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

• 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)
ANITA™ Mox Startup and Optimization at the Egan Water Reclamation Plant
Presented By

Kathy Lai, PE
Principal Engineer, M&O

Louis Storino, PE
Principal Civil Engineer, Engineering

Cindy Qin, PhD
Environmental Research Scientist, M&R
Acknowledgements

Engineering
• Kevin Fitzpatrick
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• Meagan Matias

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• Rachel Ryan

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• Meg Hollowed
• Glenn Thesing

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• 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

<table>
<thead>
<tr>
<th></th>
<th>Load Limits – lbs/day</th>
<th>Concentration Limits mg/L</th>
<th>Sample Frequency</th>
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<tr>
<td></td>
<td>DAF (DMF)*</td>
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<tr>
<td></td>
<td>Monthly Average</td>
<td>Weekly Average</td>
<td>Daily Maximum</td>
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<tr>
<td></td>
<td>Monthly Average</td>
<td>Weekly Average</td>
<td>Daily Maximum</td>
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<tr>
<td>April-Oct.</td>
<td>375 (626)</td>
<td>751 (1,251)</td>
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<td>Nov.-Feb.</td>
<td>901 (1,501)</td>
<td>2,002 (3,336)</td>
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<tr>
<td>March</td>
<td>575 (959)</td>
<td>1426 (2377)</td>
<td>2,002 (3,336)</td>
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* Load limits based on design maximum flow shall apply only when flow exceeds design average flow
Partial Nitritation-Deammonification

1/2 Nitritification

NH$_4^+$ → NO$_2^-$ → NO$_3^-$ → N$_2$

Aerobic

-60% O$_2$

Anoxic

COD -100%

Credit to Kruger for slide
• Moving Bed Biofilm Reactor
Challenges

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

Credit to Kruger for slide
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

Engineering

Kruger

M&O

M&R
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)
Primary Settling Tanks
Aeration Tanks
Secondary Clarifiers
Sludge Thickening
Post Dig Sludge Dewatering by Centrifuges
Anaerobic Digesters
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
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
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 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
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

### AM Reactor 2 - HSR

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<th>Reactor #2</th>
<th>Reactor #3</th>
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<th>NO2-N</th>
<th>NO3-N</th>
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#### NH2-N

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#### NO3-N

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#### Alkalinity

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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)

Design flow = 0.23 MGD

Design removal: 75% NH3-N

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

- **Egan Influent Ammonia Load**
- **Anita™ Mox Effl Load**

Graph shows data from 18-Aug-16 to 11-Nov-17.
ANITA™ Mox Startup Data – Percent Ammonia Load from Sidestream

- Influent Ammonia Load
- % Ammonia Load from ANITA™ Mox
- 7 per. Mov. Avg. (% Ammonia Load from ANITA™ Mox)
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
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
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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