Implementing & Optimizing Phosphorus Removal at Activated Sludge Wastewater Treatment Plants

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Massachusetts Institute of Technology (MIT):
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BS Biology

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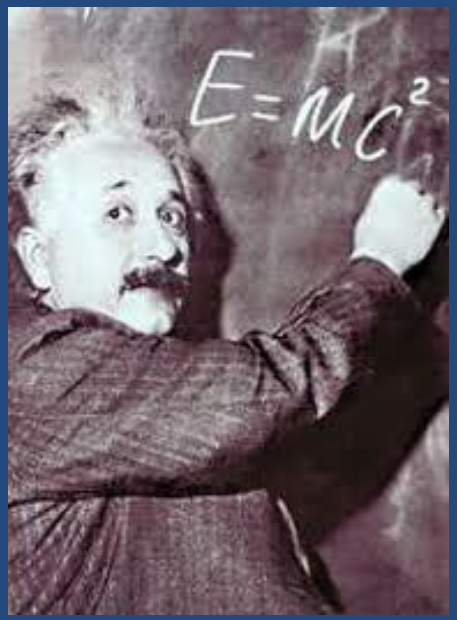
Grant Weaver, PE & wastewater operator

Webinar
February 18, 2014

The Water Planet Company

www.cleanwaterops.com

Implementing/Optimizing P-Removal at Activated Sludge wastewater treatment plants



Upcoming Webinars

P&N Removal in Activated Sludge – March 18, 2014

Sequenced Aeration – April 2014

N&P Removal in Oxidation Ditches – May 2014

Trickling Filter Operations – June 2014

Today's Webinar

Phosphorus Removal for Operators

Habitats

Mainstream and Sidestream Fermentation Processes

Modifying Operations to Create the Right Habitats

Questions & Answers

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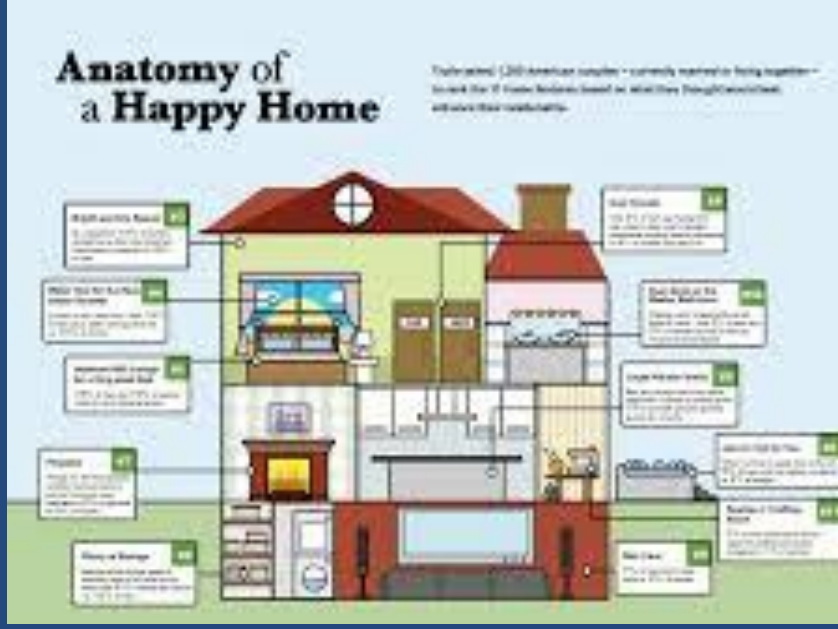


To optimize biological phosphorus removal, wastewater treatment plant operators need to provide bacteria with the habitats they like best.

Knowing a bit about technology …

Getting okay with trying new things …

Given the flexibility to experiment …

A good operator can make most any treatment plant provide better Phosphorus Removal.

Phosphorus Removal: What an Operator needs to know

ONE. Convert soluble phosphorus to TSS …

- Biologically
- Chemically

TWO. Remove TSS

Rules of Thumb:

0.05 mg/L of soluble phosphorus (ortho-P) remains after treatment

Each 1 mg/L TSS contains up to 0.05 mg/L total-P

TSS Removal Requirements

Since all but 0.05 mg/L of the soluble Phosphorus can be converted to TSS Phosphorus (Biologically and/or Chemically)

And, because approximately 5% of Effluent TSS is Phosphorus

… To meet a total-P limit, the effluent TSS needs to be kept to the max TSS number shown in the table.

P Limit	max TSS
0.1	1
0.2	3
0.3	5
0.4	7
0.5	**9**
0.6	11
0.7	13
0.8	15
0.9	17
1.0	**19**
1.1	21
1.2	23
1.3	25
1.4	27
1.5	29

Biological Phosphorus Removal: Converting liquid phosphorus to solid phosphorus

Zero Oxygen Habitat (Fermentation)

Bacteria break down BOD to create volatile fatty acids (VFAs)

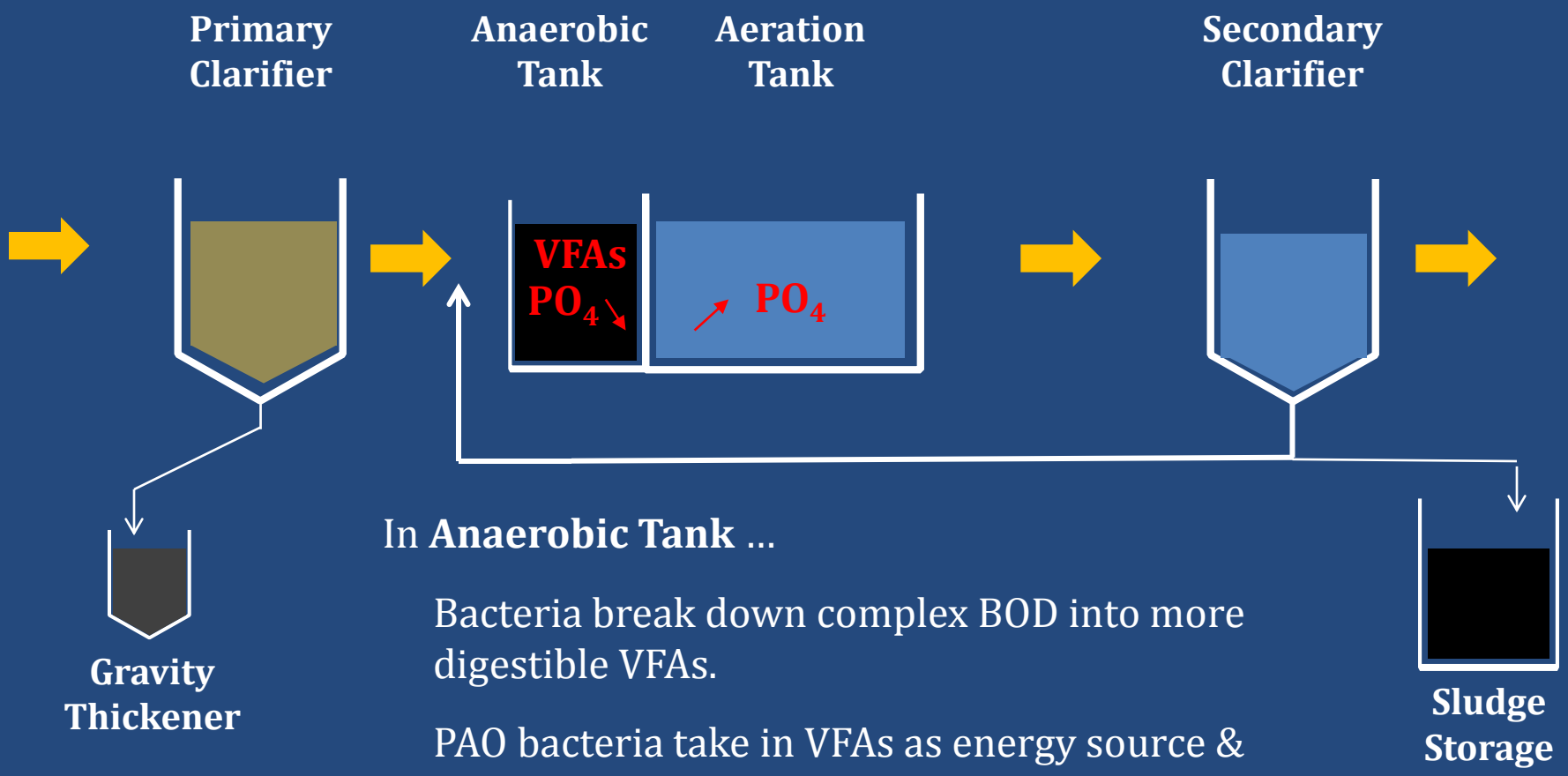
Other bacteria (PAOs) take in the VFAs as an energy source and temporarily release more ortho-P into solution

