CampusEnergy2021

BRIDGE TO THE FUTURE

Feb. 16-18 | CONNECTING VIRTUALLY

WORKSHOPS | Thermal Distribution: March 2 | Microgrid: March 16

Cooling Tower Blowdown Recovery

at the Ucla Cogeneration Facility

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Q&A Will Not Be Answered Live

Please submit questions in the Q&A box.
The presenters will respond to questions off-line.

Project History

2013

Evaluation of Status Quo
Cooling Tower Blowdown of 27 million gallons of water per year and ongoing drought conditions

2014

Sustainability Study
UCLA study to identify opportunities to reduce the use of municipal water at the UCLA Cogeneration facility

2015

Design & Procurement
UF/RO selected as most efficient and effective solution

2016

Blowdown Recovery System Commissioning
Blowdown Recovery System placed online to recover and reuse cooling tower blowdown

Worley energy | chemicals | resources

Ucla

Kurita

- *In 2016, the UCLA Cogeneration facility commissioned a cooling tower blowdown recovery system to recycle water used by the cooling tower in order to reduce usage of municipal water supply*
- *Concept designed to remove particulates and dissolved solids from the cooling tower water and return 45% to the cooling tower as make-up*
- *Since implementation, this concept has recycled over **30 million gallons** of water*
- *Estimated reduction in cooling tower water use of 5% with a goal of returning an average of 1 million gallons of blowdown to the cooling tower each month*

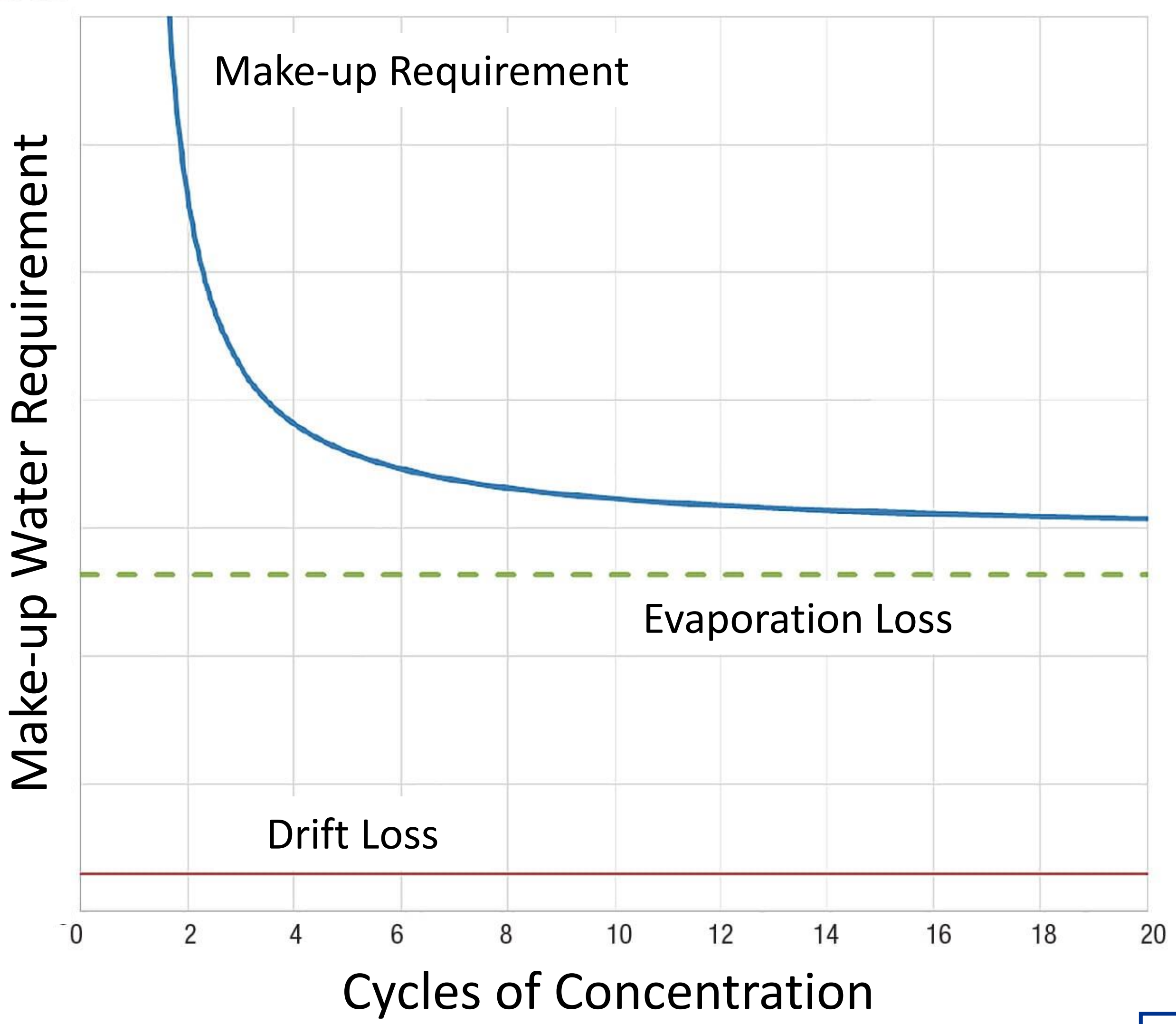
Concept Consideration

Why was blowdown recycling chosen as the most effective way to reduce water use when compared to make-up water pretreatment?

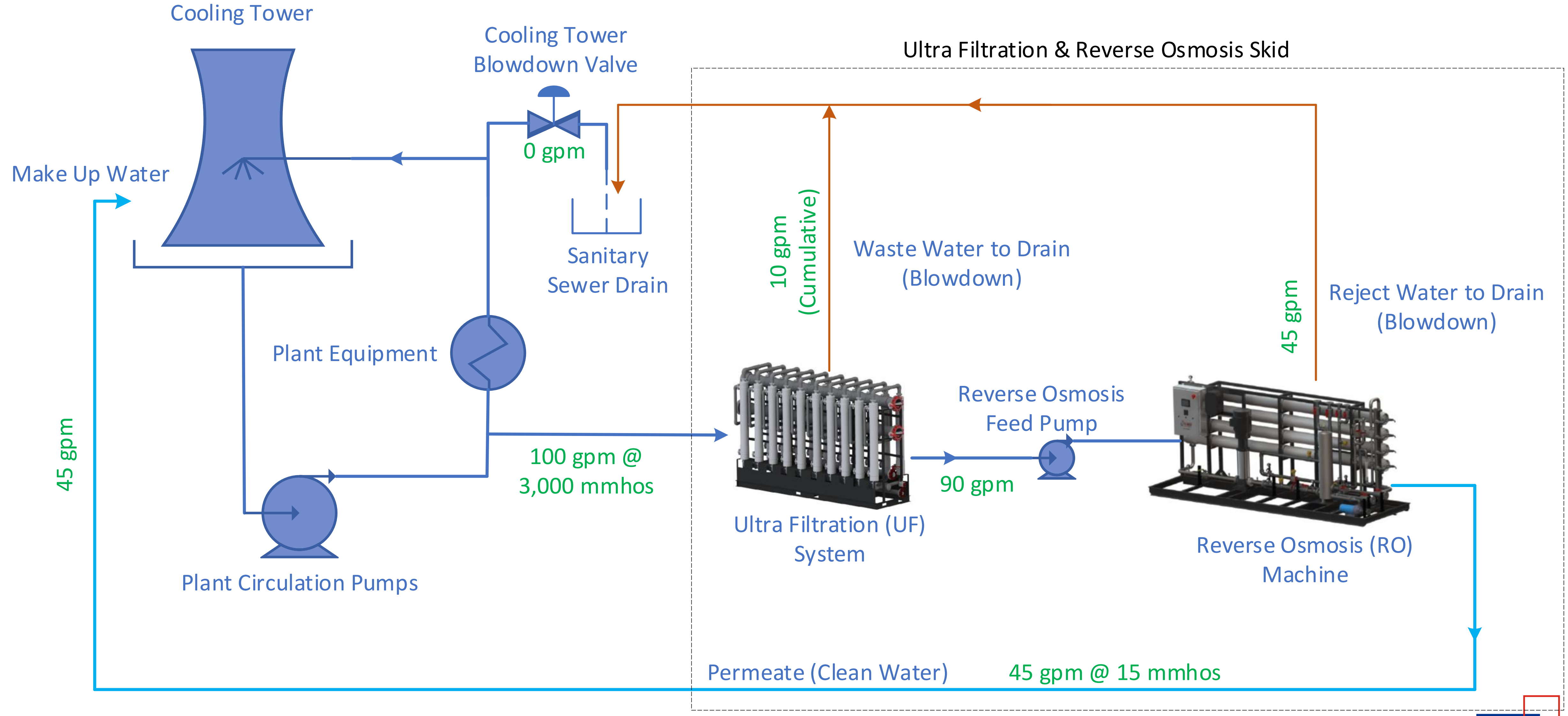
- Make-up water savings diminish as plant cooling tower cycles of concentration increase
- Less water volume considering evaporation

Can it be done efficiently?

