ENVIRONMENTAL ENGINEERING

Notes by-

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[OURCES OF WATER SUPPLY]

Artificial Rainfall:-

Spraying silver iodide or compressed carbon di oxide in vapourized form on water bearing clouds. At temp. of -15°C water vapour will condense & freeze are solid nuclei present in the clouds & the starts falling in the form of snow or rain.

Following are imp. points for artificial rainfall:-

1) Vaporization of Silver iodide or compressed CO_2 is carried out when atmospheric i.e. metrological conditions are favourable.
2) It does not alter or modify the weather condition. Hence not effective remedy for serious drought.
3) Not economical.

Total quantity of water on earth = 1455×10^6 km^3.

Sea =	94 %
Underground water =	4 %
Glaciers =	1.65 %
Lakes, rivers, soil moisture =	0.35 %
Total.	100 %

Area of sea = 71 %
Area of land = 29 %

Sources of water:-

1) Precipitation / Runoff
2) Surface Sources:- a) Lakes & streams.
   b) Ponds.
   c) Rivers.
   d) Storage reservoirs.
3) Underground Sources:- a) Infilteration galleries.
   b) A° Infilteration wells.
   c) Springs
   d) Wells

EE-B

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* Surface runoff :-

Rainfall on an area is expressed in mm over the entire area for a fixed interval of time say hr, day, month, year etc.

∴ Quantity of water = Rainfall (mm) × Area of catchment (mm^2)

Losses of water :-

a) Evaporation :- loss of water from land & water surface due to action of heat radiated by sun.

b) Percolation :- Penetration of water in to soil. It may or may not reach to underground source of water. - If reaches - infilteration.

c) Transpiration :- loss of water caused by leaves of growing vegetations.

∴ Surface runoff = Precipitat^n − (Evaporat^n + Percolat^n + Transpirat^n)

* Disadvantages of surface runoff :-

1) To store surface runoff, costly reservoirs are essential.
2) Erosion of soil.
3) Loss of water.
4) Occurance of flood.

* Catchment area : The upstream area contributing to the water of a river is known as catchment area.

* Runoff coefficient = $\frac{\text{Surface runoff}}{\text{Total rainfall on a area for a fixed time}}$

This runoff coeff. indicates % age of water available for consumption after all losses.

* Factors affecting runoff coeff :-

1) Area of catchment ∝ Runoff coeff.
2) Characteristics of catchment :- size, slope, vegetation, porosity, shape etc.
3) Condition of ground at the time of rainfall :-

Dry cond^n ⇒ More absorpt^n of water ⇒ Less runoff coeff

Wet cond^n ⇒ Less ⇒ More

4) Intensity of rainfall:-
Heavy rainfall in short time ⇒ less time for absorpt^n ⇒ More runoff coeff.
Light rainfall in long time ⇒ More ⇒ Less

5) Interval bet^n two successive shower:-
Smaller ⇒ More surface runoff coeff. & vice versa.

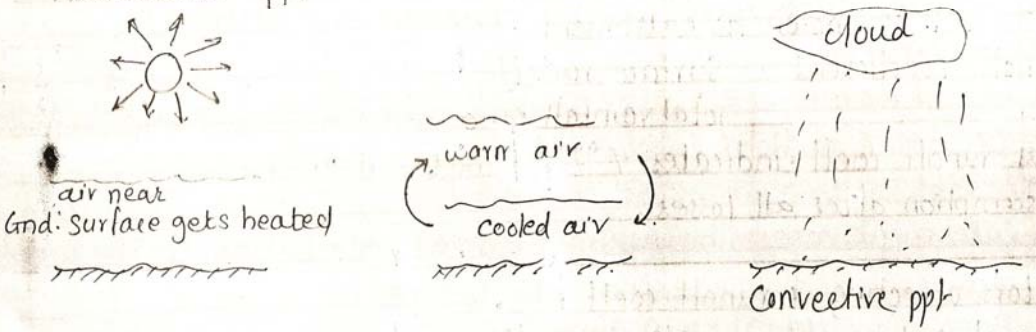
6) Season of rainfall:-
Hot season ⇒ less runoff coeff
Cold season ⇒ More runoff coeff

7) Yearly rainfall ∝ Runoff coeff.

* Precipitation - The water returns to surface of earth in various forms like rain, snow, drizzle, fog, smog, moisture. etc.

* Type of precipitation:-
a) Convective ppt
b) Cyclonic ppt
c) Orographic ppt.

a) Convective precipitation:-
On hot day, gnd. surface gets heated, in an unequal manner. This warmer air gets replaced & lifted by cooled air. Due to movement of such air an air current of high vel. forms causing ppt. known as convective ppt.



b) Cyclonic ppt:-
A cyclone is air mass having dia 800-1600 km moving with vel. 50 km/hr. The pre. inside cyclone is low & acts as chimney through which gas is lifted. Air lifted gets expand, cooled & ultimately gets condensed causing cyclonic ppt.

