REMOVING ORTHOPHOSPHATE AND IMPROVING DEWATERABILITY OF DIGESTED SLUDGE BY POST-DIGESTION AIRPREX® PROCESS

OWEA Biosolids Workshop

December 7, 2017

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Discussion Outline

- Quick History on CNP
- Phosphorus in WWTPs
- AirPrex Deep Dive
  - How it works
  - Review of data
  - Review of key benefits
- Bonus – CalPrex Pre-digestion recovery
- Summary

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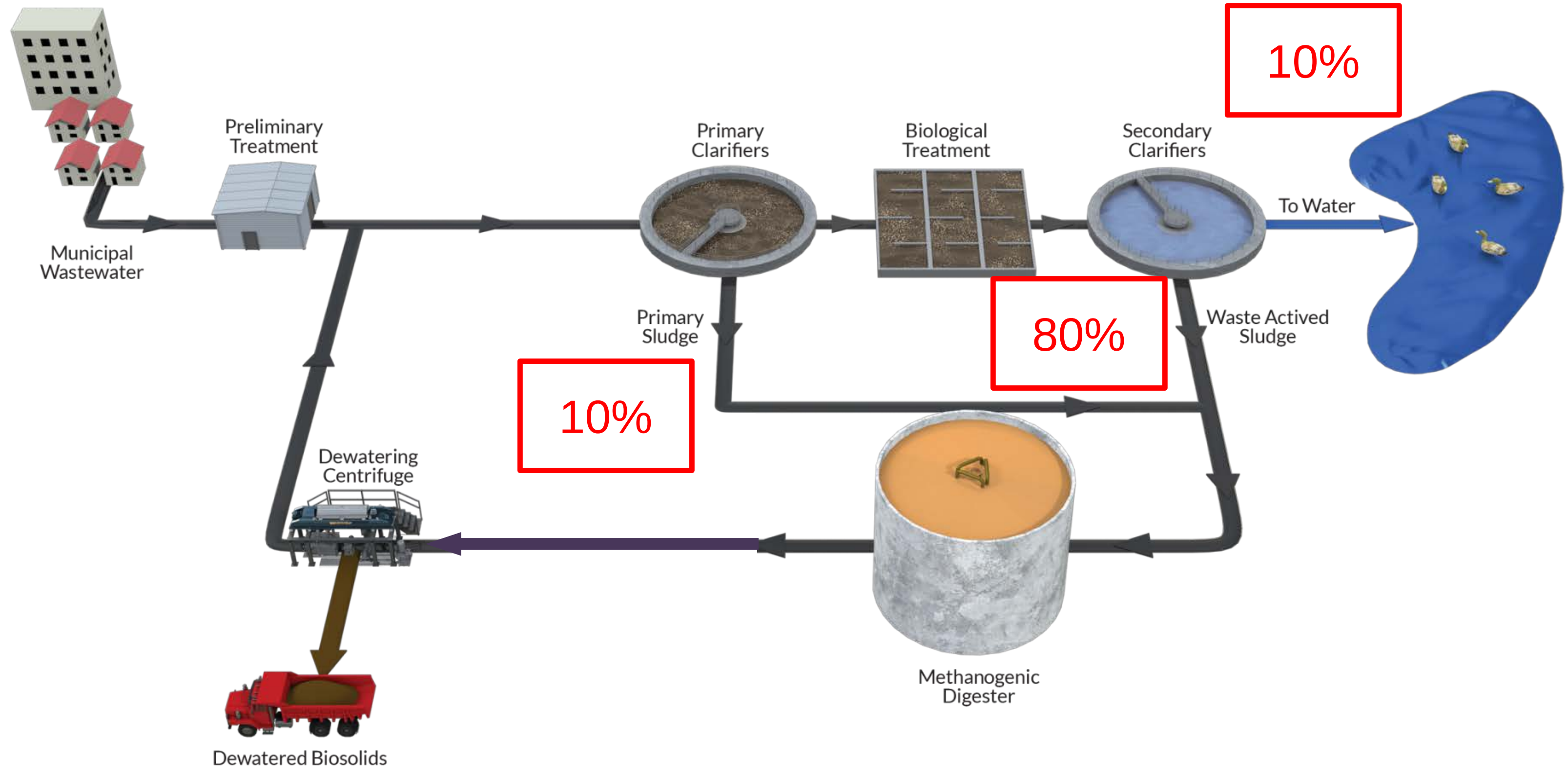
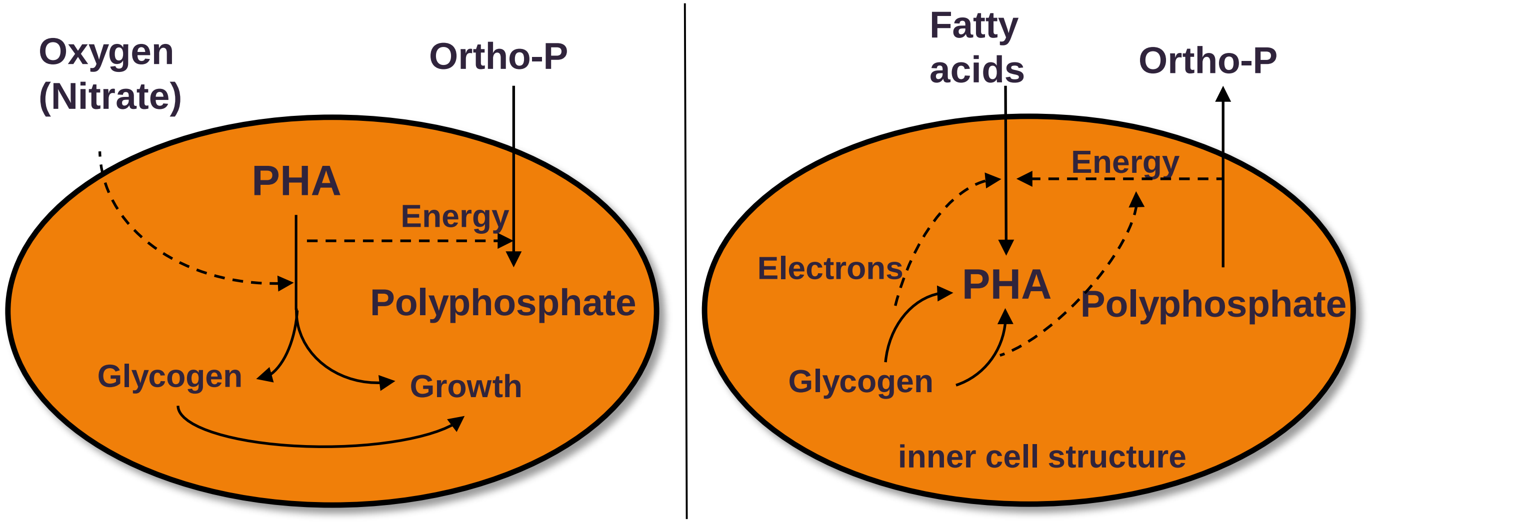
History of CNP and AirPrex