Oxygen Rich Habitat (Aeration Tank)

PAO bacteria use the stored energy to “bulk up” on ortho-P

Biological Phosphorus Removal: Mainstream Flow Fermentation Processes

Bio-P Removal: Mainstream Fermentation Process



In **Anaerobic Tank** …

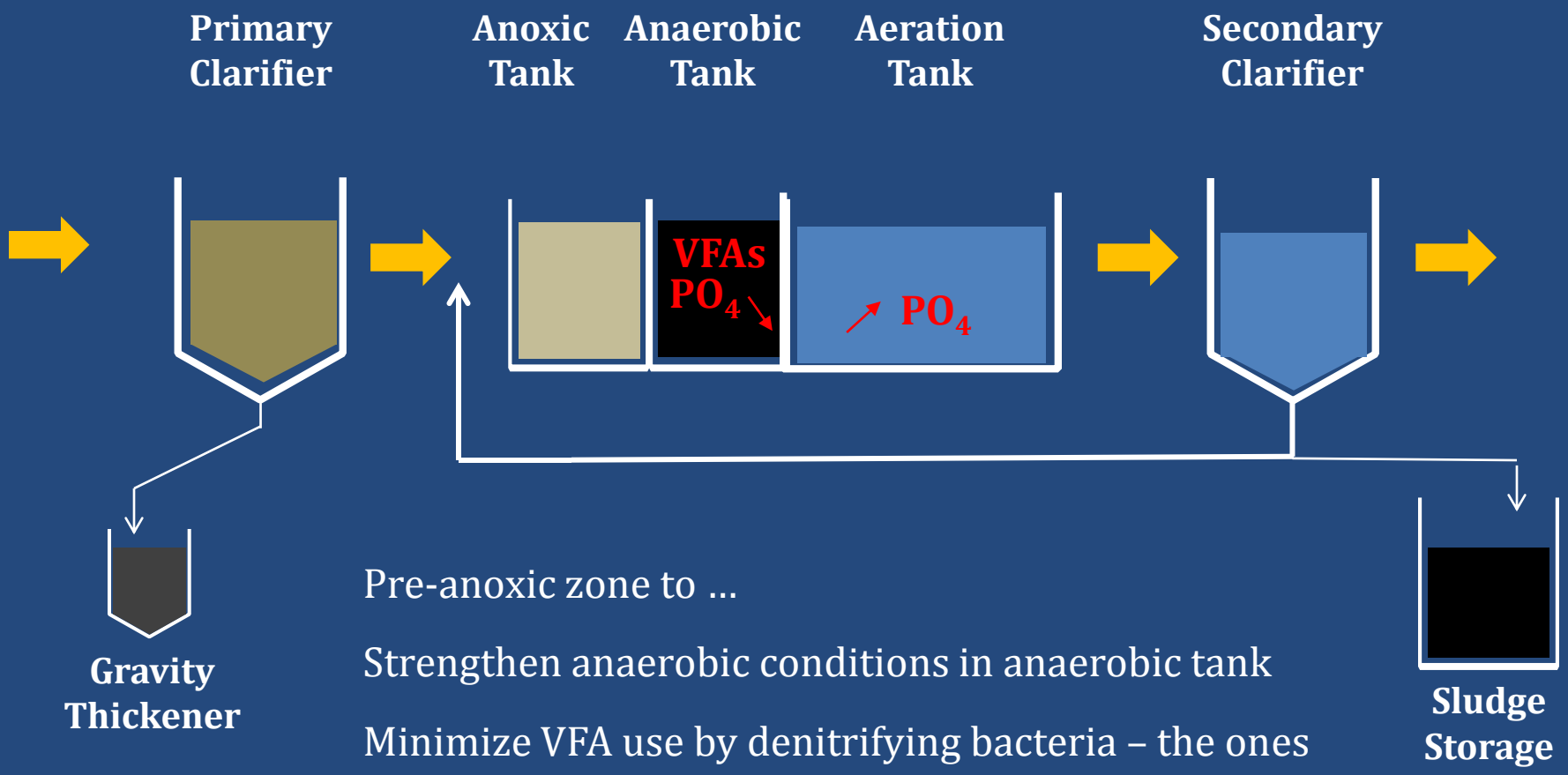
Bacteria break down complex BOD into more digestible VFAs.

PAO bacteria take in VFAs as energy source & temporarily release PO_4 into solution.

In **Aeration Tank** …

PAO bacteria use VFAs to take PO_4 out of solution.

