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City of London
Nutrient Removal Facilities Plan

OTCO Class III & IV Workshop
Thursday August 3, 2017

Presented by:
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Strand Associates, Inc.®

Dan Leavitt, Superintendent
City of London, OH

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Presentation Outline

- About City of London WWTP
- Nutrients – Why Now?
- Process Exploration, Bench Testing
  - Total Nitrogen Removal
  - Chemical Phosphorus Removal (briefly)
  - Biological Phosphorus Removal
- Paths Forward

City of London WWTP

Source: Dan Leavitt

City of London WWTP

- Upgrade in 2007
- Design Flow 5.8 MGD
- Peak Flow 17.1 MGD
- Cost $24 + Million
- Annual Loan Payment
- $1.77 Million

Source: Dan Leavitt

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City of London WWTP

Source: Dan Leavitt

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City of London WWTP

London WWTP Service Area:

- London Population 9,900
- 3700 homes
- Two State Correction Institutions, 4100 Inmates
- Average Flow 2.68 MGD
- Annual Revenue $2.88 Million
- Staff of 5 employees

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London WWTP Nutrient Why Now?

- No Limits on Nutrient
- TP Weekly
- NO2-NO3 Monthly
- Ortho. P Monthly

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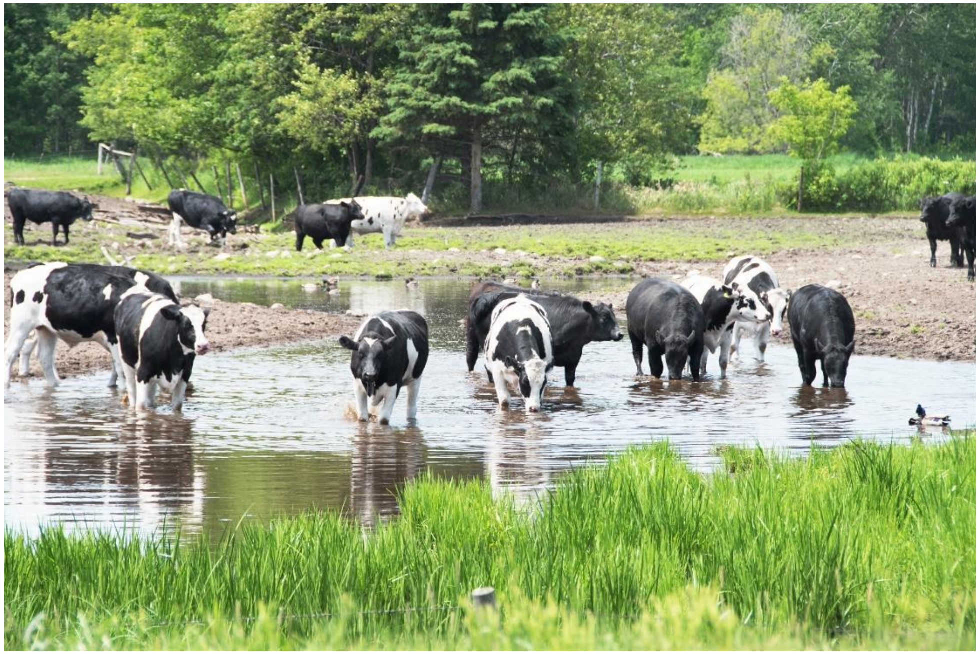
London WWTP Nutrient
Why Now?

- City of London WWTP Discharge to Oak Creek
- Oak Creek feeds Deer Creek
- Deer Creek feeds Deer Creek Lake
- and State Park



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London WWTP Nutrient
Why Now?

Source: Dan Leavitt

With permission of: www.DeerCreekStateParkLodge.com

London WWTP Nutrient
Why Now?

Source: Dan Leavitt

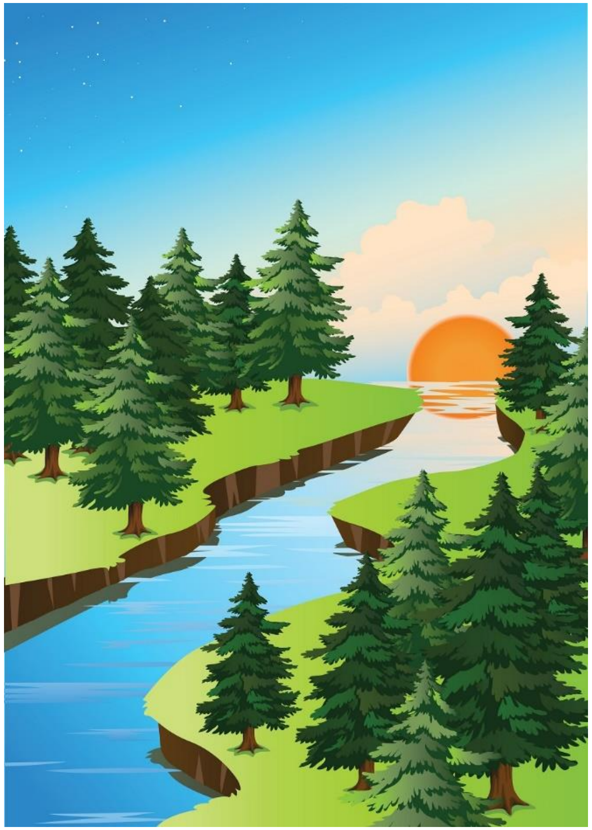
Source: Dan Leavitt

London WWTP Nutrient
Why Now?

Source: Dan Leavitt

London WWTP Nutrient
Why Now?

- Only Major plant above the lake
- We are the flow of Oak Creek
  - Low flow Stream 1.5 MGD
  - Design flow 5.8 MGD
  - Avg Flow 2.8 MGD



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London WWTP Nutrient
Why Now?

Loading

Plant Data- 3 Months

TP

	Influent	Primary	Effluent
Average	3.86	4.01	1.76
Maximum	8.94	10.2	3.66

London WWTP Nutrient
Why Now?

Loading

Septic Hauling

- 2016 – 2,753,615 Gallons
  $188,335
- Septic TP = 250 mg/L
  (USEPA)
- 15 Lbs TP per day

Source: Dan Leavitt

London WWTP Nutrient
Why Now?

Loading

Belt Press Supernatant

- Class A anaerobic digester system
- 2016 Sludge Press -5.67 MG
- 22 lbs TP per day in the Supernatant

Source: Dan Leavitt

London WWTP Nutrient
Why Now?

What Do We Know

- Major on the stream
- Make up the stream
- Potential source of high loads of Nutrients

- NO_2-NO_3
- Avg 9.47
- Max 12.2

London WWTP Nutrient
Why Now?

- Not a normal Plant
- How do we treat the Nutrient?
  - Chemically
  - Biological
  - Both

London WWTP Nutrient
Why Now?

- We Need Help!
- Who do we Hire?
- How do we pay for it?

London WWTP Nutrient
Why Now?

- OEPA – Water Pollution Control Fund (WPCLF)
- Nutrient Reduction Project funding
- $100 million available
- 0% interest loans!
- Must be for reduction of Nutrient!

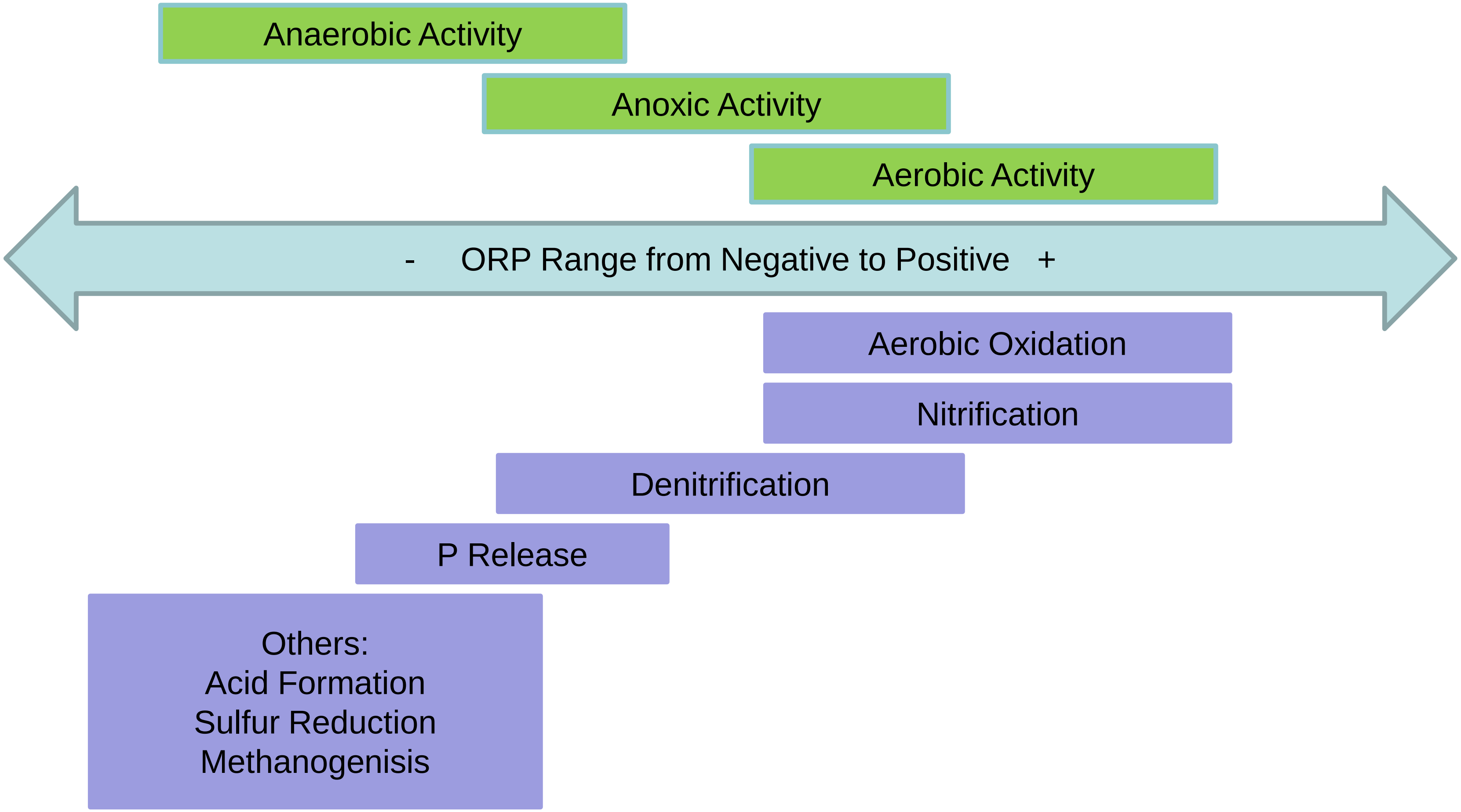
London WWTP Nutrient
Why Now?

