SAWEA Workshop Al Khobar Saudi Arabia - Membrane Bioreactor Design Challenge

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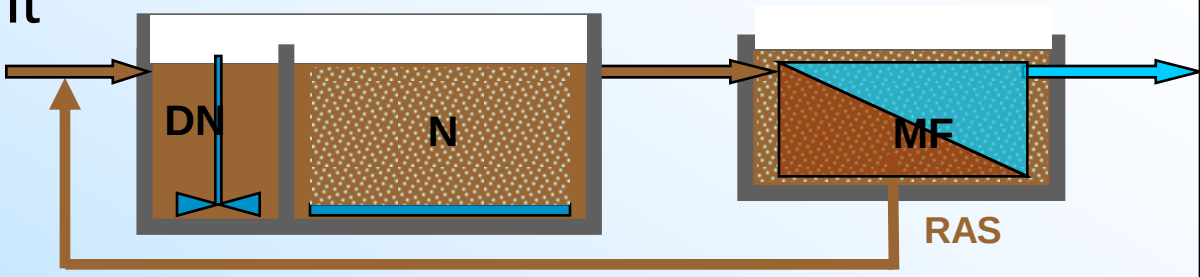
Design Basis – Starting Point

- Location – Municipality Near Jeddah
- Industrial Standard Design Requirements
- MOMRA Compliant
- Drivers –
  - Reliability
  - Reuse



- Design Basis: 9500m3/day, PFT=4Qav.annual
  - BOD5=150mg/l, TSS=300mg/l,TKN=40mgN/l
  - Alk.=100mg/l, FOG<30mg/l, TP=4mgP/l

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Data Assessment – What do we have and what do we need?

- Effluent discharge
  - Set by MOMRA unrestricted reuse
    - COD=50mg/l, BOD5=10mg/l
    - NO3-n=10mg/l,NH4-n=5mg/l
    - TSS=10mg/l
    - FOG = none
- Geography – Near Jeddah
- Information?
  - How it arrives, when it arrives, daily peaks, Rain events, public holidays – 4Qav.annual
  - BOD value and Safety factor
    - Historically BOD 200-250mg/l and 1.5-2Q

