REUSE NOW

Industrial Water

Use and REUSE Workshop

ISWS San Antonio, TX

Larry Gurnari | Veolia Water Solutions & Technologies

VEOLIA WATER

Solutions & Technologies

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Presentation Overview

- OVERVIEW
- VEOLIA
- TECHNOLOGIES
- CASE STUDIES
- WATER IMPACT INDEX

REUSE NOW

- Something For Everybody:
  - Technologies
  - Unit processes/applications
  - Case studies including operating data
- Focusing on the different technologies and how they have been applied in REUSE applications world wide.
- No polynomials, organic chemistry (or inorganic chemistry for that matter)

REUSE NOW

- The US reclaims 6.5 % of treated (municipal) waste water ~(2.3 billion gals./day)
- Singapore reclaims 30%
- Israel reclaims 70%
- Australia reclaims 8%; but several projects on the board so this percentage will increase
- Industrial water usage growing at annual average rate of 3.7%
- Estimated annual industrial water withdrawals are in the 1.8 T gals (ie 10^9) (700 B m3)

REUSE NOW

- DEFINE REUSE?
  - Treat an “on site” source, use it on site and return water (discharge)
  - Treat an “off site” source (import) use it on site and return water
  - Treat on site and also treat discharge on site with no or some reduced return
  - Any treatment that reduces the amount of fresh water consumed while still meeting return limits (NPDES, POTW) for whatever might be discharged
  - Imperative no matter what conserve water at all stages
  - Crucial to work to together (Industry, Municipalities, Agriculture and Agentices)

REUSE NOW

- REUSE PROJECT SPECTRUM
  - Easy >>> Complex
  - Low Volumes (gpm) >>> MGD size
  - Less $ >>> $ MM
  - Weeks or months >>> Years

REUSE NOW

- IMPEMENTATION
  - Survey Plant (absolutely)
  - Bench Test (probably)
  - Pilot Demonstration Test (maybe)
  - Add/Change Chemistry
  - Add Equipment (refurbish)
  - Add Services (support, training, analytical)
  - Add Equipment, Chemistry & Services (bundled or wrap)
  - Change/Modify SOP’s

Why REUSE

- Water Stress due to:
  - Population growth
  - Global climate changes
  - Industrial development
  - Droughts
- Cost & (un)reliability of supplies
- State regulatory will eventually enforce mandatory REUSE
- Pollution abatement; must treat anyway

Key Benefits Of Water REUSE

- Clients need to treat effluent anyway; why not recycle and reduce fresh water consumption
- Lowering fresh water consumption should lower operating water costs (water cost will increase over time as ***True Cost of Water*** is rationalized and accepted)
- Ability to expand production without increasing water consumption or negatively impact local enivronment
- Regulatory compliance and environmental sustainability working toward a ***Green Footprint***

The Paradigm Shift

- Waste Water >>> Water
- Recover Water
- Recover Energy
- Recover Resources

Scrap the Waste Water mentality

…(it's water); it may be off spec water; it may require treatment;

but it is a recoverable and valuable resource

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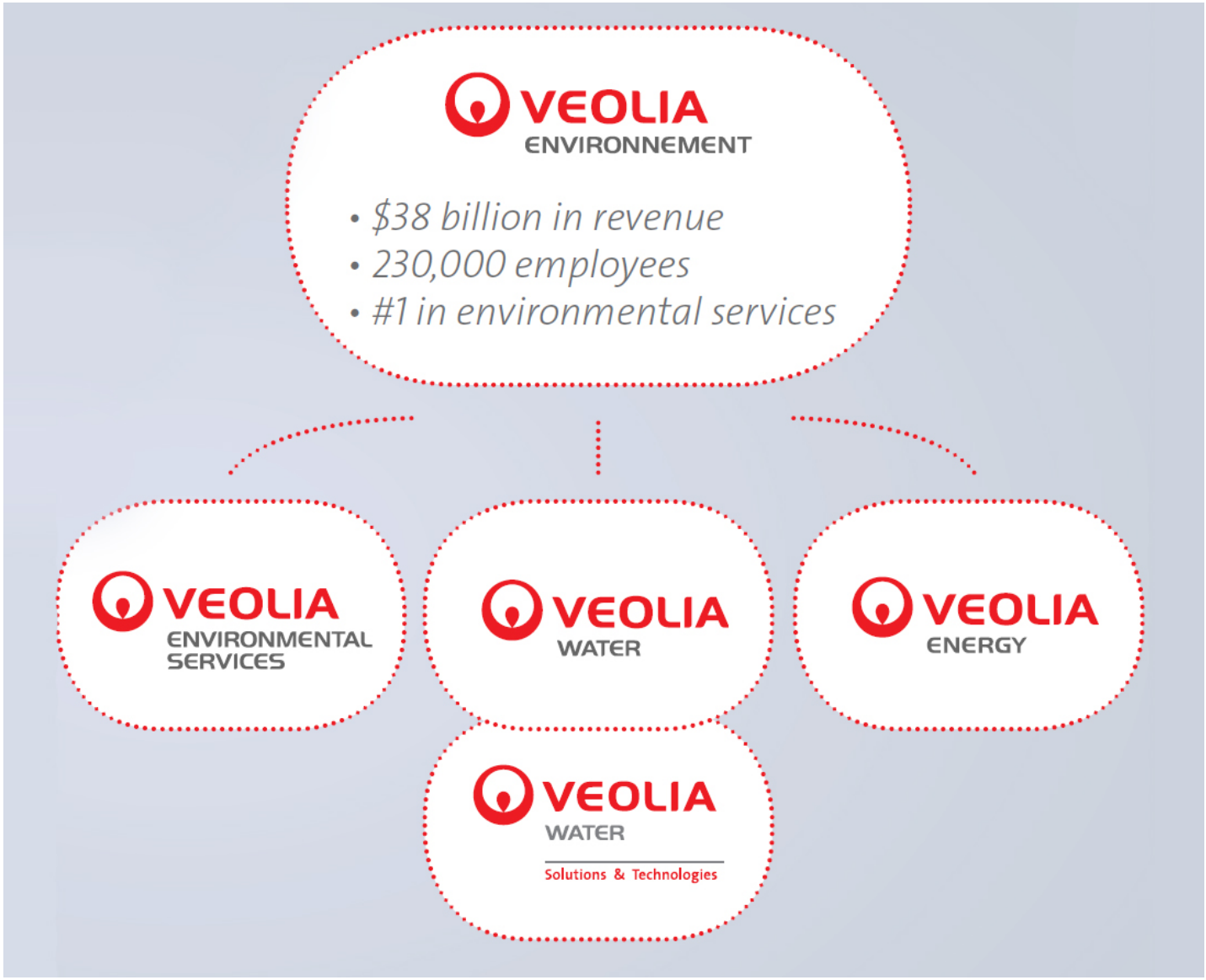
Veolia Environnement

- Organization
- Veolia Water
- Key Figures

Veolia Environnemnt



Veolia Water

- World Leader in Water and Waste Water
- Specialized in Outsourcing Services for
  - Municipal authorities
  - Industrial and service companies
- Major designer and integrator of technological solutions providing Water and Waste Water facilities and services worldwide

Key Figures

- *89,094 Employees*
- *Provides water service to 100MM people*
- *Provides Waste Water service to 71MM people*
- *$15.9B revenue in 2012*

Veolia Water Solutions & Technologies

- Global Network, Local Expertise
  - Technology and application development
  - Process design expertise; plant survey & evaluation; including bench-scale to full-scale pilot demonstrations
  - Pre-engineered and custom designed systems; variety of execution methods to suite the client including Mobile solutions
  - Hydrex™ chemistry/chemicals

Key Figures

- *10,767 Employees*
- *Operating 54 countries*
- *Over 350 proprietary technologies*
- *$3.1B revenue in 2012*

Veolia Water Solutions & Technologies

132 Business Units Worldwide
in **54 countries**

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REUSE Design Considerations

- Sources
- Quality
- Users (Current & New)
- Drivers

REUSE Design Considerations

- SOURCES:
  - Surface, Groundwater, Well; (City)
  - Cooling Tower Blow Down
  - Boiler Blowdown
  - Stormwater/Rainwater
  - Waste Water (Municipal & Industrial REUSE are already inter-related and will become more so)

REUSE Design Considerations

- WATER QUALITY:
  - Total Dissolved Solids (TDS) cations/anion
  - Specific Cation/Anions (Ca + Mg, SO4, Cl, SiO2)
  - Organics (DOC/TOC; BTEX, PAH's, etc)
  - Trace Metals (As, Se, Fe, Mn, Al, etc)
  - Possibly Biological (if so BOD, COD, nitrogen, pathogens, nutrients, etc)

REUSE Design Considerations

- CURRENT RETURN POINTS:
  - NPDES
  - POTW
  - Impoundment (keep on site)
  - Deepwell Disposal
  - ZLD (maybe no return of any liquid)
- NEW USERS:
  - Rates, Volumes
  - Water Quality
  - Water Stress
  - Other Options (conservation, etc)

Drivers for REUSE

- Source, Quality, Return and REUSE options drive Technology development and application knowledge
- Existing technologies, expertise and experience do and will meet water quality challenges
- The value of water will increase significantly in the future (***"True Cost of Water"***)
- Local infrastructure requirements could limit reuse opportunities (location issue)
- Many locations (expecially coastal) experiencing severe water shortages (poulation growth, climatic)
- Many existing water management strategies are unsustainable

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Technologies

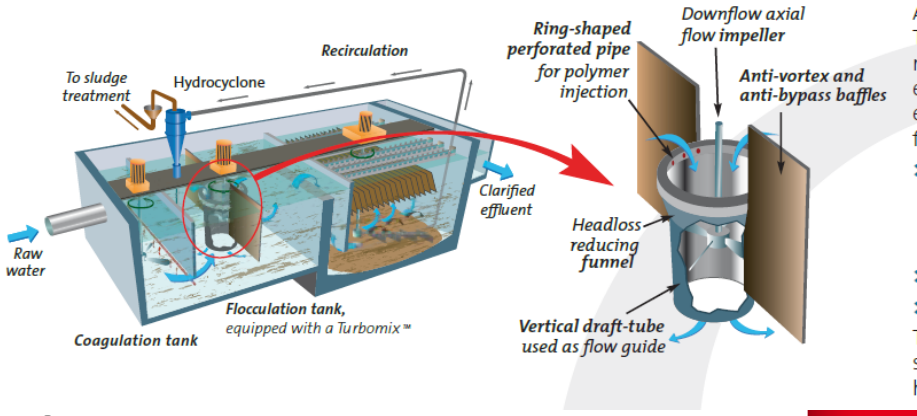
- Summary
- Main Design Features

Key Technologies

- ACTIFLO® (TSS, turbidity, softening, TOC reduction, etc.)
- MULTIFLO™ (higher TSS applications)
- Discfilter
- AnoxKaldnes™ Moving Bed Biofilm Reactor (MBBR)
- NEOSEP™ Immersed Membrane Bioreactor (MBR)
- OPUS™ & OPUS II Technologies (water recovery)
- Zero Desalination Discharge (ZDD) (water recovery; brine management as well)
- DenseSludge™ (HDS) (reduction of liquid sludge)
- New Patent on Low Level Phosphorous Removal

Available Technologies

- *Suspended Solids Removal*
  - **Actiflo®**
  - **Multiflo®**
  - **DenseSludge® and Multimedia Filters**
  - **3FM Filters® (Flexible Fibre Filter Module)**
  - **Precoat Filters**
  - **Membranes (MF, NF, Ceramic)**



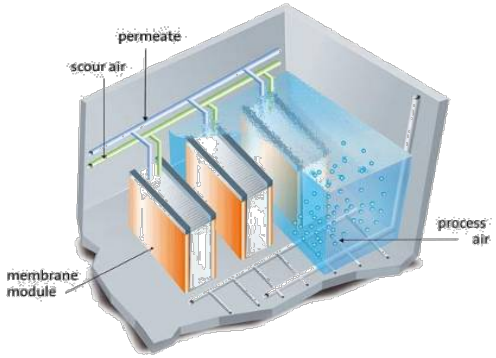
- *Dissolved Organics and Inorganics Removal*
  - **Macro Porous Polymer Extraction (MPPE®)**
  - **Granular Activated Carbon (GAC)**
  - **Reverse Osmosis (RO)**
  - **Nano Filtration (NF)**
  - **Membrane Degasification**
  - **Desalination**

- *Oil Removal*
  - **CPI, DAF, IGF, TiPSS®**
  - **Walnut Shell Filter : Power Clean®**
  - **MPPE® (L/L extraction; BTEX, PAH)**
  - **Ceramic Membranes**

Available Technologies

- *Demineralization*
  - Reverse Osmosis
  - Ion Exchange
  - Condensate polishers
  - Mixed bed polisher
  - Chemical dosing systems
  - Deaerators

- *Biological Treatment*
  - AnoxKaldnes® MBBR
  - MBR: Biosep®
  - Fluidized Media Fixed film
  - Off-gas BioFilter
  - VOC control



Available Technologies

Salt Removal

- KOH Recovery (Hardtac®)
- Multi Stage Flash (MSF) evaporation
- Multi Effect Distillation (MED)
- Reverse Osmosis (RO)
- Mechanical Vapour Compression (MVC) Evaporation
- Brine Concentration / Crystallization (ZLW or ZLD)

Cooling Water Treatment

- Side-stream filtration
- Cooling tower blow down treatment
- Zero liquid discharge and reuse

Mobile Water

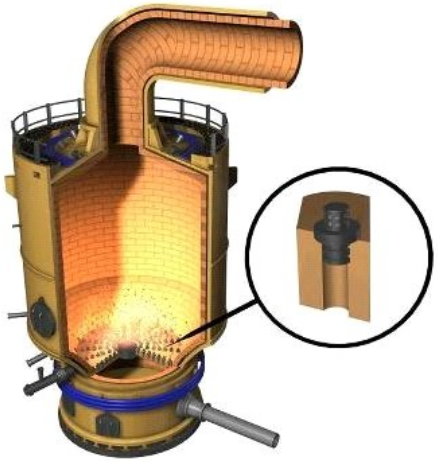
- Aquamove® / Aquadem®

Specialty Water Treatment Chemicals

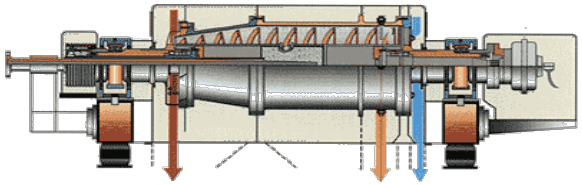
- Hydrex® products

Available Technologies

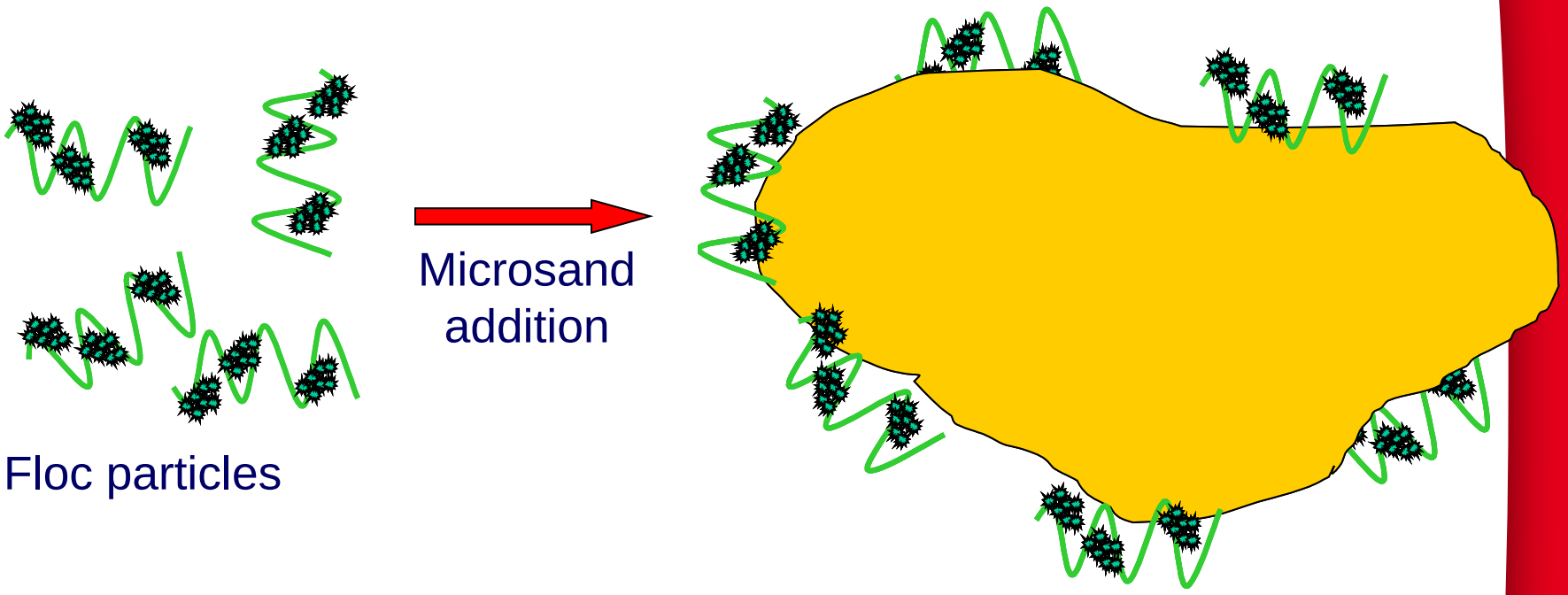
- ***Sludge Treatment***
  - **Thickening**
  - **Filter press and belt press dewatering**
  - **3 and 2 phase centrifuges**
  - **Drying**
  - **Incineration (Pyrofluid®)**
  - **Coker injection**
  - **Odor detection and control: Odowatch®**



- ***Demineralization (Ion Exchange)***
  - **Single and Mixed Beds**
  - **WAC/SAC – WBA/SBA**
  - **Selective Ion Exchange**

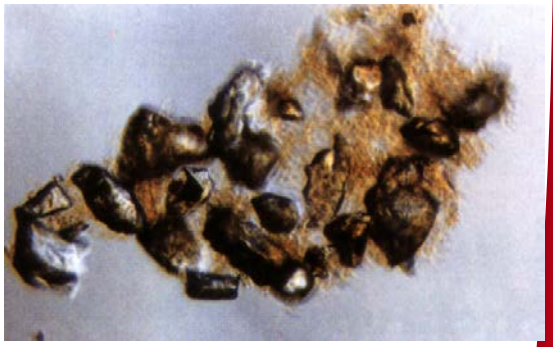


ACTIFLO® Ballasted Flocculation



ACTIFLO® Principle

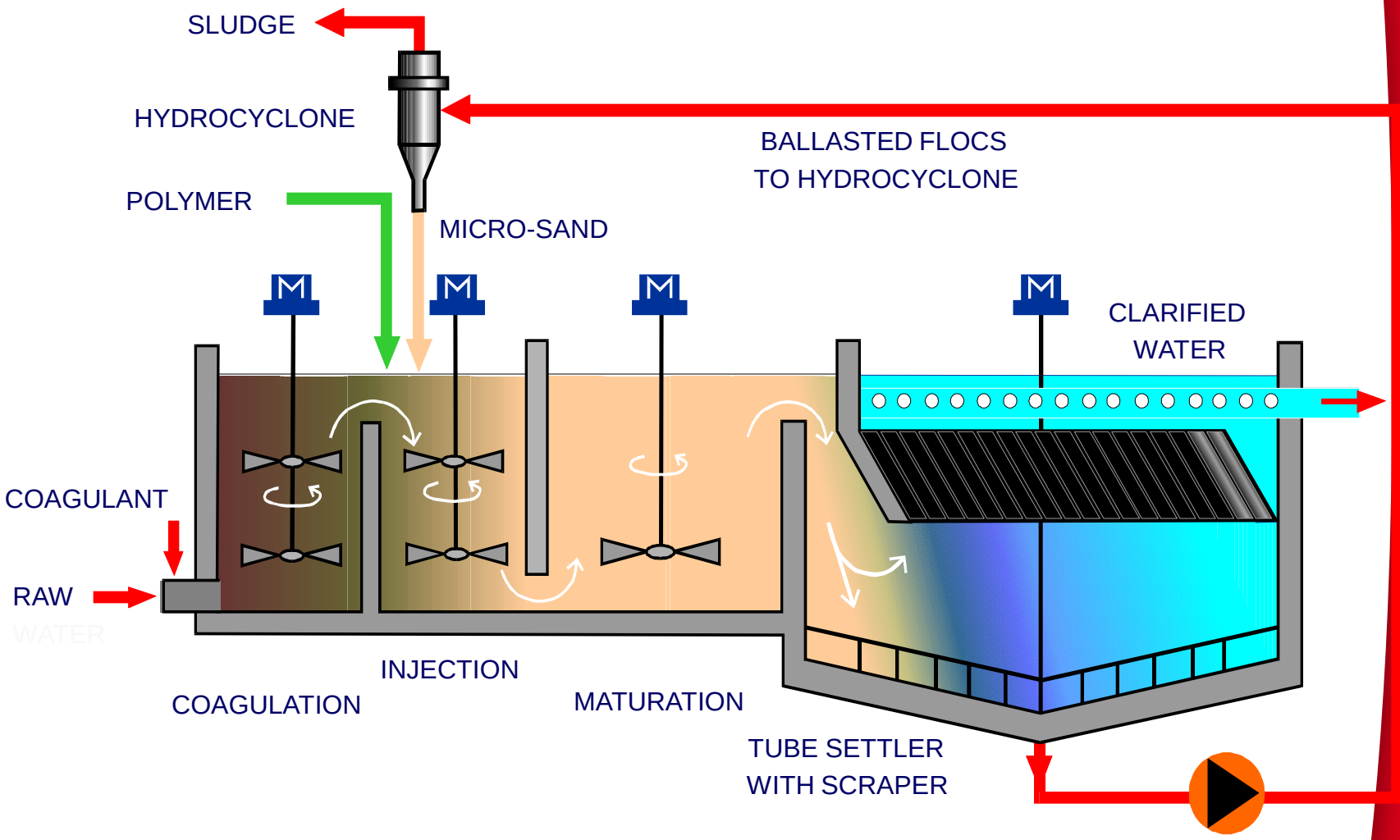
Conventional Polymer-Assisted Microsand-Ballasted



3 seconds

8 seconds

ACTIFLO® Flow Schematic



ACTIFLO® Process
Higher Rates Result in Lower Footprints

Process >>>	Conven-tional	Lamella Clarif.	Ballasted Floc.
Rise Rate (gpm/ft²) >>>	(0.2 - 0.8)	2.4 - 6.0	16.0 - 48.0
Footprint >>>			

Actiflo ThyssenKrupp Calvert, AL

MBBR (Moving Bed Bio-Reactor)

