Modern Water Management –Basic Track

Reverse osmosis Unit

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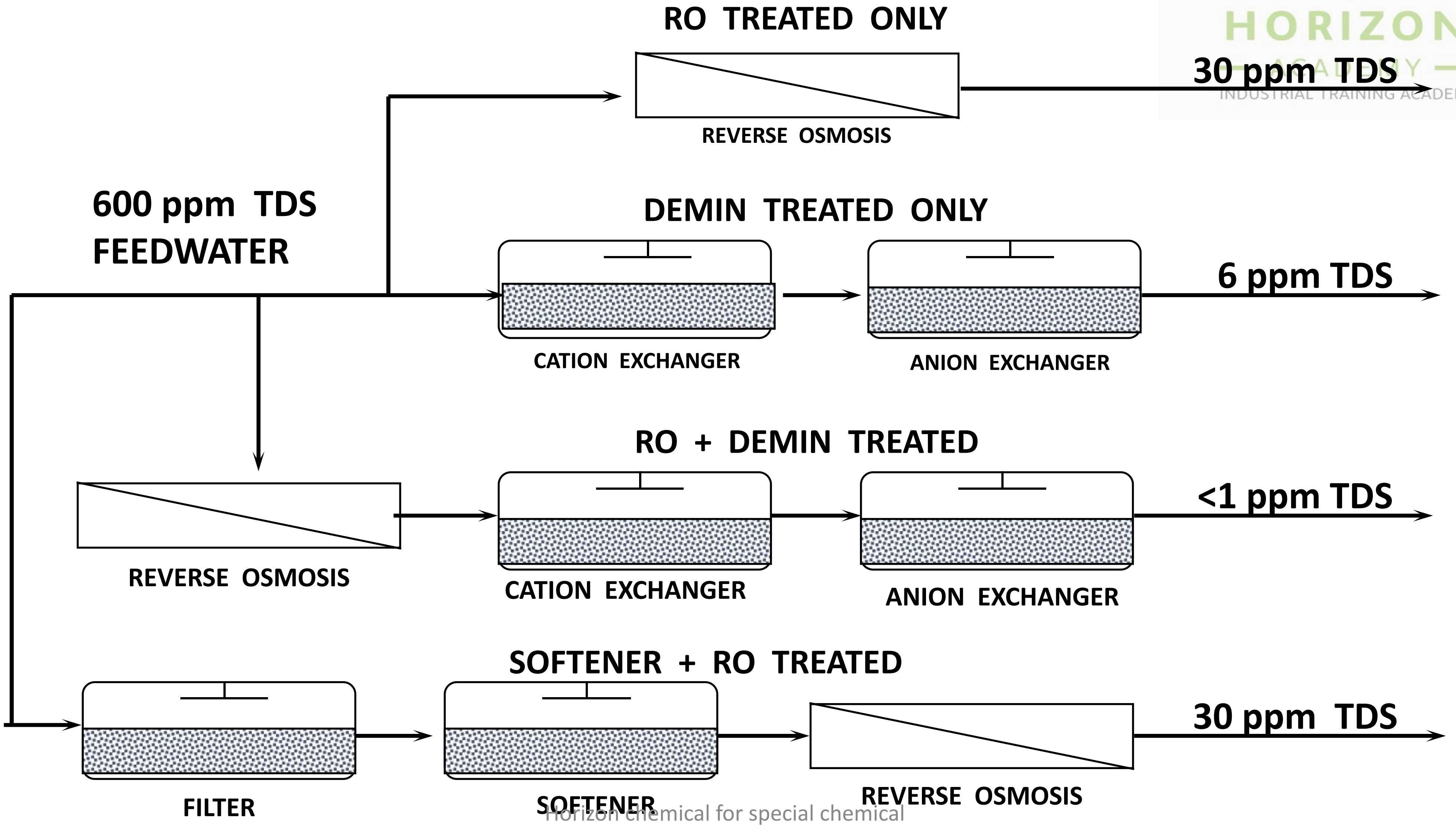
Types of Crossflow Membrane-Filtration

