Membrane SPECIALISTS

Innovative Cusomized Membrane Solutions

Wes Alexander

What do you call an operator in their element?

Dedicated.

Investigating membrane technologies; ***fundamentals of membrane construction, technology, limitations, and applications for water quality and project design***

Agenda:

- Introductions
- Membrane Overview
- Theoretical and Non-theoretical Case Studies

ABOUT US

PRINCIPALS:

David Pearson:
Graduated from Oxford University in Engineering Science. He spent 10 years with PCI Membranes in sales management and marketing roles in the UK before moving to the United States in 1997 to be the General Manager of PCI Membranes He held that and similar positions until forming Membrane Specialists LLC.

Lewis Pain:
Graduated in Environmental Chemical Engineering from Exeter University in the UK. He came to the United States in 1983 as a technical liaison between PCI Membranes in the UK and the US distributor, and he worked for PCI in the US until Membrane Specialists LLC was established. During his time at PCI, his responsibilities included sales management, marketing, commissioning, and process development.

INDUSTRIES SERVED

BIOFUELS

NUTRACEUTICALS

PULP & PAPER

INDUSTRIAL EFFLUENT

FINE CHEMICALS

FOOD & BEVERAGE

WATER TREATMENT

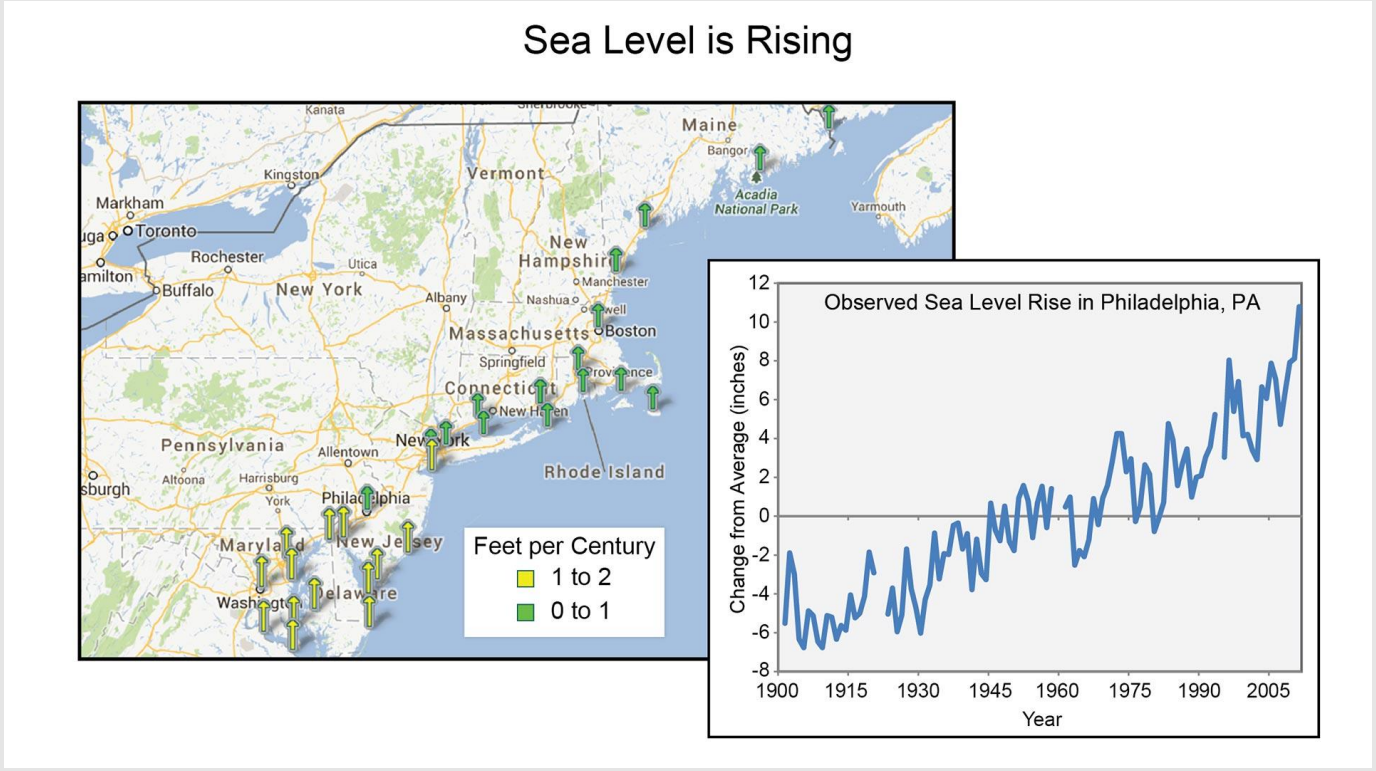
WASTEWATER

VISION:
Experts in developing and engineering innovative membrane separation processes enabling our customers to be leaders in their field.

MISSION:
Enjoy taking separation goals from concept to commercialization. We provide expertise, piloting, design and build, commissioning and support services to create an optimal process for the customer.

Membrane SPECIALISTS

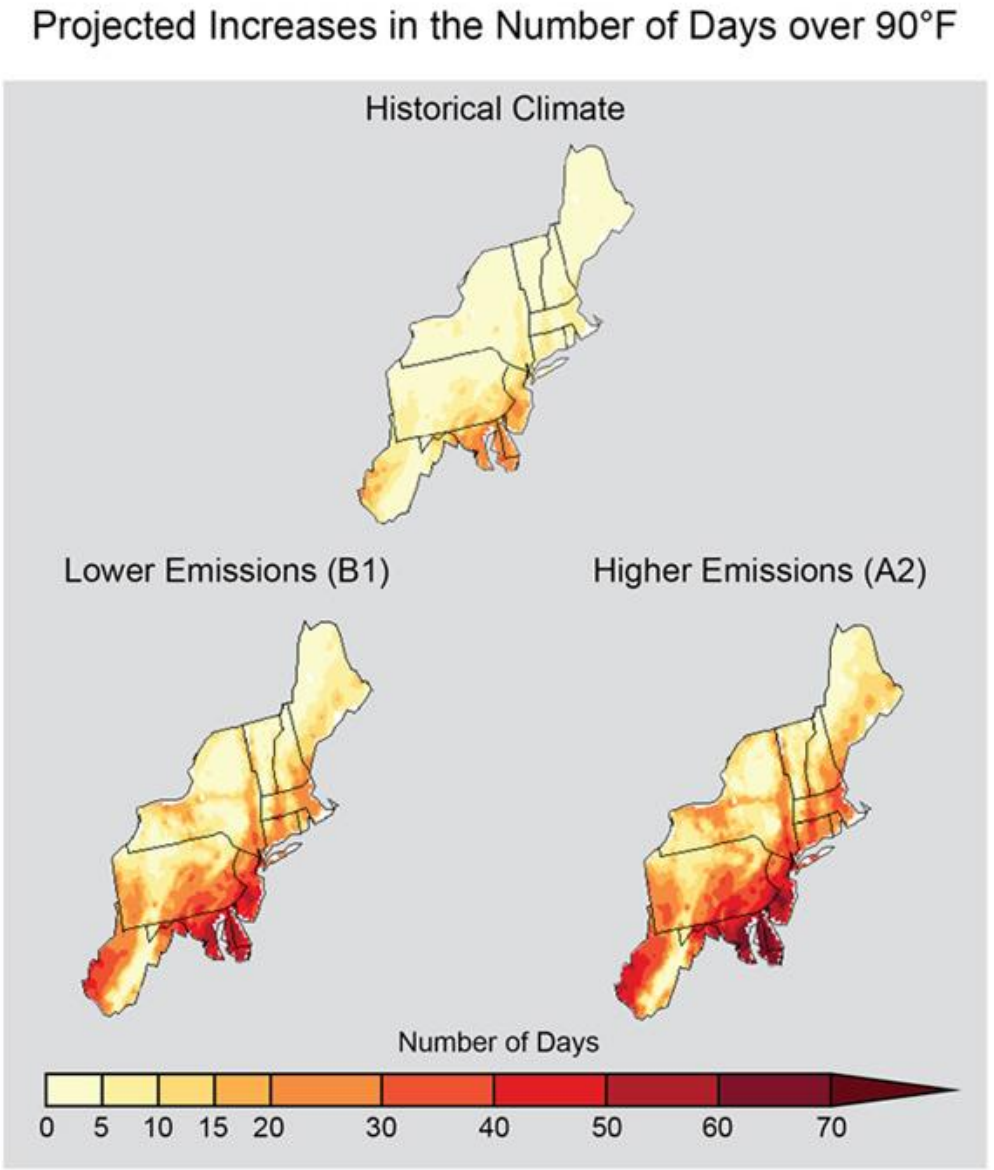
What are we facing?



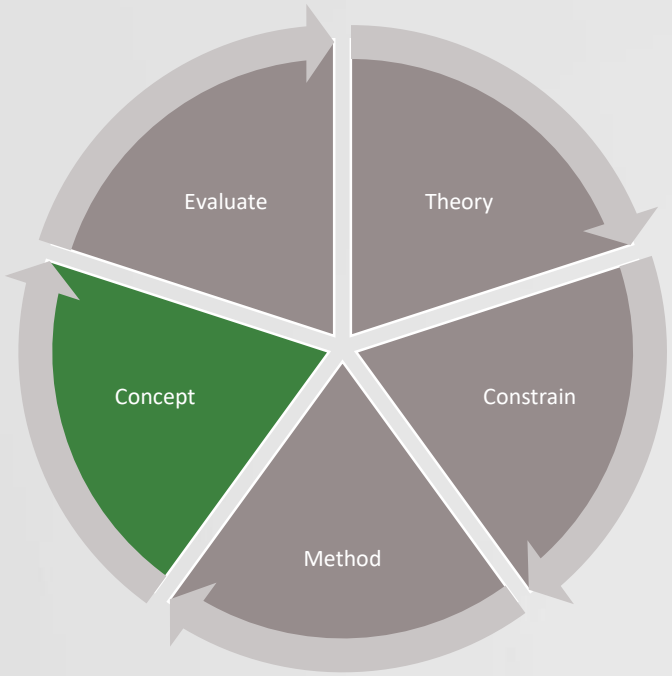
- 64% of lake acres are not clean enough to support fishing or swimming
- Between 1958 and 2010, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events)

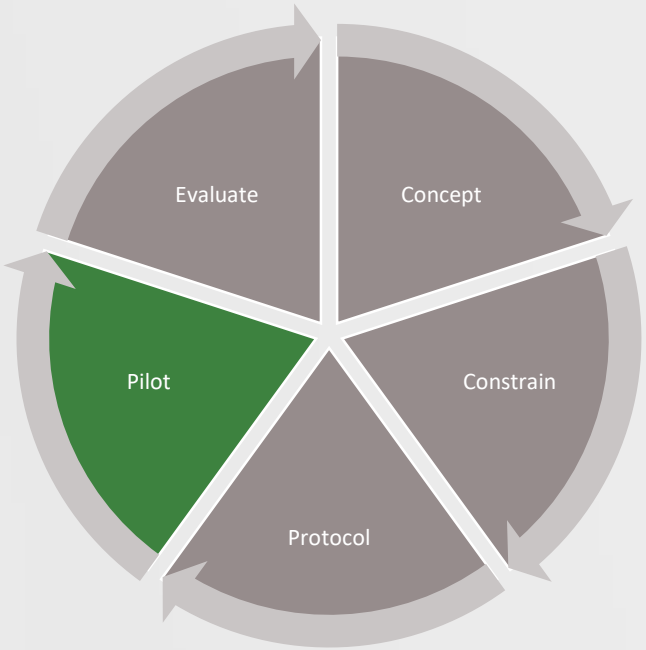
What are we facing?

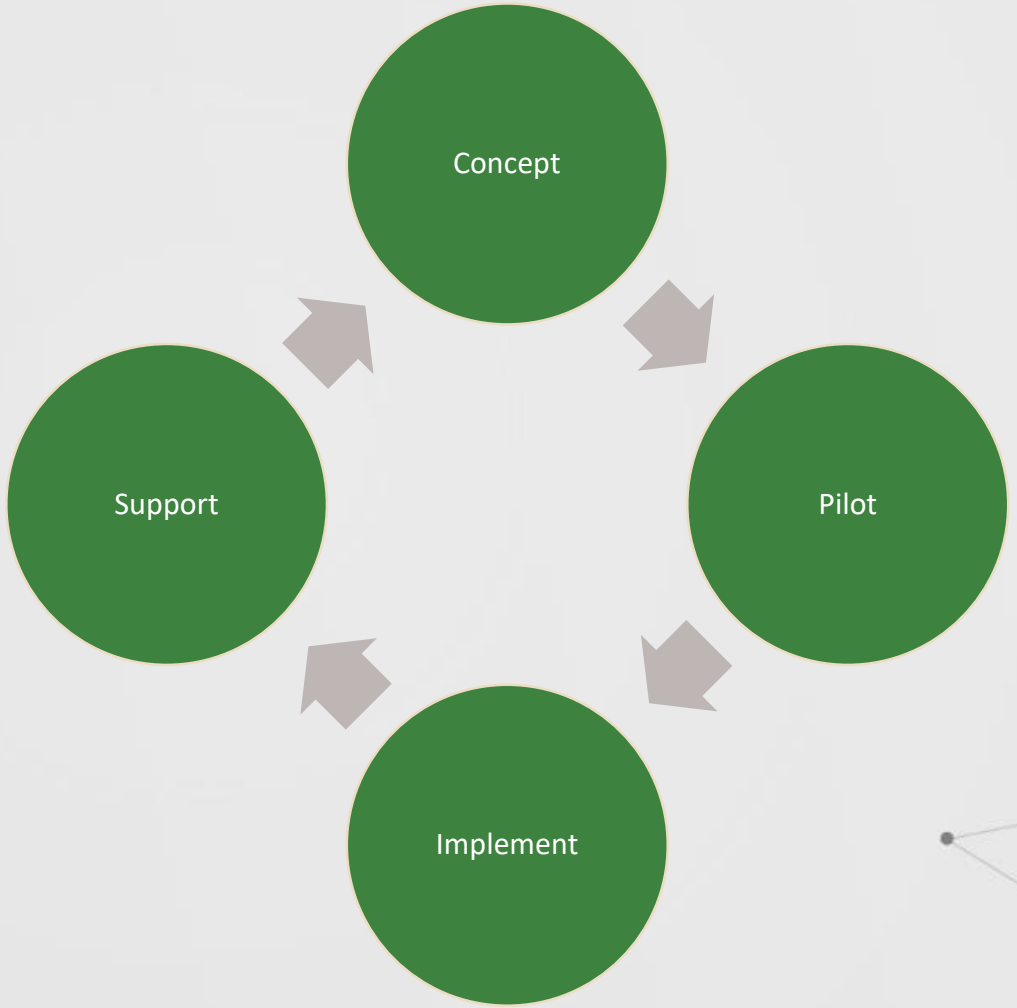
- Several studies have shown positive correlations between impervious surface area and stream temperature (Wang et al. 2003, Nelson and Palmer 2007, Imberger et al. 2008, Stranko et al. 2008).
- Heated stormwater runoff flows into lakes, streams, bays, and estuaries, which potentially increases the base temperature of the surface water. The amount of heat transferred, and the degree of thermal pollution is of great importance to the ecological integrity of receiving waters. (LeBleu et al. 2019)

