INSTITUTE OF AERONUTICAL ENGINEERING
(AUTONOMOUS)

III B.TECH II SEMESTER

LECTURE NOTES

on

ENVIRONMENTAL ENGINEERING

Prepared by

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SYLLABUS

- **Unit –I:**
- **Protected Water Supply** - Population Forecasts, Design Period - Water Demand - Types Of Demand - Factors Affecting Fluctuations - Fire Demand - Storage Capacity - Water Quality And Testing - Drinking Water Standards. Comparison from Quality and Quantity and Other Considerations – Intakes - Infiltration Galleries, Confined and Unconfined Aquifers, Distribution Systems - Requirements - Methods and Layouts.

SYLLABUS

- **Unit –II:**
- **Layout and general outline of water treatment units** - sedimentation, uniform settling velocity – principles - design factors - surface loading - Jar test- optimum dosage of coagulant – coagulation - flocculation, clarifier design - coagulants - feeding arrangements. Filtration – theory - working of slow and rapid gravity filters - multimedia filters - design of filters - troubles in operation comparison of filters - disinfection - Types of disinfection - theory of chlorination- chlorine demand and other disinfection treatment methods. Distribution systems - types of layouts of distribution systems - Design of distribution systems - Hardy Cross and equivalent pipe methods, Service reservoirs – joints, valves such as sluice valves, air valves, scour valves and check valves water meters - laying and testing of pipe lines- pump house.

SYLLABUS

- **Unit –III:**
- **Conservancy and water carriage systems** - sewage and storm water estimation - type of concentration - storm water over flows combined flow - characteristics of sewage, cycles of decay - decomposition of sewage, examination of sewage, B.O.D. and C.O.D. equations - design of sewers - shapes and materials - sewer appurtenances manhole - inverted siphon - catch basins - flushing tanks - ejectors, pumps and pump houses- house drainage - components requirements - sanitary fittings - traps- one pipe and two pipe systems of plumbing – ultimate disposal of sewage – sewage farming – dilution

SYLLABUS

- **Unit –IV:**
- **Lay out and general outline of various units in a waste water treatment plant** –primary treatment design of screens –grit chambers –skimming tanks-sedimentation tanks-principles and design of biological treatment –trickling filters- standard and high rate.

SYLLABUS

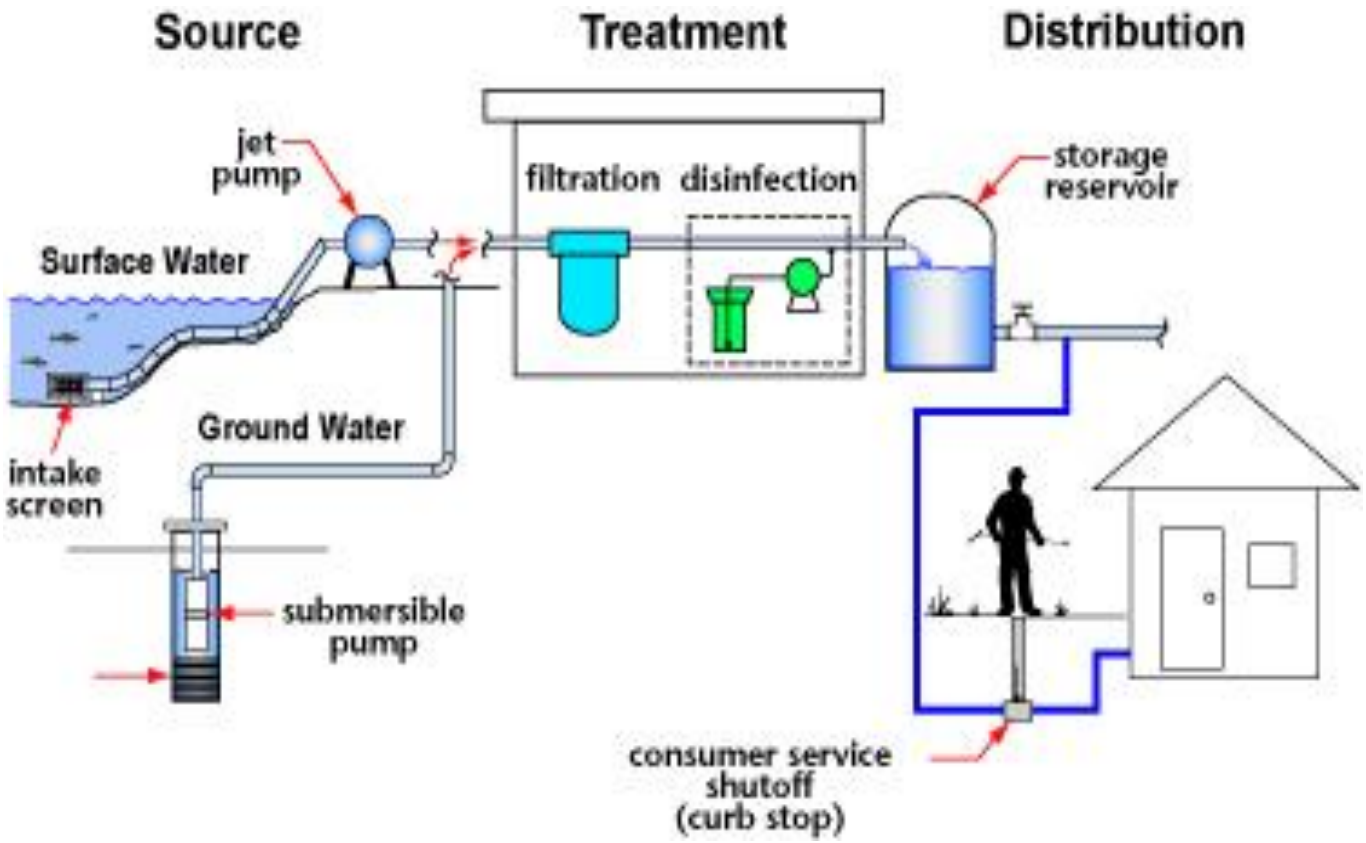
- **Unit –V:**
- **Construction and design of oxidation ponds** –sludge digestion tanks –factors effecting –design of digestion tank –sludge disposal by drying –septic tanks working principles and design-soak pits. Ultimate disposal of waste water- self purification of rivers- sewage farming.

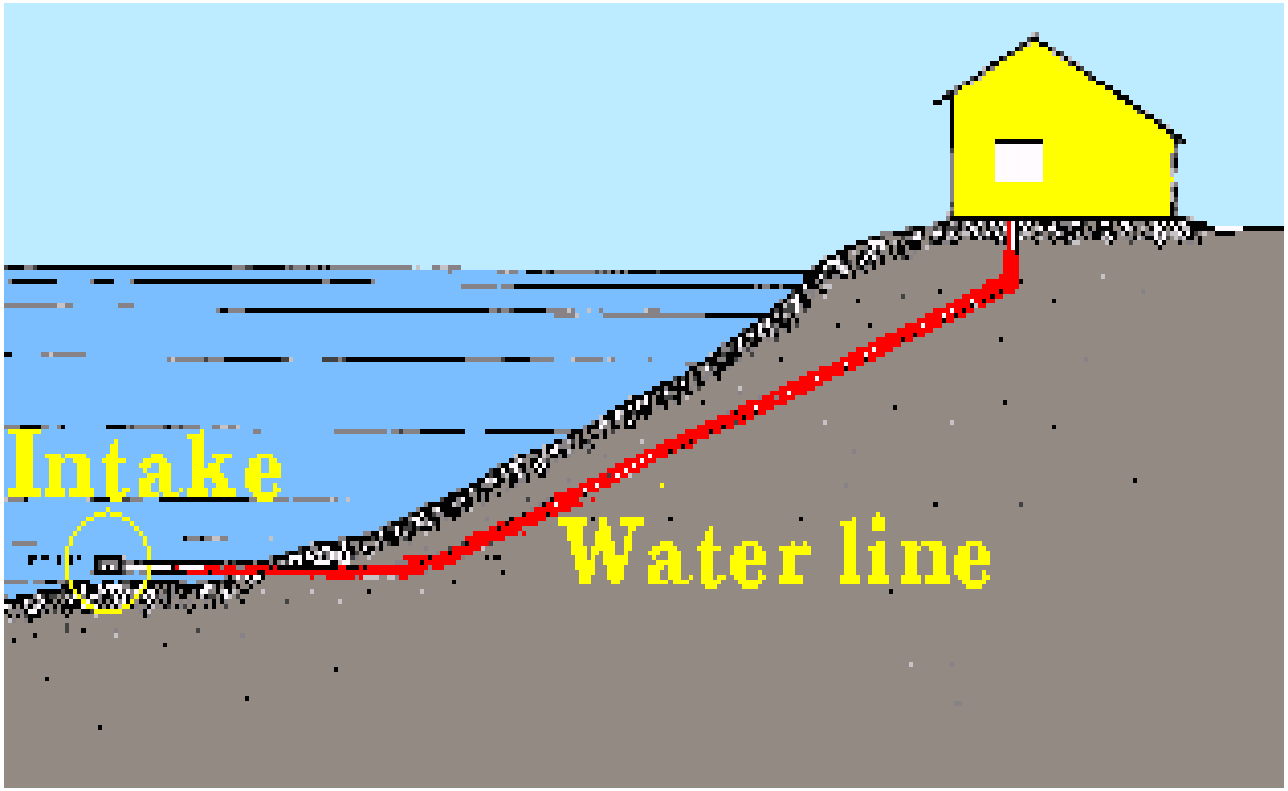
INTAKES:

The main function of the intakes works is to collect the water from various sources. The sources may be lakes, rivers, reservoirs and canals. The intake work for each type of source is designed separately according to its requirements and situations.

Intakes are structures which essentially consist of opening, grating through which the raw water from source and is carried to a sump-well by means of conduits.

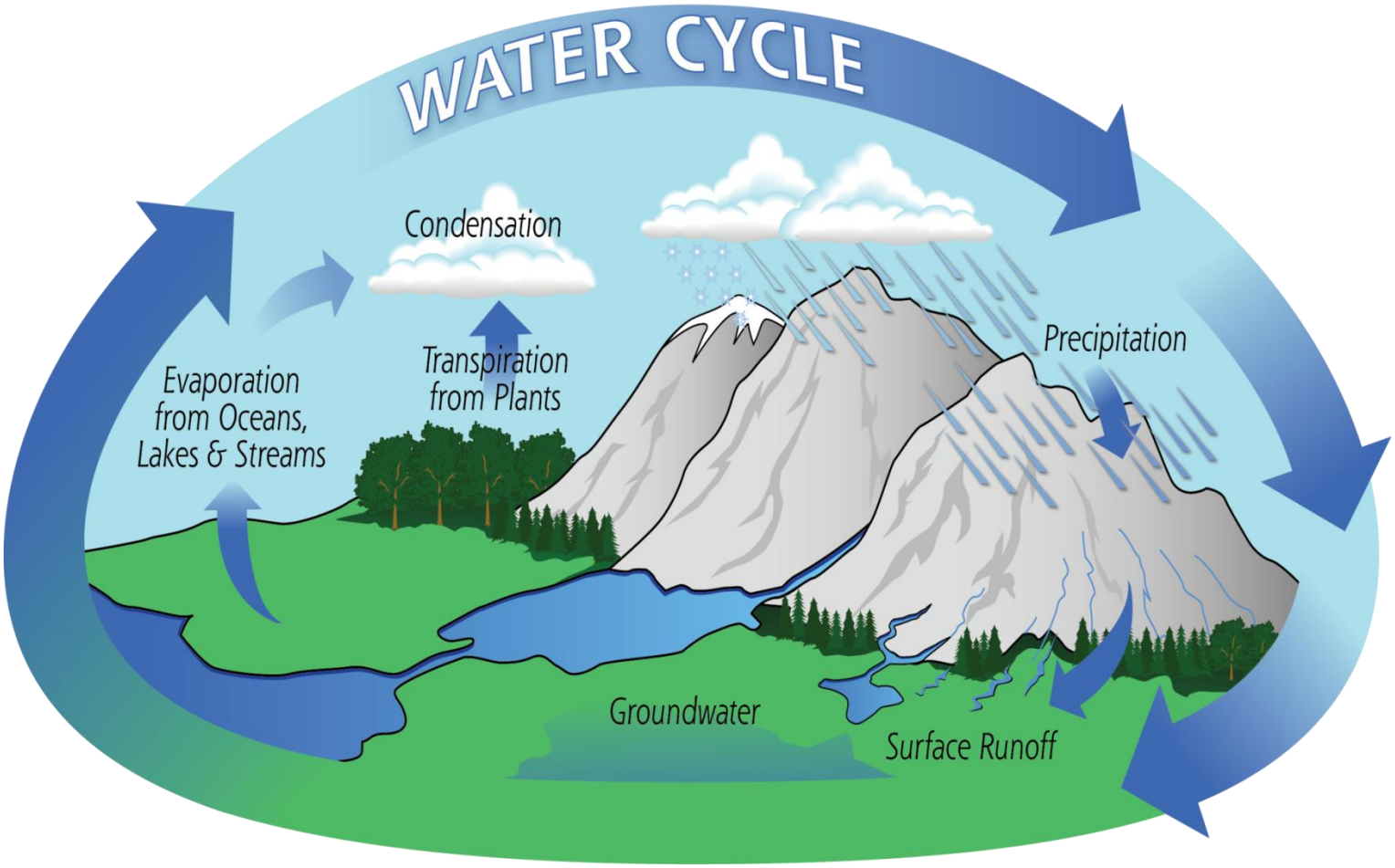
Water from the sump well is pumped through the rising mains to the treatment plant.


Source
Treatment
Distribution
jet pump
Surface Water
intake screen
Ground Water
submersible pump
filtration
disinfection
storage reservoir
consumer service shutoff (curb stop)



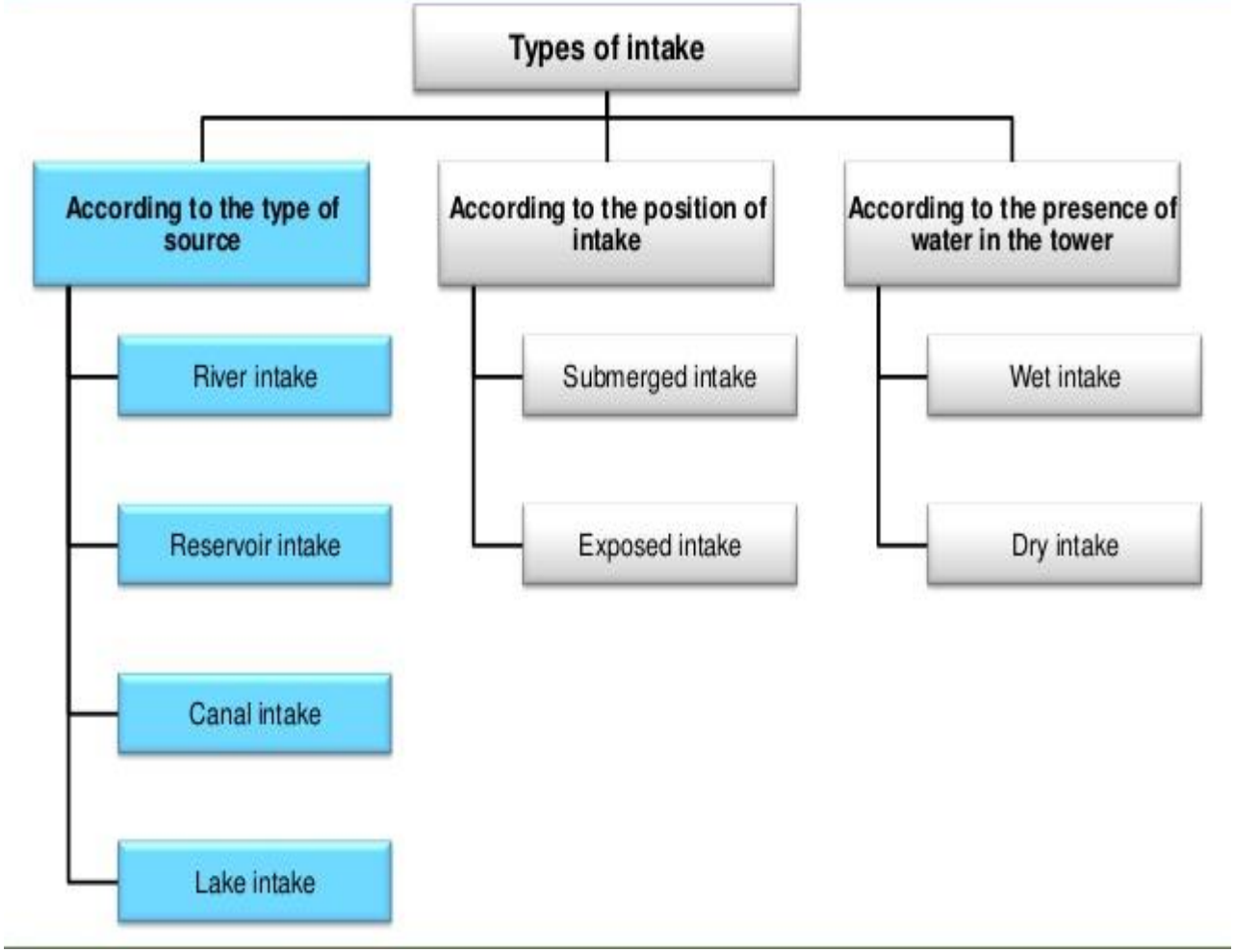
THE FOLLOWING POINTS SHOULD BE CONSIDERED WHILE SELECTING A SITE FOR INTAKE WORKS:

PERCIPITATION:



Types of Intakes

UIPM (CE - 634)
Graduate Report - 2014



- The best quality of water should be available at the site so that it can be easily and economically purified in less time to the treatment plants.

- The site should be such that intake work can draw more quantity of water if required in the future, there should be sufficient scope for future.
- The site of intake should be easily approachable without any obstruction.
- As far as possible the selection of the site should be near the treatment works, it will reduce the conveyance cost from the source of the water-

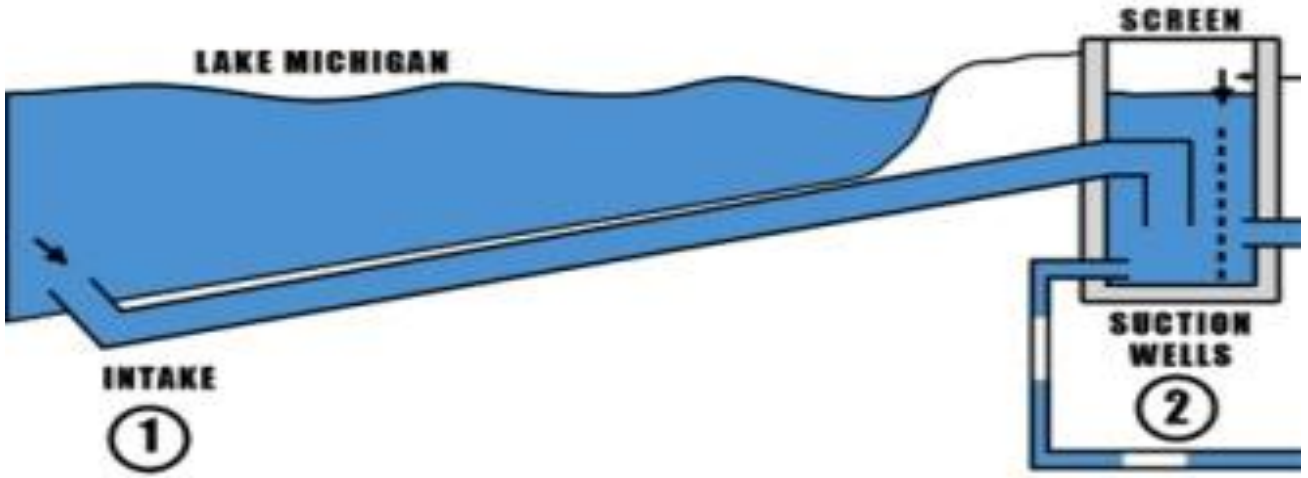
- At the site sufficient quantity should be available for the future expansion of the water-works.
- As far as possible the selection the intake should not be located in the vicinity of the point of sewage disposal.

TYPES OF INTAKES:

The intake work for each type of source is designed separately according to the requirements and situations, Depending on the source of water in intake works are classified as follows:

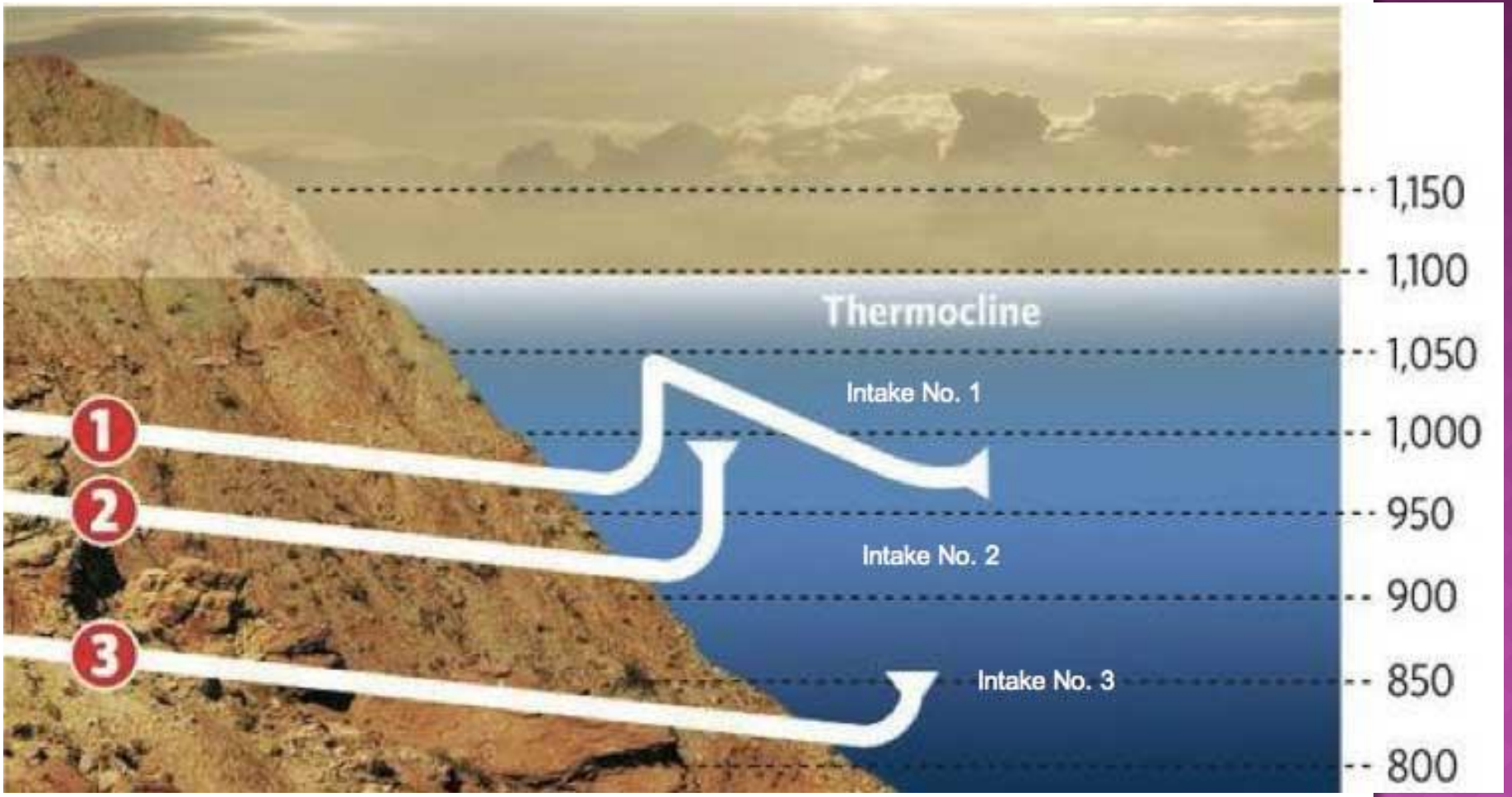
1. Lake intake
2. River intake
3. Reservoir intake
4. Canal intake

1.LAKE INTAKE:

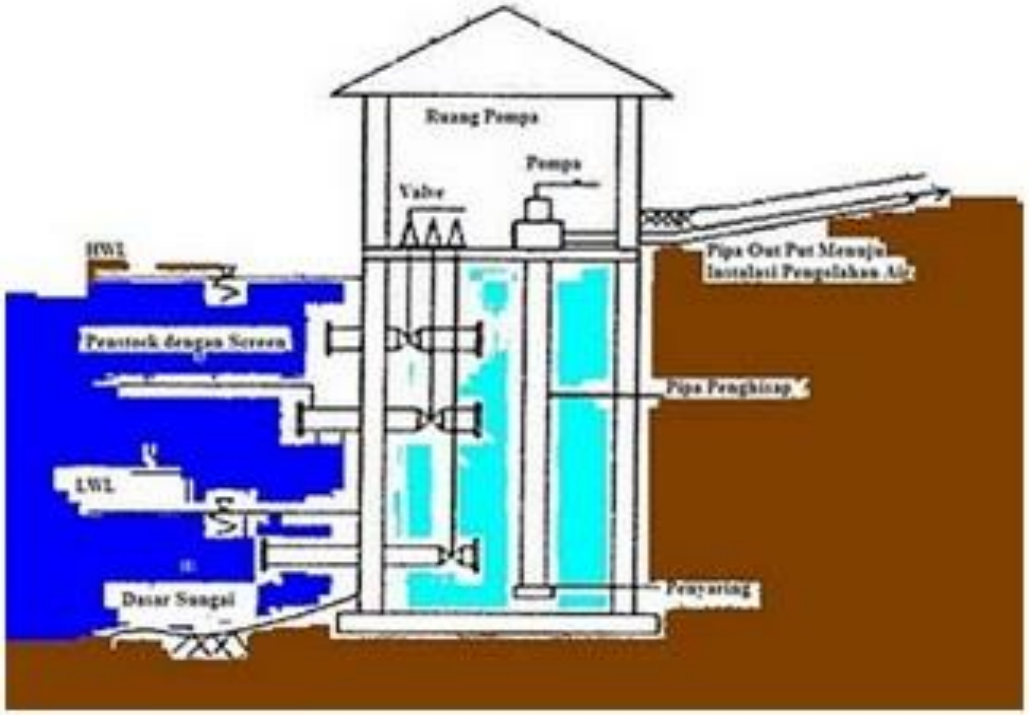


- For obtaining water from lakes mostly submersible intakes are used.
- These intakes are constructed in the bed of the lake below the slow water level so as to draw water in dry season also.
- It essentially consists of a pipe laid in the bed of the river at one end, which is in the middle of the lake is fitted with bell mouth opening covered with mesh and protected by concrete blocks.
- The water enters in the pipe through the bell mouth opening and flows under gravity to the bank where it is collected in sump-well and then pumped to treatment plant.
- If one pipe is not sufficient two or more pipes may be laid to get the required quantity of water.

- As these intakes draw small quantity of water, these are not used on big water supply schemes like rivers or reservoirs.

