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Nutrient Removal Design for the Wichita Membrane Bioreactor

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Presentation Outline

- What is a Membrane Bioreactor (MBR)?
- Nutrient removal using MBR
- Application to Wichita project

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What is a Membrane Bioreactor?

Membranes filter directly from mixed liquor

No final clarifiers

Clarification and filtration in one step

Operates at high mixed liquor solids concentrations (8000 mg/L MLSS)

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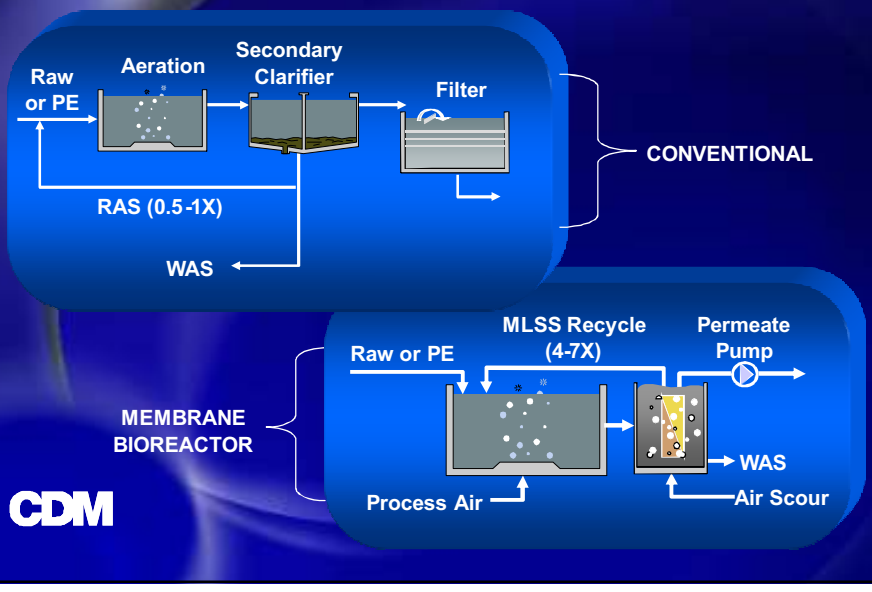
MBR vs. Conventional



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Advantages of MBR

Small footprint required (no final clarifier and smaller reactors due to high MLSS)

High quality effluent for unrestricted non-potable urban reuse and industrial use

Eliminates operational problems associated with settling of light biologically active solids in gravity settling tanks

Long sludge age ensures complete ammonia removal (nitrification) at cold temperatures

Physical barrier to coliform – reduces cost of effluent disinfection

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Membranes 101

Category	Pore Size, microns	Driving Pressure, psig
Microfiltration	0.1 – 0.2	5 – 20
Ultrafiltration	0.01 – 0.1	10 – 30
MBR membranes	0.03 – 0.4	-5 to -10
Nanofiltration	0.001 – 0.01	7 – 120
Reverse Osmosis	0.0001 – 0.001	125 – 300

