MBR Treatment of Landfill Leachate and Current PFAS Treatment Technologies

Will Welisevich – Cadex of WNY

NFS – AWMA Enrichment Seminar

1-25-24

Presentation Outline

MBR Treatment of landfill leachate & PFAS treatment options

- Due to other contaminants, treating for PFAS in raw leachate can be difficult and cost prohibitive. Treating Leachate for sewer or direct discharge, then deal with the PFAS
- Why MBR, why Out of Basin MBR?
- MBR followed by RO for concentration of PFAS
- PFAS data from MBR treatment followed by RO

Existing PFAS “treatment” systems:

Discuss several options to further concentrate or encapsulate the PFAS:

- Granular Activated Carbon
- Cement AdMix for spray on daily cover
- “Evaporation” – direct to atmosphere / Mechanical Vapor Recompression
- Foam Fractionation

Discuss options for destruction of PFAS:

- Existing Advanced Oxidation Processes
- Ultraviolet light
- Supercritical Water Oxidation
- Ozone

Definitions:

- **MBR – Membrane Bioreactor Wastewater Treatment System (aerated biological Treatment)**
- **PFAS – In this presentation PFAS will be used for the family of chemicals; Per- and Polyfluoroalkyl Substances (PFAS), including perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS)**

PROJECT QUESTIONS

Client "What is the correct system configuration to provide the necessary quality?"

- **Qualitative characterization**
- **Identify the parameters to be removed to be in compliance**
- **Direct discharge or POTW**
- **Identify technologies best suited for each parameter**
- **Design for complete system that addresses all parameters at the best CAPEX and OPEX**

TYPICAL RAW LEACHATE CONTAMINANTS

Contaminant	Min Value mg/l	Max Value mg/l
Ammonia	350	2200
BOD–5	400	6000
COD	1000	16000
Iron, Total	0.03	6
pH	7.0	8.0
Phenols	0.5	140
TDS	3000	24000
TSS	150	1000
TKN	350	3000
TOC	1000	7000

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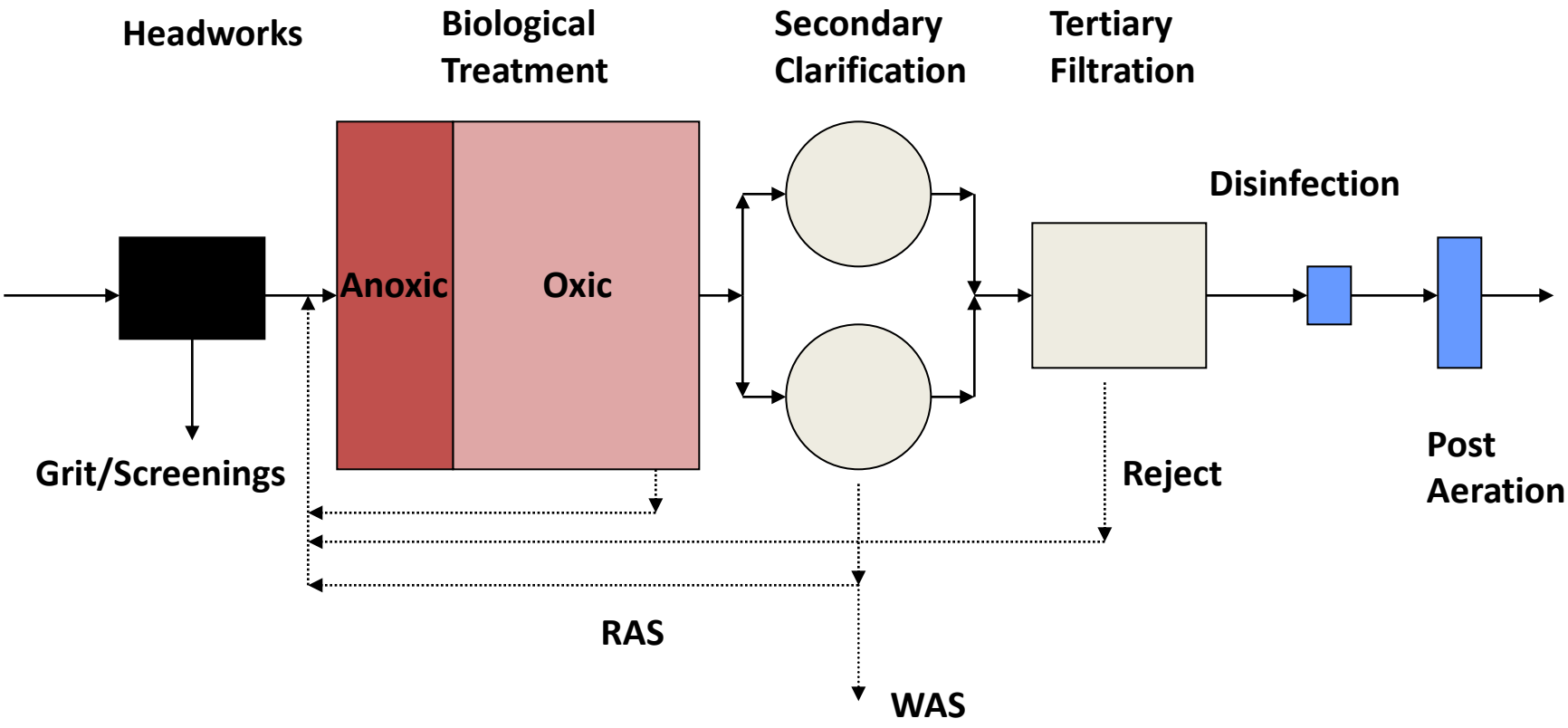
Metals	0.05	18
PFOS	0.001	0.005
PFAS	0.001	0.006
O&G	5	30
Semi-volatiles	0.010	2.0
Volatiles	0.010	1.5
PCB	0.001	0.080
Transmissivity	5%	25%
Mercury	0.0003	0.002