- Not a common water treatment process
- Ability to control operational costs to support overall economics of solution were somewhat unknown



Process Flow Diagram and Design Parameters



Ultrafiltration

- Fixed porous barrier
  - Hollow fiber PVDF
  - 0.3 mm wall thickness
- Removes bacteria, viruses, silts, sand, and other suspended solids, reducing turbidity
- Reduces Silt Density Index (SDI), serving as excellent RO feed water pretreatment
- High water production rates with a smaller footprint when compared to alternatives

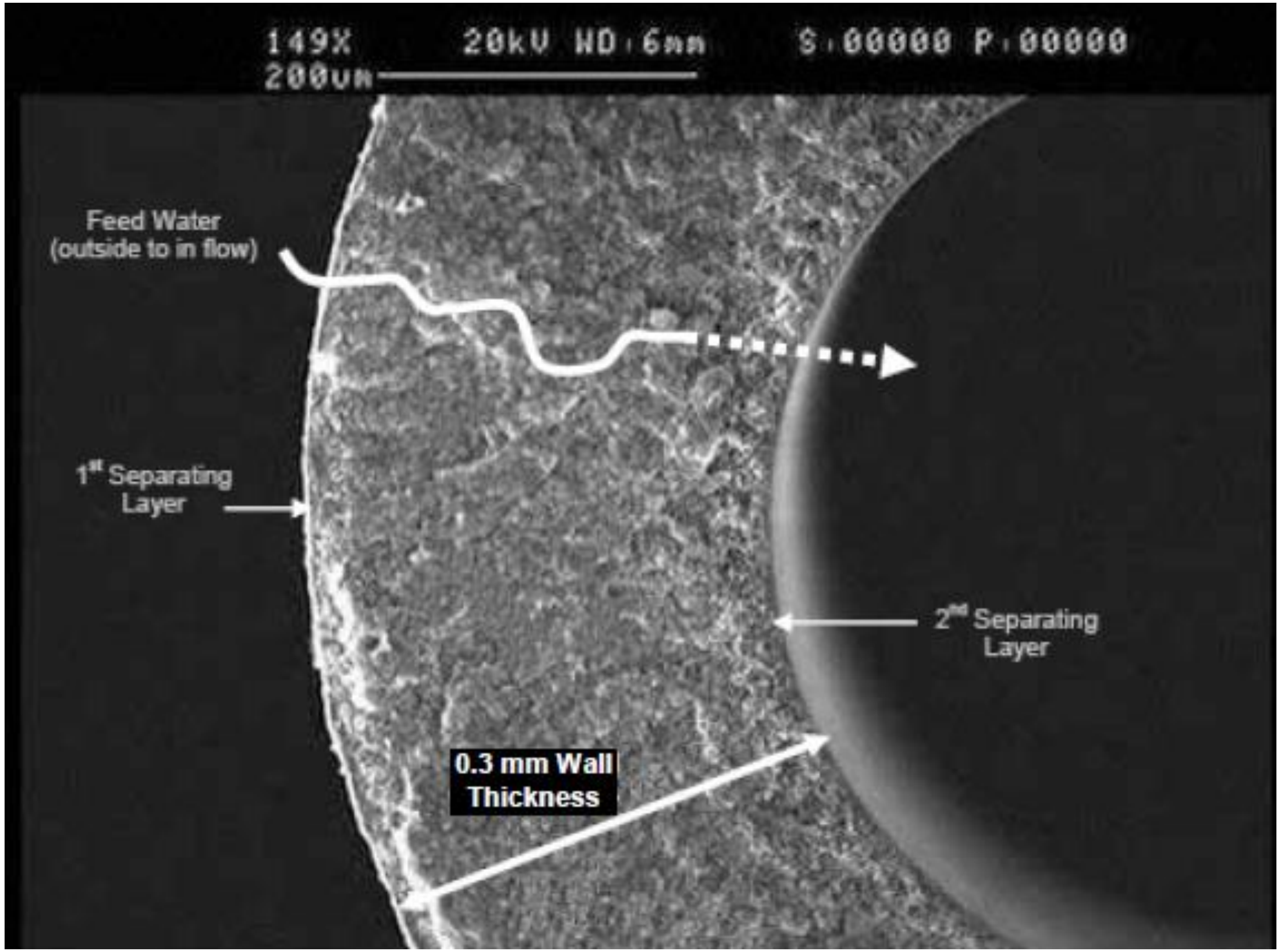
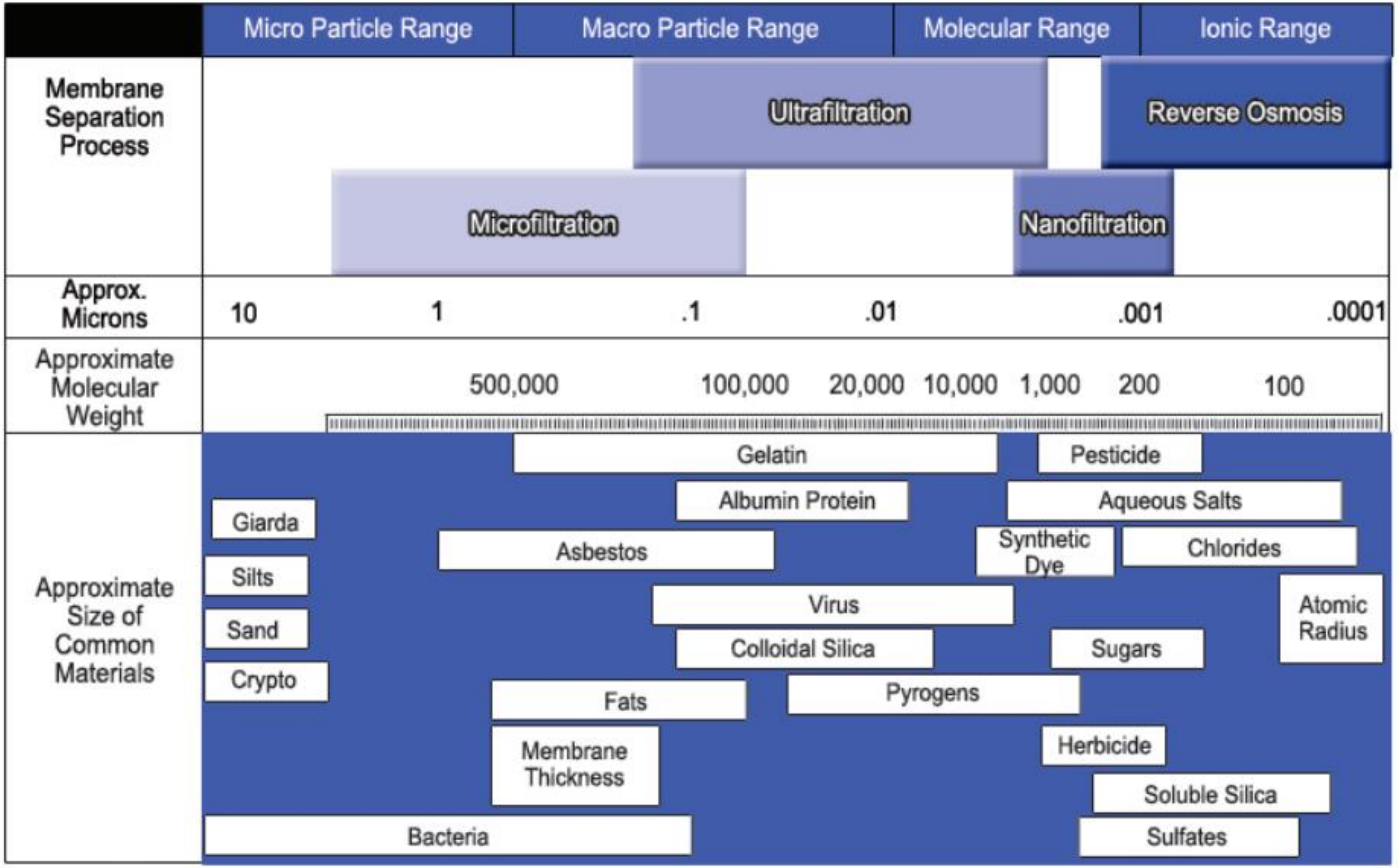