Bio-P Removal: Mainstream Fermentation Process



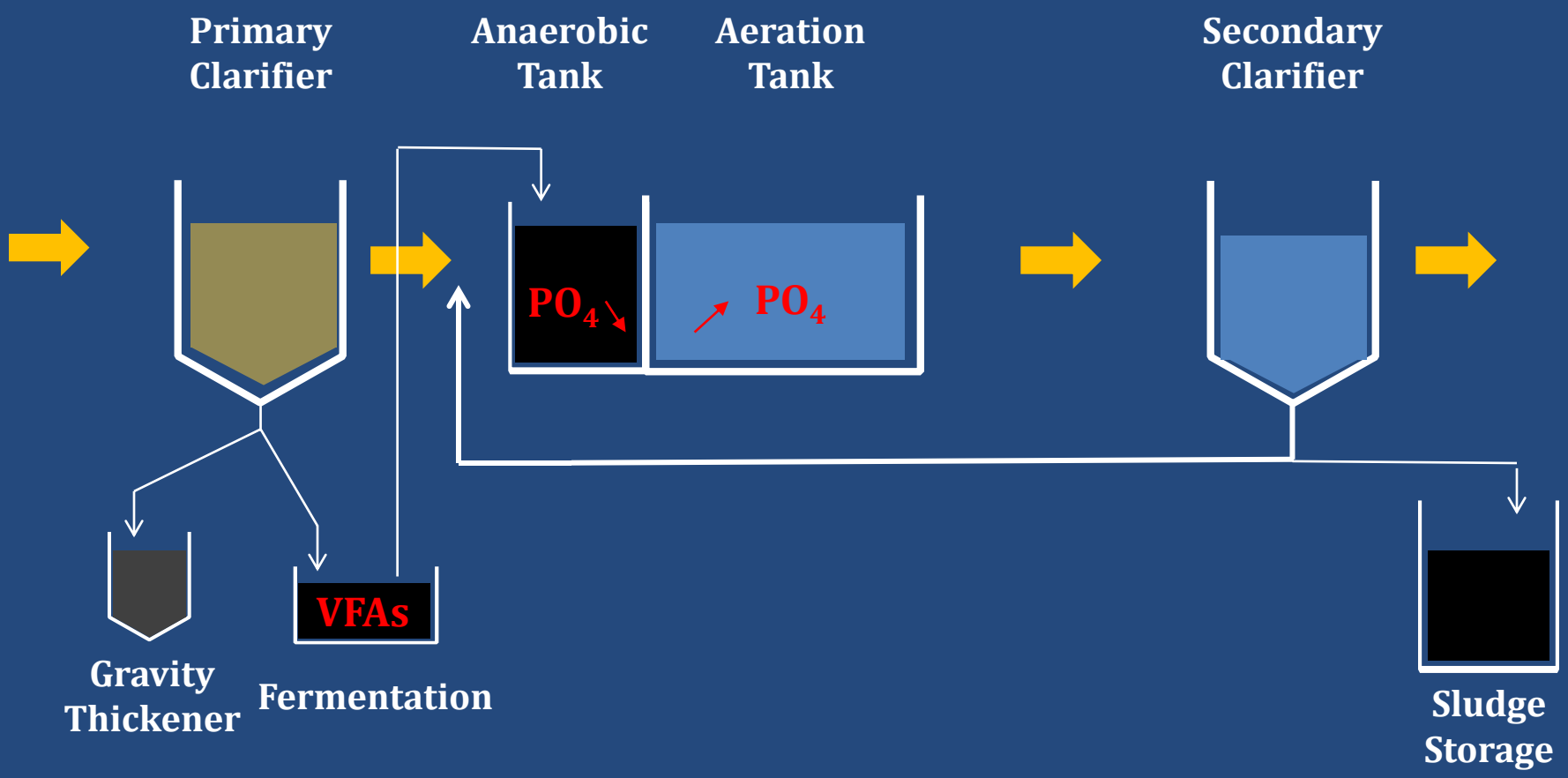
Pre-anoxic zone to …

Strengthen anaerobic conditions in anaerobic tank

Minimize VFA use by denitrifying bacteria – the ones that convert Nitrate (NO_3) to Nitrogen Gas (N_2) – by "feeding" influent to the denitrifiers.

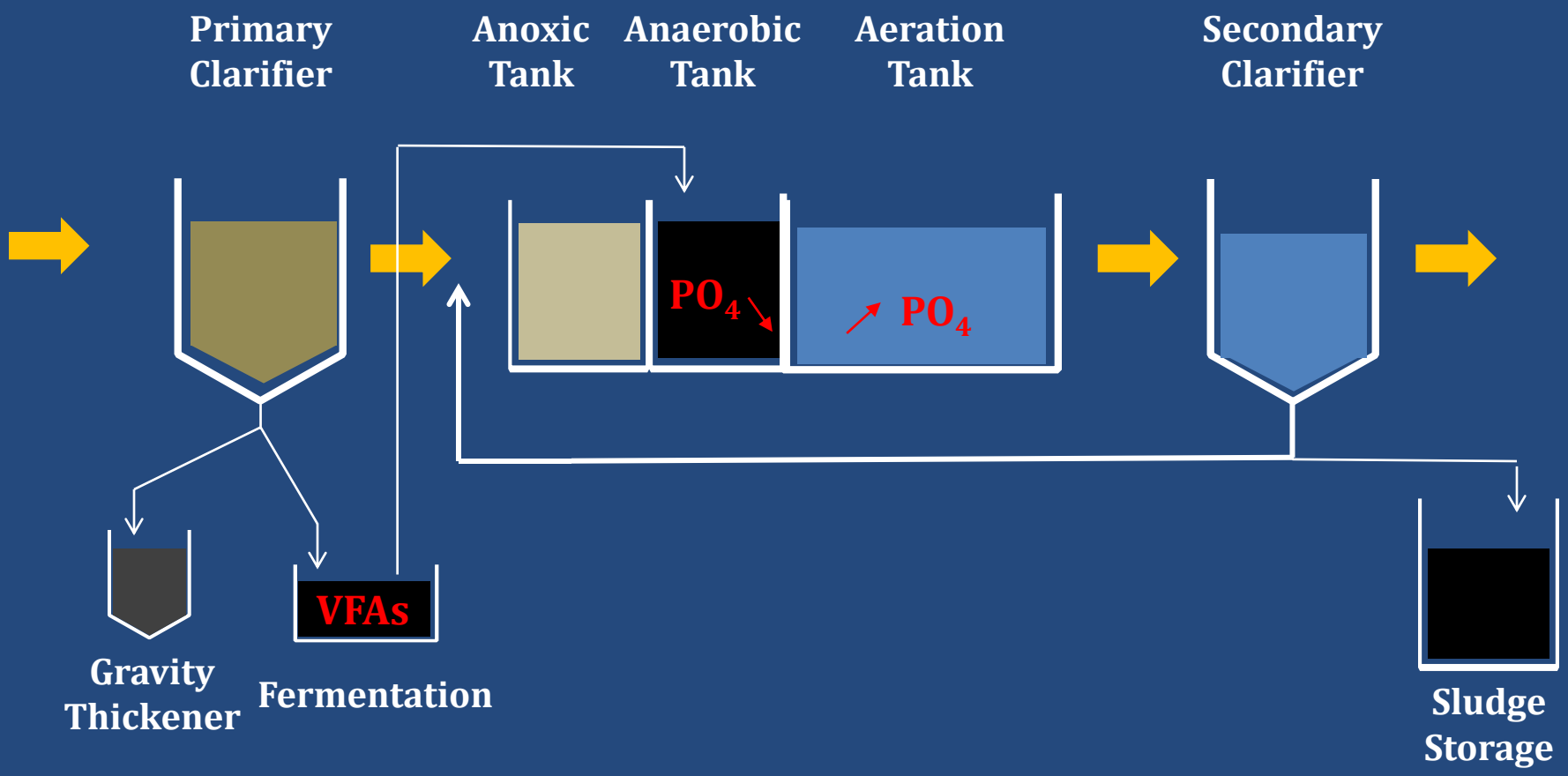
Biological Phosphorus Removal: Combined Sidestream & Mainstream Fermentation

