The Metropolitan
Water Reclamation District
of Greater Chicago

WELCOME
TO THE DECEMBER EDITION
OF THE 2017
M&R SEMINAR SERIES

BEFORE WE BEGIN

- SAFETY PRECAUTIONS
  - PLEASE FOLLOW EXIT SIGN IN CASE OF EMERGENCY EVACUATION
  - AUTOMATED EXTERNAL DEFIBRILLATOR (AED) LOCATED OUTSIDE
- PLEASE SILENCE CELL PHONES OR SMART PHONES
- QUESTION AND ANSWER SESSION WILL FOLLOW PRESENTATION
- PLEASE FILL EVALUATION FORM
- SEMINAR SLIDES WILL BE POSTED ON MWRD WEBSITE (www. MWRD.org: Home Page ⇒ Reports ⇒ M&R Data and Reports ⇒ M&R Seminar Series ⇒ 2017 Seminar Series)
- STREAM VIDEO WILL BE AVAILABLE ON MWRD WEBSITE (www.MWRD.org: Home Page ⇒ MWRDGC RSS Feeds)

Louis V. Storino, P.E., BCEE

Current: Principal Civil Engineer, Engineering Department, MWRD

Experience: Being in the Engineering Department, Collection Facilities/ Tunnel and Reservoir Plan (TARP) Section, Mr. Storino supervises a staff of five engineers, conducts engineering studies and analysis. He has been with MWRD since 1998 and has held numerous positions in both the Maintenance and Operations Department (M&O) and the Engineering Department.

Education: B.S. in Chemical Engineering and M.S. in Environmental Engineering, both from the Illinois Institute of Technology, Chicago, Illinois

MBA in Finance from DePaul University, Chicago, Illinois

Professional: Registered Professional Engineer in Illinois

Board Certified Environmental Engineer by AAEES

Member of the Water Environment Federation (WEF)

Treasurer of the Illinois Water Environment Association (IWEA)

Katarzyna (Kathy) Lai, P.E.

Current: Principal Engineer, Operations Manager, John E. Egan WRP, M&O, MWRD

Experience:

- Operations Manager at the Egan WRP, managing both waste water treatment and solids operations including biosolids processing and sidestream treatment (ANITA™ Mox).
- Senior Mechanical Engineer North Side WRP (now O'Brien WRP). Responsible for managing the mechanical maintenance of equipment within the plant and at the outlying locations.
- Associate Mechanical Engineer, at Calumet WRP. Responsible for mechanical maintenance of the plant equipment within the areas of responsibility.

Education: B.S. in Chemical Engineering, University of Illinois at Chicago, Illinois

Professional: Water Environment Federation (WEF)

Illinois Water Environment Association (IWEA)

Dongqi (Cindy) Qin, Ph.D.

Current: **Environmental Research Scientist**, Wastewater Treatment Process Research Section, M&R, MWRD

Experience: Wastewater treatment process research and development (2 WEF conference proceedings)

- Sidestream deammonification for nitrogen removal
- Enhanced biological phosphorus removal pilot and full-scale tests

Applied chemistry (24 peer reviewed journal papers; citations 1,820 times)

- Formulation of new biomedical materials
- Organic/environmental samples analyses with various instruments

Education: Ph.D. (Chemistry), Beijing University, China
M.S. (Chemistry), Jilin University, China
B.S. (Polymer Chemistry and Physics), Jilin University, China

Professional: Water Environment Federation (WEF)
American Chemical Society (ACS)

Metropolitan Water Reclamation District of Greater Chicago

ANITA™ Mox Startup and Optimization at the Egan Water Reclamation Plant

Presented By

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Principal Engineer, M&O

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Principal Civil Engineer, Engineering

Cindy Qin, PhD

Environmental Research Scientist, M&R

Acknowledgements

Engineering

- Kevin Fitzpatrick
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- Meagan Matias

M&R

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- Rachel Ryan

Kruger

- Meg Hollowed
- Glenn Thesing

Operators and Plant Staff

- Hitesh Shah (Plant Manager)
- John Kargbo
- Kent Anderson
- Adam Johnson
- April Browing
- John Alkovich
- Keith Myrda
- Kenneth Massey
- Dev Rijal
- Jeffery Simpson
- Kenneth Gavin
- Maurice Smith
- Vit Riew
- Mary Brand *

- Many more!

*Retired

Outlines

- Egan WRP
- NPDES Ammonia Limits
- Deammonification Process
- Anita™ Mox Design Summary
- Process Overview
- Startup
  - Operation
  - Monitoring and Process Control
  - System Improvements
  - Data and FISH (Fluorescence In Situ Hybridization)
- Lessons Learned
- Conclusions

John E. Egan WRP

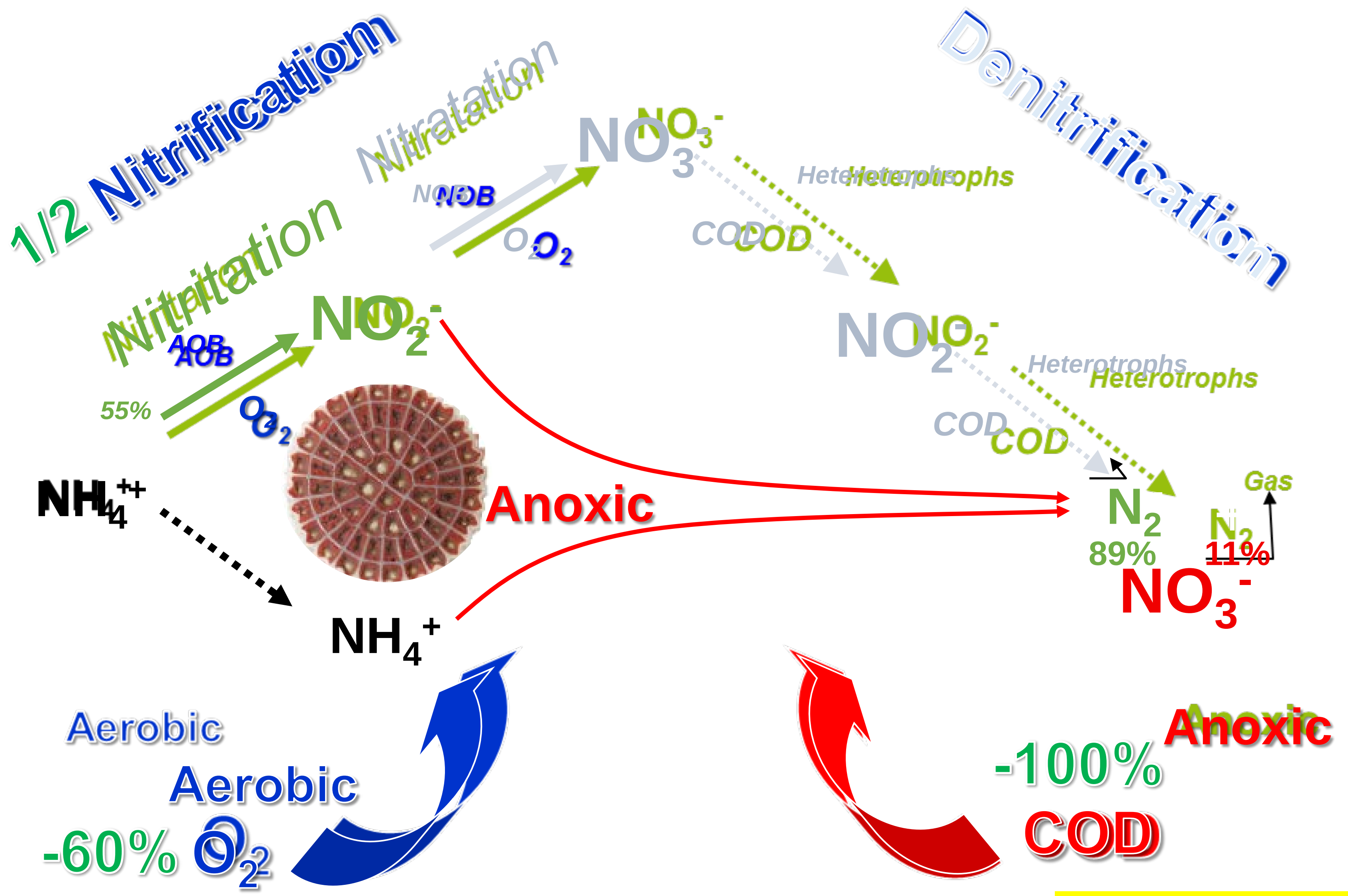
- Service Area: 44.4 square miles
- Service Population: 160,735
- Type: Single Stage Nitrification with Tertiary Filtration and Disinfection
- Design Average Flow: 30 MGD – 2016 Average Flow: 24.2 MGD
- Design Maximum Flow: 50 MGD – Storm Flow Total: 140 MGD
- Receiving Stream: Salt Creek

NPDES Limits Ammonia-Nitrogen

	Load Limits – lbs/day DAF (DMF)*			Concentration Limits mg/L			Sample Frequency
	Monthly Average	Weekly Average	Daily Maximum	**Monthly Average**	Weekly Average	Daily Maximum	Composite Sample
April-Oct.	375 (626)		751 (1,251)	**1.5**		3.0	2 days/week
Nov.-Feb.	901 (1,501)		2,002 (3,336)	**3.6**		8.0	2 days/week
March	575 (959)	1426 (2377)	2,002 (3,336)	**2.3**	5.7	8.0	2 days/week

* Load limits based on design maximum flow shall apply only when flow exceeds design average flow

