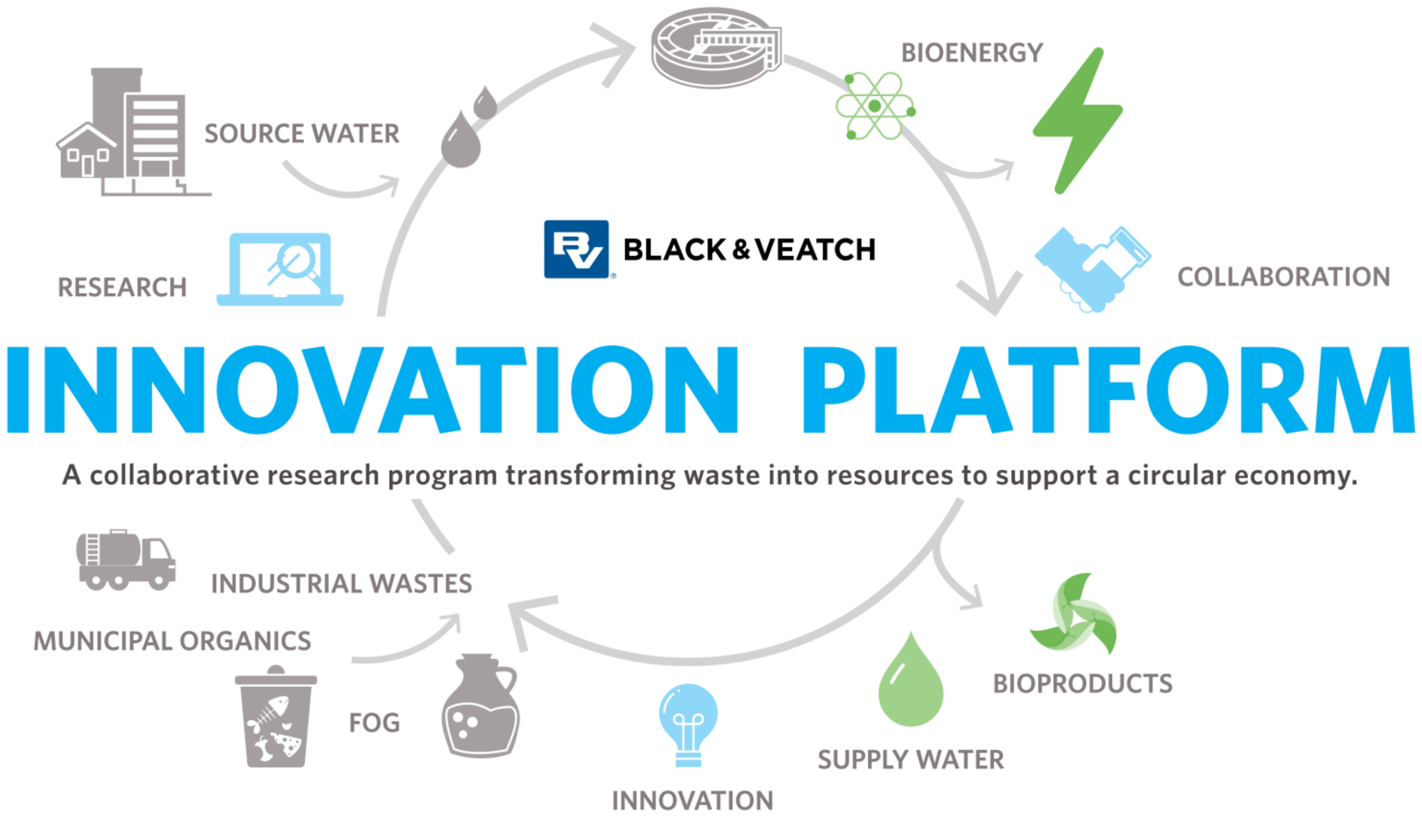


MABR Technology for Secondary Treatment Process Intensification

BLACK & VEATCH: SANDEEP SATHYAMOORTHY
YUEYUN TSE
KELLY GORDON
SAMIK BAGCHI
(CURRENTLY WITH DIGESTED ORGANICS)

SUEZ: DWIGHT HOUWELING
DAN COUTTS

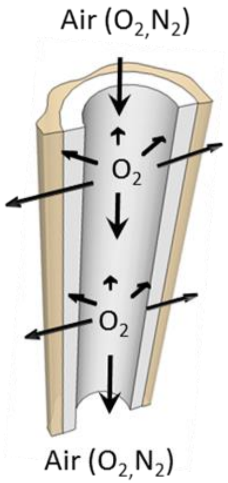
BUILDING A WORLD OF DIFFERENCE®

An MABR is…

MEMBRANES

- *Dense, hydrophobic material*
- *Hollow fiber or flat sheet configuration*

AIR DELIVERY

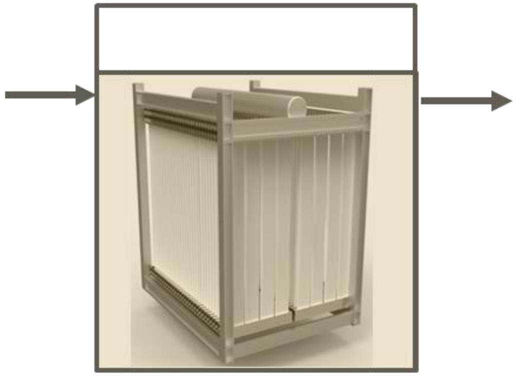


Air flows through intramembrane lumen and diffuses through membrane wall to biofilm

SUBSTRATE

Membrane cassettes are submerged in MLSS

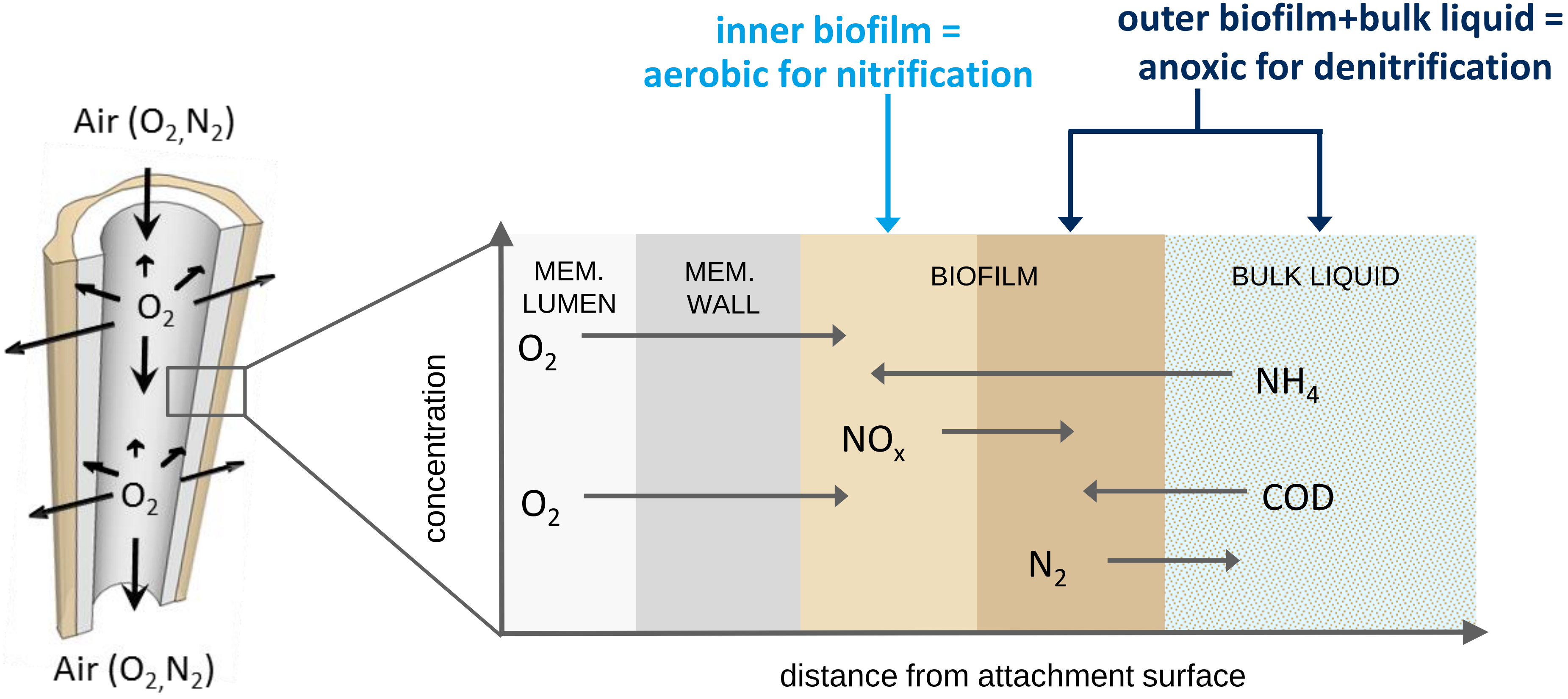
- *COD*
- *Ammonia (NH_4-N)*



"Breathing" Biofilms!

Passive delivery of oxygen results in high oxygen transfer efficiencies.

THE MABR SUPPORTS COUNTER-DIFFUSIONAL SUBSTRATE DELIVERY.



Counter-diffusional substrate delivery supports total nitrogen removal in a single biofilm and basin.