Bio-P Removal: Sidestream Fermentation Process



Nitrogen Interference: Nitrate (NO_3) will consume VFAs

Bio-P Removal: Sidestream Fermentation Process



No Nitrogen Interference

Optimizing Bio-P Removal: Mainstream or Sidestream Fermentation

Anaerobic Tank

~1 hour HRT*

ORP of -200 mV*

25 times as much BOD as influent ortho-P*

Ortho-P release (3-4 times influent ortho-P)*

Aeration Tank

High DO / High ORP

pH of 6.8+*

Ortho-P concentration of 0.05 mg/L*

*Approximate: Every Plant is Different

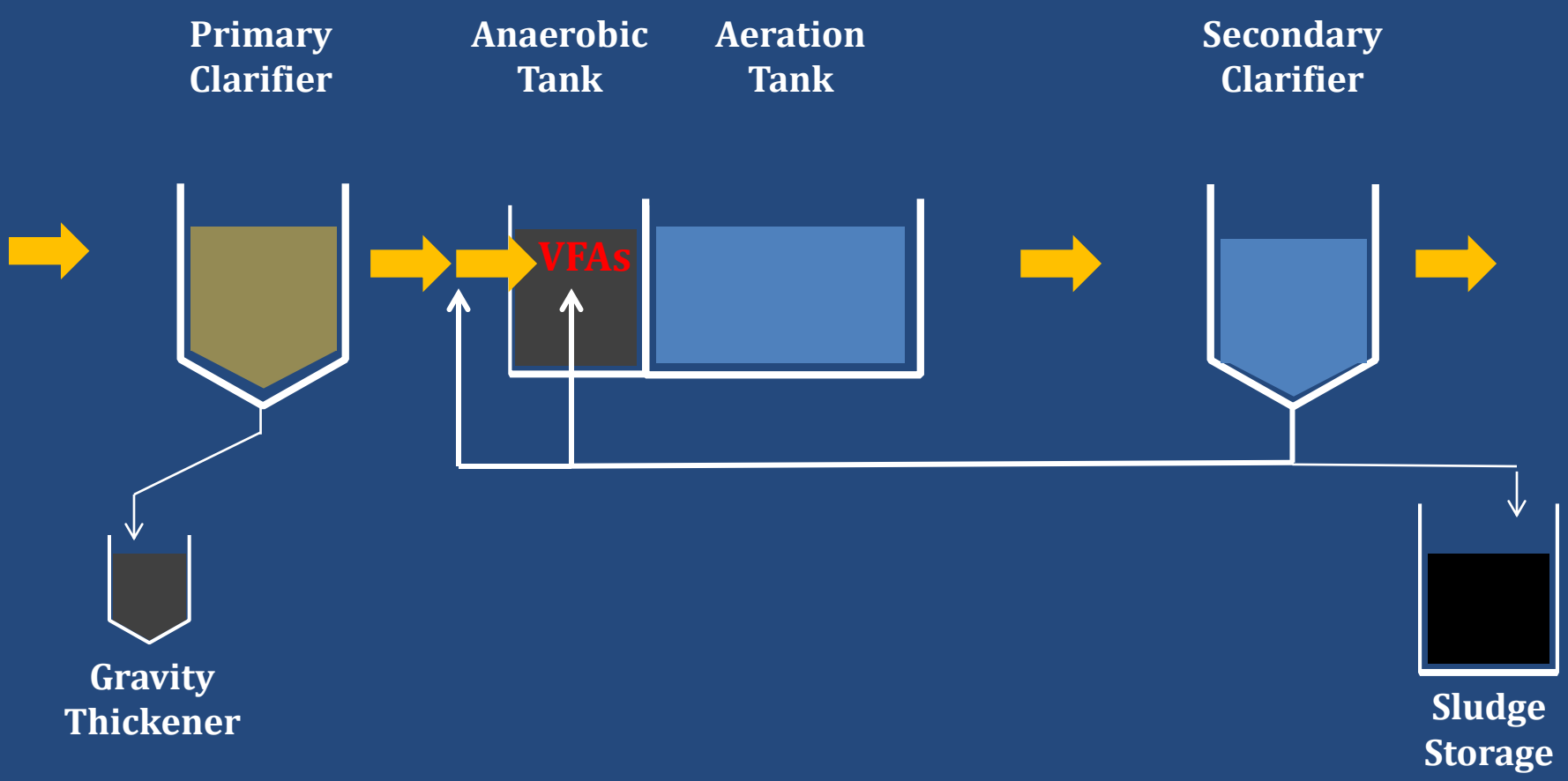
BACKGROUND INFORMATION

Experimenting with YOUR plant:
Finding the "Right" Process Control Strategy

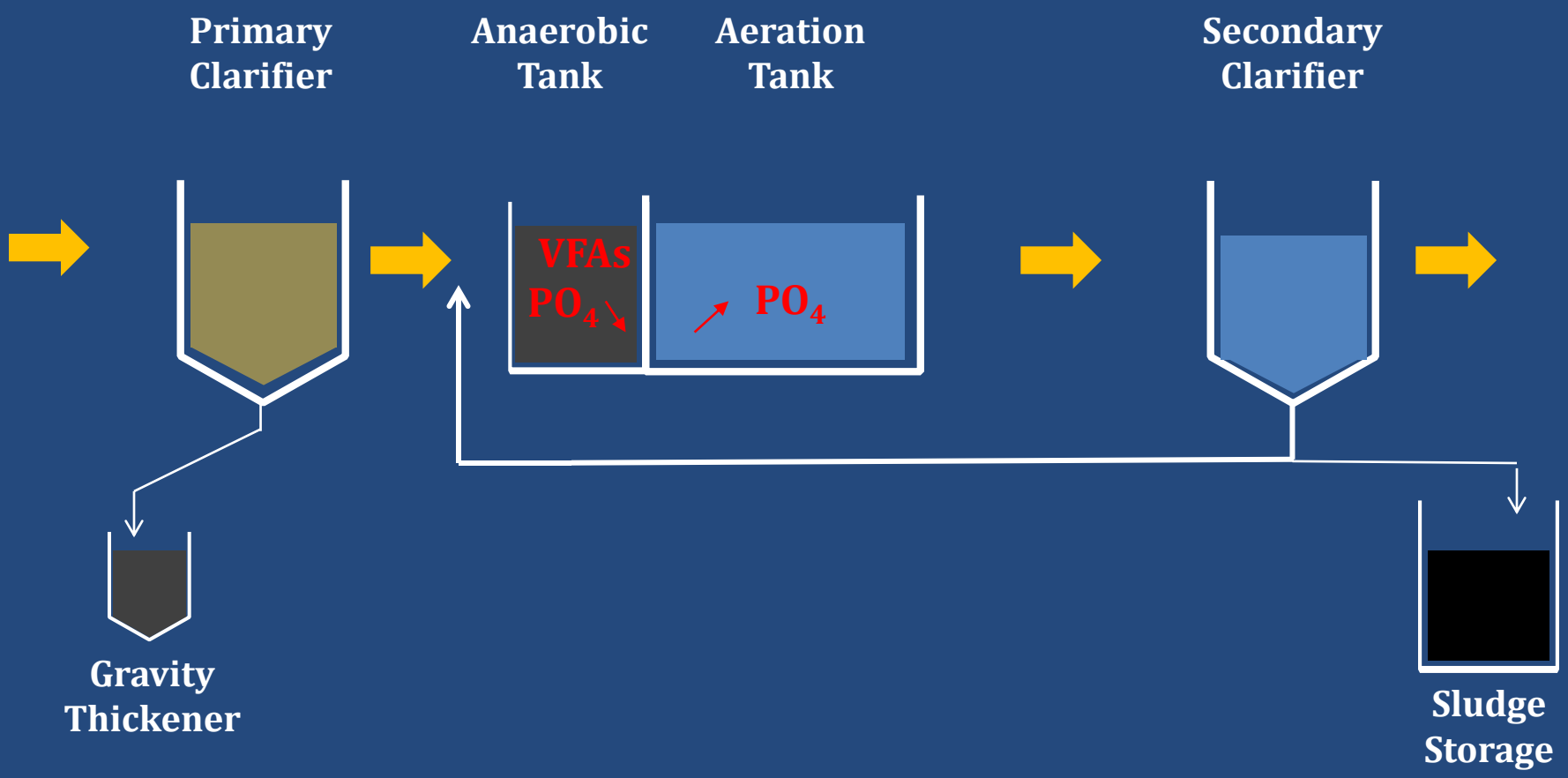
… and, Optimizing Phosphorus Removal