- Nutrient Limits are coming
- Help the Stream and Lake
- Use OEPA Money
- Interest free money for 5 years of planning
- Program end June 30, 2018

Nutrient Removal Options

	Phosphorus Control	Nitrogen Control
Physical/Chemical Processes	• Chemical precipitation • Clarification/filtration • Media adsorption/ion exchange • Chemicals + UF membranes • Reverse osmosis • Struvite precipitation	• Air or steam stripping • Ion exchange • Break-point chlorination • Activated carbon • Struvite precipitation
Biological Processes	(Enhanced) Biological Phosphorus Removal	• Ammonification (hydrolysis) • Nitrification • Denitrification • Deammonification (anammox)

An Aside On ORP



Nitrogen and You

- Current ammonia limits based on pH, temperature, and the receiving stream flow
- Future ammonia limits may be even lower based on USEPA Guidance
  - Ammonia sensitivity in freshwater mussels and snails.

Courtesy of: Strand Associates, Inc.®

Nitrification

Nitrosomonas

$$NH_4^+ + 1.5\ O_2 \rightarrow NO_2^- + 2H^+ + H_2O$$

Nitrobacter

$$NO_2^- + 0.5\ O_2 \rightarrow NO_3^-$$

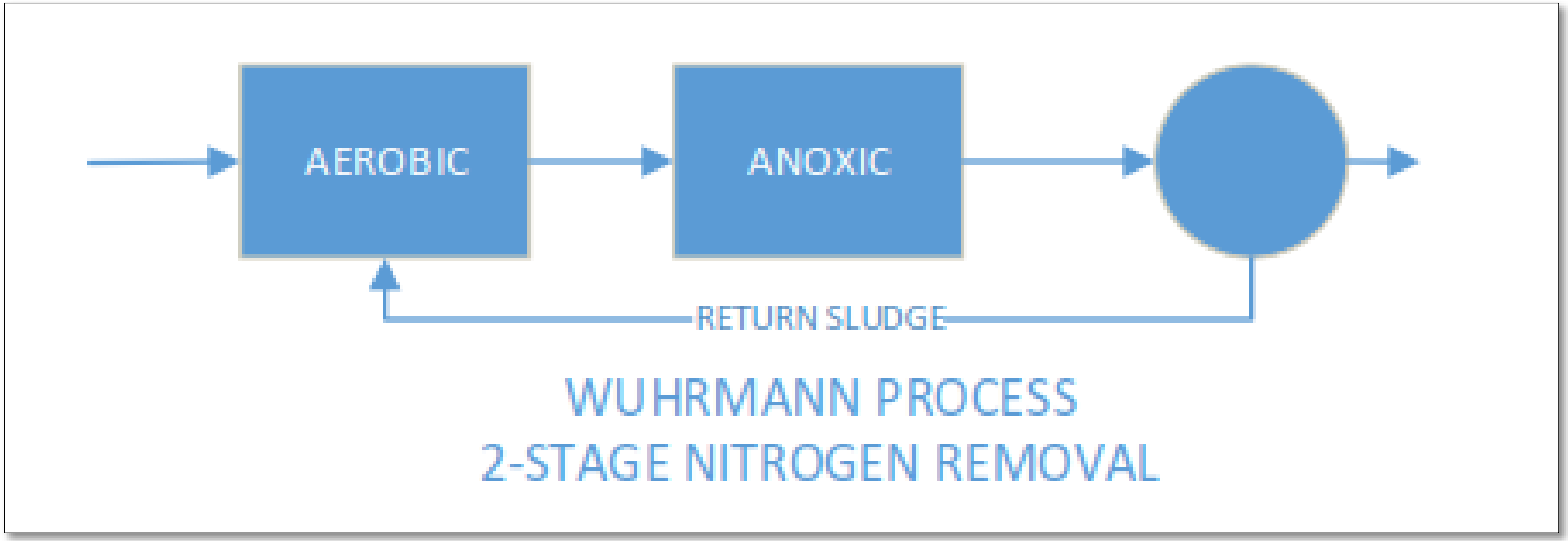
Total Nitrogen Removal Benefits

$$NH_3\text{-}N \rightarrow NO_2 \rightarrow NO_3 \rightarrow N_2$$

- Increased Settleability
- Nitrogen Removal (Good for the receiving streams)
- Alkalinity Restoration
- Oxygen Credit/Energy Savings
- Increased Oxygen Transfer
- Beneficial for BPR

Denitrification

$$NO_3^- + Organics \rightarrow Cells + N_2 + CO_2 + H_2O$$



Denitrification

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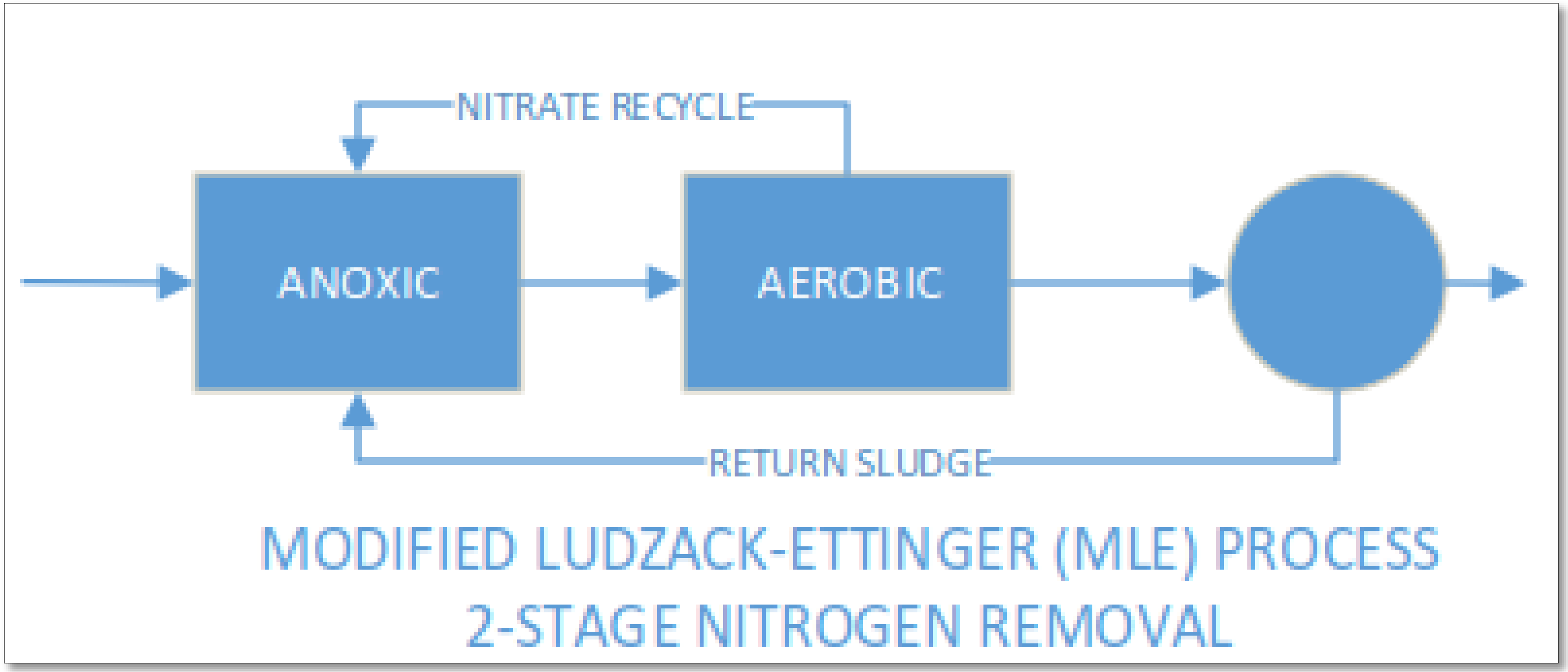
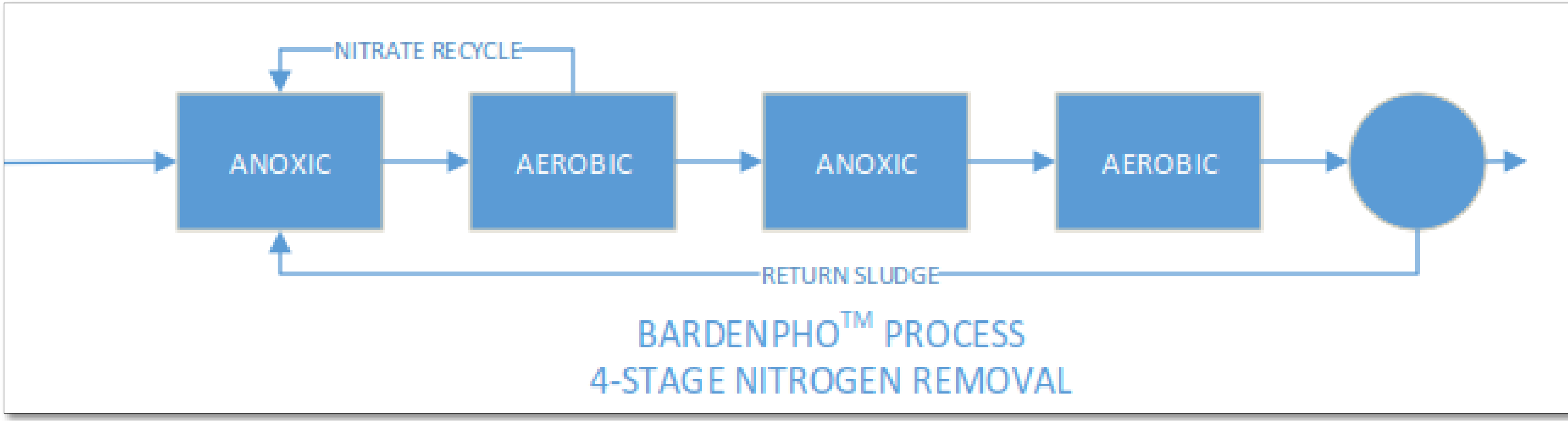
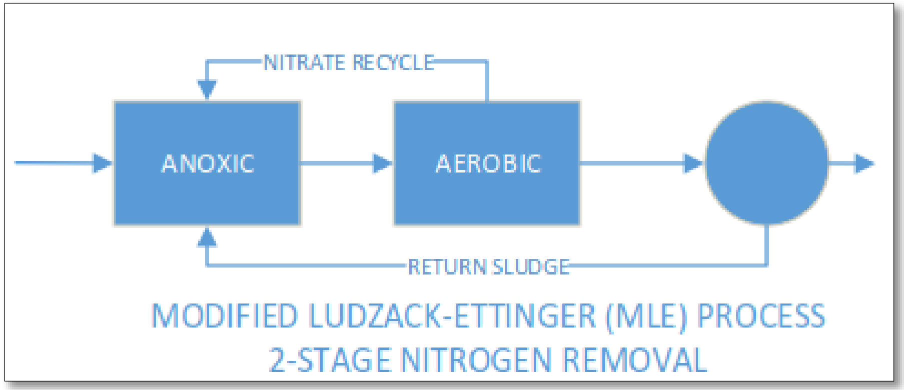


