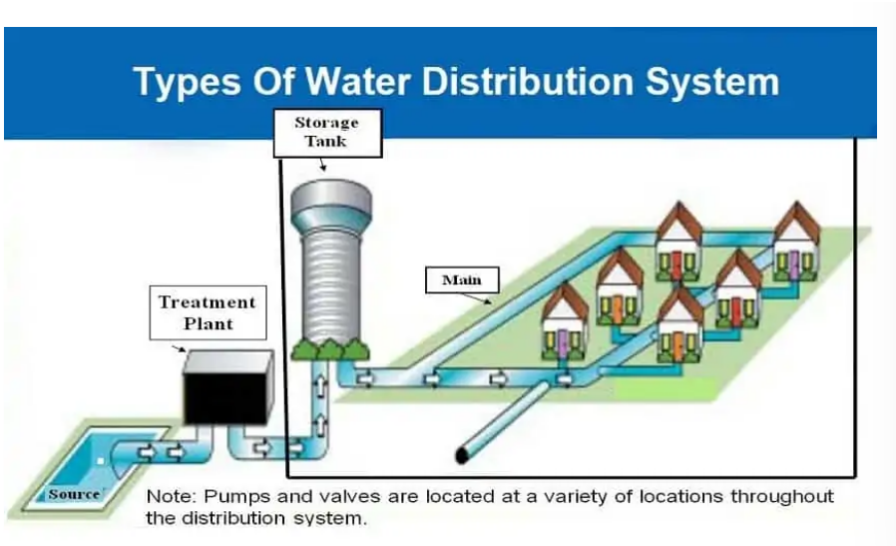
Unit –V

Distribution System

- A water distribution system is a collective system with components that are designed to carry water from the main water supply network to households. Different types of water distribution systems are used for supplying water.
  The components such as pipes, pumps, fittings valves, storage tanks, etc help in the water supply to meet the consumer needs. The main purpose of the water distribution system is to distribute quality water to the residents.

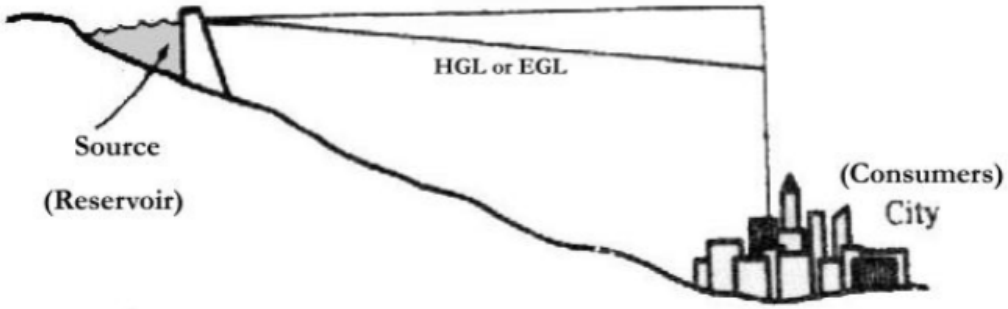


- ***Methods of water distribution system***

The method of distribution depends upon the topography of the area. The following method or system may be adopted for distribution:

1. Gravity system.
2. Combined gravity and pumping system.
3. Pumping system.

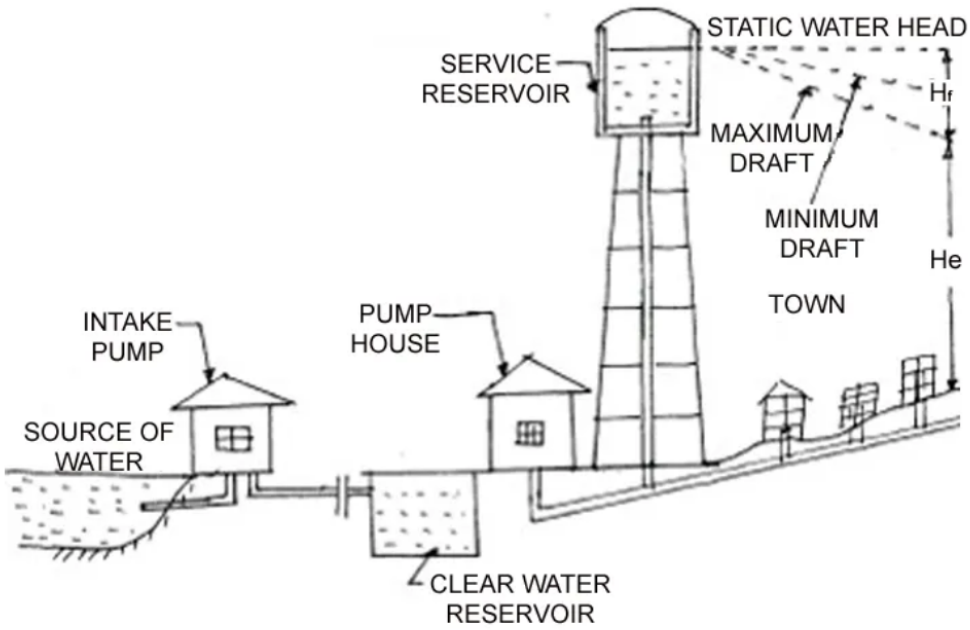
- **Gravity system:** In the gravity system, the source of water supply is so located with respect to the area of distribution that water is available with sufficient pressure at various points of the area. No pumping is normally required. Purification units are located on a hill, and the source of water supply is also located behind the hill, pumping may be required to convey water from the raw water source to the purification works.



