ACWA MBR

presents

Submerged Membrane Bioreactors using the Kubota Membrane

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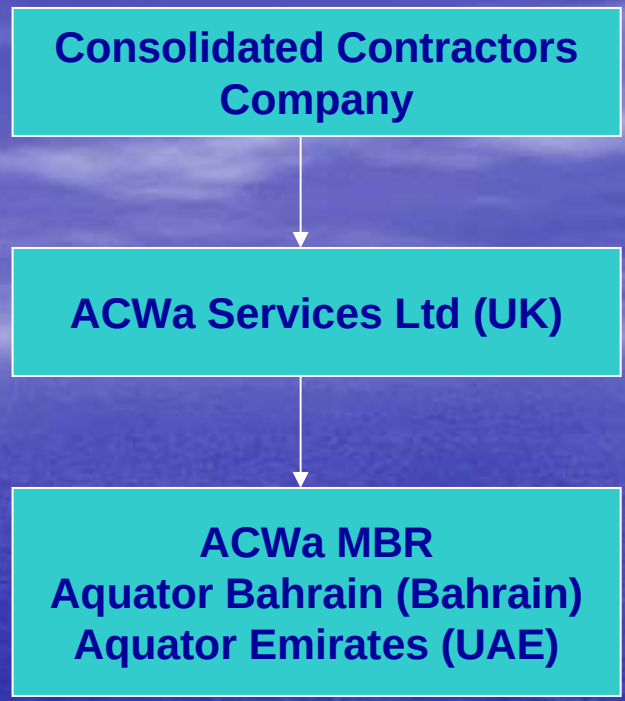
MBR Workshop, SAWEA, Nov 29th

Kubota

Presentation Overview



- Company Information
- The advantages of MBR
- Detailed information on reference plants
- Overall design of MBR plants
- The development of the Kubota membrane
- How the Kubota membrane works
- Process control of the Kubota system
- Middle East applications using Kubota membrane
- Conclusion

ACWA MBR (Aquator)

- Originally MBR Technology Ltd
  - MBR Technology has Designed and Constructed some 60 SMBR plants, beginning in 1995
- Previously part of Wessex Water
  - Responsible for the large scale development of the Kubota SMBR system
- Established in Bahrain November 2002
- Purchased by ACWa Services Ltd in Feb 2005
- Exclusive licensee for Kubota Membranes in The Middle East

The Kubota Story

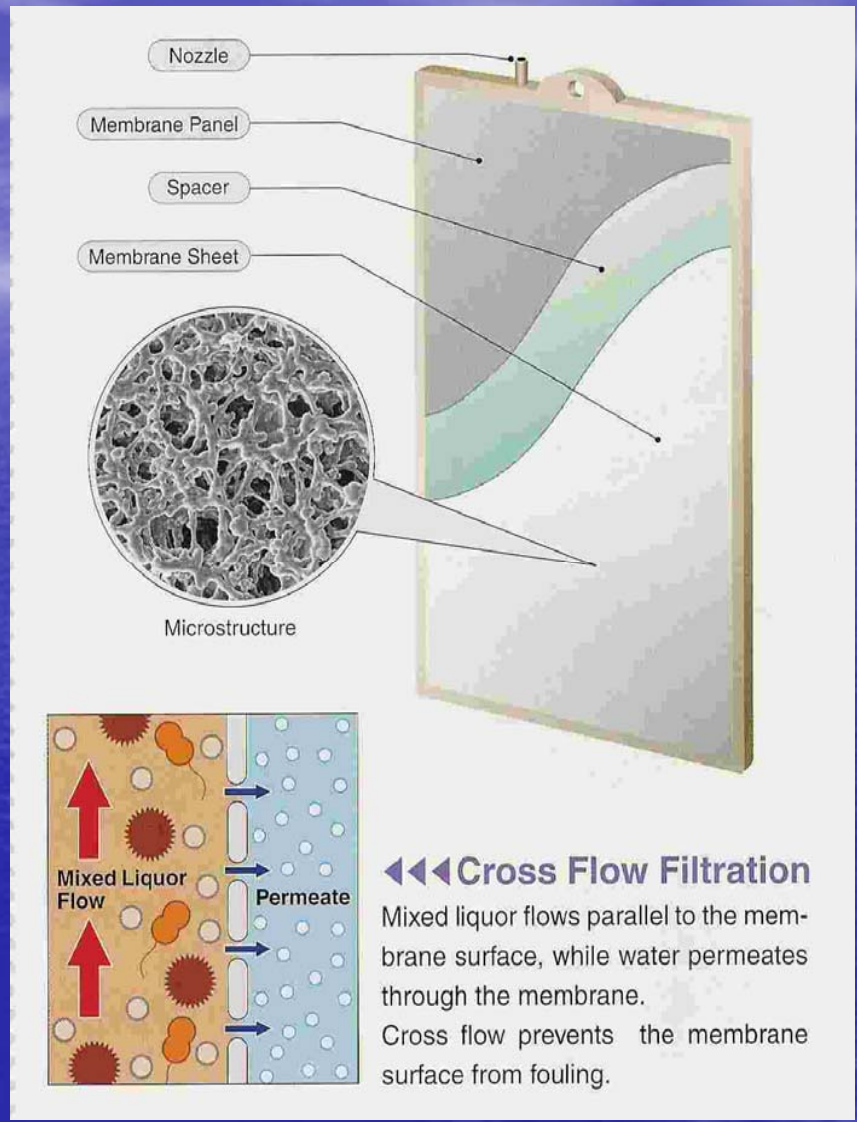
- Pilot plant and testing from 1989, following Japanese government grant to produce high quality, low footprint treatment solution
  - **The membrane was developed purposefully for wastewater treatment and not adapted from water treatment**
- First commercial plant commissioned 1991

Kubota Corporation

- One of Japan's leading Environmental companies
  - Tractors & Construction machinery
  - Pipes and valves
  - Pumps & air conditioning equipment
  - Established 1890
  - 30,000 employees
  - ~ US$10Bn turnover

The Kubota Flatsheet

- Membranes held firmly in place and cannot touch or abrade each other
- The flat sheet is more easily kept clean by coarse bubble aeration
- The flat sheet is robust and last a very long time



