Water, water everywhere and not a drop to drink - *Reverse Osmosis*

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Water, water everywhere and not a drop to drink

- The planet we inhabit has gained its nickname of the ‘Blue Planet’ due to the abundance of water covering it; about 1,260,000,000,000,000,000,000 litres.
- 70% of the earth surface is covered with water
- Only around 2.5% is freshwater
- Only 1.2% available in form of lakes, rivers, ground water..

The rest is locked up in the glaciers and ice caps.

Agenda

- RO System Overview
- Basics Osmosis / Reverse Osmosis
- RO Membranes & Arrangement
- Water Contaminants
- Possible Energy Savings

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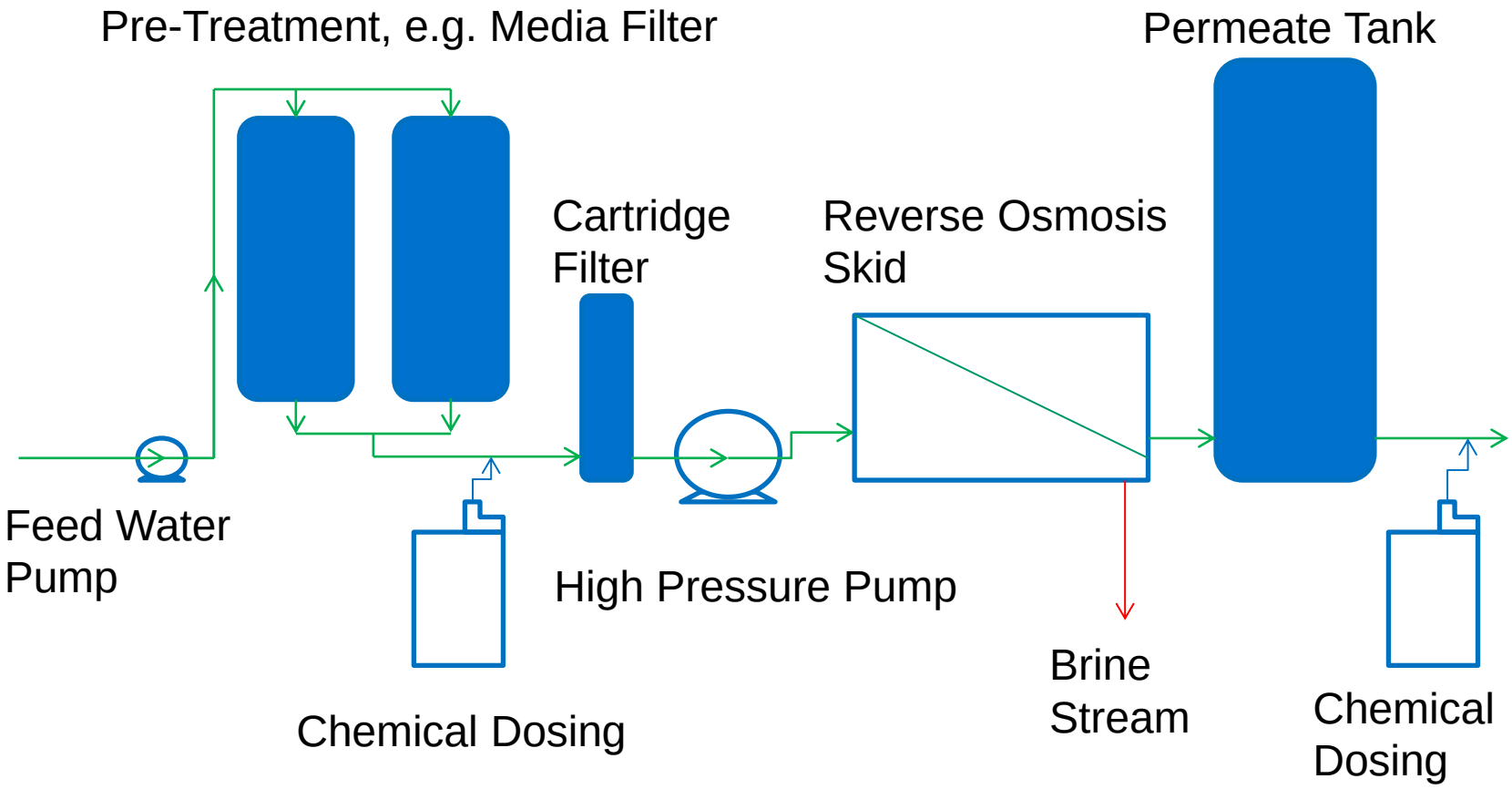
System Overview



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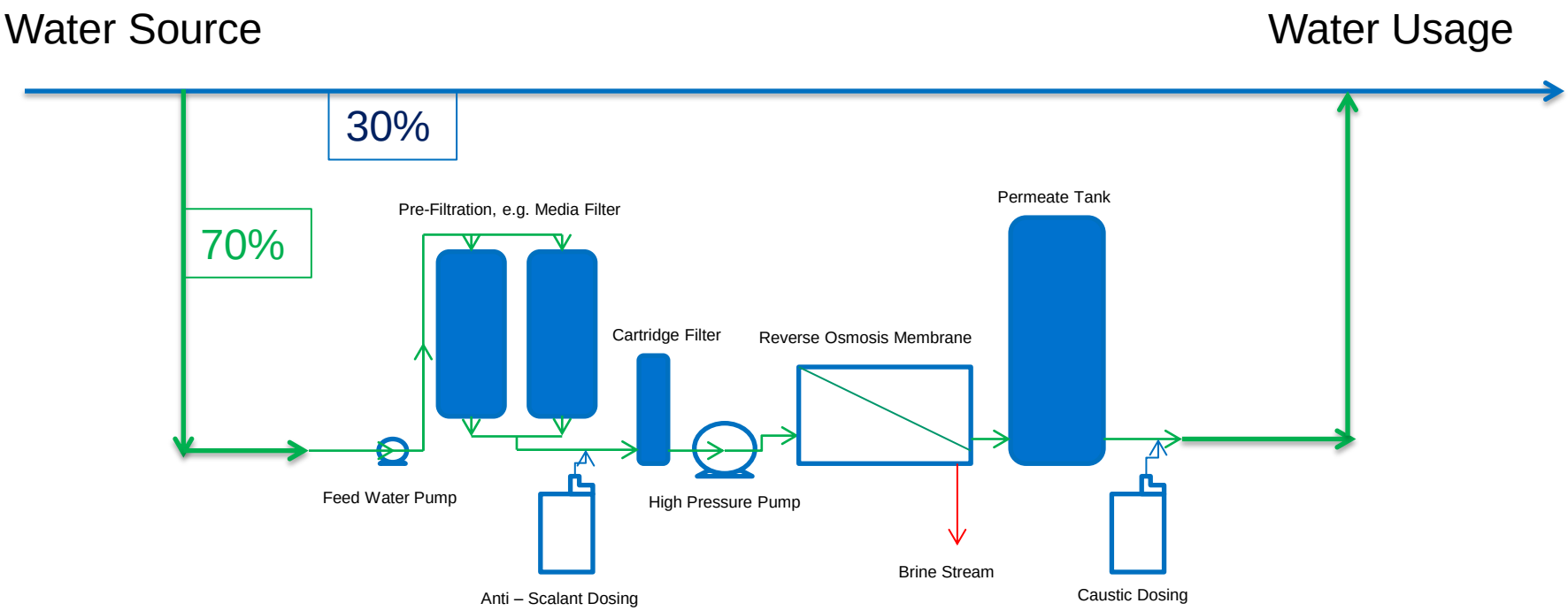
System Overview