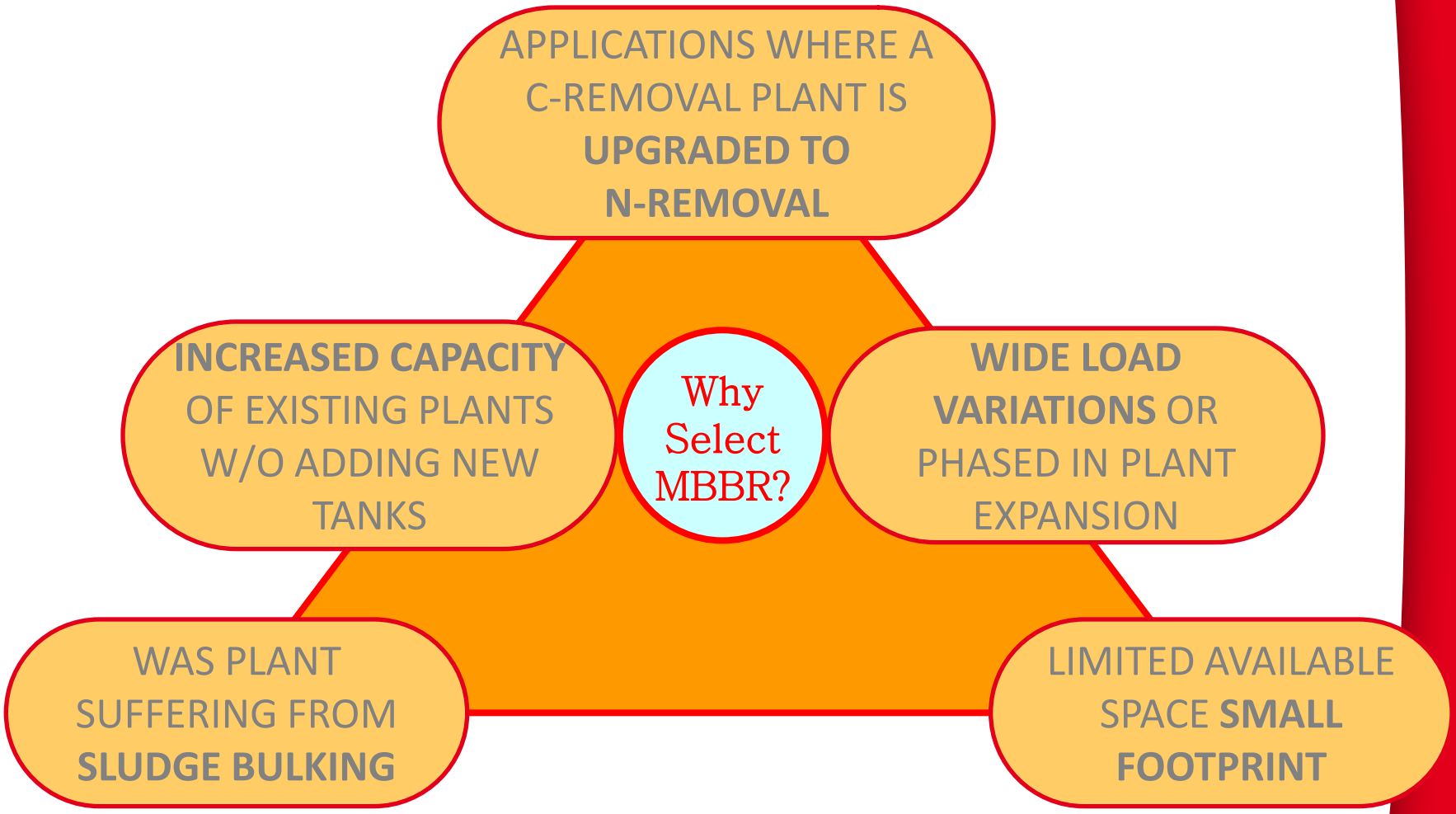
Characteristics

- AnoxKaldnes™ is the MBBR pioneer
- Biological treatment of carbon and/or nitrate using biomass attached to a moving carrier
- Continuous process, no backwash
- Compact, small footprint

Advantages

- High tolerance to load and toxicity variations
- Lower solids production (loading on clarifier)
- Better removal efficiencies at higher loading rates
- Tolerates lower operating temperature than conventional suspended growth systems

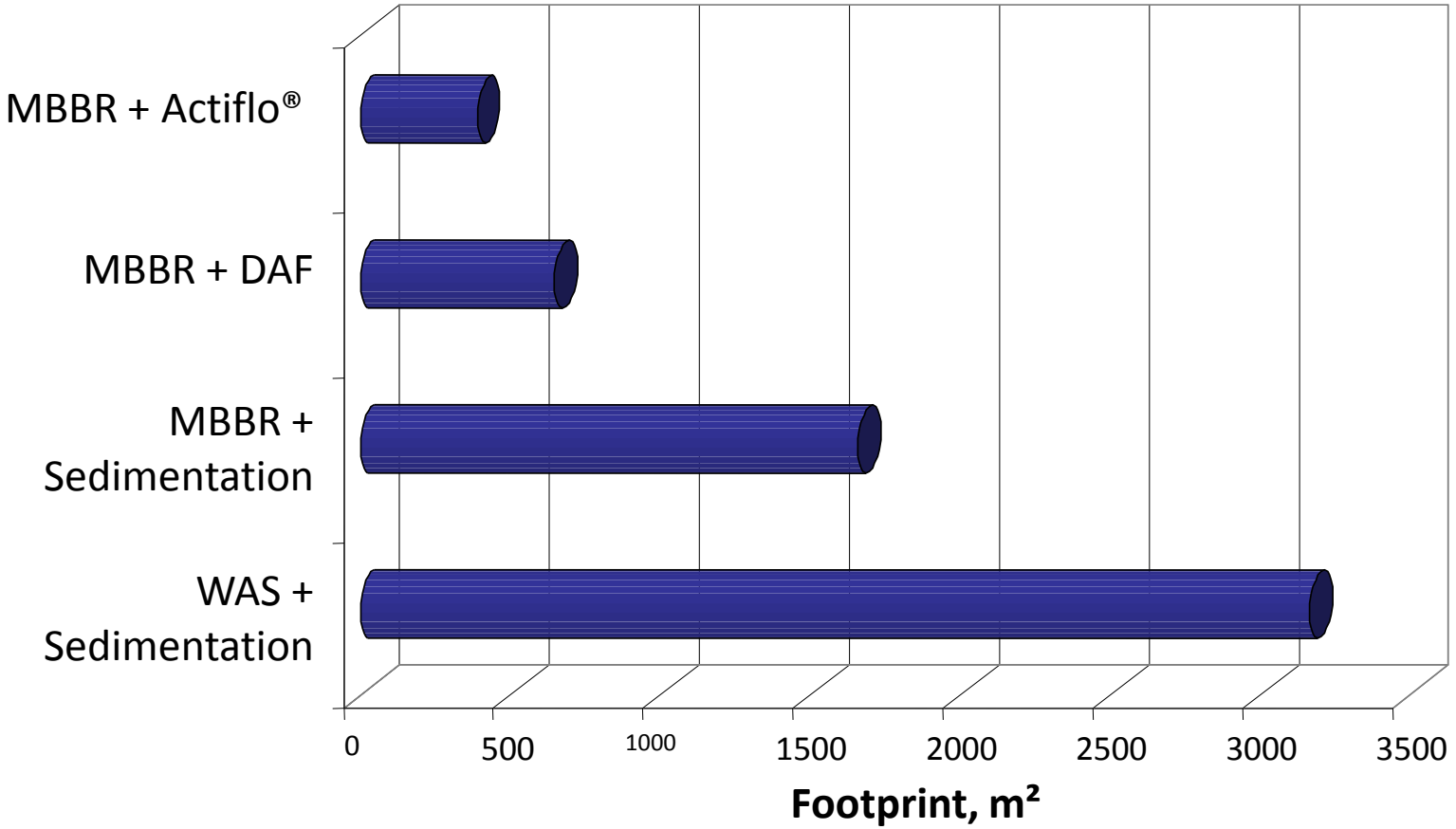
MBBR - Applications



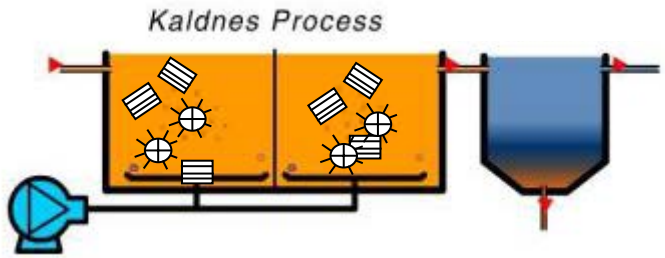
INSTALLED BASE

MORE THAN 500 UNITS IN OPERATION

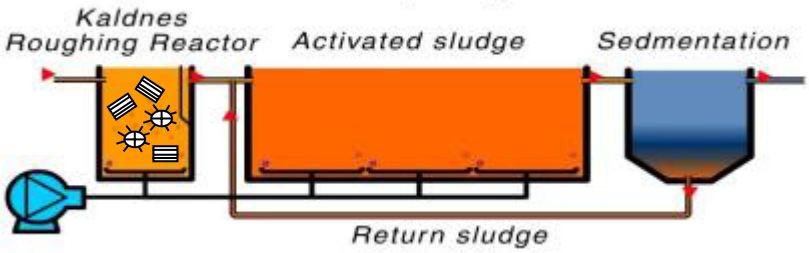
MBBR – Footprint Comparisons



MBBR Process Configurations

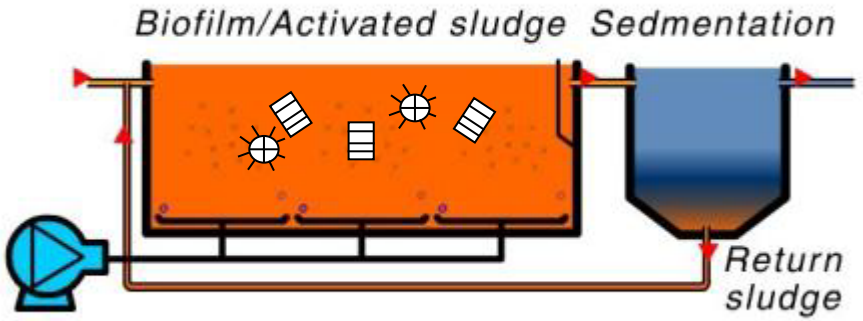


MBBR Process
(standalone no RAS; can be multiple reactors depending on BOD, Nitrify , De-nitrify, TSS loading)



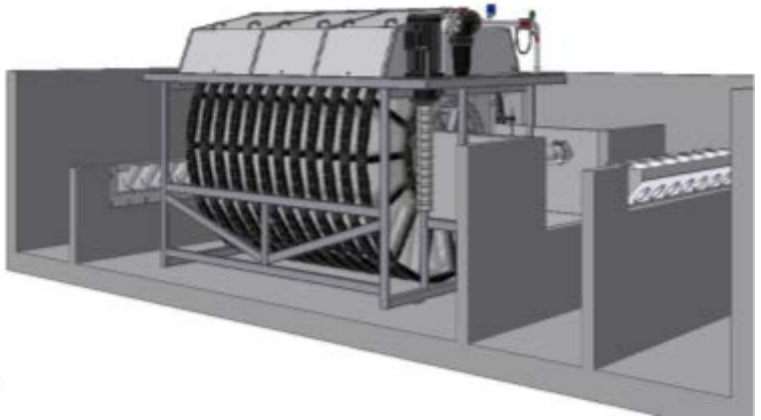
BAS™ Process
(Improve perf. or increase capacity of existing plant)

HYBAS™
(BOD >>> BOD + N)



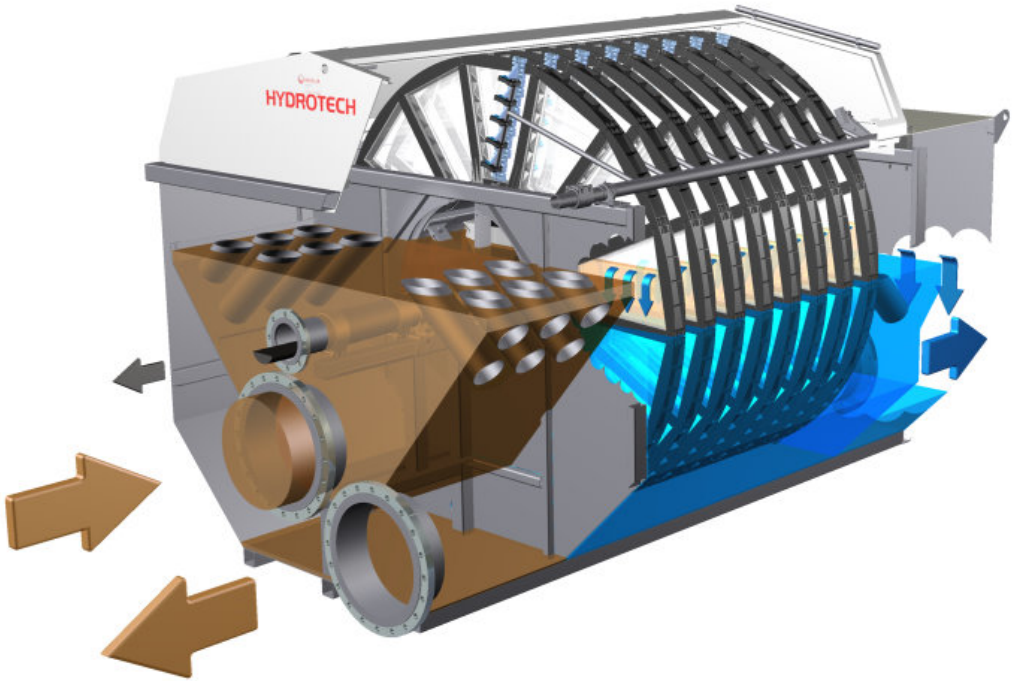
Discfilter

- Unique Filtration Technology
  - Woven Cloth Filter Elements
  - Inside -Out Pattern; Gravity Flow
  - Counter-Current Backwash Process
  - Particulate Removal
- High Rate Filtration Process
  - 70 to 80% smaller than Conv. Process
  - Small Footprint Modular Design
  - Low Capital & Installation Costs
  - Low Backwash Waste Volumes
  - Low Head Loss 8” – 12”
- Options
  - Stand alone Package Technology
  - Placement in Concrete Tanks
- Good Quality Effluent
  - Turbidity < 2 NTU

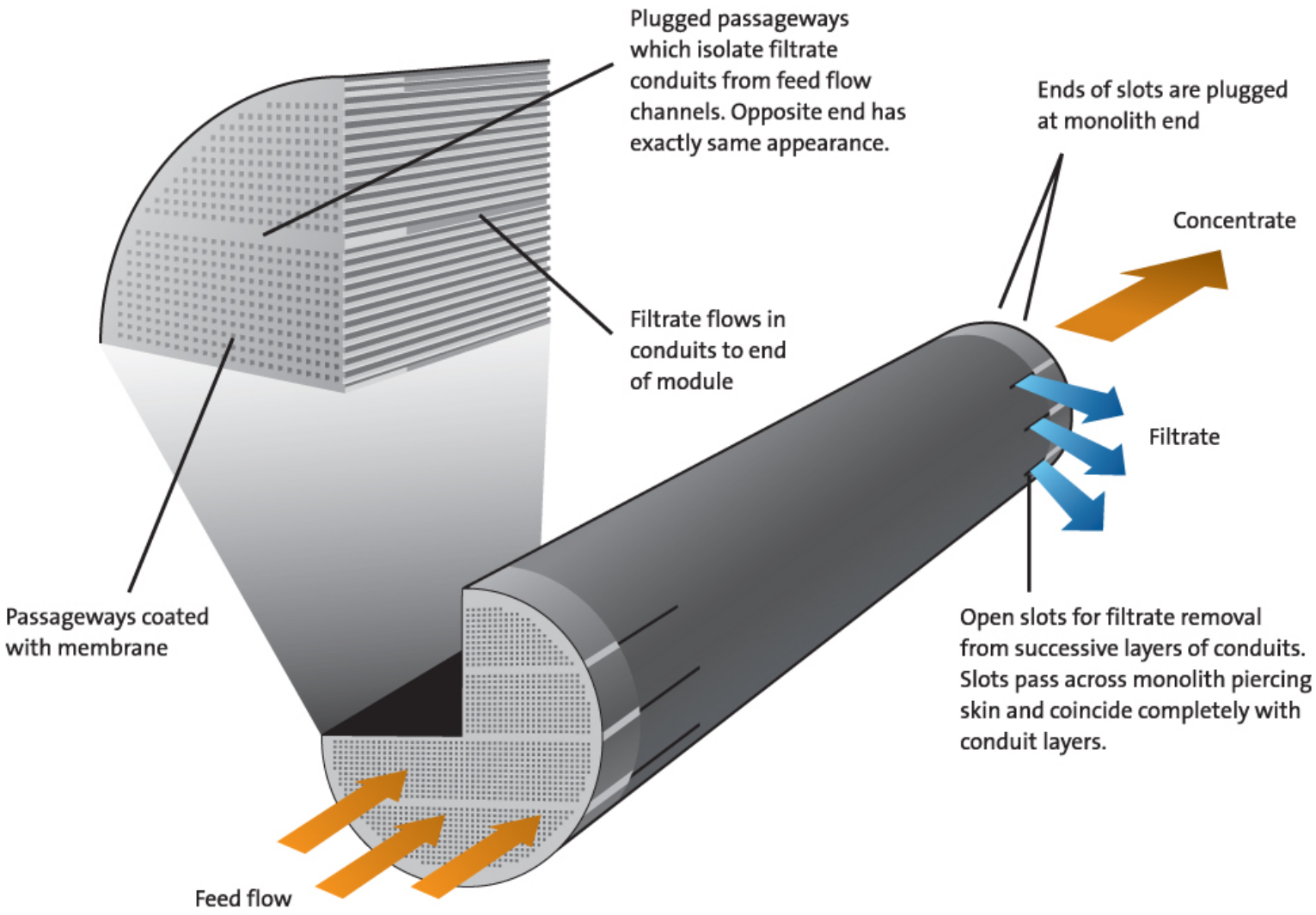


Discfilter

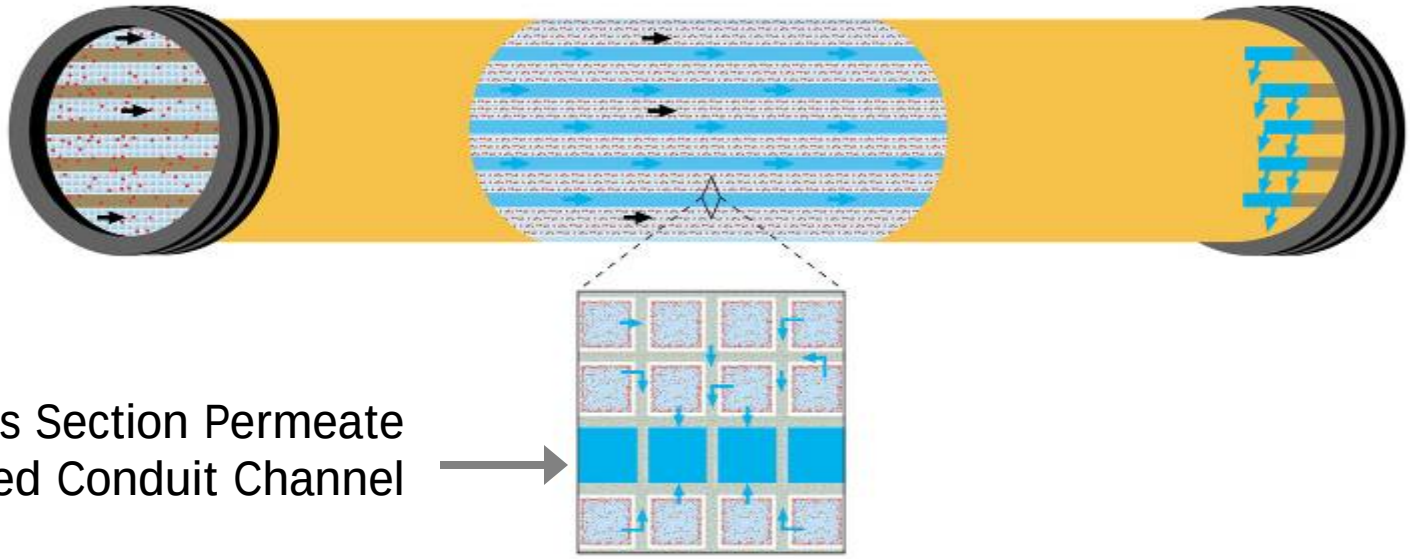
- Clarifier Polishing
- CT Make-Up & CT Sidestream Filtration
- Effluent Polishing; Title 22 Certified for Tertiary Filtration
- Gravity flow; rates up 6000 gpm per unit; multiple trains
- Integral Backwash Pump
- 10 -50 micron polyester replaceable woven screens



CeraMem Ceramic Membrane Module

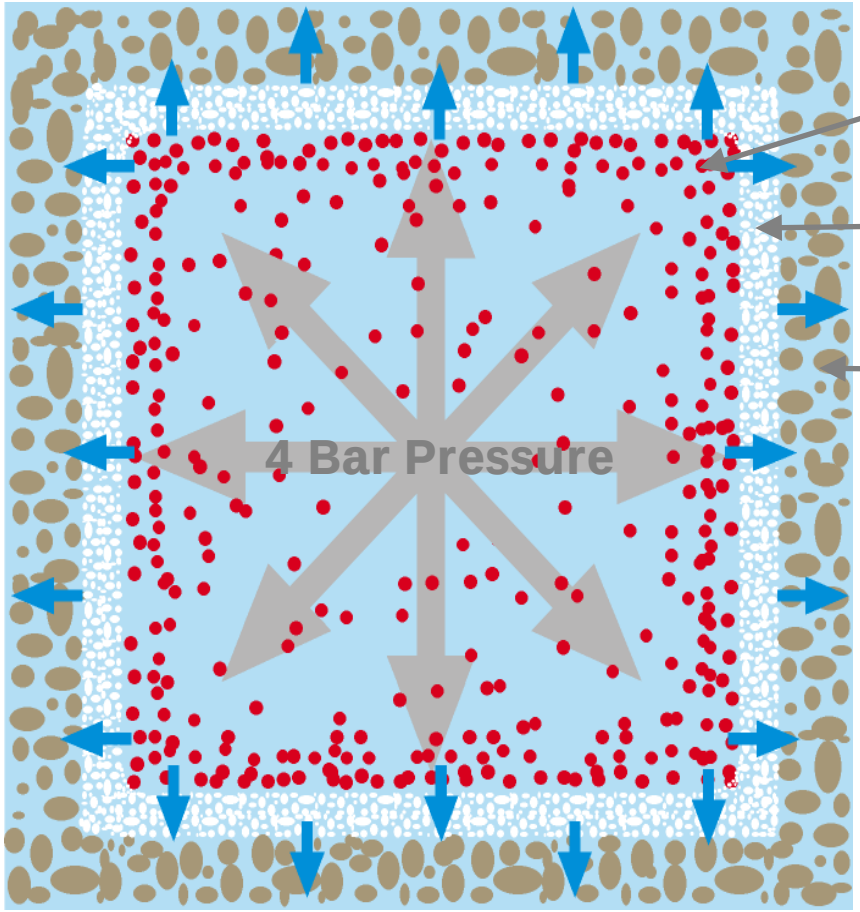


CeraMem Ceramic Module Operation



Cross Section Permeate
Filled Conduit Channel

CeraMem Ceramic Module Cross Section



Filtration Cake Layer

Membrane

Porous SiC Support

Suspended Solids

Permeate Flow Path

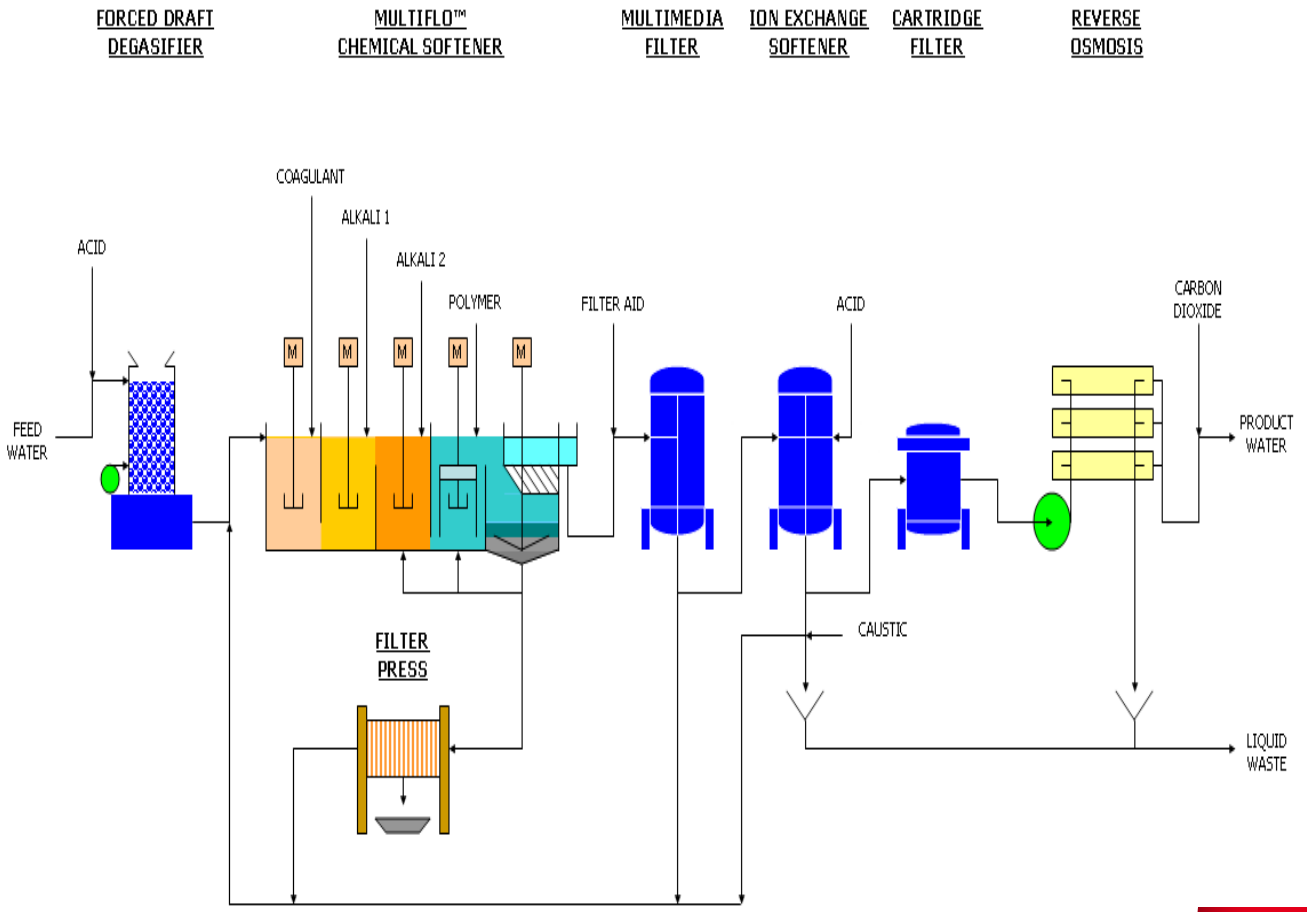
SAGD OPUS Pilot Results
Permeate, Feed, and Concentrates Samples