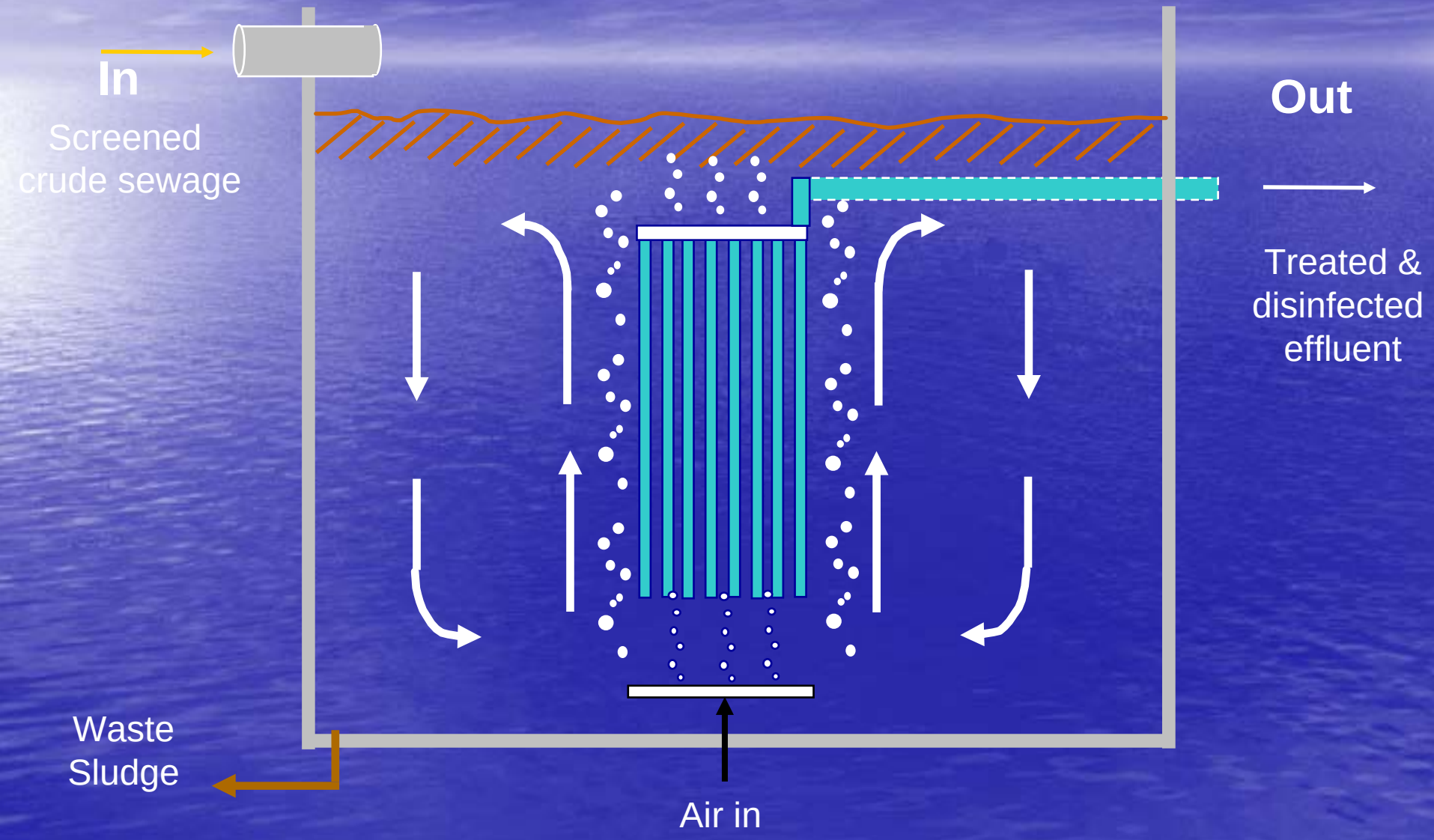
Features of the Kubota Flatsheet

- Optimum pore size (0.4µm)
  - The pore size produces > 6 log removal of bacteria and > 4 log removal of virus, and is Title 22 approved, as biofilm layer yields 0.01um performance
  - The pore size produces less resistance and thus the lowest pressure loss through the membranes
  - The lower pressure loss means less force against the membranes and thus less fouling
    - **Allows for Gravity Removal of permeate**

Features of the Kubota Flatsheet

- Self-sealing
  - Fine lattice prevents progress of biomass through the membrane
    - **Loss of integrity ≠ Impact on Effluent Quality**
- Durable construction
  - ABS & high quality polymer that lasts > 10 years
  - Ultrasonic weld of membrane to ABS lattice
  - Simple lattice structure for low pressure loss and easy gravity removal of permeate

The Kubota Flatsheet SMBR : Principle of Operation



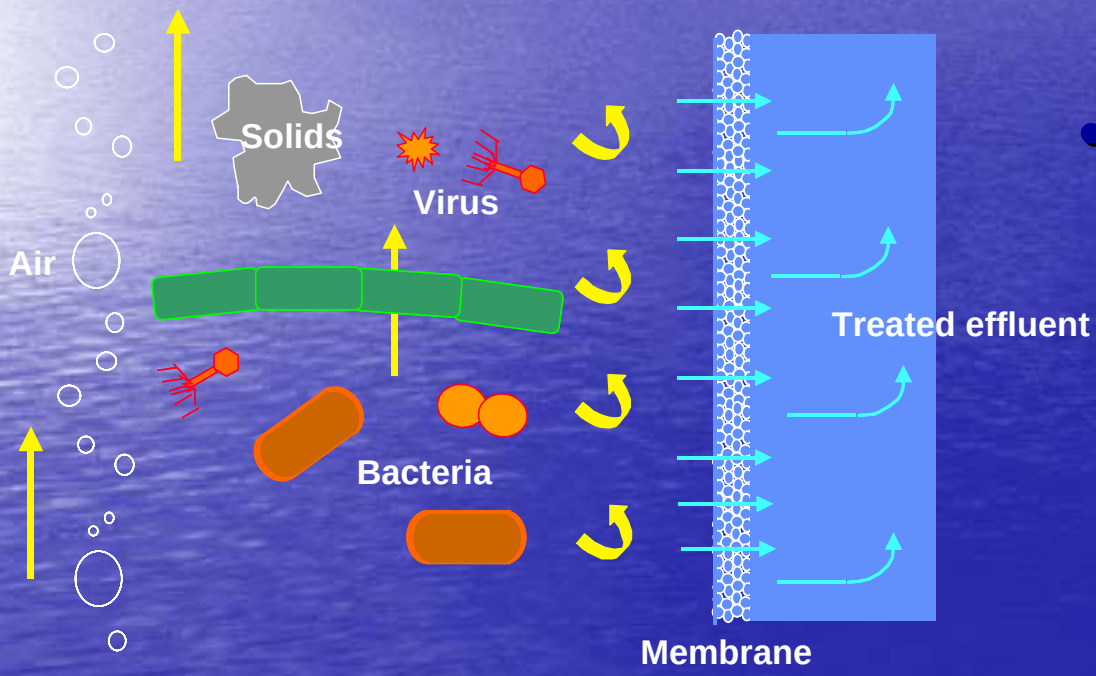
The Kubota Membrane Unit Design

- Stainless steel and high quality plastics
- Simple centipede diffuser
- Designed for easy maintenance

Operational advantages of Kubota flatsheet panel

- Panel is fixed, aeration is maintained at > 0.5m/s velocity
  - Scouring is more effective and drag force is consistent
- Pore size is optimised, so TMP is minimised
  - **Drag force is always greater than force of attachment, as both are controlled**
  - **Cake formation is eliminated**

Operational advantages of the Kubota flatsheet membrane



- No backpulsing is required
- No daily chemical cleaning required

Operational advantages of the Kubota flatsheet membrane

- Chemical cleaning, when required, is very simple
  - Only required twice per year
  - Does not require lowering of tank level
  - Does not require removal of biomass from tank
  - **Does not require removal of membranes from tank**
  - To clean a tank which is rated at 10,000m3/d would take < 1 day.

