Bio-P, Digestion and Dewatering: Unexpected Consequences?
Presentation Outline

- History/Background Information
- Supporting Evidence
- Suspected Causative Factors
- Recent Results/Findings
- déjà vu?

But first, a trivia question...
Can anyone name these devices?
Major Plant Upgrade 2006
- RBC to Bio-P Nitrifying Activated Sludge
- Anaerobic Digestion Improvements
- Belt Filter Press Dewatering
  - Pilot Testing Before Construction => Dewatered Cake ~ 22% TS

Startup Last Quarter 2006/Early 2007
- Initial Dewatered Cake ~ 17-18% TS
- Cake Solids Decreased Over Several Month Period
  - Currently Achieving 12-13% TS
  - Poor Stacking Ability
Sun Prairie WPCF
Bio-P & Anaerobic Digestion Since 1992
Added BFP in 2012
Dewatered Cake Characteristics
- Good Release From Belt
- No Free Water (Appears Typical of 18% TS +/-)
- 10-12% TS Typical
Plant Staff Worked to Optimize Performance
Dewatering Optimization Efforts

- Moved Polymer Injection & Mixing Valve Location
- Added Belt Spray Bars in Washboxes
- Increased Belt Hydraulic Pressure
- Added PRV to Eliminate Gas Binding in Feed Line
- Put Second Digester Online to Increase VS Destruction

Results: Currently Achieving ~ 15% TS

- At Similar Polymer Dosage & Sludge Feed Rate
Marquette (MI) WWTF

- Major Plant Upgrade 2009
  - RBC to Bio-P Nitrifying Activated Sludge
  - Anaerobic Digestion Improvements
  - Belt Filter Press Dewatering

- Startup
  - Initial Dewatered Cake ~ 12-14% TS
  - Changed Polymer Spring 2011
    - Currently Achieving 14-18% TS
Activated Sludge, Anaerobic Digestion, BFP Dewatering & RDP EnVessel Pasteurization
  - Dewatered Cake 15-19% TS

Converted to Bio-P ~ April 2012
  - Dewatered Cake 15-16% TS

What’s Different Than Sun Prairie, Beloit, Marquette???
  =>Anaerobic Digestion Fed Mostly Primary Sludge
However, there have been consequences...

Significant Reduction in Stack Height
Ok, Is This Real or Not???

Others Are Also Seeing This, Including:

- Hampton Roads Sanitary District Atlantic & Nansemond Plants
- Madison Metropolitan Sewerage District
- Met Council Environmental Services Empire & Blue Lake Plants
- Metro Denver, CO

A number of plants in Europe as well...
Nansemond

- Anaerobic Digestion & High Solids Centrifuges
- Originally VIP/MUCT With Supplemental Ferric
  - Dewatered Cake 22-24% TS Consistently
- Conversion to 5 Stage Bardenpho, Ostara & No Ferric
  - Dewatered Cake 18-18.5% Solids
- Was Ferric Addition Making a Difference, or Did Ostara Have an Impact?
Atlantic

- Originally HPO With CEPT (using Ferric & Polymer), Anaerobic Digestion, Centrifuge Dewatering
  - Poor Settleability Mixed Liquor
  - Dewatered Cake ~ 19% TS
- Converted HPO to A/O, Eliminated CEPT, Acid/Methane Digestion
  - Bio-P & Struvite Formation
  - Excellent Settleability Mixed Liquor
  - Dewatered Cake 15-17% TS
- Was Deterioration Related to Elimination of Ferric, Formation of Struvite, or Combination?
Anaerobic Digestion for Decades
Converted Activated Sludge to Bio-P in 1997
Added Dewatering Centrifuge for Class A Biosolids in mid-decade 2000-2010
  - Piloting Showed 22% TS Achievable
  - Full-Scale Has Only Been Able to Achieve 19% TS
Recent Solids Modifications Including:
  - Multi-Phased Digestion
  - Ostara Struvite Harvesting
MCES Empire Plant

Conversion from 2 Sludge to 1 Sludge System

New BFPs Start-Up

Anaerobic Basins On-Line

GBT Started, Co-Thickening Discontinued

Cake Solids (%)

Belt Press Cake Total Solids

Jan-05 Apr-05 Aug-05 Dec-05 Mar-06 Jul-06 Nov-06 Feb-07

Courtesy of Sprouse, 2013
MCES Initial Thoughts

Empire WWTP

- Was Deterioration in Dewatering Due to:
  - Going from two-stage to single stage activated sludge?
  - Bio-P?
  - New soluble waste streams increasing WAS/PSD ratio to digestion?
  - Combination?

