IQRA NATIONAL UNIVERSITY OF IT AND EMERGING SCIENCES PESHAWAR

SUBJECT NAME: WATER DEMAND, SUPPLY AND DISTRIBUTION

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Q1. Define desalination and briefly describe various desalination methods? Which method is more effective, please elaborate briefly?

Answer:

Desalination:

"Desalination is a water supply option that is used widely around the world and involves taking the salt out of water to make it drinkable". Or "it is a process that takes away mineral components from saline water". Many countries use desalination as a way of creating a more reliable water supply that is not dependent on rain.

Various Desalination Methods:

Two distillation technologies are used primarily around the world for desalination: thermal distillation and membrane distillation.

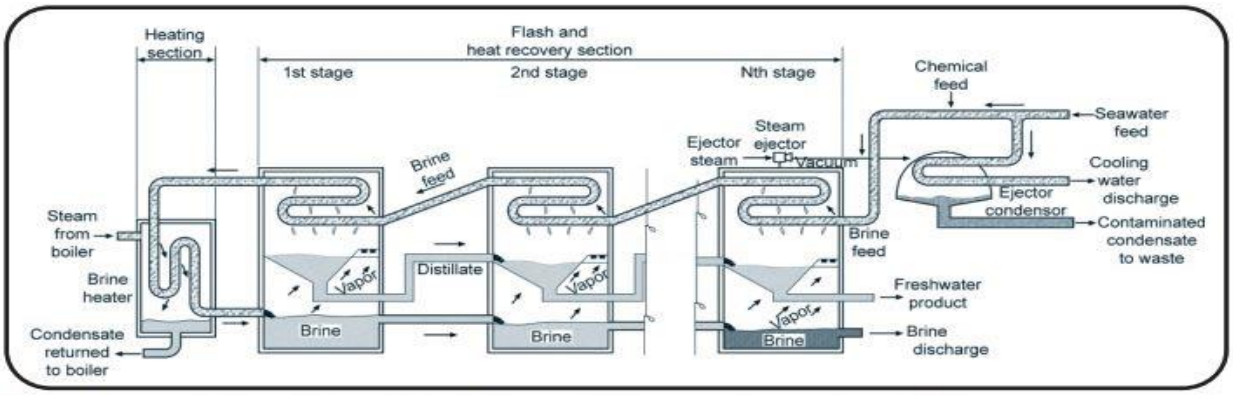
Thermal distillation technologies are widely used in the Middle East, primarily because the region's petroleum reserves keep energy costs low. The three major, large-scale thermal processes are multistage flash distillation (MSF), multi-effect distillation (MED), and vapor compression distillation (VCD). Another thermal method, solar distillation, is typically used for very small production rates.

Membrane distillation technologies are primarily used in the United States. These systems treat the feed water by using a pressure gradient to force-feed the water through membranes. The three major membrane processes are electro dialysis (ED), electro dialysis reversal (EDR), and reverse osmosis (RO).