Operational advantages of Kubota flatsheet panels

- Not significantly affected by hair and fibre
  - 3mm screen only required
- Not significantly affected by grit
  - Many plants operational without grit removal
- Not significantly affected by grease
  - Plants operational with up to 300mg/L FOG
- Very long membrane life >10 years

Operational advantages of Kubota flatsheet panels

- Gravity operation
  - No suction pumps = less mechanical equipment and less problems
  - Lower power consumption
- Higher MLSS operation
  - More effective scouring allows operation up to 18,000mg/L at competitive fluxes, up to 50,000mg/L at low fluxes
    - **Smaller footprint than other MBR plants for same sludge age**

Operational advantages of Kubota flatsheet panels

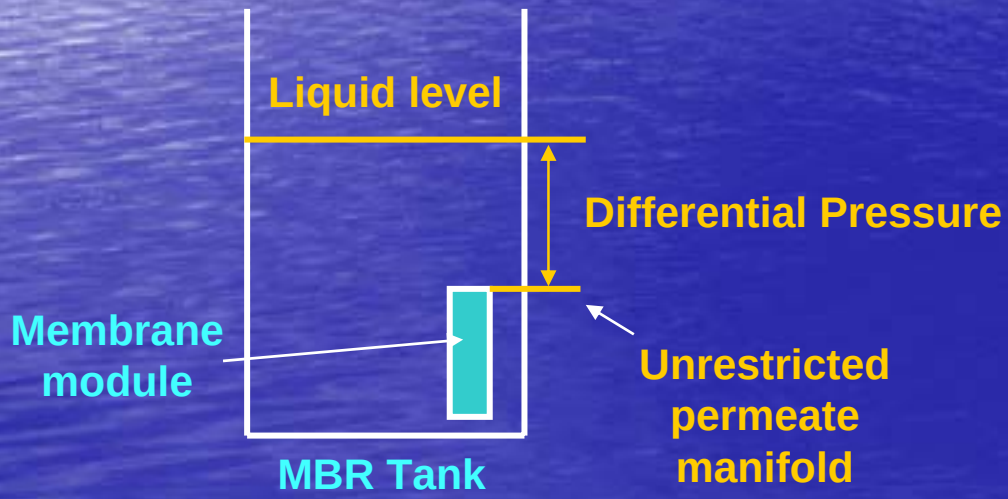
- Peaking ability
  - Can handle short term peaks up to 1.7m3/m2.d
  - As per MWH Title 22 Approval
  - General principle to adopt a 2* peaking factor
    - **Elimination or reduction in balancing volume**

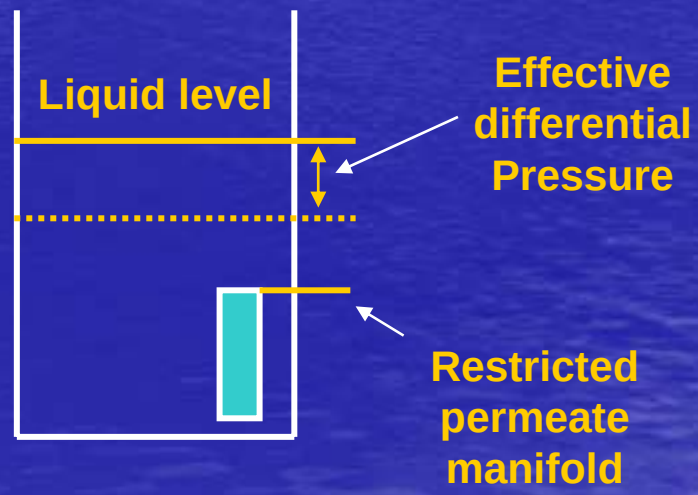
Disadvantages of the Kubota MBR System

- Is designed for wastewater and so requires incoming biological load
  - Not able to be used as tertiary filtration
  - Small footprint advantage can be lost on retrofits
  - MITIGATION
    - Expert focus and specialise on industrial and domestic wastewater treatment
    - Team up with quality process contractors (ACWA) to provide overall more economic solution
- No backpulsing / online chemical cleaning
  - A disadvantage for high fouling waste streams such as leacheate, chemical wastes
  - MITIGATION
    - Conservative flux design & overall more economic solution