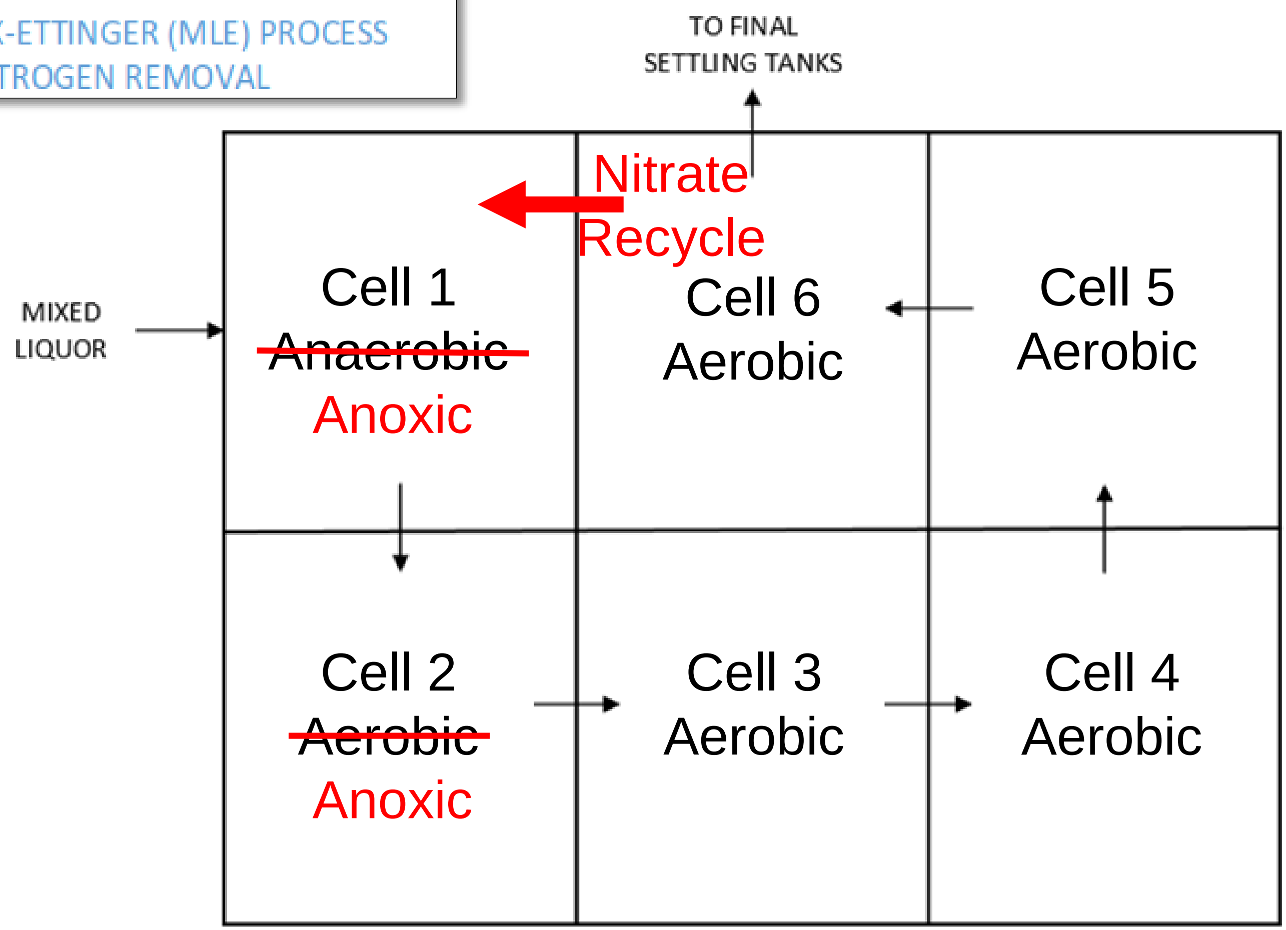
Denitrification

$$NO_3^- + \text{Organics} \rightarrow \text{Cells} + N_2 + CO_2 + H_2O$$



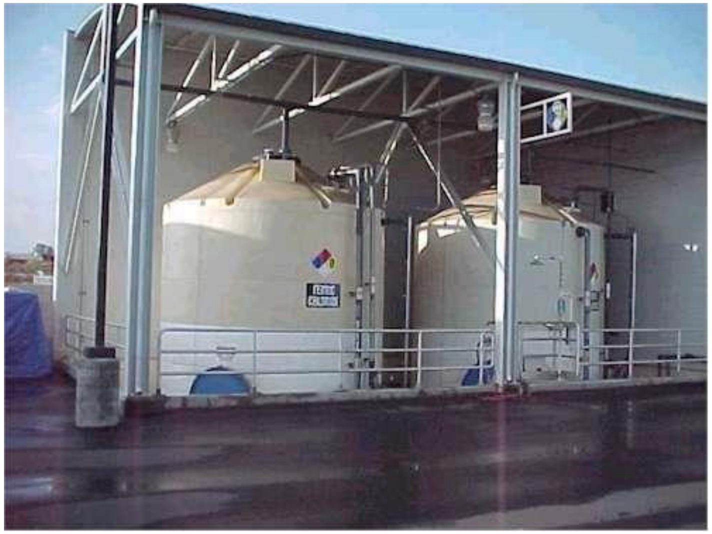
Denitrification – MLE at London





So You Have an Upcoming P Limit, Now What?

- Process Understanding Allows Informed Decision-Making
  - Chemical Phosphorus Removal
  - Biological Phosphorus Removal



Source: Strand Associates, Inc.®

Map Data: Google

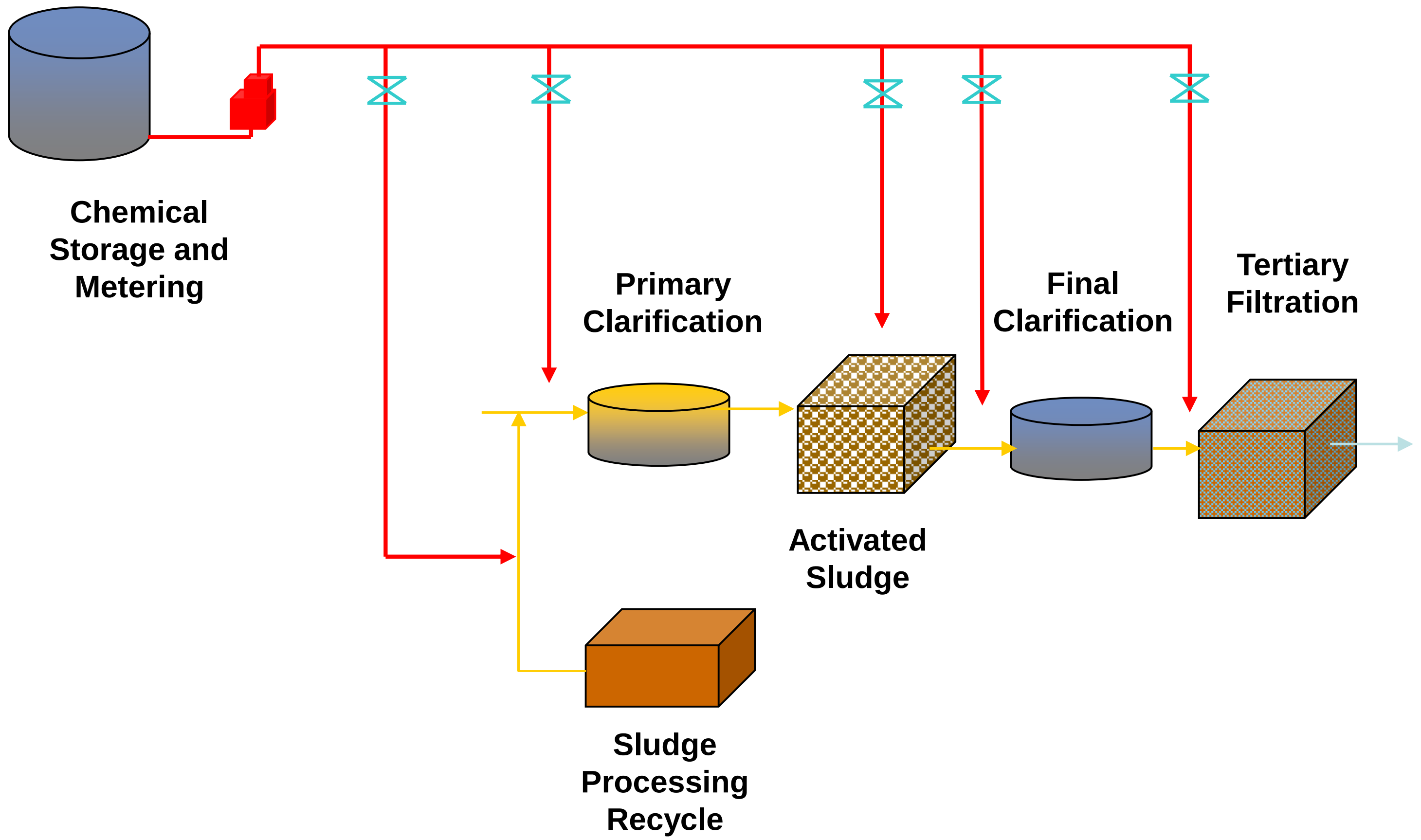
Chemical P Removal - Principles

- Chemical Phosphorus Removal
  - Add lime, iron, or aluminum salt
  - Precipitation of soluble phosphorus
  - Precipitated P removed during clarification, filtration
  - Relatively simple process
  - Higher sludge production

Source: Strand Associates, Inc.®

Chemical P Removal - Principles

CPR - Typical Schematic



Chemical P Removal - Principles

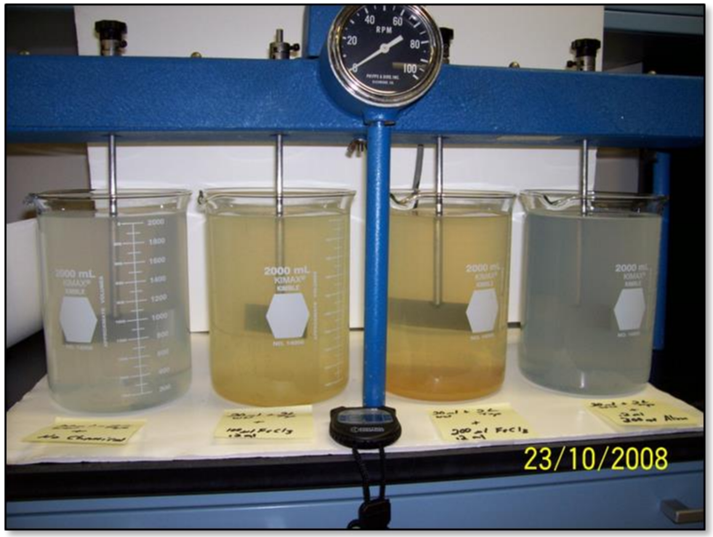
- Alum:
  - Soft water applications
  - Easier to handle/less corrosive
  - Sludge may not thicken/dewater as well
  - Monitor effluent pH
- Ferric Chloride ($FeCl_3$)
  - Hard water applications
  - Typically better sludge thickening/dewaterability
  - Highly corrosive
- Ferrous Chloride ($FeCl_2$) or Ferrous Sulfate:
  - Low cost if spent pickle liquor (hazardous waste) used
  - Pickle liquor can be of variable strength/quality
  - May need to oxidize first (add to AT or chlorinate)
  - Metals/WET Testing?

