EAST BAY MUNICIPAL UTILITY DISTRICT

EPA Grant-Funded Sidestream Nutrient Removal Study

Presentation to BACWA Board Meeting

September 26, 2014

Outline

- Overview of EPA grant-funded Sidestream Nutrient Removal Study
- Update on pilot testing of sidestream treatment technologies
- Planned next steps

EPA Project Overview

Focus on Sidestream Nitrogen Removal

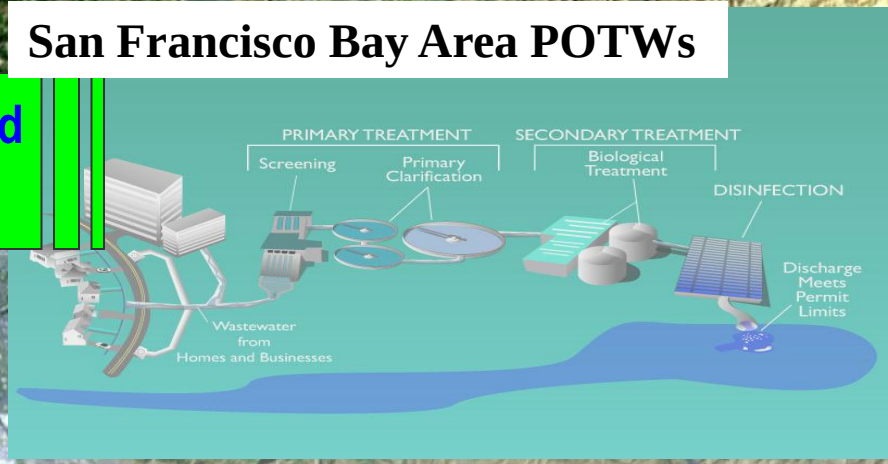
Main Tasks

- **Identify cost-effective nutrient removal technologies for sidestream treatment through literature review and bench/pilot testing at multiple sites**
- **Quantify potential nutrient load reductions and estimate cost-benefit ($/lb N removal)**
- Utilize SFEI's simulation model to demonstrate water quality improvement to the Bay, assuming full-scale implementation of sidestream treatment by POTWs
- Evaluate the role of sidestream treatment in the development of a regional approach to nutrient management