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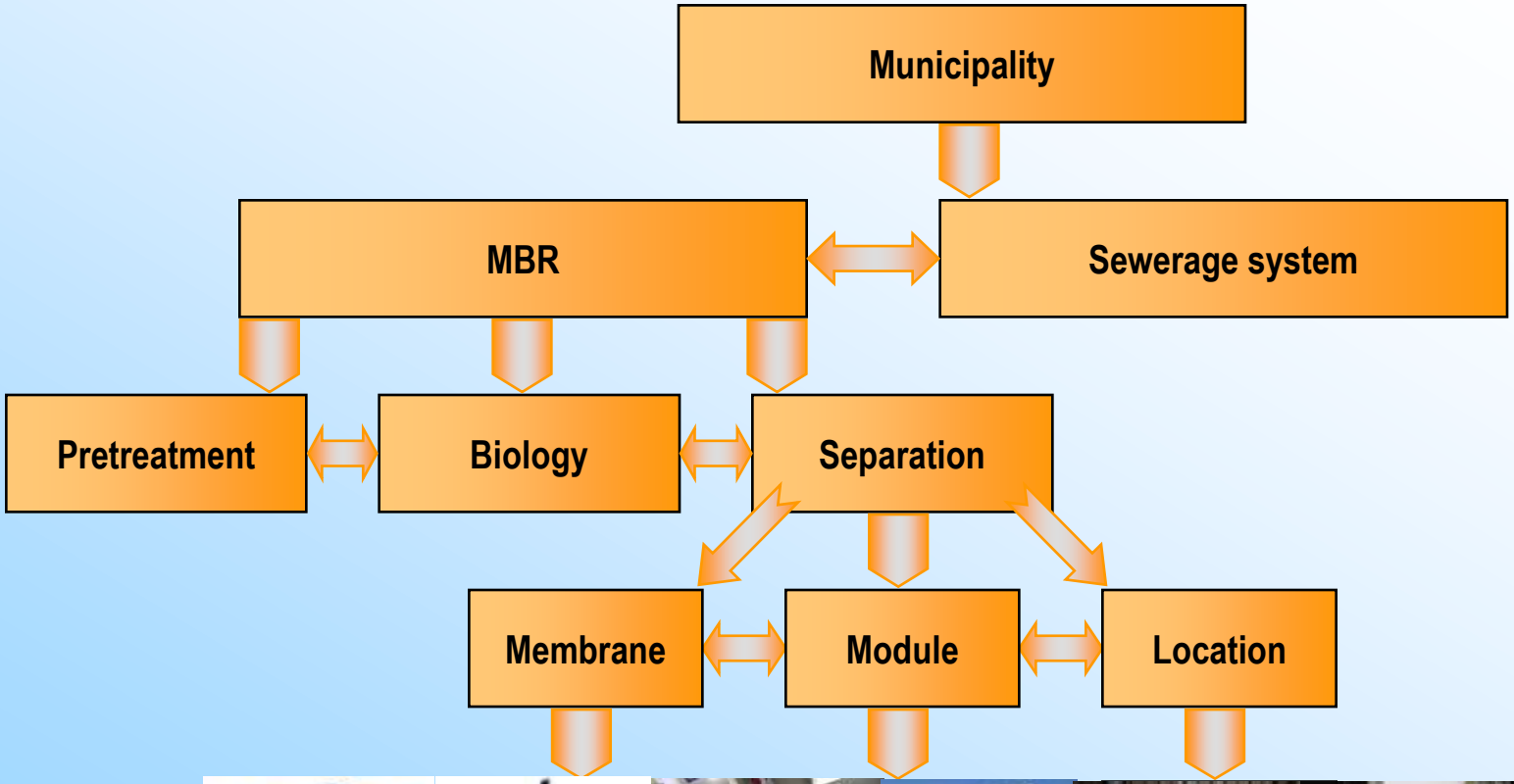
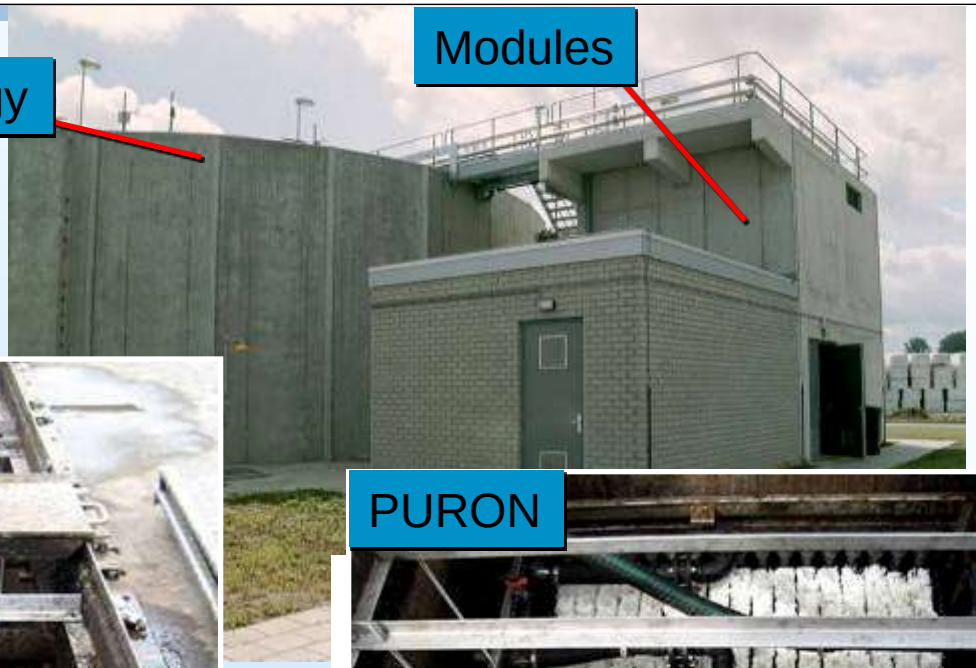
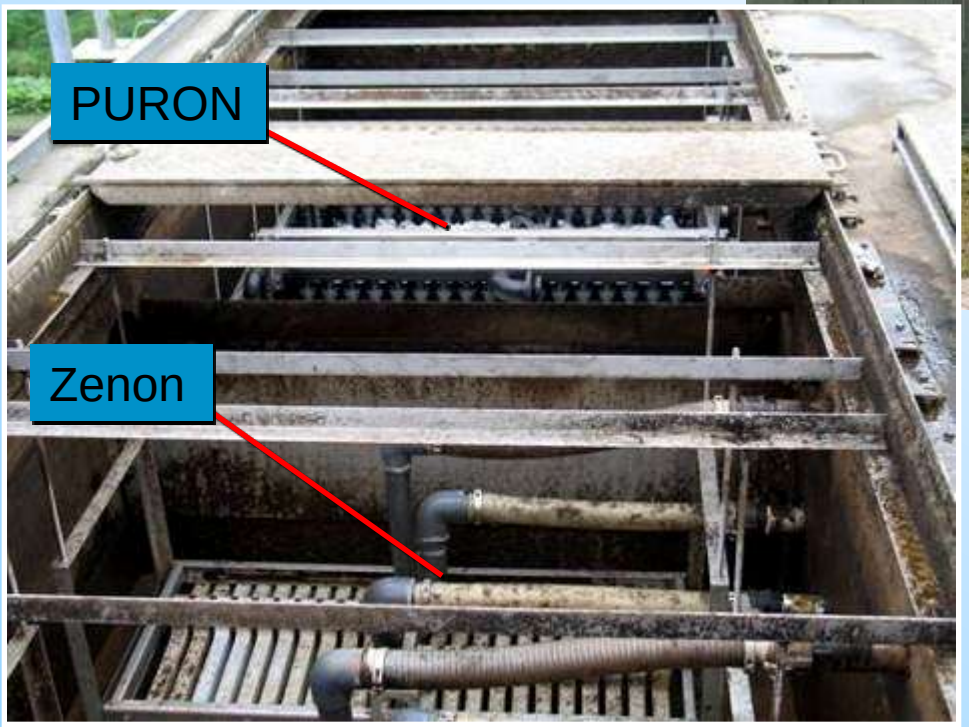
KMS Design Philosophy