Phosphorus Flows in WWTPs
- For Plants with BNR



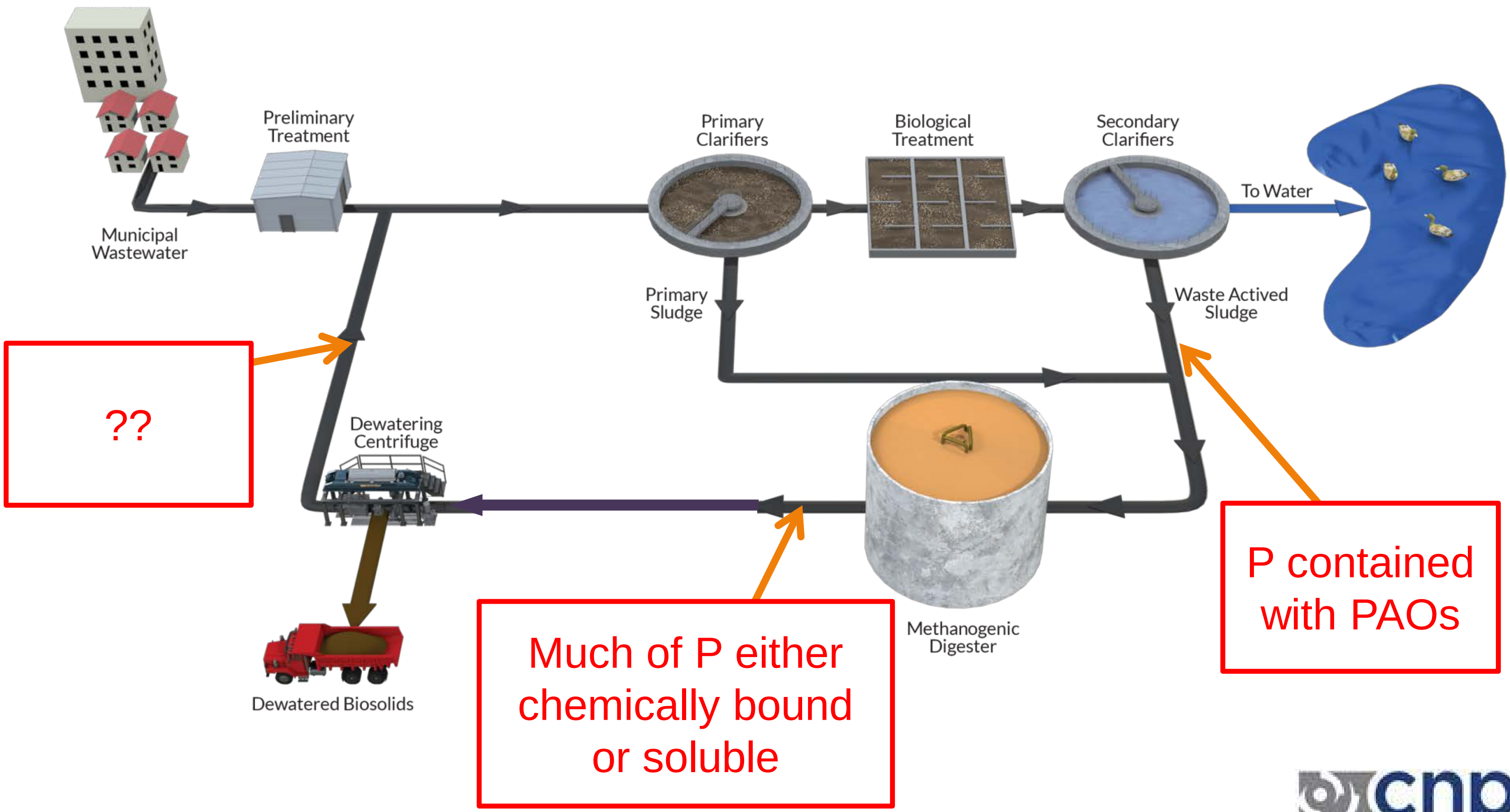
Phosphorus Acculating Organisms (PAOs)



AEROBIC Biological Zone
→
increased **PO_4 uptake** due to the formation of polyphosphates

ANAEROBIC Zone / Digester
→
PO_4 release due to the hydrolysis of polyphosphates

P in Wastewater



Nuisance Struvite Formation

AirPrex®

Sludge Optimization and P-Recovery

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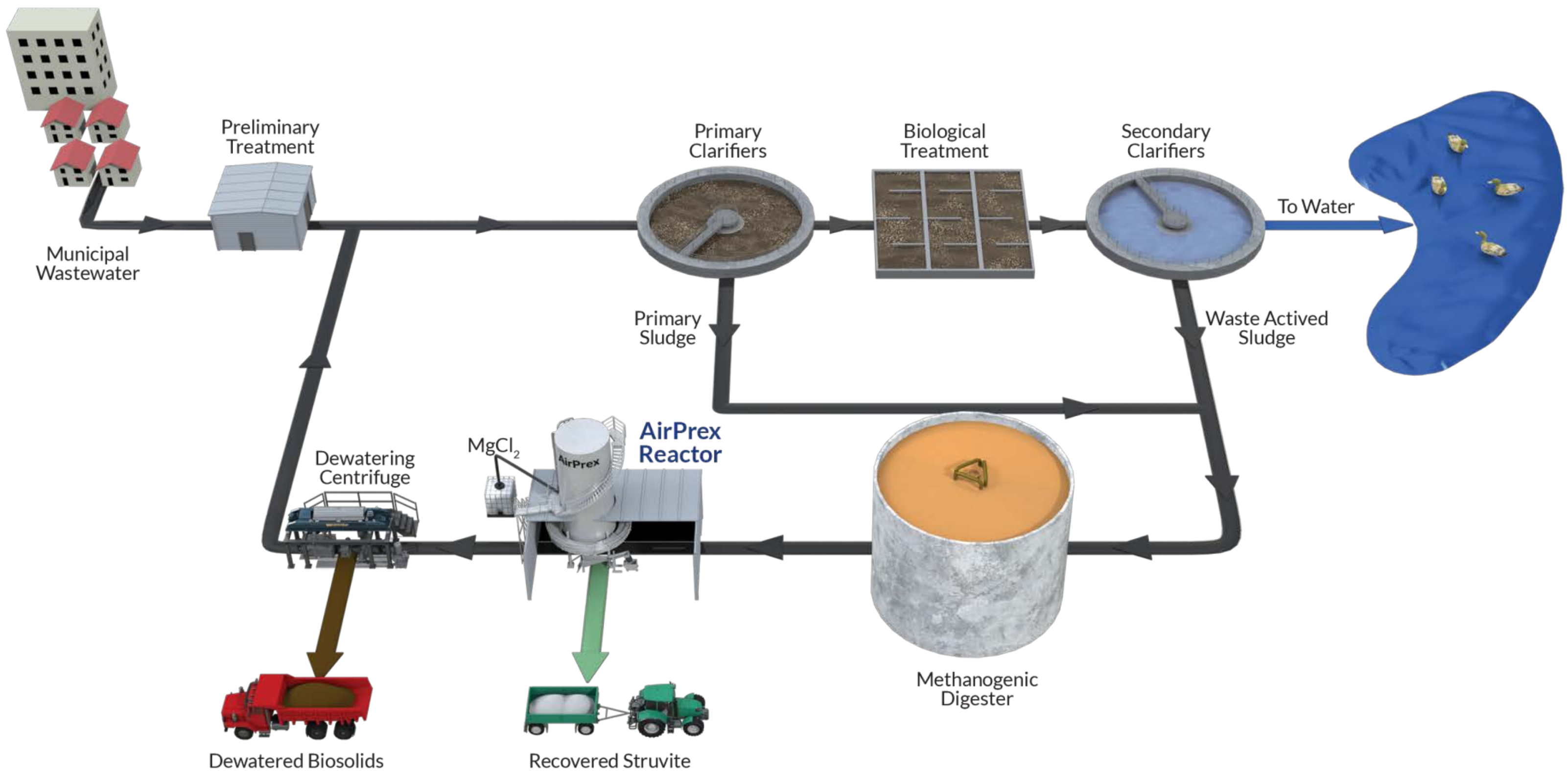
Where AirPrex Plugs In



So Why There?

1. Dewatering is always the problem area for nuisance struvite formation
   - Get it to form before dewatering and eliminate the issue