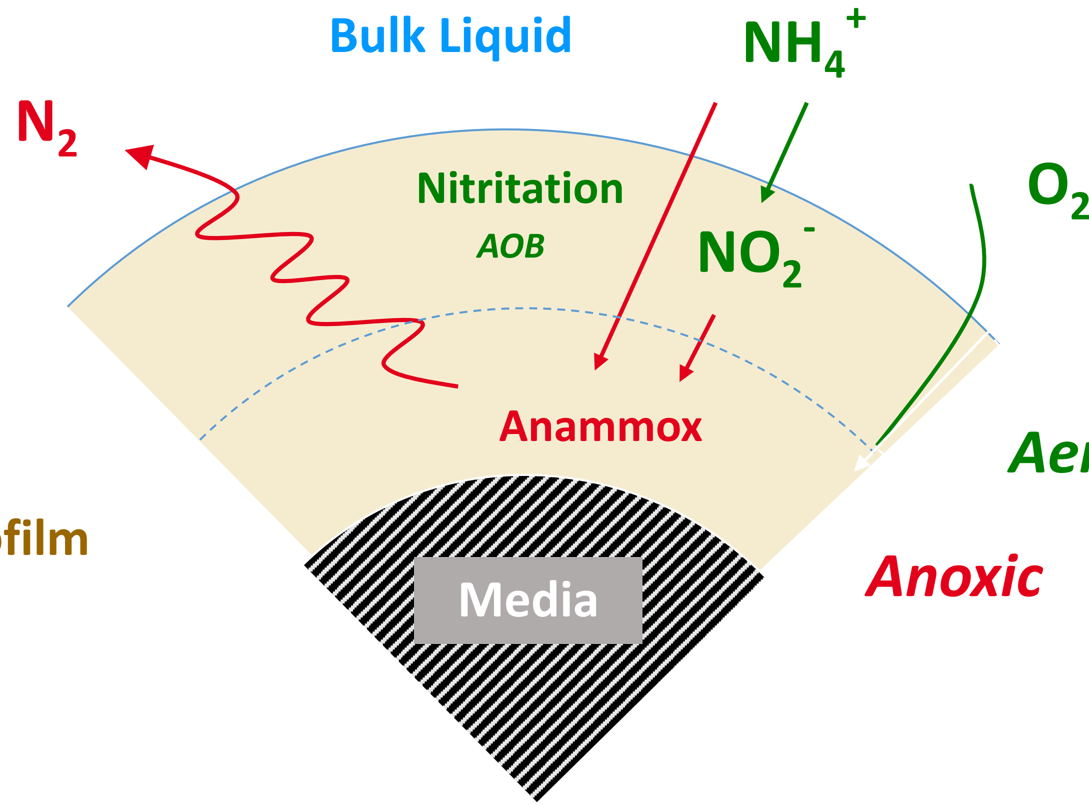
Partial Nitritation-Deammonification



Credit to Kruger for slide

ANITA™ Mox

- Moving Bed Biofilm Reactor



Biofilm

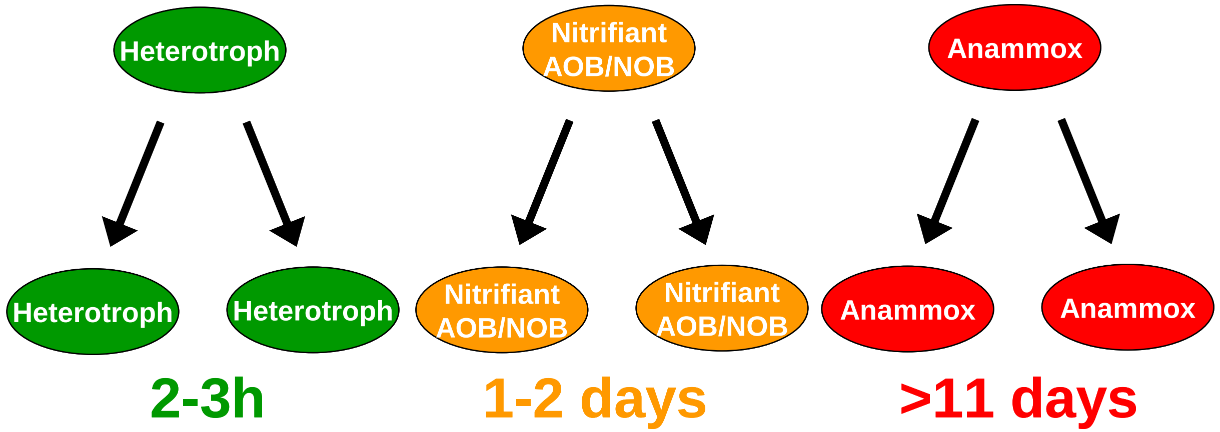
AOB

Simultaneous
in biofilm

Credit to Kruger for slide

Challenges

- Slow growth rate of anammox bacteria
- Exceeding mainstream capacity
- Alkalinity or micronutrient limitation
- Centrate availability
- Inhibiting NOB
- Temperature



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Drivers for Implementing Deammonification

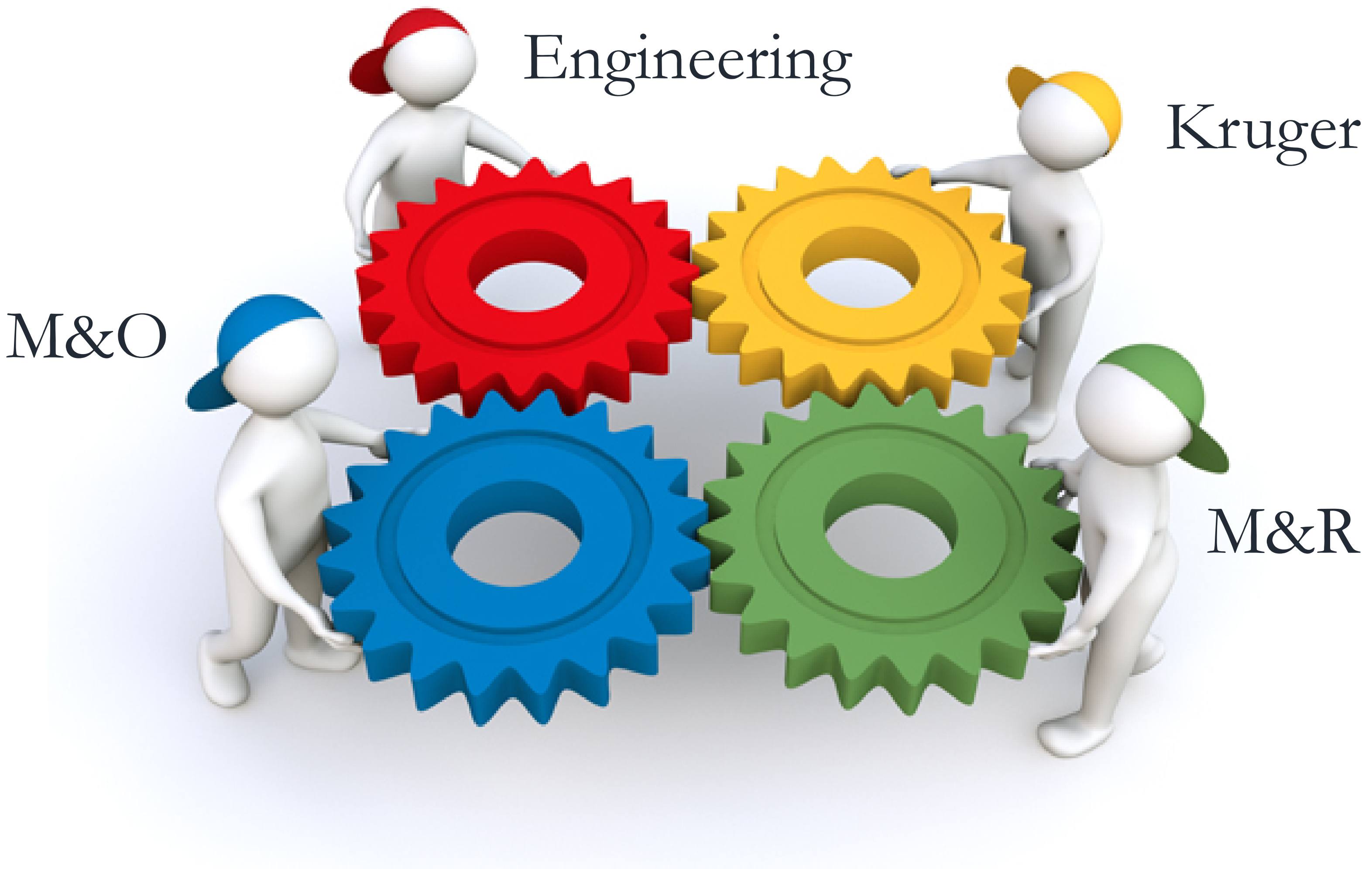
- Prior operation at Egan required centrate to be pumped from the Egan WRP to the O'Brien WRP for treatment. Centrate had up to ~45% of plant N load.

- The ANITA™ Mox project - it reduces the ammonia load (~by 75%) in the return of the plant's centrate to the secondary treatment process - will possibly allow the Egan mainstream secondary process to treat the ANITA™ Mox effluent and residual untreated centrate at the facility.

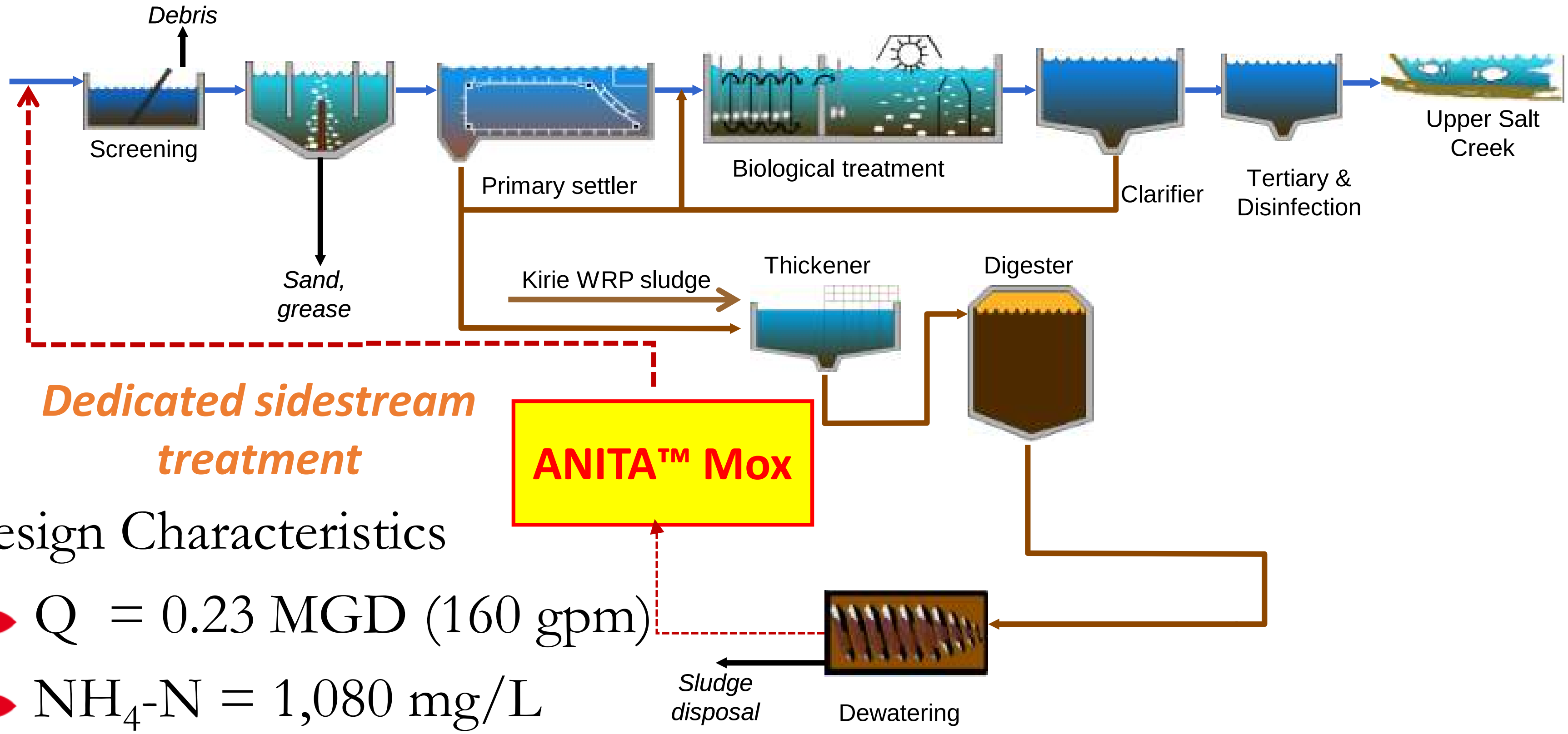
- Project plans to eliminate the pumping of centrate from the Egan WRP to the O'Brien WRP, a distance of ~17 miles.