Brine Management

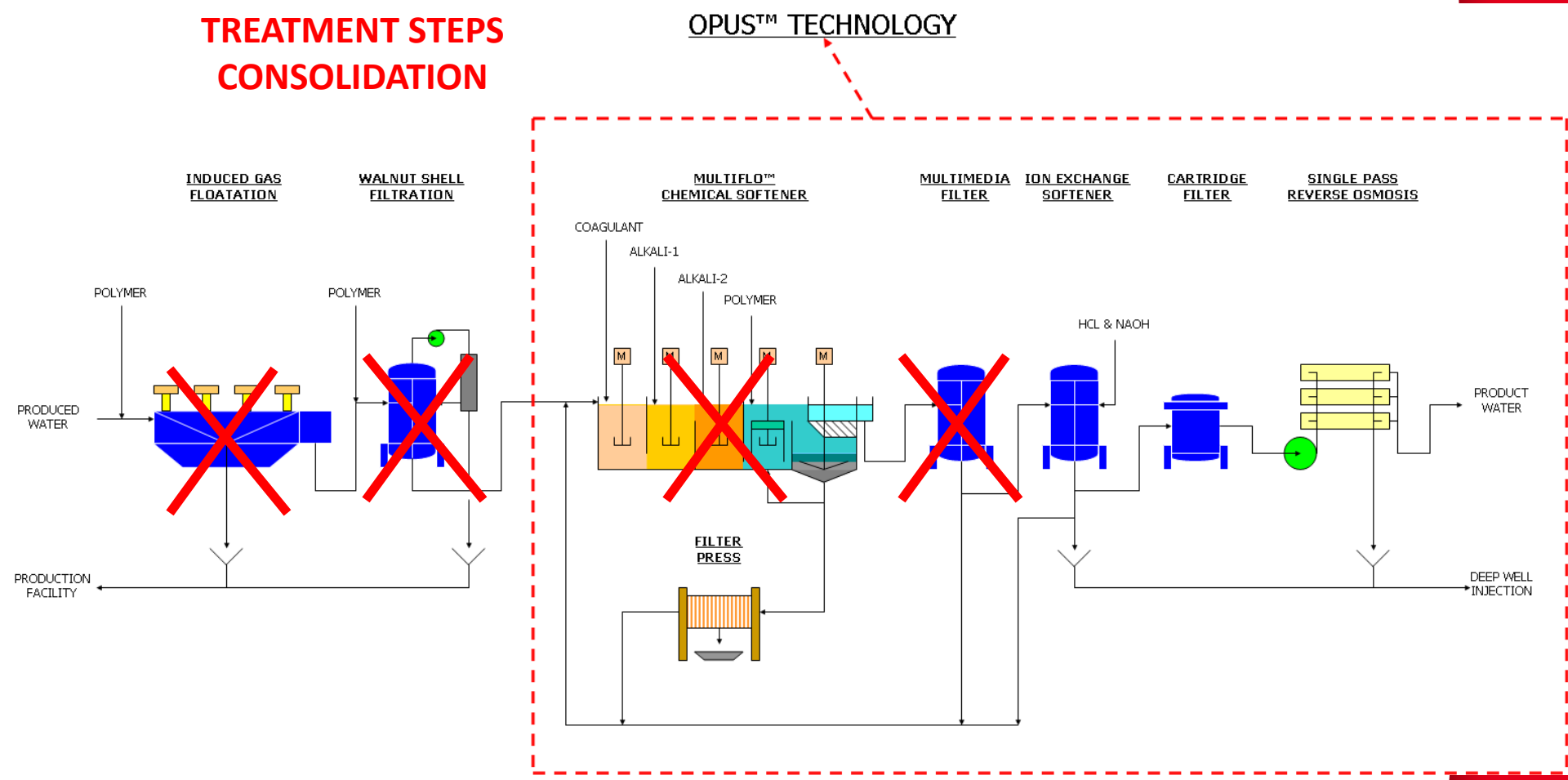
- Evaporation Ponds
  - Large Land Area; Capital Intensive (construction, liners, permitting)
  - Limited to Arid Climates Only
- Deep Well Injection (DWI)
  - Often Difficult To Permit
  - High Pumping and Monitoring Costs
  - Possible Contamination of Local Water Supplies; Deteriorate Soil Quality
  - Can be costly; level of risk to users
- Hauling
  - Expensive (Up to $0.25/gallon)
- Sewer Disposal
  - Salt impacts downstream treatment facilities
- Zero Liquid Discharge (Evaporator/Crystallizer)
  - Capital and Operation Cost Intensive for large volumes

Optimized Pretreatment & Unique Separation OPUS™

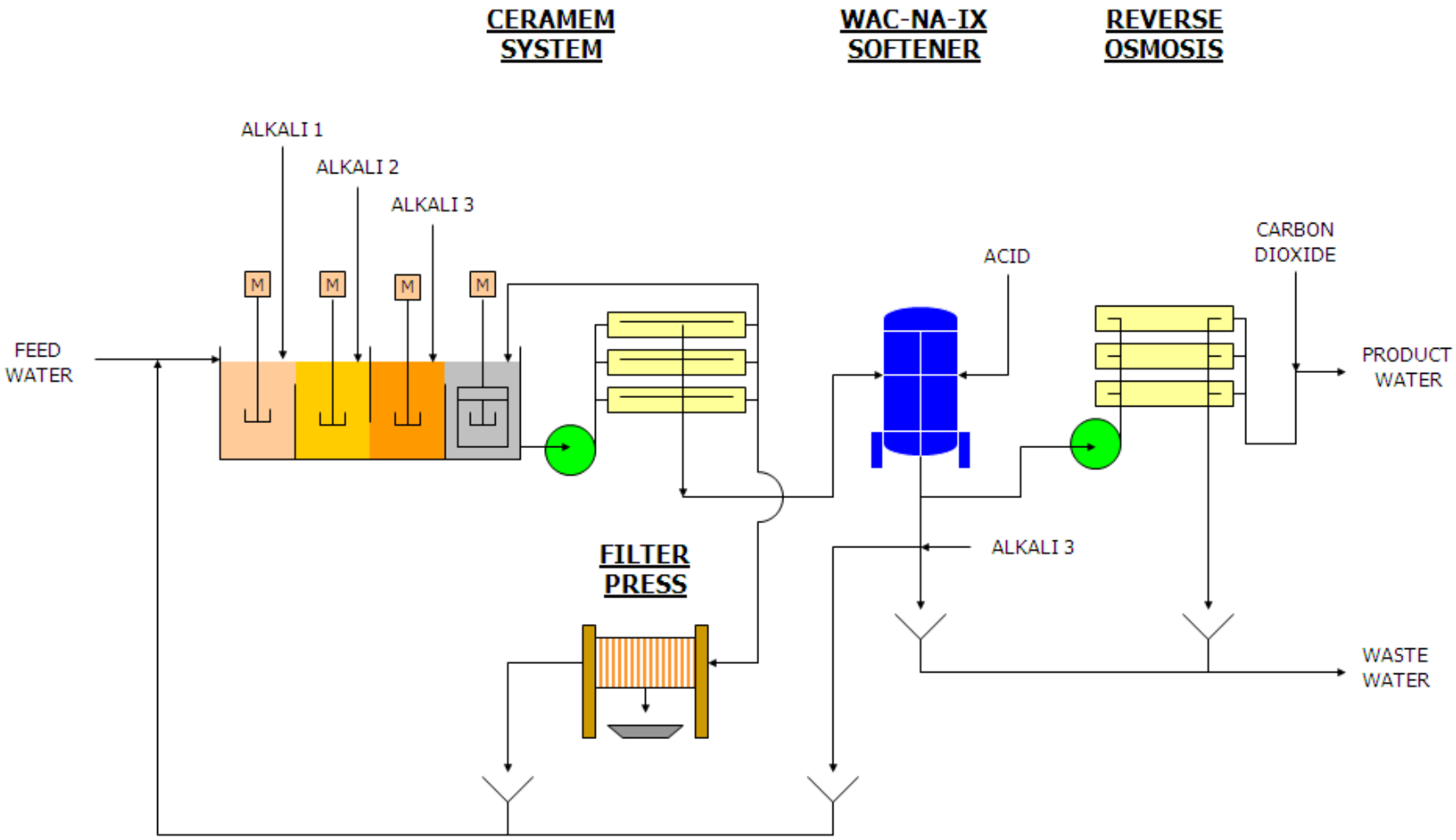
- TDS, Metals & TSS Reduction
- Tower Blowdown
- ZLD Pretreatment
- 90%+ Recoveries



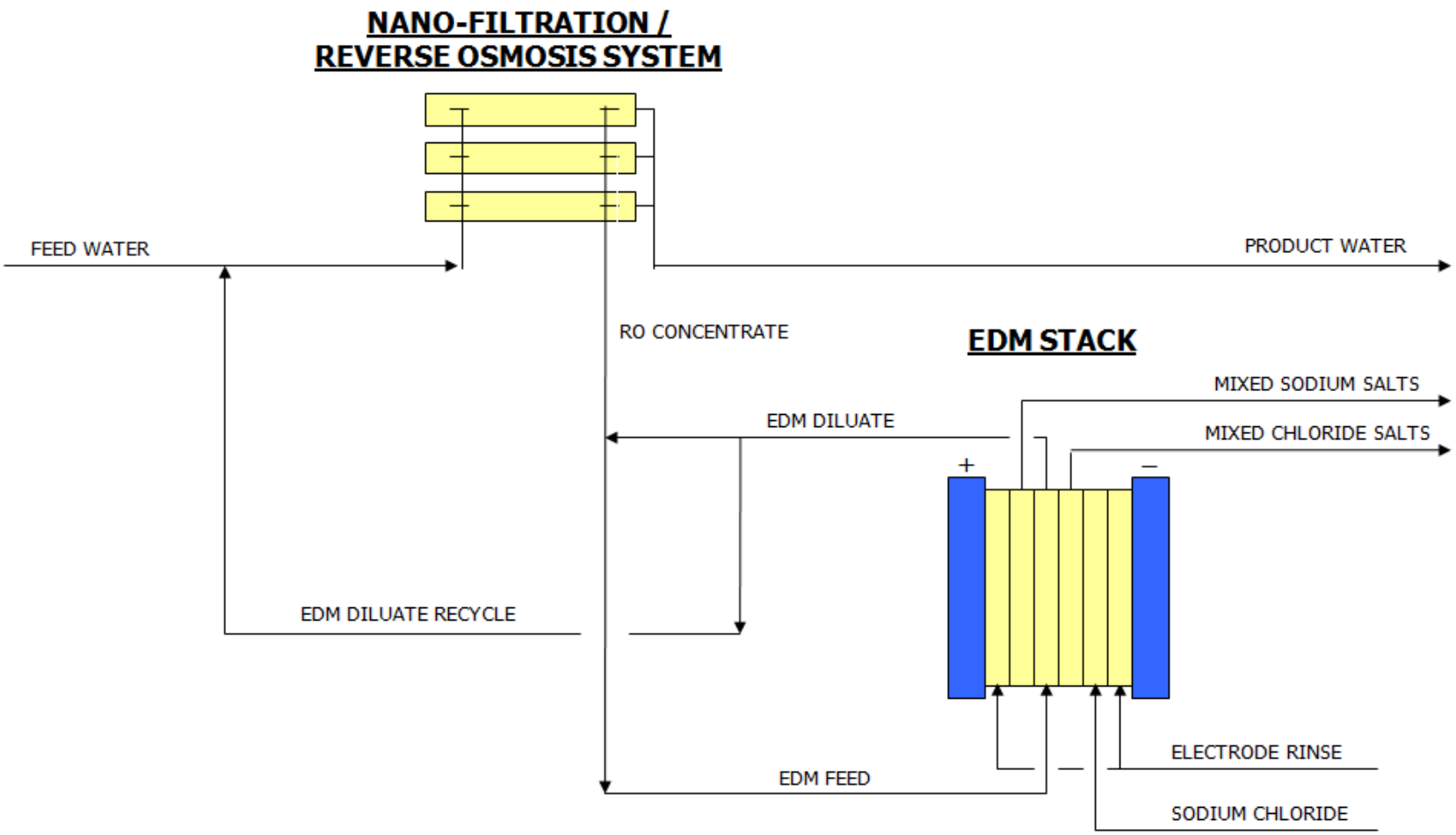
1st Generation OPUS



OPUS® II Technology

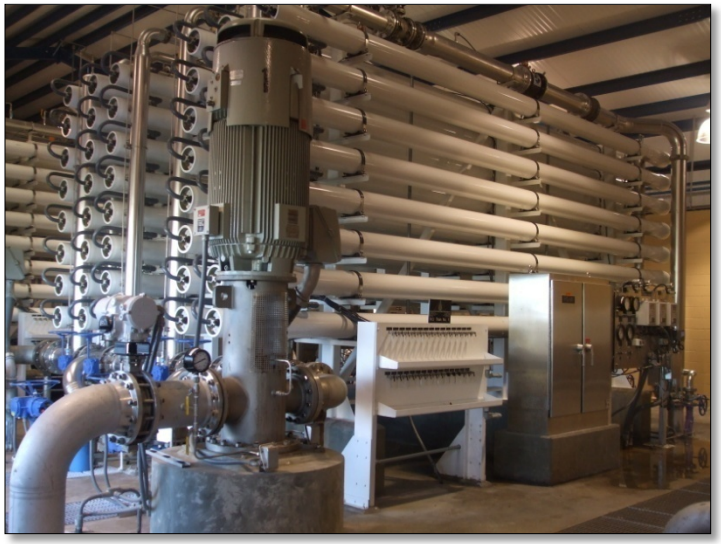


Zero Desalination Technology (ZDD)



Reverse Osmosis - Benefits

- Reliable and Consistent Technology
- Easy Operation & Maintenance
- Treated Water Meets Potable Quality Standards
- Low Chemical Consumption
  - High Salt Rejection (> 98%)
  - Effective at Removing Emerging Compounds
  - Membrane is a Physical Barrier



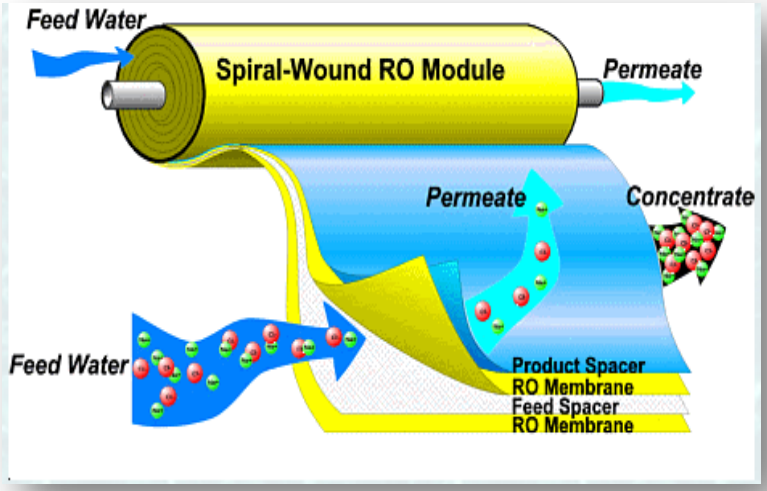
Reverse Osmosis - Considerations

- Brine Management (especially as the feed TDS increases)
  - <100% Conversion (75% Typical)
  - Salinity
  - Sustainability
- Energy if Costs Rise
- Scaling Limits Efficiency and Recovery (if it cannot be controlled)
- Pretreatment can be >50% of cost ($SDI_{15} < 3$)
- Environmental Issues for Concentrate Return
- Challenging Treatment Chemistry Especially for Potential REUSE recycle applications
  - Silica, Sulfate, Carbonate, etc.
  - Impacts Extent and Cost of Recovery

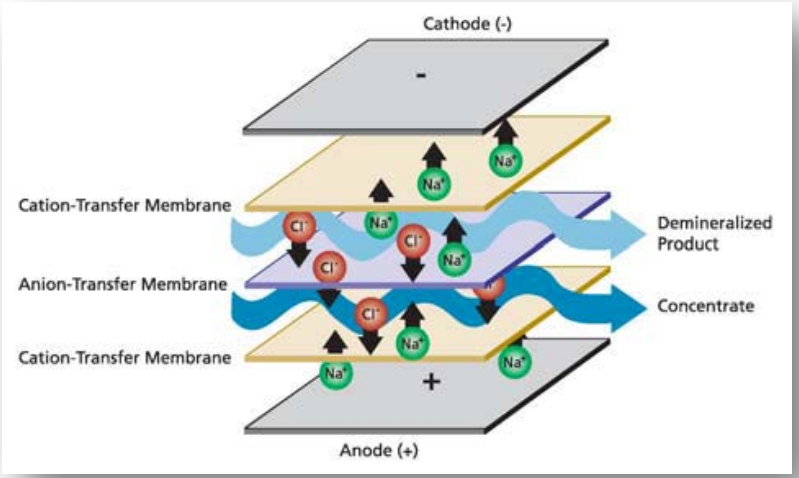
Need for Economical High-Recovery Water Systems

The ZDD Process & How it Compares to RO?

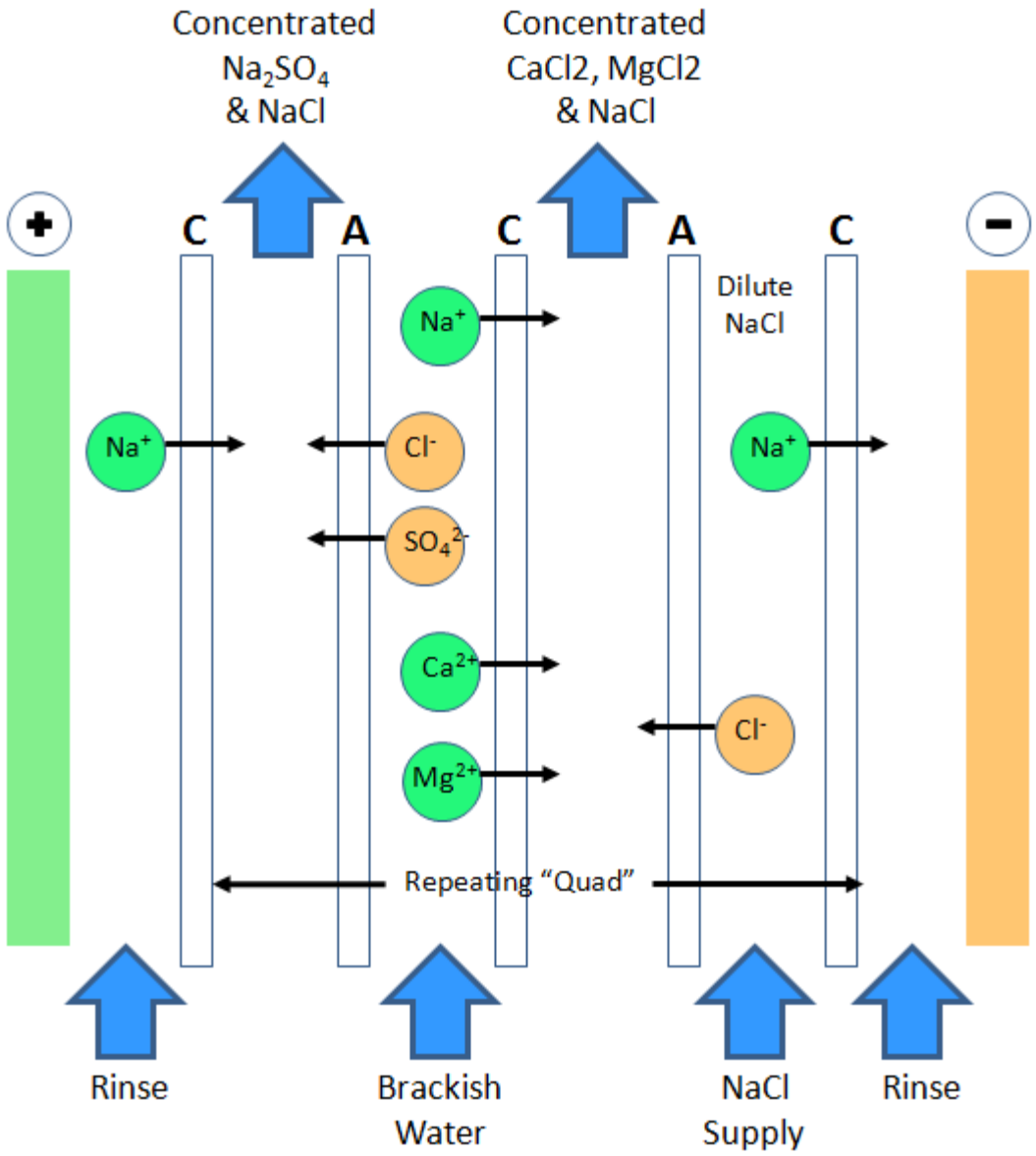
- RO or NF
  - Pressure driven process moving ions across a semi-permeable barrier to reduce TDS



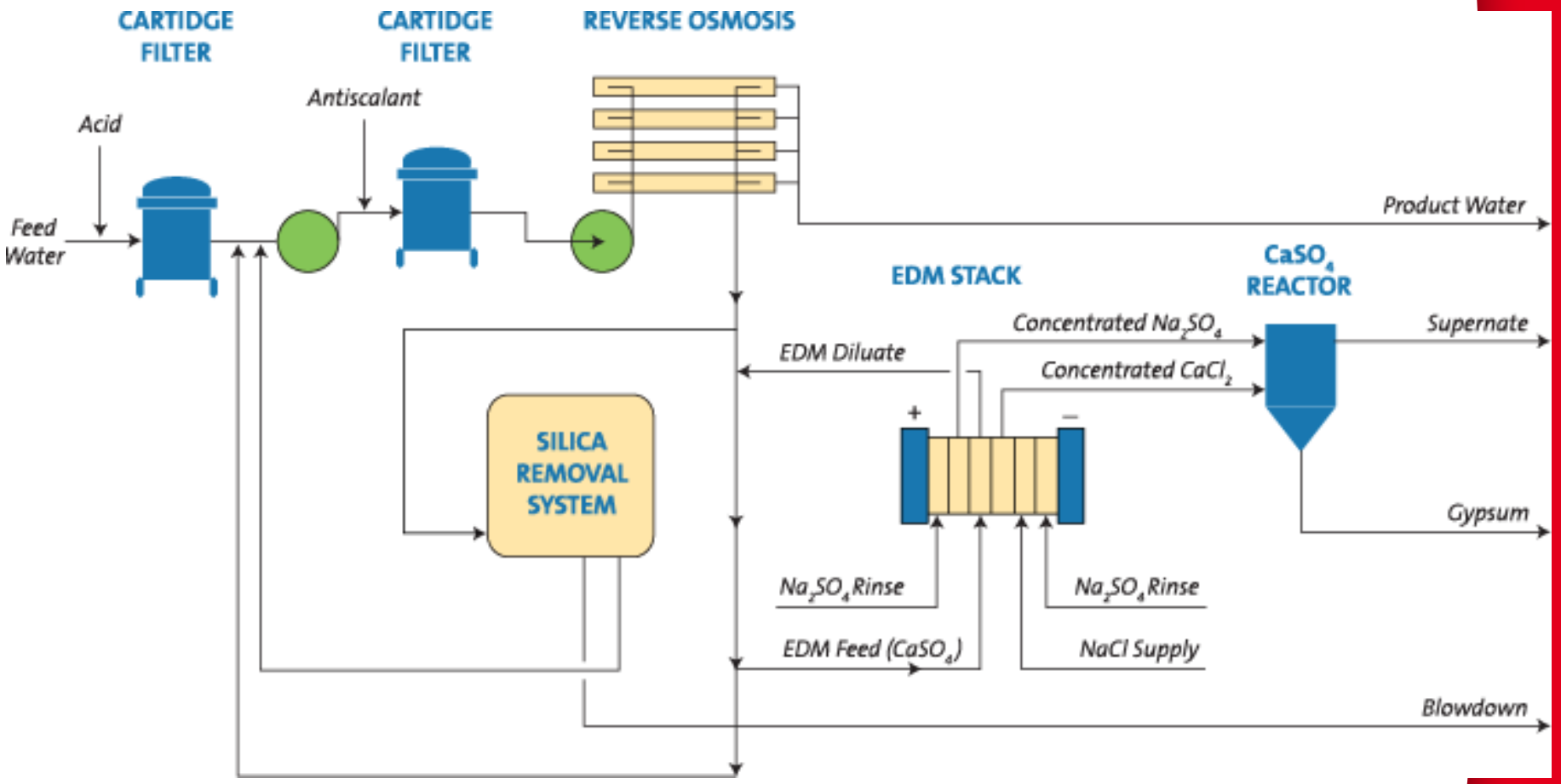
- ED
  - electricity is the driver to move ions across a membrane barrier again reducing TDS