2. We want to mitigate sidestream phosphorus

3. Removing the soluble P upstream of dewatering improves the cake dryness and reduced the polymer requirement

Denver Metro, CO - RWHTF

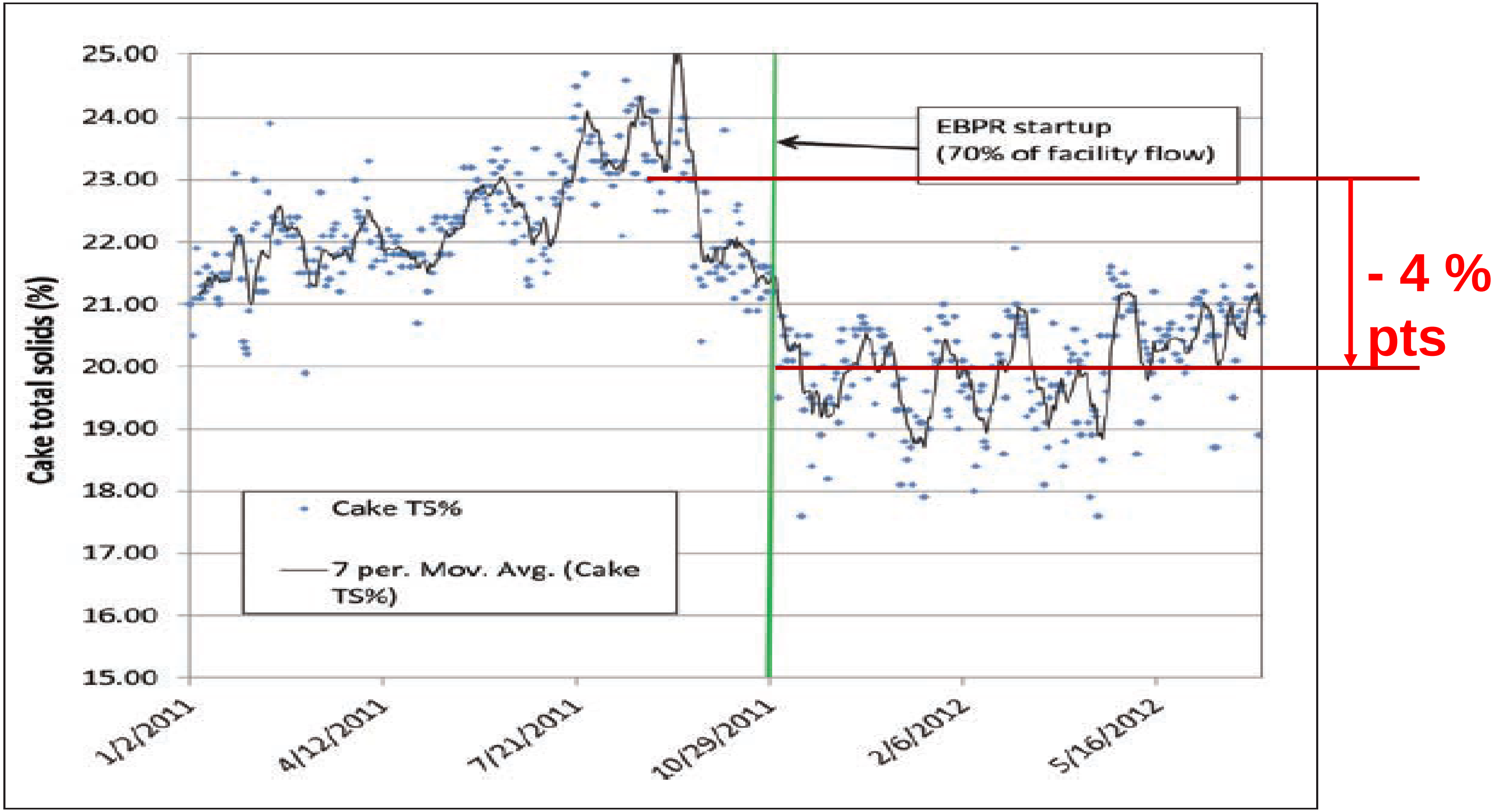
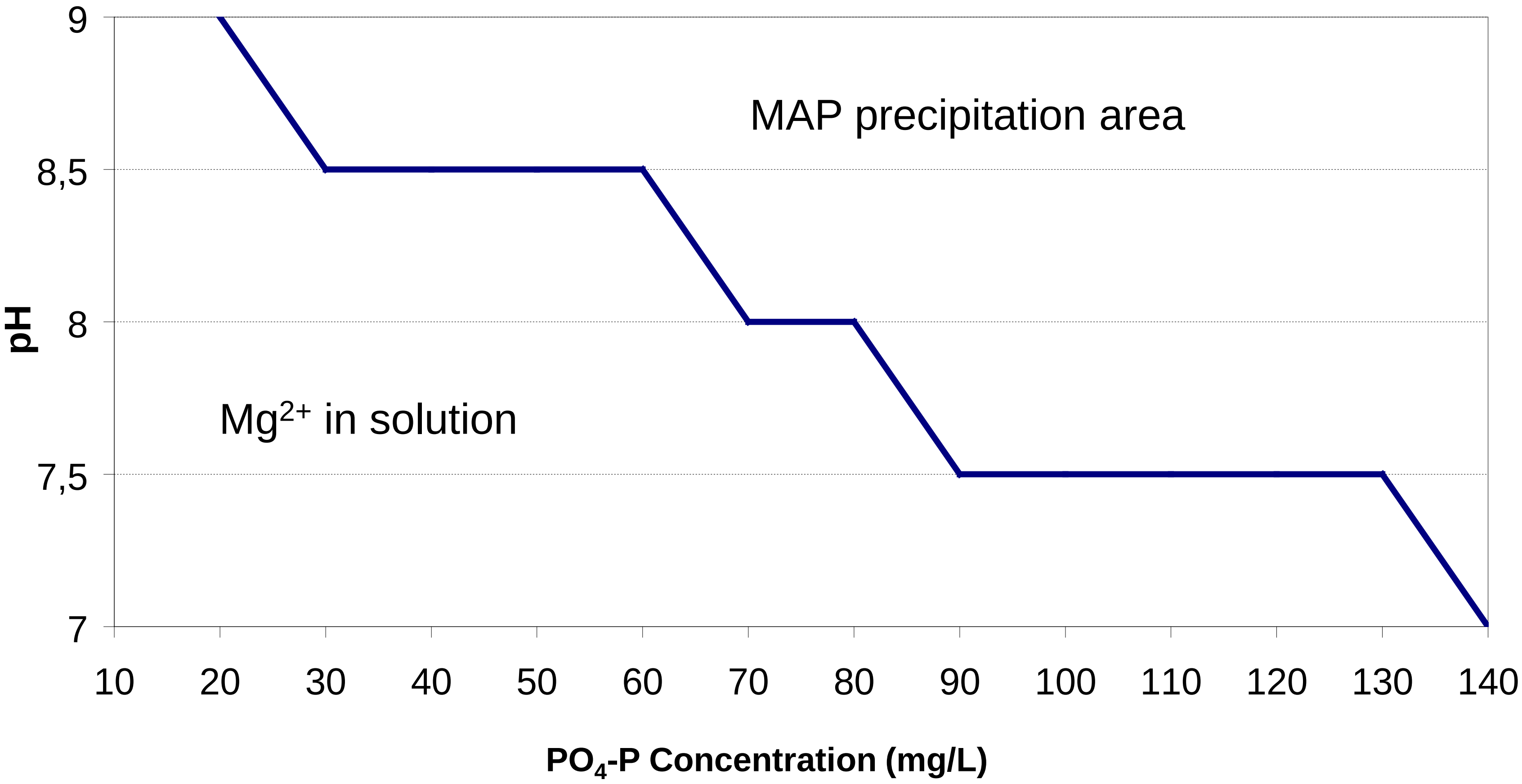


