2.500 Desalination and Water Purification
Spring 2009

Koch Membrane Systems, Inc.

Innovative Products for Water and Wastewater Treatment

Koch Membrane Systems History

1963 - ABCOR founded to commercialize separation technologies developed at MIT

1970 - ABCOR develops tubular ultrafiltration (UF) products

1977 - Koch Industries acquires 100% of equity in ABCOR

1980 - ABCOR introduces spiral wound UF products for food/dairy applications

1985 - ABCOR renamed Koch Membrane Systems, Inc. (KMS)

1991 - KMS acquires Romicon supplier of hollow-fiber UF technology

1996 - KMS acquires MPW supplier of specialty nanofiltration (NF) technology

1998 - KMS acquires Fluid Systems supplier of RO and NF spiral elements

2003 - KMS introduces 10” TARGA® UF and 18” MegaMagnum® RO elements

2004 - KMS acquires Puron® MBR (submerged) products

2006 - 1st large scale MegaMagnum System sold (66 MLD)

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KMS Overview

Employment	600 +	
Revenue	$100 + Million USA	
Facilities	Wilmington, MA	Corporate Headquarters Membrane and System Manufacturing Research and Development
	San Diego, CA	RO/NF Membrane Manufacturing
	Aachen, Germany	PURON Membrane Manufacturing
	Sales Offices	England, Germany, France, Italy, Spain, China, Bahrain, Singapore, India, Brazil, Australia
Markets	Industrial and municipal MF/UF/NF/RO membranes, chemicals, systems and services. Tubular, pressurized and submerged hollow-fiber and spiral	

KMS Overview

KMS Business Focus

- Water and Wastewater (48%)
  - Feed water and effluent treatment
  - Process water recovery and reuse
- Food, Dairy and Beverage (33%)
  - In-process applications for *consumable products*
  - All products in this focus area are FDA approved
- Specialty Applications (19%)
  - In-process applications for *industrial processes*

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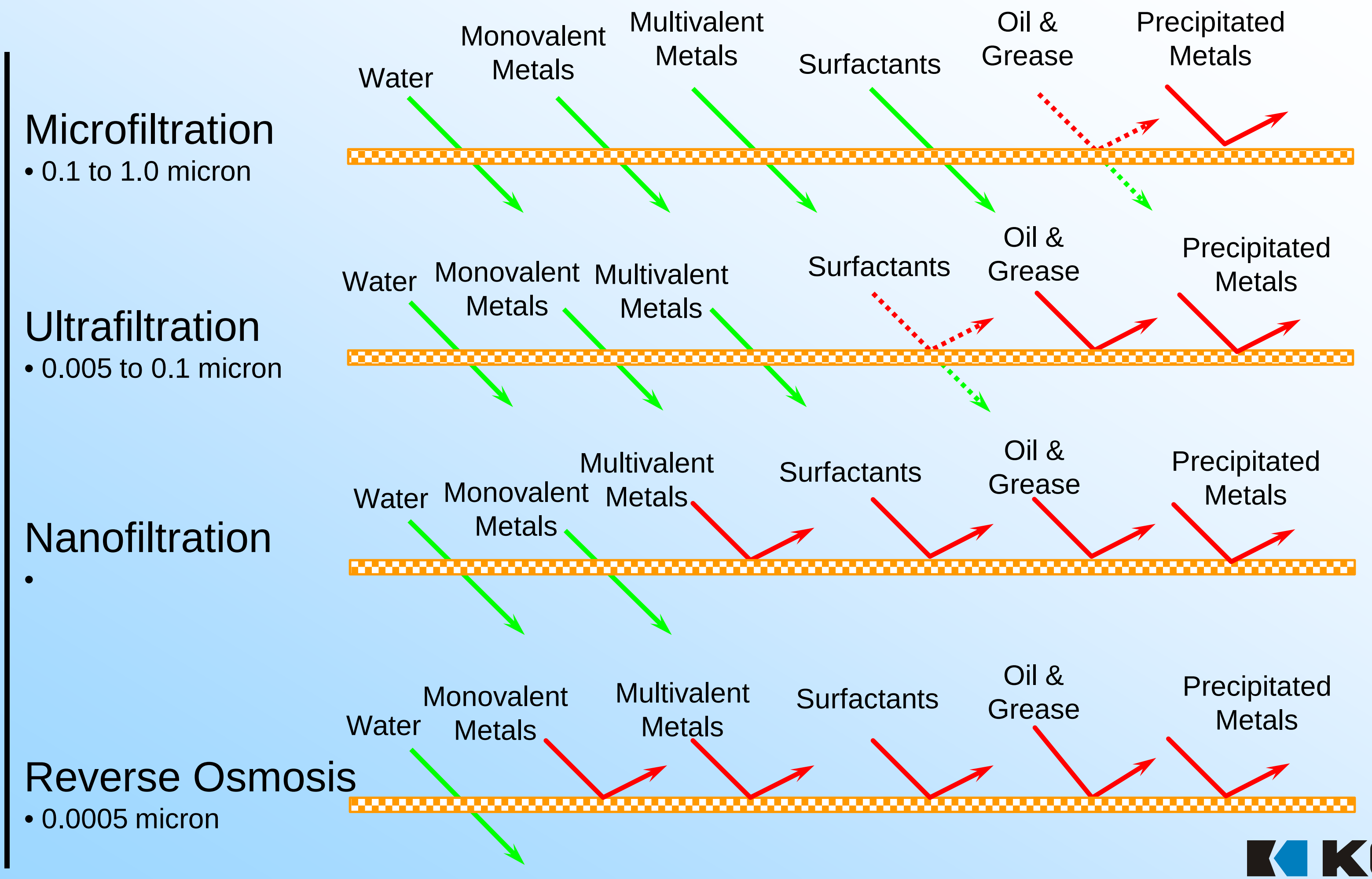
Membrane Separations



