WWTP Side Stream Treatment of Nutrients – Considerations for City of Raleigh's Bioenergy Recovery Project

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Acknowledgements

Topics for Today's Presentation

1. Side Stream Treatment Overview
    - What is side stream treatment?
    - Different types of side stream treatment systems
2. Side Stream Treatment Planning for City's Bioenergy Recovery Project
    - Bioenergy Recovery Program overview (Quick Recap)
    - Drivers for side stream treatment at NRRRF
    - Process considerations for treating high strength filtrate
    - Side stream treatment systems considered
    - LIFT SEE IT site visit of short-cut nitrogen removal systems
    - Next Steps

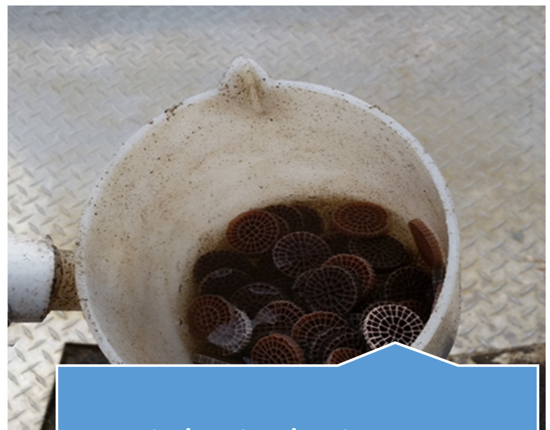
Side Stream Treatment Overview

What is Side Stream Treatment?

- Separate treatment of solids handling recycle streams
- Lessen impacts of recycle nutrient loads on main treatment process
  - Small volume, high nutrient load
  - Intermittent solids handling operations can impact peak loads
  - Potential to impact main stream nutrient removal process
    - Ammonia break through
    - Increased air demands
    - Increased chemical demands
    - Variable performance

Different Types of Side Stream Treatment

Equalization

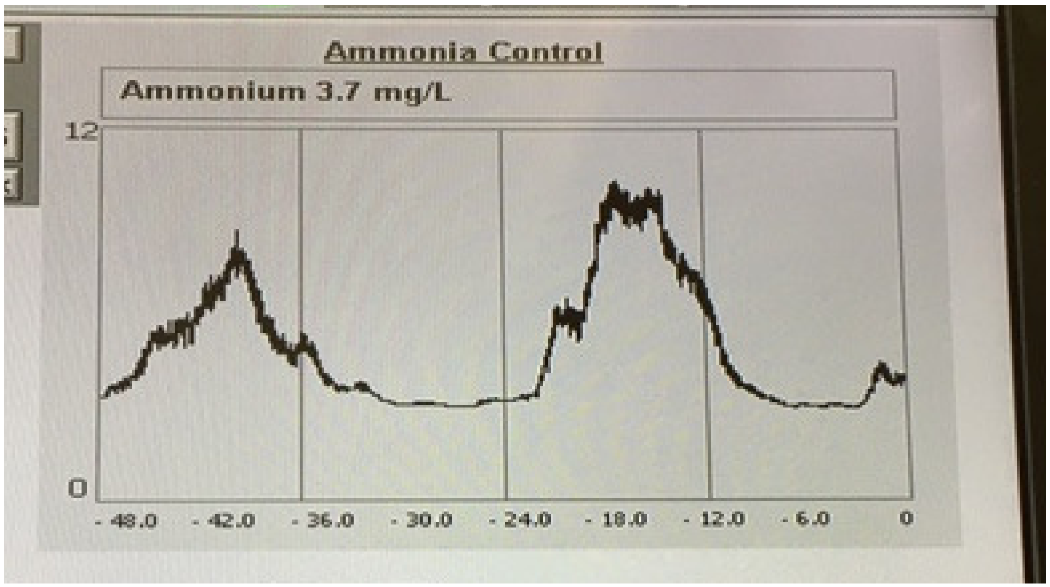


Biological Nitrogen Removal Systems

Chemical Phosphorus Removal or Phosphorus Recovery System

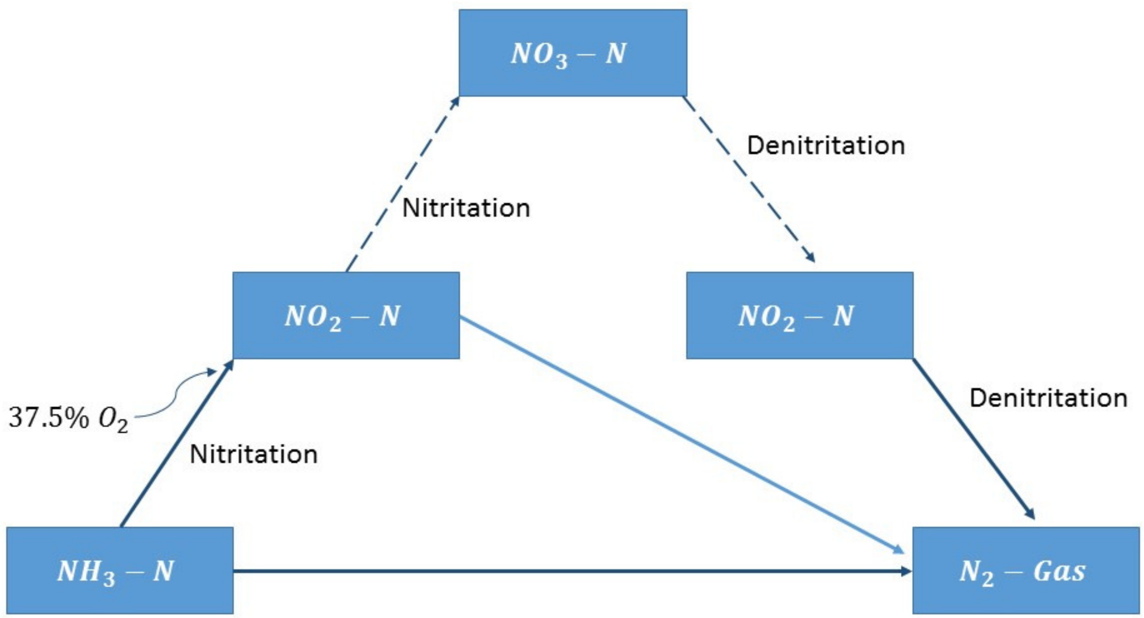
Equalization

- **Attenuate flows and/or loads from solids handling operation**
  - **Reduce potential for ammonia break through**
  - **Reduce fluctuations on air demands**
  - **Reduce fluctuations on supplemental carbon demands**



Side Stream Short-Cut Nitrogen Removal

- **Biologically treat nitrogen in side stream treatment process**
- **Often use "Short-Cut" nitrogen cycle**
  - **Reduce air required**
  - **Reduce / eliminate carbon**
  - **Several different systems available**