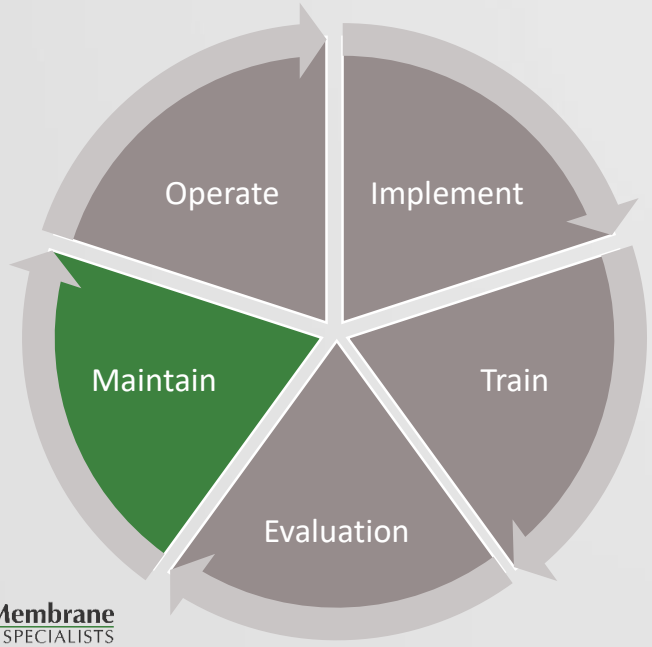


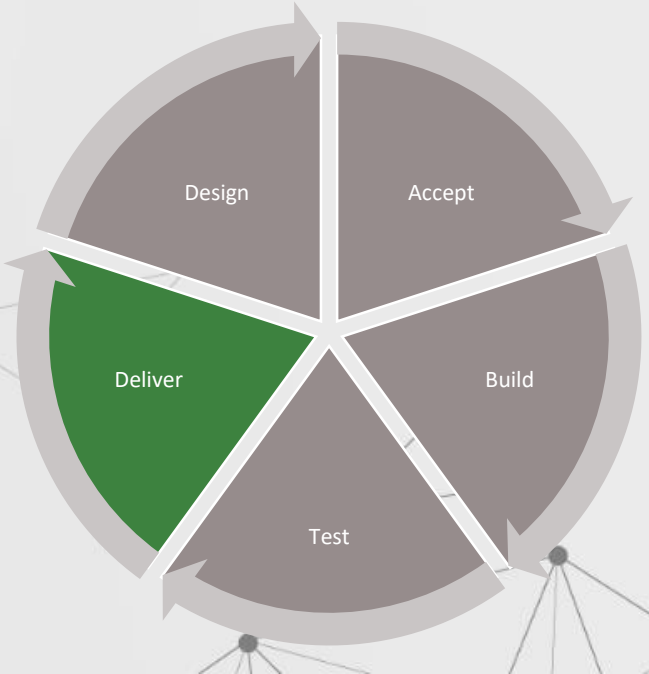
PROCESS PILLARS











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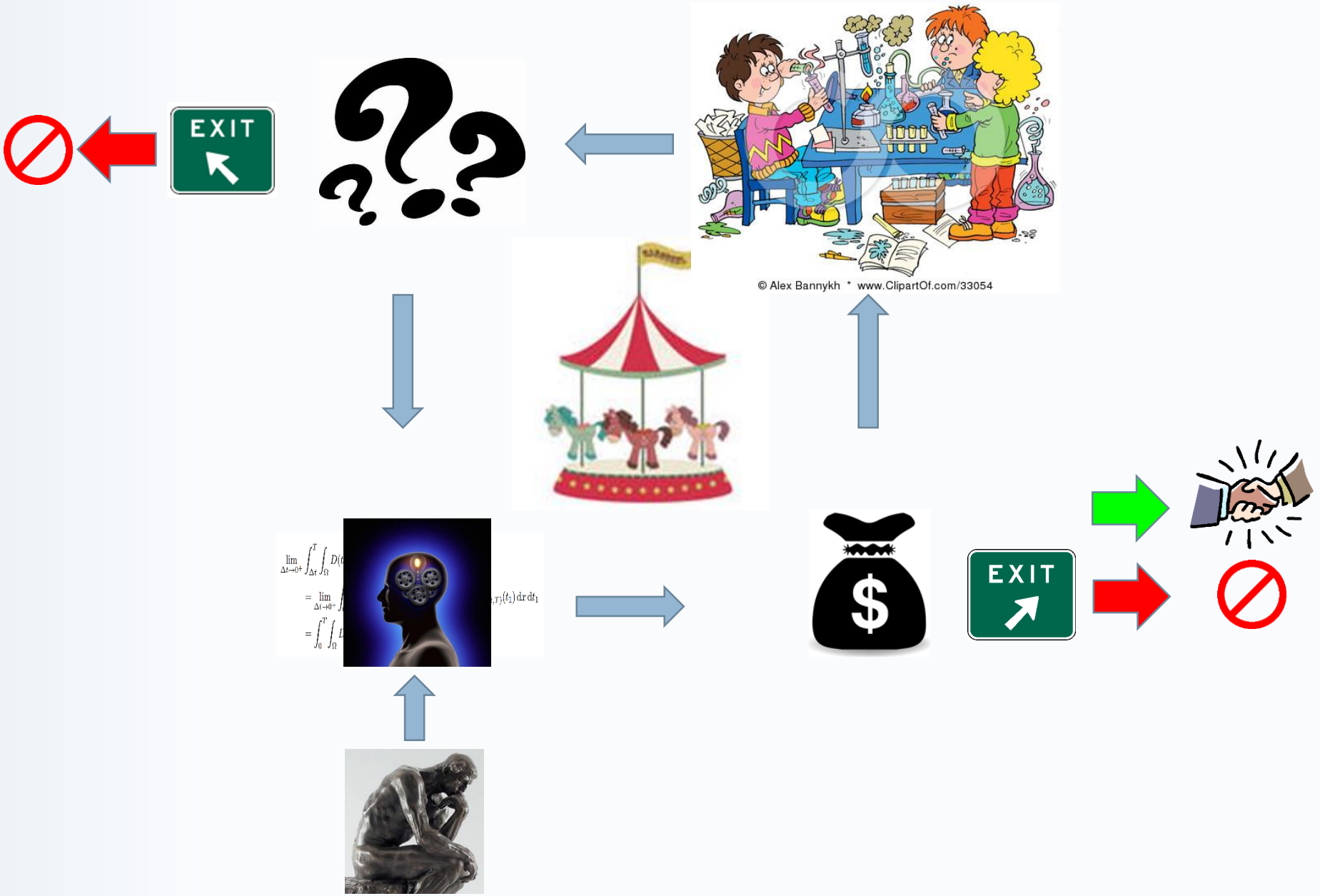
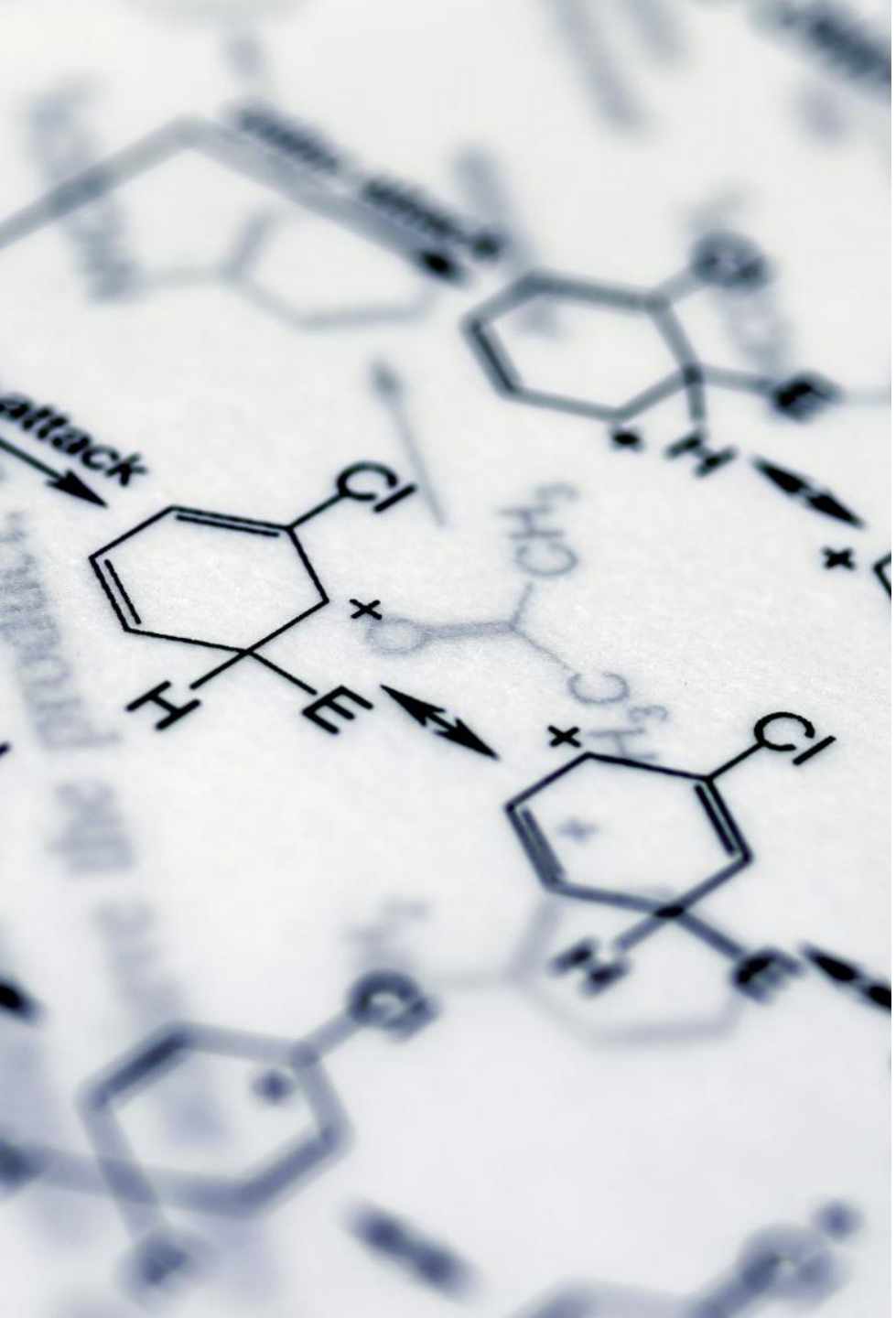
The Decision-Making Process