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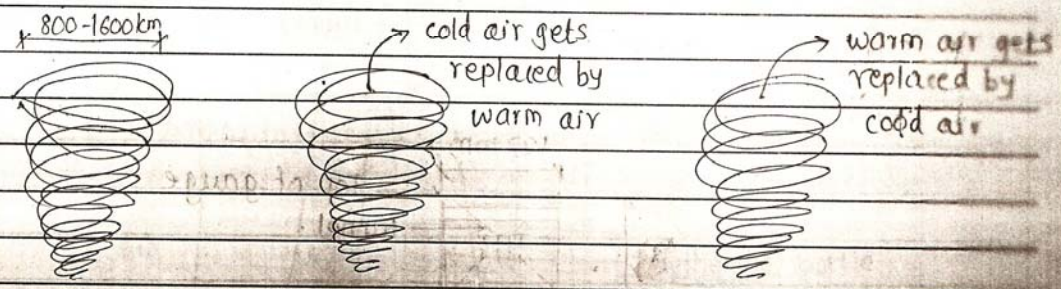
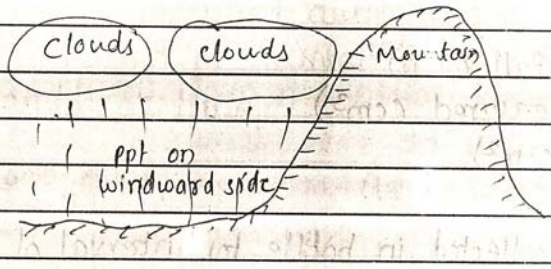
In cyclonic ppt, if cold air gets replaced by warm air, it is known as 'warm front' or on the other hand, if warm air gets lifted by replaced by cold air, it is known as 'cold front'. Ppt. caused by warm front is continuous while that of cold front is very intense & of short duration.



c) Orographic ppt. :-

When air mass strikes some natural obstructions like mountains & when they couldn't move up the causes condensation & ppt. The most of the ppt. is on windward side & little ppt on leeward side.

It is composed of shower & steady rainfall. This is reasonable for most of the heavy rain in the country.

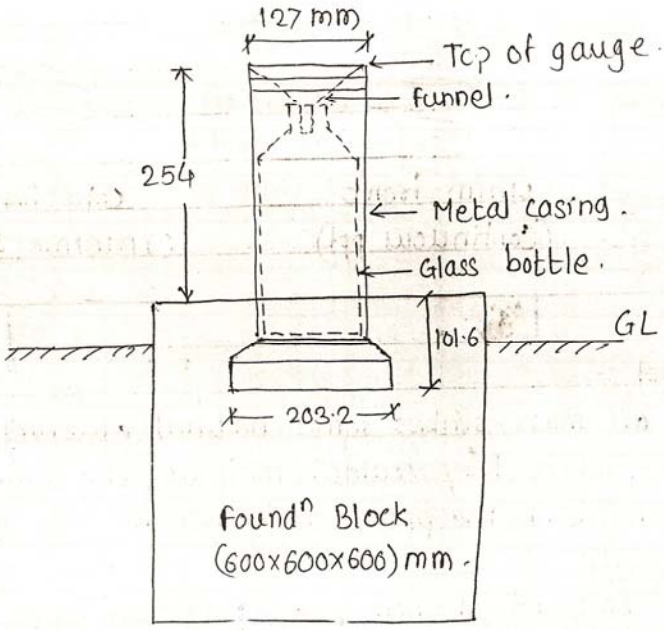


* Measurement of rainfall:-

1) Non recording rain gauges :-
   a) Simon's rain gauge.
   b) Standard non-recording rain gauge.

2) Recording or automatic rain gauge :- / Integrating / continuous rain gauge.
   a) Floating type rain gauge
   b) Tipping bucket type rain gauge.

a) Simon's rain gauge:-



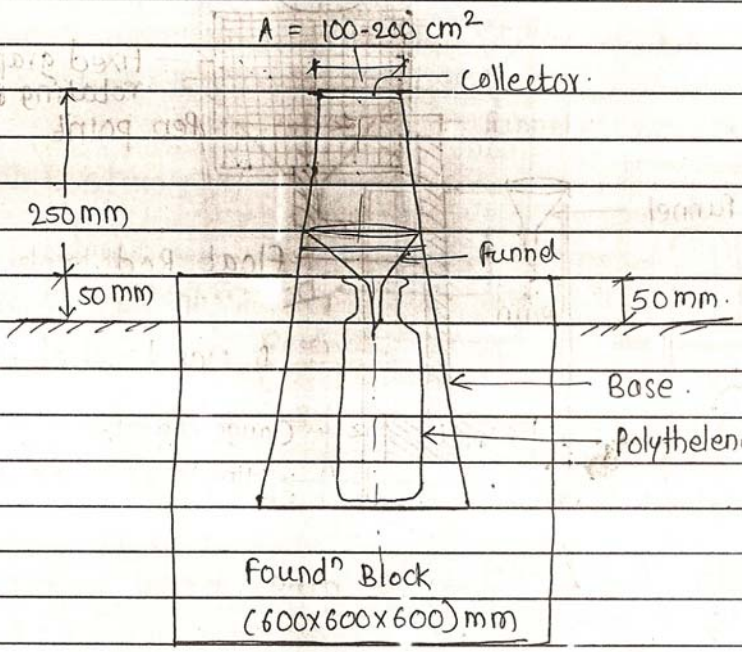
$$h = \frac{V}{A}$$

h = Depth of rain fall (cm)
V = Vol. of water measured (cm^3)
A = Area of gauge (cm^2).

Amount of rain water collected in bottle for interval of 24 hr. In case of heavy rainfall, to avoid overflow of bottle, reading may be taken at 8 hr. interval.

According to area of catchment, total qty. of water is calculated.