Photo from DOW UF Manual

Filtration Spectrum



Ultrafiltration System

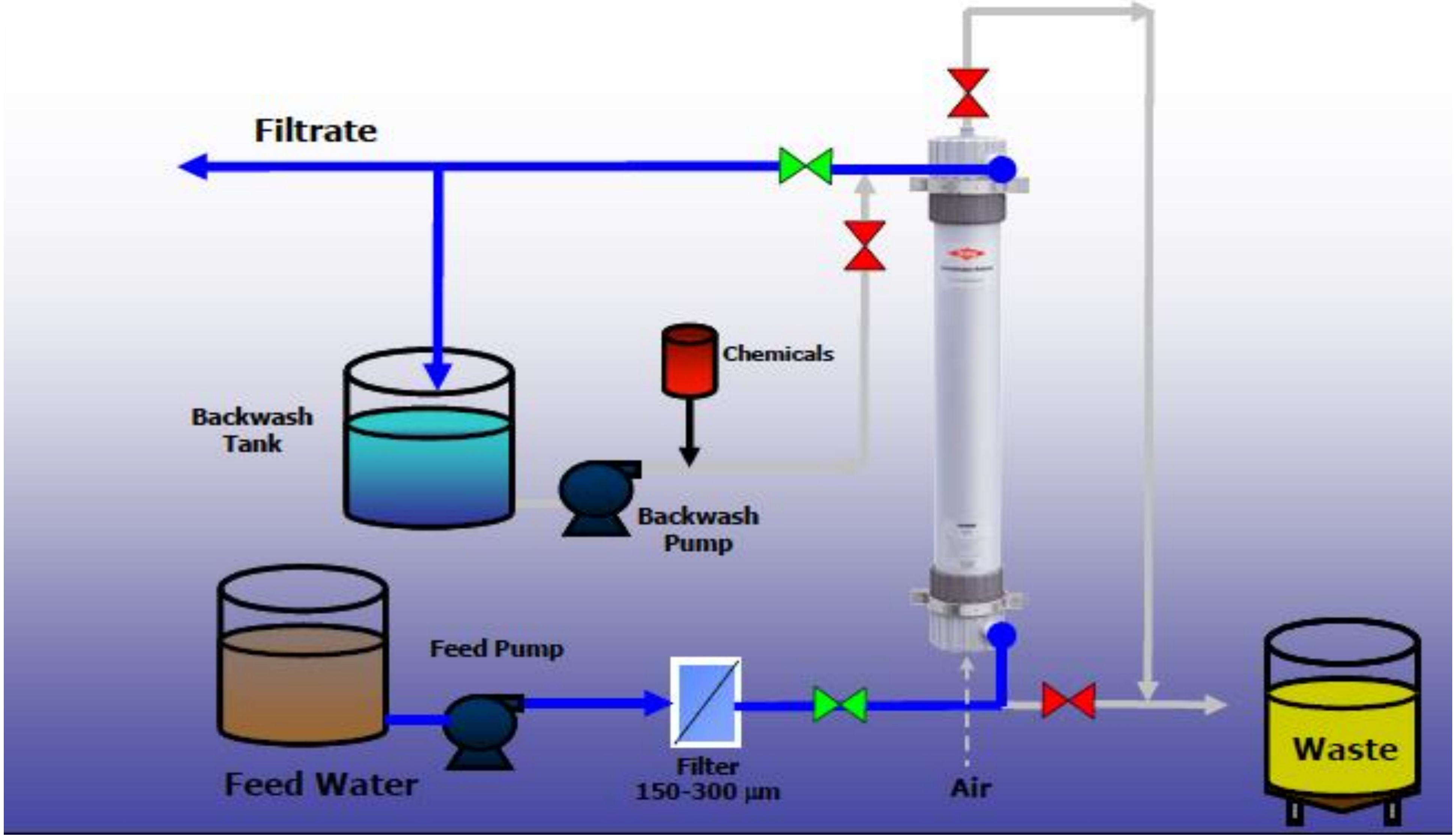
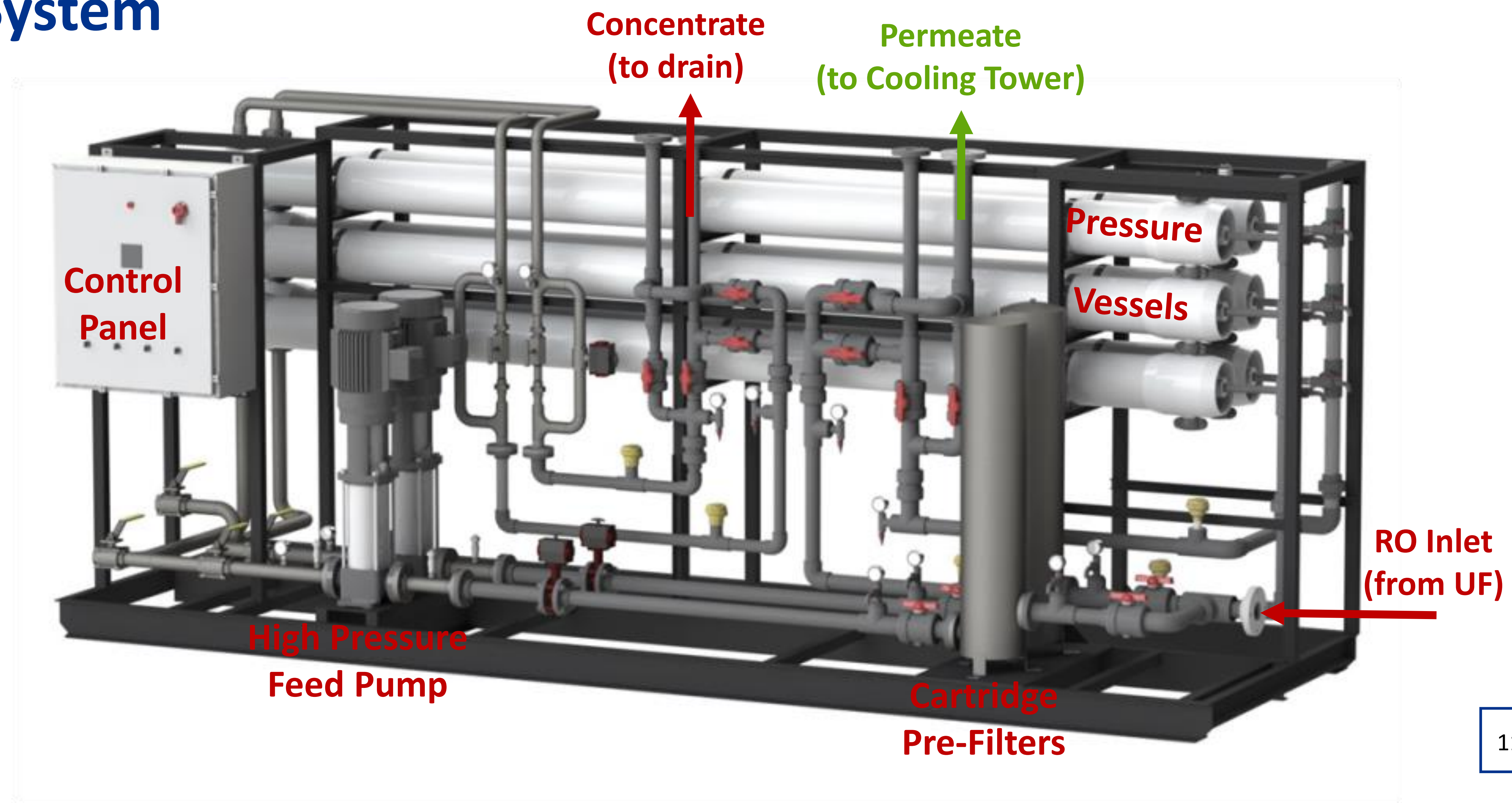
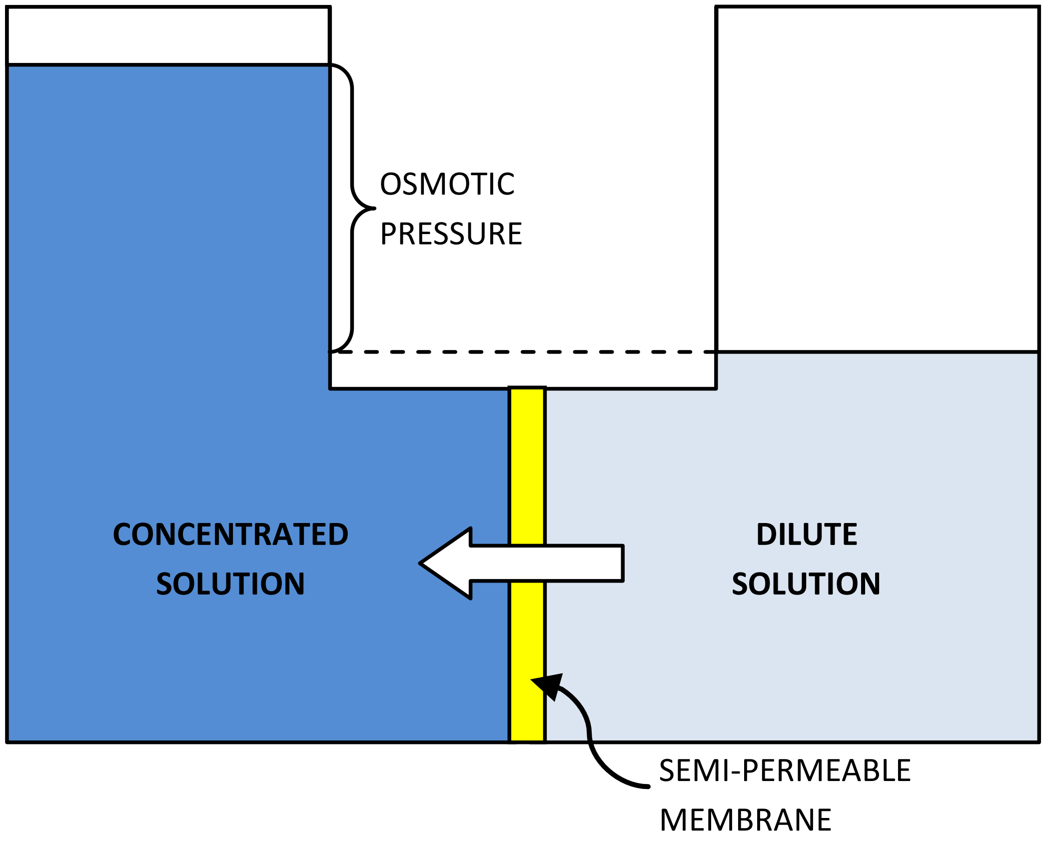


