Introduction

For

The Design of Water Treatment Plants

1. Introduction

1.1 Objectives of water treatment

The principal objective of water treatment is to provide potable water that is chemically and biologically safe for human consumption. It should also be free from unpleasant tastes and odors.

Water treatment objective is to produce both "**Potable**" and "**Palatable**".

- **Potable:** Water that can be consumed in any desired amount without concern for adverse health effects. Potable does not necessarily mean that the water tastes good.
- **Palatable**: It is a water that is pleasing to drink but not necessarily safe.

1.1 Objectives of water treatment.

Water treatment aims at producing water that satisfies a set of drinking water quality standards at a reasonable price to the consumers.

- **Main objectives of water treatment:**
  - Removal of particles.
  - Removal of dissolved solids.

    Some of the dissolved solids should stay in water at healthy concentrations.
  - Removal of pathogens.

- **Water Sources:**
  - Surface water
  - Ground water
  - Sea water

2. Water Quality

2.1 Water quality characteristics

a. Physical characteristics:

Total solids, suspended solids

Turbidity Color

Taste and odor Temperature

b. Chemical characteristics:

Many dissolved chemicals exist in water and many of them are of concern such as:

Chloride, fluorides, iron, lead, manganese, sodium, sulfate, zinc, toxic inorganic substances, toxic organic substances.

c. Microbiological characteristic:-

Pathogens: viruses, bacteria, protozoa, helminthes (Warms)

2. Water Quality

2.2 Most common raw water problems

1. Bacteriological contamination
2. Suspended & dissolved solids.
3. Hard water
4. Corrosive water
5. Iron and manganese

2. Water Quality

2.3 Water quality standards

Drinking water standards specify the maximum / optimum levels of contaminants in drinking water for the protection of human health.

See Saudi Arabian Drinking Water Standards

See the EPA Primary drinking water standards

See the WHO drinking water standards

Secondary MCLs (mg/L)

TABLE 6.3 Secondary Standards For Drinking Water

Contaminant	Level	Contaminant effects
Aluminum	0.05–0.2 mg/L	Water discoloration
Chloride	250 mg/L	Taste, pipe corrosion
Color	15 color units	Aesthetic
Copper	1 mg/L	Taste, porcelain staining
Corrosivity	Noncorrosive	Pipe leaching of lead
Fluoride	2.0 mg/L	Dental fluorosis
Foaming agents	0.5 mg/L	Aesthetic
Iron	0.3 mg/L	Taste, laundry staining
Manganese	0.05 mg/L	Taste, laundry staining
Odor	3 threshold odor number	Aesthetic
pH	6.5–8.5	Corrosive
Silver	0.1 mg/L	Skin discoloration
Sulfate	250 mg/L	Taste, laxative effects
Total dissolved solids	500 mg/L	Taste, corrosivity, detergents
Zinc	5 mg/L	Taste

2. Water Quality

2.4 Water classification by source

Ground Water vs. Surface Water

Groundwater	Surface water
Constant composition	Variable composition
High mineral content	low mineral content
low turbidity	High turbidity
Low color	Colored
Low or no D.O.	D.O. present
High hardness	low hardness
High Fe, Mn.	Taste and odor

3. Water treatment methods

3.1 Unit operations and Unit processes

Water treatment plants utilize many treatment processes to produce water of a desired quality.

These processes fall into two broad divisions: -

A) Unit operations: (UO)

Removal of contaminants is achieved by physical forces such as gravity and screening.

B) Unit processes (UP)

Removal is achieved by chemical and biological reactions.

3. Water treatment methods

3.2 Most common treatment methods

Coagulation and flocculation (UP)

Softening (UP)

Reverse osmosis RO (UP)

Electrodialysis (UP)

Ion exchange (UP)

Adsorption (UO)

Precipitation (UP)

Disinfection (UP)

Sedimentation (UO)

Filtration (UO

4. Water Treatment Plants (WTP)

4.1 Most common water treatment plants

Water treatment plants can be classified as:-

A) Simple disinfection:-

It is a direct pumping and chlorine injection. Used to treat high quality water.

B) Traditional filtration plants: (surface water)

Removes: color, turbidity, taste, odor, and bacteria (sedimentation+filtration plant)

C) Direct filtration plants: (surface water)

If the source water has better quality with lower solids, flocculation and sedimentation can be omitted; this modification is called**.**

D) Softening plants: - (ground water)

5. Water treatment design steps

- Master planning.
- Process train selection.
- Preliminary hydraulic design.
- Conceptual plant layouts
- Plant hydraulic profile
- Design criteria
- Requirements for ancillary facilities
- Plant in-site facilities & networks
- Architectural and structural concepts for the plant buildings
- Provisions for future expansions of the plant facilities,
- Drawings and specifications.

6. Water Plant Design Requirements

The most important initial parameters to consider are:

- Raw water quality
- Treated water quality requirements
- Population data.
- Water consumption information.
- Climatic conditions.
- Volume or flow rate requirements
- General lay out of the zone surrounding the city.
- City Master plan showing water sources, land use and contour levels

7. WTP site area selection

Factors affecting WTP site area selection:

- Proximity of plant site to the source water and to area served
- Consideration of water transmission requirements to the plant and the water distribution system
- Proximity of plant site to ultimate treatment waste disposal location
- Environmental and land use concerns
- Subsurface and geotechnical considerations
- Land availability, cost, and zoning
- Compatibility with surrounding existing and planned developments
- Potential for flooding and storm water handling requirements
- Availability of utilities (power, natural gas, sewer, telephone)
- Site topography and accessibility
- Vulnerability to security risks and natural disasters

8. Sitting of plant facilities layout

Factors affecting Sitting of plant facilities layout:

- Topography elevation changes across the site
- Plant site buffer and security requirements
- Physical features, barriers, or constraints within the site
- Floodplain limits and flood protection requirements
- Drainage and storm water detention provisions
- Piping and conduits between structures
- Vehicle access and parking for plant personnel, public, and deliveries
- Natural gas, power, sewer, and telephone utility routing

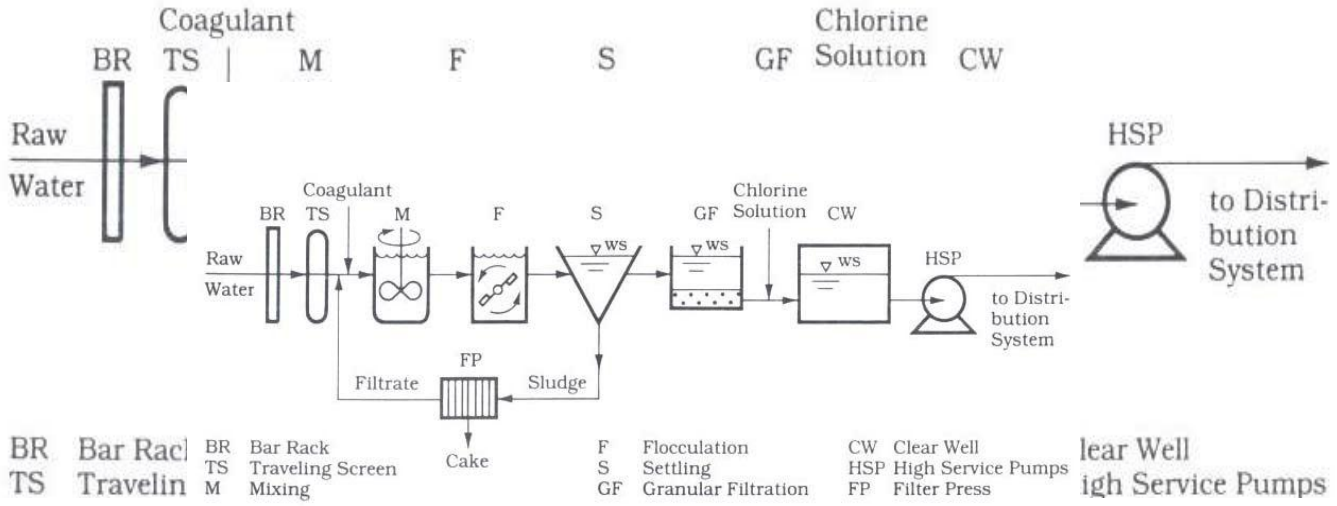
9. Coordination of Design Disciplines

- Process Design.
- Hydraulic Design
- Site Surveying.
- Geotechnical Investigation.
- Structural Design.
- Mechanical Design.
- Electrical Design.
- Instrumentation Design.