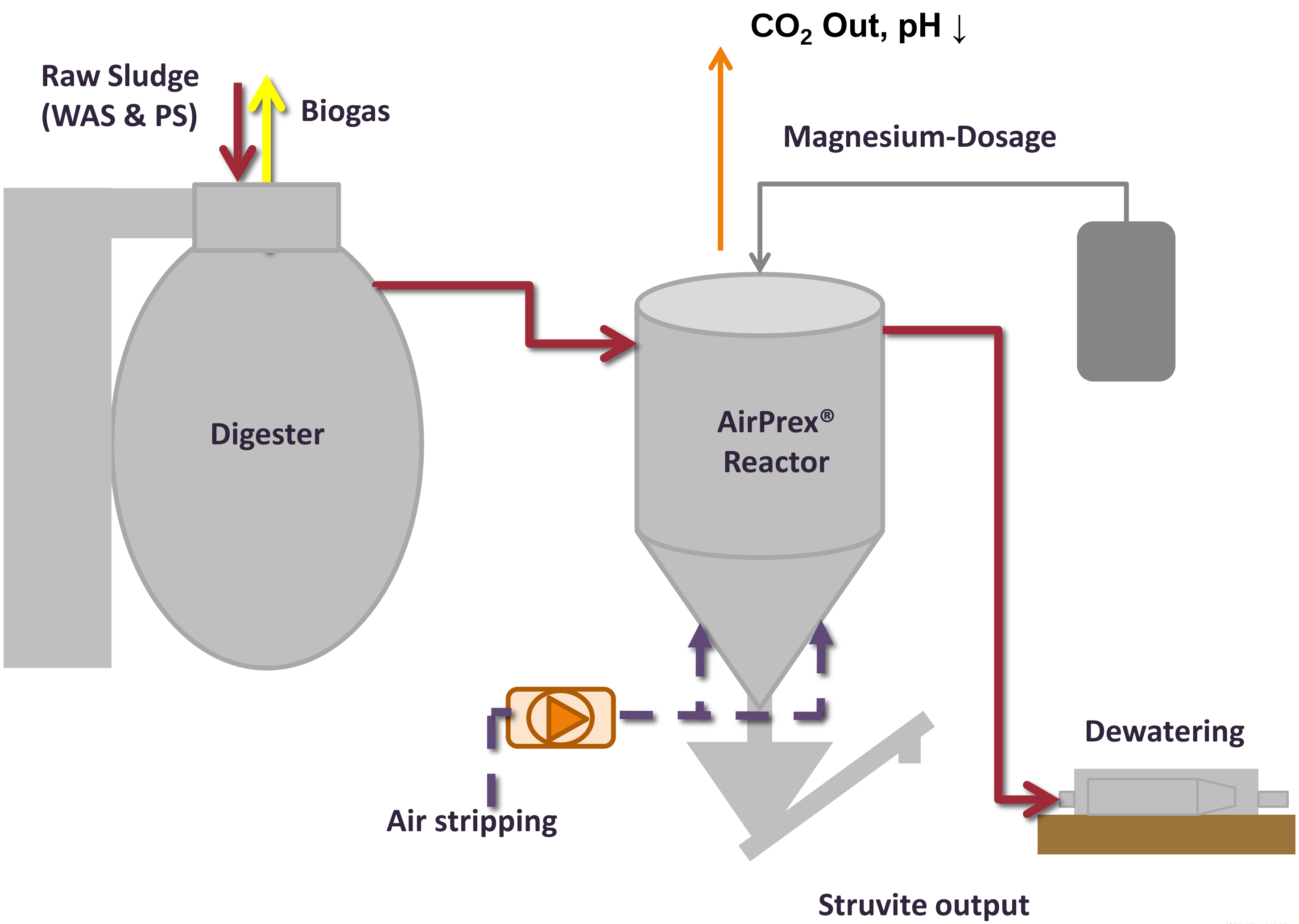
Figure from Cavanaugh, L., K. Carson, C. Lynch, H. Phillips, J. Barnard, and J. McQuarrie (2012). "A Small Footprint Approach for Enhanced Biological Phosphorus: Removal: Results from a 95 MGD Full-Scale Demonstration," WEFTEC 2012 Proceedings (October 2012).

So Why There?

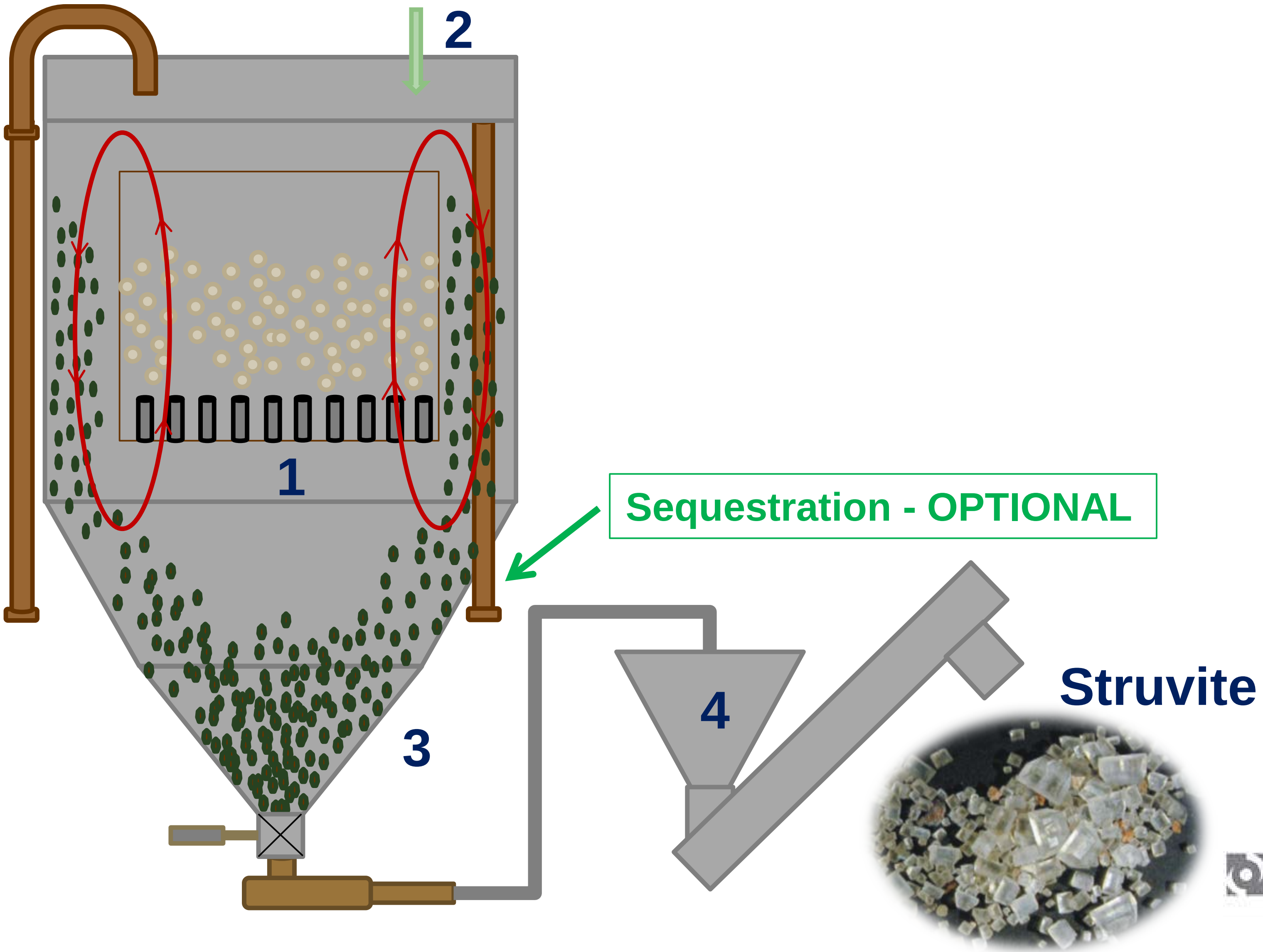


9
8,5
8
7,5
7
pH
MAP precipitation area
Mg2+ in solution
10
20
30
40
50
60
70
80
90
100
110
120
130
140
PO4-P Concentration (mg/L)

