UNIT –III

PART-I: SOURCES OF WATER SUPPLY

Sources of Water Supply: Surface sources of water: Lakes, Rivers, Impounding Reservoirs, Capacity of storage reservoirs, Mass curve analysis. Groundwater sources of water: Types of water bearing formations, springs, Wells and Infiltration galleries, Yields from wells and infiltration galleries.

- ***Introduction:*** Precipitation, which includes rain, snow, hail and sleet is the primary sources of water. Rainfall is the most important component of the precipitation. As it falls on the ground, a portion of it is intercepted by vegetation and depression storage. A part of it is lost by evapotranspiration, and certain portion percolates into the ground in the form of ground water and the remaining flows on the ground as runoff and finally joins the streams and rivers.
- ***Sources of Water Supply:*** Sources of water include rivers, streams, lakes, ponds, etc.

  There is large variation, in the water yield of the surface sources, which vary from season to season. The development, reliability and quantity of water mainly depends on the following :

  (i) The selection of the site for collection works,

  (ii) Preparation and control of the catchment area,

  (iii) The choice of the type of reservoir,

  (iv) The treatment of reservoir sites as well as operation of the reservoir,

  (v) The design, construction and maintenance of dams and dikes,

  (vi) The design, construction and maintenance of intake and outlet structures.

Sources of water

All sources of water can be broadly classified as follows:

(a) Surface sources. These can be further divided as

(i) Streams

(ii) Lakes

(iii)Rivers

(iv)Ponds

(v) Impounded reservoirs

(vi) Stored rain water and cisterns.

(b) Ground sources: These can be further divided as

(i) Springs

(ii) Infiltration galleries

(iii) Porous pipe galleries

(iv) Wells.

❖ ***Surface sources***

- ***Streams:*** In mountainous regions streams are formed by the run off. The discharge in streams is much in rainy season than other seasons. Those streams which dry up in summer and contain water only during rainfall are known as ‘Raining Streams'. The quality of water in streams is normally good except the water of first run-off. But sometimes run-off water while flowing over ground is mixed with clay, sand and mineral impurities. All the suspended impurities can be removed in settling tanks upto certain extent, but the dissolved impurities require special treatment. The streams generally flow in valleys and are the main source of water supply to villages of hills which are situated near them.
- ***Lakes:*** In mountains at some places natural basins are formed with impervious beds. Water from springs and streams generally flows towards these basins and 'Lakes' are formed. The quantity of water in the lakes depends on its basin capacity, catchment area, annual rainfall, porosity of the ground etc. The quality of large lakes is good than that of the small lakes. But lakes which are situated at high altitudes contain almost pure water which can be used without any treatment. Lake water is available only to those towns and cities which are situated near them, such as Naini Tal in U.P.

- ***Rivers:*** Rivers are born in the hills, when the discharge of large number of springs and streams combine together. In mountains the quantity of water in rivers remains small, therefore at such places these are called as small rivers. But as the river moves forward more and more streams combine in it and it increases its discharge. Therefore rivers grow bigger and bigger as they move forward due to increase in their catchment area. Rivers are the only surface sources of water which have maximum quantity of water which can be easily taken, therefore at the very ancient times the town and cities started developing along the banks of rivers. Mostly all the cities which are situated near rivers discharge their used water of sewage in the rivers, therefore, much care should be taken while drawing water from the river. River water has self-purification action, due to which it automatically becomes clean in some distance travel from the point of disposal of sewage. In summer the quality of river water is better than that in monsoon, because in rainy season the run-off water also carries with it clay, silt, sand etc., which make the water turbid. River water should always be used after necessary treatment. Some rivers are snow fed and perennial, and have water throughout the year therefore they do not require any arrangement to hold the water. But some rivers dry up wholly or partly in summer; therefore they require special arrangement to meet the water demand during hot weather.
- ***Ponds:*** These are depressions in plains like lakes of mountains, in which water is collected during rainy season. Sometimes ponds are formed when much excavation is done for constructing kaccha houses in villages, embankment for road and railways, and manufacture of bricks. Generally the quantity of water in ponds is very small and contains large amount of impurities. In the villages mostly the used water flow towards ponds and further contain mates its water. The water of ponds is used for washing clothes, animals bathing and drinking. In some backward villages people also

take bath in the dirty water of ponds. The water of ponds cannot be used for water-supply purposes due to its limited quantity and large amount of impurities.