Nutrient Load Reduction

San Francisco Bay

San Francisco Bay Area POTWs



Update on Pilot Testing of Sidestream Treatment Technologies

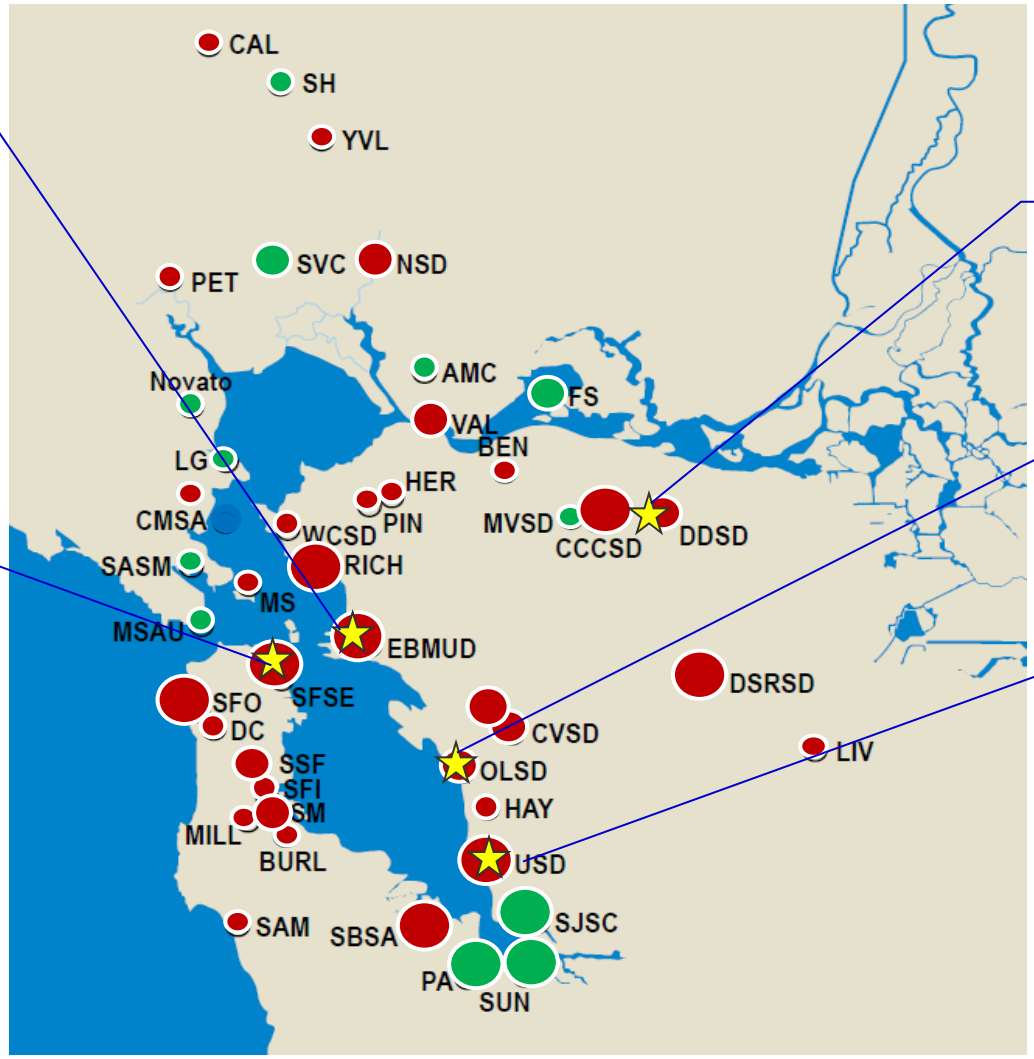
Bench and Pilot Testing by POTWs

EBMUD:
Anammox
- Suspended -growth
- Attached-growth

Ongoing

SFPUC:
Anammox
- Suspended -growth
- Attached-growth
- Biozeolite

Operated for 3-5 months



DD: CANDO
Schedule extended

OLSD: Zeolite anammox
Started

USD: Krüger ANITA™ Mox
Completed

CANDO = Coupled Aerobic-anoxic Nitrous Decomposition Operation process, DD = Delta Diablo, OLSD = Oro Loma Sanitary District
USD = Union Sanitary District; SFPUC = San Francisco Public Utilities Commission

Pilot Testing Objectives

Pilot Test Objectives

Evaluate cost-effective sidestream treatment technologies on:

- Applicability for treating sidestreams with various characteristics
- Optimal process control & operational parameters
- Process performance and comparison
- Feasibility of growing anammox bacteria from activated sludge

Which technology?

What %N removal?

Data Usage

To quantify potential **nutrient load reductions** for cost-benefit ($/lb N removal) analysis of sidestream treatment by POTWs.

Typical Sidestream Characteristics for ANITA™ Mox

Typical Sidestream Characteristics	
*The values below are typical evaluated sidestream characteristics. Values outside these ranges could result in an increased or decreased removal rate and can be evaluated on a project by project basis.	
Temperature, °C	20-35*
Ammonia-N, mg/L	200-2,000*
sbCOD/N ratio	< 1*
TSS, mg/L	< 2,000*
Ratio of Alkalinity, mg/L to NH_4-N, mg/L removed $CaCO_3$: NH_4-N removed	> 4*

Source: Krüger (October 2014)

Pilot Testing Data Collection

	Variables
Key sidestream characteristics	Ammonia-N concentration
	Alkalinity/N ratio
	Temperature
	Total and soluble COD
	TSS
Process control strategy	pH range
	DO range
	Temperature
Process performance	Specific ammonia loading rate
	Ammonia and Inorganic Nitrogen removal efficiency
	Chemical usage
	Process stability
	Energy consumption