Water after treatment to clean for consumption!



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Basics Osmosis / Reverse Osmosis

Osmosis – Definition

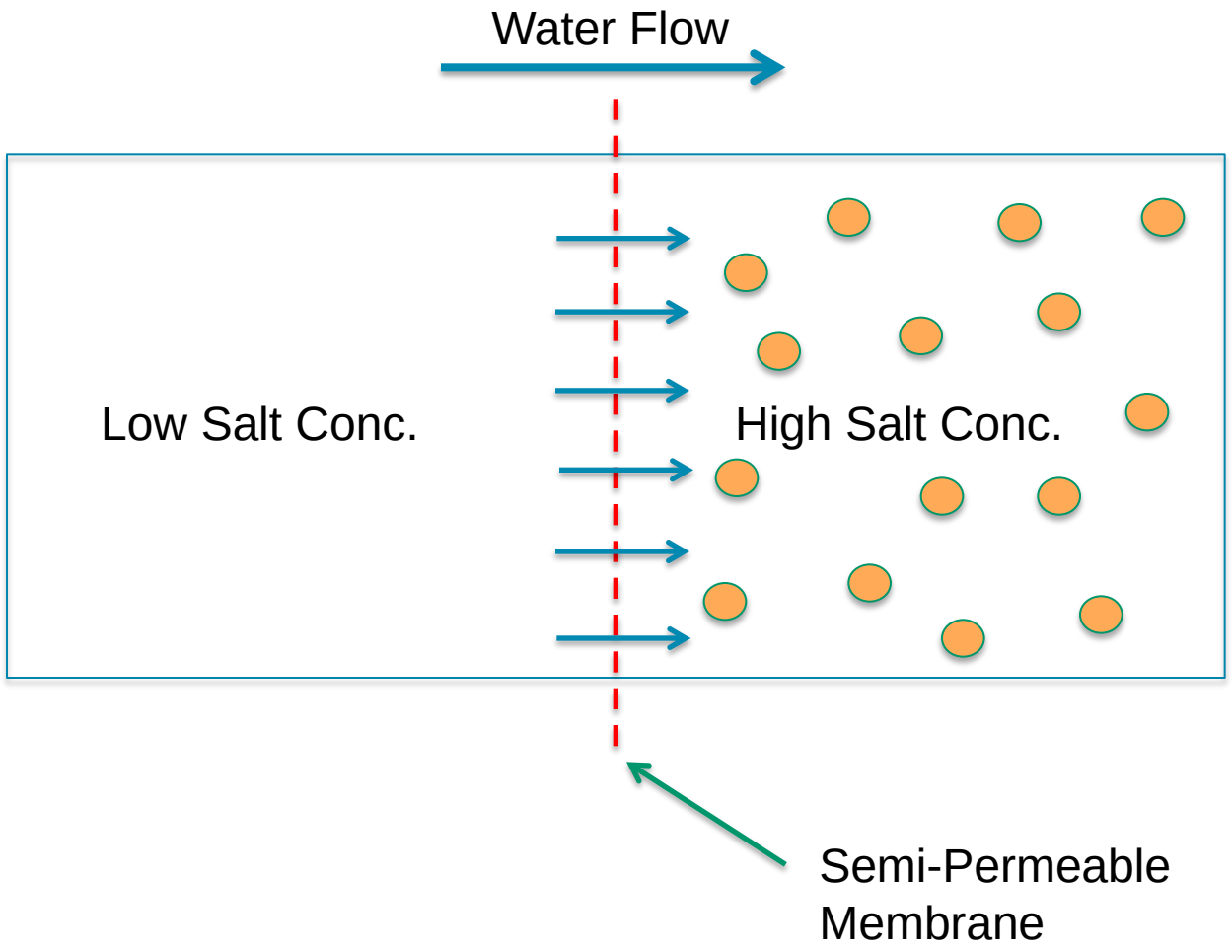
A Process developed by Mother Nature by which Water Molecules (H_2O) tend to pass through a Semi-Permeable Membrane from a less concentrated Solution to a higher concentrated Solution.

The Semi-Permeable Membrane lets only Water pass through.