- ***Impounded Reservoirs:*** Mostly it is found that there is great variation in the quantity of river water during monsoon and summer season. The discharge in some rivers remains sufficient to meet the hot weather demand, but in some rivers the flow becomes very small and cannot meet the requirements of hot weather. In such cases it becomes essential to store the water for summer season. The water can be stored in the river by constructing a bund, a weir or a dam across the river at such places where minimum area of land is submerged in the water and the reservoir basin remains cup-shaped having maximum possible depth of water. The construction of imponded reservoirs is not feasible under the following conditions:
  - When the average annual flow is lower than the average demand, as in this case no extra water is available to meet the hot weather demand.
  - When the rate of flow in the streams in dry season is more than the demand.
- ***Stored Rain water:*** At some places where ground water or surface water is not easily available the only way is to store the rain water in cisterns or tanks from roofs of buildings. The rain water from roofs and pucca courtyards is collected in water- tight tanks with the help of channels. Water stored in this way is limited and can never be utilized for water supply schemes on large scale.

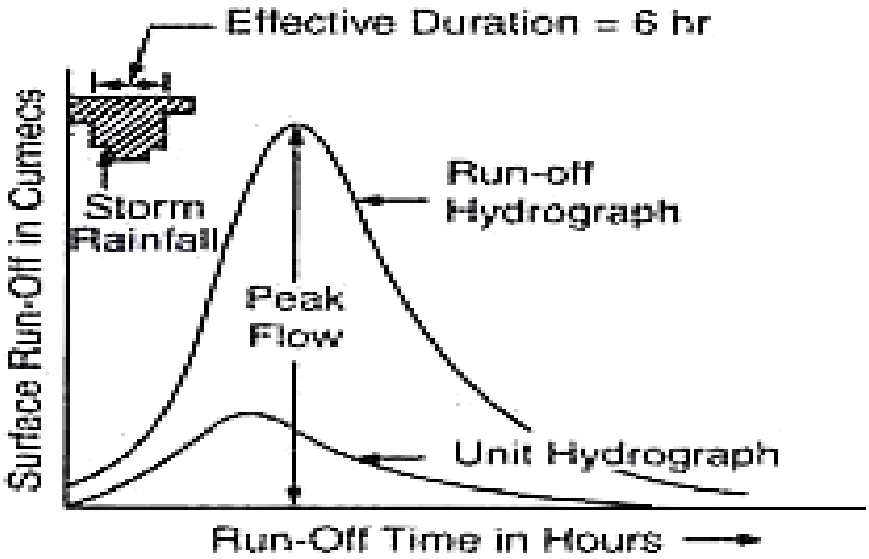
- **Reservoir Storage Capacity:** The capacity of the storage reservoirs depends on the rates of inflow, losses and demand or outflow. For determining the capacity of the storage reservoir to be constructed, these are to be calculated first. The inflow and outflow values are to be determined for various months of the years. The deficits and surpluses of water are calculated, and the storage capacity is made equal to the total deficit. For remaining on the safer side, the ‘dry year in which the inflow was

minimum and the outflow was maximum is generally chosen for this purpose. Practically, it has been noted that sometimes the drought conditions continue for longer periods, therefore, the storage capacity must be sufficient to meet the requirements in the worst possible conditions. For the design or calculation of reservoir storage capacity the records of at least previous three consecutive years should be collected.