Chemical P Removal - Principles

- Sodium Aluminate ($Na_2Al_2O_4$)
  - Increases solution pH
    - May be useful when pH or alkalinity is low
  - MOP 8 indicated "experience has shown that performance of sodium aluminate to be somewhat inferior to that of alum…"
    - Jar Test
- Proprietary Chemicals
  - Many of the same active ingredients as the commodity chemicals
  - May protect knowledge of ingredients
  - Jar test or pilot to evaluate marketing claims
- Lime (not used very often)

CPR Jar Test - Purpose

- Dose Rates
- Determine Side Effects
  - pH Depression
  - Alkalinity Loss



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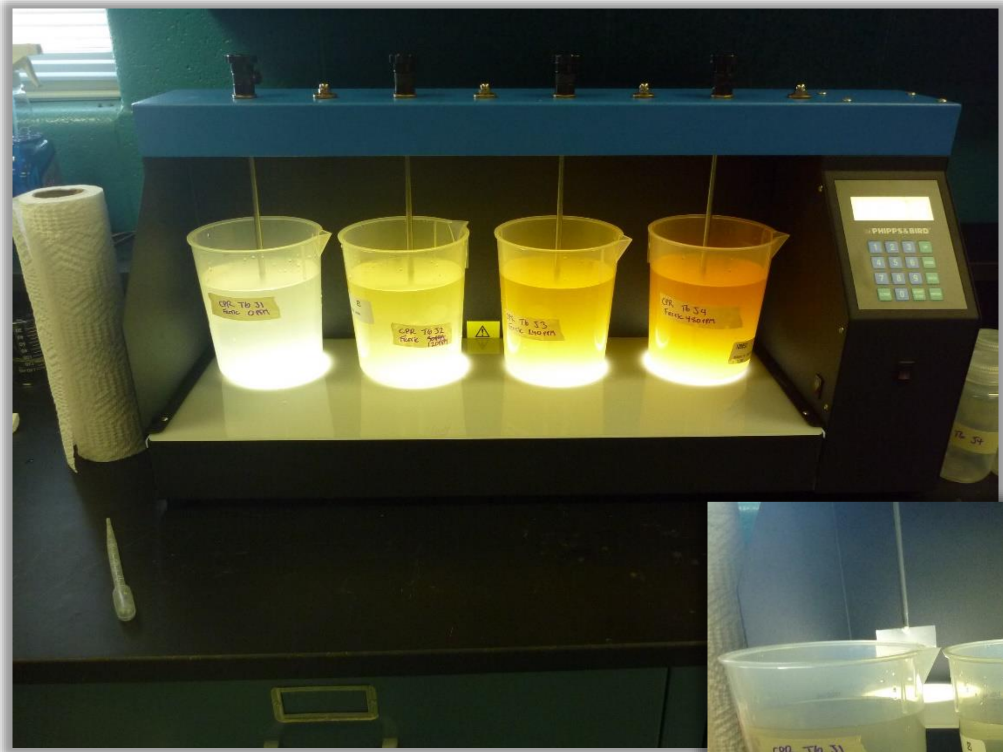
CPR Jar Test



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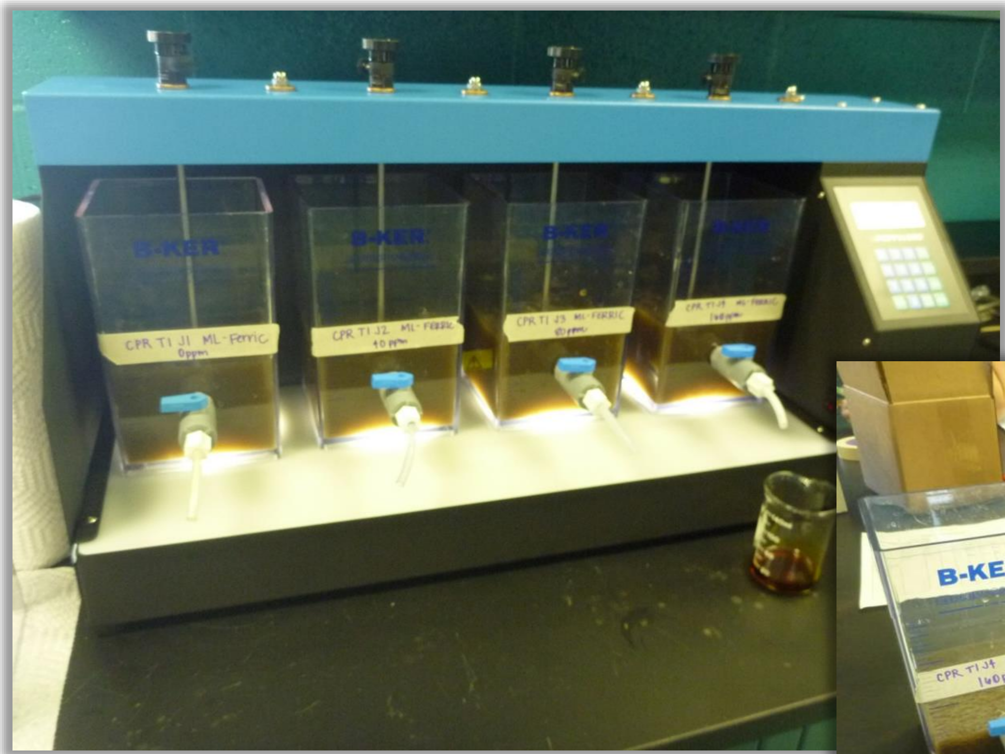
CPR Jar Test



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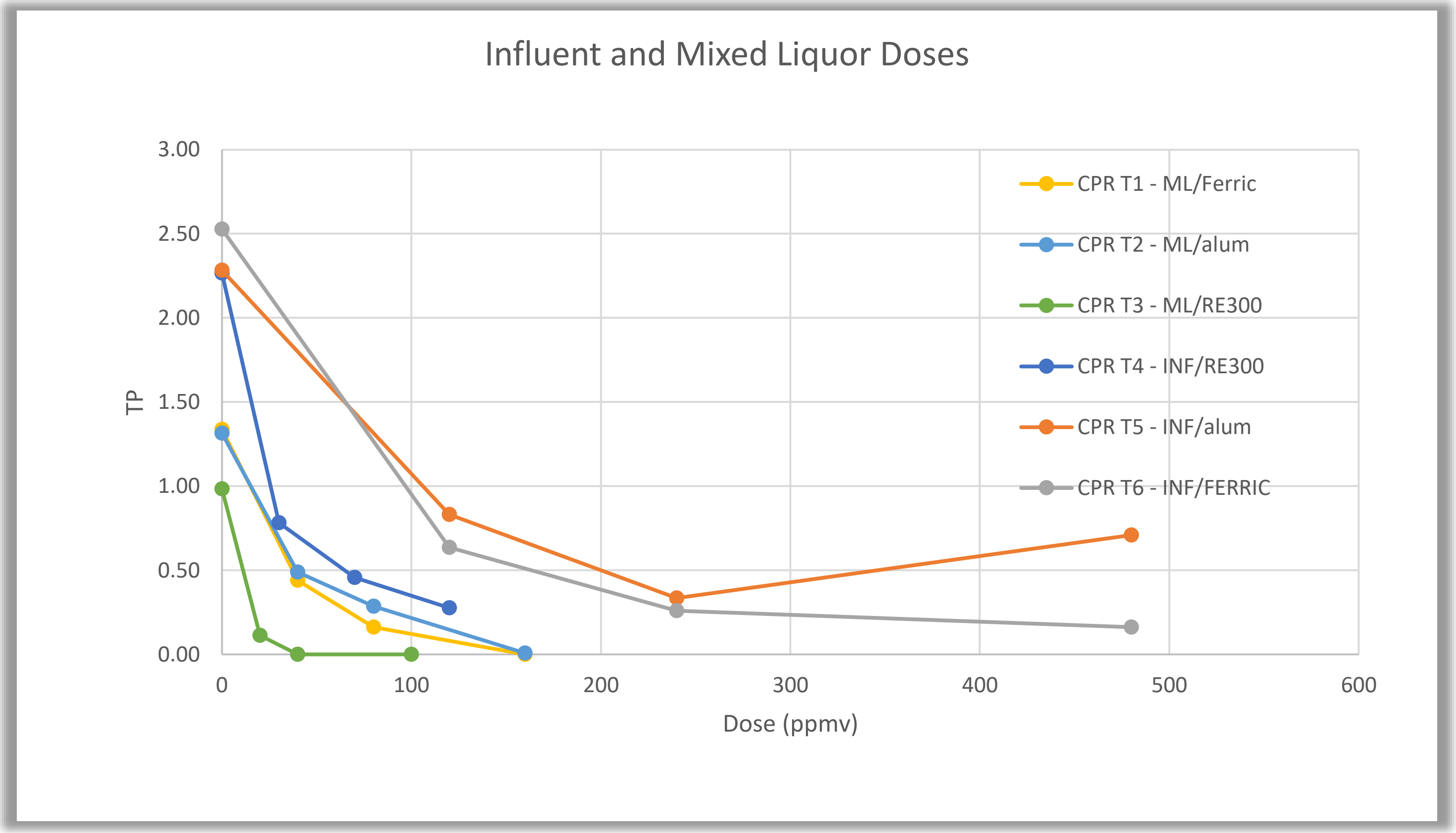
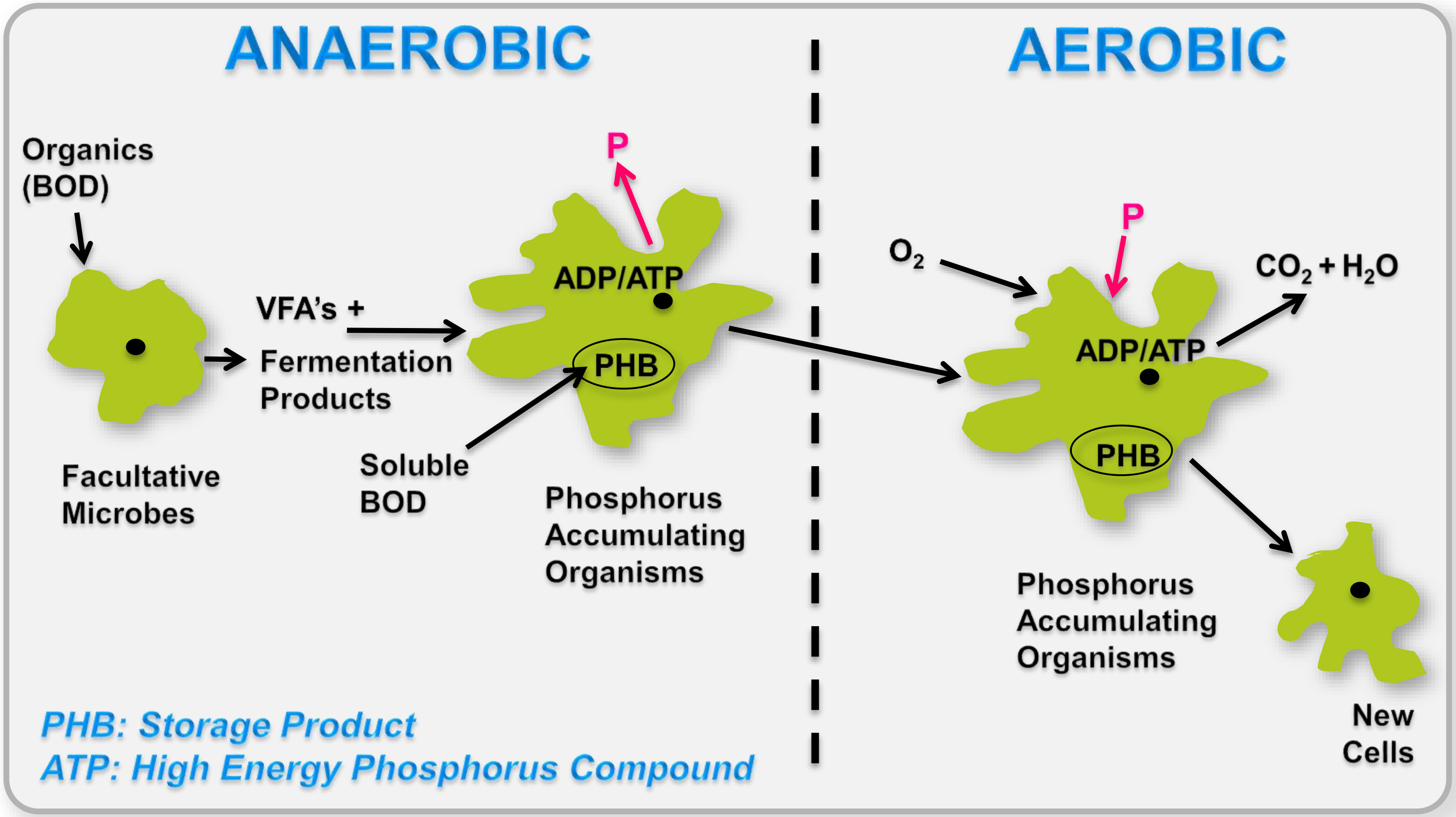
CPR Jar Test - Results