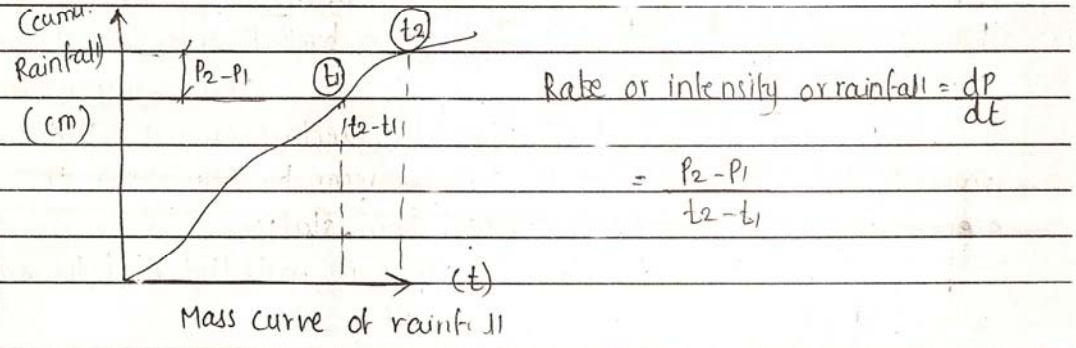
b) Standard non-recording rain gauge:-



Area of collector = 100 - 200 cm².
Size of polythelene bottle - 2, 4, 10 lit.

a) Recording or automatic rain gauges:-

Rainfall is record d on a graph paper fixed on a rotating drum. The mechanis n is such that cumulative curve is obtained autom tically. This curve is known as "Mass curve of rainfal" & it p oduces record of cumulative rainfall Vs. time.



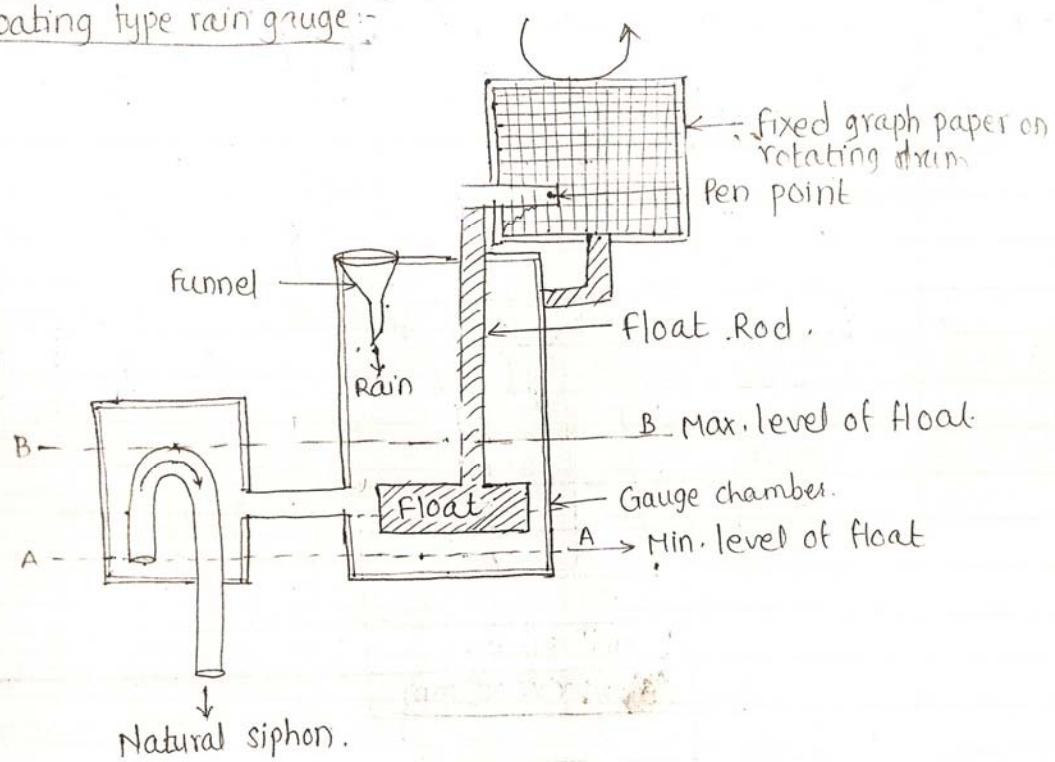
Rate or intensity or rainfall = $\frac{dP}{dt}$

$= \frac{P_2 - P_1}{t_2 - t_1}$

Mass curve of rainfall

II] Recording type rain gauge / Integrating / Continuous Rain gauge :-

a) Floating type rain gauge :-



~~a) Rotating Drum~~ :- A rotating drum consist of graph paper fixed around it. A pene point which is in contact with graph paper moves up with the rise of float. The rain water enters through funnel gets collected in gauge chamber. When the chamber get filled up to level B-B a natural ~~syl~~ siphon starts working & rain water is drained out. At the same time floket moves downward & process continues.

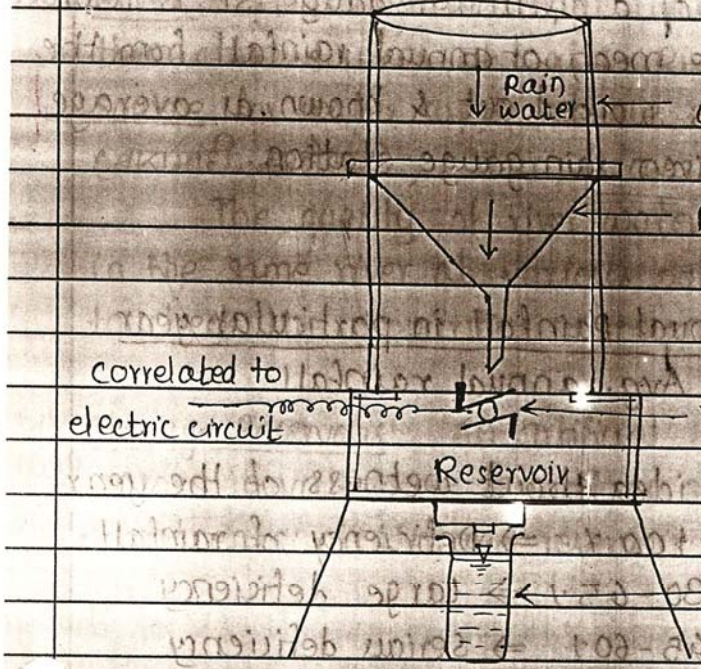
This type of rain gauge is commonly used in India.

b) Tipping bucket type gauge :-

Rain water enters in circular collector & from funnel it falls over a two compartment tipping bucket having capacity of each bucket of 0.1 mm as shown in fig. As a bucket fills for 0.1 mm, it tips, emptying ~~to~~ in to reservoir, moving to second compartment.