Interchangeability (Small)

De Wierde (NL)





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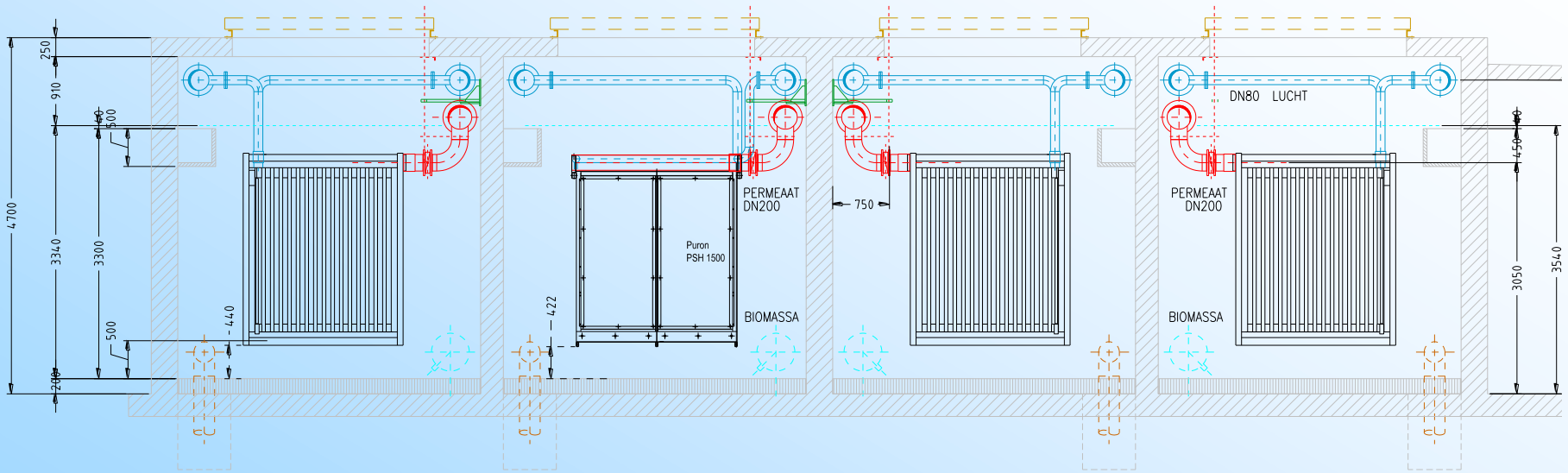
Interchangeability (Large)



The Wastewater system-Local Data

- Background Information
  - Internet
  - Local contacts
  - Local companies

Climate

Unlike other Saudi Arabian cities, Jeddah retains its warm temperature in winter, which can range from +15 °C (59 °F) at midnight to +25 °C (77 °F) in the afternoon. Summer temperatures are considered very hot and break the +40 °C (104 °F) mark in the afternoon dropping to +30 °C (86 °F) in the evening. Rain usually falls in Jeddah in small amounts in December.

Some unusual events often happen during the year, such as dust storms in summer, coming from the Arabian Peninsula's deserts or from North Africa. Snow does not fall in Jeddah but ice pellets occasionally fall in January.

Jeddah Climatological Data[5] [hide]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	33 (91)	35 (95)	38 (100)	40 (104)	42 (108)	47 (117)	42 (108)	42 (108)	42 (108)	41 (106)	41 (106)	34 (93)	
Average high °C (°F)	29 (84)	29 (84)	29 (84)	33 (91)	35 (95)	36 (97)	37 (99)	37 (99)	36 (97)	35 (95)	33 (91)	30 (86)	33 (91)
Average low °C (°F)	19 (66)	18 (64)	19 (66)	21 (70)	23 (73)	24 (75)	26 (79)	27 (81)	25 (77)	23 (73)	22 (72)	19 (66)	22 (72)
Record low °C (°F)	9 (48)	11 (52)	13 (55)	12 (54)	13 (55)	19 (66)	21 (70)	23 (73)	21 (70)	20 (68)	17 (63)	10 (50)	
Rainfall mm (in)	5 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	25 (1.0)	31 (1.2)	61 (2.4)