- Higher doses needed for influent vs mixed liquor
- Effectiveness at high doses decreases



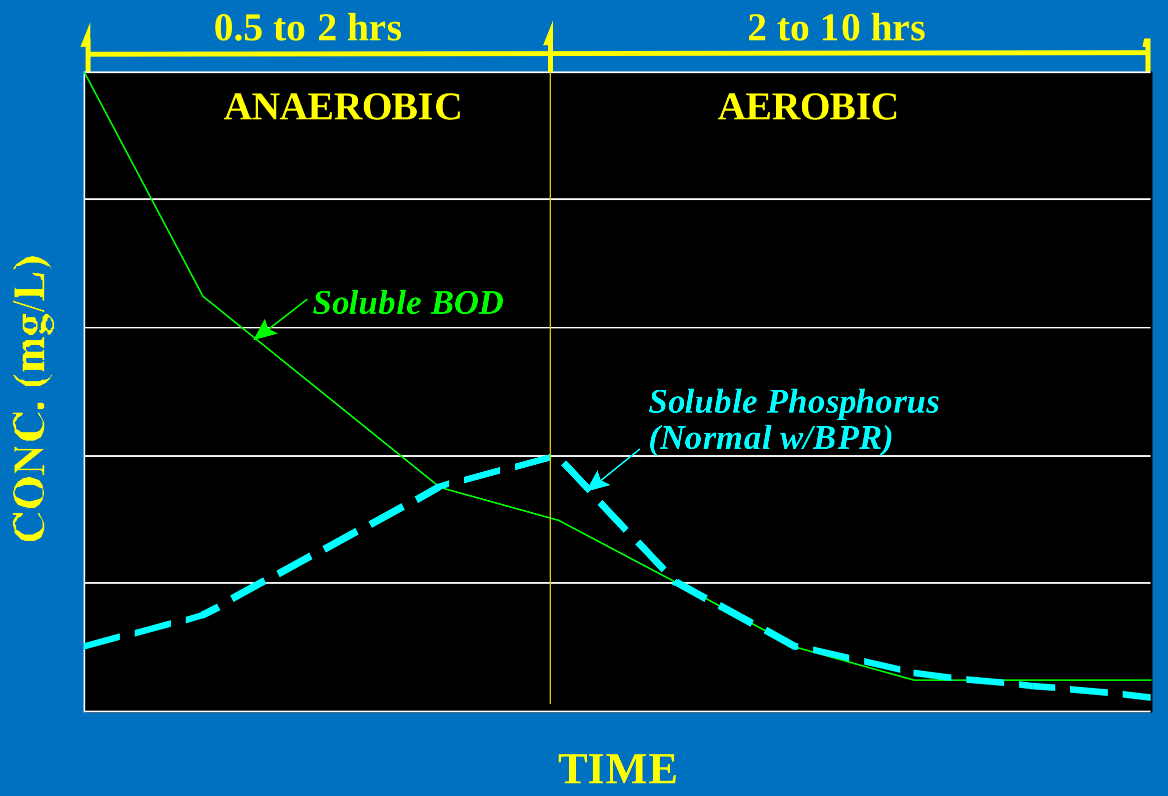
Biological P Removal - Principles

- Facilitate Growth of Phosphorus Accumulating Organisms (PAOs)