Electrodialysis Metathesis (EDM)



ZDD Process Flow Diagram



Treatment Options

- 4.0 MGD Feed Water Design Basis Comparing four different operating scenarios
  - Conventional BWRO (75% Recovery) → **511 gpm** Evap Pond
  - Chemical Softening + High Recovery RO (90% Recovery)
  - ZDD with NF + EDM (98% Recovery)
  - ZLD with RO + Evaporator + Crystallizer (>99% recovery)

Thermal Technologies

- Evaporators
  - Rising film
  - Falling film
  - Natural circulation
  - Forced circulation
- Crystallizers
  - Enhanced Forced Circulation
  - Forced circulation crystallization
  - Falling film crystallizers

CoLD™ Process

Crystallization

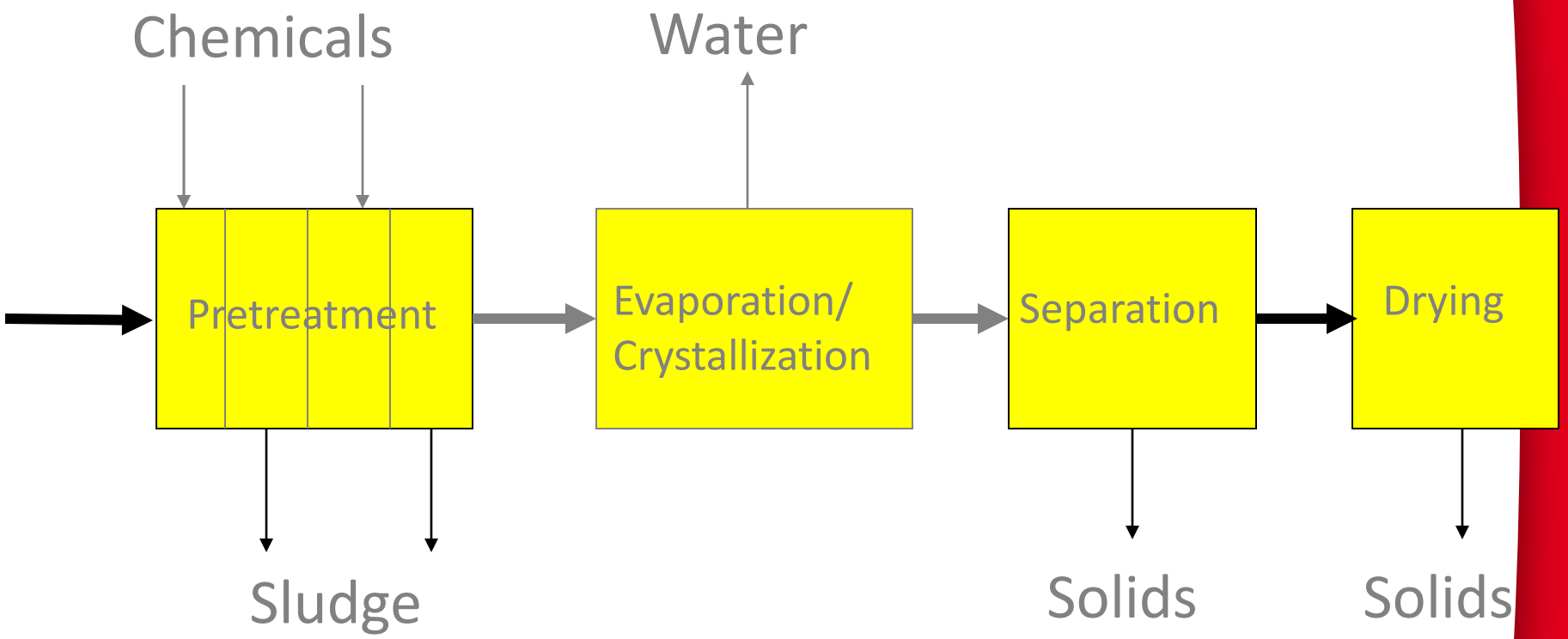
of high solubility salts at

Low Temperature and

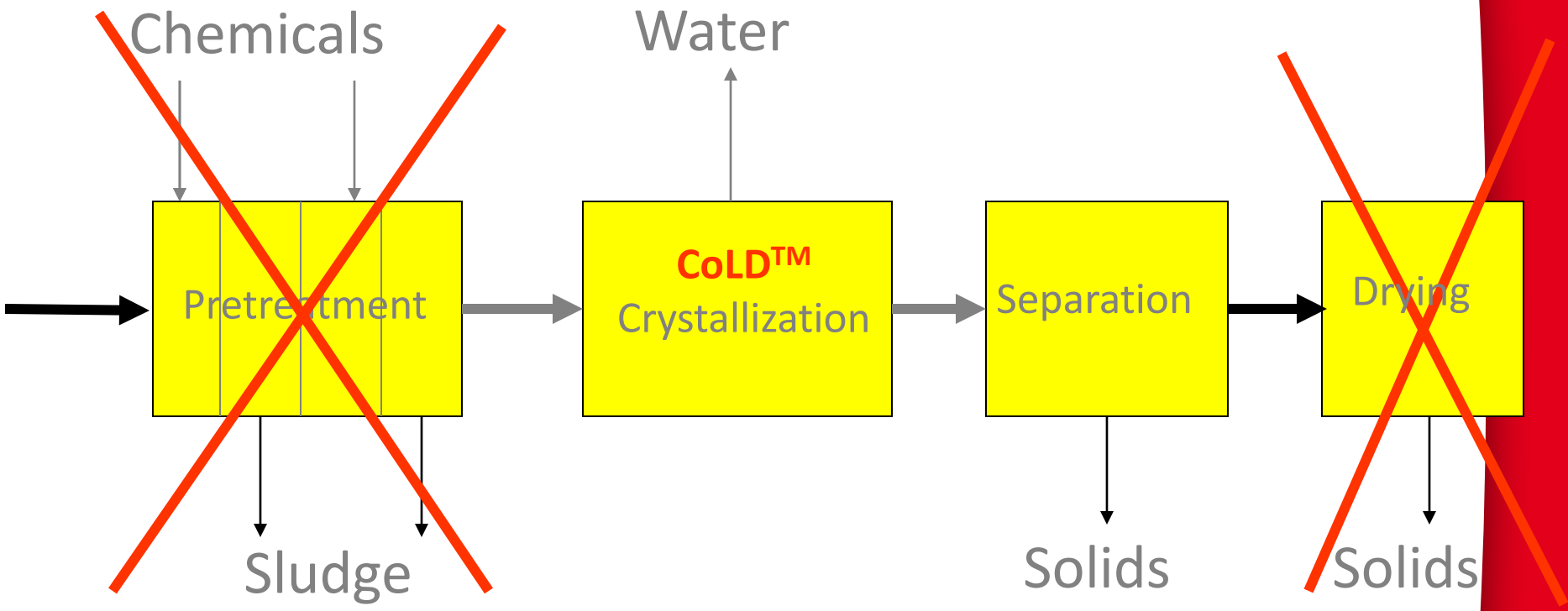
Deep Vacuum

U.S. Patent 8,052,763

Past Practice

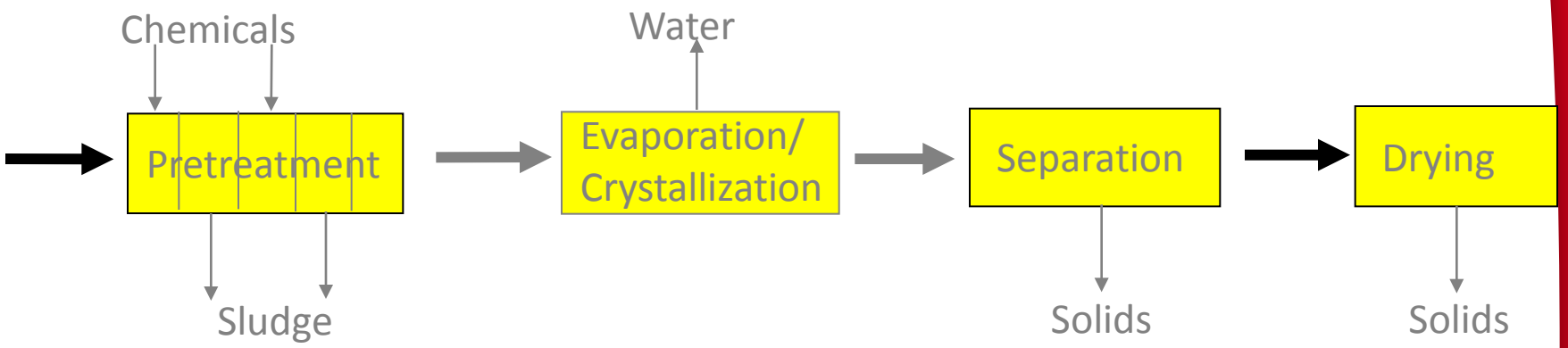


CoLD™ Process

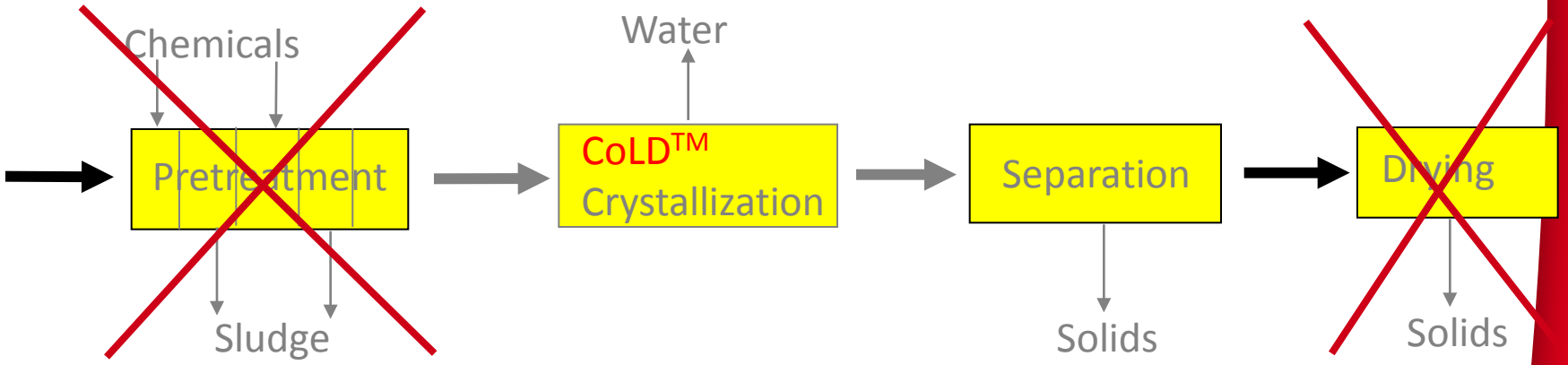


CoLD™ Advantages

Basic Flowsheet for ZLD



CoLD™ Flowsheet for ZLD

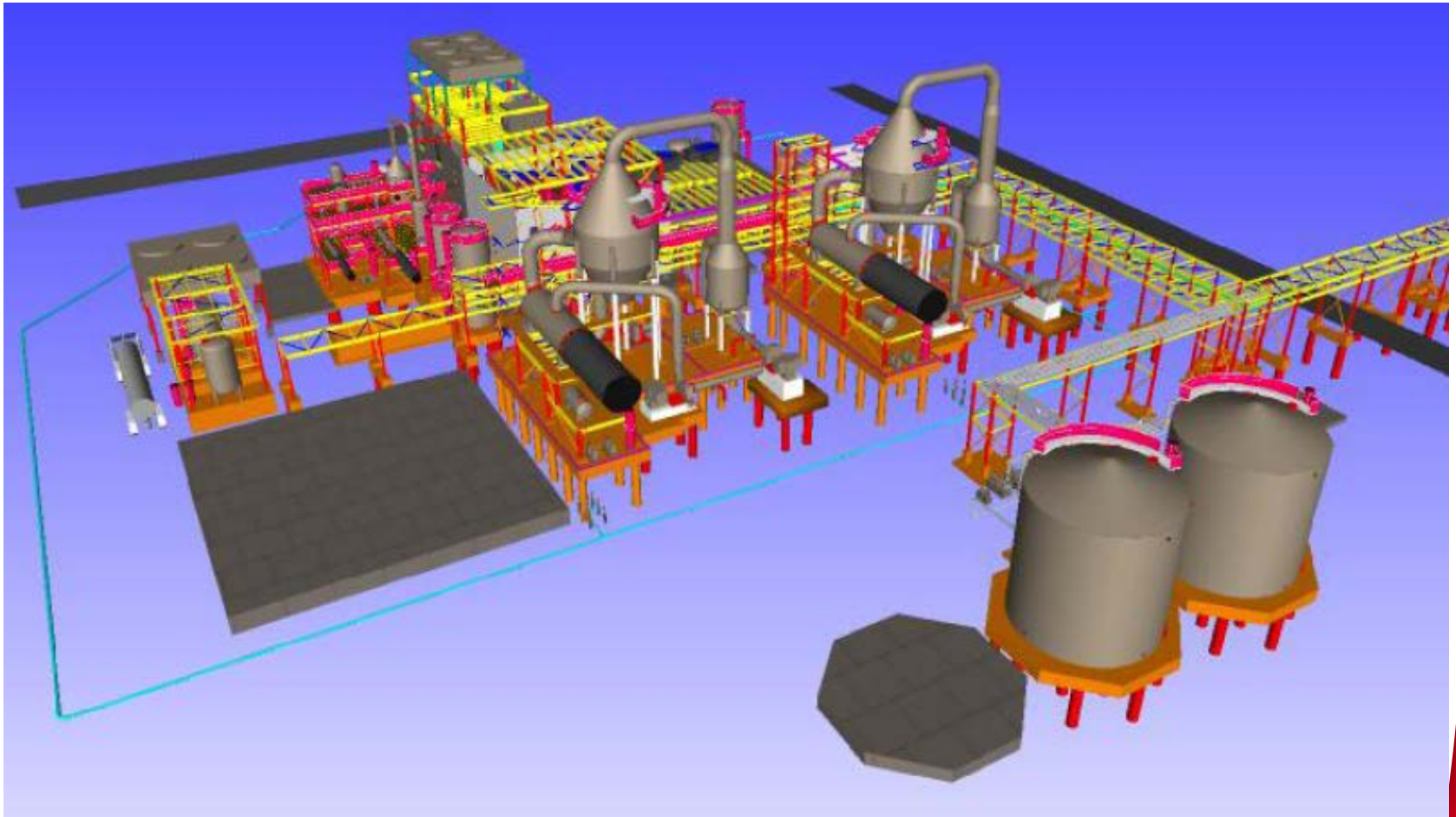


Advantages of CoLD™ Process

- No Chemicals, Less Sludge
- Lower Energy Requirement
- Simple System, Less Operator Attention
- Robust System
- Lower Capital Cost

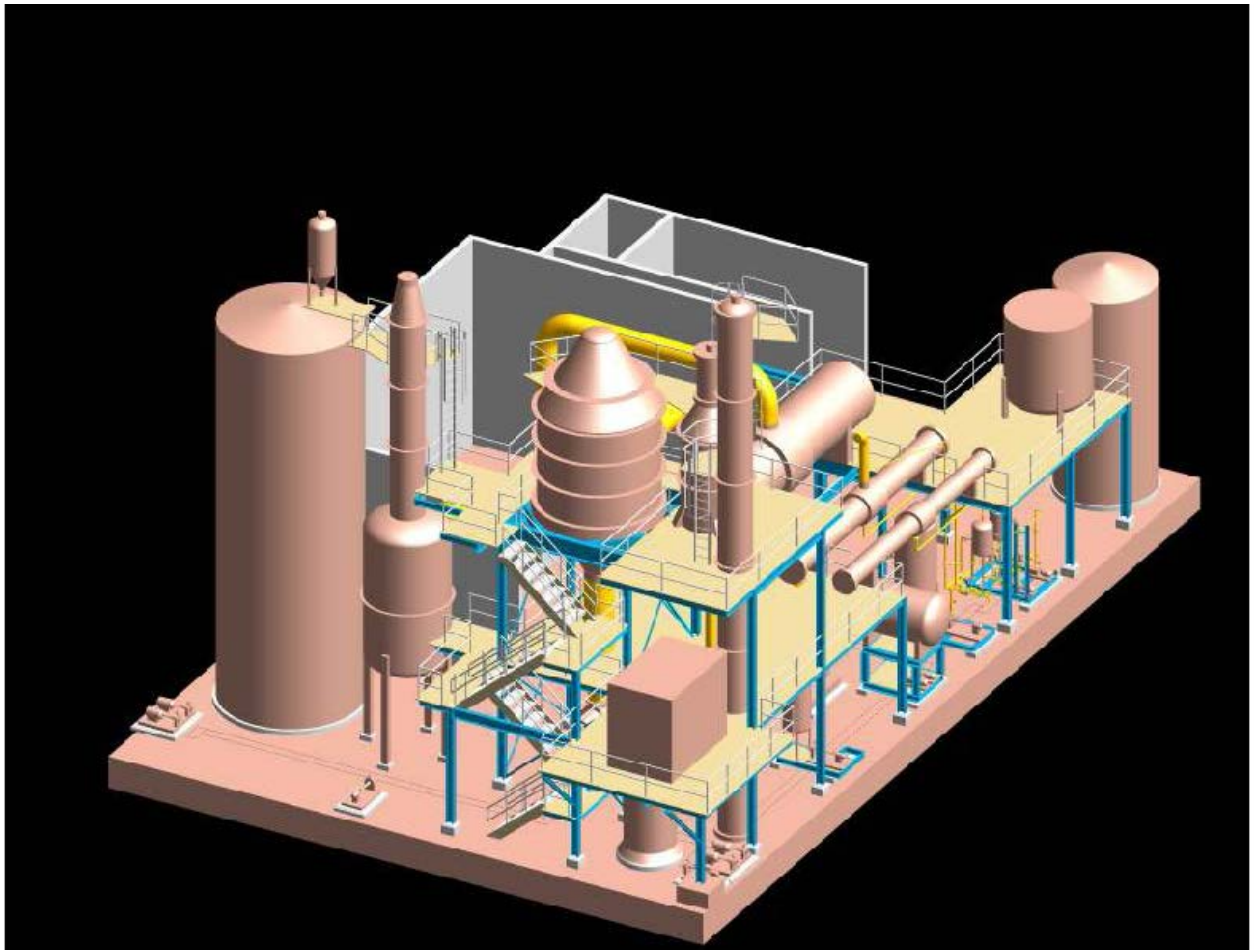
ZLD System for IGCC Power Plant (Start-up 2012)

- 630 MW IGCC Power Facility
- Zero Liquid Discharge System by HPD Includes two CoLD™ Crystallizers
- Produces Clean Water for Discharge and Dry Salt for Landfill Disposal



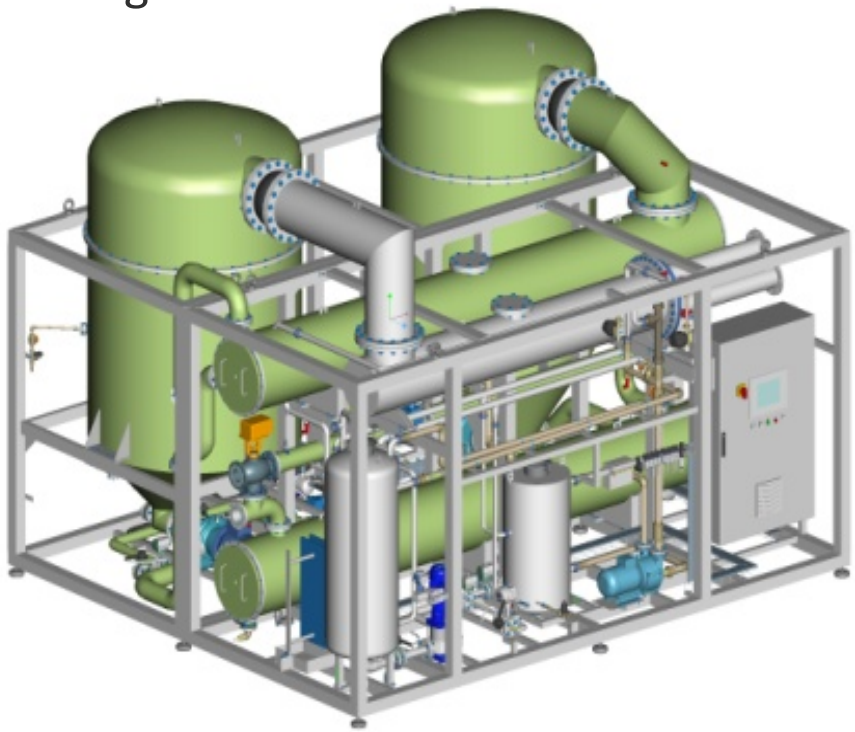
ZLD System for IGCC Power Plant (Start-up 2012)

- 335 MW IGCC Power Facility
- Zero Liquid Discharge System by HPD Includes CoLD™ Crystallizer
- Produces Clean Water for Re-use and Dry Salt for Landfill Disposal