10. Examples of Water Process Flow Diagrams

Surface Water Treatment

Rapid Sand Filtration Plant



Ground water supply systems

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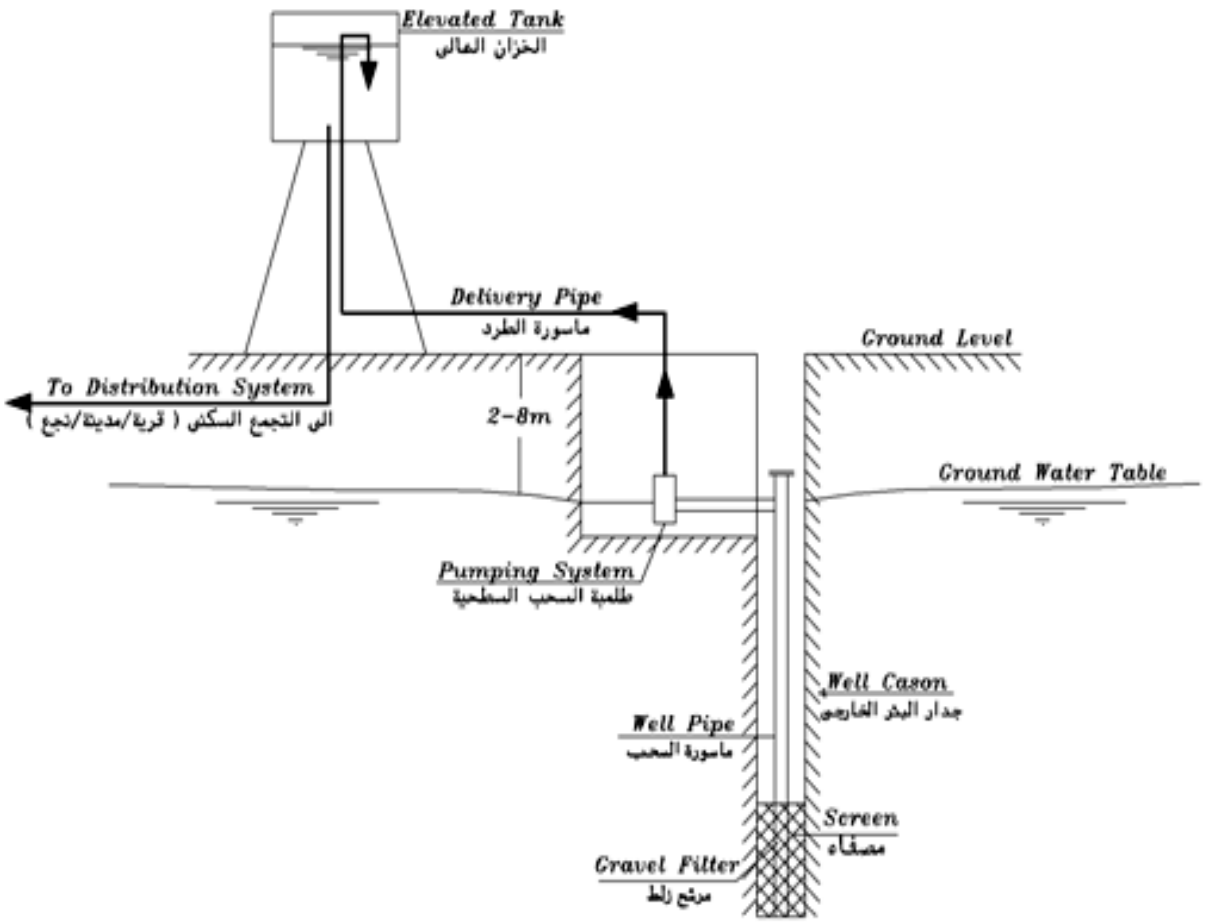
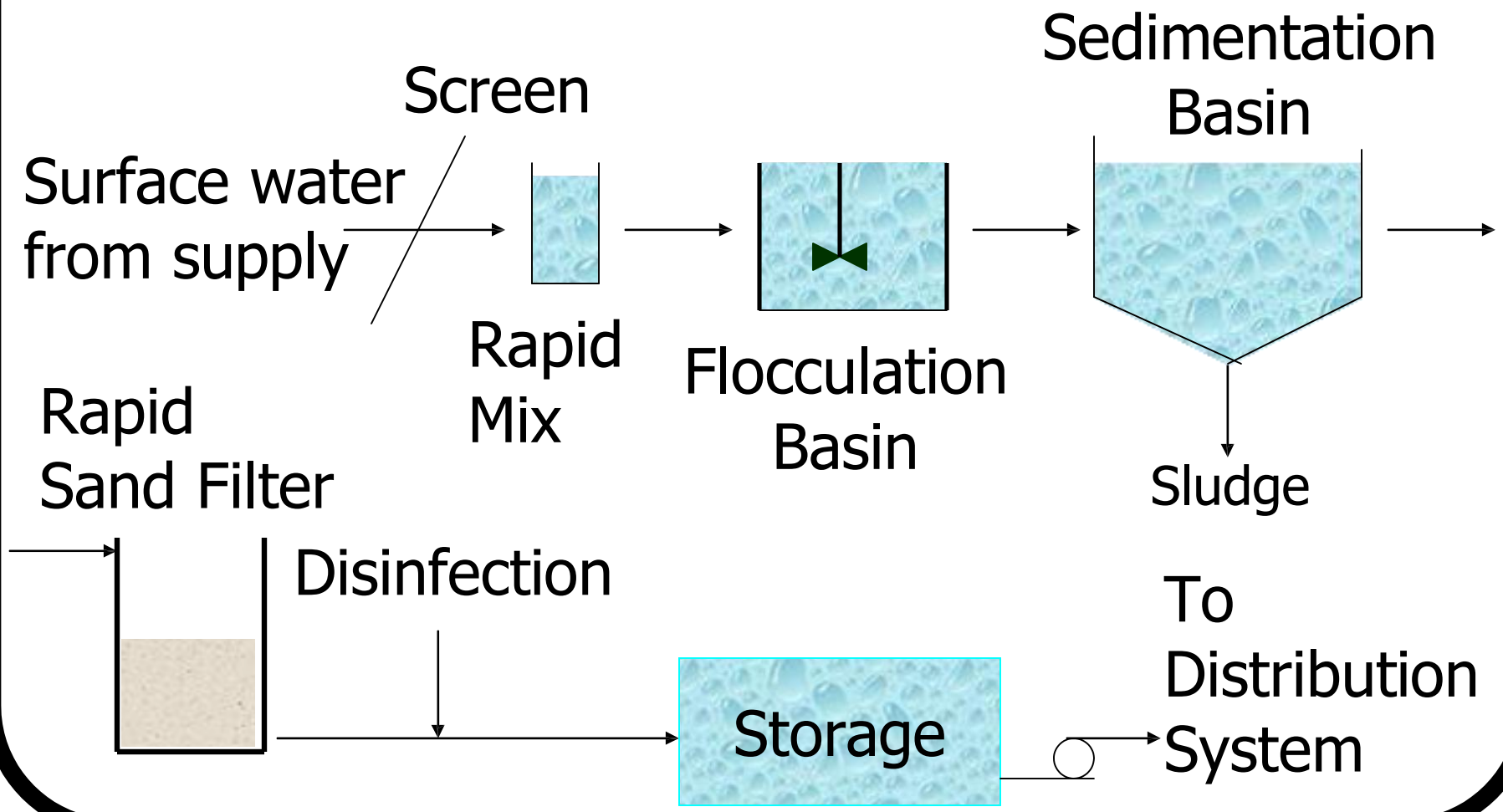
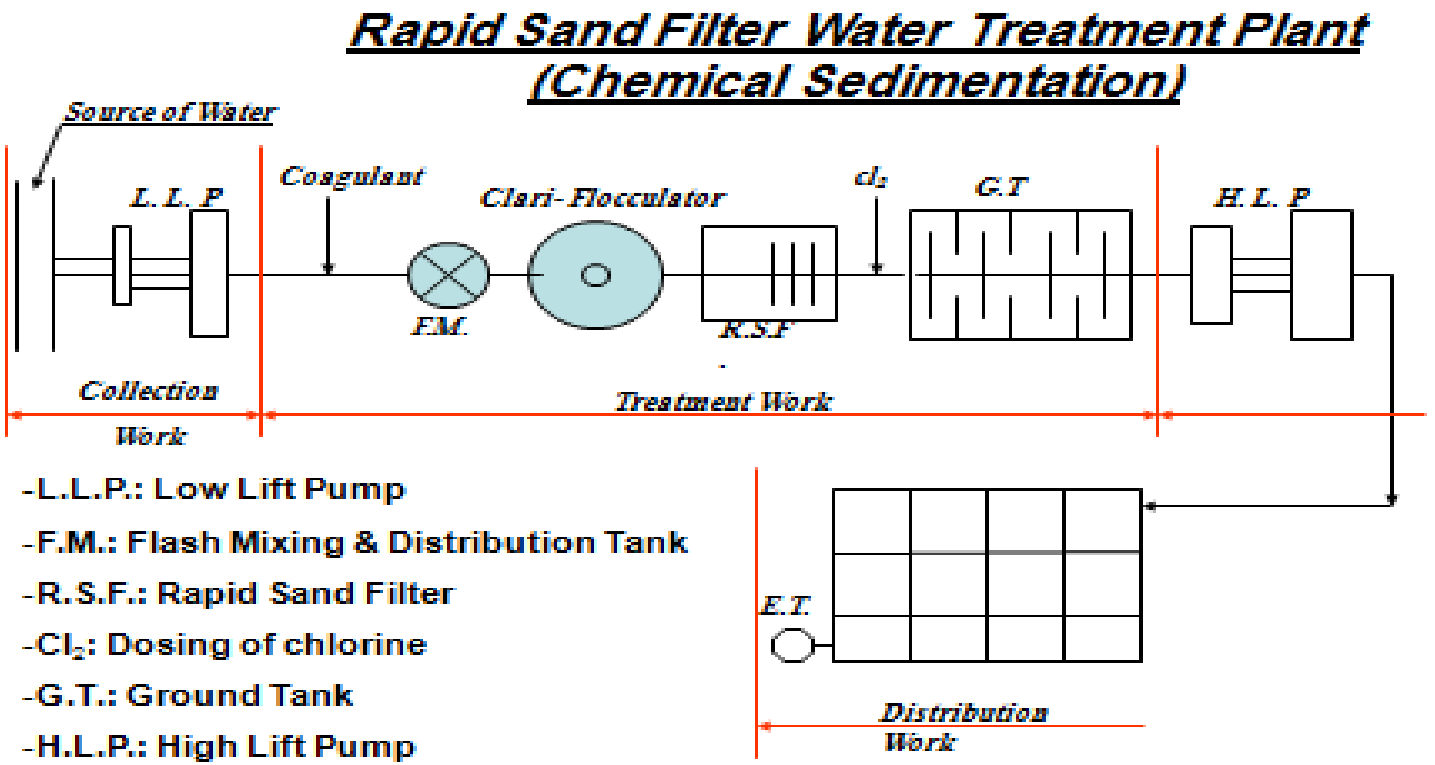