Create a Mainstream Fermentation Zone

Mainstream Bio-P Removal in Conventional AS Plant

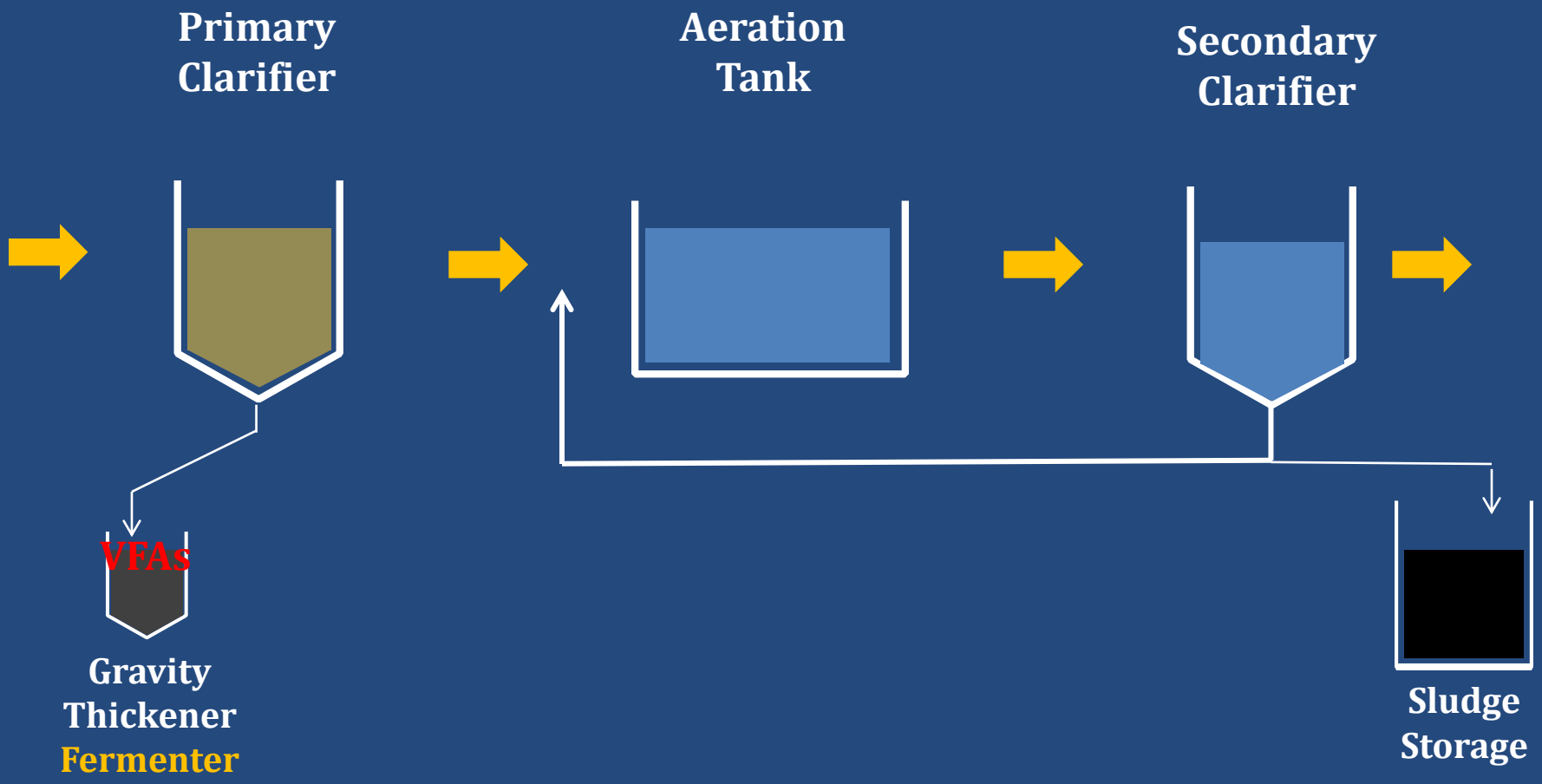


Mainstream Bio-P Removal in Conventional AS Plant

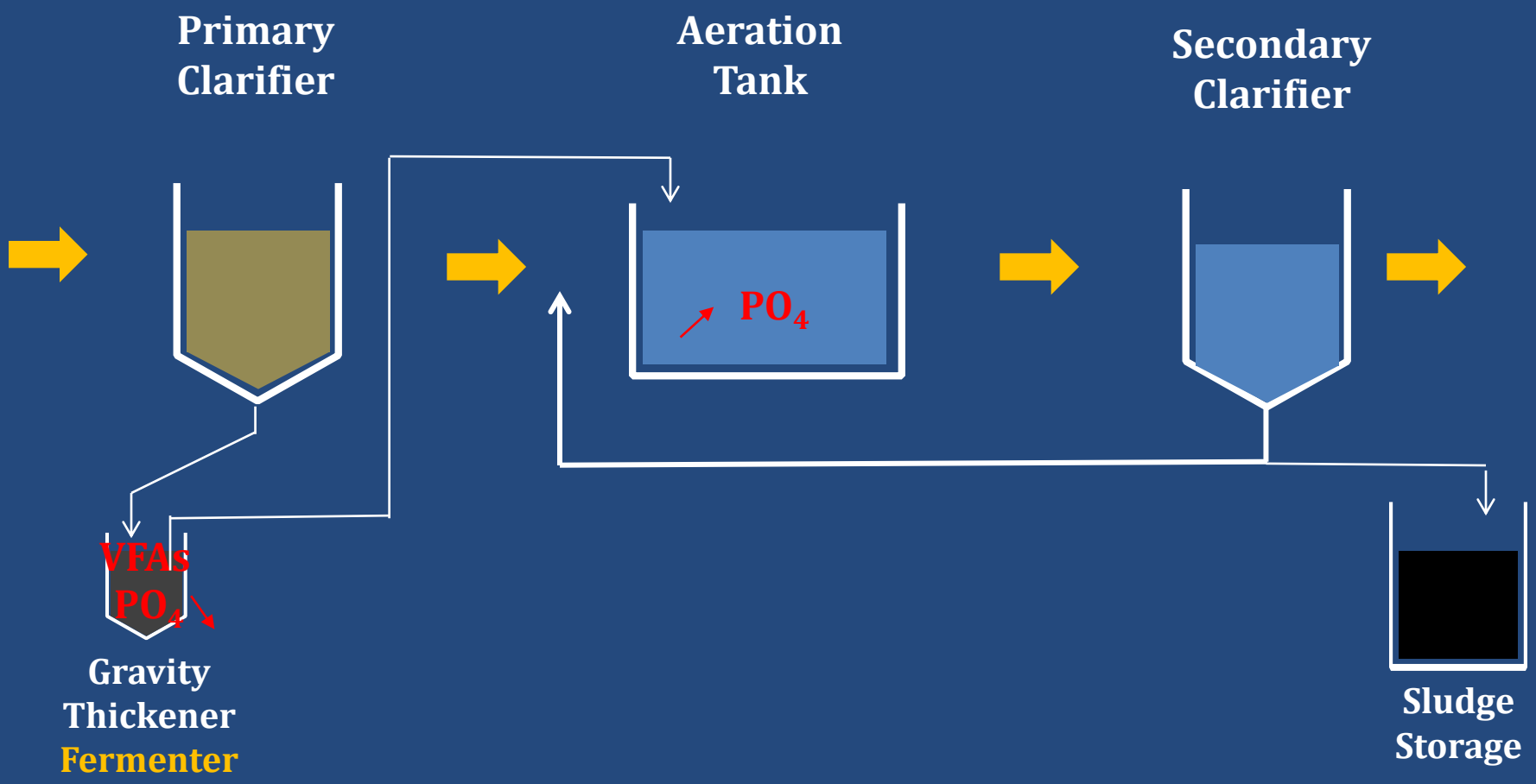


Create a Sidestream Fermentation Zone

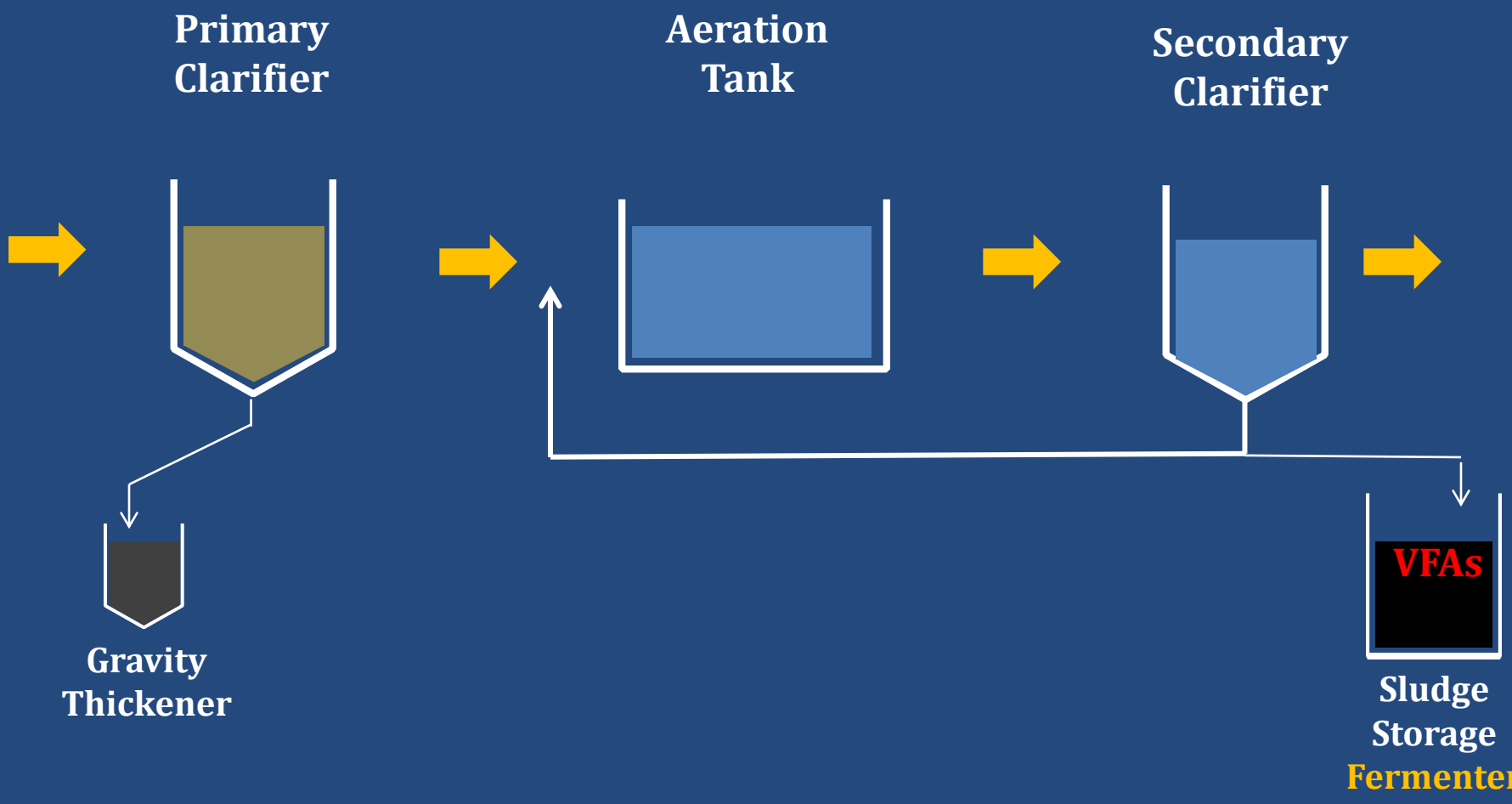
Sidestream Biological-P Removal: Gravity Thickener