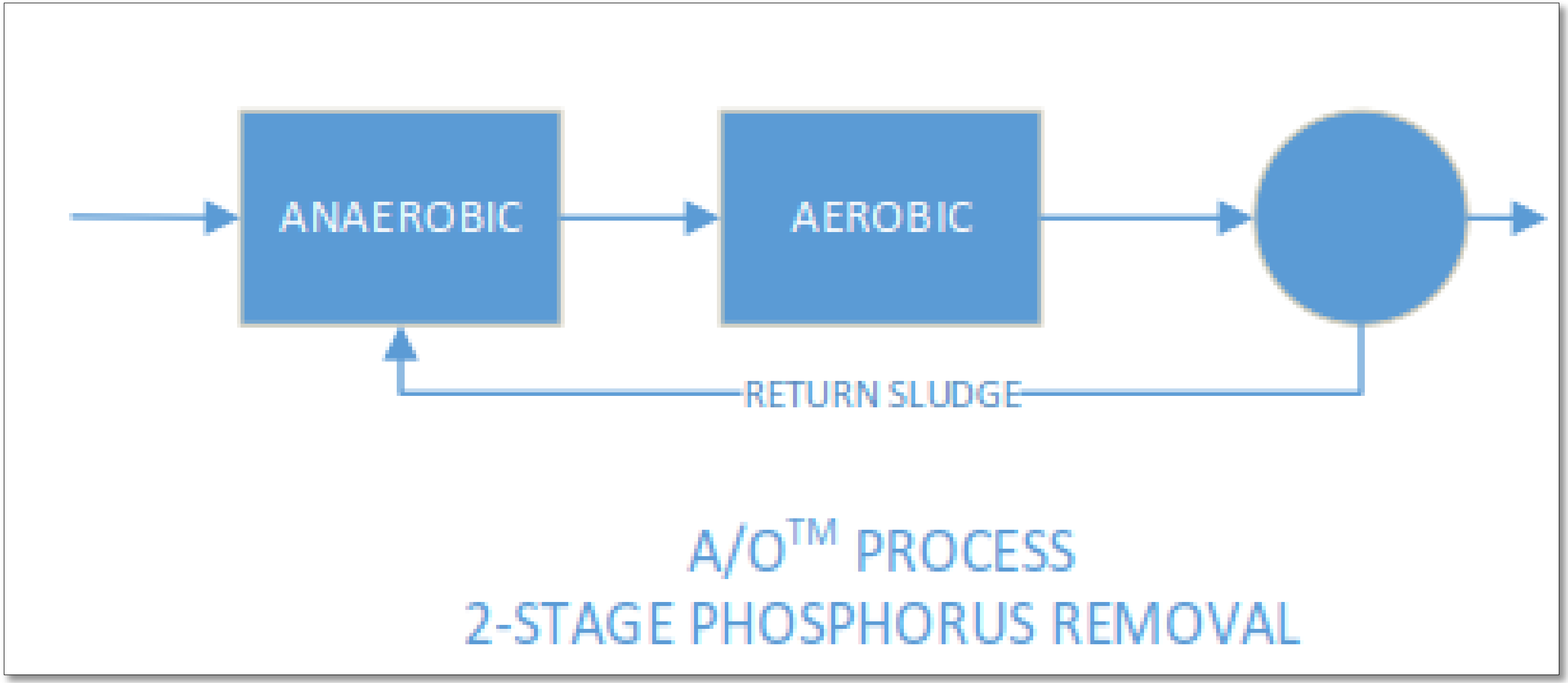


Biological P Removal - Principles

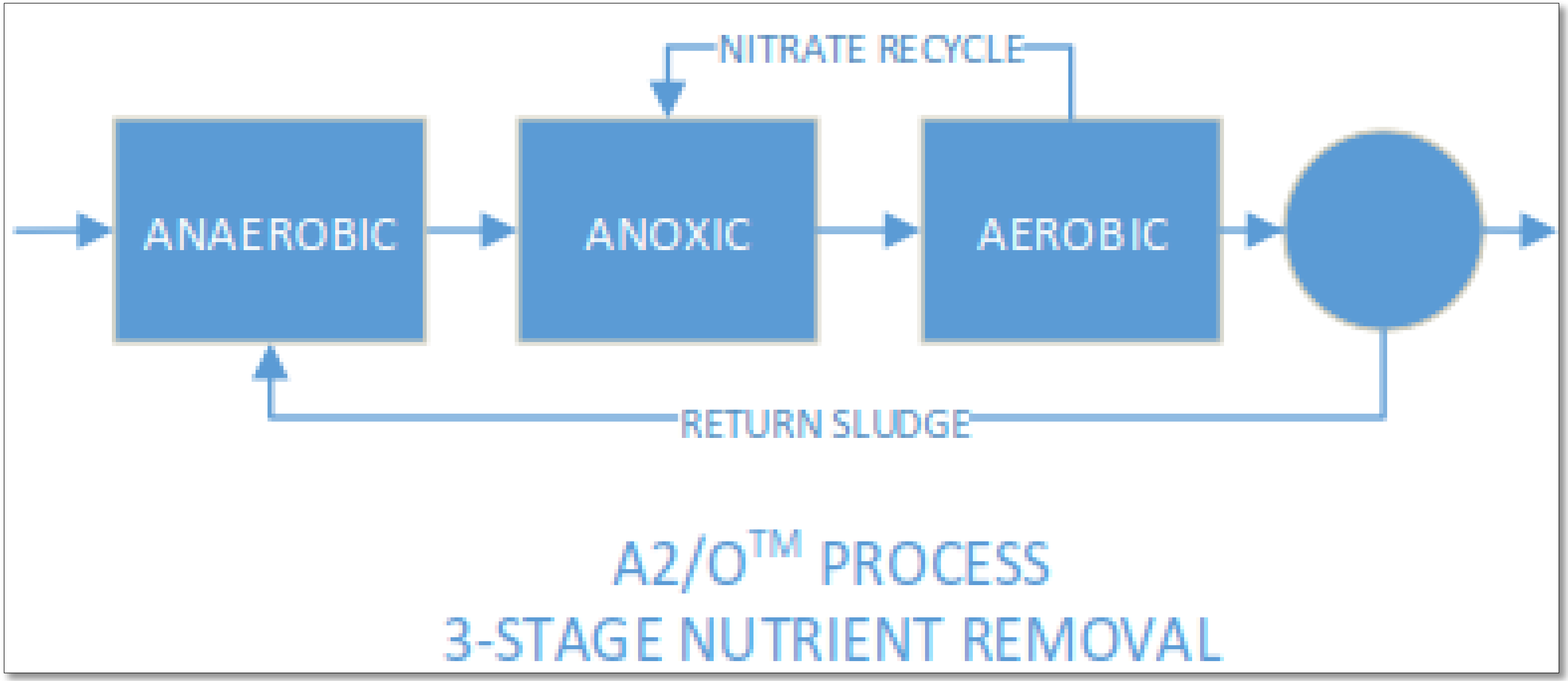
Phosphorus cycle involves release in anaerobic zone, "luxury" uptake in aerobic zone



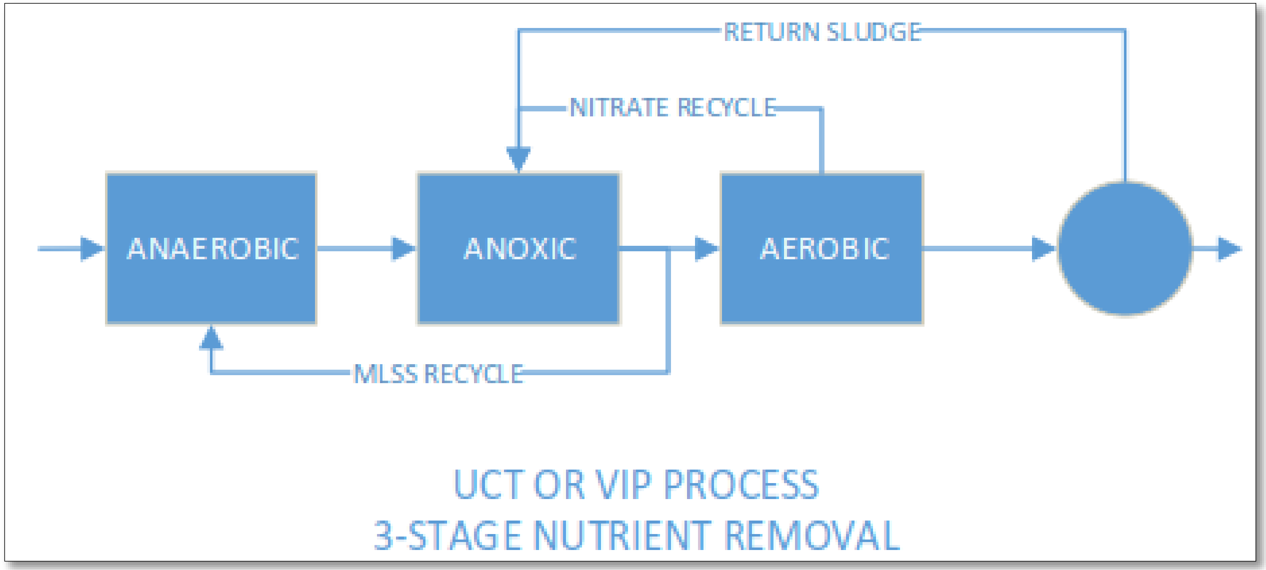
Biological P Removal - Principles

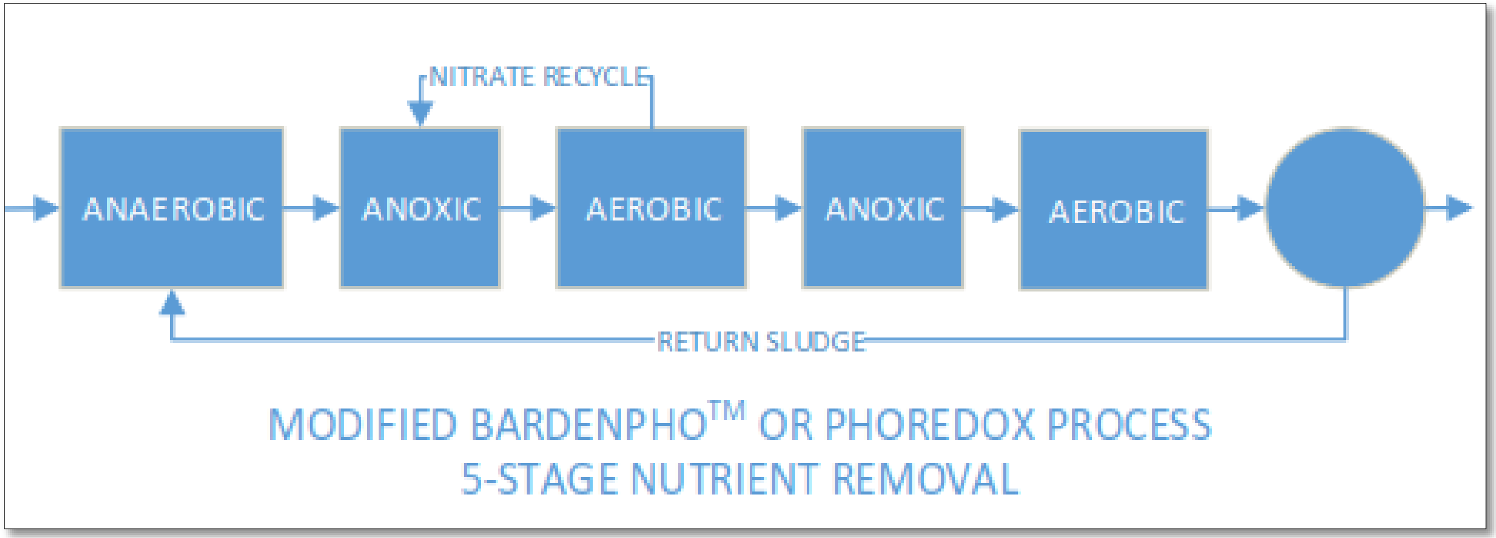


Biological P Removal - Principles



Biological P Removal - Principles





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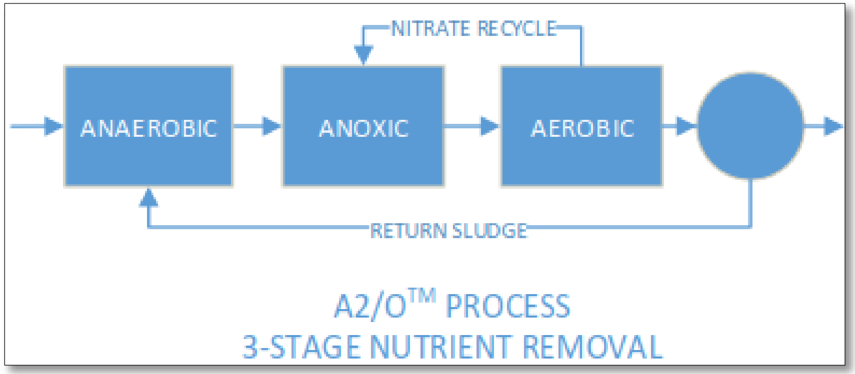
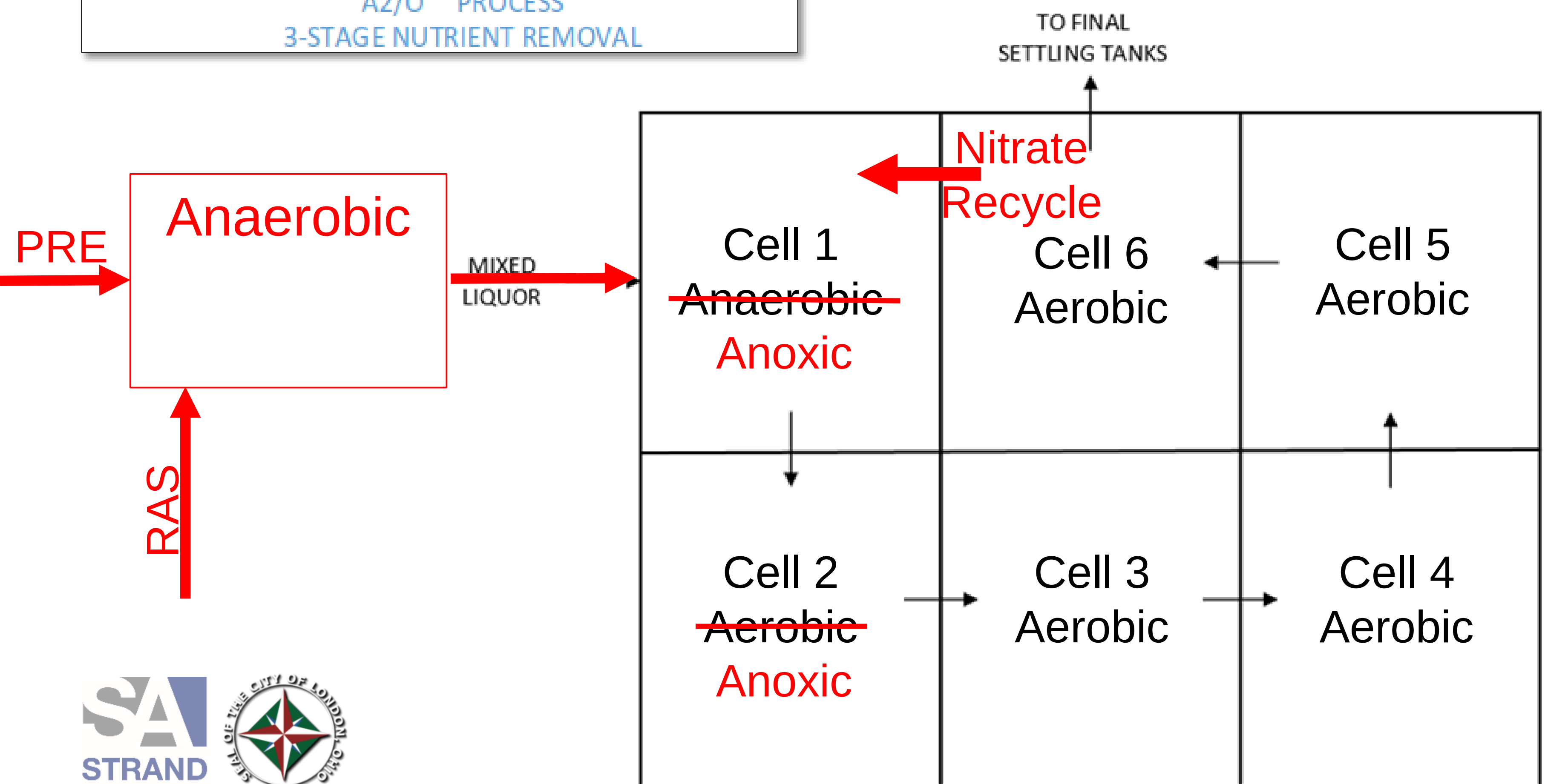
BPR – A2/O at London