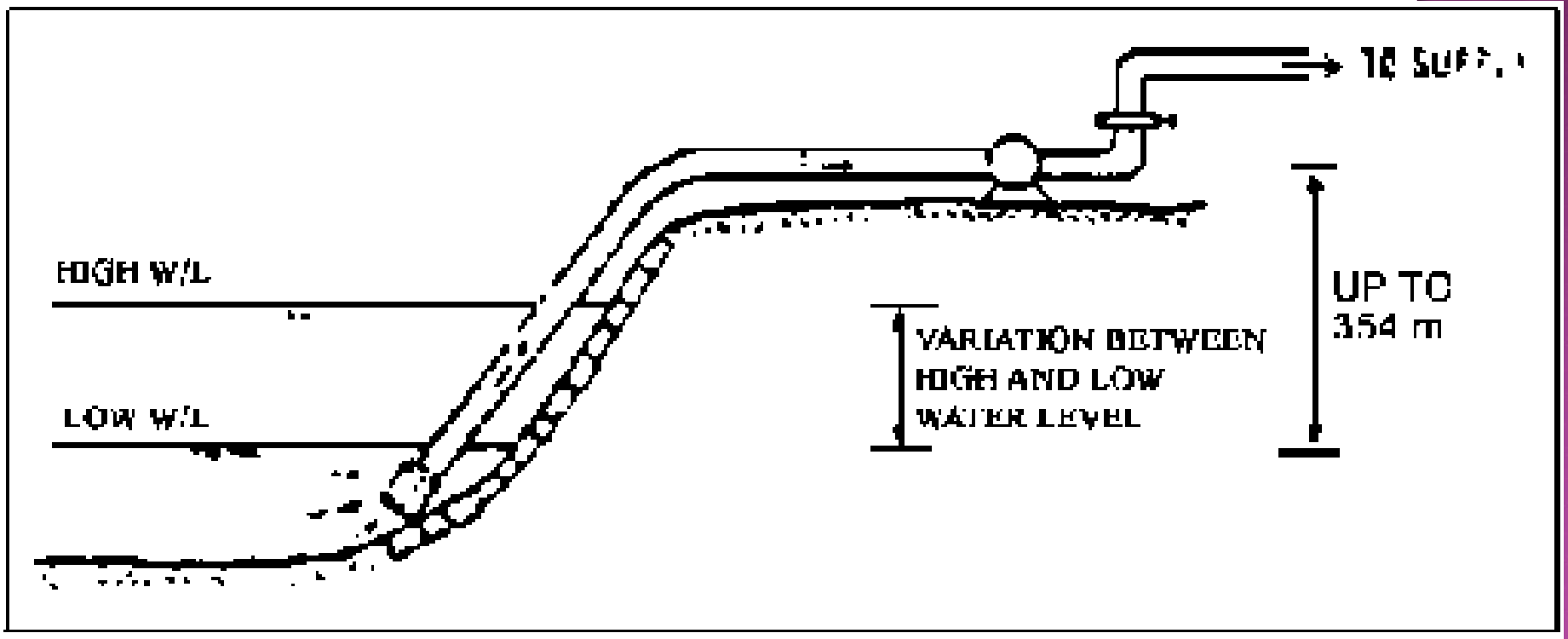


2. RIVER INTAKE:

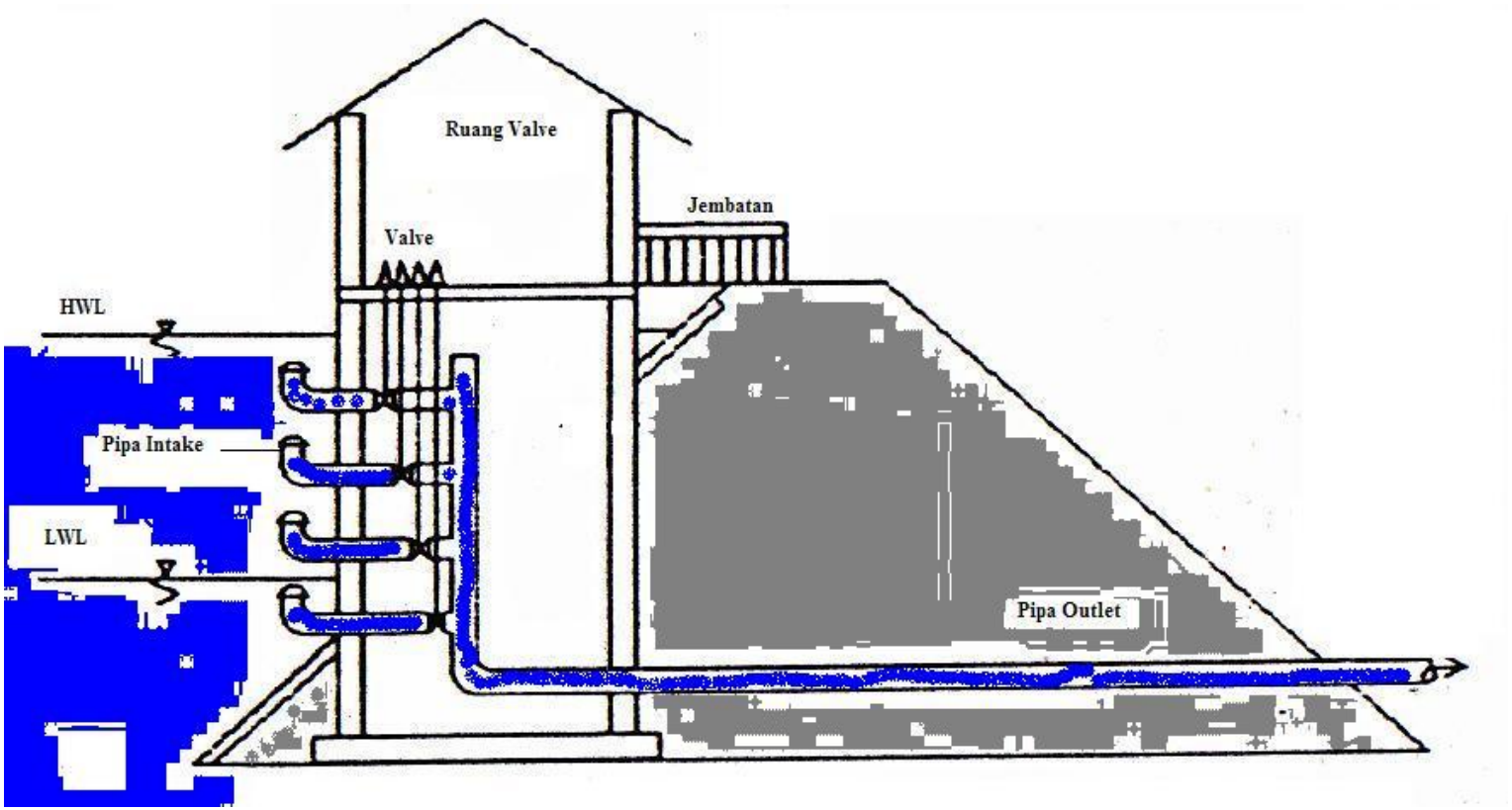


- Water from the rivers is always drawn from the upstream side, because it is free from the contamination caused by the disposal of sewage in it.
- It has circular masonary tower 4 to 7m in dia constructed along the bank of the river at such place from where required quantity of water can be obtained even in the dry period.
- The water enters in the lower portion of the intake known as sump-well from penstocks.
- The penstocked are fitted with screens to check the entry of floating solids.
- Number of penstock opening are provided in the intake tower to admit water at different levels.
- The opening and closing of penstock valves is done with the help of wheels provided at the pump-house floor.

- In case of emergency and temporary works , movable intakes can be used .
- The water is directly pumped from the river and sent for the treatment and distribution.

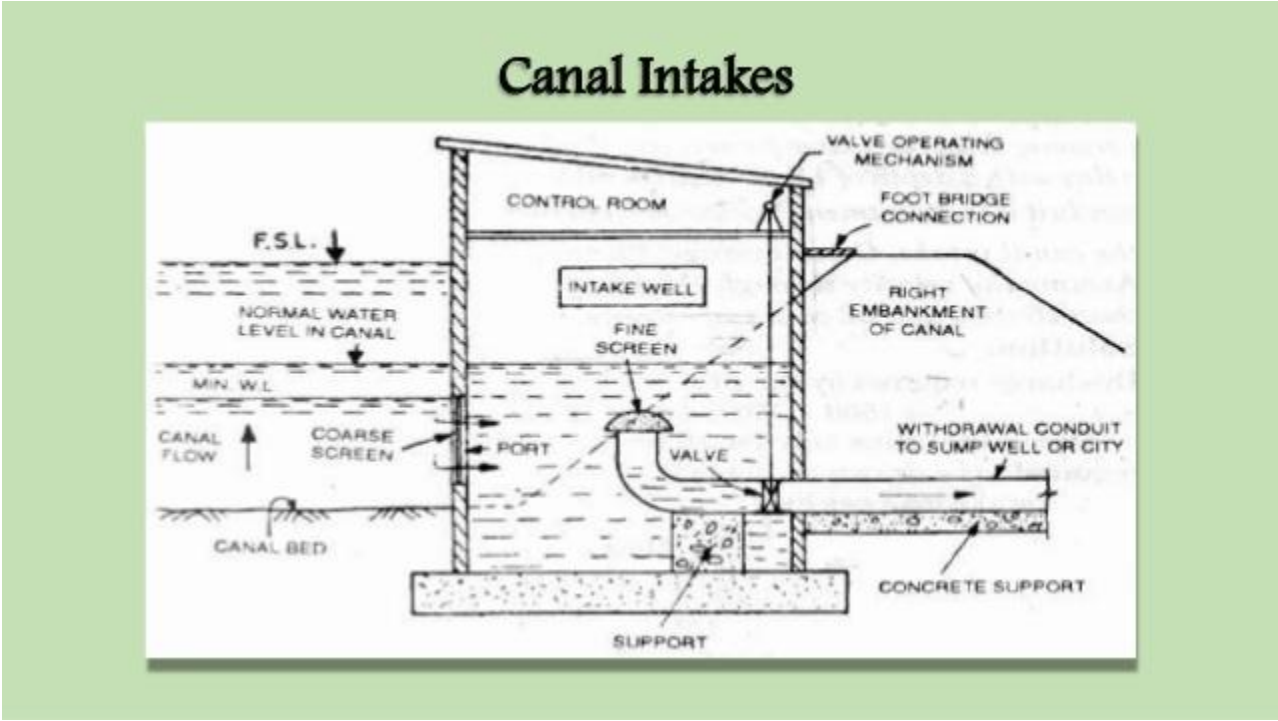


3. RESERVOIR INTAKE:



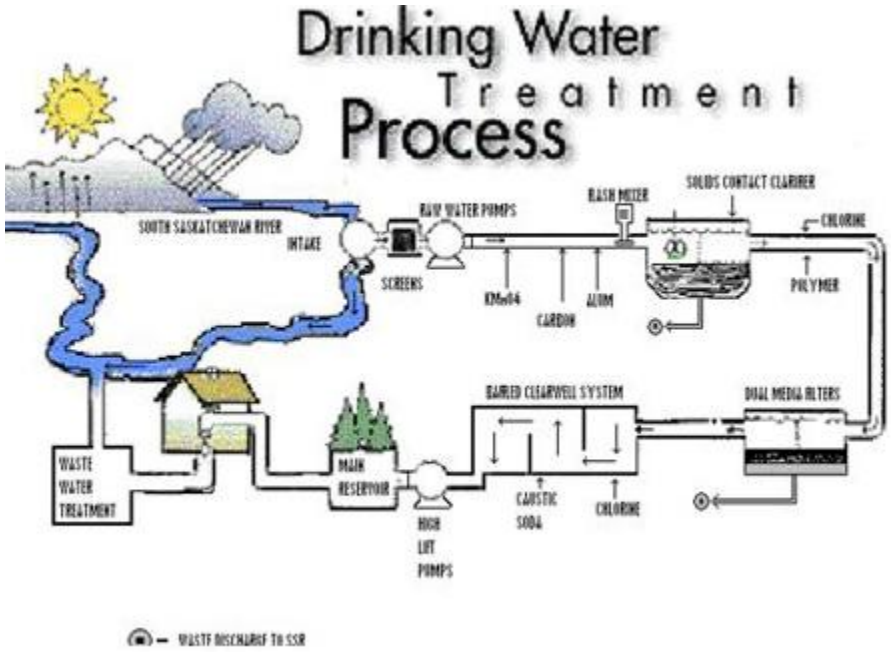
- Reservoir intakes which mostly used to draw the water from earthern dam reservoir. It essentially consists of an intake tower constructed on the slope of the dam at such place from where intake can draw sufficient quantity of water even in the driest period.
- Intake pipes are fixed at different levels, so as to draw water near the surface in all variations of water level.
- These all inlet pipes are connected to one vertical pipe inside the intake well.
- Screens are provided at the mouth of all intakes pipes to prevent the entrance of floating and suspended mstter in them.
- The water which enters the vertical pipe is taken to the other side of the dam by means of outlet pipe.
- At the top of the intake tower sluice valves are provided to control the flow of water.

4.CANAL INTAKE

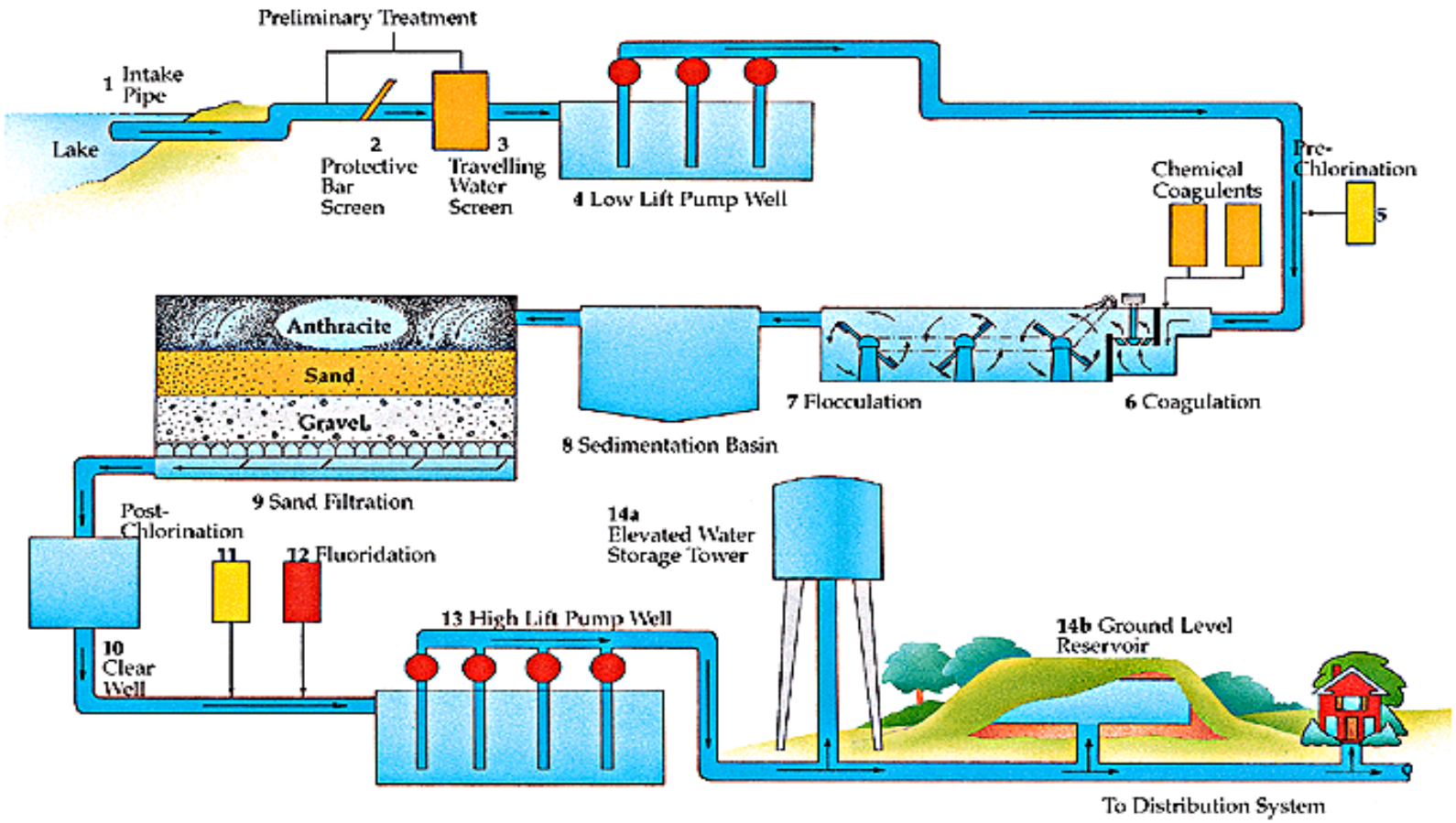


- Canal intake is a very simple structure constructed on the bank.
- It essentially consists of a pipe placed in a brick masonry chamber constructed partly in the canal bank.
- Other side of chambers as opening is provided with coarse screen for the entrance of water.
- The pipe in side chamber is provided with a bell-mouth fitted with a a hemispherical fine screen,
- The out-let pipe carries the water to the other side of the canal bank from where it is taken to the treatment plants.
- One sluice valve which is operated by a wheel from the top of the masonry chamber is provided to control the flow of water in pipe.

TREATMENT PLANT:



WATER TREATMENT PLANT
SURFACE WATER SUPPLY

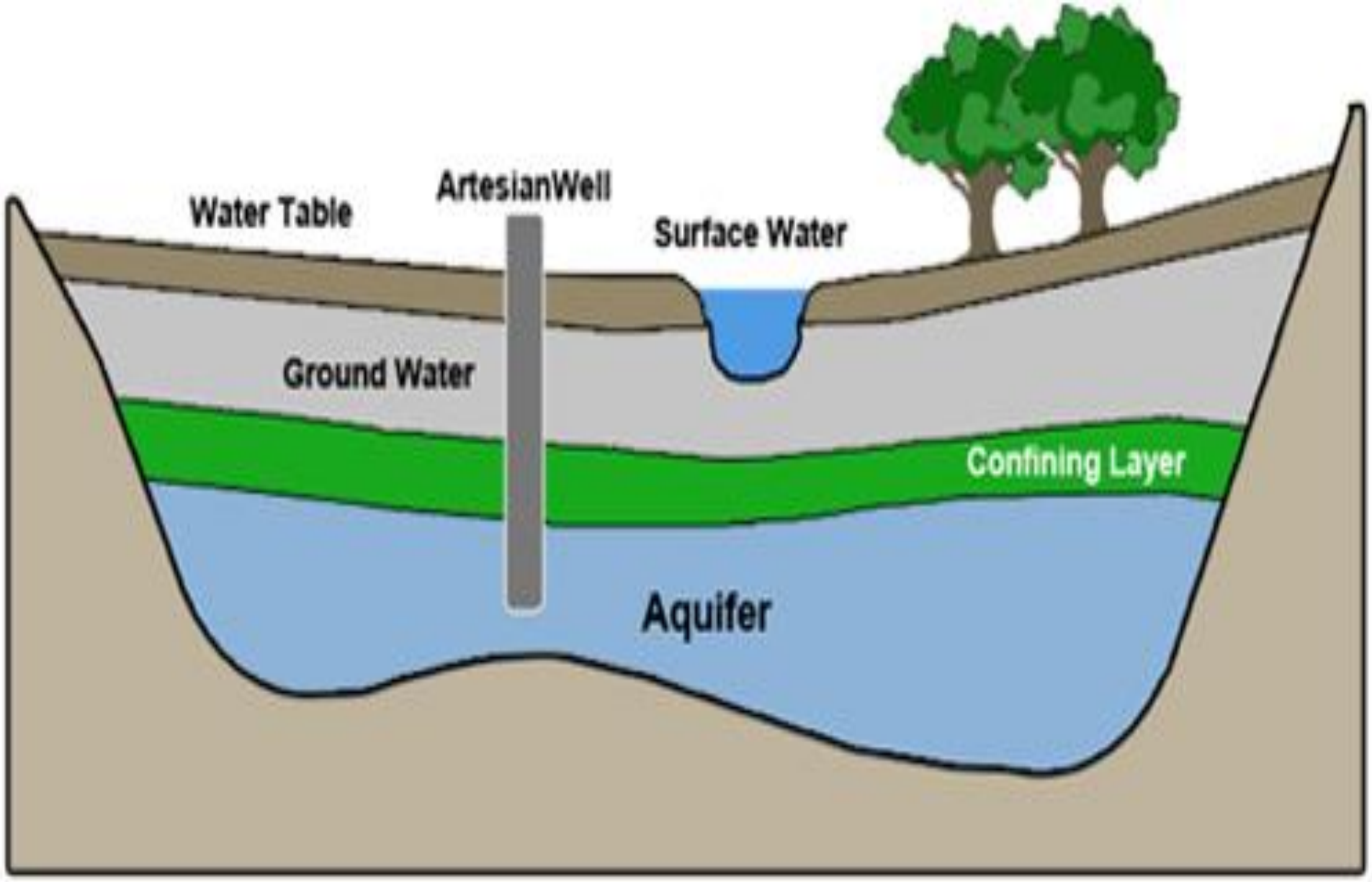


AQUIFERS

1.CONFINED AQUIFER
2.UNCONFINED AQUIFER

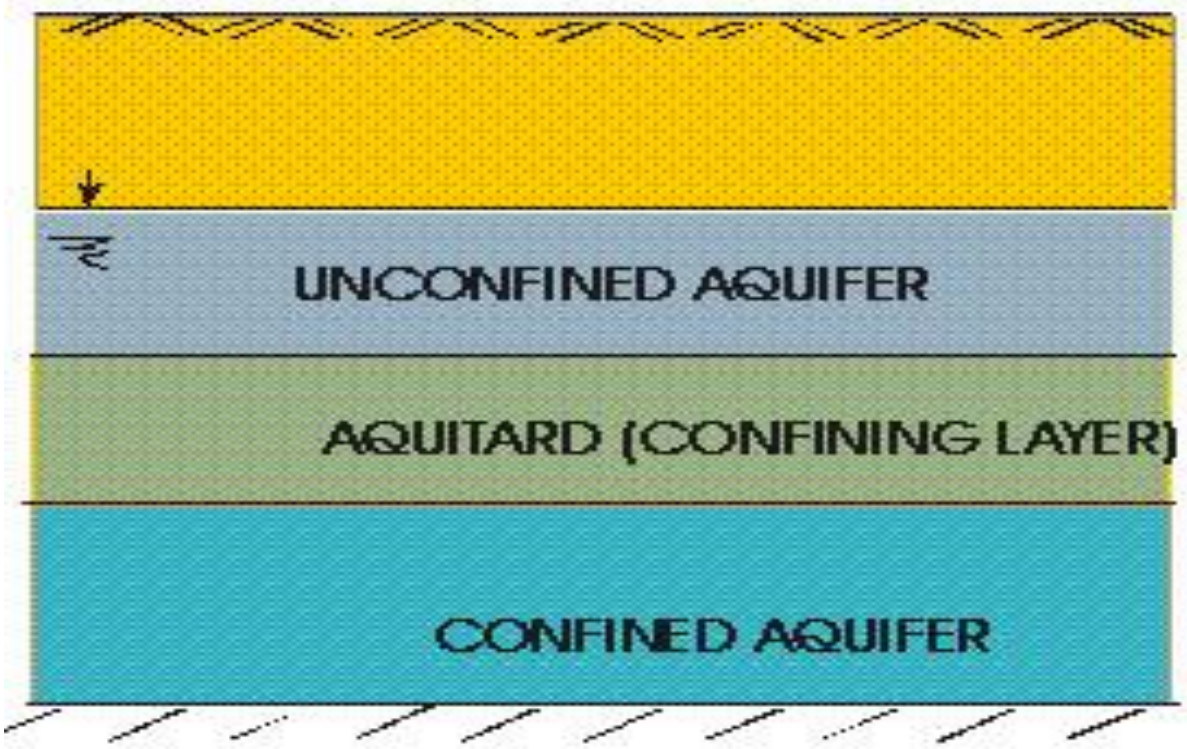
WHAT IS AN AQUIFER???

- An **aquifer** is an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted using a water well.
- The study of water flow in **aquifers** and the characterization of **aquifers** is called hydrogeology.


Water Table
ArtesianWell
Surface Water
Ground Water
Confining Layer
Aquifer

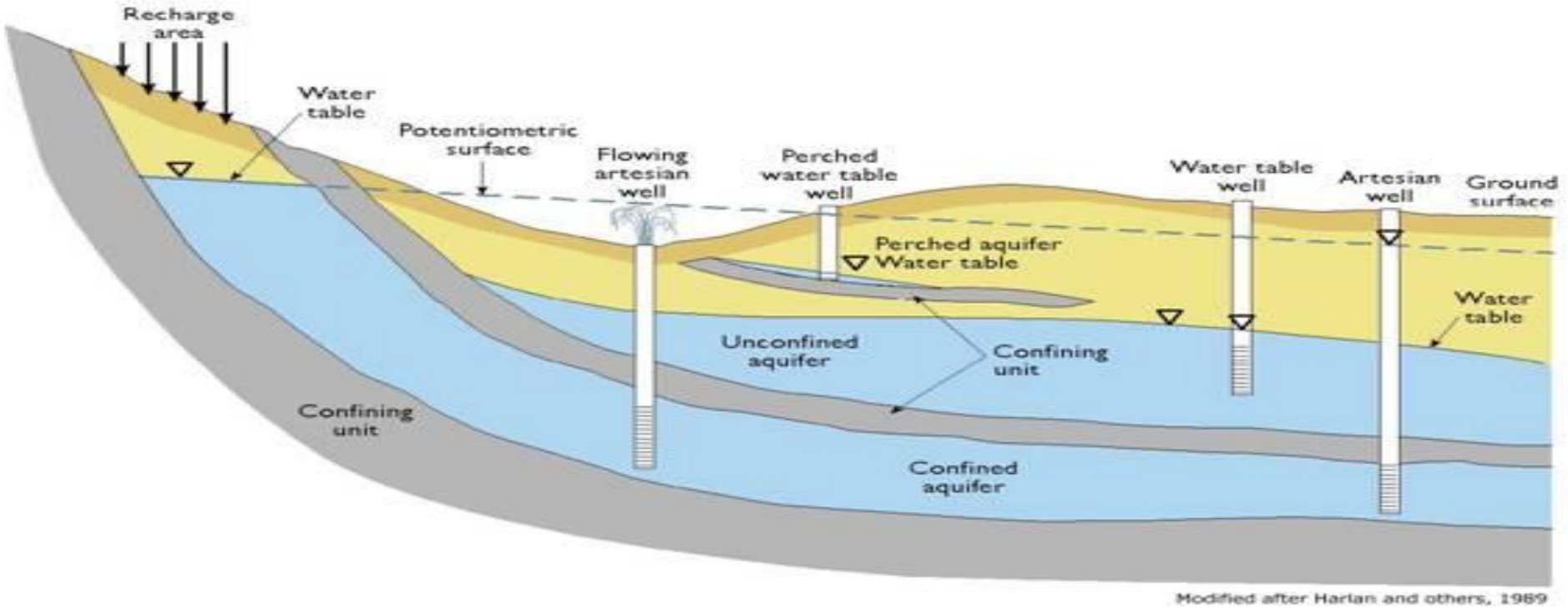
WHAT IS CONFINING LAYER(AQUITARD)?

- Geological material through which significant quantities of water can not move, located below unconfined aquifers, above and below confined aquifers. Also known as a confining bed.



