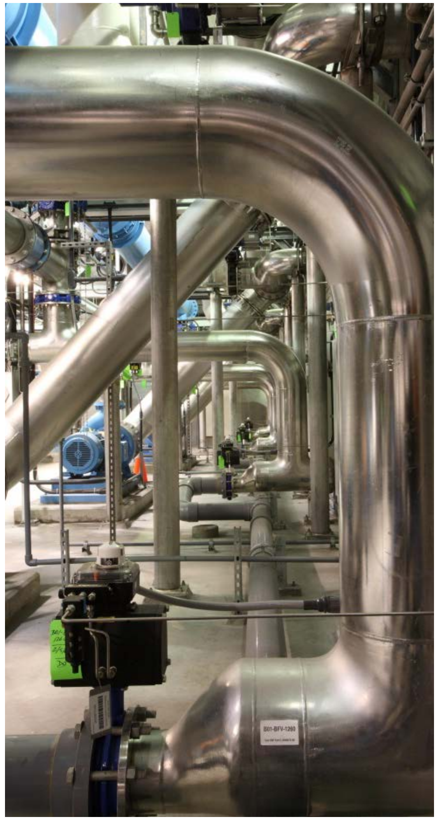
Evaluation of Source Water Control Options and the Impact of Selected Strategies on Direct Potable Reuse

WRRF 13-12

June 9, 2016



WateReuse Webcast Series

A Few Notes Before We Get Started…

- Today's webcast will be 60 minutes.
- There is 1 (one) Professional Development Hour available.
- A PDF of today's presentation can be downloaded when you complete the survey at the conclusion of this webcast.
- Links to view the recording and to download the presentation will also be emailed later.
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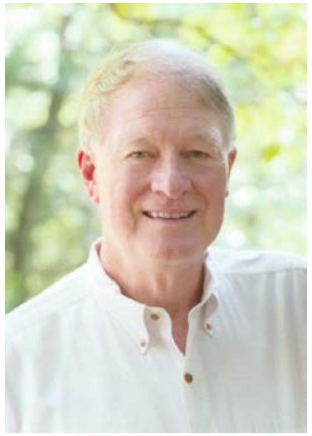
Today's Presenters



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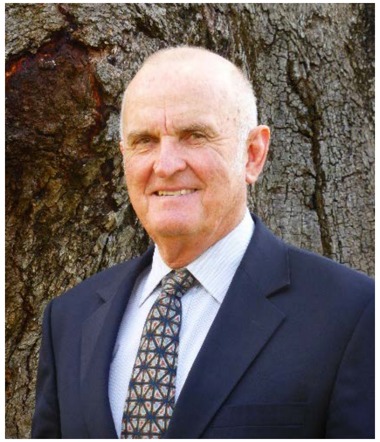

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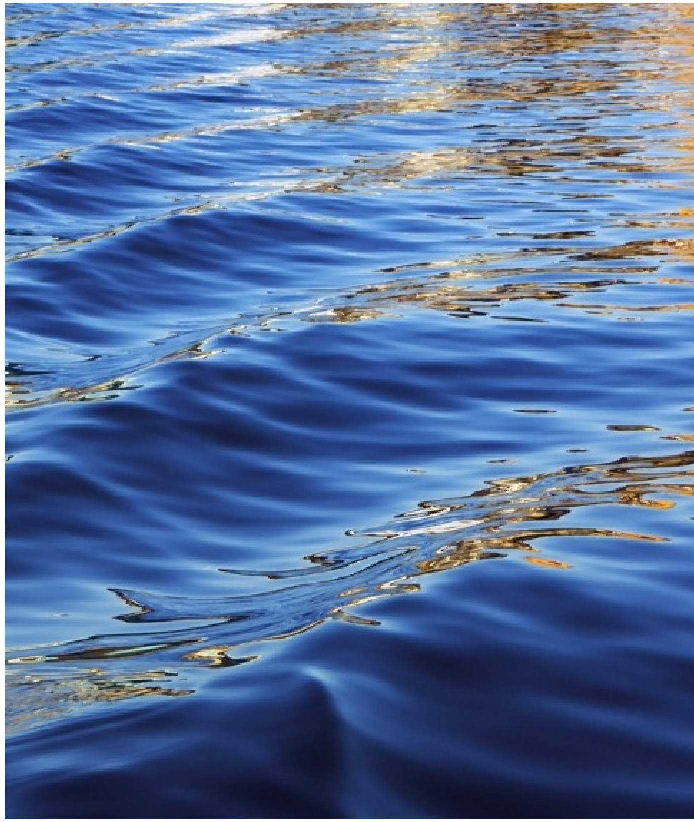
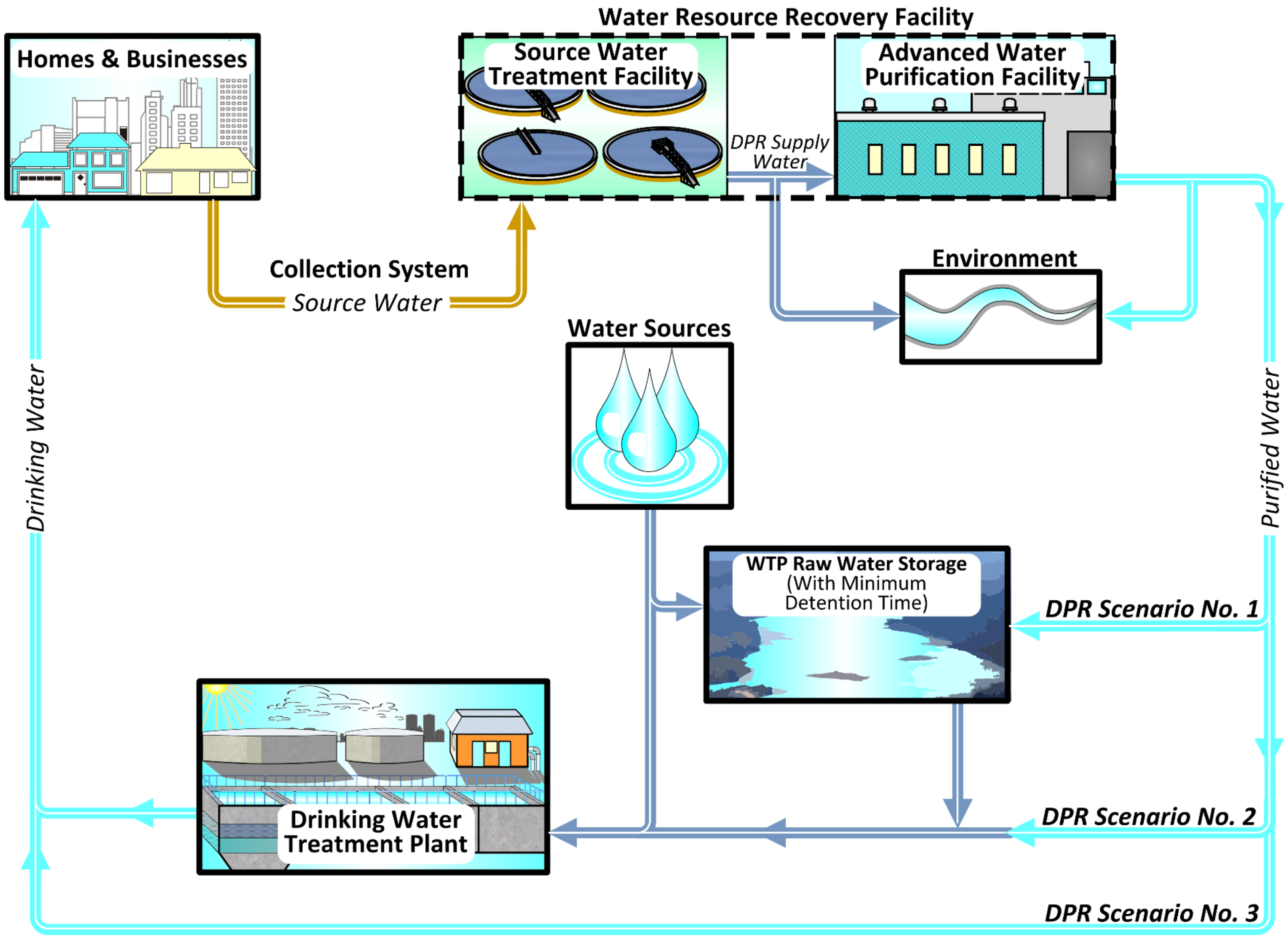
Introduction

Alan



Webinar ‘Outline’



Acknowledgements

Utilities

Project Advisory Committee

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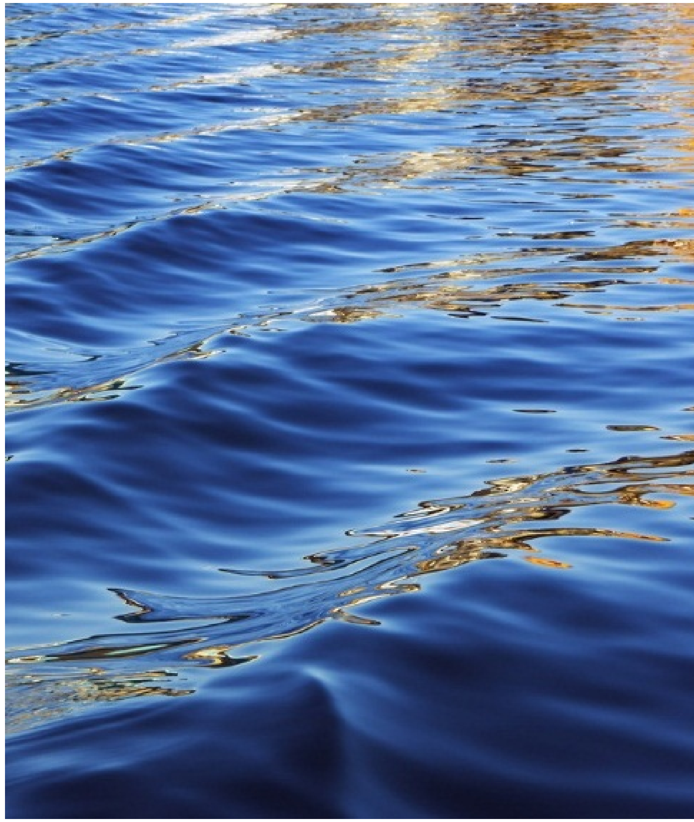
Source Control – a Snapshot

Ian



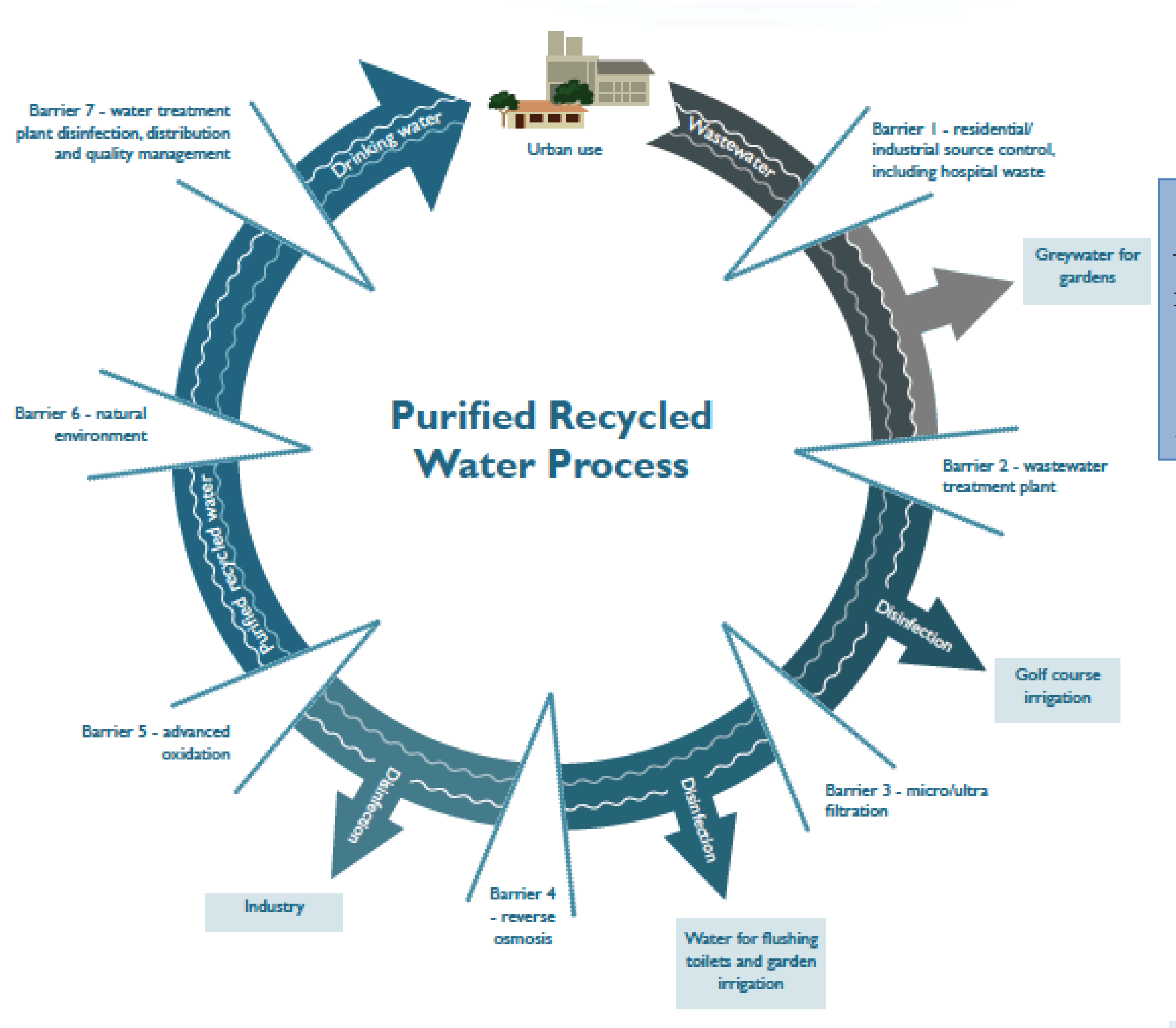
Source Control - Agenda

This presentation will address the following:

- Why is Source Control important?
- What does a Source Control Program typically consist of?
- Source Control in Australia
- Examples of 'innovative' components of some Source Control Programs

Why Source Control?

- A rigorous & appropriately designed Source Control Program (SCP) is required to protect not only the assets in the collection system and worker/community health but also the performance of the downstream WWTP.
- Source Control is 1st Barrier and the WWTP the 2nd Barrier in any water recycling scheme; these two Barriers become very significant in any Potable Reuse application, be it IPR or DPR, as the quality of effluent produced by the WWTP has direct bearing on the operating cost & performance of the downstream AWTP.
- The WWTP is the most cost-effective means of removing a wide range of CoCs, while also producing a feedwater to the AWTP that is low in TOC, turbidity, N and P – hence its operation must be protected by the 1st Barrier – the SCP.



The Multi-Barrier Principle – the basis of any water recycling scheme

1st Barrier = Source Control
2nd Barrier = WWTP

Source Control Programs

A SCP typically consists of:

- Regulations governing both volume and mass discharges of selected pollutants – latter being dependent upon the type and nature of the discharge;
- Regulations governed by legal statutes and policed/monitored by receiving entity, be it a utility or an operator on behalf of the utility;
- Concentration limits for selected contaminants assessed through risk assessment;
- Cost structures based on volume and mass loadings discharged, latter linked to WWTP costs;
- Planning powers in some countries to control location of certain industries in selected catchments – examples in Windhoek, Namibia; Cape Town, South Africa and in Singapore. Trade waste regulations also used to promote industry relocation, e,g, Sydney, Australia;
- Regular surveillance of housekeeping practices within industries and monitoring of all discharges;
- Regular monitoring of nodal points in collection system;
- Regular discussions with all industries to engage on waste-minimisation practices and control of inadvertent discharges.

Australia – Example of Source Control Risk Assessment (2007)


Risk assessment of inputs to Canberra's sewerage system

Summary of 10th September 2007 workshop for ActewAGL and key stakeholders

18th September 2007

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The *Risk Management Process* adopted:

- Define approach to hazard identification & risk assessment
- Identify & document hazards/hazardous events for each system component
- Estimate risk level for each hazardous event & each hazard
- Determine significant risks & document priorities for risk management
- Evaluate major uncertainties & consider actions to reduce uncertainty
- Identify existing preventive measures & estimate residual risk
- Identify alternative preventive measures to reduce risk to acceptable levels
- Document preventive measures & strategies to address each significant risk
- Assess preventive measures to identify CCPs (in line with HACCP procedure)
- Establish mechanisms for operational control, and
- Document CCPs, critical limits and target criteria.

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WSAA: Australian Sewage Quality Management

Released in July 2012. Guides Utilities through a 12-element risk framework that aligns these Guidelines with both the Australian Drinking Water Guidelines (ADWG, 2011) and the Australian Guidelines for Water Recycling (AGWR, 2005 & 2008).

Five key objectives of managing inputs to the collection system are:

- *Safety of people* – workers and the community;
- *Protection of assets (pipes, plant & equipment)* –appropriate regulations;
- *Protection of treatment processes* – to maintain optimum levels of treatment;
- *Regulatory & Licence compliance* – self explanatory;
- *Facilitation of recycling* – wastewater no longer viewed as a ‘waste’; utilities are producing recycled water, biosolids and energy.

Member utilities were benchmarked against the five objectives in 2012/13. Each objective was measured against the 12-element risk framework and this will be repeated in 2016.

Examples of 'innovative'[(a)] components of some Source Control Programs

Note(a) Included in regular monitoring programs focusing on illegal discharges

- **Denmark** – use of mobile activated sludge unit to pinpoint toxic discharges; works on the principle that *autotrophs* (i.e the nitrifiers) are more sensitive to toxic upset than *heterotrophs*;
- **Singapore** – use of VOC analysers at nodal points in the collection system to identify high VOC discharges; some 40 units installed and in operation;
- **Australia** – development of sensors for real-time data acquisition within a collection system.

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Singapore – Source Control Program incorporates VOC monitoring

- System can detect VOCs with ionization potential less than 10.6eV in gaseous sample & provide early warning of high VOCs discharge
- System can assist in identifying patterns of high VOCs dischargers and identifying the implicated sub-catchments / areas
- Effective deployment of manpower to catch illegal discharges that can eventually alleviate illegal discharges
- Considering use of Microbial Fuel Cells in 'problem' catchments.

Compound	Ionization Potential	Can it be ionized by UV lamp of 10.6eV ?
Styrene	8.4eV	Yes
Benzene	9.24eV	Yes
MEK	9.54eV	Yes
Toluene	8.82eV	Yes
Methylene Chloride	11.32eV	No
Oxygen	12.1eV	No
Carbon monoxide	14.01eV	No

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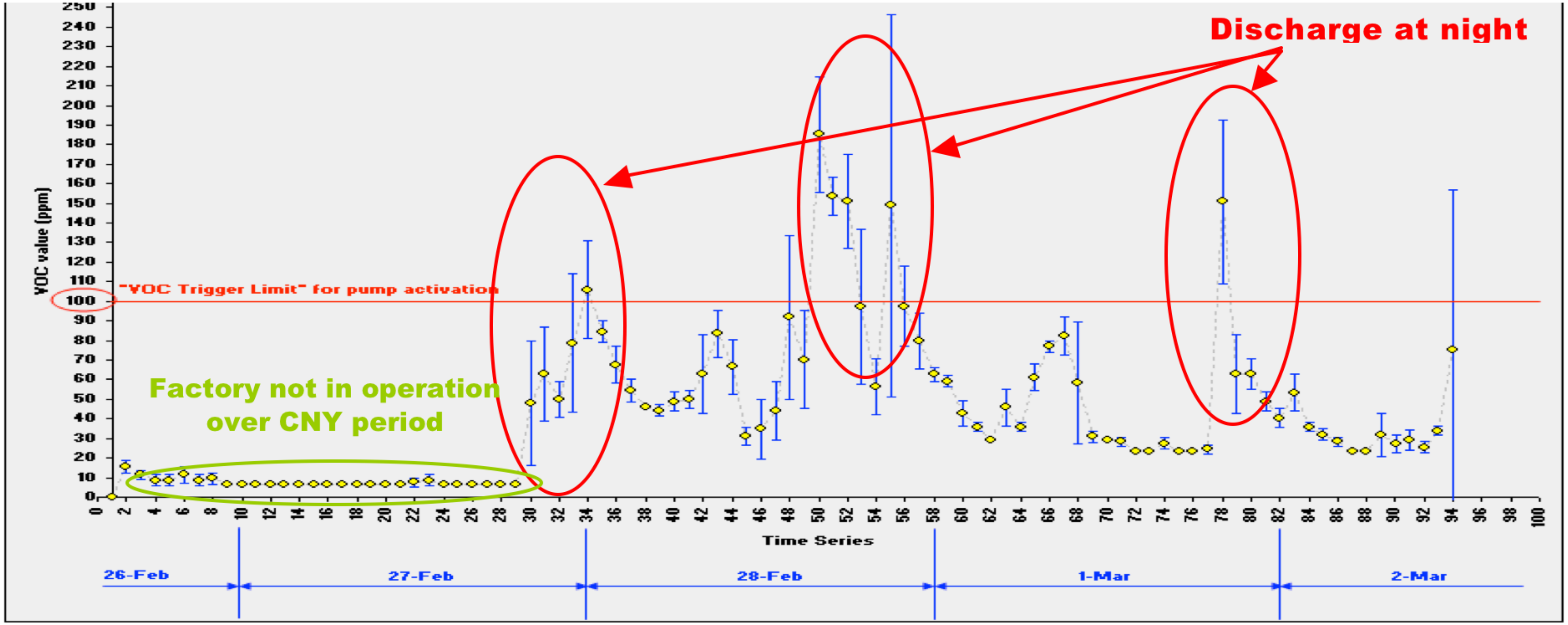
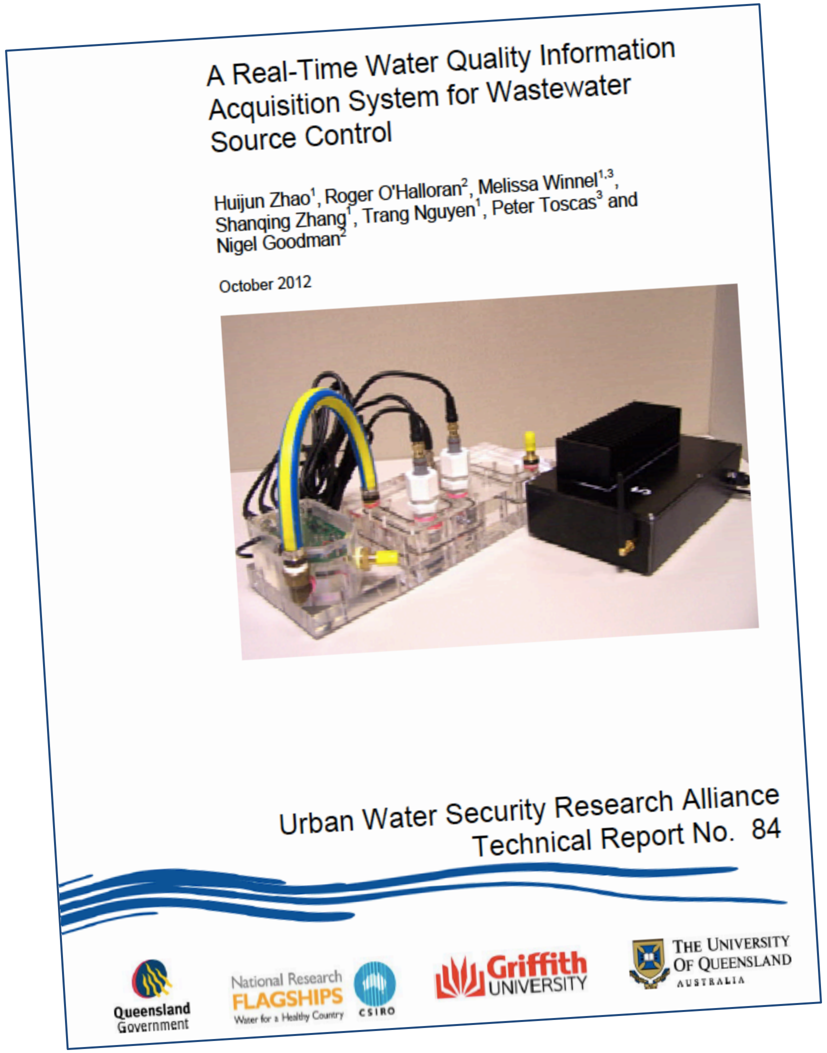
Singapore – Use of the VOC analysers



Source: Law, I (2008). *The Future Direction for Potable Reuse*. Water, Vol 35, No 8, 58-63, December.