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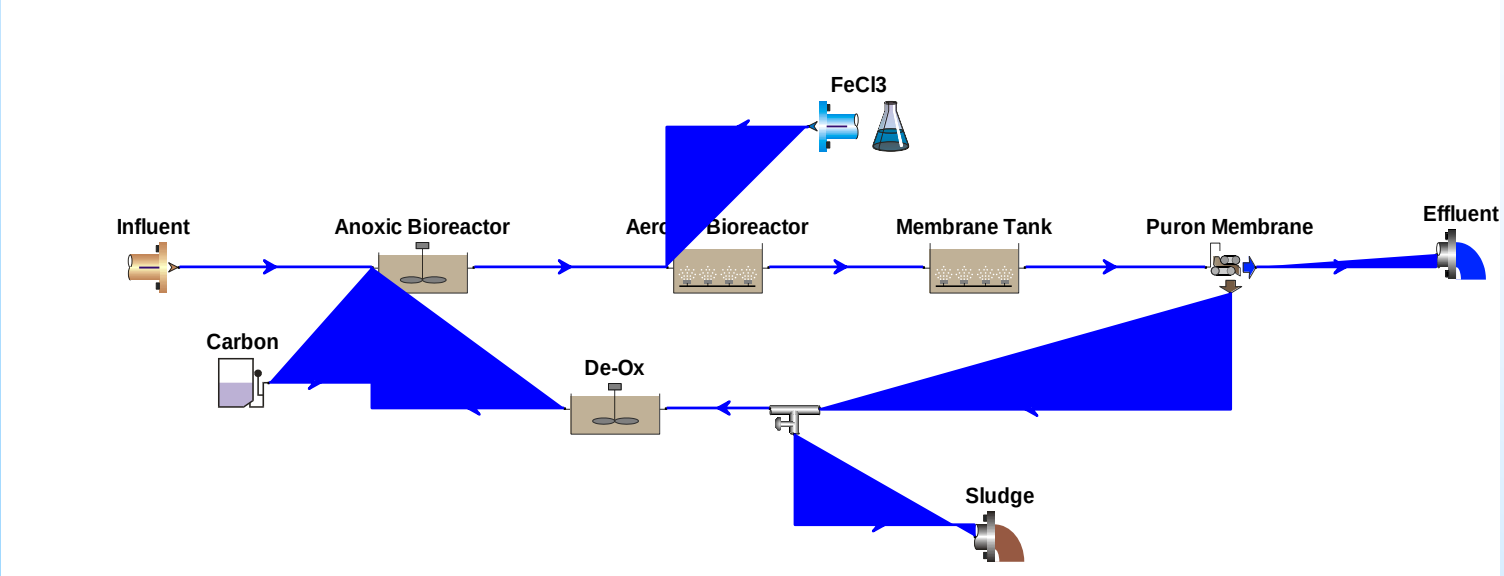
Design Calculation

- KMS uses two models:
  - Static ASM-BNR spreadsheet that is specific to MBR and is purely in-house developed technology
  - Dynamic Model from the USA (Biowin)



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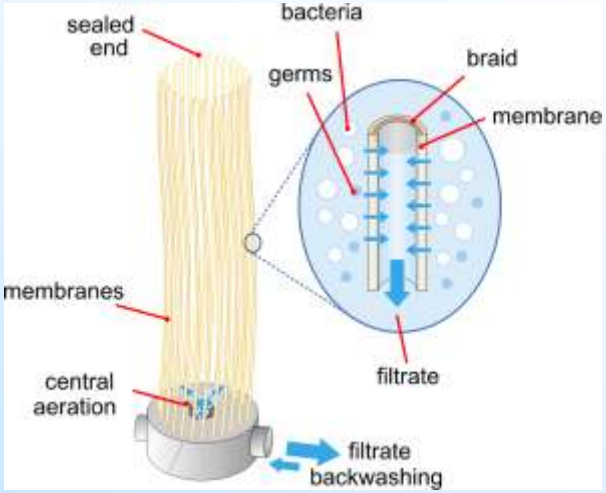
MBR Design Outputs 1

- Expected Effluent Quality (Day average)
  - COD <35mg/l, BOD<5mg/l, NH4<1mg/l, NO3<5mg/l, TSS<1mg/l
  - Water suitable for MOMRA unrestricted reuse
- Calculated Process
  - 8 to 10g/l Biomass
  - Pre-treatment
  - Pre-denitrification
  - Nitrification with alkalinity addition
  - PURON®Membrane Filtration
  - De-Oxygenation