Surface Water Treatment



Rapid Sand Filter Water Treatment Plant



-L.L.P.: Low Lift Pump

-F.M.: Flash Mixing & Distribution Tank

-R.S.F.: Rapid Sand Filter

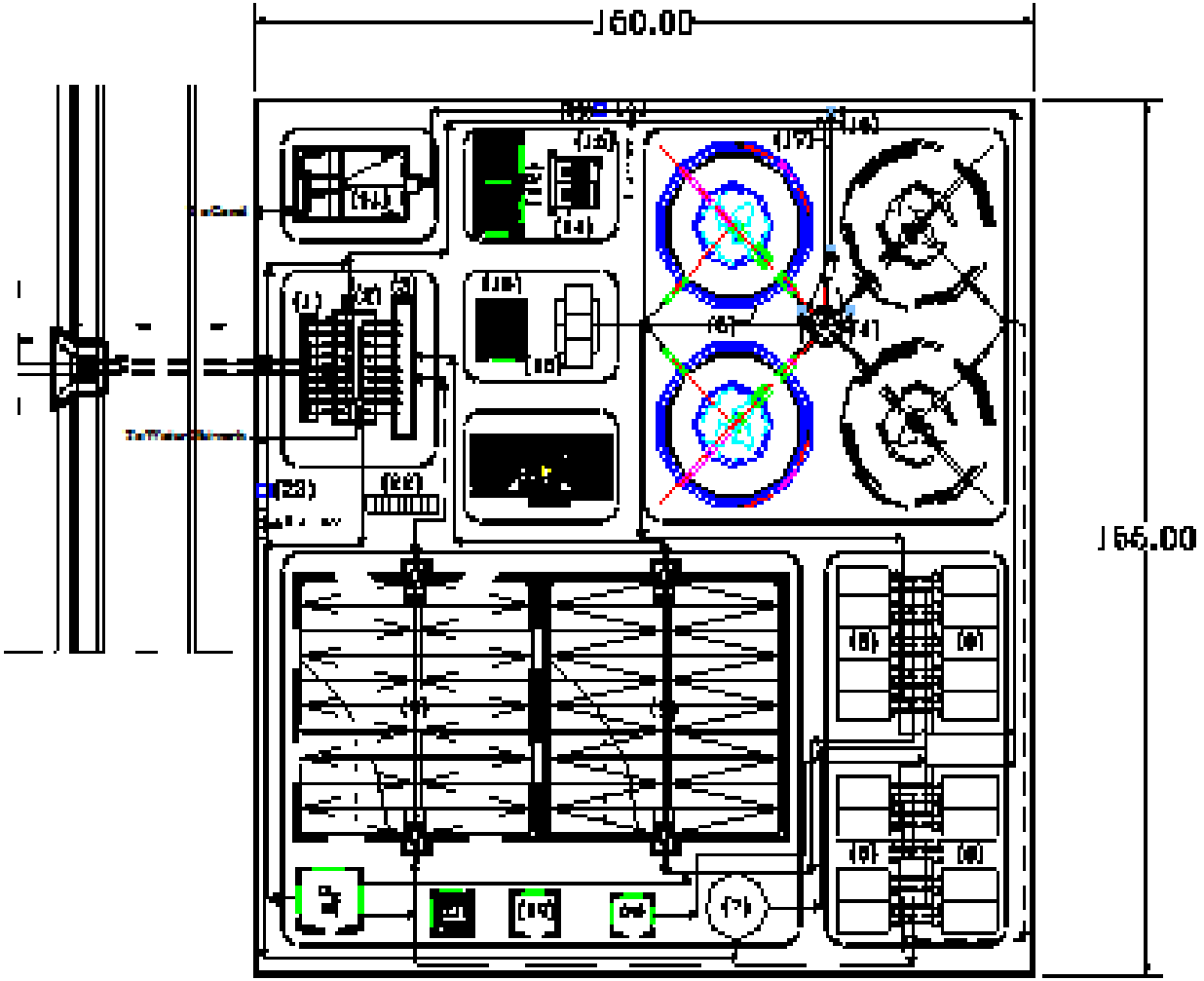
-Cl_2: Dosing of chlorine

-G.T.: Ground Tank