- The installation was using the existing infrastructure:
  - Retrofit thickener tanks
  - Aeration demand provided by the plant's existing blower capacity

ANITA™ Mox Implementation – Collaborative Efforts



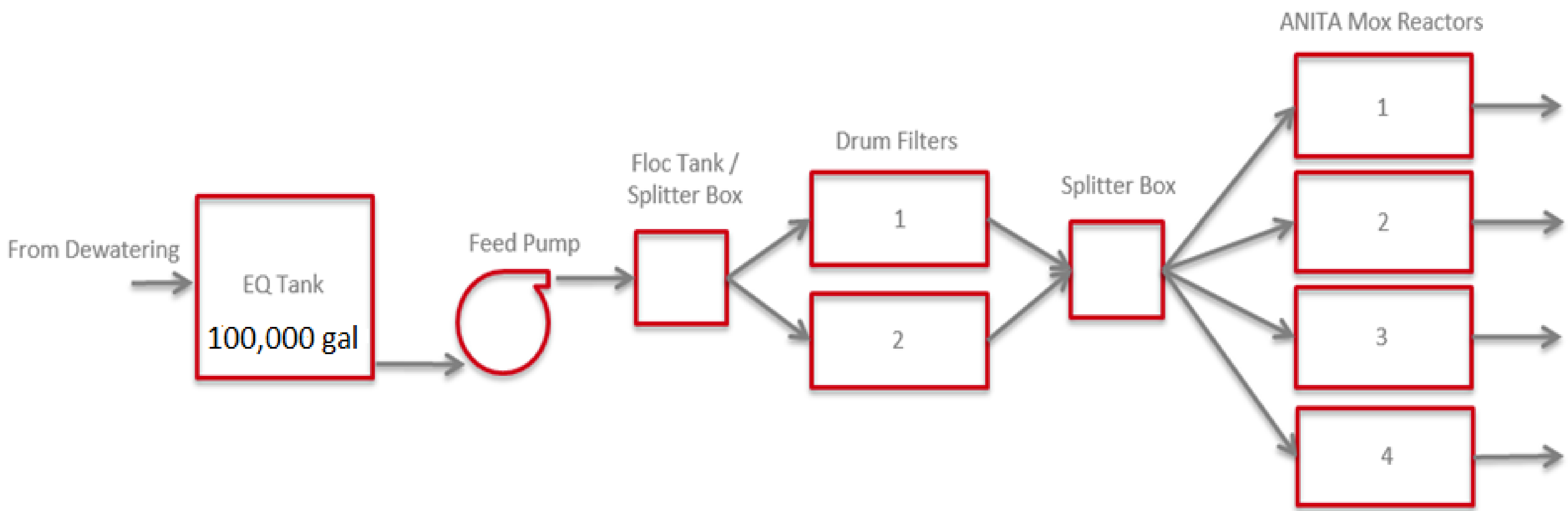
ANITA™ Mox Design Summary



- Design Characteristics
  - Q = 0.23 MGD (160 gpm)
  - NH_4-N = 1,080 mg/L
  - TKN = 1,160 mg/L
  - Temperature = 27.5 °C
  - NH_4-N removal > 75%
  - Total N removal > 65%
- Retrofit of existing DAF tanks
- Startup seeded from Hampton Roads Sanitary District – James River Treatment Plant (Virginia)

Post Dig Sludge Dewatering by Centrifuges
Primary Settling Tanks
N
Anaerobic Digesters
Sludge Thickening
Aeration Tanks
ANITA™ Mox Process
Screen & Grit Tanks
Tertiary Sand Filters
Secondary Clarifiers

Process Overview



EQ Tank

- Level indicator
- Mixers
- Feed pump

Instruments:
pH, NH3/NO3, TSS

Drum Filters 1 & 2

- Polymer feed
- Floc Tank

Reactors 1 - 4

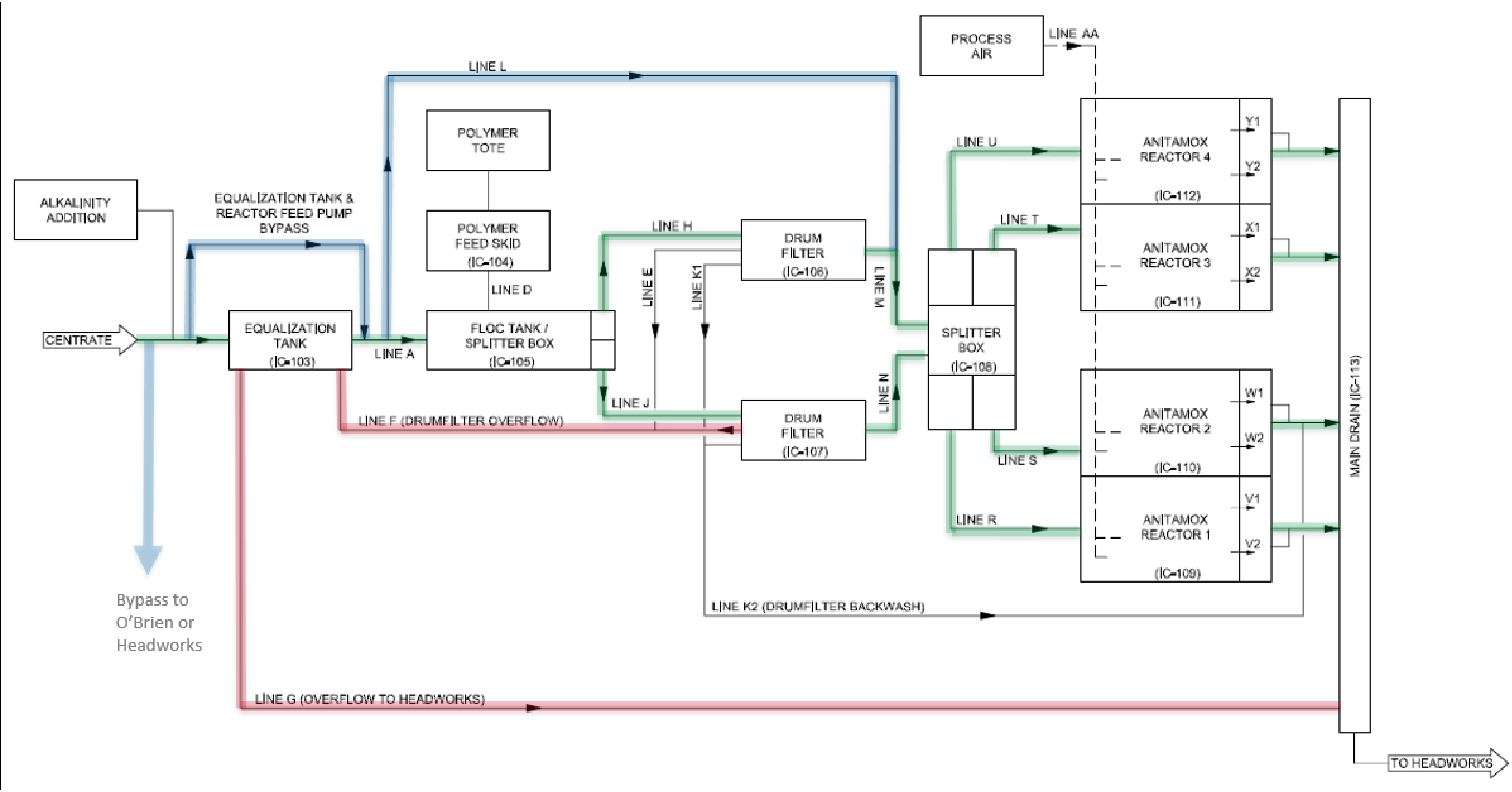
67,968 gallons each

- Media
- Diffuser Grid
- Mixer
- Effluent Screens
- Level Switch

Instruments:
pH, DO, NH3/NO3

Credit to Kruger for slide

Process Flow Diagram



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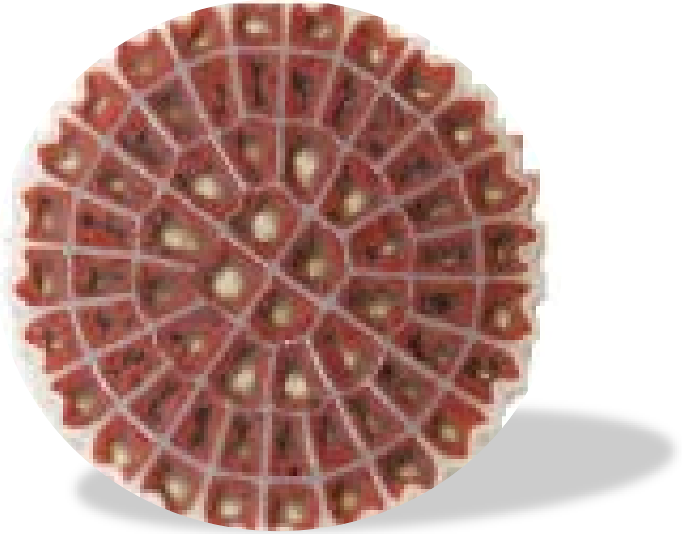
ANITA™ Mox Centrate Treatment (construction photo) at the Egan WRP.