How it Works

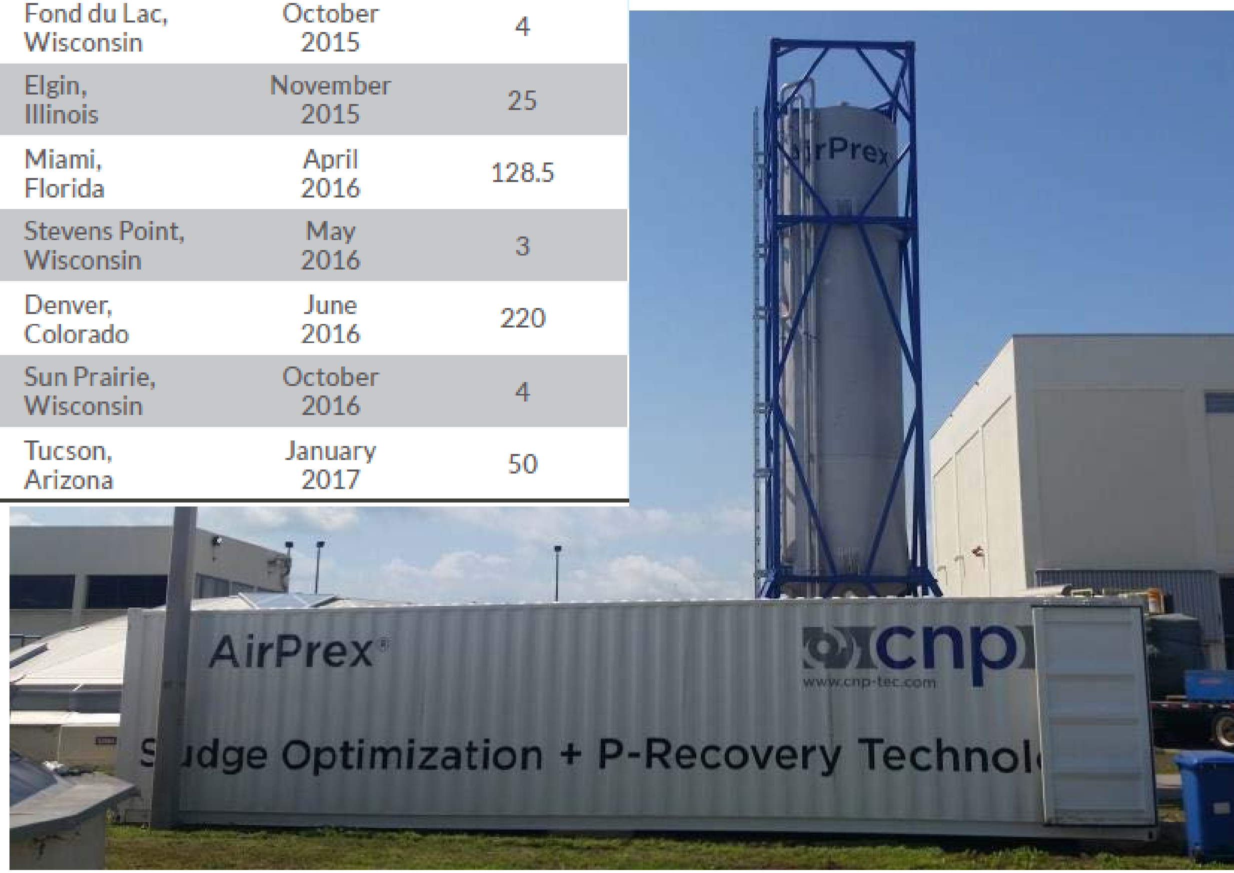

CO2 Out, pH ↓
Raw Sludge
(WAS & PS)
Biogas
Magnesium-Dosage
Digester
AirPrex®
Reactor
Dewatering
Air stripping
Struvite output

How it Works



Notable Pilot Tests

			Plant Size MGD
Fond du Lac WWTP	Fond du Lac, Wisconsin	October 2015	4
Fox River Water Reclamation District	Elgin, Illinois	November 2015	25
Miami-Dade South District Plant	Miami, Florida	April 2016	128.5
Stevens Point WWTP	Stevens Point, Wisconsin	May 2016	3
RWH Treatment Facility at Metro WWRD	Denver, Colorado	June 2016	220
Sun Prairie WWTP	Sun Prairie, Wisconsin	October 2016	4
Tres Rios Water Reclamation Facility	Tucson, Arizona	January 2017	50



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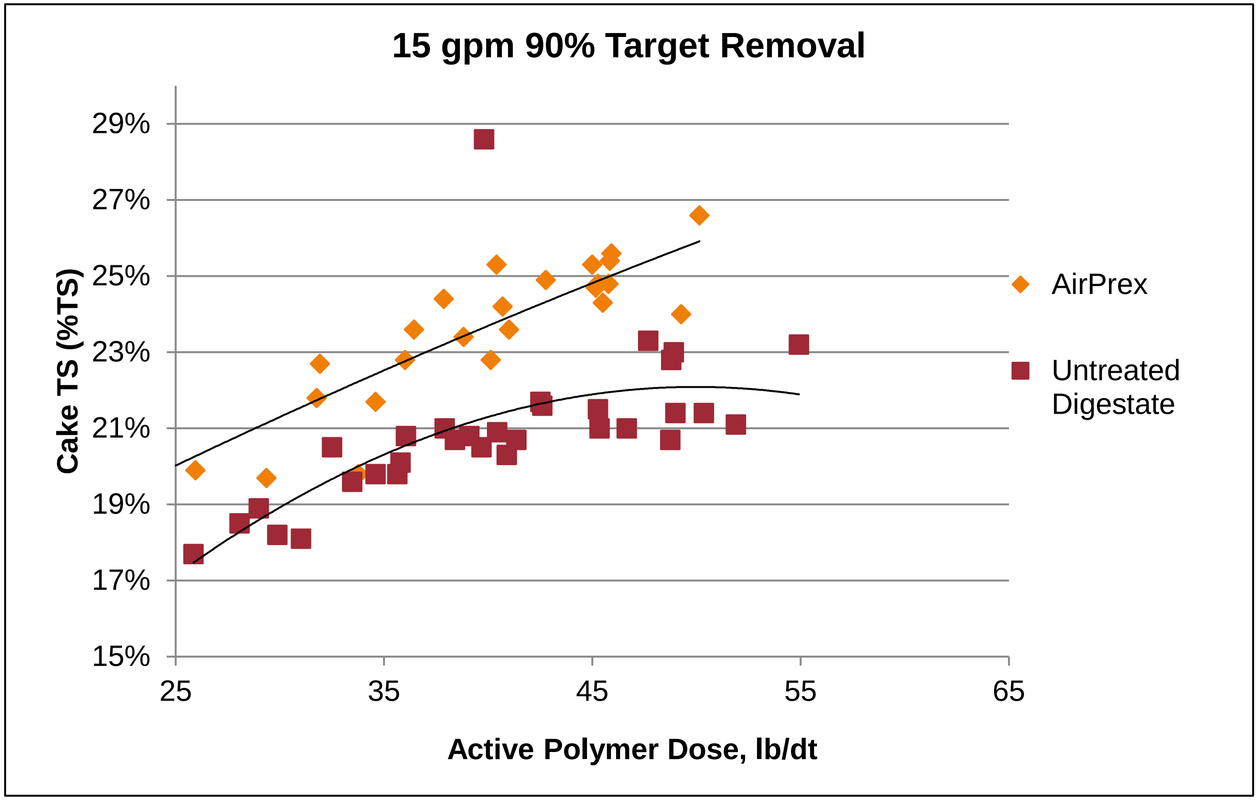
What to Expect as a Result

- Improvement Cake Dryness
  2 to 5 percentage points
- Reduction in Polymer
  10 to 40 % reduction