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MBR Design Outputs 2

- Pre-treatment:
  - Coarse Screen 6mm
  - Equalisation 3000 to 5000m3 (optional)
  - Sand/Fat removal
  - Fine Screen 3mm punched holes
  - Screenings recovery/washing/compaction
- Pre-denitrification: (40% over design)
  - 1000m3 plug flow with mixing
  - RAS supplied via Membrane return and DeOx @ 2250m3/h at Qav to 4500m3/h at 4Q
  - Overflow to Nitrification
- Nitrification: (40% over design)
  - 2600m3 semi-Plug flow
  - Aeration SOTRav=251kgO2/h to SOTR(4Q)=884kgO2/h
  - Split Aeration System with DO control (SP 2.0 and 0.8mgO2/l)
  - pH control via lime dosing to add alkalinity (220mg/l req.)
  - Foam scavenging system + Antifoam oil dosing (as req)
- Membranes:
  - Volume of System 750m3 with 45.000m2 installed - 3 trains of 10xPSH1500
  - Aeration designed for 25%,33% and 50% - Installed Blower capacity 12.000Nm3/h and 3.960Nm3/h operational@300mbar
  - Filtration tank design = Suitable for most Submerged membrane suppliers (additional cost=0)
  - Minimum Permeate storage (combined pipework)
  - Cleaning via Automated Maintenance Cleaning in Biomass and yearly Recovery Cleaning
  - Pumped Feed and gravity return design or gravity feed pumped return
- De-Oxygenation Tank
  - 400m3 with mixing (part of DN zone) Maybe operated as selector.

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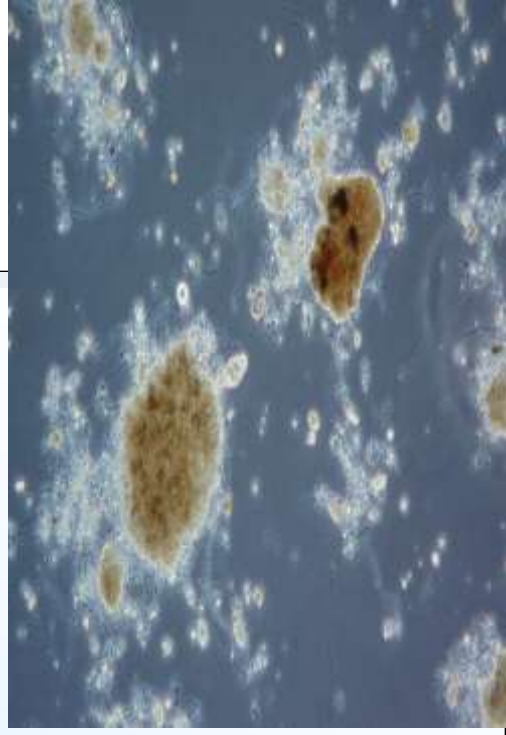
MBR Design Outputs 3



- Biological Summary at 20°C: (40% over design)
  - Total Biomass volume = 4750m3 @ 8 to 10g/l
  - MLSS (system max) = 39.456 to 49.307kg
  - MLSS(-/- Mem zone) = 32.000 to 40.000kg
  - F:M = 0.120 to 0.095kgCOD/kgMLSSd
  - HRT = 12 hrs Qav to 3 hrs Qmax (6hrs if equalised)
  - SRT = 18days@8g/l to 24days@10g/l
  - WAS = 2130kg/d to 2080kg/d
  - RAS = 4.7:1 to 9:1av to 2.3:1 at 4Q (4.5:1 if equalised)
  - Aeration required = SOTRav=251kgO2/h to SOTR(4Q)=884kgO2/h
  - Volume flow Air = 3600av Nm3/h to 11000(4Q) Nm3/h @5mWH and Alpha of 0.6
  - Alkalinity dosed as lime at ~50-100kg/d (as required)

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System Configuration- Philosophy

- Key Words
  - Robustness
  - Reliability
  - Operability
  - Maintainability
- Configuration
  - 3 trains with future extension to 4 (Parallel or series)
  - 15% Buffer capacity in Bioreactor (variable level)
  - Combined sludge distribution for membranes
  - Pumped feed gravity return