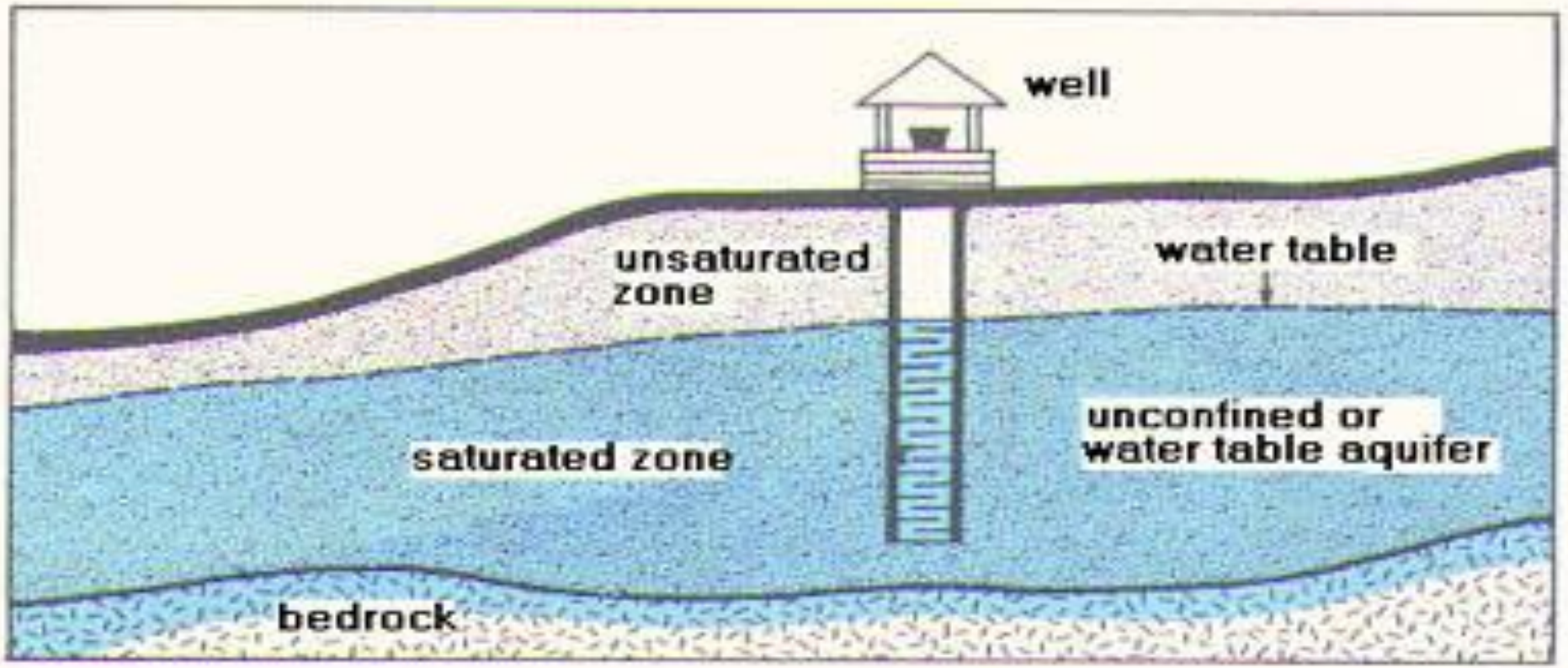
1.CONFINED AQUIFER(ARTESIAN)

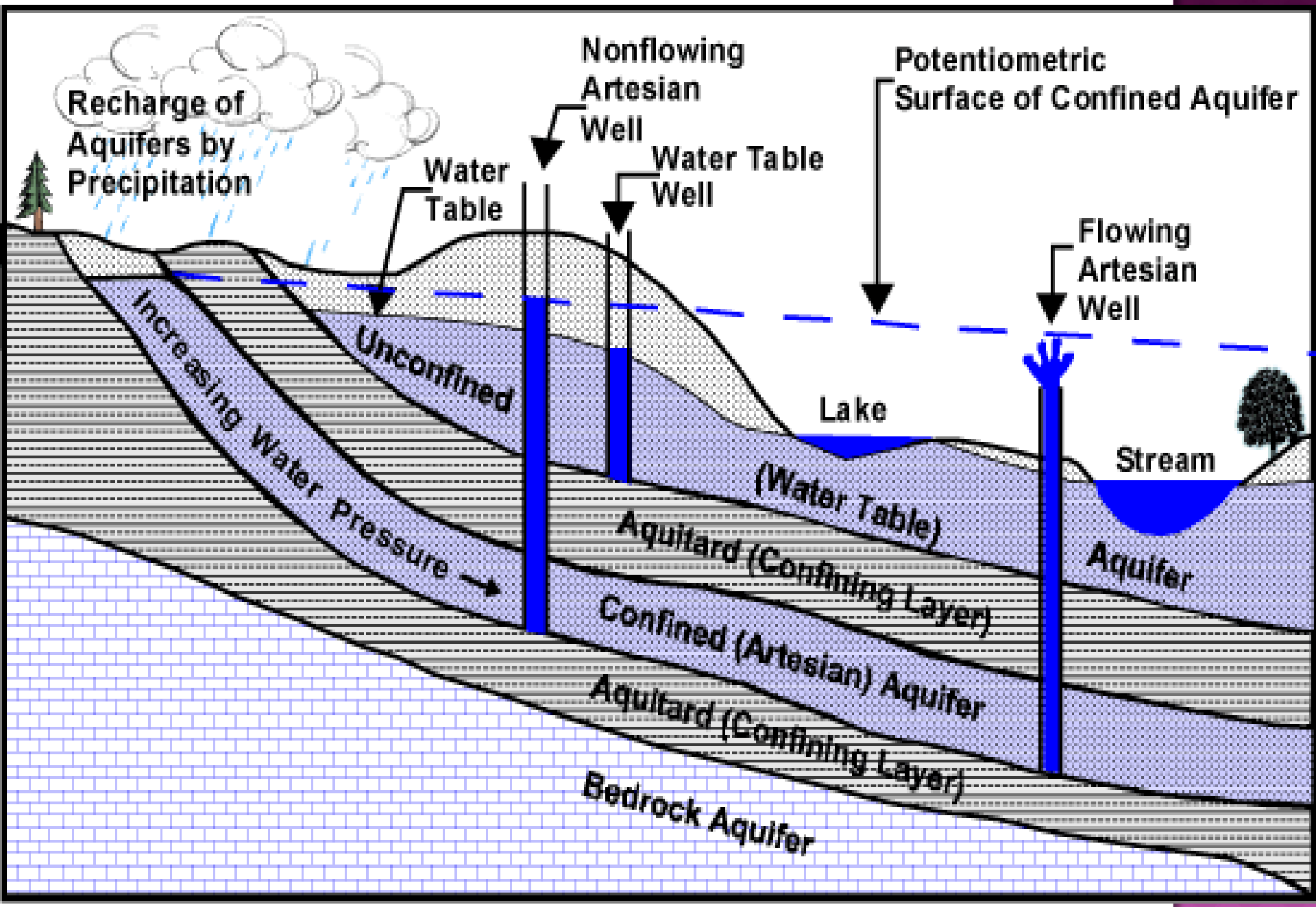
- Confined aquifers are those in which an impermeable dirt/rock layer exists that prevents water from seeping into the aquifer from the ground surface located directly above.



2.UNCONFINED AQUIFER (WATER TABLE AQUIFER):-

- **Unconfined aquifers** are those into which water seeps from the ground surface directly above the **aquifer**.

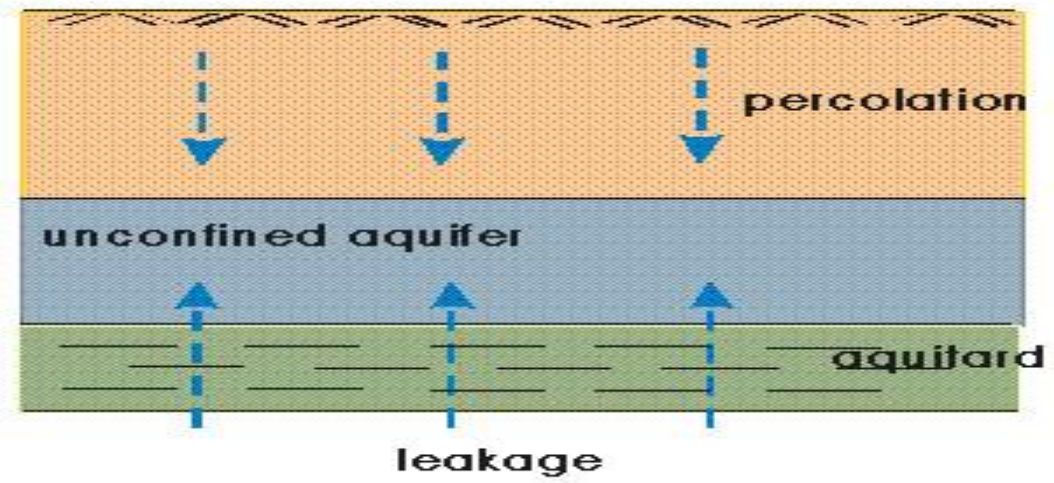



Recharge of Aquifers by Precipitation
Nonflowing Artesian Well
Water Table
Water Table Well
Potentiometric Surface of Confined Aquifer
Flowing Artesian Well
Unconfined
Increasing Water Pressure
Lake
Stream
(Water Table) Aquifer
Aquitard (Confining Layer)
Confined (Artesian) Aquifer
Aquitard (Confining Layer)
Bedrock Aquifer

NATURAL RECHARGE OF THE AQUIFERS?

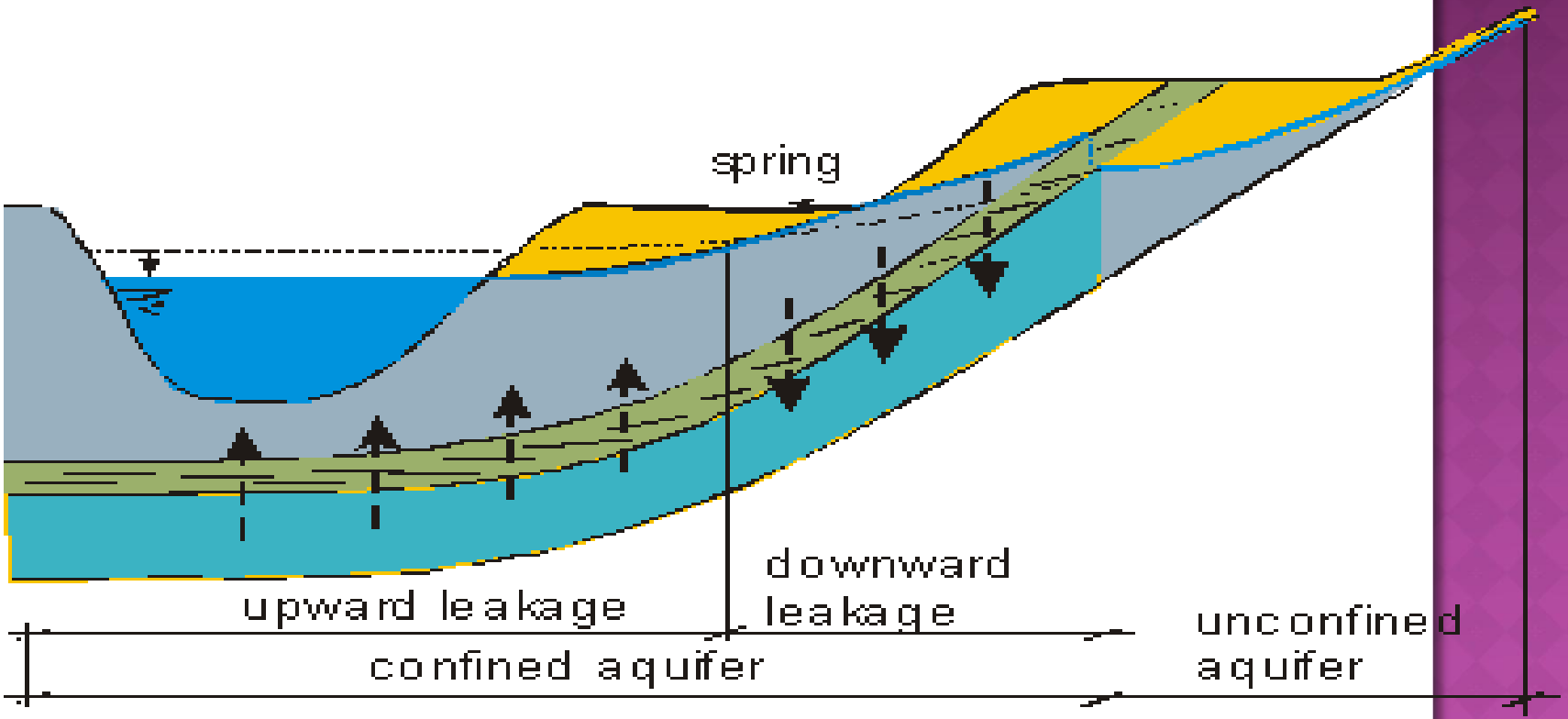
Unconfined aquifers:

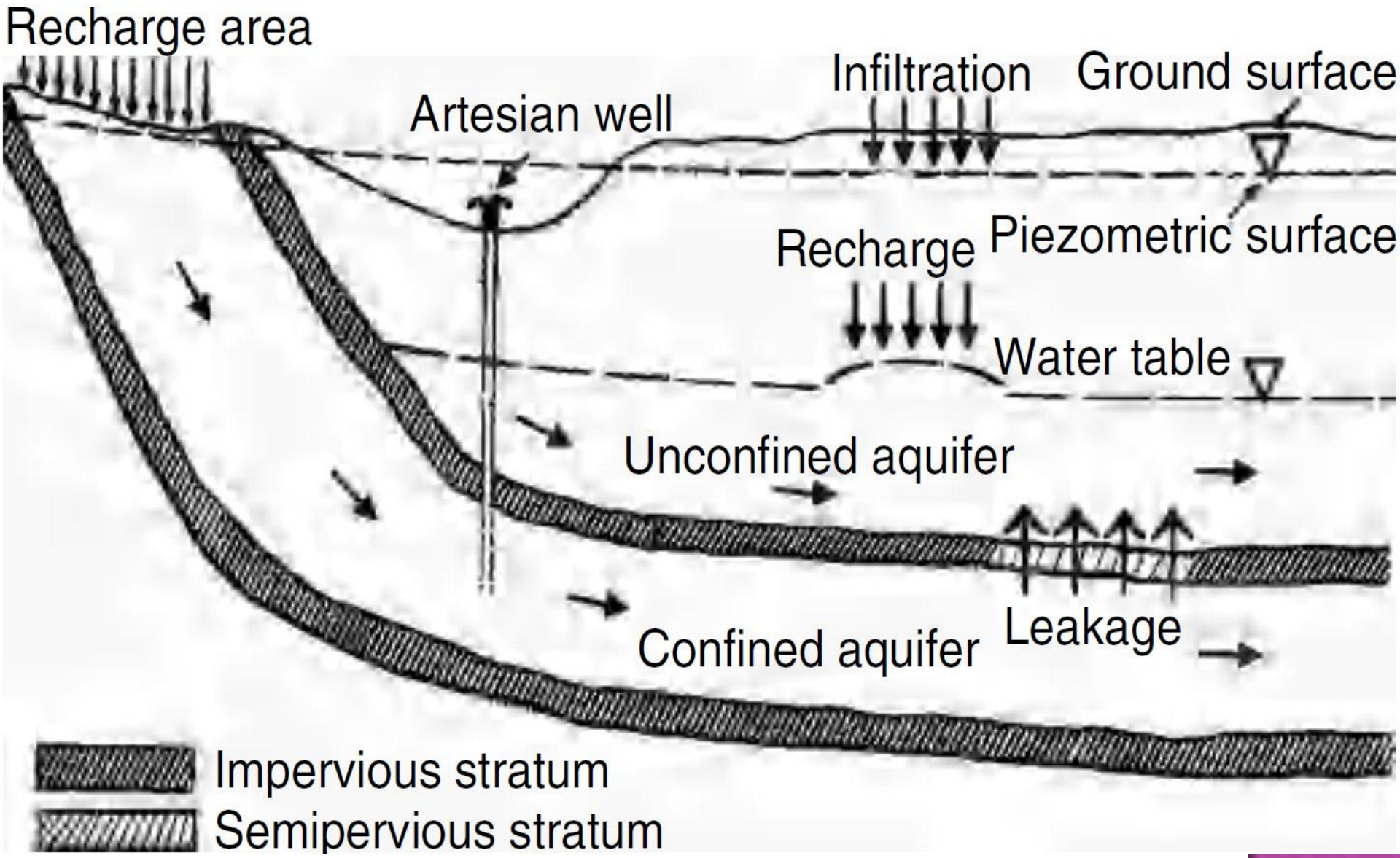
- Natural recharge of the unconfined aquifers is mainly due to the downward seepage (or percolation) through the unsaturated zone of the excess water over passing the field capacity of the soil. Recharge can also occur through upward seepage (leakage) from underlying aquifers.



Confined aquifers:

- A regional confined aquifer is directly recharged by precipitation in the area where the aquifer crops out, having the same characteristics as an unconfined aquifer.




Recharge area
Infiltration
Ground surface
Artesian well
Recharge
Piezometric surface
Water table
Unconfined aquifer
Leakage
Confined aquifer
Impervious stratum
Semipervious stratum

INFILTRATION GALLERIES:

- Infiltration galleries is a conduit,

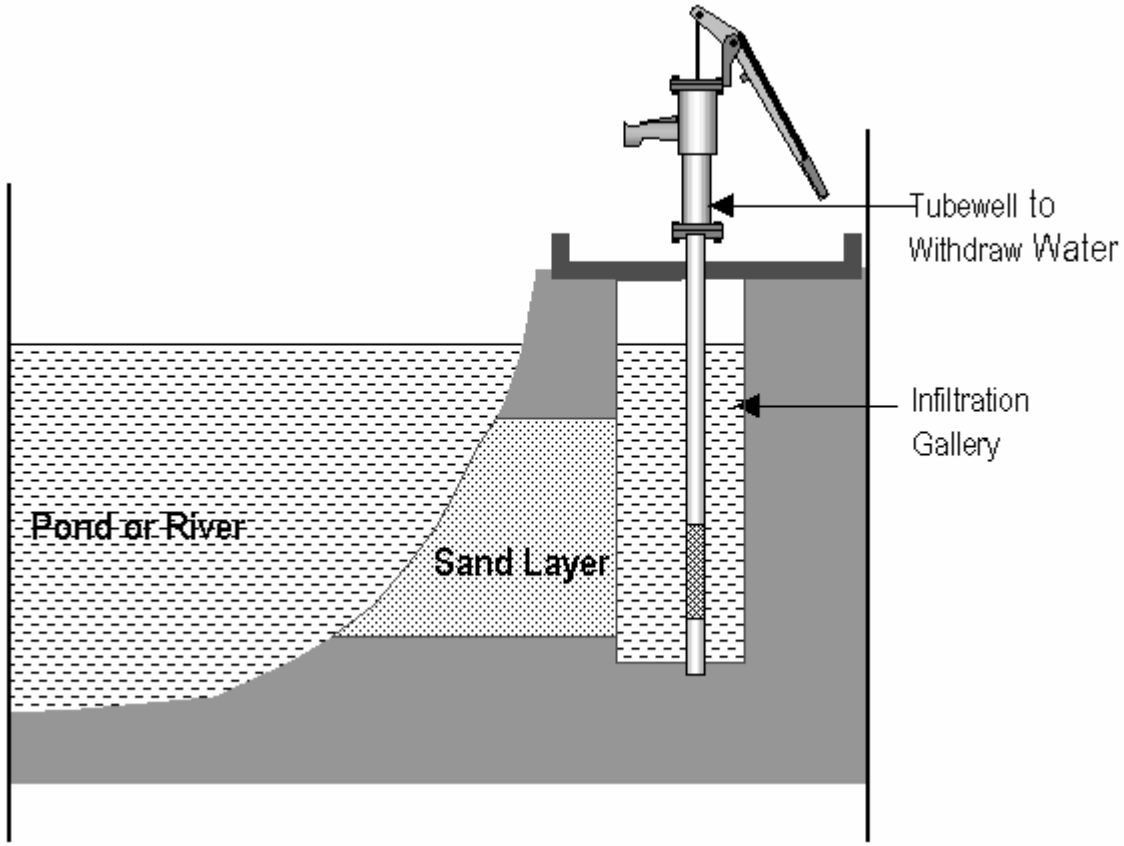
built in permeable earth, for collecting ground water.

- 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 holes on sides at right angle to the direction of flow.
- These underground tunnel used for tapping underground water near rivers, lakes or streams are called “INFILTRATION GALLERIES”.
- These are also known as Horizontal walls.

Infiltration Gallery

- Infiltration Galleries (IG) or wells can be constructed near perennial rivers or ponds to collect infiltrated surface waters for all domestic purposes. Since the water infiltrate through a layer of soil/sand, it is significantly free from suspended impurities including microorganisms usually present in surface water. Again, surface water being the main source of water in the gallery/well, it is free from arsenic. If the soil is impermeable, well graded sand may be placed in between the gallery and surface water source for rapid flow of water.

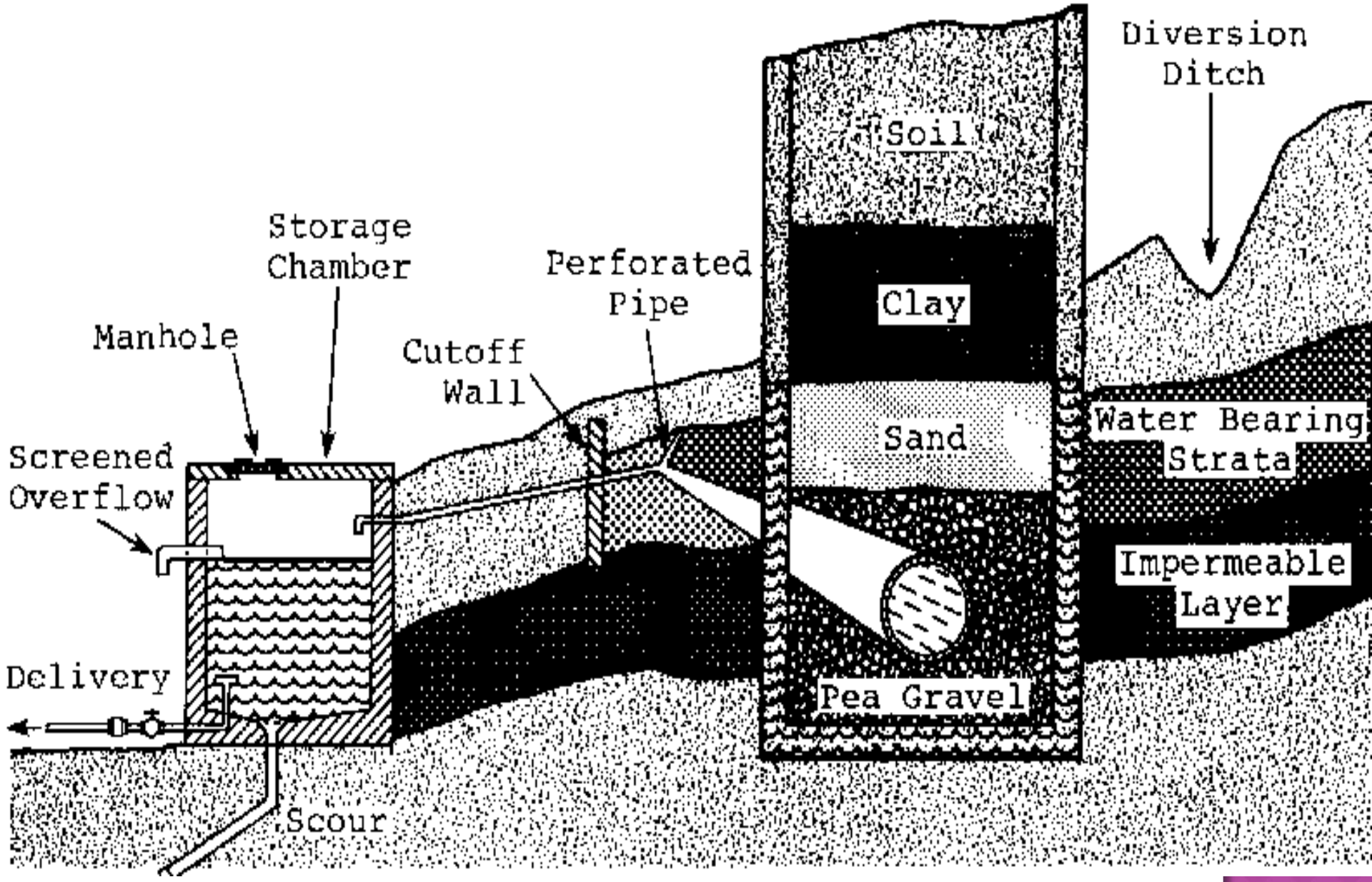
EXAMPLE:-


Tubewell to
Withdraw Water
Infiltration
Gallery
Pond or River
Sand Layer

- Infiltration galleries can be used to collect sub-surface flow from rivers. Water is taken to a collective well, or sump, and then pumped to a storage tank.
- Infiltration galleries vary in size, from a few meters feeding into spring box, to many kilometers forming an integral part of unban water supply.

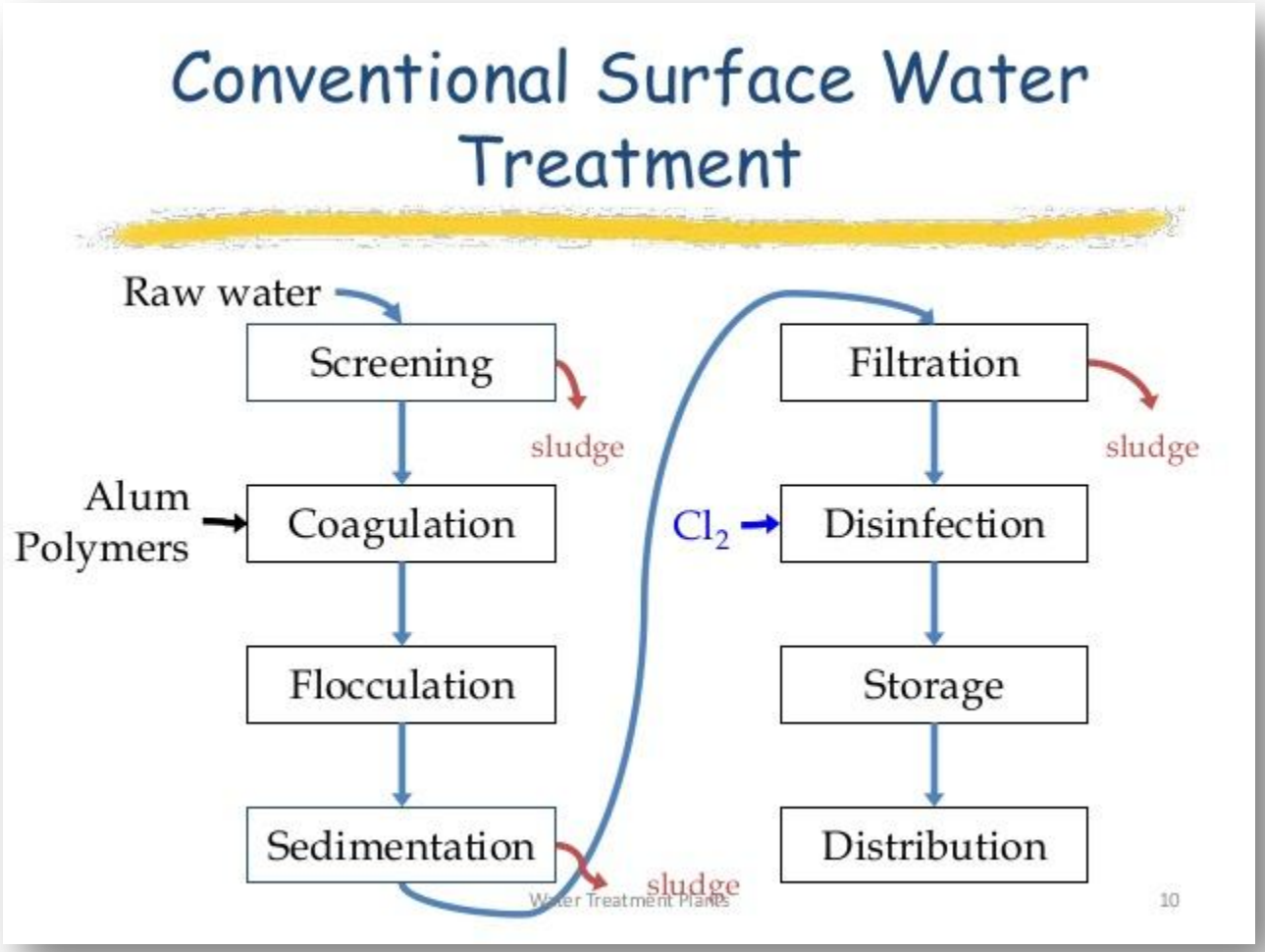
CONSTRUCTION OF GALLERIES:

- To ensure a continuous supply of water , infiltration galleries should be built in the end of dry season and should be at least one meter under the dry season water table.
- Excavate a trench to at least 1 m below the water table,
- Lay graded gravel on the base of the trench.
- Lay the pipe or drain blocks on top of the gravel. Cover the top and sides with more graded gravel.
- Cap the gravel with an impermeable layer of clay to prevent surface water entering the gallery.


