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MABR for Nutrient Removal Intensification– Central San Pilot

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Outline

- Treatment Plant Background
- New Regulatory Limits on Total Inorganic Nitrogen (TIN)
- Membrane Aerated Biofilm Reactor (MABR) Technology Overview
- Pilot Project
  - Questions
  - Results
  - Conclusions
- Next Steps

Treatment Plant Background


San Francisco Bay Area
Martinez, California
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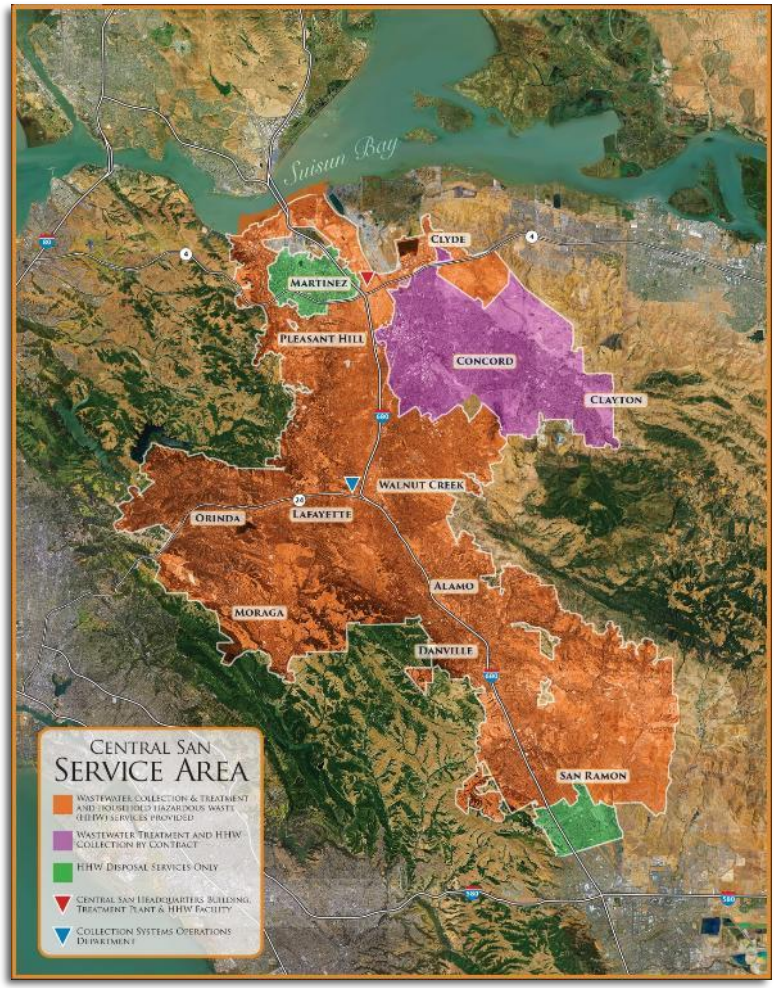
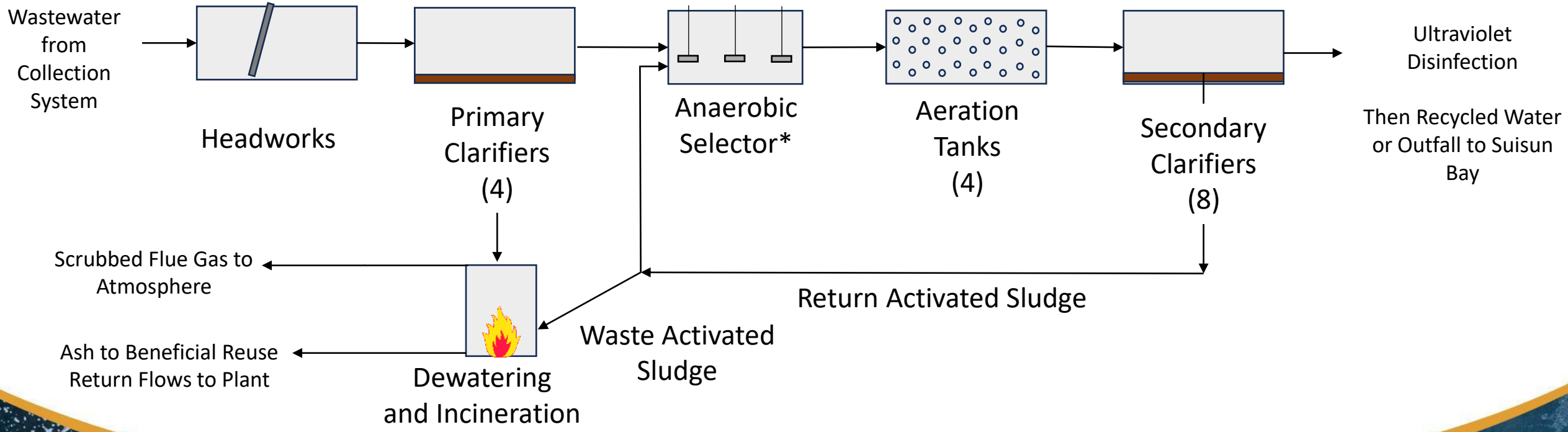
San Francisco
San Jose

Central San Overview



- Nearly 500,000 residents & 15,000+ businesses. No large industrial dischargers.
- 35 million gallon flow per day
- Existing plant about 50 years old
- 26 years of compliance with Wastewater Regulatory Permit
- 1,500+ miles of sewer pipes
- Inspecting, Cleaning, and Maintaining Crews on-call 24-7

Central San Current Wastewater Treatment Plant Secondary Process Flow Configuration



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Existing Treatment Plant Constructed for Carbon Removal

- Conventional activated sludge system with 1.2 day solids retention time (SRT).
- 26 years of National Pollutant Discharge Elimination System Compliance, 1 of 14 agencies nationwide.
- Existing process removes ~20% of influent total inorganic nitrogen (TIN) through solids being incinerated in the Multiple Hearth Furnaces. This converts nitrogen in the solids into nitrogen gas. Central San's existing recycled water program helps customers beneficially reuse nitrogen in landscape irrigation.
- However, biological process cannot further remove TIN without expansion to accommodate high mixed liquor concentrations or process intensification with a new technology.

New Regulatory Limits on Total Inorganic Nitrogen (TIN)

Bay Area Nutrients Watershed Permit

On July 10, 2024, the San Francisco Regional Water Quality Control Board adopted an Order requiring all Bay Area wastewater agencies to seasonally reduce their discharge of total inorganic nitrogen (TIN) by 40%, relative to 2022, effective October 2034.

California Water Boards

Media Release

Regional Water Board adopts permit requiring critical investments to protect San Francisco Bay

Necessary sewage treatment upgrades over next decade will limit threat of 'red tides' that endanger water quality, aquatic species

July 10, 2024 **Contact:** Blair Robertson—Information Officer

OAKLAND – To help protect water quality and aquatic life in San Francisco Bay for generations to come, the San Francisco Bay Regional Water Quality Control Board adopted a permit today that will for the first time require nutrient reductions for all wastewater treatment plants discharging into the bay.

The new permit, adopted under the Clean Water Act after years of monitoring and research, will go into effect Oct. 1. It requires that 40 sewage treatment plants must collectively reduce nitrogen discharges by 40% compared to 2022, when a "red tide" harmful algal bloom (HAB) triggered a massive fish kill in the San Francisco Bay. Nutrients are discharged into the bay from sewage treatment plants' wastewater. Excessive nutrients are a major contributor to HABs, which cause a dramatic depletion in dissolved oxygen levels, killing aquatic species.