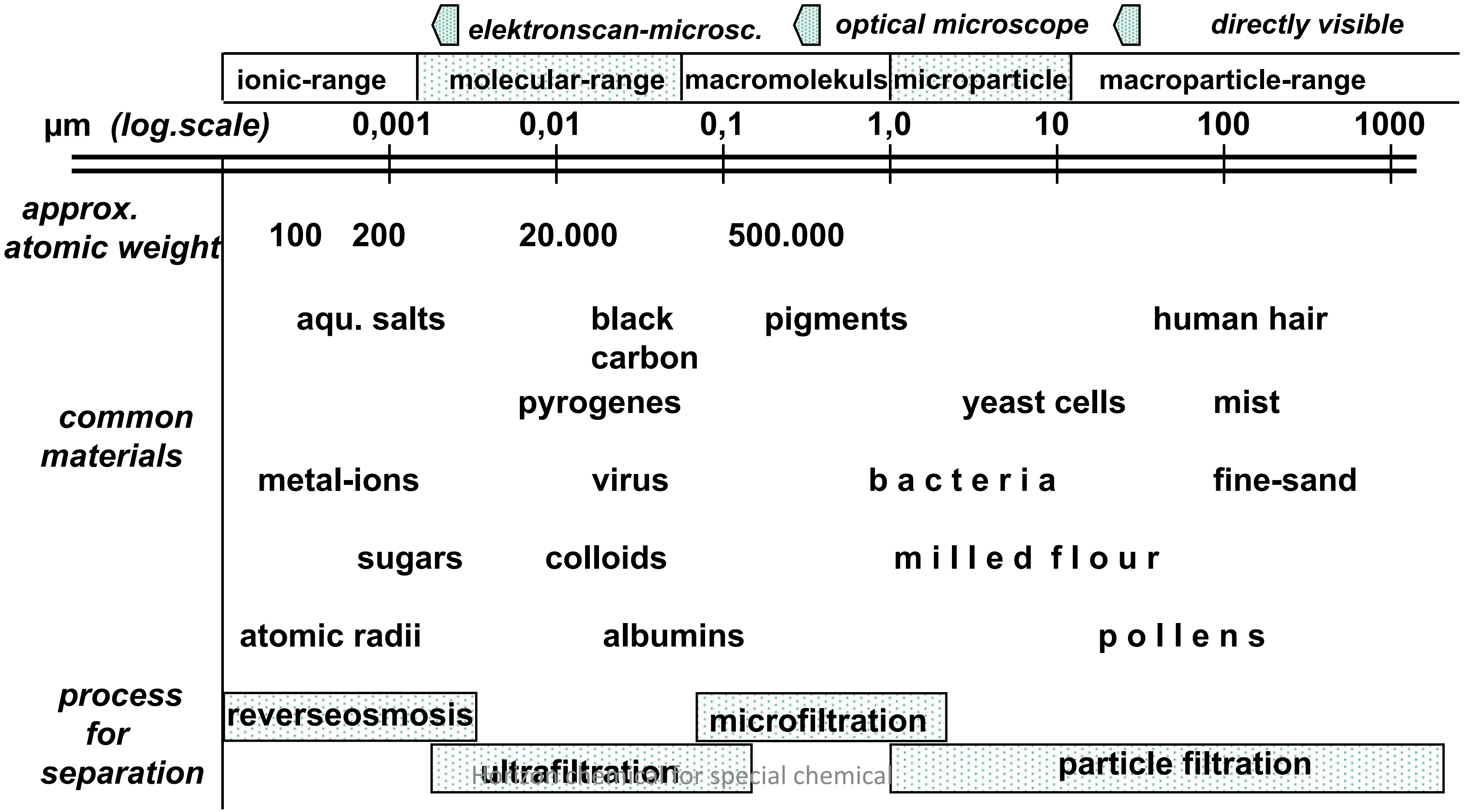
	Microfiltration	Ultrafiltration	Nanofiltration	Reverse Osmosis
Range	macro molec.	Molecular	sub molecular	Ionic
Particle size [Microns]	1.0 - 0.1	0.1 - 0.01	0.01 - 0.001	< 0.001
Removes	Susp. solids Large colloids Bacteria	Proteins Colloids Organics	Pyrogens Divalent ions Virus	Small organics Metals Salts
Molecular Weight	>100,000	10,000 – 100,000	200 - 20,000	< 300
Operating Pressure	60 kPa	60-600 kPa	1350-1750 kPa	1350-5550 kPa
Pretreatment needs	Low	Medium	High	High
Capital Cost	Low	Medium	High	High