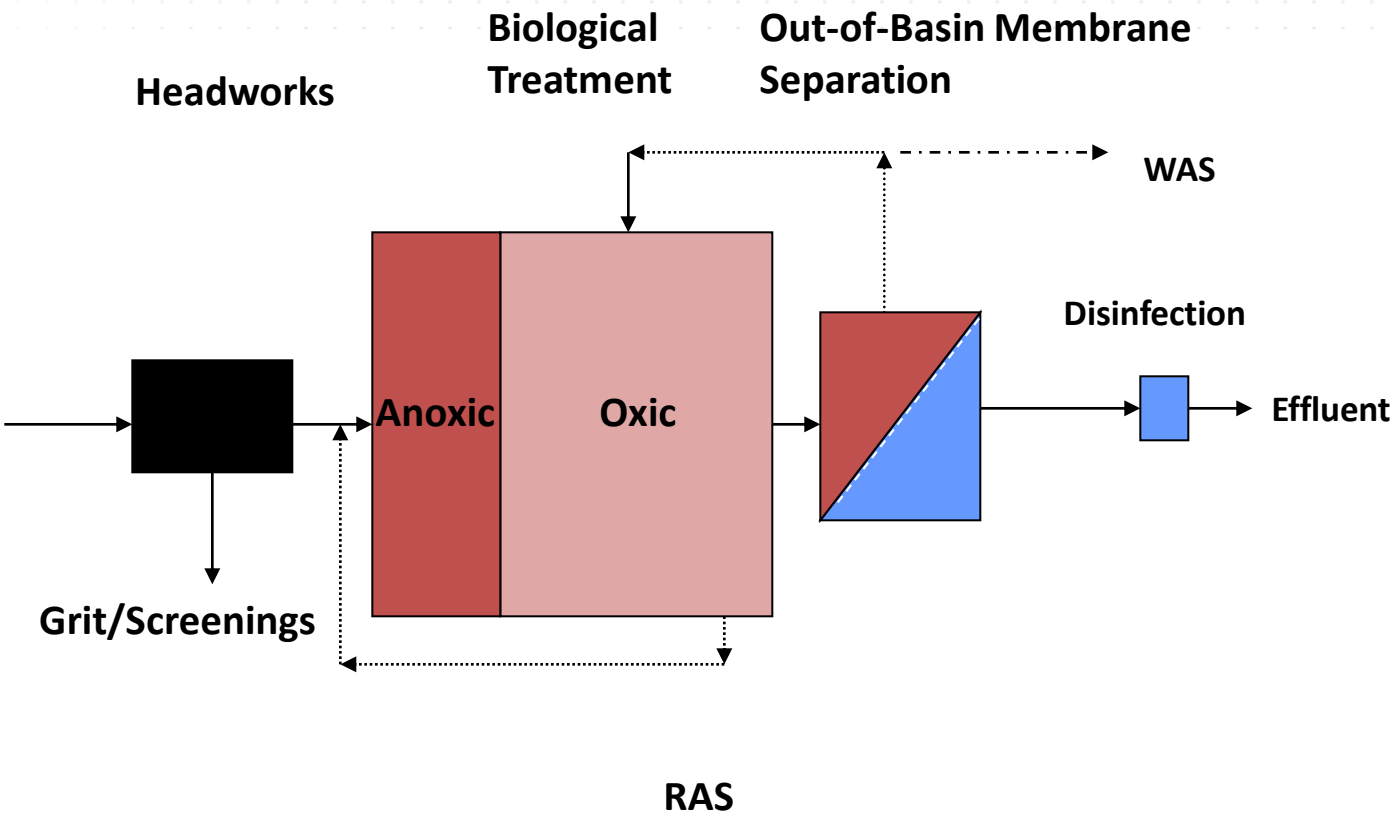
Technologies Available

- **Treating for PFAS in Raw Leachate can be cost prohibitive**
- **SBR / MBBR**
- **Membrane Bioreactor**
- **UF + Reverse Osmosis**
- **MBR + RO**
- **Pretreatment + MBR**
- **MBR + Post Treatment**
- **Pretreat + MBR + RO**

Conventional Treatment Plant

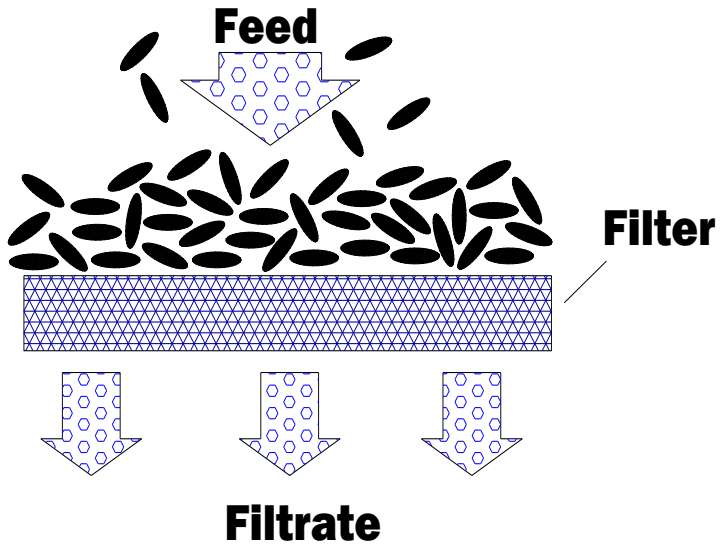


Out of Basin MBR Treatment Plant



IN- BASIN MBR UF

- UF modules are in the basin with a low flow
- Membranes subject to organic fouling
- Flow is from outside in