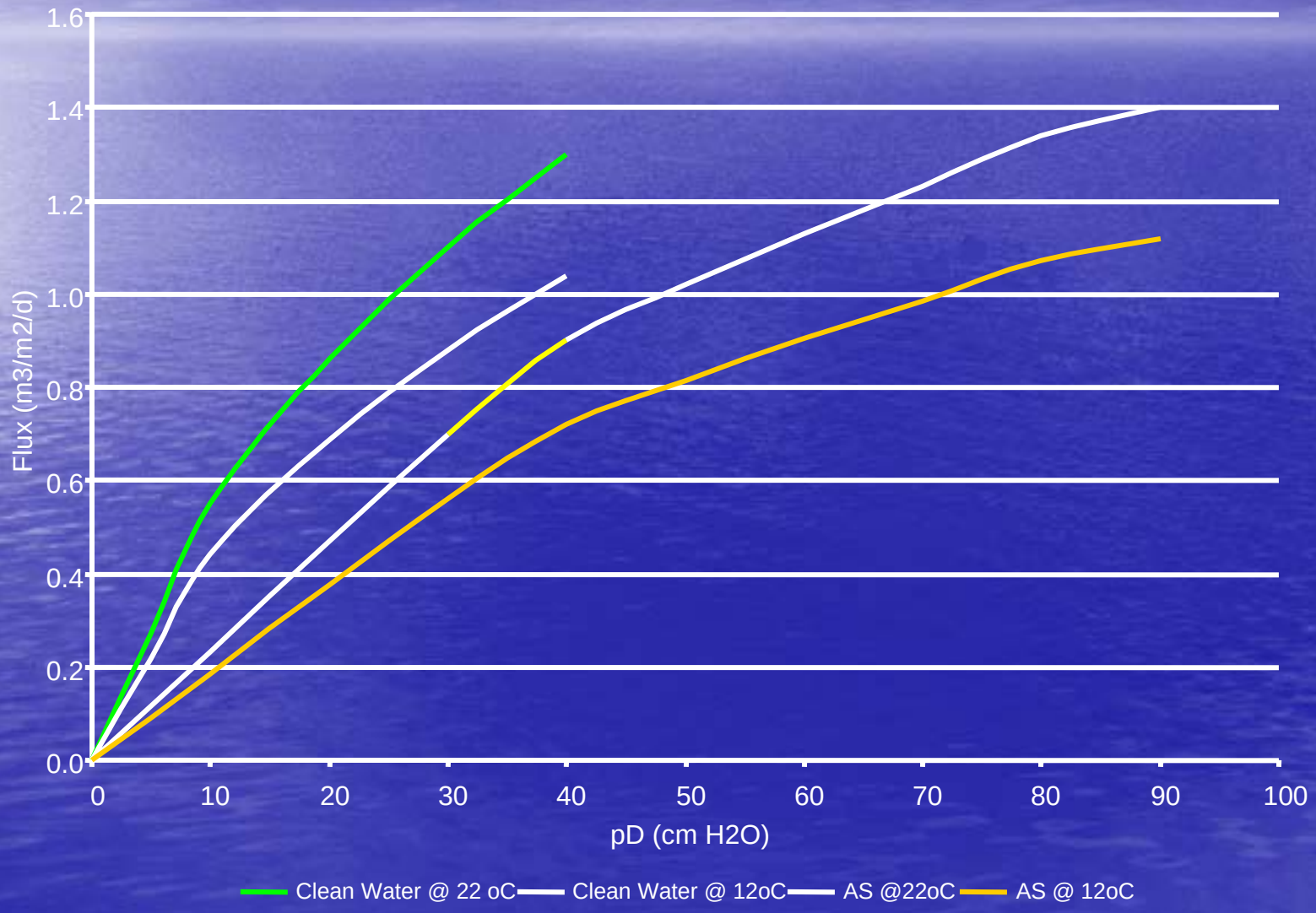
Process Control of the Kubota MBR system

- The system is always operated in subcritical conditions
- A fixed level is adopted, which always provide in excess of the TMP requirements

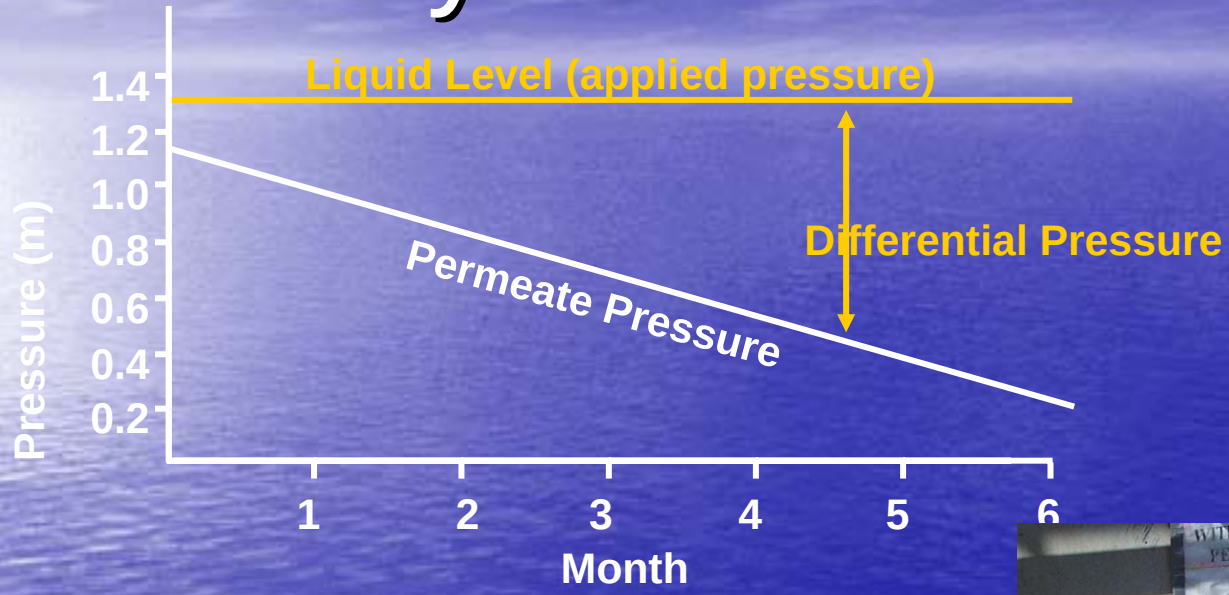




Process Control of the Kubota MBR system



Process Control of the Kubota MBR System



Change in differential pressure over time at a constant permeate flow.