Membrane Chemistries

- Membrane Chemistries:
  - Polysulfone (PSF)
  - Polyethersulfone (PES)
  - Polyacrylonitrile (PAN)
  - Polyvinylidene fluoride (PVDF)
  - Cellulose Acetate (CA)
  - Polypropylene (PP)

Membrane Configurations

- Membrane Product Configurations:
  - Tubular
  - Spiral wound
  - Hollow fiber
    - Pressurized
    - Submersible

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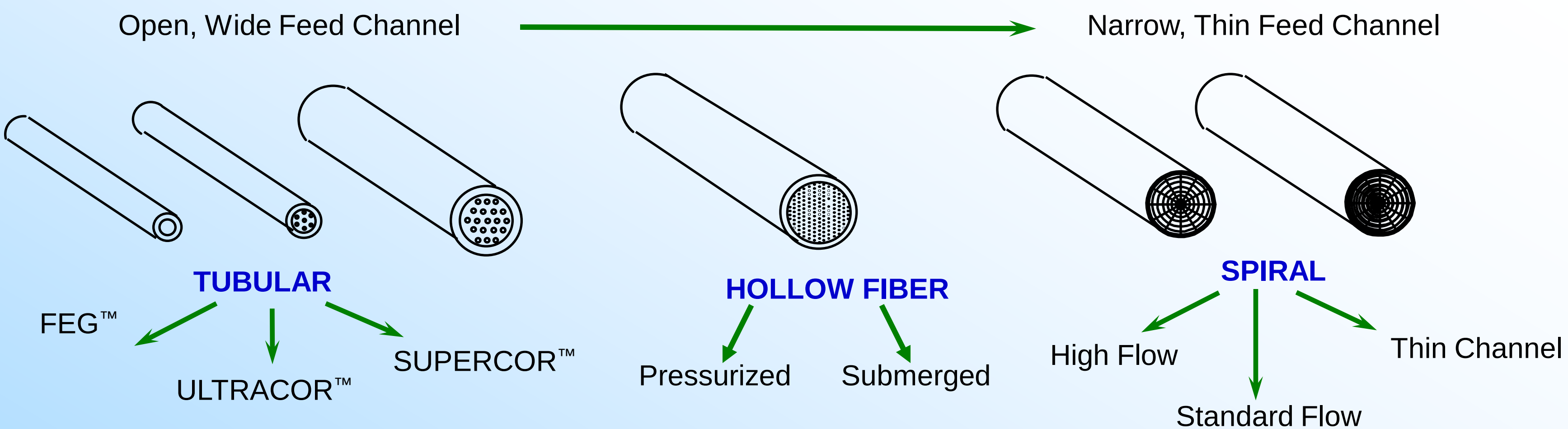
Membrane Configurations



Relative Characteristics

	Tubular	Hollow Fiber	Spiral Wound
Flow Channel Size	———	Decreasing	———→
Membrane packing density	———	Increasing	———→
Concentrate Solids	———	Decreasing	———→
System Footprint	———	Decreasing	———→

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Tubular Products

<u>Product Characteristics</u>

- Processes a variety of streams with high suspended solids
- Proprietary PVDF (MF) and PES (UF) membrane formulation
- Available in 1 inch and ½ inch ID tubes
- Sanitary and industrial product designs

Konsolidator™ 336 UF System

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Hollow Fibers (Pressurized)

<u>Product Characteristics</u>

- Propriety modified PS membranes
- Inside to Outside permeate flow direction
- Available in 10,000 and 100,000 MWCO
- Available in 35 mil (0.9 mm) and 43 mil (1.1 mm) fiber ID
- Modular Designs for Future Expansions
- Larger Size Cartridges reduce Capital and Operating Costs

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Hollow Fiber (Vacuum)

<u>Product Characteristics</u>

- Proprietary PES reinforced hollow-fiber membrane
- Single header design to minimize sludge buildup
- Efficient air sparging for high energy efficiency

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Sanitary Spirals

Product Characteristics

- Proprietary TFC formulations
- MF, UF, NF and RO membranes
- High area elements for reduced capital expenditure
- Sanitary element with net outer wrap
- 31 mil and 46 mil feed spacer
- High temperature options

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Water Spirals

<u>Product Characteristics</u>

- Proprietary TFC membrane formulations
- NF and RO membranes
- High area elements for reduced capital expenditure
- Hard outer wrap for element structural integrity
- 28 and 31 mil feed spacers
- High salt rejection options

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SelRO® Membranes

Product Characteristics

- Proprietary membrane formulation
- Stable at high acid and caustic concentrations
- Stable in organic solvents
- UF and NF membranes
- Spiral configurations

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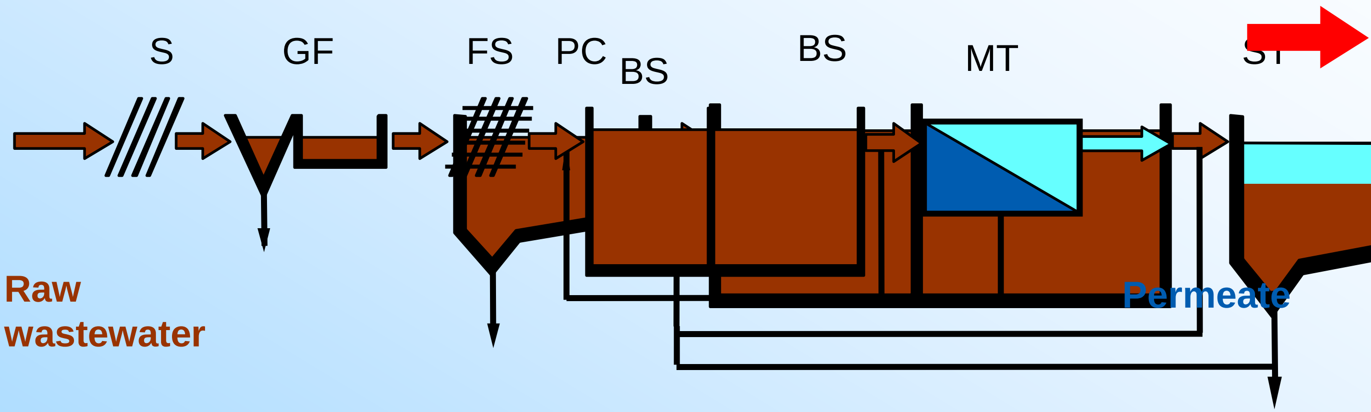
Membrane Bioreactor (MBR)