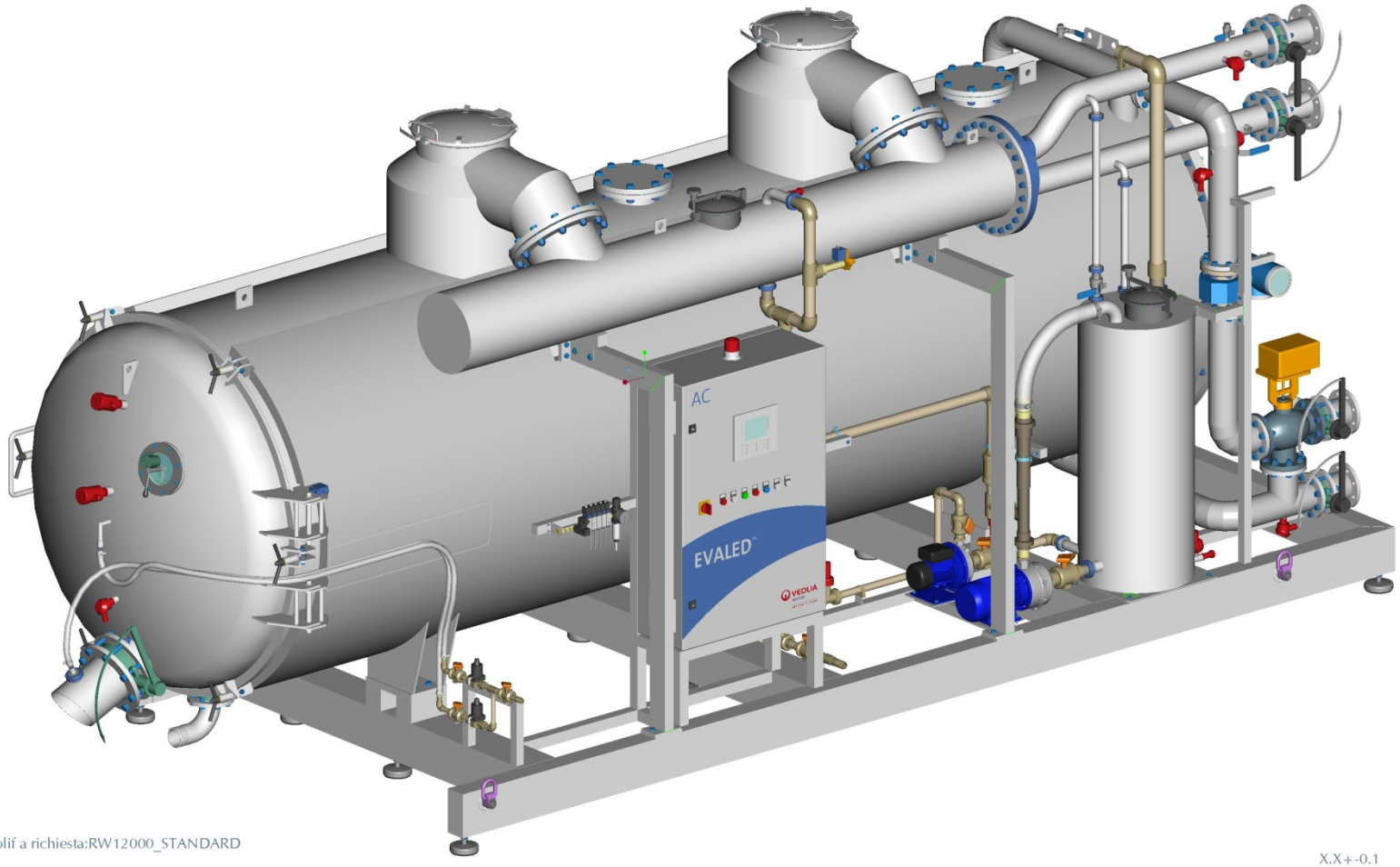


EW 60000 Spectra Energy Canada

- Evaporator
  - Double Effect Forced Circulation
  - Also Forced Circ MVR design



RW Type Concentrator Rio Tinto Mining



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ACTIFLO® Turbo - Aquamove Trailer

Mobile Pilot Demonstration Units – Biological Treatment

NEOSEP® and AnoxKaldnes™ MBBR

6

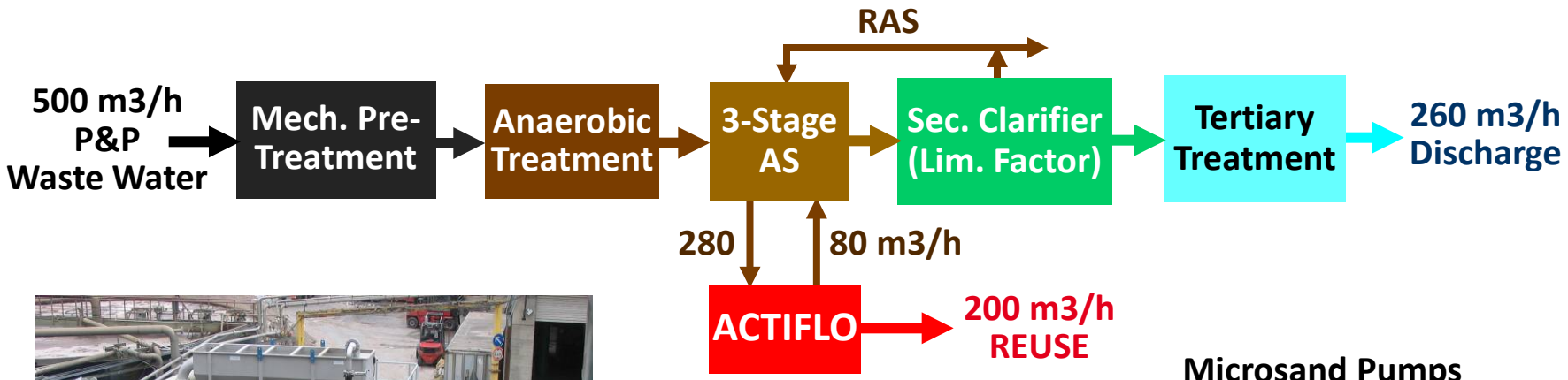
Case Studies

- Summary
- Project Specifics

Weig, Mayen, Germany

- Before Upgrade: 300 m3/h
- WWTP Expansion to 500 m3/h
- Limited Space for Expansion of Secondary Clarifier

Start-up Year :	**2006**
Application :	**Secondary Clarif. of AS for REUSE as PW (Plant Second. Clarifier Limiting Factor)**
Market Segment :	**Pulp & Paper**
Total Capacity :	**7 MLD**
Number of Units :	**1**
Configuration :	**ACTIFLO w/o Lamella; 30 m/h Rise Rate**
Raw Water Source :	**Activated Sludge Basin**
Parameters :	**TSS in/out: up to 6,500 / < 50 mg/l Limit**

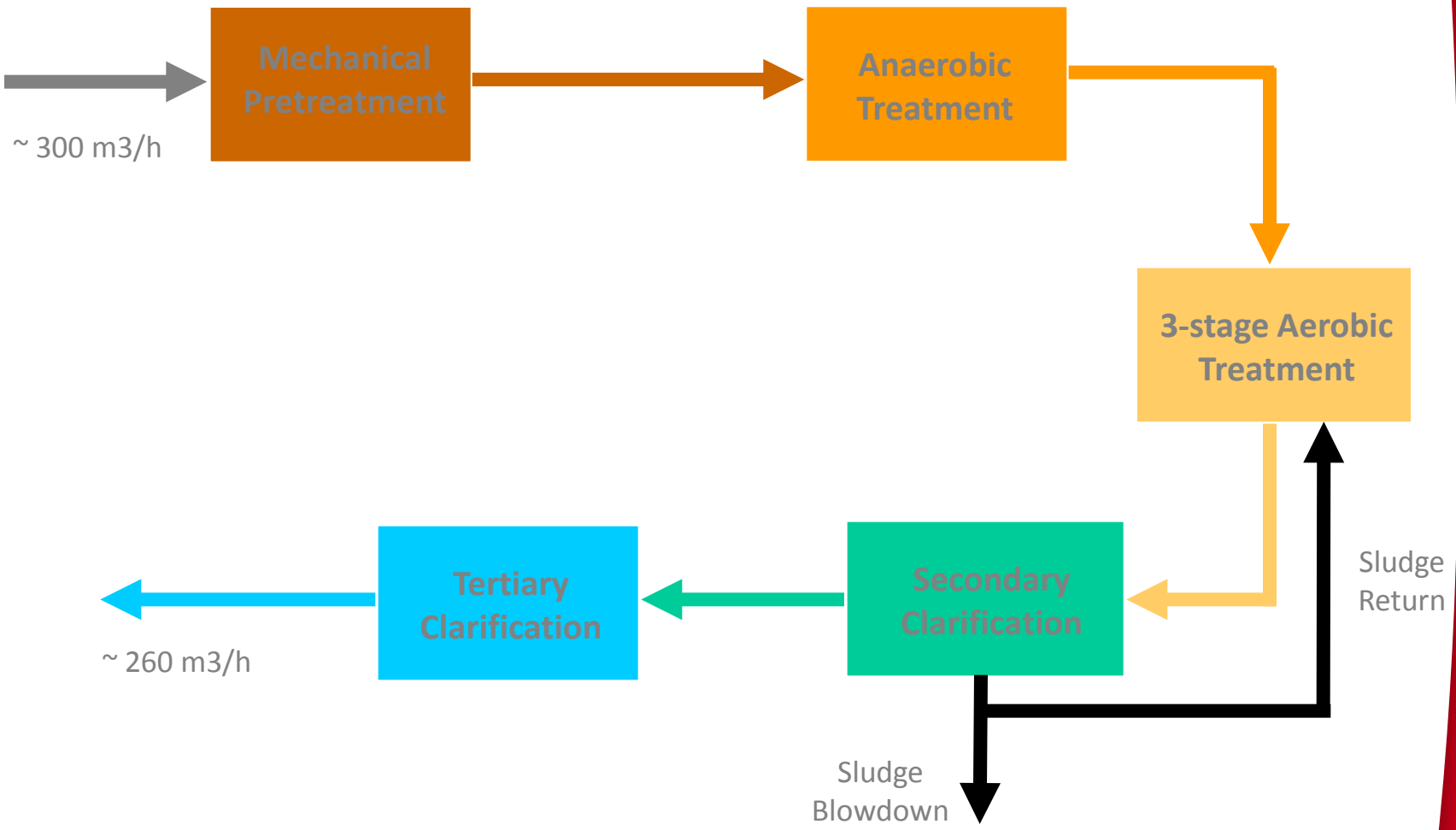


ACTIFLO Fitted in an extremely Tight Space

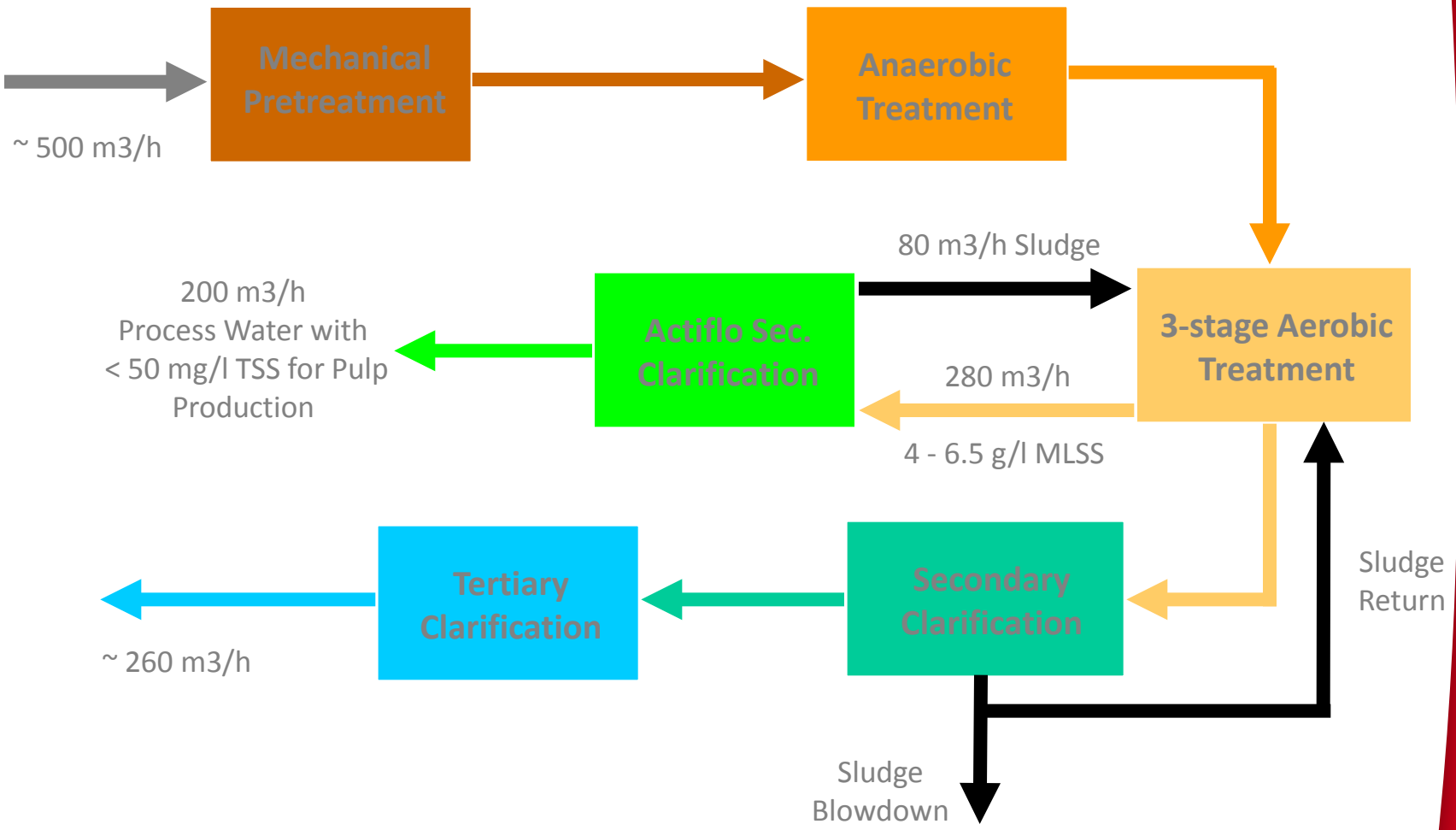
Weig Details

Microsand Pumps

Weig Paper Process Scheme before Upgrade



Weig Paper Final Process with Upgrade

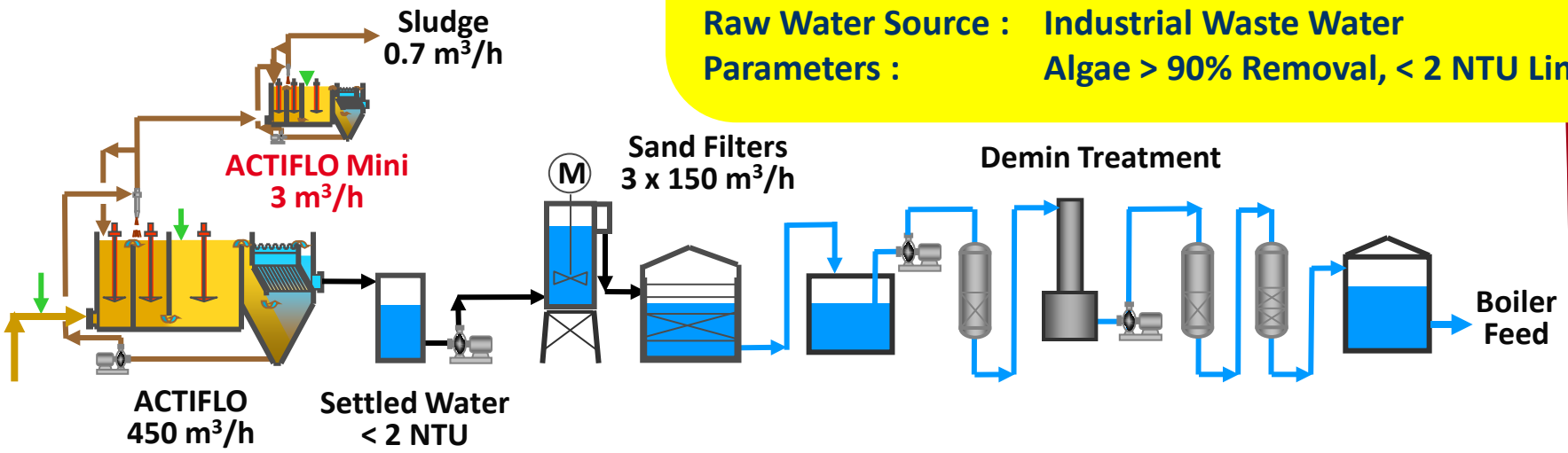


Weig Limited Space to Upgrade System

Actiflo Installed Upgrading Plant Performance

Idemitsu Kosan Chita, Japan

Start-up Year :	2008
Application :	REUSE WW for Boiler Feed
Market Segment :	Oil & Gas Refining/Petrochemical
Total Capacity :	2.9 MGD (11 MLD) + 13.7 gpm AFM
Number of Units :	Single Actiflo Train
Configuration :	ACTIFLO Mini for Sludge Thickening
Raw Water Source :	Industrial Waste Water
Parameters :	Algae > 90% Removal, < 2 NTU Limit



ACTIFLO for Algae & TSS Removal

ACTIFLO Mini used for Sludge Thickening

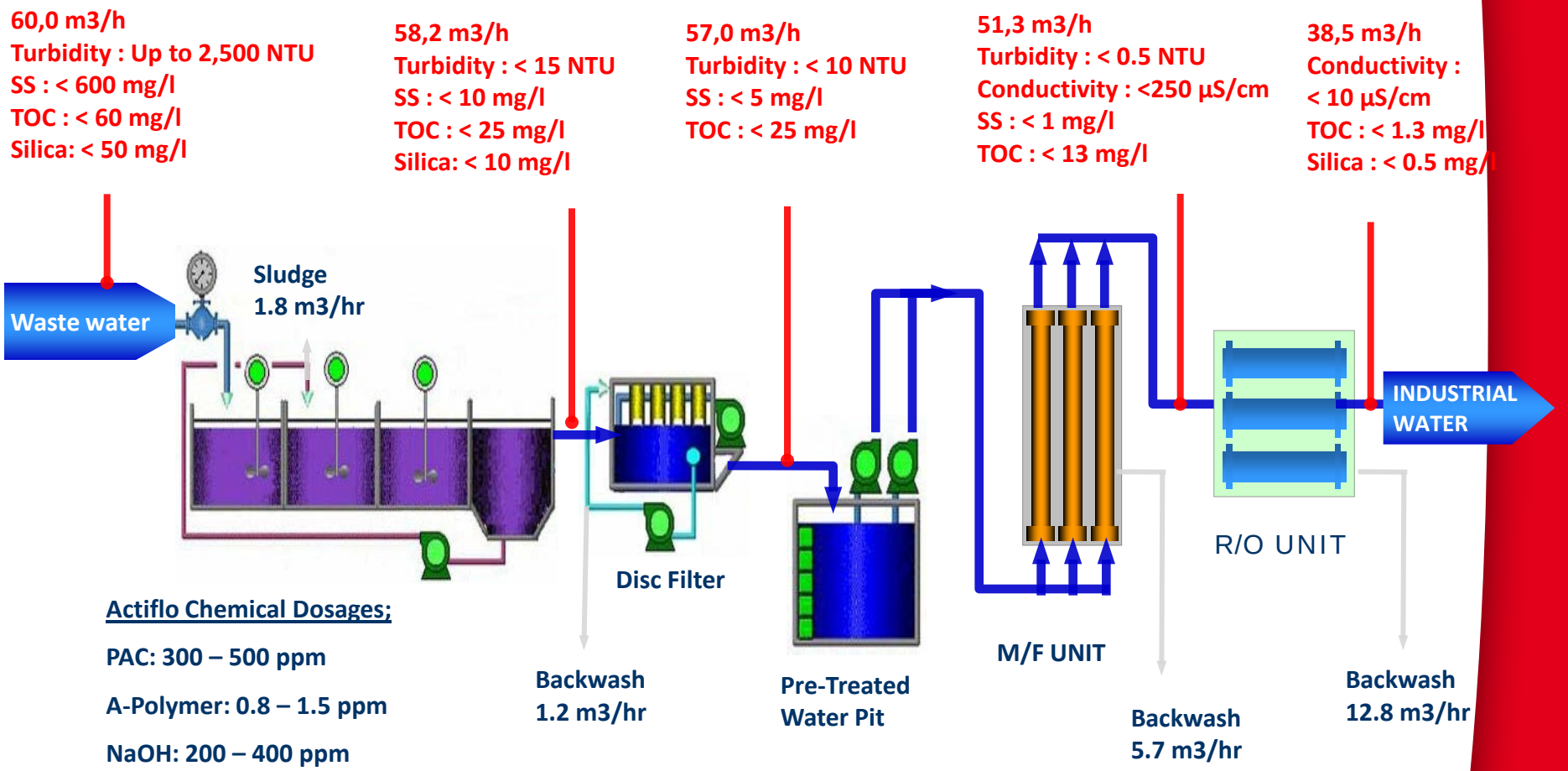
Idemitsu Kosan, Chita, Japan - 1 x 450 m^3/h (2008)

- DESIGN CONDITIONS:
  - Remove Turbidity & Algae *(Melosira ~3,500 cells/ml)*
  - Inlet Raw Water Turbidity; (Design < 15 NTU); (Actual 1.5 - 6 NTU)
  - Treated Turbidity: < 2 NTU
- OPERATING RESULTS:
  - Minimize Liquid Sludge Flow to < 4.4 gpm (< 1 m3/h)
  - Treated TSS: Algae > 90% removal
  - Treated Turbidity: 2 NTU
- TREATMENT FEATURES:
  - Liquid Sludge from the Main Actiflo is treated with a smaller Actiflo (aka Mini ActifloMini to reduce the volume by % 40
  - The Mini Actiflo is mounted above the main Actiflo unit to minimize the footprint to (60' LG X 12'W)
  - Able to remove a majority of the Algae and produce 2 NTU water

LG Siltron P3 - 1 x 264 gpm (60 m3/h) Gumi, S. Korea

Start-up Year:	**2005**
Industry:	**Semiconductor – Silicon Wafer Manufacture**
Application:	**High TSS water from silicon cutting & polishing process**
Equipment:	**Actiflo + Hydrotech Discfilter (Actidisk), MF, RO**
Goal:	**SDI_{15} < 3; Turbidity < 1 NTU**
Total Capacity:	**264 gpm (60 m3/h) (1.4 MLD)**
No. of Units:	**1 Train**
Water Source:	**Industrial Waste Water**
Parameters : details	**Please refer to Process Schematic for additonal**
Advantages:	**Packaged design providing a compact footprint** **Start-Stop operation to match wafer manufacturing demand** **High Automated with little or no operator attention**

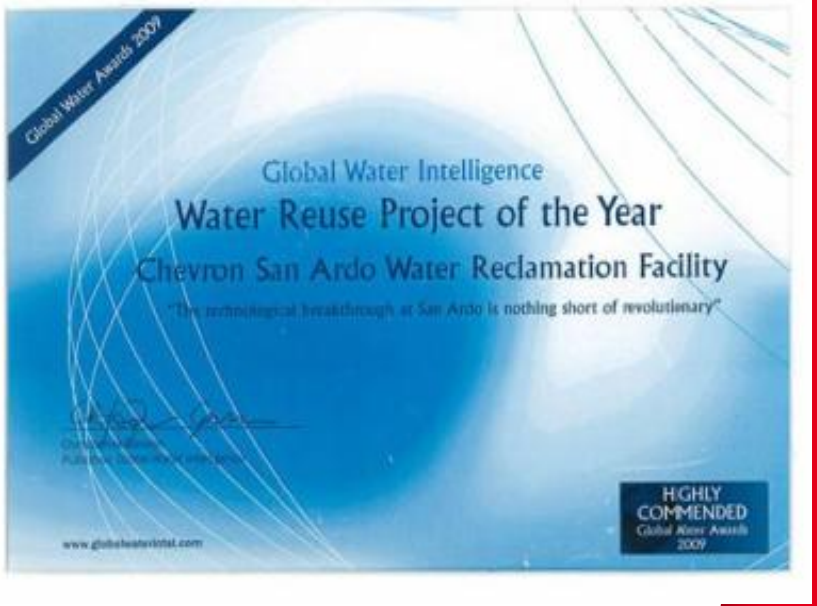
LG Siltron P3,
Process Schematic with Operating Results



LG Siltron P3 - Actidisk Equipment Arrangement

Chevron San Ardo Facility Produced Water Case Study

- OPUS Technology Applied
  - Treat PW for REUSE:
    - →Surface Water Discharge
    - →OTSG Make-Up
  - System Capacity
    - →2,100 gpm
  - Recovery Rates :
    - →System Recovery > 75%; RO > 81%
  - RO CIP Requirements
    - →Once 3 to 4 months; No Standby RO, > 99% Availability



Chevron San Ardo Facility
Produced Water Case Study - Treatment

CONSTITUENT (ppm)	PRODUCED WATER	[1] SURFACE DISCHARGE QUALITY SPECIFICATION	FINAL TREATED QUALITY
TDS	7,000	600	120
SODIUM	2,300	100	43
CHLORIDE	3,400	150	11
SULPHATE	133	150	120
NITRATE	10.0	5.0	N.D.
BORON	26.0	0.64	0.24
pH	7.5	6.5 ~ 8.4	7.0