Water Quality Comparisons

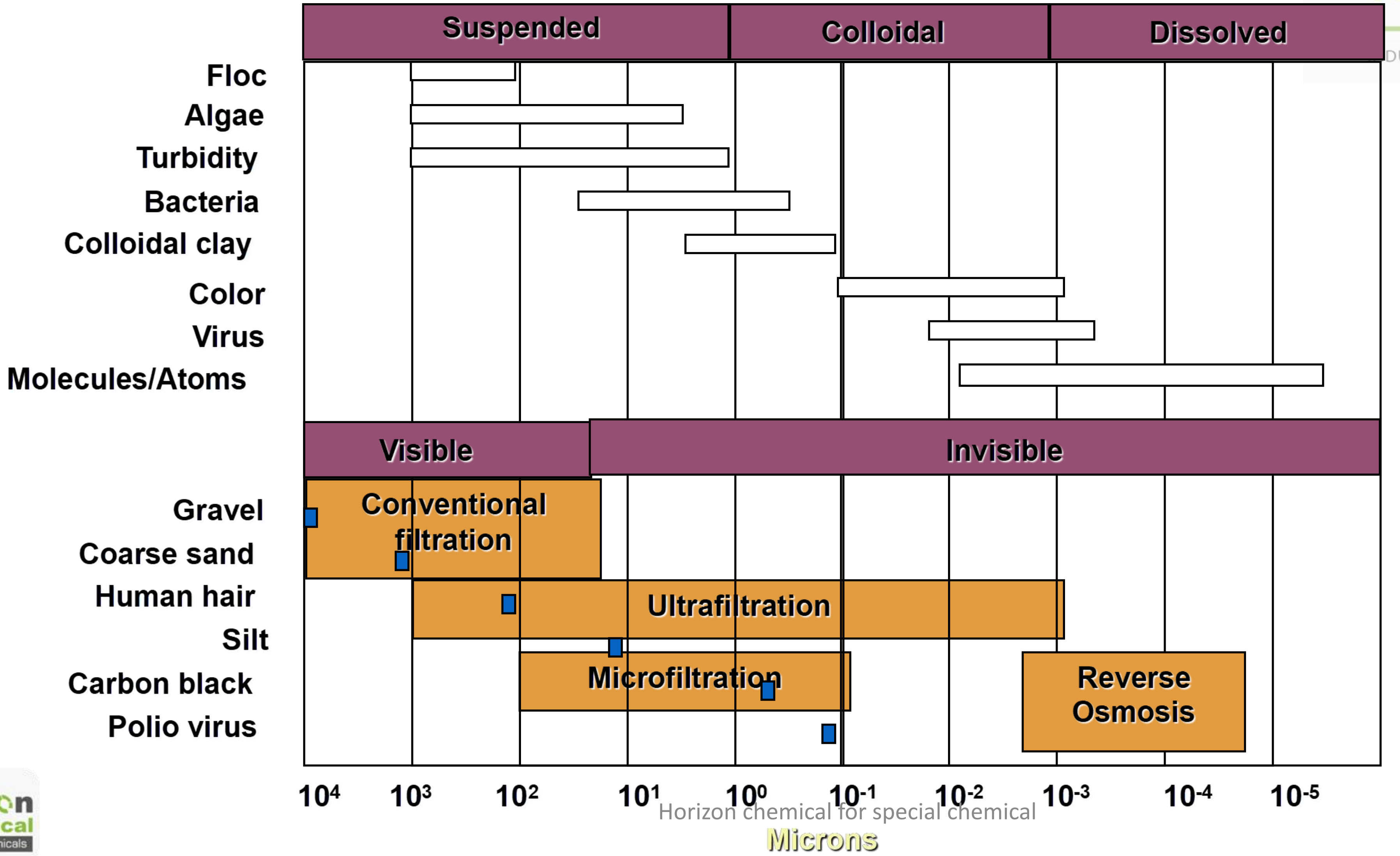


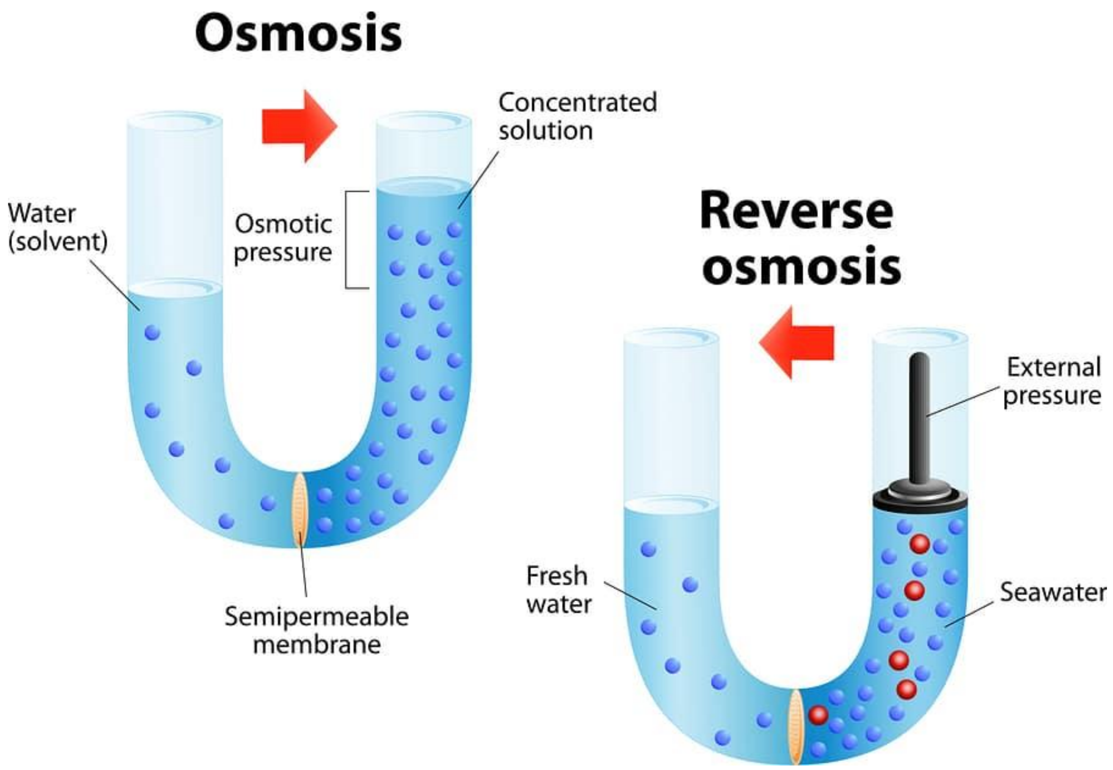
REVERSE OSMOSIS

Filtration - spectrum



Size Range Of Solids vs Separation Process





- **Osmosis** is a process where a weaker saline solution will tend to migrate to a strong saline solution.

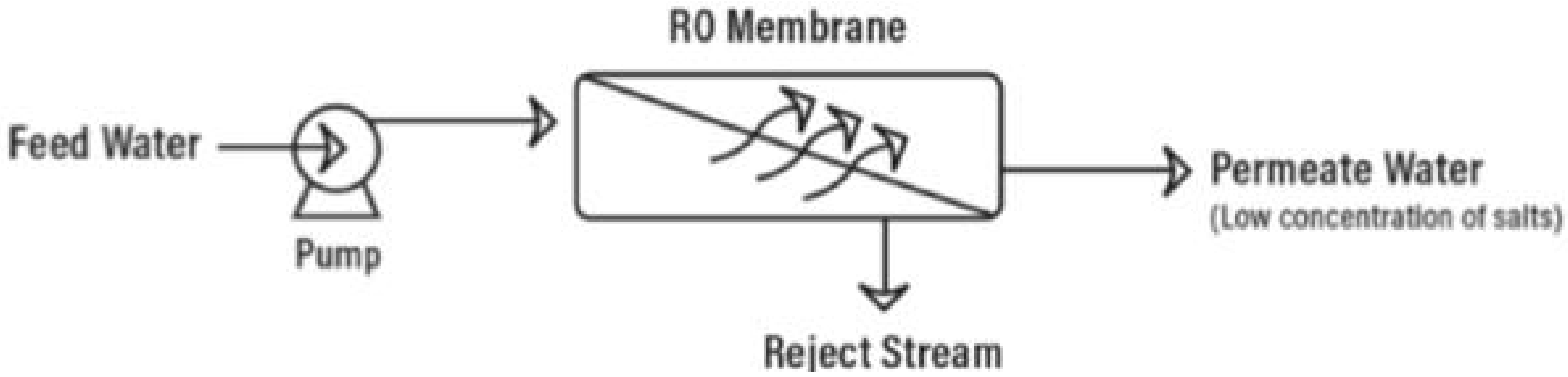
- **Reverse osmosis** is the process of osmosis in reverse. whereas osmosis occurs naturally without the energy required, to reverse the process of osmosis you need to apply energy to the more saline solution. a reverse osmosis membrane is a semi-permeable membrane that allows the passage of water molecules.