Toxins from HABs can cause illnesses through direct contact, inhalation, and fish and shellfish poisoning. HABs can be particularly devastating to indigenous communities and subsistence fishers.

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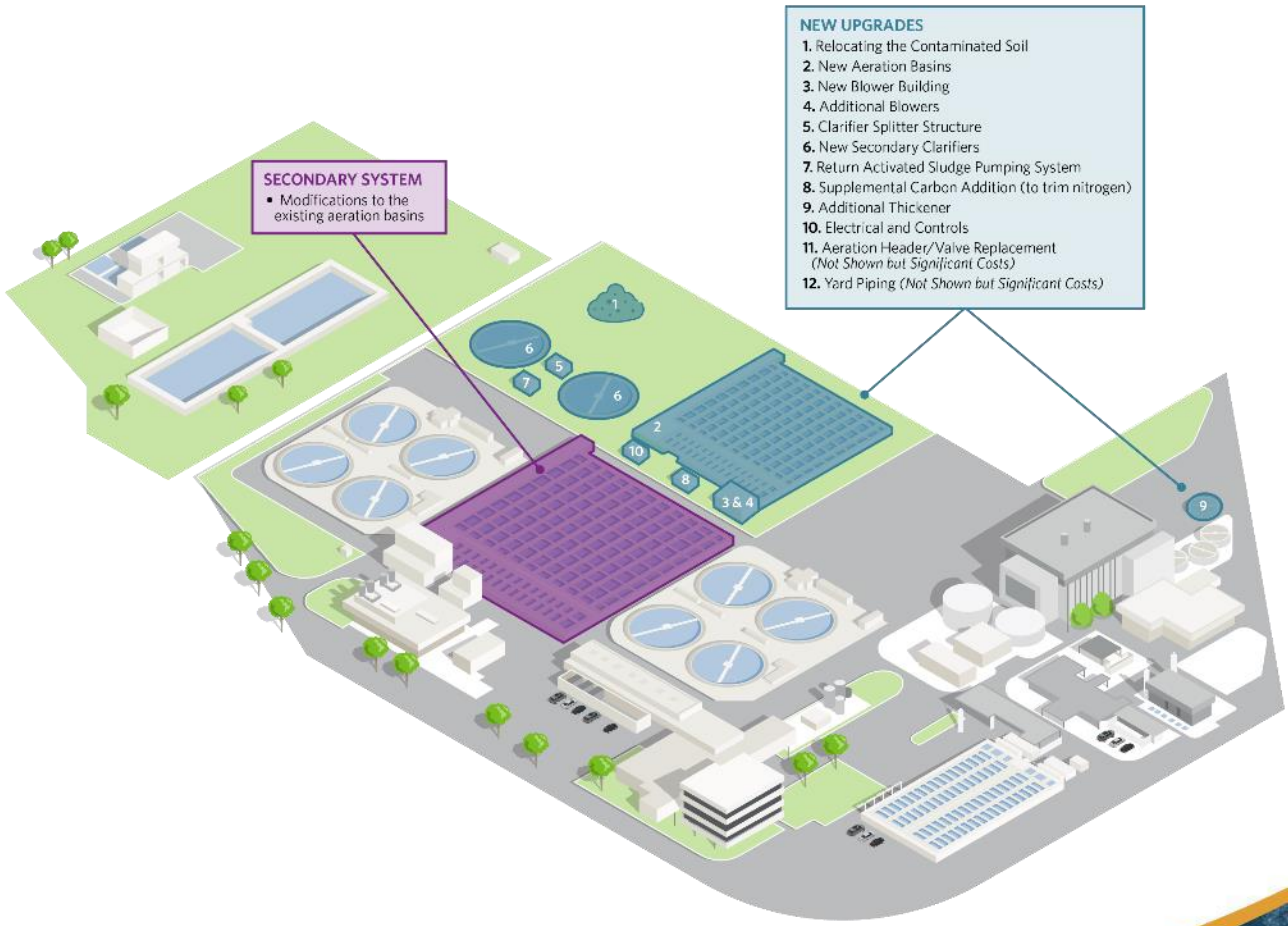
Past Planning Studies Identified Modified Ludzack Ettinger (MLE) as Best Scoring Placeholder for TIN Reduction

- Established and proven treatment process. Increases SRT for slower growing nitrifiers.
- Significant construction effort for contaminated soil relocation/removal and new secondary clarifiers and aeration tanks.
- Placeholder cost is $700+ million for contaminated soil removal, new aeration tanks, secondary clarifiers and supporting electrical/mechanical equipment.



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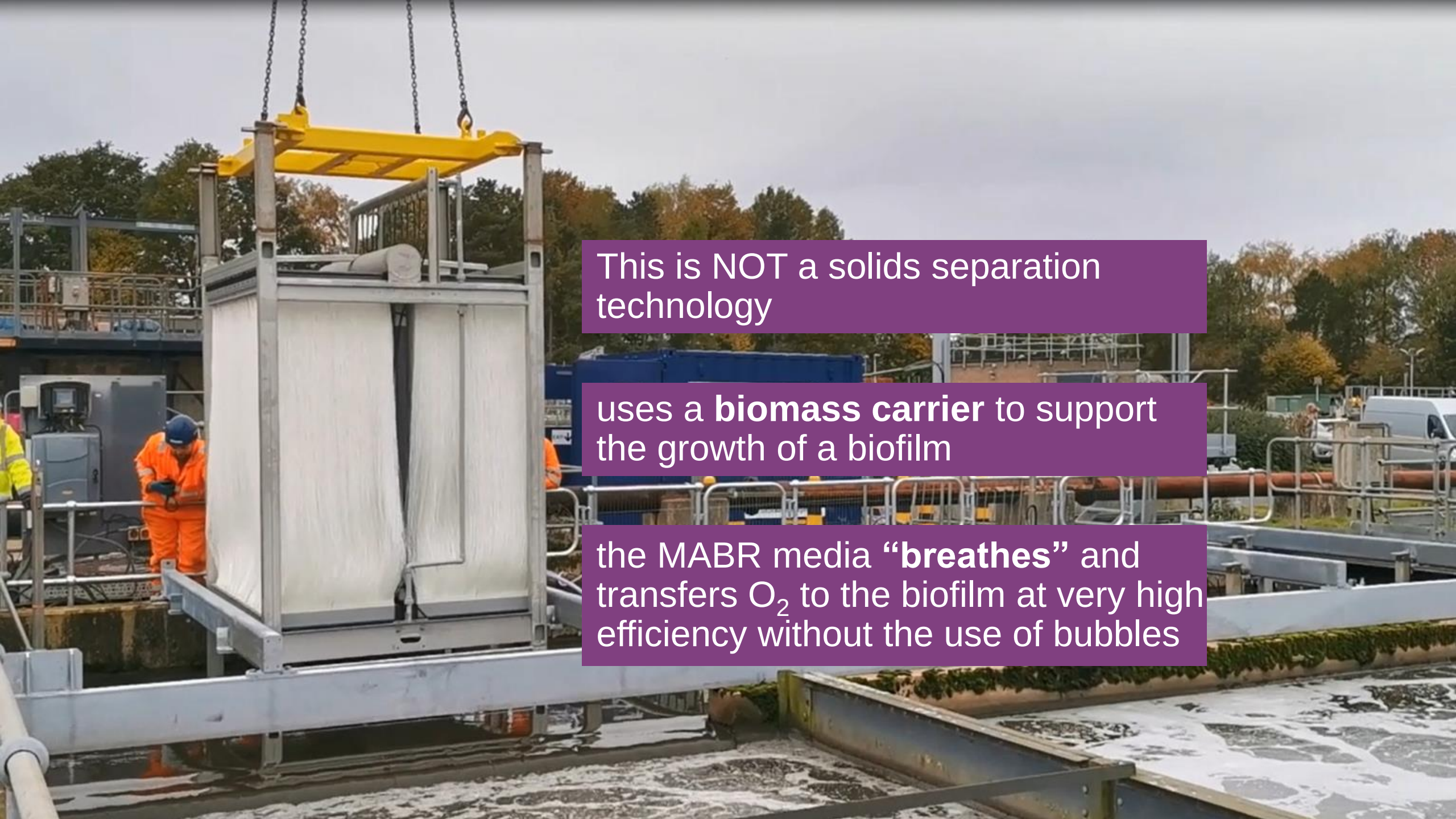
MABR Technology Overview



