{2.303 \log_{10} [r_2/r_1]}}$$

Special case.

→ If Bottom of well penetrates only upto the top surface of confining aquifer.





$$Q_s = A\,V$$

$$= (2\pi r_w^2)\,Ki$$

$$= 2\pi r_w^2 \cdot K \cdot \frac{S_0}{r_w}$$

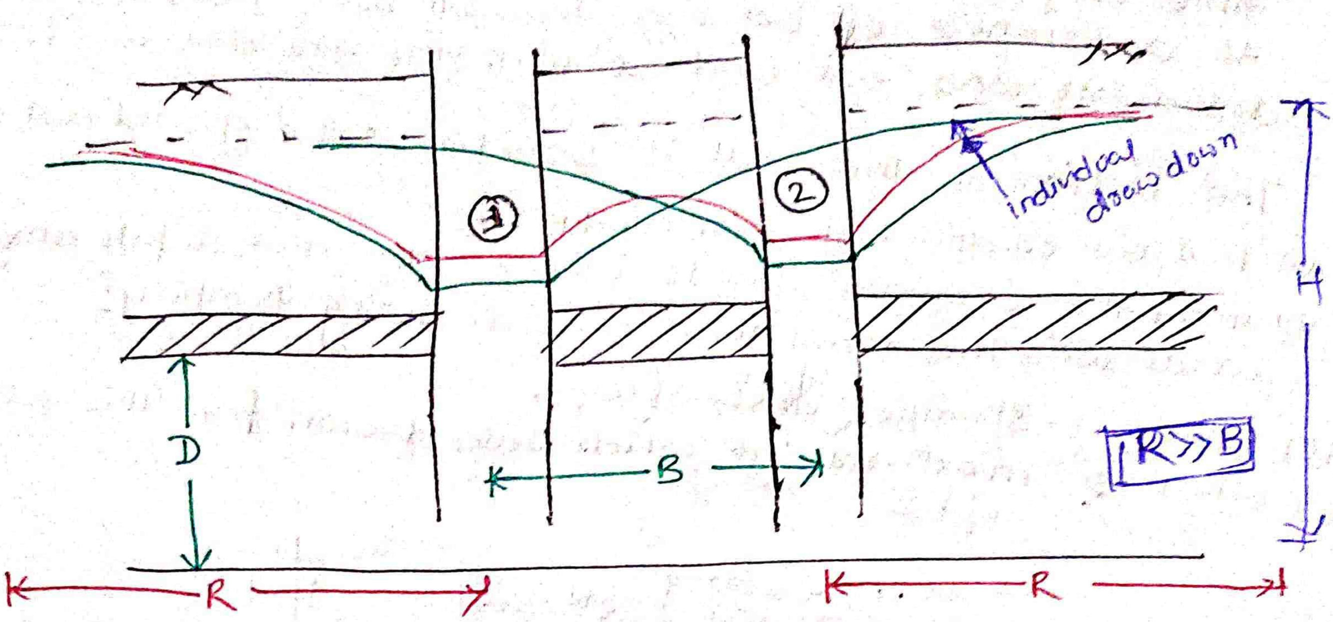
$$\boxed{Q = 2\pi r_w K S_0} \quad \text{(i)}$$

$$Q_R = \frac{2\pi KH(D - h_w)}{2.303\log_{10}(R/r_w)}$$

$$\boxed{Q_R = \frac{2\pi K H S_0}{2.303\log_{10}(R/r_w)}} \quad \text{(ii)}$$

$$Q_s = \left(\frac{1}{20} \text{ to } \frac{1}{30}\right) Q_R$$

If two wells are situated nearby to each other such that their draw down interfere within the radius of influence.