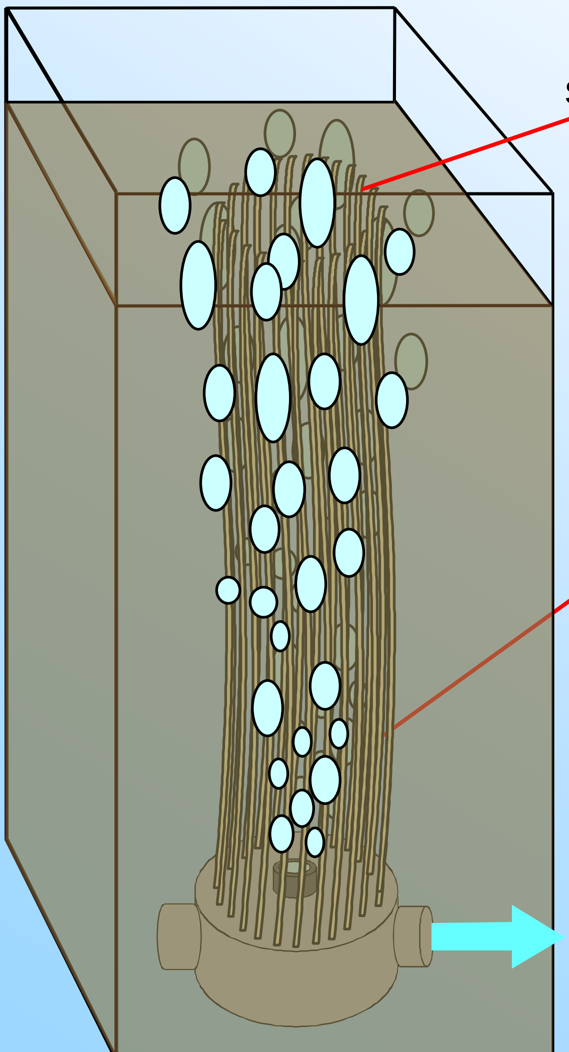
Membrane bioreactor (MBR)



Combination of biological step and solid liquid separation

S	=	Step screen	ST	=	Sedimentation tank
GF	=	Grit and fat removal	TC	=	Third cleaning step (e.g. filtration + disinfection ozone or UV)
PC	=	Primary clarifier			
BS	=	Biological step	MT	=	Membrane technology