Nature strives for Equilibrium

Basics Osmosis

Osmosis



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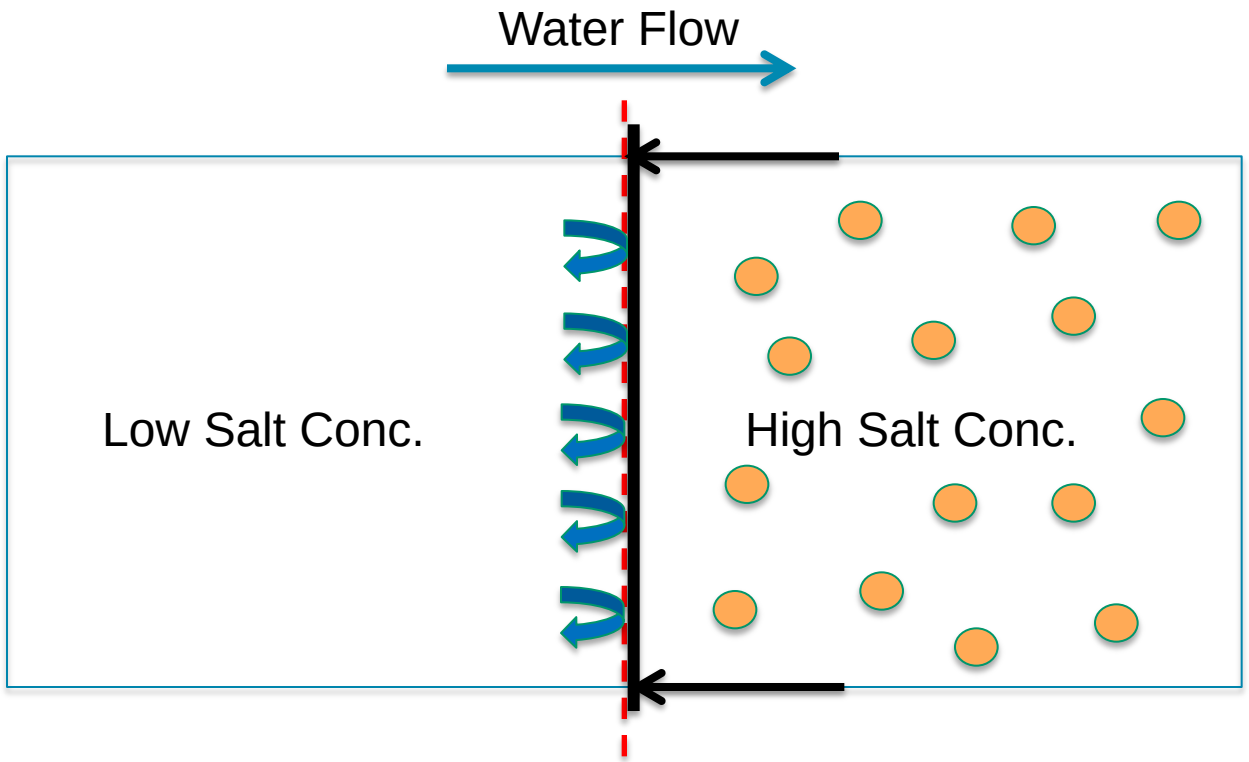
Basics Osmosis

Osmosis – Can be stopped by applying pressure



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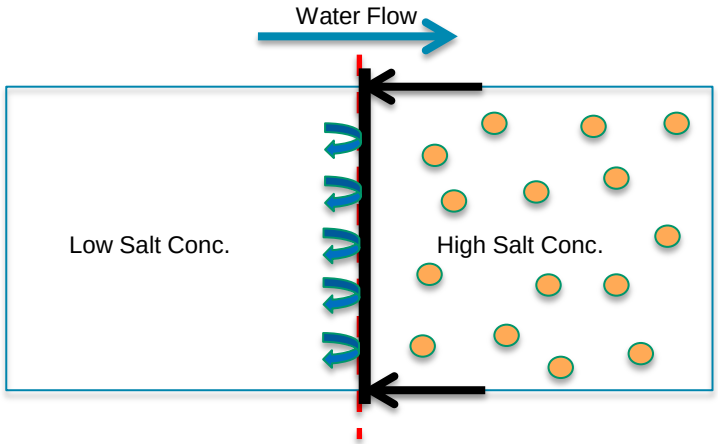
Basics Osmosis

Osmotic Pressure

TDS	Osmotic Pressure
100 mg/l	1 psi, 0.07 bar
1,000 mg/l	10 psi, 0.7 bar
3,000 mg/l	30 psi, 2.1 bar
35,000 mg/l	350 psi, 24 bar



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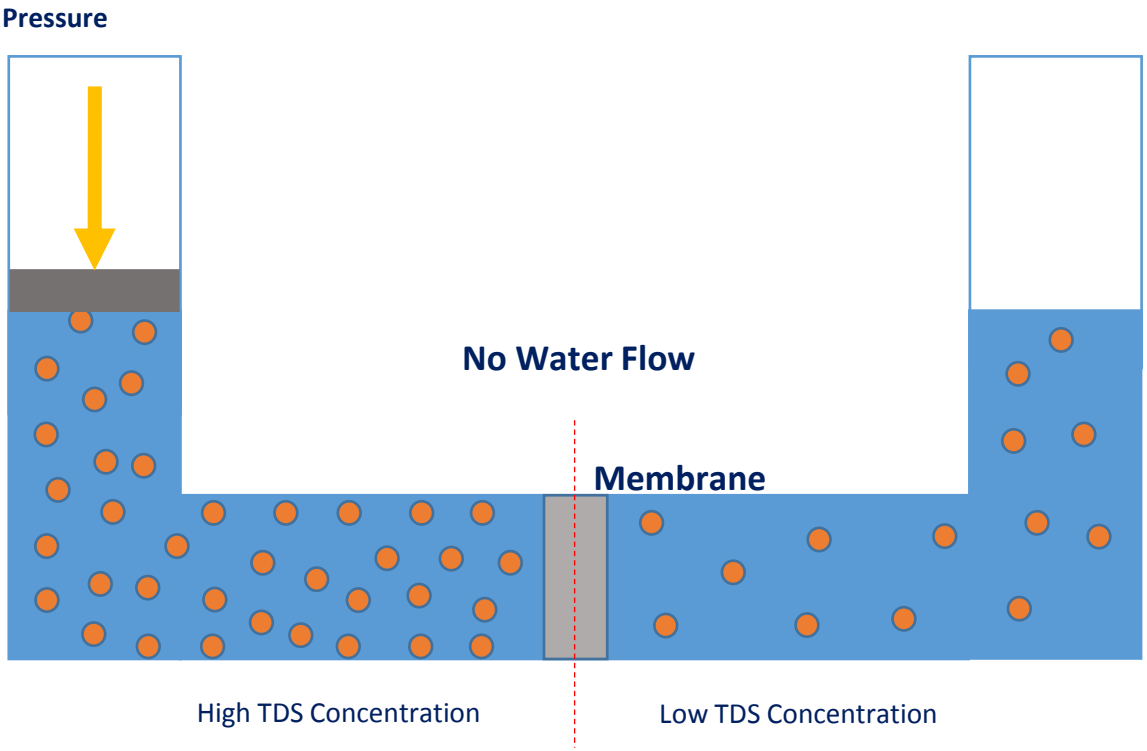
Reverse Osmosis