BENEFITS OF AN MABR

a Bubbleless Aeration Device

- Fine aeration control

&

a Biofilm Technology

- Intensified treatment
- Support slow growing organisms

SYNERGY

- Efficient aeration driven by biofilm activity
- High abundance of nitrifying organisms in biofilm
- Total nitrogen removal in a single reactor

VALUE PROPOSITION OF MABR TECHNOLOGY

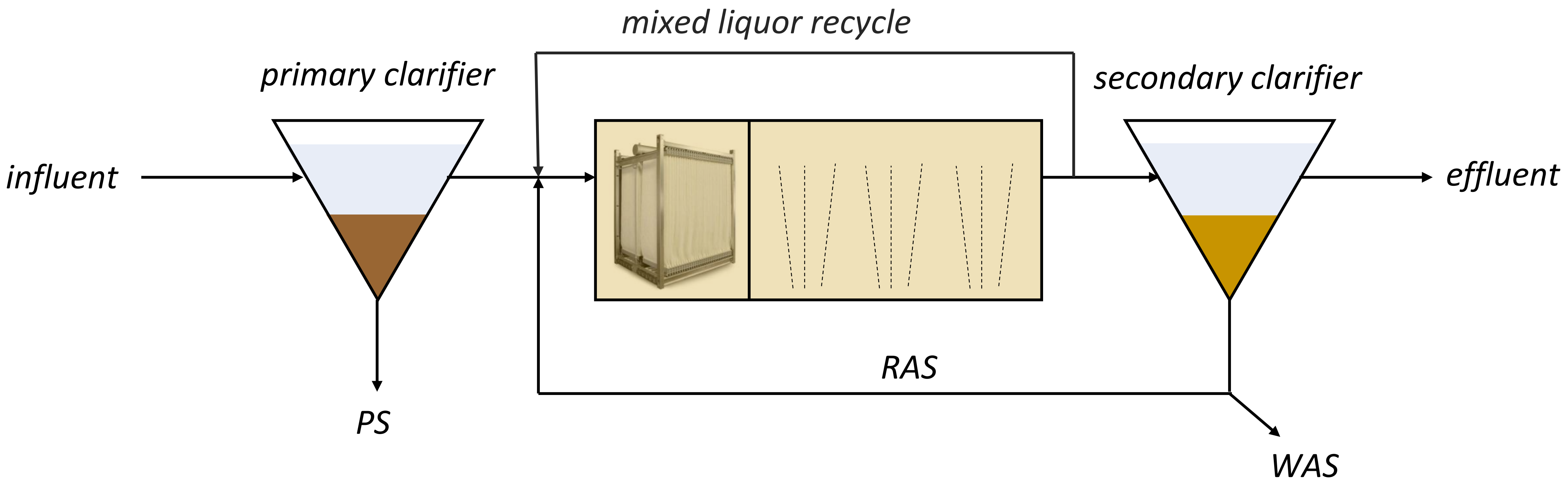
- Support **total nitrogen removal** in the **same tank**
- **Retrofit existing aeration tanks** and achieve **process intensification**

→ **Reduce CAPEX**

- Achieve efficient oxygen transfer rates
- Reduce internal recycle pumping
- Reduce **supplemental** biodegradable organic **carbon requirements** for denitrification

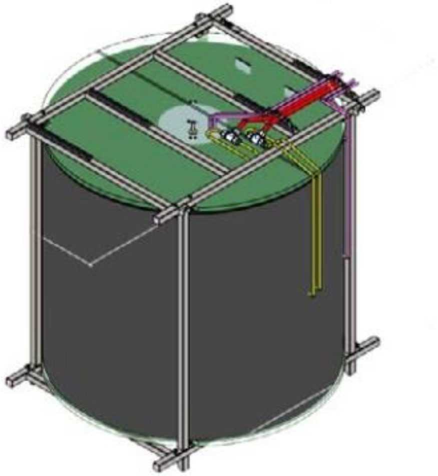
→ **Reduce CAPEX AND OPEX**

MABR achieves nitrification/denitrification in the anoxic zone.