Closer look at the reactor interior, mixers, air grid and effluent screen

Startup and Operation

- Typical startup estimated to take approximately 14 weeks
- Seeded media installed in two separate events a week apart
  - August 17, 2016 and August 24, 2016
  - Egan system used 10% seeded media, remainder 90% new media
    - 50 cubic meter bags of seeded media
    - 450 cubic meter bags of new media



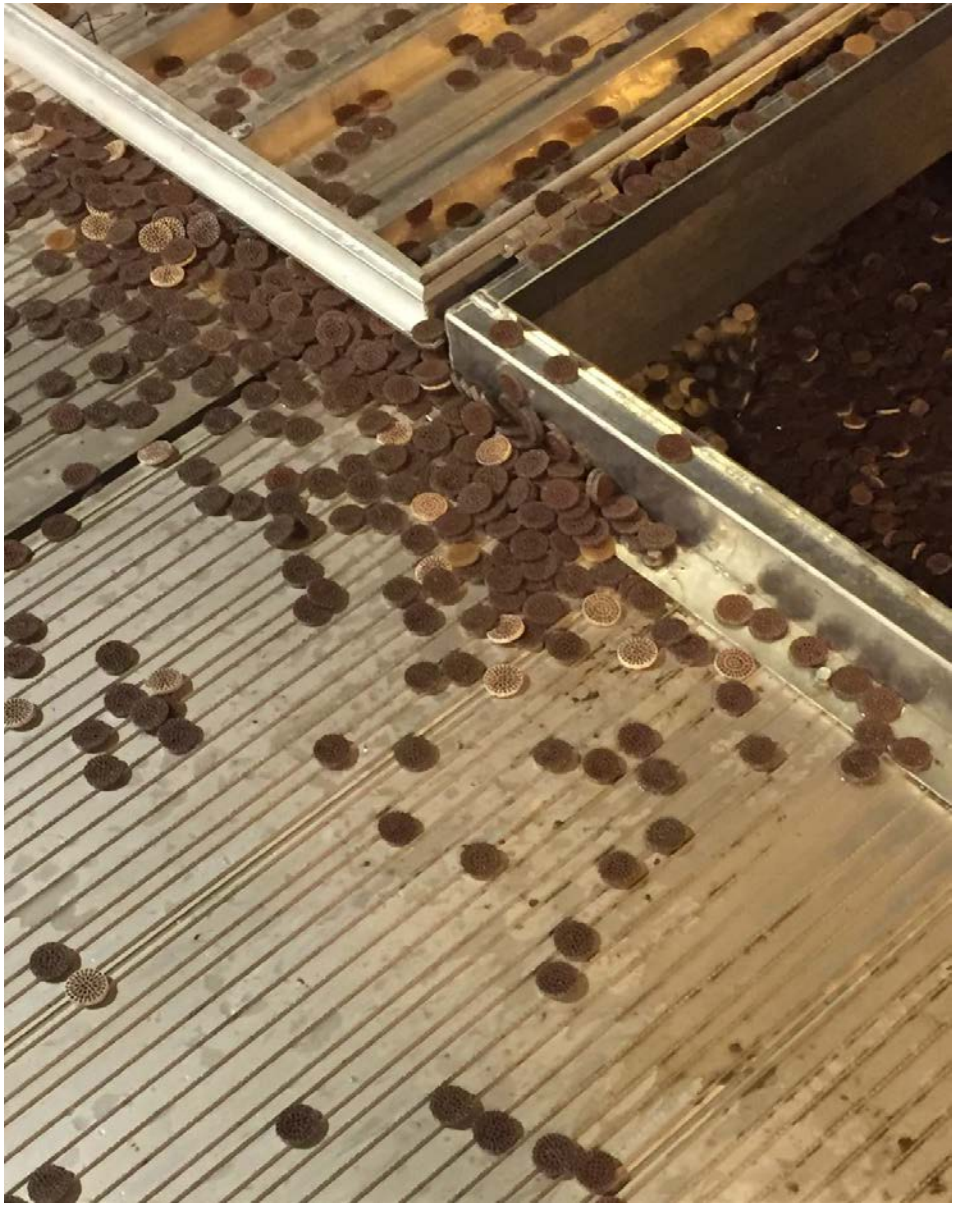
Pre-startup: New media conditioning

Startup process:

1. Batch
2. Intermittent
3. Continuous at low flow rates (80 gpm) and increasing
4. Continuous at design rates

Loading Seeded Media Into Reactors

Loading Seeded Media Into Reactors



Startup

Three stages of startup

- Initial Startup
  - August 26, 2016 – December 22, 2016
  - Achieved 120 gpm for 7 days
  - Average flow 44 gpm
- Standby Period
  - December 23, 2016 – August 2017
  - System placed in idle 29 days (10 day max cont)
  - Maintained low flow (avg 13 gpm)
- Secondary Startup
  - August 2017 – Present
  - Currently at daily flow of ~80 gpm on weekdays (50% of design flow)
  - Expect to reach design rate at end of March 2018

Startup

Startup process interruptions resulting in on-going startup:

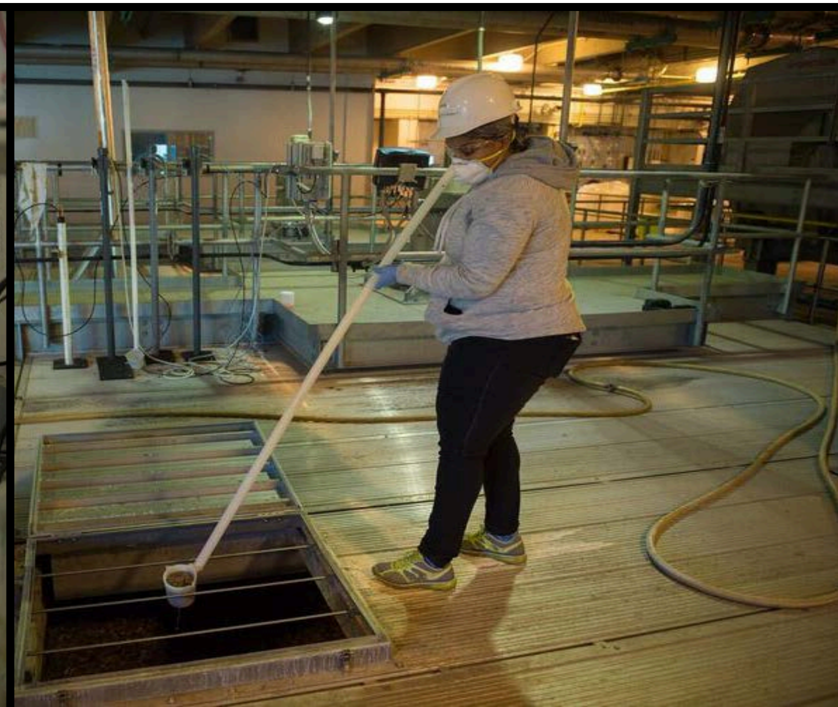
- Dewatering building operations Monday thru Saturday (utilize Equalization Tank volume on weekends)
- Blower baghouse maintenance – blower/plant shutdowns (Fall 2016)
- Primary Digester contract work, loss of ability to make Class B biosolids
  - Mid December 2016 - Centrifuge operation limited to once per week, sufficient to fill EQ tank and support minimum feed to ANITA™ Mox
- Dewatering process equipment issues following contract work to upgrade facility and extended equipment outage (centrifuge fail, conveyor fail)
- Plant secondary treatment upset (September 2017), current winter start-up conditions, and no centrate treatment on-site prior to ANITA™ Mox

Egan ANITA™ Mox Media Progression

Sampling and Analysis

Treatment Plant Operators collect samples

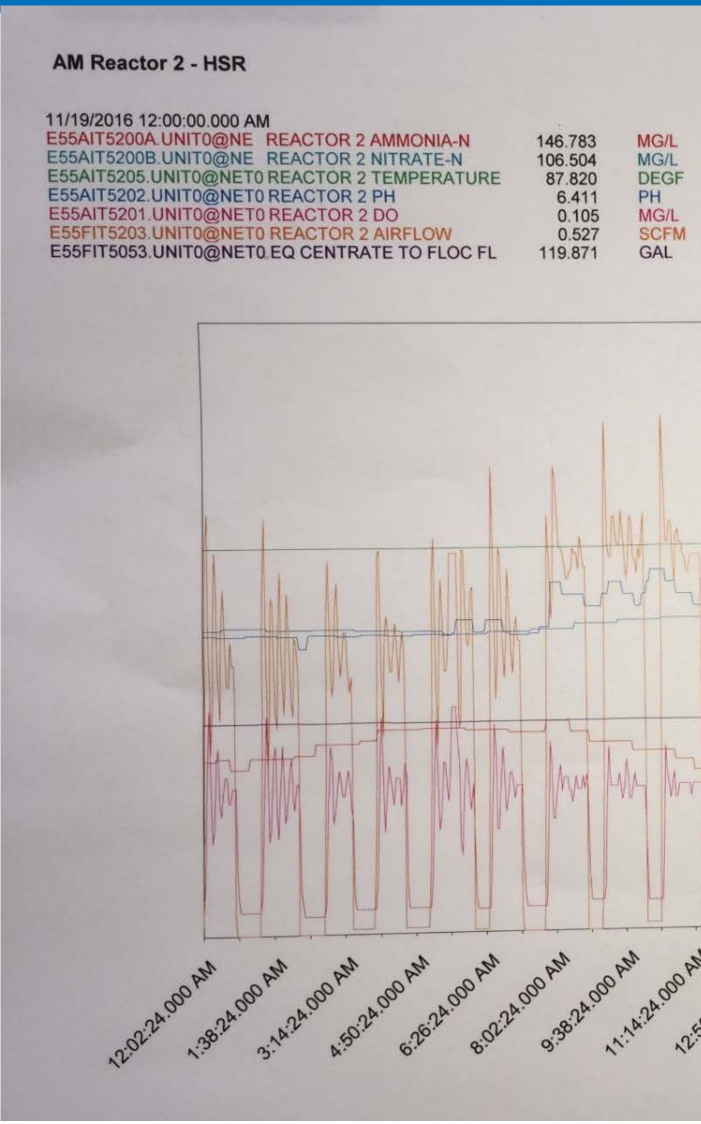
- Daily samples for process control analyzed in TPO lab
  - Ammonia-N, Nitrate-N, Nitrite-N, pH, and Alkalinity
  - TPOs make process corrections and adjustment based on results
- Samples also submitted to District Analytical Lab Division (ALD) for similar and additional analyses and reporting – 3 to 5 times per week depending on parameters