Diversion
Ditch
Soil
Storage
Chamber
Perforated
Pipe
Clay
Manhole
Cutoff
Wall
Water Bearing
Strata
Screened
Overflow
Sand
Impermeable
Layer
Delivery
Pea Gravel
Scour

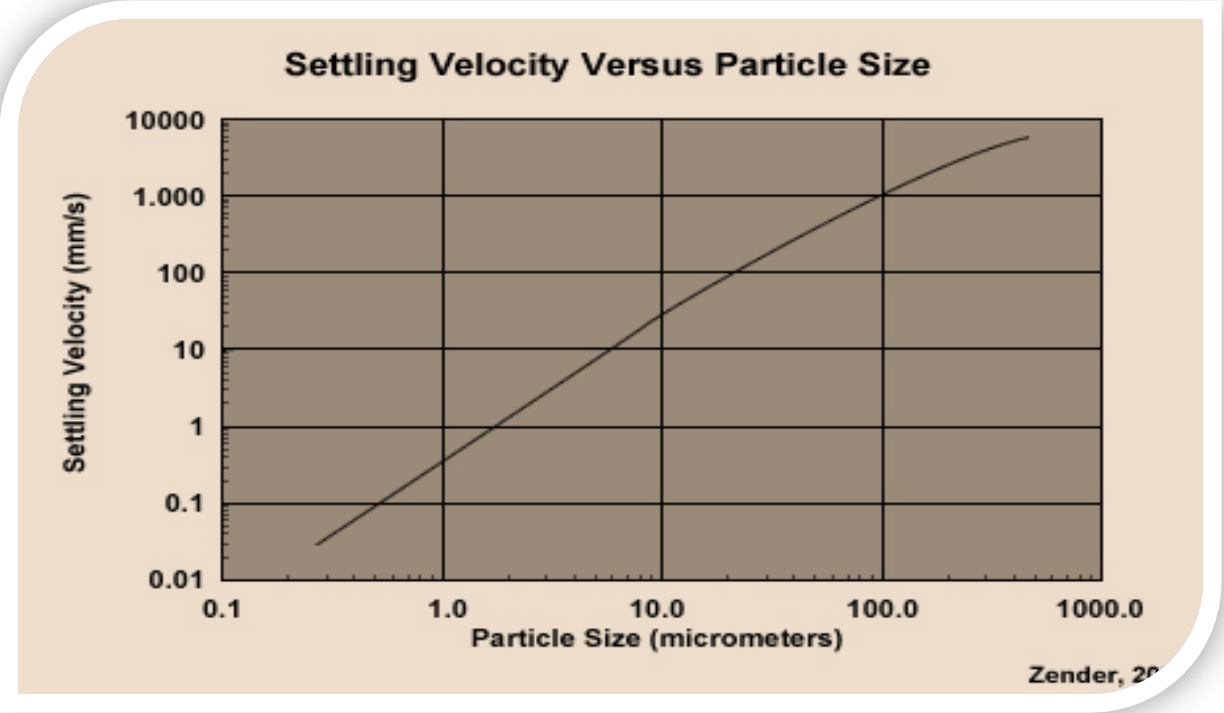
TREATMENT PLANT

LAYOUT OF WATER TREATMENT:



UNIFORM SETTLING VELOCITY:

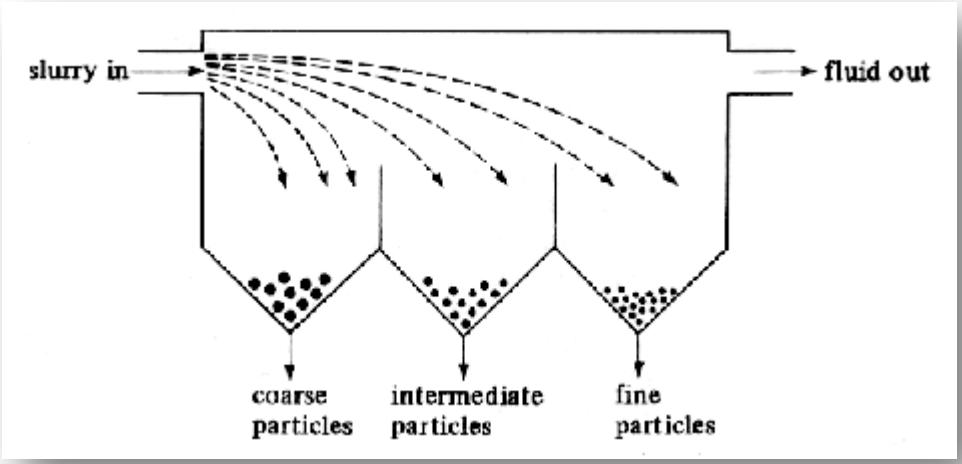
- Settling is the process by which particulates settle to the bottom of a liquid and form a sediment.
- Particles that experience a force, either due to gravity or due to centrifugal motion will tend to move in a uniform manner in the direction exerted by that force.



THINGS THAT MATTER FOR SETTLING PROCESS?

- Size, shape and specific gravity of the particles.
- ***Discrete particle settling*** - Particles settle individually without interaction with neighboring particles.
- ***Flocculent Particles*** – Flocculation causes the particles to increase in mass and settle at a faster rate.
- ***Hindered or Zone settling*** –The mass of particles tends to settle as a unit with individual particles remaining in fixed positions with respect to each other.

The purpose of a Water Treatment Plant is to remove particulates and pathogens from water that may pose a health threat to consumers.


slurry in
fluid out
coarse particles
intermediate particles
fine particles

PRINCIPLES OF WATER TREATMENT:

The Principles of Water and Wastewater Treatment Processes has been divided into the following Units:

- Water Quality
- Physical Processes:

Microbes and other colloidal particles can be physically removed from water by various processes. The sizes of the microbes are especially important for their removal by sedimentation and filtration.

- Chemical Processes:

Calcium hydroxide (hydrated lime) ($Ca(OH)_2$):

Is dosed at the start and end of the treatment process. The pre-dose increases the alkalinity for optimal coagulation as well as the hardness and buffering capacity of water (resistance to change in pH). The post-dose is to raise the pH to within drinking water guidelines and the optimum level for the residual disinfectant.

- Sludge Treatment:

Sludge is produced from the treatment of wastewater in on-site (e.g. septic tank) and off-site (e.g. activated sludge) systems. The primary aim of wastewater treatment is removing solids from the wastewater.

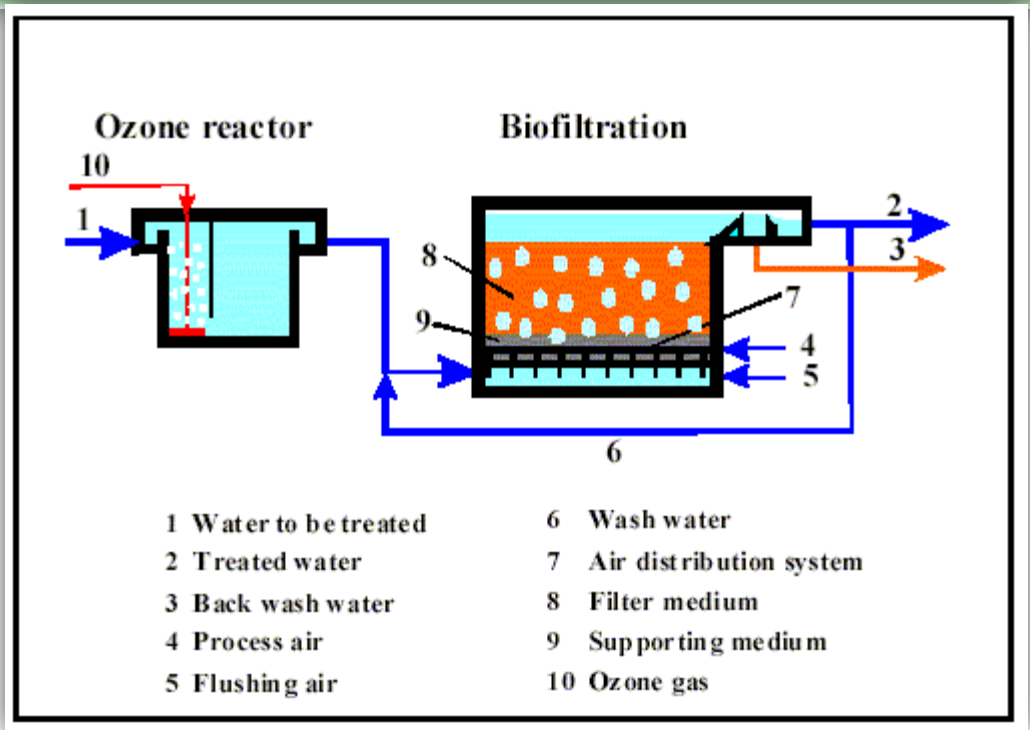
- Odour Management:

Wastewater treatment plant odours are common. Perimeter odour neutralising spray systems can be used to great effect to control **wastewater treatment plant odours.**

(Biofiltration systems can treat several contaminants simultaneously, without the use of chemicals. With 95% odour removal efficiency, our biofiltration systems can treat a wide range of contaminants.)

Biofiltration

Biofiltration is a means of removing odorous and non-odorous gases from waste air-streams utilising multi-strain micro-organisms to biologically degrade volatile organic compounds (VOC's) to simpler forms i.e. CO_2 and water. Multi-strain micro-organisms can even degrade landfill gas and petrol vapour to simple non-polluting forms.



SURFACE LOADING

Calculating the surface loading gives a guide to how much water can be processed each day per area of sedimentation tank.

- Surface loading is one of the most important factors affecting the effectiveness of the sedimentation process. The surface loading rate is used to determine if the sedimentation tanks and clarifiers are under loaded or over loaded.
- If actual surface loading is > the design values then this indicates the tanks are overloaded.
  If actual surface loading is < the design values then this indicates the tanks are underloaded.

- The surface loading test calculates the volume of water being treated over a period of time over surface area of the tank.

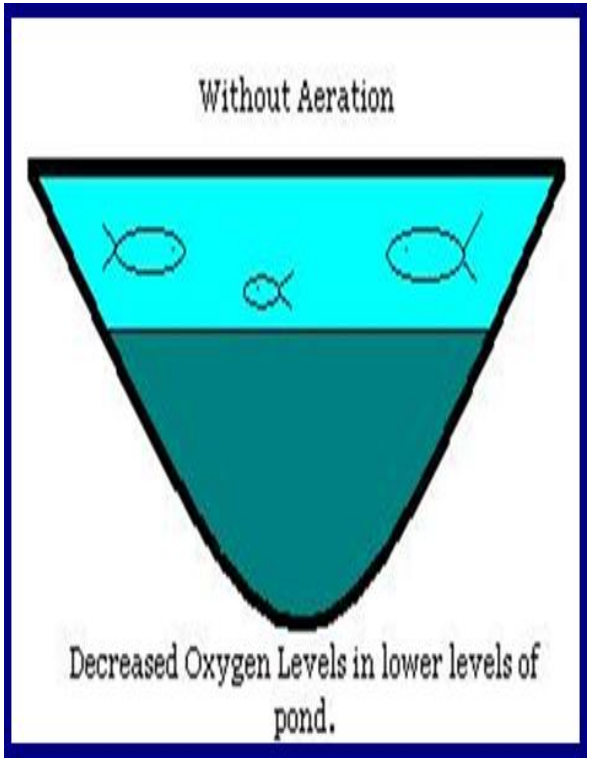
$$\text{surface loading (kL per day per m}^2\text{)} = \frac{\text{flow rate (kL per day)}}{\text{surface area of tank (m}^2\text{)}}$$

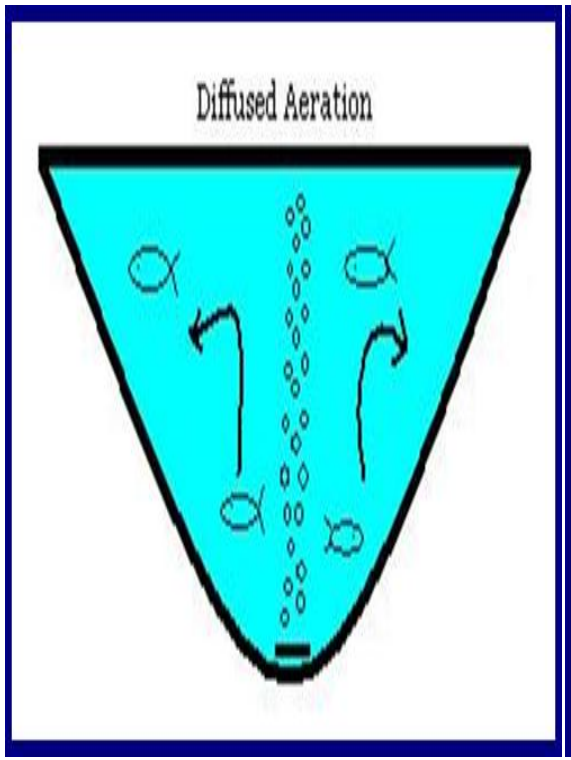
AERATION:

- Aeration (also called aerification) is the process by which air is circulated through, mixed with or dissolved in a liquid or substance.
- Passing the liquid through air by means of fountains, cascades, paddle-wheels or cones.

USES:

- Production of aerated water for drinking purposes.
- Secondary treatment of sewage or industrial wastewater through use of aerating mixers/diffusers.
- To increase the oxygen content of water used to house animals, such as aquarium fish or fish farm.
- In chemistry, to oxidise a compound dissolved or suspended in water.


Without Aeration
Decreased Oxygen Levels in lower levels of pond.


Diffused Aeration


Surface Aeration

WATER QUALITY TESTING

- As the quality of source water varies daily in every season, it is necessary that the water samples for analysis should be collected frequently.
- According to the quality of water it should be treated.

The following are the tests which are done During water quality test:

a) Physical test.
b) Chemical test.
c) Biological test.

A) PHYSICAL TEST:

1.TEMPERATURE: The temperature of water is measured by means of ordinary thermometers.

- From the temperature the MASS density(P=m/v), viscosity, vapour pressure and surface tension of water can be determined.
- The temperature of surface water is generally same to the atmospheric temperature, while that of ground water may be more or less than atmospheric temperature.
- The most desirable temperature for public supply is between 4.4 °c to 10 °c.
- Temperature above 28 °c are undesirable and above 35 °c are unfit for public supply, because it is NOT PALATABLE(NOT ACCECTABLE TO TASTE).

2.COLOUR: The color of water is usually due to presence of organic matter, but sometimes it is also due to mineral and dissolved organic and inorganic impurities.

- Before testing the color of the water, first of all total suspended matter should be removed from the water by centrifugal force in a special apparatus.
- After this the color of water is compared with standard color solution.
- The permissible color for domestic water is 20p.p.m on platinium cobalt scale.
- The color in water is not harmful but it is objectionable.

3. TURBIDITY: It is caused due to presence of suspended and colloidal matter in the water.

- The character and amount of turbidity depends on the type of soil over which the water has moved.

There are two types of turbidimeters:

1) Based on visual method(through naked eye).
2) Based on direct (meter readin

B) CHEMICAL TEST:

- In the chemical testing of water those test are done that will reveal the sanitary quality of the water.
- The chemical test involve the determination of total solids, hardness, chlorides, iron and manganese etc.

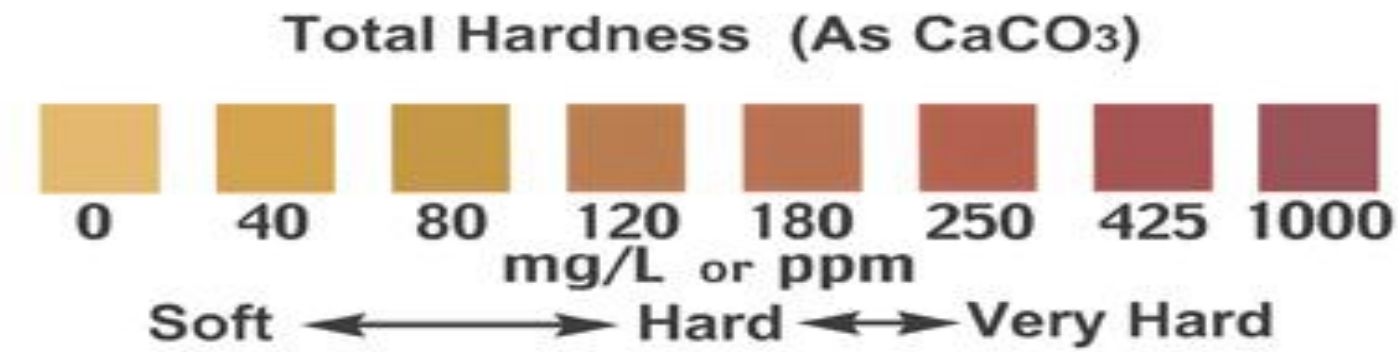
1. **Total solids:**

- Total solids is a measure of the suspended and dissolved **solids** in water.

- The quantity of suspended solids is determined by filtering the sample of water through a fine filter, drying and weighing.
- The quantity of dissolved and colloidal solids is determined by evaporating the filtered water(obtained from the suspended solid test) and weighing the water.
- The total solids in a water sample can be directly determined by evaporating the water and weighing it.
- By weighing we can determine the inorganic solids and deducting it from total solids.

2)HARDNESS:

- It is the property of water which prevents the lathering (form) of the soap.
- It is caused due to the presence of carbonates and sulphates of calcium and magnesium in the water.
- Also in the presence of chlorides and nitrates of calcium and magnesium cause hardness in the water.
- Hardness is usually expressed in mg/lit or p.p.m of calcium carbonate in water.
- In the past the hardness was determined by soap test, in which the standard soap sol was added in the water and it was shaked to see the formation of lather for 5 min. The



Water Hardness Scale		
Grains Per Gallon	Milligrams Per Liter (mg/L)or Parts Per Million (ppm)	Classification
ess than 1.0	less than 17.1	Soft
1.0 - 3.5	17.1 - 60	Slightly Hard
3.5 - 7.0	60 - 120	Moderately Hard
7.0 - 10.5	120 - 180	Hard
over 10.5	over 180	Very Hard

3) CHLORIDES:

- The natural water near the sea or mines have dissolve sodium chloride(Nacl).
- The presence of chlorides may be due to the mixing of saline water (**Saline water** is water that contains a significant concentration of dissolved salts (mainly NaCl) and is commonly known as saltwater) and sewage in the water.
- Excess of chlorides is dangerous and unfit for use. The chloride can be reduced by diluting the a water.
- Chlorides above 250p.p.m are not permissible(not allowed) in water.

The chloride can be determined by titrating the water with silver nitrate(Agno3) and potassium chromate(k2cro4), in that titration process reddish colour will be formed if chlorides are present.

4) IRON AND MANGANESE

- These are generally found in ground water. If these are present less than 0.3 p.p.m. it is not objectionable . But it exceeds 0.3p.p.m the water is not suitable for domestic and laundering purposes.
- The presence of iron and manganese in water makes brownish red colour in it, leads to growth of micro-organisms. Iron and manganese also cause taste and odour in the water.
- The quality of iron and manganese is determined by colorimetric methods.
- In these methods some colouring agents are added in the water and compared with standard colour solutions.

5)PH VALVE

- In general, a water with a pH < **7** is considered acidic and with a pH > **7** is considered basic.
- The normal range for pH in surface water systems is **6.5 to 8.5** and for groundwater systems **6 to 8.5**.
- Alkalinity is a measure of the capacity of the water to resists a change in pH that would tend to make the water more acidic.

PH SCALE

0 TO 7 → 7 ← Slightly above 7 to 14

(Acidic range) (Alkaline range)

3) BIOLOGICAL TEST:-

- In a biological test the following two tests are done:-

a) **TOTAL COUNT OF BACTERIA:-** In this method total number of bacteria present in millimeter of water is counted. The sample of water is taken, 1 ml of sample water is diluted in 99ml of sterilized water.

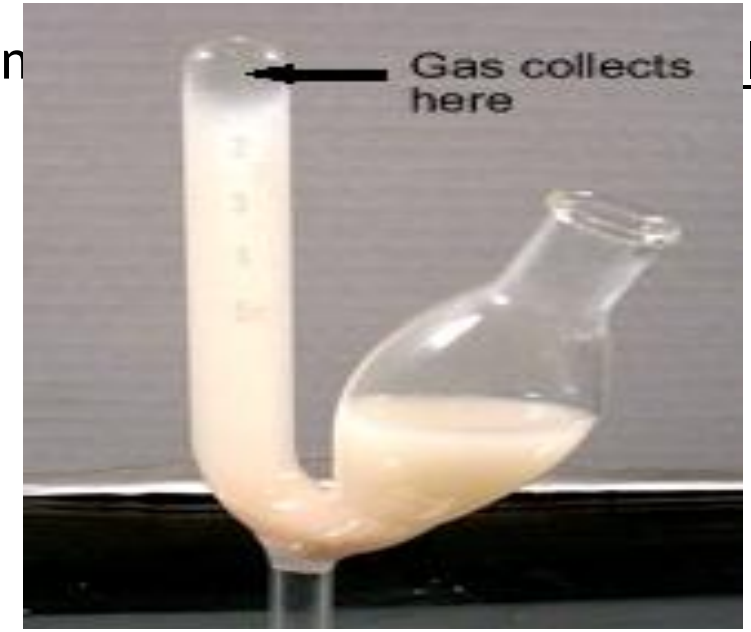
1. Sterilized Water (absence of any bacteria in the water).
2. Distilled water (that has many of its impurities removed through distillation. Distillation involves boiling the water and then condensing the steam into a clean container).

- This mixture is kept in incubator at 37°c for 24hrs.
- After it the sa ncubator and counted by mea

b) BACTERIA COLI(B-COLI)TEST:

- There are 2 tests B-coli first is presumptive and second confirmative.
- In the presumptive test definite amount of diluted sample of the water in standard fermentation tubes is kept in inclubator at 37°c for 24hrs. If some gas is produced in the fermentation tube , indicates the presence of B-coli.
- And it again kept in incubator at 37°c for 48 hrs, if there is formation of gas in the tube , it confirms the presence of B-coli and the water is unsafe to use.

This method is known as "MULTIPLE TUBE FERMENTATION TECHNIQUE".

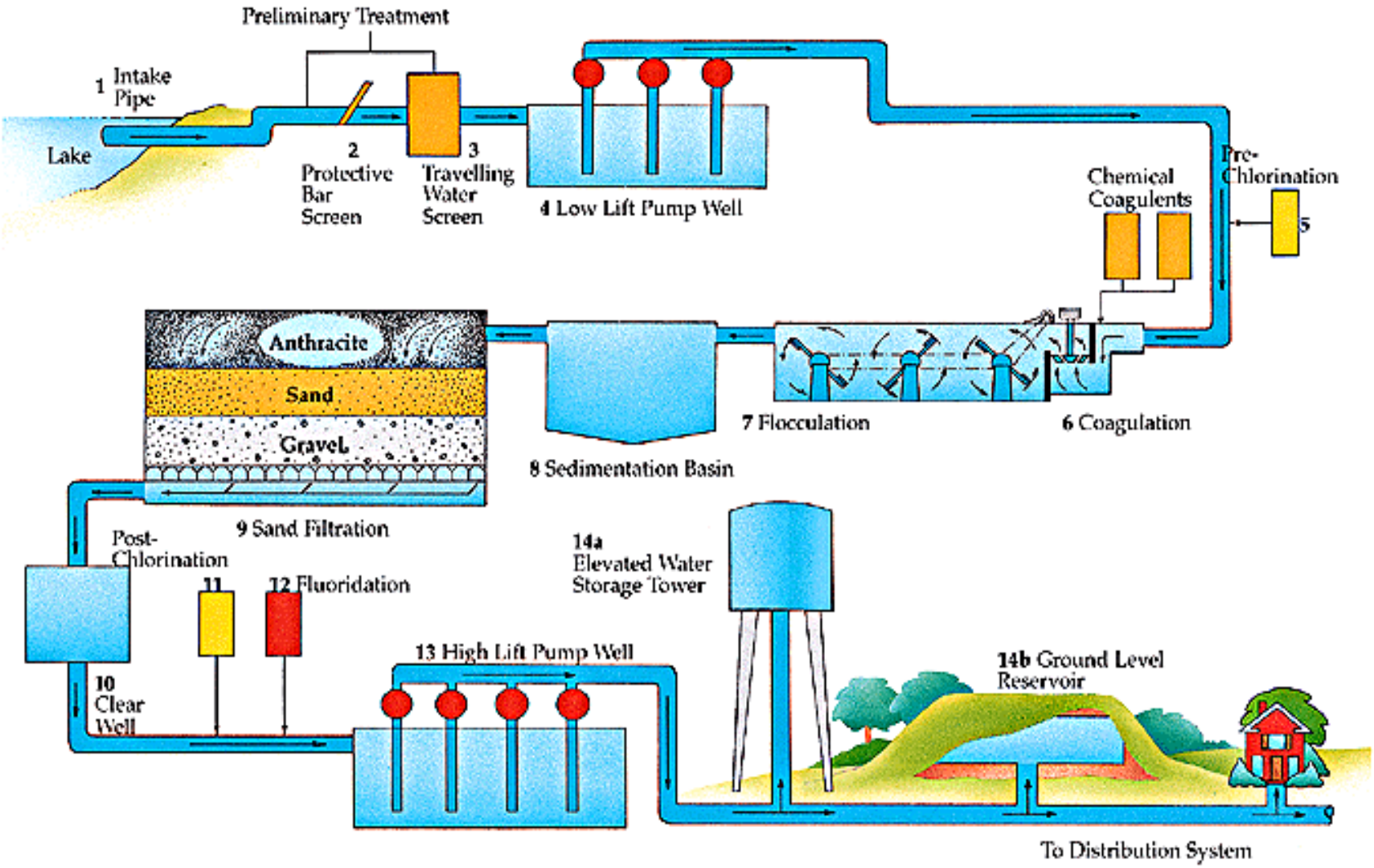


WATER TREATMENT

DEFINATION:

- A **wastewater treatment plant** is a physical plant where various physical, biological or chemical processes are used to change the properties of the wastewater (e.g. by removing harmful substances) in order to turn it into a type of water (also called effluent) that can be safely discharged into the environment or that is usable for a certain reuse purpose.
- By-products from wastewater treatment plants, such as screenings, sewage sludge, odorous gases are also treated in a wastewater treatment plant.

WATER TREATMENT PLANT
SURFACE WATER SUPPLY



1.PRELIMINARY TREATMENT:

- The purpose of preliminary treatment is to protect the operation of the wastewater treatment plant which can damage pumps, or interfere with subsequent treatment processes. Preliminary treatment devices are, therefore, designed to:

1. Remove or to reduce in size the large, entrained, suspended or floating solids. These solids consist of pieces of wood, cloth, paper, plastics, garbage, etc. together with some fecal matter.