Side Stream Phosphorus Removal

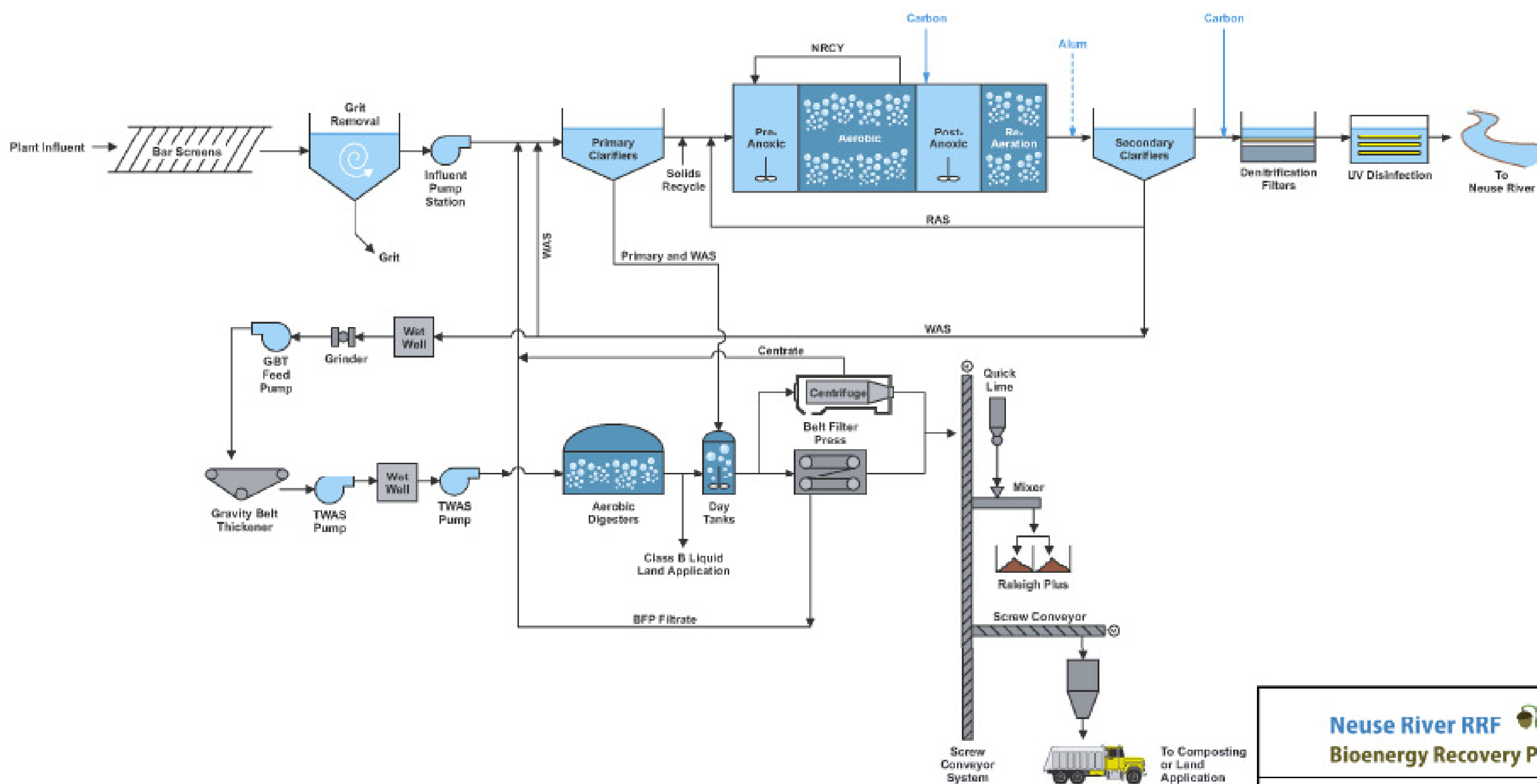
- **Add coagulant for chemical phosphorus removal**
- **Or utilize process to recover phosphorus**
  - **Add chemicals to produce struvite in controlled environment**
  - **Obtain phosphorus rich product that can be used as fertilizer**
  - **Several different systems available**

Side Stream Treatment Planning for Bioenergy Recovery Project

Neuse River Resource Recovery Facility

- Currently expanding from 60 to 75 mgd
- Planning for expansion to 90 mgd (~ 2040)
- Centralized biosolids processing
  - Lime stabilization, composting, and some Class B liquid land application
- Converting to advanced digestion (Thermal Hydrolysis)
- Includes side stream nitrogen removal for Phase 1