Inorganic Nitrogen: sum of NH_4^+, NO_2^-, and NO_3^-

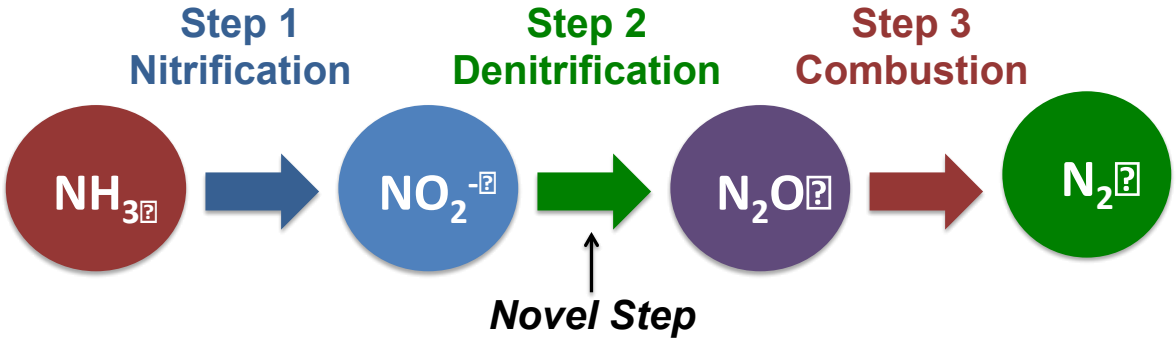
To-date Pilot Testing Results

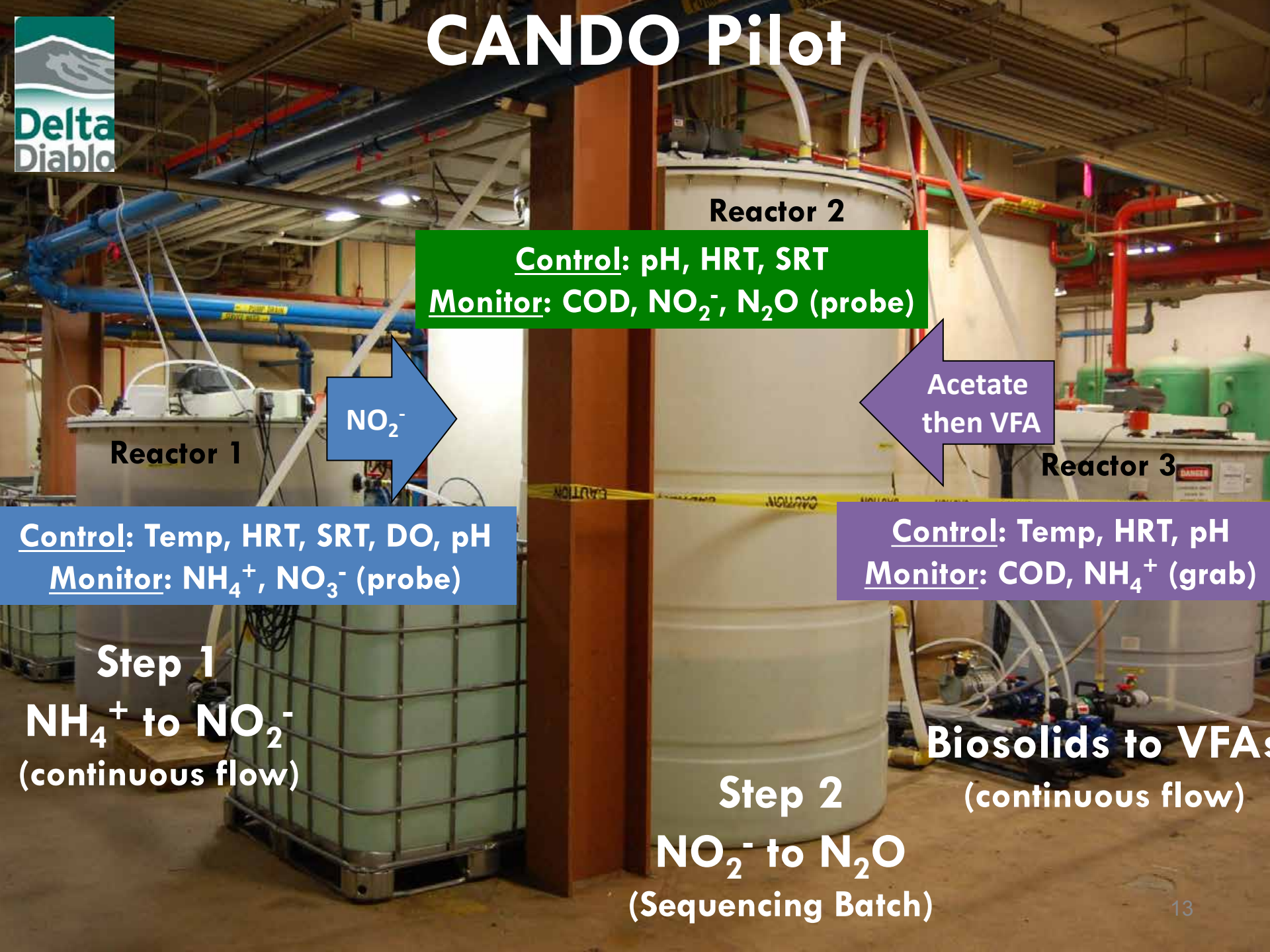
EAST BAY MUNICIPAL UTILITY DISTRICT

Delta Diablo CANDO Pilot Testing Update

9/22/2014

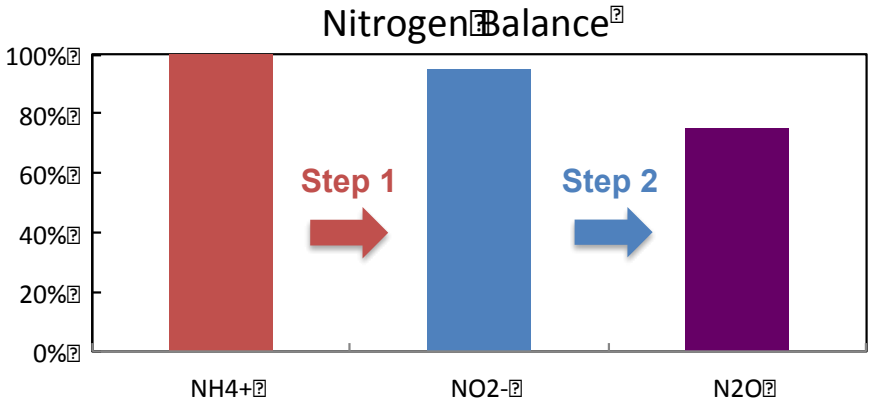
Completed Bench-Scale Demonstration




CANDO Pilot
Delta Diablo
Reactor 2
Control: pH, HRT, SRT
Monitor: COD, NO_2^-, N_2O (probe)
NO_2^-
Acetate then VFA