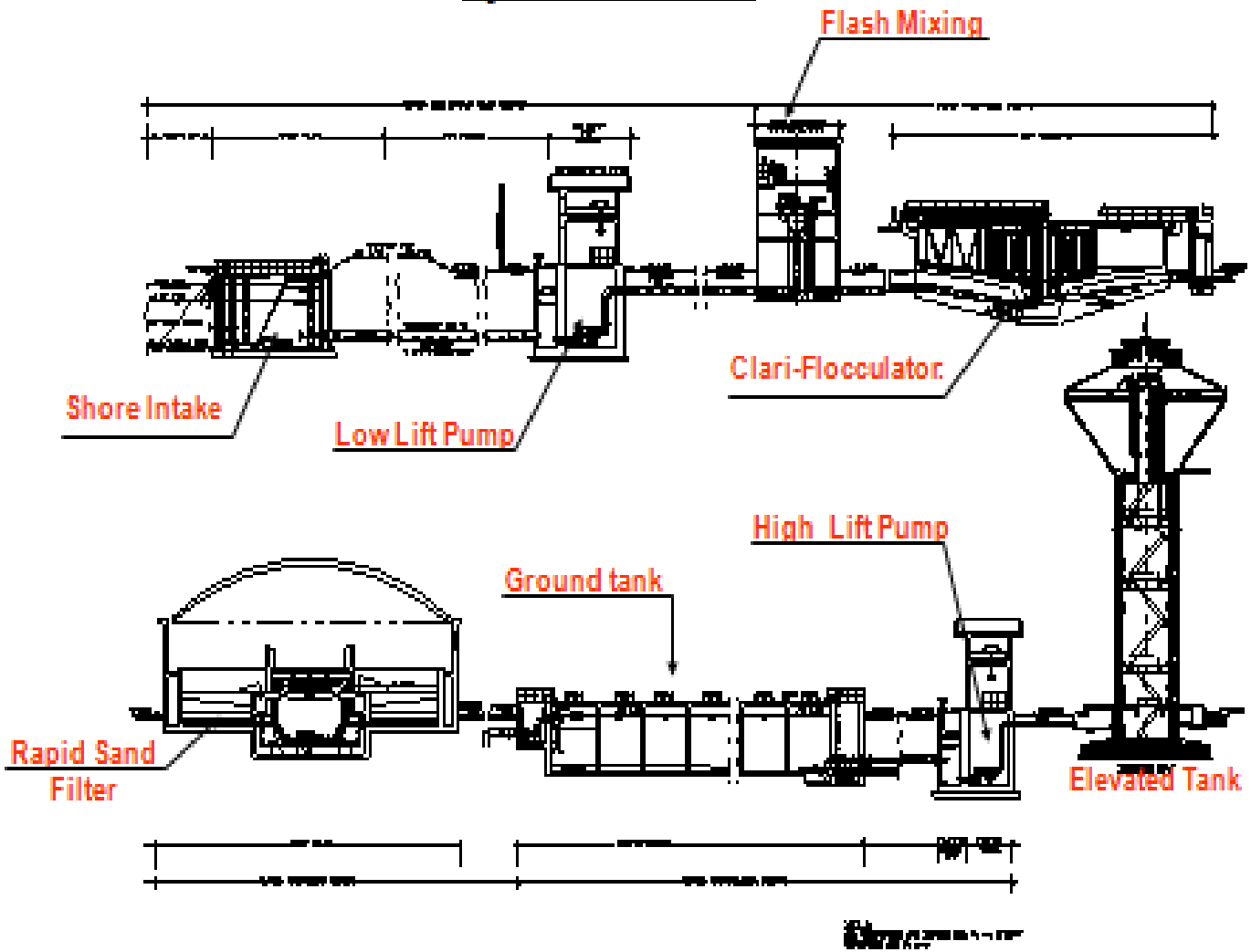
-H.L.P.: High Lift Pump

-E.T.: Elevated Tank

Layout of Water Treatment Plant

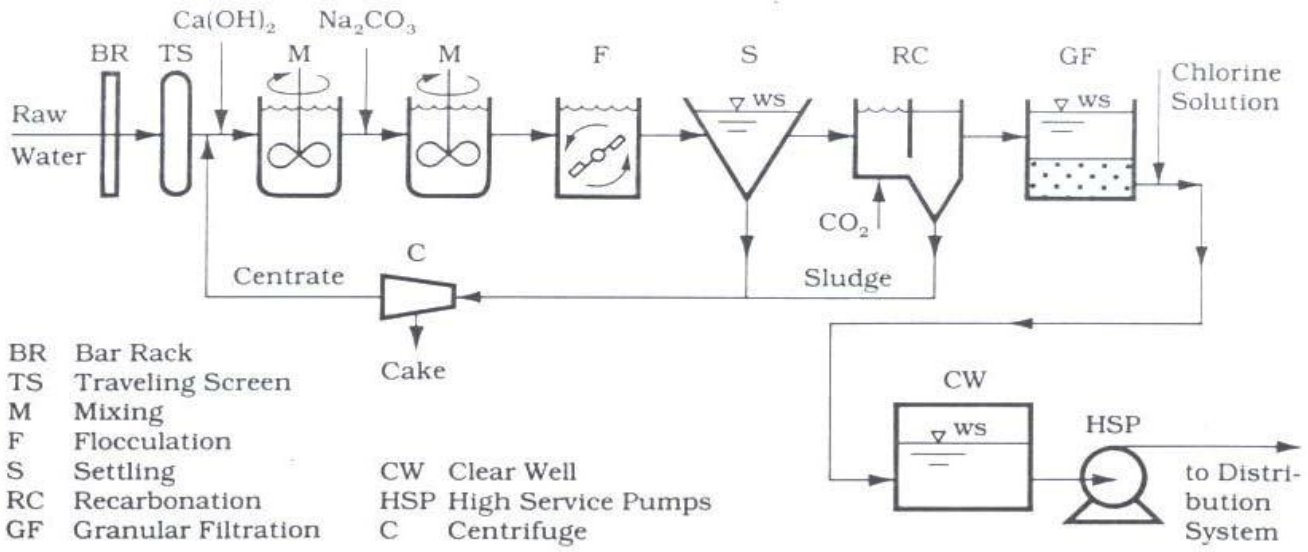


Hydraulic Profile

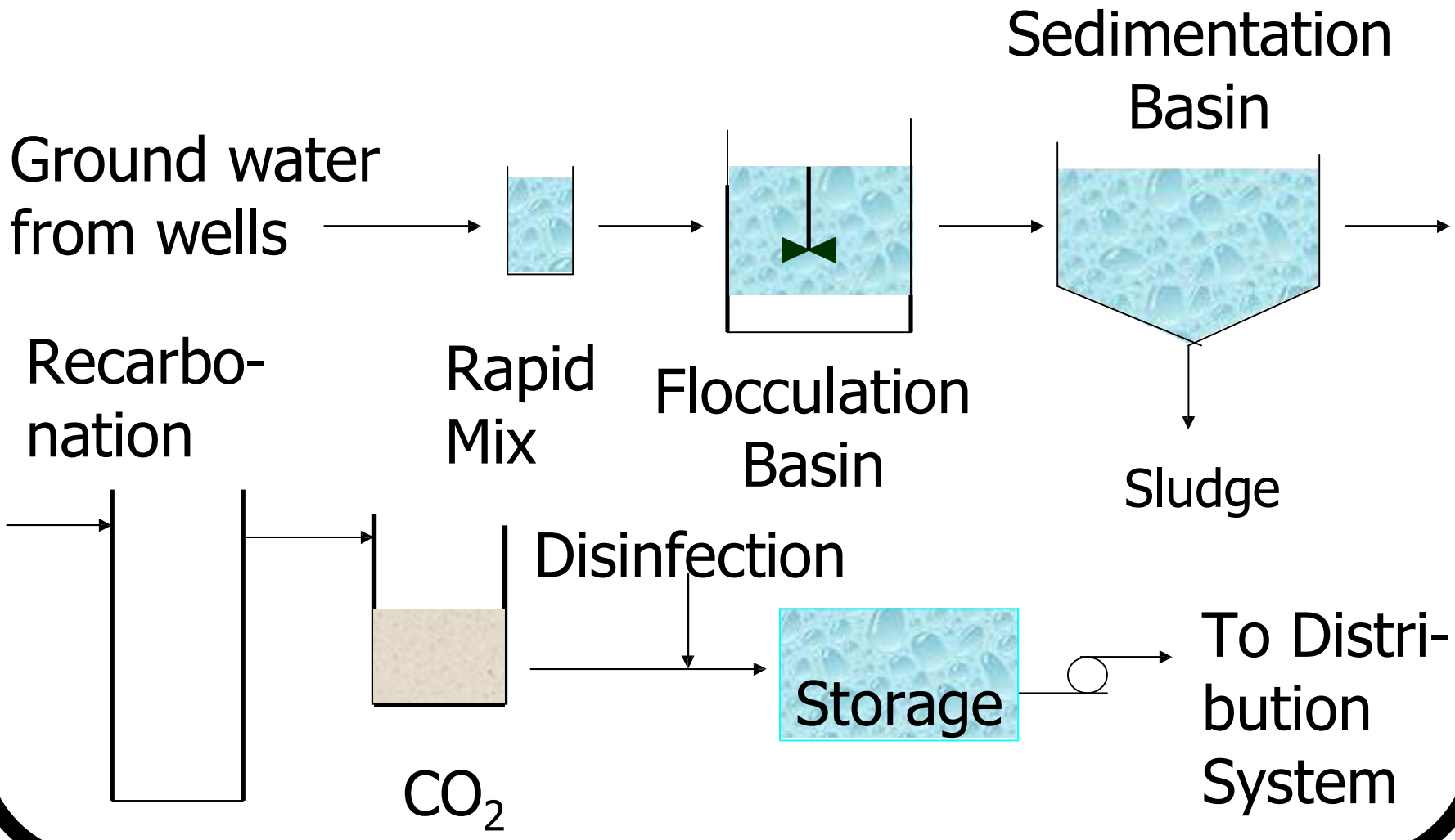


Lime-Soda Softening Plant