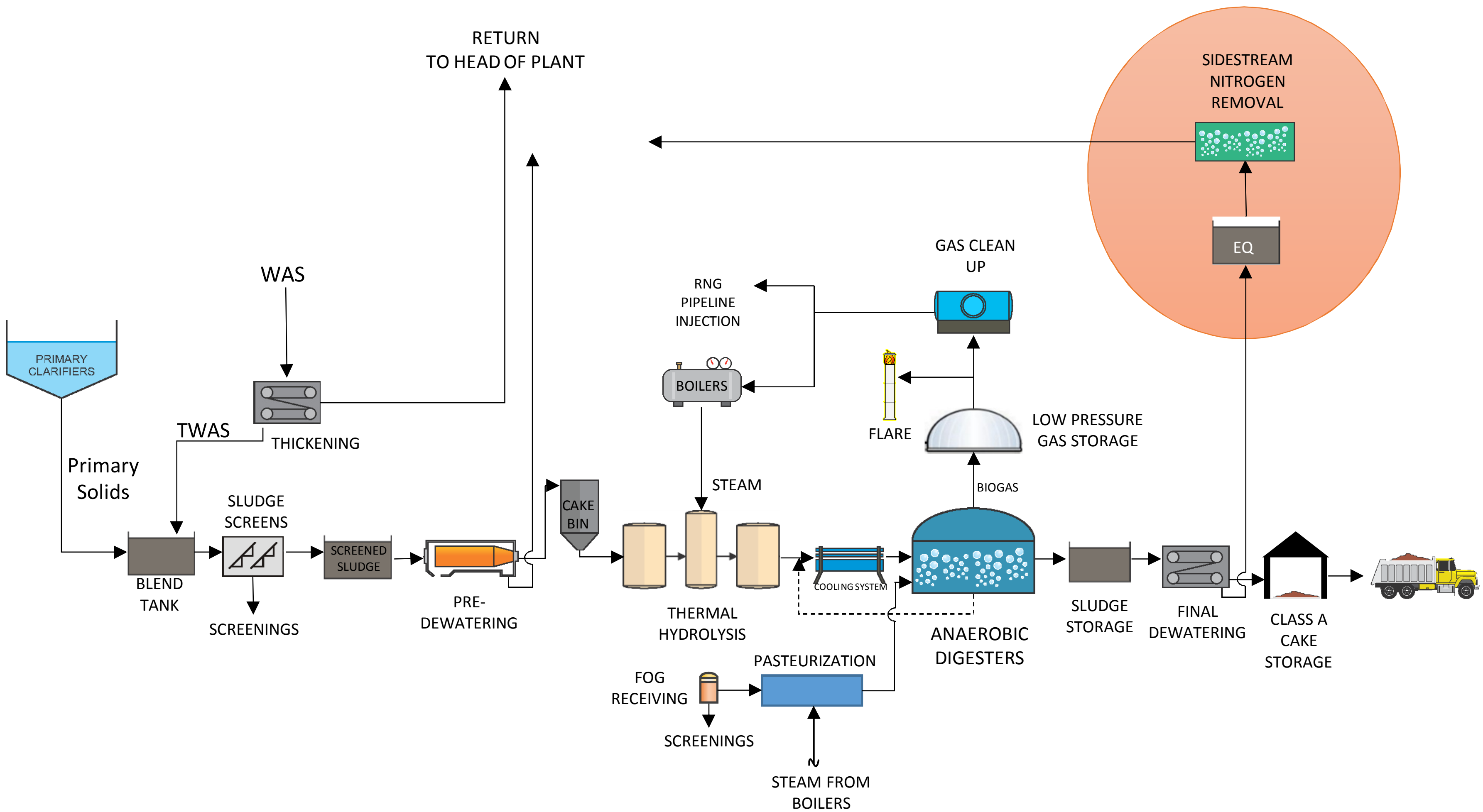
NRRRF Existing Process Flow Diagram



Neuse River RRF
Bioenergy Recovery Program

EXISTING
PROCESS FLOW DIAGRAM
FIGURE 1-1

Proposed Biosolids Process



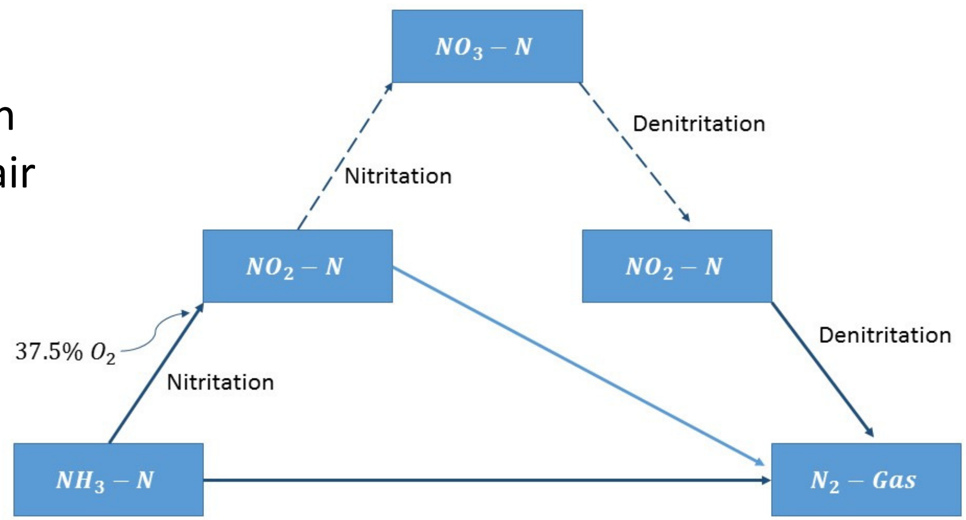
Visualization of the New Residuals Handling Complex (30-Percent Design Concept)

Side Stream Treatment - Drivers

Drivers for Side Stream Nitrogen Removal

- **Improved VSR across digestion increases nutrient mass loadings in the sidestream. (+20%)**
- **Deammonification offers a reduced energy and reduce carbon pathway for nitrogen removal.**
  - **~$600,000 additional O&M costs to treat in main stream process at current flows and loads**

✓ No Carbon
✓ 60% less air



Drivers for Side Stream Phosphorus Removal

- **Improved VSR across digestion increases nutrient mass loadings in the side stream**
  - **Increased risk for struvite precipitation**
  - **Opportunities for P recovery**
- **Side stream TP loads signficantly lower with chemical P vs. biological P removal**
  - **Plan to stay with chemical P removal for now at NRRRF**
  - **Provisions for side stream alum addition at multiple locations**
- **Site layout allows for space for future phosphorus recovery**

Description	50% Ultimate	Ultimate	Side Stream TP Concentration (mg/L)
Side Stream TP Load with Chemical P Removal (lbs/day)	240	470	94
Side Stream TP Load with Biological P Removal (lbs/day)	710	1,420	284

Process Considerations for Treating High Strength Filtrate

NRRRF Projected Side Stream Loads

- **TKN and NH_4 loads from BioWin Modeling, mass balance, and literature**
- **BOD, COD, CODs, Alkalinity values estimated from literature and other facilities**
- **Ultimate design based on 90 MGD Design Flow (2040)**
  - **Install 1 train designed to treat 50% of ultimate (90 MGD) load now**
- **1x Dilution Water – Necessary for effects of high COD in THP Effluent**

Description	50% Ultimate	Ultimate	Diluted Conc (mg/L)
Sidestream Flow (mgd)	0.15	0.30	
Dilution Water Flow (mgd)	0.15	0.30	
TKN (lb N/day)	3,375	6,750	1,350
NH_3 (lb N/day) (85% of TKN)	2,869	5,738	1,150
BOD (lb/day)	125-1,000	250-2,000	50 – 400
COD (lb/day)	7,874	15,748	3,150
CODs (lb/day)	6,750	13,500	2,700
TSS (lb/day)	1,751	3,503	700
Alkalinity (lb/day)	10,125	20,250	4,050

THP Digestate Challenges

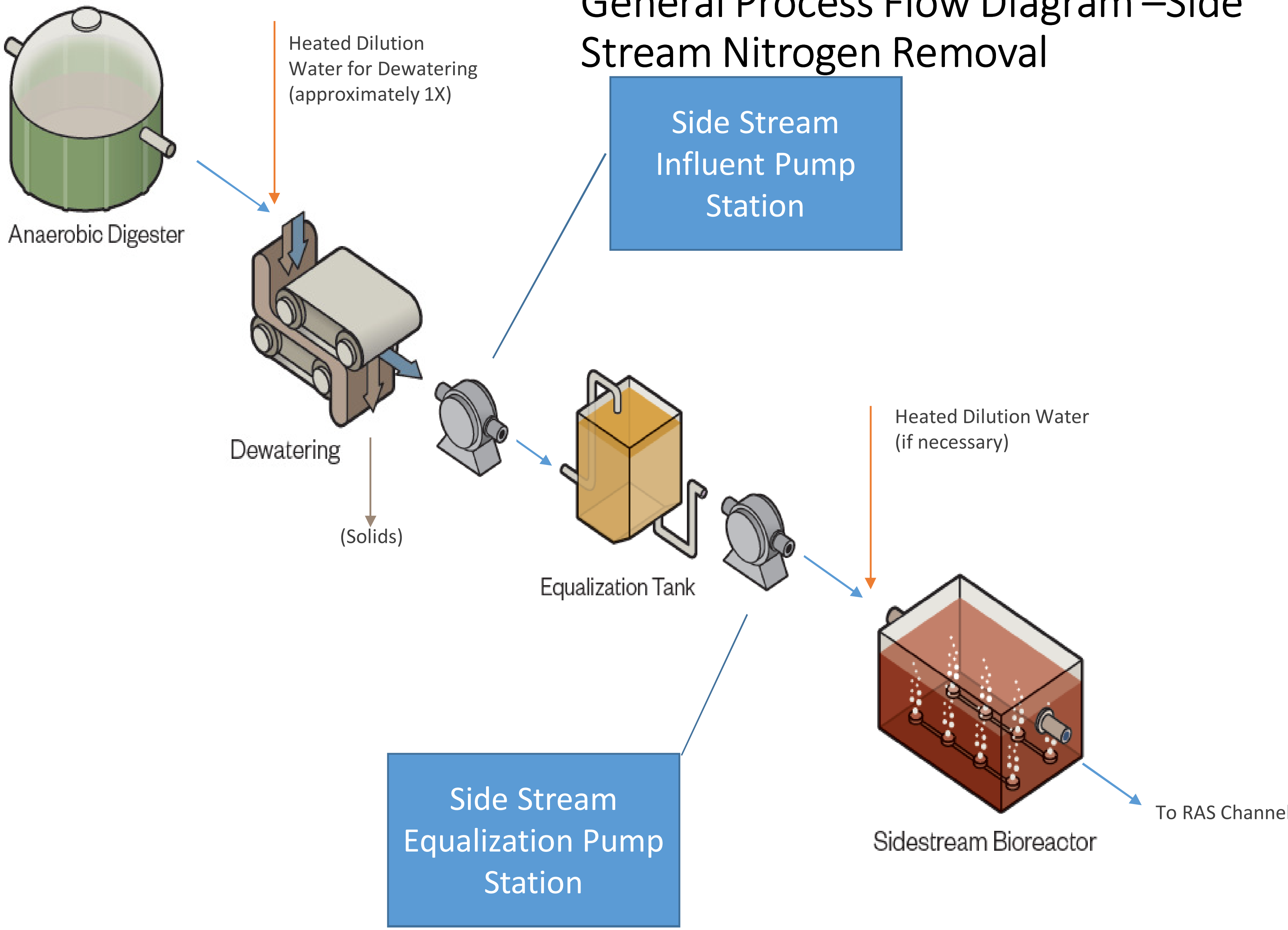
High TKN	• Potential to inhibit AOBs • Alkalinity and NH_3-N balance
High COD	• Potential to Inhibit AOBs • Increased competition between annamox and heterotrophs
High TP	• Increased risk for struvite formation
Other Potential Challenges	• Elevated TSS • Elevated Polymer • Diffusion Limitations