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BPR Process Understanding Still Evolving Today

- Conventional mainstream anaerobic zone promotes Accumulibacter PAO that needs supply of VFA (acetic and propionic)
- Mainstream conditions not ideal for symbiotic PAO species like Tetrasphaera, which can ferment glucose and amino acids and other higher carbon forms and also store phosphorus
- Sidestream anaerobic fermenter allows Tetrasphaera produce VFA that allows Accumulibacter to also function alongside
- Tetrasphaera denitrify under anoxic conditions
- Keys to the puzzle:
  - Need ORP < -300 mV; most anaerobic zones struggle to get -150 mV
  - Impossible to achieve with NO3 or DO present
  - Turbulence, air entrainment, air mixing prevent low ORP

Biological P Removal - Principles

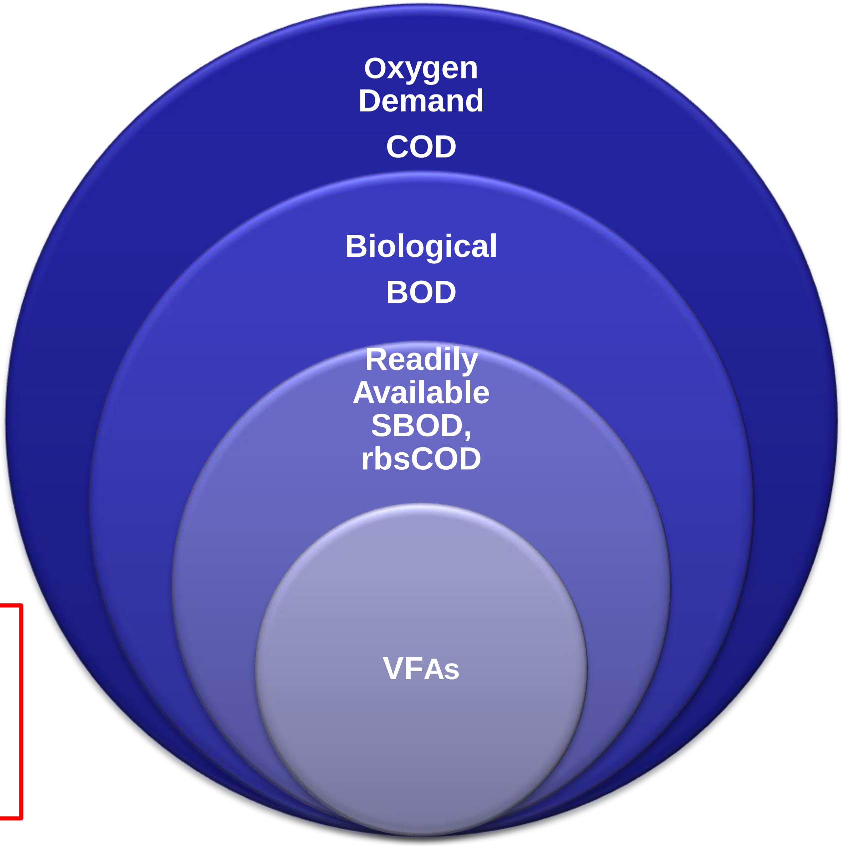
Where is BPR a Good Candidate?

- Where BPR tends **TO** work
  - Plants with long sewers/force mains
  - High strength wastewater
  - Large industrial flows with high soluble BOD
- Where BPR tends **NOT** to work
  - Plants with low strength wastewater
    - Fermentation step or soluble BOD may need to be added
  - Attached growth plants
    - Trickling filters/Rotating Biological Contactors (RBCs)
  - Plants that use co-thickening

Key Influent Data

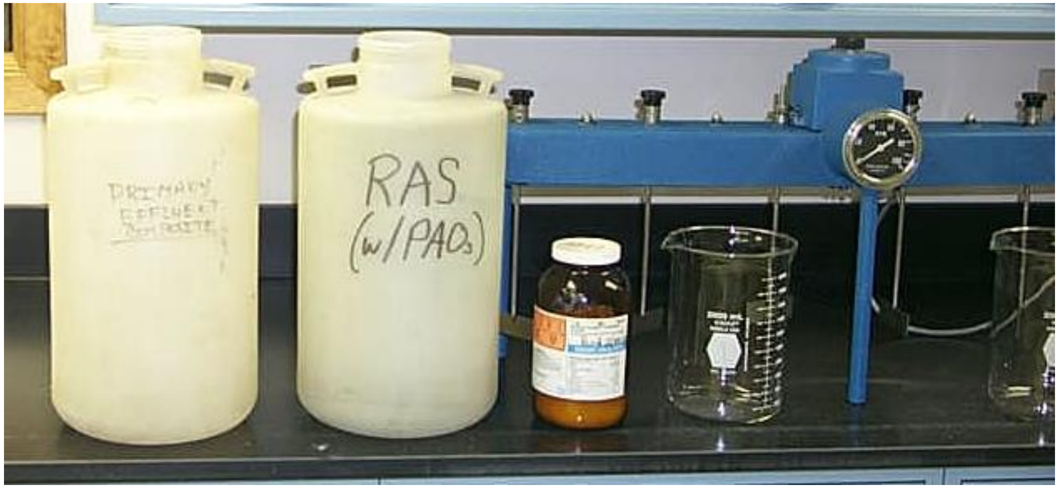
- Minimum recommended influent concentrations and ratios
  - Readily biodegradable soluble COD: 60 mg/L
  - BOD_5/TP: 20
  - Soluble BOD_5/soluble phosphorus: 15
  - Total COD/TP: 50

London:
$CBOD_5$/TP = 44 mg/L (Influent)
$CBOD_5$/TP = 36 mg/L (Primary Effluent)



Bench-Scale Testing

- Bench “Potential” BPR Testing
  - Determine if wastewater has enough VFAs and soluble BOD to facilitate BPR
  - Measure phosphorus release with target WWTP raw wastewater and biomass from BPR WWTP



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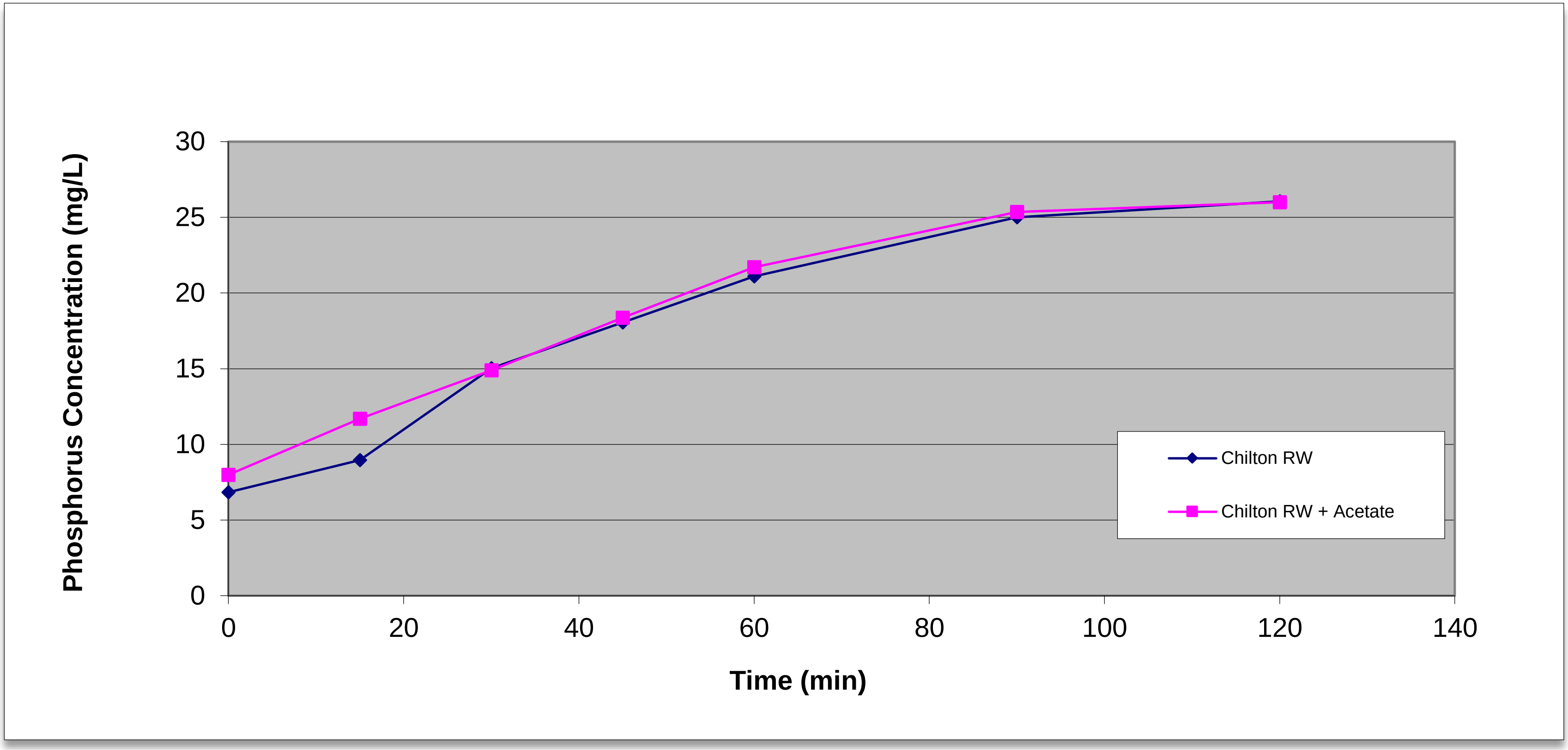
Bench-Scale Testing