- **Determination of Reservoir capacity with the help of Hydrograph**

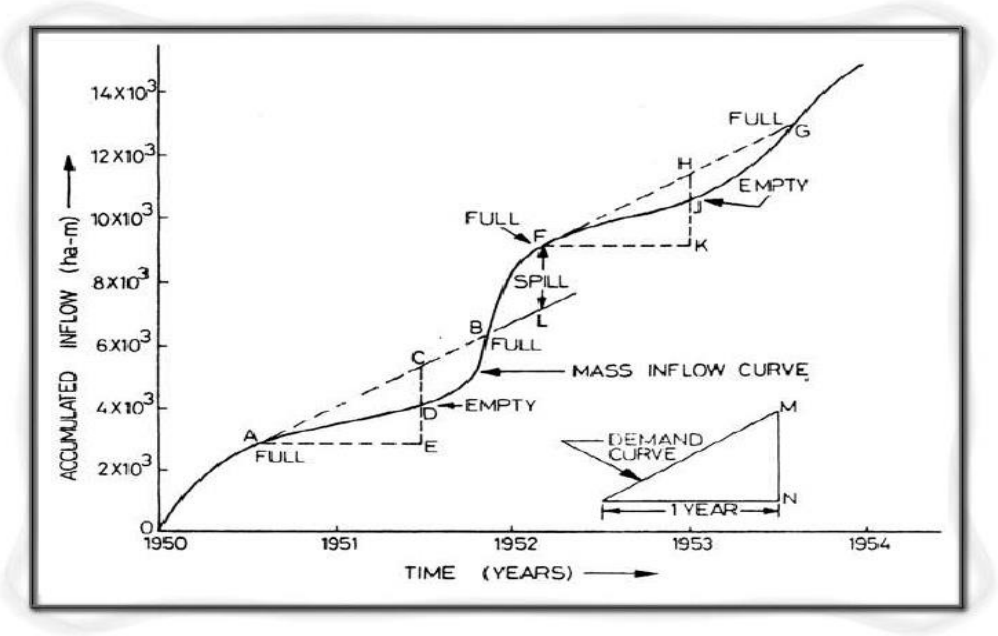
1. This method is not common in determining the capacity of the reservoir to be constructed.
2. In the method the stream flow data at the site of the reservoir are determined. In case f large reservoir monthly inflow rates are calculated, whereas in case of small reservoirs the daily inflow data are collected.
3. In case the exact inflow data at the site of reservoir are not available, the data at other points of the stream or on nearby streams are collected and adjustments are made for the exact site.
4. The quantity of consumption (including losses) is determined for different months of the various years.
5. Now the quantities of the yield and the consumption (including losses) as calculated above are plotted to the same scale on a common graph as shown in figure. The curves so obtained are called *Hydrograph.*
6. If the yield curve is above the consumption curve, it indicates that inflow of water is more than the demand. It indicates surplus water which can be stored.
7. If the yield curve is below the consumption curve, it indicates the deficit, which is to be met out by storing the surplus water.

8. The maximum cumulative total deficit is determined from the hydrograph, which is equal to the minimum storage capacity of the reservoir.
9. The exposed area of the water surface increases due to construction of the reservoir, which increases the evaporation losses. Sometimes the losses due to the evaporation and seepage are so huge that the every purpose of constructing the reservoir is not fulfilled. Seepage from the reservoir should also be added in the losses while determining the capacity of the reservoir.



- **Determination of Reservoir capacity with the help of mass curve:**
  1. The mass curve or consumption and yield can be used to determine the reservoir storage capacity. Fig shows the mass curve of consumption and yield.
  2. The demand lines drawn tangent to the high point A.B.C…. of the mass curve, represent the rate of withdrawal from the reservoir. Point *P, Q, R.* at which the demand line intersecting the mass curve of consumption denotes the points, at which the reservoir is full.

3. The vertical distance at any point between the demand line and the mass curve of consumption, denotes the water wasted over the spillway.
4. The design of the spillway should be done such that, it should be sufficient to discharge the flood water.
5. When the total yield is more than the total consumption, the mass curve of yield remains above the mass curve of consumption and vice versa.
6. The storage capacity or the requirement in dry weather will be found by adding the maximum ordinates of loops in the adjoining deficit and excess periods.
7. If the cumulative quantity of water yield is continuously in excess, both the mass both curves interact each other, which denotes that before this point the yield was less than the estimated consumption.
8. For this period necessary provision of water is to be made.



❖ ***Ground sources***

➢ ***Springs:*** Sometimes groundwater reappears at the ground surface in the form of springs. Springs generally can supply small quantity of water; hence these cannot be used as source of water to big towns. Good developed springs can be used as water supply sources for small hill towns. Due to presence of sulphur in some springs, they discharge hot water. Such hot water springs are only useful for taking dips for cure of certain skin diseases. They are not useful for public water supply. Generally springs are formed under the following circumstances

1. When surface of earth drops sharply below the normal ground water table.
2. When due to an obstruction ground water is collected in the form of reservoir and forces the water to overflow at the surface
3. When a fissure in an impervious stratum allows artesian water to flow in the form of springs