Australia: Real-Time Data Acquisition


A Real-Time Water Quality Information Acquisition System for Wastewater Source Control

Huijun Zhao[1], Roger O'Halloran[2], Melissa Winnel[1,3], Shanqing Zhang[1], Trang Nguyen[1], Peter Toscas[3] and Nigel Goodman[2]

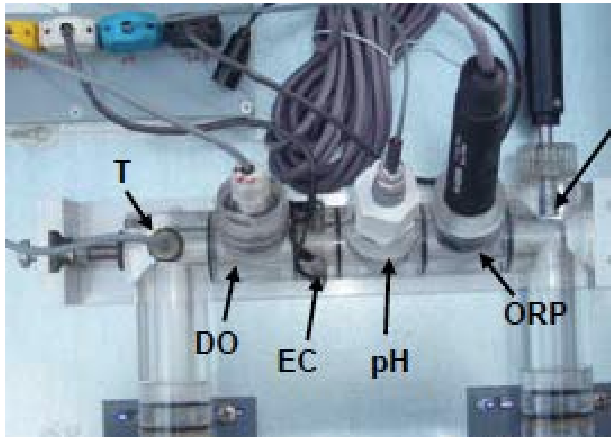
October 2012

Urban Water Security Research Alliance
Technical Report No. 84

Queensland Government
National Research FLAGSHIPS Water for a Healthy Country
CSIRO
Griffith UNIVERSITY
THE UNIVERSITY OF QUEENSLAND AUSTRALIA

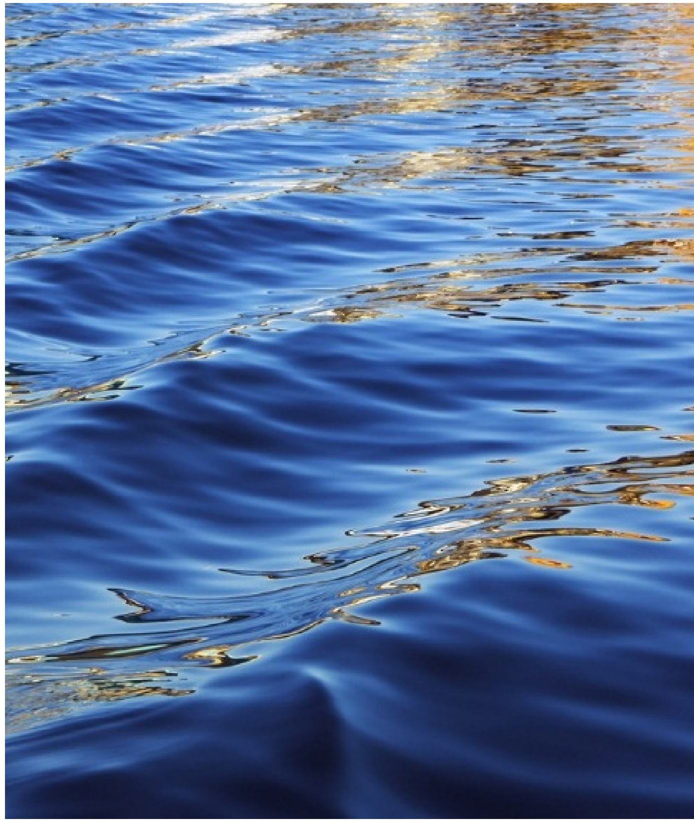
Five year research project:
Stage 1: Current sensors not applicable to raw sewage applications;
Stage 2: Development of sensor system for Temp, pH, Conductivity, Turbidity, DO and ORP with integrated real-time event detection for both Raw Sewage and WWTP effluent;
Stage 3: Field trials at an operating WWTP = succcessful

System currently being further developed with support of four of Australia's major Utilities; the aim being a useful and functional tool for Source Control.

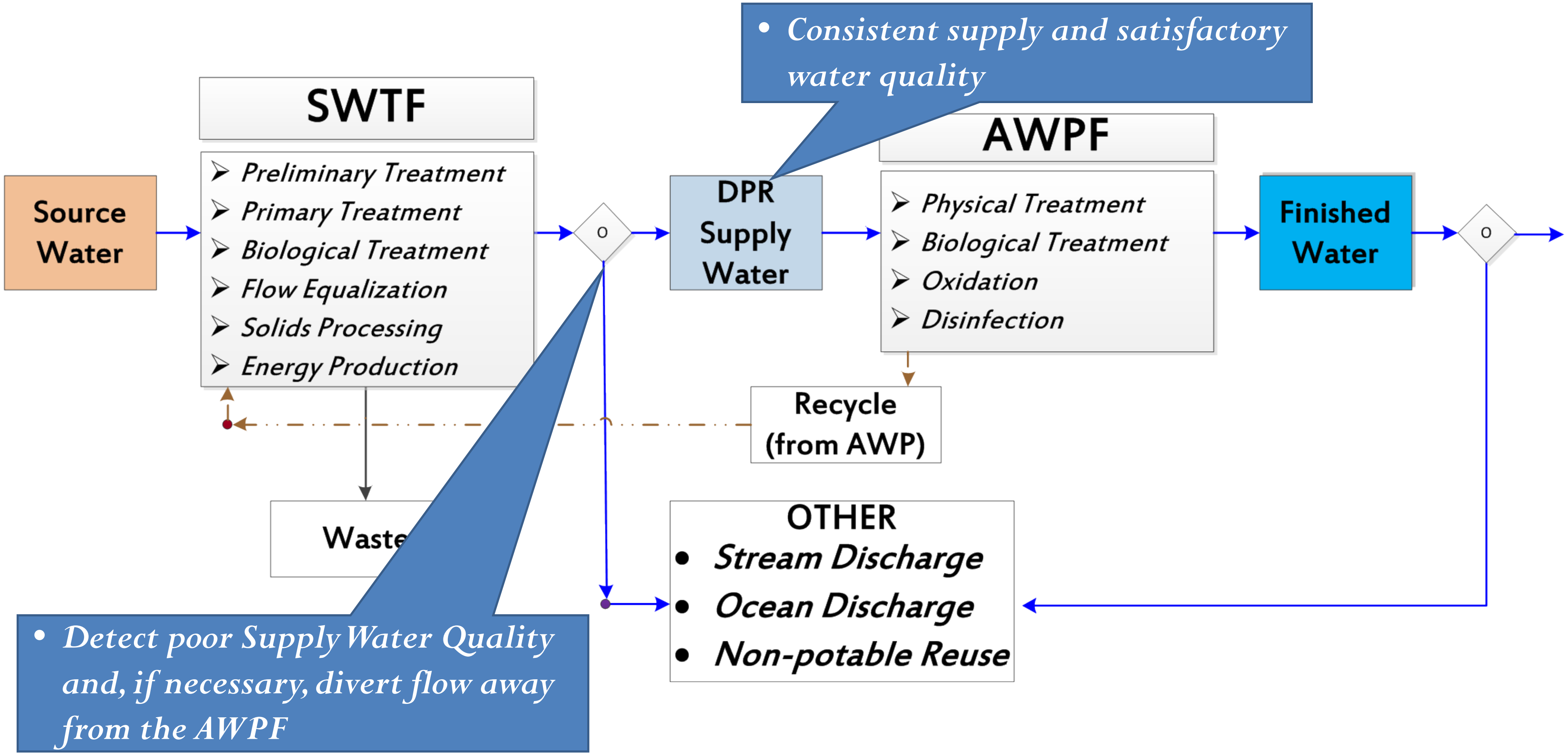


Source Water Treatment Facility Design, Operation and Optimization for Potable Reuse

Sandeep



Principal Objectives of a Source Water Treatment Facility



Desirable Supply Water Quality

Constituent	Supply Water Recommended Target	SWTF Impacts and Implications
Nitrogen Species		
Ammonia-N	• Fully Nitrification: NH_3-N < 0.5 mg-N/L	• Robust biological process design, control & operation
Nitrite, Nitrate-N	• Low Total Inorganic Nitrogen: <10 mg-N/L	• Incorporate denitrification in WRRF
Phosphorus	• Low TP/OP levels	• If necessary, incorporate coagulation/flocculation and separation
Organic Carbon	• DOC/AOC *target*	• Target low supply water COD levels
Solids		
Turbidity	• Low turbidity (target consistently < 2 NTU)	• Effective management of secondary separation process
TSS	• Low TSS (< 10 mg/L)	
TDS	N/A	• Effective management of the AWP recycle & other side streams
Compounds of Emerging Concern		
DMA and other NDMA pre-cursors	• Low (N)DMA precursors	• Effective management of solids handling polymer use (and if practiced RAS polymer use)
Other CECs	N/A	
Residual Coagulant/ Polymer	N/A	• Effective management of solids handling polymer use (and, if practiced, RAS polymer use) • Effective management of coagulant use (e.g., for CEPT)

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Section has Four Focus Areas

- **Nitrogen Management**
  - Target a consistently fully nitrified effluent
  - Target a TN < 10 mg-N/L
- **Flow and Load Variation Management**
  - Attenuate source water flow variation and provide a consistent supply-water flow to AWP
- **Sidestream Management**
  - Experiences suggest that onsite solids processing may result in AWP challenges
  - Effective sidestream management is a key element of successful DPR implementation
- **Management of CECs**
  - Biological treatment is a relatively cost effective means to degrade and transform CECs.
  - But – Not all CECs are (effectively) transformed
  - CEC biodegradation/biotransformation is linked to biological process design/operation