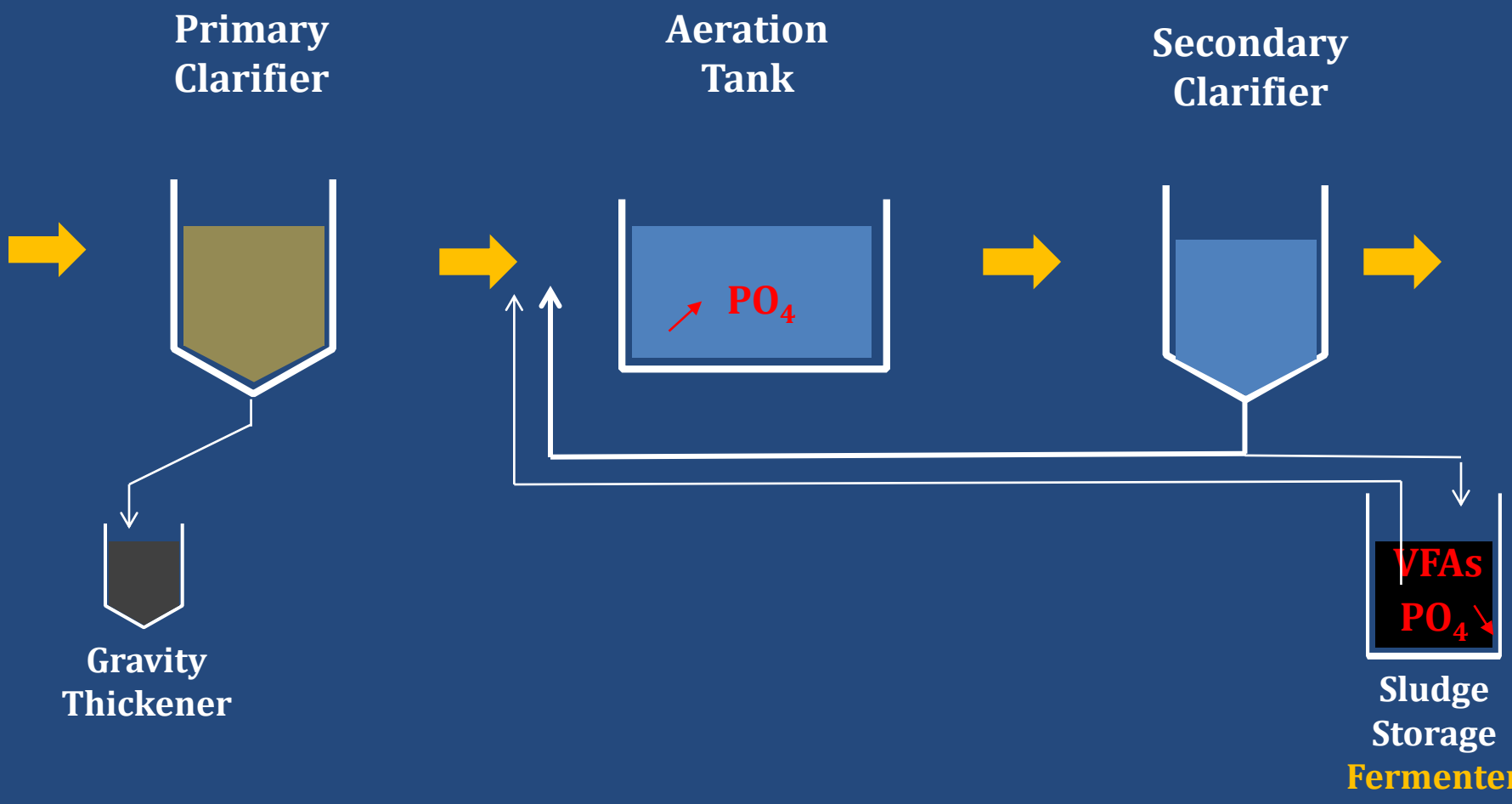
Sidestream Biological-P Removal: Gravity Thickener