PRE- CHLORINATION:

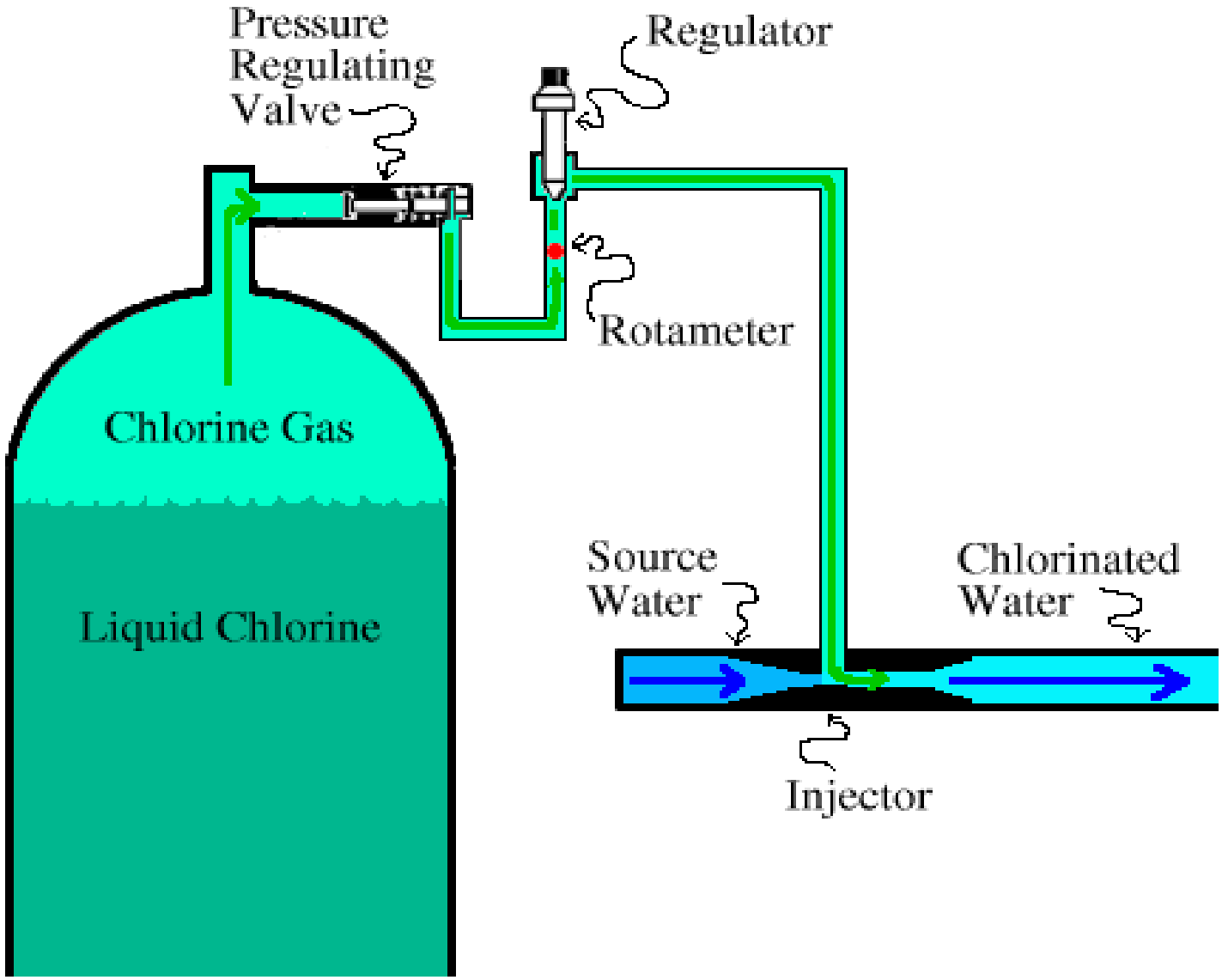
- Pre-chlorination is a process that involves adding chlorine to the collection system of industrial plants and other Treatment plant, mainly for corrosion and odor control.
- It is also applied for the purpose of disinfection and for the removal of oil particles.
- It is also used in water treatment to control aquatic growth as well as taste, and as aid in settling and coagulation.
- In pre-chlorination, chlorine is added to the raw water prior to flash mixing and post screening.
- The excess chlorine is beneficial in the various stages of treatment by:

1.Aiding coagulation

2.Controlling of algae problems

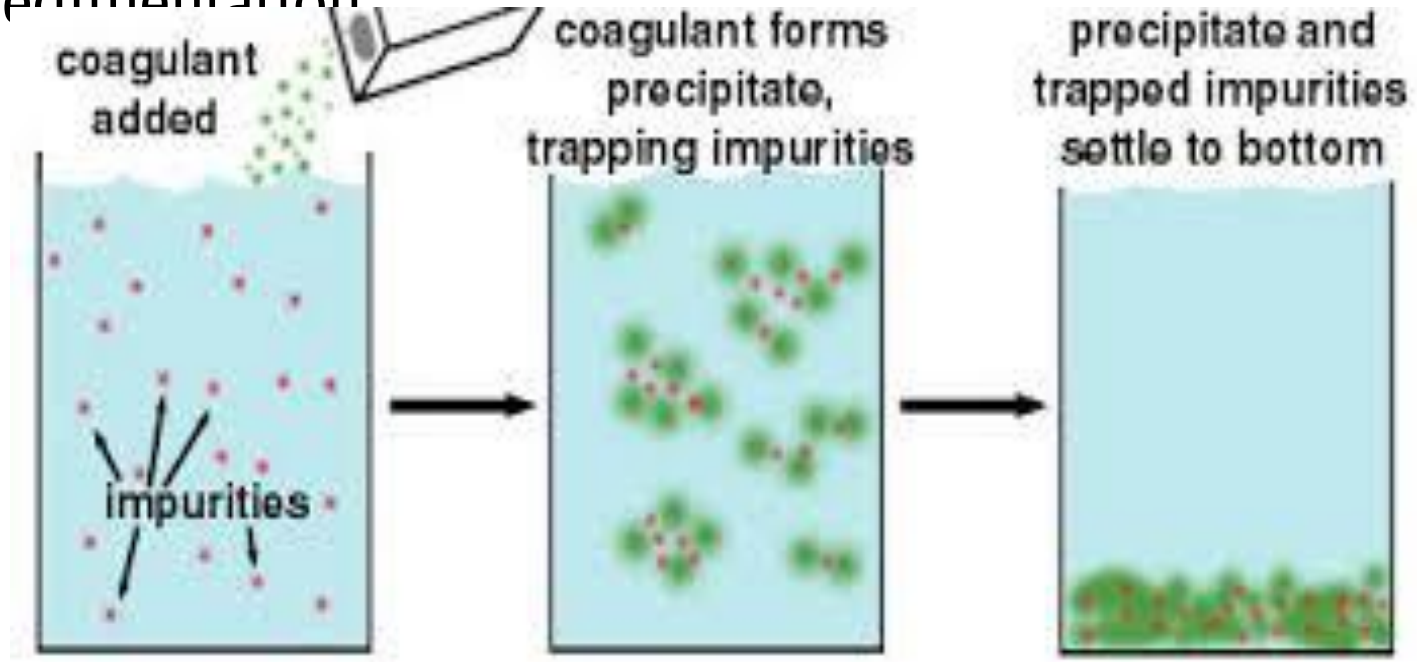
3.Reducing odor and mud ball formation

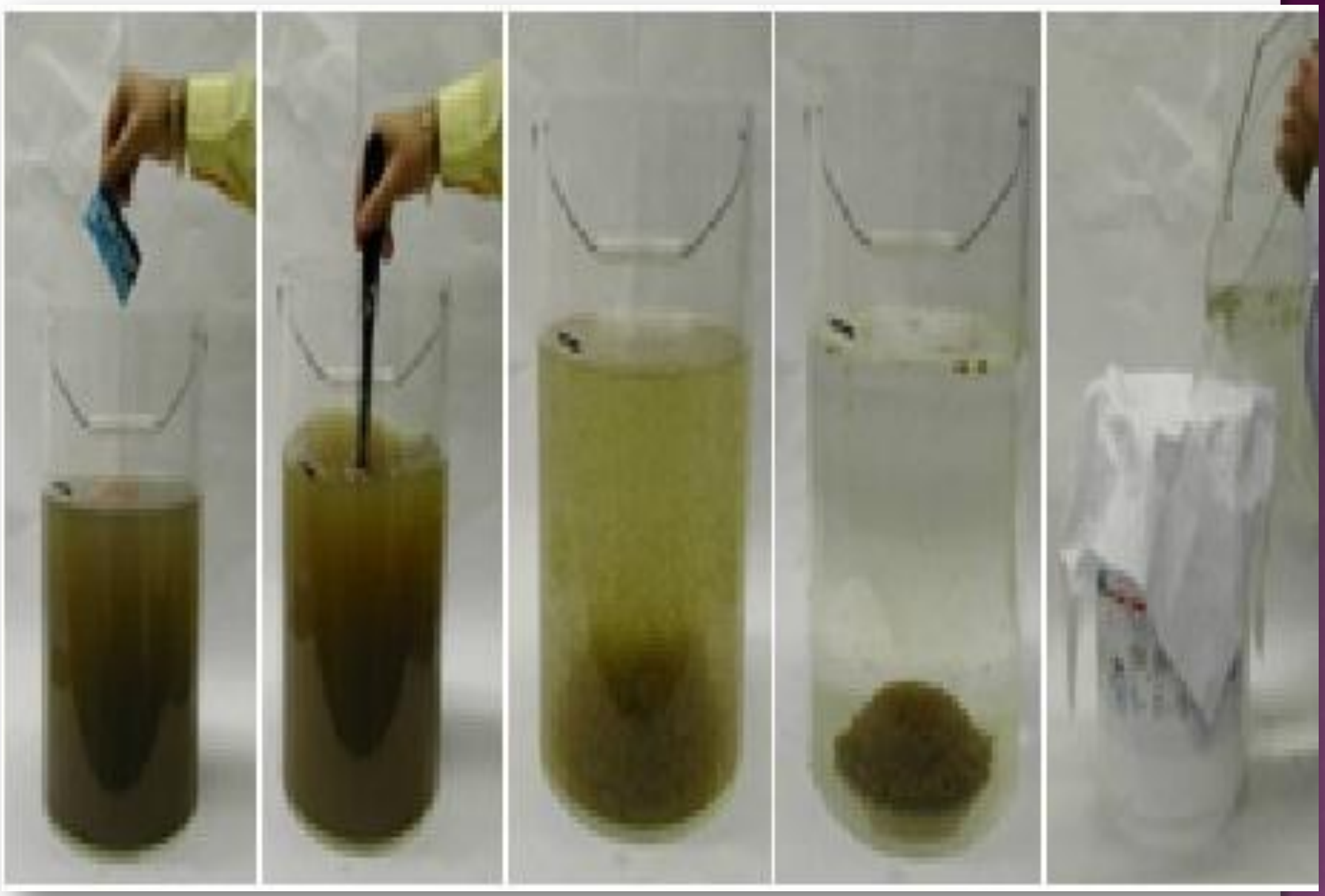
ACTUAL CHLORINATION PROCESS:



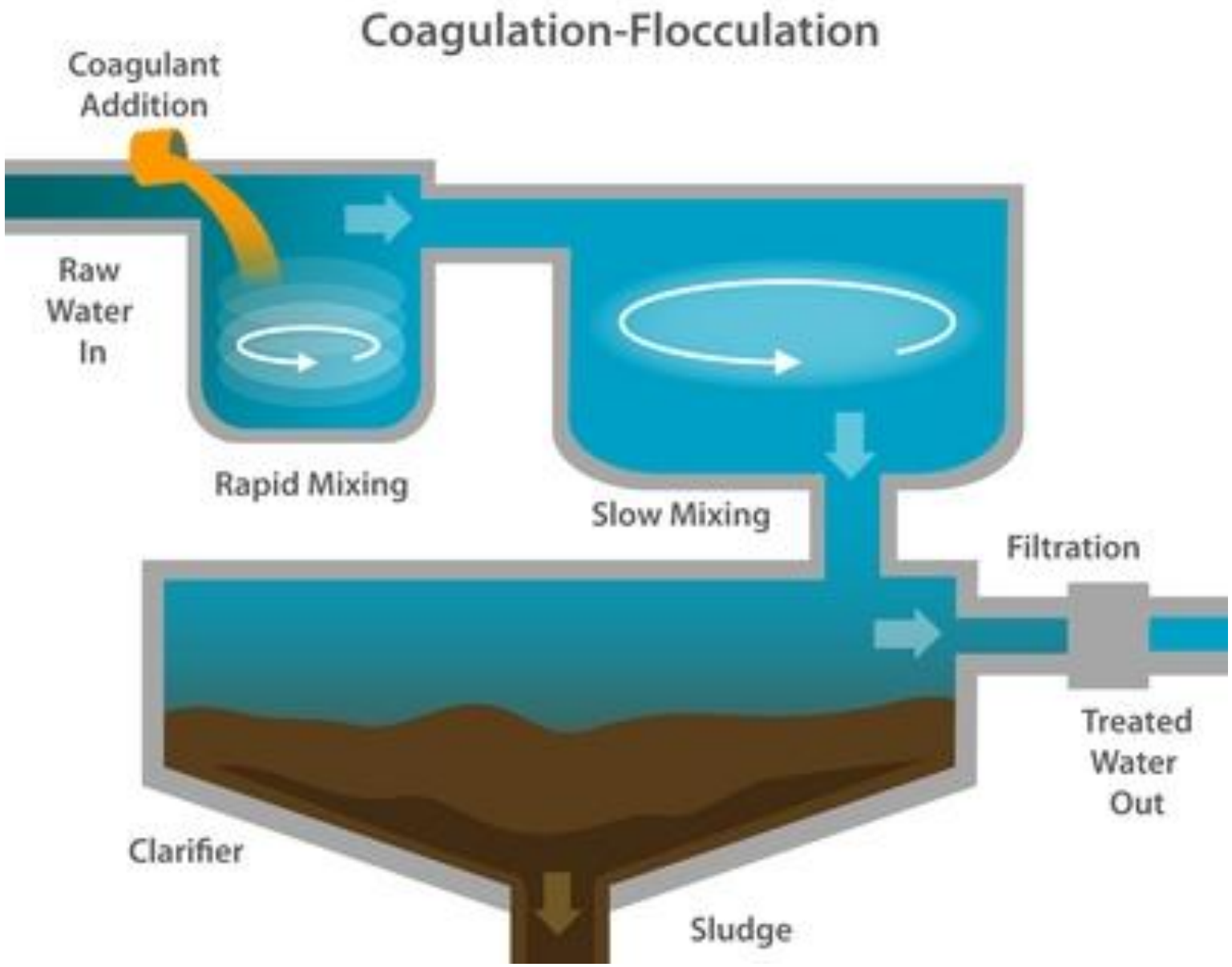
2.COAGULATION:

- Coagulation removes dirt and other particles suspended in water. Alum and other chemicals are added to water to form tiny sticky particles called "floc" which attract the dirt particles.
- The combined weight of the dirt and the alum become heavy enough to sink to the bottom during sedimentation.



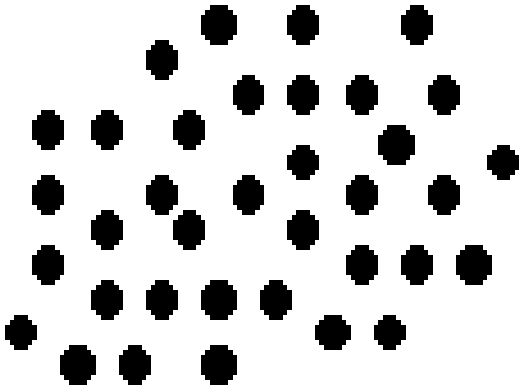


- Solids are removed by sedimentation (settling) followed by filtration. Small particles are not removed efficiently by sedimentation because they settle too slowly; they may also pass through filters. They would be easier to remove if they clumped together (coagulated) to form larger particles, but they don't because they have a negative charge and repel each other (like two north poles of a magnet).
- In coagulation, we add a chemical such as alum which produces positive charges to neutralize the negative charges on the particles. Then the particles can stick together, forming larger particles which are more easily removed.
- The coagulation process involves the addition of the chemical (e.g. alum) and then a rapid mixing to dissolve the chemical and distribute it evenly throughout the water.


Coagulation-Flocculation
Coagulant Addition
Raw Water In
Rapid Mixing
Slow Mixing
Filtration
Treated Water Out
Clarifier
Sludge

3.FLOCCUATION:

- **Flocculants** are used in water treatment processes to improve the sedimentation or filterability of small particles.

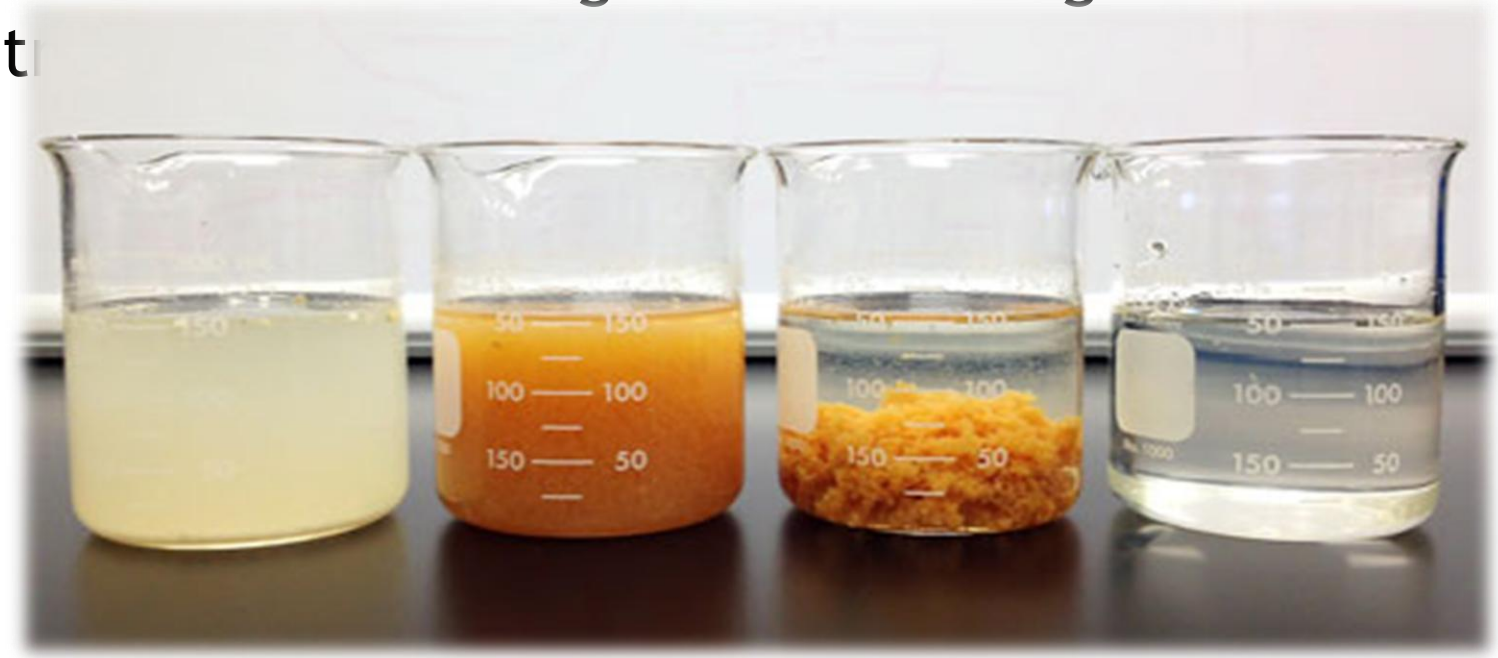


dispersed

flocculated

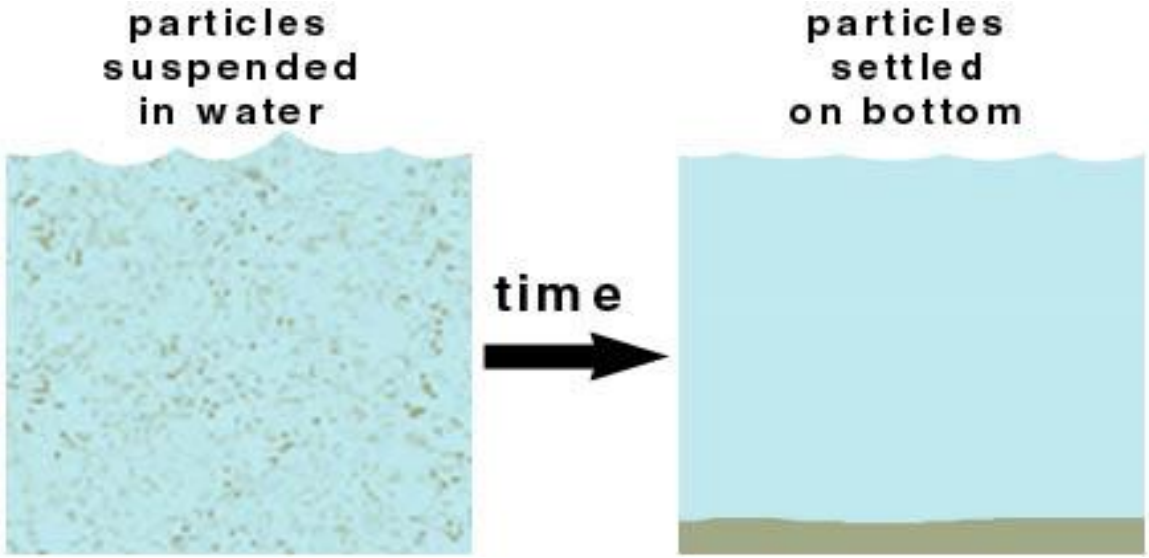
FLOC:

- A soft or fluffy particle suspended in a liquid or the fluffy mass of suspended particles so formed. Floc may be mineral as for clay, chemical as in water treatment or biological as in sewage t



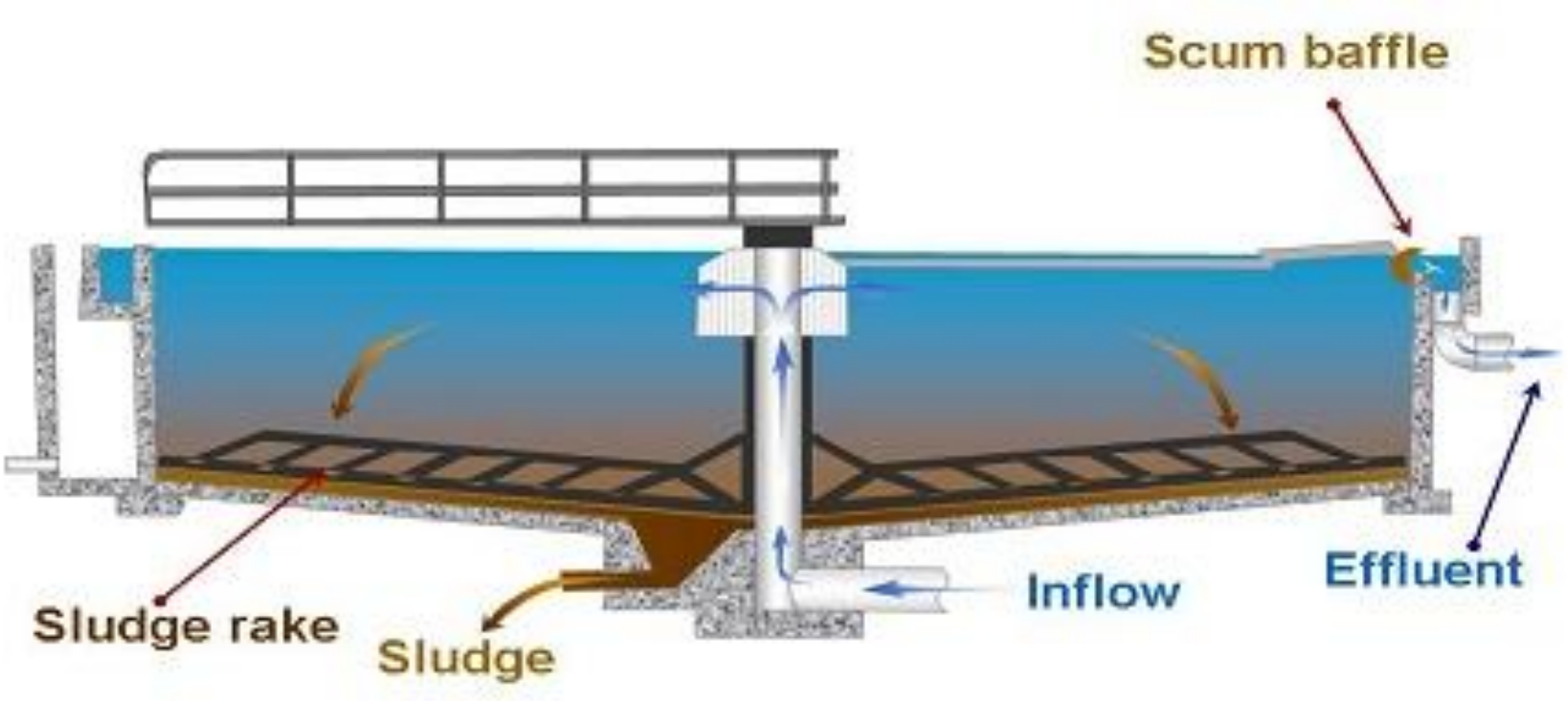
4.SEDIMENTATION PROCESS:

- **Sedimentation** is a physical water treatment process using gravity to remove suspended solids from water.



- The particles that settle out from the suspension become sediment, and in water treatment is known as sludge. When a thick layer of sediment continues to settle, this is known as consolidation.

- Solid particles entrained by the turbulence of moving water may be removed naturally by **sedimentation** in the stilwater of lakes and oceans.



5.SAND PURIFICATION:

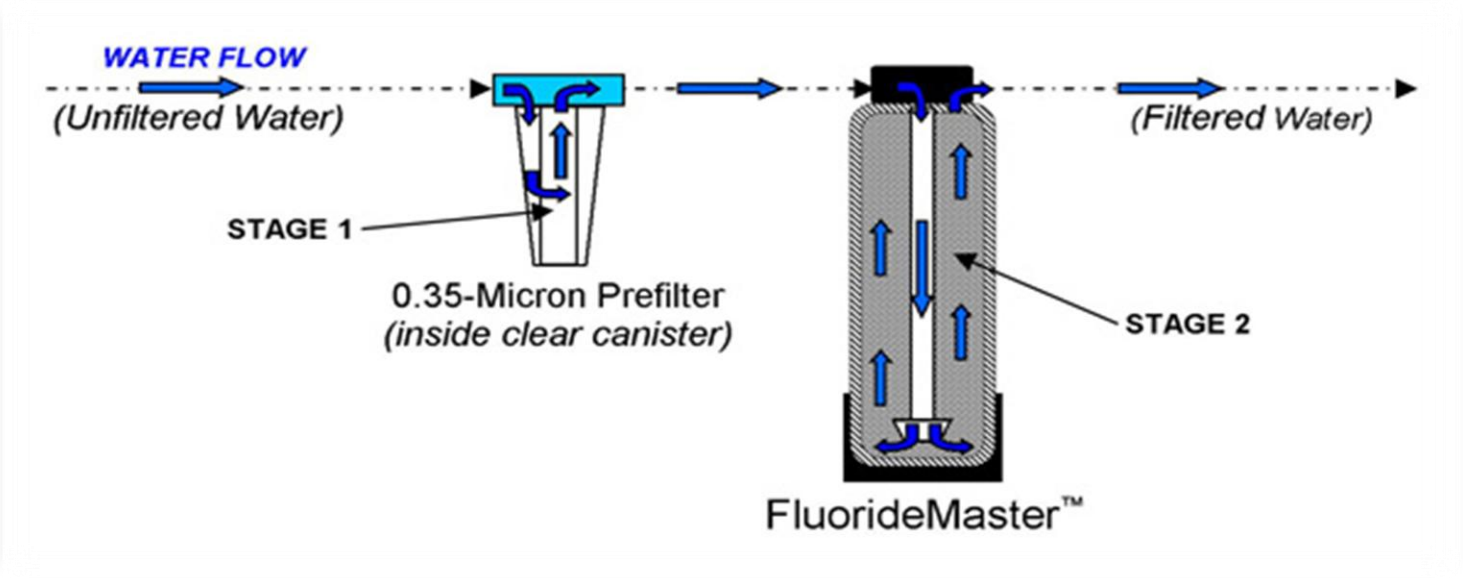
- **Sand filters** are used for water purification. There are three main types;
- Rapid (gravity) sand filters.
- Sand filtration is a frequently used very strong method to remove suspended solids from

6. POST CHLORINATION:

- Post Chlorination is the final process in water treatment.
- The chlorine will kill any bacteria or viruses remaining in the water and it is important that a minimum level of chlorination remains in the water through the storage and distribution.
- If needed, additional chorine is added to the finished water that leaves the water plants. Low levels of chlorine (approximately 0.2 to 1.0 part per million) must be maintained in the distribution systems pipes and home plumbing to prevent the growth of microorganisms.