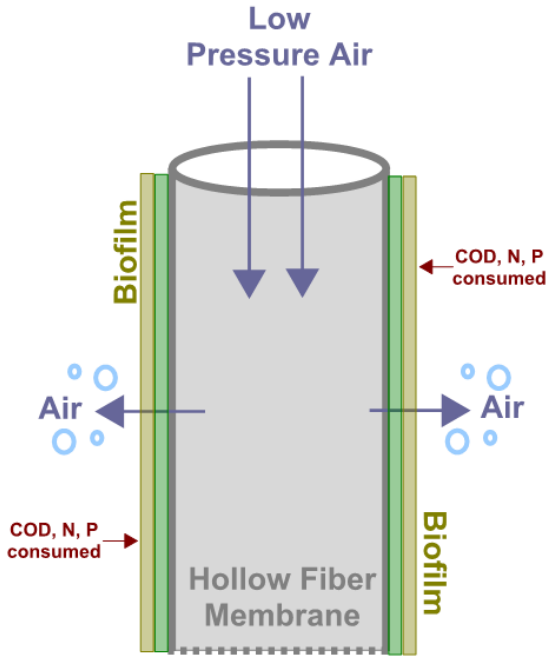
This is NOT a solids separation technology

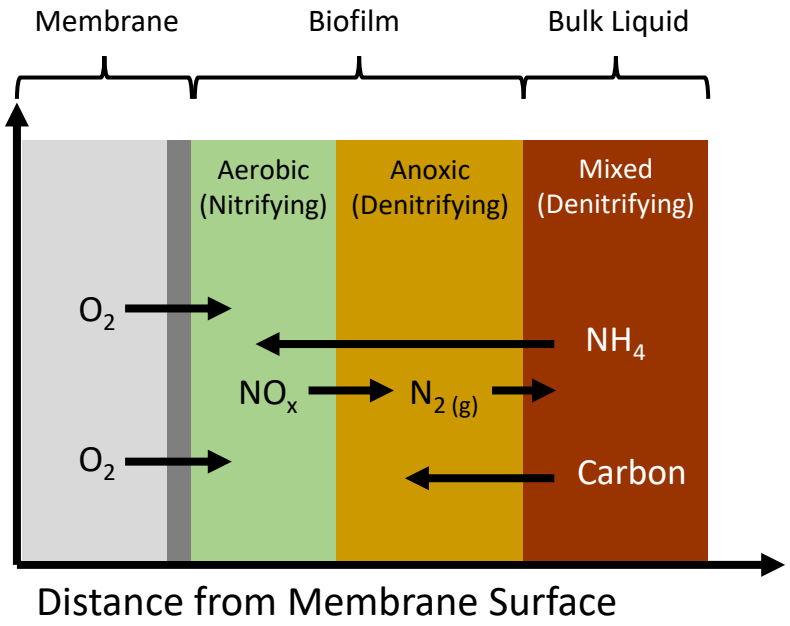
uses a **biomass carrier** to support the growth of a biofilm

the MABR media **“breathes”** and transfers O_2 to the biofilm at very high efficiency without the use of bubbles

MABR Process Intensification Technology Overview

- Membrane cassettes placed into an unaerated zone. Air flows through the membrane inside and diffuses outwardly. The membrane surface serves as a medium to foster biofilm growth.
- This biofilm bacteria attached to the cassettes use nitrogen as food (unlike Central San's current bacteria population). Therefore, the biofilm provides nutrient removal capacity without adding aeration basins/ clarifiers.