Osmotic Pressure



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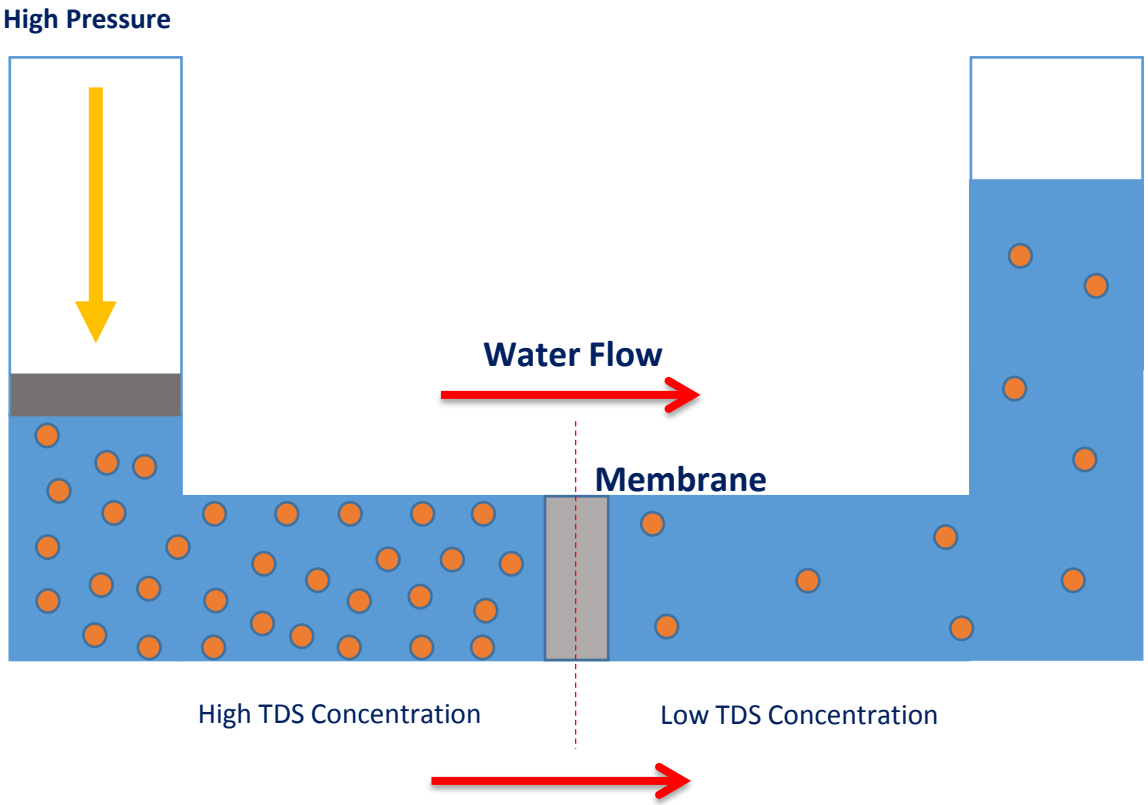
RO Overview

Reverse Osmosis



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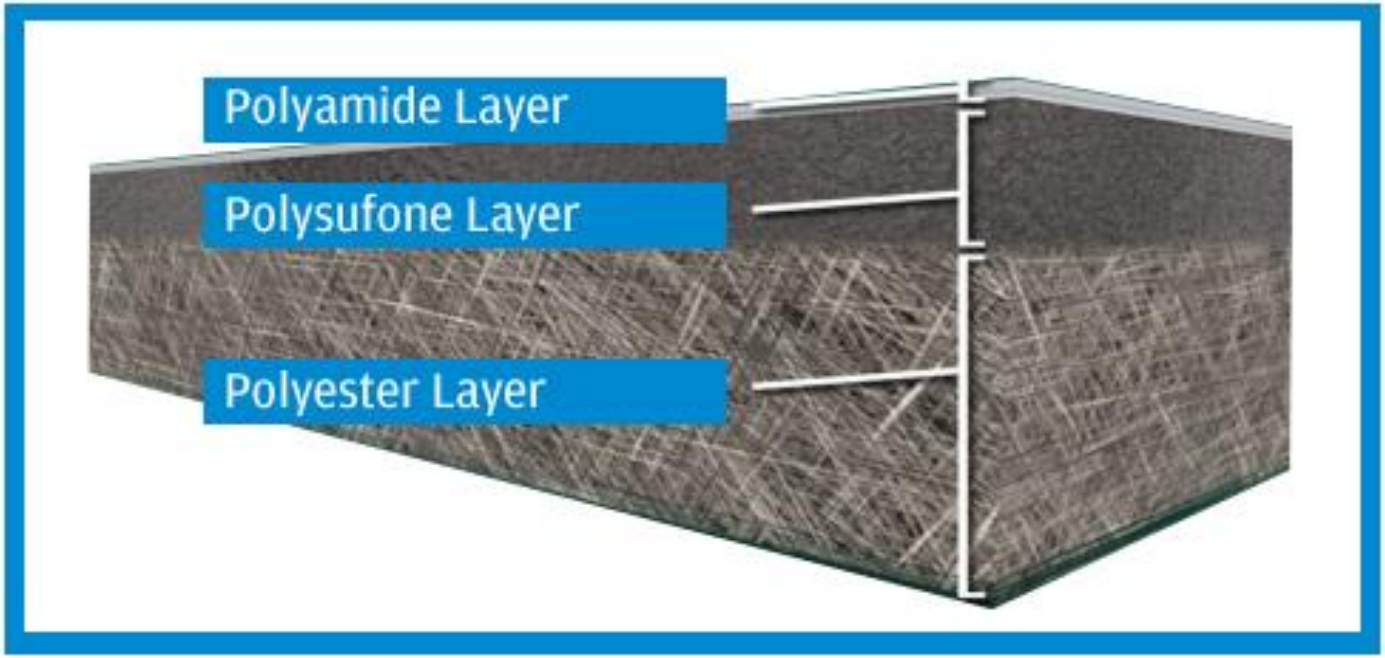
RO Membranes & Arrangement