7.FLOURIDATION:

- Water **fluoridation** is the controlled addition of **fluoride** to a public water supply to reduce tooth decay.
- Water fluoridation is the addition of the chemical **fluoride** to public **water supplies**, for the purpose of reducing **cavities**.`

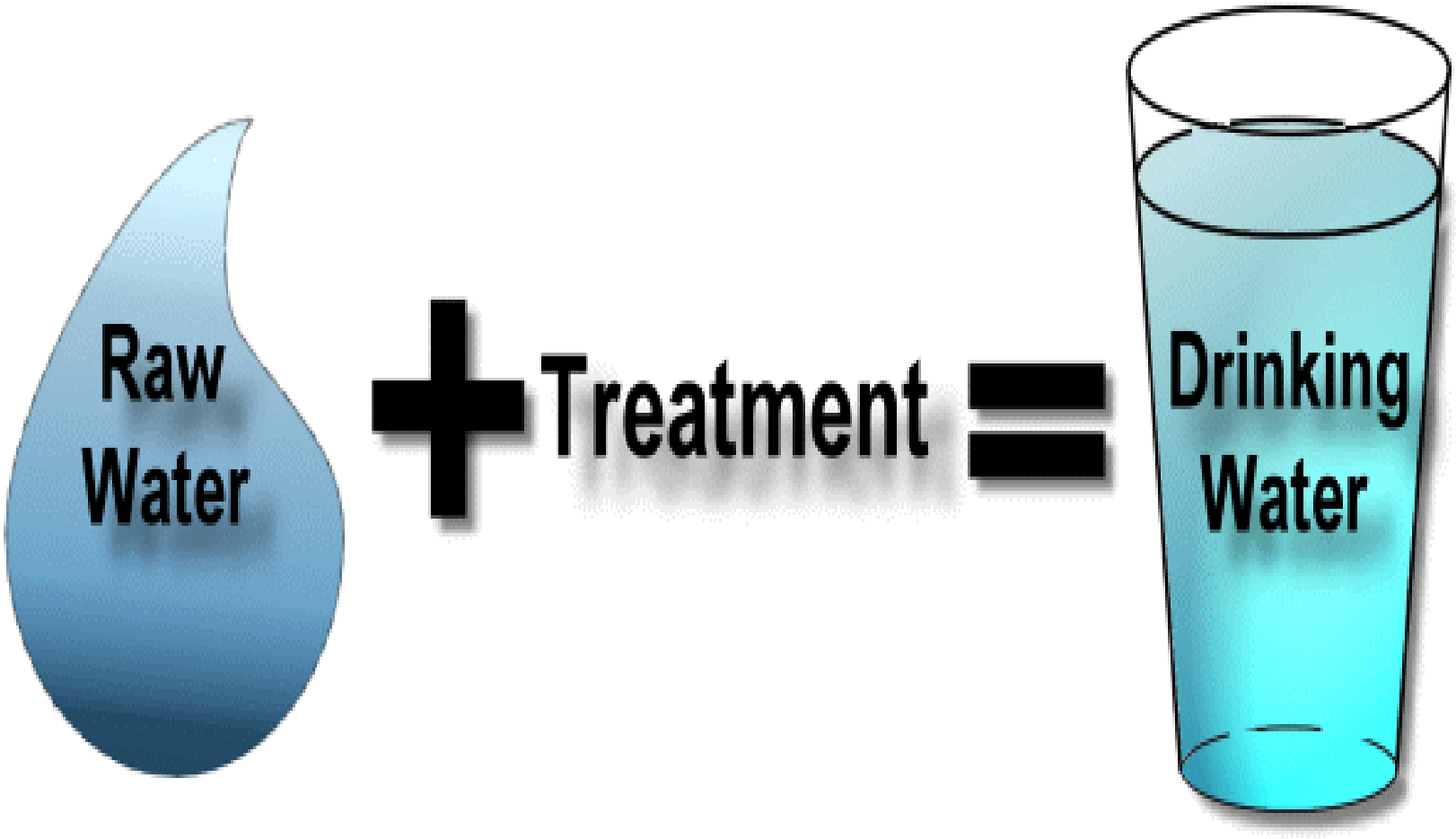


FLOURIDATION

- **Water fluoridation** is the controlled addition of fluoride to a public water supply to reduce tooth decay. Fluoridated water has fluoride at a level that is effective for preventing cavities; this can occur naturally or by adding fluoride.

ADVANTAGES:

- Water purification is the removal of contaminants from untreated water to produce drinking water that is pure enough for the most critical of its intended uses, usually for human consumption.
- Measures taken to ensure water quality not only relate to the treatment of the water, but to its conveyance and distribution after treatment as well.

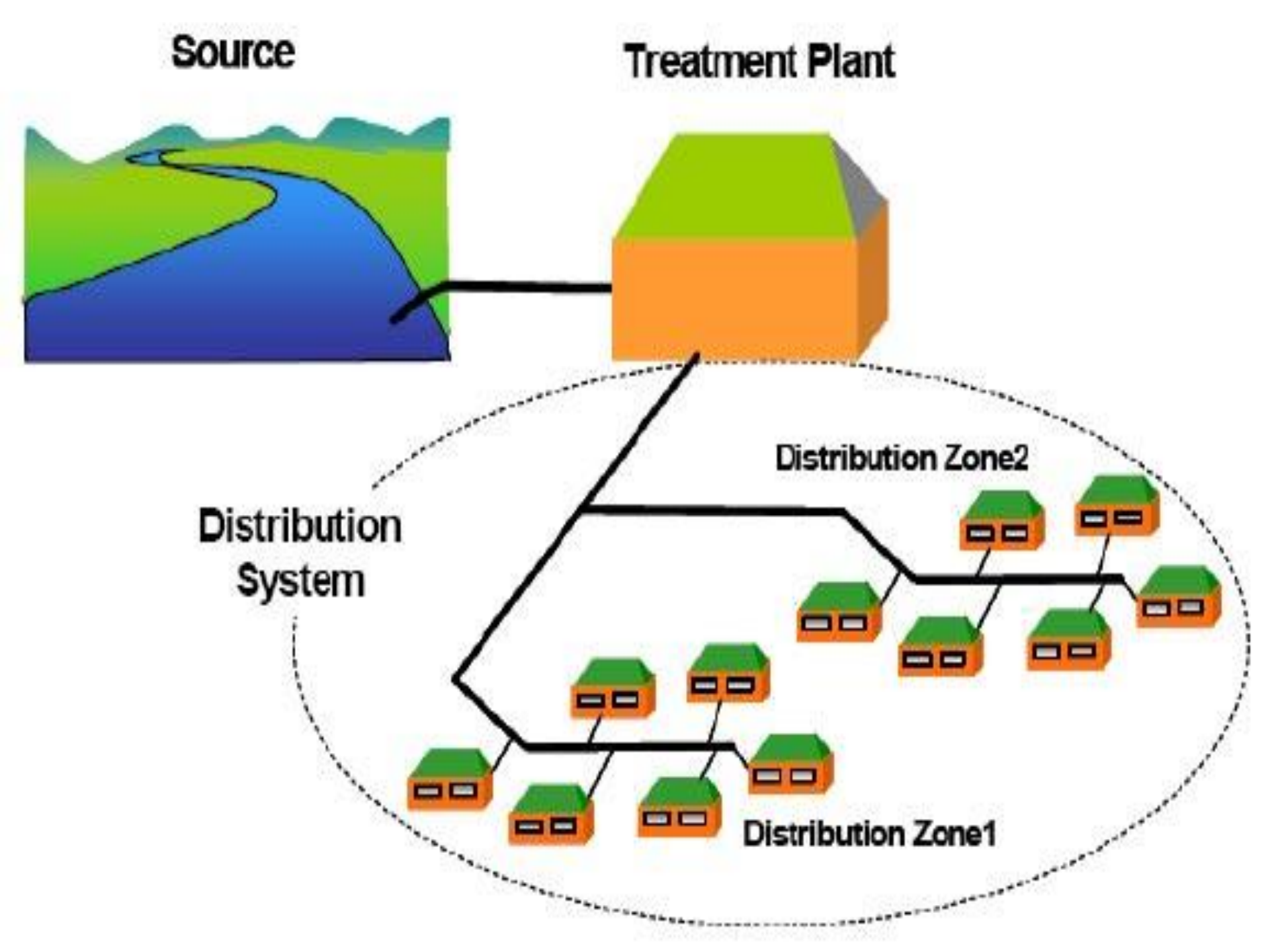

Raw Water
+
Treatment
=
Drinking Water

save water

DISTRIBUTION SYSTEM

WHAT IS DISTRIBUTION SYSTEM?

- Distribution system is the part of the water works which receives the water from the pumping station in the form of gravity flow or pumping system and delivers it throughout the town which is to be served.
- The distribution system consists of pipes of various sizes, valves, meters, pumps, distribution reservoirs, hydrants etc.


Source
Treatment Plant
Distribution Zone2
Distribution System
Distribution Zone1

REQUIREMENTS OF DISTRIBUTION SYSTEM?

- The pipe lines carry the water to each and every street, road.
- Valves control the flow of water through the pipes.
- Meters are provided to measure the quantity of water consumed by the town.
- Hydrants are provided to connect the water to the fire fighting equipments during fire.
- Service connections are done to connect the individual building with the water line passing through the streets.

- Pumps are provided to pump the water to the elevated service reservoirs or directly in the water mains to obtain the required pressure in the pipe lines.

REQUIREMENT FOR GOOD DISTRIBUTION SYSTEM?

- It should convey the treated water up to the consumers with the same degree of purity.
- The water should reach to every consumer with the required pressure head.
- Sufficient quantity of treated water should reach for the domestic and industrial use.
- It should be able to transport sufficient quantity of water during emergency such as fire- fighting.
- It should be reliable so that even during breakdown or repairs of one line water should reach that locality from other line.

LAYOUT OF DISTRIBUTION SYSTEM:

Generally there are four different systems of distribution which are used,

Depending upon their layout and direction of supply, they are classified as follows:

1.Dead end or tree system.

2.Grid Iron system.

3.Circular or ring system.

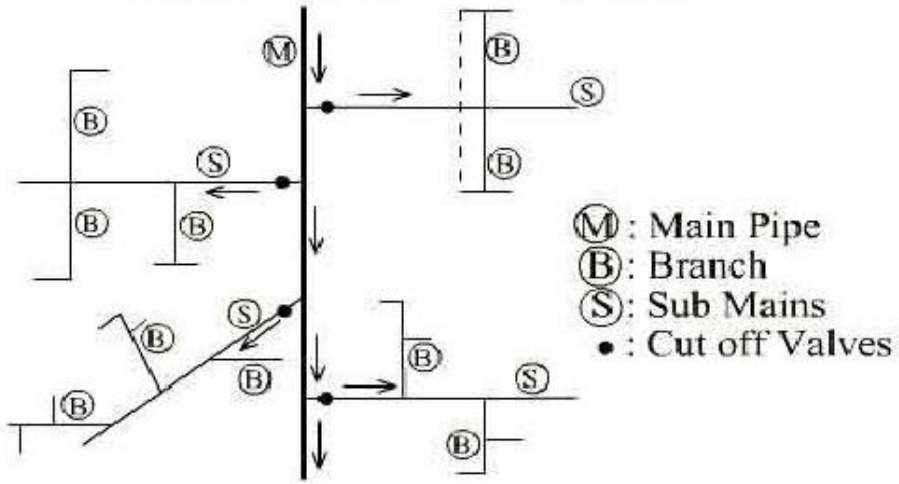
4.Radial system.

1)DEAD END OR TREE SYSTEM:

Dead End System...

- It is suitable for old towns and cities having no definite pattern of roads.

Dead End or Tree System

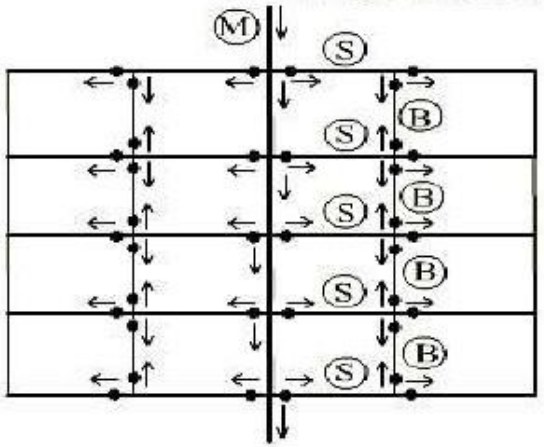


2)GRID IRON SYSTEM:

Grid Iron System...

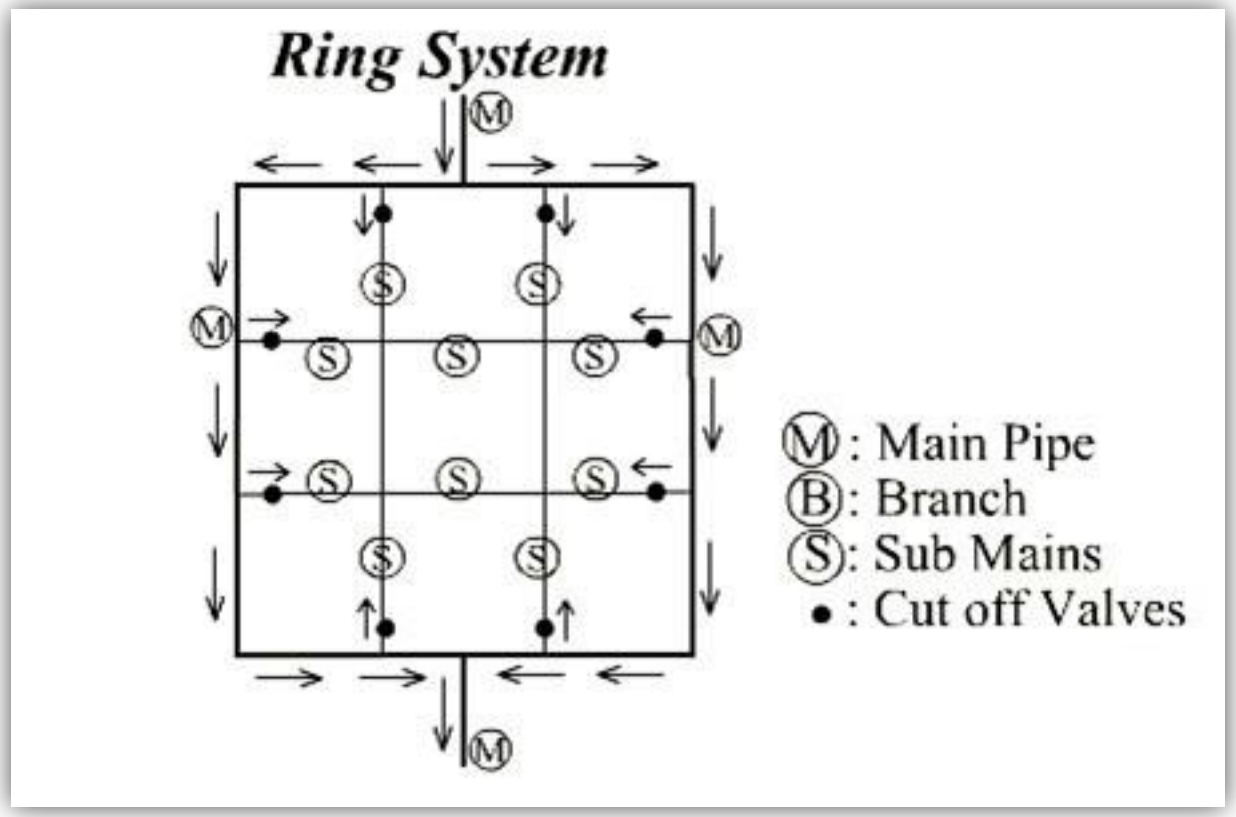
- It is suitable for cities with rectangular layout, where the water mains and branches are laid in rectangles.

Grid-iron System

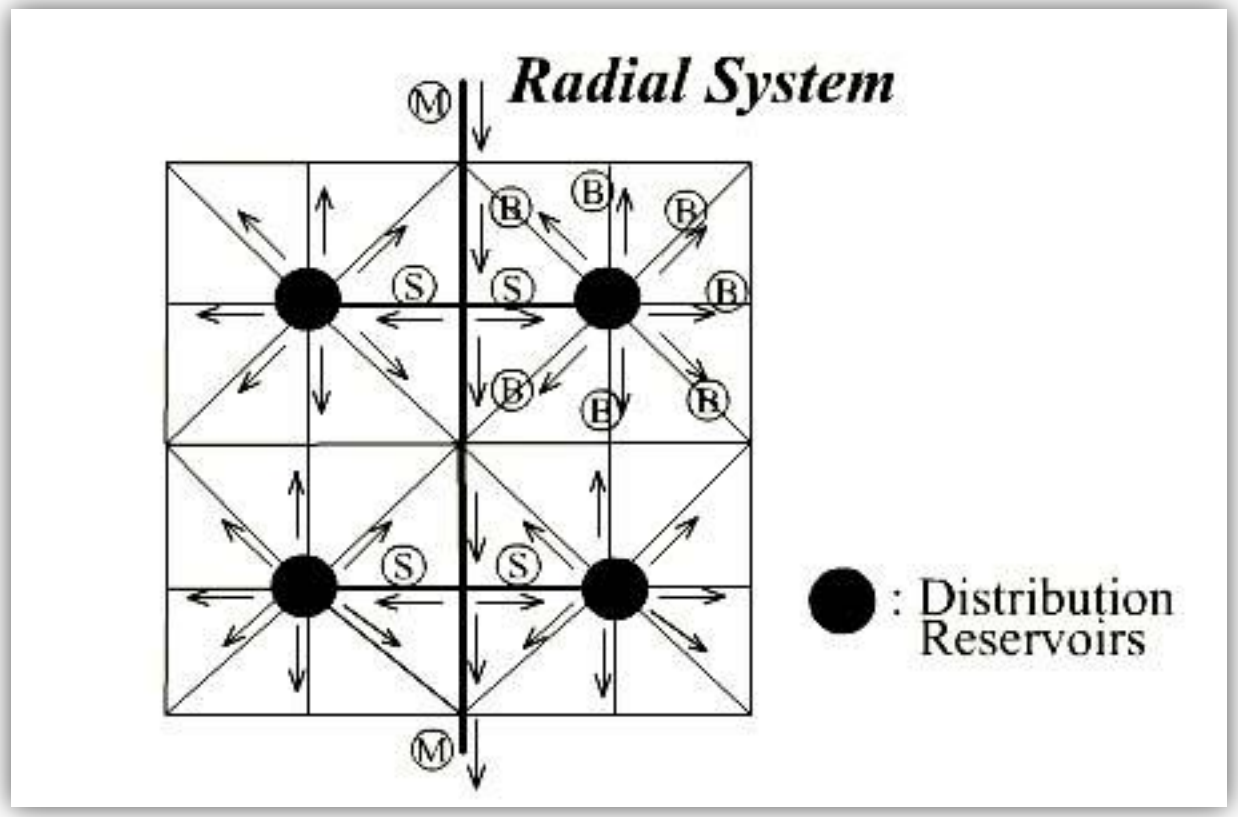


Ⓜ : Main Pipe
Ⓑ : Branch
Ⓢ : Sub Mains
• : Cut off Valves

3)CIRCULAR OR RING SYSTEM:



4) RADIAL SYSTEM:

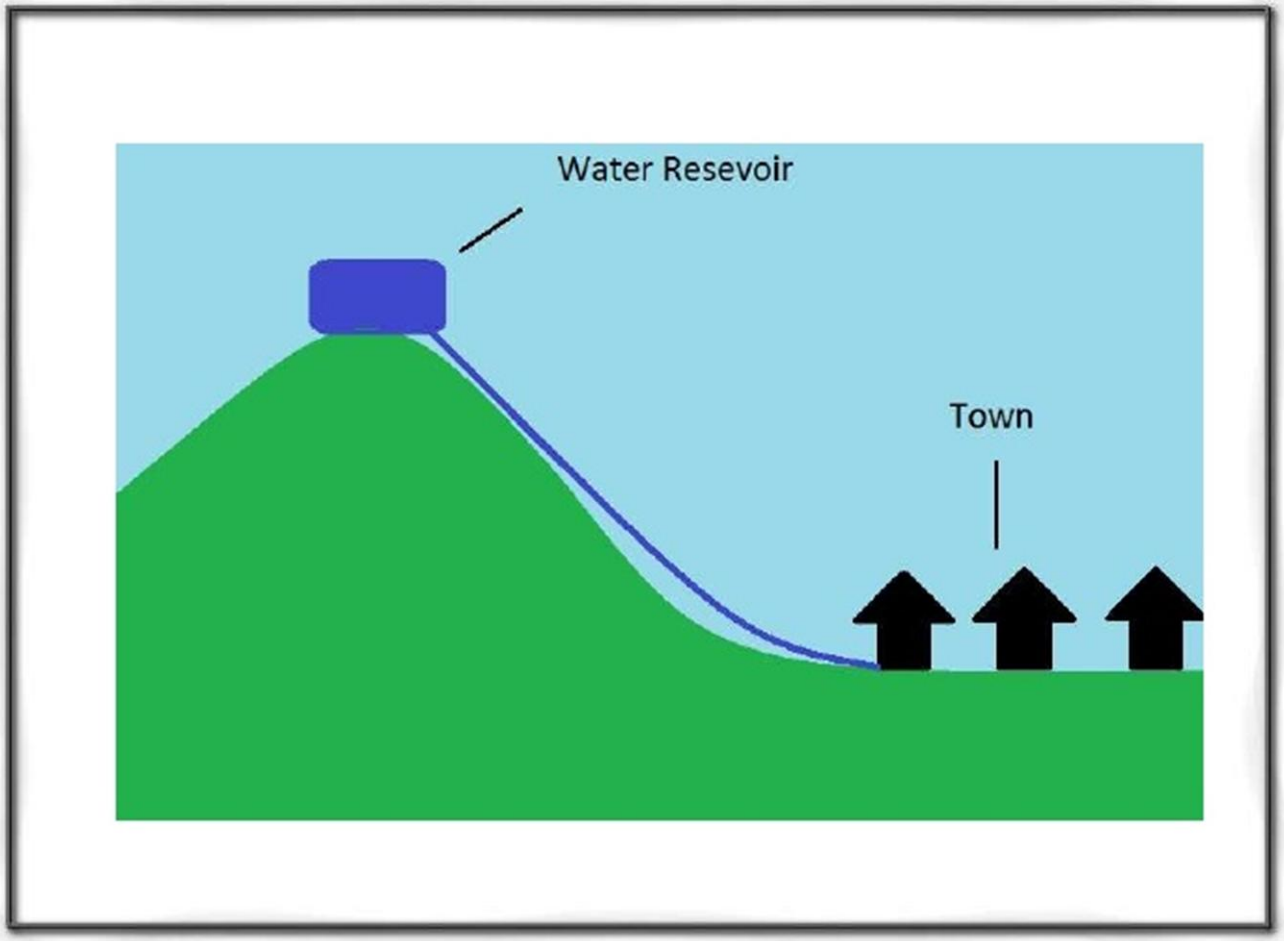


TYPES OF DISTRIBUTION SYSTEM:

- Depending upon the methods of distribution , the distribution system is classified as follows:

1. Gravity system
2. Pumping system
3. Dual system or combined gravity and pumping system.

1) GRAVITY SYSTEM:

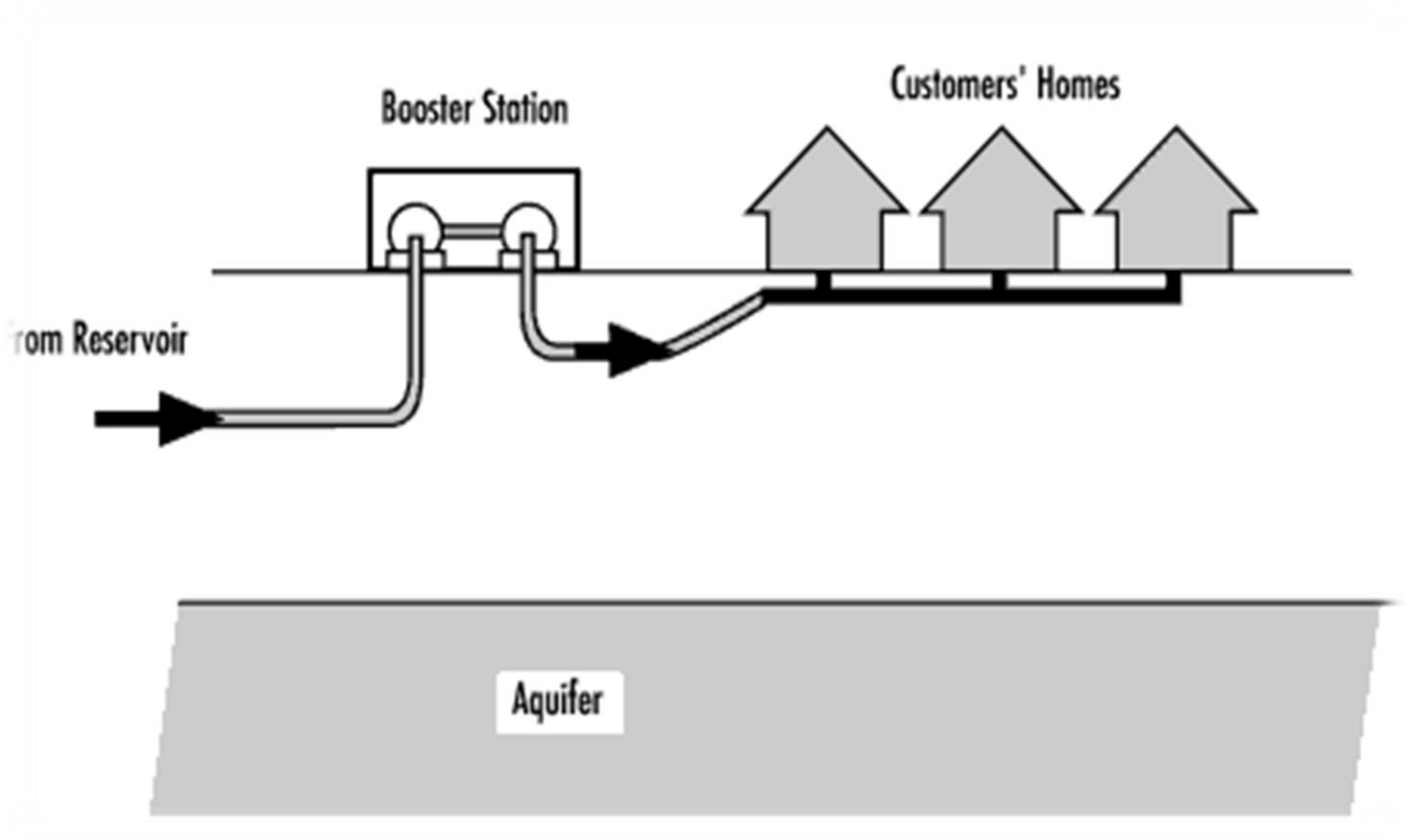


- This method is much suitable when source of supply such as lake, river or impounding reservoir is at sufficient height than city.
- The water flows in the mains due to gravitational force, as no pumping is required, therefore it is most reliable system for the distribution of water.
- In this system usually pumping is not required at any stage, in case the source of water supply is lake situated at the hill, low lifting pumping is required to lift the water up to water treatment plant.