Process Monitoring and Control? Covered in a separate section

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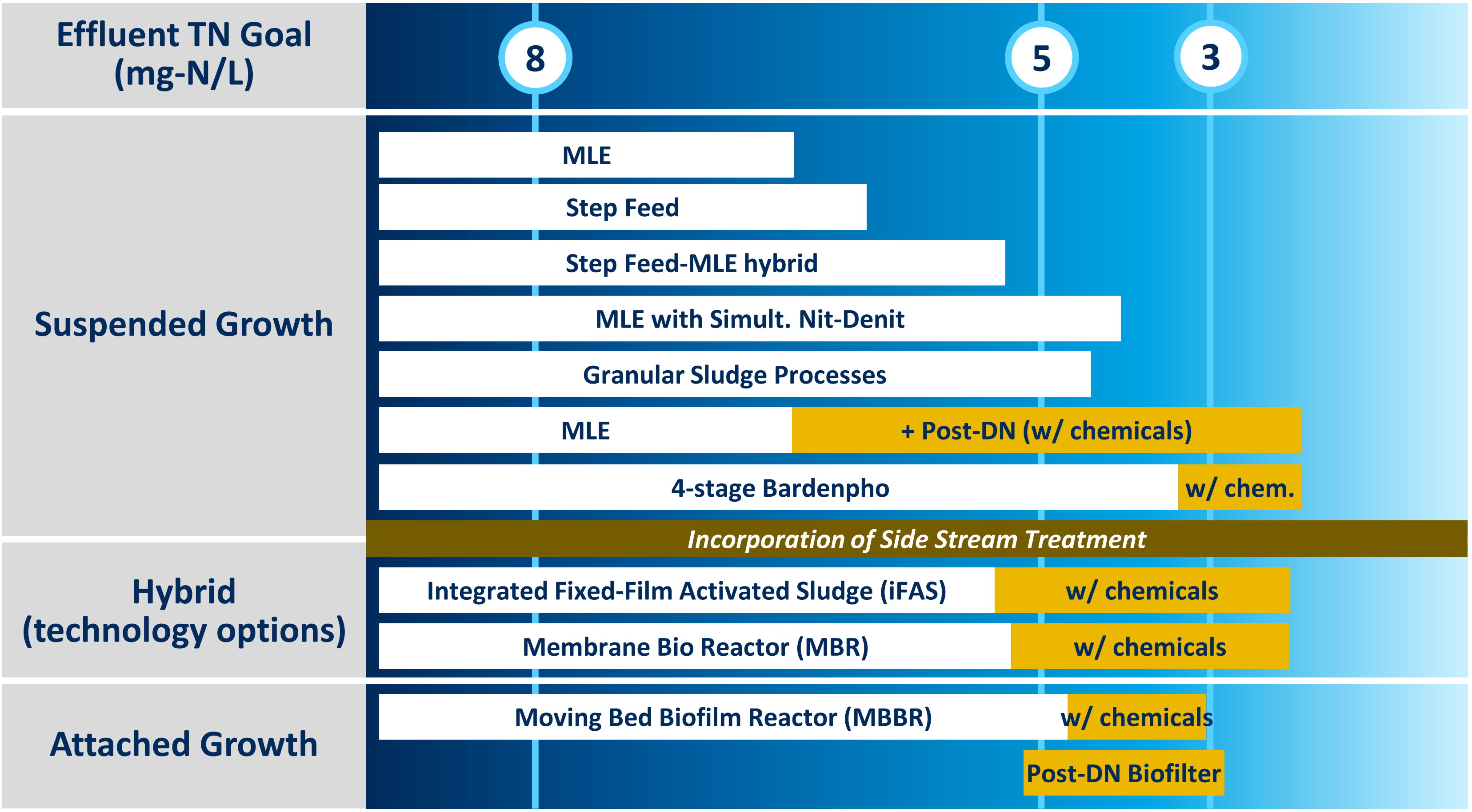
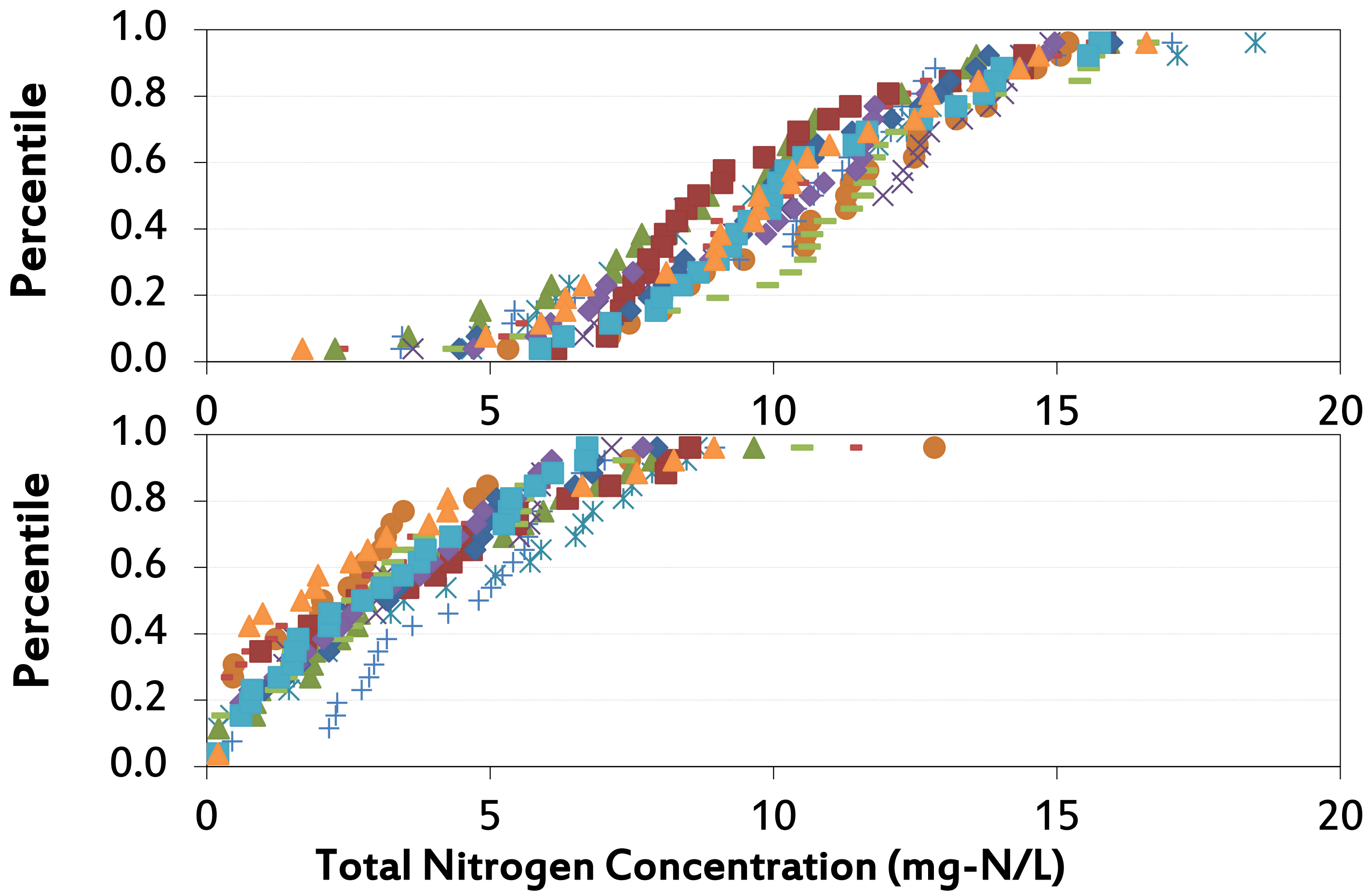
Factors which can be managed to Enhance Nitrogen Removal

- **SRT**
  - **Mixed Liquor Conc.**
- **Process Selection**
  - **CAS vs. MBR**
  - **CSTR(s) vs. plug flow**
- **Process Config**
  - **Redox Condition**

Nitrogen Management
Biological Process Configuration Options



Nitrogen Management – A Note about Targets



12 months mock data

N = 25/month

Monthly Avg. = 10 mg-N/L

Monthly SD = 3 mg-N/L

Monthly TN < 10 mg-N/L

N = 25/month

95th Perc. of Monthly Data < 10 mg-N/L

Monthly SD = 3 mg-N/L

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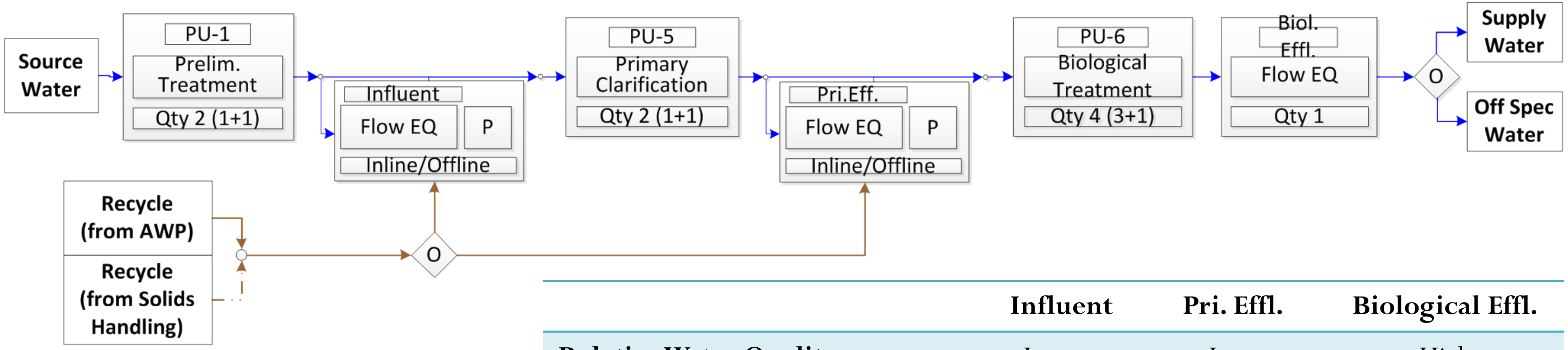
Flow Equalization Options



	Influent	Pri. Effl.	Biological Effl.
Relative Water Quality	Lowest	Low	High
Odor Potential	Very High	High	Very Low
Slime Growth	Very High	High	Minimal
Operational Burden	Highest	Moderate	Lowest
Incorporate "Off-Spec Water" Management?	No	No	Yes, Proactive
Incorporate Load Management?	Yes	Yes	No
Comments			

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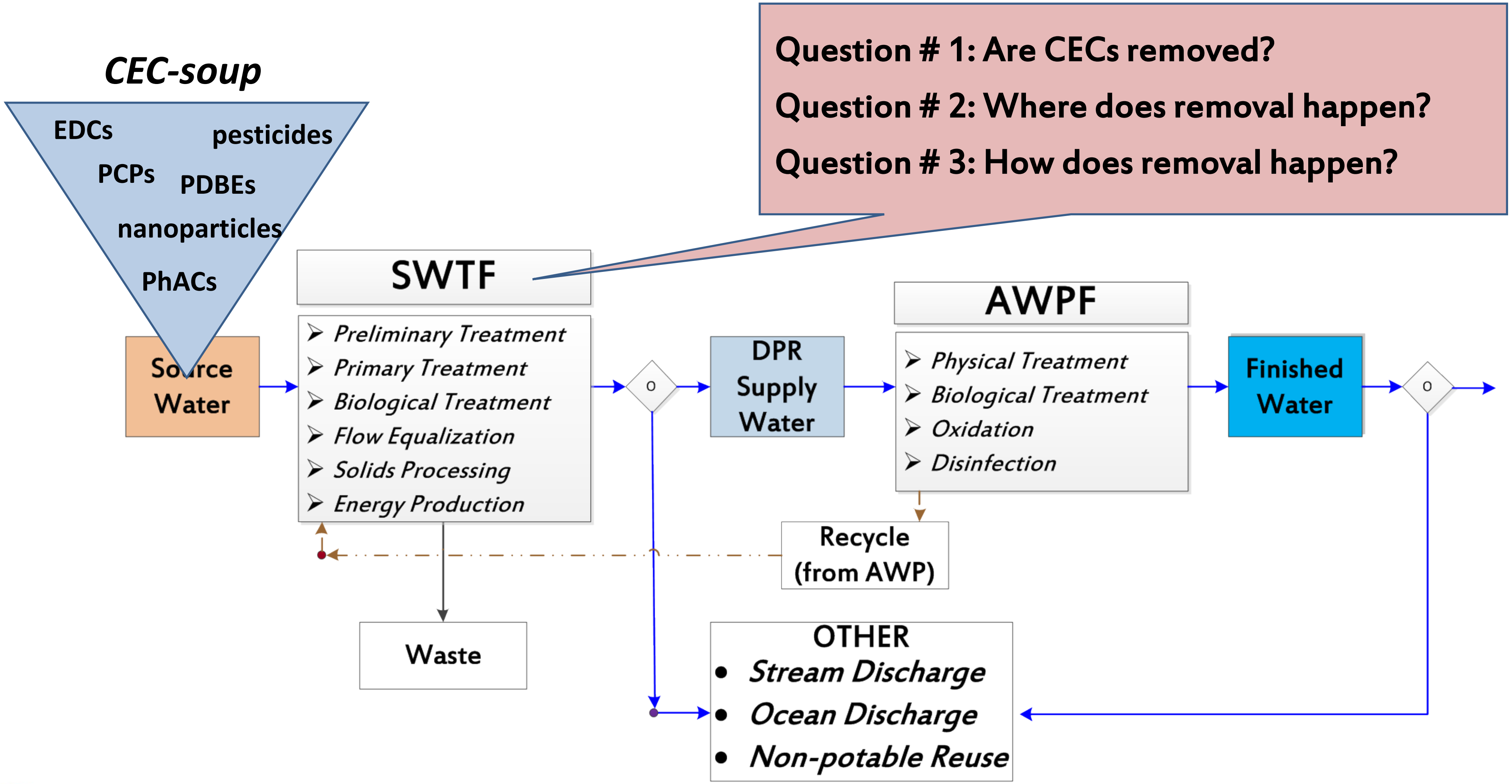
Nitrogen Management	Flow/Load Management	Sidestream Management	CEC Management

Solids Handling Sidestream Management Options

Management Strategy	Brief Description
Remove from System	Send it somewhere else
Flow/Load Balancing	The sidestream load is stored in an equalization tank fed at a controlled rate into the mainstream process.
Partial Nitrification	Ammonia-N >> Nitrate-N BUT, No supplemental alkalinity addition => incomplete nitrification
Nitritation/ Denitritation	Ammonia-N >> Nitrite-N (i.e., nitritation) >> Nitrogen gas (i.e., denitritation). (e.g., SHARON and STRASS process)
Deammonification	(some) Ammonia-N >> Nitrite-N (i.e., PARTIAL nitritation) (remainder) Ammonia-N & Nitrite-N >> Nitogen gas (Anammox)