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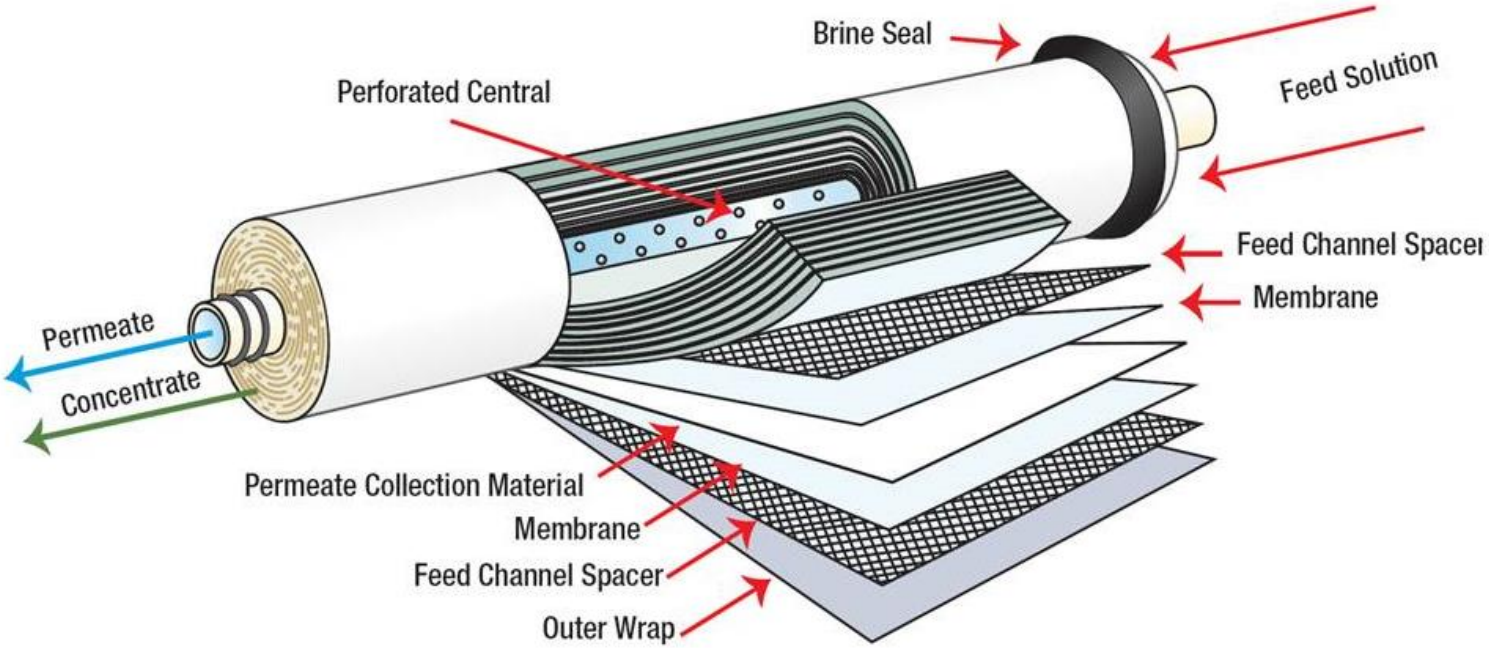
RO Membranes & Arrangement

RO Membrane



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RO Membranes & Arrangement

RO Membrane

https://www.youtube.com/watch?v=9vTM7qXSlUg

https://www.youtube.com/watch?v=YlMGZWmh_Mw

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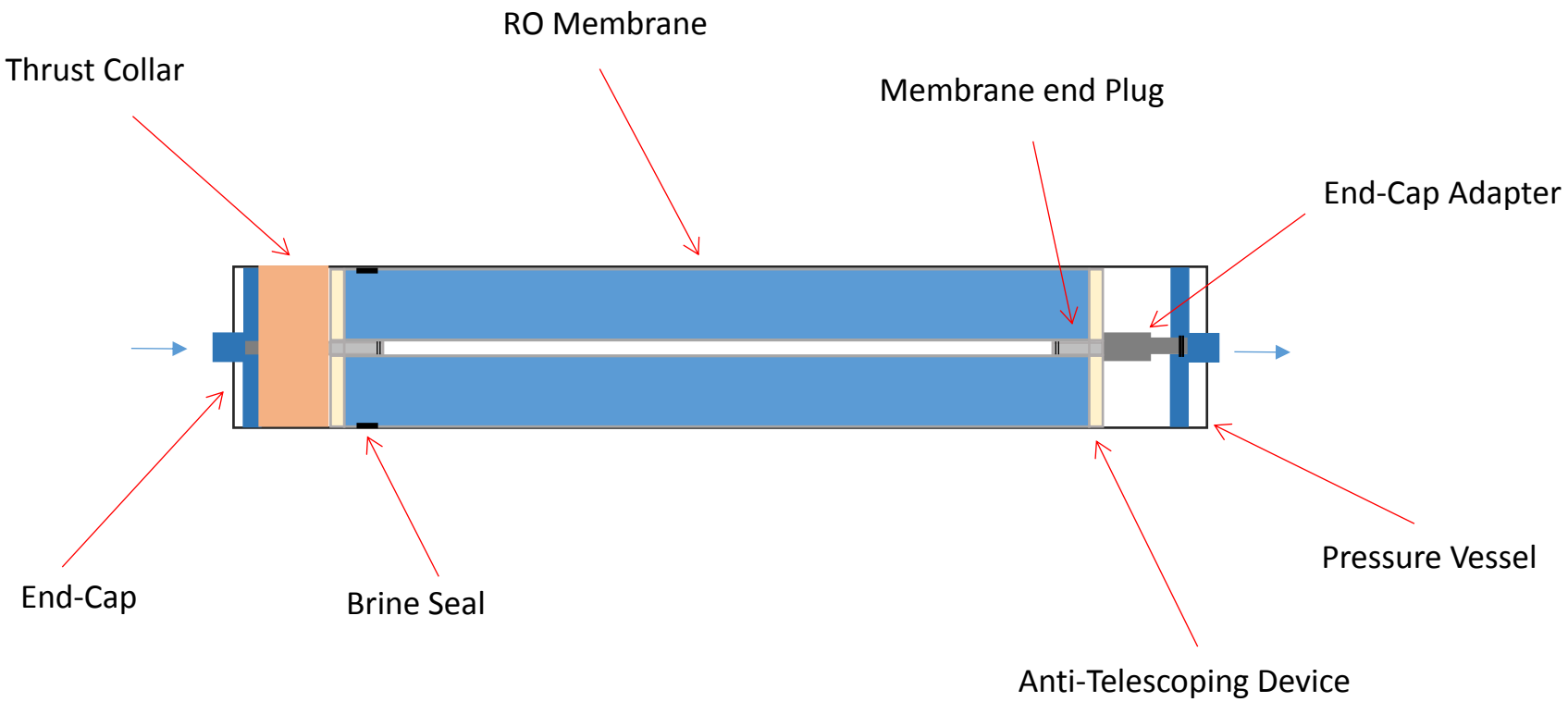
RO Membranes & Arrangement