Reactor 1
Reactor 3
Control: Temp, HRT, SRT, DO, pH
Monitor: NH_4^+, NO_3^- (probe)
Control: Temp, HRT, pH
Monitor: COD, NH_4^+ (grab)
Step 1
NH_4^+ to NO_2^-
(continuous flow)
Biosolids to VFAs
(continuous flow)
Step 2
NO_2^- to N_2O
(Sequencing Batch)

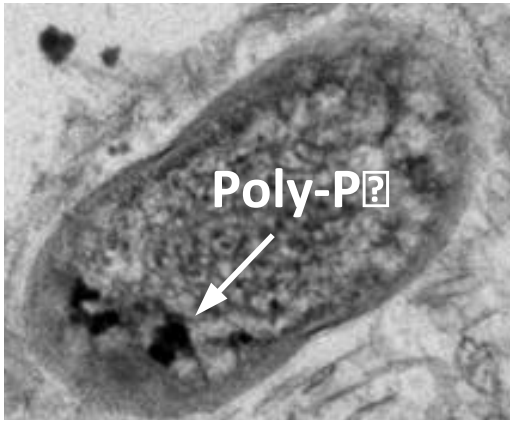
CANDO Pilot Testing Goals

(1) Achieve at least same N-balance as bench-top test



75% Conversion to N_2O
95% N-Removal

(2) Maximize P-recovery?