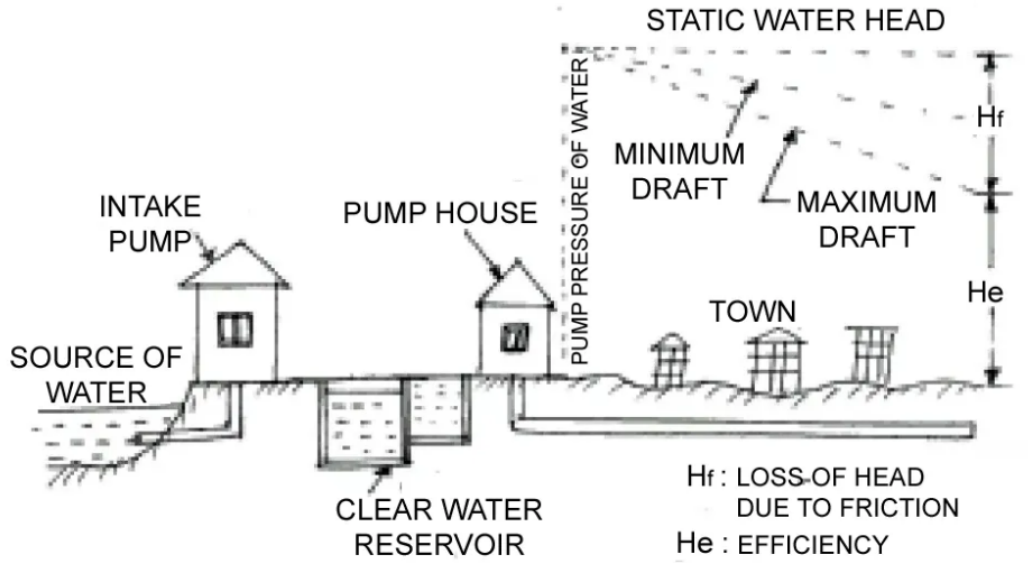
Gravity-Supply System

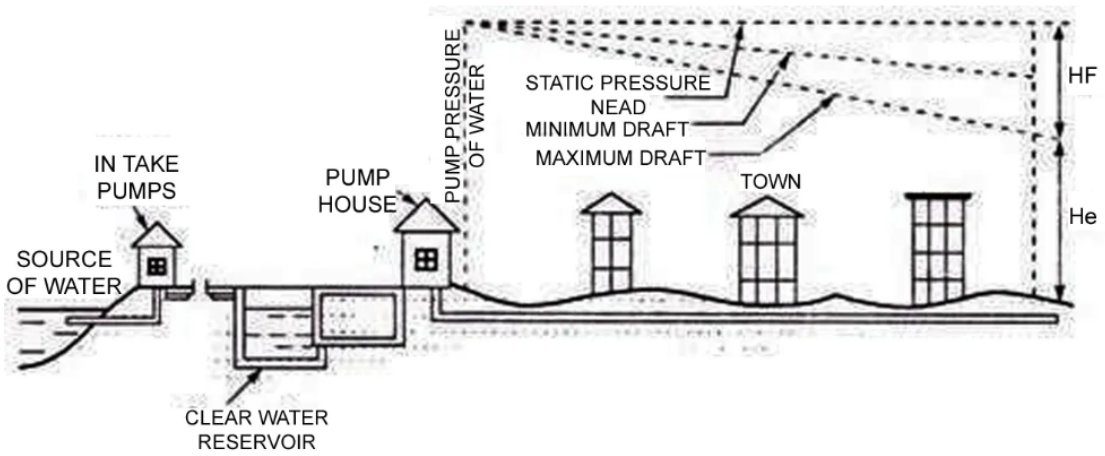
6

- **Combined gravity and pumping system:** This system is the most common system adopted in most cases. Generally, the water purification works are located almost at the same level as the area of distribution. The water from the elevated reservoir then flows under gravity, as illustrated.



- **Pumping system:** In this system, water is pumped directly into the distribution system to achieve the required pressure. Such a system is not desirable. Generally, double pumping is required, first to pump raw water from the source to the treatment works and then to pumps must be run at varying speeds according to the variation in the distribution.

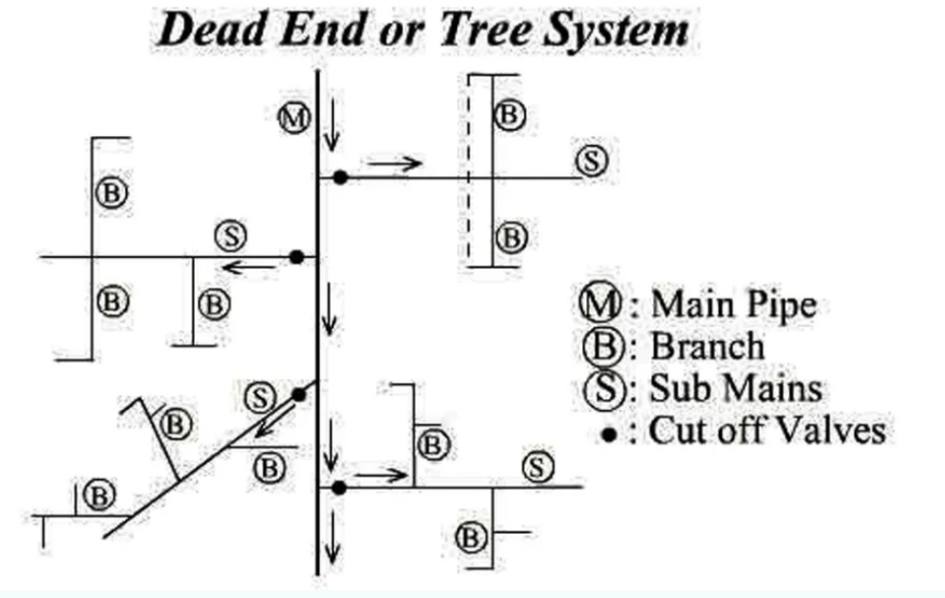




❖ ***Layout of Distribution Networks:*** In practice there are four different systes of distribution are under usage. Depending upon their direction and layout, they are classified as follows:

1. ***Dead End or Tree System:*** In this type of water distribution system, many sub-main pipelines are connected to a single main pipeline that runs along the centre of the building. Dead end water distribution system is also known as the Tree system.

   The sub-main pipelines are further divided from both sides into branches that connect various service areas of the building. This system is most suitable for unsystematic areas like old towns and cities with definite patterns of roads.