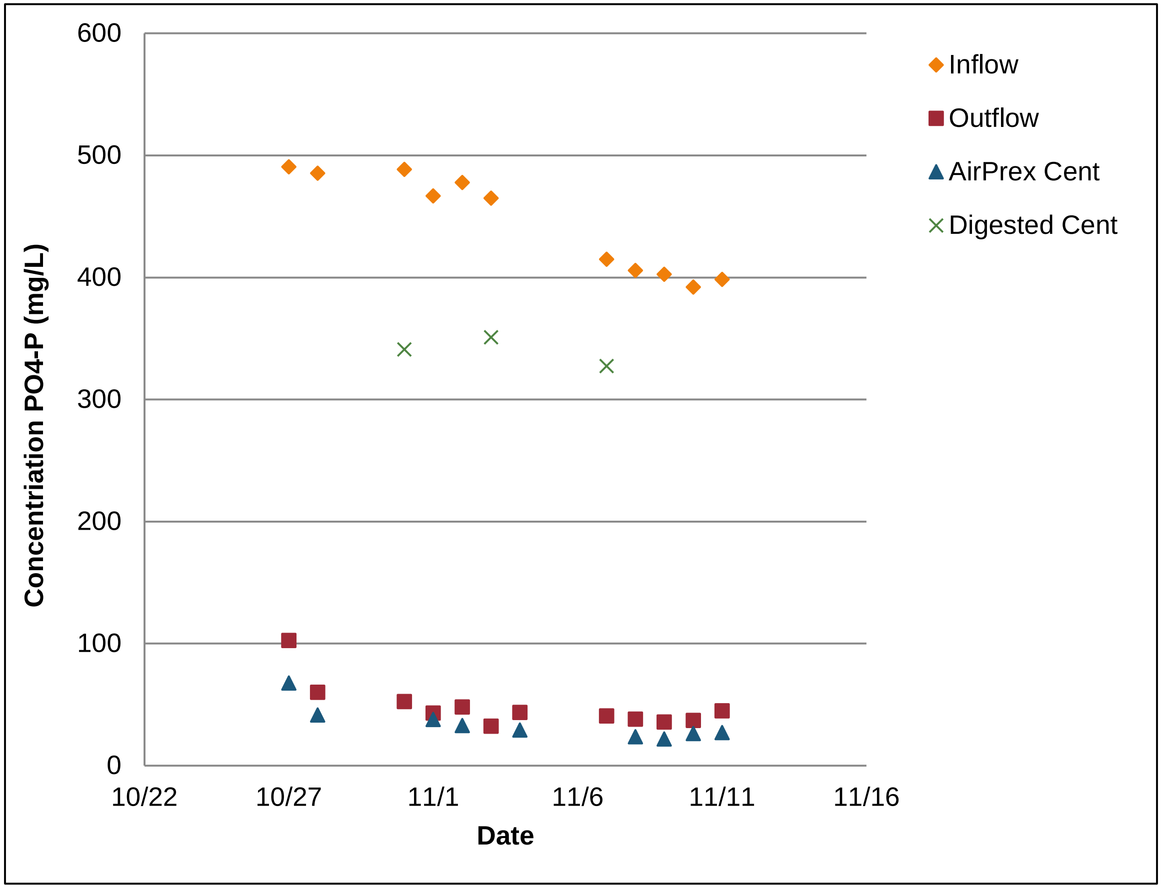


Data Collected during Denver Metro Pilot Test, Summer 2016

Struvite sample collected during Airprex Pilot in Miami-Dade

What to Expect as a Result

- 90% Reduction of Sidestream OP

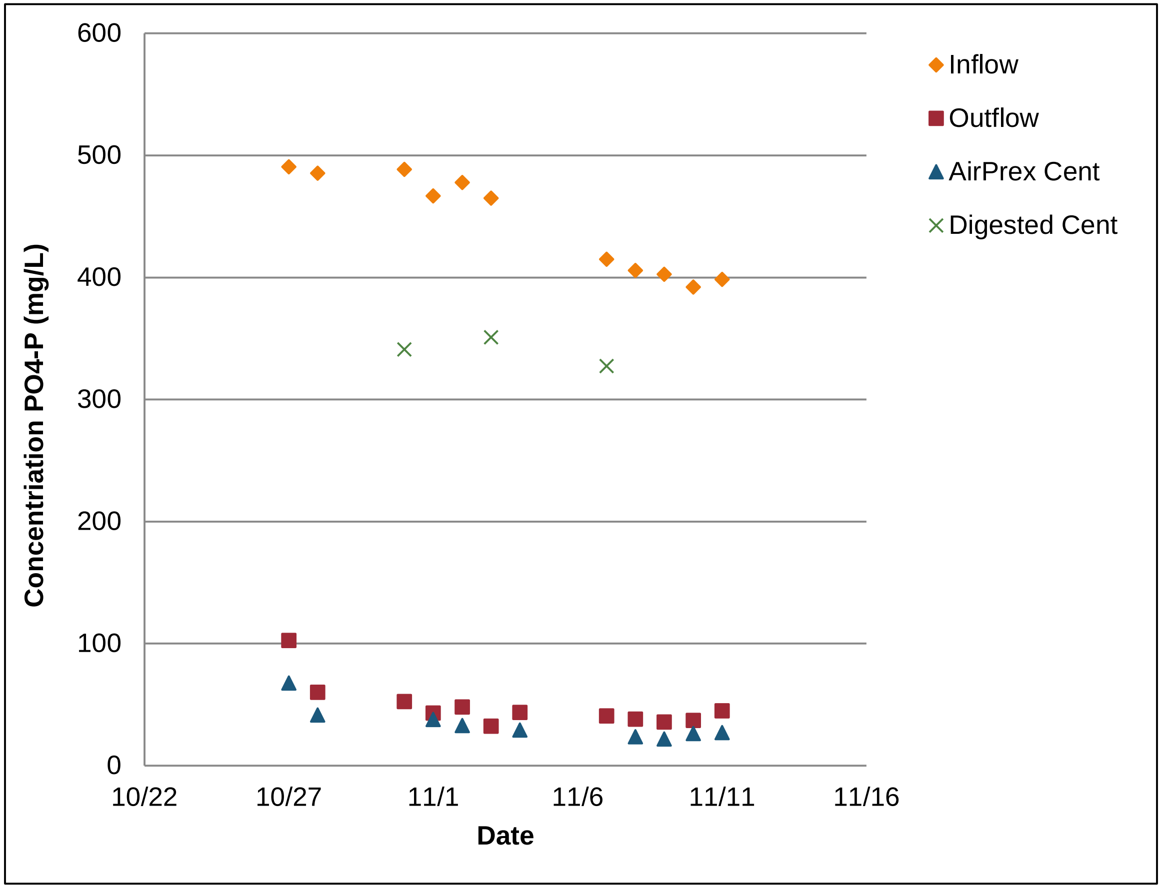


Data Collected during Sun Prairie, WI Pilot Test, Fall 2016

Struvite sample collected during Airprex Pilot in Miami-Dade

What to Expect as a Result

- 90% Reduction of Sidestream OP
- Subsequent Reduction in Digester TP



Data Collected during Sun Prairie, WI Pilot Test, Fall 2016

Struvite sample collected during Airprex Pilot in Miami-Dade

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What to Expect as a Result

– Reduction in Digester influent Phosphorus as Observed at the SunPrairie, WI Pilot Test

Modeling completed by MWH based on Denver Metro Pilot

- Suggests 30% Reduction in Digester TP Concentration when System Reaches Steady State.

Pilot Testing Summary

			Plant Size MGD	After AirPrex		
				Orthophosphate Reduction (%)	Dry Cake Solids Increase (%-points)	Polymer Reduction (%)
Fond du Lac WWTP	Fond du Lac, Wisconsin	October 2015	4	>90	+2	-15
Fox River Water Reclamation District	Elgin, Illinois	November 2015	25	>90	+2	-10
Miami-Dade South District Plant	Miami, Florida	April 2016	128.5	>90	+4	-10 to -20
Stevens Point WWTP	Stevens Point, Wisconsin	May 2016	3	>90	+5	-25 to -35
RWH Treatment Facility at Metro WWRD	Denver, Colorado	June 2016	220	>90	+4 to 5	-15 to -25
Sun Prairie WWTP	Sun Prairie, Wisconsin	October 2016	4	>90	+3	-10 to -25
Tres Rios Water Reclamation Facility	Tucson, Arizona	January 2017	50	>90	+4	-30 to -50

Example Installation

- Amsterdam, Netherlands – Installed 2014

AirPrex® - Amsterdam WWTP (Netherlands)

AirPrex® - Savings for Amsterdam

AirPrex Installations

Full Scale Installations				After AirPrex		
Wastewater Treatment Plant	Location	Year Built	Plant Size MGD	Orthophosphate Reduction (%)	Dry Cake Solids Increase (%-points)	Polymer Reduction (%)
Mönchengladbach-Neuwerk (Niersverband) WWTP	Mönchengladbach-Neuwerk , Germany	2009	80	>90	+3	-15
Berlin Wasserbetribe (BWB) WWTP	Berlin, Germany	2010	120	>90	+3 to 4	-20
Wieden-Echten (Reest & Wiedn) WWTP	Echten, Netherlands	2013	30	>90	+3	-15
Amsterdam-West (Waternet) WWTP	Amsterdam, Netherlands	2014	170	>90	+3	-25
ASG Salzgitter North WWTP	Salzgitter, Germany	2015	20	>90	+2	-15
Jing Nan Tianjin WWTP	Tianjin, China	2016	120	>90	Centrate Recovery	
Uelzen WWTP	Uelzen, Germany	2017	10		Pending Start-Up	
Wolfsburg Entwasserungsbetriebe (WEB) WWTP	Wolfsburg, Germany	2017	25		Pending Start-Up	
Liverpool WWTP	Medina, Ohio	2017 Start-up	9		Pending Start-Up	
Little Patuxent Water Reclamation Plant, Howard County	Savage, Maryland	2017 Start-up	29		Pending Start-Up	

As of June 2017 – Denver Metro Announced AirPrex Selected as Technology of Choice for their Nutrient Recovery Project