Example Short-Cut Nitrogen Removal "Process Enhancement" Strategies

Dilute filtrate (≥1:1)	• Reduce AOB inhibition to high ammonia and COD (Figdore et al, 2011)
AOB in suspension; annamox on media (ANITA™ Mox IFAS configuration)	• Improve substrate diffusion (Zhao et al)
Higher operating DO	• Reduce oxygen diffusion limitation (Zhang et al, 2016)
Better annamox selection	• Increase annamox retention (Zhang et al, 2016)
Pretreat filtrate	• Reduces struvite potential; reduces annamox competition (Remy et al, 2016)

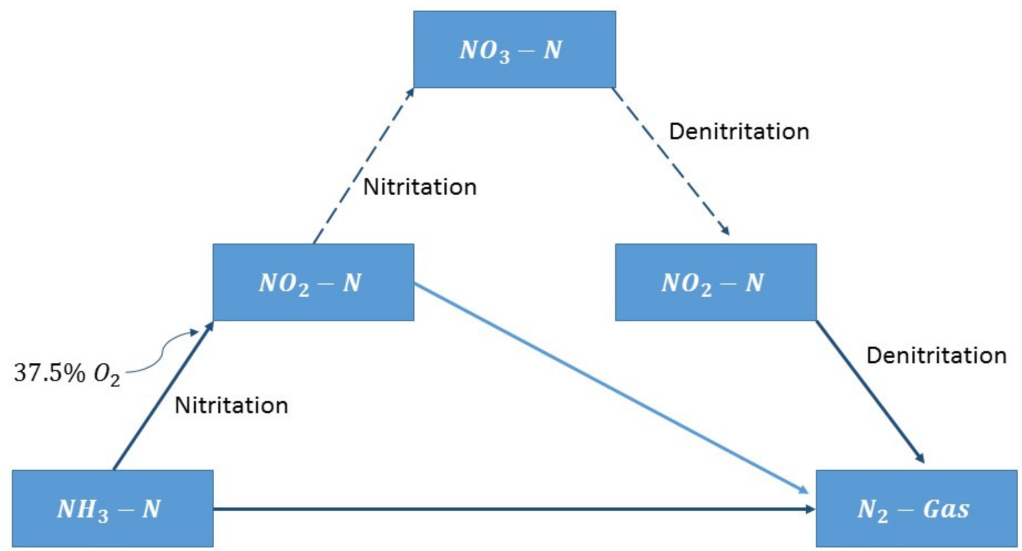
Proposed Side Stream Treatment Systems for NRRRF

General Process Flow Diagram –Side Stream Nitrogen Removal



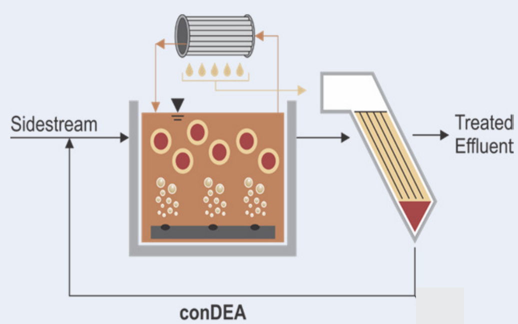
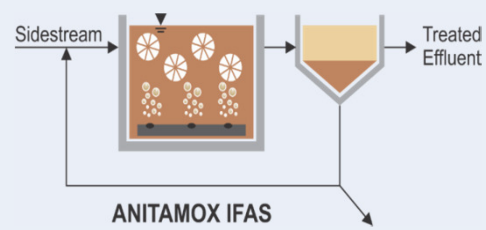
Side Stream will use Deammonification

- **Short-Cut Nitrogen Removal**
- **Ammonia Oxidizing Bacteria (AOB)**
  - **Aerobically convert ½ of ammonia to nitrite**
- **Anaerobic Ammonia Oxidizing Bacteria (annamox)**
  - **Oxidize ammonia under anoxic conditions**
  - **Utilize nitrite as oxygen source**
- **No carbon needed**
- **Some residual NO_3-N**



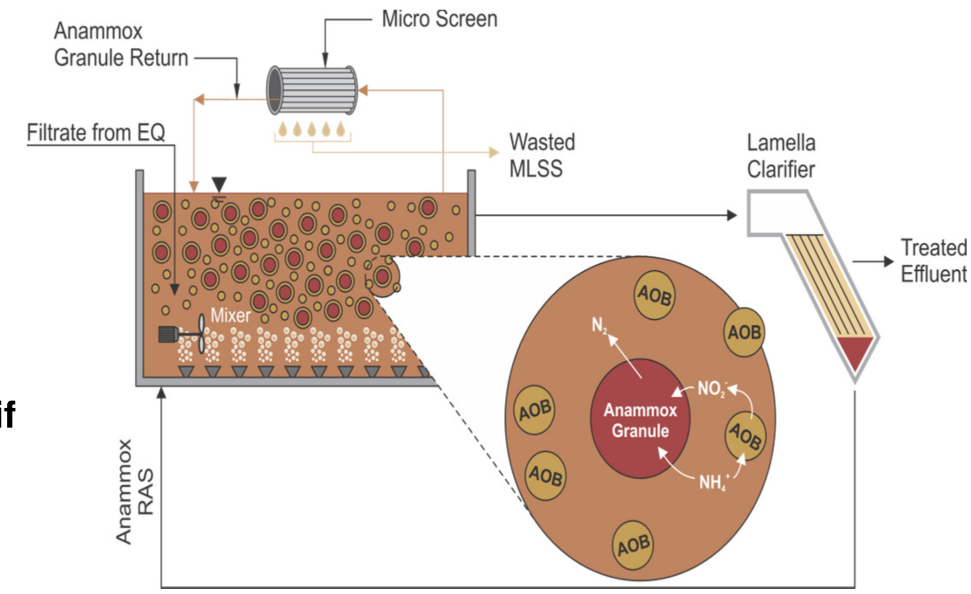
Deammonification Technologies Considered