[2] For Once Through Steam Generation (OTSG) Total Hardness <2 ppm as $CaCO_3$

Produced Water System Jobsite
Chevron San Ardo Facility

Darling Quarter Commonwealth Bank Place Sidney, Australia

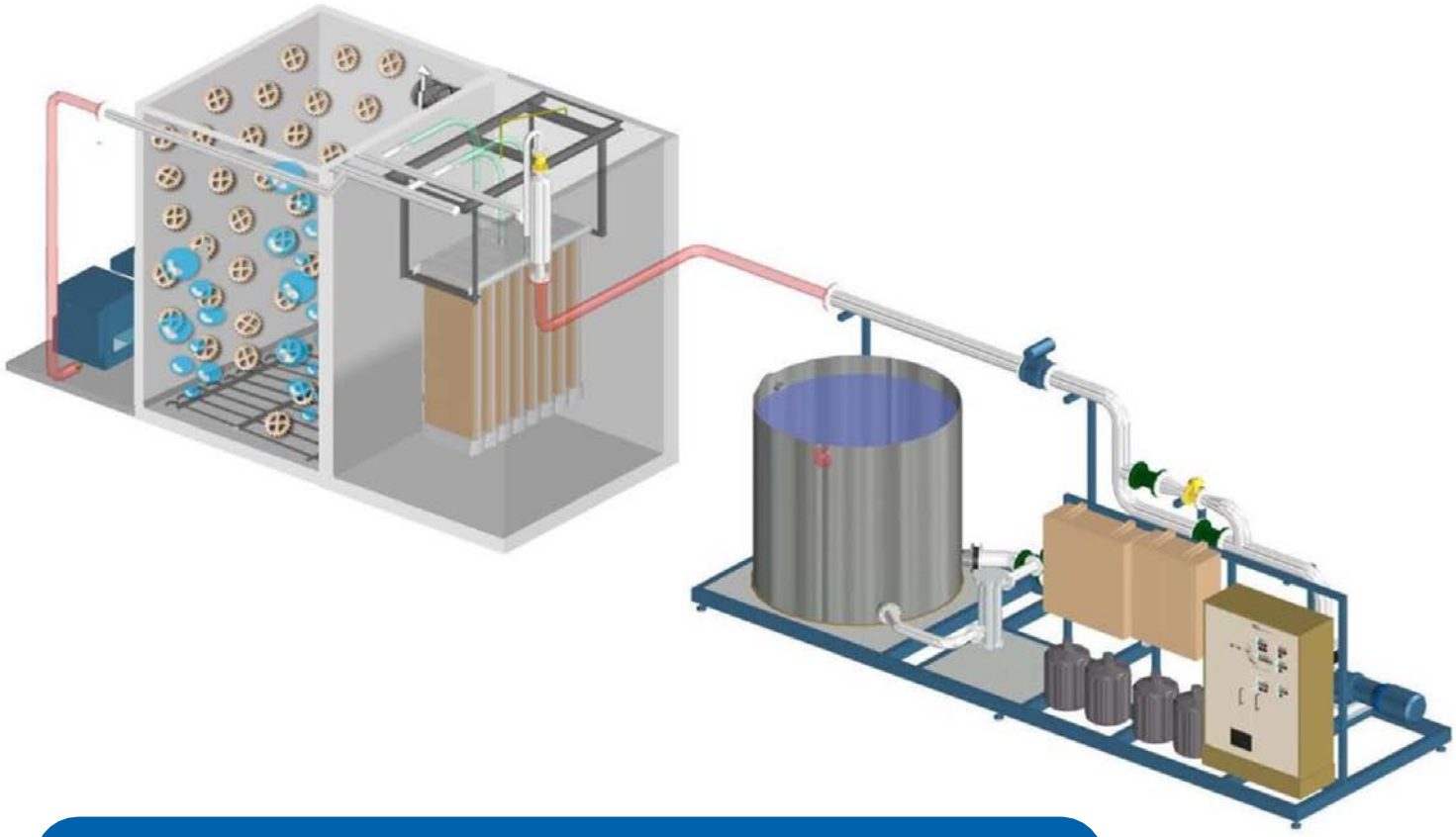
- Commercial office and leisure space redevelopment
- Located in Darling Harbour next to the Sydney CBD
- Green Star rating: 6 Star/World Leader

greenstar

BUILDING DESIGN REDUCES:

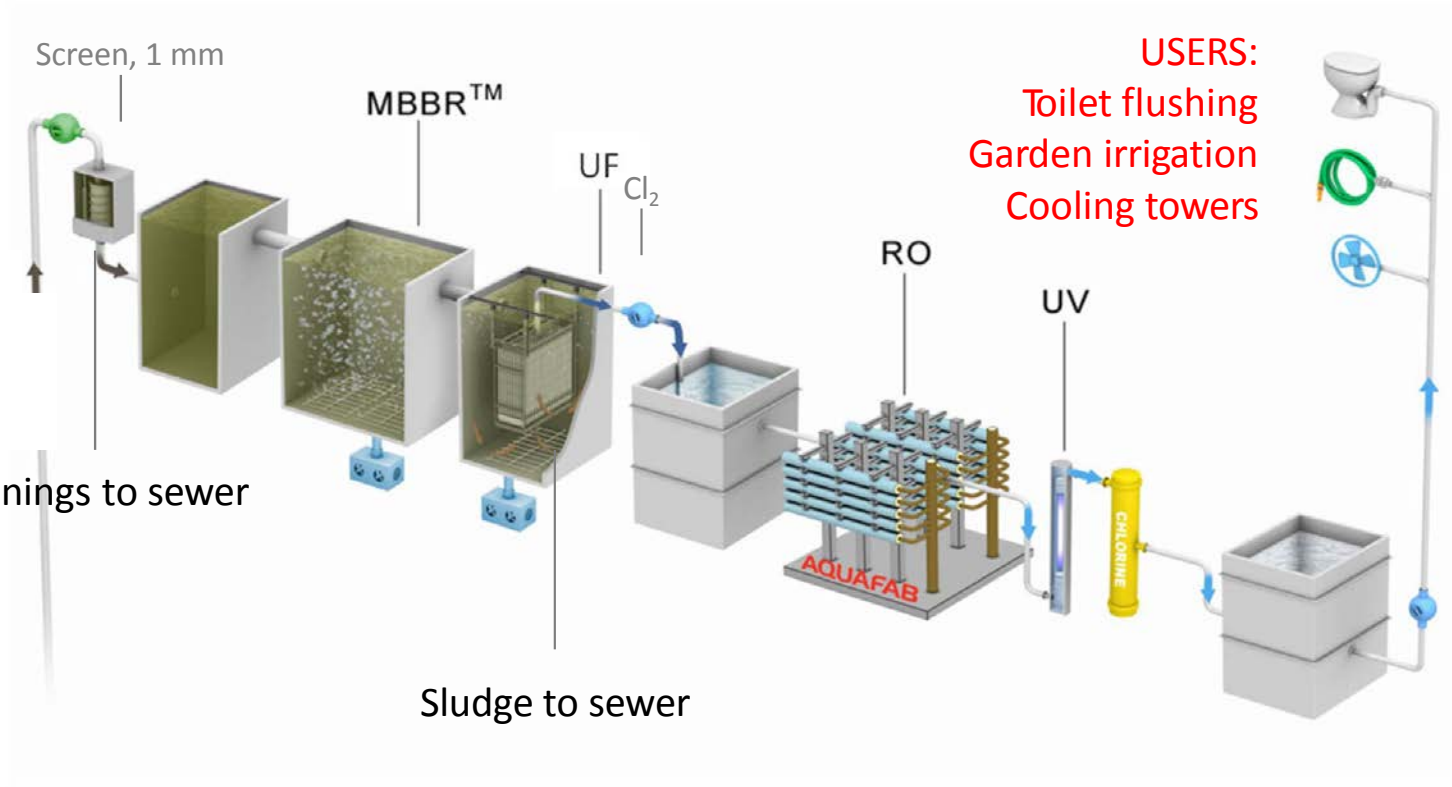
- CO_2 emissions by 2,500 tonnes per year
- Potable water use by 92%
- Very small footprint available for the RWP in the basement of the building (2475 ft2) (230 m2)

Darling Quarter REUSE
Innovative Technology Combination



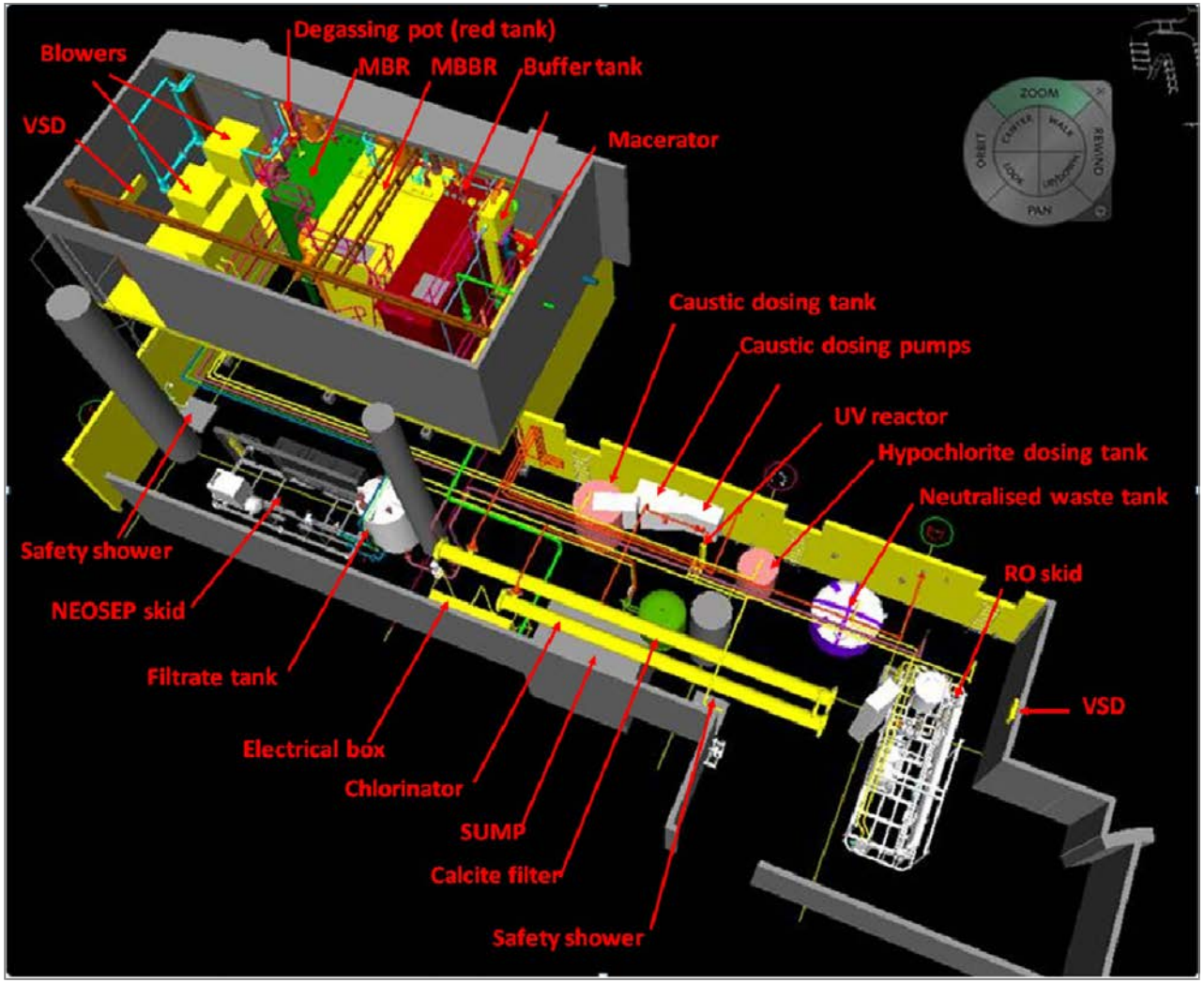
MBBR + UF

Darling Quarter REUSE
Simplified Block Flow



7.9 MM gals (60 MM liters) of drinking water are saved each year

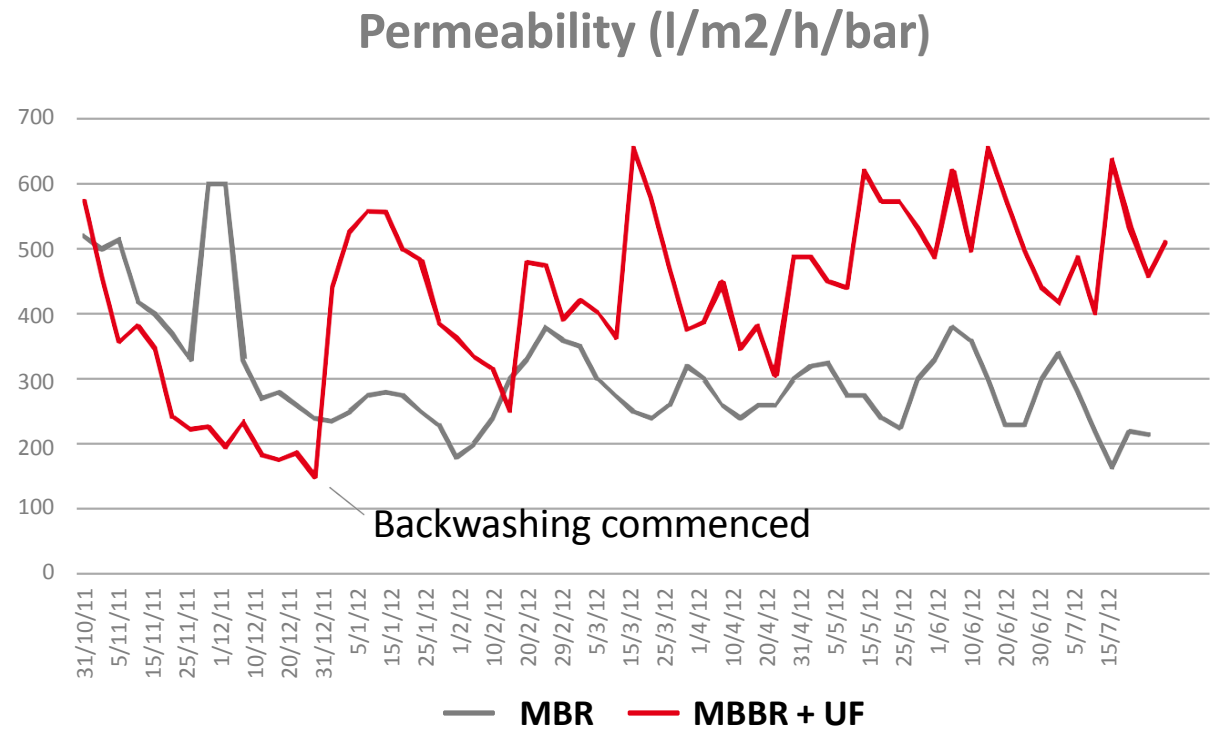
Darling Quarter REUSE Equipment Footprint



Treated Water Quality exceeds Australian Recycled Water Guidelines

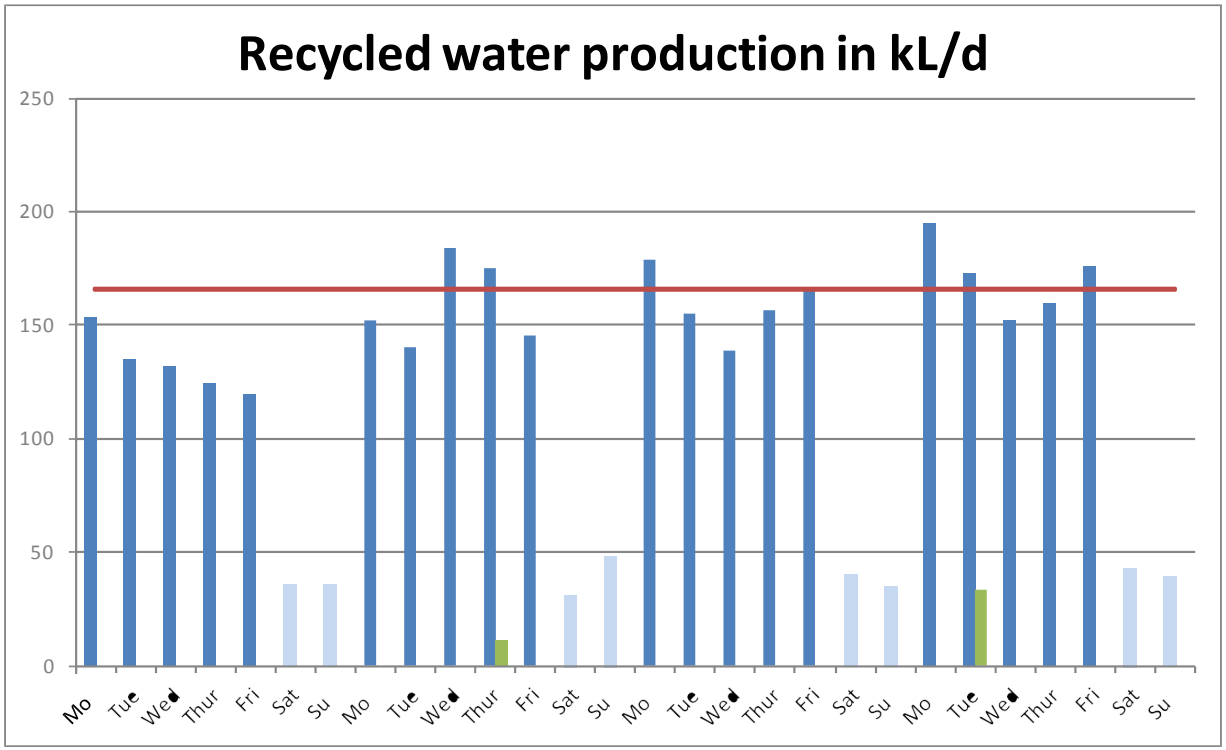
PARAMETERS	WATER QUALITY ACHIEVED
BOD5	<5 mg/L
TSS	<5 mg/L
pH	6.0-9.0
Turbidity	<0.2 NTU
Conductivity	20 – 50 µS/cm
E. Coli	<1cfu/100mL
Coliphages	<1pfu/100mL
Clostridia	<1cfu/100mL
Validated virus reduction	6.6 log reduction
Validated bacteria reduction	12.1 log reduction
Validated protozoa reduction	8.1 log reduction

MBBR+UF Performance Compared to MBR



- Higher permeability and longer cleaning intervals (4 times less chemical used) for MBBR + UF compared to MBR

Recycled Water Plant Performance



- Potable water top off when demand is too high; > 98% utilization using produced recycled water
- Darling Quarter potable water consumption is 0.18 kL/m2/year (more than 4X below best practice guidelines : 0.77kL/m2/Year)

Darling Quarter Engineering Excellence Awards Winner Sydney 2012

- Building and Structures category

BUILDING AND STRUCTURES

EXCELLENCE AWARD WINNER

COMMONWEALTH BANK PLACE AT DARLING QUARTER

Arup

Joint Entrants: Lend Lease, Veolia Water Solutions & Technologies

Commonwealth Bank Place is the largest commercial office development in Sydney's CBD. The unique development is located within Darling Quarter, a new 1.5-hectare precinct that includes a new playground, retail terrace, children's theatre and community green.

The project represents best practice in terms of:

- Place making – in particular, the integration of amenities for tourists, locals and employees into the new precinct reactivates the area.
- World class sustainability - Commonwealth Bank Place is characterised by world class sustainability initiatives including tri-generation system, and black-water and rain-water systems. Integrating these initiatives into real-time displays ensures that tenants can see the tangible benefits of their behaviour.
- Best practice and novel engineering – the building pushes the envelope in terms of engineering and architecture. The full height atria is supported by thin steel pillars and intersected with floating pods and cantilevered stairs which extend into the void to achieve the open feel desired by the architect and the tenant.

SHELL Pearl GTL Complex, Qatar
Waste Water / REUSE / ZLD

REUSE

Client Overview & Requirements

- The Pearl GTL project (2011) comprises the development of upstream gas production facilities, as well as an onshore GTL plant to produce:
  140,000 bpd of GTL products
  120,000 bpd of associated condensate
  LPG (Ethane) 320,000 bpd

Project Description

- Effluent Treatment Plant
- Treatment of the cooling water blow-down for reuse in the process
- Management and optimization of water cycle targeting Zero-Liquid Discharge target
- **2 X 4400 gpm; all of the facility WW is treated to supply Process and Boiler Feed Water**

Shell Project Investment …$19B;
$500MM for Water Treatment REUSE

Technologies & Solutions

- Several unit processes including UF & RO
- Actiflo (100% effluent recycle)
- Sludge treatment using BC+C to minimize volume production of dewatered sludge and salt

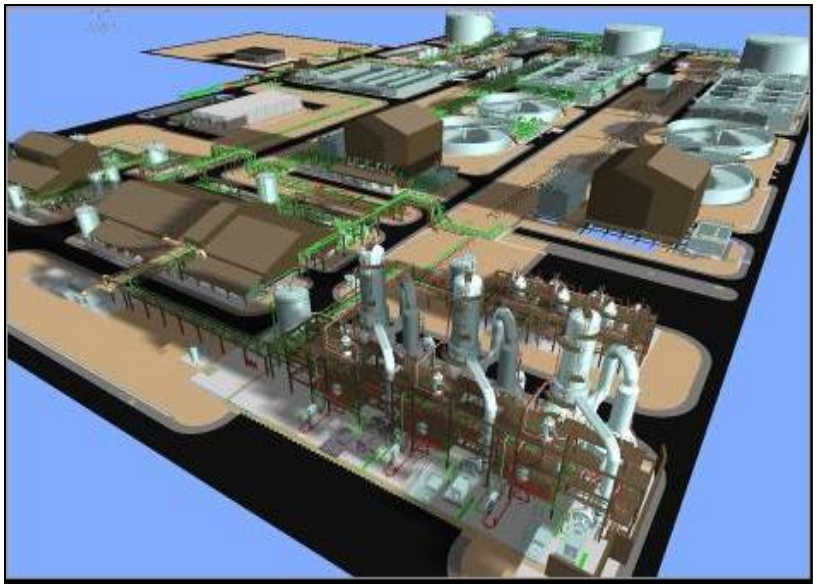
Technical Data

- Removal of solids, oil, dissolved organics, salts and pathogens

SHELL Qatar, Pearl GTL complex, Qatar

Technologies and Technical data

- **Cooling Tower Blowdown:**
- **Hollow fiber SUF** PVDF membranes built with interchangeability for future maintenance; recovery rate > 90%
- **Single-pass RO** units with sea water membranes. The recovery rate is > 85% and the operating pressure = 16 bars.
- **Effluent Treatment (ETP) and Water Reuse:**
- Influent contains: Oil, organic acids, alkalinity
- CPI units for oil/water separation
- **2 Biotreater trains** using activated sludge
- **Hollow fiber SUF** PVDF membranes built with interchangeability; to meet future maintenance; recovery rate > 85%
- **3 Double-Pass RO** units for TDS removal, including CIP units. Trains 1 and 2 have a recovery rate > 80%; the third common train has a recovery > 30%. Operating pressure is 19-20 bars.