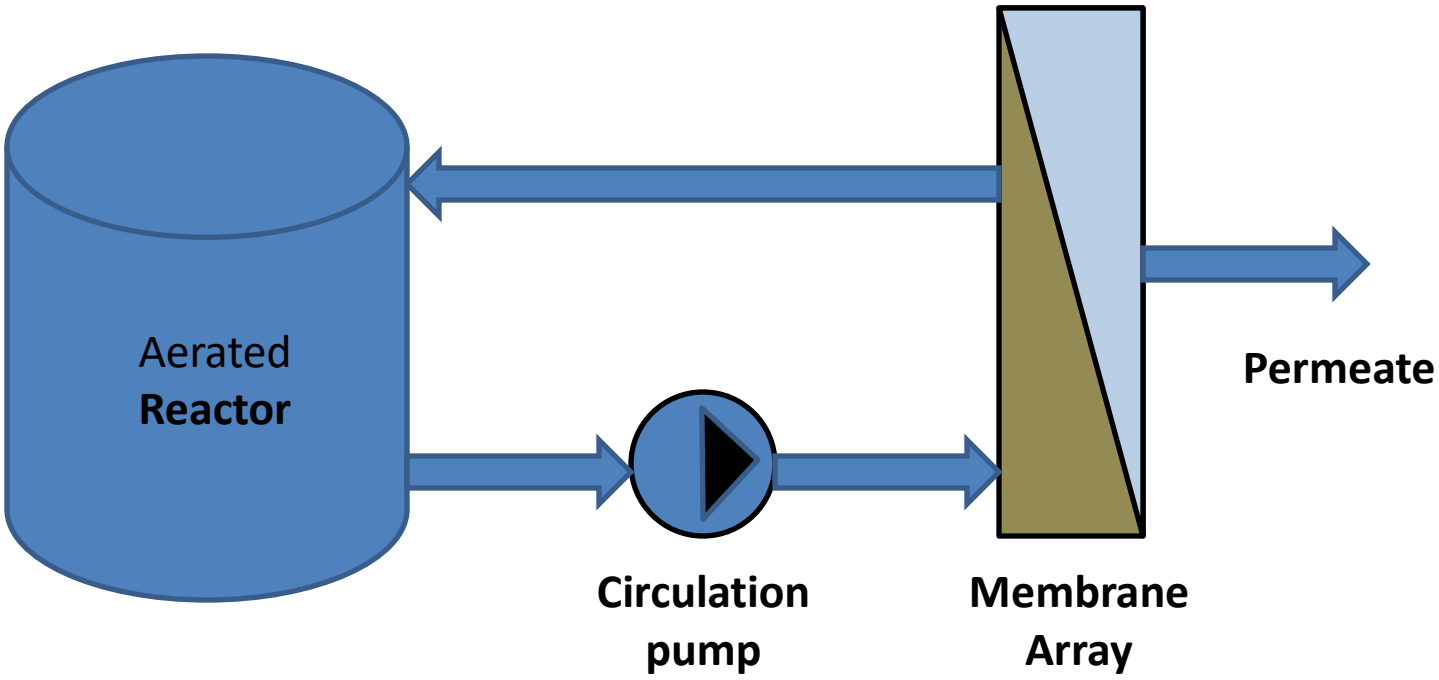
Out of Basin MBR UF

- External UF modules
- Inside out flow at a high flow rate
- Module easily replaced without confined space certification

Membrane Basics

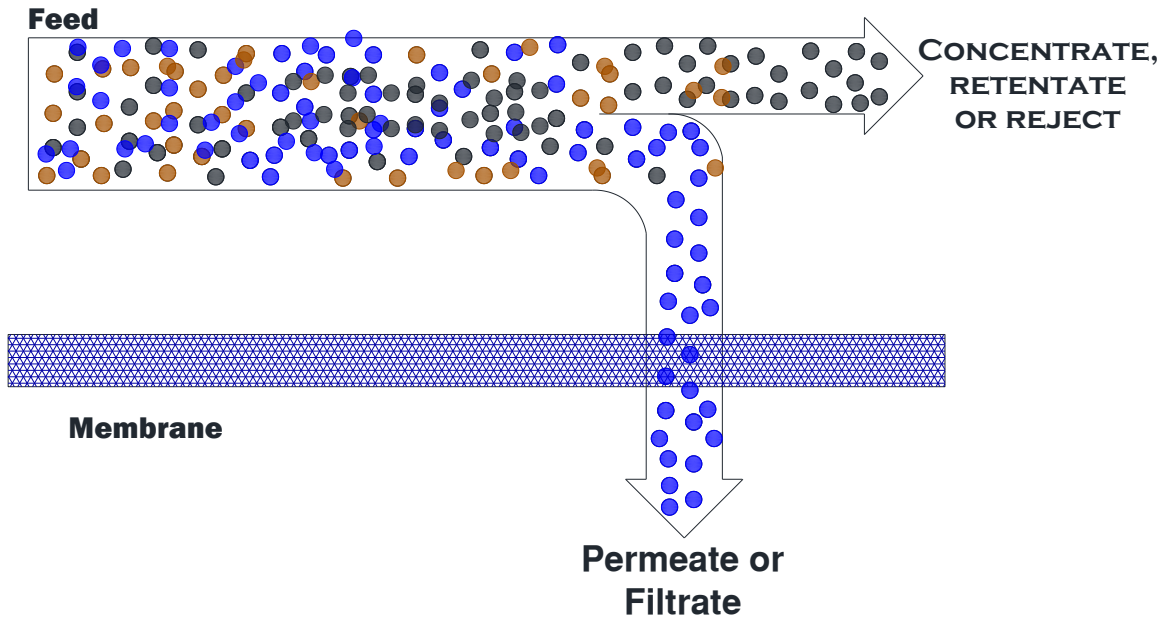
In-Basin and Out of Basin

Basis of crossflow system



CROSS-FLOW ULTRA FILTRATION

- **Feed – up to 4 m/sec crossflow rate**
- **Permeate**
- **Reject/Retentate/Concentration**



Out of Basin UF Skids

Why Out of Basin MBR?