Management of CEC Removal



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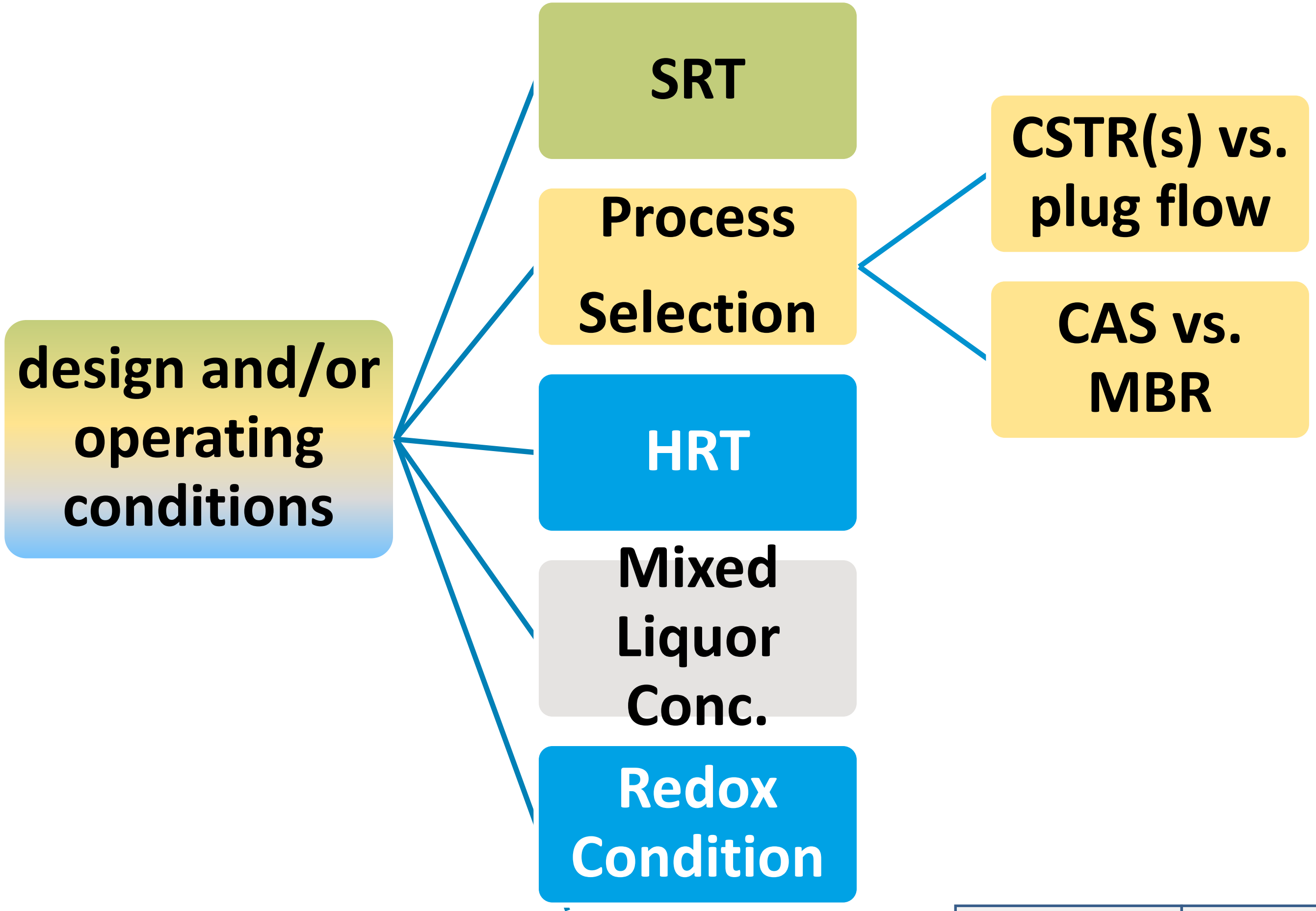
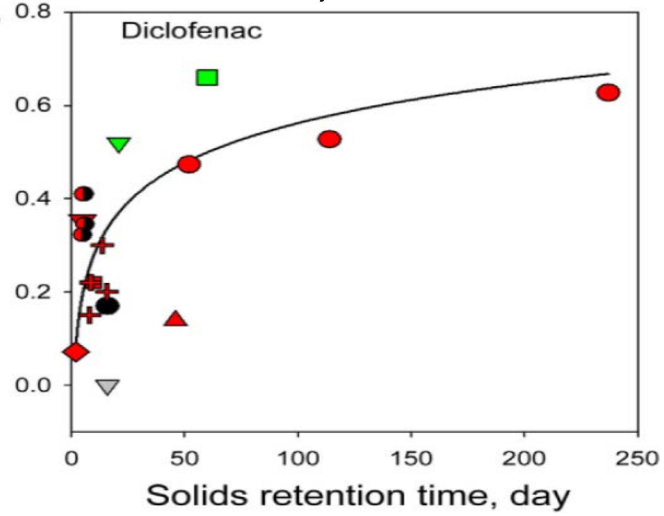
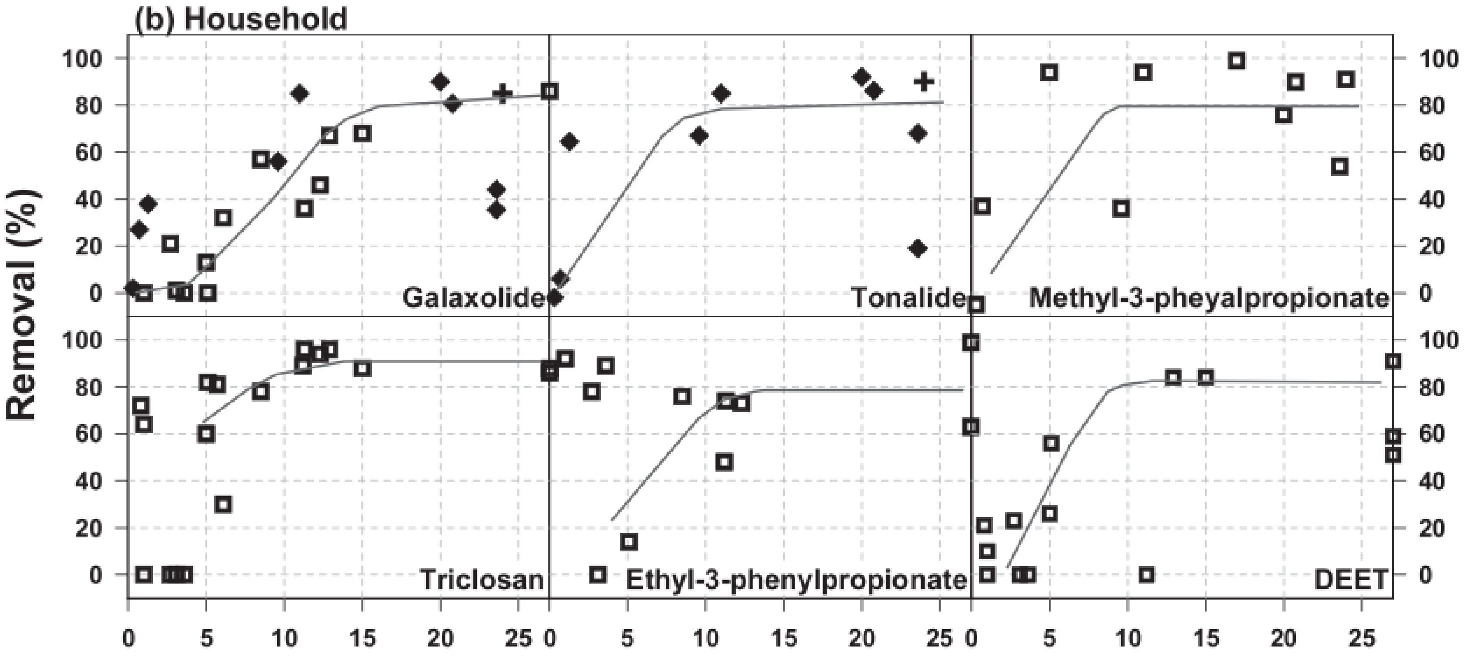
Factors which influence CEC *Removal*



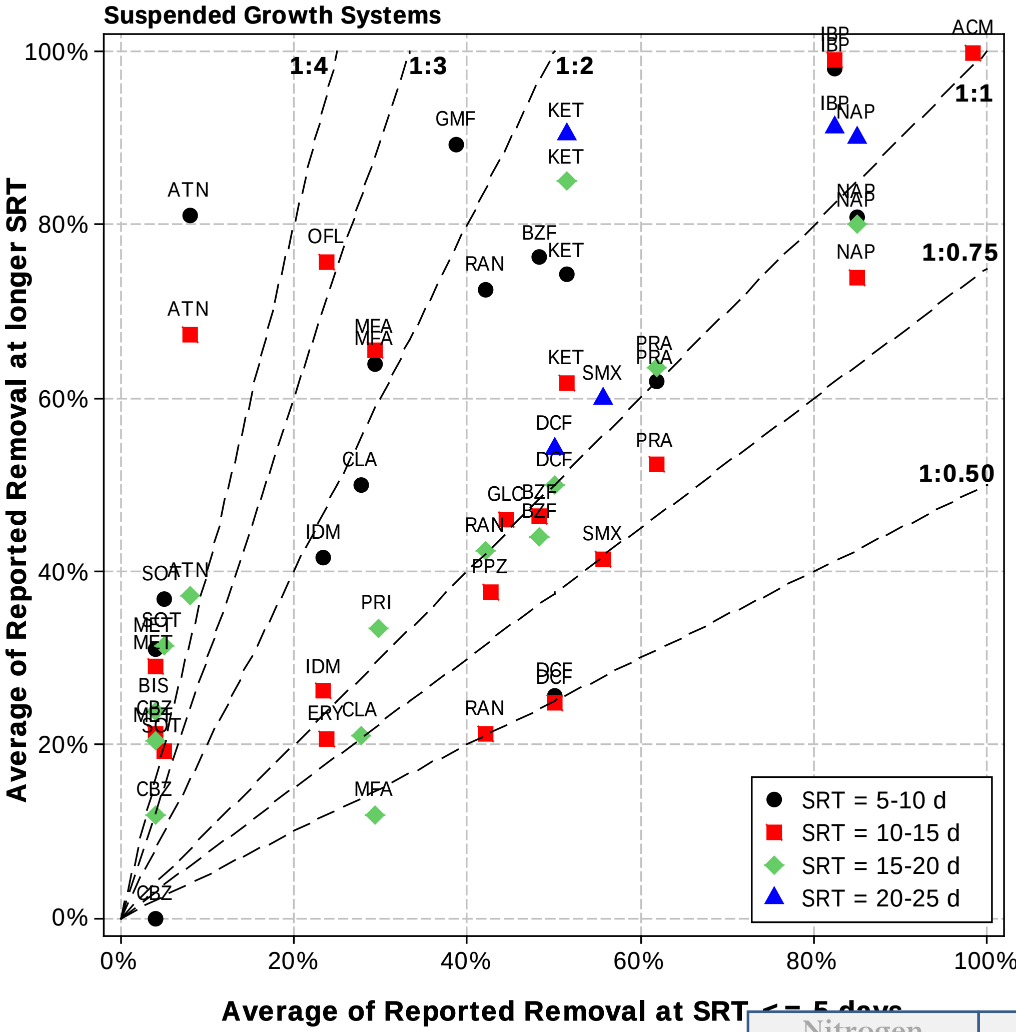
How does SRT Relate to CEC Removal?