Diagram from DOW UF Manual

Reverse Osmosis System

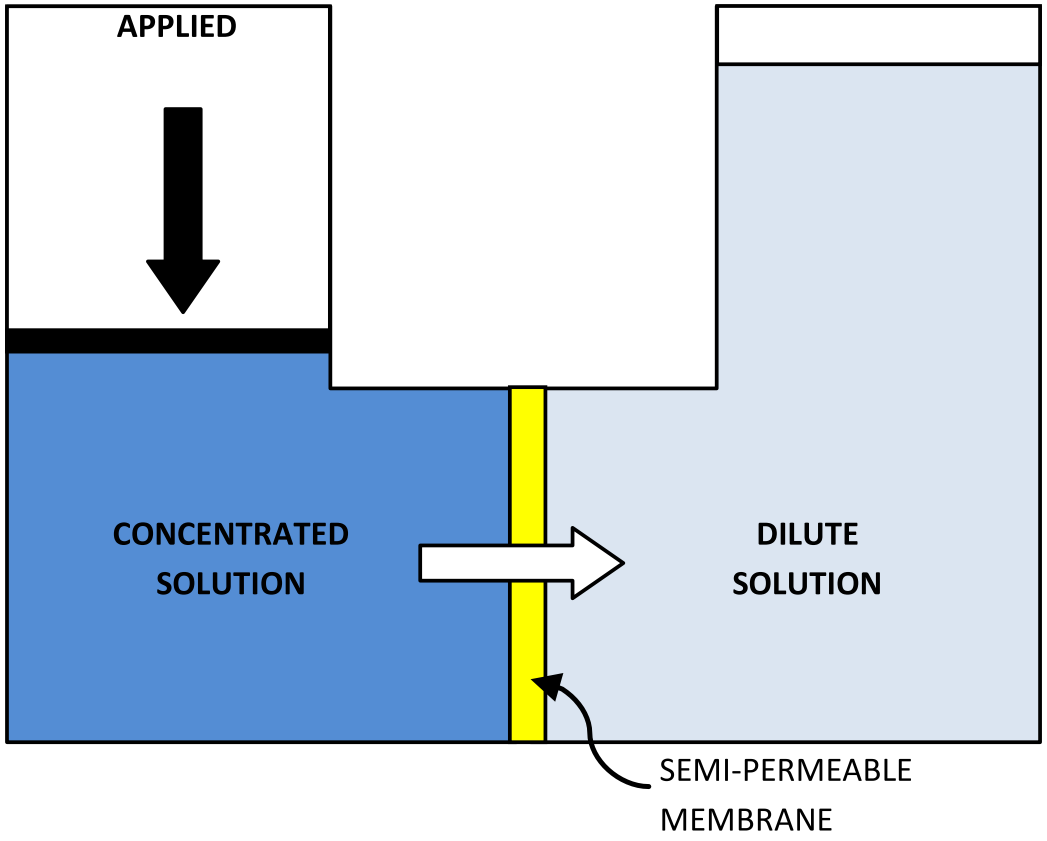


Osmosis



Water diffuses through a semi-permeable membrane from dilute solution to concentrated solution in order to equalize solution strength. Ultimate height difference between columns is the "osmotic" pressure.

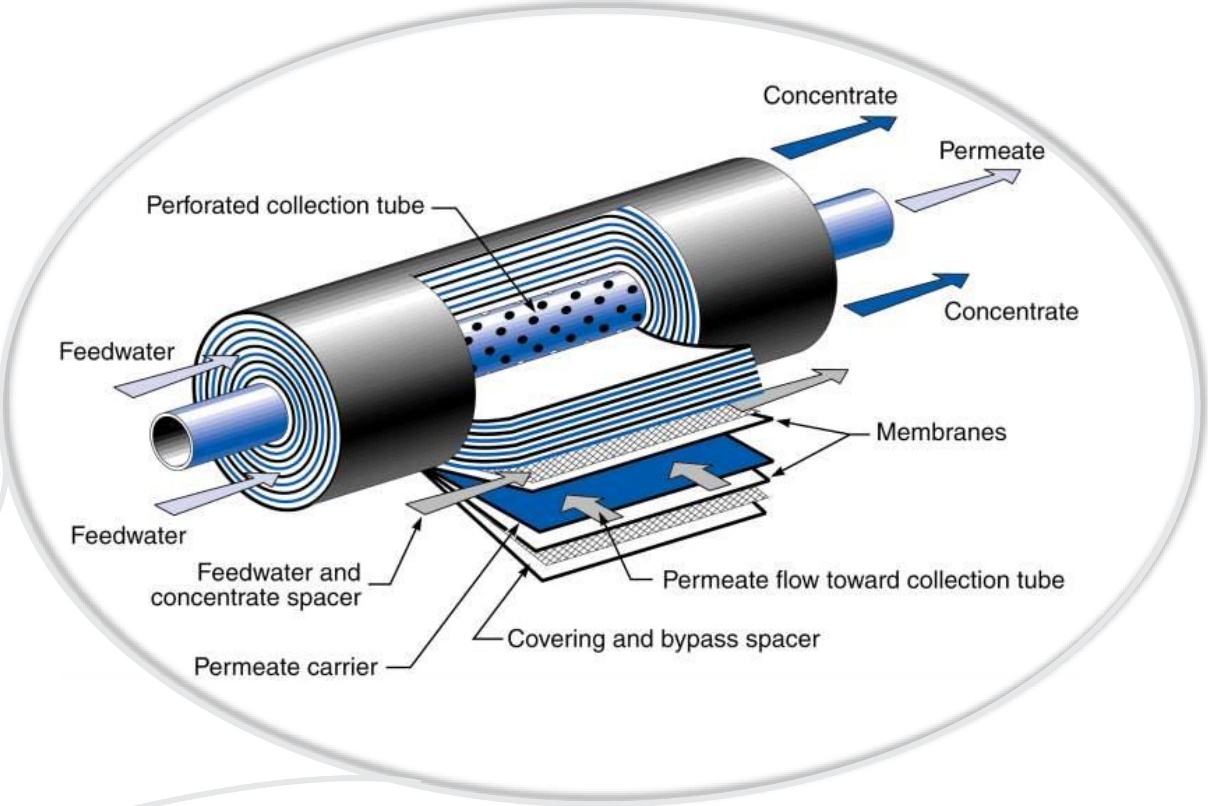
Reverse Osmosis

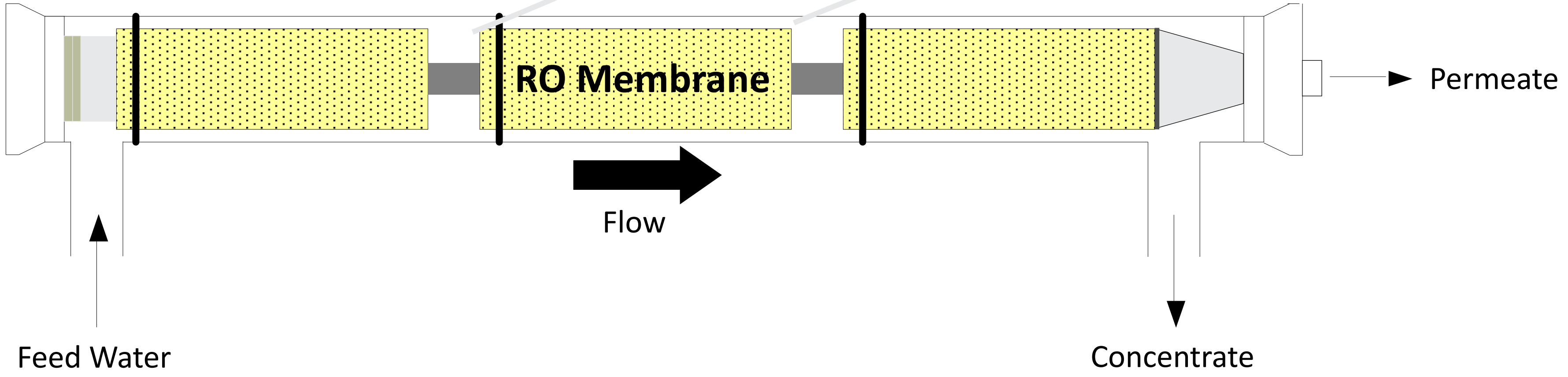


Applied pressure in excess of osmotic pressure reverses water flow direction. Hence the term "reverse osmosis".