1. Thermal technologies

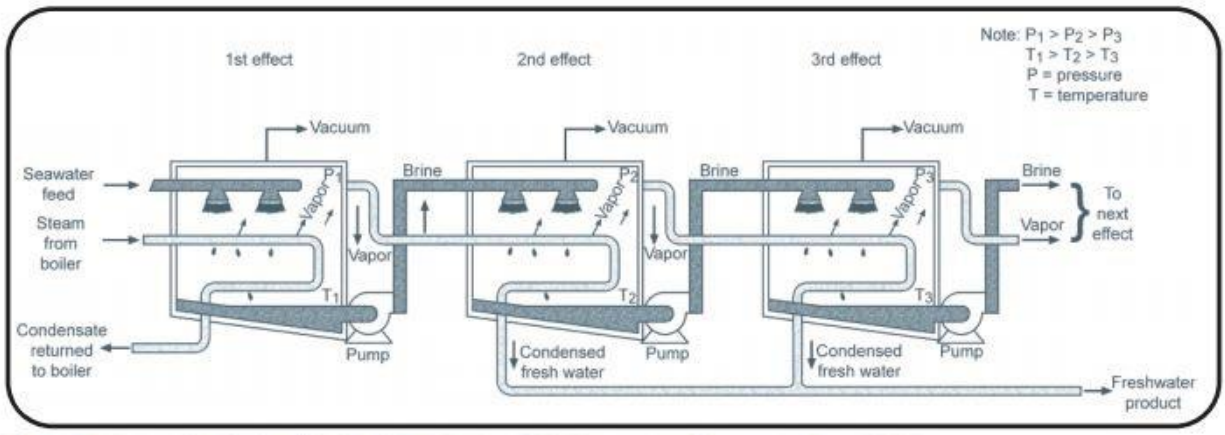
a) Multi-stage flash distillation

Multi-stage flash distillation is a process that sends the saline feed water through multiple chambers. In these chambers, the water is heated and compressed to a high temperature and high pressure. As the water progressively passes through the chambers, the pressure is reduced, causing the water to rapidly boil. The vapor, which is fresh water, is produced in each chamber from boiling and then is condensed and collected.



b) Multi-effect distillation

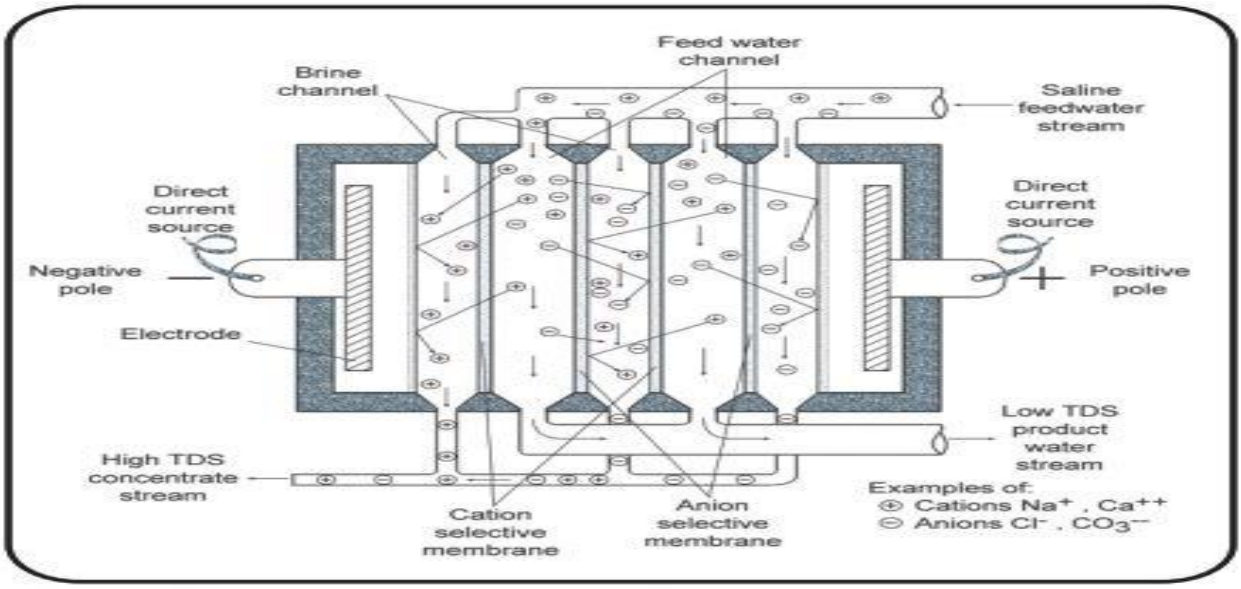
Multi-effect distillation employs the same principals as the multi-stage flash distillation process except that instead of using multiple chambers of a single vessel, MED uses successive vessels (Fig. 2). The water vapor that is formed when the water boils is condensed and collected. The multiple vessels make the MED process more efficient.