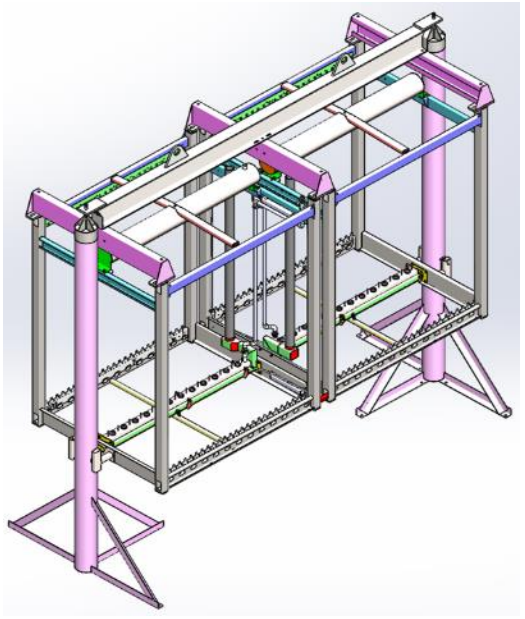




MABR Deployment Methods

beam mount

wall mount

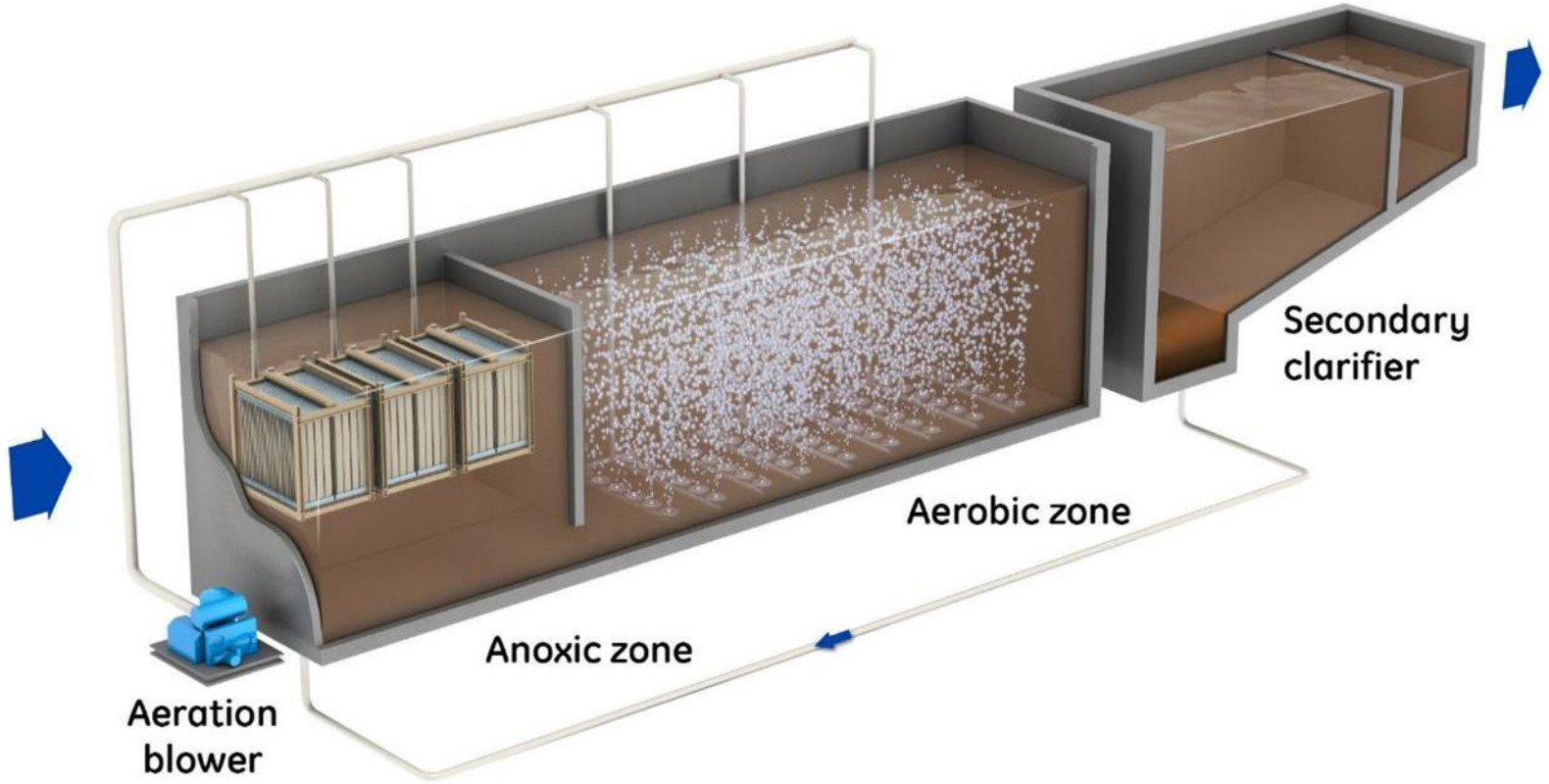


floor mount

steel tank

Example MABR Treatment Train

- Increased biomass inventory in existing volume enables: (i) nutrient removal & (ii) an increase in treatment capacity
- First MABR Installation in the United States was in 2017. **This is the first time we are aware of a pilot project where the SRT of the main plant was unchanged.**

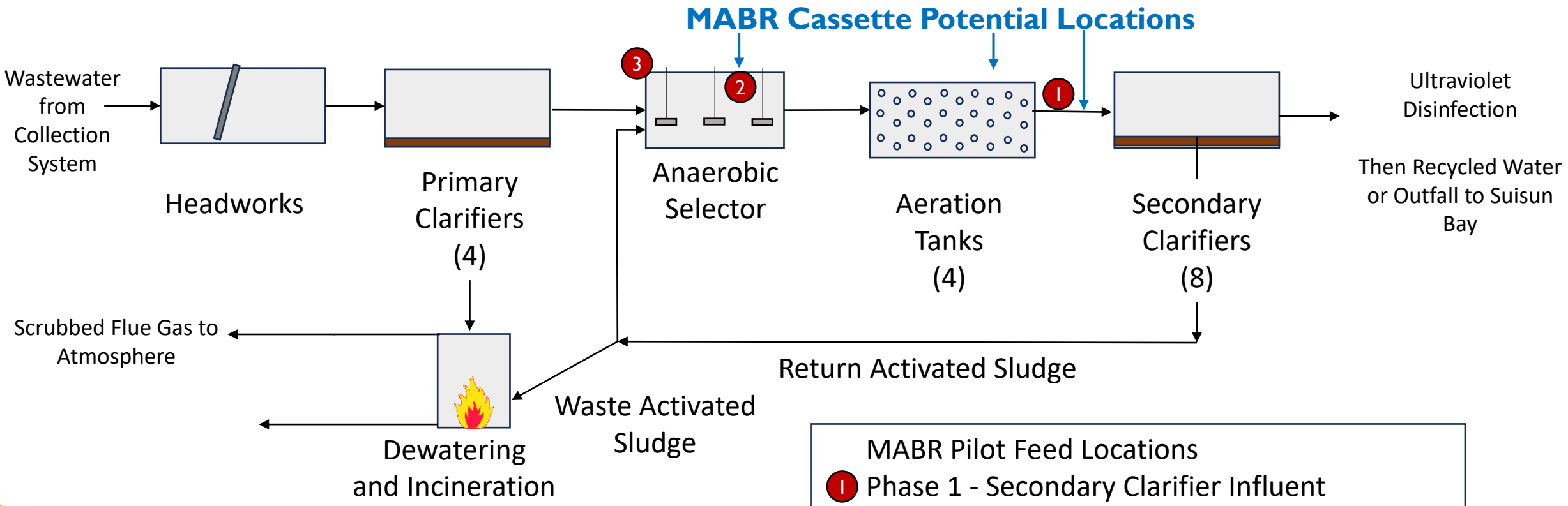


Pilot Project Questions and Equipment

MABR Pilot Results Key Questions

- Can nitrogen removing bacteria live on the MABR when being fed with Central San bacteria that do not remove nitrogen?
- Can the nitrogen removing bacteria grow in the presence of cyanide from the incinerator air pollution control equipment?
- Can biofilm thickness control equipment mitigate high sCOD feed water?
- Will nitrogen removal rate be similar at Central San to treatment plants that already remove nitrogen?