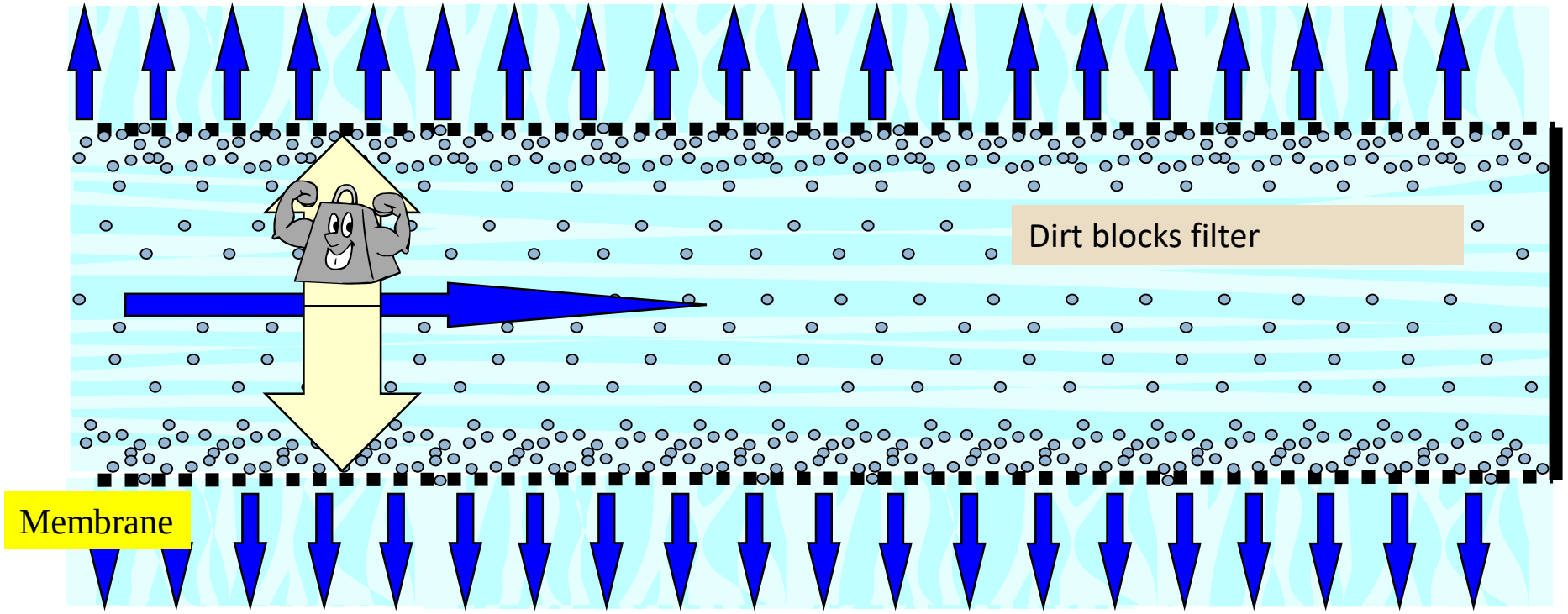




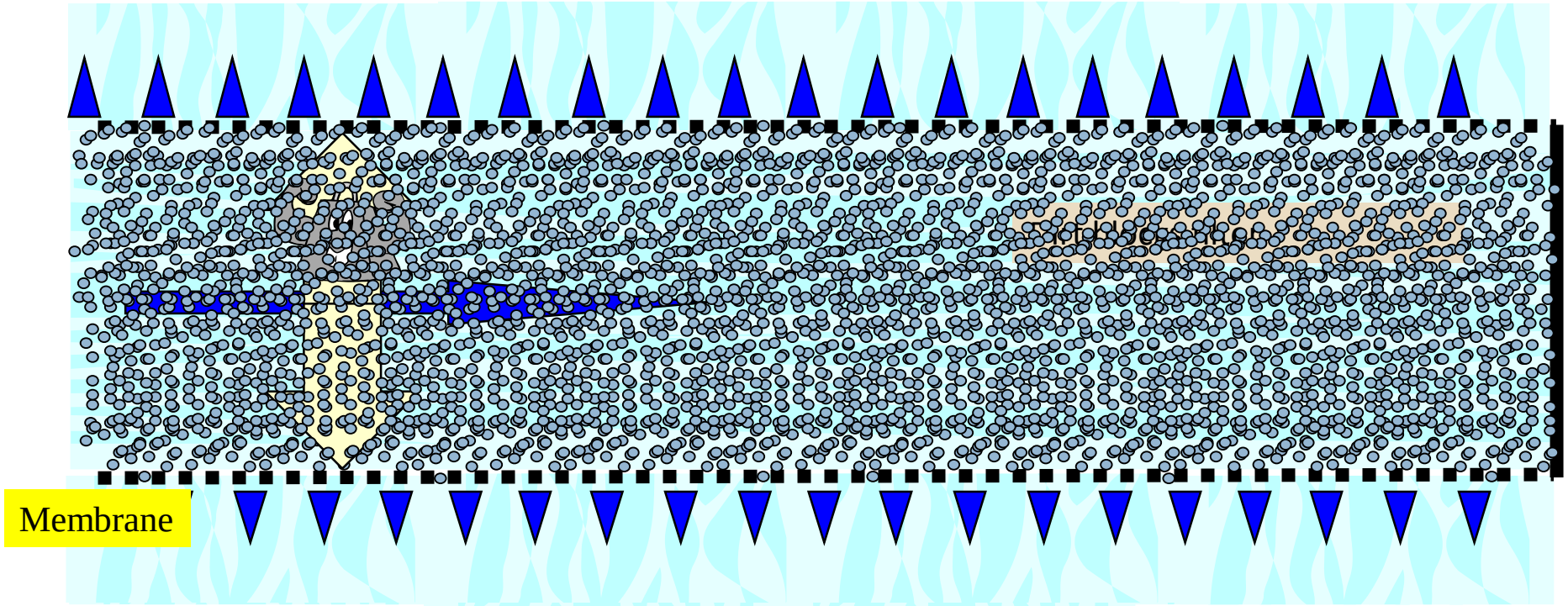
What is a membrane?

- Semi-porous material, typically a polymer like PVDF
- Allows some liquid to pass through the material called substrate
- Liquid which passes is called permeate or filtrate
- Liquid which does not pass is called retentate
- Besides the pore-size, various formats are used as well