Virus = 0.0045 – 0.2 microns

Soluble BOD = 0.003 – 0.08 microns

Coliform Bacteria = 1 – 2 microns

Protozoa > 0.7 microns

Biomass floc > 9 microns

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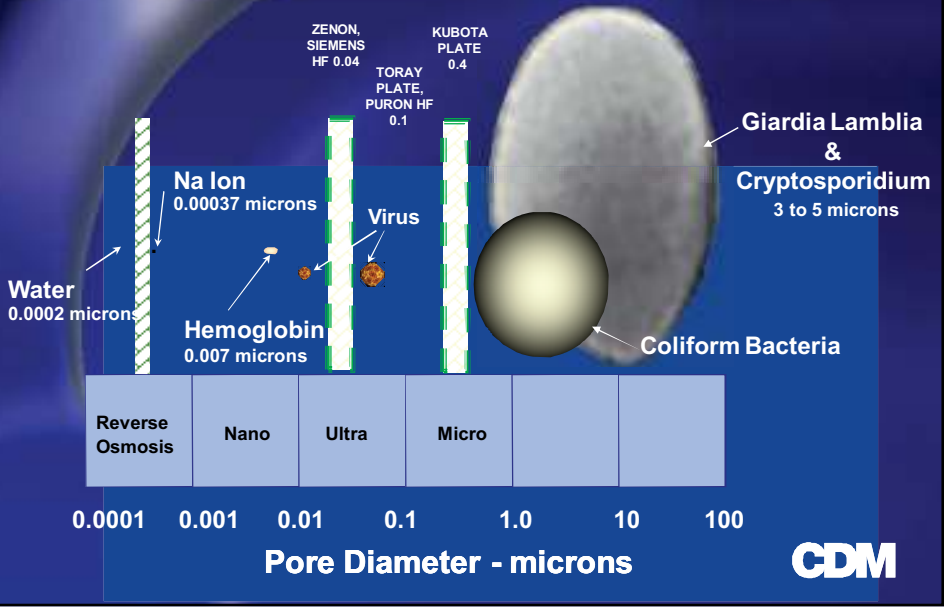
Membrane Contaminant Removal



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MBR Terminology

Pretreatment = Fine screens, 1-3 mm

Flux = gfd, gallons / square foot / per day

TMP = Transmembrane Pressure, psi

Specific Flux = Flux/TMP, gfd/psi

Permeate = Clean water pulled through the membranes

Finishing = Proprietary final production step for membranes – critical to final pore size distribution

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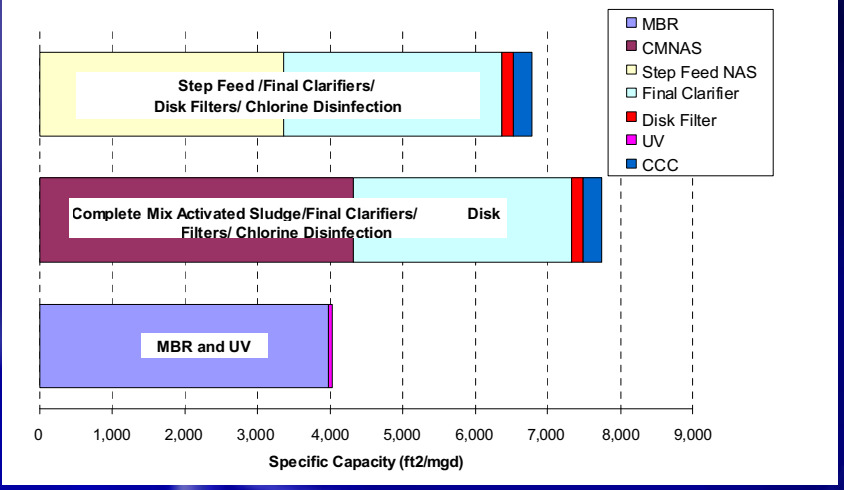
Space Requirements
MBR vs. Alternate Technologies



Hollow Fiber Membranes

Plate Membranes

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Nutrient Removal in MBR

- 8-10 day SRT required for proper membrane performance – nitrification easily achieved
- Biological N and P removal enhanced by high MLSS
- Biological N and P removal hindered by high oxygen in membrane tank return flow
- Separate recycle pumping may be required
- Chemical P removal favored

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Wichita MBR Draft Permit Limits

Parameter	Monthly Avg (mg/L)	Annual Avg (mg/L)
BOD	20 (summer) 25 (winter)	-
TSS	30	-
NH_3	1.4 (summer) 4.8 (winter)	-
e. Coli	160 cfu/mL	-
Total P	-	1.5 (0.5 operational goal)
Total N	-	8 (5 operational goal)