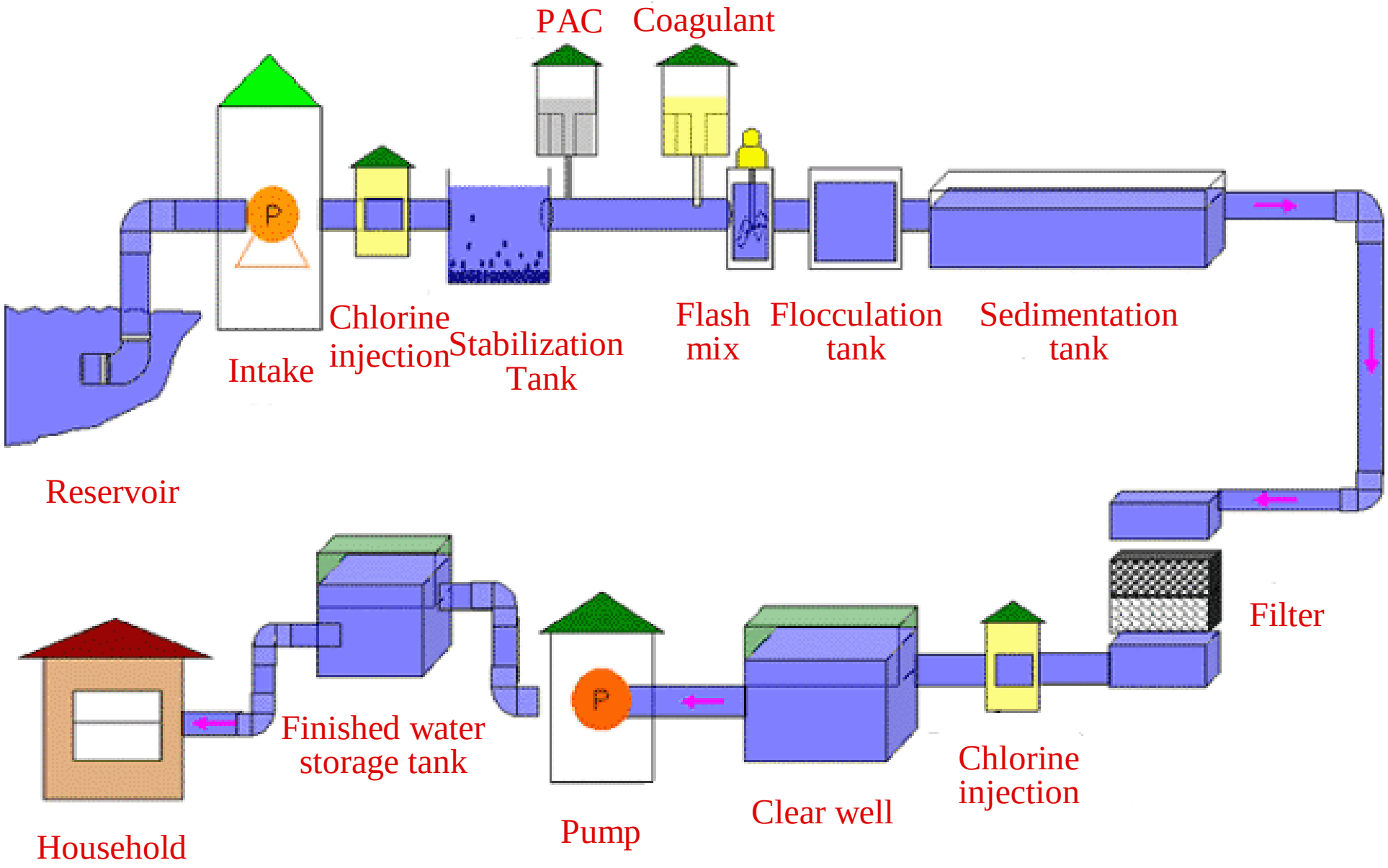
Figure 1.2. Lime-Soda Softening Plant



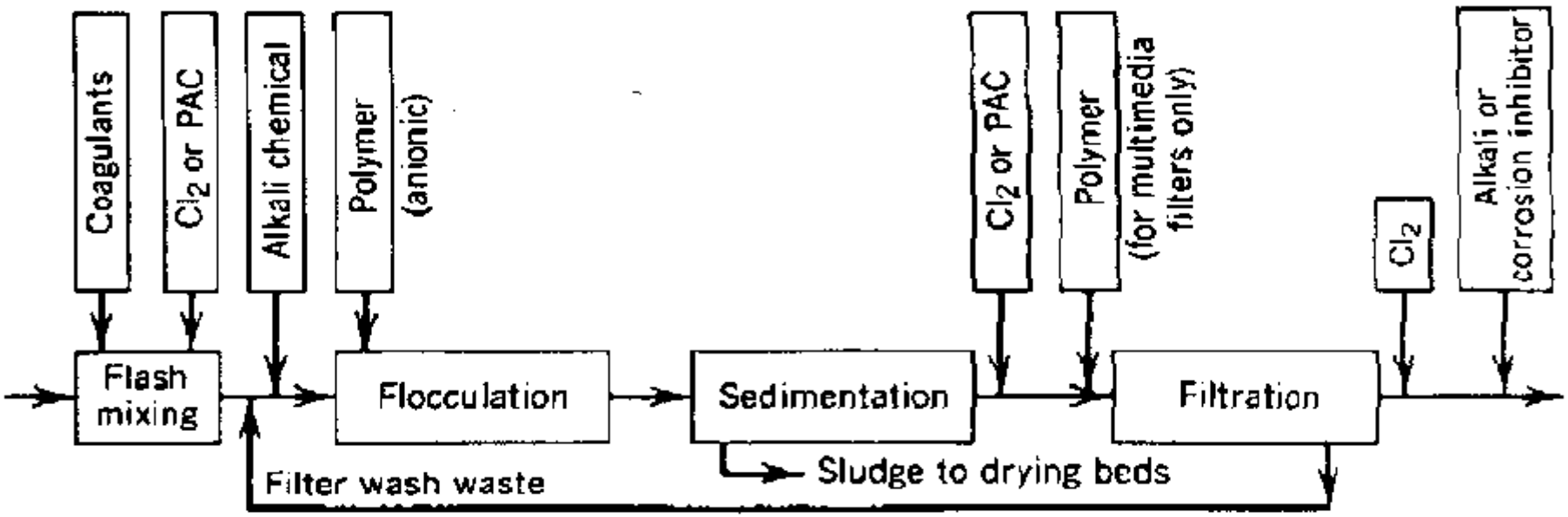
Groundwater Treatment



Treatment Flow Chart



Conventional Water Treatment Process

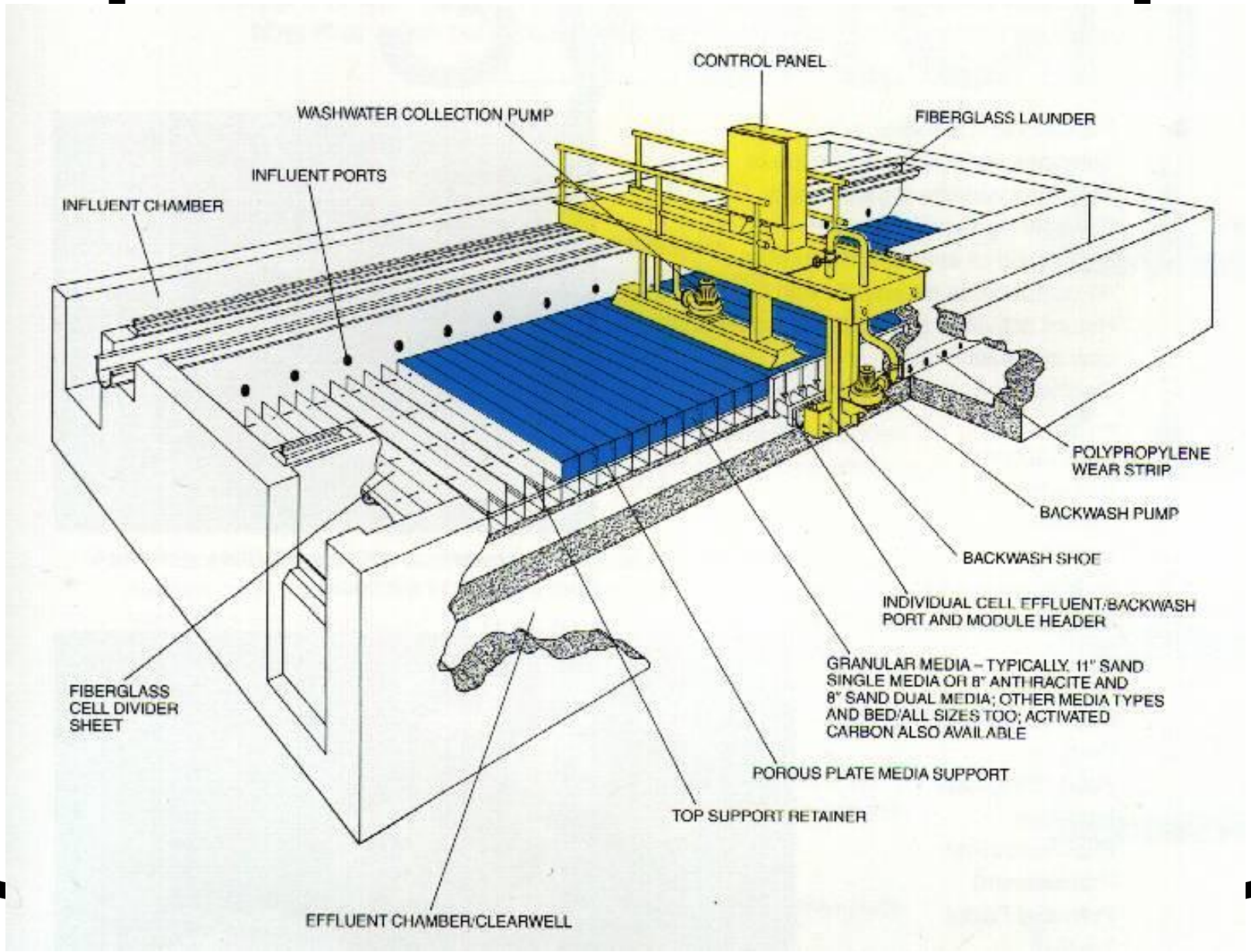


Sedimentation