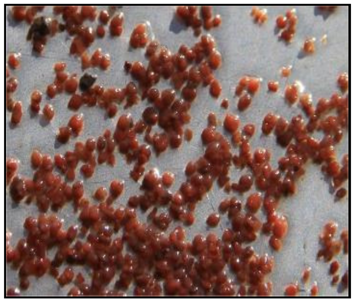
- **Two Recommended from PER**
  - **World Water Works conDEA™**
  - **Kruger ANITA™ Mox IFAS**

	WWW conDEA™	**Kruger ANITA™ Mox IFAS**
Reactor configuration	Flow Through	Flow Through
Biomass characteristic	Flocs and granules	Biofilm on media and flocs (IFAS)
Proprietary retention strategy	Micro-Screen and Lamella Plate Settlers	Plastic carriers, screens, and clarifier
Process Diagram		

World Water Works conDEA™

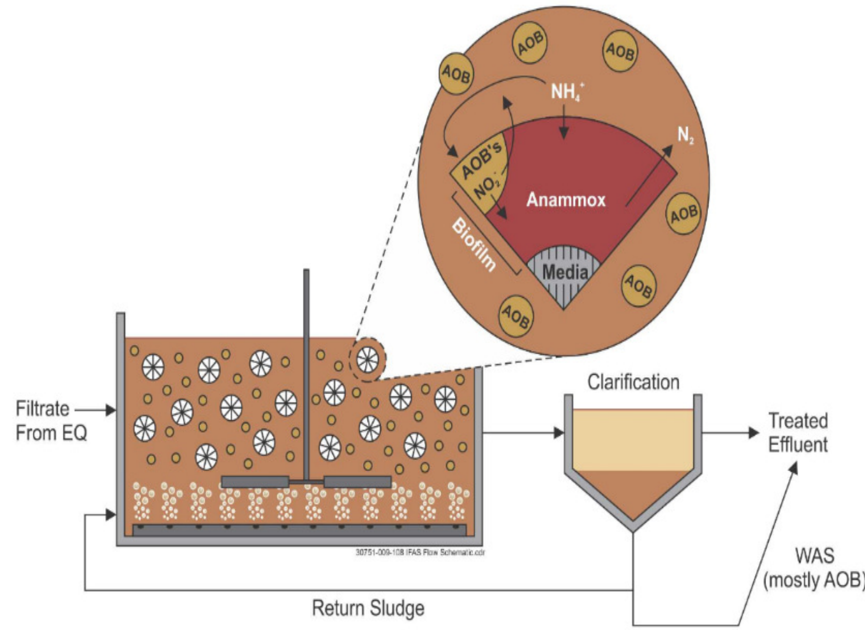
- **Continuous flow through process**
- **Annamox bacteria suspended in granular form**
- **MicroScreen is use to retain anammox and waste NOB**
  - **Selects for large annamox granules**
  - **100% of flow can best through screen if clarifier upset**
- **Messner Panel Aeration (Fine bubble)**
- **New Lamella clarifier for solids separation**
- **Strass is running with MicroScreen configuration**
- **No US installations yet using revised configuration**