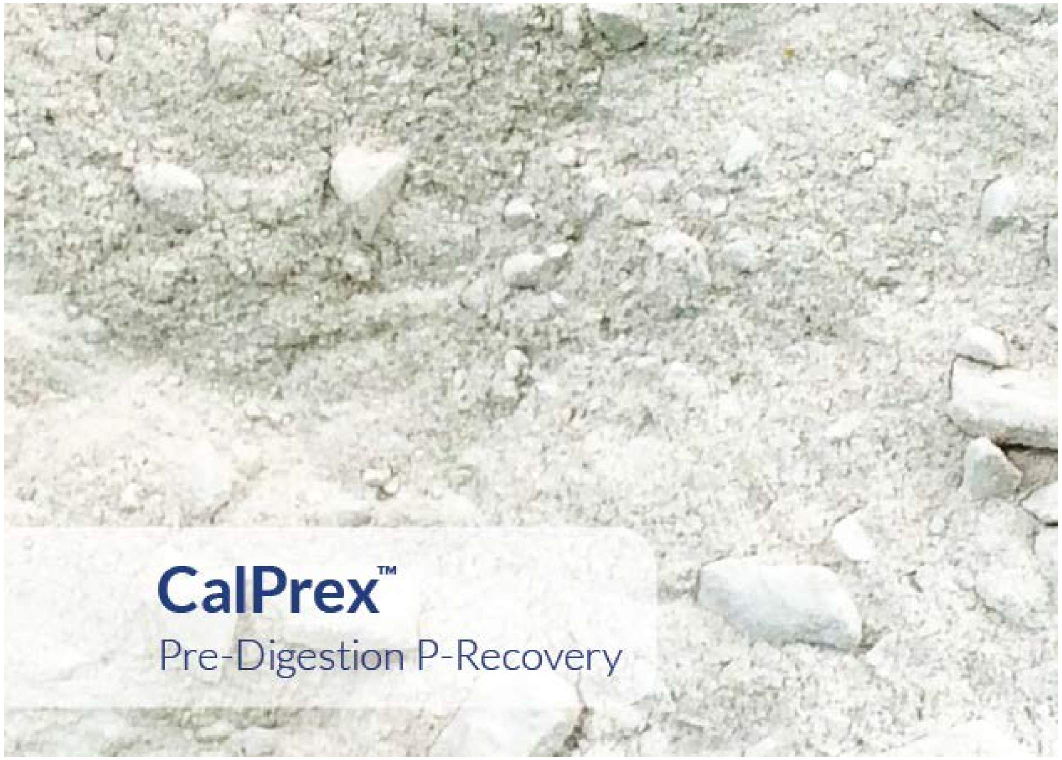
Key Benefits of AirPrex

- Reduction of OP recycle by > 90%
- Improved Dewatering
  - 3-5% point improvement in cake DS
  - Up to 40% reduction in polymer
- Low hanging fruit, easier to implement than pre-digestion recovery technologies.

CNP CalPrex for Pre-Digestion Recovery

What is Brushite?

Distinction of Phosphorus Minerals



Brushite is a higher value product Commercial value = $250 - $300 / ton
versus
$75 - 100 / ton for Struvite

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What is Brushite?

Distinction of Phosphorus Minerals

Brushite (dicalcium phosphate or dical) forms in slightly acidic conditions of pH 4.5 – 6.5 and is a good fertilizer.

$Ca^{2+} + H_2PO_4^- + 2H_2O \leftrightarrow CaHPO_4 \cdot 2H_2O + H^+$

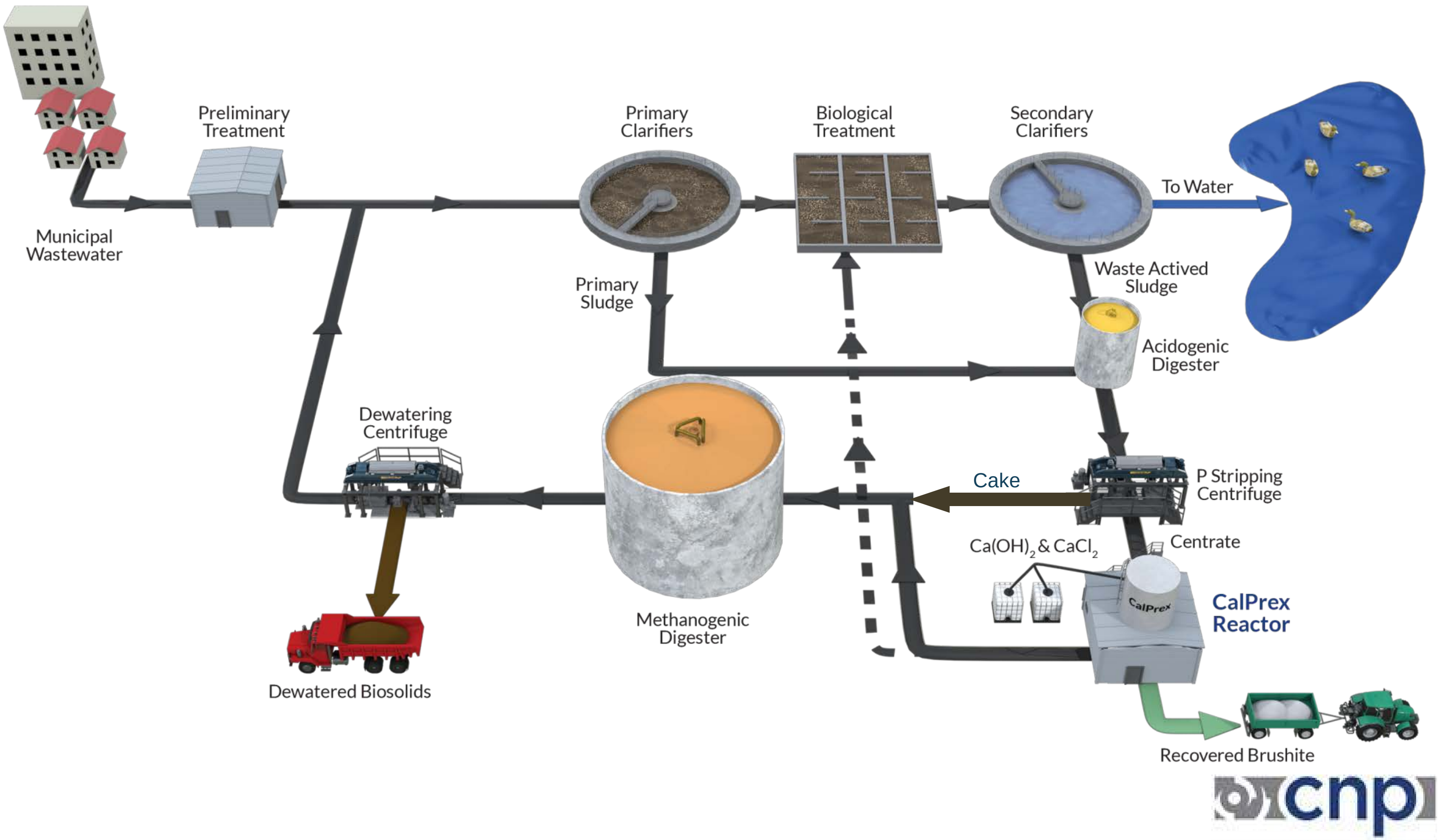
Struvite (magnesium ammonium phosphate) forms in slightly alkaline conditions of around pH 8 and is a good fertilizer.

$NH_4^+ + Mg^{2+} + HPO_4^{2-} + 6H_2O \leftrightarrow NH_4MgPO_4 \cdot 6H_2O + H^+$

Hydroxylapatite forms under alkaline conditions of pH 9 and is NOT a good fertilizer.