TECHNOLOGY PROVIDERS

fluence



suez

OXYMEM
SMART AERATION

KNOWLEDGE GAPS OF MABR

Fundamental Understanding

- Microbial Community Structure
- AOB/NOB ratio

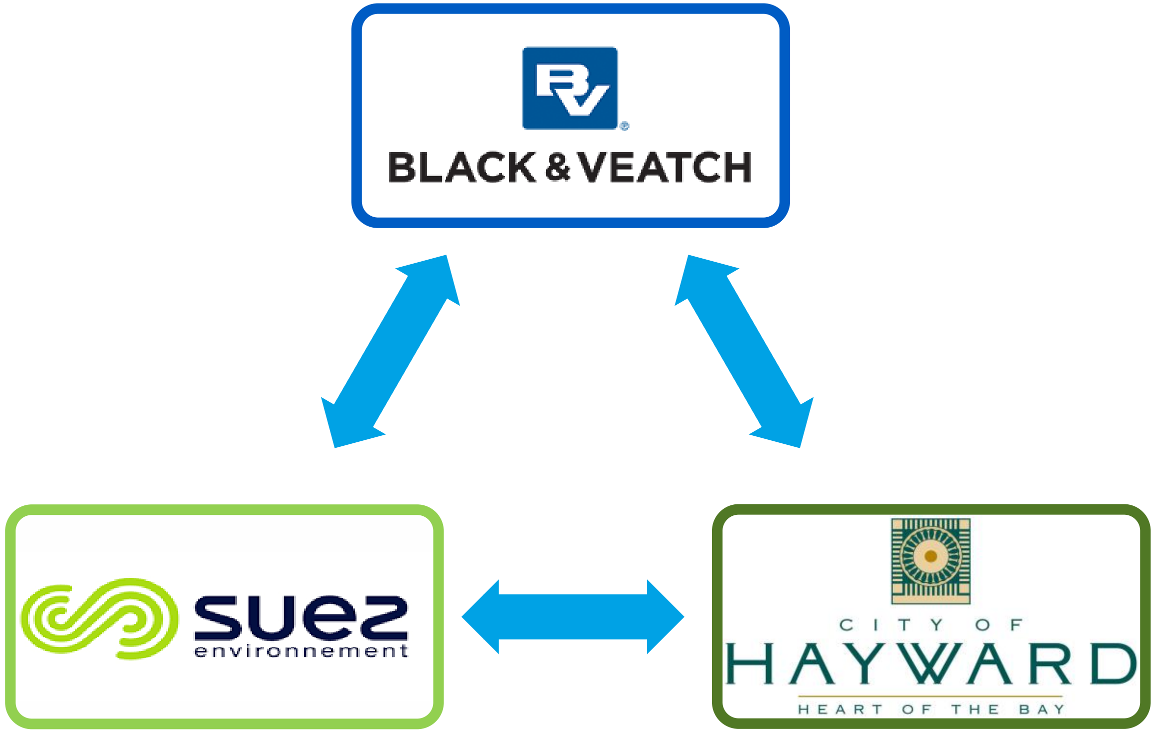
Operational Challenges

- Optimal SRT
- Impact of C:N ratio
- Biofilm Management

Scale up Challenges

- No of cassettes
- Nitrification Rate

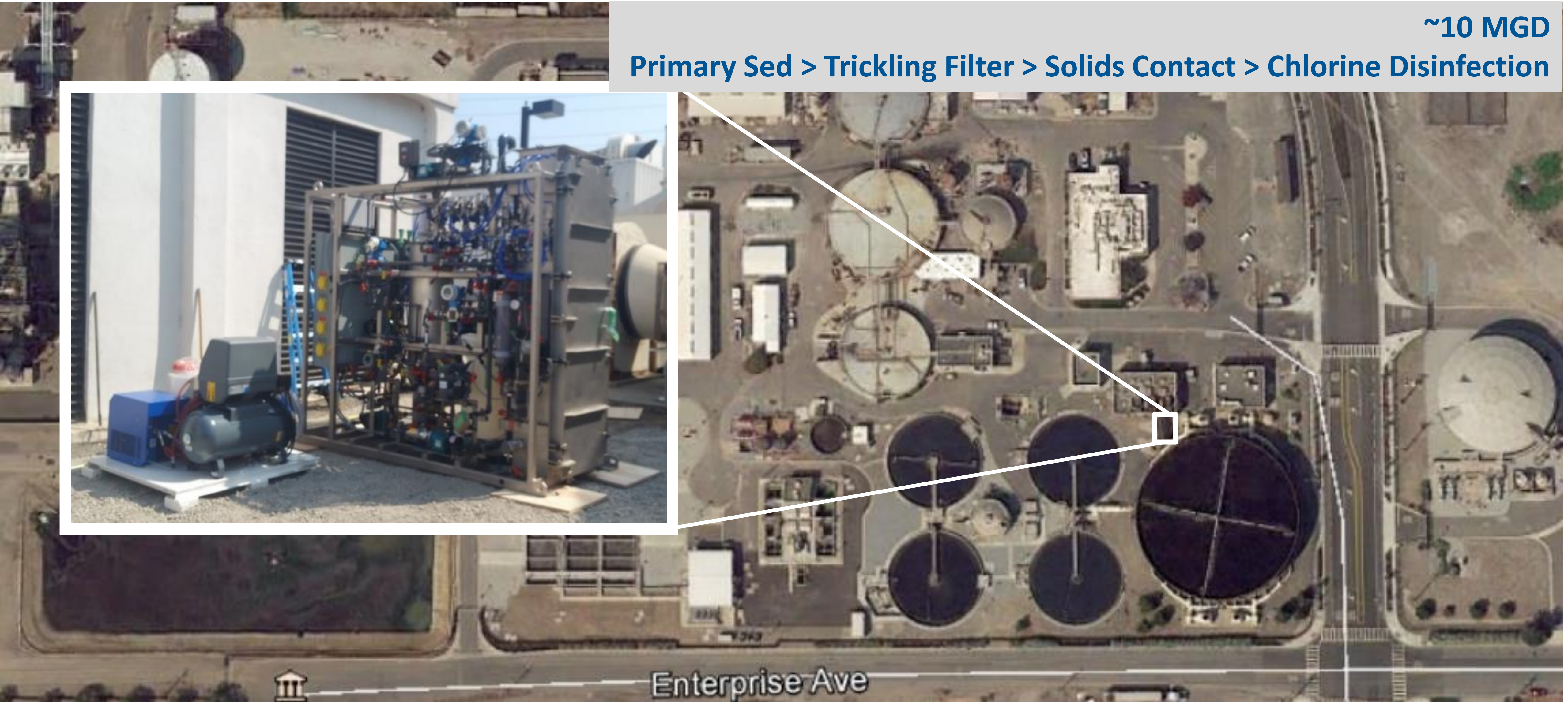
MABR Research Collaborative



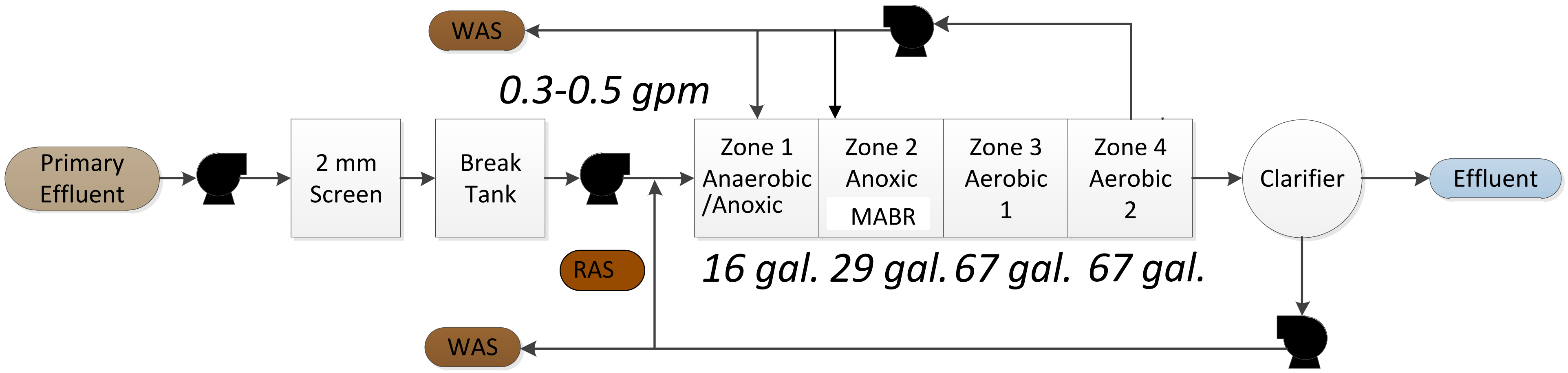
MABR Pilot @ Hayward WPCF

~10 MGD

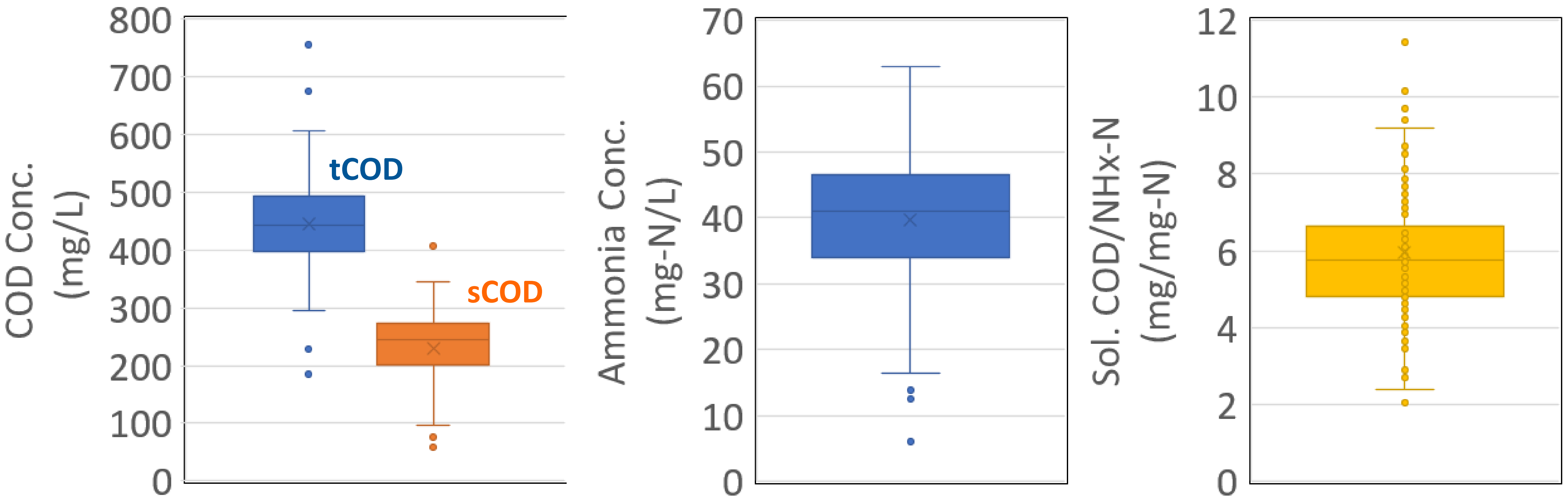
Primary Sed > Trickling Filter > Solids Contact > Chlorine Disinfection



Pilot Overview



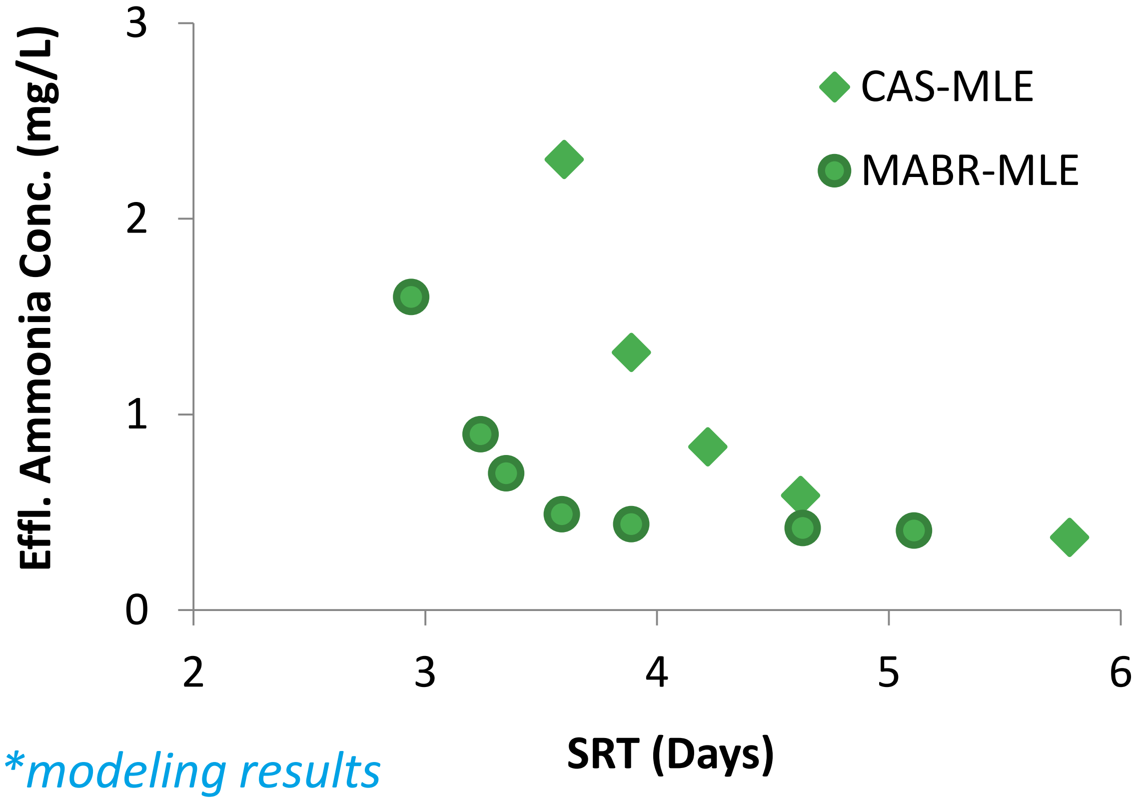
An introduction to the pilot influent/Hayward PE



- Grab samples
- Samples typically collected ~9 – 11 am

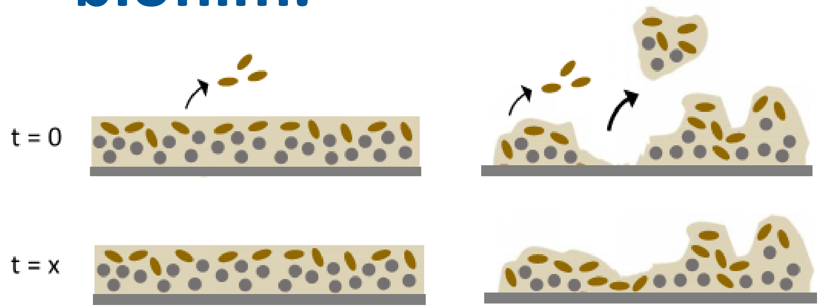
MABR Pilot Research Question # 1

*Evaluate the **aerobic solids retention time (SRT)** required to achieve **nitrification** in an **MABR** configuration compared with a **Suspended Growth BNR** configuration*



1. Lower nitrification "work" required by suspended sludge

2. "Seeding" effect by the biofilm.