Example - Ideal Testing Response



Bench-Scale Testing

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Bench-Scale Testing

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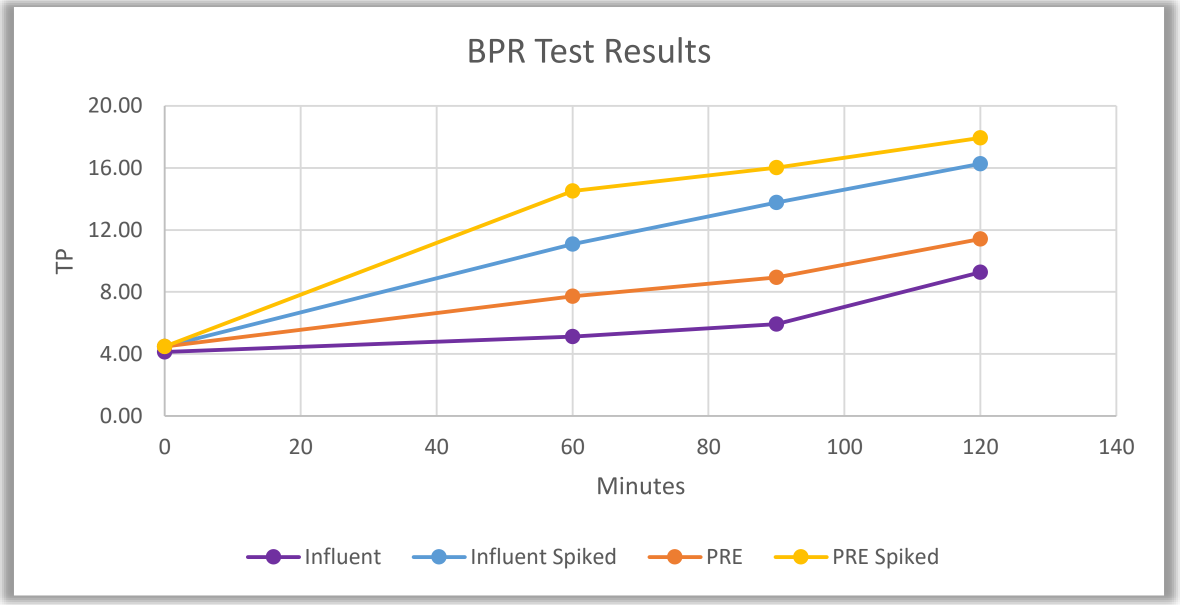
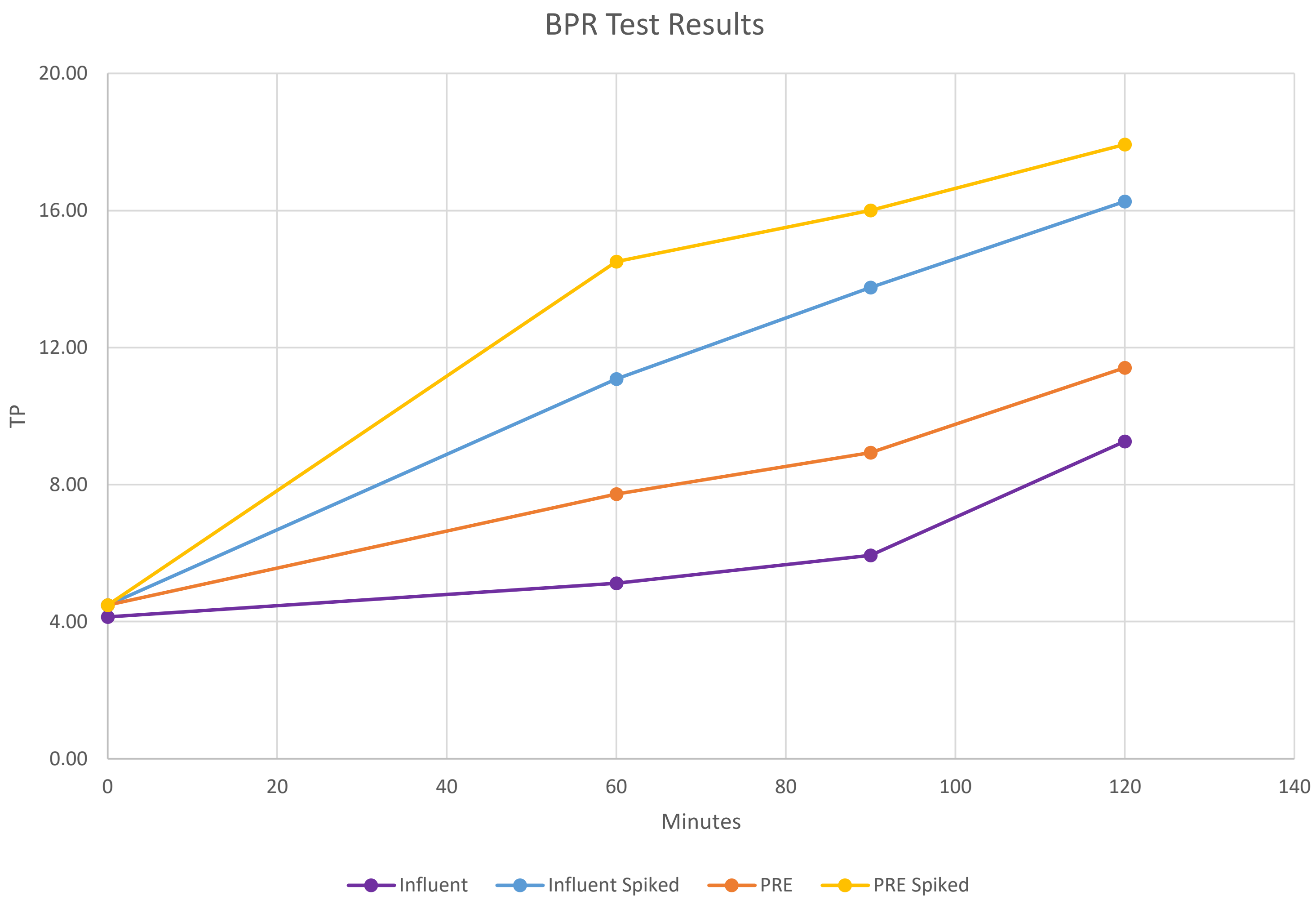
London Bench Test Results - BPR

- Anaerobic phosphorous release larger in spiked sample
- Moderate potential for BPR, limited by lack of “food” in influent
- Fermentation in primary clarifiers, and jar test



BPR Test Results



P-Removal Summary

- P limits are coming
- CPR or BPR can meet 1 mg/L when implemented properly
- Important to understand pros and cons of each process before making decision

Factor	CPR	BPR
Capital Costs	Lower	Higher
Operation	Easier?	More Difficult?
Maintenance	Higher Cost	Lower Cost
Reliability	Higher	Lower
Sludge Costs	Higher	Lower
Lower Limits	May Meet/Filtration	Add CPR/Filtration

Paths Forward

- Finalizing Present Worth Analysis Currently
  - Appears that both CPR and BPR are going to be about equal in present worth
- Future Nutrient Project includes
  - Add Denitrification for Total Nitrogen Removal
  - Implement A_2/O Process for Bio-P Removal

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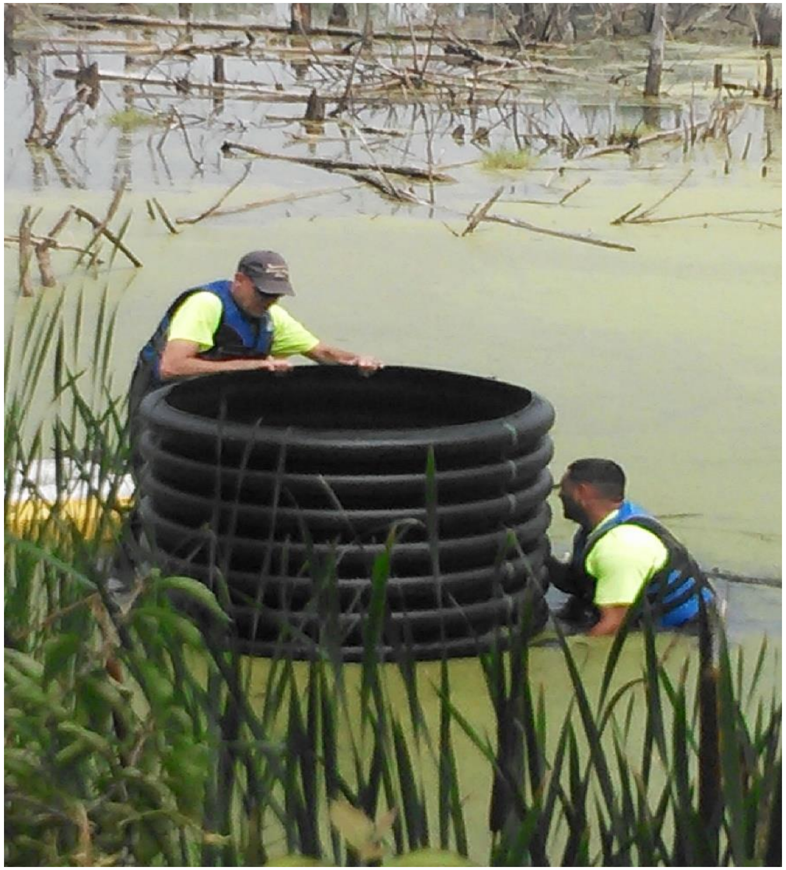
Not Good

Source: Dan Leavitt

Not Good!!

Source: Dan Leavitt

Another Fun Day at the Office!



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