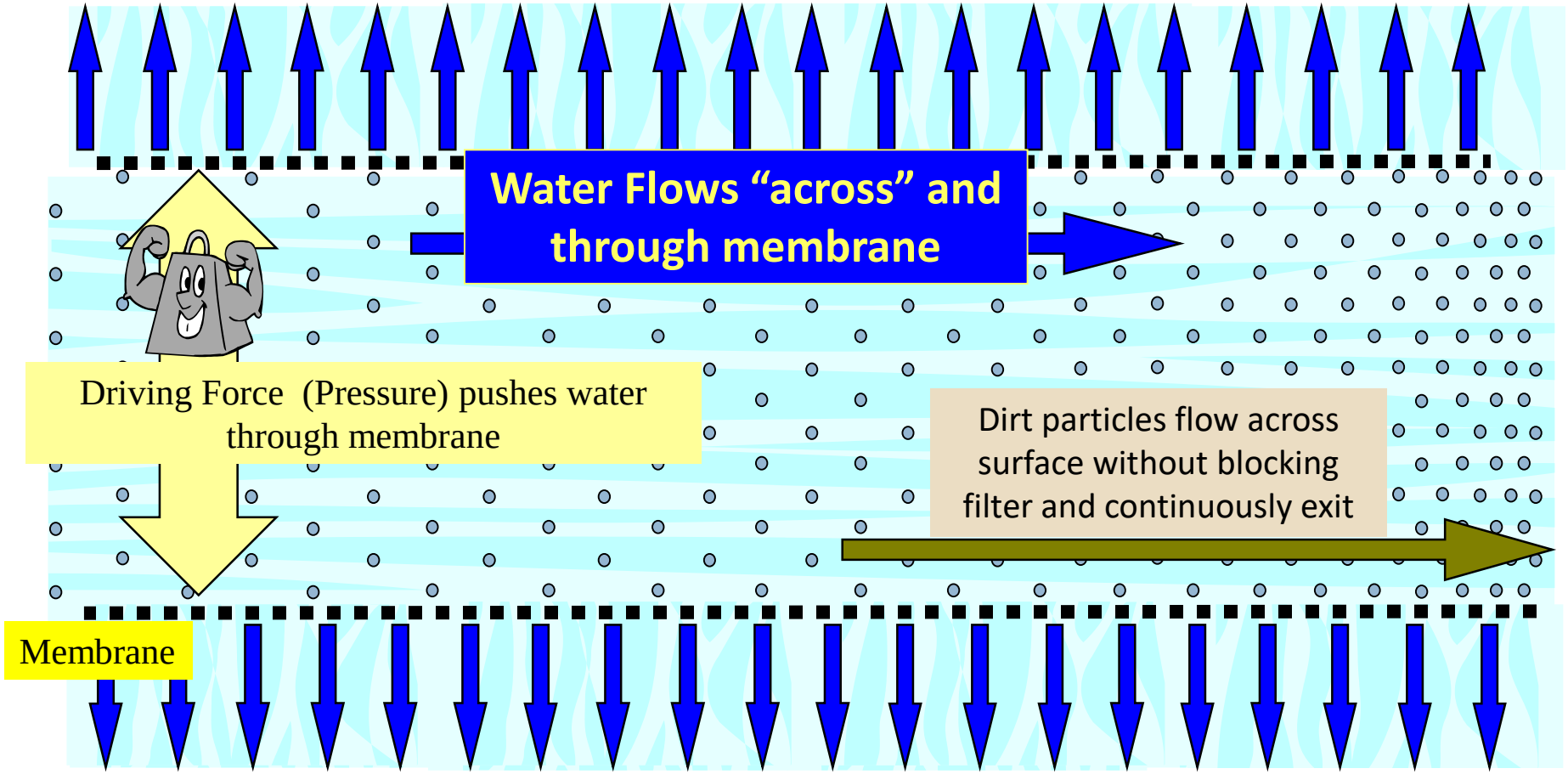
“Dead End” Filters



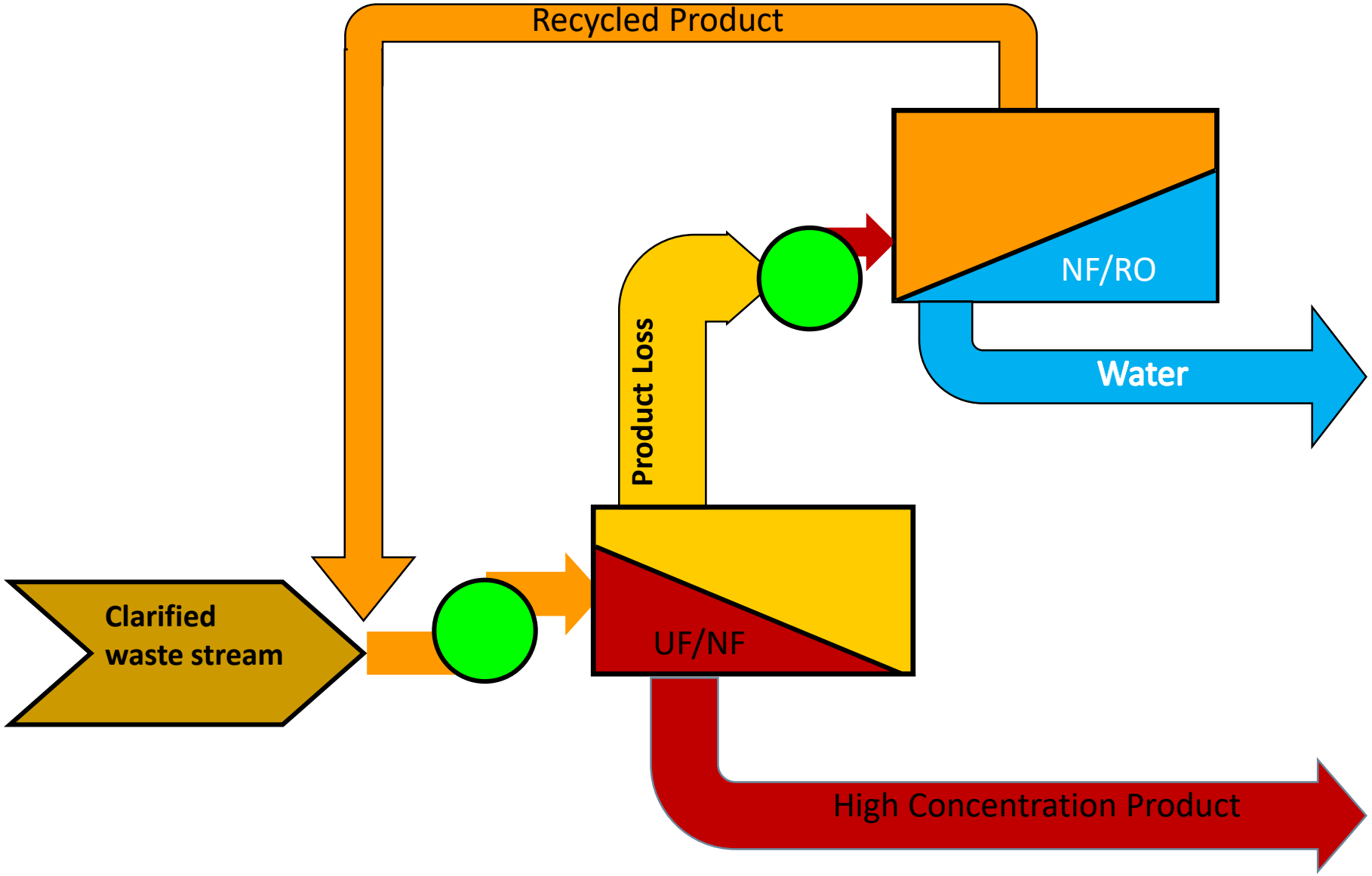
“Dead End” Filters



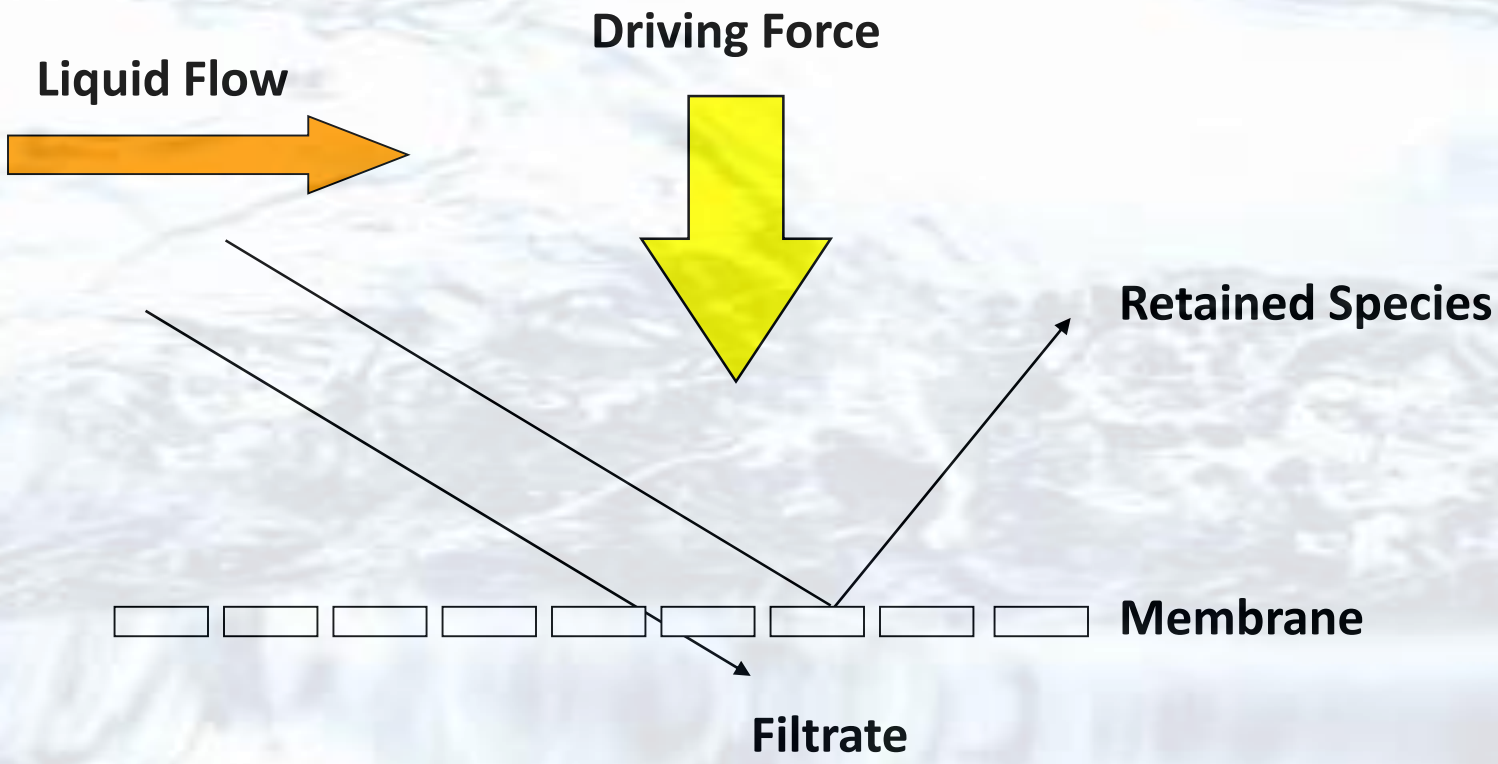
“Cross Flow” Membranes



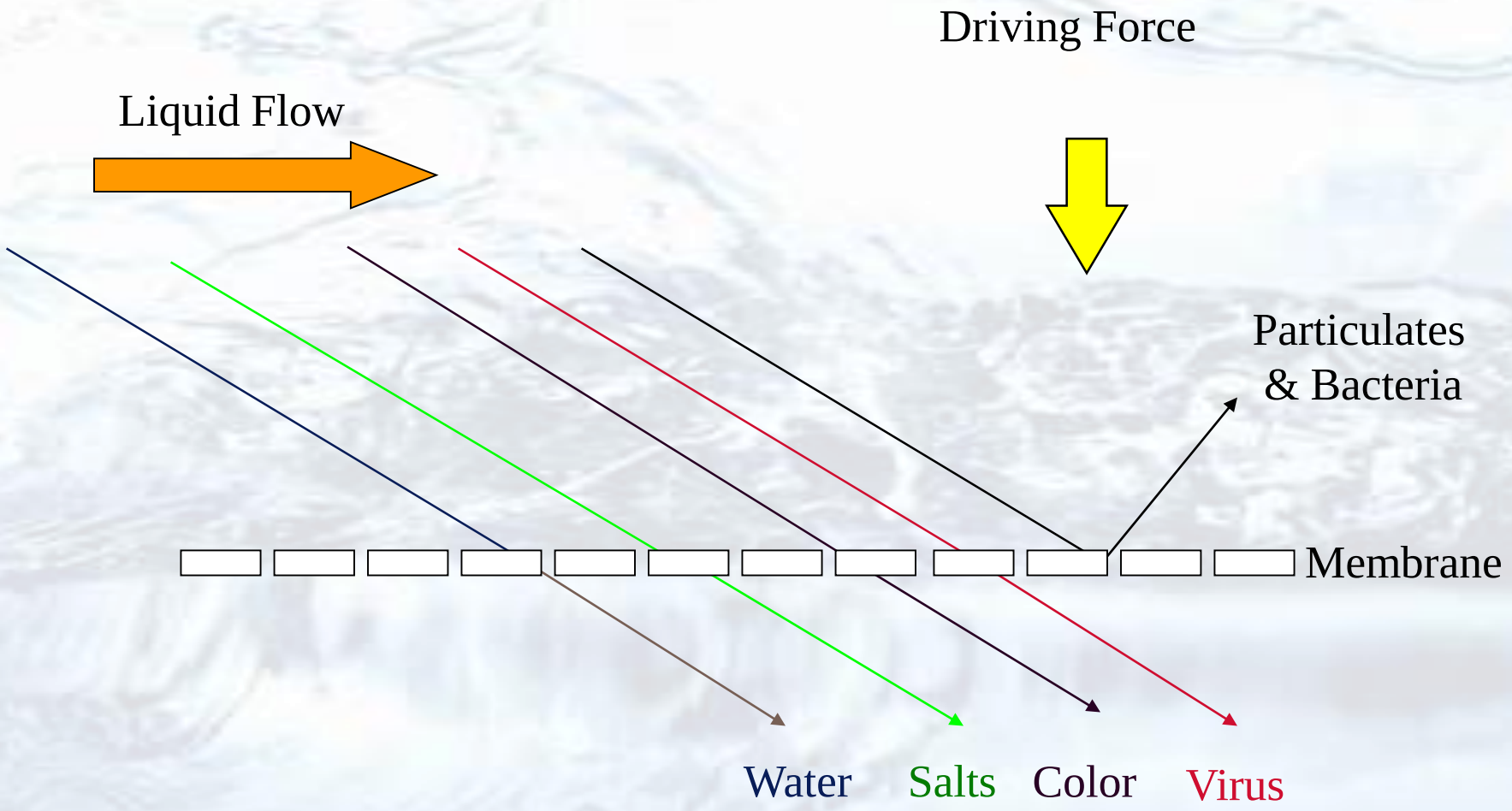
What is reject? What do you do with it?