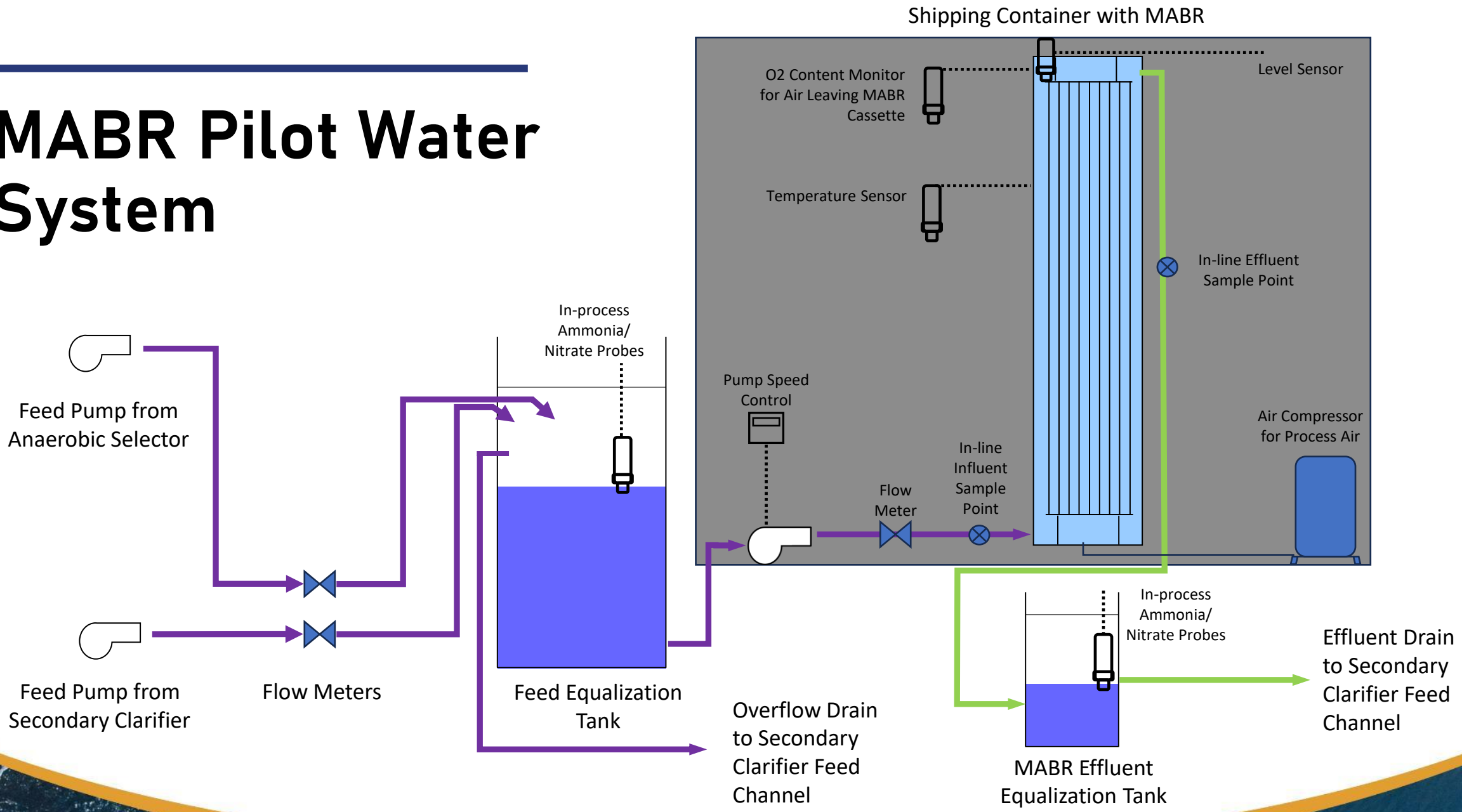
MABR Pilot Influent Water Locations



Pilot Testing Phase Description

Phase	Difficultly	TIN (i.e. food for nitrifying bacteria)	Bioavailable Soluble Carbon for Nitrate Removal	Cyanide	Existing Plant Mixed Liquor (1.2-day SRT)?
1. Secondary Clarifier Influent	"Easier"	Good	None	None	Yes
2. Anaerobic Selector	"More Challenging"	Better	Good	Typical for Treatment Plant	
3. Anaerobic Selector + Extra Primary Effluent	"Most Difficult"	Best	Better, but maybe too much?	Above Typical for Treatment Plant	

MABR Pilot Water System



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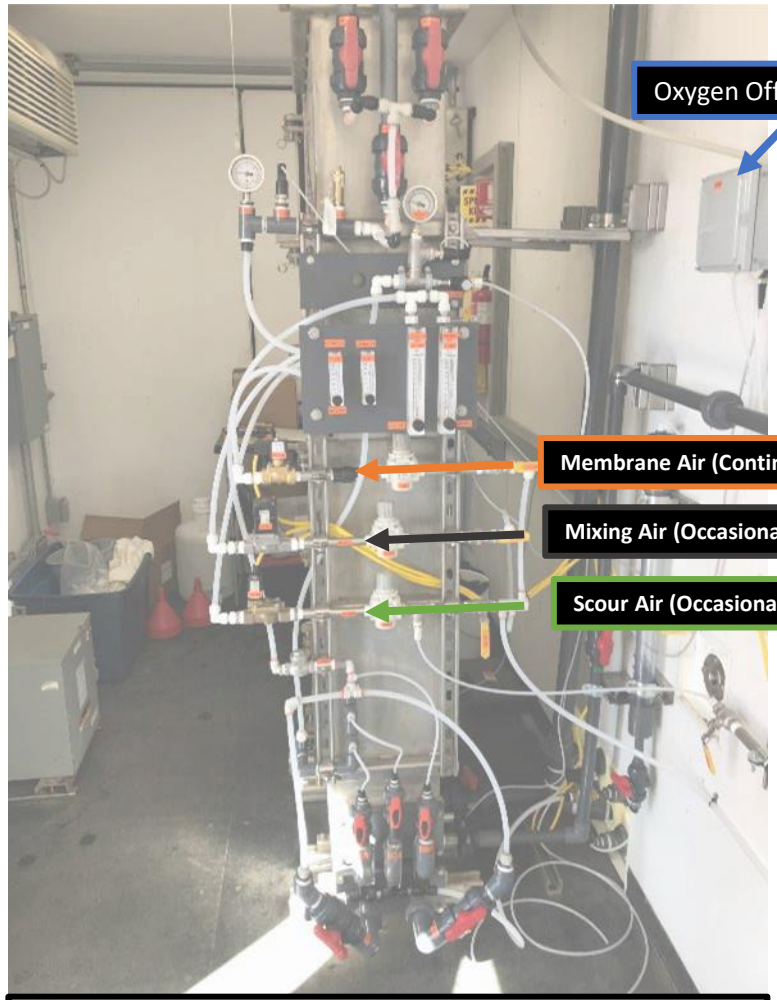
MABR Pilot Air System

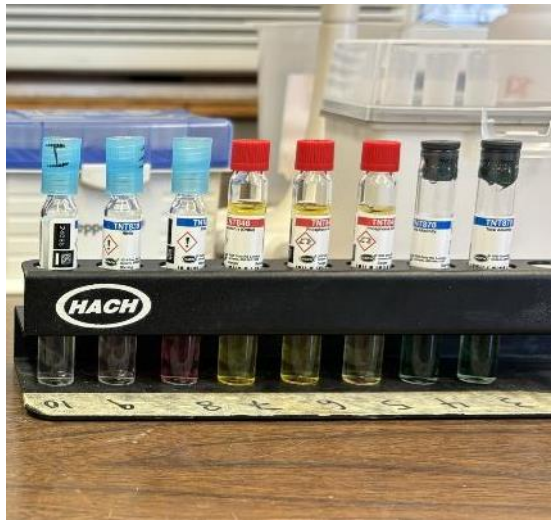
Membrane	Air goes in and out of membrane. Oxygen diffuses to biofilm. No air contact with water.
Mixing	Air occasionally bursts from bottom of tank through water to keep tank well mixed and help control biofilm growth.
Scour	Once per day air burst from bottom of tank for 5 minutes to help control biofilm growth.
Oxygen Off-gas Sensor	Measures % Oxygen in the Membrane Off-gas air to track transfer efficiency. Less % Oxygen in the off-gas means more went to biofilm.