Plosz et. al., 2012





But increasing SRT is NOT always the solution



Nitrogen Management	Flow/Load Management	Sidestream Management	CEC Management

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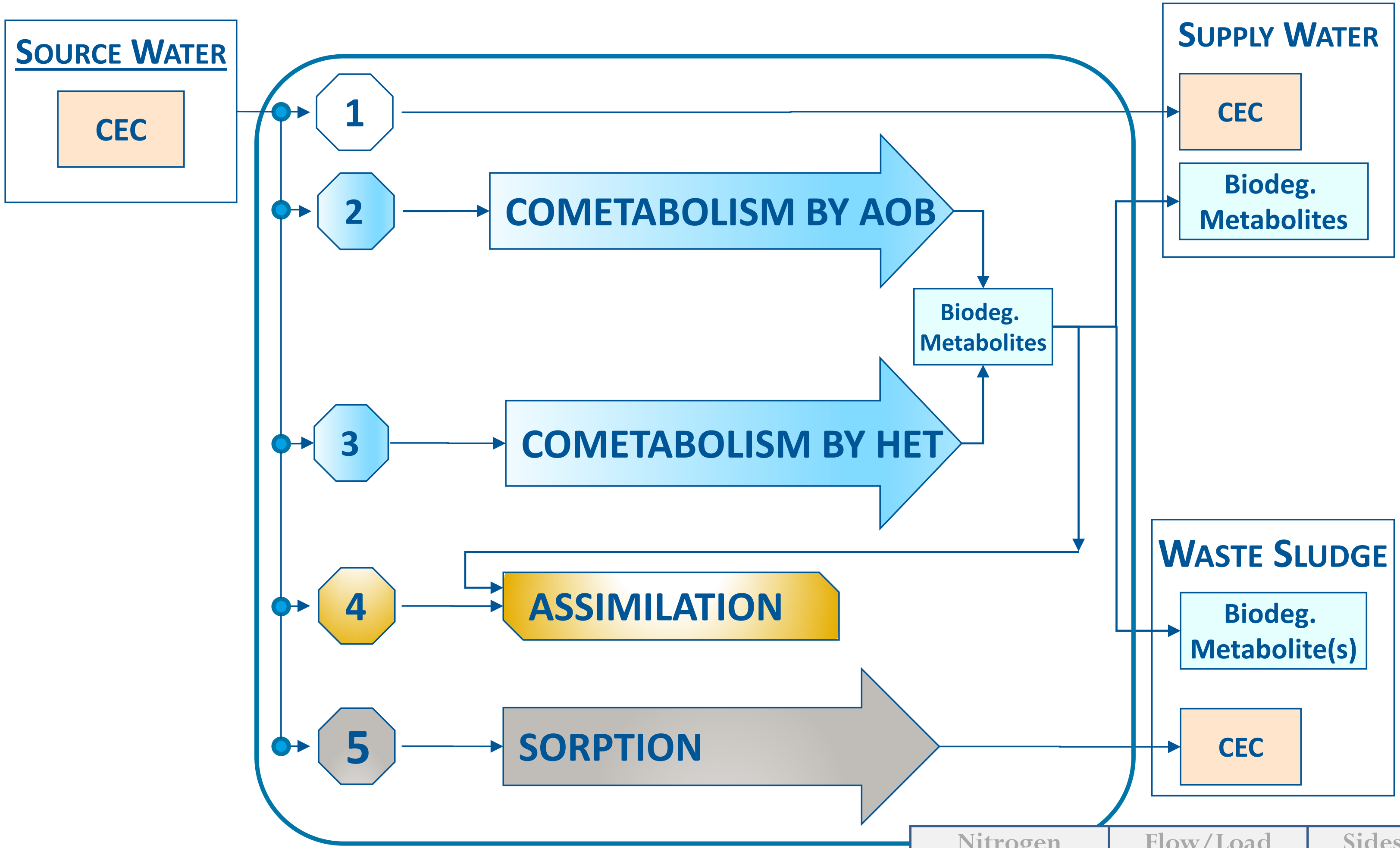
Fate of CECs in Biological Treatment Systems



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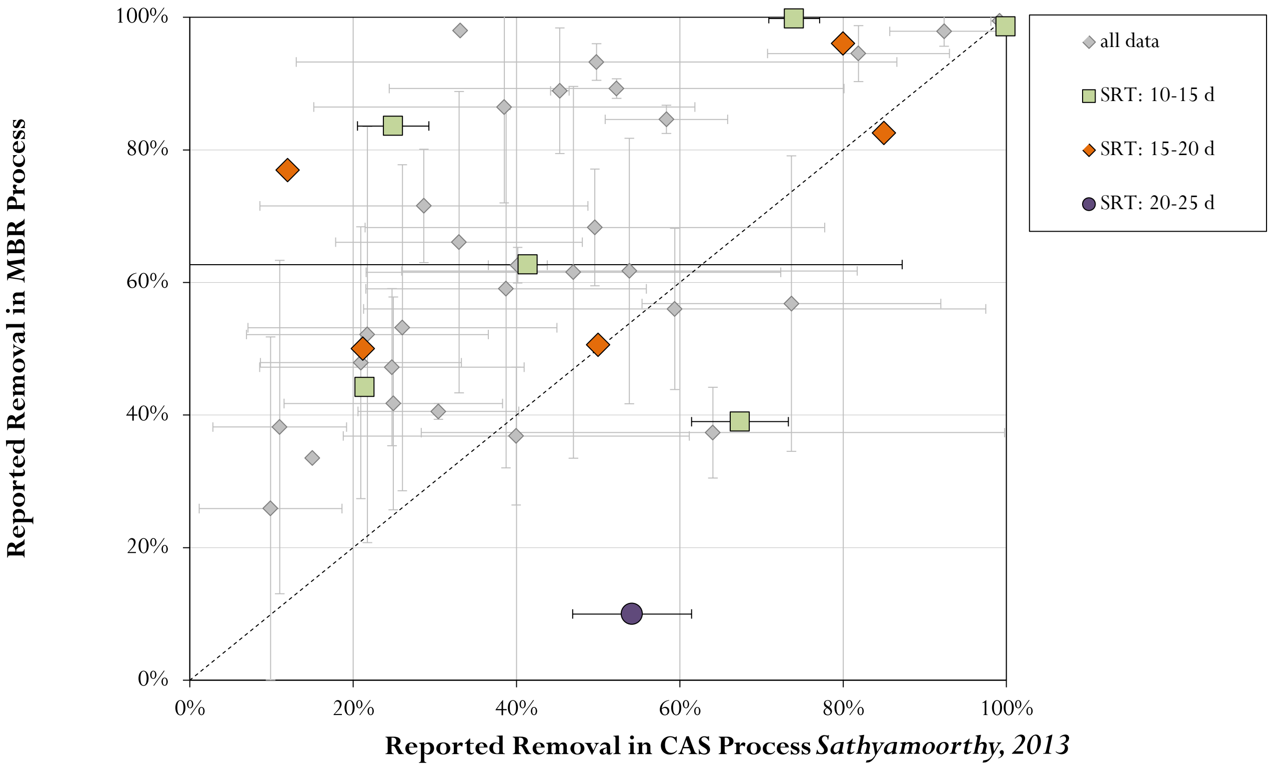
Nitrogen Management	Flow/Load Management	Sidestream Management	CEC Management

Suspended growth vs. MBR for PhAC removals

- Difference of "opinion" and results

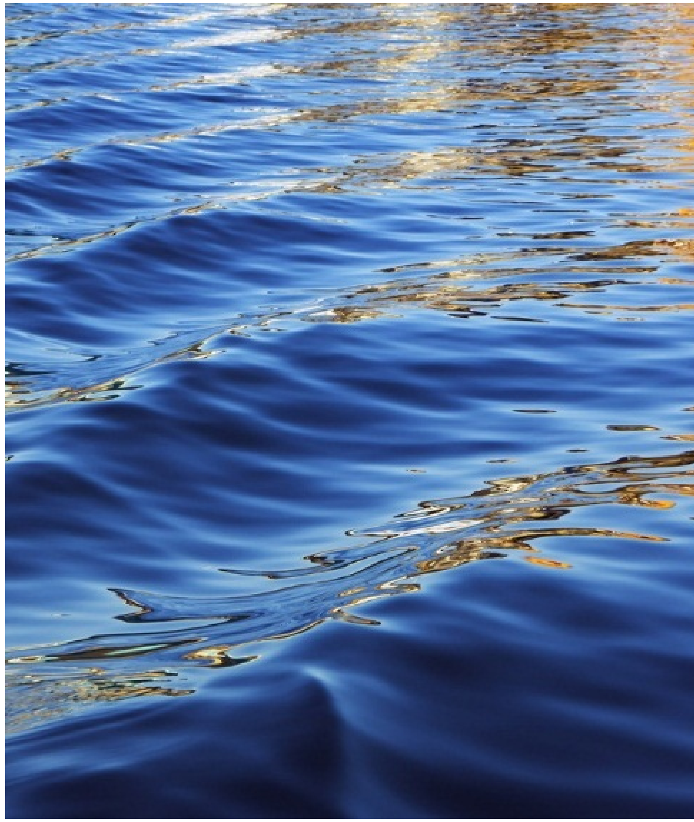
No Difference	MBR better
Clara et al. (2005) WERF (2007)	Camacho-Munoz et. al. (2012) Weiss & Reemstma (2008) Radjenovic et al. (2007) Gobel et al. (2007)



Sathyamoorthy, 2013

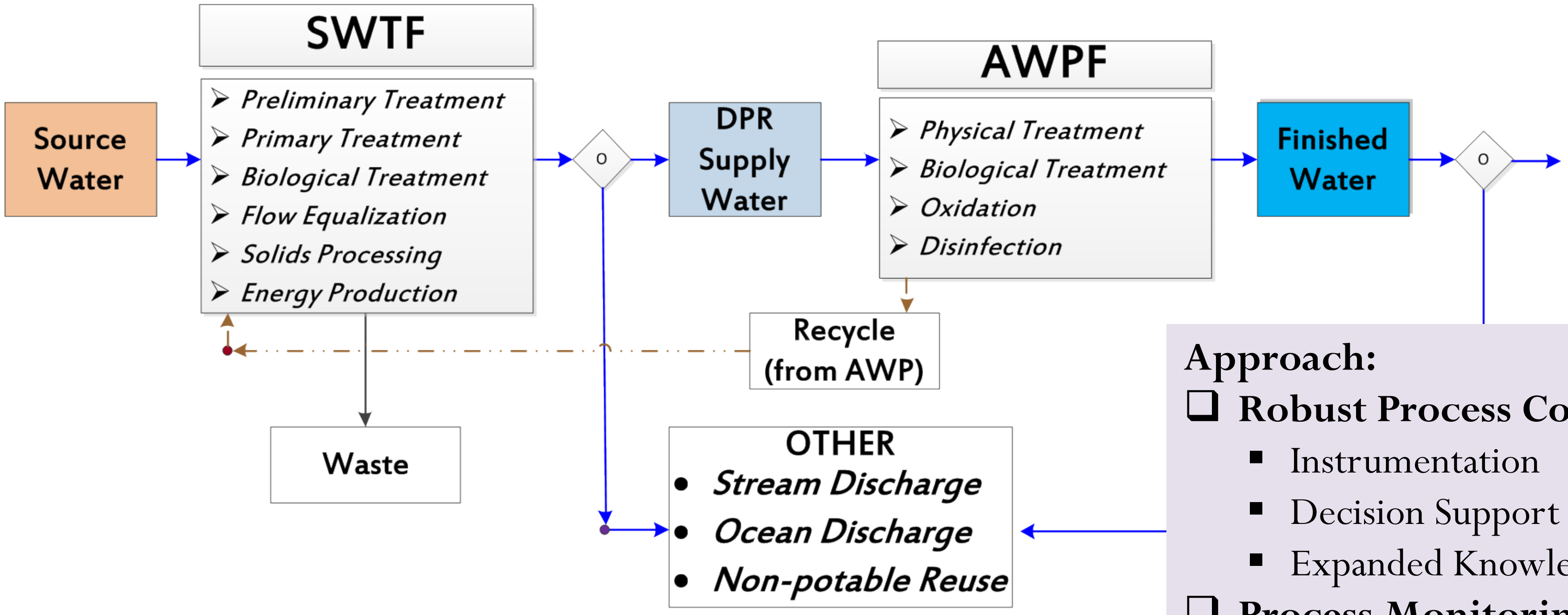
Source Water Treatment Facility Process Monitoring and Control