2. Electrodialysis:

The membranes used in electrodialysis and electrodialysis reversal are built to allow passage of either positively or negatively charged ions, but not both. Ions are atoms or molecules that have a net positive or net negative charge. Four common ionic molecules in saline water are sodium, chloride, calcium, and carbonate.

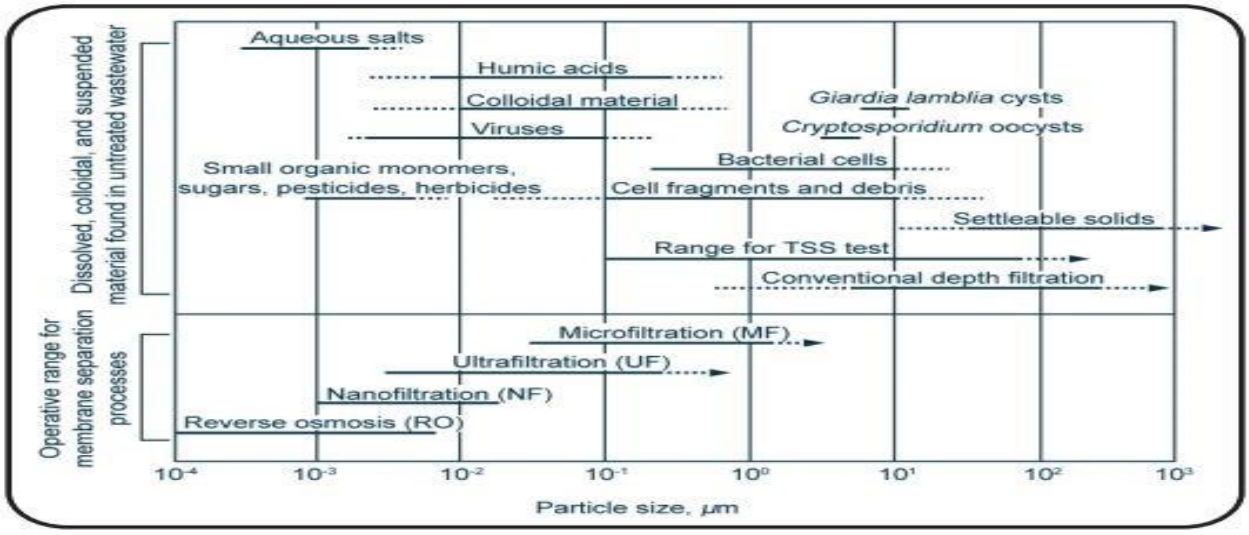
Electrodialysis and electrodialysis reversal use the driving force of an electrical potential to attract and move different cations (positively charged ions) or anions (negatively charged ions) through a permeable membrane, producing fresh water on the other side.



3. Reverse Osmosis:

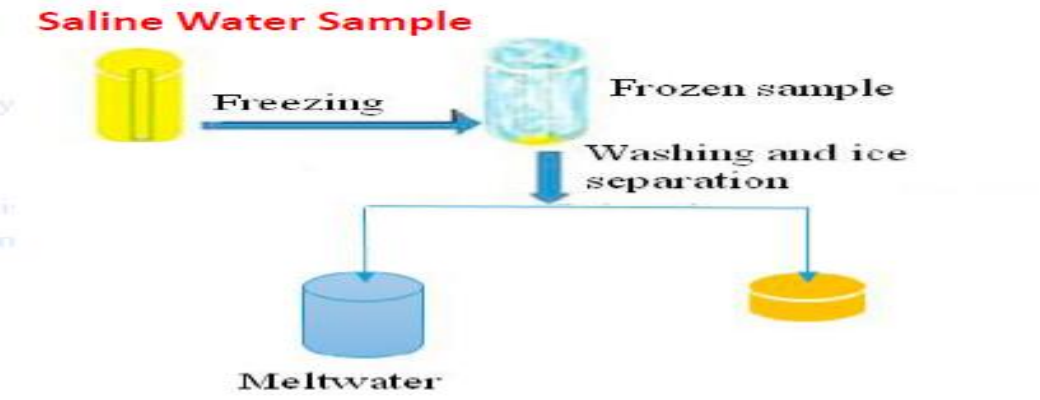
Reverse osmosis uses a pressure gradient as the driving force to move high-pressure saline feed water through a membrane that prevents the salt ions from passing.