When the surface of the earth drops sharply the water bearing stratum is exposed to the atmosphere and springs are formed. This type of spring is also called as 'Gravity" or -Shallow spring and water table to such springs varies with the rainfall. The formation of springs when ground water rises through a fissure in the upper impervious stratum is known as `.Artesian springs ' and generally have constant rate of flow because water comes out by a constant pressure. When the water-bearing stratum has too much hydraulic gradient and is closed between two impervious stratums such types of springs are formed. These springs usually have a large length of Catchment watershed and their outcrop is too much far area away from the spring. The water comes out in the form of springs under pressure. It is common practice to construct pucca - tank (collecting tank) at the point of springs to collect the spring water and prevent its wastage. To safeguard against the contamination of water these

tanks are covered from three sides with masonry walls and roof is provided at the top. At the front side door is provided which is closed during nights and it prevents the wild animals to contaminate the water also.

- ***Infiltration Galleries:*** We have seen earlier that ground water travels towards lakes, rivers or streams. This water which is travelling can be intercepted by digging a trench or by constructing a tunnel with hole on sides at right angle to the direction of flow of underground water. These underground tunnel used for tapping underground water near rivers, lakes or streams are called ‘Infiltration Galleries'. Underground water may be allowed to enter these infiltration galleries either from both sides or one side as desired. The yield from these galleries may be as much as 1.5×10^4 litres/day/meter length of the infiltration gallery. Sometimes these are also known as horizontal walls. For maximum yield the galleries should be placed at the full depth of the aquifer.
- ***Yield of an infiltration gallery:*** **Refer to notes**.
- ***Porous Pipe Galleries:*** When there is large quantity of ground water existing over a wider area, it can be cheaply collected by laying porous pipes or pipes with open joints in the full area at some distance. These longitudinal and cross pipes will be given a slope such that they bring the water towards a point, where a well is constructed to take out the water. These porous pipes should be surrounded 'with gravel and broken stone pieces to increase their intake capacity.
- ***Wells:***
  - ***Classification of Wells:*** Depending upon the method of construction, wells are classified as follows:

a) Dug wells

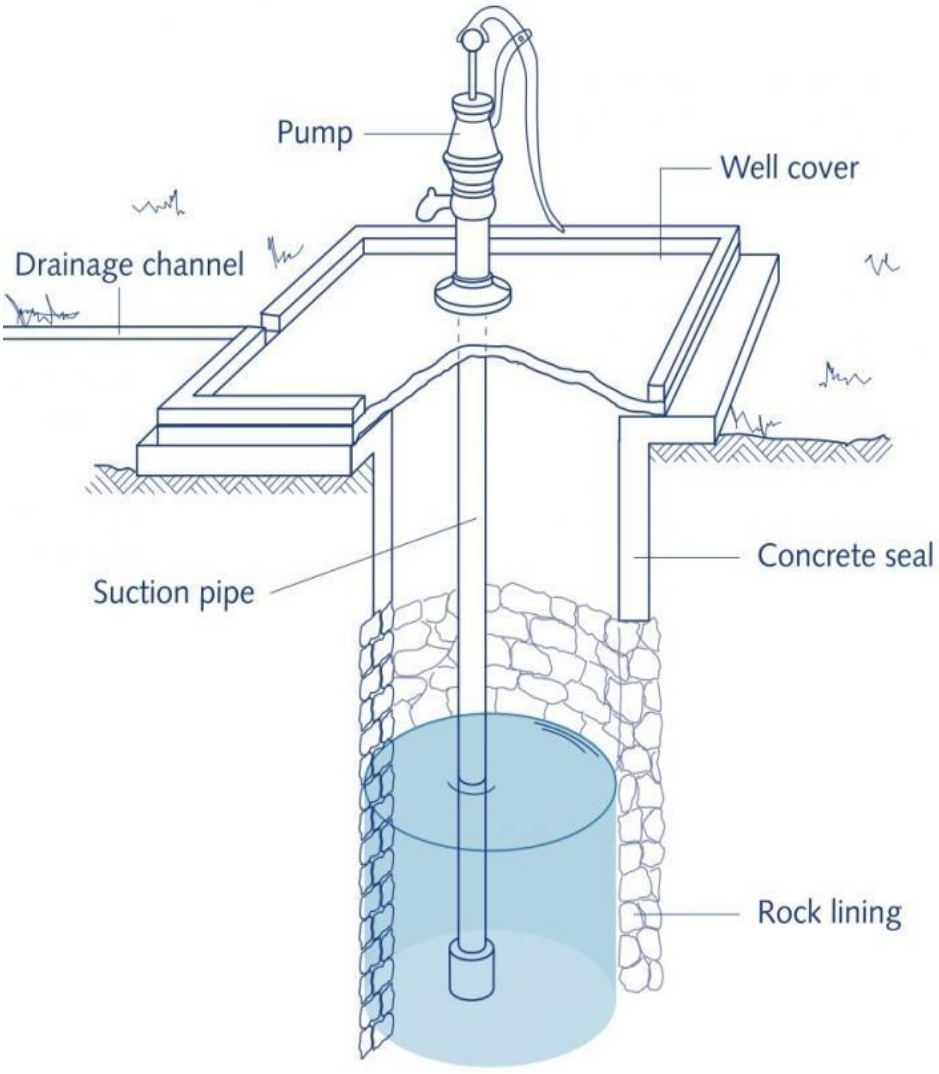
b) Driven wells

c) Sunk wells

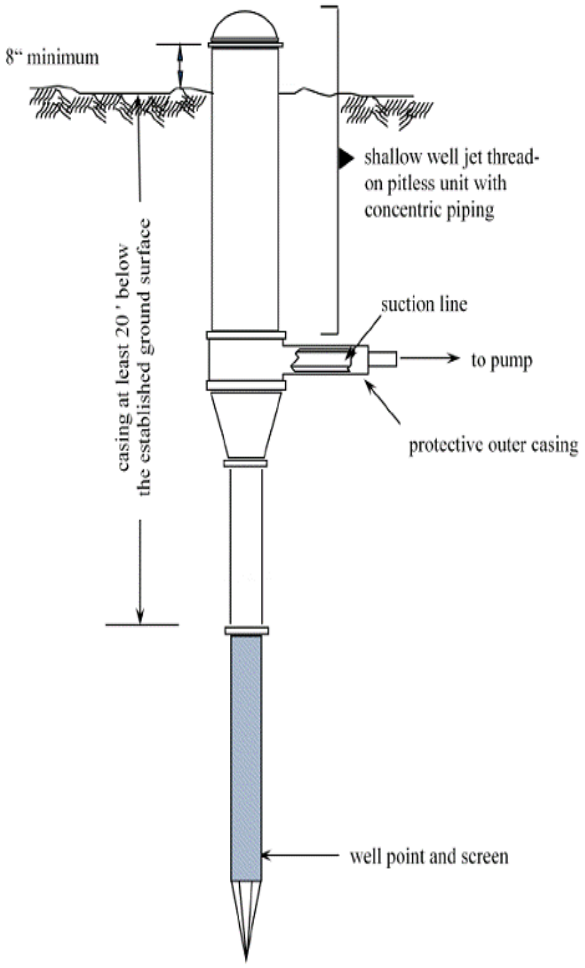
d) Tube wells

1. ***Dug wells or Percolation Well:*** Sometimes these are also known as Draw Wells or Open Wells. These are shallow wells which are usually confined to soft ground, sand and gravel. The diameter of these wells may be between 1 to 4 m and depth may be upto 20 m depending on the requirement and geological structure of the earth. These wells are suitable for small discharge of about 20 cu.m/hour. The walls of these wells may be constructed with precast R.C.C. blocks, bricks or stone masonry. The thickness of the staining of the well mainly depends on the depth of the well and varies from 50 cm to 75 cm. For the construction of such wells first of all a well curb of steel, wood or R.C.C. is constructed at the site over which masonry work is done upto about 1.5 m height. Now the earth from the inside of the curb is excavated by means of pick-axes and shovel. Due to self-weight the masonry wall will sink gradually. More and more masonry work will be done as the excavation proceeds till the well is sinked upto required depth. After complete sinking parapet wall will be constructed over the well, and a platform with outward slope will also be constructed around the well. Sometimes roofs on pillars are also constructed over the well to protect it from contamination. Dug wells are very cheap in construction, therefore these are very popular in rural areas and small towns due to their large diameter and these wells act as a small storage reservoir also and can meet all types of small demands. These wells should be disinfected frequently to avoid the risk of contamination, because these wells generally are in poor sanitary conditions. As the open wells are constructed upto limited depth, their yield is also limited. If the ground water storage is also limited. The quantity of water which can be withdrawn from these wells also depends on the critical velocity for the soil. Water cannot be

withdrawn at higher rate, as it will lead to the disturbance of the sail particles which may further lead to the sinking of the well staining. The yield of the open wells can be increased by providing an 8- 10 cm diameter bore-hole in the centre of the well, which will tap more quantity of water from the aquifer below the hard stratum. If the well curb of the existing open-well is resting on soft stratum, and the mota stratum is not at greater distance, it will be better to sink the well further.