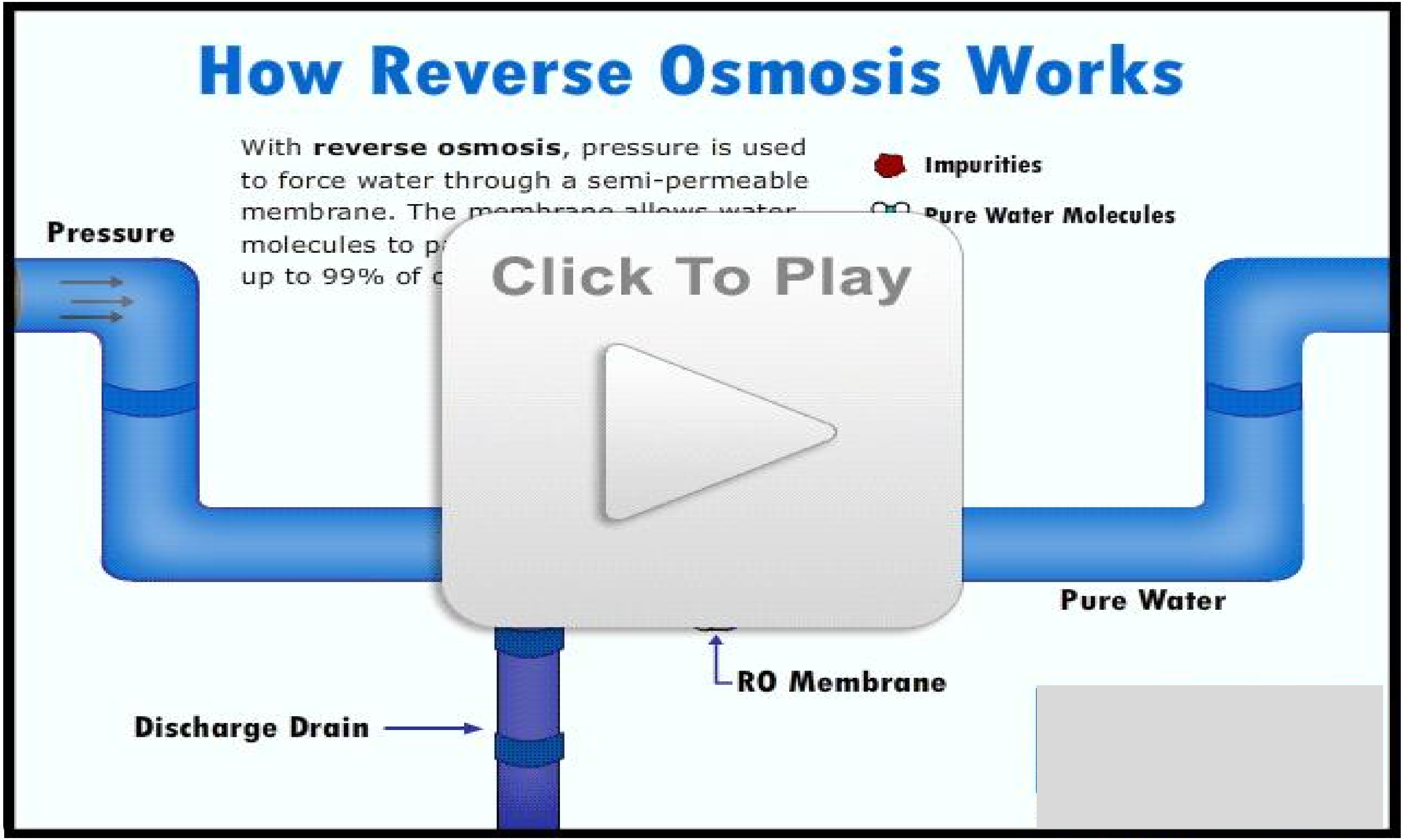
How does Reverse Osmosis work?

The amount of pressure required depends on the salt concentration of the feed water.

feed water: good water and bad water.

The ‘bad’ water is the water that contains all the contaminants that were unable to pass through the RO membrane and is known as the concentrate, reject, or brine. **Permeate** is the water that was pushed through the RO membrane and contains very few contaminants.




How Reverse Osmosis Works
With reverse osmosis, pressure is used to force water through a semi-permeable membrane. The
molecules to p
up to 99% of
Impurities
Pure Water Molecules
Pressure
Click To Play
Pure Water
RO Membrane
Discharge Drain

What will Reverse Osmosis remove from water?