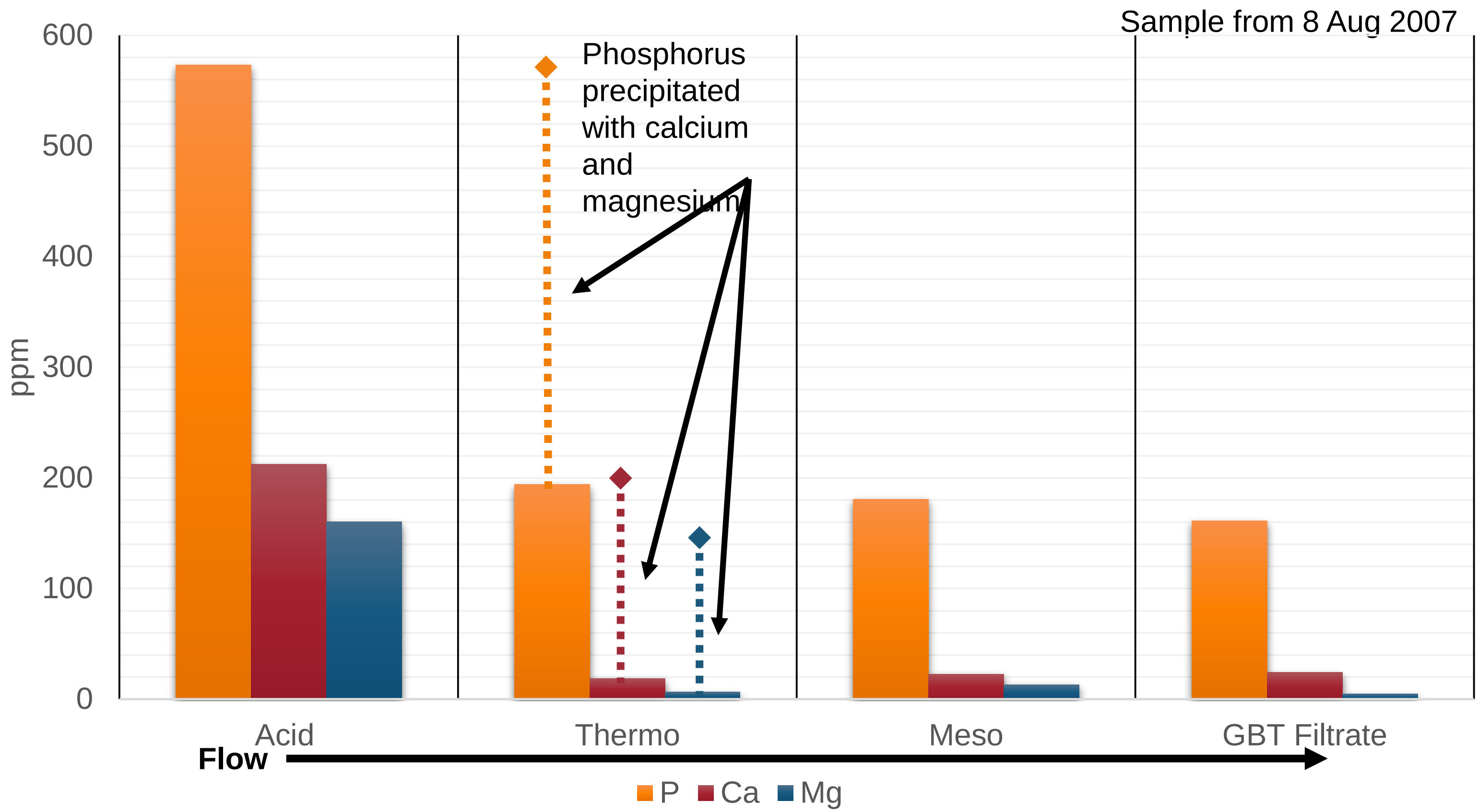
$3Ca^{2+} + 2HPO_4^{2-} + xH_2O \leftrightarrow Ca3(PO_4) \cdot 2xH_2O + 2H^+$

CNP CalPrex for Pre-Digestion Recovery

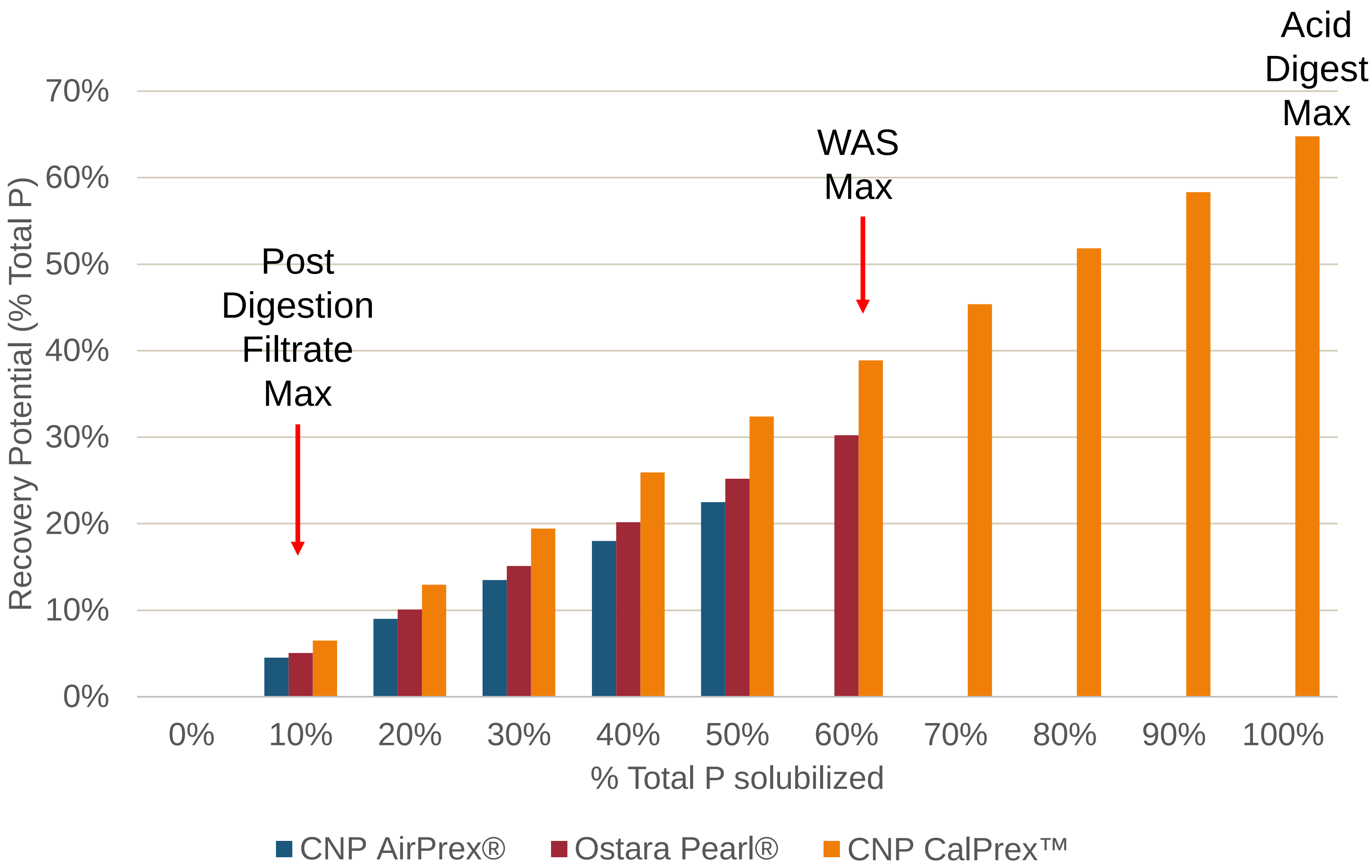


Why Acid Phase Digestion –

Soluble Ions During Anaerobic Digestion



Phosphorus Recovery Potential



CNP CalPrex Pilot

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Key Benefits of CalPrex

- Lower chemical cost for $Ca(OH)_2$ versus $MgCl_2$
  - ~ $0.06 per lb
  - Roughly 10-20% the cost of $MgCl_2$ on a per lb. of P-removed basis
- Where acid digester used
  - Can remove highest amount of TP of currently available technologies
- Brushite has higher commercial value than Struvite

Summary

- Implementation of AirPrex
  - Reduce sidestream OP by 90%
  - Reduce digester influent TP by estimated 30% at steady state
  - Improve Cake DS by 3 to 5 percentage point
  - Reduce polymer requirement by 10 to 40%
- Implementation of CalPrex
  - TP removal rates of over 50% possible as a separate stream
  - Key to success is good P-release, best achieved via acid phase digester
  - Produce higher value fertilizer
- Combined Solution
  - Maximize TP diversion and fertilizer production while maximizing solids dewaterability