The tipping of bucket completes electric circuit. The cumulative rainfall can be obtained at the control room by transferring the electric waves of definite frequency from gauge station.

Thus this type of rain gauge is installed in hilly area where access in not possible everytime.



Tipping bucket Rain Gauge.

As automatic rain gauge gives cumulative rain, they are known as Integrating Rain Gauge & as they record rainfall continuously without inspection the, are also known as continuous Rain Gauge.

The rain gauges are evenly distributed over a plane area so that they can obtain representative figure of rainfall for entire area.

For hilly area they are spaced closer & for plane areas, one rain gauge station is situated for an area of 130 km².

* Factors affecting site selection for rain gauge station:-

1) Location:- They should not be located in slopping, valley, hilly areas & should be installed in a large flat area & at key point.
2) Side Protection:- Side of rain gauge st° is protected from strong winds, other factors like animals or human etc.
3) Obstruction:- Rain gauge st° should not be obstructed by any building, trees, walls etc, within the radius of double the ht. of rain gauge from ground.

* Average annual Rainfall:-

The annual rainfall of a given rain gauge st^n is re for a number of year & the mean of annual rainfall from record of 35 years or so is worked out & known as aver annual rainfall at the given rain gauge station.

* Index of Wetness :-

$$\text{Index of wetness} = \frac{\text{Annual Rainfall in particular year}}{\text{Avg. annual rainfall}}$$

Index of wetness gives idea about wetness of the ye

Index of wetness $< 100\%$ ⇒ Deficiency of rai

→ 30-45% ⇒ Large deficiency

→ 45-60% ⇒ serious deficiency

→ $> 60\%$ ⇒ disastrous deficienc

* Minimum annual Rainfall:- (Bad year / dry year / Sub-normal

The study of rainfall for a given rain gauge st^n is r for number of years & then minimum annual rainfall recorded. The storage capacity of reservoir is based on H data.

* Types of Sources:-

According to proximity to the gnd surface, sources are cl

I] Surface Sources:-

(तळे) a) Lakes:- Large body of water within land with imper

Lakes are the sources of water for adjoining area. while locating Water treatment plant, it should be cor that supply should not less than the demand, or other there will be deficiency of water during hot season.

(तलाव) b) Ponds:- It is man-made body of standing water small quantity of water is very small containing impurities So pond can not be considered as source of u supply.

c) River :- It is observed that rivers are more throughlly studied than other sources of water. River contributes major principal source for water supply scheme. In case of non-perennial rivers (बारामाही नसलेल्या), a dam is constructed across river.

The quality of river water is not same in all rivers & in the same river at various position. Therefore it is essential to check the impurities in the river.

d) Storage Reservoirs :- An artificial lake formed by const^n of dam across a valley is termed as storage reservoir. The major components of storage reservoir are :- i) Dam
ii) Spillway
iii) Regulatory accessories, gate.

Storage reservoirs are also a major source of water supply scheme for big cities.

* Fact Factors affecting selection of source :-
1) Economy
2) Elevation :- Flow should be by gravity so that const^n & maintenance cost of pumping equipments are avoided.
3) Location :- Nearer to city to avoid cost of pipes, regulatory valves etc
4) Quality of water :-
5) Quantity of water :-

* Factors affecting selection of site for reservoir :-
1) Submerged area.
2) Availability of 3M (Man, Matl, Machinary)
3) Found^n condition.
4) Geological conditions.
5) Cht. of catchment area.
6) Dist. bet^n site & distribution area.
7) Elevation of reservoir
8) Transportat^n or communicat^n facility / accessibility
9) Nature of land to be acquired

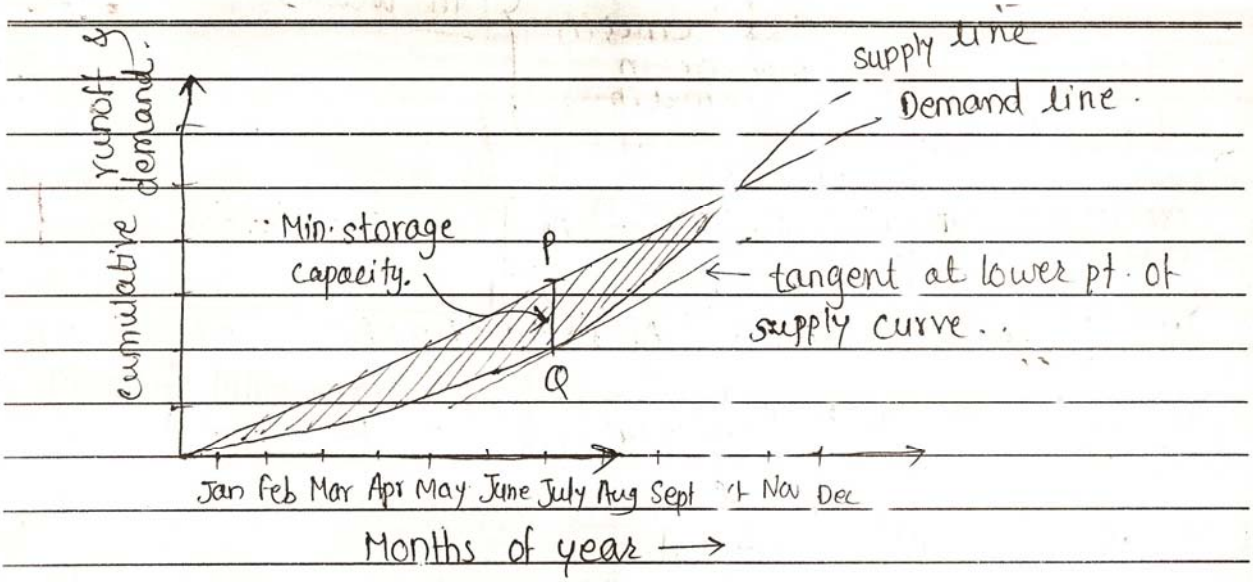
10) Quality & quantity of water.
11) Watertightness of bed.