PURON Product Concept

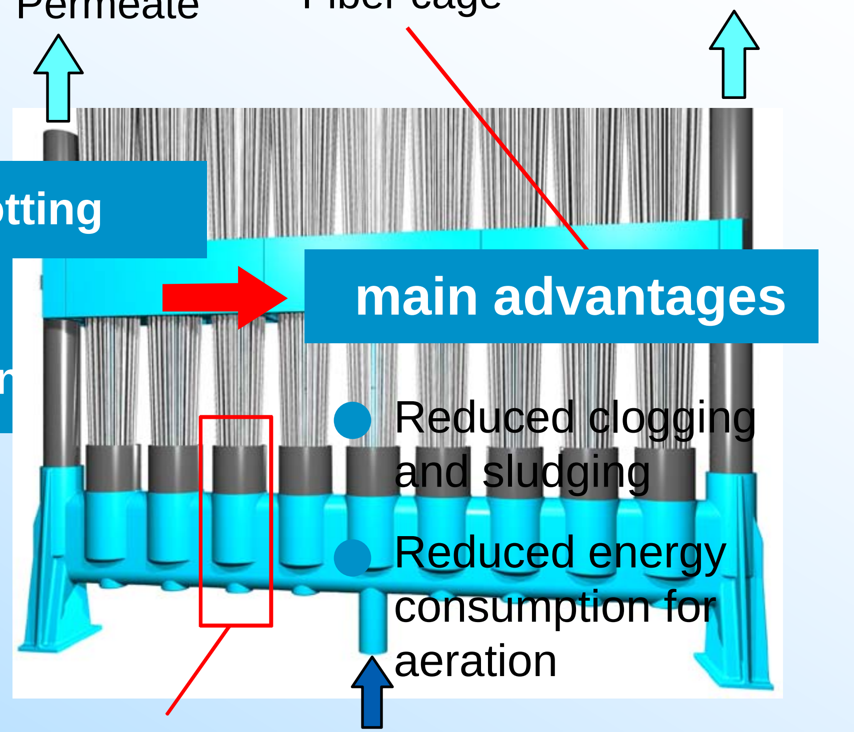


PURON – module row

One side potting

+

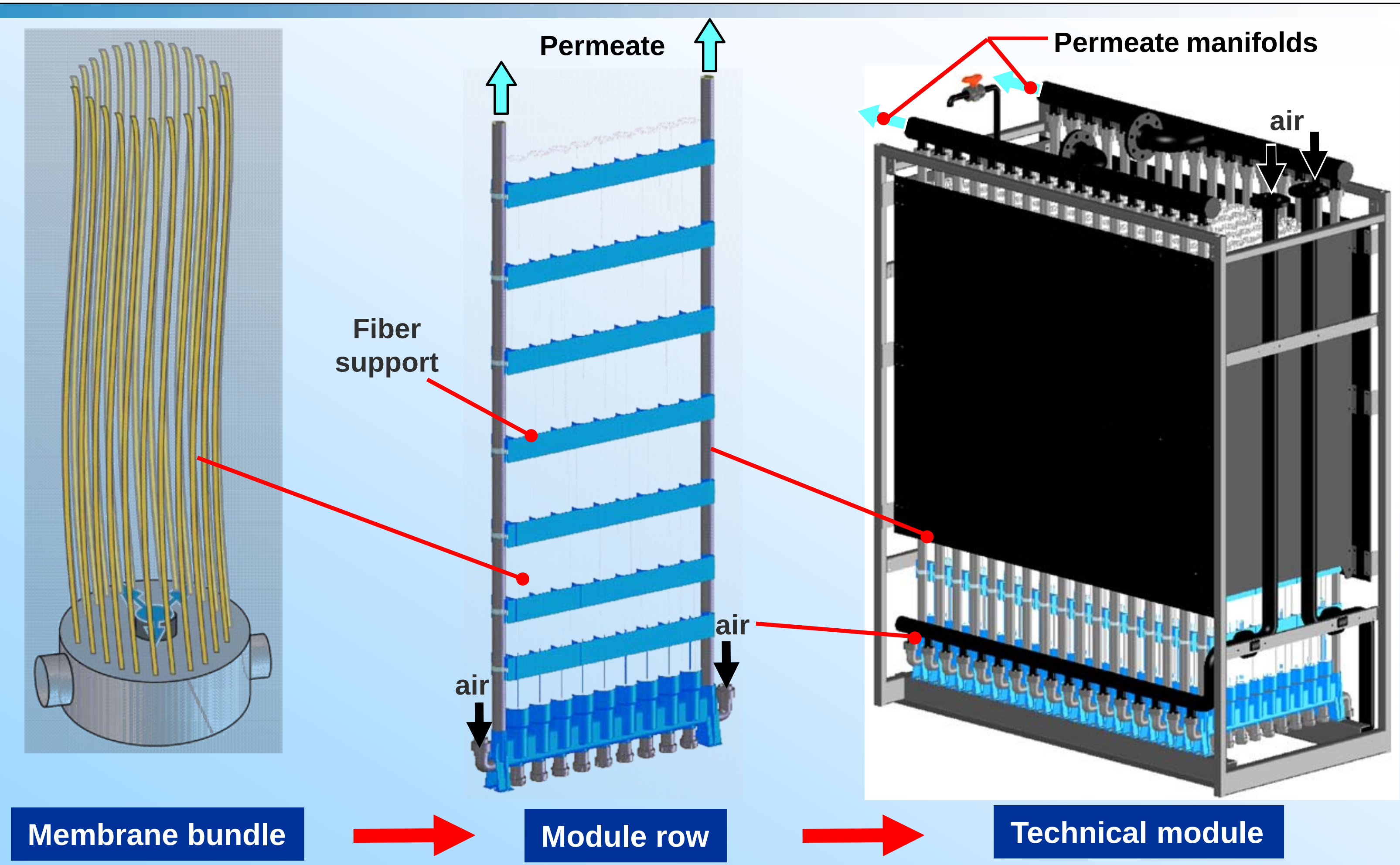
Central air in



main advantages

- Reduced clogging and sludging
- Reduced energy consumption for aeration

PURON Product Concept



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PURON Module Description

- Standard Sizes
  - 30 m^2
  - 250 m^2
  - 500 m^2
  - 1500 m^2
- Integrated permeate and aeration headers
- Available hardware to permit easy installation with both DIN and US piping

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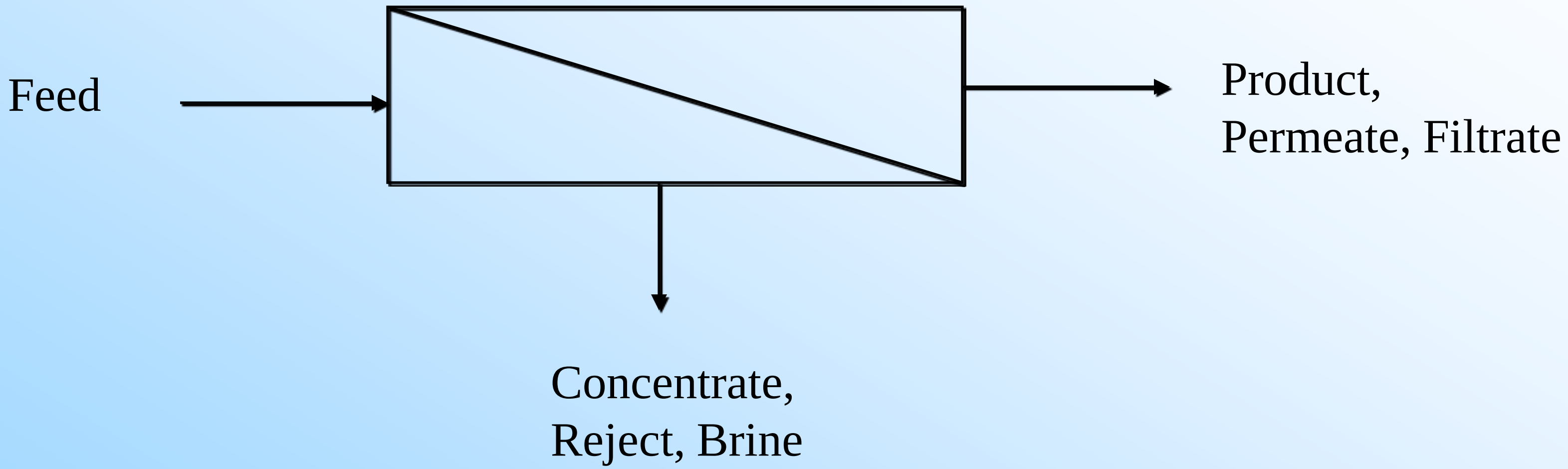
RO Terminology

- Membrane: plastic cast on flat sheet support material
- Element: spiral wound device
- Pressure Vessel (Tube): element housing
- Bank (stage): pressure vessels arranged in parallel
- Array: configuration of vessels by bank; i.e., 4:2:1
- Two Pass: RO permeate treated in two elements in series

RO Terminology

Process Flows



RO Terminology

% Recovery =
Percentage of feed water that becomes product water

$$\% \text{ Recovery} = \frac{\text{Permeate flow}}{\text{Feed flow}} \times 100$$