Reverse Osmosis

- Spiral wound membrane contained in fiberglass vessels
- Removes dissolved solids to produce high purity water (“permeate”)
- Dissolved solids concentrate on outside of membrane and discarded through wastewater (“reject”)
- Susceptible to fouling
  - Scale Formation
  - Excessive Bacteria
  - Particulates





Chemistry Parameters

Cooling Tower Water

Conductivity < 3000 umhos
Free Chlorine 0.15 – 0.35 ppm
ATP (Bacteria) < 50 RLU

UF Influent

Turbidity < 30 NTU
TSS < 1 ppm
Iron < 0.10 ppm

RO Feed Water

TDS < 2000 ppm
Free Cl < 0.01 ppm
Cellular ATP = 0 RLU
Silica < 100 ppm
Turbidity < 1 NTU
SDI < 3

RO Permeate

Conductivity
< 50 umhos

Key Performance Indicators

Permeate Production
Water Reused as Cooling Tower Make-up

1,000,000 gallons/month

Operational Costs
- Membrane Maintenance
- Membrane Life
- Chemical Costs
- Service Costs
- System Repairs

< 50% of water savings

System Efficiency
Percentage of UF Inlet (blowdown) returned to cooling tower

> 45% of system Inlet

UCLA ENERGY SYSTEMS

Daily Water Report: 1/4/2021

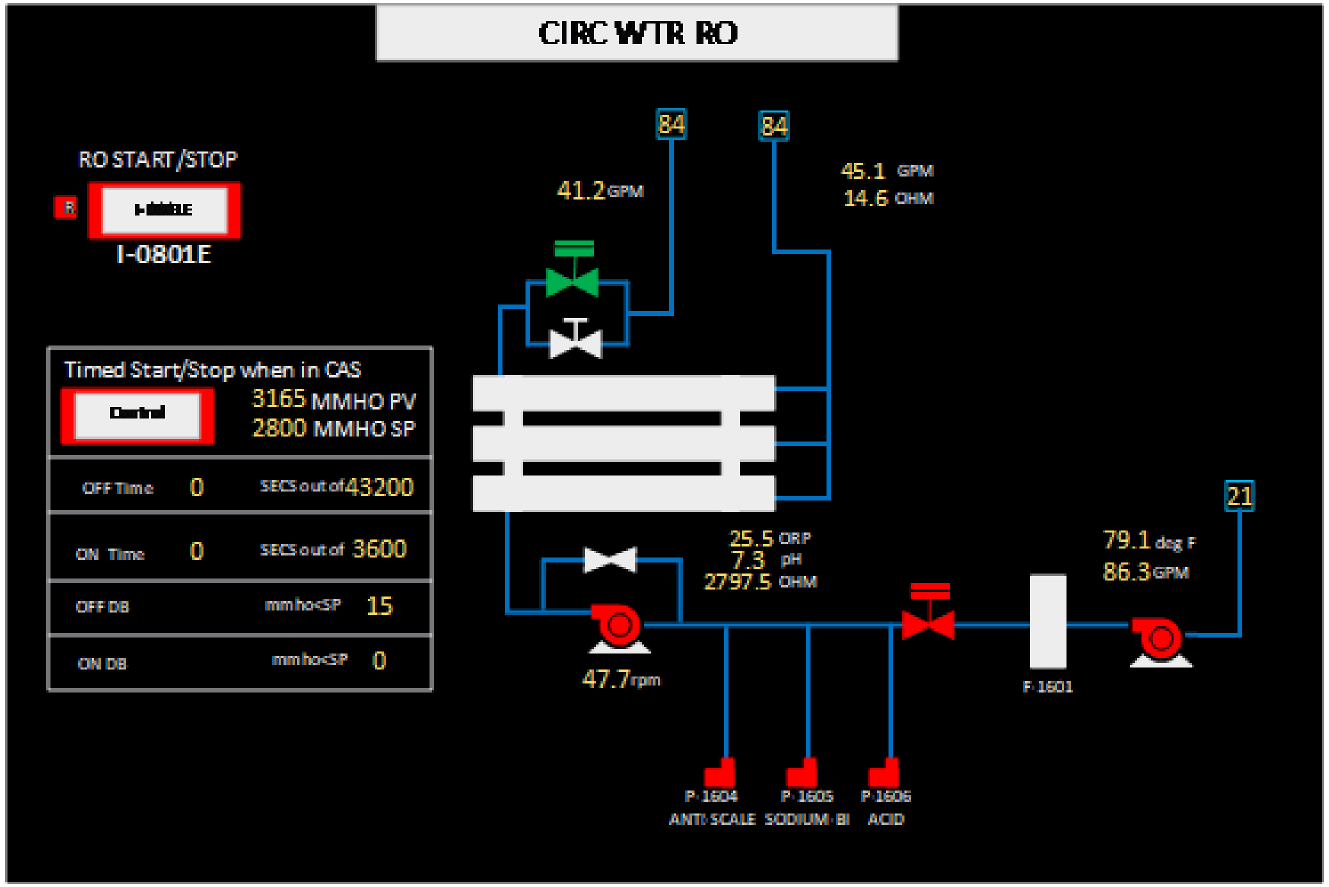
Cooling Tower Summary:

Raw Wtr C.T. Make Up:	173,798 Gallons
CHS C.T. Make Up:	97,930 Gallons
RO C.T. Make Up:	1,889 Gallons
CT Blow Down:	215 Gallons
RO3 Reject:	37,588 Gallons
RO3 Permeate:	38,781 Gallons
Well to CT (direct):	60,500 Gallons
Evaporation:	333,902 Gallons

Blowdown Water Reuse Summary

Lessons Learned – Design & Installation

- Materials of construction
  - Chemical compatibility
  - Corrosive nature of purified water
- Integration of blowdown recovery system into balance and operations of plant
  - On/Off cycling based on conductivity
  - Alarming control scheme
  - Operation based on seasonal load variation
- Wastewater considerations
  - Membrane Clean-In-Place
  - UF Chemically Enhanced Backwash
  - Maintaining proper flow parameters during cleaning steps