Sedimentation Tank

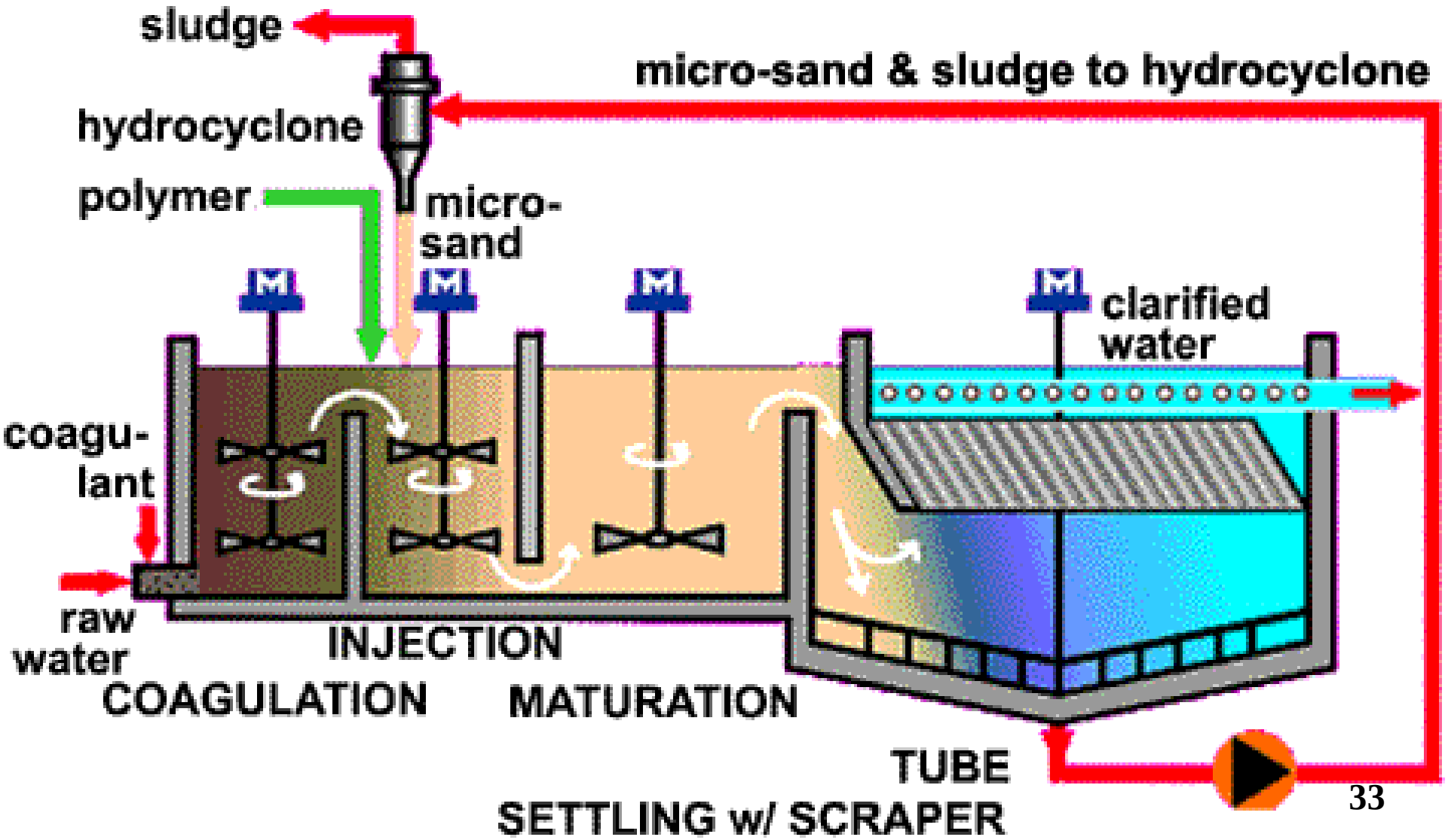
Circular Clarifiers

Automatic Backwash Filter

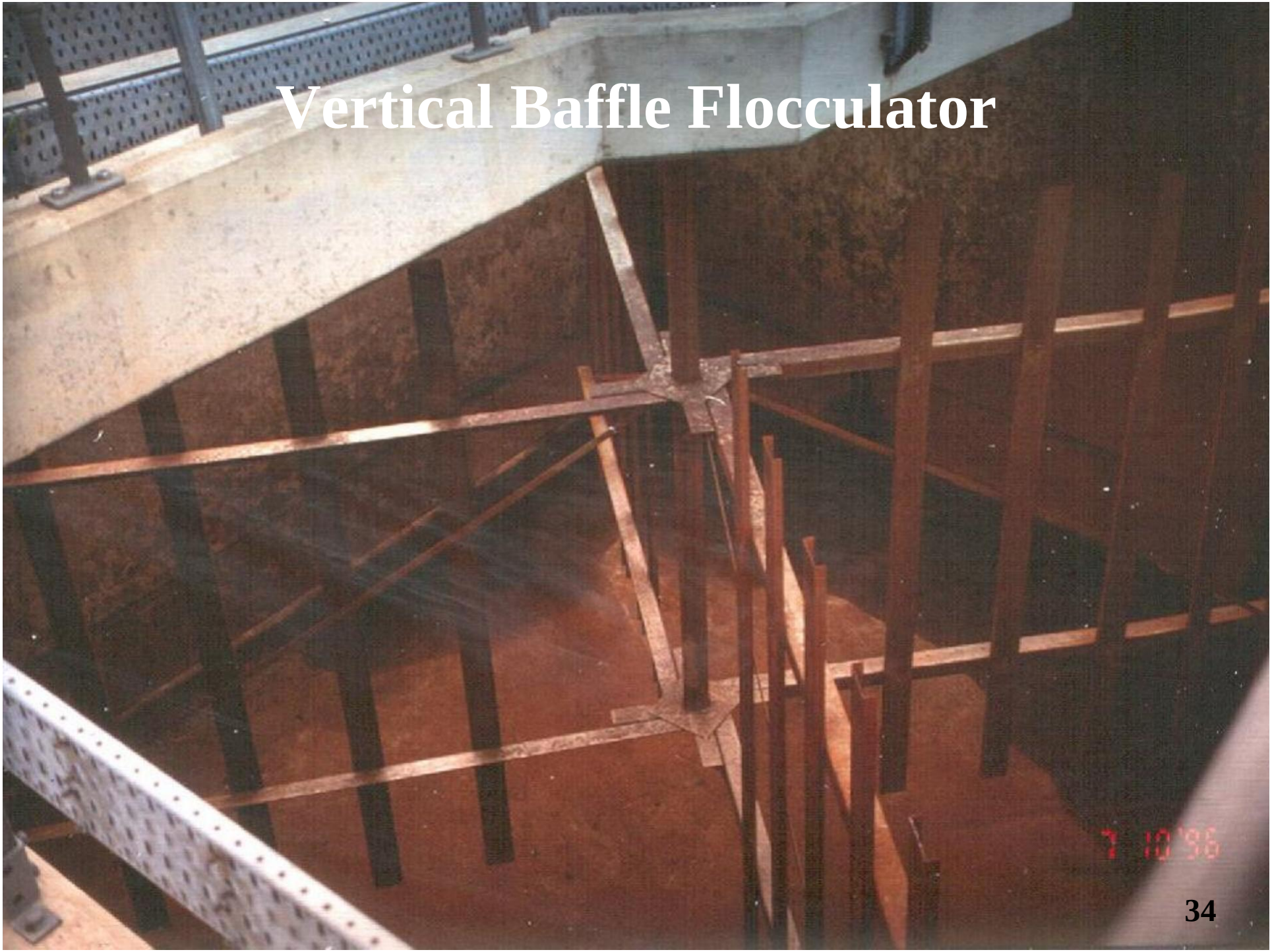


Filtration

Flocculator



Vertical Baffle Flocculator



Flocculation

FIGURE 9–7

Paddle flocculator.