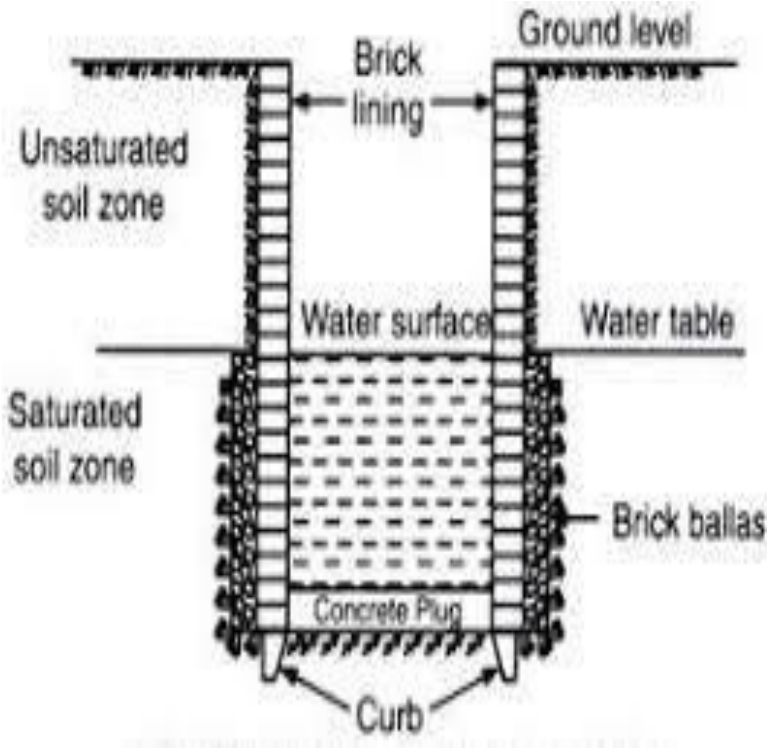


2. ***Driven wells:*** These are constructed by driving a casing pipe 25 to 100mm in diameter into the sandy unconsolidated unconfined aquifer to a depth of about 25m. The lower end of the pipe is provided with closed and pointed well point. The pipe is driven with hammer or by wet jet. The pipe is perforated or attached with strainer at bottom above the well point, through which water enters into the pipe end, is then pumped out.



3. ***Sunk wells:*** When soils are loose and cannot withstand open excavation, well are constructed in this method. A well curb with cutting edge made up of R.C.C. is placed on the ground. Masonry or hollow concreted blocks in mortar is constructed to some

height on the curb. In place of masonry. R.C.C. rings can also be placed. Then the earth with in the curb is scooped out by hand tools and thrown out, thus sinking the R.C.C. rings or masonry slowly. This method of placing rings, excavations and sinking is continued until the required depth is reached.



4. ***Tube wells:*** The maximum discharge, which is available from the ordinary open wells, is between 4 to 5 liters/sec. due to their low yield open wells are useful for small locality or private dwellings. For small localities or private estates there may be their own source of water supply. It is not economical to install pumps in these wells, due to their low yield. For obtaining more yields, now a day's tube-wells are commonly used. These wells essentially consist of blind pipes and strainer pipes, ands their supply of water is from large number of aquifers. As India has enormous quantity of ground water which can be easily tapped by the tube wells. Now a day's tube-wells are becoming more and more popular for supplying water to cities, colonies private estates, factories, industrial areas and also for irrigation purposes.

Mostly all state governments of India have tube-well departments for the construction of tube-wells. Some private companies also undertake tube-well construction. The depth of the tube-well may vary from50 to 500 *mm* and the maximum yield from the tube-well may be about 200 *litres/sec.* the yield of the average tube-well is about 50 *litres /sec.* It is very difficult to construct tube-wells in the hill areas, as boring in rocks is very difficult. But some tube – wells have been constructed in hill regions with success.

- ***Yield of a well:*** **Refer to notes**.