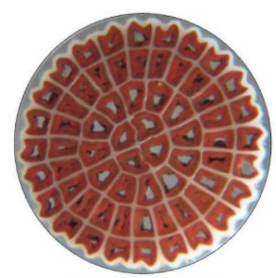




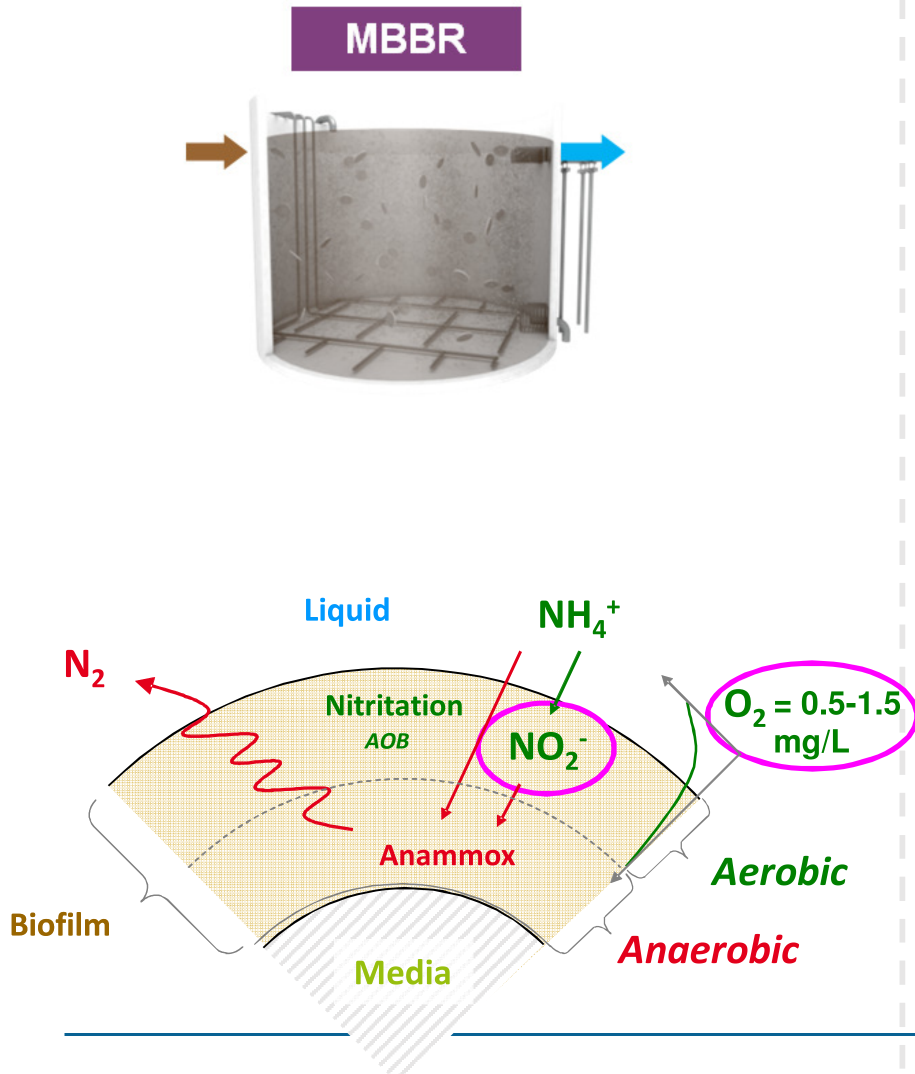
Kruger ANITA™ Mox IFAS

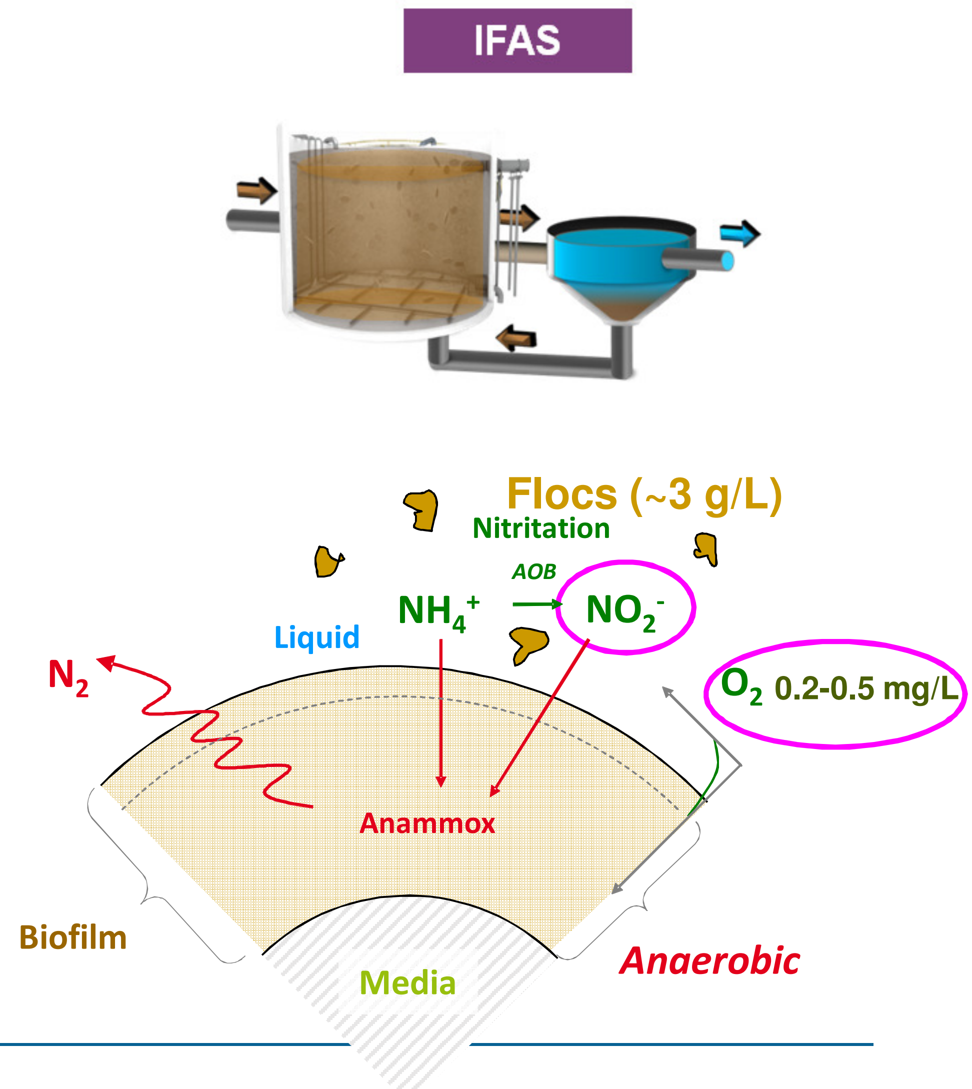
- **Continuous flow through process**
- **Anammox bacteria colonized on plastic media carriers**
- **Medium Bubble Aeration System**
- **Majority of AOBs are in the suspended phase (Zhao et al)**
- **Clarifier used for solids return, waste from RAS line to maintain design liquid phase SRT**
- **No US installations of <u>sidestream</u> IFAS system**





ANITA™ Mox – MBBR vs. IFAS Configuration





Figures courtesy of Veolia (with permission)

New to US Marketplace: Ovivo-Paques AnammoPAQ™

Design Info	AnammoPAQ
Reactor configuration	Flow Through
Biomass characteristic	Granules
Proprietary retention strategy	Inclined Plate Settlers – weight-based selection