Activated sludge process consisting of an aeration tank and a membrane unit that separates treated effluent from bio-solids – operates at higher concentrations of mixed liquor suspended solids (MLSS)

Membrane provides an absolute barrier based on particle size. No solids carry-over occurs enabling exact control of the solids retention time (SRT)

The system promotes slow growth microorganisms and degradation of constituents that are normally considered recalcitrant

ALWAYS HIGH QUALITY

Membrane filtration at 0.03 µm always assures high quality discharge

- **Positive filtration prevents upsets**

No upsets possible

- **Sludge bulking does not matter**

High MLSS concentration assures high rates of treatment

- **Changes in feed strength are more easily accommodated**

No treatment chemicals required for sludge settling

High consistent quality provides the best feed to reverse osmosis with no worries about system upsets

Contaminant Removal Challenges

- **Metals**
- **Ammonia**
- **TDS**
- **Metals**
- **PCBs**
- **Transmittance**
- **Oil & Grease**
- **High COD**
- **Toxic & Inhibitory Substances**
- **PFAS**
- **Mercury**

Installed

- **Jet mix/aeration pumps inc. installed spares**
- **Jet Mix pumps**
- **Membrane circ. pumps + CIP**
- **Duplex membrane skid**
- **Chemical feeds in foreground**

REVERSE OSMOSIS After MBR

- **High pressure, 200 – 1,800 psi**
- **Rejects salts and low molecular weight solutes - used for desalination.**
- **Require pre-filtration**
- **Typical RO Reject is 20%**

RO System Installed

PFAS REMOVAL

- **RO system can be designed to meet any discharge requirements**
- **Has been successfully used on industrial wastewater and landfill leachate for PFAS removal**
- **PFAS will be concentrated in reject stream**
- **RO Reject (concentrate) rates typically 20% of original volume**

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PFAS Permeate Results with RO

	ng/l	ng/l	ng/l	ng/l	ng/l	ng/l		
	A - Raw	A - RO Permeate	B - Raw	B - RO Permeate	C - Raw	C - RO Permeate	D- Raw	D- RO Permeate
N-ethyl perlouorooctanesulfonamidoacetic acid - NEtFOSAA	ND	ND	61.4	ND	ND	ND	<330	ND
N-methyl perfluorooctanesulfonamidoacetic Acid - NMeFOSAA	ND	ND	53.4	ND	104	ND	<330	ND
Perfluorobutanesulfonic acid - PFBS	630	0.62			4460	2.9	1220	ND
Perfluorodecanoic acid - PFDA	70	ND	1,050	ND	ND	ND	1250	ND
Perfluorododecanoic acid - PFOoA	ND	ND			ND	ND		ND
Perfluoroheptanoic acid - PFHpA	580	0.65	550	ND	802	ND	593	ND
Perfluorohexanesulfonic acid - PFHS	190	ND			540	ND		ND
Perfluorohexanoic acid - PFHxA	1,900	2.2	1,160	ND	3200	ND	2410	ND
Perfluorononanoic acid - PFNA	91	ND	52.4	ND	ND	ND	<165	ND
Perfluorooctanesulfonic acid - PFOS	88	ND			134	2.6	228	ND
Perfluorooctanoic acid - PFOA	1,100	1.3			1280	2.9	1250	ND
Perfluorotetradecanoic acid - PFTeDA	ND	ND			ND	ND	<165	ND
Perfluorotridecanoic acid - PFTrDA	ND	ND	ND	ND	ND	ND	<165	ND
Perfluoroundecanoic acid - PFUnA	ND	ND			ND	ND		

MBR + RO

PFAS Treatment Technologies

Concentration, Encapsulation, Adsorption

- **Granular Activated Carbon**
- **Cement Mix for spray on daily cover**
- **“Evaporation” direct to atmosphere / Mechanical Vapor Recompression**
- **Foam Fractionation**
- **Advanced Oxidation Processes**

PFAS Treatment Technologies

Adsorption followed by Reactivation

- **Granular Activated Carbon**
  - **Calgon Carbon – Reactivation with multi-hearth furnace/kiln @ 1700 – 1800^{o}F**
  - **2 step process kiln + thermal oxidizer**
  - **Destruction efficiency of at least 99.9%**
  - **Regeneration – at or below 212^{o}F with steam or hot N_2 may not remove the PFAS and may not destroy any PFAS**