Reverse Osmosis can remove 95-99% of the dissolved salts (ions), particles, colloids, organics, bacteria, and pyrogens from the feed water. An RO membrane rejects contaminants based on their size and charge.

Because an RO system does not remove gases, the permeate water can have a slightly lower than normal pH level depending on CO2 levels in the feed water as the CO2 is converted to carbonic acid.

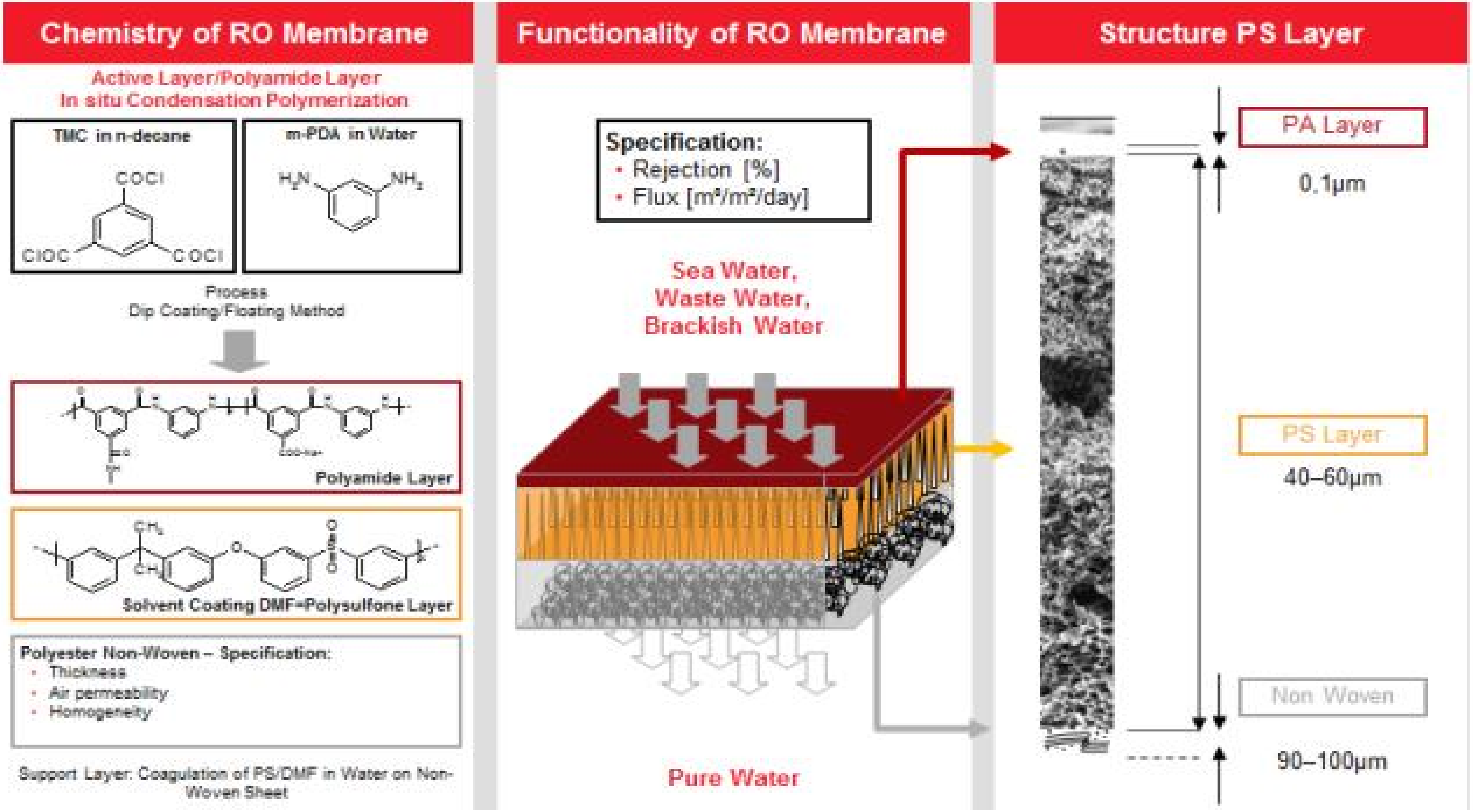


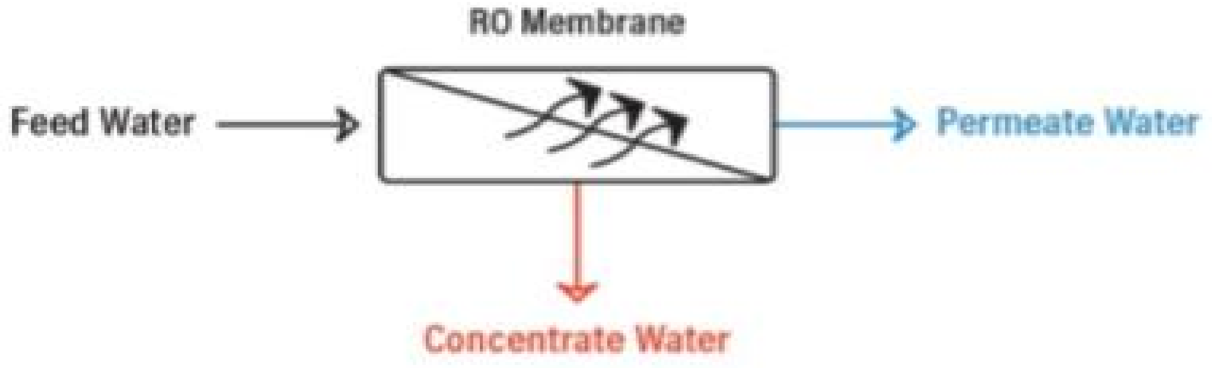
Figure 1.3: Structure of RO membrane

the difference between a 1 and 2-stage RO System

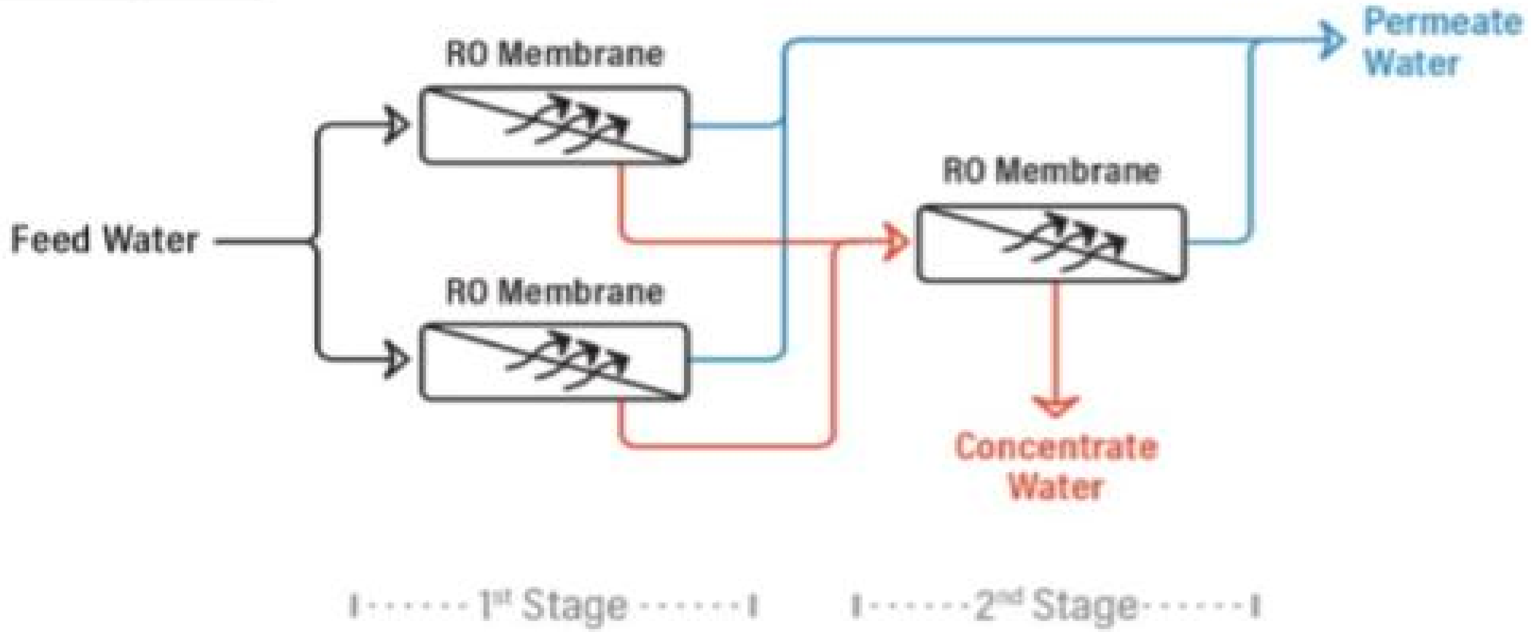
- Difference between a 1 and 2-stage RO System In a one-stage RO system, the feed water enters the RO system as one stream and exits the RO as either concentrated or permeate water.

- In a two-stage system the concentrate (or reject) from the first stage then becomes the feed water to the second stage. The permeate water is collected from the first stage and is combined with permeate water from the second stage. Additional stages increase the recovery from the system.

1 Stage RO System



2 Stage RO System



The difference between a single pass and a double pass RO system

- The difference between a single pass RO system and a double pass RO system is that with a double pass RO, the permeate from the first pass (first RO) becomes the feed water to the second pass (or second RO) which ends up producing a much higher quality permeate because it has essentially gone through two RO systems.

- The double pass system also allows the opportunity to remove carbon dioxide gas from the permeate by injecting caustic between the first and second pass. C02 is undesirable when you have mixed bed ion exchange resin beds after the RO. By adding caustic after the first pass, you increase the pH of the first pass permeate water and convert C02 to bicarbonate (HCO-) and carbonate (CO-2) for better rejection by the RO membranes in the second pass.