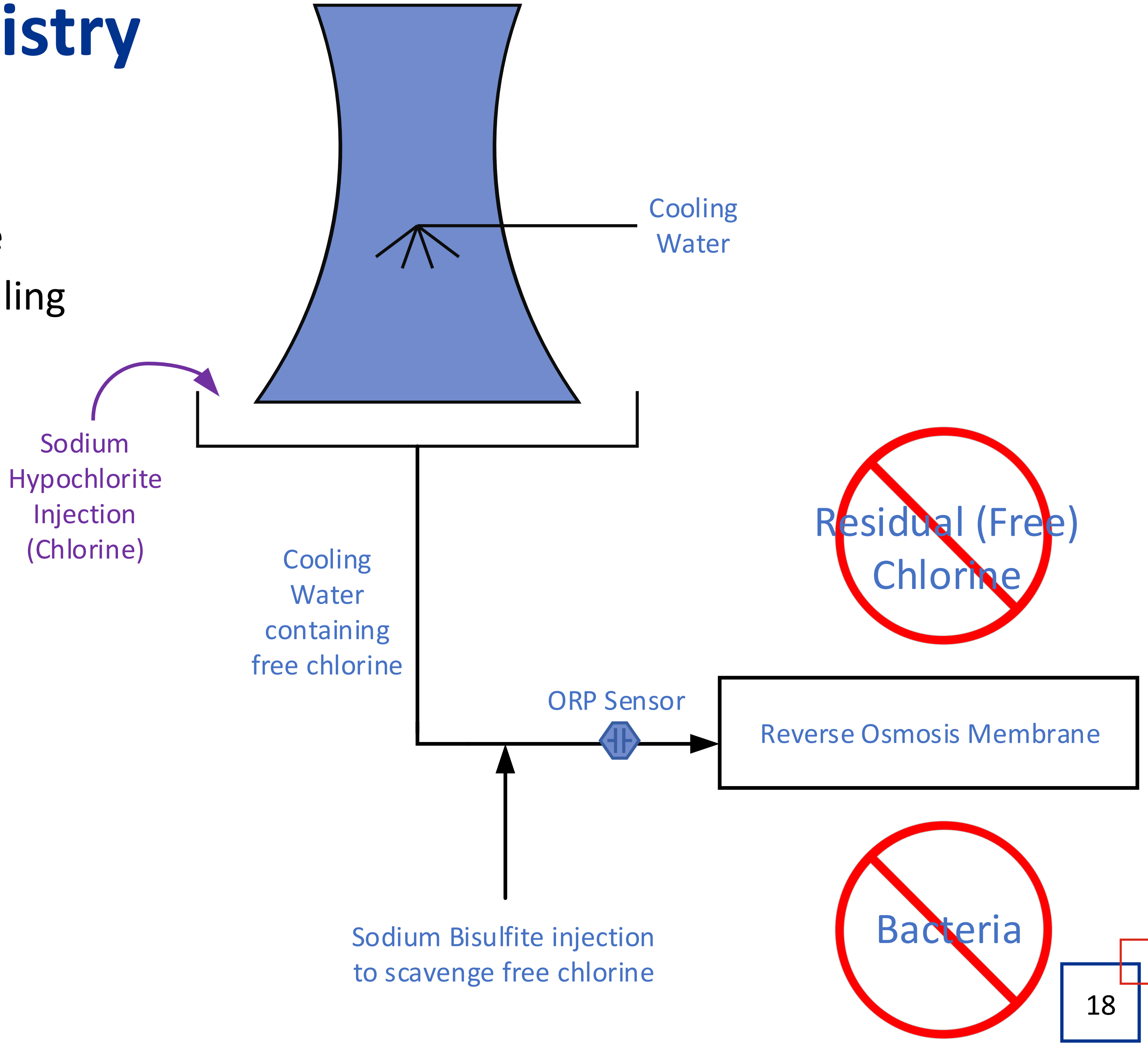


Lessons Learned - Chemistry

- Chemically Enhanced Backwash
  - Discontinued use of sodium hydroxide
  - Use of stronger acid due to metals fouling
  - Increased acid and bleach feed rate

- RO Feed Water Chemistry
  - Bisulfite Injection
  - Control of Biological Activity

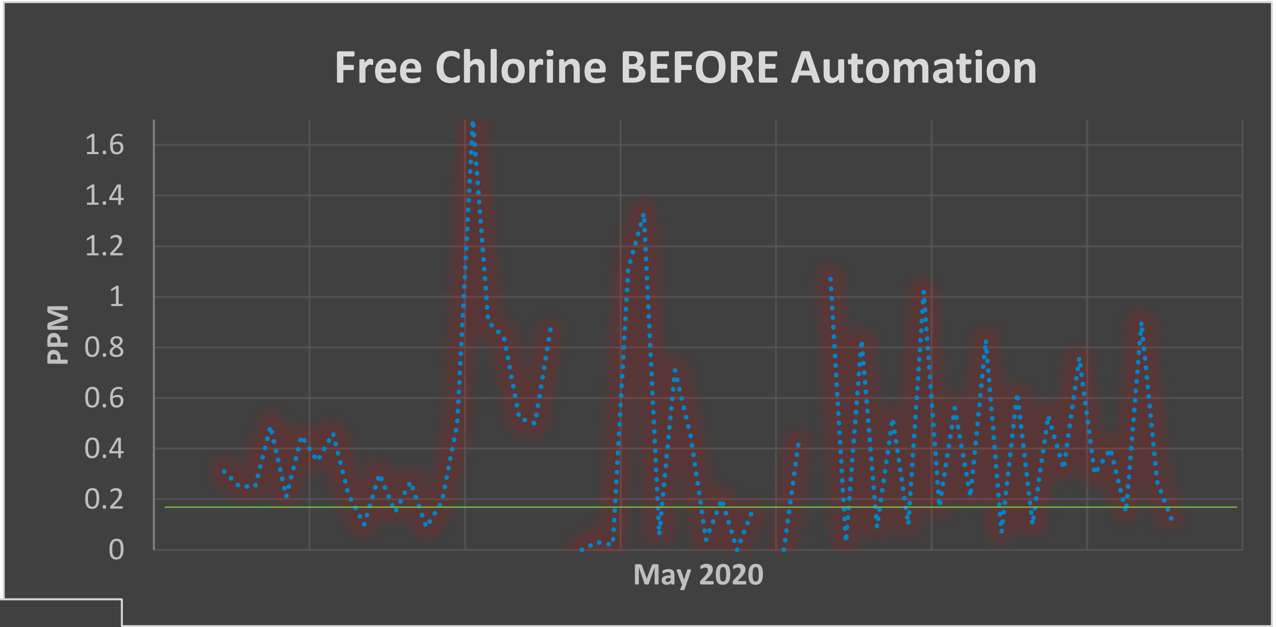
- Tower Chemistry Stabilization
  - Free chlorine control
  - Dissolved & Suspended solids control
  - Control of Biological Activity

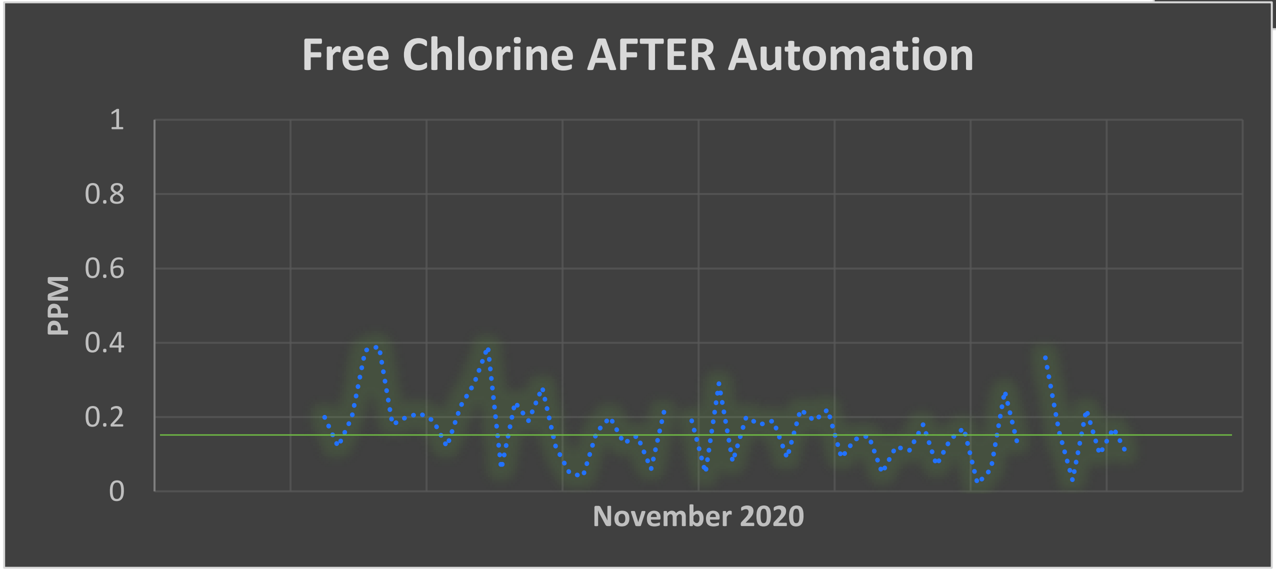


Lessons Learned - Chemistry & Operations

- Manual control of cooling water chemical injection insufficient for blowdown recovery system operation

- Significant fluctuation in free chlorine
  - High free chlorine causes RO to shut down
  - Low Free chlorine causes severe biofouling