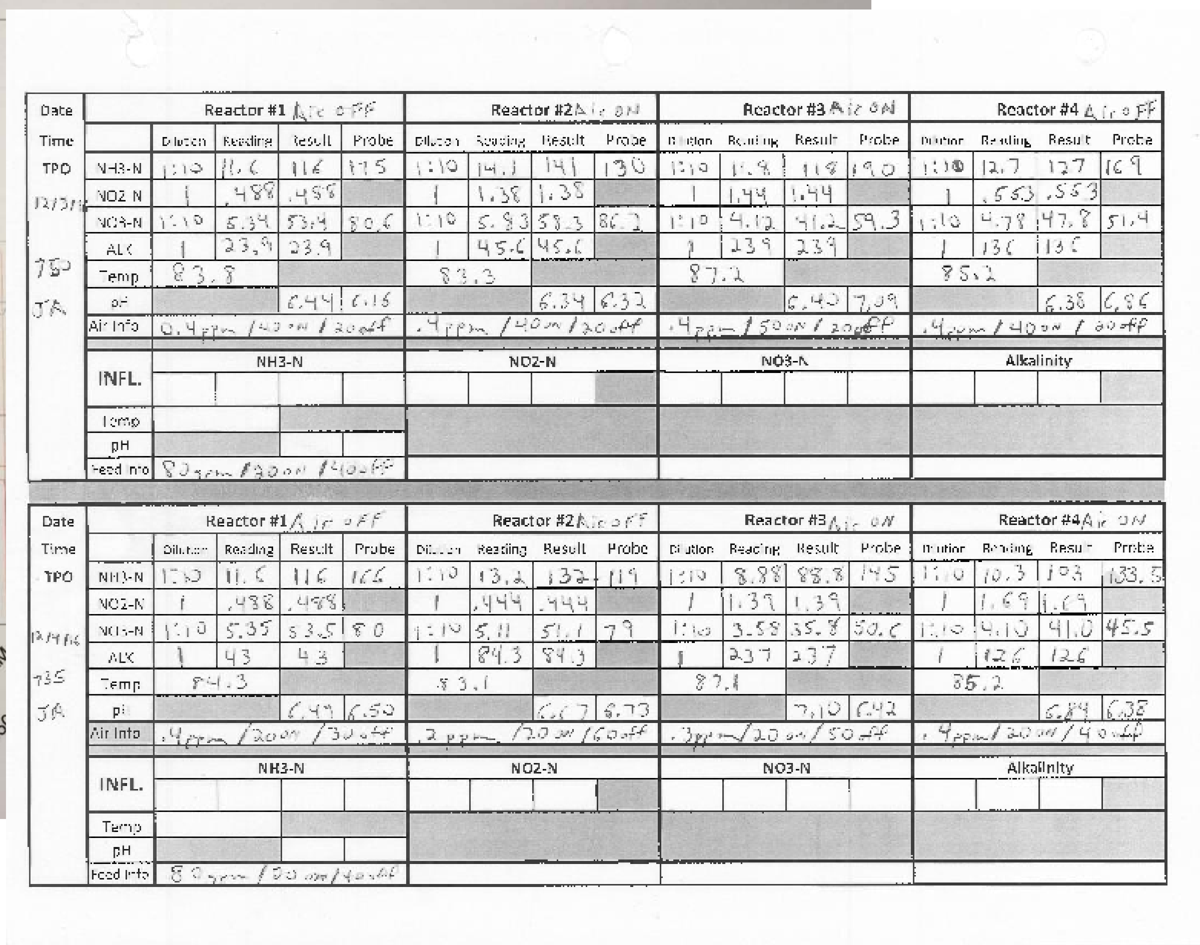


Monitoring, Review and Adjustments

- Daily sample results and 24-hr DCS trend data forwarded to the team consisting of Egan M&O operators, Kruger, and District Engineering and M&R staff
- Initially, process change recommendations provided by Kruger
- Currently, all process changes initiated by District operators, Kruger reviews results and trends and provides input as needed
- Process very robust: daily samples are sufficient for monitoring; once startup completed and stable operations established, daily sampling will be reduced to fewer weekly samples
- Process very robust: with centrifuge outages and the very low flow operations, system responds well when returned to continuous operation

Monitoring DCS Trends & Bench Sheets





Date / Time / TPO		Reactor #1 Air off				Reactor #2 Air on				Reactor #3 Air on				Reactor #4 Air off			
		Dilution	Reading	Result	Probe	Dilution	Reading	Result	Probe	Dilution	Reading	Result	Probe	Dilution	Reading	Result	Probe
12/3/16	NH3-N	1:10	11.6	116	175	1:10	14.1	141	130	1:10	11.9	119	190	1:10	12.7	127	169
	NO2 N	1	.488	.488		1	1.38	1.38		1	1.44	1.44		1	.553	.553	
	NO3-N	1:10	5.34	53.4	80.6	1:10	5.83	58.3	86.2	1:10	4.12	41.2	59.3	1:10	4.78	47.8	51.4
	ALK	1	23.9	23.9		1	45.6	45.6		1	239	239		1	136	136	
750	Temp	83.8				83.3				87.2				85.2			
JA	pH			6.44	6.16			6.34	6.32			6.40	7.09			6.38	6.86
	Air Info	0.4ppm/40on/20off				.4ppm/40on/20off				.4ppm/50on/20off				.4ppm/40on/20off			

INFL.	NH3-N	NO2-N	NO3-N	Alkalinity
Temp				
pH				
Feed Info	80gpm/30on/40off			

Date / Time / TPO		Reactor #1 Air off				Reactor #2 Air off				Reactor #3 Air on				Reactor #4 Air on			
		Dilution	Reading	Result	Probe	Dilution	Reading	Result	Probe	Dilution	Reading	Result	Probe	Dilution	Reading	Result	Probe
	NH3-N	1:10	11.6	116	166	1:10	13.2	132	119	1:10	8.88	88.8	145	1:10	10.3	103	133.5
	NO2-N	1	.488	.488		1	.444	.444		1	1.39	1.39		1	1.69	1.69	
12/4/16	NO3-N	1:10	5.35	53.5	80	1:10	5.11	51.1	79	1:10	3.58	35.8	50.6	1:10	4.10	41.0	45.5
	ALK	1	43	43		1	84.3	84.3		1	237	237		1	126	126	
735	Temp	84.3				83.1				87.1				85.2			
JA	pH			6.49	6.50			6.67	6.73			7.10	6.42			6.84	6.38
	Air Info	.4ppm/20on/30off				.2ppm/20on/60off				.3ppm/20on/50off				.4ppm/20on/40off			

INFL.	NH3-N	NO2-N	NO3-N	Alkalinity
Temp				
pH				
Feed Info	80gpm/20on/40off			

Process Control

- Reactors Effluent Ammonia-N range: 150-200 mg/L
  - Adjust the aeration rate
- Reactors pH (6.5-7.0)
  - Adjust the aeration rate
  - Adjust feed rate
  - Add alkalinity (soda ash)
- Reactors Nitrite levels (<10 mg/L)
  - Elevated nitrite-N undesirable to anammox bacteria and levels need to be kept low

Dosing for Alkalinity

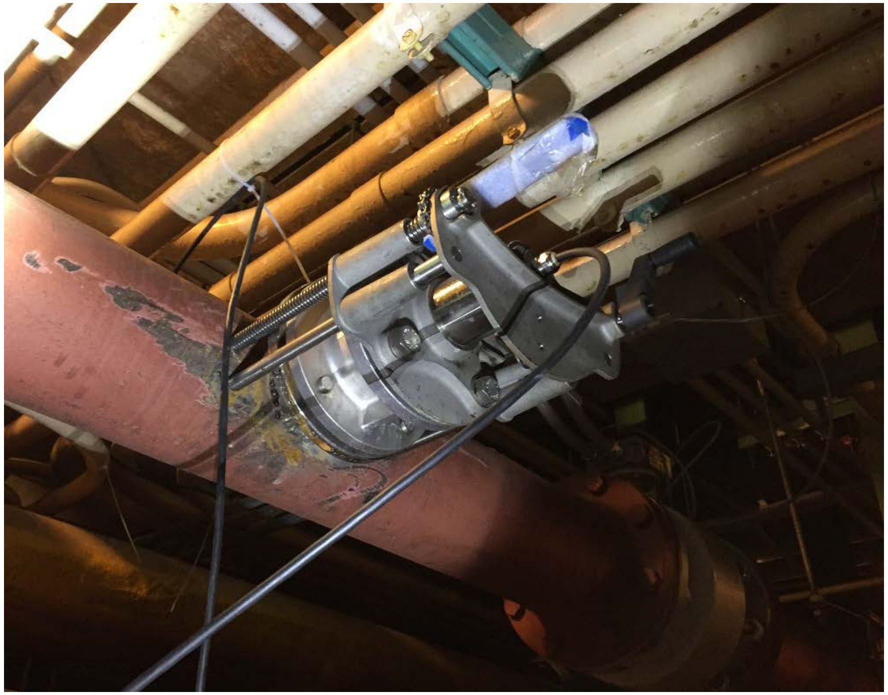
- Egan uses ferric chloride in dewatering process; this reduces available alkalinity making centrate alkalinity deficient
- Supplement with Soda Ash

Improvements

- Equalization Tank operates at varying levels during process start-up, on weekends, and during low flow standby period conditions – probes designed for continuous full submergence
- Installed sample tank with small sample pump to recirculate centrate and get continuous instrument readings

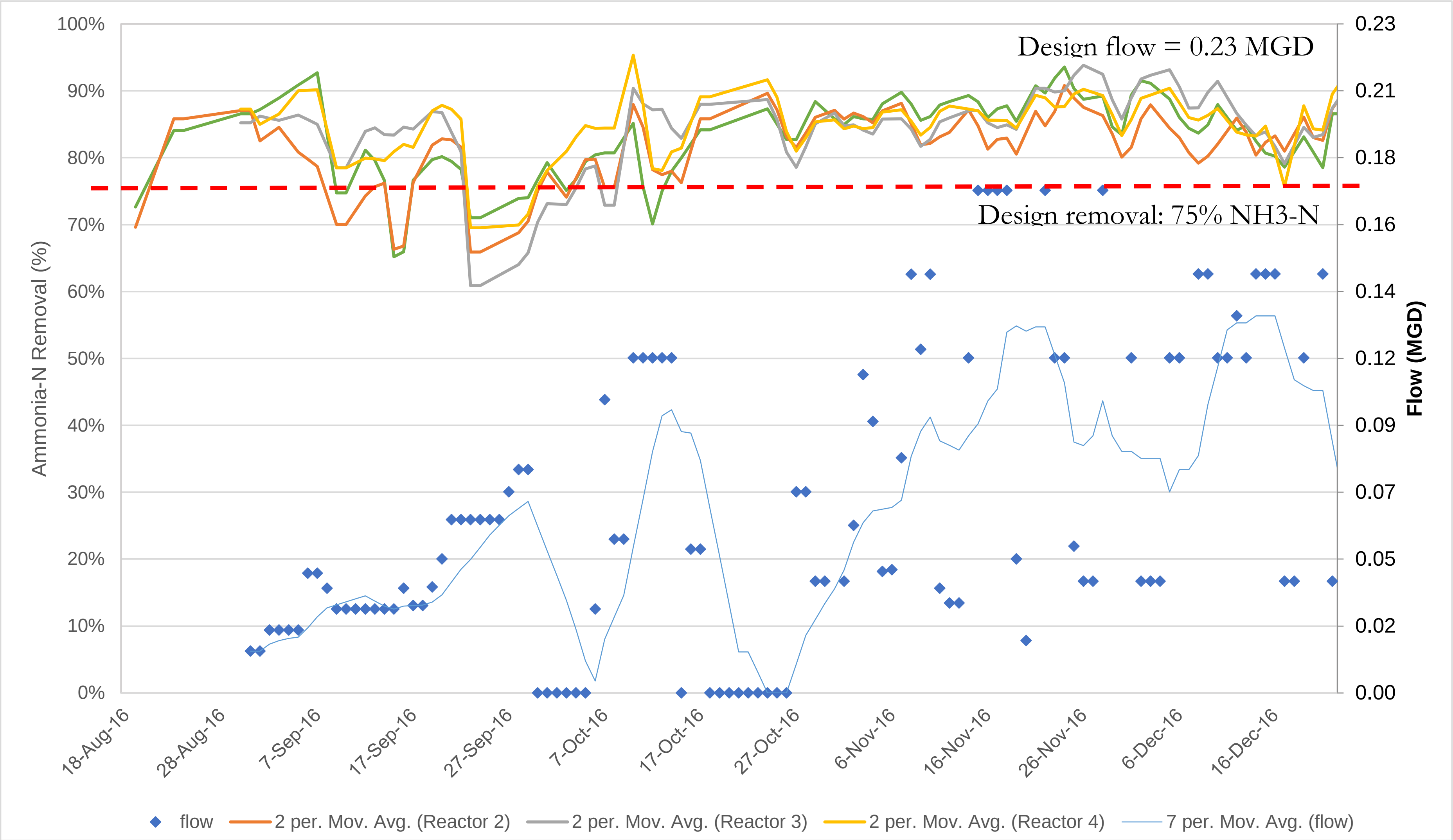
Improvements

- Added a Suspended Solids probe to the centrate line from Dewatering to ANITA™ Mox.
- Limited supervision of centrifuges on/off shifts. High suspended solids content detected to take centrifuge off production.