**modeling results*

SRT & Suspended SRT (S.SRT)

Suspended Growth (SG) process:

$$\text{SRT [T]} = \frac{\text{Biomass Inventory [M]}}{\text{Wasted Biomass [M/T]}} = \frac{X_{ML}\,[M/L^3] \times V_{BIO}\,[L^3]}{Q_{WAS}\,[L^3/T] \times X_{WAS}\,[M/L^3]}$$

MABR-SG Hybrid process:

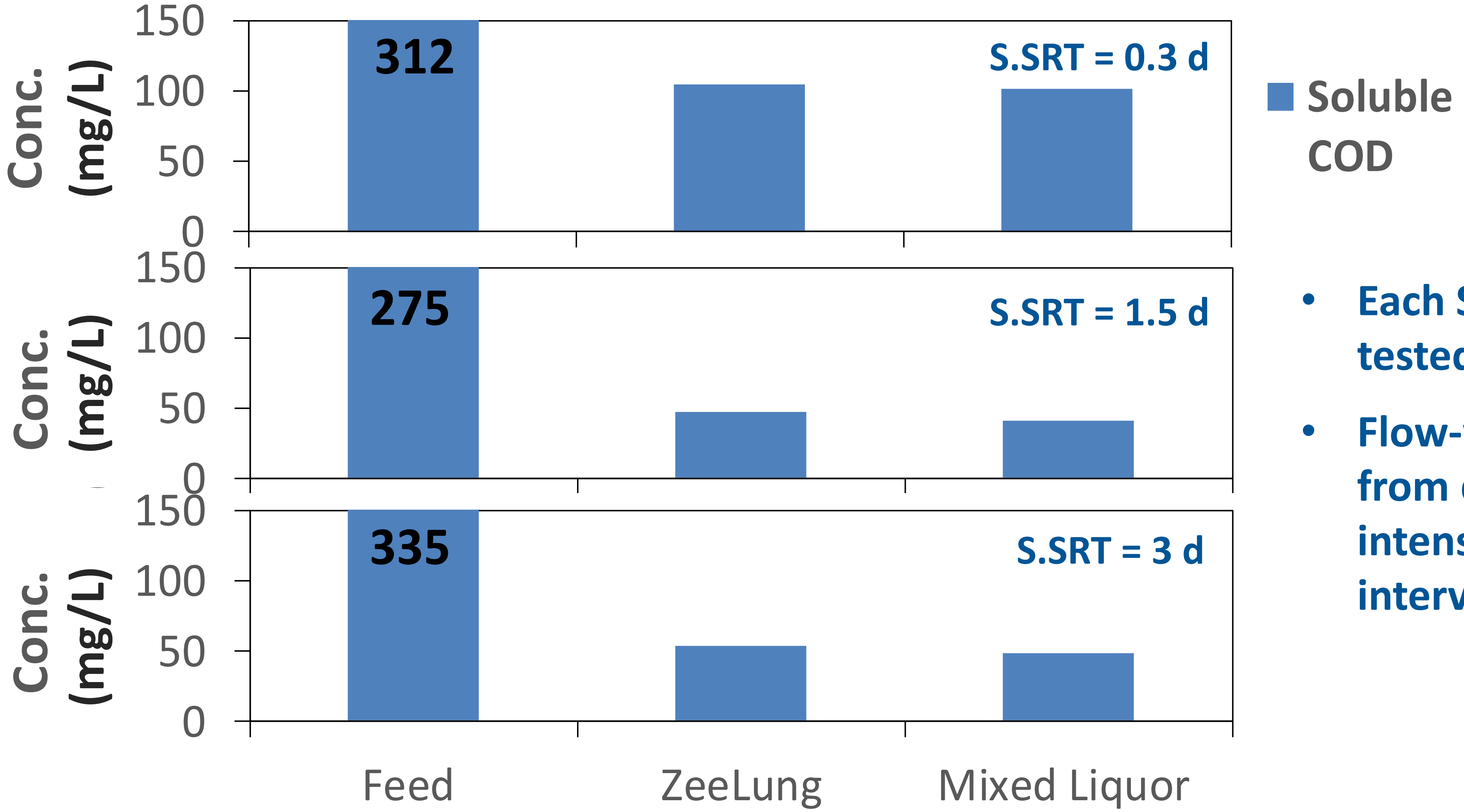
$$\textit{Suspended}\ \text{SRT [T]} = \frac{\textit{Suspended}\ \text{Biomass Inventory [M]}}{\text{Wasted Biomass [M/T]}} = \frac{X_{ML}\,[M/L^3] \times V_{BIO}\,[L^3]}{Q_{WAS}\,[L^3/T] \times X_{WAS}\,[M/L^3]}$$

There's also ADDITIONAL BIOMASS ON THE BIOFILM AT A "BIOFILM SRT"

MABR ADDS ~1-5 g-biomass/m^2-MABR Surface Area

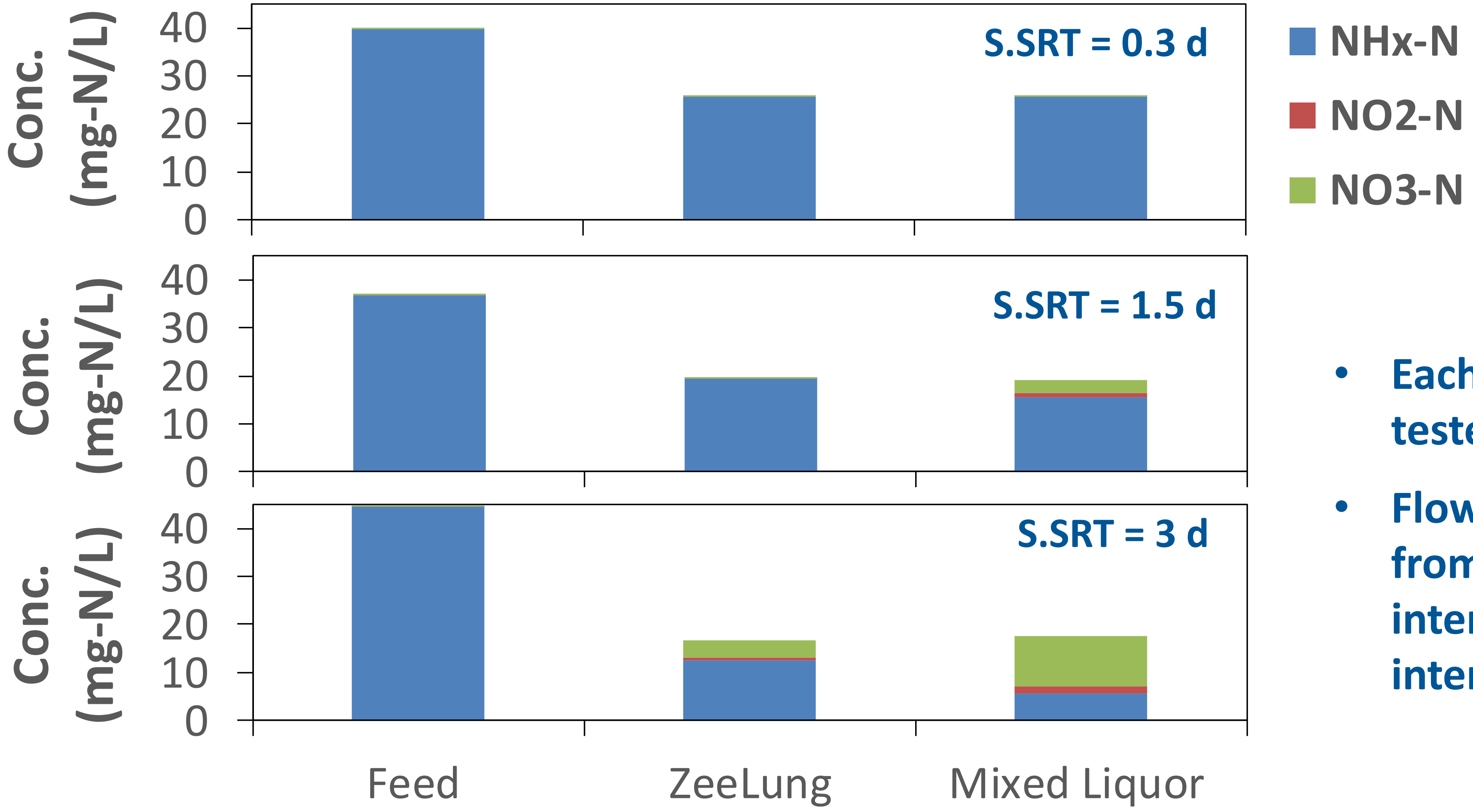
(In the pilot – MABR SA = 10 m^2 => 10 – 50 g biomass added ≅ 15 – 80 mg/L SS

Pilot (MABR+ Sus. Growth) Performance At Different SRTs



- Each SRT Condition tested for > 5X SRT
- Flow-weighted average from duplicate 24-h intensive sampling (2h interval) results