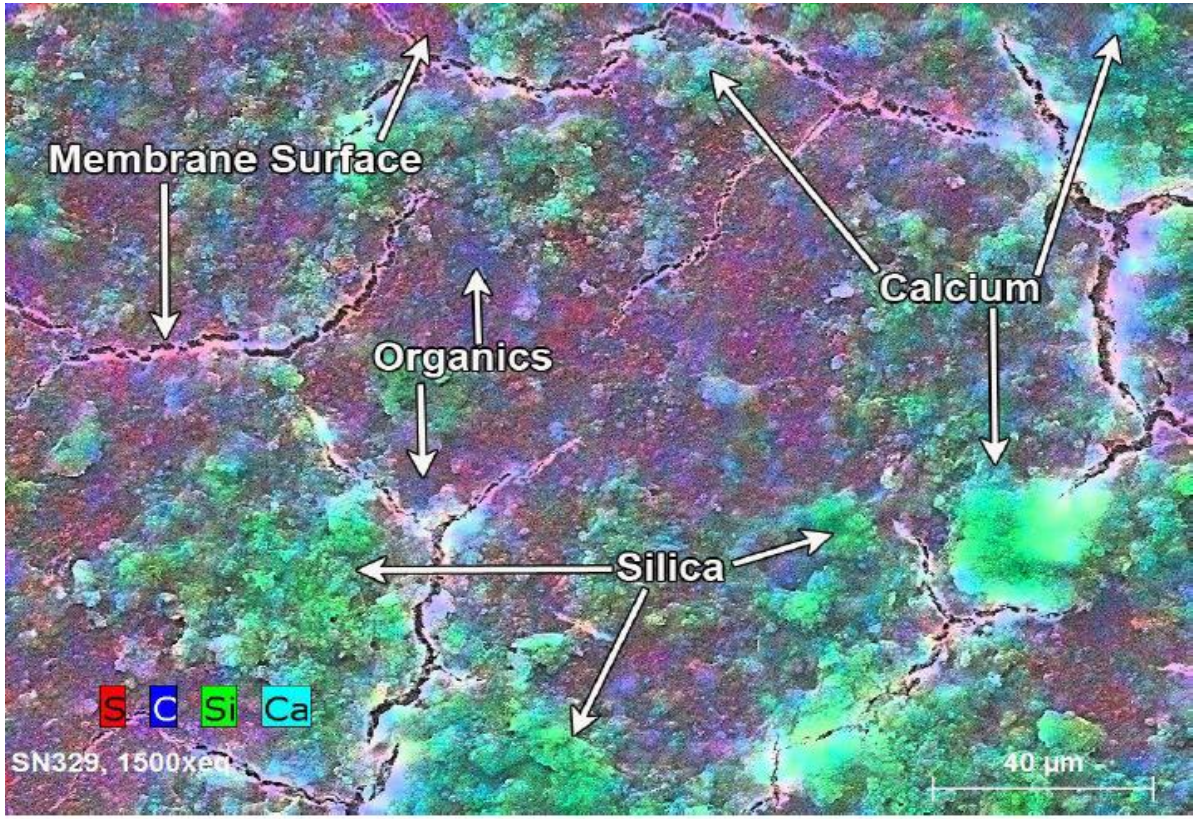




- Installation of Kurita LUMYN controller in 2020
  - Sensor control of key chemistry parameters
  - Automated chemical injection based on sensor values
  - Remote monitoring
  - Stabilized free chlorine concentration

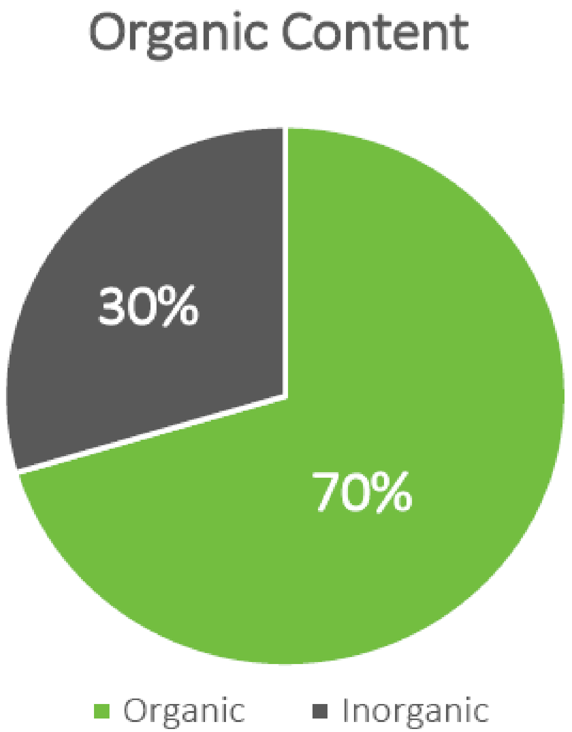
Membrane Analysis

- **Membrane analysis performed by Avista Technologies identified type and extent of membrane fouling**
  - Implementing biocide feed directly into RO
  - Monitor ATP results weekly to evaluate biological activity and adjust biocide program accordingly
  - Antiscalant pump failure likely cause of inorganic fouling, however, may explore alternative product