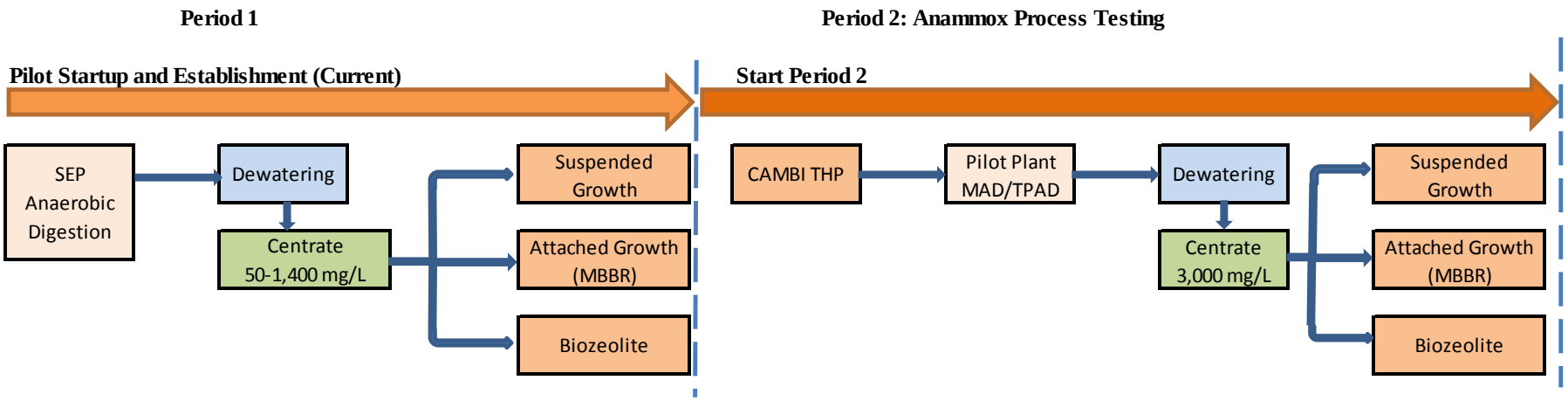
(3) Use fermented biosolids for carbon

SFPUC Sidestream Nitrogen Removal Study

September 22, 2014

Overview

- **SFPUC pilot testing three processes:**
  - Suspended-growth
  - Attached-growth
  - Biozeolite
- **Two-phased project:**



THP = Thermal Hydrolysis Pretreatment; MBBR = Moving Bed BioReactor; MAD = Mesophilic Anaerobic Digestion
TPAD = Temperature-phased Anaerobic Digestion

Reactor Data

Reactor	Suspended-growth	Attached-growth	Biozeolite
Volume	24-gallon	24-gallon	24-gallon
Reactor operation	SBR fill-hold-draw operation	MBBR semi- or continuous flow	semi- or continuous flow
Carrier (media)	None	Kaldnes plastic media (filled 50% reactor volume)	3/4" diameter Zeolite
Target NH_4^+-N loading rate for Period 1 (kg NH_4^+-N/m^3/d)	0.5	0.8	1.0

Simplistic control strategy utilizing a PLC to monitor and control:

-Dissolved oxygen levels
-Airflow
-Feed Flow/Level
-Aerobic/anoxic periods
-Recirculation/Mixing

Pilot Setup

Summary

Reactor Performance				
Anammox Process	**Target Loading** (kg NH_4^+-N/m^3/d)	**Current Loading** (kg NH_4^+-N/m^3/d)	**Ammonia Removal Efficiency**	**TIN Removal Efficiency**
Suspended-growth	0.5	0.2	67%	62%
Attached-growth	0.8	0.13	63%	63%
Biozeolite	1.0	0.6	69%	68%

- **Next Steps:**
  - Increase to target ammonia loads by the end of 2014
  - Achieve >90% ammonia removal and >75% TIN removal

EBMUD PRESENTATION 09/22/14

ZEOLITE ANAMMOX DE-AMMONIFICATION PROCESS

ORO LOMA SANITARY DISTRICT
Jimmy Dang, P.E.
Rob Collison, P.E.