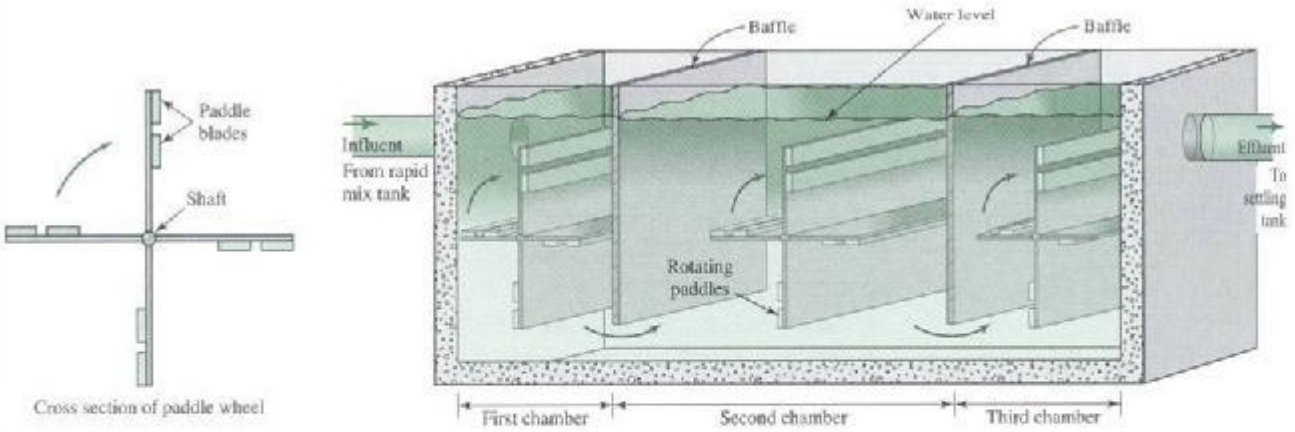
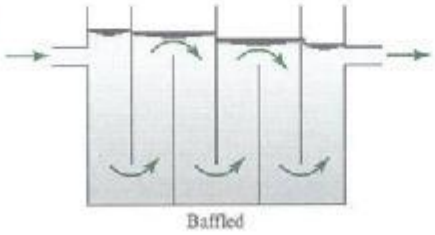
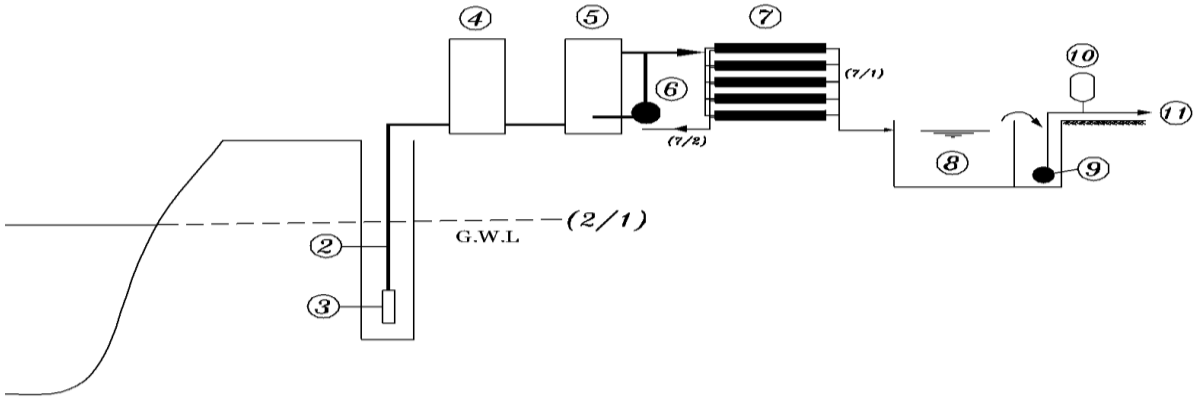


FIGURE 9–8

Baffled chamber flocculator.



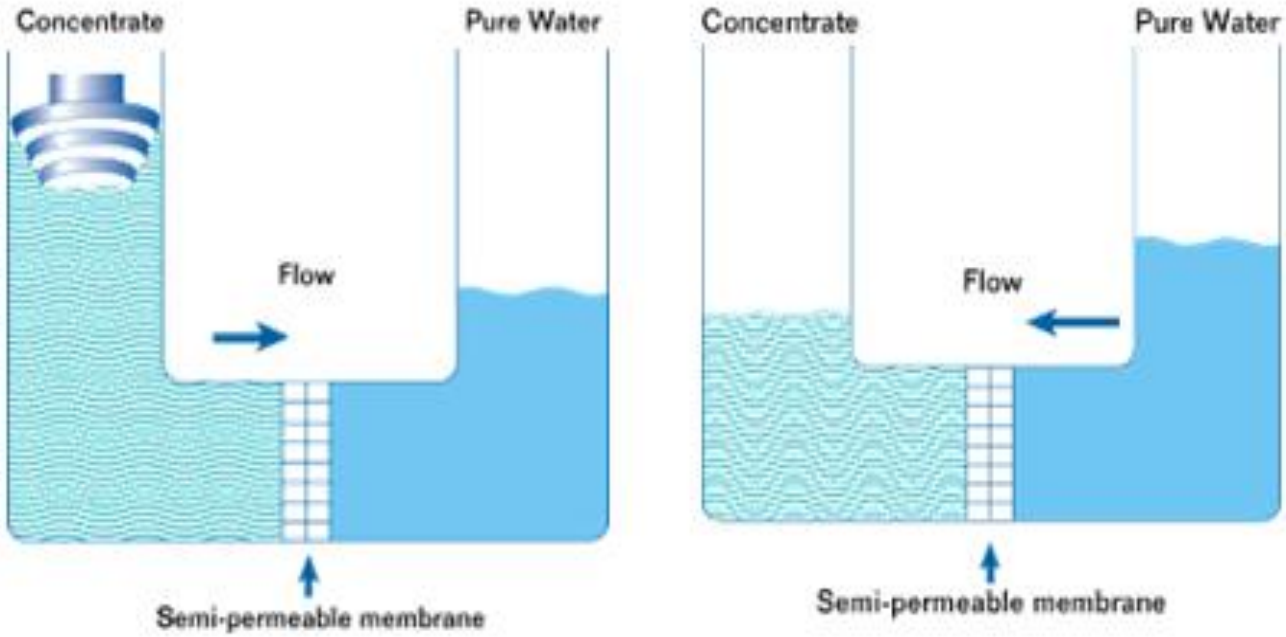
Sea Water Desalination Plant
(R.O. Plant)