Advantages of Dead-End Water Distribution System

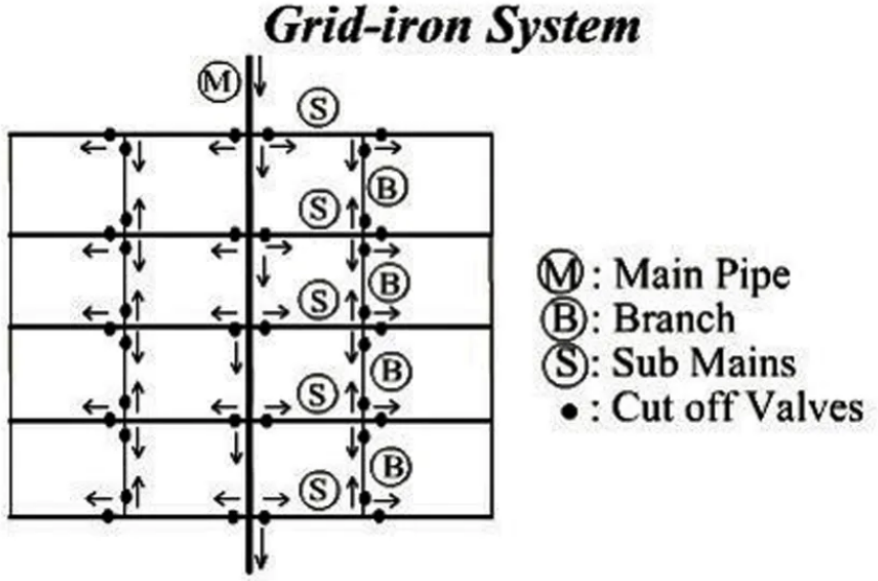
- This system is cost-effective.
- Pipe laying is easy, no skilled labourers are required.
- Determination of discharge and pressure quantity can be done easily due to a smaller number of valves.

Disadvantages of Dead-End System

- The chances of Stagnation of water in pipes are high due to many dead ends.
- The pipes should have a large diameter and longer length due to high circulating flow from all directions.
- The available water pressure is low, so a pumping system is required to meet the supply pressure requirement.
- Because of high head loss in the system, the discharge availability for firefighting is very limited.
- High risk, Due to only one main water supply pipeline to the entire building.

2. ***Grid Iron System:*** In a grid-iron system, the main pipeline, Sub main pipeline, and branch pipelines are interconnected to each other in the form of a grid system. A Grid-iron water distribution system is also known as an interlaced system or reticulation system. The requirement of the total length of the pipeline is more

due to more connections and it helps to maintain water pressure evenly. A Grid-iron water distribution system is best suited for modern well-planned cities as the water main pipeline and branches are laid in a rectangle layout.



Advantages of Grid Iron System

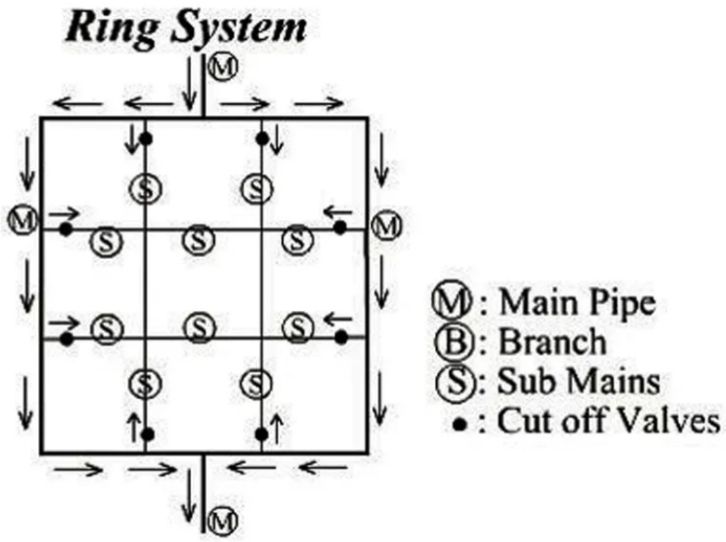
- Due to no dead ends water is continuously flowing through pipelines.
- Maintenance and repair work can be carried without out disrupting water flow.
- This water distribution system provides the required discharge quantity for firefighting.
- There is a minimum head loss because of the interconnection of pipes.