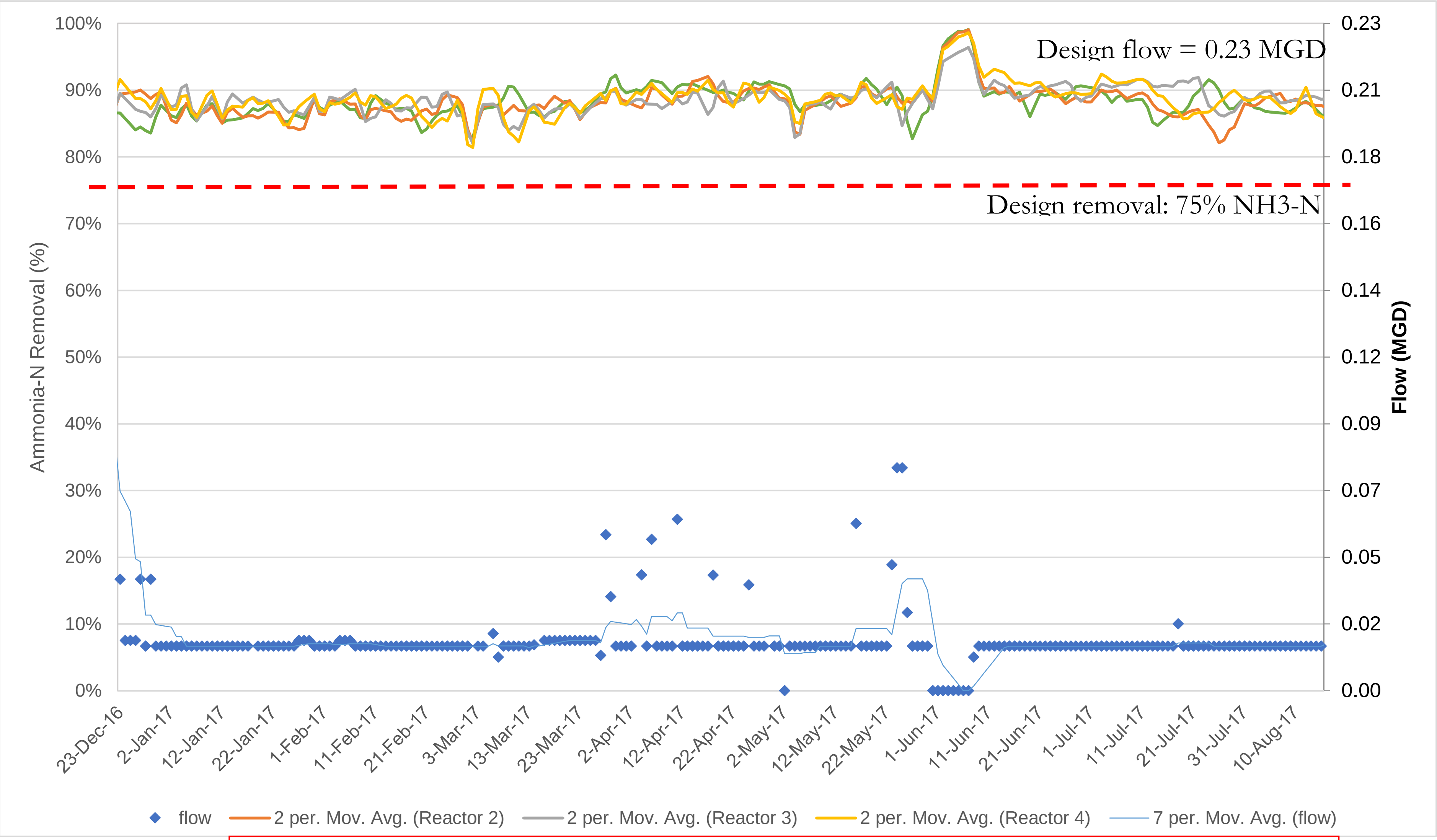
- Alert control room so operator can go correct the operation and prevent high solids from reaching process (high solids undesirable to ANITA™ Mox process).

ANITA™ Mox Initial Startup (8/31/16-12/22/16)



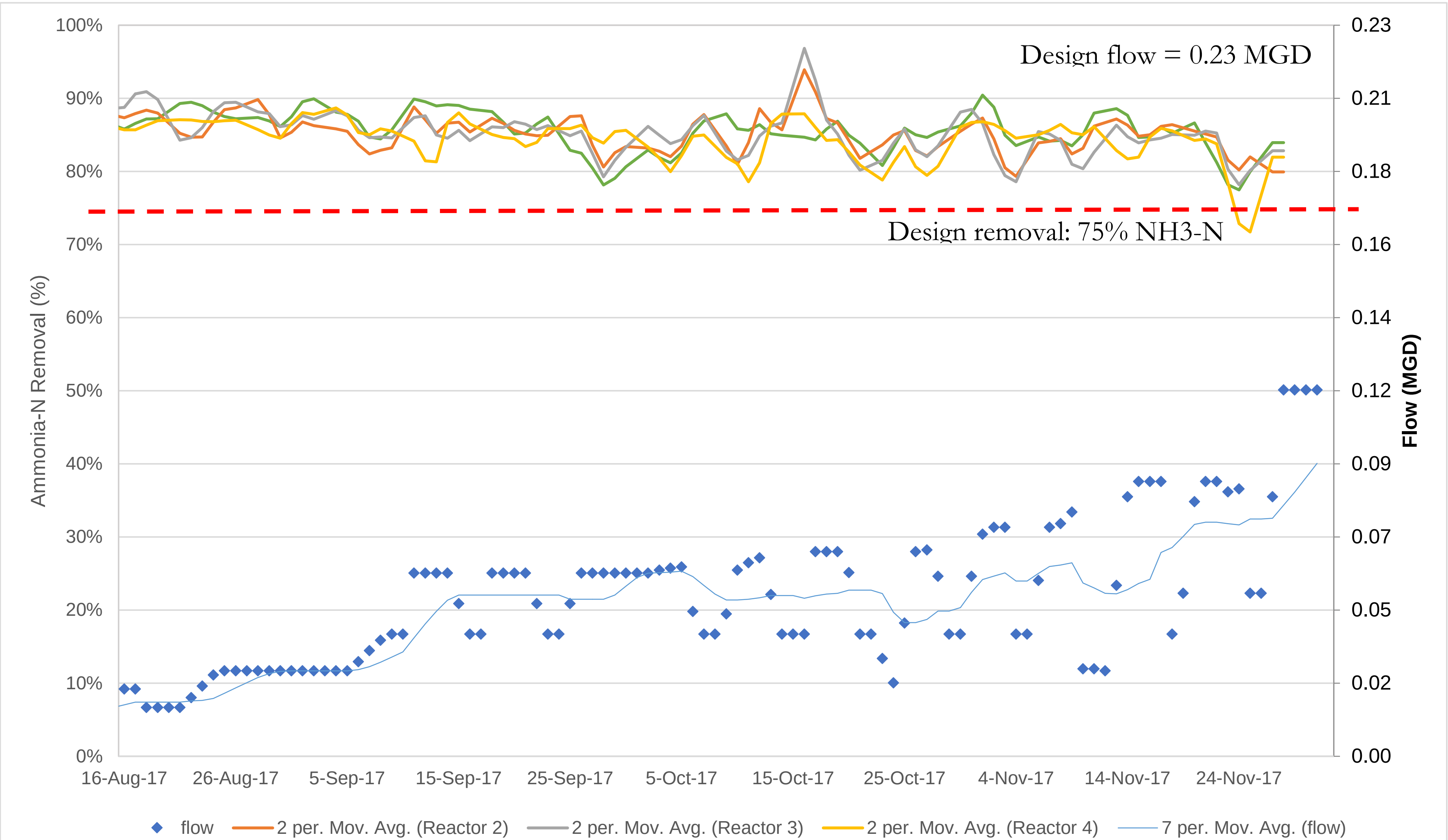
Averages during Initial Startup:
Influent Ammonia-N: 938 mg/L; Effluent Ammonia-N: 159 mg/L; Ammonia-N Removal: 83%

ANITA™ Mox Standby Period (12/23/16-8/15/17)