Example:

Permeate flow = 90 gpm

Feed flow = 100 gpm

Recovery = 90%

RO Terminology

% Salt Rejection =
Percentage of salt in feed that does not pass across membrane

$$\left(1 - \frac{\text{Permeate TDS}}{\text{Feed TDS}}\right) \times 100$$

Examples:

Feed TDS = 35,000 ppm

Permeate TDS = 200 ppm

% Rejection = 99.4%

Permeate TDS = 400

% Rejection = 98.9%

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RO Terminology

% Salt Passage =
Percentage of salt that passes through the membrane

$$\frac{\text{Permeate TDS}}{\text{Feed TDS}} * 100$$

Permeate TDS = 200 ppm	Permeate TDS = 400 ppm
Feed TDS = 35,000 ppm	Feed TDS = 35,000 ppm
% Rejection = 99.4%	% Rejection = 98.9%
% Salt Passage = 0.57%	% Salt Passage = 1.14%

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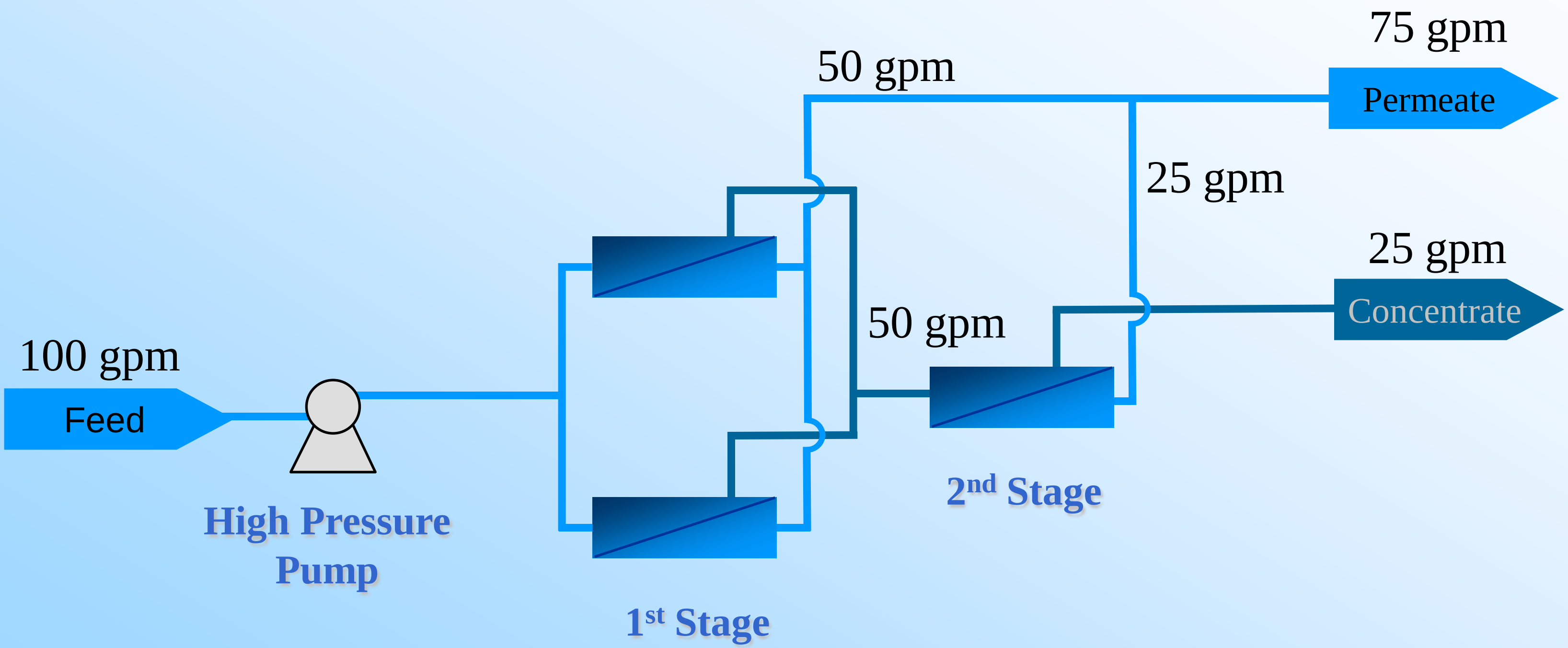
RO Terminology

Stage and Arrays (2/1 array)

Each stage increases water recovery



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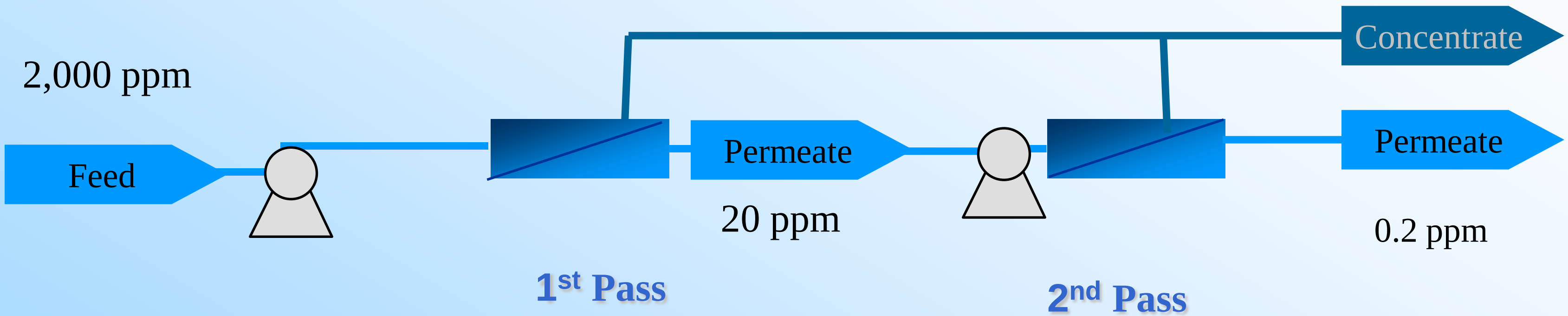
RO Terminology