PFAS Treatment Technologies

Adsorption followed by Reactivation

- **Foam Fractionation**
  - **Multiple companies engaged in FF**
  - **Using specific or proprietary Ion Exchange resins**
  - **Desorbing with solvents / proprietary tech**
  - **Resin can be disposed of as is or desorbed**
  - **After desorption – followed by various "Advanced Oxidation Processes"**
  - **Revive / ECT2 / StreamGo / Altra etc.**

PFAS Treatment Technologies

Encapsulation

- **Cement Mix for spray on daily cover**
  - **LafargeHolcim developed admix specifically for Landfill Leachate RO concentrate**
  - **Cement binder mixed on-site**
  - **Sprayed on as Alternative Daily Cover**
  - **Admix developed specifically for each RO Reject**
  - **Ran SPLP test on the 1310B Structural Integrity cores not the setup daily cover**

    (Synthetic Precipitation Leaching Procedure)

PFAS Treatment Technologies

A member of LafargeHolcim

Sample Analytical Results

Site 1	As Received	SPLP
Sand	Results	Results
	ppt	ppt
PFNA	150	ND
PFOS	630	0.75
PFOA	2,400	4.6
Site 2		
No sand		
PFNA	222	ND
PFOS	383	ND
PFOA	7,460	30.5

PFAS Treatment Technologies

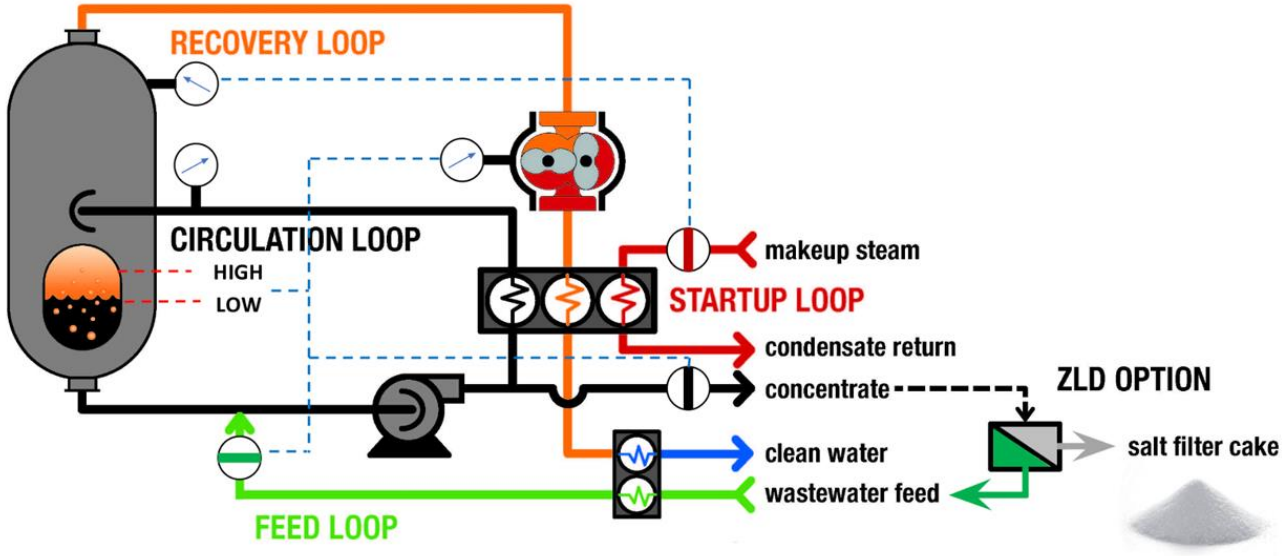
Concentration - Evaporation

- **Direct to atmosphere**
  - **Potential PFAS in air emissions???**

PFAS Treatment Technologies

Concentration - Evaporation

- **Mechanical Vapor Recompression**
  - **No air emissions, evaporative distillation**



PFAS Treatment Technologies

Advanced Oxidation Processes

- **Ultraviolet Light**
- **Ozone**
- **Supercritical Water Oxidation**
- **Hydrogen Peroxide**
  - **Issues include:**
  - **Contact time**
  - **Interference from concentrates (TDS, humic & fulvic acids, recalcitrant COD etc.)**

Questions

Contact Info:

Will Welisevich
Cadex of WNY
716-435-5257
will@cadex.net