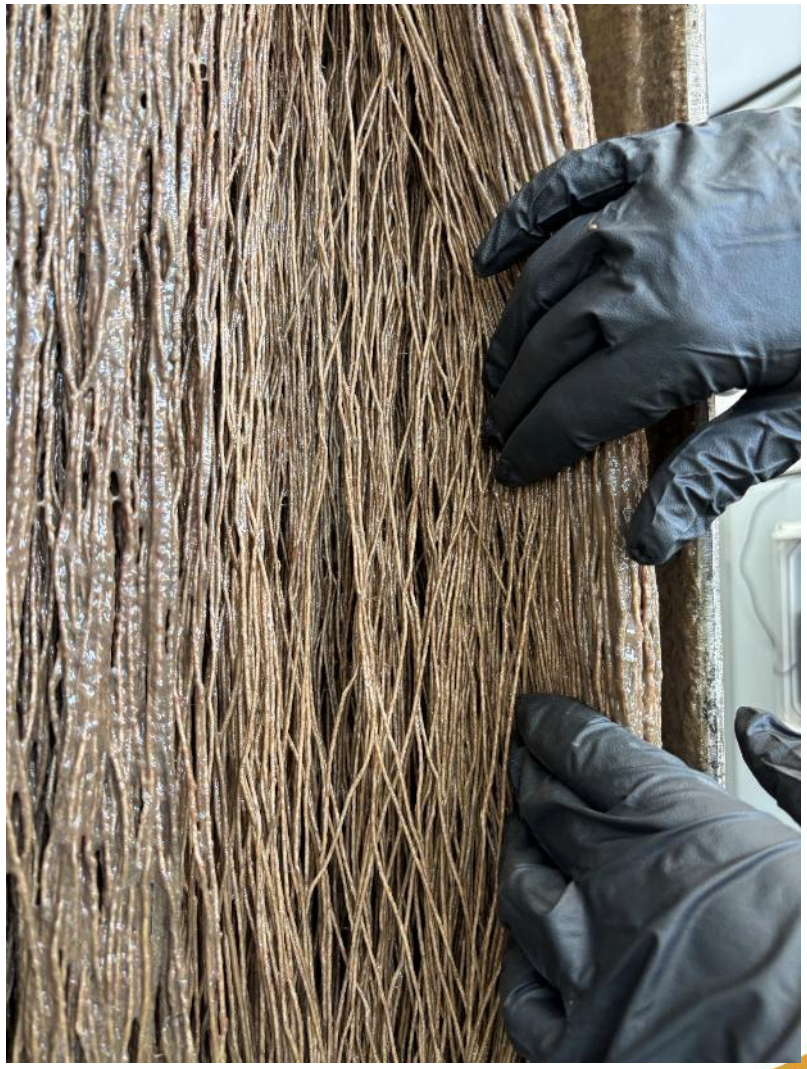


Note: Air for pilot system travels through small flexible piping and enters in bottom of tank. Routes to be shown during tour.

Data Collection

- Daily sampling using test kits
- Online instruments included flow meters and probes to capture 24/7 data on off gas oxygen content, influent and effluent ammonia and nitrate.





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Pilot Installation February/March 2024

Central San's Project Team

Consultant Project Team

Mike Falk, P.E., Ph.D

HDR, Inc. (Lead Consultant)

VEOLIA

Equipment Vendors

Paul Pitt, P.E., Ph.D, BCEE

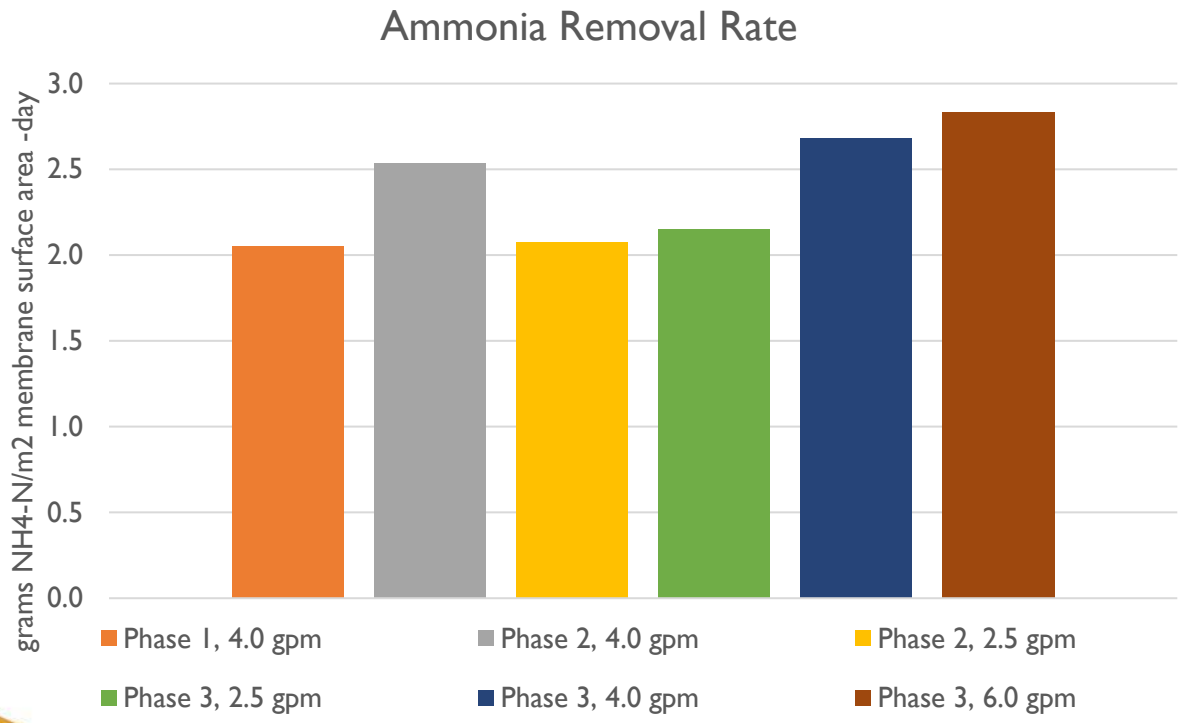
Hazen and Sawyer (Peer Review)

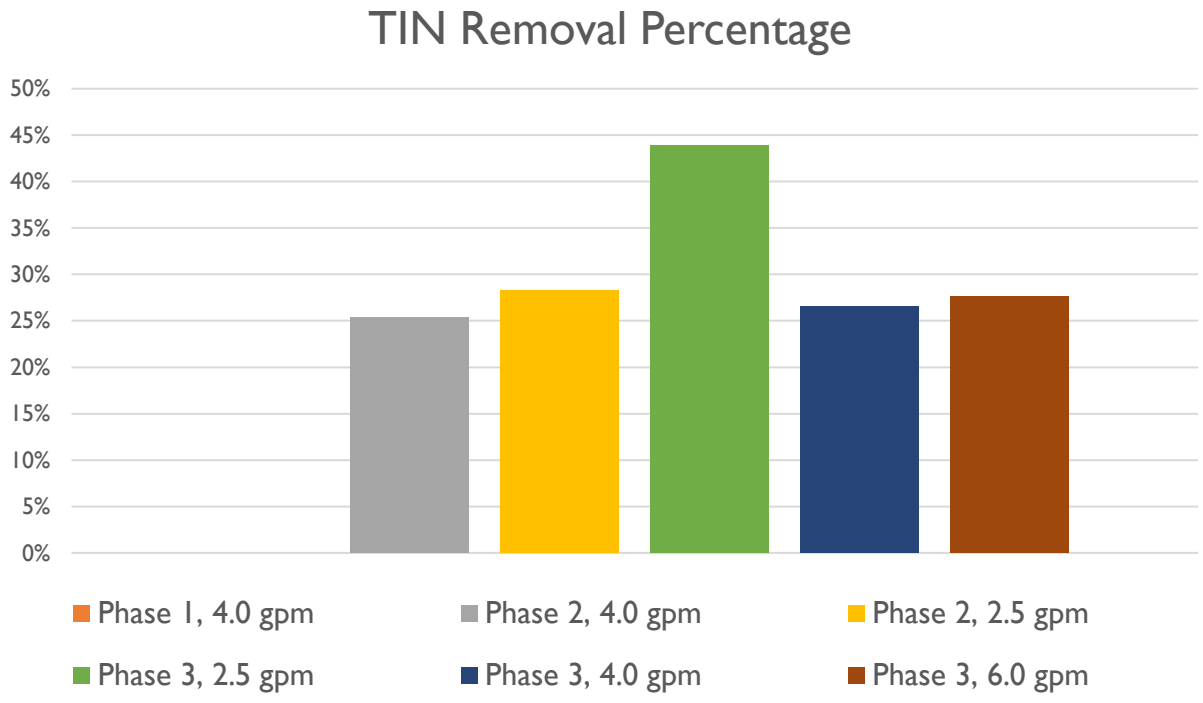
Glen Daigger, P.E., Ph.D, BCEE NAE

One Water Solutions, LLC (Peer Review)