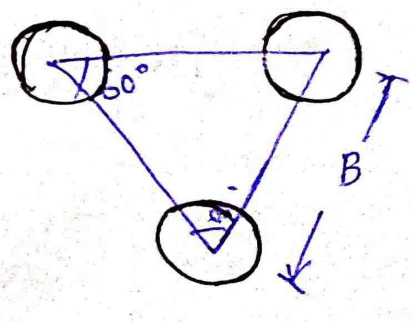


$$Q_1 = Q_2 = Q_T = \frac{2\pi KD(H-h_w)}{2.303\log_{10}(R/R_w)}$$

$$Q_1' = Q_2' = \frac{2\pi KD(H-h_w)}{2.303\log_{10}\left(\frac{R^2}{r_w B}\right)} < Q_1 = Q_2$$

$$Q_T' = Q_1' + Q_2' > Q_T$$

(3) $$Q_1'' = Q_2'' = Q_3'' = \frac{2\pi KD(H-h_w)}{2.303\log_{10}\left(\frac{R^3}{r_w B^2}\right)}$$



$$Q_1'' = Q_2'' = Q_3'' < Q_1' = Q_2' < Q_1 = Q_2$$

$$Q_T'' = Q_1'' + Q_2'' + Q_3'' > Q_T' > Q_T$$

Q A 60cm dia well is pumped at a rate of 1360 l/m. Measurement in a nearby test well are made at the time as follow:-

At a distance of 6m from the well being pumped, the drawdown was 6m and at 15m the drawdown was 1.5 m.

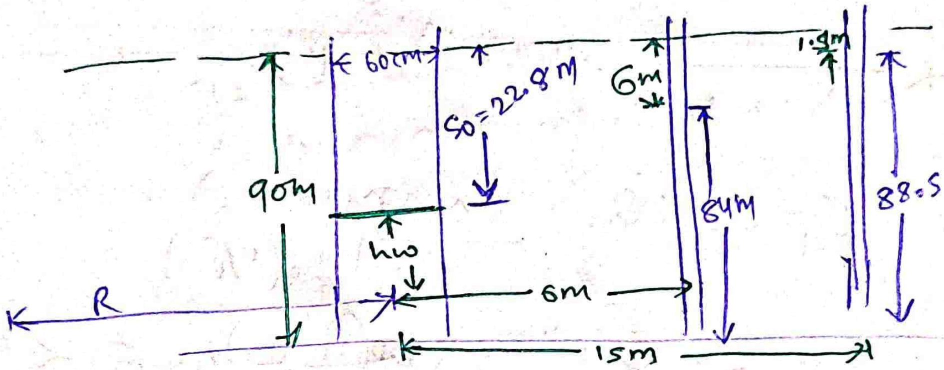
The bottom of the well is 90m below the ground watertable.

(a) find out co-efficient of permeability.

(b) If all the observed points where one the dupits case, what was the draw down in well, during pumping?

(c) what is specific ~~gravity~~ capacity of well.

(c) what is maxm rate at which water drawn from this well.



$Q = 1360$ l/min $= \frac{1360 \times 10^{-3}}{60}$ m^3/s $= 0.0226$

(1) $$Q = \frac{\pi K[h_2^2 - h_1^2]}{2.303 \log_{10}\left(\frac{r_2}{r_1}\right)}$$

$r_w = \frac{60}{2} = 30$ cm $= 0.3$

$$\frac{1360 \times 10^{-3}}{60} = \frac{\pi K\left[88.5^2 - 84^2\right]}{2.303 \log_{10}\left(\frac{15}{6}\right)}$$

$$K = 8.51 \times 10^{-6} \text{ m/sec.}$$

(2) $$Q = \frac{\pi K\left[h_1^2 - h_w^2\right]}{2.303 \log_{10}\left[\frac{r_1}{r_w}\right]}$$

$$\frac{1360 \times 10^{-3}}{60} = \frac{\pi \times 8.51 \times 10^{-6} \times \left[84^2 - h_w^2\right]}{2.303 \times \log_{10}\left[\frac{6}{0.3}\right]}$$

$$2540.306 = 84^2 - h_w^2$$

$h_w = 67.198$ drawdown $= 22.80$

(c)

for, $Q = Q_{sc} \Rightarrow S_0 = 1\,m$

$h_w = H - S_0 = 90 - 1 = 89\,m$.

By Dupuit's theory.

$$Q = \frac{\pi K (H^2 - h_w^2)}{2.303 \log_{10} (R/r_w)}$$

$$\frac{1360 \times 10^{-3}}{60} = \frac{3.14 \times 8.51 \times 10^{-6} [90^2 - 67.22^2]}{2.303 \log_{10} (R/0.3)}$$

$R = 20.5\,m$

$$Q_{sc} = \frac{\pi K (H^2 - h_w^2)}{2.303 \log_{10} (R/r_w)}$$

$$= \frac{\pi \times 8.51 \times 10^{-6} (90^2 - 89^2)}{2.303 \log_{10} (20.5/0.3)}$$

$Q_{sc} = 1.13 \times 10^{-3}\, m^3/sec$.