* Storage Capacity of reservoir :-
There are two methods for calculating storage capacity

a) Analytical mtd :-
b) Graphical / Mass curve mtd :-

a) Analytical mtd :-
1) Calculate avg. monthy rainfall for each month.
2) Calculate avg. coeff. of runoff for each month.
3) Surface Runoff = avg. monthy rainfall × avg. coeff.
4) Net Supply = Surface Runoff − Losses (Evapo. + percolat
per month.
5) Calculate monthly demand.
6) Deficiency or surplus water = supply − demand.
7) The total deficiency of water for successive months gives capacity of reservoir.

b) Graphical or mass curve mtd :-
1) Consider worst year for calculating storage capacity. Th are marked along x axis.
2) Draw demand line on graph. as cumulative demand i.e. if demand for Jan is d_1, & that of feb is d_2, mar ordinates are d_1, (d_1+d_2), $(d_1+d_2+d_3)$ ... resp.
3) Surface runoff per month = Avg. rainfall per month × coeff. of
4) Net supply = surface runoff − losses.
5) The cumulative of net supply is drawn on graph. If is r_1 for Jan, r_2 for Feb, r_3 for Mar, ... then ordinate of r_1, Feb (r_1+r_2), Mar $(r_1+r_2+r_3)$ & so on ...
6) The portion below the demand line (hatched) is indi shortage or deficiency of water.
7) To calculate min. storage capacity to satisfy this deficien draw a tangent at lowest point of supply curve (Q). T vertical ordinate at this pt. Q to demand line (P) i.e. PQ



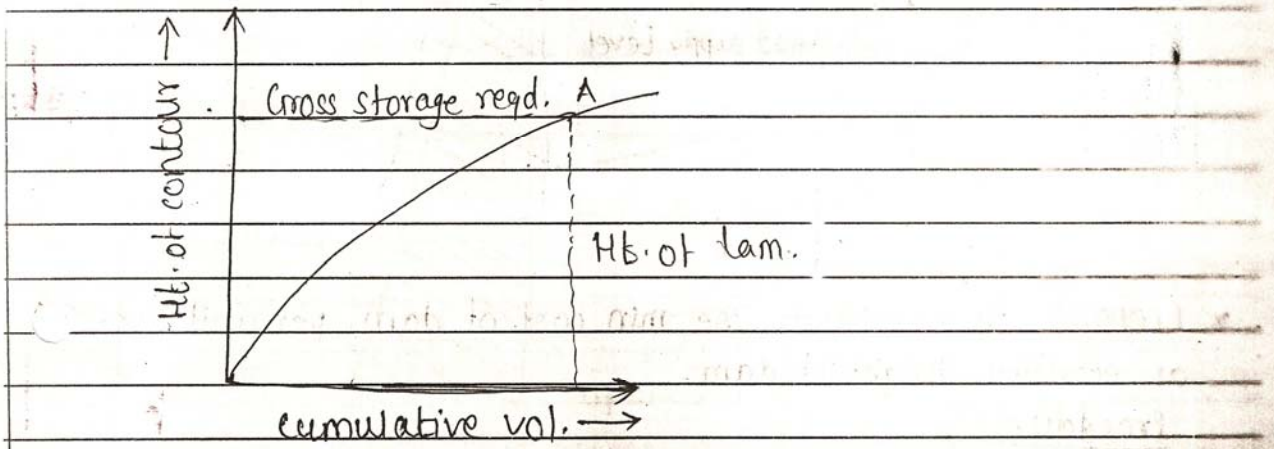
Fixing the height of dam :→

Draw contour map by surveying the site of dam.

Calculate area of each contour by planimeter.

Starting from lowest contour, cumulative vol. of contour is calculated. $V = A \times h$.

A statement showing cumulative vol Vs elevat^n of contour is prepared & plotted graphically.



The graph shows vol. of water stored for diff. heights. Thus from above graph, by drawing line at Pt. A from where we can get min. Ht. of dam for given storage capacity.

Vol. of water stored bet^n two successive contour is determined by trapezoidal formula or prismoidal formula as.