Sandeep



Objectives & Approach of a Process Monitoring & Control Program

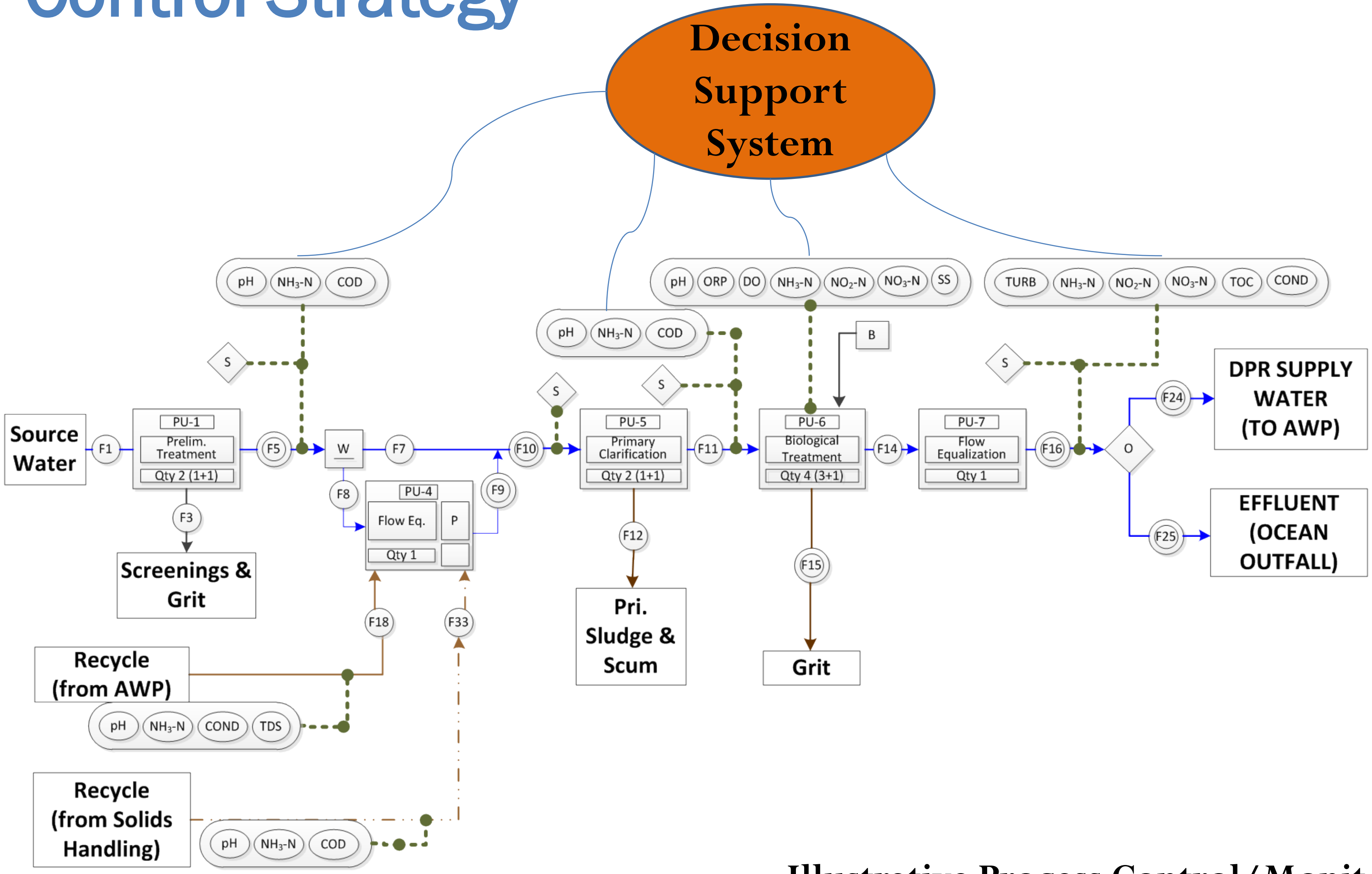
Reduce the risk of AWP production capacity loss and/or production of off spec water quality



Approach:

- **Robust Process Control:**
  - Instrumentation
  - Decision Support
  - Expanded Knowledge Base
- **Process Monitoring:**
  - Chemical constituents
  - Pathogens

Identify Monitoring Points & Develop a Process Control Strategy



Illustrative Process Control/Monitoring Strategy

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Identify the Critical Water Quality Parameters, Alert & Maximum Levels

- Two Examples:

Parameter[1]	Alert Level[2]	Max. Level[2]
Supply Water Turbidity (NTU)	1.0	3.0
Supply Water Ammonia-N (mg-N/L)	0.5	1.0

Notes:

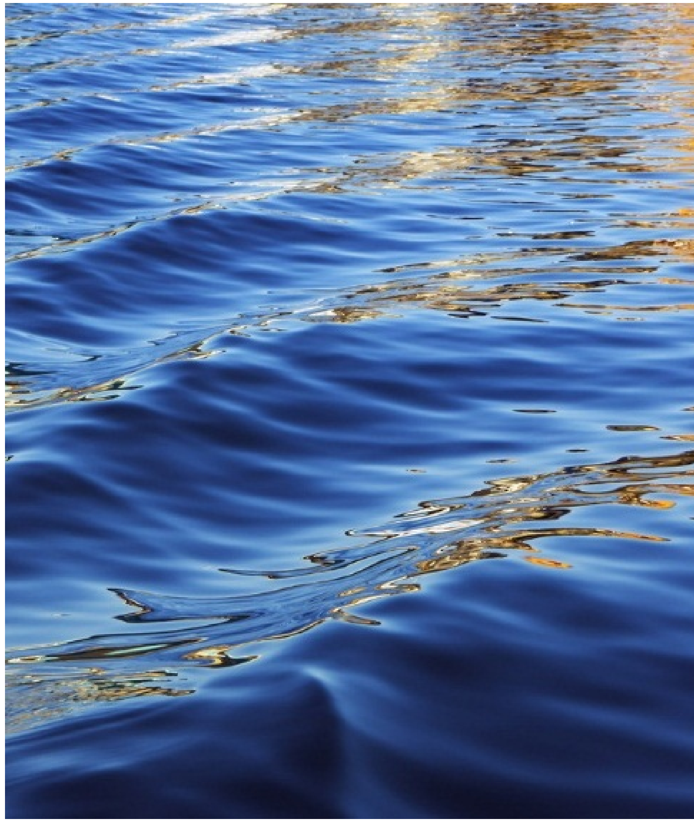
1. Note that this Table is provided as an example only and is not intended to be exhaustive. The complete set of parameters relevant at a particular WRRF will depend on the overall process configuration and should be developed through a hazard/risk management process by WRRF senior personnel and process SMEs.
2. The Alert Level and Max. Level for each process parameter will be predetermined, documented and shown on the SCADA screen (Manager adjustable only).

Identify What Actions Should be Taken In the Event Of…(an example)

Supply Water Quality	< Alert Level	> Alert Level	> Alert Level	= Max. Level
Turbidity	• No Action Required	• Inspect sample tubing/instrument (verify NOT false negative) • Assess separation process operation (e.g., sludge fluff blanket level, etc.) • Evaluate operating conditions & make operational modifications if required & possible (e.g., is HLR > design HLR – bring more clarifiers online) • Inform shift supervisor, separation process SME, AWP lead operator and AWP process SME • Evaluate and confirm readiness for mitigation measures	• Implement mitigation measures • Inform shift supervisor, process SME and plant manager/chief operator	• Divert Supply Water to alternate end use points (i.e., NOT to to AWP facility)
Ammonia-N	• No Action Required	• Inspect sample tubing/instrument (verify NOT false negative) • Assess biological process current and recent-historical (e.g., previous 6 hours) trends (NH_3-N, DO , MLSS, WAS, etc.). If trend analysis indicates system/mechanical/control failure – address through corrective action plan/SOP • Inform shift supervisor, biological process SME, AWP lead operator and AWP process SME • If ammonia measurements through AWP process are manual – inform AWP operators and/or lab staff to initiate more frequent[4] sampling/analyses until advised to stop	• Implement mitigation measures • Inform shift supervisor, process SME and plant manager/chief operator	• Assess impacts on AWP process and DPR water quality (AWP process configuration dependent) and implement

Impact of DPR Supply on AWP Process Design and Operations

Jay

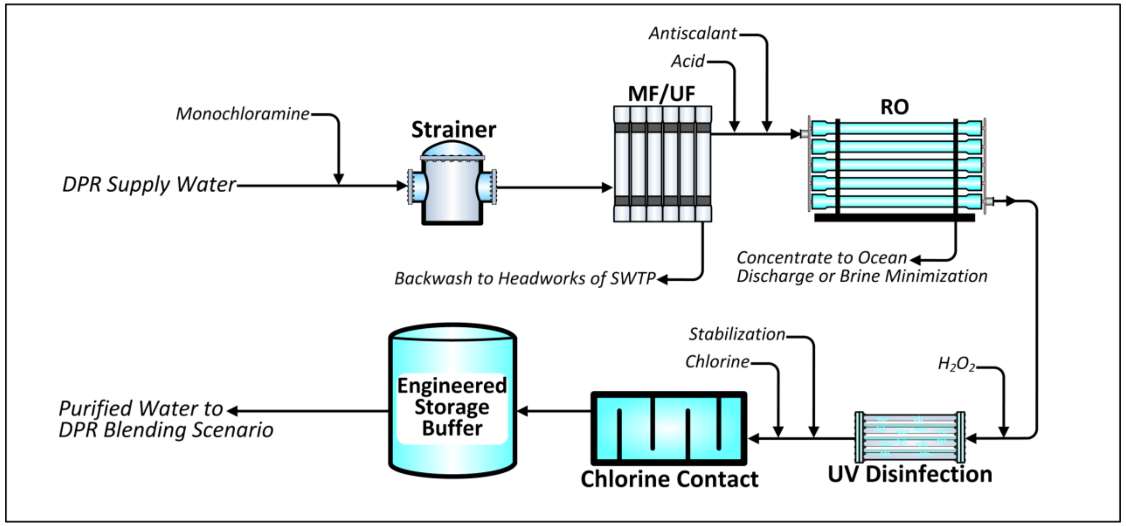


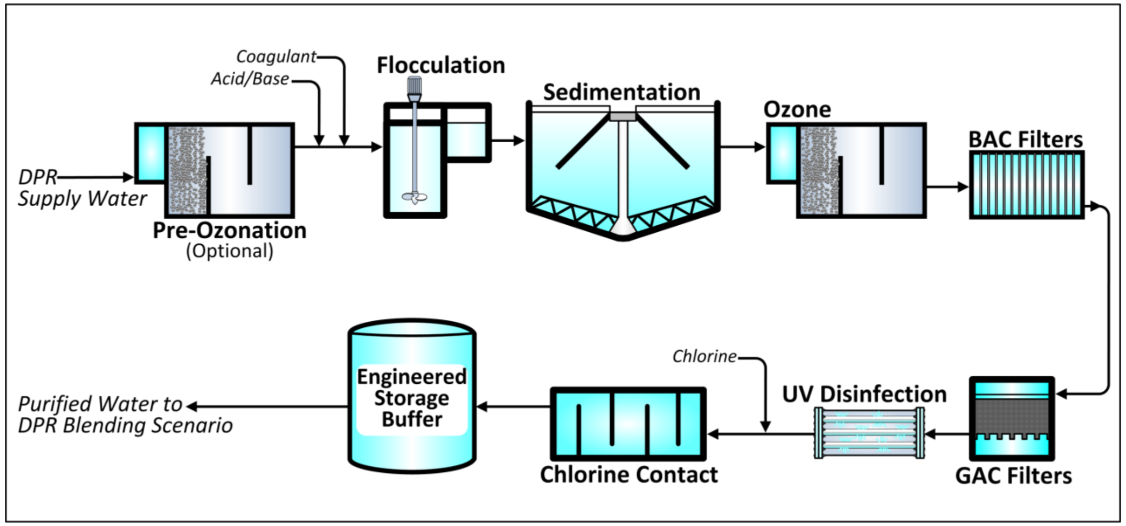
DPR Supply Impacts on AWP Unit Processes - Agenda

This section will address the following:

- Example of DPR Treatment Trains;
- Key DPR Supply Water Quality Constituents that can impact AWP Process design/operations;
- Impact of Poor DPR Supply Water Quality and Flow Variations on AWP Process design/operations.