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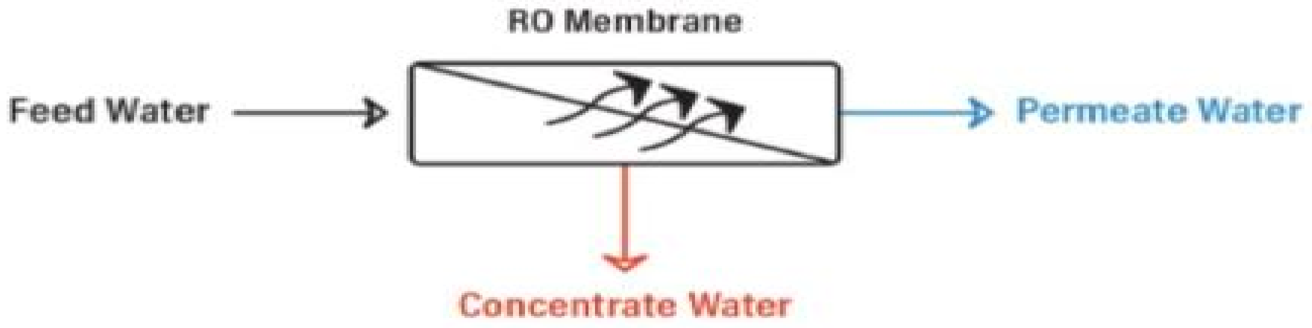
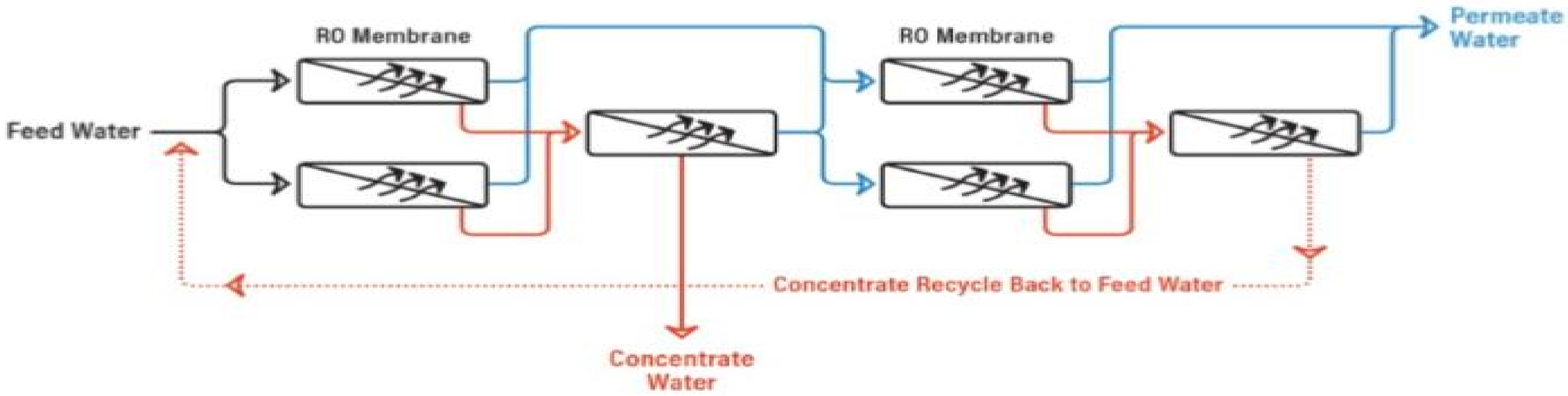
Single Pass RO



Double Pass RO



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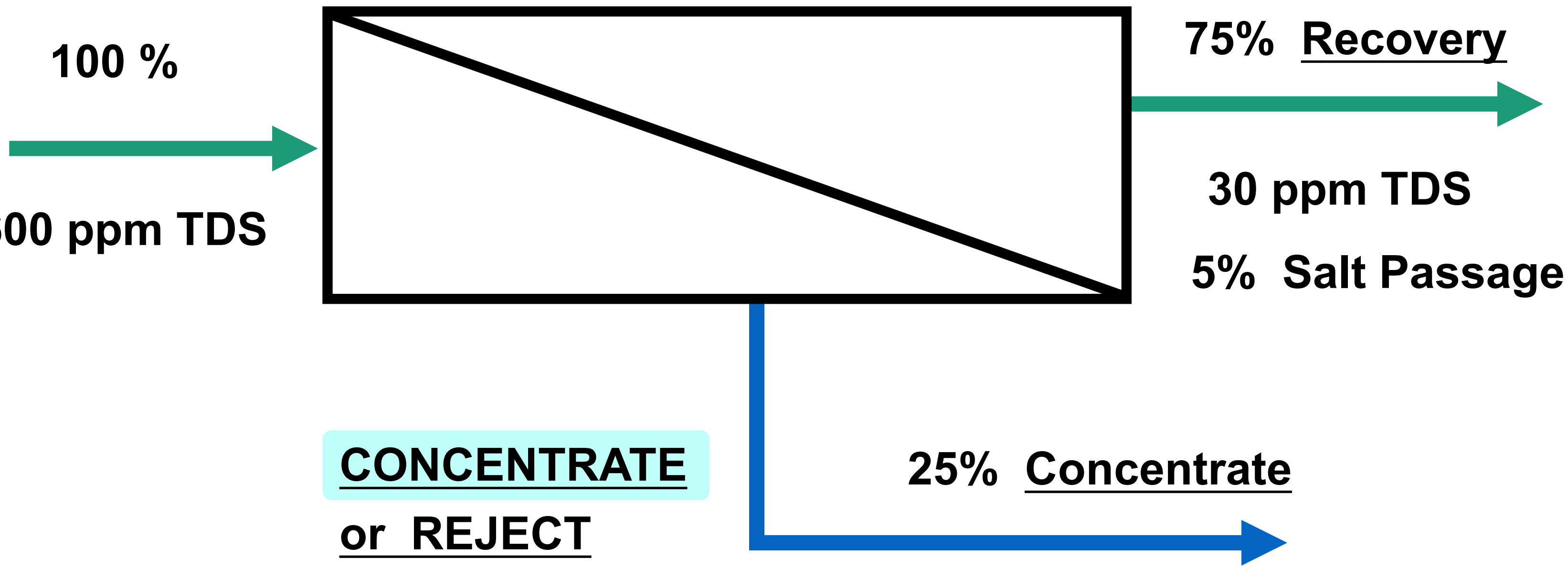

Problems related to RO.