There are several membrane treatment processes, including reverse osmosis, Nano filtration, ultrafiltration, and microfiltration. The pore sizes of the membranes differ according to the type of process. Because the RO membrane has such small pores, the feed water must be pretreated adequately before being passed through it. The water can be pretreated chemically, to prevent biological growth and scaling, and physically, to remove any suspended solids.



4. Freezing:

It is based on the principle that water excludes salts when it crystallizes to ice. It involves three steps: Ice formation, ice washing, and ice melting to obtain fresh water with subsequent removal of contaminants.



Most effective desalination method:

- As there are four main methods for desalination.
- The most advanced one among these is reverse Osmosis, as it is completely purifies saline water but because of high advancement it is costly as well.
- So, we can't exactly tell hundred percent suitable method in term of cost and efficiency because it depends upon requirements.
- If we are working on smaller scale and lower level so according to me distillation is most suitable.
- But both in terms of cost and efficiency I will say that freezing is effective one as it works good as well as required less cost.

Q2. Briefly describe merits and demerits of 4 types of water distribution layouts? Which layout will you recommend for newly proposed township in hilly area? Support your answer with justification?

Answer:

Water Distribution System Layout:

- Objective is to distribute adequate quantity of water at adequate pressure to individual consumers
- The treated water transmitted and/or stored is distributed
- Main elements of a water distribution systems:
- Pipe network with necessary valves and other appurtenances
- Pumping stations and Storage facilities
- Service connections with valves and fittings
- Fire hydrants (provided only on ≥150 mm size distribution lines)
- Layout of a distribution system is determined by:
- Size and location of water demands
- Street patterns and topography
- Location of water treatment and storage facilities
- A service area can have more than one distribution systems

Layouts of Distribution System

The distribution pipes are generally laid below the road pavements, and as such their layouts generally follow the layouts of roads.

There are in general four different types of pipe networks; any one of which either single or in combination, can be used for a particular place. They are:

a) Dead End System
b) Radial System
c) Grid Iron System
d) Ring System

a) Dead End System

Advantages:

- Relatively cheap.
- Determination of discharges and pressure easier due to less number of valves.

Disadvantages:

- Due to many dead ends, stagnation of water occurs in pipes.

b) Radial System

Advantages:

- It gives quick service.
- Stagnation does not occur.

Disadvantages:

- The end of distributor near to the substation gets heavily loaded;
- When load on the distributor changes, the clients at the distant end of the distributor face serious voltage fluctuations;

c) Grid Iron System

Advantages:

- Water is kept in good circulation due to the absence of dead ends.
- In the cases of a breakdown in some section, water is available from some other direction.

Disadvantages:

- Proper designing is relatively difficult.

d) Ring System

Advantages:

- Water can be supplied to any point from at least two directions.

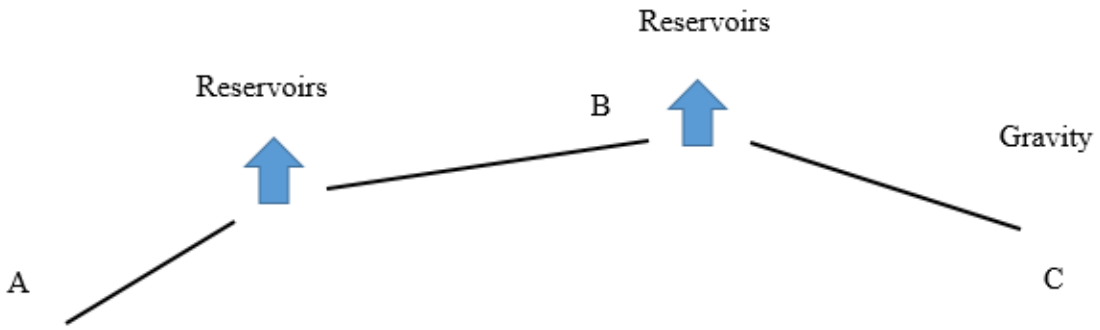
Disadvantages:

- Ring is very expensive n requires more materials
- High maintenance cost; &
- It is not usable when the client is located at the center of the load.