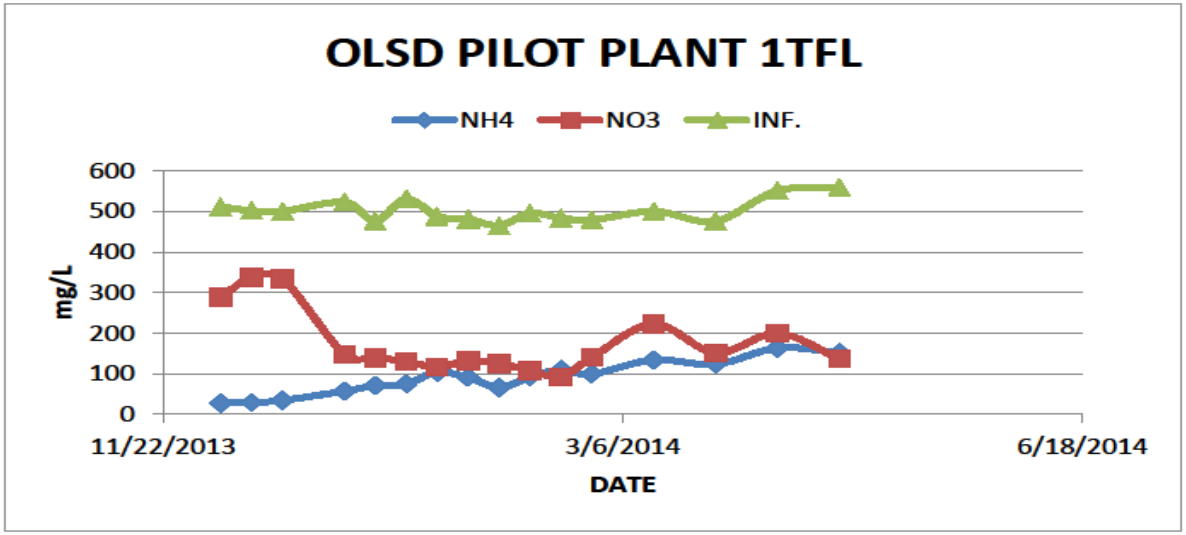
INTRODUCTION

- Zeolite-anammox is a fixed film bio-reactor
- Zeolite aggregate graded from 0.25” to 1” sized aggregate media
- Pilot plant of six 55-gallon drums
- Currently running transitional system – 20,000-gallon baker tank treating 10% of side-stream flow
- Aeration by re-circulating trickling filter

PILOT PLANT

- Commissioned November 2012, ended June 2014
- Very fast anammox establishment (7 weeks)

PILOT PLANT



- Influent 500 mg/L NH_4^+-N
- Effluent 100 mg/L NH_4^+-N; 100 mg/L NO_3^--N

- 80% NH_4^+-N removal, 60% TIN removal
- 0.35 kg/m^3/day NH_4^+-N removal (~0.44 kg/m^3/day NH_4^+-N loading rate)

TRANSITIONAL SYSTEM

- Volume 20,000 gallons
- Flow 10 gpm
- Re-circ. 50 gpm

- Teething troubles

- Total cost: $70K (design, construction, materials)

TRANSITIONAL SYSTEM

NEXT STEPS

- Build filter to remove TSS
- Nitrifier establishment period
- Anammox establishment period
- Monitor TSS levels, biofilm thickness, and porosity of system

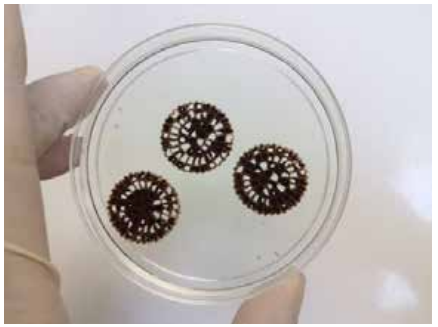
Union Sanitary District
Anitamox Sidestream Pilot Study

Tim Grillo, R&S Team Coach

EPA Sidestream Nutrient Removal Study
Workshop 2
EBMUD September 22, 2014

Study Objectives

- To determine whether sidestream treatment using the Kruger Anitamox (MBBR) is a viable alternative for reducing the ammonium in the USD treatment plant effluent.



- Determine whether a full scale implementation is feasible for USD
- Determine whether centrate dilution will be an effective struvite control strategy

Study Phases

- Phase I – To evaluate process parameters for the **continuous feed** with **undiluted centrate**
- Phase II – To evaluate process parameters for the **intermittent feed** with **undiluted centrate**
- Phase III – To evaluate process parameters for the **continuous feed** with **diluted centrate**
- Phase IV – To evaluate Process Parameters for the **intermittent feed** with **diluted centrate**

Project Progress

- Field testing is completed
- The pilot plant had been demobilized and returned to Krüger
- Data validation and reduction has begun
- Krüger has agreed to provide a conceptual design of alternatives for full scale projects.

Preliminary results

- Preliminary results indicate that sidestream treatment with the Anitamox MBBR is a viable alternative for reducing ammonium in Union Sanitary District treatment plant effluent
- Preliminary results indicate that centrate dilution will not be a useful method to control struvite in a full scale system
- Krüger's conceptual design will help us to determine whether a full scale system can meet site constraints
- Interesting results for nitrate production during intermittent feeding – may need further consideration.

Questions ?