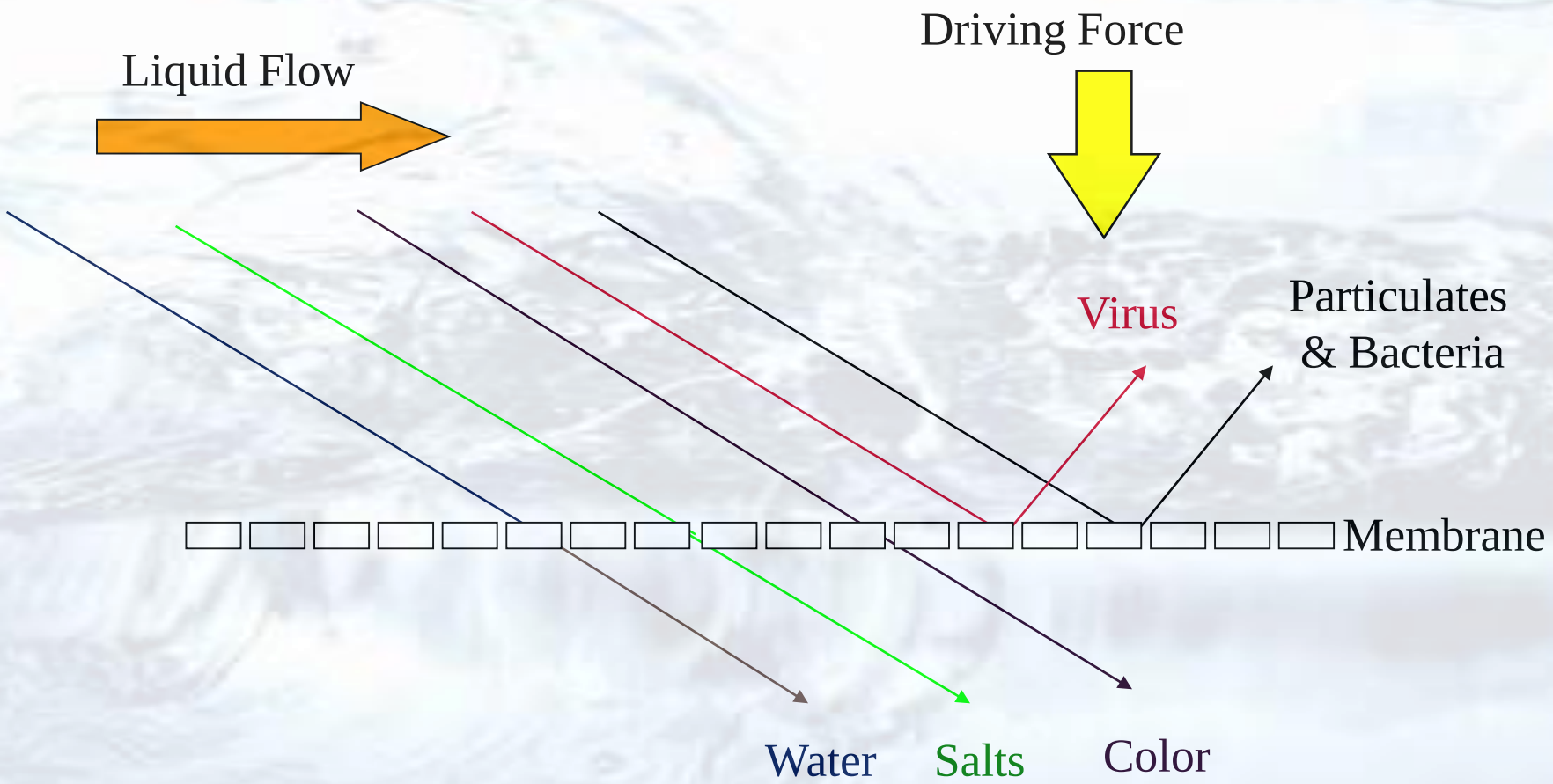
Membrane Separations - A Basic View



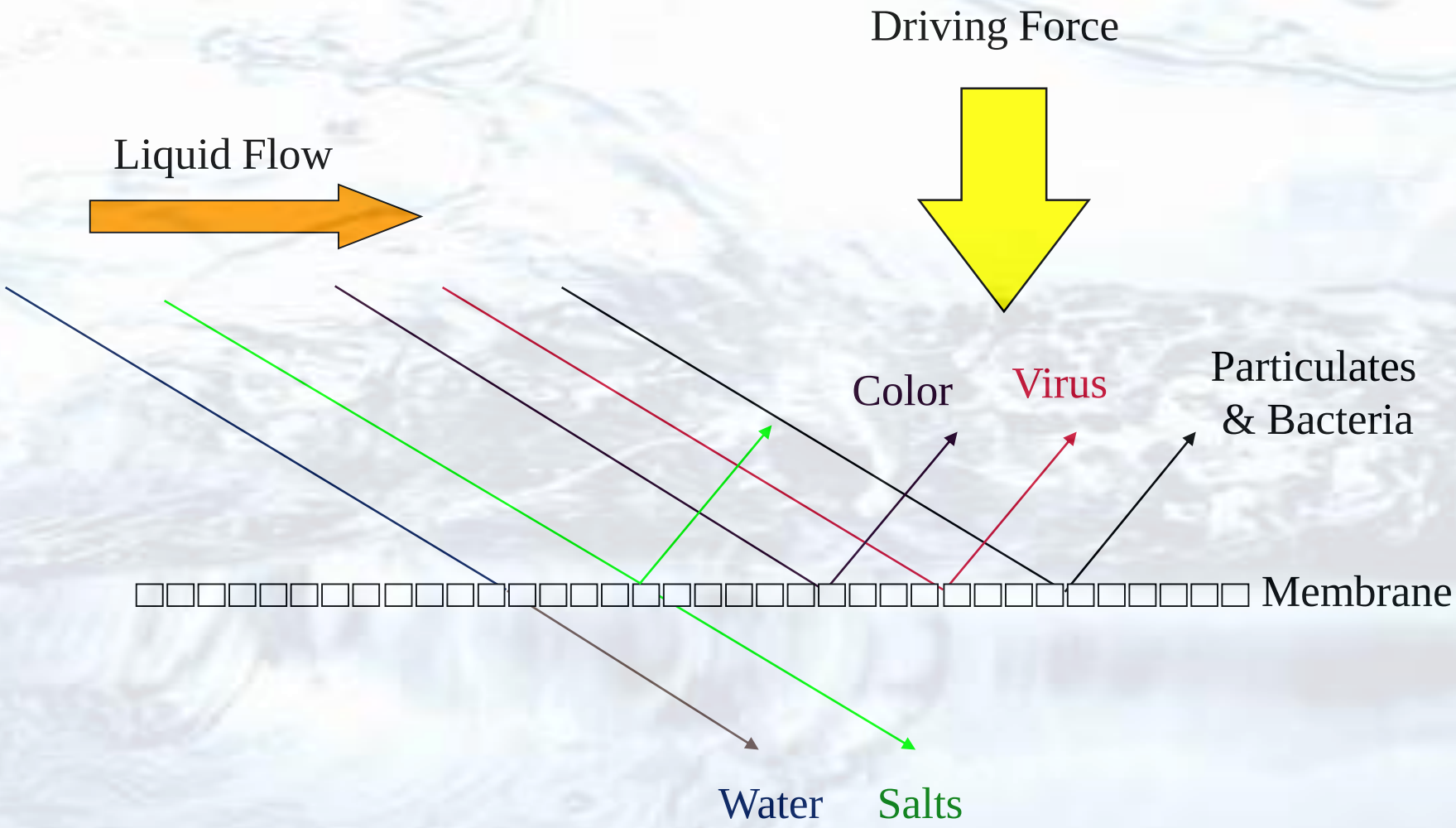
MICROFILTRATION



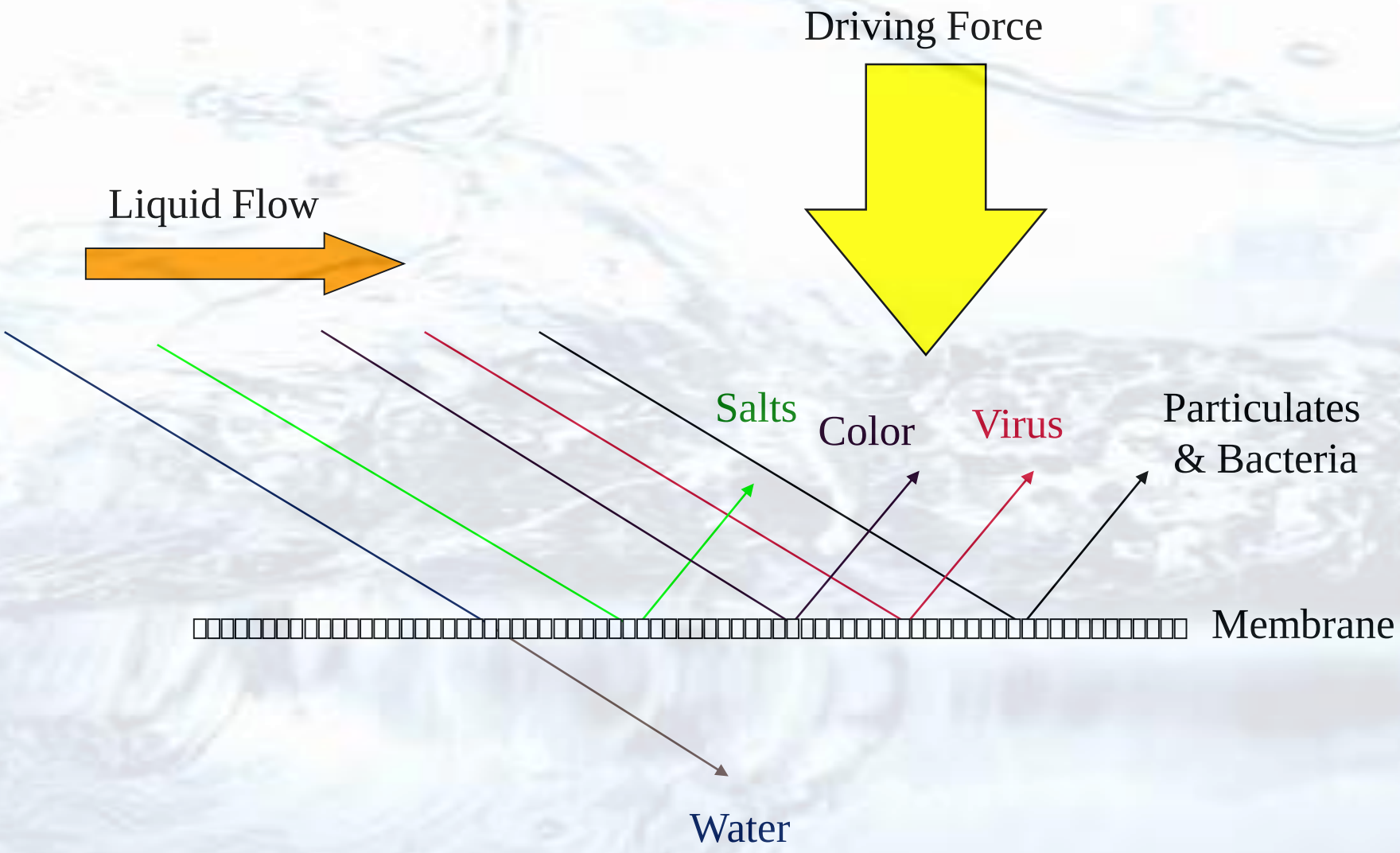
ULTRAFILTRATION



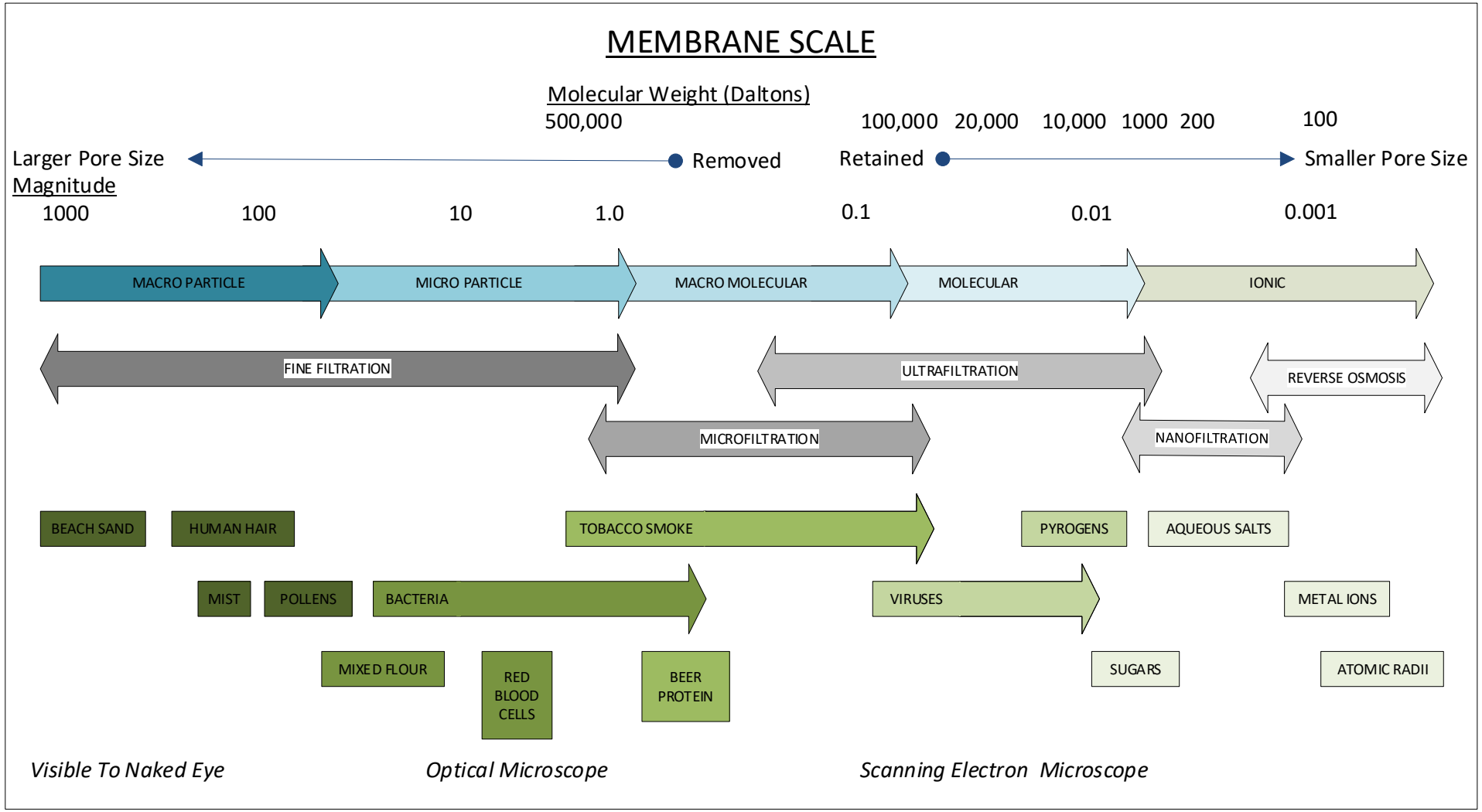
NANOFILTRATION



REVERSE OSMOSIS



How Are Membranes Classified?



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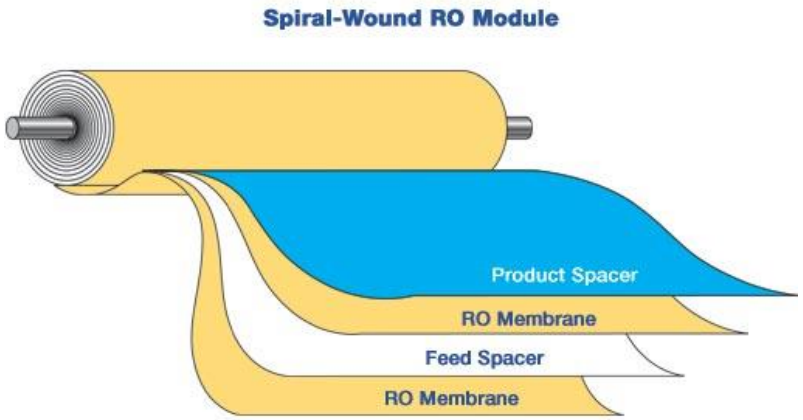
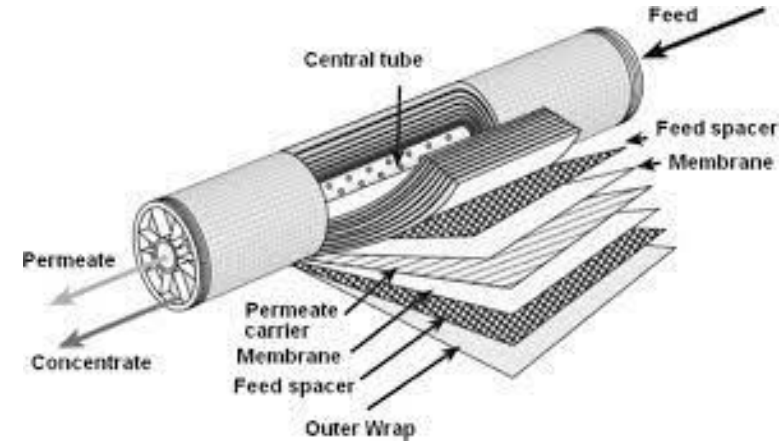
Membrane Format?

Spiral

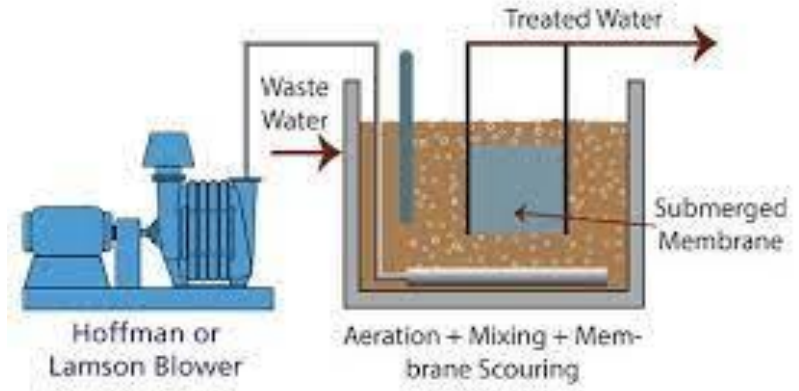


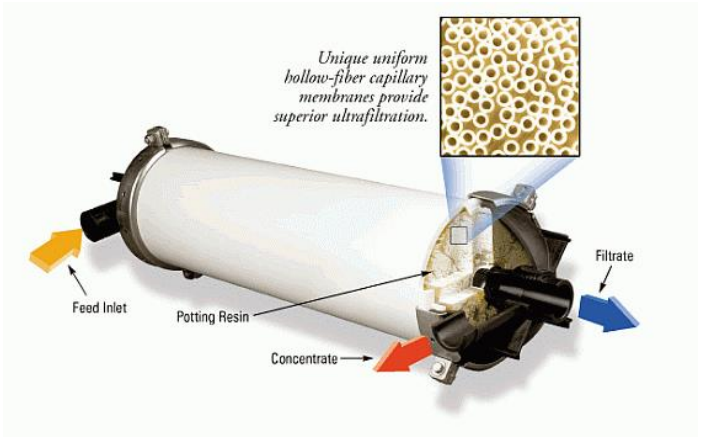


Spiral System Fermentation

Membrane Format?