Powai - www.iitb.ernet.in
Delhi - www.iitd.ernet.in
Kharagpur - www.iitkgp.ernet.in
Madras - www.iitm.ac.in
Guwahati - www.iitg.ernet.in
Kanpur - www.iitk.ac.in
} IIT websites

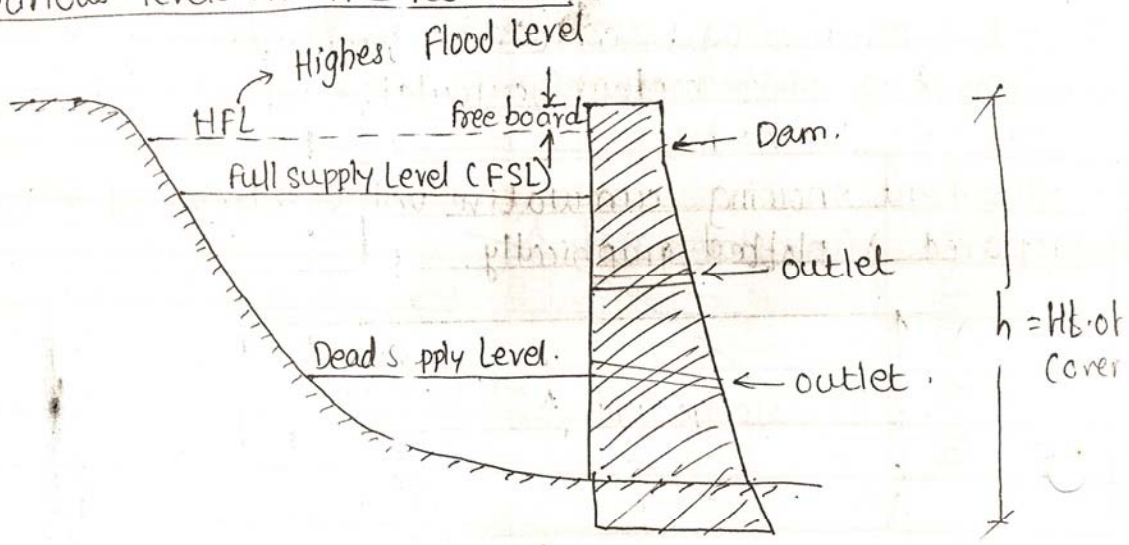
$$V = h\left[\frac{A_1 + A_n}{2} + A_2 + A_3 + A_4 \cdots + A_n\right] \rightarrow \text{Trapezoidal formula}$$

$$V = \frac{h}{3}\left[A_1 + 4(A_2 + A_4 + \cdots + A_{n-1}) + 2(A_3 + A_5 + \cdots + A_{n-2}) + A_n\right]$$

$n \Rightarrow$ odd only $\rightarrow$ Prismoidal formula.

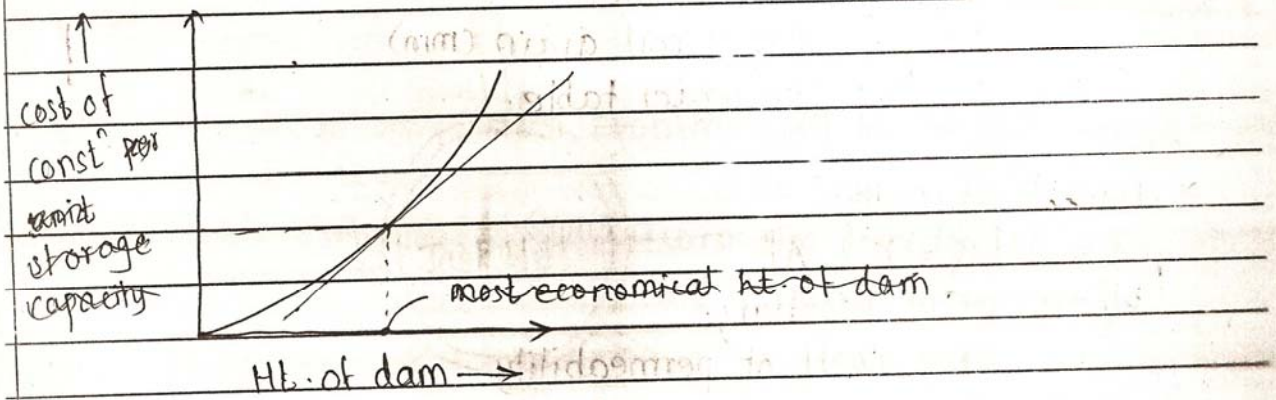
Where, V = Vol.
h = Contour interval.
$A_1, A_2, \ldots A_n$ = Areas enclosed by various contours

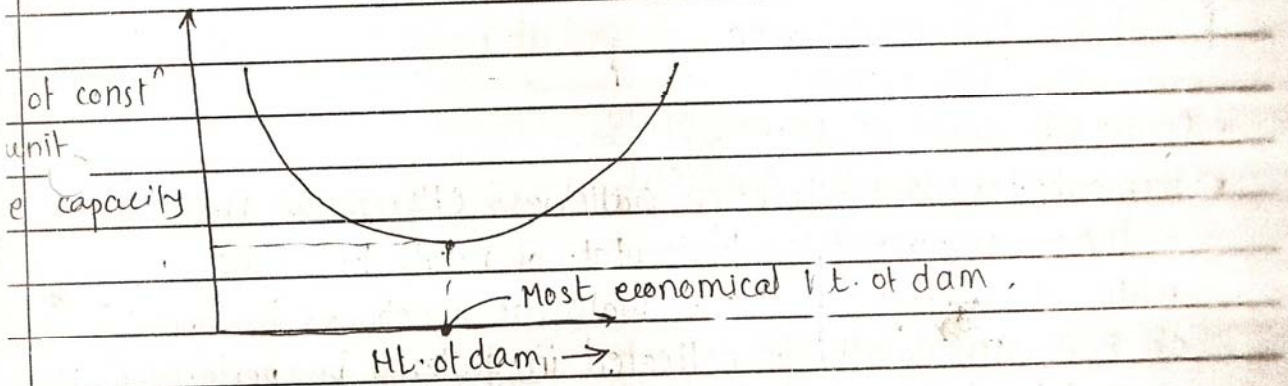
* Various levels in the reservoir:-



* Economic Ht. of dam:- The min. cost of dam per unit storage as economic height of dam.