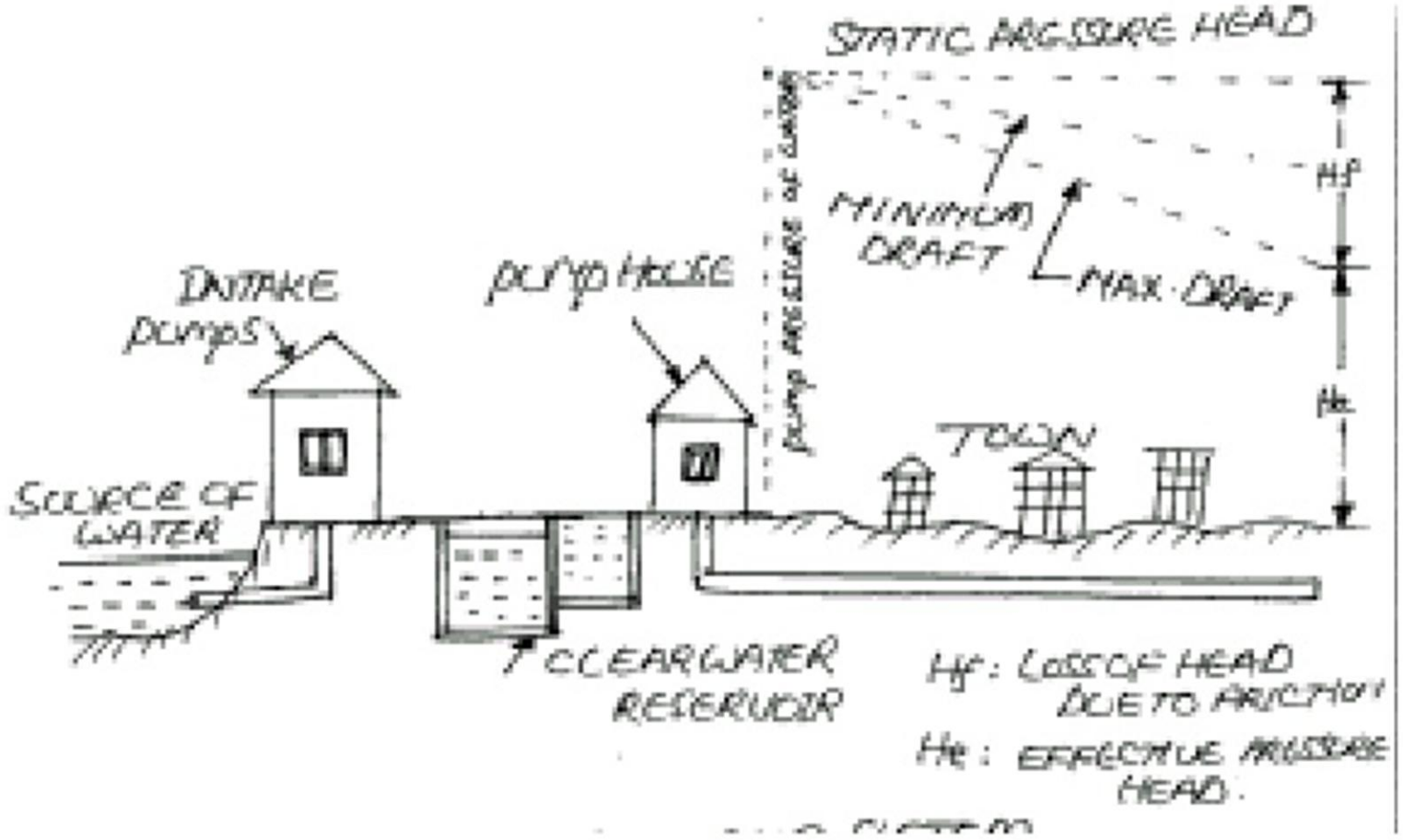
- **ADVANTAGES:**
-

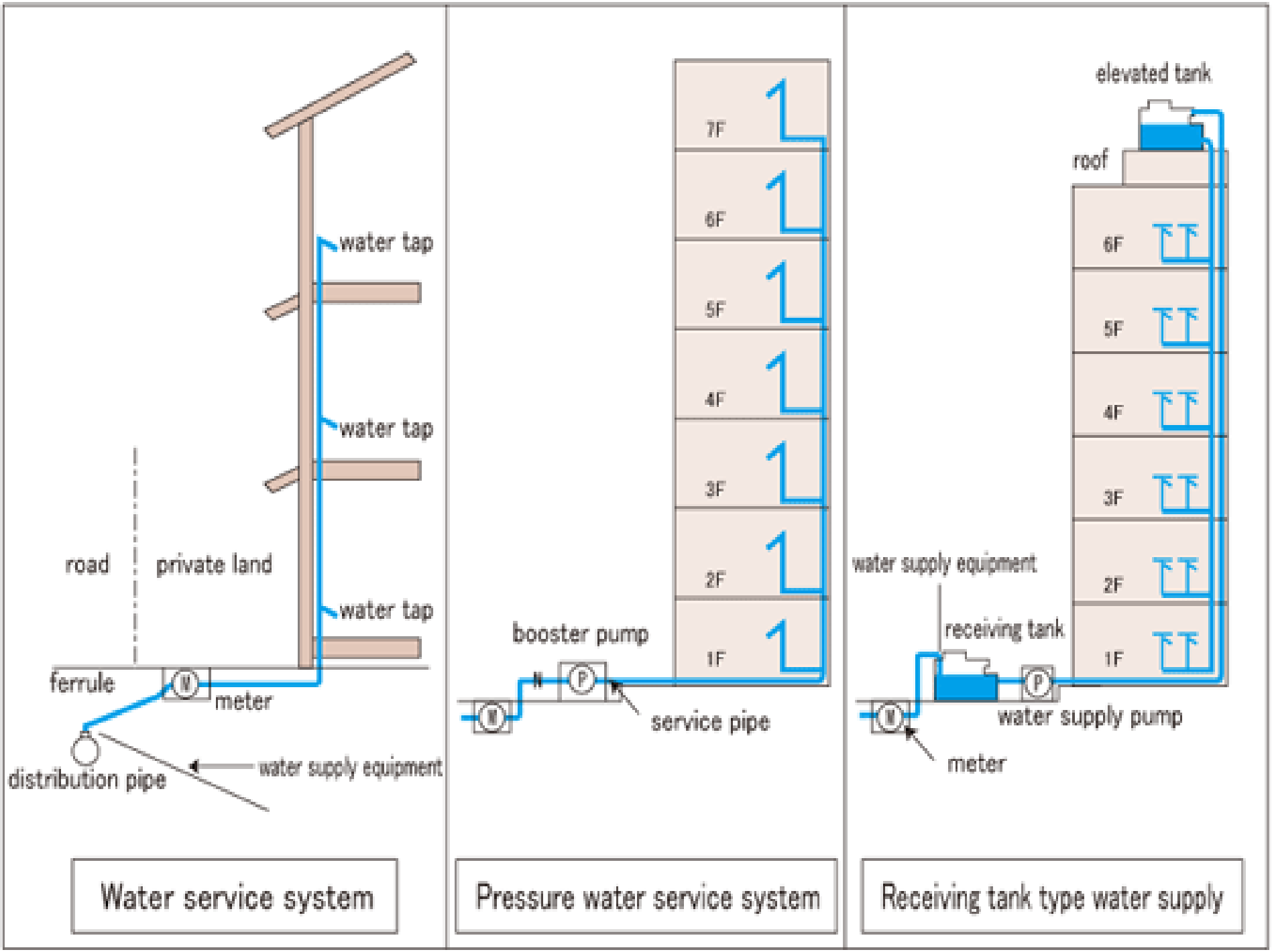
- **DISADVANTAGES:**
- But in case of fire attack the water had to be pumped.

2)PUMPING SYSTEM:



- High lift pumps are required and their operations are continuously watched.
- If power fails, the whole supply of the town will be stopped, therefore it is better to have diesel pumps also in addition to the electric pumps as stand bye.
- **ADVANTAGE:**
- During fires, the water can be pumped in the required quantity by the stand-bye units also.

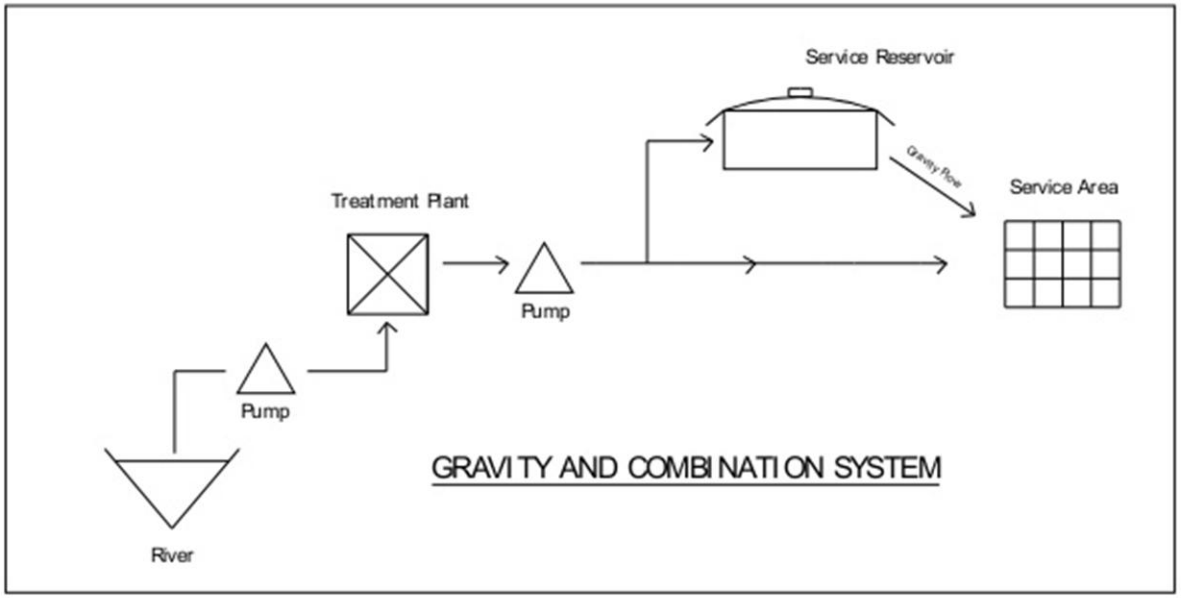

STATIC PRESSURE HEAD
PUMP PRESSURE OR GAUGE
MINIMUM DRAFT
MAX. DRAFT
Hf
He
INTAKE PUMPS
PUMP HOUSE
TOWN
SOURCE OF WATER
CLEAR WATER RESERVOIR
Hf: LOSS OF HEAD DUE TO FRICTION
He: EFFECTIVE PRESSURE HEAD.


water tap
water tap
water tap
road
private land
ferrule
meter
distribution pipe
water supply equipment
Water service system
7F
6F
5F
4F
3F
2F
1F
booster pump
service pipe
Pressure water service system
elevated tank
roof
6F
5F
4F
3F
2F
1F
water supply equipment
receiving tank
water supply pump
meter
Receiving tank type water supply

3)DUAL SYSTEM:

Gravity & Pumped System

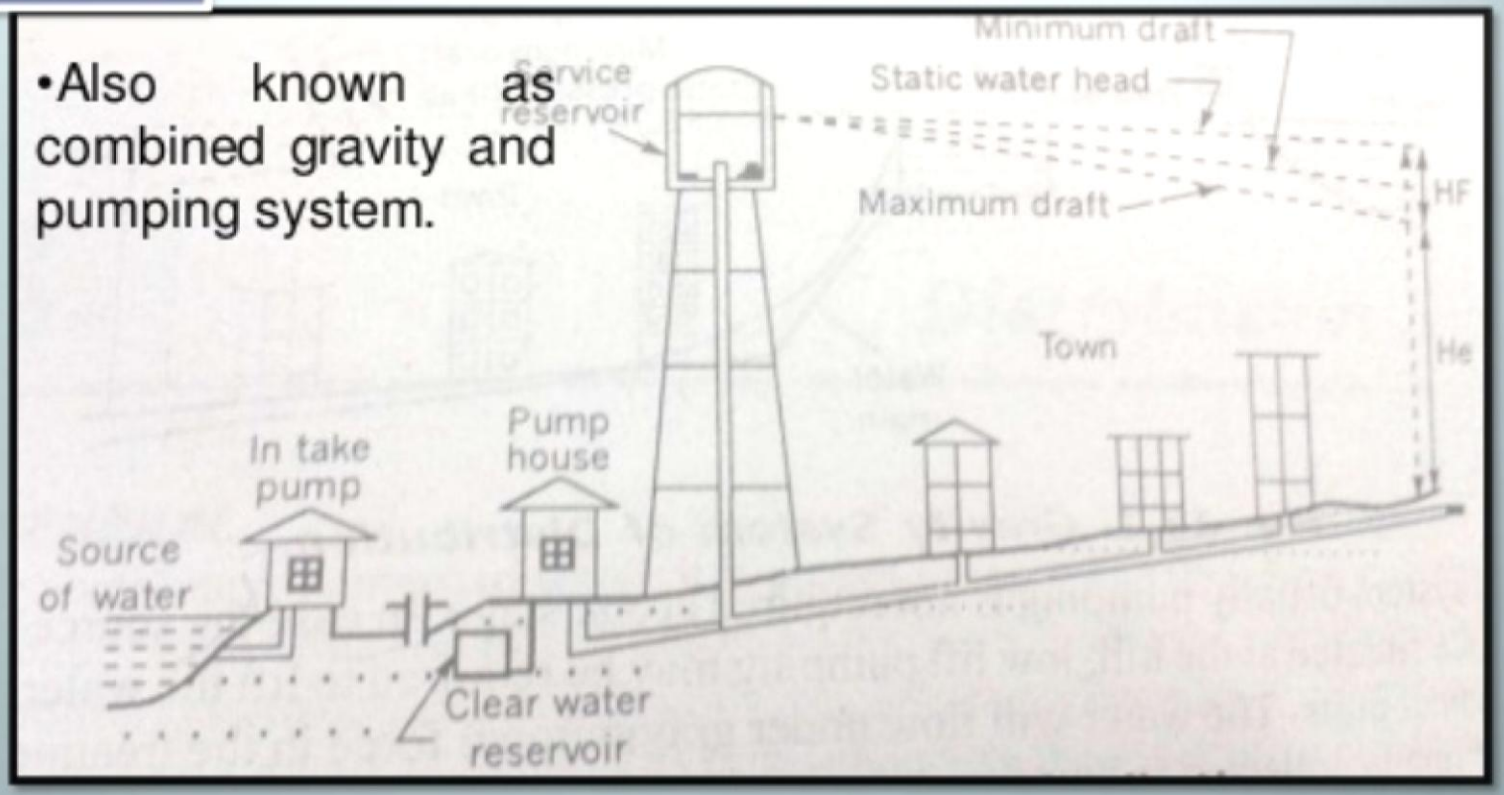
TAS 3107 C10



- em.
- The pump is connected to the mains as well as to an elevated reservoir.
- In the beginning when water demand is small the water is stored in the elevated reservoir, but when demand increases the rate of pumping, the flow in the distribution system comes from the both the pumping station as well as from elevated reservoir.

DUAL SYSTEM

•Also known as combined gravity and pumping system.



•Pump is connected to the mains as well as to the elevated reservoir

•when less water demand - **water is stored in elevated reservoir**

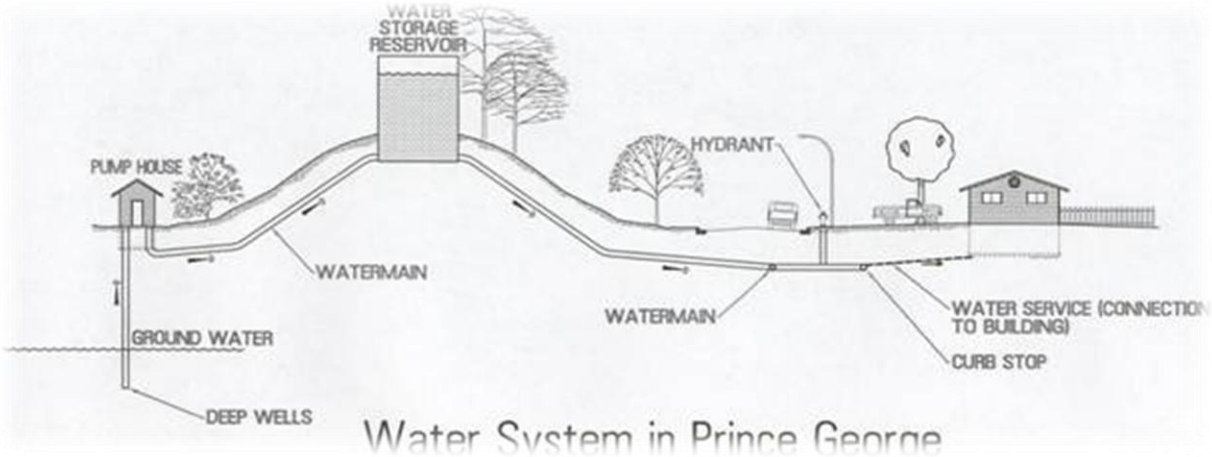
•With increase in water demand – **water comes from both pumping station as well as reservoir**

•More reliable and economic

•Require uniform rate of pumping

•During power failure and fire fighting water stored in reservoir can be used

- ADVANTAGES:
- This system is more reliable and economical.
- The water stored in elevated reservoir meets the requirements of demand during breakdown of pumps and for fire fighting.
- The balance reserve in the storage reservoir will be utilized during fire. In case the fire demand is more, and if required the water supply of few localities may be closed.


WATER
STORAGE
RESERVOIR
PUMP HOUSE
HYDRANT
WATERMAIN
WATERMAIN
WATER SERVICE (CONNECTION
TO BUILDING)
GROUND WATER
CURB STOP
DEEP WELLS
Water System in Prince George

DAMS

dam is a solid barrier constructed at a suitable location across a river valley to store flowing water and used for

- Hydropower
- Irrigation
- Water for domestic consumption
- For drought and flood control
- Other additional utilization is to develop fisheries

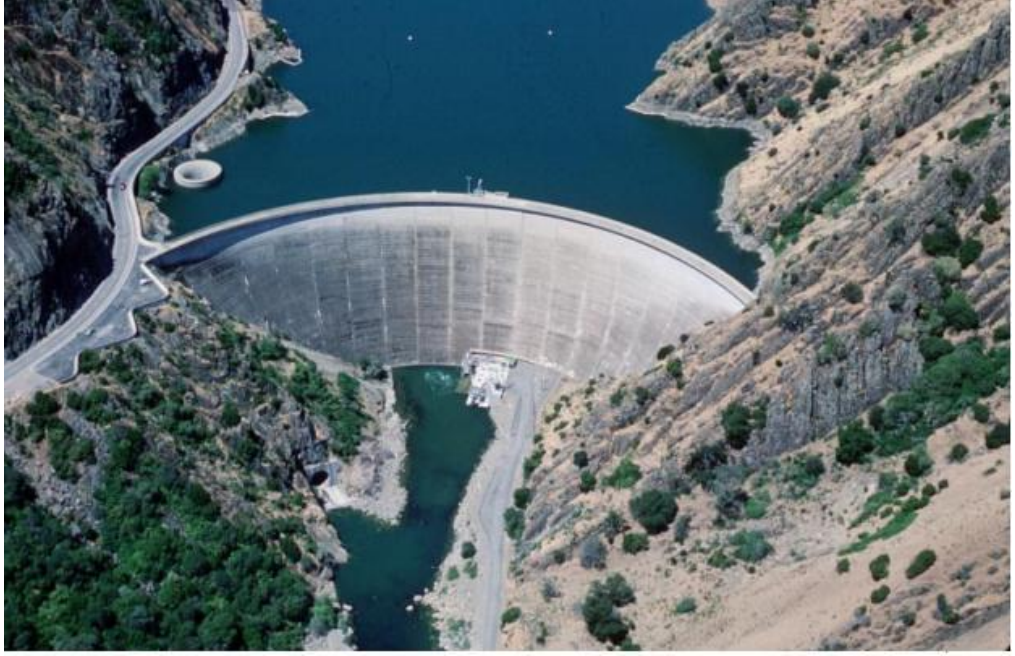
TYPES OF DAMS

there are four types of dams. They are

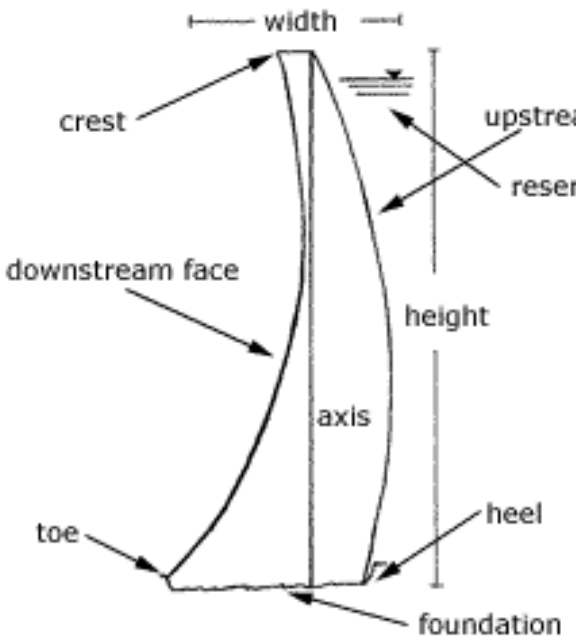
- Arch dam
- Gravity dam
- Buttress dam
- Earth dam

ARCH DAM

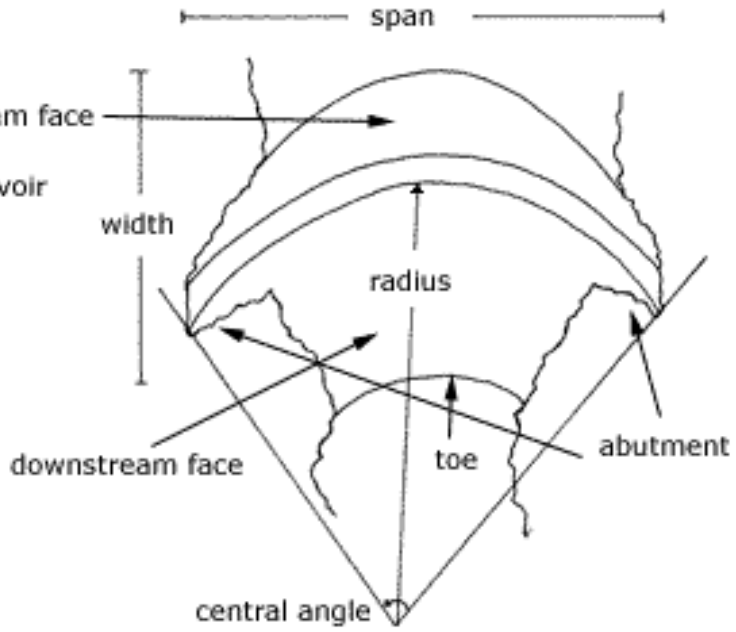
- this type of dams are concrete dams which are curved or convex upstream in plan. It is dependent upon the arch action for its strength.
- Arch dam is thinner and requires less material for construction compared to other dams.
- Arch dams are built across narrow deep river gorges.



cross section

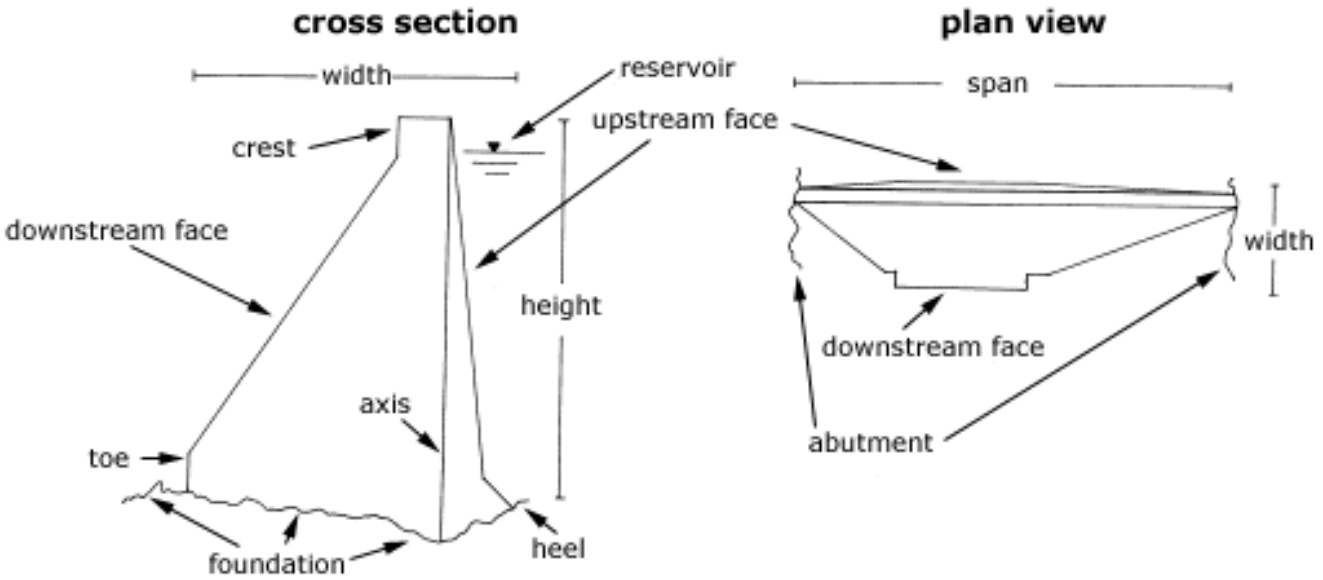


plan view



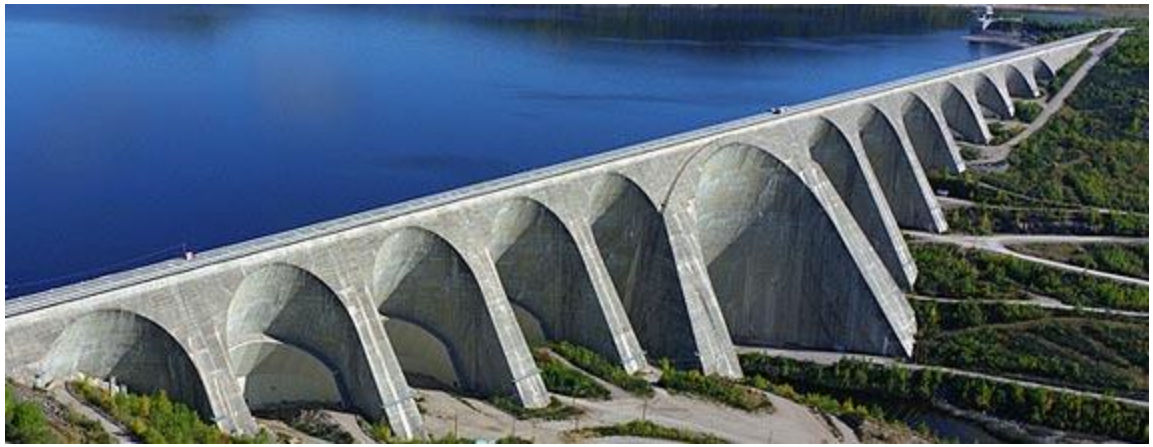
GRAVITY DAM

- Gravity dams are the dams which resist the horizontal thrust of water entirely by their own weight
- they use their weight to hold back the water in the reservoir
- Made of earth or rock fill or concrete

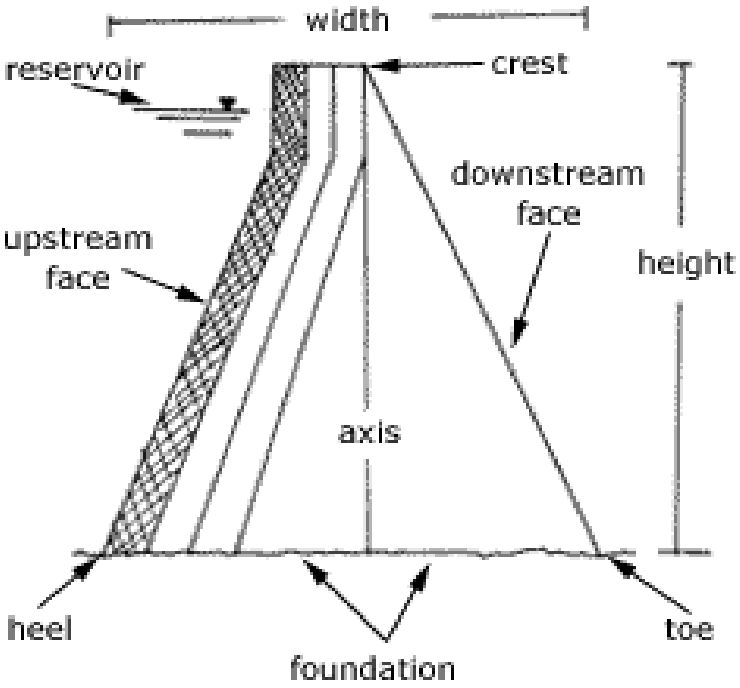

cross section
width
reservoir
crest
upstream face
downstream face
height
axis
toe
heel
foundation
plan view
span
width
downstream face
abutment

BUTTRESS DAM

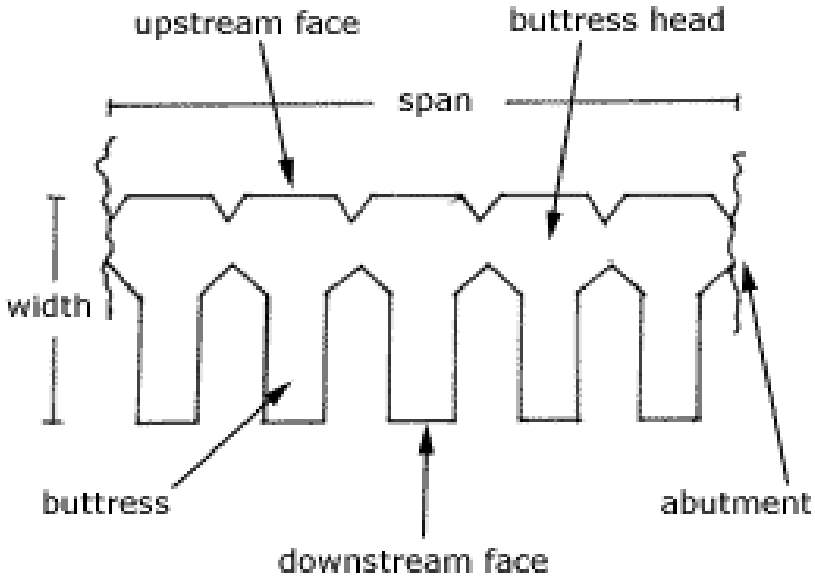
- Buttress dams are dams in which the face is held up by a series of supports.
- Buttress dams can take many forms – the face may be flat or curved.
- Usually buttress dams are made of concrete and may be reinforced with steel bars.