Or $$Q_{sc} = \frac{Q}{S} = \frac{\frac{1360 \times 10^{-3}}{60}}{22.78}$$

$= 9.9 \times 10^{-4}\, m^3/sec$

50

Non- Equilibrium flow [Unsteady flow]

Theis theory :→ Gives the solution of this in terms of well function. $w(U)$

Well function → it is a complex integral which is used to find drawdown in well pumping.

$$w(U) = -0.5772 - \ln U + U + \text{Higher terms of } U$$

$\rightarrow$ neglected.

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

S = storativity.
T = transmissibility.
t = time after which draw down is calculated in observation well.

$$S(t, r) = \frac{Q}{4\pi T} \times \text{well function}$$

$$s(t, r) = \frac{Q}{4\pi T} \times w(U)$$

As per Jacob's Modification,

$$w(U) = -5772 - \ln\left(\frac{r^2 S}{4Tt}\right)$$

$$w(U) = \ln\left(\frac{4Tt}{r^2 S}\right) - 0.5772$$

$$s(t, r) = \frac{Q}{4\pi T}\left[\ln\left(\frac{4Tt}{r^2 S}\right) - 0.5772\right]$$

Q Give the characteristic of different formation in which ground water exist. A fully penetrating artesian well is discharging at a rate of 25 liter/s. The storage co-efficient and transmissibility of the acquifer are 4.5×10^{-4} and $0.15\ m^2/min$ respectively. Find the drawdown at,

(i) A radius of 5m distance after 2 hours pumping.
(ii) A radius 180m distance after 1 day pumping.

Using the following approximation well function.

$$W(U) = -0.5772 - \ln(U) + U$$

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

① r (5m, 2hrs)

$$U = \frac{5^2 \times 4.5 \times 10^{-4}}{4 \times 0.15 \times 2 \times 60} = 1.5625 \times 10^{-4}$$

$$W(U) = -0.5772 - \ln(U) + U$$
$$= -0.5772 - \ln(1.5625 \times 10^{-4}) + 1.5625 \times 10^{-4}$$
$$= 8.187$$

S (5m, 2h)

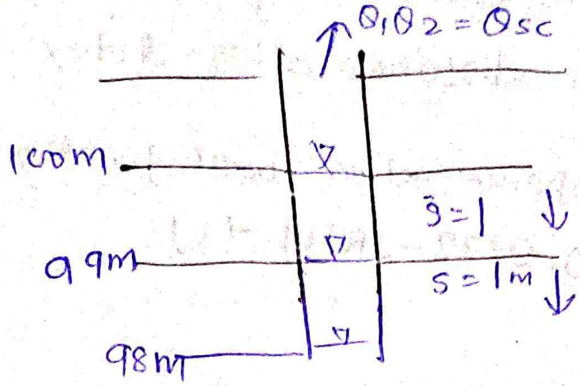
$$= \frac{Q}{4\pi T}(W(U))$$

$$= \frac{25 \times 10^{-3}}{4 \times \pi \times 0.15} \times 8.187$$
$$= 6.51 m.$$

② r (~~180m~~ 180m, 24hr) = 3.087

Specific Capacity of tube well.

- Rate of flow through the well per unit drawdown.
- It is calculated for initial 1st meter fall of height of water in well.
- And it is not same for all the unit drawdown.



Note:-

$$Q = \frac{\pi K (H^2 - h_0^2)}{2.303 \log_{10}(R/r_w)}$$

$$= \frac{\pi K (H - h_0)(H + h_0)}{2.303 \log_{10}(R/r_w)}$$

$$= \frac{\pi K S_0 (H + h_w)}{2.303 \log_{10}(R/r_w)}$$

$$\boxed{S_0 = C_1 Q}$$ — Aquifer loss.

$$h_f = \frac{fl v^2}{2gd} = \frac{f l Q^2}{2gd A^2}$$

$$\boxed{S_w = C_2 Q^2}$$ well loss.