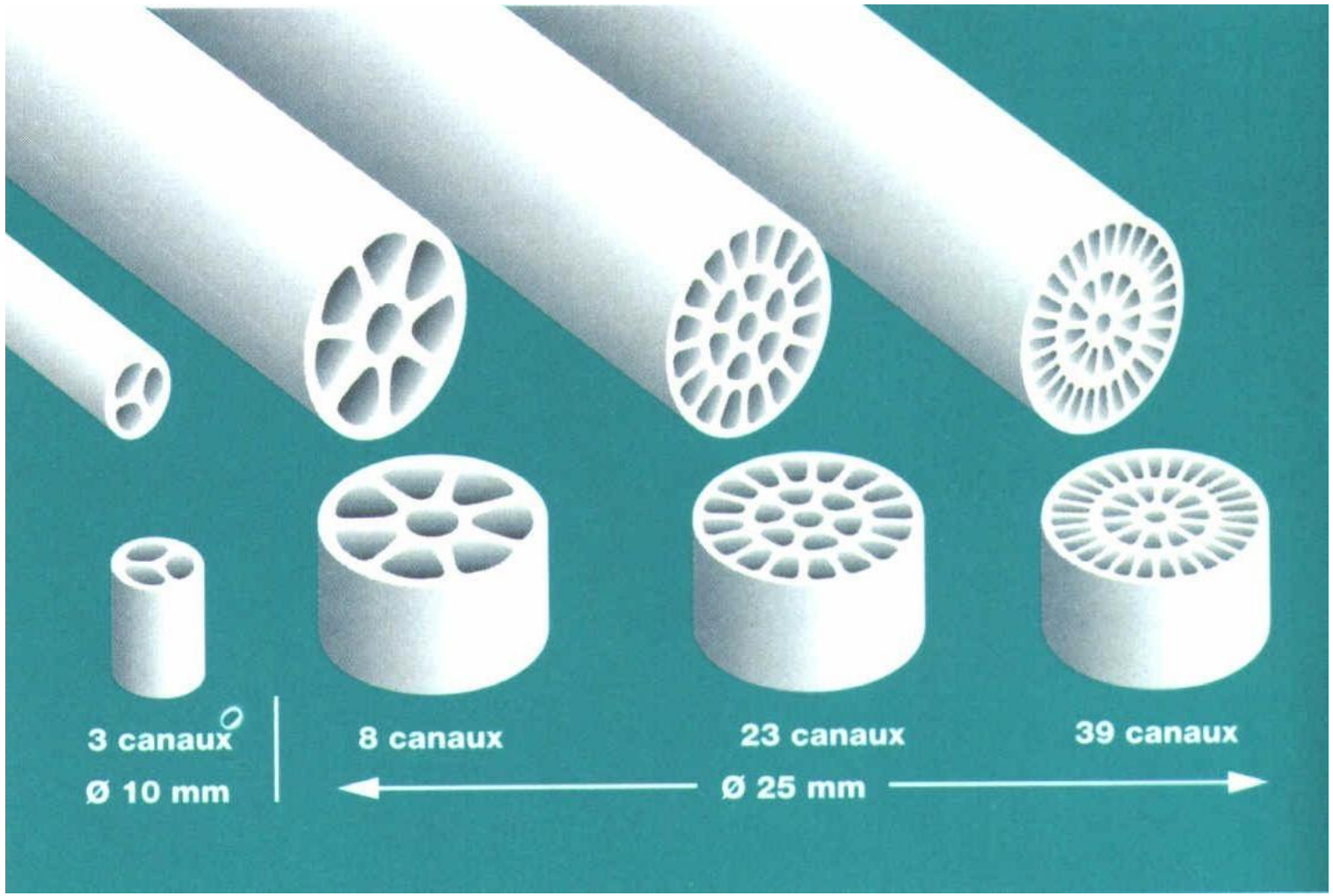
- Hollow Fiber
- Submerged





Hollow Fiber System

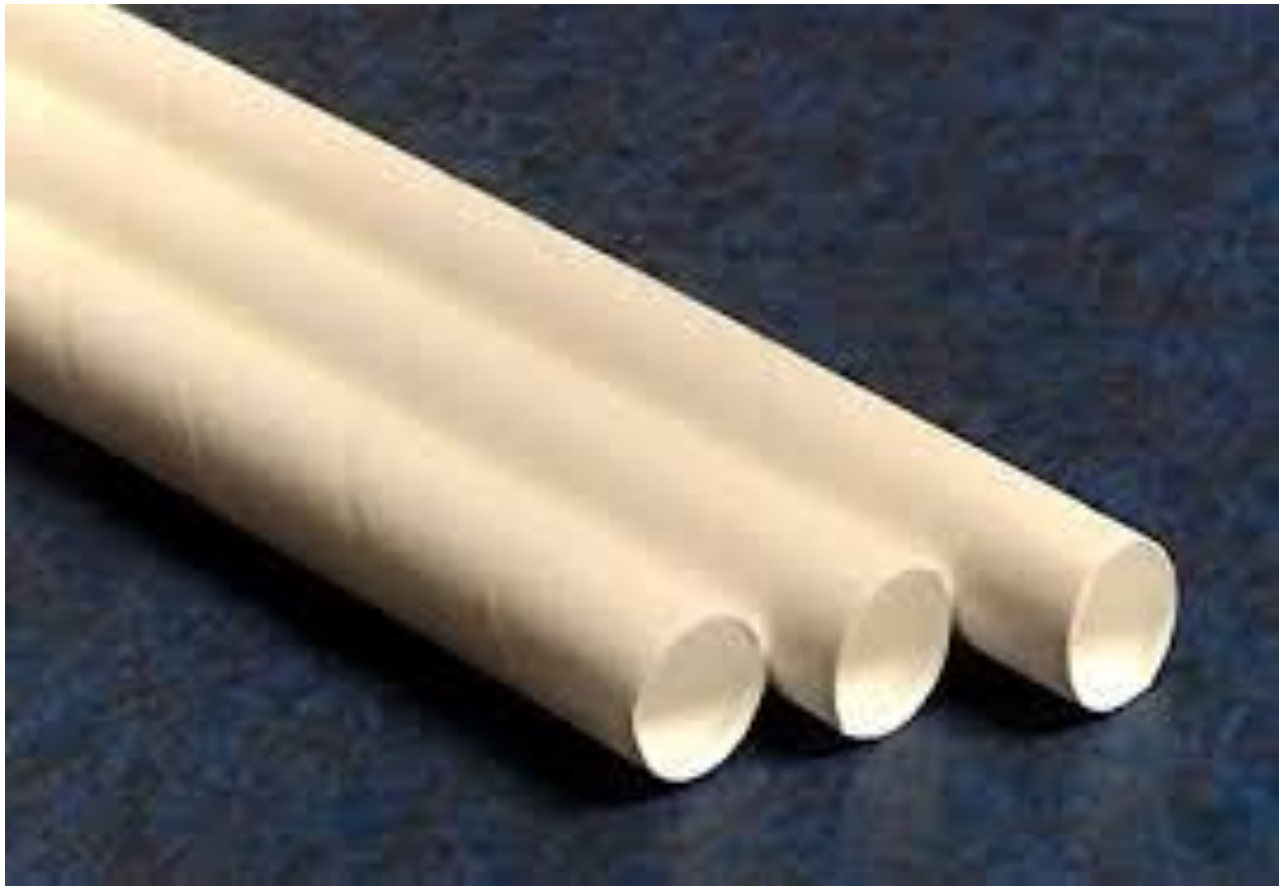
Membrane Format? | Ceramic



Membrane Format?

Ceramic Membranes

Ceramic System



Membrane Format?

Tubular

Tubular Membranes & Modules

- Tubular membranes
- 20+ types, RO>>MF
- robust / high solids capability

- Tubular modules
- stainless steel and ABS plastic
- supported / unsupported
- Up to 930 psi/63 bar
- Up to 85°C/175°F

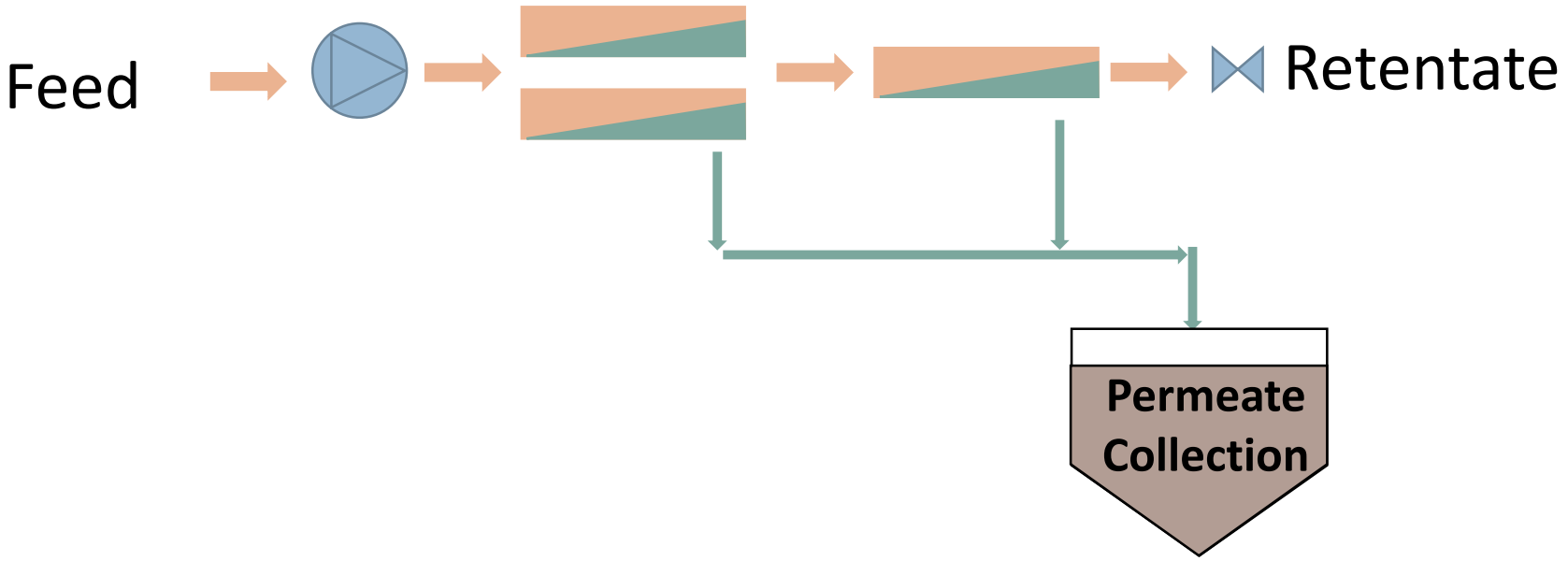
Tubular System

- 300 m^3/hr of bleach effluent in Magnesium Sulfite Mill concentrated to 6 m^3/hr
- 50% + COD removal
- Sodium removal from recycle loop

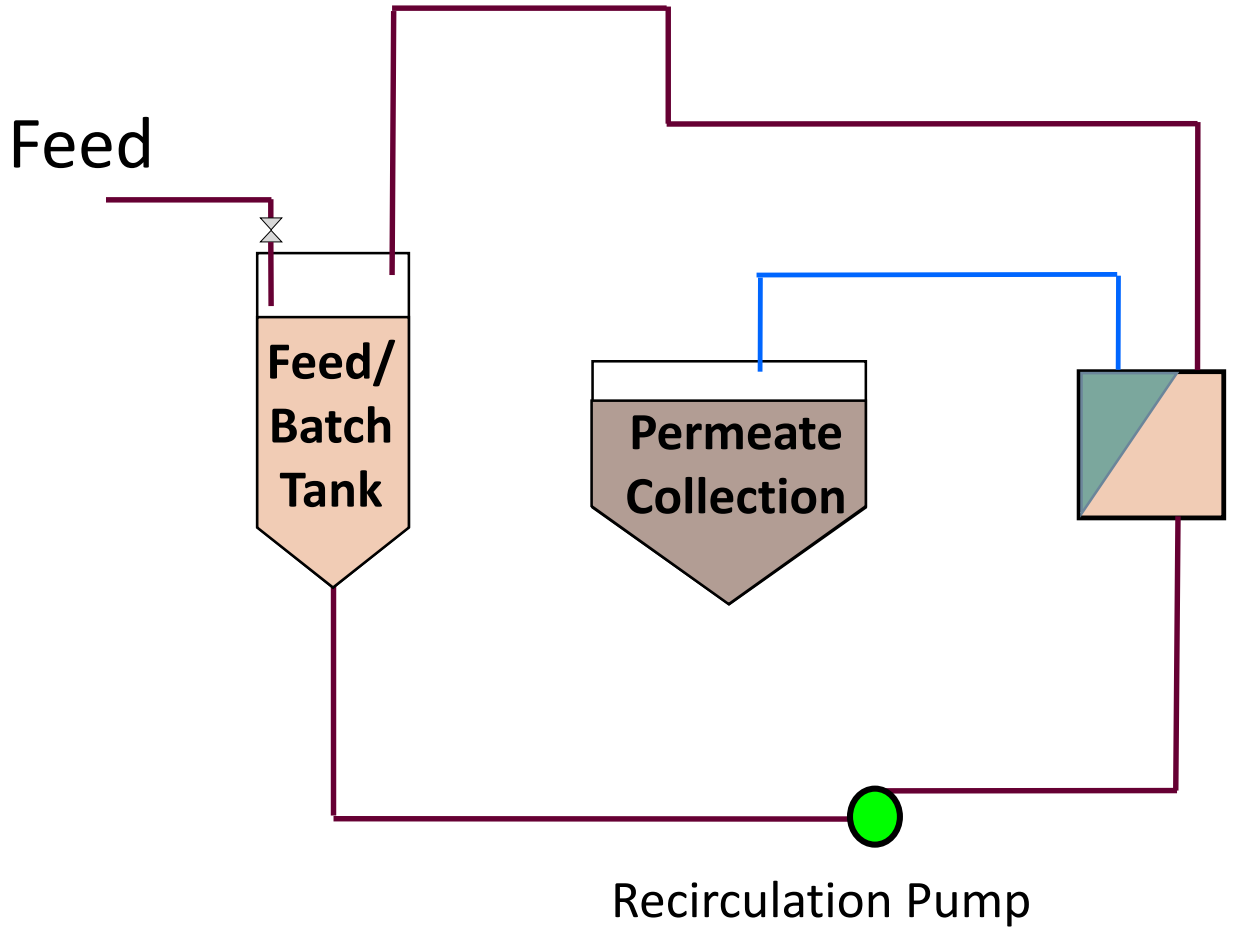
Advantages/Disadvantages of Configurations

Configuration	Cost	Energy	Temp	Viscosity	Suspended Solids	Fiber
Spiral	5	4	3 45 – 60C	1	1	0
Hollow Fiber	4	5	3 40 – 60C	1	2	0
Tubular	3	3	4 30 – 80C	5	5	5
Ceramic	2	2	5 300C	4	5	2