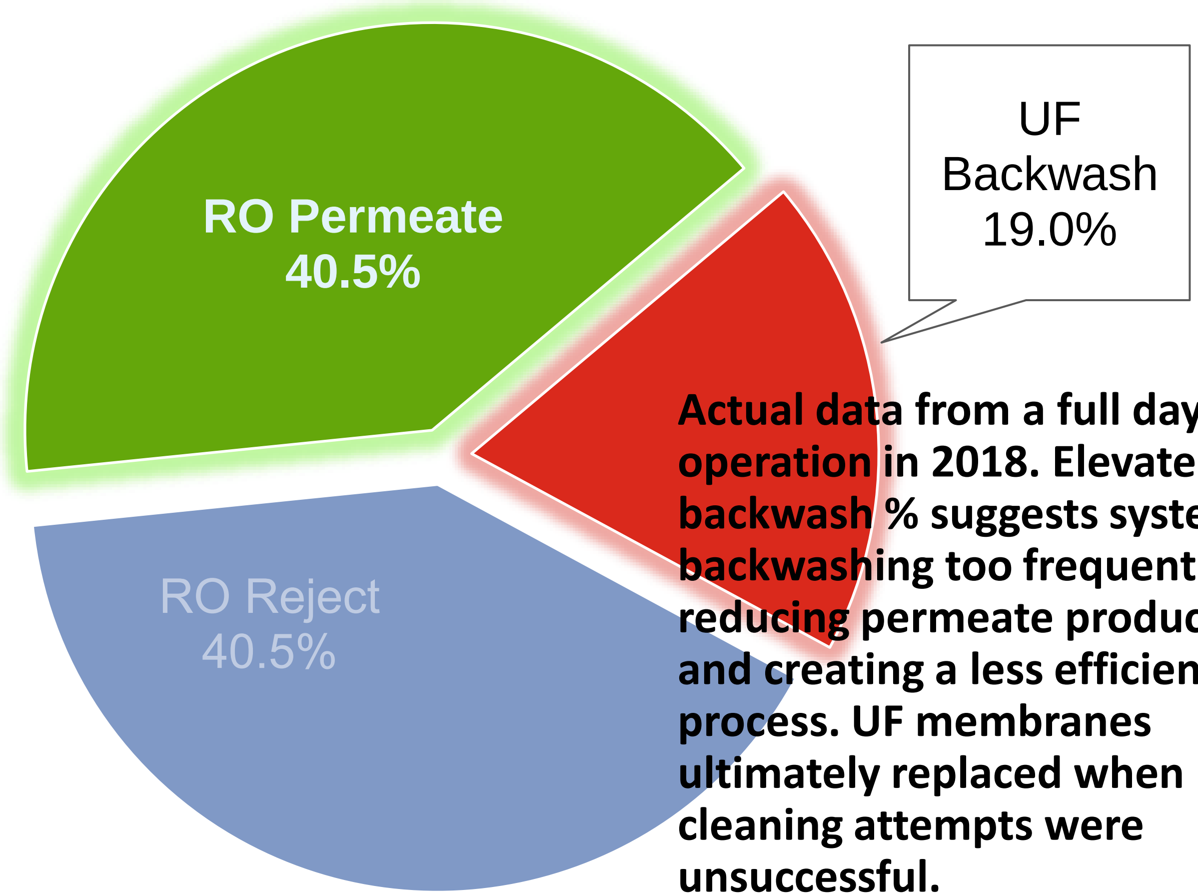


CEI image (1500x) of the membrane surface with labels

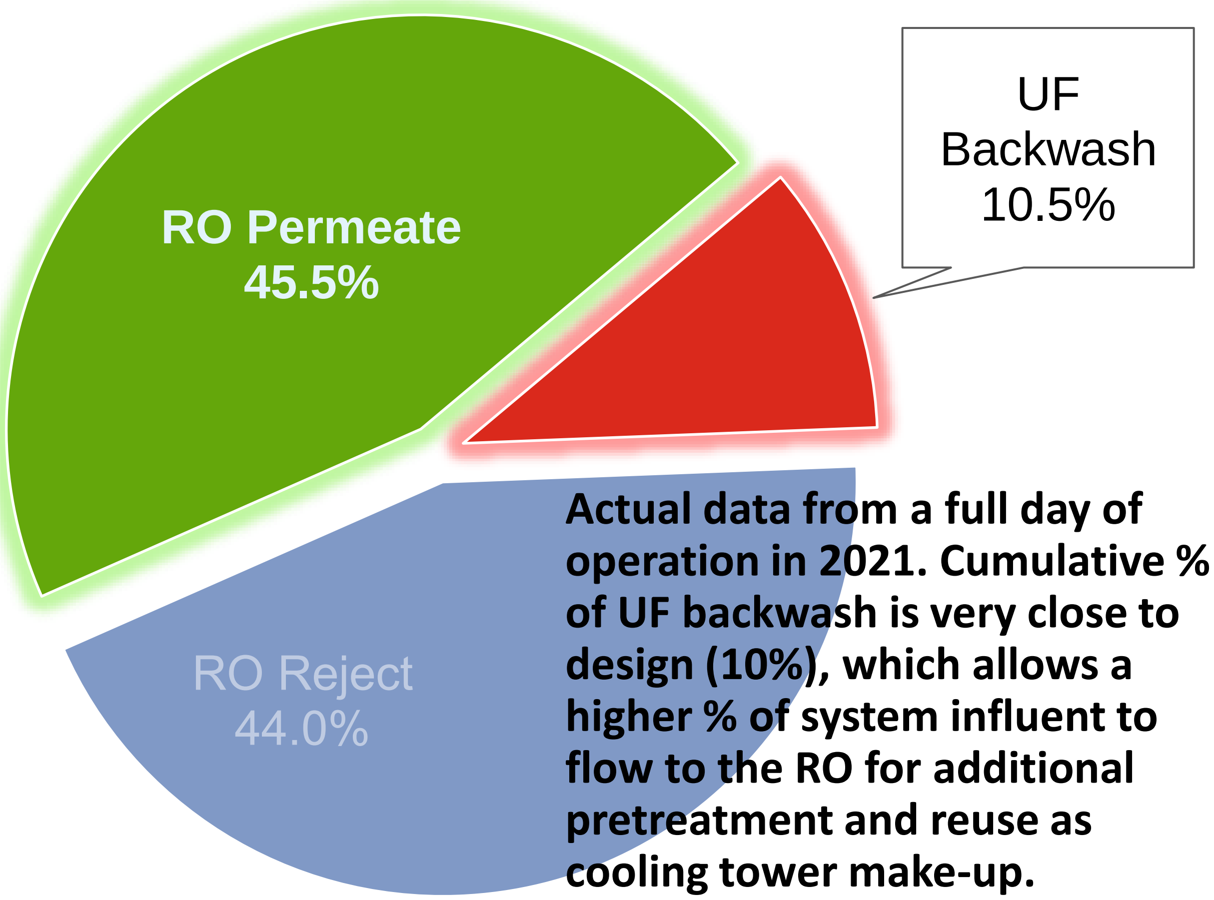
- **Offsite Membrane Cleaning**
  - Second set of membranes to reduce downtime
  - More effective than Clean-In-Place
  - Ability to inspect and evaluate membranes individually
  - Reduces onsite chemical exposure and disposal
  - Reduces membrane maintenance cost



System Influent Breakdown



Actual data from a full day of operation in 2018. Elevated UF backwash % suggests system is backwashing too frequently, reducing permeate production and creating a less efficient process. UF membranes ultimately replaced when cleaning attempts were unsuccessful.

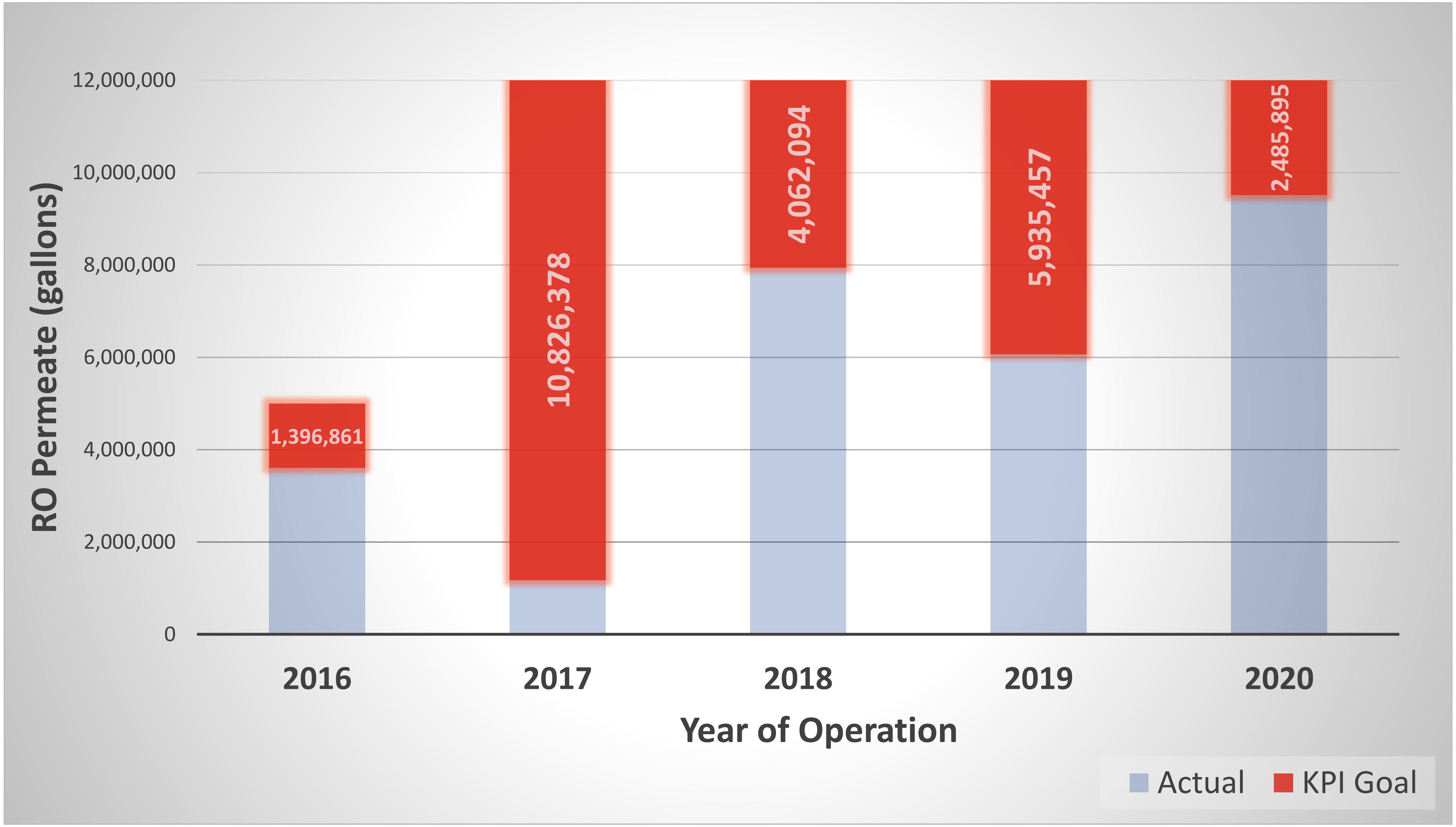


Actual data from a full day of operation in 2021. Cumulative % of UF backwash is very close to design (10%), which allows a higher % of system influent to flow to the RO for additional pretreatment and reuse as cooling tower make-up.

Monitoring permeate production as a % of overall system influent water (blowdown) is important for evaluating system efficiency considering a higher percentage of RO permeate indicates more efficient blowdown reuse. To improve efficiency, adjustments have been made to system operation and monitoring, such as…

- Plant control system alarming
- More in depth operator training
- Increasing RO recovery from 50% to 52.5%
- Reducing RO pre- and post-flush time

Achieving Our Goal



Recent & Future Improvements

- **Recently increased RO recovery based on updated Scale Inhibitor Projection Program (SIPP) results**
- **Supplemental blowdown valve manually operated during cooler months**
- **Less downtime after cooling tower non-oxidizing biocide dose**
- **System PLC program modifications to optimize performance**
- **Remote monitoring and data collection to better identify inefficiencies**
- **Supplemental biocide feed directly into RO to limit biological activity**
- **Explore alternative antiscalant products to eliminate silica fouling and increase recovery**
- **Storage tank to capture water when tower load requires blowdown > UF Inlet (100 gpm)**

Conclusion

In 2020, the blowdown recovery system at the UCLA Cogen was able to reduce municipal water use by

9.5 million gallons

which is equivalent to approximately

$155,000 in reduced utility costs

with

NET savings of approximately $75,000

With continued improvements to system operation and design, we anticipate achieving our goal of

12 million gallons of cooling tower blowdown reused per year

in 2021, which is equivalent to approximately

$200,000 in reduced utility costs for the UCLA Cogen

with

NET savings of over $100,000 per year

Thank you for your time and attention!

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