Two Pass System

Each pass improves product water quality



RO Terminology

Flux =
Permeate produced per unit time per unit membrane area

$$\frac{\text{Permeate Flow (gal/day)}}{\text{Membrane Area (ft}^2\text{)}} = \text{gfd}$$

$$\frac{\text{Permeate Flow (liters/hour)}}{\text{Membrane Area (m}^2\text{)}} = \text{lmh}$$

LMH = GFD * 0.59

RO Terminology

Rate of fouling is a function of flux

Maximum sustainable flux is a function of the feed water properties (water source)

Water Source	Average Flux, GFD
RO Permeate	20 - 30
Deep Well	17 - 20
Lake	12 - 16
Canal/River	10 - 14
Wastewater	8 - 12

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RO Terminology

Flux and production rate sets number of elements (membrane area)

System recovery defines the array

Recovery	Banks	Array	Element/Vessels
50%	1 bank	----------	6 vessels
75%	2 banks	2:1 array	6 vessels
82%	2 banks	2:1 array	7 vessels
90%	3 banks	4:2:1 array	6/7 vessels

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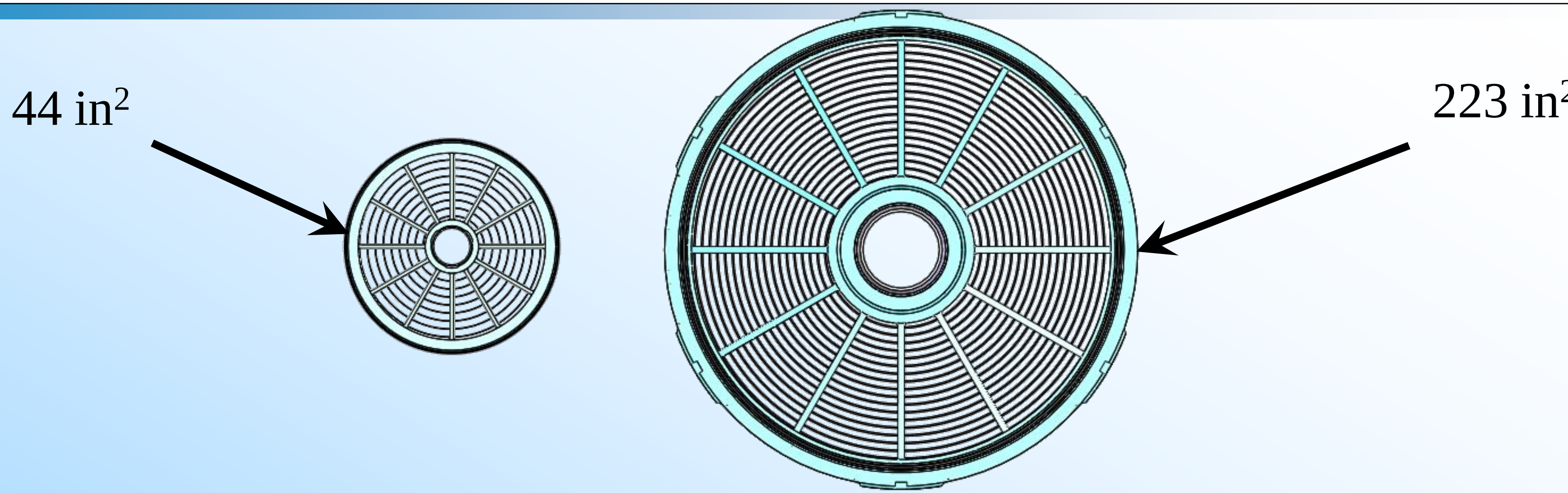
MegaMagnum®
Element Area Comparison

Large Diameter RO Element Comparison



Nominal Diameter (inches)	Element OD (inches)	Core OD (inches)	Available Area (inches2)	Area Ratio
18.00	17.2	3.5	223	5.1
17.25	16.4	3.5	201	4.5
16.00	15.2	3.5	172	3.9
12.75	11.6	2.5	101	2.3
8.00	7.65	1.62	44	1

18 inch comparison: Factor of five scaling compared to 8 inch
Nominal 30% more membrane area than 16 inch

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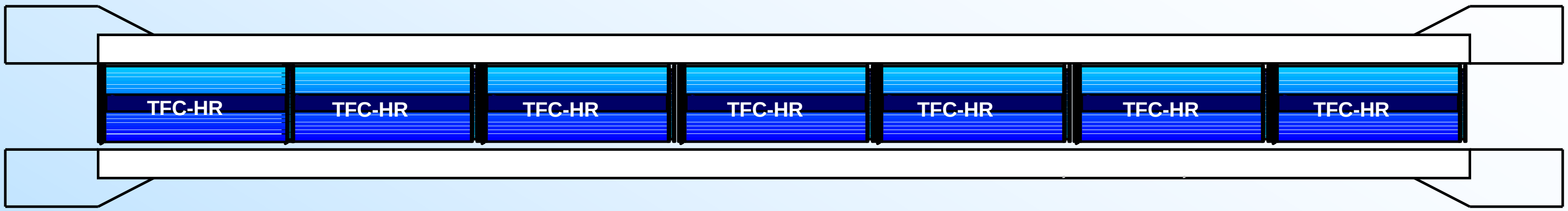
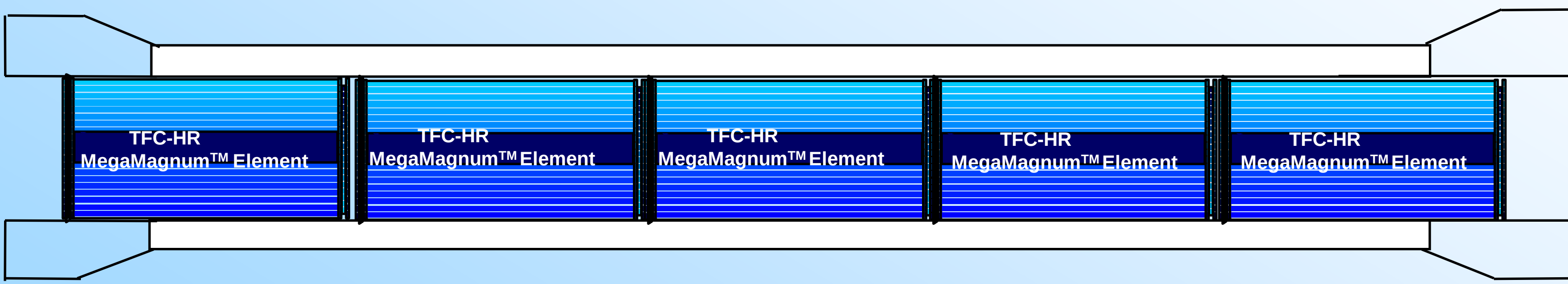
MegaMagnum® Membrane
8” versus 18” Element Comparison