Disadvantages of Grid Iron System

- In the grid-iron system, the requirement for cut-off valves is high.
- It is not cost-effective due to more requirements of pipe length for laying.
- This system requires longer pipe lengths with a larger diameter.

3. Circular or Ring System: In this water distribution system, the whole system is enclosed by the main pipeline in a radial or

rectangular shape. as you can see in the above fig. smaller areas are enclosed by the sub-main pipeline. In case of any failure of one system, a very small area will be affected. The area ahead of the affected area can get water from other system points. The ring distribution system requires a higher number of valves. In this system, water can be supplied to any point from two directions.



Advantages of Ring Distribution System:

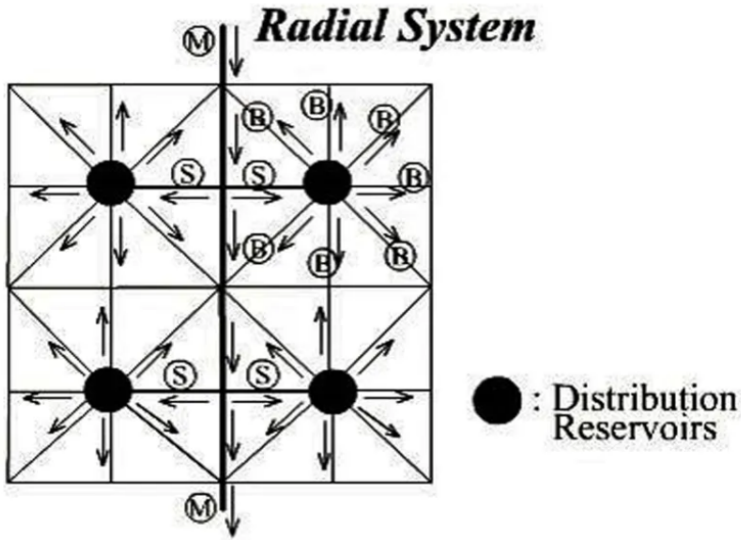
- The discharge rate is high when compared to other distribution methods.
- Maintenance and repair work can be carried without out disrupting water flow.
- Due to a smaller number of interconnections, the head loss is minimum.
- Due to no endpoints, stagnation of water is minimal or zero.

Disadvantages of Ring Distribution System

- It is not cost-effective, because the requirement of pipe length for laying is more.
- The requirement for cut-off valves is more.
- This system requires skilled laborers for laying pipelines.

4. Radial System: In a radial system, the area is divided into various zones. The main water supply pipeline is connected to the distribution reservoir or storage tank which is kept in the middle of each zone.

Then supply pipes are laid radially (as shown in the figure) from the distribution reservoir to households.



Advantages of Radial System

- This type of water distribution is most suitable for high-rise buildings.
- Disruption of water supply during any maintenance or repair work is very low.
- The radial system supplies water with high discharge and with minimum head loss.
- This system offers quick service.

Disadvantages of Radial System

- It is not economical as the number of distribution reservoirs is more.

- Due to more connections, this system requires more length of pipe laying system.

❖ ***Analysis Of Distribution Systems:*** Refer to notes.

❖ ***Distribution Systems in Multi-Storeyed Buildings:***

❖ Pressure in the distribution system depends on

(i) Domestic use

(iii) Economic considerations

(v) Future demand

(ii) Fire demand

(iv) Topography

For domestic services, the supply pressure depends upon number of storeys upto which water is to be lifted without additional use of booster pumps.

For residential area a pressure of 0.6 to 15 kg/cm2 is sufficient.

Providing greater pressure in pipe than the required valve makes the system costly.

Following minimum residual pressure should be provided at the ferrule points.