cross section

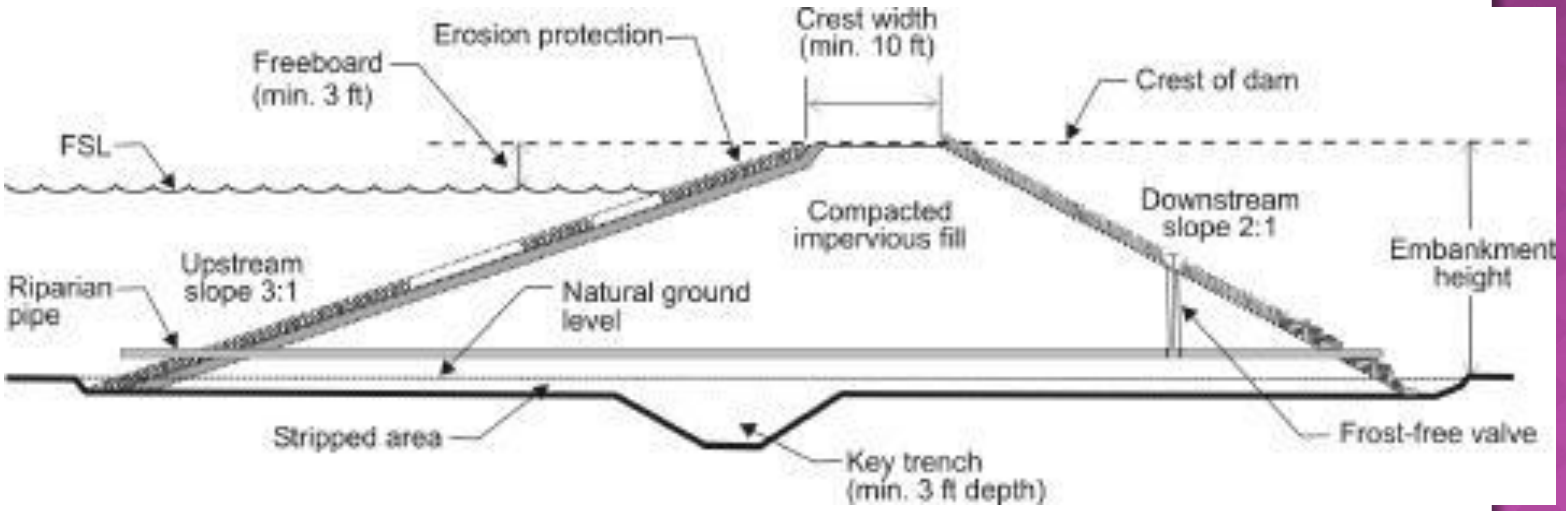


plan view



EARTH DAMS

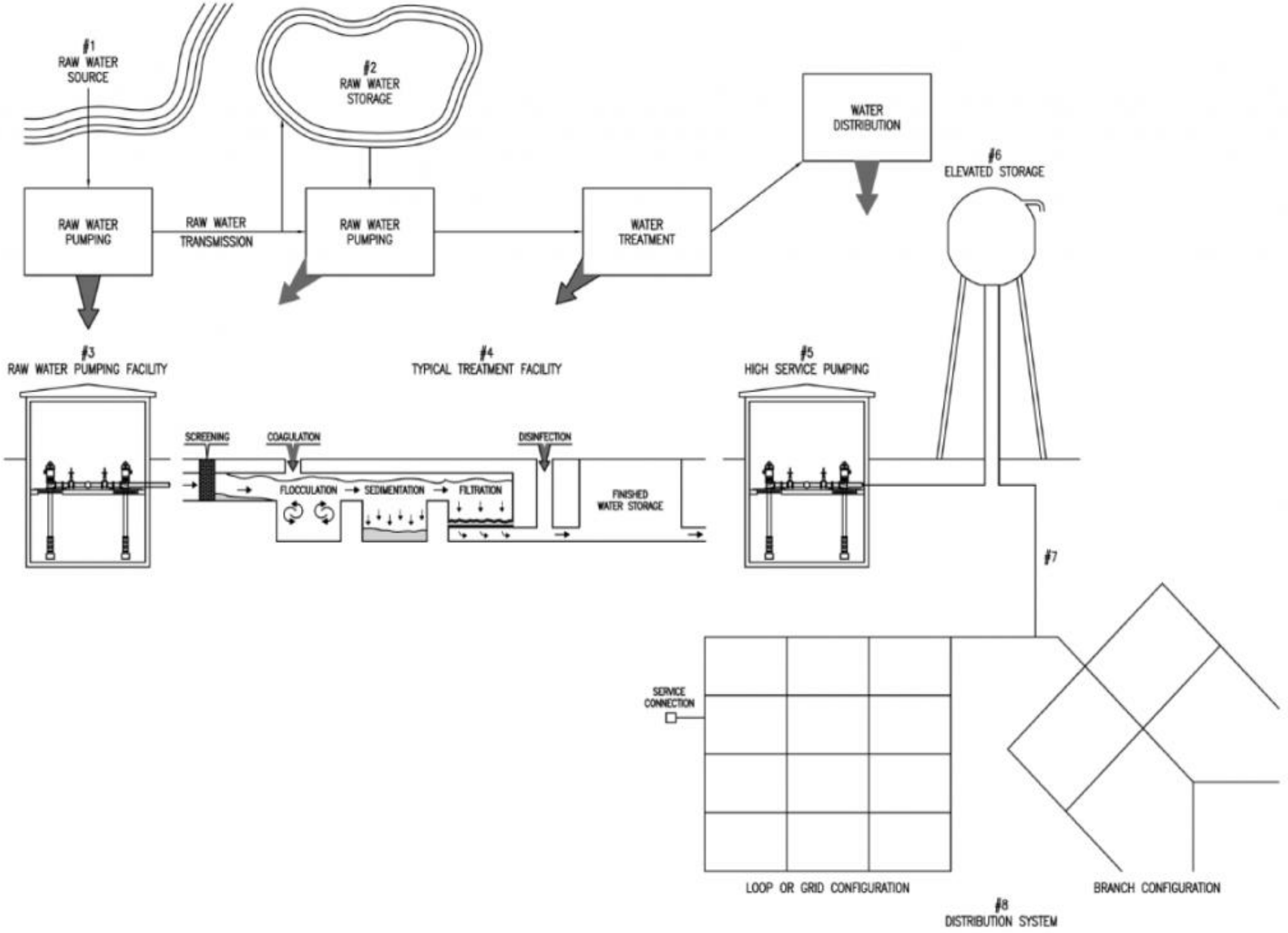
- Earth dams are trapezoidal in shape
- Earth dams are constructed where the foundation rocks are weak to support
- Earth dams are relatively smaller in height and broad at the base
- They are mainly built with clay, sand and gravel. Hence they are also known as Earth fill dam or Rock fill dam


Freeboard
(min. 3 ft)
Erosion protection
Crest width
(min. 10 ft)
Crest of dam
FSL
Compacted
impervious fill
Downstream
slope 2:1
Embankment
height
Riparian
pipe
Upstream
slope 3:1
Natural ground
level
Stripped area
Key trench
(min. 3 ft depth)
Frost-free valve

DISTRIBUTION SYSTEM

FACTORS TO BE CONSIDERED IN THE DESIGN OF DISTRIBUTION SYSTEM:

- Type of flow- whether continuous or intermittent.
- Method of distribution- whether by gravity or by pumping.
- Probable future demand based on increase in population. This also includes the industrial demand as well as fire – fighting requirements.
- Period to be considered in with life of pipes used. The system should be designed anticipating the future of the town or city.


#1
RAW WATER
SOURCE
#2
RAW WATER
STORAGE
WATER
DISTRIBUTION
#6
ELEVATED STORAGE
RAW WATER
PUMPING
RAW WATER
TRANSMISSION
RAW WATER
PUMPING
WATER
TREATMENT
#3
RAW WATER PUMPING FACILITY
#4
TYPICAL TREATMENT FACILITY
#5
HIGH SERVICE PUMPING
SCREENING
COAGULATION
DISINFECTION
FLOCCULATION
SEDIMENTATION
FILTRATION
FINISHED
WATER STORAGE
#7
SERVICE
CONNECTION
LOOP OR GRID CONFIGURATION
BRANCH CONFIGURATION
#8
DISTRIBUTION SYSTEM

- Hydraulic Gradient: A line joining the points of highest elevation of water in a series of vertical pipes rising from a pipeline in which water flows under pressure.
- According to HAZEN- WILLIAMS the flow-formula is written as:

V=velocity of flow in pipe m/sec.

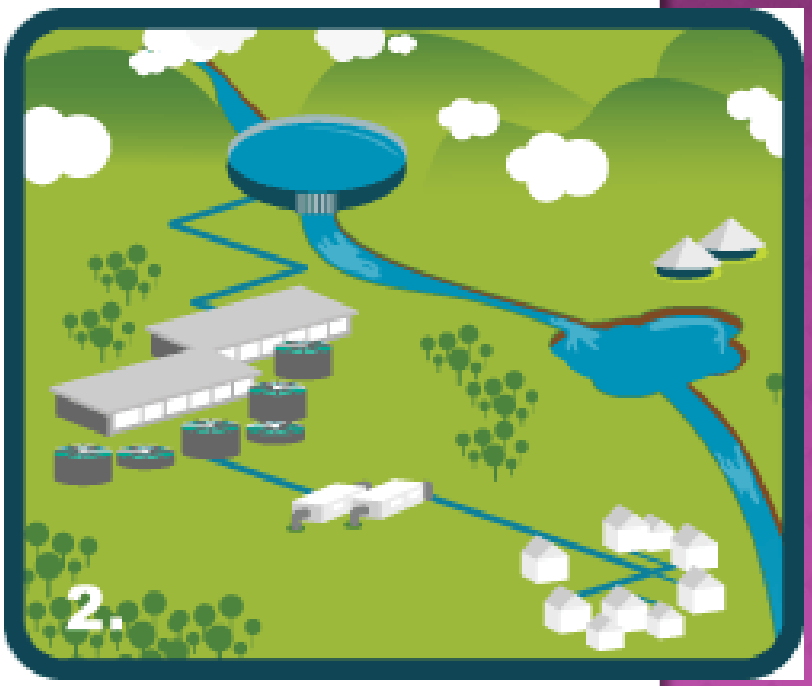
M= radius of the pipe in m.

I= Hydraulic gradient.

C=friction coefficient whose valve depends on type of pipe used.

FORMULA:

$$V = 0.85\ C\ .\ M^{0.63}\ .\ I^{0.54}$$

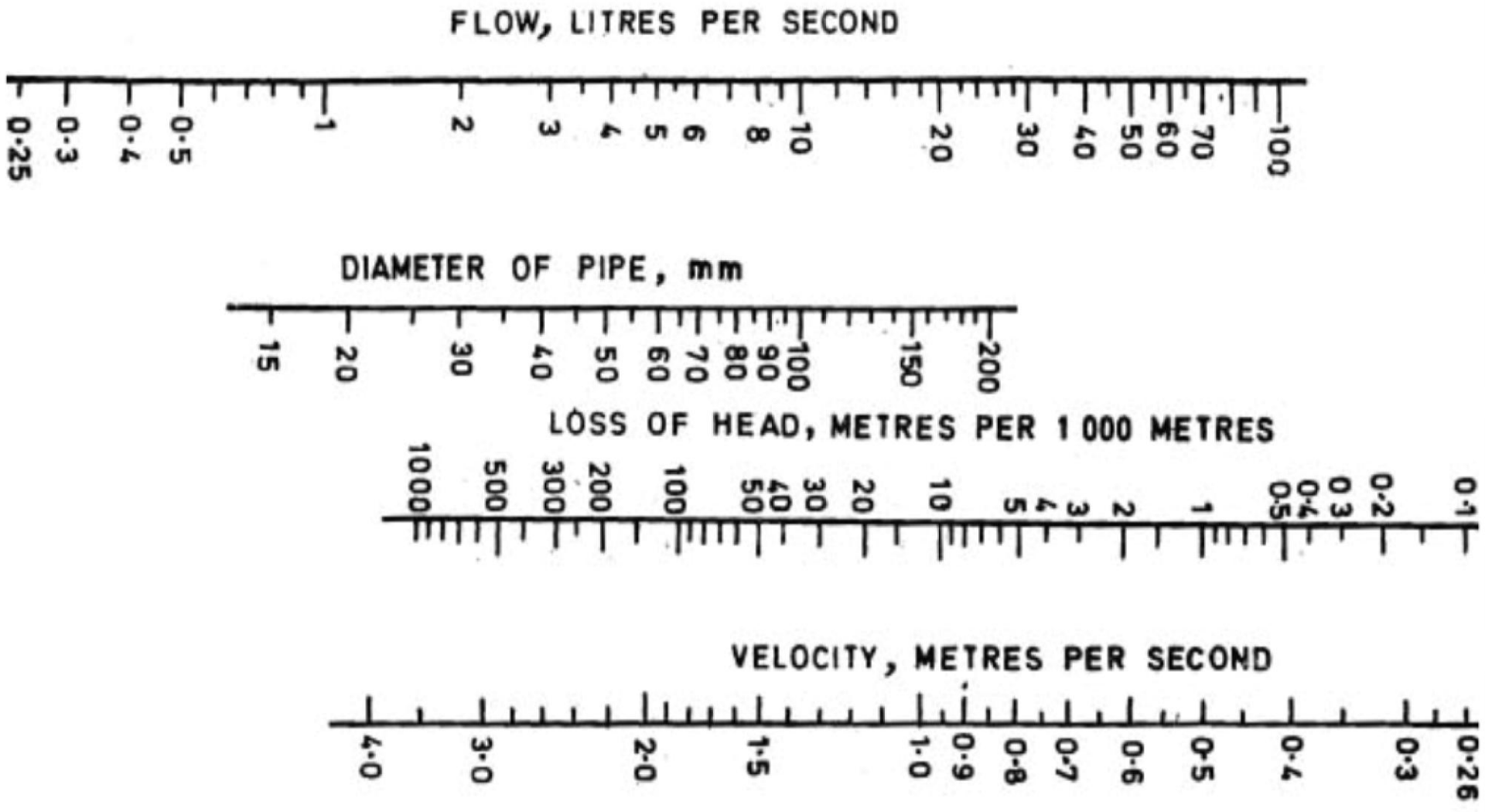


THE DESIGN PROCEDURE AS BEEN OUTLINED AS BELOW:

a) Prepare a contoured plan of the city or town, locating the positions of districts or distribution zones with their population, service reservoirs, pumping stations, main roads and streets and other small features. A small scale (1/10,000) may be used.

b) Estimating the rate of demand for all purposes including fire demand and determining the quantity flowing in each section of pipe lenght. This gives the average daily flow in the pipe. The max flow will be 3 times.

c) Assuming the pipe sizes, The velocity of flow varies 0.9-1.2 m/sec.


FLOW, LITRES PER SECOND
0·25
0·3
0·4
0·5
1
2
3
4
5
6
8
10
20
30
40
50
60
70
100
DIAMETER OF PIPE, mm
15
20
30
40
50
60
70
80
90
100
150
200
LOSS OF HEAD, METRES PER 1 000 METRES
1000
500
300
200
100
50
40
30
20
10
5
4
3
2
1
0·5
0·4
0·3
0·2
0·1
VELOCITY, METRES PER SECOND
4·0
3·0
2·0
1·5
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·26

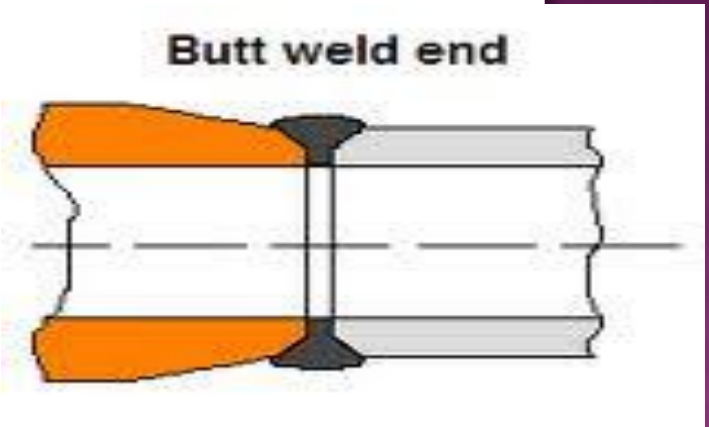
JOINTS:

- A point at which parts of an artificial structure are joined.

Types:

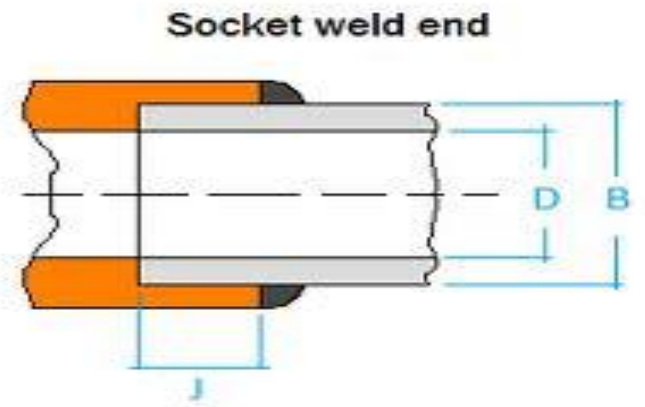
1. Butt-welded Joints
2. Socket-welded Joints
3. Threaded or Screwed Joints
4. Grooved Joints
5. Flanged Joints
6. Compression Joints

1.BUTT WELDED JOINTS:



- Butt-welding is the most common method of joining piping used in large commercial, institutional, and industrial piping systems.
- Material costs are low, but labor costs are moderate to high due to the need for specialized welders and fitters.

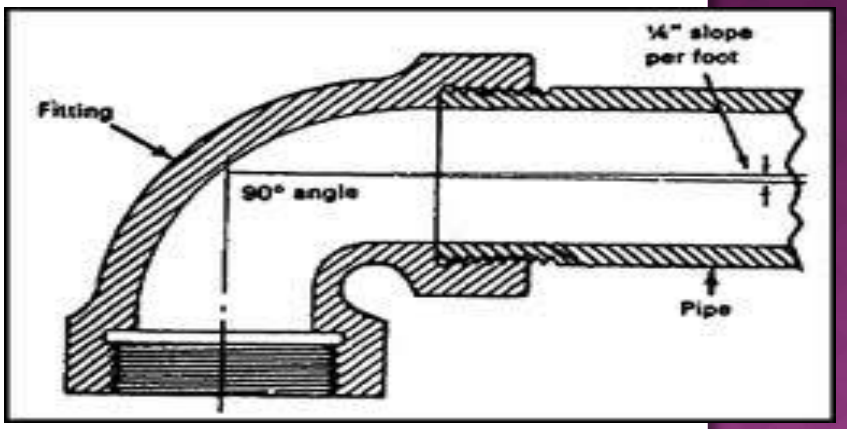
2. SOCKET-WELDED JOINTS



- Socket-welded construction is a good choice wherever the benefits of high leakage integrity and great structural strength are important design considerations.
- Construction costs are somewhat lower than with butt-welded joints due to the lack of exacting fit-up requirements and elimination of special machining for butt weld end preparation.

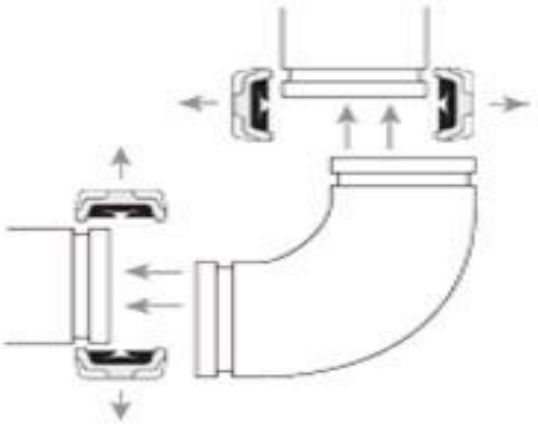
3. THREADED OR SCREWED JOINTS:

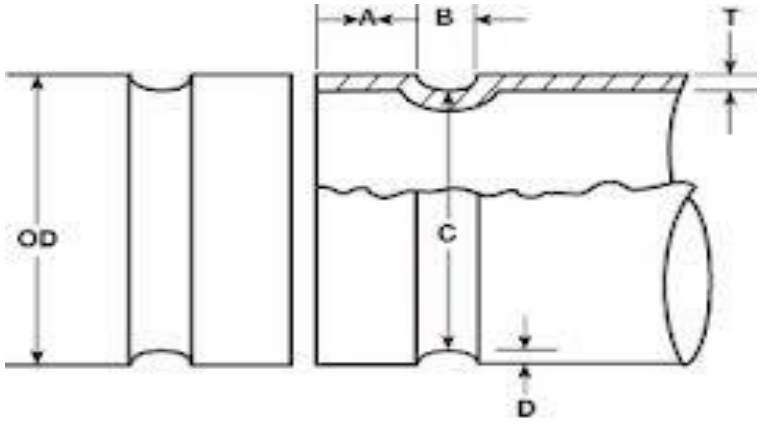
- Threaded or screwed piping is commonly used in low-cost, noncritical applications
  such as domestic water, fire protection, and industrial cooling water systems.
- Installation productivity is moderately high, and specialized installation skill requirements
  are not extensive.
- Rapid temperature changes may
  lead to leaks due to differential thermal expansion between the pipe and fittings.


¼" slope
per foot
Fitting
90° angle
Pipe

4. GROOVED JOINTS:

- The main advantages of the grooved joints are their ease of assembly, which results in low labor cost, and generally good leakage integrity.
- They allow a moderate amount of axial movement due to thermal expansion, and they can accommodate some axial misalignment.
- The grooved construction prevents the joint from separating under pressure.



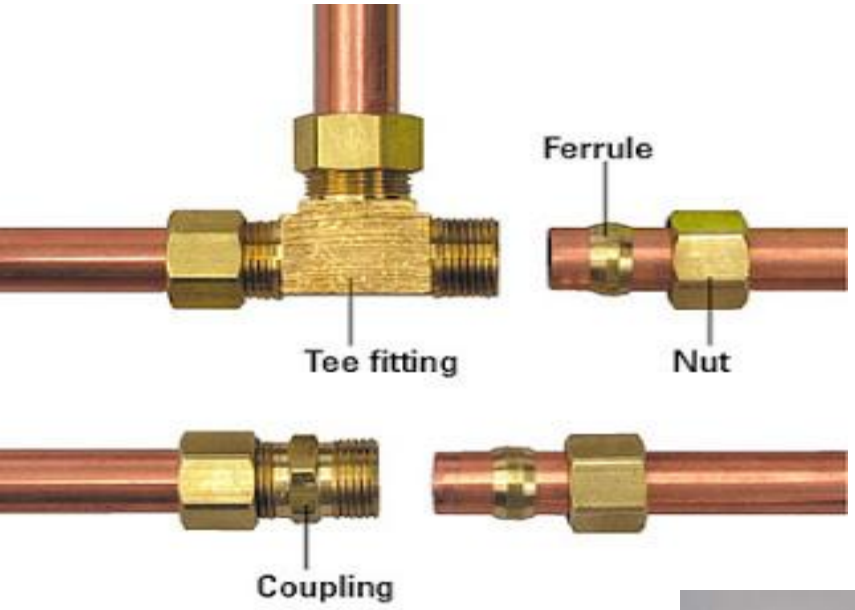

A
B
T
OD
C
D

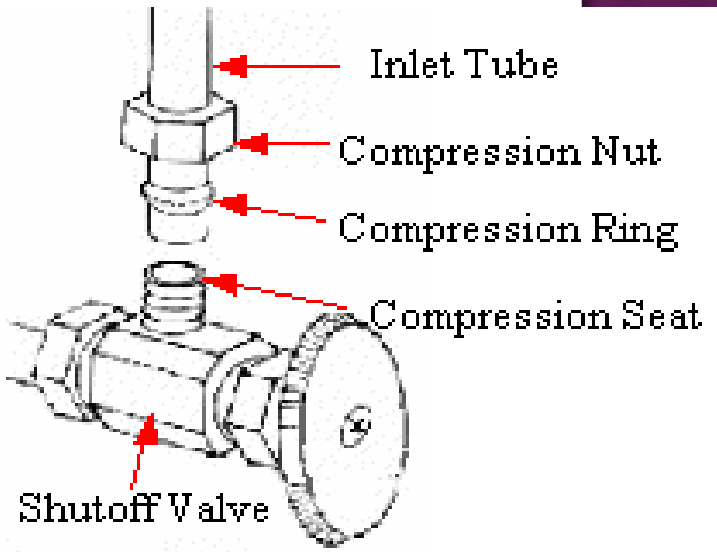
5. FLANGED JOINTS:

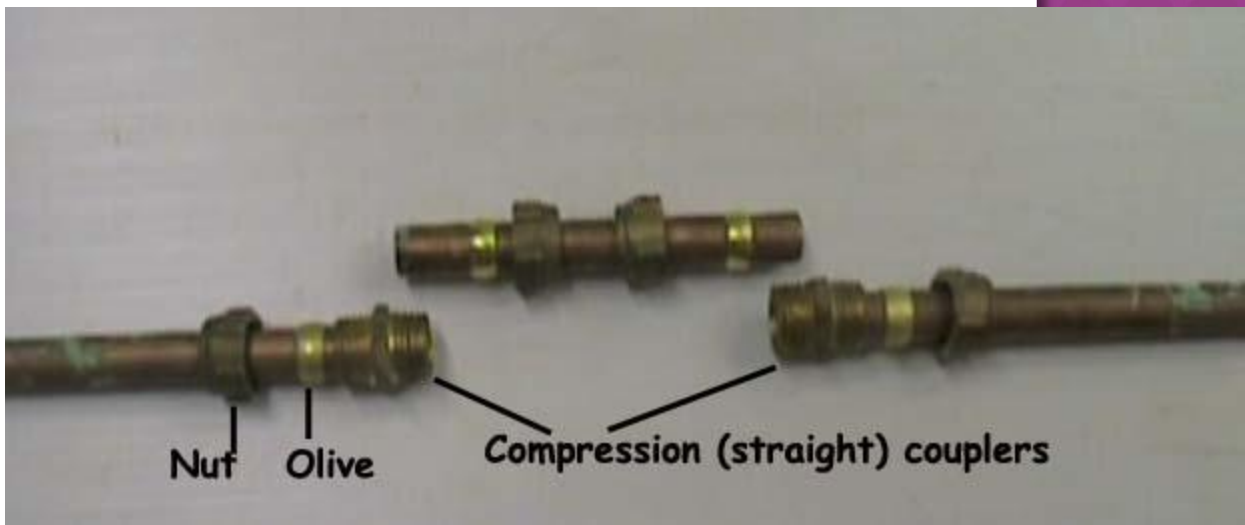
- Flanged connections are used extensively in modern piping systems due to their ease of assembly and disassembly; however, they are costly.
- Contributing to the high cost are the material costs of the flanges themselves and the labor costs for attaching the flanges to the pipe and then bolting the flanges to each other.
- Flanges are normally attached to the pipe by threading or welding, although in some special cases a flange-type joint known as a lap joint may be made by forging and machining the pipe end.

6. COMPRESSION JOINTS:

- Compression sleeve-type joints are used to join plain end pipe without special end preparations.
- These joints require very little installation labor and as such result in an economical overall installation. Advantages include the ability to absorb a limited amount of thermal expansion and angular misalignment and the ability to join dissimilar piping materials, even if their outside diameters are slightly different.


Ferrule
Tee fitting
Nut
Coupling


Inlet Tube
Compression Nut
Compression Ring
Compression Seat
Shutoff Valve


Nut
Olive
Compression (straight) couplers