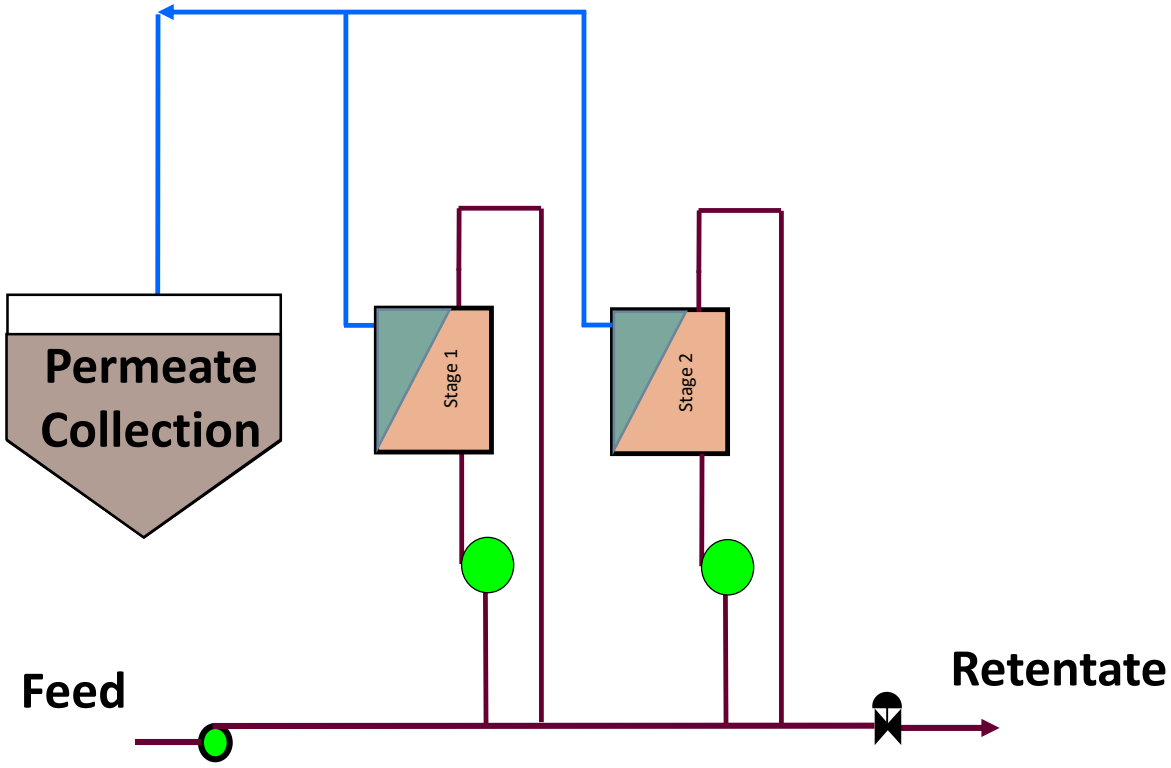
Tapered – Once Through Design



Batch or Topped Batch Design



Continuous Feed and Bleed



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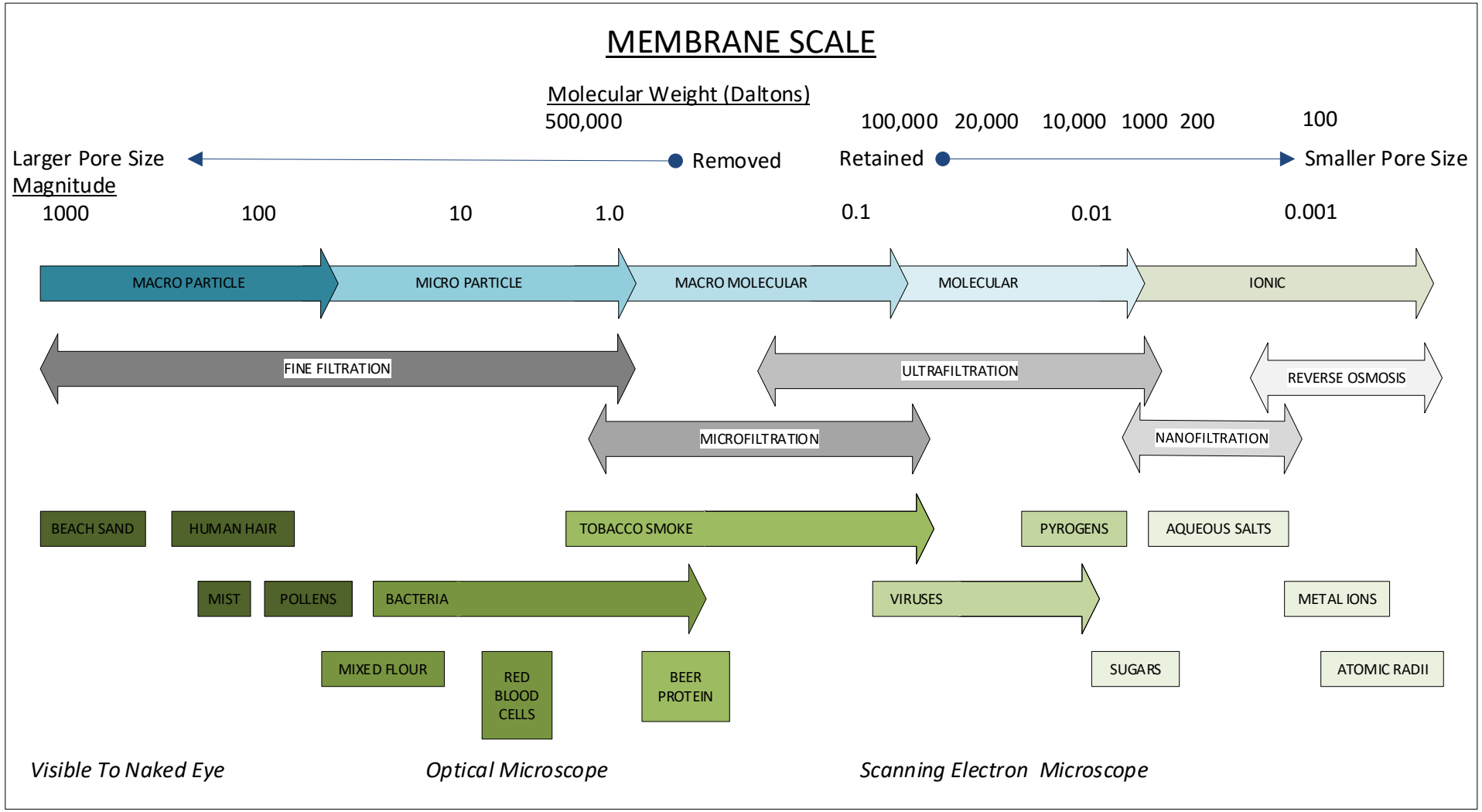

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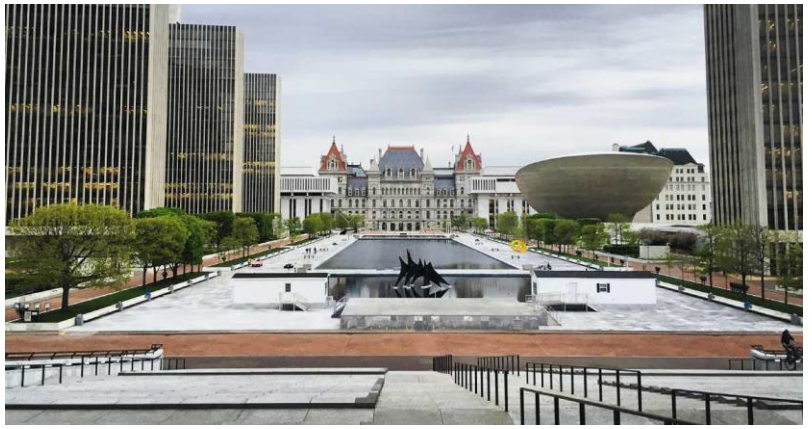
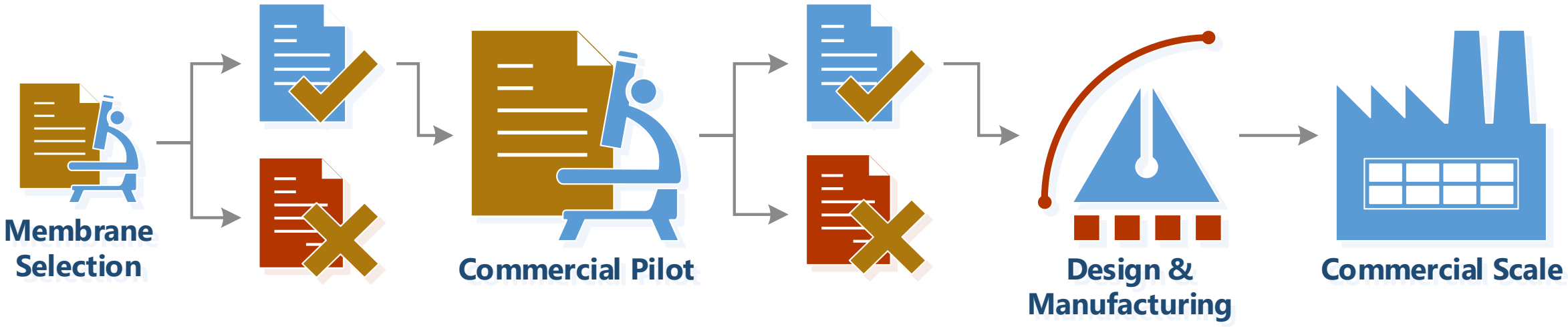
What is Stormwater?

And… how do membranes play a role?

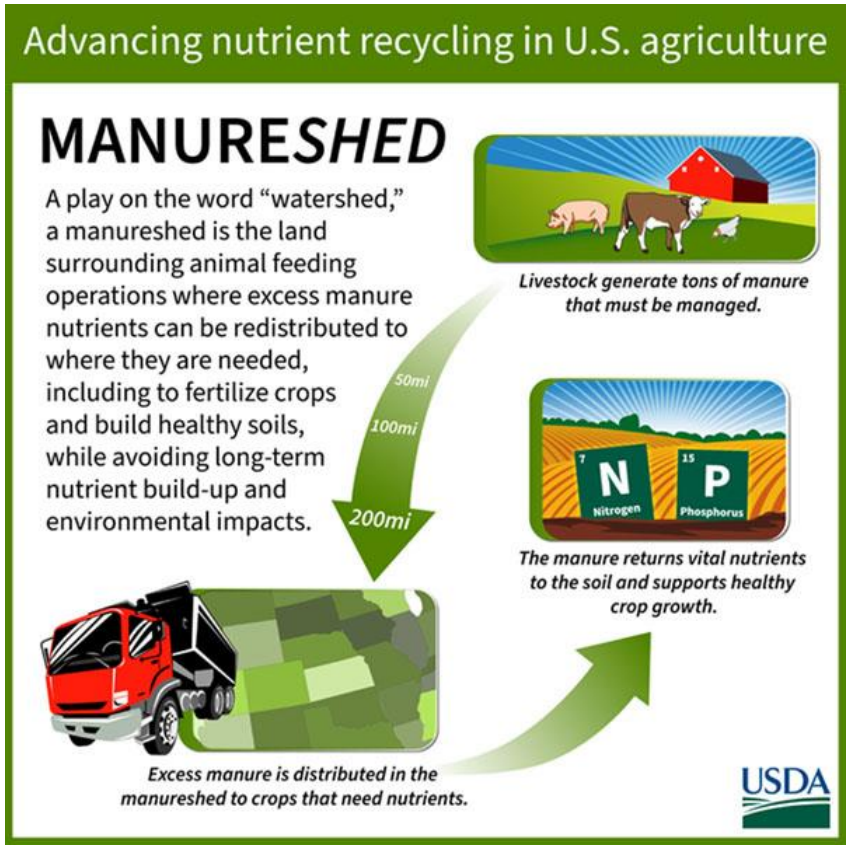


Landscapes of Stormwater Management

Overview of Objectives

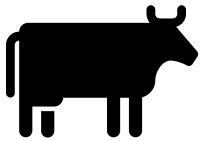


Case Study: Manureshed

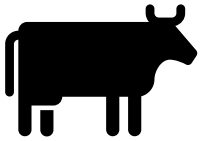


Case Study: Manureshed

180,000 farms in the northeast

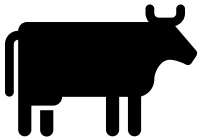


250 Cows

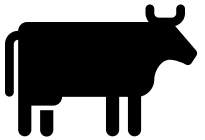


250 Cows

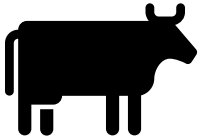
250 Cows



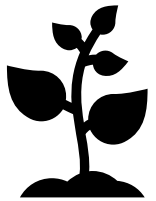
250 Cows



250 Cows



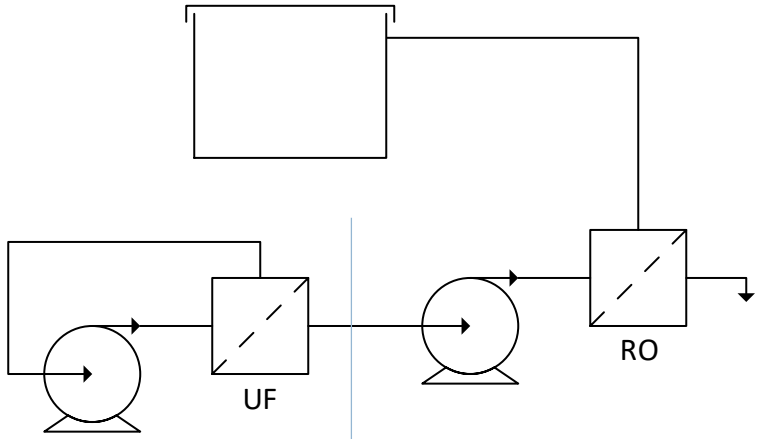
250 Cows



Case Study: Manureshed

Variables: DAF or no DAF?