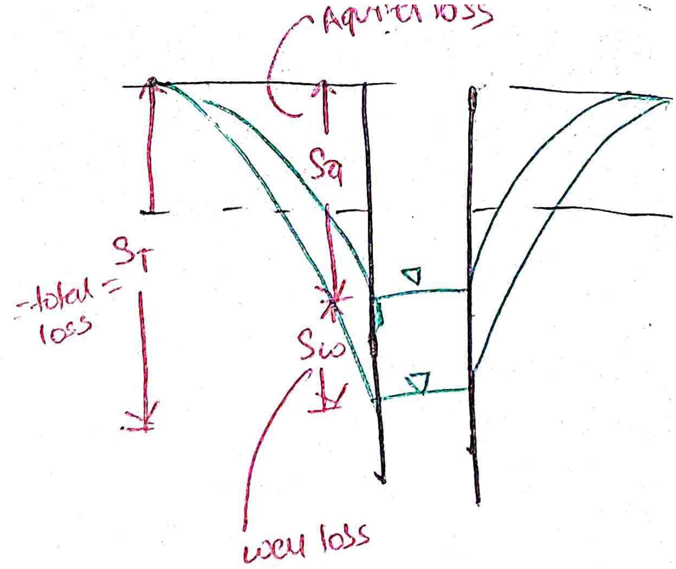
$$S_T = S_a + S_w = C_1 Q + C_2 Q^2$$

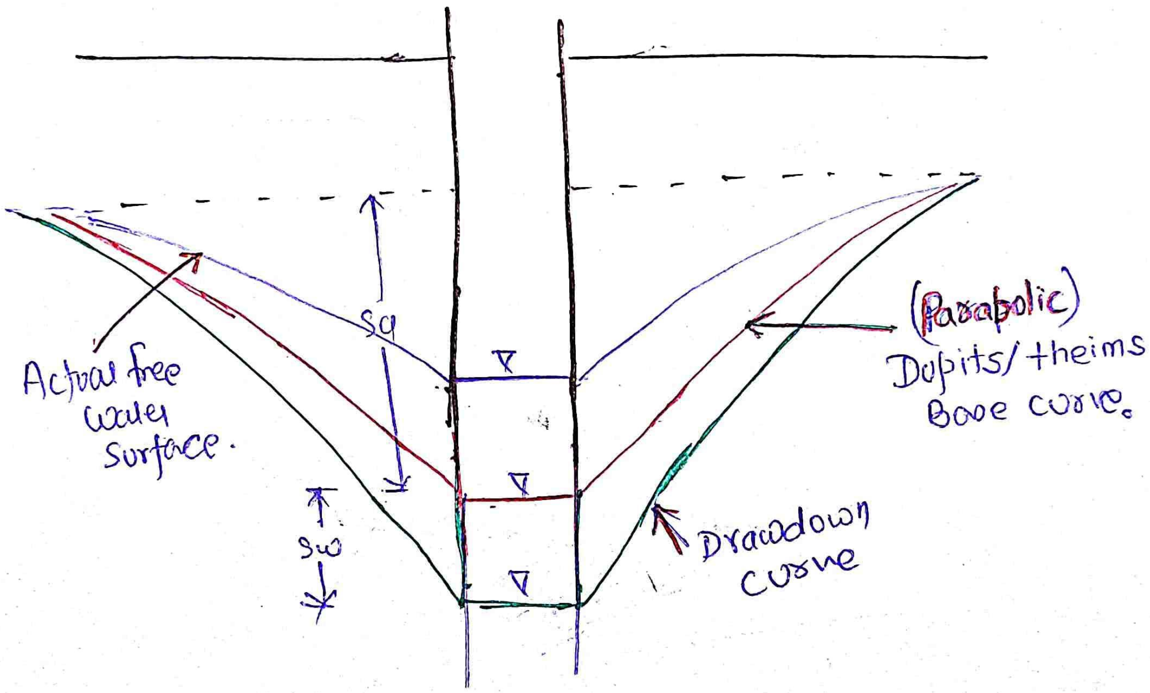
Specific capacity $= SC = \dfrac{Q}{S_T}$

$$= \frac{Q}{C_1 Q + C_2 Q^2}$$

$$\boxed{SC = \frac{1}{C_1 + C_2 Q}}$$

$$\boxed{SC \propto \frac{1}{Q}}$$





Well development:- Quantity ↑ , Quality ↑