8” x 40” x seven long typical elements

Typical seven long vessel = one KMS MegaMagnum element



One KMS MegaMagnum vessel = five typical 8” vessels

18” x 61” x 5 long per KMS MegaMagnum vessel

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MegaMagnum®
Pressure Vessel

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MegaMagnum®
MM3 Package System

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Projects

MBR/RO System
Joe White Malting, Australia

Projects

MBR/RO System

Joe White Malting, Australia

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Projects

MBR/RO System
Joe White Malting, Australia

Projects

MBR/RO System
Joe White Malting, Australia

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Projects

Western Corridor Recycled Water Project

Application:	Recycle municipal wastewater
Recycle Capacity:	232,000 m^3/day (~ 60 MGD)
Project Budget:	$1.6 billion USA
Project Overview:	Construction of ~ 200 km large diameter pipelines and associated infrastructure
	Construction of three new advanced water treatment plants (AWTP)
	Bundamba: 66,000 m^3/day (17.4 MGD)
	Gibson Island: 100,000 m^3/day (26.4 MGD)
	Luggage Point: 66,000 m^3/day (17.4 MGD)

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Projects

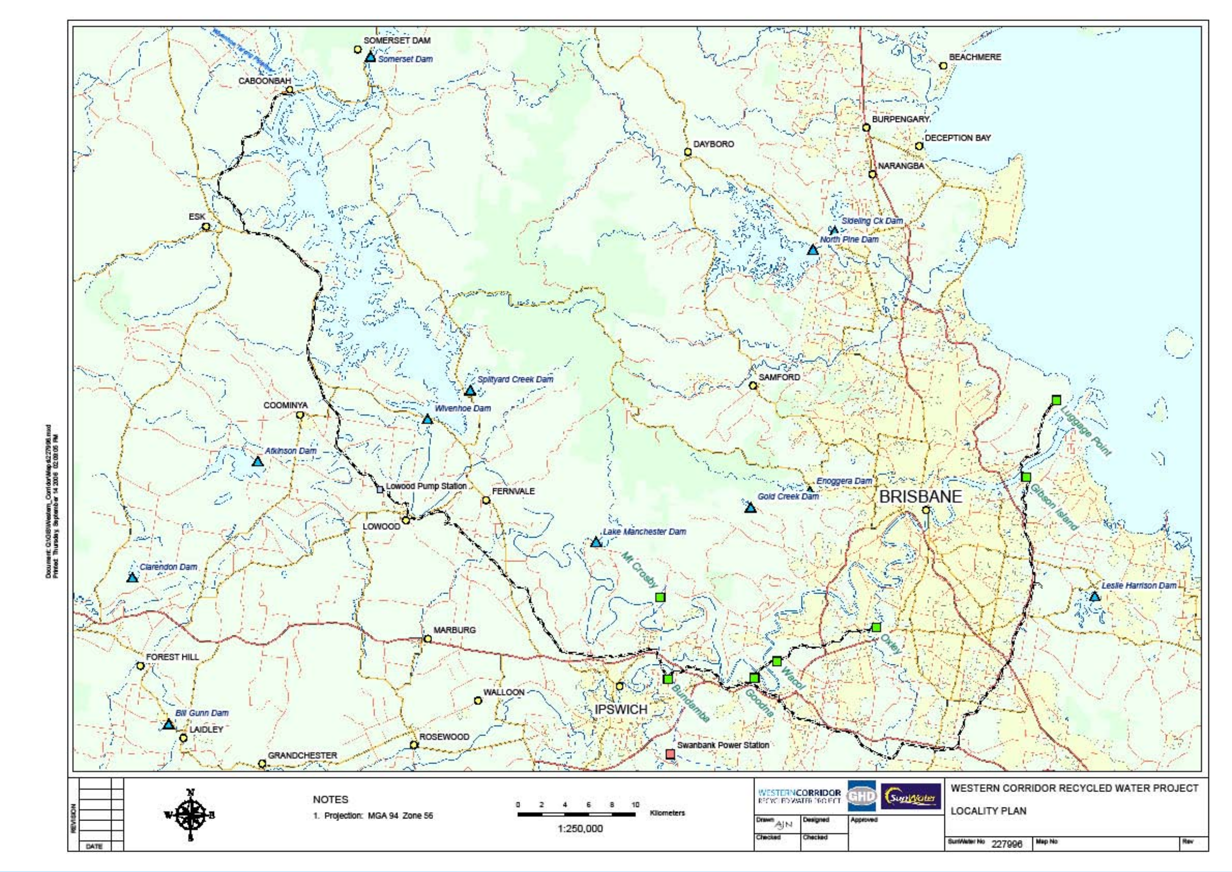
Project Implementation

Recycle water from the Bundamba AWTP is pumped to and used as cooling tower and boiler makeup water at the Swanbank and Tarong Power Stations

Recycled water replaces water that is otherwise removed from municipal water reservoirs; thereby replenishing the local drinking water supply.