Pilot (MABR+ Sus. Growth) Performance At Different SRTs

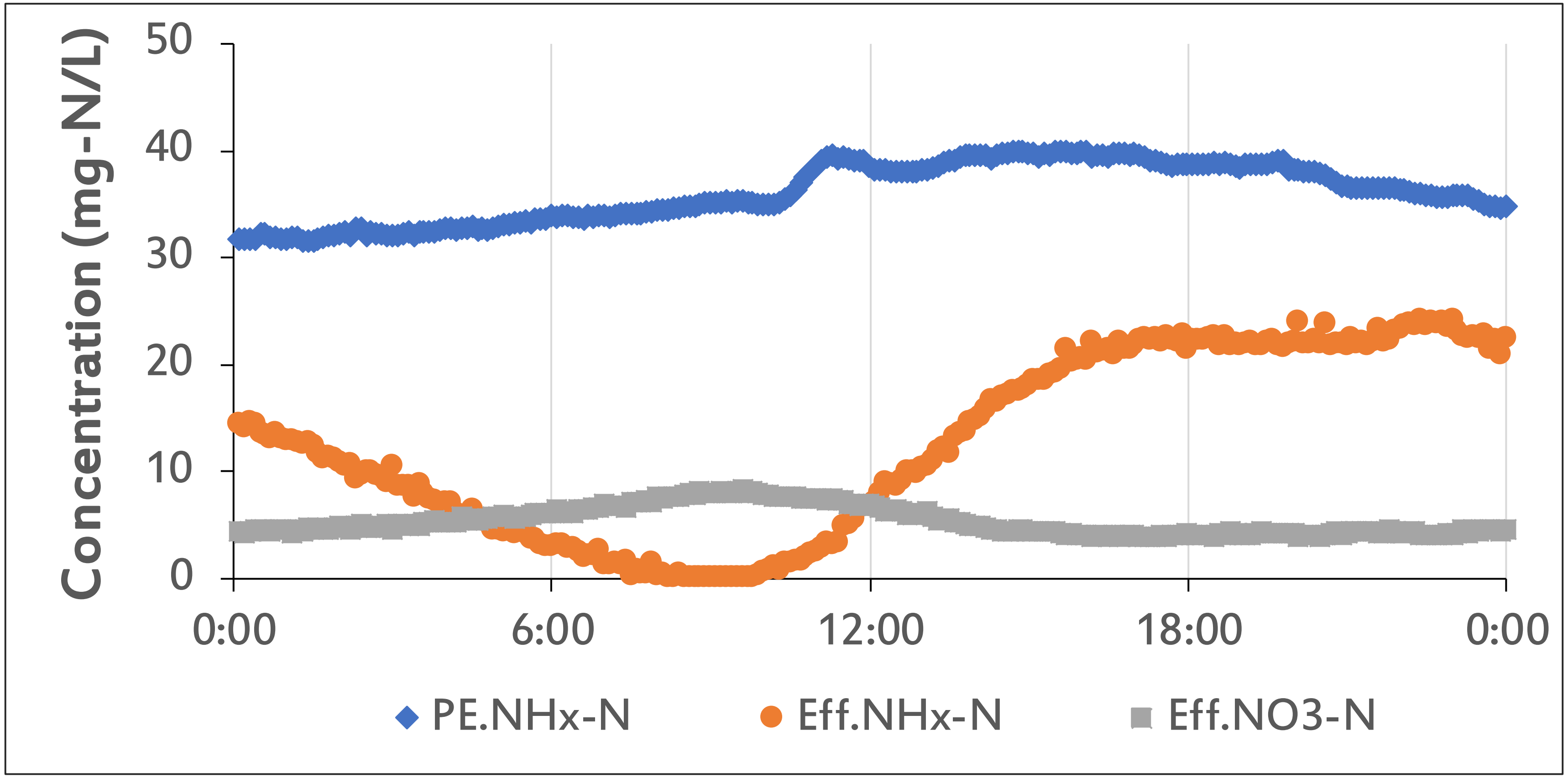


- Each SRT Condition tested for > 5X SRT
- Flow-weighted average from duplicate 24-h intensive sampling (2h interval) results

Typical Performance with Diurnal Flow

Influent = Diurnal Flow (matching Hayward WPCF pattern (avg. = 0.4 gpm)
RAS = $60\%xQ_{INF}$
MLR = $200\% \times Q_{INF}$

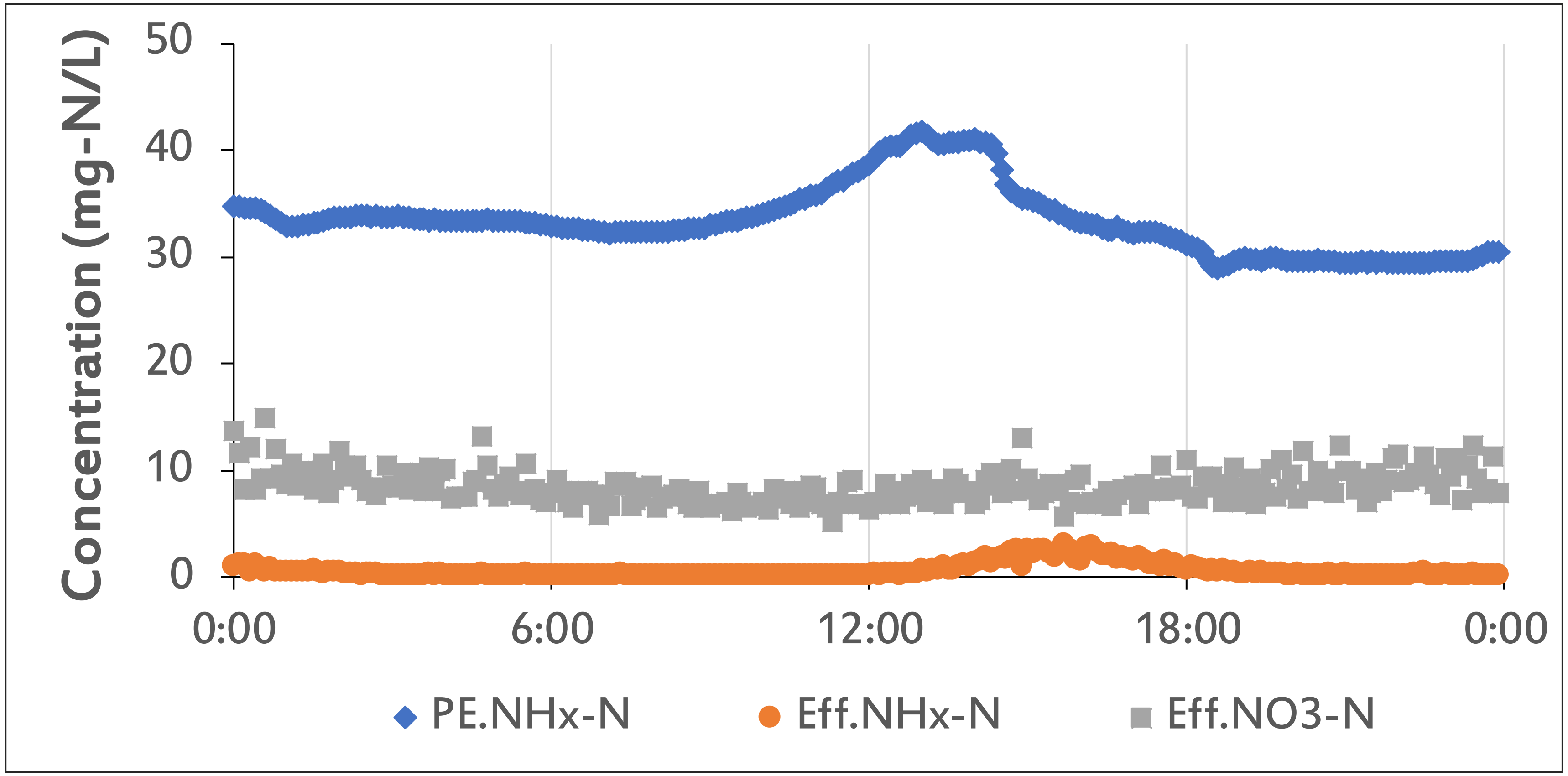
Temp. ~ 18-19 ^{o}C
MLSS ~ 1,340 mg/L
Aerobic $SRT_{SUSP.GR}$ ~ 1.5 d



Typical Performance with Diurnal Flow

Influent = Diurnal Flow (matching Hayward WPCF pattern (avg. = 0.4 gpm)
RAS = 60% x Q_{INF}
MLR = 200% x Q_{INF}

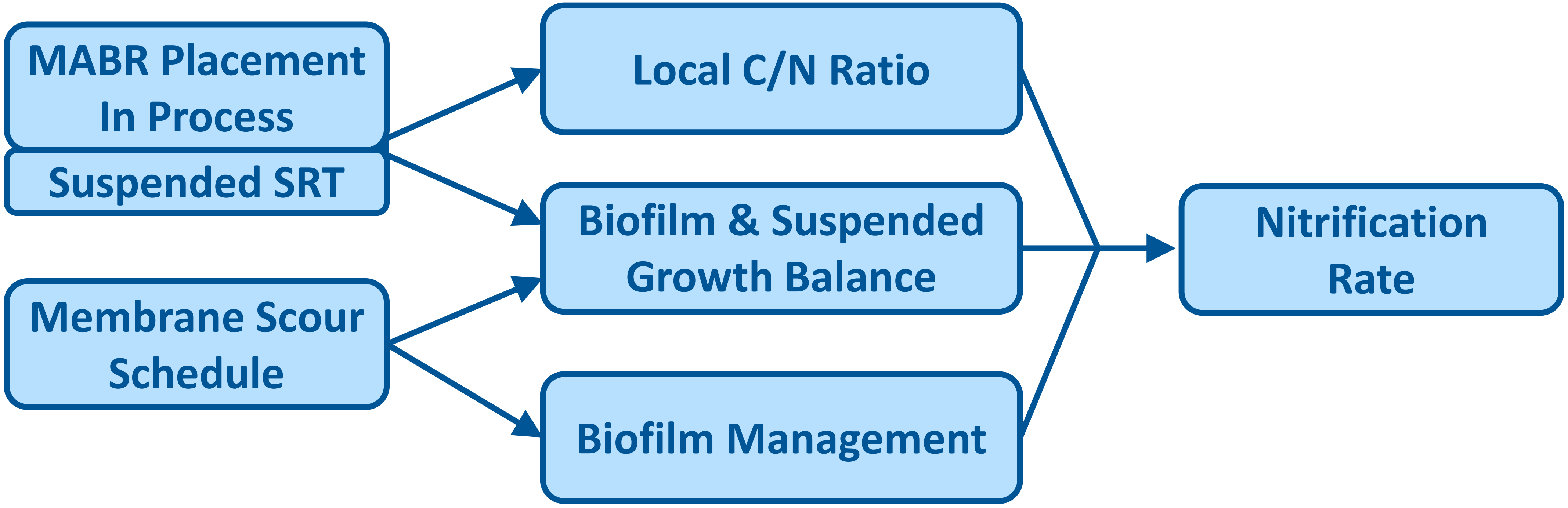
Temp. ~ 18-19 °C
MLSS ~ 1,600 mg/L
Aerobic $SRT_{SUSP.GR}$ ~ 3d



Preliminary Conclusions

- The **counter-diffusional** substrate delivery scheme leads to **TN removal in one Tank**.
- TN removal can be achieved at suspended SRTs lower than conventionally required/designed through MABR intensification
- **Biofilm Management**, **C/N Ratio**, **Balance between Biofilm** and **Suspended Growth** are critical to efficient MABR Design.