Flexibility#1

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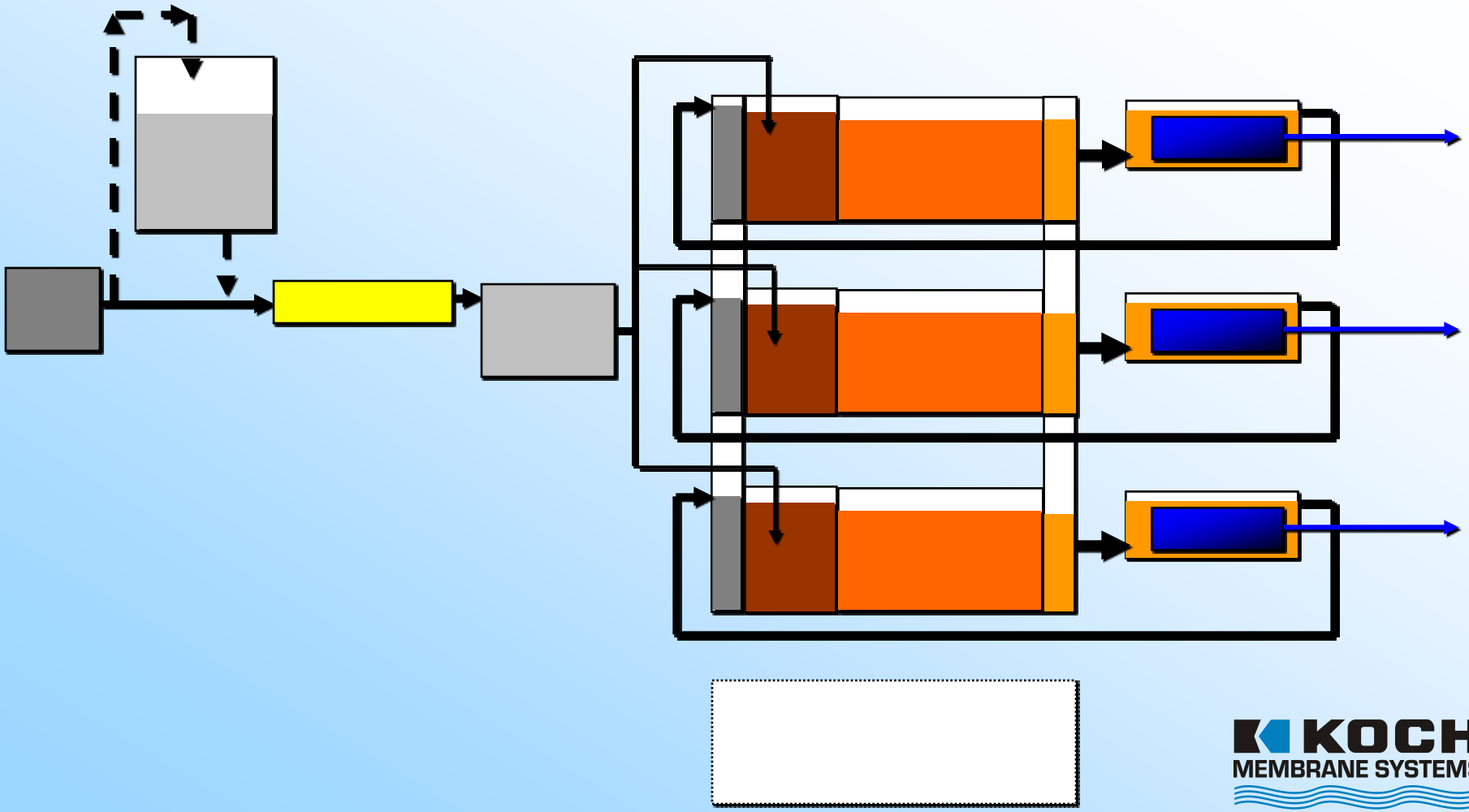
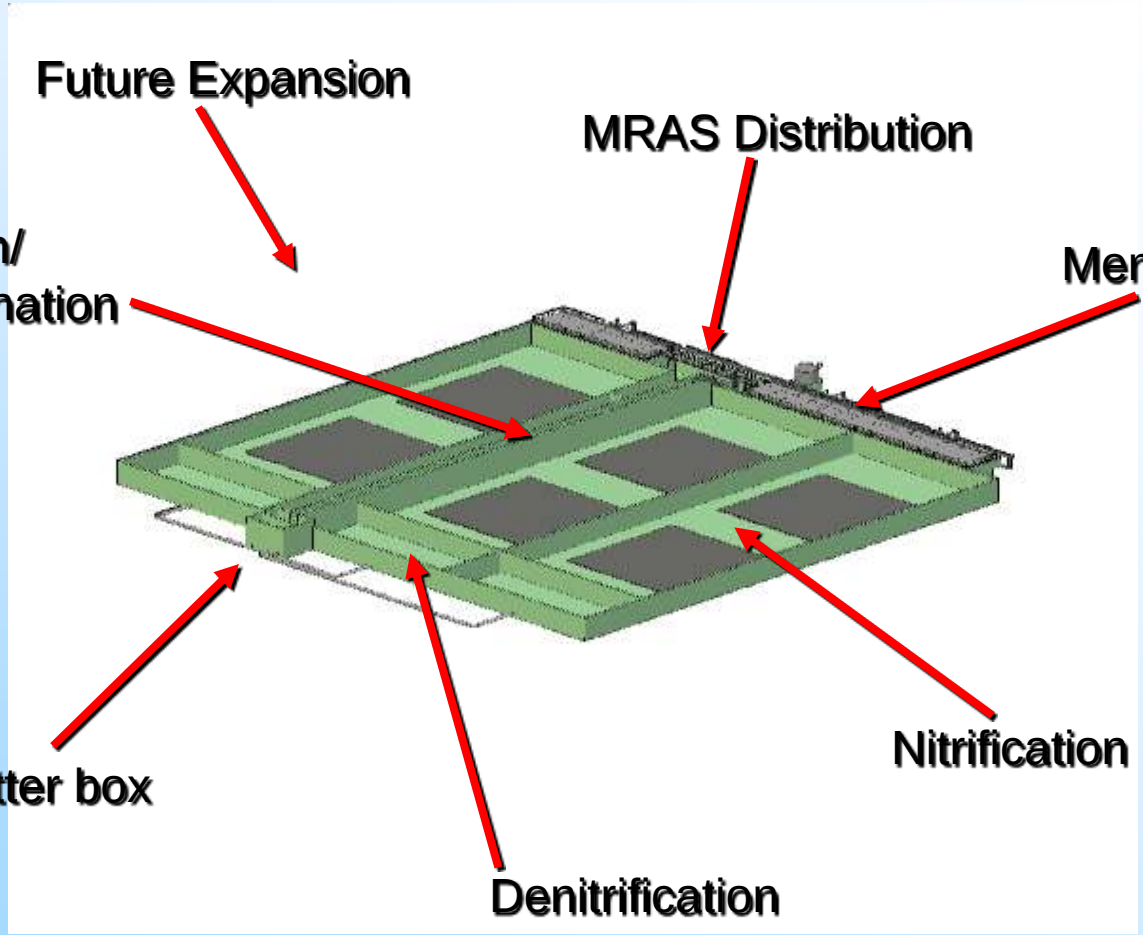
System Details-Process Flow