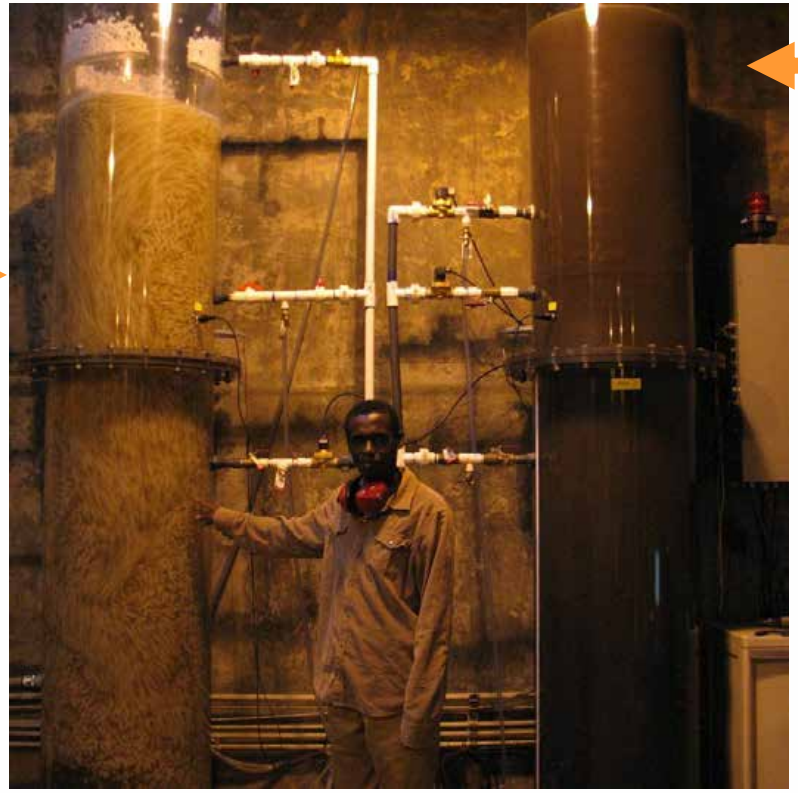
EBMUD Anammox Pilot Testing Update

Anammox Pilot Test Goals

- **Test feasibility of anammox in treating high ammonia centrate (~2,000 mg/L)**
- **Grow anammox bacteria from activated sludge**
- **Compare two anammox processes side-by-side**
- **Evaluate impacts of operational and control parameters**

Reactor 2: Attached-growth

(260-gallon moving bed biofilm reactor MBBR)



Reactor 1: Suspended-growth

(260-gallon sequencing batch reactor SBR)

Anammox Pilot Testing

Reactor 2: Attached-growth

(Started in September 2013, with NO anammox seed)

Reactor 1: Suspended-growth

(Started in June for nitritation first, then July 2013 for anammox with 1-gal anammox seed from HRSD)

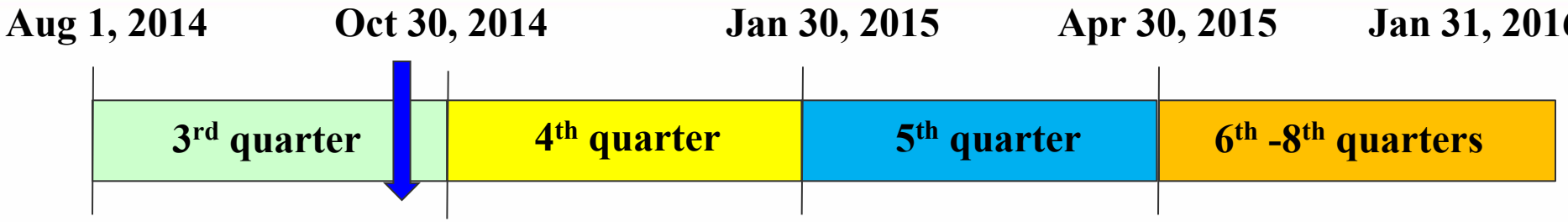
Added 1-gal anammox seed to 260-gallon reactor

Anammox Pilot Results To Date

- **Anammox population was growing till the process upsets occurred at the end of June 2014**
  - We have been able to increase ammonia loading to more than 0.4 (suspended-growth) and 0.6 (attached-growth) kg NH_4^+-N/m^3-reactor/day, while still achieving more than 90% ammonia-N removal.
- **Activated sludge can be used as the seed to start an anammox reactor**

Next Steps for EPA Project

Next Steps



- **Coordinate pilot testing [EBMUD/POTWs]**
- **Finalize Sidestream Data Questionnaire and start data collection [HDR/BACWA/EBMUD]**
- **Prepare for next Team Workshop and EPA Progress Review Meeting [EBMUD/Team]**
- Finalize literature review report [HDR]
- Develop Scope of Work for EBMUD/ReNUWIt contract [EBMUD/ReNUWIt]

Questions/Comments

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