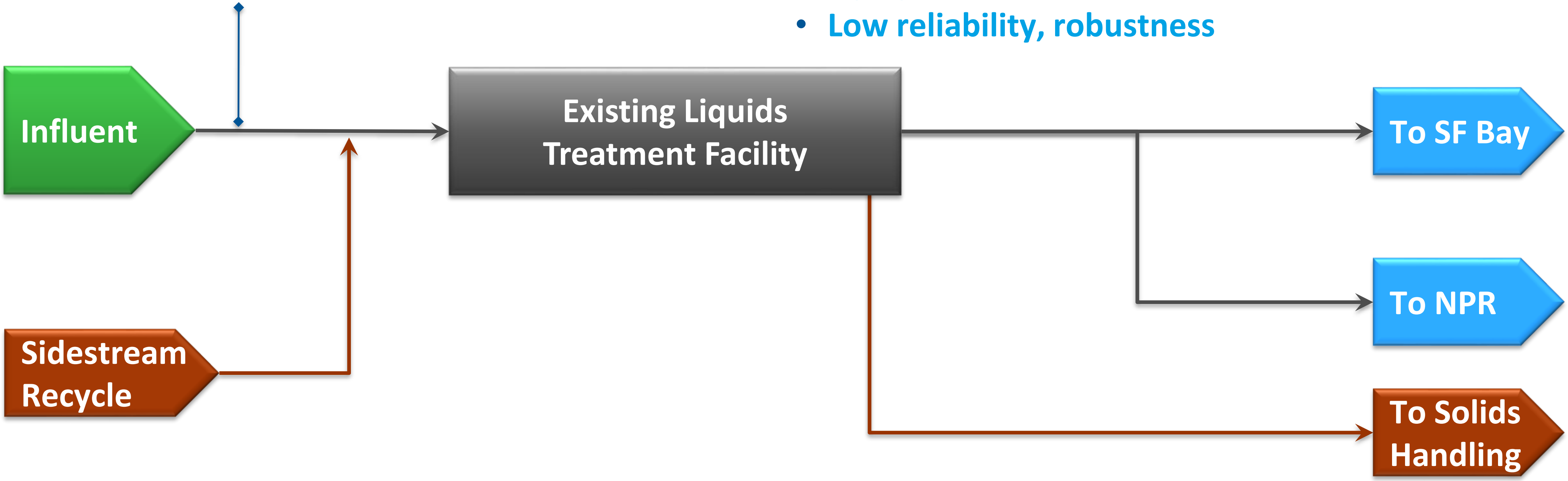
Key Factors to Consider for MABR Design



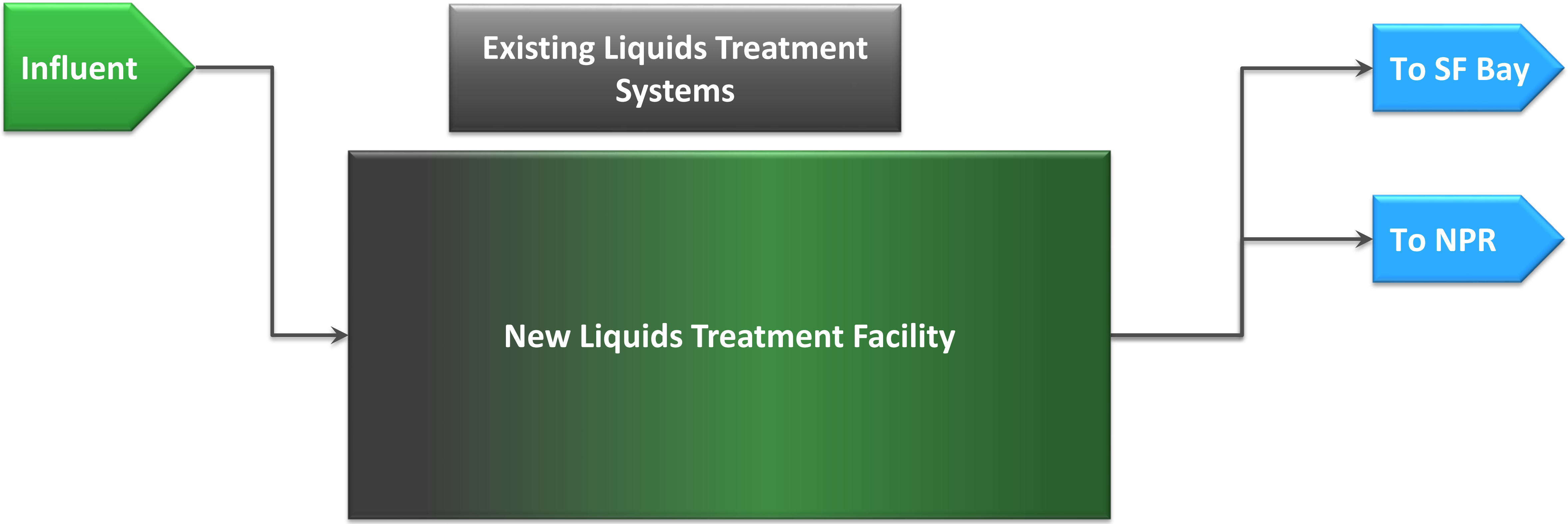
Consider expansion of an existing WRRF at an adjacent site