Process Control of the Kubota MBR System

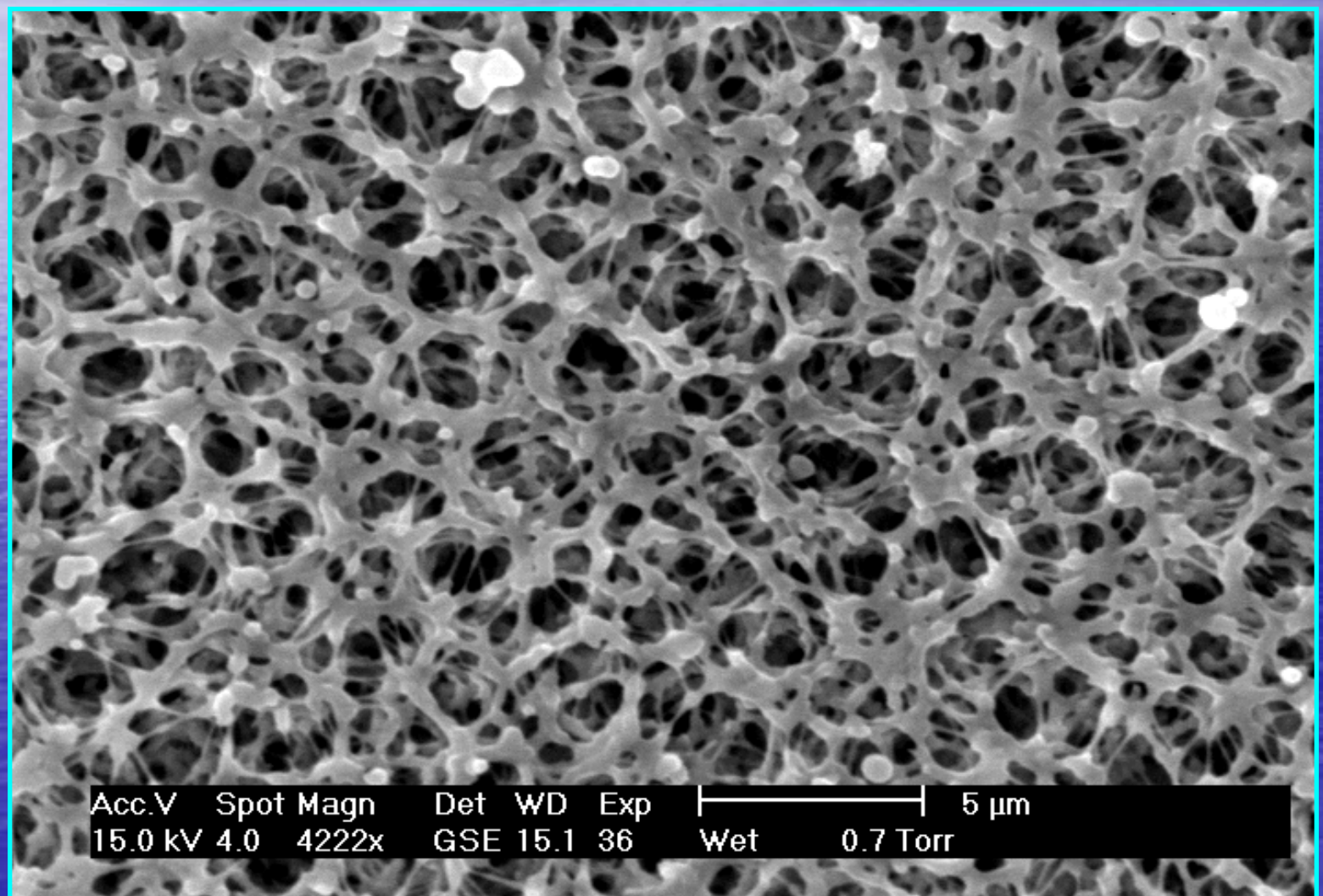
Permeate Outlet Control Valves

		Tank 1	Tank 2	Tank 3	Tank 4
Look Up Table Liquid Depth SP1	0.00 M	-0.0 l/s	-0.0 l/s	-0.0 l/s	-0.0 l/s
Look Up Table Liquid Depth SP2	0.00 M	-0.0 l/s	-0.0 l/s	-0.0 l/s	-0.0 l/s
Look Up Table Liquid Depth SP3	0.00 M	-0.0 l/s	-0.0 l/s	-0.0 l/s	-0.0 l/s
Look Up Table Liquid Depth SP4	0.00 M	-0.0 l/s	-0.0 l/s	-0.0 l/s	-0.0 l/s
Look Up Table Liquid Depth SP5	0.00 M	-0.0 l/s	-0.0 l/s	-0.0 l/s	-0.0 l/s
Look Up Table Liquid Depth SP6	0.00 M	-0.0 l/s	-0.0 l/s	-0.0 l/s	-0.0 l/s
Look Up Table Liquid Depth SP7	0.00 M	-0.0 l/s	-0.0 l/s	-0.0 l/s	-0.0 l/s
Look Up Table Liquid Depth SP8	0.00 M	-0.0 l/s	-0.0 l/s	-0.0 l/s	-0.0 l/s
Look Up Table Liquid Depth SP9	0.00 M	-0.0 l/s	-0.0 l/s	-0.0 l/s	-0.0 l/s
Look Up Table Liquid Depth SP10	0.00 M	-0.0 l/s	-0.0 l/s	-0.0 l/s	-0.0 l/s
Tank 1 Maximum Flow Rate	-0.0 l/s				
Tank 2 Maximum Flow Rate	-0.0 l/s				
Tank 3 Maximum Flow Rate	-0.0 l/s				
Tank 4 Maximum Flow Rate	-0.0 l/s				

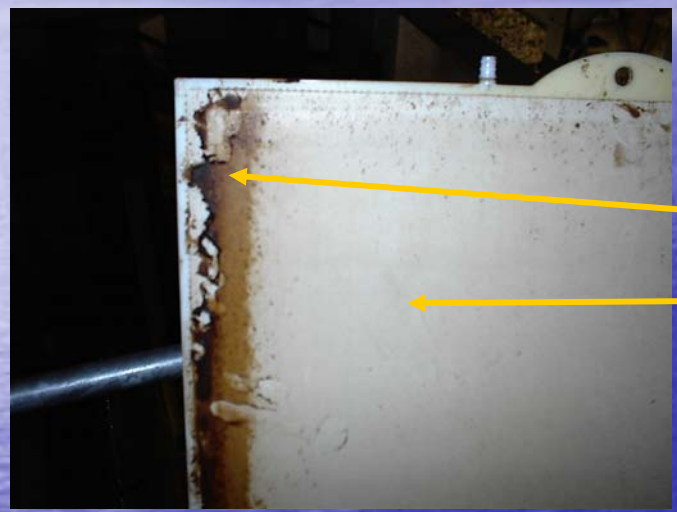
	Height	per tank
1	2000	14.5
2	1975	11.9
3	1950	10.6
4	1925	9.3
5	1900	7.9
6	1875	6.6
7	1850	4.0
8	1825	2.6
9	1800	1.3
10	1775	0.0

Process Control of the Kubota MBR System – Fouling Control

New membrane surface



Process Control of the Kubota MBR System – Fouling Control



Foulants

Potential foulants:

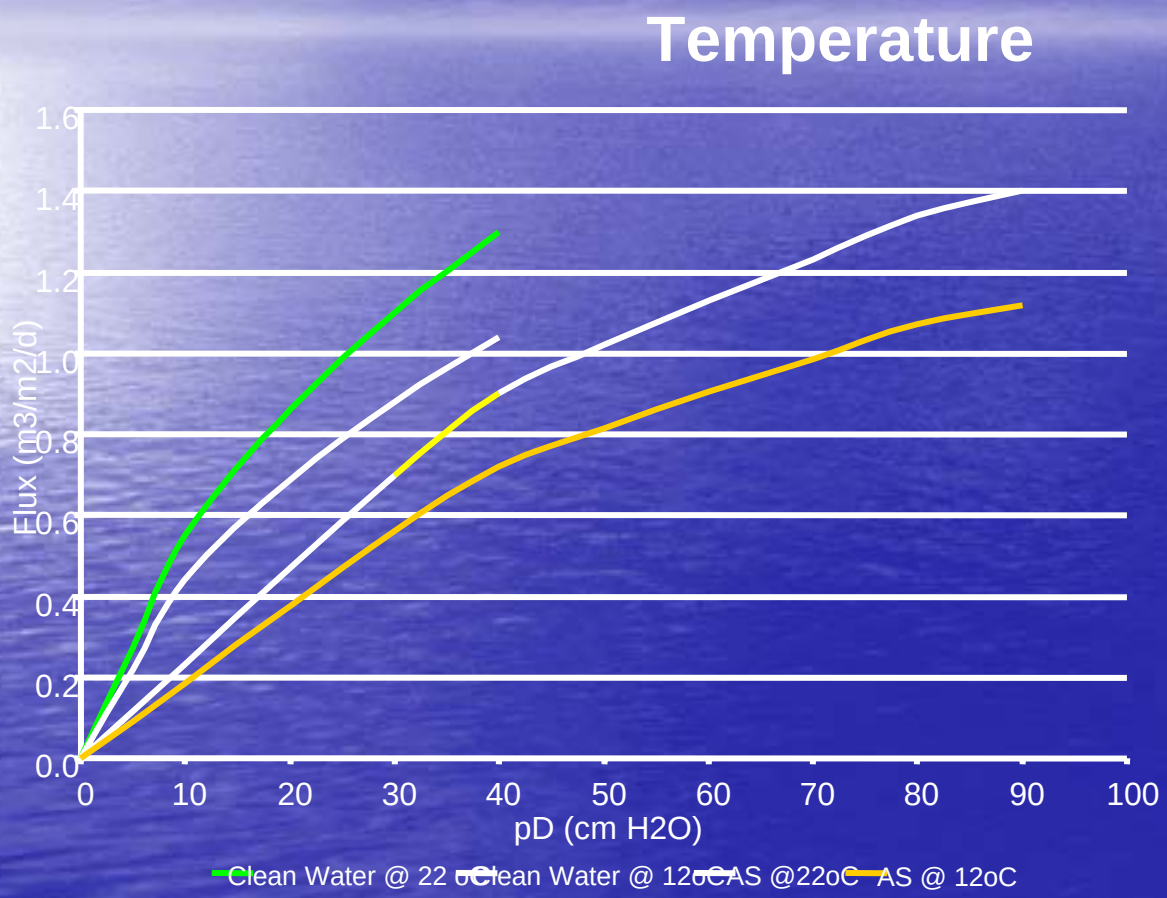
1. **Biomass**
2. **Organic slimes**
3. **Inorganic precipitants**
4. **Fats, oils and greases**

Process Control of the Kubota MBR System – Fouling Control

Aeration

1. **Permeate production without aeration will result in the membranes fouling.**
2. **Permeate production with low aeration with gradually result in membrane fouling.**
3. **An uneven distribution of air along the membrane module will result in membrane fouling.**

Process Control of the Kubota MBR System – Fouling Control



1. As the liquid temperature rises the viscosity decreases
2. For every 1^{o}C increase in temperature there is a 2% increase in permeate flowrate

Process Control of the Kubota MBR System – Fouling Control

MLSS concentration

1. The ideal MLSS range is 10,000 to 15,000 mg/l
2. At exceptional low MLSS the membrane is separating raw sludge liquors, which will foul the membranes.
3. At MLSS<7,000 mg/l the cross flow velocity is reduced
4. At MLSS>20,000 mg/l the liquid viscosity is increased significantly and the cross flow velocity reduced

Process Control of the Kubota MBR System

- TO PREVENT CAKE FORMATION
- Membrane Relaxation
  - Operate at 55mins on / 5mins off
- High Rate Air Scour
  - Increase airflow rate for 30mins per day
- TO REMOVAL MICROBIAL FOULING
- Chemical clean of membanes
- TO REPLACE DAMAGES AND SELF-SEALED MEMBRANES
  - Pro-active inspections after 4 years and then every 3 years thereafter

Middle East Installations

- ACWA MBR is the leading MBR Designer/Supplier in the Middle East, with the following milestones
  - Commenced with Tubli Bay trial (Bahrain) in 2002
  - First full size commercial plant, British American Tobacco, Turkey, Operational Nov 2002
- 15 installations operational or under construction, including what will be the largest SMBR plant in the world, Al Ansab, at 78,000m3/d

Installation Locations - 1

Location: Torbali, Turkey

Client: BAT

Application : Industrial Waste

Capacity: 680m3/d

Operational since Oct 2002

Location: Izmir, Turkey

Client: JTI

Application : Industrial Waste

Capacity: 360m3/d

Operational since Jan 2005

Location: Jordan

Client: Dyncorp

Application : Labour Camp Waste

Capacity: 900m3/d

Operational since Nov 2004

Location: Al Kharj, Saudi Arabia

Client: Almarai

Application : Industrial Waste (Dairy)

Capacity: 4000m3/d

Operational since June 2005

Client: Almarai

Application : Domestic Waste

Capacity: 600m3/d

Operational since May 2005

Installation Locations - 2

Location: Tubli Bay, Bahrain

Client: Bahrain Sewerage Directorate

Application : Pilot Plant

Capacity: 5m3/d

Operational 2002-2003

Location: Messaeid, Qatar

Client: Technip/QVC

Application : Industrial Waste (Vinyl)

Capacity: 300m3/d

Operational since Nov 2003

Location: OGD3/Ruwais, Abu Dhabi, UAE (4 plants)

Client: CCC

Application : Domestic Waste

Capacity: 500m3/d * 4

Operational Dec 2005

Location: Sharjah, UAE

Client: Sharjah Municipality

Application : Containerised Unit

Capacity: 150m3/d

Operational Apr 2005

Location: Palm Jumeirah, Dubai

Client: Nahkeel / Metito

Application : Domestic Waste

Capacity: 21,700m3/d

Operational July 2006

Location: Greens, Dubai

Client: EMAAR / Metito

Application : Domestic Waste

Capacity: 12,000m3/d

Operational March 2005

Location: Al Ansab, Muscat, Oman

Client: OWSC

Application : Domestic Waste

Capacity: 78,000m3/d

Operational Nov 2006

Industrial Case Study 1: BAT Industrial Plant

- Combined Cigarette/Domestic Waste
- 680m^3/d Daily Flow
- COD ~ 2000 mg/L
- TSS ~ 550 mg/L
- Client : British American Tobacco
- Location : Izmir, Turkey
- Status: Operational since October 2002