RO Membrane



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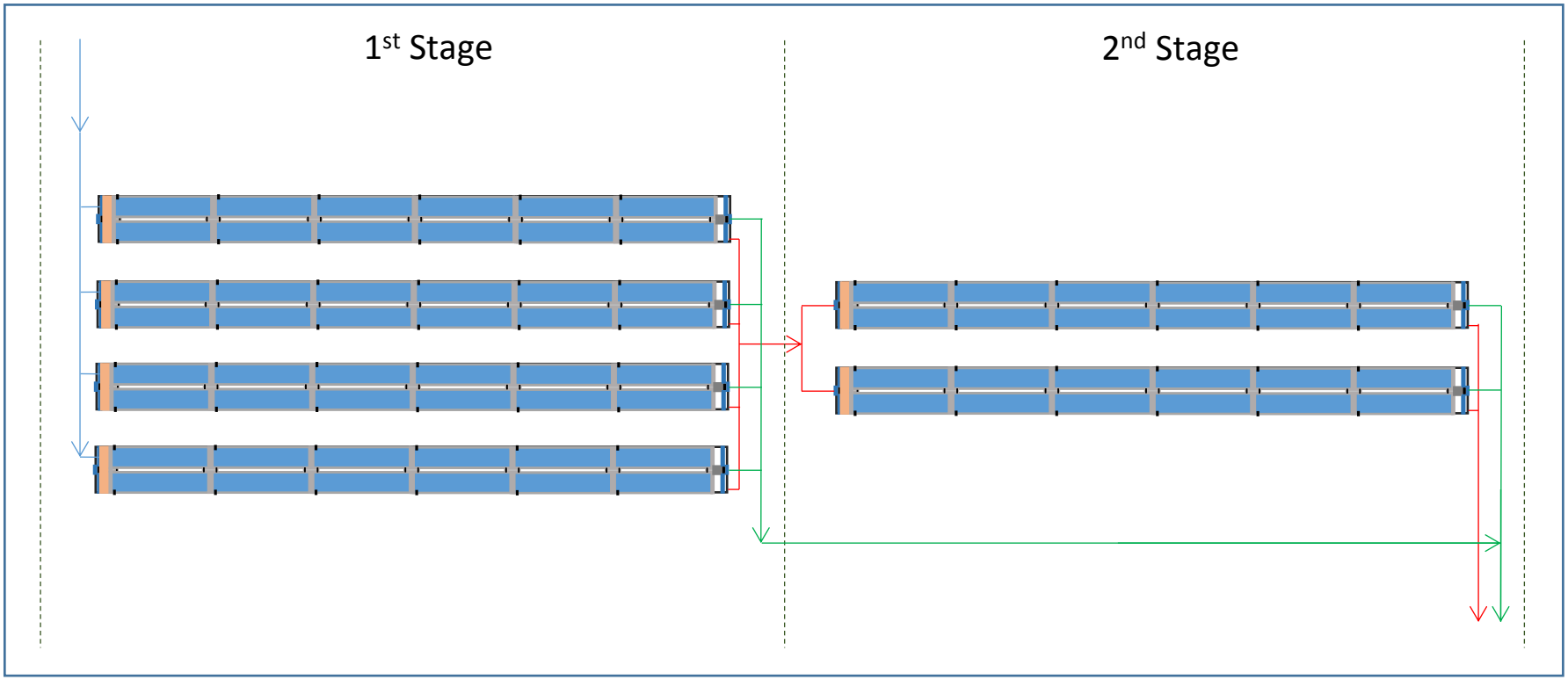
RO Membranes & Arrangement

2 Stage Arrangement



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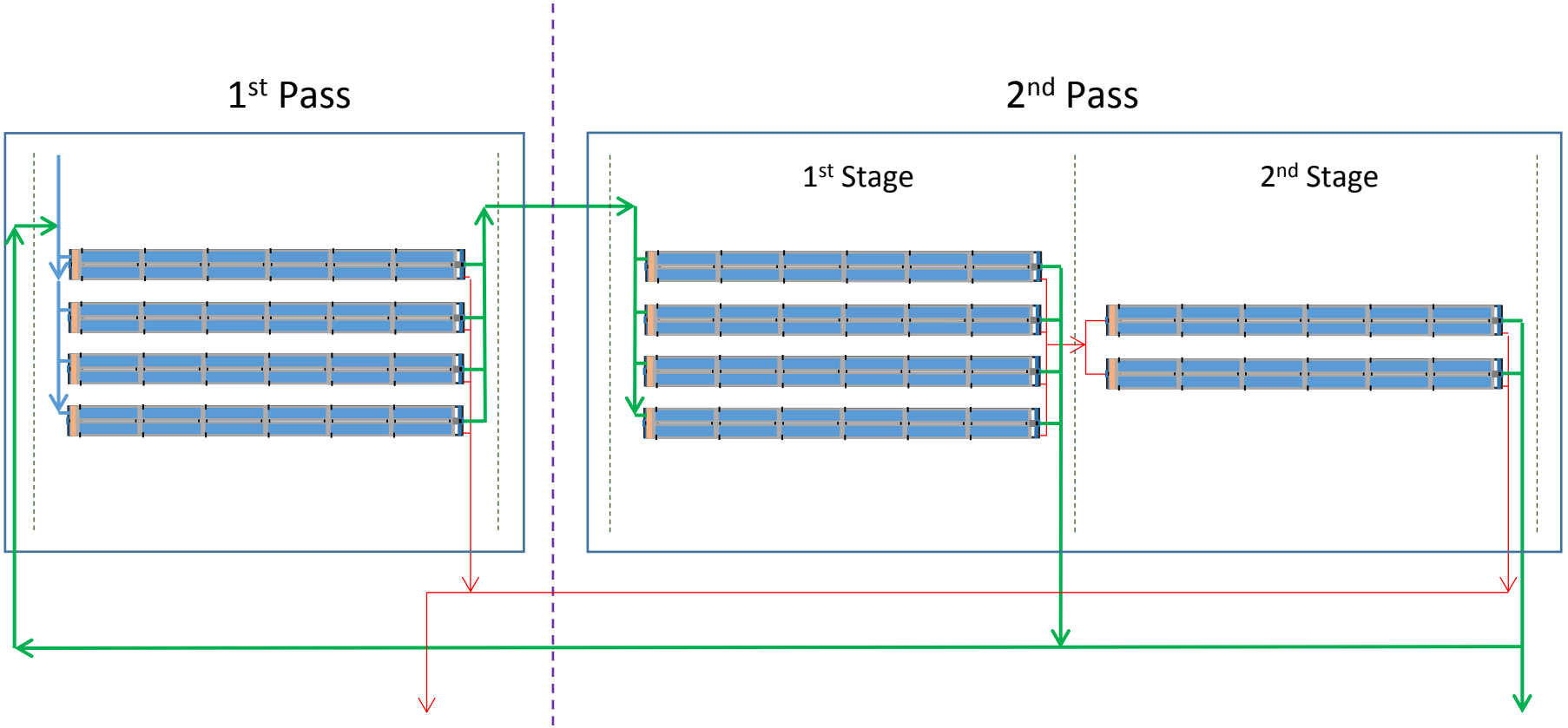
RO Membranes & Arrangement