	Q MGD	NHx, mg-N/L	sTN, mg-N/L
AA	22	24	~35-36
MM	28	22	~33-34

- Aging facility
- Low reliability, robustness

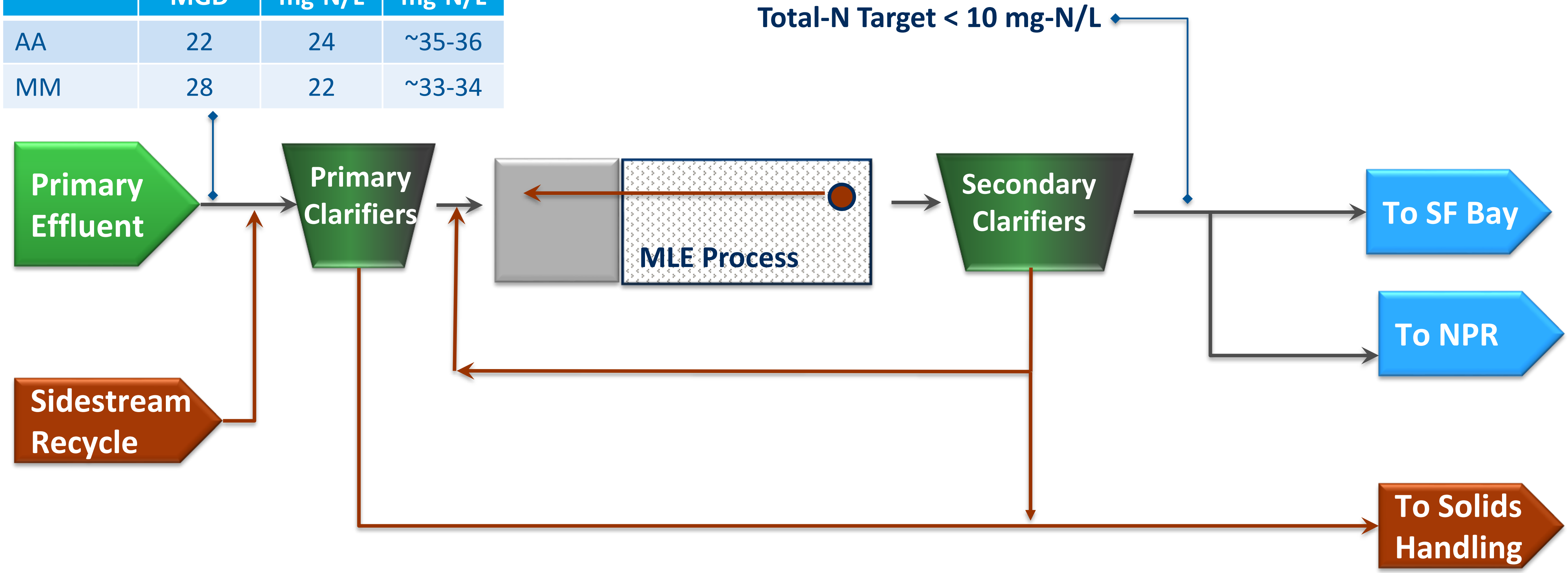


Consider expansion of an existing WRRF at an adjacent site

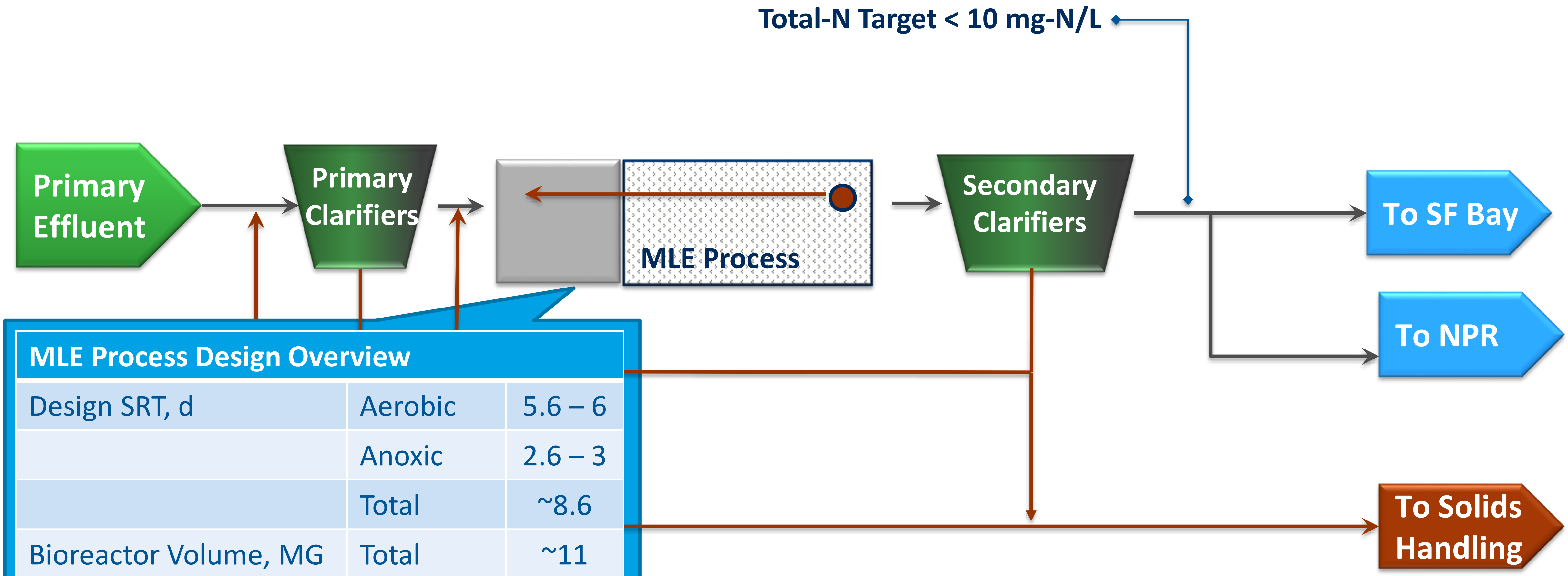


New WRRF Design (at "greenfield" site)

	Q MGD	NHx, mg-N/L	sTN, mg-N/L
AA	22	24	~35-36
MM	28	22	~33-34



New WRRF Design (at "greenfield" site)
Process Design Summary



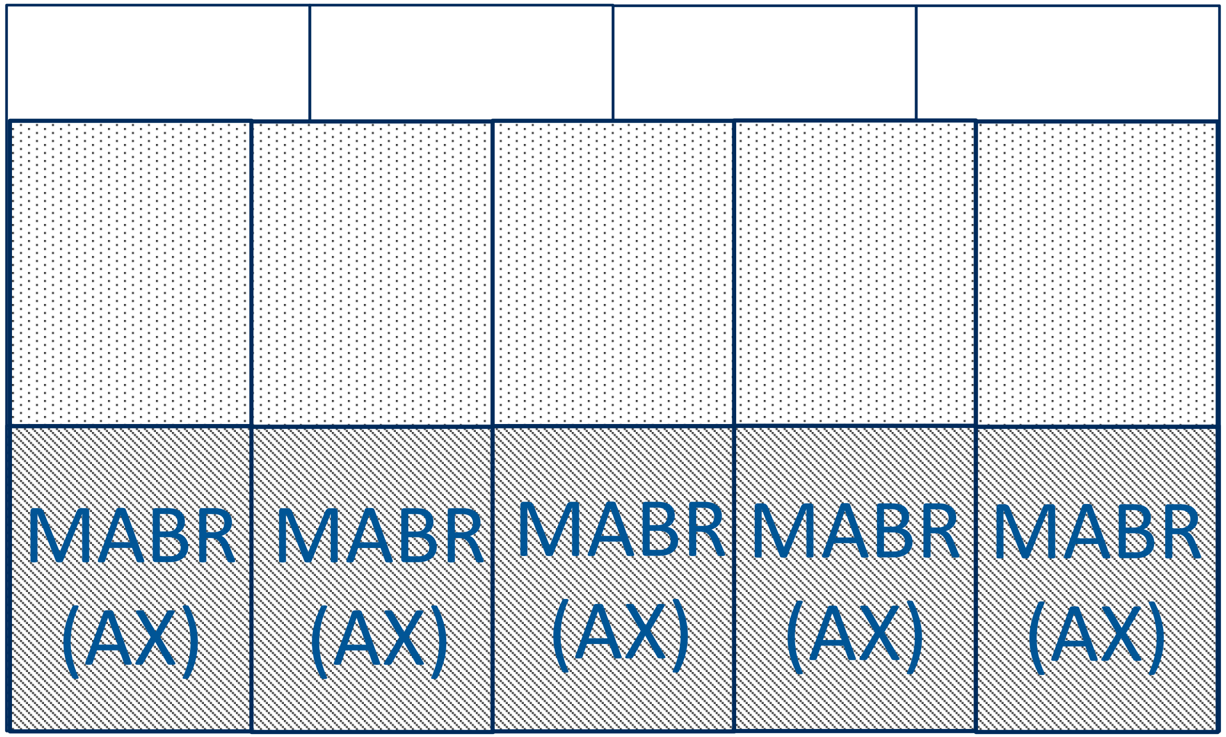
MLE Process Design Overview		
Design SRT, d	Aerobic	5.6 – 6
	Anoxic	2.6 – 3
	Total	~8.6
Bioreactor Volume, MG	Total	~11
Side Water Depth, ft		25
Target MLSS, mg/L		~2,500

Can Process Intensification Help Enhance the Process Design?

- What is the potential suspended SRT (and resulting volume) reduction?

- What are some trade-offs to consider?

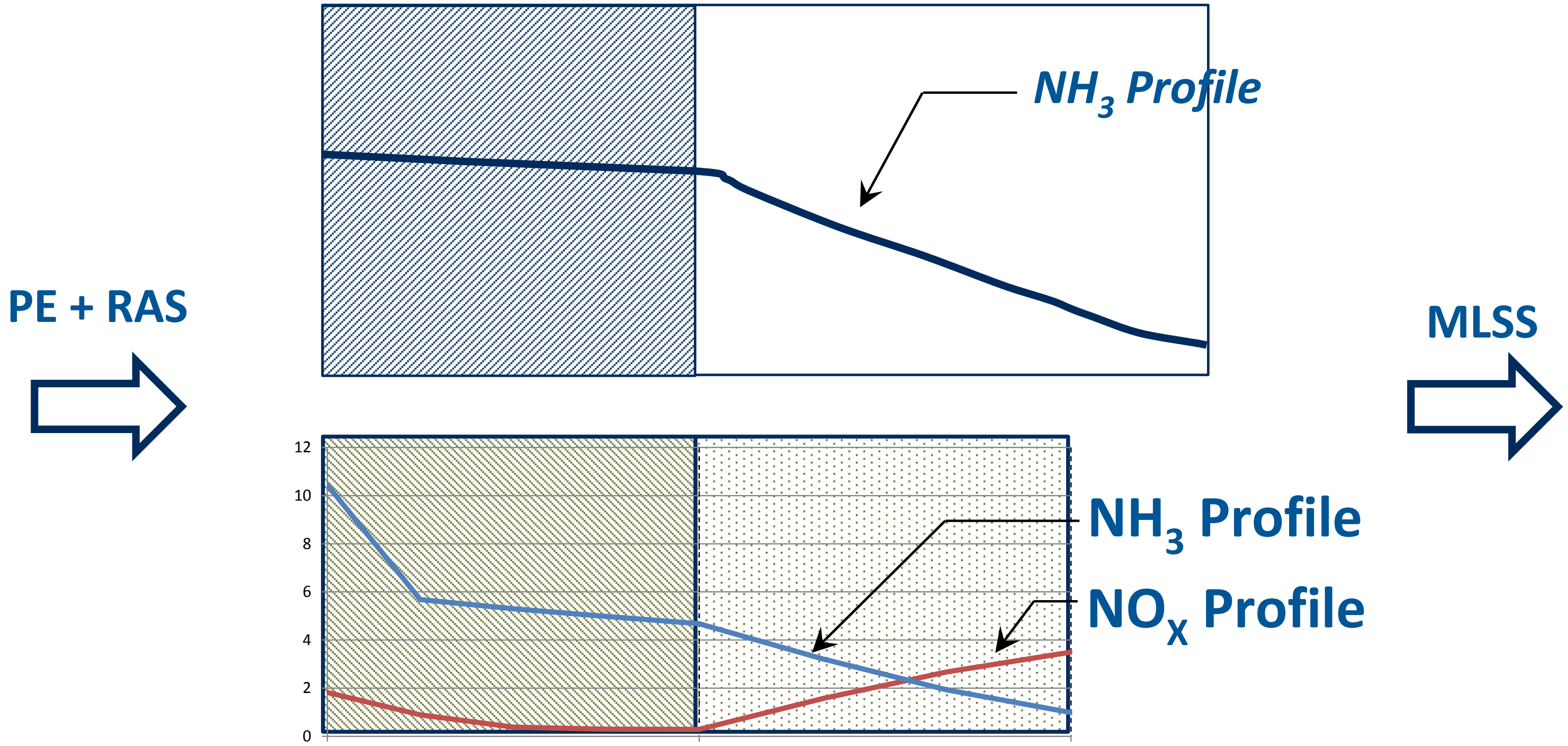
Incorporation of MABRs into the MLE design