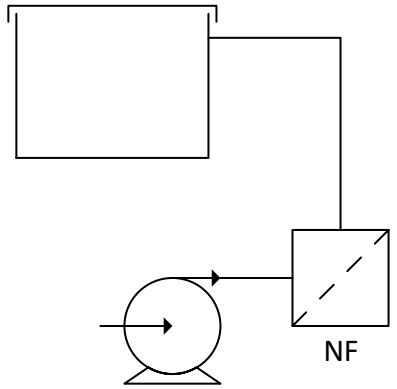
Option 1



Tubular

Spiral

Option 2

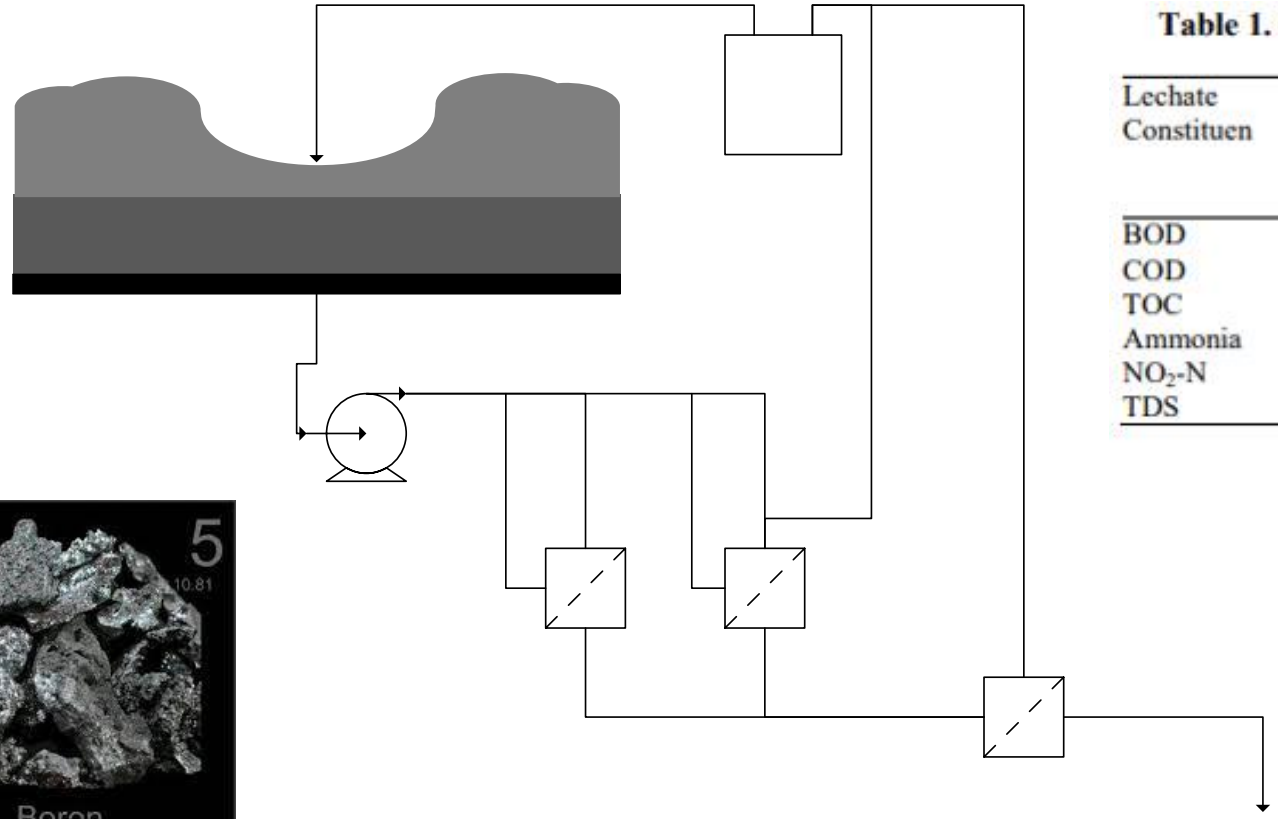


Tubular

Case Study: Manureshed

	250 Cow	500 Cow	1000 Cow
Feed flow rate (gpm)	14	28	56
Required permeate 2 press system (gpm)	13.3	26.6	53.2
Concentrate 2 press system (gpm)	0.7	1.4	2.8
m2 membrane area to make permeate	76	151	302
# of A37 membranes	16	30	60
Required permeate DAF (gpm)	13.72	27.44	54.88
Concentrate DAF (gpm)	0.3	0.6	1.1
m2 membrane area to make permeate	78	156	312
# of A37 membranes	16	30	60

Case Study: Leachate



Typical representation of Leachate Quality (Raw)

Table 1. Concentration of some leachate constituents at different phase

Lechate Constituen	Transition phase (0- 5 years)	Acid formation phase (5-10 years)	Methane Fermentation (10-20 years)	Final maturation phase(>20)
BOD	100-11000	1000-5700	100-3500	4-120
COD	500-22000	1500-71000	150-10000	30-900
TOC	100-3000	500-28000	50-2200	70-260
Ammonia	0-190	30-3000	6-430	6-430
NO_2-N	0.1-500	0.1-20	0.1-1.5	0.5-0.6
TDS	2500-14000	4000-55000	1100-6400	1460-4640

DESIGN SPECIFICATION

Duty Specification (nominal)

Feed:	Landfill leachate (methanogenic)
Feed volume:	10,000 gpd
Feed TDS:	up to 1.9 ppt
Feed pH:	6 to 6.5 (corrected by sulfuric acid if necessary)
Volumetric concentration factor:	10 times
Operating temperature:	70 to 85 deg F
Operating pressure:	500 to 800 psi
Maximum operating pressure:	900 psi

Case Study: Landfill Leachate

Full Run						
Run Date	Total Permeate	Run Time	Average Permeate Rate	Temp	Start Conductivity	Final Conductivity
		Hours	Gpm			
11/14/2015	2685.36	7.63	5.863	69.45	19.328	45.438
1/26/2016	2345.59	8.67	4.511	60.97	17.134	38.283
3/5/2016	3089.74	8.00	6.437	69.77	13.279	40.013
3/17/2016	2723.72	7.20	6.305	67.68	11.19	38.935
3/18/2016	2668.58	10.88	4.087	66.98	14.214	37.963
4/27/2016	2085.43	9.37	3.711	69.46	12.06	30.735

Oystra®

Oystra® is a modular wastewater processor capable of producing clean and safely dischargeable water from human septage and other forms of organic waste. Oystra® receives infeed wastewater and cleans the water to the level required by the application. Approximately 50-75% of the incoming volume is converted to high quality water for reuse.

A REVOLUTIONARY WAY TO CLEAN WATER

CRANE ENGINEERING

In collaboration with

Membrane SPECIALISTS

WHAT ARE THE BENEFITS?

75% TREATED WATER

25% CONCENTRATE

HIGH WATER RECOVERY

Treated water is discharged to environment

SOLIDS CAPTURE

Consolidated disposal or potential nutrient re-use

EASE OF USE

Modular design with complete automation improves operation and reliability

Oystra®

WHAT CAN OYSTRA DO FOR YOUR WASTE STREAMS?

WATER & FOOD PROCESSING

Pharmaceutical and Personal Care Products > 90% Removal of Most PPCP Compounds

HUMAN WASTE

OYSTRA® EFFLUENT QUALITY FROM HUMAN SEPTAGE TESTING IN WI & WA							
	USE	BOD mg/L	COD mg/L	E Coli MPN/100mls	TSS mg/L	pH	Turbidity NTU
Oystra Gold	Surface Dischargeable	33	35	1.4	2	6.5	0.95

INDUSTRIALWASTE

Isolate harmful contaminants and produce dischargeable clean water

Per- and Polyfluoroalkyl Substances (PFAS)

> 90% Removal of PFAS by RO

ANIMAL WASTE SWINE & DAIRY

Fatty and Organic Solids separation and liquid clarification

Oystra®

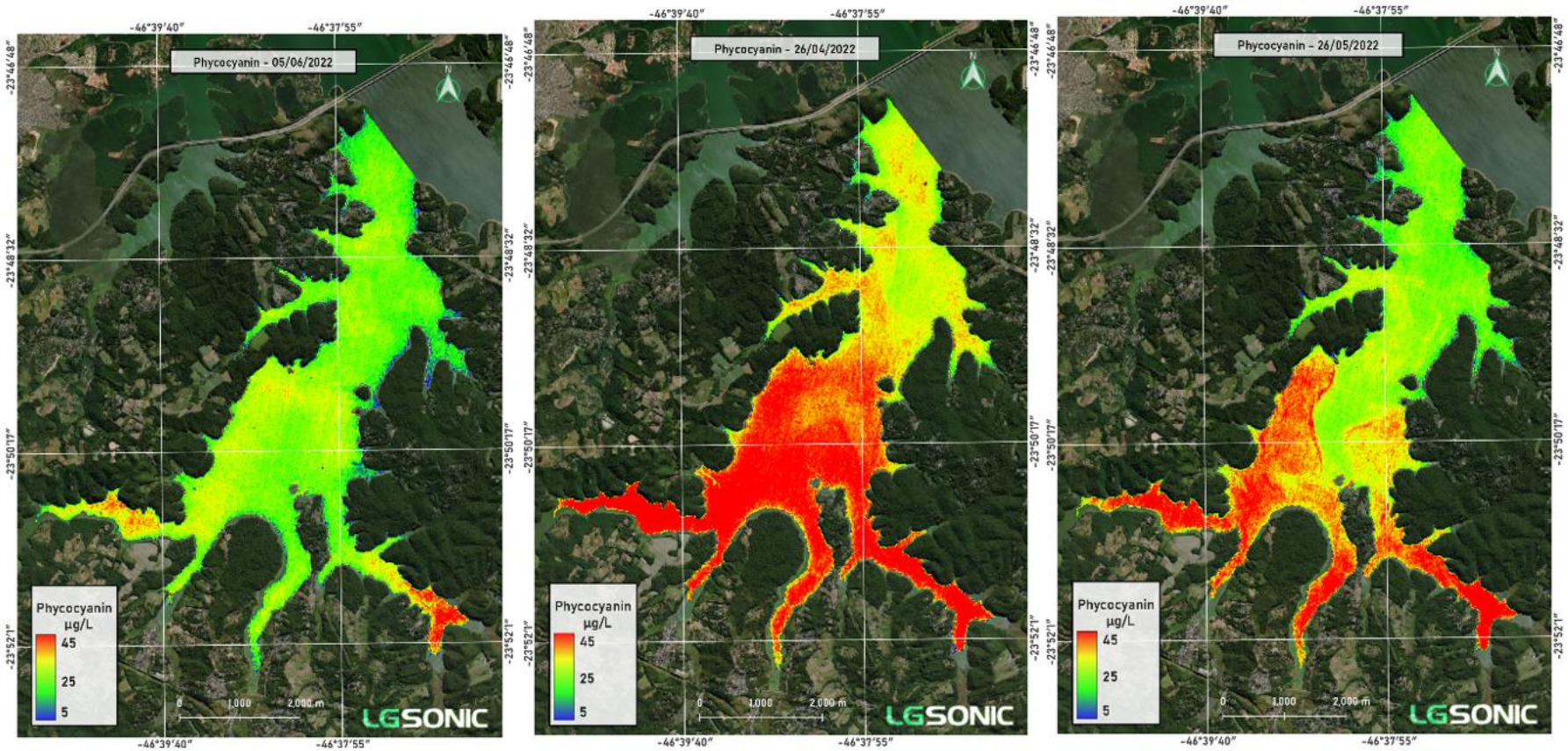
AUTOMATION

Modular design and intelligent programming support robust processing regardless of feed material.

Complete automation prevents down-time and mechanical failure freeing the operator to manage the facility.

Oystra®

Case Study: HABs



"Eutrophication, a process where nitrogen and phosphorus build up in a water body, is one of the main pollution issues endangering freshwater lakes. The growth of potentially harmful algae blooms (HAB), which can be extremely toxic, results from eutrophication. Globally, over 100,000 lakes experience HABs."

Source: World Economic Forum https://www.weforum.org/agenda/2022/09/freshwater-lakes-toxic-algal-bloom/

Case Study: HABs

Factors which effect HABs:

- Temperature
- Season
- Time of Day
- Depth of Intake
- Weather events/factors

“During the night, some ocean algae species can swim up to 20 meters down.”

Questions:

- How much of the HABs needs removed?
- What daily volume would be required to mitigate an area?
- What is the waste stream?
- Monitoring and mitigation integration?

Perhaps in the future?

- Lagoon Cleanup
  - Collaborate across multiple sites
- WWTP to WTP
  - Can stormwater influence feasibility
- Other Industrial Runoff

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QUIZ

1. What type of membrane is best for cow poop?
    A. It depends
    B. A only
    C. All of the above

2. Provided all geometries work, which is the most capital cost effective membrane?
    A. Ceramic
    B. Tubular and Ceramic
    C. Spiral
    D Hollow Fiber

3. What is the best membrane format?
    A. It depends
    B. A only
    C. All of the above

3. What is the best system design for apple juice clarification?
    A. It depends
    B. A only
    C. All of the above

5. Which range of membranes excludes viruses and bacteria?
    A. Microfitration, Ultrafiltration, Nanofiltration, Reverse Osmosis
    B. Ultrafiltration, Nanofiltration, Reverse Osmosis
    C. Nanofiltration, Reverse Osmosis
    D. Reverse Osmosis only

6. What is the difference between Nanofiltration and Ultrafiltration?
    A. It depends
    B. A only
    C. All of the above

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Separation is the Solution to Sustainability

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Membrane SPECIALISTS

THANK YOU!

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