Suitable water distribution for hilly area:

For hilly area, its most effective to first of all divide the whole area in to different zones and to pumps water to each zone and store there is in reservoir, then for the next zone again pump the water and storing in reservoir and so on, because we cannot lay the distribution throughout in one network, we have to do it number of patches or zones.

So radial layout will be more effective with combined pumping and gravity system that is to lift the water to the reservoir or storage tank and then supply through gravity pipes networks.



Q3 What are different types of reservoirs used in water supply systems? Briefly describe its importance and how its storage capacity be calculated?

Answer:

Reservoirs:

A reservoir is a man-made lake or large freshwater body of water. Many people think of a reservoir as a lake and might even use the words interchangeably. However, the key difference is that reservoirs are artificial and made by humans, while lakes are naturally occurring bodies of water. Reservoirs are great because they provide a supply of water for when naturally occurring bodies of water, like lakes or rivers, run dry.

Types of Reservoirs:

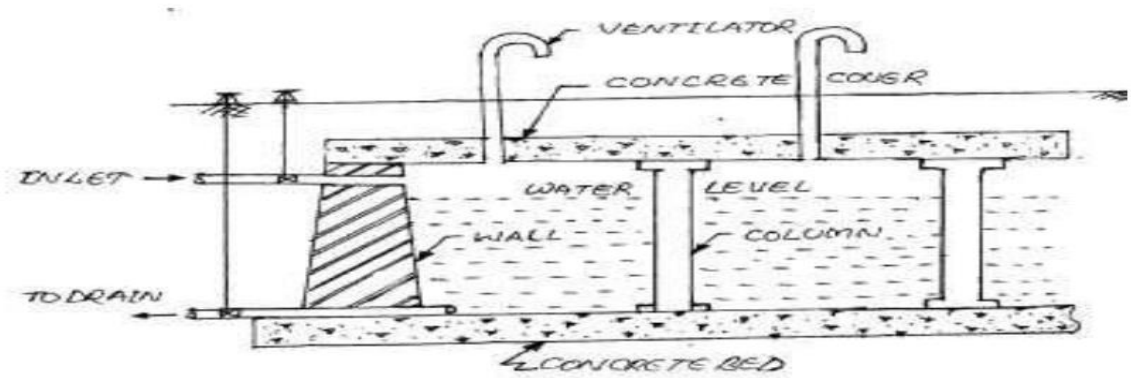
Depending upon their elevation w.r.t ground it may be classified into:

1. Surface reservoirs
2. Elevated reservoirs

Surface reservoirs:

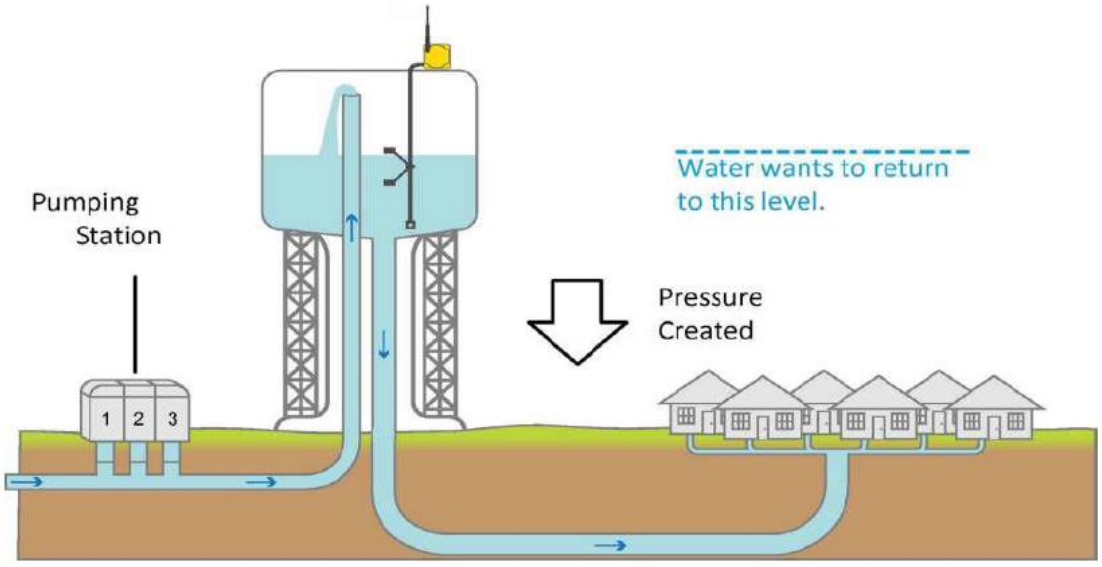
- The side walls are designed to take up the pressure of the water, when the reservoir is full and the earth pressure when it is empty.