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Wichita MBR Design Criteria

Parameter	Annual Avg, mg/L	Max Month Avg, mg/L
BOD influent	240	290
TSS influent	185	230
TKN influent	48	53
Total P influent	7	10
TN effluent	5	8
TP effluent	0.5	1.5
SRT	10 days	

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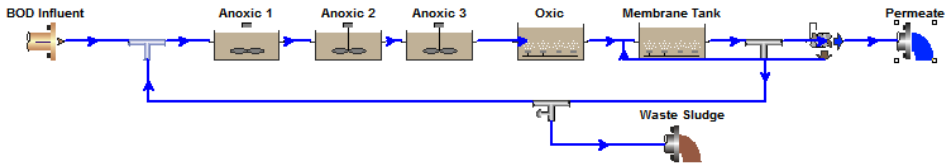
N Removal Design of Wichita MBR

- Design goal 5 mg/L TN
- Conventional anoxic-oxic configuration with recycle from membrane tank



- 6 mg/L TN achievable with 8X recycle
- 8 mg/L TN with 5X recycle

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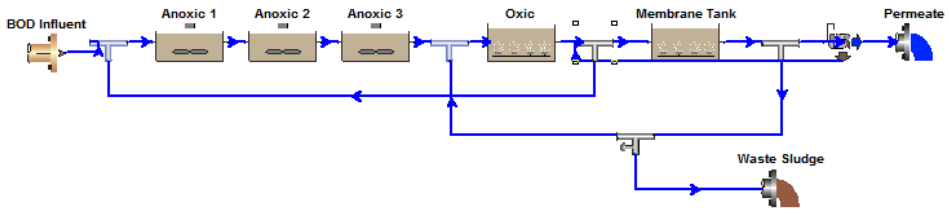
N Removal Design of Wichita MBR (cont.)

- Design goal 5 mg/L TN
- Conventional anoxic-oxic configuration with dual recycle



- 5 mg/L TN achievable with 12X internal recycle and 4X membrane recycle
- 8.5 mg/L TN with 5X internal recycle

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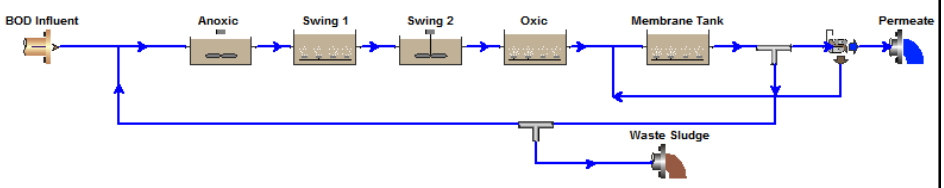
N Removal Design of Wichita MBR (cont.)

- Design goal 5 mg/L TN
- Anoxic/swing zones/oxic configuration (chosen design)



- 5 mg/L TN achievable with 5X membrane recycle

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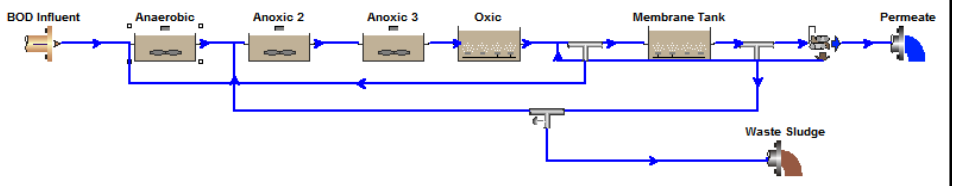
P Removal Design of Wichita MBR

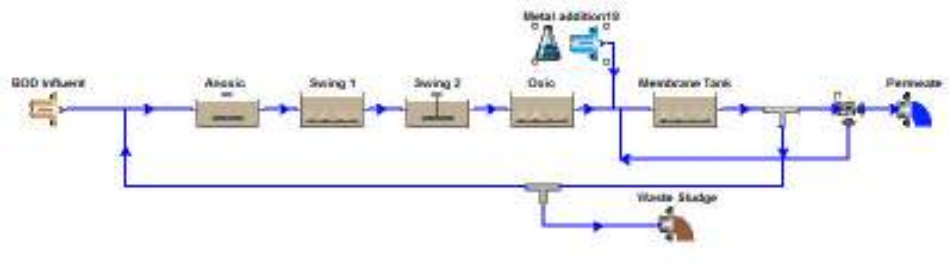
- Design targets 1.5, 0.5 and 0.3 mg/L TP
- Bio-P with dual recycle
- Must drop SRT to min. acceptable 8 days