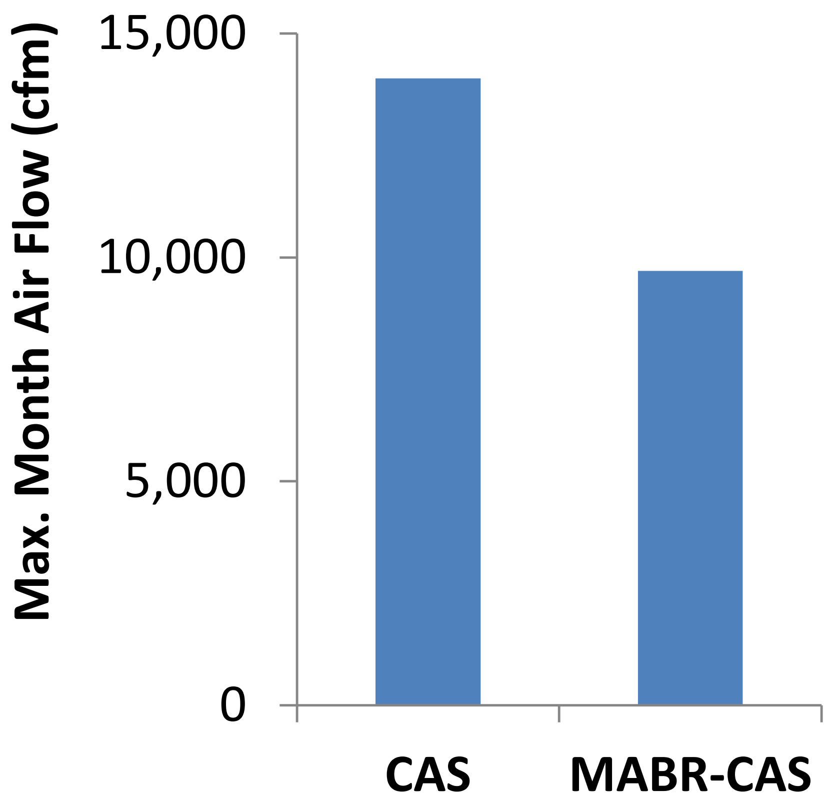
- **Current CAS Design**
  - ~ 11 MG
  - ~35% AX, 65% AE
  - $MLSS_{MAX.MONTH}$ ~ 2,500 mg/L

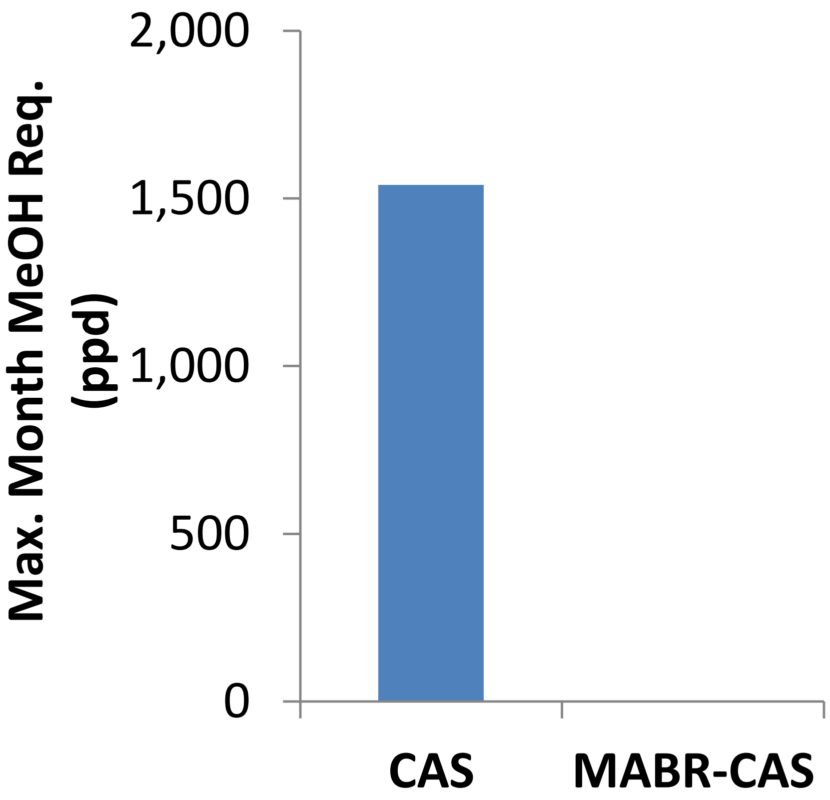
- **MABR-AS Design**
  - ~ 8 MG
  - ~ 50% AX
  - $MLSS_{MAX.MONTH}$ ~ 2,500 mg/L

Where is ammonia removal occurring?



Aeration & Chemical Use Benefits





Tradeoffs

- Replacing potentially expensive concrete with equipment
  - More detailed tradeoff analyses required – including LCC, etc.
- But – are there benefits of reducing the SWD and overall tank depth?
  - Safety, operability, etc.
- Can this not be planned for as part of a future "plug-and-play" solution?
  - Yes…& No
  - Overall plant design/integration and system design are critical
    - (any) technology needs to be "best positioned" for success
    - For MABRs – hydraulics are key: shortcuiting, bypassing, best use of membrane area, etc.

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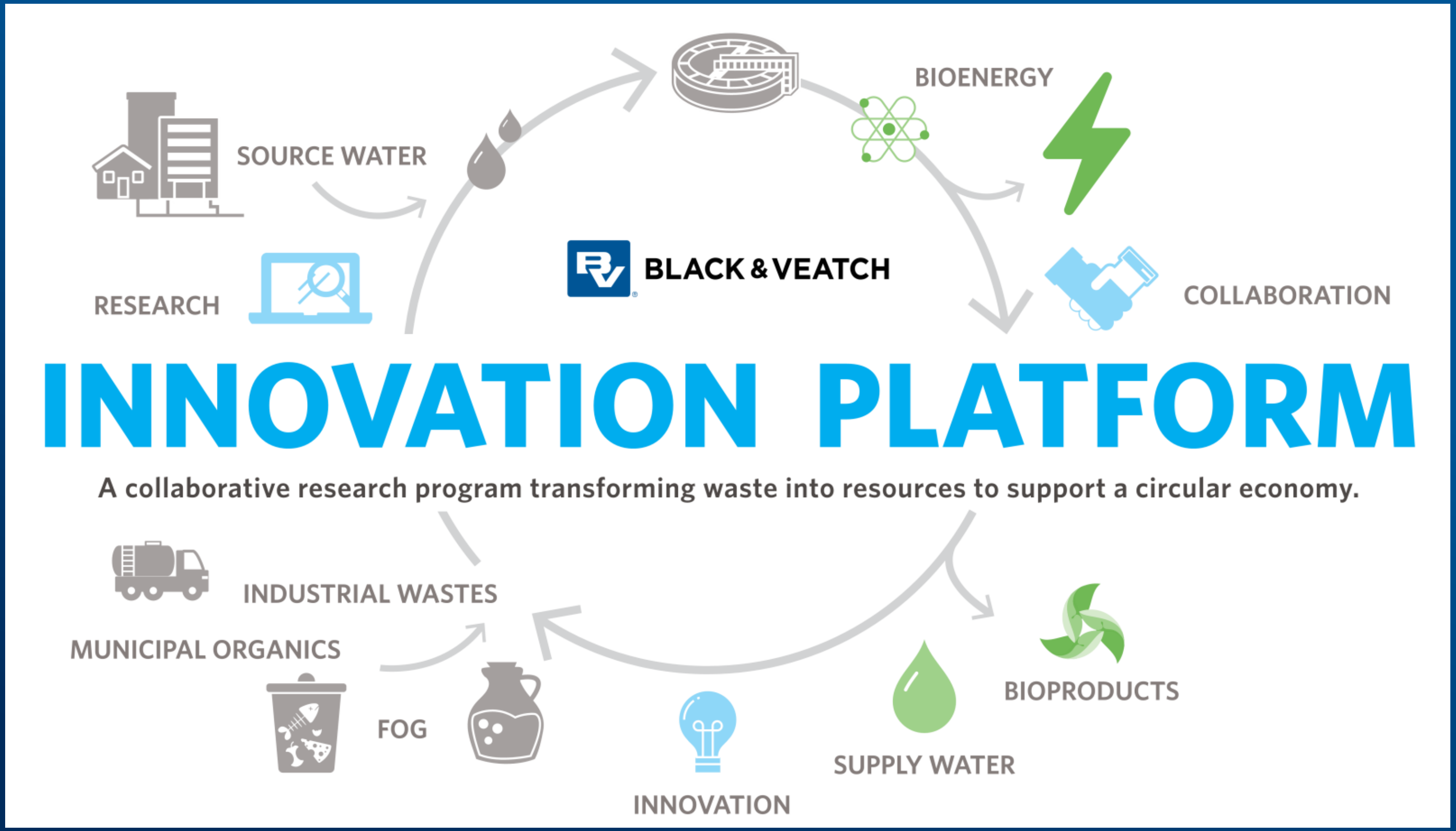

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