Pilot Results

Ammonia and TIN removal dependent on influent ammonia and available carbon





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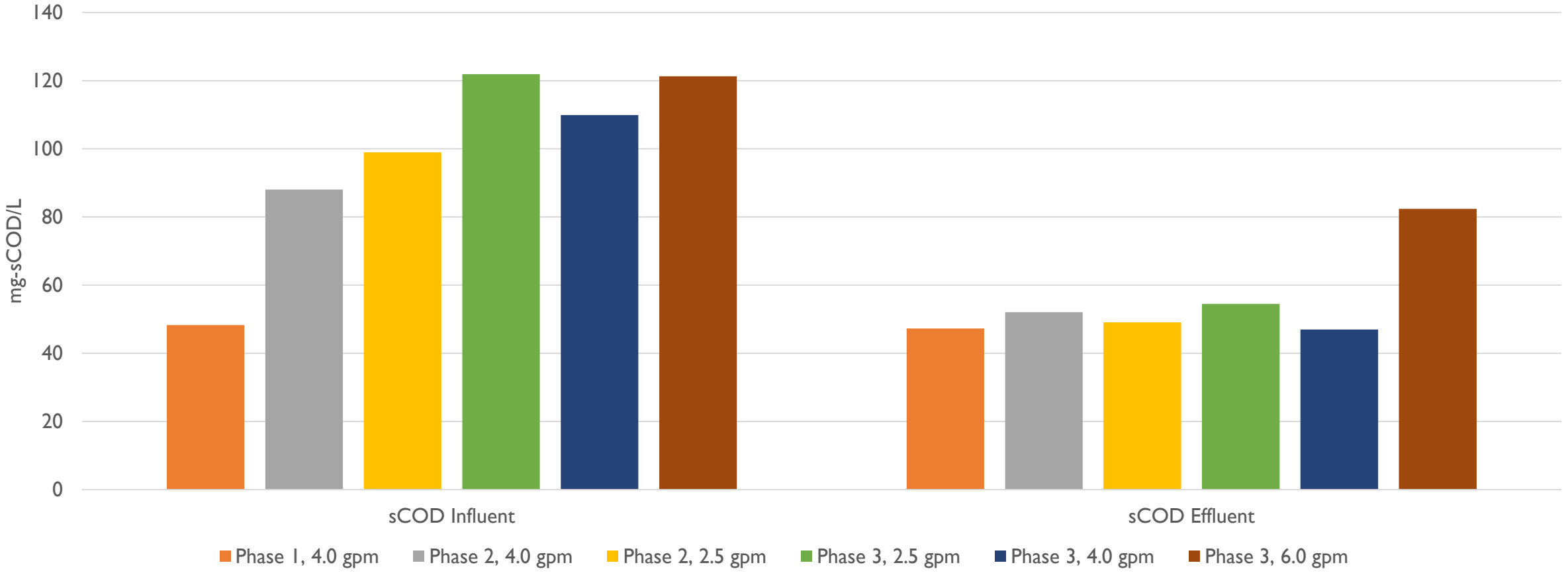
sCOD limiting in all but final test phase. Biofilm shown to efficiently utilize it.