System Details-Process Flow



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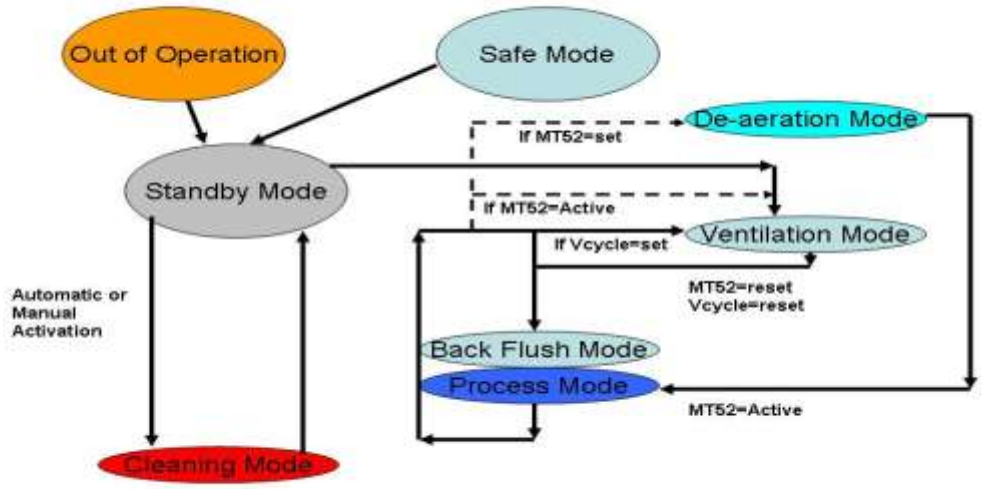
System Details-Automation

- Plant is fully Automated (2hrs/d Manual intervention)
  - Biology (fully automated)
  - Membranes (see below)
- System is designed to be Intrinsically Safe
- Hydraulics are intrinsically balanced



Permeate Production Off
= Membrane Aeration Sleep

Permeate Production Optimum
= Membrane Aeration Optimum

Permeate Production Maximum
= Membrane Aeration Maximum

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System Details-Equipment

	Item Decription	Type	Size	Nr.
1	Coarse Screens	Rake/bar	1600m3/h	1+1
2	Sand+Fat Removal	Aerated German Design	2000m3/h	1
3	Fine Screens	Static/Rotating Drum	500m3/h	2+A
4	Washer Compacter	Standard Design	25m3/h	1
5	DN Mixers	Submerged Type	1.5kW	3+1stock
6	Nitrification Aeration	FBD or equivalent	2000Nm3/h	6
7	Nitrification Blowers GM80L	Roots	4000Nm3/h	3+1
8	WAS Pumps	PD (8hr/d)	25m3/h	1+1
9	Sludge Ciculation Pump to Fine Screen	Submerged Pump	40m3/h	1+1stock
10	Dosing Pumps for Alkalinity	Membrane Pumps	100 l/h	1+1stock
11	Membrane RAS supply	Wall Pumps 1mH	1500m3/h	3+1stock
12	Membrane tank drain pump	Open Centrifugl	200m3/h	1+1stock
13	Membrane Permeate Pumps(VX186-390Q)@N-1	Rotating Lobe reversible	300-620m3/h	3+1stock
14	Membrane Blowers GM80L	Roots	4000Nm3/h	3+1
15	Chemical Pumps (NaOCl+Citric Acid+NaOH)	Membrane Pumps	1000 l/h	3+2stock
16	MC/RC water pump and Tank fill	Centrifugal	50-200m3/h	1+1stock
17	De-Oxygenation Mixers	Submerged Type	1.5kW	2
18	Membranes	PURON	45000m2	30