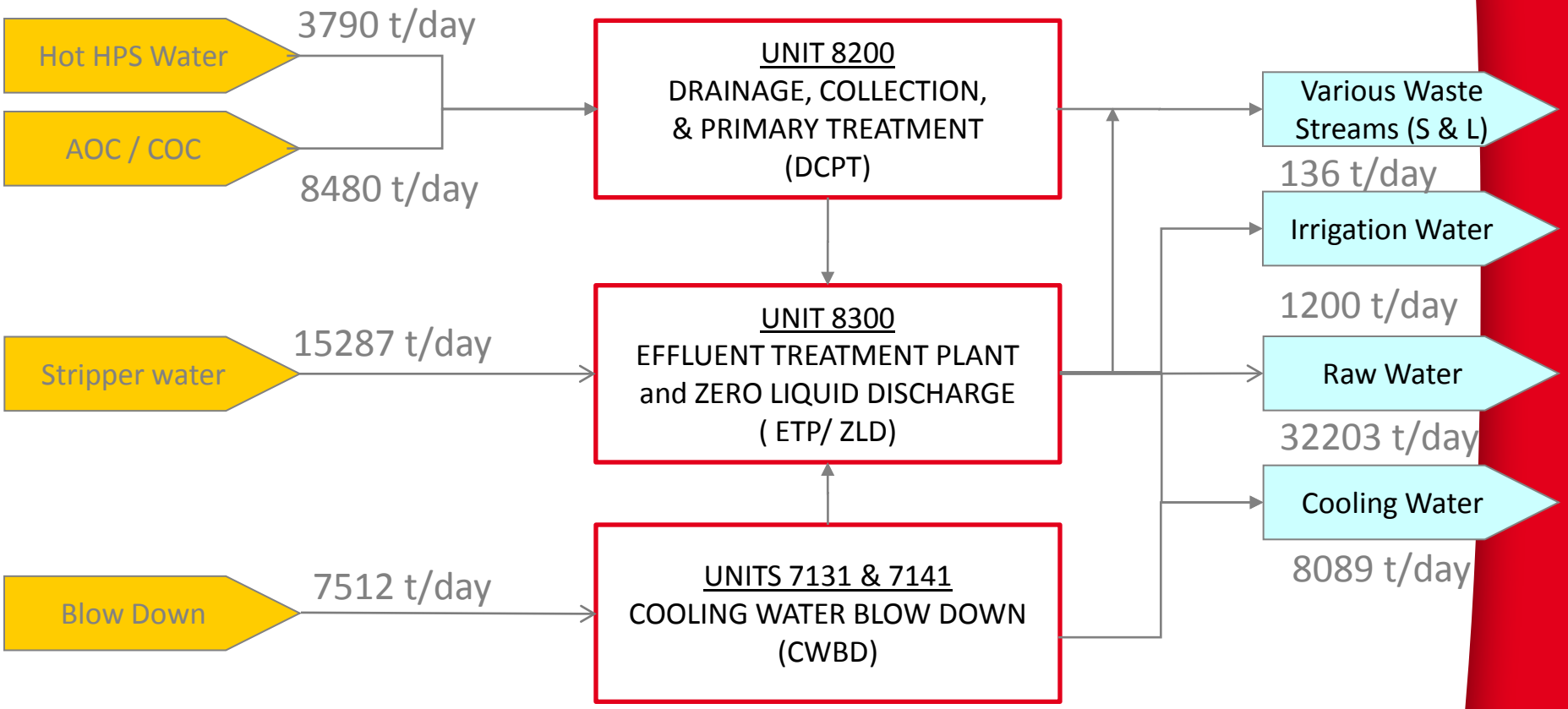


- Brine from RO is treated by **Evaporation** and **Crystallization** to achieve zero liquid discharge.
- Actiflo™ clarification
- Bio-sludge dewatering through centrifugation before composting.

SHELL Water Re-use with Zero Liquid Discharge Gas to Liquids (GTL) SHELL, Qatar

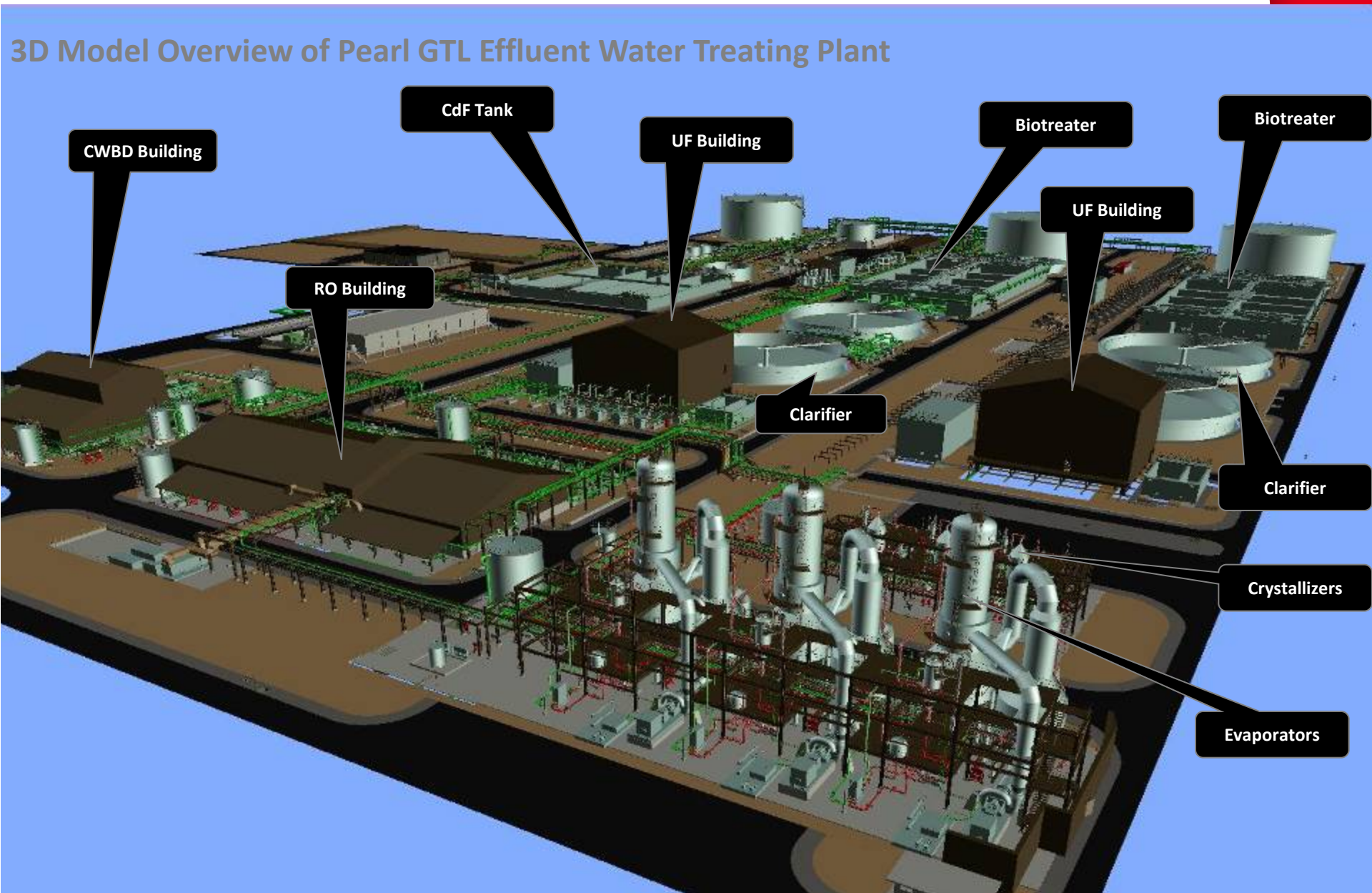
REUSE

Overall Scheme of Main Units and Flows:



SHELL PEARL GTL, QATAR - Effluent Plant

3D Model Overview of Pearl GTL Effluent Water Treating Plant



ZLD for Shell Pearl GTL complex – Qatar - EPC contract delivered in 2011

FFU, Biotreaters & Clarifiers

ZLD for Shell Pearl GTL Complex - Qatar - EPC Contract Delivered in 2011

ZLD for Shell Pearl GTL complex – Qatar - EPC contract delivered in 2011

SHELL Qatar Pearl GTL Complex Qatar

Submerged Ultrafiltration

Reverse Osmosis

Evaporation

Biotreater

SASOL Landlord, South Africa REUSE

Client Overview & Requirements

- Established in 1950 by South African government, Sasol is a global energy company with operations in chemicals, fuels and gas, and has now 50 entities w/ 30,000 employees.
- Headquartered in Johannesburg, South Africa engaged in the commercial production and marketing of chemicals and liquid fuels; with a growing interest in oil and gas exploration.
- Waste Water being reused for Sasol's fuels enhancement and polymers expansion project.

Project Description

REUSE

- Cooling towers blowdown reuse through construction of water treatment plant and water purification installations

Technologies & Solutions

- 2 Multiflo® clarifiers, a patented process, using lamella plates
- 3 treatment trains consisting of:
  - Submerged membrane.
  - Ion exchange softeners
  - Reverse osmosis & MB demin system

Scope of Supply

- Design, construction and commissioning

Technical Data

- See treatment line details

SASOL Landlord, South Africa REUSE

Treatment line details

- Clarified Water
  - MULTIFLO 300 feeding the demineralization unit, chill tower of oxygen plant, process cooling water make up, and also desalination plant with reduced flow
- Cold Lime Softener
  - MULTIFLO 300 with lime and soda-ash to reduce TOC, hardness, silica
  - Also treating CTBD for (full reuse) and
- Submersible Membrane
  - Pre-treatment through T- type strainers with 1 mm screen opening
    - → Control of pH, Turbidity, Conductivity, Hardness
    - → UF can also be fed directly, with clarified water or even CTBD water
  - UF Membrane system (7075 m^2 per train, 36 $l/m^2.h$, outlet with SDI< 3)

REUSE

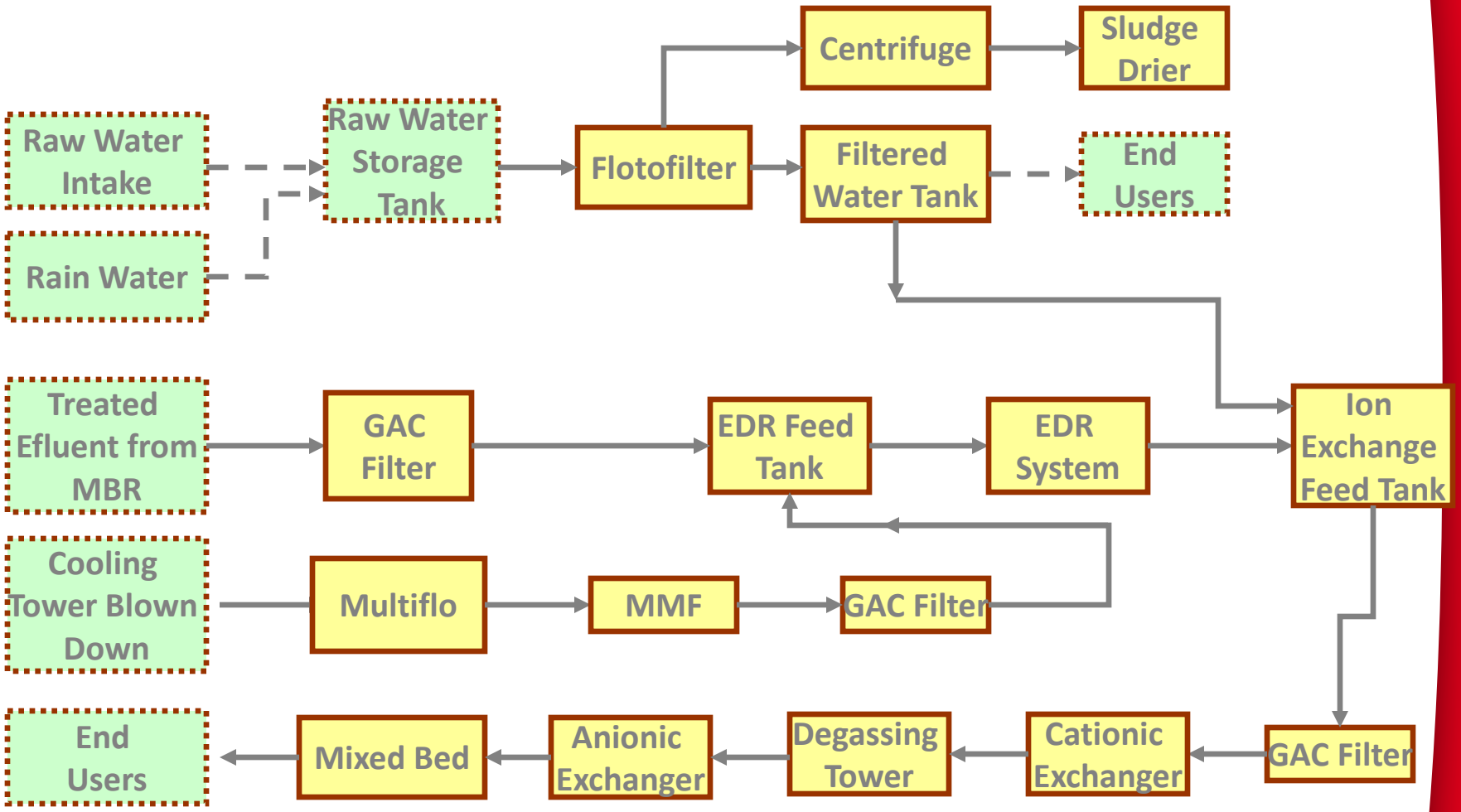
- IX Exchange
- RO
- Mix Bed
- Flow-rate : 4580gpm

PETROBRAS RNEST
Pernambuco , Brazil

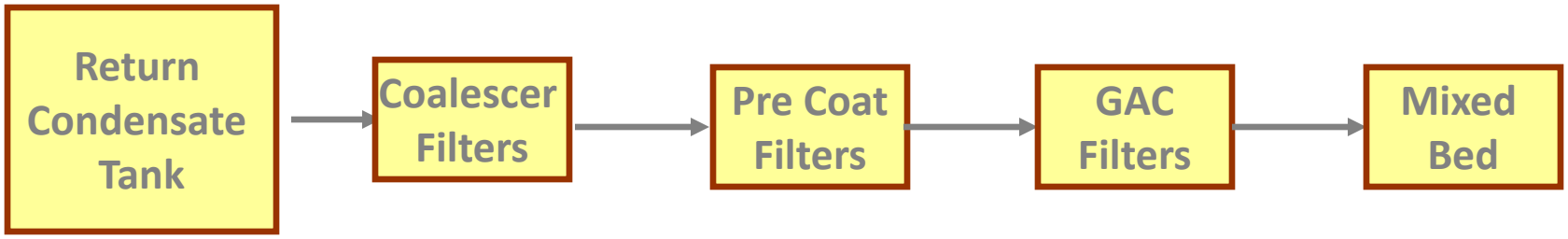
REUSE

- CLIENT: Petrobras new refinery (200.000 bpd) with a Water/REUSE Water Treatment Plant 12.7 mgd/8800 gpm (2000 m3/h)
- MARKET: HPI/CPI
- START DATE: 03.2009
- FINISH DATE: 12.2012
- EXECUTION: Engineering + Equipment + Civil + Erection + Commissioning + Assisted Operation
- MAIN PROCESS: Floto-filtration >>>Demineralization>>> Sludge Treatment >>>Dewatering (Centrifuge)>>> GAC Filtration>>>EDR Treatment + Blowdown Treatment (using Multiflo)

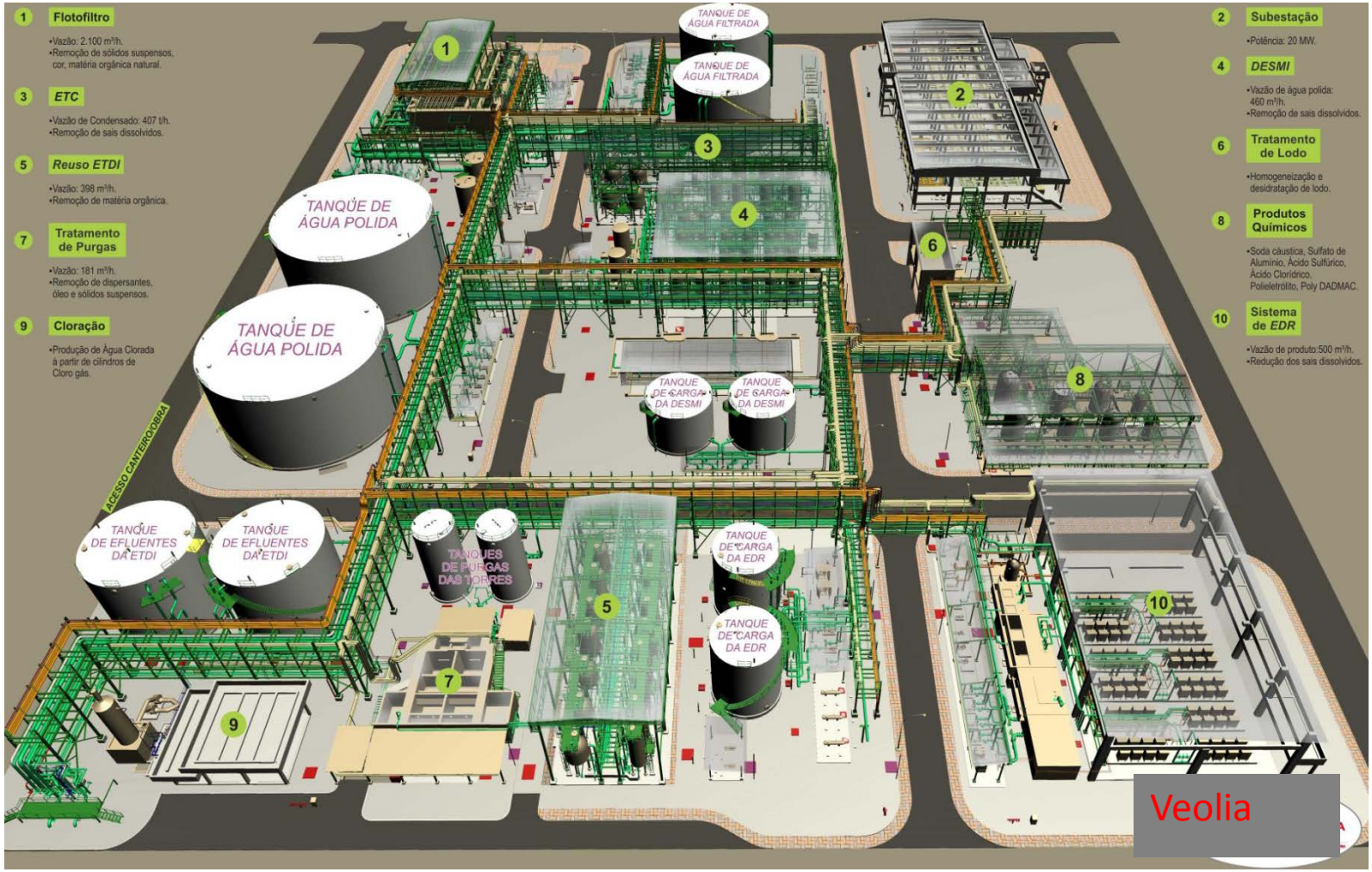
PETROBRAS RNEST
Pernambuco , Brazil



PETROBRAS RNEST – Return Condensate Treatment 3.5 mgd/2467 gpm (560 t/h)



PETROBRAS RNEST
Pernambuco , Brazil



PETROBRAS RNEST
Pernambuco , Brazil

PETROBRAS RNEST
Pernambuco , Brazil

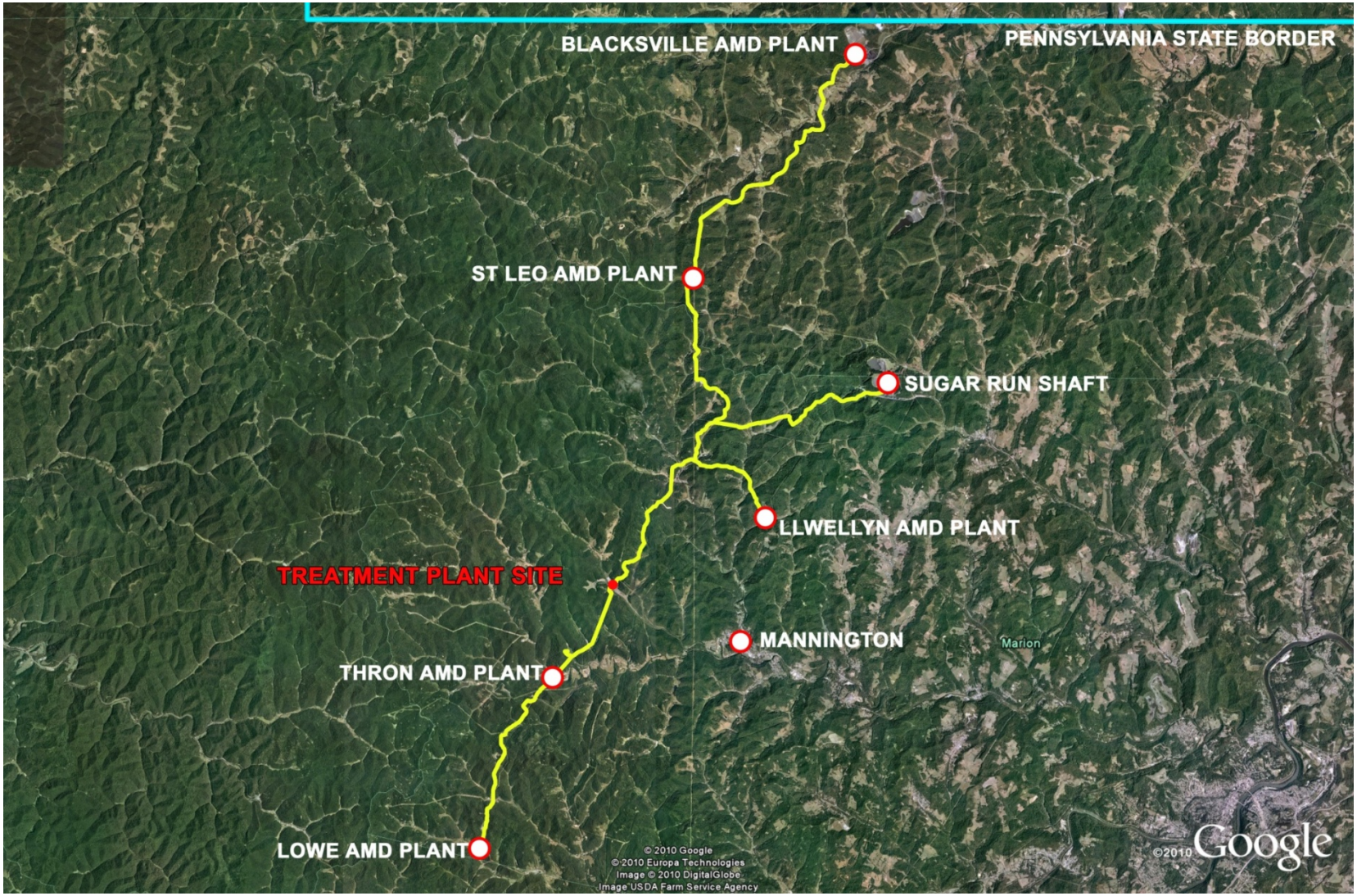
CONSOL Energy Mine Water Treatment
The Issue – Mine Water Discharge

- West Virginia Department of Environmental Protection new regulations on chlorides in discharges to receiving streams
- Three mines discharge conventionally treated mine drainage from six different locations
- Current treatment for pH, metals, and TSS removal at the points of discharge does not address Chloride removal
- Risk associated with the disposal of treatment residuals

CONSOL Energy Mine Water Treatment
The Solution – Zero Liquid Waste

- After much review Consol Energy decided to move forward with a centralized treatment facility that creates Zero Liquid Waste (ZLW)
- The ZLW concept differs from ZLD in that a large quantity of water is discharged, however this water is compliant with environmental discharge requirements
- The water that is discharged is low in TDS and chlorides improving the overall quality of the river allow users located downstream to use this water
- Waste residuals are condensed into a solid that is properly disposed in an on-site landfill
- No liquid waste from the water treatment operation leaves the site

CONSOL Energy Water Treatment - Mine Locations



CONSOL Energy Water Treatment - Project Challenges

- Substantial capital and human resources required to meet the requirements for:
  - Project Execution
  - Facility construction (tight schedule)
  - Commissioning & Operations