Biofilm Visual Inspection

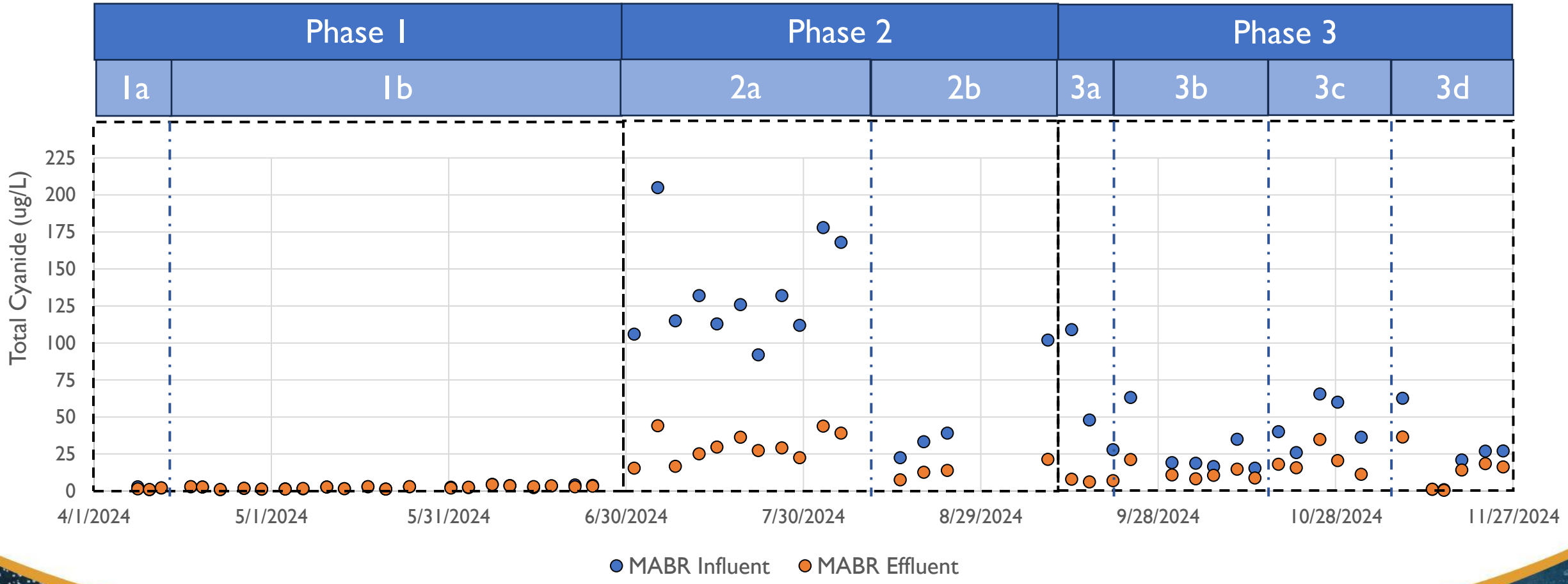
Day 0

May 15th - Mid
Secondary Clarifier Feed

Oct 10th - Early
Phase 3- Selector + PE

Nov 8th - Late Phase
3- Selector + PE

MABR Pilot Influent/Effluent Cyanide Data



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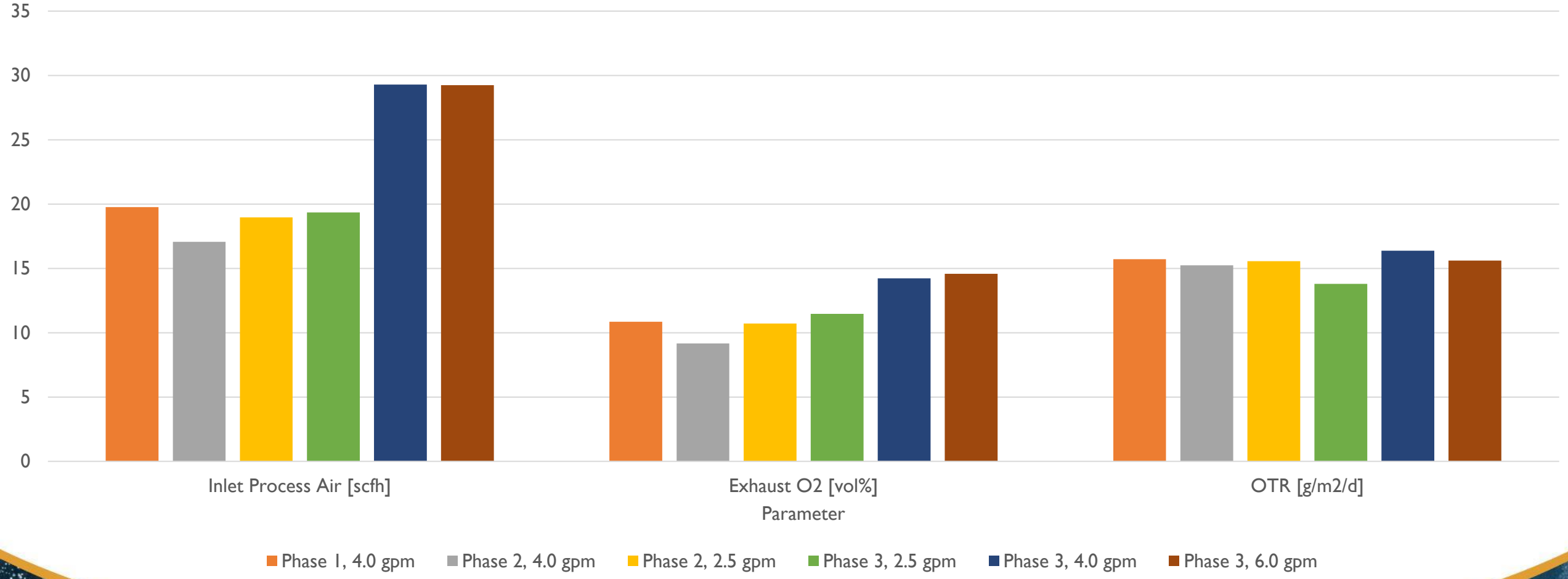
MABR Off-gas Data suggests efficient oxygen transfer



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Next Steps

MABR Pilot Results Are a Building Block of the Nutrient Management Project

CWEA MABR Tour September 26, 2024 at Central San

- 85 operators and engineers from local treatment plants and consultants from across the Bay Area registered for the tour and presentation.
- They were excited to learn about the MABR pilot project and asked many interesting questions.

CWEA San Francisco Bay Section Dr. Jenkins Research Achievement 2024

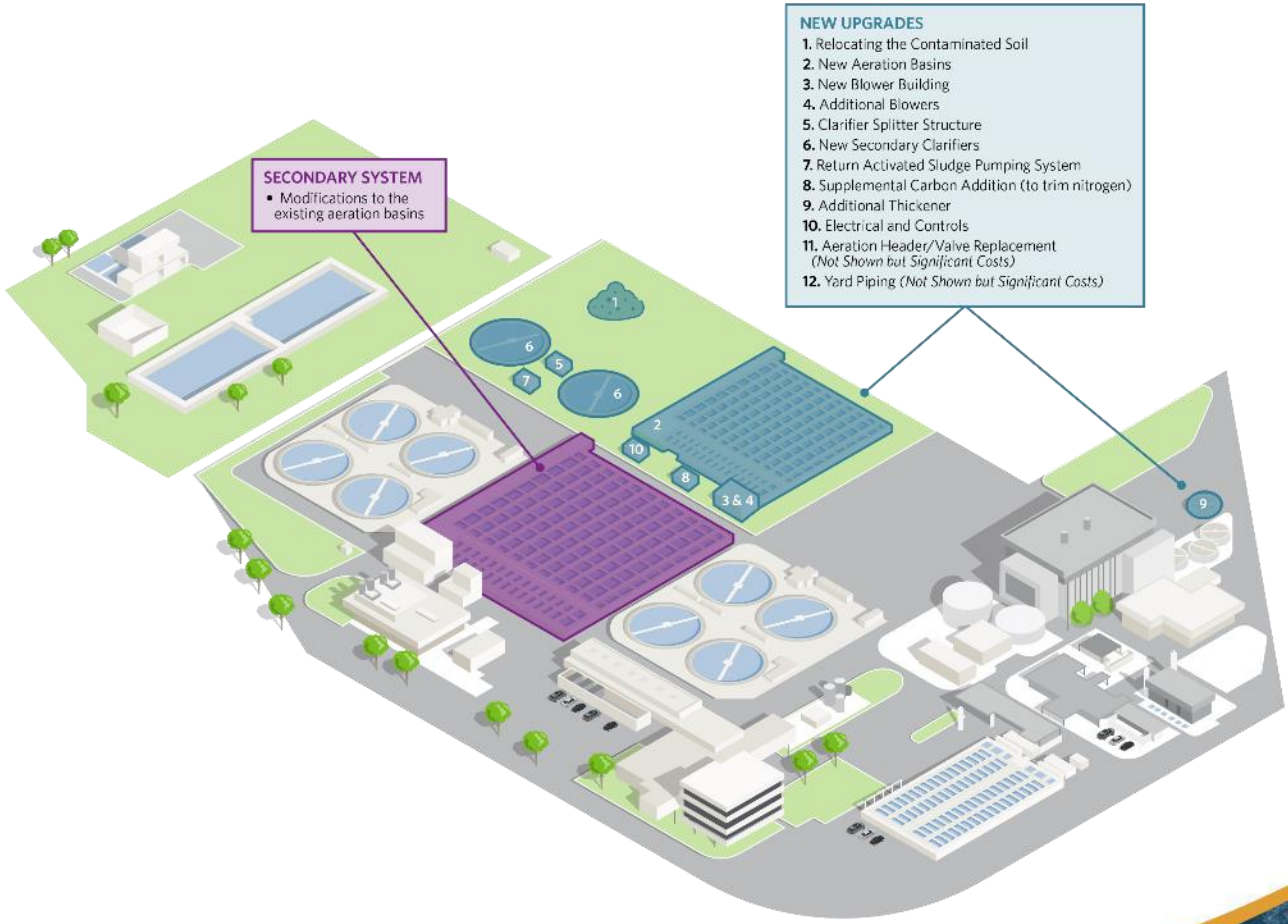
MABR Pilot Results are Promising for Central San

Initial Pilot Questions:

- ✓ Can nitrogen removing bacteria live on the MABR when being fed with Central San bacteria that do not remove nitrogen?
- ✓ Can the nitrogen removing bacteria grow in the presence of cyanide from the incinerator air pollution control equipment?
- ✓ Can biofilm thickness control equipment mitigate high sCOD feed water?
- ✓ Will nitrogen removal rate be similar at Central San to treatment plants that already remove nitrogen?
- ? Will the pilot results translate at full-scale? This is a cutting edge and unproven application of this technology.
- ? What is the full-scale installation cost?
- ? What are other considerations including system N20 emissions?

Full-scale MABR Testing planned during upcoming renovation of one of four existing aeration tanks

- Full-scale testing will continue addressing the process related questions from the pilot test.
- And ultimately inform if intensification with MABR is a better alternative than the $700 million conventional expansion with MLE.
- Intriguing technology with
  - High energy efficiency
  - Maximize value of existing tankage
  - Faster and less expensive than new tank construction



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Questions