- The position of ground water table is also considered while designing these reservoirs.
- The floors of these reservoirs may be constructed with R.C.C slab or stone blocks with sufficient water proofing.
- To obtain water tightness bitumen compounds are used at all construction joints.
- For aeration of water and inspection, manholes, ventilation pipes and stairs are provided.



Elevated Storage Reservoirs:

- Elevated Storage Reservoirs (ESRs) also referred to as Overhead Tanks are required at distribution areas which are not governed and controlled by the gravity system of distribution.
- These are rectangular or circular in shape.
- If the topography of the town is not suitable for gravity system, the elevated tank or reservoir are used to provide sufficient pressure head.
- They are constructed where combine gravity and pumping system of water distribution is adopted.



Importance of Reservoirs:

Reservoir serve many purposes and thus have got much importance:

Water in rivers varies with time, during raining seasons or snow melts the rivers may overflows its banks so reservoir may be constructed there to control flooding.

During extended dry periods (Drought) water availability can only be possible if it's already stored in reservoirs and thus formers can water their crops and home businesses can function properly.

Reservoir can be used for boating and fishing and others forms of recreation.

Dams, that creates reservoirs are used generate electricity.

Water in reservoir is still, so sediment materials sink to bottom thus making the water clear.

Storage Capacity:

The total storage capacity of a distribution reservoir is the summation of:

1. Balancing Storage:

- The quantity of water required to be stored in the reservoir for equalizing or balancing fluctuating demand against constant supply is known as the balancing storage (or equalizing or operating storage).

2. Breakdown Storage:

- The breakdown storage or often called emergency storage is the storage preserved in order to tide over the emergencies posed by the failure of pumps, electricity, or any other mechanism driving the pumps.
- A value of about 25% of the total storage capacity of reservoirs, or 1.5 to 2 times of the average hourly supply, may be considered as enough provision for accounting this storage.

3. Fire Storage:

- The third component of the total reservoir storage is the fire storage.
- This provision takes care of the requirements of water for extinguishing fires.
- Fire demand maybe calculated by the given formulas:
- The total reservoir storage can finally be worked out by adding all the three storages.

Storage Capacity Calculation:

$$Q_F = 65\sqrt{P}(1-0.01\sqrt{P})$$

Q_F = fire demand *l/s*
P = population in thousands

$$Q_F = 53\sqrt{P}$$

Q_F = fire demand *l/s*
P = population in thousands

$$Q_F = 320 * C\sqrt{A}$$

Q_F = fire demand flow m^3/d
A = areas of all stories of the building under consideration (m^2)
C = constant depending on the type of construction;

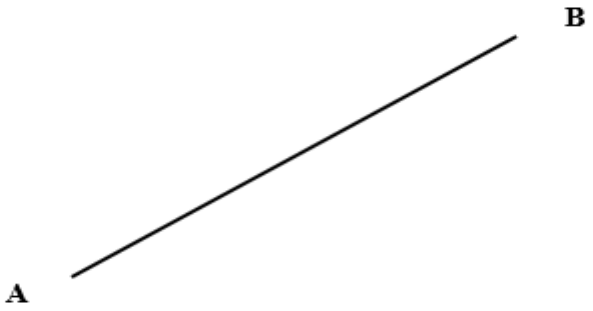
Q4 Why pumps are used in water supply schemes and how to calculate pump curve to meet water demand?