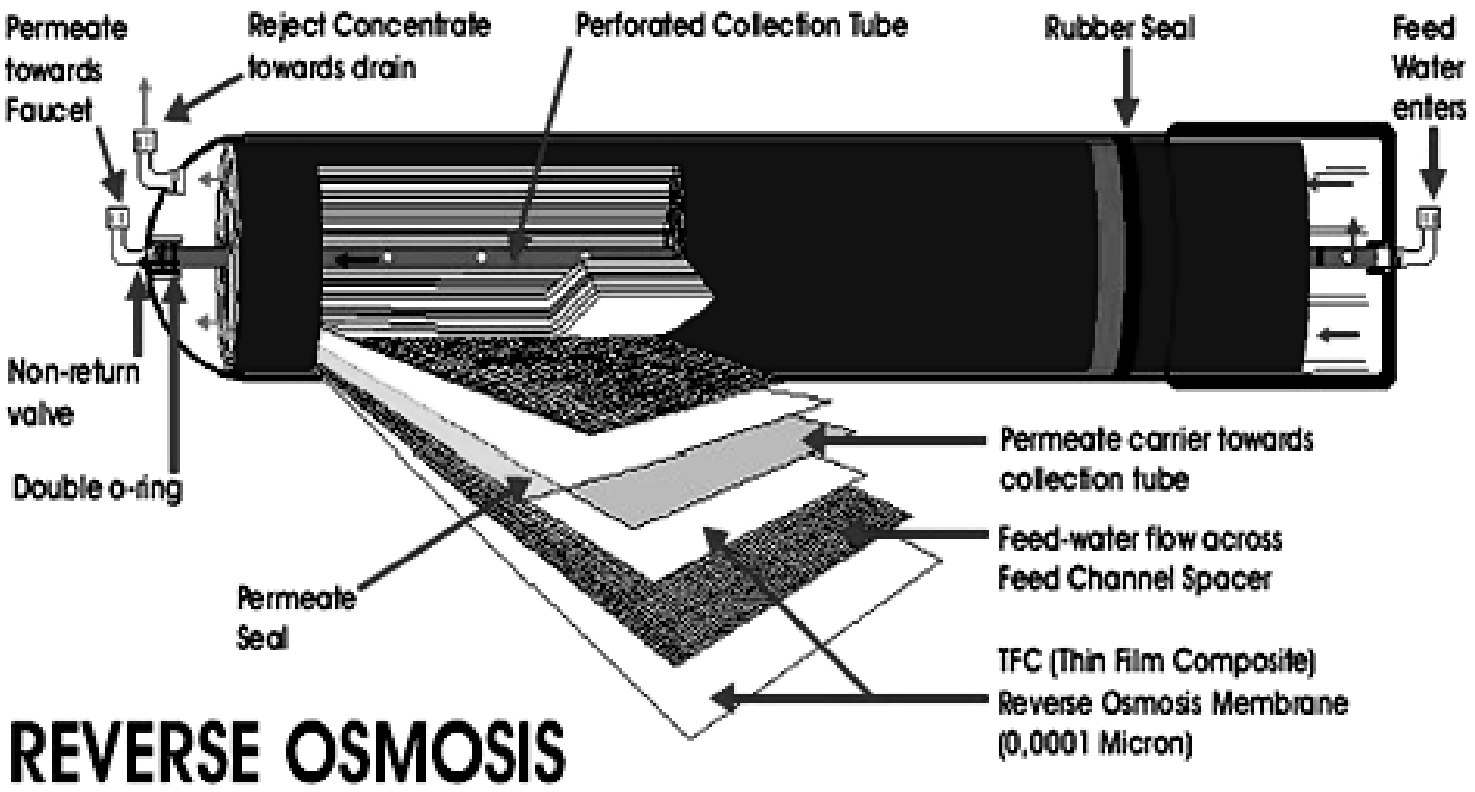


1- Sea Water
2- Well
2/1- G.W.L Ground Water Level
3- Pump
4- Microfilter
5- Ultra filter
6- Extra HLP > 40 bar
7- RO units

7/1- Fresh Water
7/2- Brine Water back to sea
8- GWT
9- HLP
10- Pressure System
11- To NetWork

What is the Reverse Osmosis?..؟ ماهوالضغط الاسموزى المنعكس

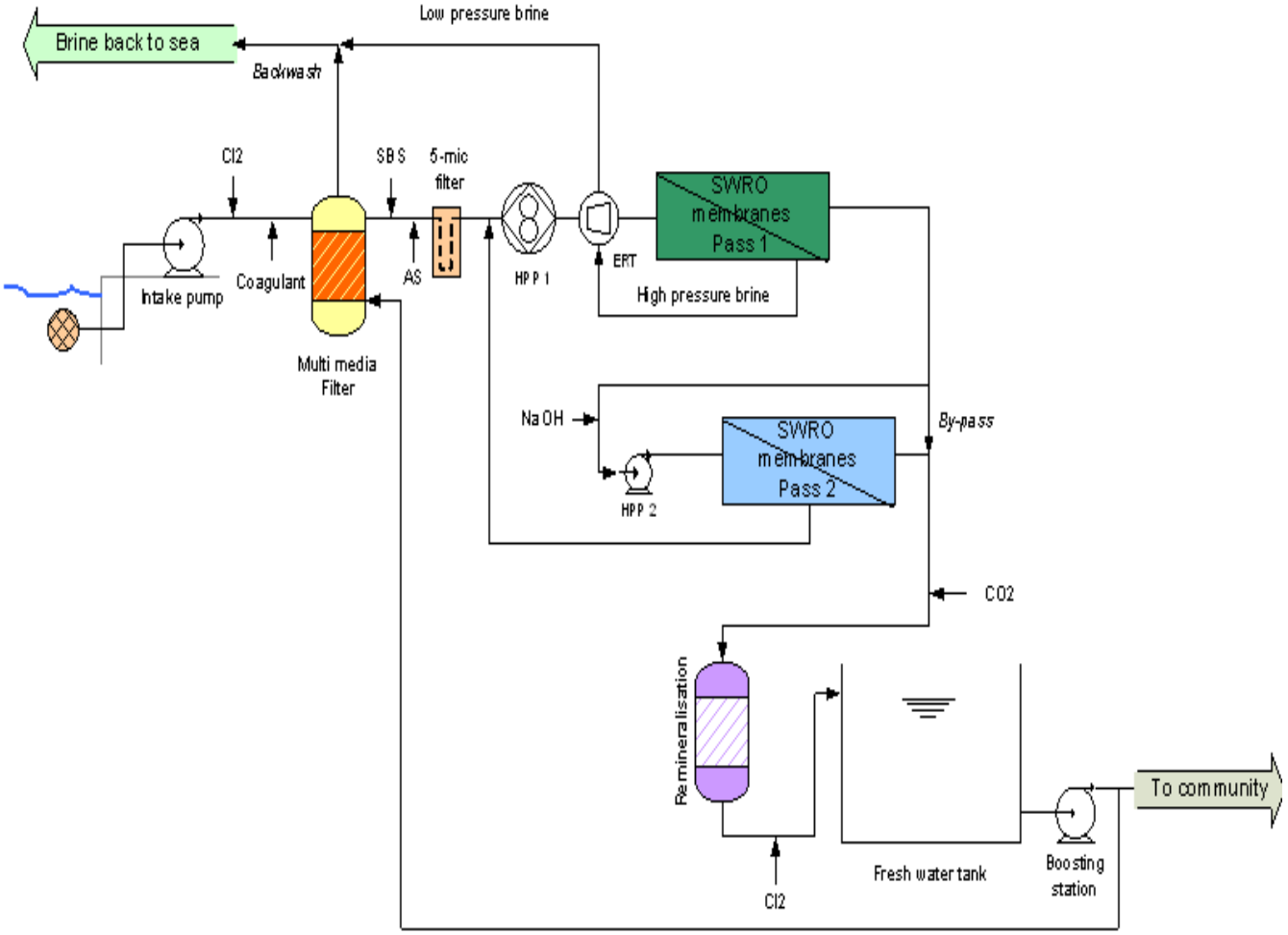



Permeate towards Faucet
Reject Concentrate towards drain
Perforated Collection Tube
Rubber Seal
Feed Water enters
Non-return valve
Double o-ring
Permeate carrier towards collection tube
Feed-water flow across Feed Channel Spacer
Permeate Seal
TFC (Thin Film Composite) Reverse Osmosis Membrane (0,0001 Micron)
REVERSE OSMOSIS

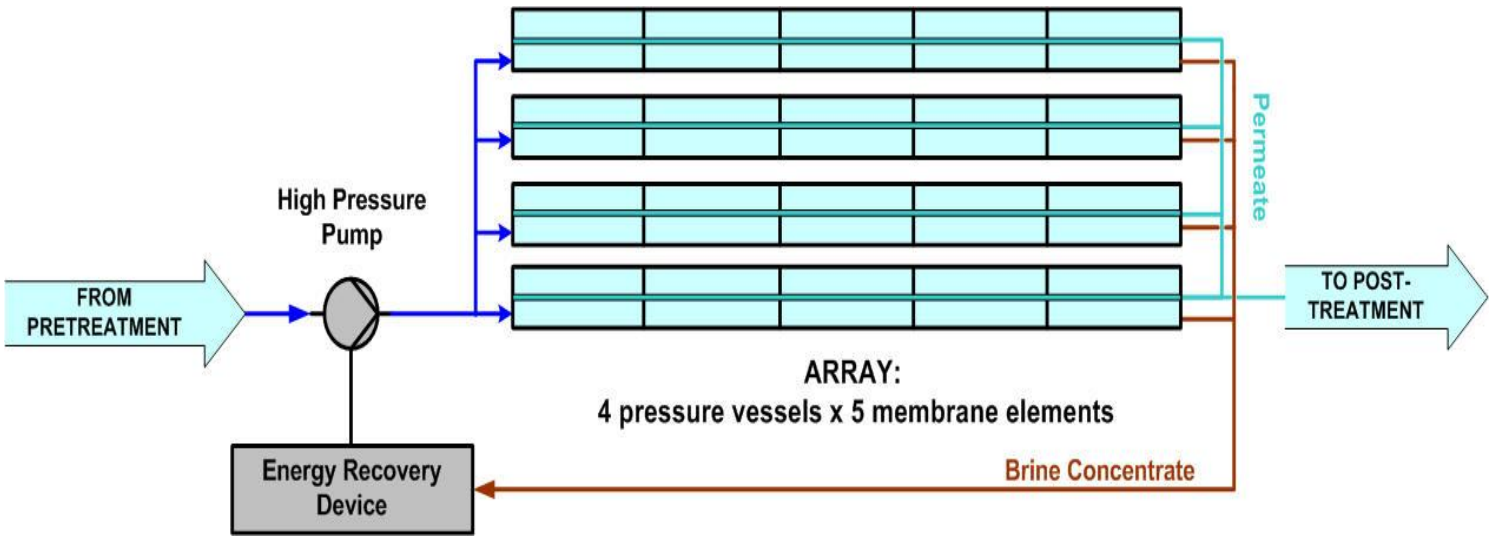
R.O. Units

R.O. Units

RO Process Flow Diagram



RO Process Flow Diagram



RO Units

RO Units

UV Disinfection