Blue Lake WWTP

- Bio-P, Dewatering, Added Anaerobic Digestion
- Dewatering Has Deteriorated Since Digestion Added
Suspected Causative Factors

- Soluble P Concentration of Digested Sludge
  - Evidence that soluble Ortho-P binds water to solids

- Divalent Cation Bridging (DVC)
  - Prominent Divalent Cations are Mg$^{2+}$, Ca$^{2+}$ and Fe$^{2+}$
  - Prominent Monovalent Cations are Na$^{+}$ and K$^{+}$
  - Decreased Divalent Cation content results in deteriorated flocculation, settling, dewatering
Most Sludge Floc Surfaces Are Anionic
Common Cations in Wastewater

Monovalent – Single Plus (+) Charge:
- Sodium
- Potassium

Divalent – Double Plus (++) Charge:
- Magnesium
- Calcium
- Iron
DVC Theory, in a Nutshell

Courtesy of Sprouse, 2013
When Divalent to Monovalent Cation Content Decreases, Dewatering Deteriorates

- e.g., Struvite formation, reducing soluble Mg$^{2+}$ content in sludge
What’s The Future Look Like? Focused Research Efforts Currently Underway...

- Bucknell University, HRSD & Clean Water Services
  - Lab Scale Digesters (M/D Cation Ratio & Concentrations, Effect of Specific Cations – Particularly K\(^+\))
  - National Survey (With Cooperation From Many)

- Madison MSD
  - Effect of Ferric, Digestion Phasing, Dewatering Polymers & Struvite Harvesting on Dewatering Performance

- MCES
  - Effect of Cation Addition & Dewatering Pretreatment Aids on Dewatering Performance

*We’re on a learning curve, similar to struvite a couple decades ago.*
Madison MSD Findings

It’s Complicated...

➤ Adding Ferric Improves Thickening & Dewatering Performance
  ▪ Is This Due to Less Soluble Phosphorus or More Divalent Cations?

➤ Ferric Addition is Constrained by Desire to Produce Marketable Struvite Product
  ▪ Either Precipitate Reduces Soluble Phosphorus
  ▪ Struvite Reduces Divalent Cation Content
Early Returns...MCES

- Unaerated Bio-P WAS Storage (3 Days HRT) with Ferric Addition
  - Cake Solids Increases of 0.5-5% TS
  - Type of Cation Addition Matters (e.g., FeCl₃ vs Fe(OH)₃ vs AlCl₃)

- Digested Sludge Pre-Dewatering Treatment
  - CO2 Stripping Followed by Addition of Divalent/Trivalent Cations (Mg, Fe, Ca)
  - Cake Solids Increases of 2-3% Attained

*MCES continues to experiment...*
Empire WWTP

- Ferric Chloride & WAS Storage Both Improve Dewaterability

![Graph: Cake Solids (%TS) vs Iron Dose (lb Fe / dt of feed solids)]

(Courtesy of Sprouse, 2015)
A Final Thought...

As with many issues in our industry – are we simply re-learning the past?
Acknowledgements

- Hampton Roads Sanitary District, Virginia Beach, VA
  - Charles Bott
- Madison Metropolitan Sewerage District
  - Steve Reusser
- Metropolitan Council Environmental Services, St. Paul, MN
  - George Sprouse
- Metro Wastewater Reclamation District, Denver, CO
  - HDR, Inc.: JB Neethling, Mario Benisch
Acknowledgements

- Sun Prairie WPCF
  - John Krug, Lee Graves
- Beloit WPCF
  - Harry Mathos
- Marquette WWTF
  - Curt Goodman, Mark O’Neil
- Kiel WWTP
  - Kris August
Thanks for your attention!

Bill Marten, PE, BCEE
Donohue & Associates, Inc.
731 N. Jackson Street, Suite 610
Milwaukee, WI 53202
Phone: 414.217.6909
Email: wmarten@donohue-associate.com