BAT Industrial Plant, Turkey

Industrial Case Study 2: Qatar Vinyl Industrial ETP

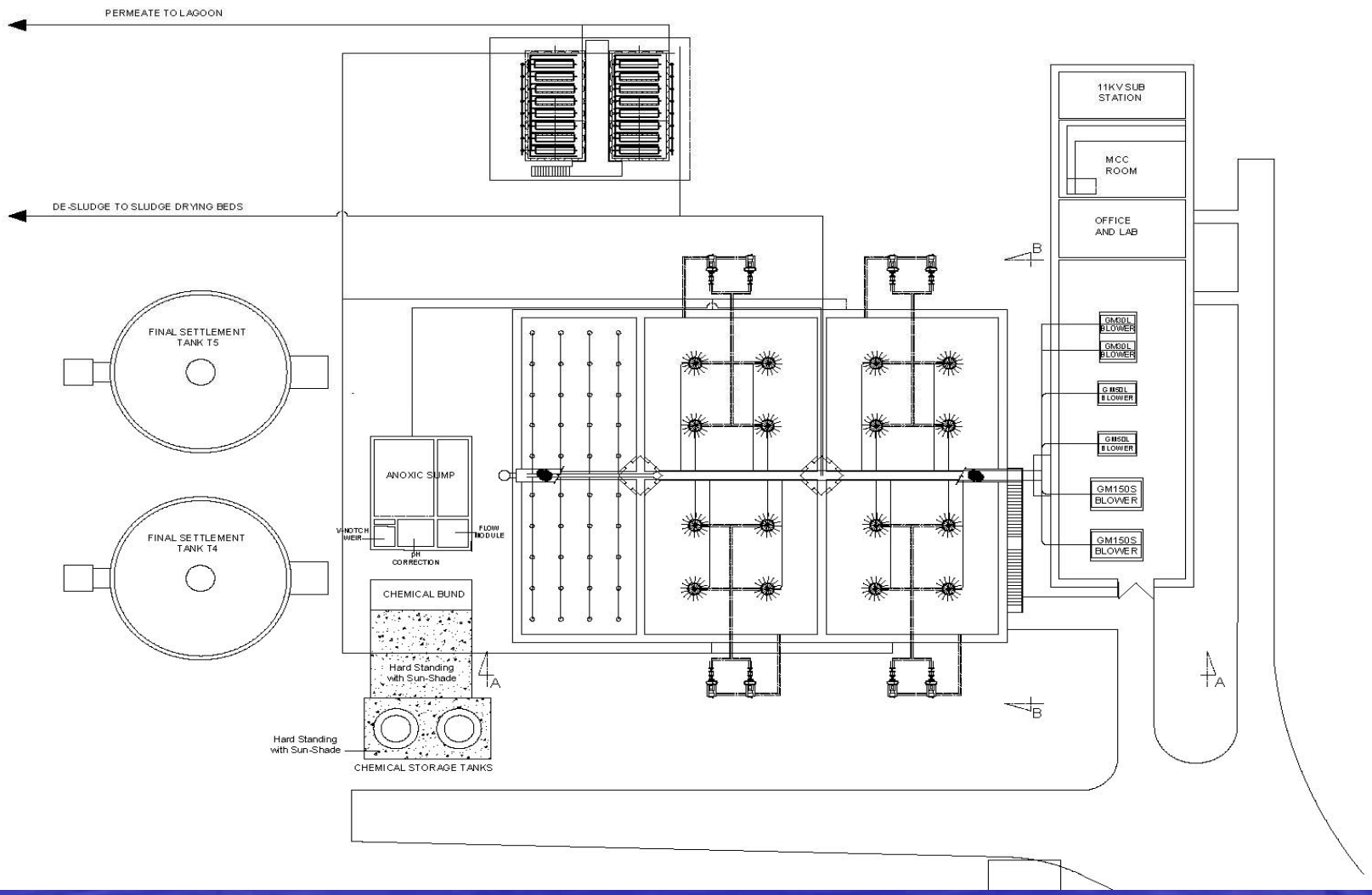
- Existing plant – poor settling sludge
- MBR Retrofit to retain biomass and increase effluent quality
- Design Flow : 320m^3/day
- Client : Technip (Rome)
- COD ~ 2,000mg/L
- Cl^- ~ 10,000mg/L
- Location: QVC, Messaid Industrial City, Qatar
- Status: Operational since November 2003

Qatar Vinyl Industrial ETP

Industrial Case Study 3: Almarai Industrial Plant, KSA

- Waste from dairy operations, Al Kharj
- Full flow 4000m^3/d
- 12 no. EK400 membrane units (up to 16)
- COD ~ 2000mg/L
- Retrofit of existing conventional plant
- Client : Saudi Berkefeld – Wetico
- End User : Almarai Corporation
- Status: Operational since June 2005

Almarai Industrial ETP - Diagram



Domestic Case Study 1: Almarai Domestic Plant, KSA

- Sewage waste from workers, Al Kharj
- Full flow 750m^3/d
- 4/6 no. ES200 membrane units
- Client : Saudi-Berkefeld WETICO
- End-User: Almarai Company Ltd
- Status: Operational since April 2005

Almarai STP : Photo

Domestic Case Study 2: Jordan Labour Camp, Blackwater

- Sewage waste from trainees/workers
- Design flow 360m^3/d, upgradable to 900m3/d
- 4/9 no. ES200 membrane units
- Client : Morganti / CCC
- Circular Steel tanks due to rapid construction requirement
- Status: Commissioned January 2005

Jordan Blackwater Treatment : Photos

Domestic Case Study 3: Palm Jumeirah Undeground STP

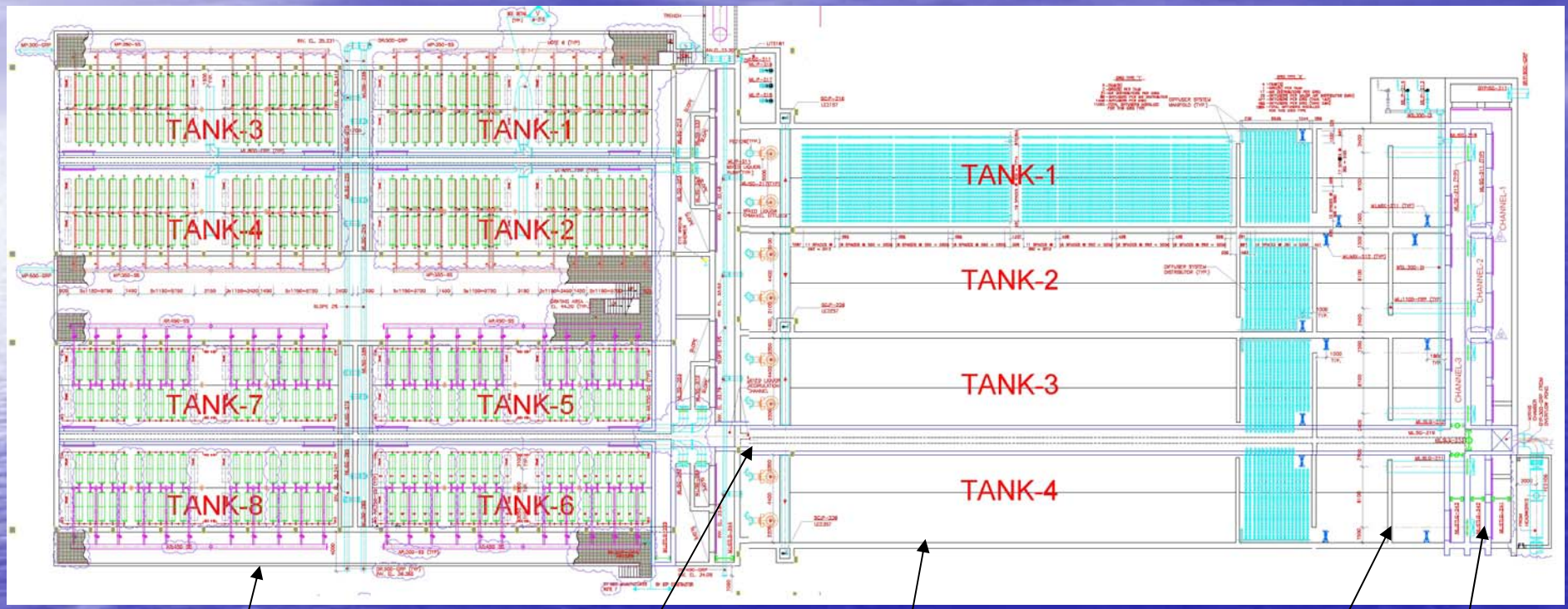
- Nahkeel requirements
  - Aesthetic, preferrably ‘unseen’ plant
    - Minimised footprint
  - No odour
  - No noise
  - Minimised sludge production
  - Low operator requirements
  - Very high effluent quality for recycling onto parks and gardens
- -> Underground MBR Installation