Projects

Project Implementation



Projects

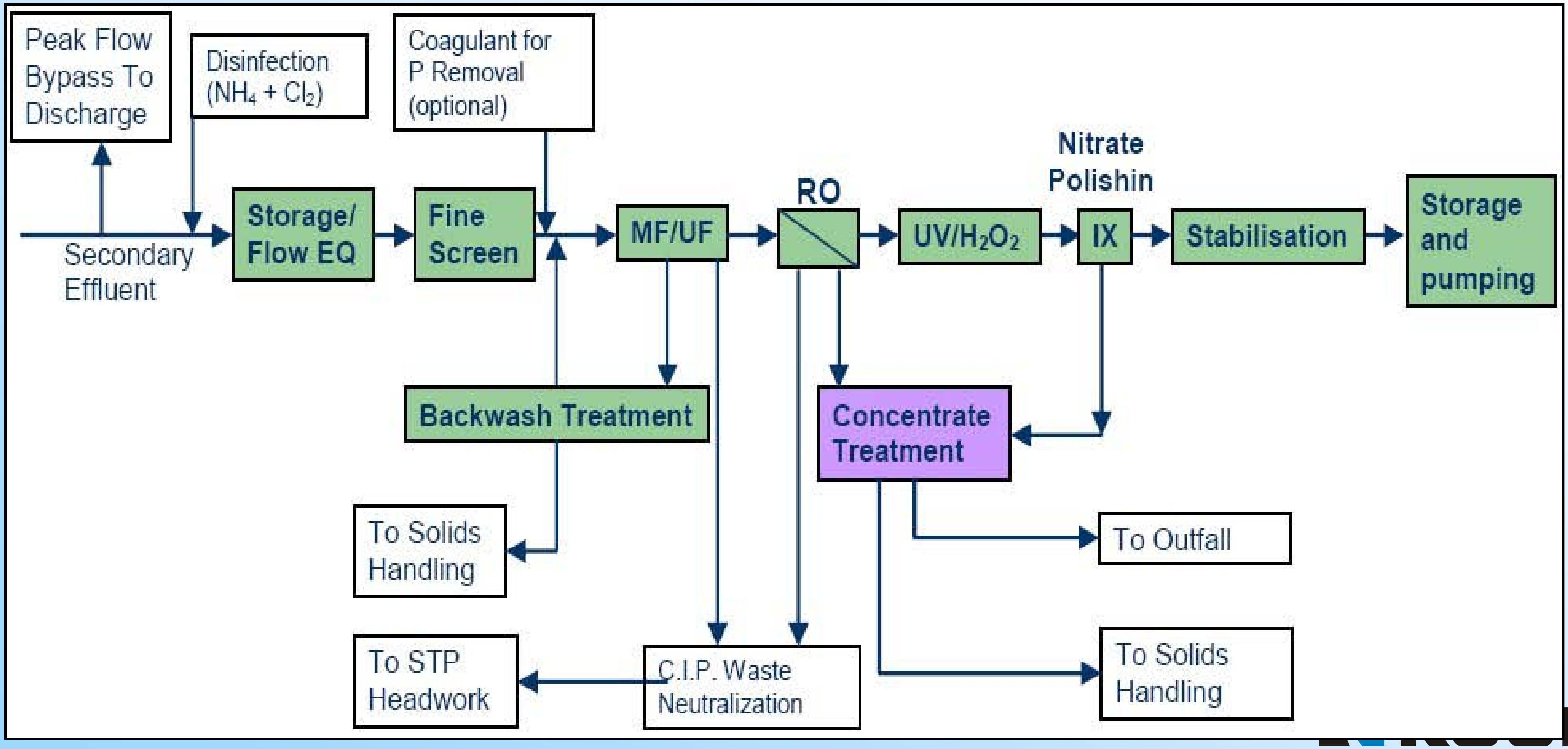
Project Description

- Feed Water: Secondary clarified sewage (flocculation)
- Multi-stage advanced treatment process
  - Microfiltration (MF)
  - Reverse osmosis (RO)
  - Advanced oxidation (UV/Peroxide)
  - Disinfection and Stabilization

Projects

Bundamba Project

Process Flow Sheet



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Projects

RO Membrane System

Bundamba Project (Phase 1A)

Projects

Element Loading

Bundamba Project (Phase 1A)

Projects

MF Membrane System

Bundamba Project (Phase 1A)

Projects

RO Membrane System

Bundamba Project (Phase 1A)

Projects

Ashkelon SWRO Project

Project Overview

- Largest SWRO Plant in World
- Provides ~ 15% of domestic consumer demand
- Start-Up => December 2005
- Capacity => 330,000 m^3/day (~ 87 MGD)
- BOT project (25 years)
- Facility transfers to Israel Government at end of term

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Projects

Ashkelon SWRO Project

Project Finances

- Project cost ~ $212 million
- Funding => 23.5% equity/76.5% debt
- Water tariff => $0.527/m3 (~ $2.00/kgal)
- Tariff based on fixed (58%) and variable (42%) costs
- Fixed cost covers capital expenditures
- Variable costs covers energy, membrane, chemicals

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Projects

Ashkelon SWRO Project

SWRO Plant Description

- Dedicated 80 MW gas turbine power plant
- Open seawater intake
- Dual media gravity filtration
- Two autonomous plants with shared seawater intake
  - 165,000 m^3/day each plant
  - 40,700 RO elements (total)/seawater and brackish type

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Projects

Ashkelon SWRO Project

SWRO Plant Water Specifications

(Before Post-treatment)

< 80 ppm TDS

< 20 ppm Chloride

< 40 ppm Sodium

< 0.4 ppm Boron

Projects

Ashkelon SWRO Project

Overview of RO Facility

http://www.water-technology.net/projects

Projects

Ashkelon SWRO Project

8 inch Pressure Vessels

http://www.water-technology.net/projects

Projects

Ashkelon SWRO Project

DWEER Energy Recovery Device

http://www.water-technology.net/projects