Sidestream Biological-P Removal: Sludge Storage

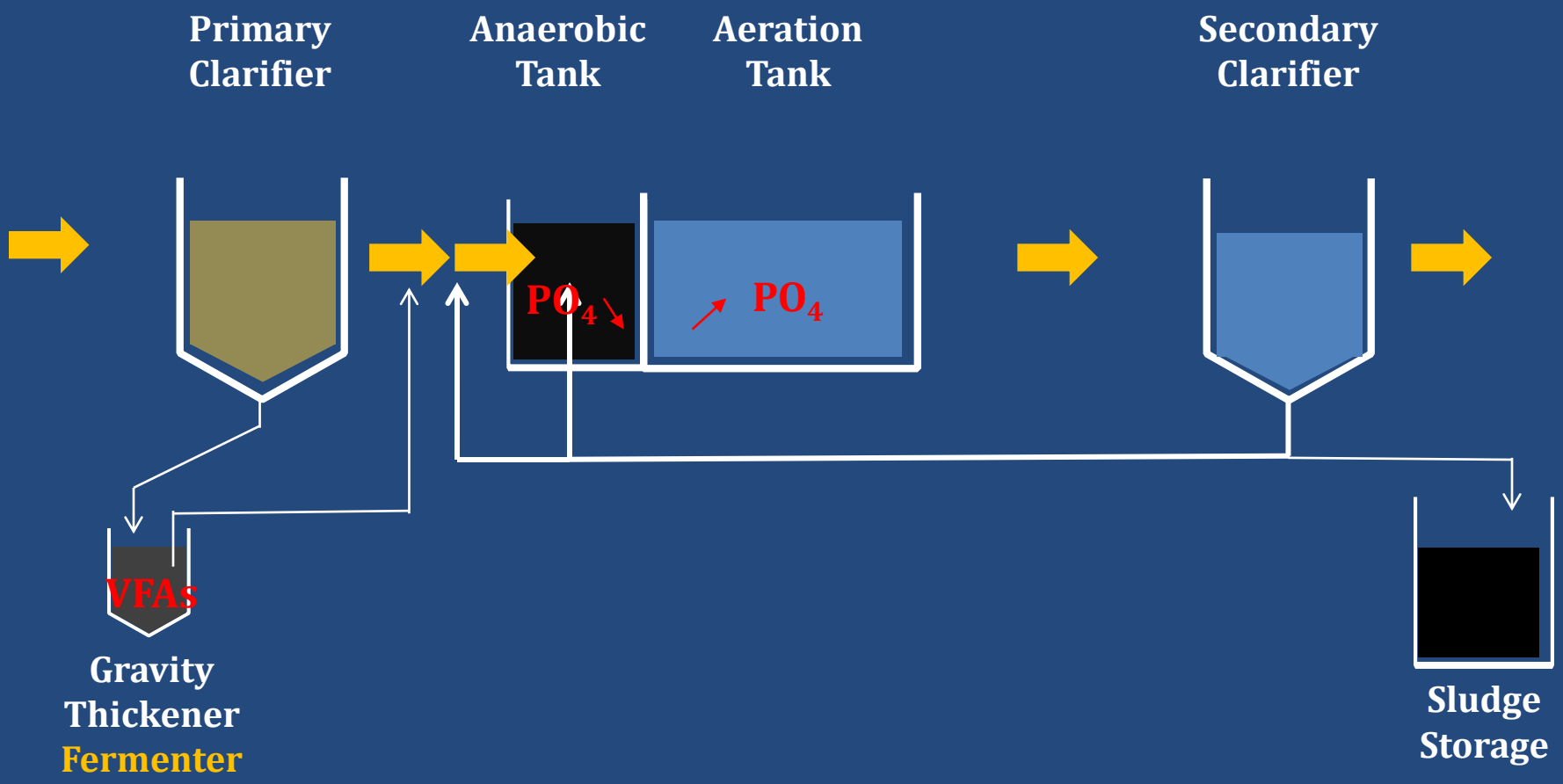


Sidestream Biological-P Removal: Sludge Storage

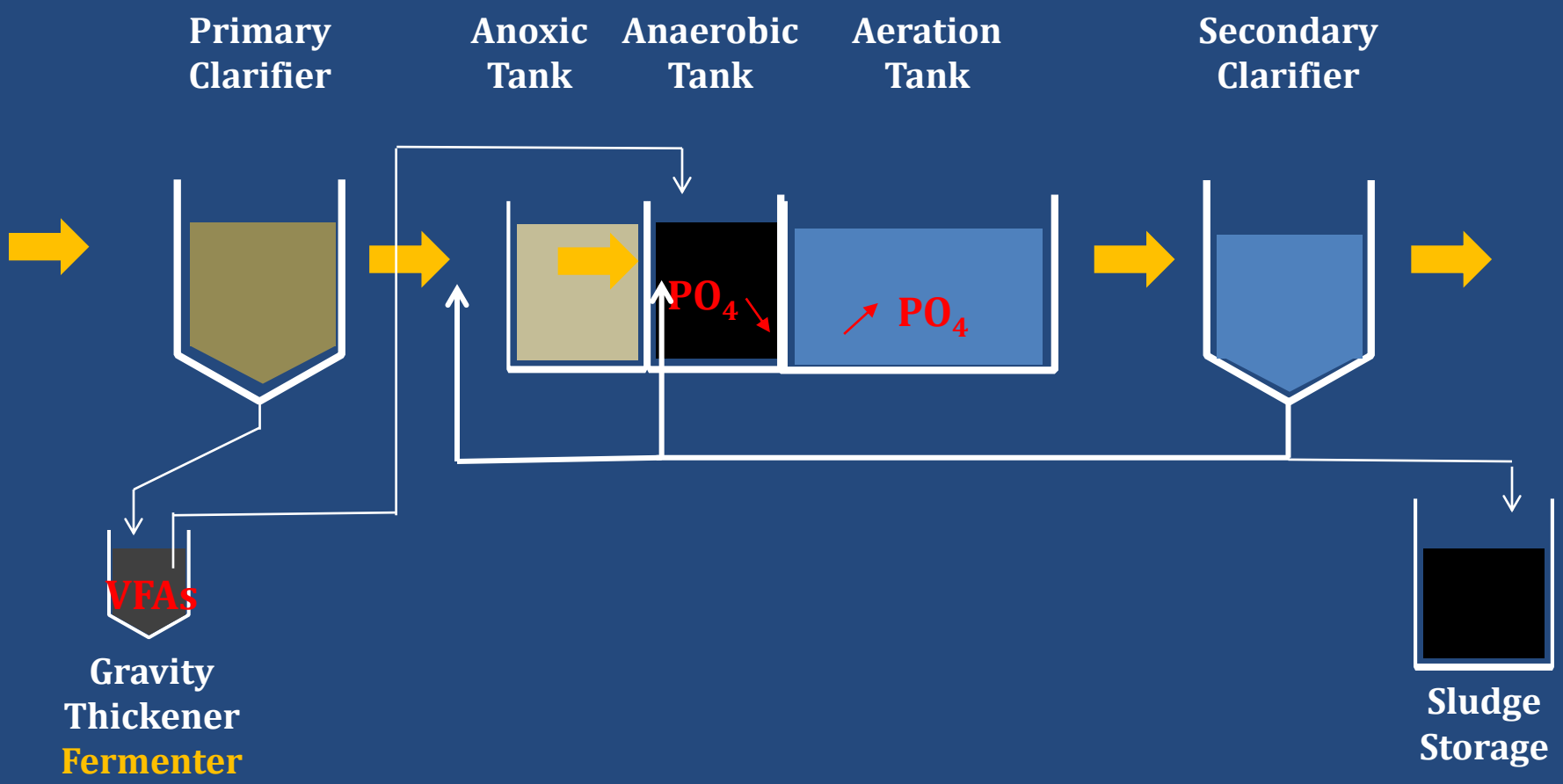


Create Both Mainstream & Sidestream Fermentation Zones

Sidestream & Mainstream Bio-P Removal



Sidestream & Mainstream Bio-P Removal



No Nitrogen Interference

Optimizing Fermentation: Mainstream or Sidestream

Anaerobic Tank

~1 hour HRT*

ORP of -200 mV*

25* times as much BOD as influent ortho-P

ortho-P release (3-4 times influent ortho-P)*

Aeration Tank

DO of 2.0 mg/L*

pH of 6.8+*

ortho-P concentration of 0.05 mg/L*

*Approximate: Every Plant is Different

Summary

Operational changes allow many (most) Activated Sludge Plants to biologically remove phosphorus - and - as a bonus create a biological selector for filament control.

Find opportunities for mainstream as well as sidestream fermentation zones.

Recognize that two things occur in the anaerobic tanks:

- VFA formation (hard to digest compounds converted to easy-to-eat molecules)
- PAOs use volatile fatty acids as an energy source (food)

Aeration Tank habitat is important: DO & pH

Bio-P converts soluble-P to an effluent TSS rich in P …

- TSS control is critical!

Minimize VFA use by Nitrate (NO_3)

Monitor and Adjust DAILY for the rest of your life!

THE WATER PLANET COMPANY

Making clean water affordable

Special thanks to …

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Gene Connell, Missoula, MT

Thank You!

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Upcoming Webinars

11 AM EST March ’18th: Activated Sludge N&P Removal

April ‘14: Sequenced Aeration, an Innovative/Effective Process Design

May ‘14: N&P Removal in Oxidation Ditches

June ‘14: Trickling Filter Operations