Palm Location

Domestic Case Study 4: Al Ansab Water Recycling, Oman

- Will be the worlds largest submerged membrane plant, to treat a daily flow of up to 78,000m^3/day
- Contract award December 2003
- Collaborative design between Metcalf & Eddy and Aquator
- Part of the ‘Muscat Water Plan’

Al Ansab : General Arrangement



Membrane Tanks

Recycle Channel

Aeration Tanks

Anoxic Tanks

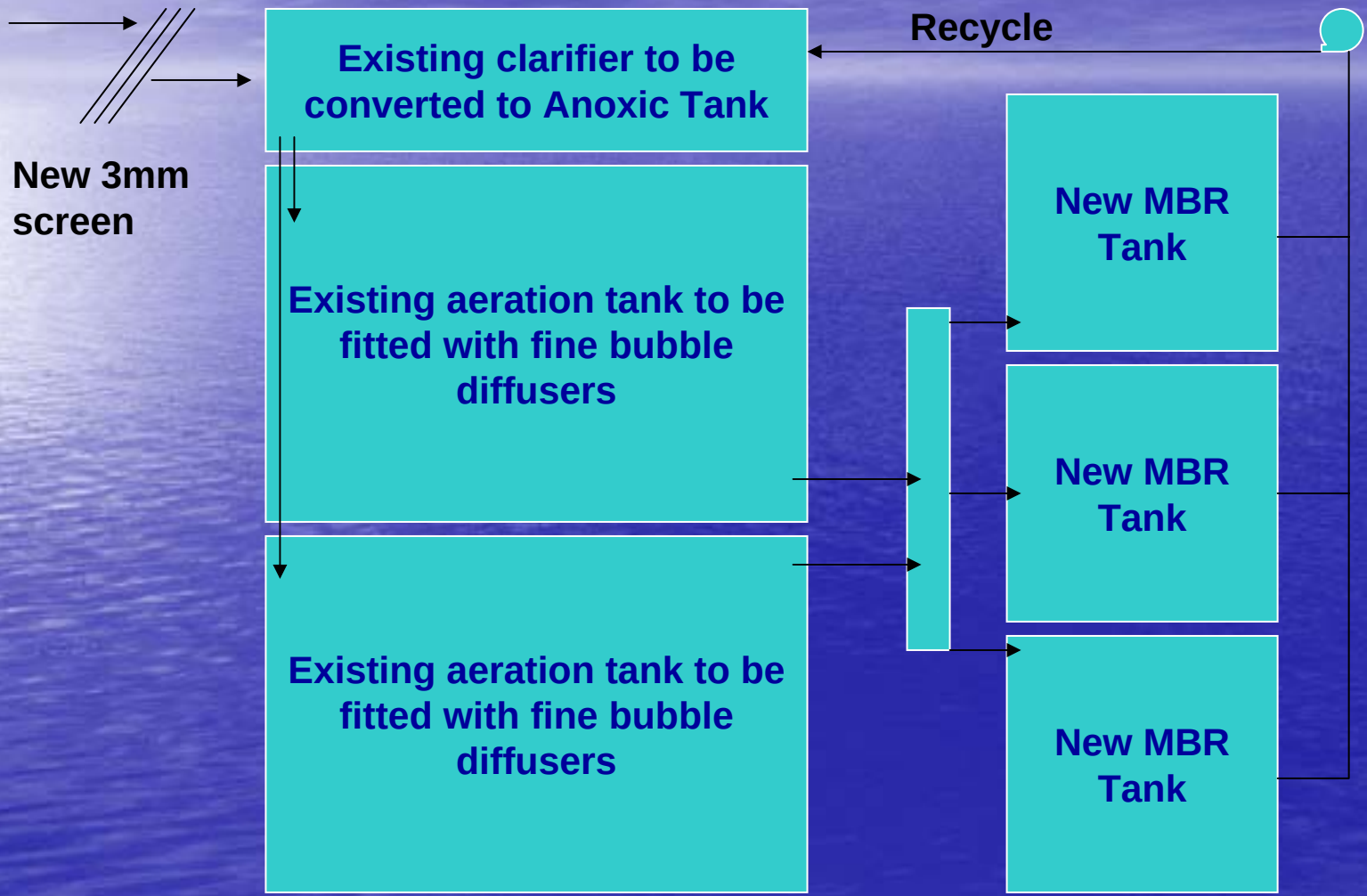
Distribution Chambers

- **Total footprint of treatment tanks is 150m * 50m**

Domestic Case Study 5: Greens MBR Expansion

- Upgrade of existing extended aeration plant from 3,000m3 -> 12,000m3/d
- Surface aerators replaced with fine bubble aeration to allow increased MLSS
  - -> Maximise existing asset
- Client : Metito
- End User : EMAAR Properties
- ACWA MBR Scope: Design, supply membrane units, supervision installation and commission
- Status: To be operational March 2006

Greens MBR : Schematic



Domestic Case Study 6: Ruwais/ODG3 Containers

- 1,000m3/d flow from labour camp
- Short term requirement
  - Mobile plant required
- Irrigation Reuse
- Very short construction time available
- Client : CCIC
- ACWA MBR Scope: Complete turnkey contract, including commissioning and operations assistance
- Status: To be operational December 2005

Conclusions

- The Kubota membrane is a remarkable invention that has stood the test of time
- It is the most robust and simple MBR solution