- Anaerobic zones required – 0.5 hrs to achieve 1.5 mg/L P, 1 hr for 0.5 mg/L, 2 hr for 0.3 mg/L
- Slight interference with N removal (6 mg/L TN)

P Removal Design of Wichita MBR (cont.)

- Design targets 1.5, 0.5 and 0.3 mg/L TP
- Chemical P with swing zones (chosen design)



- 0.1 mg/L P with 5 mg/L alum dose (as Al)

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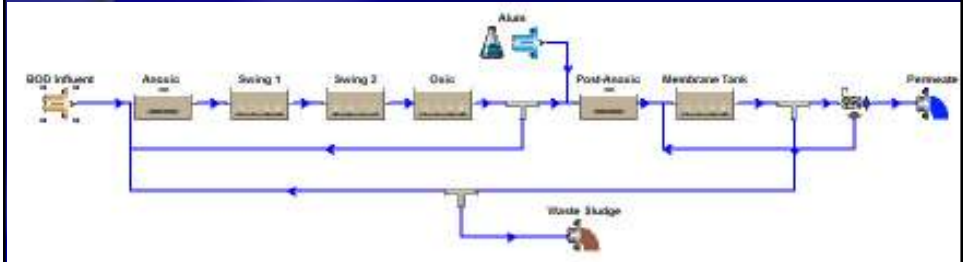
Final Design of Wichita MBR

- Design for potential future limits of 3 mg/L TN and 0.3 mg/L TP
- Post-Anoxic Zone (desirable to ensure effluent TN of 5 mg/L)
- Additional internal recycle pump (5X) to meet 3 mg/L TN (supplemental C may be required)



- 2.6 mg/L TN and 0.1 mg/L TP

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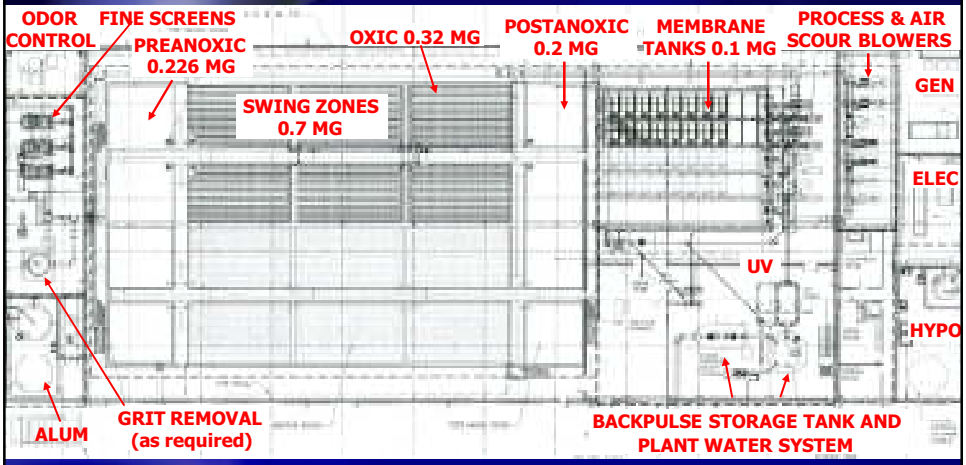
Layout of Wichita MBR



- Basins for 6 MGD – Equipment for 3 MGD
- Totally enclosed in 400 ft. by 150 ft. building
- Just bid for $22 M – $5.5/gal

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