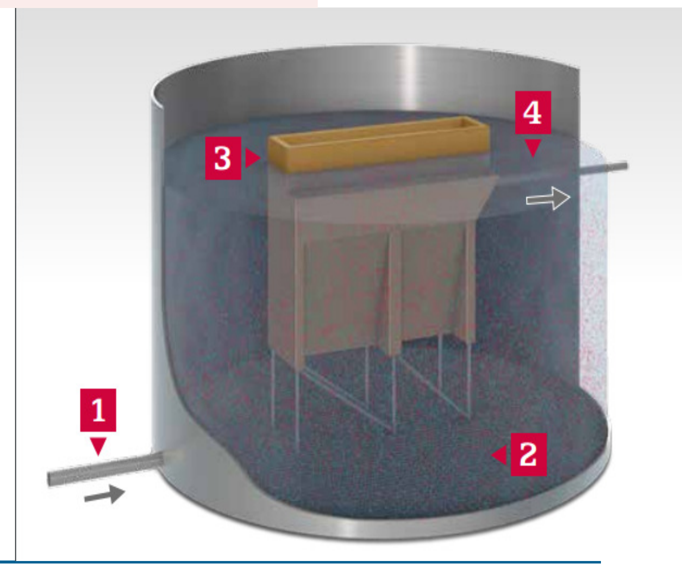
ANAMMOX®,
how it works

1 Ammonia-rich influent

2 Aerators for mixing and ammonia removal process

3 ANAMMOX® separator for biomass retention

4 Effluent exits the reactor

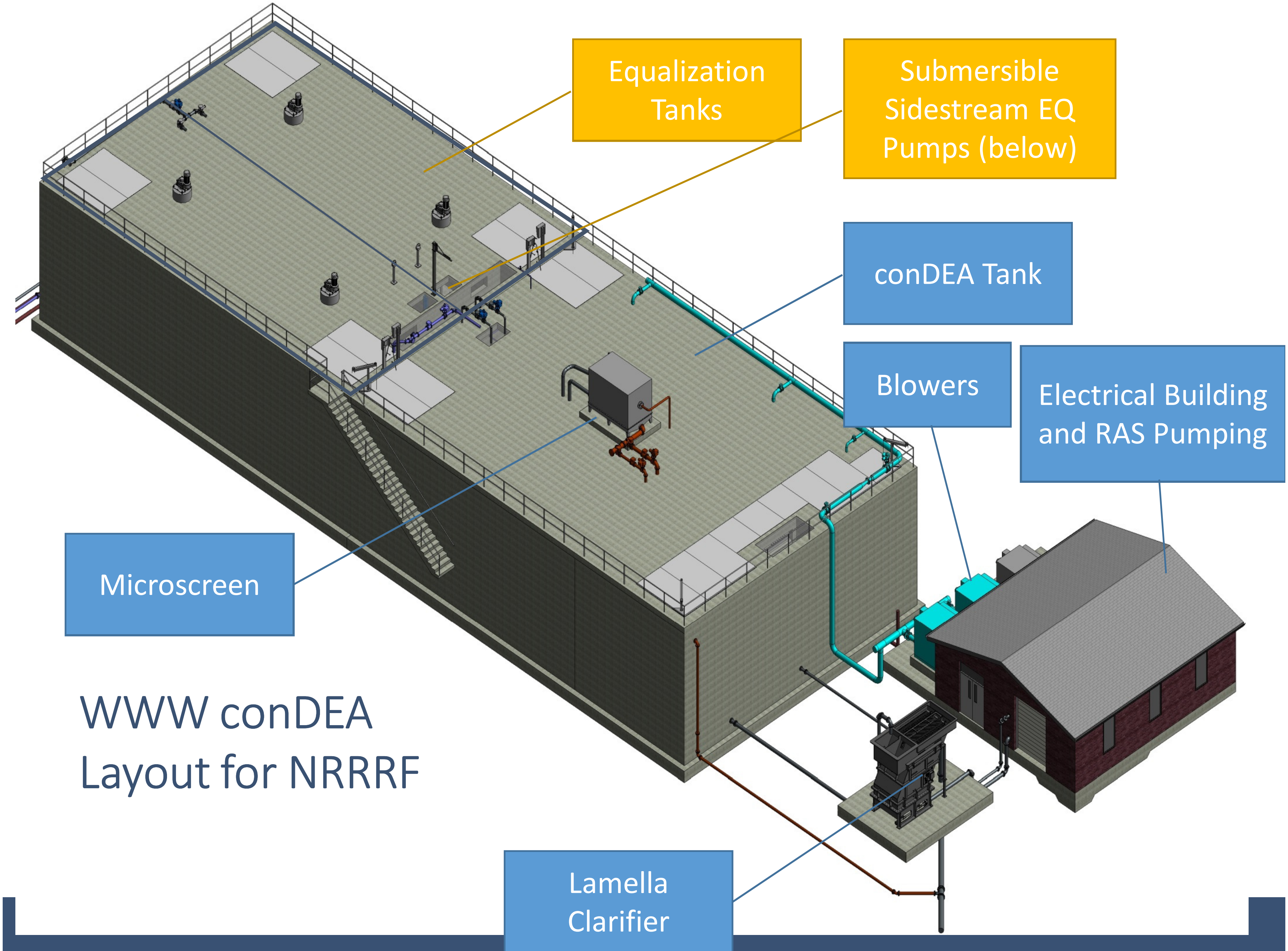


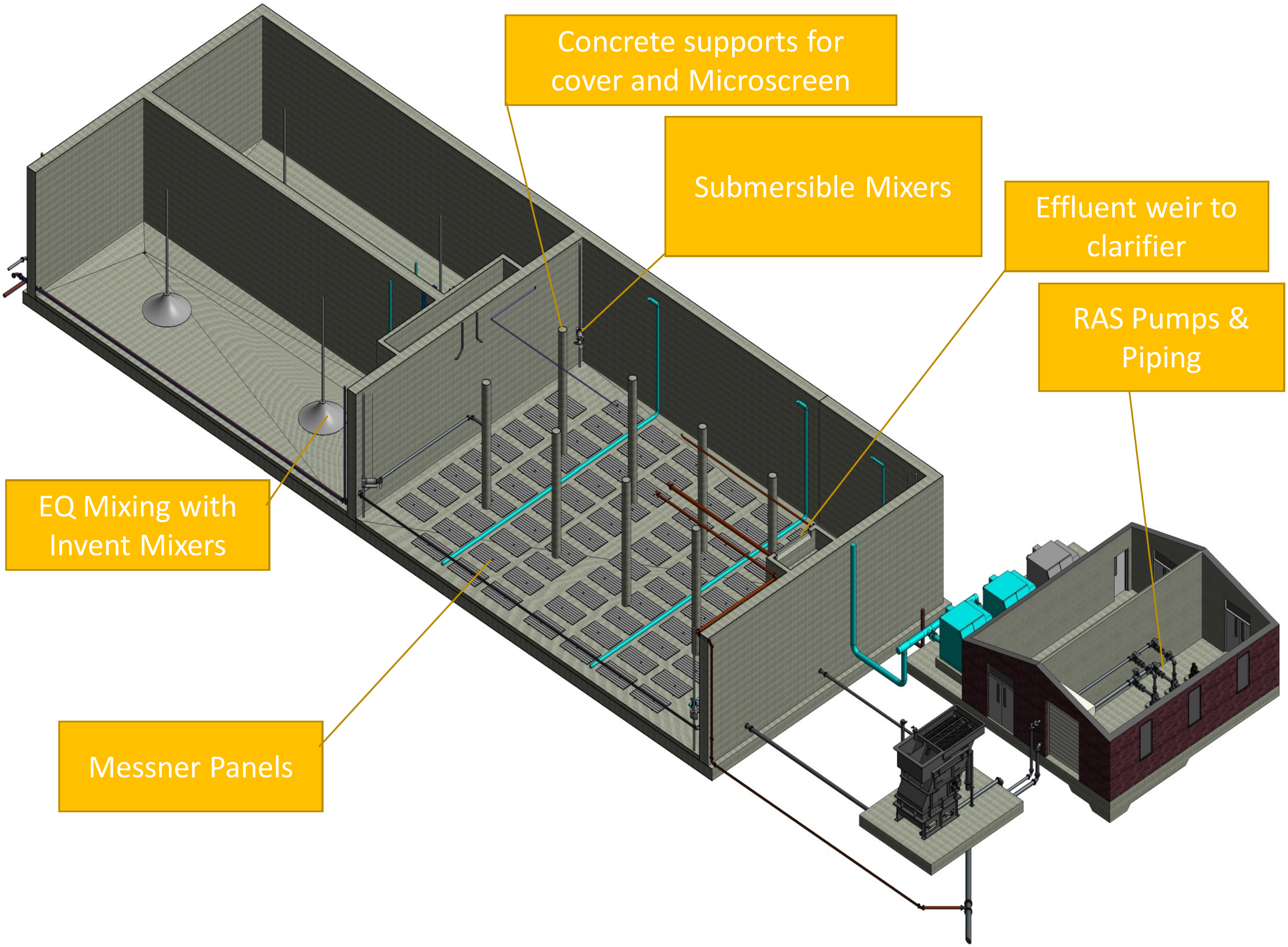
Figures courtesy of PAQUES / Ovivo

New to US Marketplace: Ovivo-Paques AnammoPAQ™

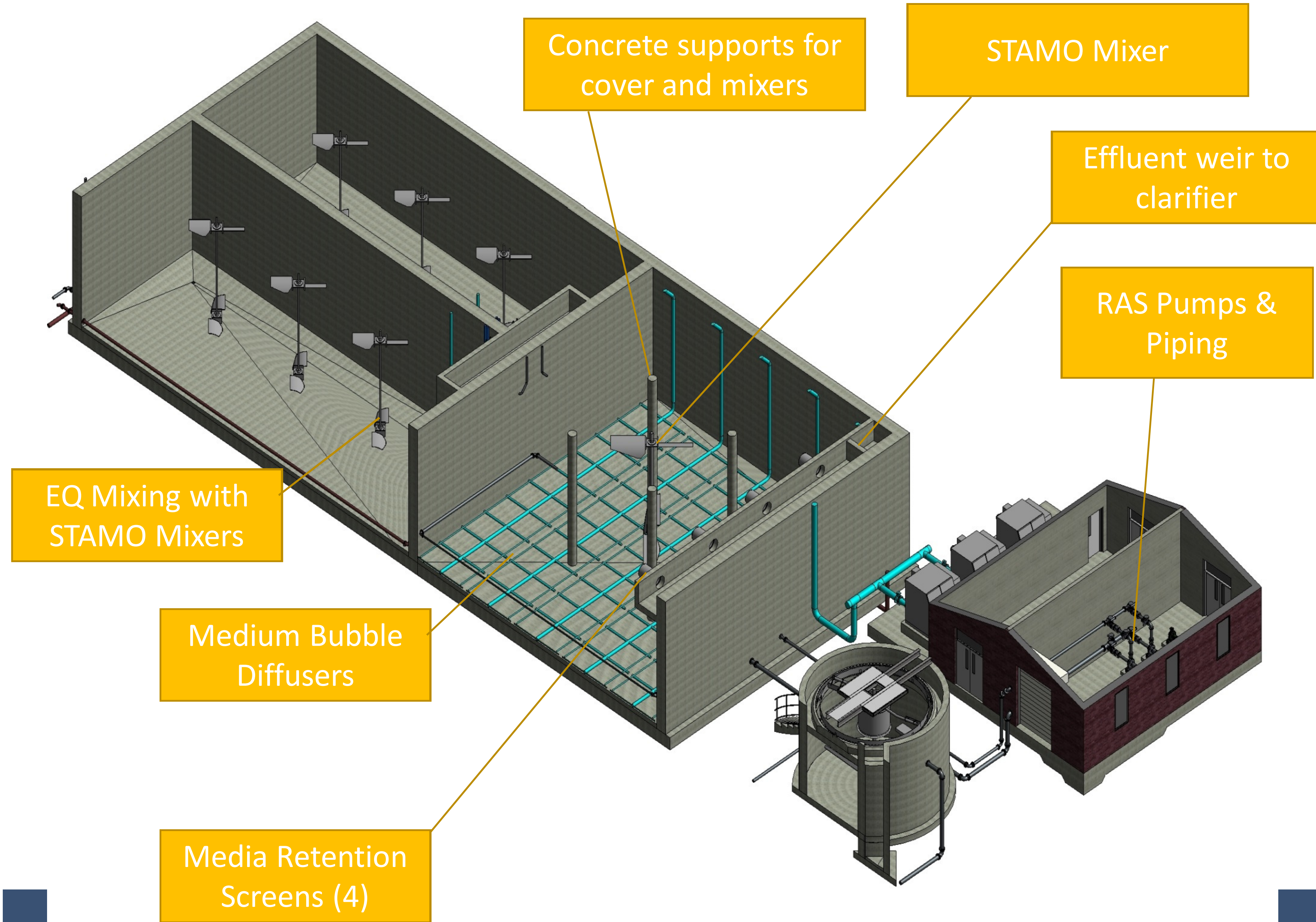
- Continuous flow through process
- Completely granular system
- Anammox and AOB bacteria co-exist on granules
- No RAS; Single pass operation
- Granules retained in system through separator
- Occasional “sluicing” of excess granules
- 35 references (0 in USA/1 downstream of THP)
  - Largest unit 10 metric tons of nitrogen/day
  - Install at Olburgen in service for 10 years
- Purportedly higher loading rate

WWW conDEA Layout for NRRRF





Concrete supports for cover and Microscreen
Submersible Mixers
Effluent weir to clarifier
RAS Pumps & Piping
EQ Mixing with Invent Mixers
Messner Panels


Concrete supports for cover and mixers
STAMO Mixer
Effluent weir to clarifier
RAS Pumps & Piping
EQ Mixing with STAMO Mixers
Medium Bubble Diffusers