Example DPR Treatment Trains





Process flowsheets adapted from WRRF 13-03 & WRRF 11-02

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Supply Water Quality Impacts on AWP Unit Operations - I

- MF/UF
  - Inorganics (e.g. metal hydroxides, carbonates)
  - Particulate/colloids (e.g. inert particles, clays, silts)
  - Bacteria
  - Organics (e.g. NOM -long chain high MW, polymer residual)

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Impacts of Poor DPR Supply Water Quality and Flow Variations on MF/UF Process Design/Operation

Example Impacts	Potential Mitigation Strategies
Operations: • Increased membrane fouling (increased cleaning frequency) • Trains may need to be taken offline during low flow periods	• Provide additional pre-treatment (e.g. chloramines, in-line coagulation, ozone/BAC) • Optimize SWTF (e.g. SRT, nitrification/denitrification, chemical dosing) • Provide upstream flow equalization
Design • Lower design flux (higher capital equipment costs/larger foot-print requirement)	

Supply Water Quality Impacts on AWP Unit Operations - II

- RO
  - Inorganics (e.g. silica, calcium, aluminum, phosphates, iron, etc.)
  - Particulate/matter (e.g. colloidal calcium phosphate)
  - Organics (e.g. NOM, polymer residual)

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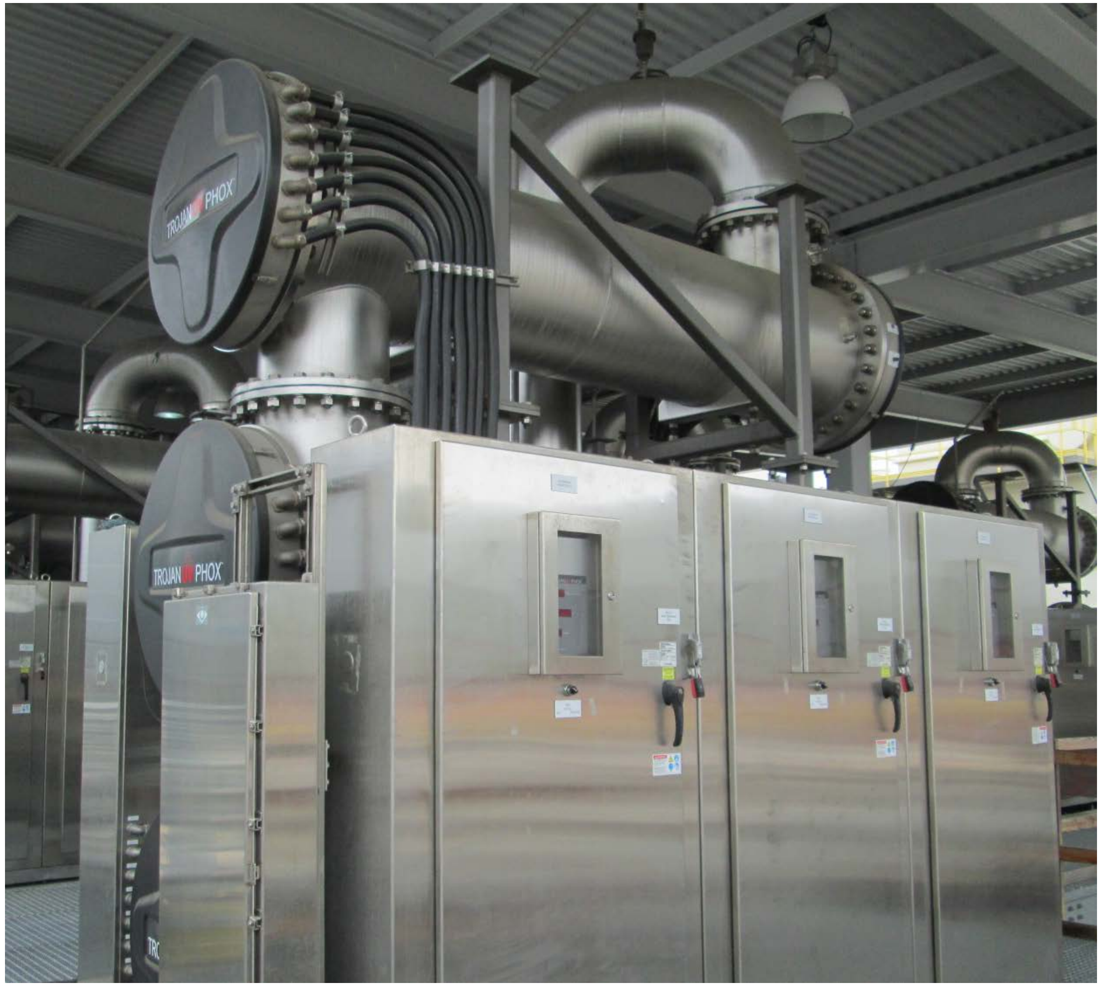
Impacts of Poor DPR Supply Water Quality and Flow Variations on RO Process Design/Operation

Example Impacts	Potential Mitigation Strategies
Operations: • Increased membrane scaling/fouling (increased cleaning frequency) • Reduces recovery • Trains may need to be taken offline during low flow periods	• Optimize chemical pre-treatment and monitoring • Optimize SWTF (e.g. SRT, nitrification/denitrification, chemical dosing) • Provide upstream flow equalization
Design: • Lower recovery limits design capacity and increases concentrate flow • May require partial second pass or additional treatment process to meet nitrogen / boron limits	

Supply Water Quality Impacts on AWP Unit Operations - III

- UV/AOP
  - Trace Organics / CECs (e.g. 1,4 Dioxane, Nitrosamines)
  - DBP precursors



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Impacts of Poor DPR Supply Water Quality and Flow Variations on UV-AOP Process Design/Operation

Example Impacts	Potential Mitigation Strategies
Operations: • Increased UV/oxidant doses required to meet target effluent water quality requirements • UV reactor power reduction or take reactors offline during low flow periods.	• Implement comprehensive source control strategies • Minimize/control NDMA formation
Design • Increased number of UV reactors and size of peroxide dosing system with wide range of turndown • Increase size/capacity of peroxide quenching	

Supply Water Quality Impacts on AWP Unit Operations - IV

- Ozone/BAC
  - Inorganics (e.g. iron, manganese, sulfides, bromide etc.)
  - Organics (DOC)

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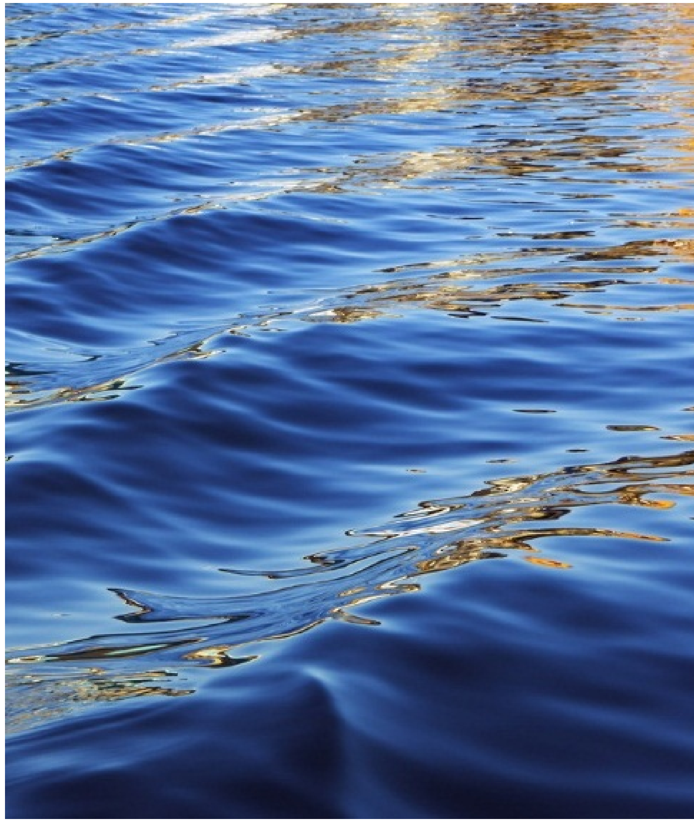
Impacts of Poor DPR Supply Water Quality and Flow Variations on Ozone-BAC Process Design/Operation

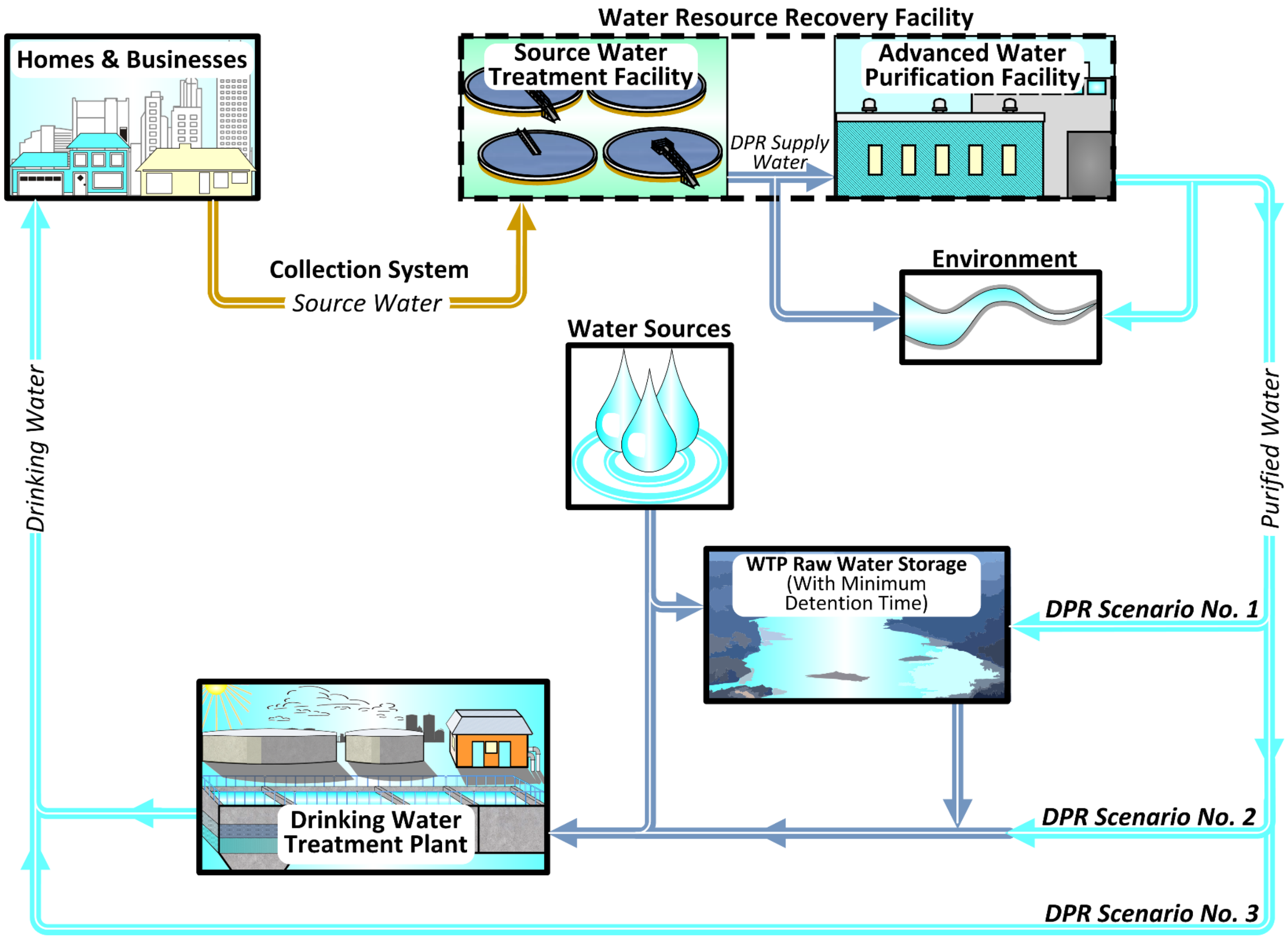
Example Impacts	Potential Mitigation Strategies
Operations: • Increased ozone demand • Shorter BAC filter runs/negative impact on filter biology • By-product formation (bromate/NDMA, etc.)	• Implement comprehensive source control strategies • Optimize SWTF (e.g. SRT, nitrification/denitrification) • Provide upstream flow equalization
Design • Larger ozone generators • Ozone injector /ozone residual monitoring to accommodate wide range of flow variation. • Size / design of downstream AWP processes	

Final Thoughts

Alan



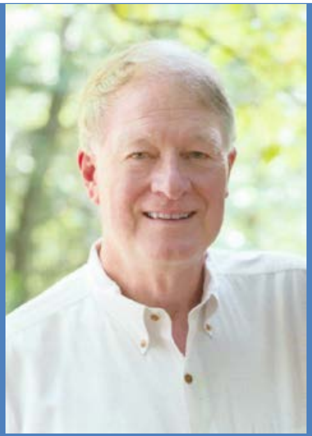
Highlights of Findings

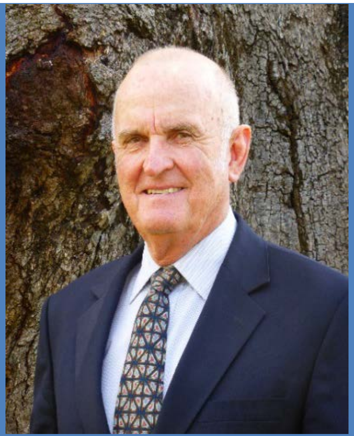


WateReuse

Future Directions

WATEREUSE





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Type Your Questions in the Chat Box

A survey will appear in this window at the conclusion of this webcast