Residential Districts

Upto 3 storey: 2 kg/cm^2

3-6 storey: 2 to 4 kg/cm^2

6-10 storey 4 to 4.5 kg/cm^2

Commercial Districts 5 kg/cm^2

A minimum velocity of 0.6 m/sec should be maintained. The greater is the design pressure the costlier it will be but will cause more convenience to the consumers.

❖ **Manual of Water Supply Recommends**

Residual pressures at Ferrule point:

Single storey building-7 m

two storey building- 12 m

Three storey building- 17m

Distribution system should not ordinarily be designed for residual pressures exceeding 22 meters. Multi storeyed buildings needing higher pressure should be provided with boosters.

❖ **Minimum Pipe sizes**

Manual recommends:

Town with population up to 50,000: 100 mm diameter
Town with population > 50000: 150 mm diameter.
Pressure more than 70 m in the distribution system are generally undesirable and maximum and maximum allowable pressure is of the order of 100 m, which generally equals the design pressure for plumbing fixtures, like pipe fittings etc.

PUMPING

- ***Necessity of pumping***: Water may be required to be pumped under the following situations.
  - When the elevation of the source of water supply is such that the water will not flow into the mains by gravity.
  - When it is required to increase or boost up pressure in the mains.
  - When water must be lifted from one level to another.
- ***Classification of pumps***: Depending upon the functions to be performed, pumps can be classified into various categories as described below.
  - ***According to the class of service:*** These may be deep well pumps, high lift pumps, booster pumps, stand by pumps.
    - *Deep well pumps* operate in tube wells and pumps water into the reservoirs or directly into the distribution system.
    - *Low lift pumps* operate for small heads such as at treatment plants for pumping water from storage tanks to high-level tanks or mixing chambers.
    - *High lift pumps* are for large heads as for pumping water from clear water reservoirs into the elevated tanks or directly into the distribution systems.
    - *Booster pumps* are used to increase the pressures in parts of distribution system, where adequate pressures cannot be had either because of greater elevation or excessive loss of head in the distribution pipes.
    - *Pumps for fire – service* are intended to build up pressure to the extent required for efficient firefighting in case of multi stored buildings.
    - *Stand up pumps* are essential features of large pumping installations where auxiliary forms of power is also available.

- ***According to the form of motor power:*** These are electric motors, diesel engines and steam engines. Economic factors such as size of plant, cost of electricity, oil, gasoline, coal, and the cost supervision chiefly effect the selection.
    - *Electrically driven pumps* are generally employed in all modern medium and small pumping plants.
        - Advantages are freedom from smoke and dust, quite operation, economical supervision and economy of floor space for pumps and motors.
        - Main disadvantage is the frequency of power interruption, necessitating provision of standby power arrangement.
    - *Diesel engines* are reliable, economical for pump drives but not very commonly used because of lower speeds than those required for centrifugal pumps.
        - As compared to the electrically driven pumps, they are costlier to install and maintain.
        - They are suitable for use only in small capacity.
    - *Gasoline engines* are rarely used because of high codt in continuous operation.
        - They are however suitable for stand by service and are effective for moderate heads.
    - *Steam engines* find use in case of large pumping plants where considerations are production of power at lower cost, durability of service and flexibility of operation.
- ***According to the mechanical principles of operation:*** this is, by far, the most important classification. Based on this are the following three types of pumps very commonly used.
    - *Displacement pumps* work on the principle of mechanically inducing vacuum in a chamber thereby drawing in a volume of water which is then mechanically displaced and forced out of the chamber. They are of two types.
        (i) The reciprocating pump, a piston or a plunger operates in a closed cylinder, its forward stroke producing vacuum which draws in water through an inlet valve from a suction pipe, the return stroke pushing water out through an outlet valve in a delivery pipe.
        (ii) The rotary pump, gears cams or screws enmesh rotating in opposite direction in the casing and force the water around and out in each revolution.