2 Pass Arrangement



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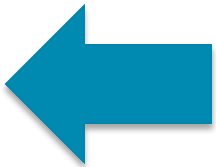
Water Contaminants

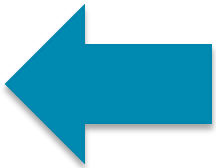
Water Contaminants

- Suspended
  - Larger than 0.01 micron
  - > 1 micron will settle
  - < 1 micron is colloidal
  - Non – uniform distribution in the water body



Pre Treatment

- Dissolved
  - Smaller than 0.01 micron
  - Uniform distribution in water body
  - Too small to be seen with naked eye
  - Don’t settle out



Focus RO

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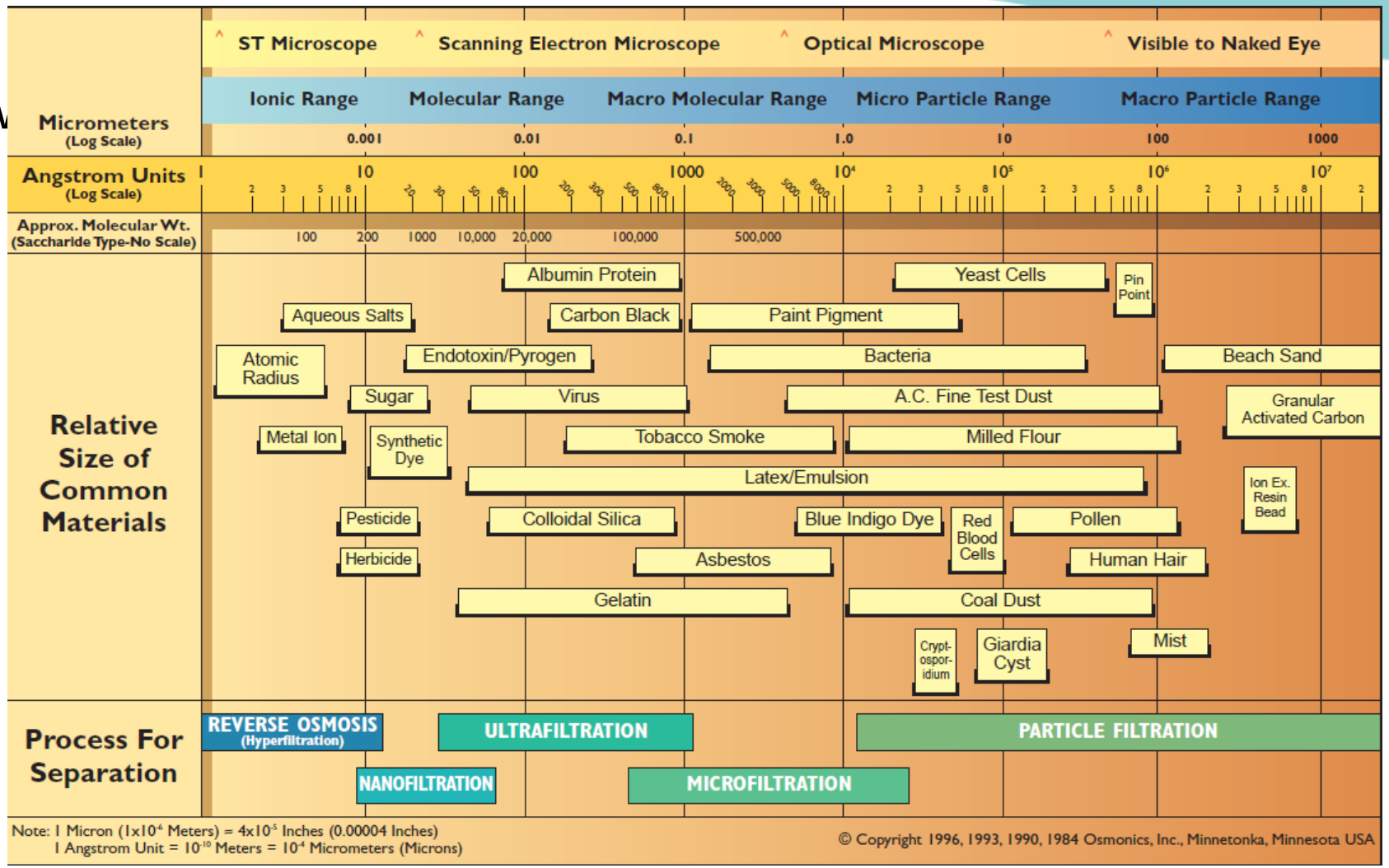
Water Contaminants

W



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Water Contaminants

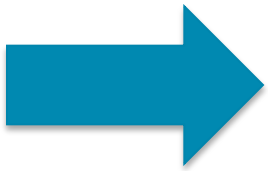
Dissolved Contaminants

- Charged Contaminants (Ions)
- Uncharged Contaminants (e.g. Water, Organics, Gases)