Procedure:-
i) Estimate various heights of proposed dam.
ii) Estimate storage capacity for each ht.
iii) Calculate cost of const° per unit storage capacity.
iv) Plot a graph by taking ht of dam on x axis & const° per unit storage capacity on y axis as shown.
v) The lowest point on the curve gives most economic of dam.





Underground Sources:-

Infilteration: The movement of water from surface to the soil. It does not reach up to ground water table.

Percolaetion:- The water reaches to ground water table after they passes through soil.

x Aquifer:- / Water bearing strata:- Pervious layers are known as aquifer. as water passes from pervious layer easily & it is not possible to pass from impervious layer.

* Movement of ground water & its velocity:-

forces acting on underground water -

1) Gravity
2) Molecular attraction of surface tension.
3) Hydraulic properties.

According to Hazen's formula, velocity of flow is given by,

$$V = C \cdot d^2 \cdot S$$

Where, V = Avg. vel. of flow (m/day)
c = Coeff = 400-1000
d = eff. size of soil grain (mm)
S = slope of water table.

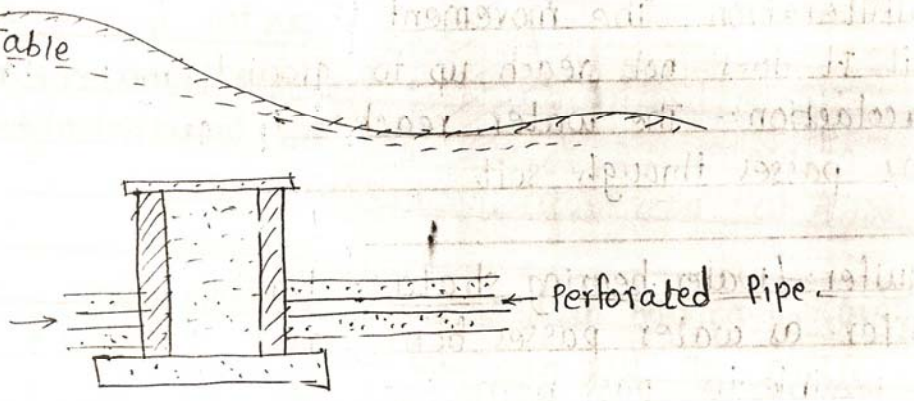
* Darcy's Formula:-

$$Q = K\,i\,A$$

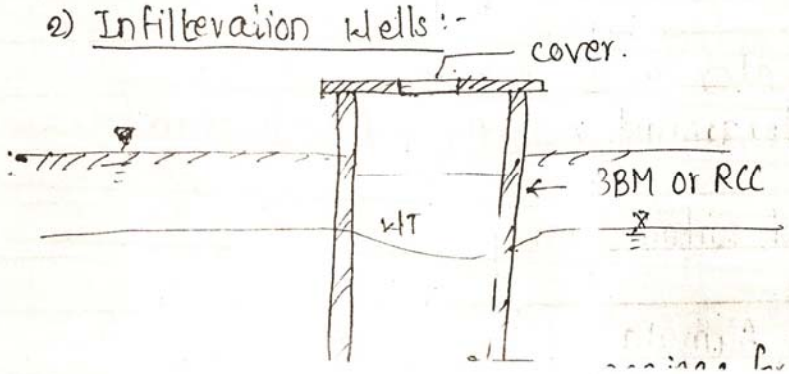
Where Q = Discharge
K = Coeff. of permeability
i = Hydraulic gradient
A = c/s area

* Types of underground sources:-
* Permeability:- ▷ Infilteration Galleries:- (Horizontal Well)

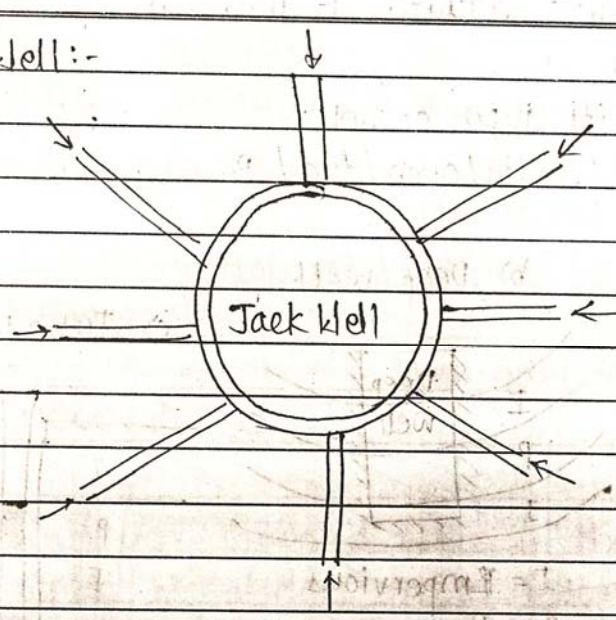
They are constructed horizontal or nearly horizontal in the water bearing strata. The walls are constructed by bricks & slab is of RCC. The water is collected in galleries by perforated pipe & pumped out.



2) Infiltevation Wells:-



Jack Well:-

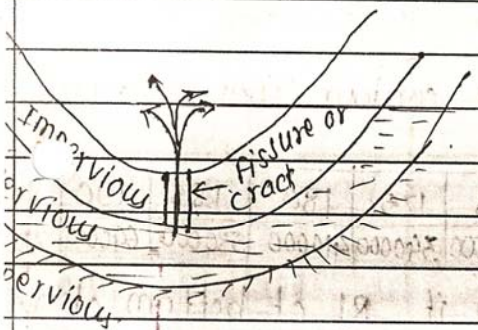


Springs:- When ground water appears at the surface of earth due to any reason, is known as spring.