Media Retention Screens (4)

LIFT SEE IT
Site Visits - Highlights

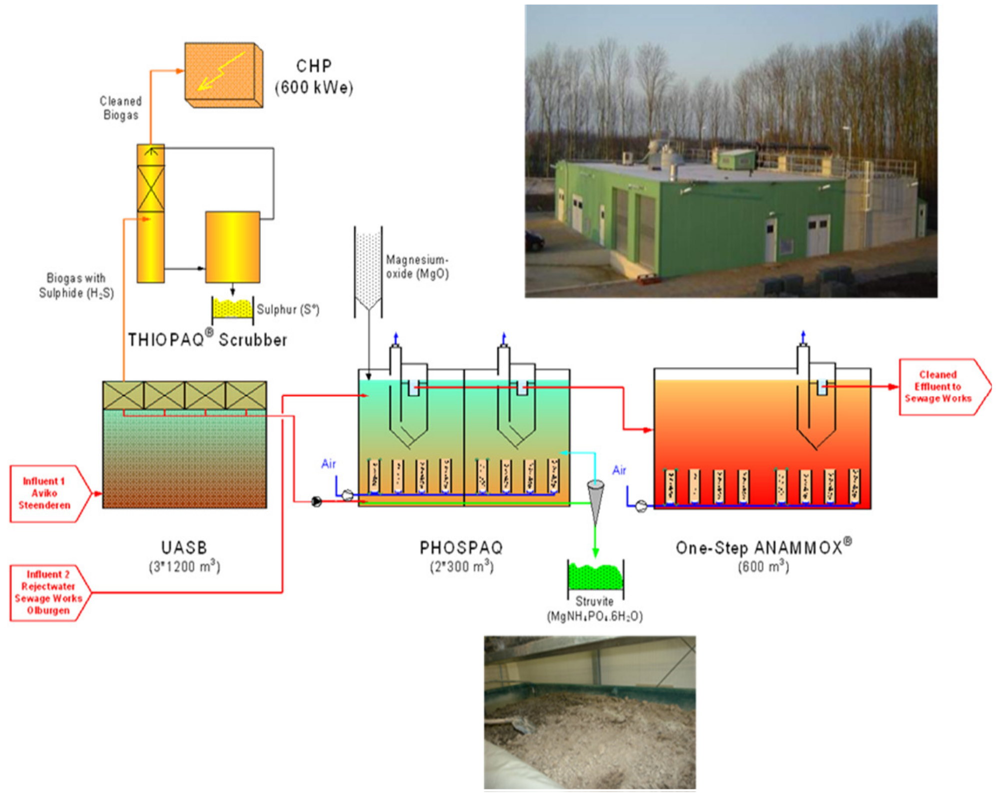
"The LIFT Scholarship Exchange Experience for Innovation & Technology Program (SEE IT) is an initiative spearheaded by WE&RF, WEF, and NACWA to provide scholarships for utility personnel to visit other utilities with innovations of interest and to share experiences with their peers"

http://www.werf.org/lift/LIFT_SEE_IT.aspx

World Water Works conDEA™ , Amersfoort, NL

○ conDEA reactor　○○ Cyclone separation device　○○○ Process Flow diagram　○○○○ MLSS from Reactor　○○○○○ Clarifier wet well in center of reactor

Ovivo-Paques AnammoPAQ™, Olburgen, NL



Veolia ANITA™ Mox IFAS, Boras, Sweden

○ IFAS System ○○ Media retention screens ○○○ Stamo Mixer ○○○○ Foam Air Lift Pump ○○○○○ IFAS Clarifier

Next Steps

- Regroup on LIFT SEE IT Site Visit Findings with Design Team
- Finalize selection criteria (cost and non-cost)
- Develop weighted scoring system
- Obtain updated proposals
- Evaluate using selection criteria and weighted scoring system
- Finalize selection and move forward with final design of side stream treatment system

Thank You!