- **Fouling**
- Fouling occurs when contaminants accumulate on the membrane surface effectively plugging the membrane.
- Fouling typically occurs in the front end of an RO system and results in a higher pressure drop across the RO system and a lower permeate flow. This translates into higher operating costs and eventually the need to clean or replace the RO membranes.

Fouling can be caused by the following:

- 1. Particulate or colloidal mater (dirt, silt, clay, etc.)
- 2. Organics (humic/fulvic acids, etc.)
- 3. Microorganisms (bacteria, etc.). Bacteria present one of the most common fouling problems since RO membranes in use today cannot tolerate a disinfectant such as chlorine and therefore microorganisms are often able to multiply on the membrane surface. They may produce biofilms that cover the membrane surface and result in heavy fouling.
- 4. Breakthrough of filter media upstream of the RO unit.

- **Scaling**
- As certain dissolved (inorganic) compounds become more concentrated than scaling
- can occur. If these compounds exceed their solubility limits, then they can
- precipitate on the membrane surface as scale. The results of scaling are a higher pressure drop across the system, higher salt passage (less salt rejection), and low permeate flow. An example of a common scale that tends to form on an RO membrane is calcium carbonate ($CaCO_3$).
- **Chemical Attack**
- Modern thin film composite membranes are not tolerant to chlorine or chloramines. Oxidizers such as chlorine will 'burn' holes in the membrane pores and can cause irreparable damage. The result of the chemical attack on an RO membrane is a higher permeate flow and a higher salt passage (less salt rejection). Therefore, microorganism growth on RO membranes tends to foul RO membranes so easily since there is no biocide present to prevent its growth.
- **Mechanical Damage**
- Part of the pretreatment scheme should involve pre and post-RO system plumbing and controls. If 'hard starts' occur mechanical damage to the membranes can occur. Likewise, if there is too much backpressure on the RO system then mechanical damage to the RO membranes can also occur. These can be addressed by using variable frequency drive motors to start high-pressure pumps for RO systems and by installing check valve(s) and/or pressure relief valves to prevent excessive back pressure on the RO unit that can cause permanent membrane damage.

Pretreatment

- **Anti-scalants/Scale Inhibitors**

Antiscalants and scale inhibitors are chemicals that can be added to feed water before an RO unit to help reduce the scaling potential of the feed water. Antiscalants and scale inhibitors increase the solubility limits of troublesome inorganic compounds. By increasing the solubility limits, you can concentrate the salts further to achieve a higher recovery rate.

- **Multimedia filter**

- **Water Softening**

A water softener can be used to help prevent scaling in an RO system by exchanging scale-forming ions with non-scale-forming ions. As with an MMF unit, it is important to have a 5-micron cartridge filter.

- ## Sodium Bisulfite

By adding sodium bisulfite (SBS or SMBS), which is a reducer, to the water stream before an RO at the proper dose you can remove residual chlorine and chloramines.

- ## Granular Activated Carbon (GAC)

GAC is used for both removing organic constituents and residual disinfectants (such as chlorine and chloramines) from water. GAC media is made from coal, nutshells, or wood. Activated carbon removes residual chlorine and chloramines by a chemical reaction that involves a transfer of electrons from the surface of the GAC to the residual chlorine or chloramines.

The disadvantage of using a GAC before the RO unit is that the GAC will remove chlorine quickly at the very top of the GAC bed. This will leave the remainder of the GAC bed without any biocide to kill Microorganisms. A GAC bed will absorb organics throughout the bed, which is potential food for Bacteria, so eventually, a GAC bed can become a breeding ground for bacteria growth which can pass easily to the RO membranes. Likewise, a GAC bed can produce very small carbon fines under some circumstances that have the potential to foul an RO. A cartridge filter should be placed after a GAC and before an RO to protect membranes from carbon fines

Arrangement Of Filters And Units

- Sand filter
- Cartridge filter
- Activated carbon
- Softener (optional)
- Multimedia filtration (optional)
- RO unit
- Demineralization unit (optional)

RO Cleaning

- Successful membrane cleaning relies on both the effectiveness of the cleaning compounds, their professional application, and the design and operation of the cleaning equipment. For the best results, RO membrane cleaning should be performed with both high and low-pH cleaning chemicals.

- **High pH RO Water Purifier Cleaning**
- The high pH Cleaning is performed in order to remove biological or organic foulants, both of which contain carboxylic functional groups. Weak acids will gain an anionic charge at the high pH allowing them to disperse. High-pH cleaning chemicals chelate the calcium that bridges foulants and biofilms to each other and to the membrane surface. Commodities such as NaOH are only mildly effective because of their inability to remove the calcium bridging.

- **Low pH RO Water Purifier Cleaning**
- In some cases a low pH cleaning may be the better option prior to a high pH cleaning.
- However organic foulants can lose their anionic charge if a low pH cleaning is performed first and can end up being compacted into the membrane. To find out which option is best for your system Complete Water Solutions can evaluate your system, including performing a foulant analysis.

- **Perform RO Membrane Cleaning In Stages**
- Membrane cleaning results are best reached if each stage is cleaned individually. This will allow for the maximum flow velocity during cleaning. If both stages of a system with a 2:1 array are cleaned simultaneously, each pressure vessel in the second stage will receive twice the flow velocity as the first stage. This would in turn cause membrane telescoping in the second stage if the first-stage elements are cleaned at optimal flow velocity. Alternately, by basing the flow velocity on the second stage, the first-stage membranes would not receive sufficient surface scouring.

Thank you