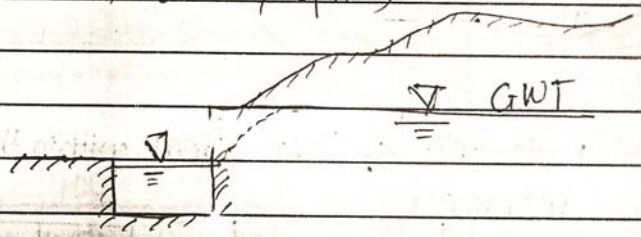
Types of springs:-

a) Artesian springs
b) Gravity spring
c) Surface spring.

Artesian Spring



b) Gravity spring



c) Surface spring

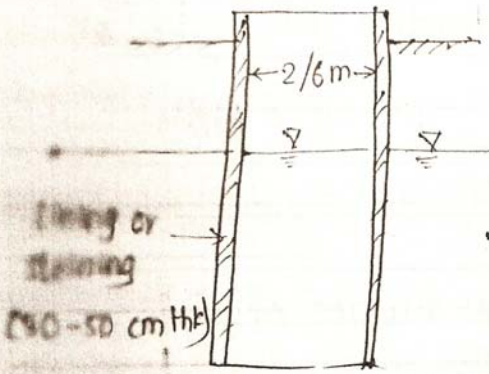
Wells:- An artificial hole created on the ground for seaching any fluid (oil, gas, water) is known as well. In India, about 70-75% population depend on well for wls.

The slope of water bearing strata should be always towards well, so that even in the hot season water is available in the well.

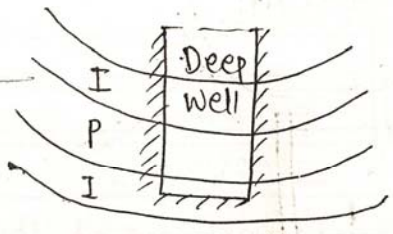
If the porosity of anti aquafer is more, more water will be collected in the wel

following are diff. types of well:-

a) Shallow well:- / Draw / Gravity / open / dug / Percolation well.

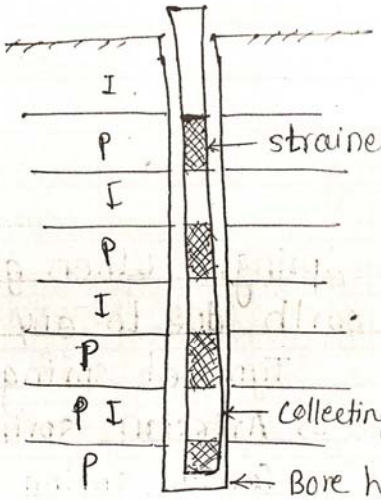


b) Deep well

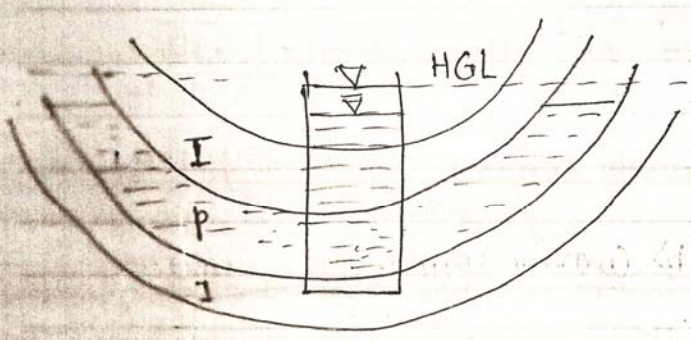


I = Impervious
P = Pervious.

c) Tube well:- (Bore)



d) Artesian Well:-



Eg: Following are the areas within the contour lines of a proposed reservoir

Contour	150	155	160	165	170	175	180	185	190	195
Area enclosed (m^2)	2000	11000	74000	150000	290000	340000	410000	530000	640000	730000

Calculate the capacity of reservoir if RL of bottom of reservoir is 150m & that of water level is 195 m.

Sol: Use: Trapezoidal formula,

$$V = \frac{h}{3}\left[\frac{A_1 + A_n}{2} + A_2 + A_3 + \cdots + A_{n-1}\right]$$

$$= \frac{5}{3}\left[\frac{2000 + 730000}{2} + 11000 + 74000 + 150000 + 290000 + 340000 + 410000 + 530000 + 640000\right]$$

$$= 12408000\ m^3$$

By Prismoidal formula,

$$V = \frac{h}{3}\left[A_1 + 4(A_2 + A_4 + \cdots + A_{n-1}) + 2(A_3 + A_5 + \cdots + A_{n-2}) + A_n\right]$$

$$= \frac{5}{3}\times 10^3\left[2 + 4(74 + 290 + 410 + 640) + 2(74 + 290 + 410 + 640)\right] + \frac{5}{3}\times 10^3\left[\frac{640+730}{2}\right]$$

$$= 11890300\ m^3.$$

For a particular proposed reservoir the estimated const^n cost with possible hts. of dam are as follows.

Ht. of dam (m)	Estimated cost (Rs)	storage capacity (Mm^3)
50	30	400
60	36	450
70	42	600
80	48	657
90	57	678
100	65	747

Calculate most economical h. of dam w.r.t. const^n cost only.

Ht.	Cost	storage capacity	Cost of const^n per unit storage capacity (Rs/m^3)
50	30	400	0.075
60	36	450	0.080
70	42	600	0.070
80	48	657	0.073
90	57	678	0.084
100	65	747	0.087

As above table shows, cost of const^n is per unit storage capacity is min. @ 0.070 for ht. 70 m

∴ Most economical ht. of dam = 70 m.

Draw Graph, Ht. of dam - x axis Vs cost of const^n per unit storage capacity - y axis.