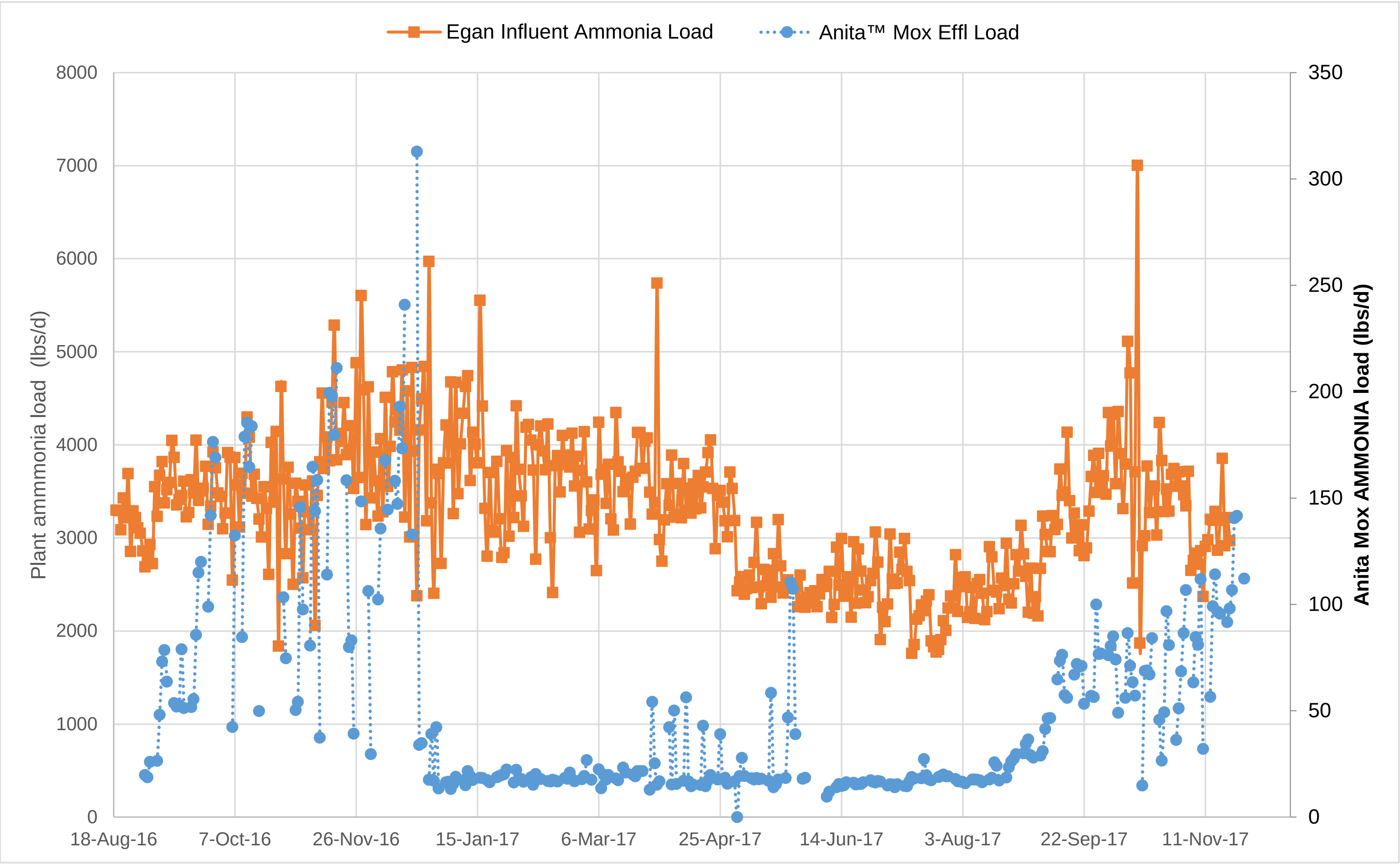
Averages during Standby Period:
Influent Ammonia-N: 1,160 mg/L; Effluent Ammonia-N: 133 mg/L; Ammonia-N Removal: 88%

ANITA™ Mox Secondary Startup (8/16/17-present)

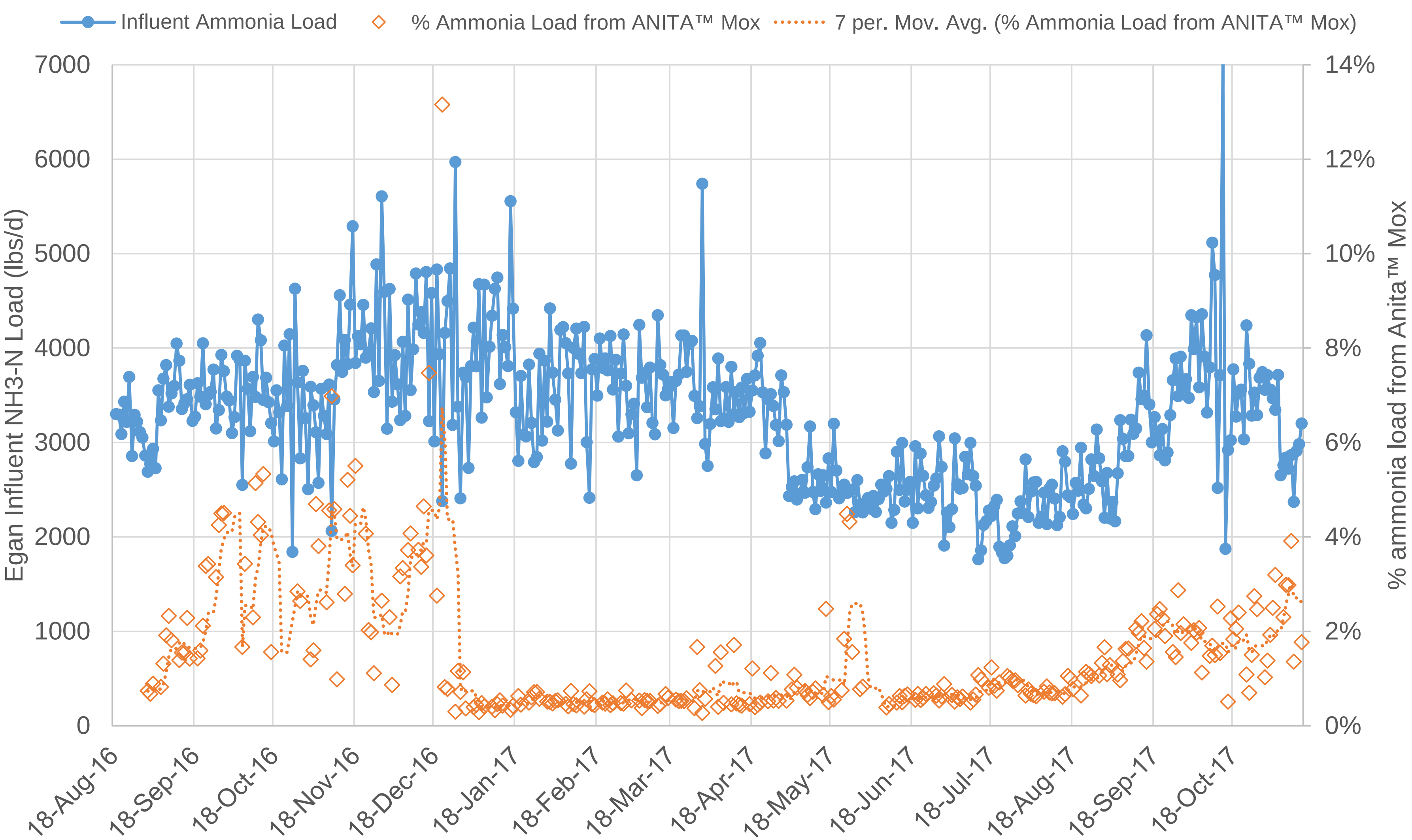


Averages during Secondary Startup:
Influent Ammonia-N: 970 mg/L; Effluent Ammonia-N: 145 mg/L; Ammonia-N Removal: 85%

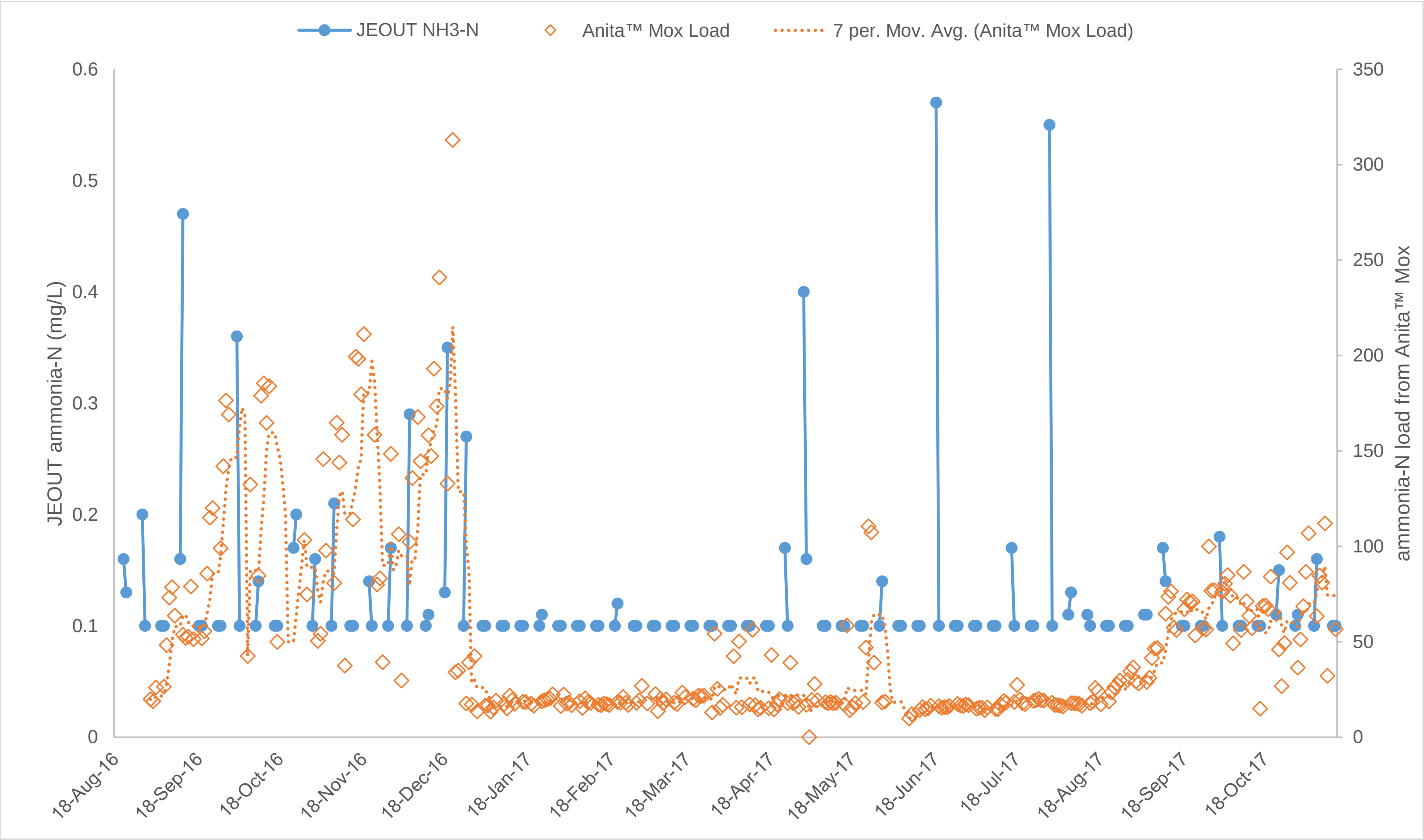
ANITA™ Mox Startup Data –Ammonia Load from Sidestream and Plant Influent