Water Contaminants

Ions

- Charged Atoms or Molecules
  - One Charge (1^+ or 1^-)
  - Two Charges (2^+ or 2^-)
  - Three Charges (3^+ or 3^-)
  - More Charges not common



Positive Charged Ions = Cations

Negative Charged Ions = Anions

Water Contaminants

Common Cations

- Hydrogen (H^+)
- Sodium (Na^+)
- Calcium (Ca^{2+})
- Magnesium (Mg^{2+})
- Strontium (Sr^{2+})

Water Contaminants

Common Anions

- Hydroxide (OH^-)
- Chloride (Cl^-)
- Bicarbonate (HCO_3^-)
- Bisilicate ($HSiO_3^-$)
- Carbonate (CO_3^{2-})
- Sulfate (SO_4^{2-})

Water Contaminants

RO Membrane Rejection

- Charged Contaminants are rejected based on Charge
- Uncharged Contaminants are rejected based on Molecular Weight

Water Contaminants

RO Membrane Rejection

Dissolved Contaminants		Suspended Contaminants	
Charged	Uncharged	Living	Non - Living
1^+ / 1^- = 99.0% 2^+ / 2^- = 99.5% 3^+ / 3^- = 99.8%	0-20 mol = 0% 20-50 mol = 0-40% 50-100 mol = 40-90% 100-200 mol = 90-99% > 200 mol = 99% Gases = 0% rejection	Should not be present.	

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Water Contaminants

mol Water H_2O

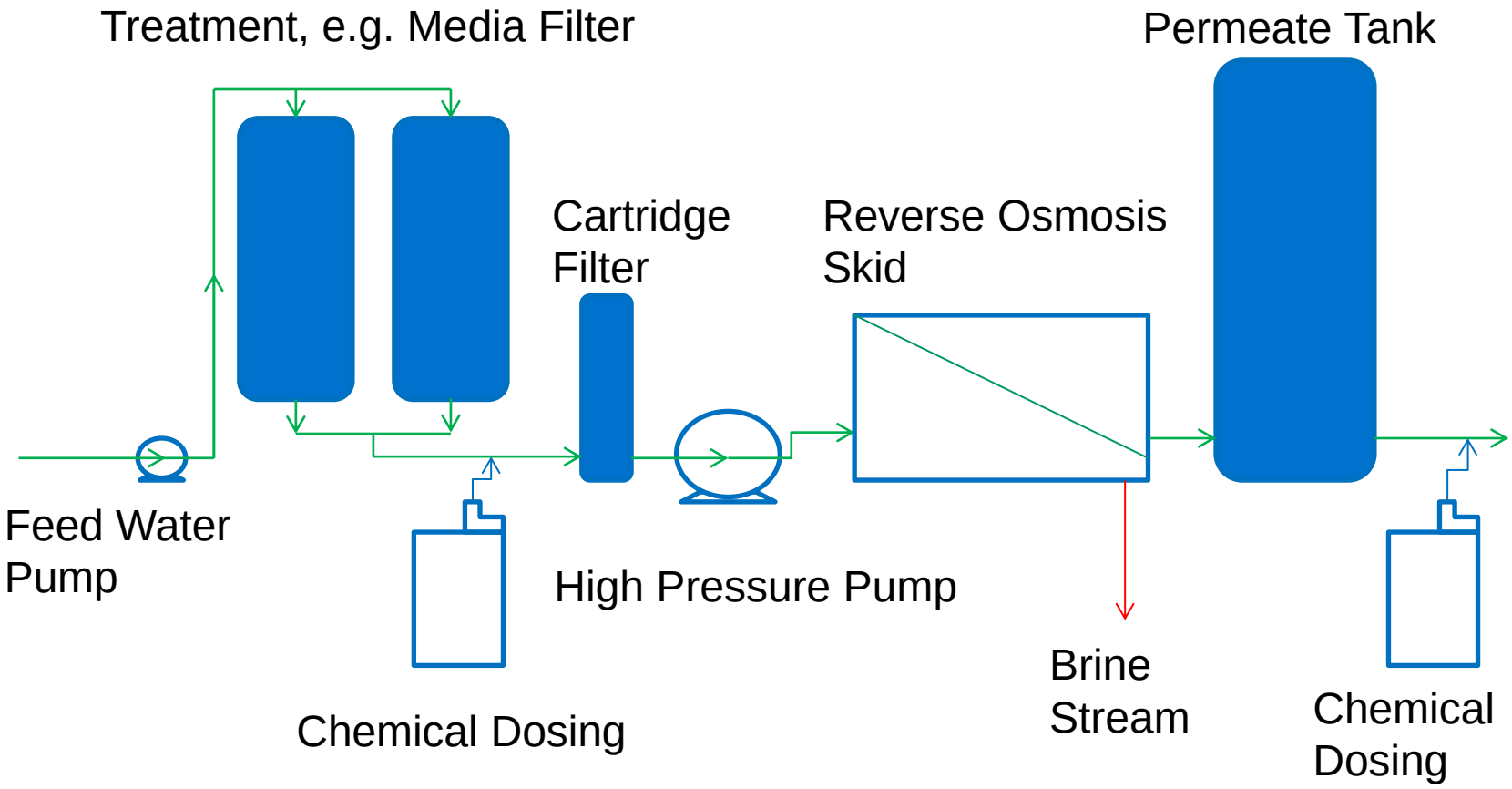
- Hydrogen (H^+) = 1 mol
- Oxygen (O^{2-}) = 16 mol

Total = 2 x 1 mol + 16 mol = **18 mol**

(H_2O)

18 mol < 20 mol hence no rejection of H_2O

System Overview



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Energy Savings

Energy Recovery Device (ERD)

Specific Energy per Year with VFD & ERD

Year	Spec. energy
1	3.24 kwh/m^3
2	3.28 kwh/m^3
3	3.32 kwh/m^3

Specific Energy without VFD 5.5 kwh/m^3

Significant Energy savings (compared to no VFD and no Energy Recovery Device):

Savings: based on 240m3/day & 0.18 AUD / kwh

Year	Yearly kW Savings	Yearly AUD Savings
1	197,976 kW	$ 35,635.-
2	194,472 kW	$ 35,004.-
3	190,968 kW	$ 34,374.-
Total	**583,416 kW**	**$ 105,013.-**

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Energy Savings

https://www.youtube.com/watch?v=lEhlzO-CccY

https://www.youtube.com/watch?v=J81mcTV7tUw

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Thanks for your attention…

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