Answer:

Pumps:

"In simple terms we can say that pumps are devices used to transfer water from one point to another that are at different and to overcome the resistance along the path".

Simple figure showing difference in heights:



To transport water from A to B, pump is required.

Why Pumps are used in water supply schemes:

Pumping in water schemes is necessary sometimes, when water is pumped directly into the system (e.g. from lakes) or where pressure has to be increased because there is an insufficient difference in water level in gravity flow distribution systems.

Explanation with reference of an examples:

Let's elaborate pumping with reference on an example.

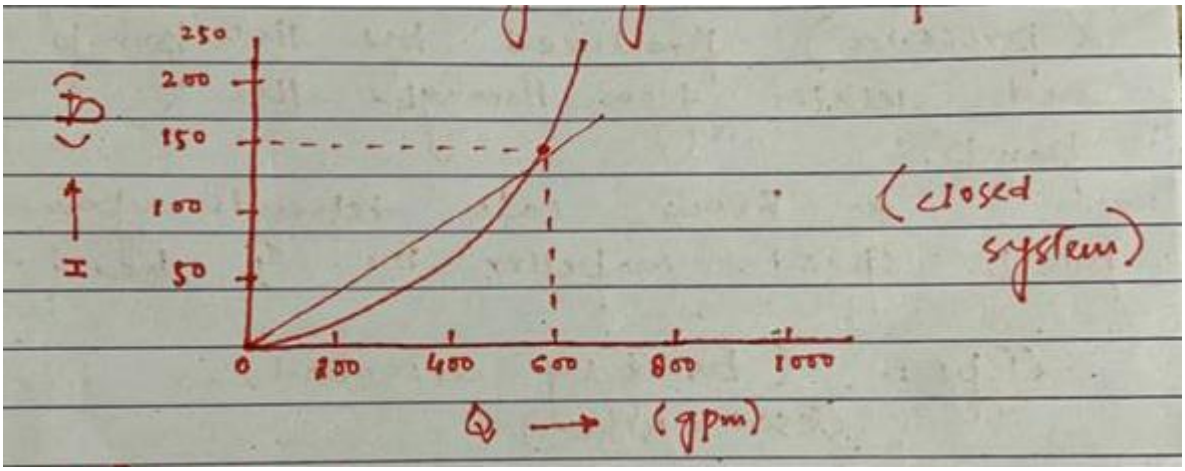
If there is over head tank and water to be supplied from overhead tank to community, so pumping will be necessary to fill up the overhead tank. Sometimes twice pumping is required that is first pumping out water from ground to reservoir for storage and then pumping from reservoir to overhead tank.

Calculating the Pump Curve:

- Pump curve typically include performance metric based on pressure flow, Horse power, Impellers, Trim and net positive suction head is required (NPSHr).
- Pump curves are useful because they show pump performance metrics based on head (pressure) produced by the pump and water flow through the pump.
- Flow rate depends upon pump speed, Impeller dia and head.

Steps (briefly described closed systems):

- Draw an X-Y axis first of all.
- On X-axis is represented flow rate g/minute, let say 0-1000 g/minute, dividing in 200 intervals.
- On Y-axis is head represented from 0-250 feet let suppose and dividing in 50 feet increments.
- Normally we account for static head, but considering here closed loop system, so we don't into account static head.
- Let's flow rate (Q) is 600 gpm at head (H) 150 ft. Plot this on graph and draw a line joining them.
- Now we considered closed system typically that sometimes may not fit, so instead of straight line, draw an arc joining the points.



Open System:

Same is closed but static head involved and as shown as