ANITA™ Mox Startup Data – Percent Ammonia Load from Sidestream



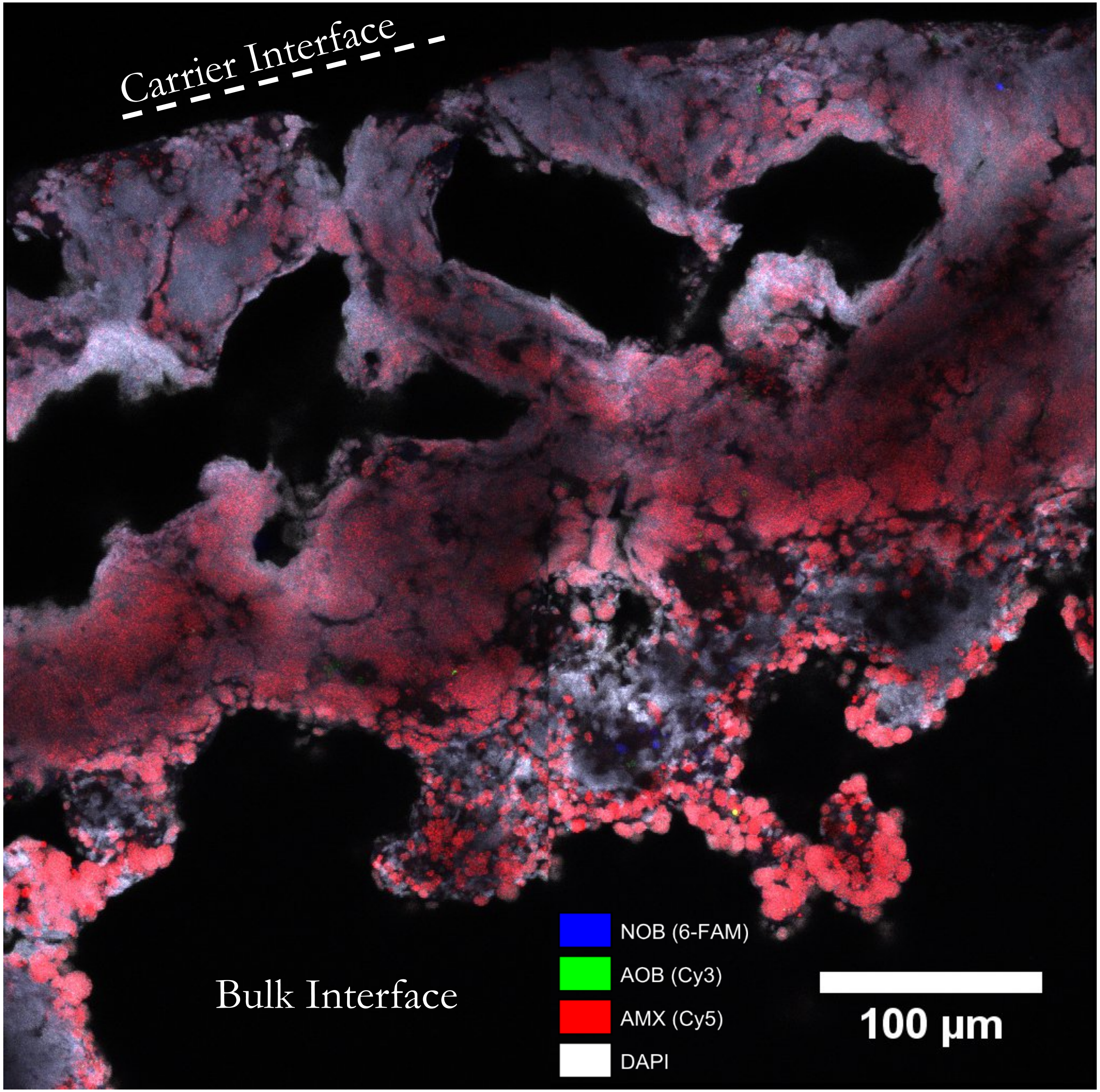
ANITA™ Mox Startup Data – JEOUT NH3-N



JEOUT NH3-N is monitored twice per week.

Egan ANITA™ Mox Reactor "Seed Carrier Biofilms"

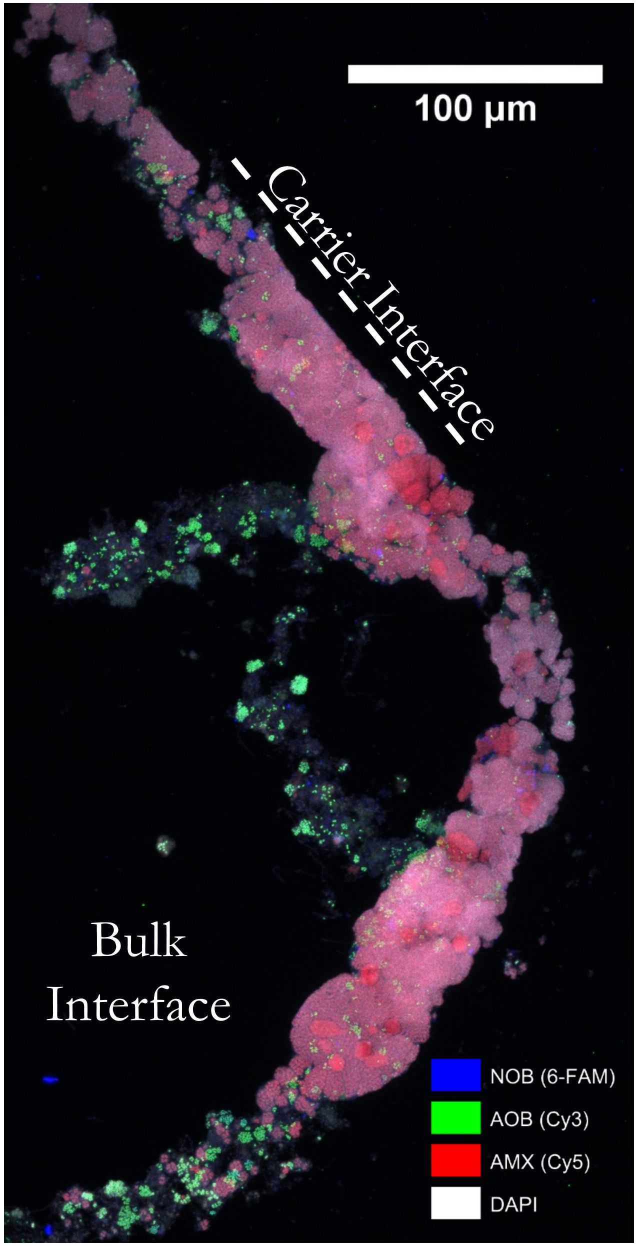
- Little to no AOB/NOB signal on seeded carrier biofilms
- Strong anammox (AMX) signal distributed throughout the thickness of the biofilm
- Anammox signal is strongest at the bulk/biofilm interface and does seem to decrease closer to the carrier/biofilm interface



K5 Seed Carrier, Egan WRP ANITA™ Mox Reactor, Sampled October 12, 2016
(Alex Rosenthal, Wells Group, Northwestern University)

Egan ANITA™ Mox Reactor "New Carrier Biofilms"

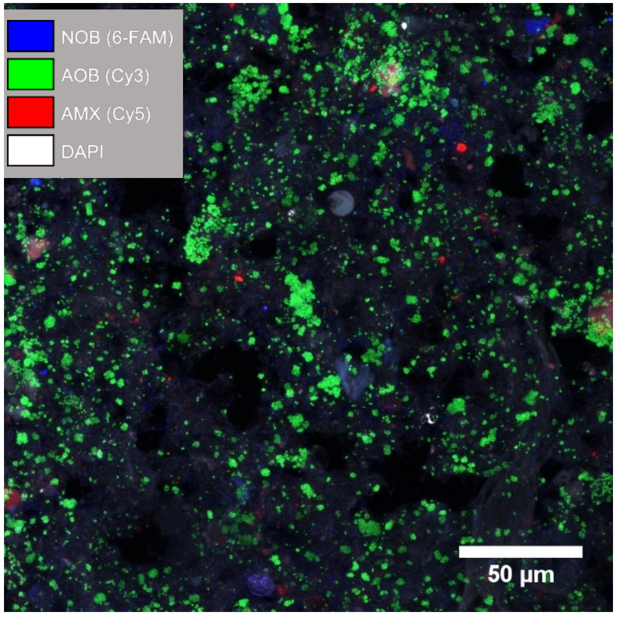
- ~20-50 micron thick "patchy" **anammox** signal detected on new carriers
- **AOB** signal detected with varied spatial patterns of enrichment
  - Basal layer (see lower left corner)
  - Finger-like protrusions extending from the basal layer (often connected to anammox basal layer biofilm)
  - Some microcolonies embedded within dense anammox signal
- Very little **NOB** detected

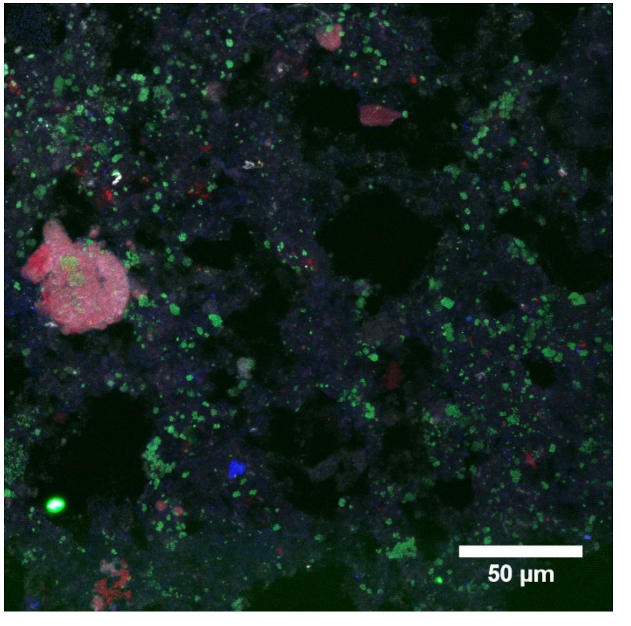


K5 New Carrier, Egan WRP ANITA™ Mox Reactor, Sampled October 12, 2016 (Alex Rosenthal, Wells Group, Northwestern University)

Egan ANITA™ Mox Reactor "Suspension"

- Apparent selective enrichment of **AOB**.
- A few **anammox** microcolonies observed in most micrographs
- Very low abundance of **NOB** signal
- SRT is seemingly high enough to support AOB enrichment in the reactor suspension





Suspended Solids, Egan WRP ANITA™ Mox Reactor, Sampled October 12, 2016 (Alex Rosenthal, Wells Group, Northwestern University)

Lessons Learned from ANITA™ Mox Startup

1. Daily sampling is helpful in preventing process upset
2. System can maintain activity even at very low flows for extended periods of time
3. Maintaining some activity during down times allows for less stressful restart
4. Installing a suspended solids probe upstream of the diversion valve to ANITA™ Mox process allows for early detection of high solids and upstream equipment adjustment before centrate gets to the process
5. If EQ tank is to be operated at varying levels, consider location of instrumentation
6. If system is alkalinity deficient, having reliably working alkalinity dosing system will prevent back breaking manual dosing to keep up with system demand

Conclusions

- Successfully implemented ANITA™ Mox into existing, unused basins with collaborations between Engineering, M&O, M&R Departments and Kruger.
- Nitrogen removal in sidestream has allowed flexibility to plant operations and should help mitigate odor problems in pipelines.
- Feeding the system at low flows while repair of mechanical equipment upstream assisted in secondary startup
- Startup expected to be completed by the end of March 2018
- Despite various challenges:
  - Ammonia removal has averaged greater than 75%
  - TIN removal has averaged greater than 65%
- This project provides the District with invaluable knowledge, experience and opportunity to move towards the Mainstream Deammonification; learned experiences of sidestream and mainstream Deammonification @ Egan WRP may be applied to other District facilities.

QUESTIONS?

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