- *Centrifugal pumps*. These employ the principle of centrifugal force to impart energy to the water. Water entering the pump casing is revolved by a wheel called impeller which discharges it in a direction at right angles to its original direction of flow. In doing so the kinetic energy of water is converted into static or pressure head.
  - Advantages
    i. Low initial cost
    ii. Simple mechanism, operation, and repair
    iii. Stability of flow
    iv. Safe against high pressure
  - Disadvantages
    i. Limited suction head
    ii. Low efficiency over a wide range of head and discharge
- *Airlift pumps*. In this compressed air from an air pipe is admitted into an education pipe at its lower end through a foot piece or air diffuser.
  - The mixture air and water has a lower specific gravity than water alone and thus it rises to the surface
  - With the continued supply of air, the column of water in the education pipe is forced upward ultimately discharging from an outlet at the top.

➢ ***According to the position of pumps shaft:*** pumps may be classified as horizontal shaft and vertical shaft pumps.

- *Horizontal shaft pumps* have such characteristics as large head room, ease of maintenance, lower cost for equal capacities, less of corrosion, abrasion, and higher efficiency.
- *Vertical shaft pumps* are commonly used as deep well pumps. These have such characteristics such as lesser floor space requirement, positive suction, higher discharge head, higher initial cost, and difficulty in maintenance.

❖ ***Selection of pump:*** In selecting any type of pump it is necessary to study the complete range of pump duties, its characteristics, and the situation of service. The general requirements of pump selection are:

i. *Capacity:* It should be capable of carrying required quantity of water
ii. *Reliability of operation*: A pump should be sure of service in working and not fail suddenly or cause any trouble.
iii. *Efficiency:* It should not have low efficiency.

iv. *Power:* Power requirement for running a pump should not be high.
v. *Cost:* The pump should not only be cheap in cost, but its cost of operation and maintenance should also not be high.

- A *Reciprocation type* of pump would be suitable for the following situations.
    i. Where it is necessary to pump water against high but variable heads with a higher suction lift.
    ii. Where waters are comparatively clear
    iii. Available finances are ample for installations and operation.
    iv. Where flow could be pulsating in nature.
- A *Rotary pump* would be suitable for small discharges and moderate heads and in case of waters which are nonabrasive i.e., free from grit or sand.
- The *Centrifugal type of pump* would be eminently suitable for large capacities both for raw and treated water supplies because of number of advantages possessed by this pump.

❖ **Total Lift of the pump:** The total lift or total head against which the pump should work includes lift, discharge lift and the total loss of head due to friction, entrance and exit etc. in suction and rising units.

If,

Suction = H_a

Discharge lift = H_d

Total loss of head = H_l

Total head/ total lift, $H = H_a + H_d + H_l$

The difference between the low water level and the pump is *Suction Lift*.

The difference between the point of discharge and the pump is *Discharge Lift.*

If the water is discharged into an airtight vessel, the equivalent pressure head of air should also be added to calculate total head against which the pump has to work.

❖ **Horsepower of pump:** the horsepower of a pump can be determined by calculating the work done by a pump in rising the water to a height H.

Let the pump rise W kg of water to height H meters.

Then work done by the pump = W * H m.kg

= W*Q*H m.kg/sec

Where, W = density of water in Kg/m^3

Q = Water discharge by the pump in m^3/ sec

Then water horsepower = (Discharge * Total head)/75

Or

WHP=

But break horsepower = WHP/ efficiency
Or

BHP =

- **Economic diameter of pumping main:** For pumping a particular fixed discharge of water, it can be pumped through bigger diameter pipe at low velocity or through lesser diameter with vey high velocity.
  But id the diameter of the pipe is increased, it will lead to the higher cost of the pipeline.
  On the other hand, if the diameter of the pipe is reduced, the increased velocity will lead to higher frictional head loss and will require most horsepower for the required pumping, thereby increasing the cost of pumping.
  For obtaining the optimum efficiency, it is utmost necessary to design the diameter of the pumping main, which will be overall most economical in initial cost as well as maintenance cost for the pumping the required quantity of water.

  Following formula by Lea is commonly used in determining the diameter of the pumping mains.

  D= 0.97 to 1.22 √Q

  D = Economical diameter of pipe in metres
  Q = required discharge of water to be pumped.
  The above formula gives the optimum velocity of water flow between 0.8 to 1.35 m/sec.