CONSOL Energy - Design Criteria

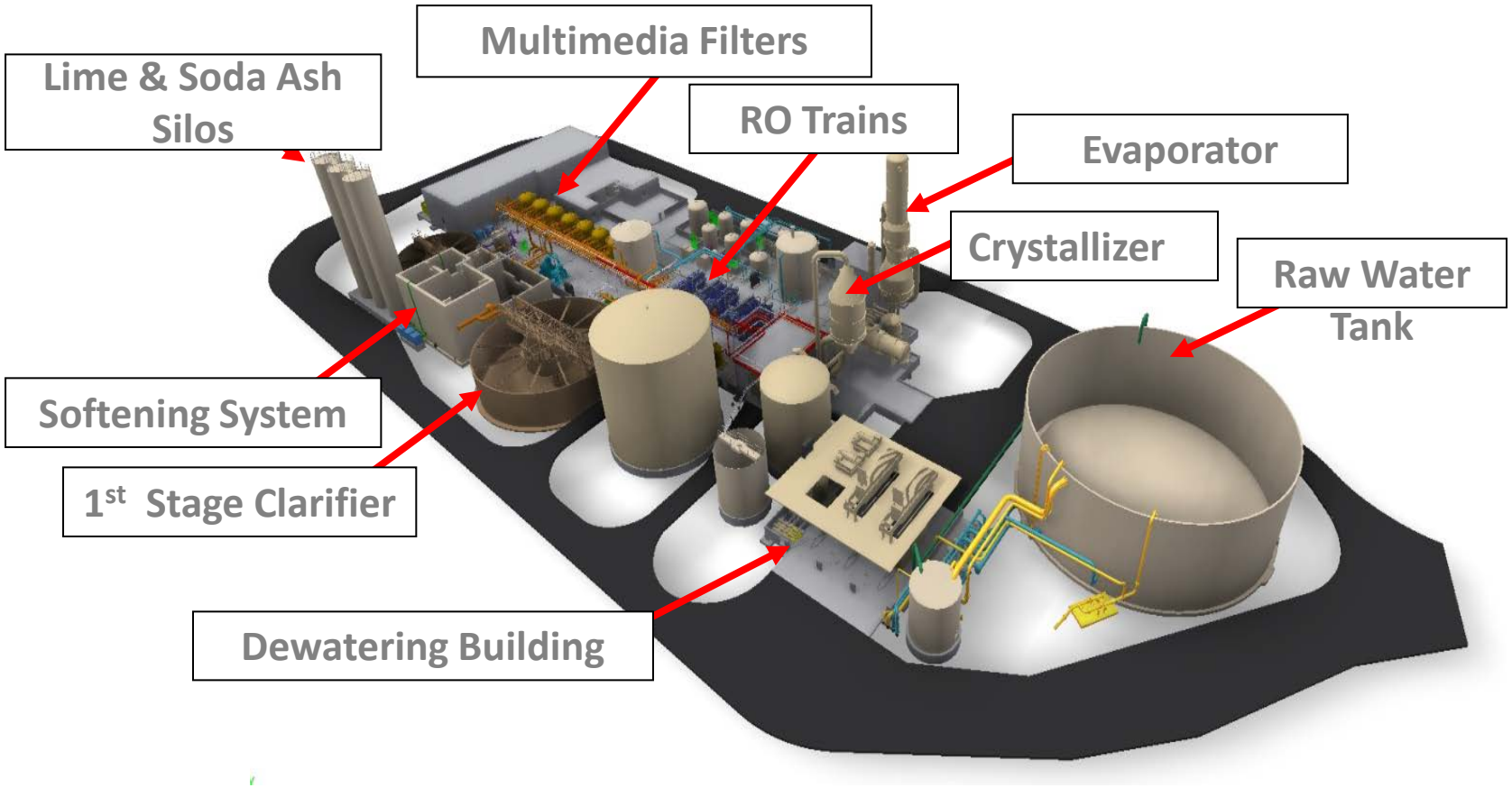
Influent Water Quality

Parameters	Maximum
Design Flow, GPM	3500 max (1750 min)
pH, S.U.	5 – 10
Temperature, deg F	38 – 85
Chlorides, mg/L	1,500
Sulfates, mg/L	5,500
Iron, mg/L	150
Manganese, mg/L	2
Aluminum, mg/L	8
TDS, mg/L	10,000
TSS, mg/L	150

Key Effluent Requirements

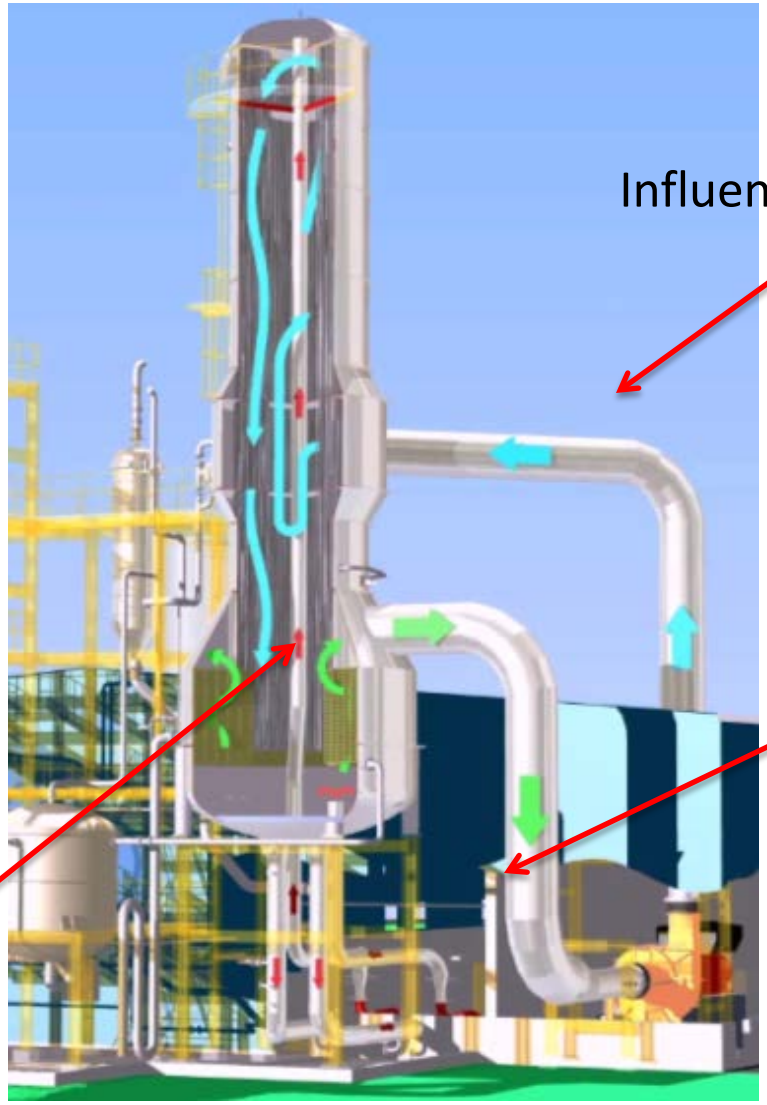
Parameters	Maximum Effluent Concentration
Chlorides, mg/L	< 218
TDS, mg/L	<150*
pH, S.U.	6 to 9

CONSOL Energy - Facility Overview



Consol Energy - Reverse Osmosis System

Evaporator Design – Falling Film



Brine Management System

Consol Energy - Treatment Plant Site

Photograph from mid-July 2012

LG Empire Upstate NY Power Project

- Commercial operation began in September 2010
- New York State's voluntary Brownfield Cleanup Program (reinvestment of resources in the environmental remediation and redeployment of existing non-productive sites)
- Use of municipal effluent (gray water) rather than fresh (groundwater) water resource

LG Empire NY Power Project – Water Quality

Ions	Gray Water	Sand Filter	Cl_2 Contact	Demin	Demin (treated)
Turbidity NTU (avg./max/peak)*	3.8 / 7 / ---	2 / 5 / 10			**< 1**
TSS (ppm) (avg./max/peak)*	8 / 22 / 45	7 peak			**< 1**
Conductivity (µS)	747			< 0.1	**0.05 ppb**
TDS (ppm)	780				
Silica (mg/l as SiO_2)	7.2			< 10 ppb	**3.1**
Sodium (mg/l as ion)	89			< 10 ppb	**0.4 ppb**
TOC (ppm)	5.7			< 100 ppb	**35/48 ppb**
Chloride (mg/l as ion)	144			< 10 ppb	**0.003 ppb**
Sulfate (mg/l as ion)	38			< 10 ppb	**< 0.005 ppb**
DOC (ppm)	5.0				
CA Title 22 Sec. 60301.230 (a) 1 & (b)			Yes		
*Maximum allowable ≤ 5% of 24 hour period. Peak not to be exceeded at any time.					

7

Water Impact Index

- True Cost of Water
- WIIX
- Case Example

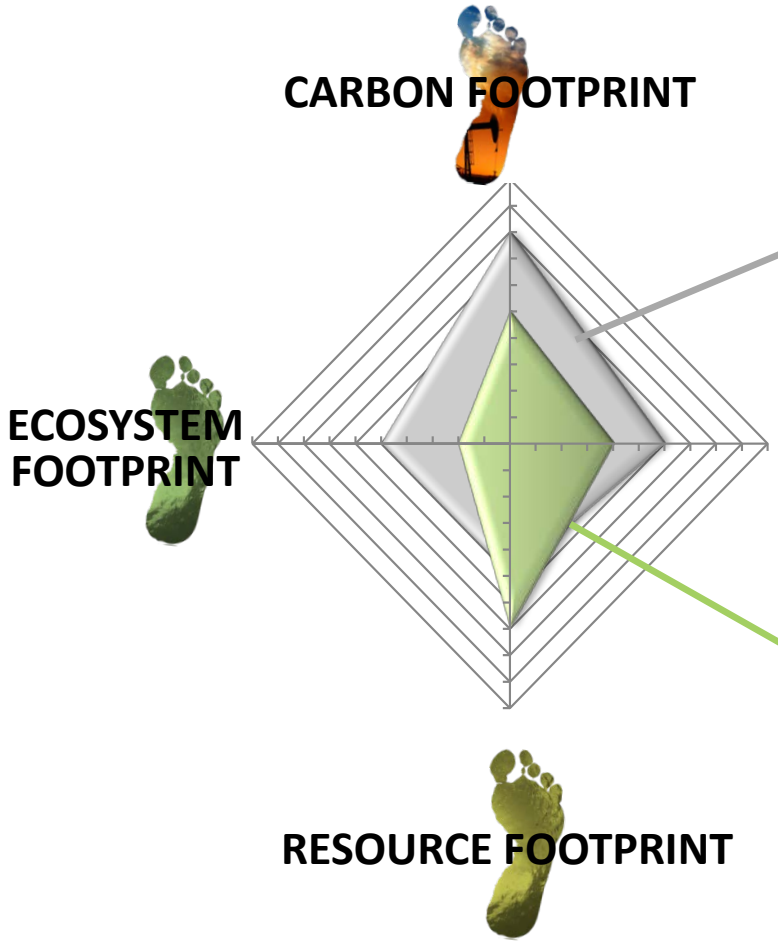
Journey Towards Sustainable Growth

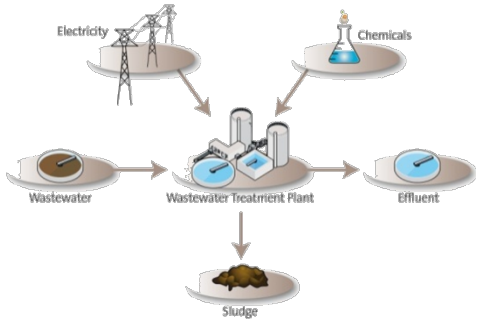
CARBON FOOTPRINT → ***WATER IMPACT INDEX*** → ***ENVIRONMENTAL FOOTPRINT*** → ***GREEN FOOTPRINT***

True Cost of Water

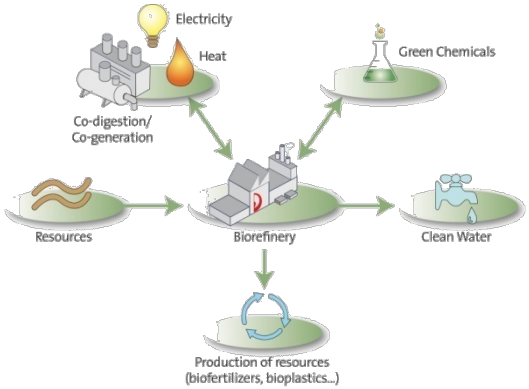
The Environmental Footprint

"a decision-making tool for sustainability"





Standard Plant



Bio-Refinery

Veolia Environnement's Vision

Become *"the benchmark for sustainable growth"*

Antoine FREROT

Three main challenges :

-> Decarbonate (Reduce CO_2 Emissions)

-> Dehydrate (Reduce Water Impact Index)

-> Dematerialize (Reduce Resource Consumption)

Fills a critical need by defining the standards used to measure and make decisions

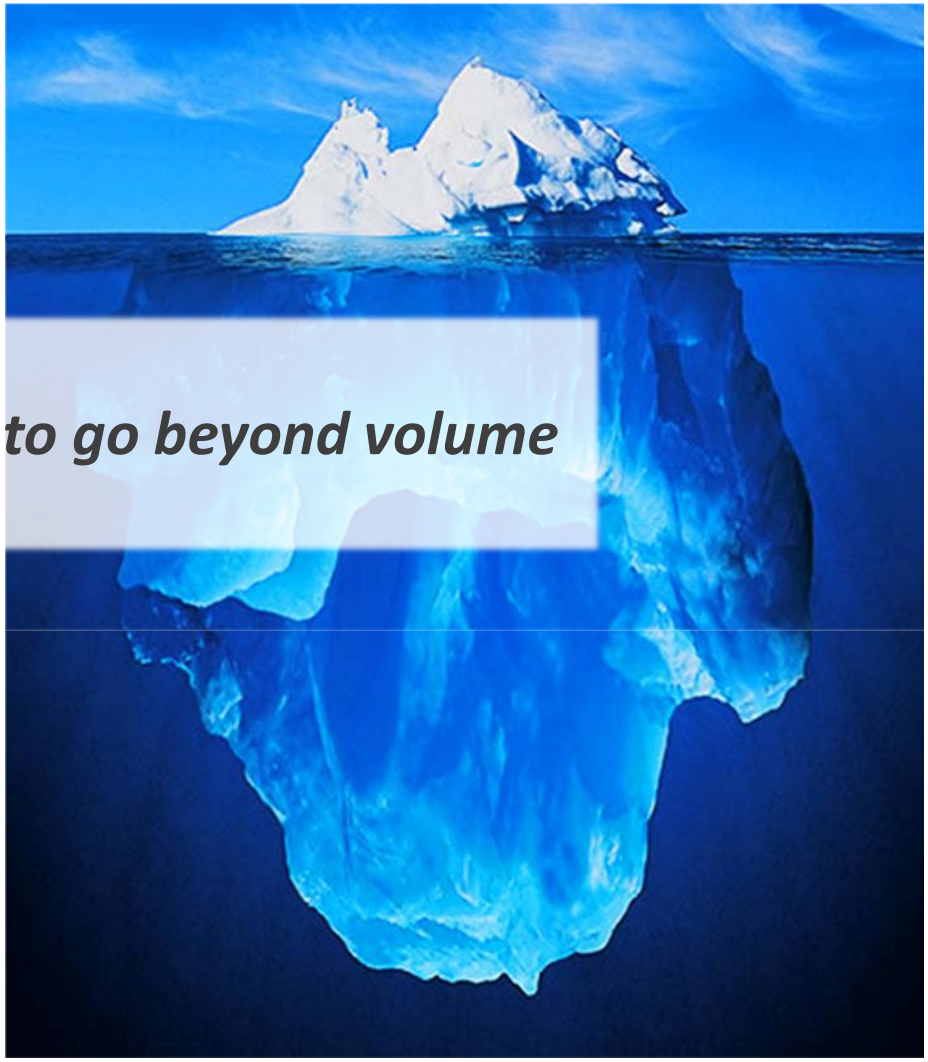
Simple volumetric approaches are sometimes limited; do not provide a holistic view

VOLUMETRIC APPROACH

- reduction of water use
- water recycling

BEYOND VOLUMETRIC APPROACH

- improvement of discharge quality
- use of lower water quality
- groundwater recharge



Water Impact Index Formula

WATER IMPACT = INDEX

VOLUME
- Water Quantity
- Volume of water used - extracted and released

x

QUALITY
- Water quality - extracted and released

x

STRESS
- The Water Stress Index
- Local hydrological context, freshwater scarcity

WIIX = $V_{withdrawn}$ * $Q_{with.}$ * Stress – $V_{released}$ * $Q_{rel.}$ * Stress

$$\mathrm{WIIX} = \sum_j \left(W_j \times \min_l \left(1; \frac{Cref_l}{C_{j,l}} \right) \times WSI_j \right)_j - \sum_k \left(R_k \times \min_l \left(1; \frac{Cref_l}{C_{k,l}} \right) \times WSI_k \right)_k$$

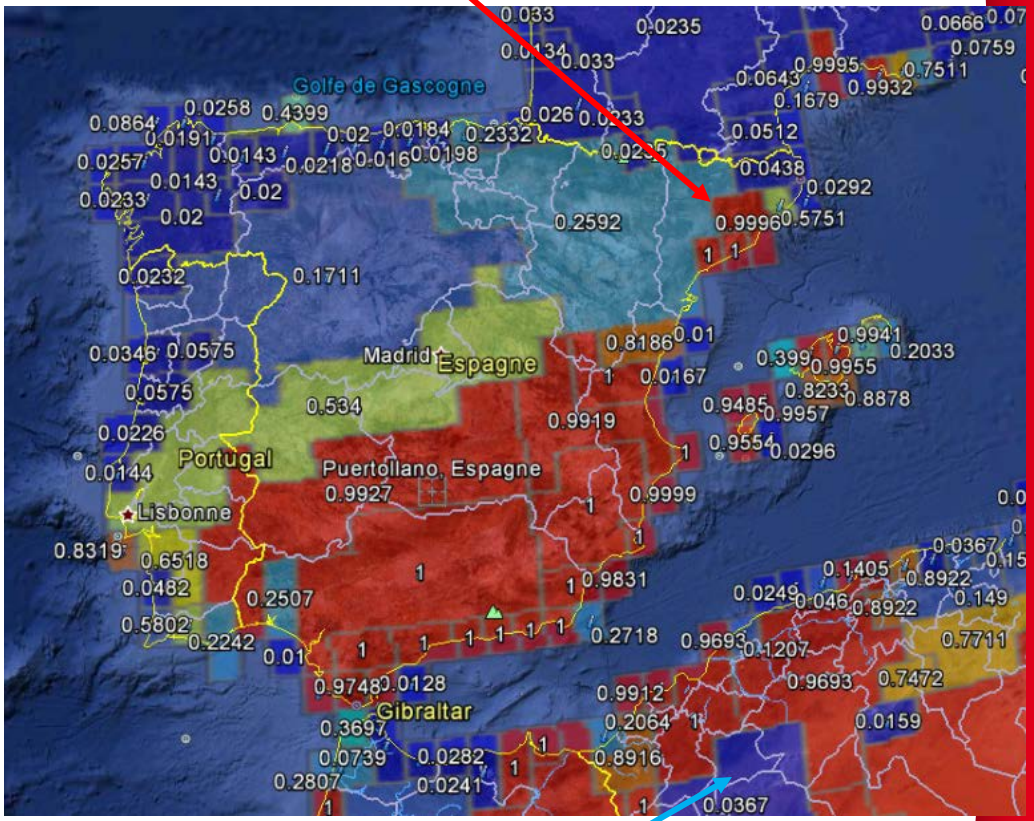
Water Stress Index

- The WSI takes into account:
  - Water Usage
  - Availability
  - Stored Water (water in stock)
- An independent index
  - Created by Pfister (Zürich) in (2009)

$$0 < WSI < 1$$

No Stress **High Stress**

WSI=0.996 -> High Stressed Area



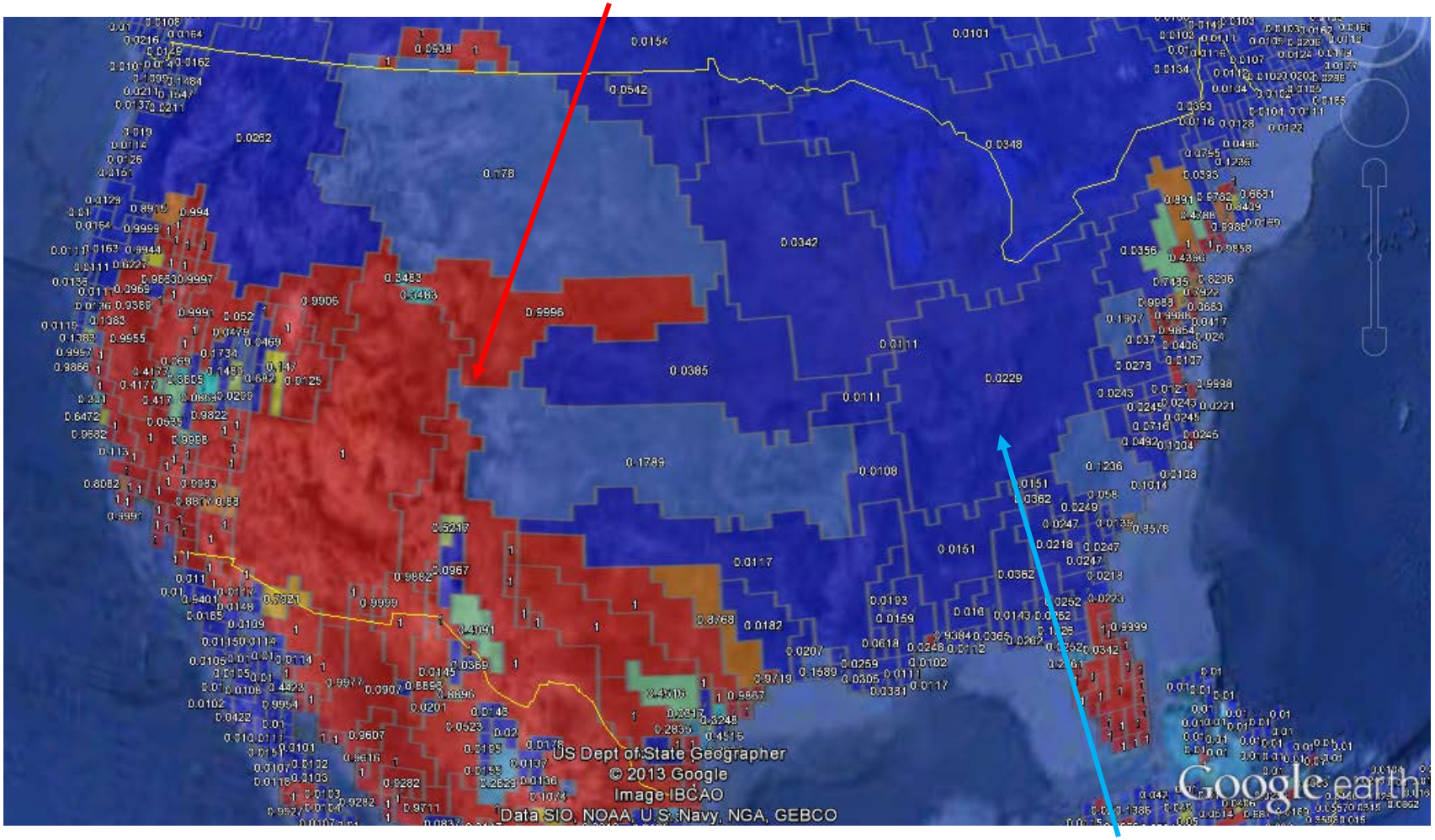
No Stress

Available on Google Earth after downloading the link below
http://www.ifu.ethz.ch/staff/stpfiste/Impact_factors_LCA_pfister_et_al.kmz

Water Stress Index

0 < WSI < 1

High Stress



No Stress

Available on Google Earth after downloading the link below

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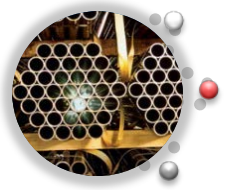
What about the calculations? 4th step , Water stress



STRESS
- The Water Stress Index
- Local hydrological context, freshwater scarcity

VOLUME
- Water Quantity
- Volume of water used - extracted and released

X

QUALITY
- Water quality - extracted and released

X

STRESS
- The Water Stress Index
- Local hydrological context, freshwater scarcity

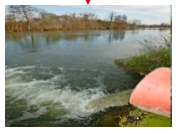
$$WIIX = V_{with} * Q_{with} * Stress - V_{rel} * Q_{rel} * Stress$$

The Water Impact (WIIX) Frameworks

Direct WIIX

Indirect WIIX

Energy



Chemicals

Waste

8

Close

- Summary
- Q & A

Conclusion

- Waste Water is a **valuable resource**
  - Can be used to drive sustainable growth
- Knowledge, integration, and technologies can be used to maximize the value of incorporating REUSE
- Investment in these technologies and a strong commitment to water reuse will:
  - Provide for the conservation of local fresh water resources
  - Protect the client's assets, performance and capital investment

This approach and mindset not only for ***sustainable water management***, but also for ***environmental***

Conclusion

- REUSE
  - The culmination of what we learned from across industry sectors and engineering disciplines covering municipal and industrial
- Paradigm Shift
  - From Water as a waste >>> Waste Water as a resource
- Not Easy, Not Quick, Not Free, Not “Not Needed”
- Believe it, Embrace it, Promote it

NO REUSE!

Questions, Discussion & Follow-Up

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