Equipment Warrantee is standard 2 years
Membrane Warrantee is 7-10 years Pro-rato

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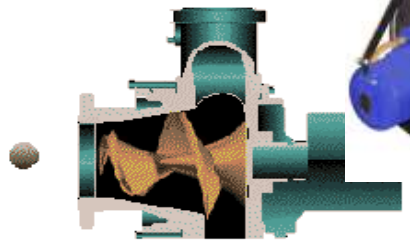
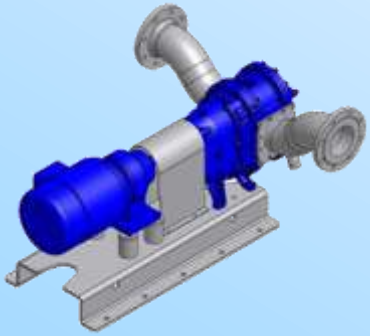
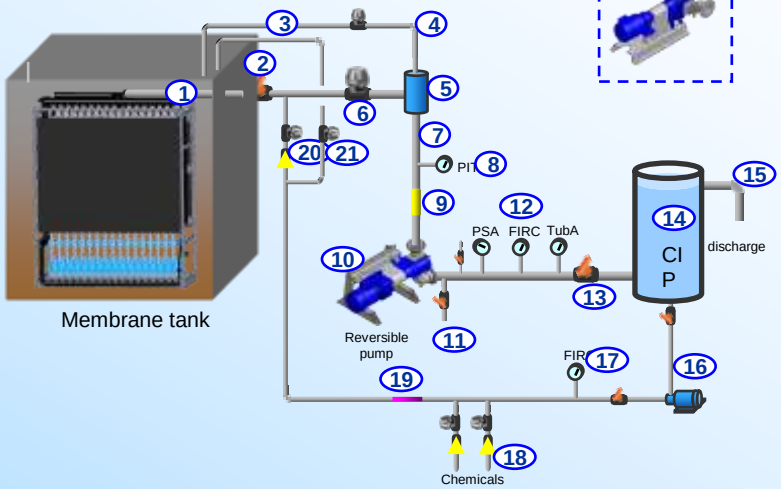
System Details-Equipment 2







Membrane tank

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System Details-Utilities Needed

- Based on Annual average of 9500m3/d

	Item	Utility	Units	Per year	Per m3
1	Pre-treatment	Energy	kWh	87600	0.02
		Water	m3	0	0
2	Biology	Energy	kWh	1095000	0.31
3	Membranes	Energy	kWh	963600	0.28
		Water	m3	0	0
4	Instrumentation	Energy	kWh	26280	0.01
	Totals	Energy Water		**2.2M**	**0.62**

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System Details-Chemicals

- MC – 1x/week max to 1x/month optimised in biomass
  - 1000mg/l NaOCl at pH>10 60minutes @3 LMH
  - Occasional Citric/Inorganic Acid at pH2.5 30 minutes
- RC – 1x/year - Soaking
  - 1000mg/l NaOCl at pH12 4hrs at 30°C or 8-12hr
  - 2000mg/l CA at pH2.5 4hrs at 30°C or 8-12hr
- Yearly Totals based on worst case:
  - NaOCl@15% = 37m3
  - Citric Acid@50% = 6m3
  - Inorganic acid in drums = 2m3 (RC pH adj.)
  - Alkali in drums = 2m3 (RC pH adj.)
- Other Chemicals:
  - Alkalinity = 18 – 36 tonne/year (as req.)

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System Details-Operation

- System is in principle unmanned.
  - 2 hour per day Process supervision (operator)
  - 30 minutes per day Performance monitor (supervisor)
  - Plant access via modem/intranet
  - Data processing (1 day/week)
- RC procedures would require operator presence
  - Max 6 days/year
- Maintenance:
  - According to equipment specifications
  - Membrane inspection (KMS) for warrantee

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KMS Design Advantages

- Designed with Interchangeability in mind at the offset
- Built in flexibility in three trains with future expansion in mind
- Complete redundancy built in for membranes and biology and full flexibility in sludge distribution
- Complete symmetrical design for membrane system optimisation
- 3 train to 4 train will allow 33% aeration to 25% aeration with no change to the system infrastructure
- Buffer capacity built into design
- N-1 situation covered for average flow and equalised 4Q flow
- Far less wear and tear on aeration valves - <200.000 cyc/year

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Thank you very much for your attention

The new 1500 PURON® Module

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