The role of an adequate Anaerobic Mass Fraction on RAS Hydrolysis/Fermentation for Sustainable EBPR process

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INTRODUCTION

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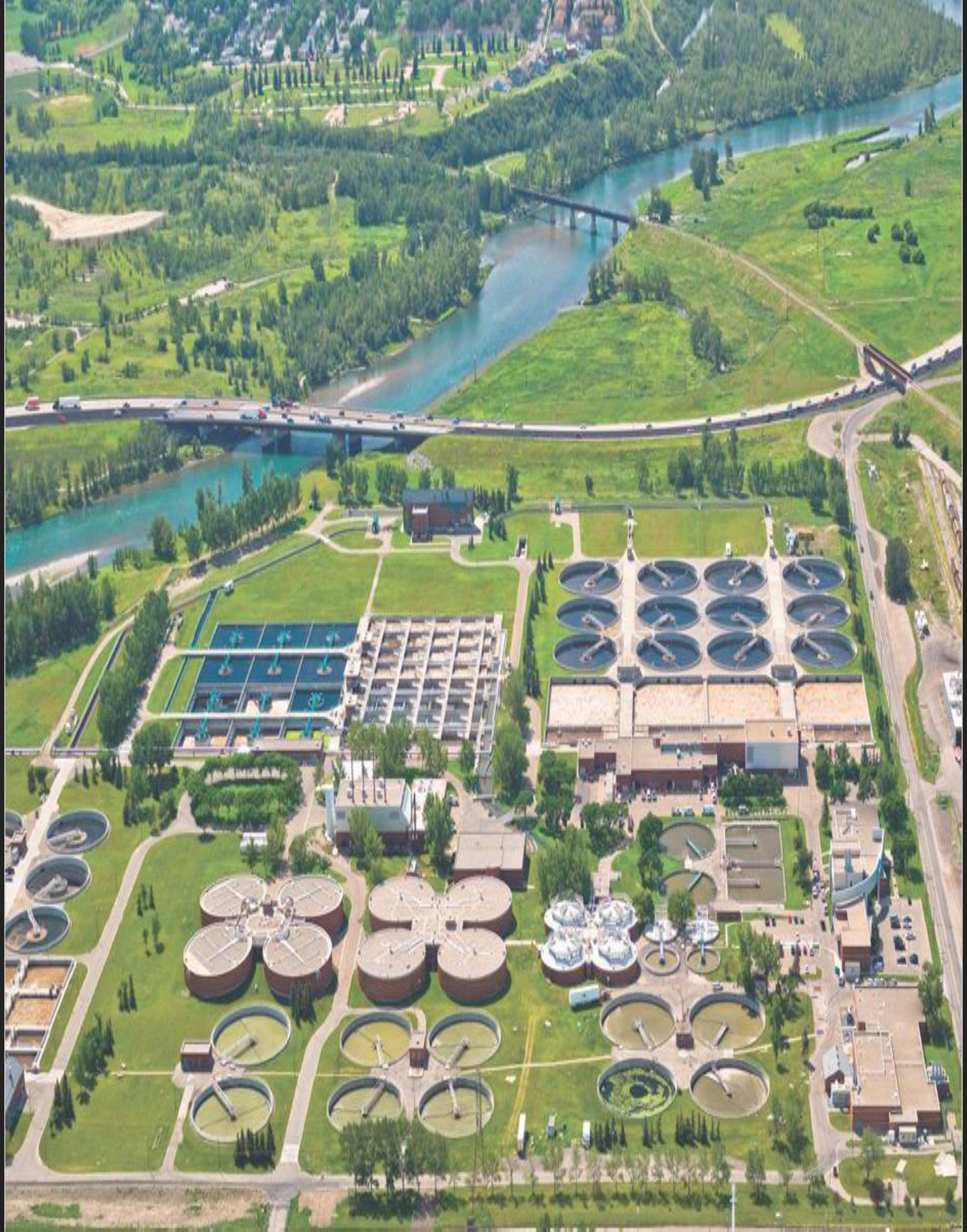


Agenda

1. Process Introduction
2. Plant Background
3. Study Framework
4. Results
5. Conclusions and Next Steps

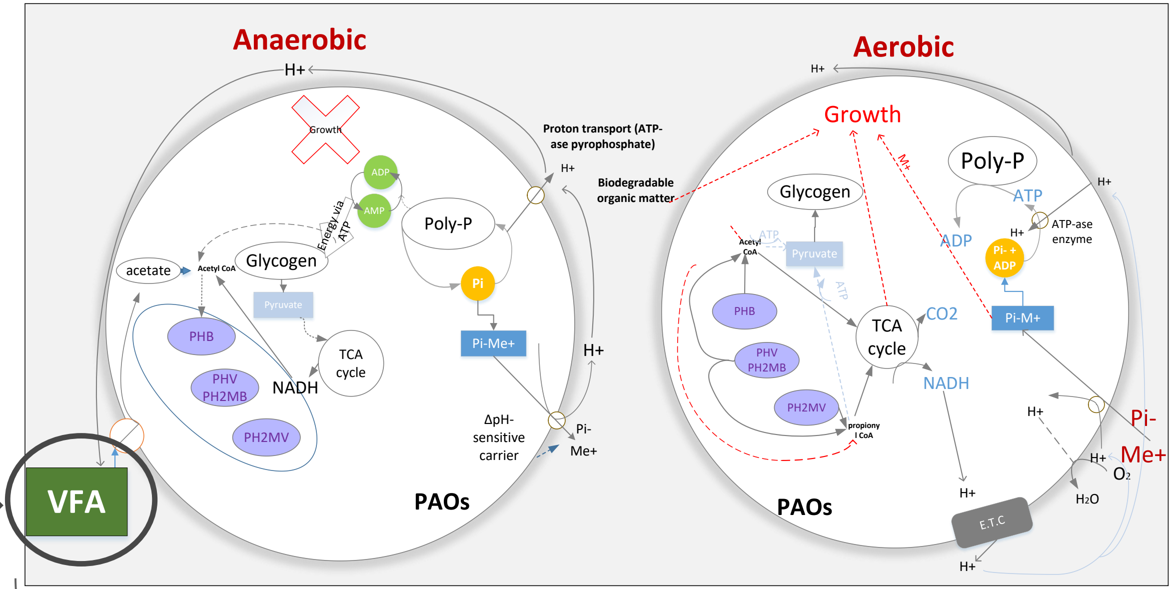
Process Introduction

RAS fermentation Hydrolysis

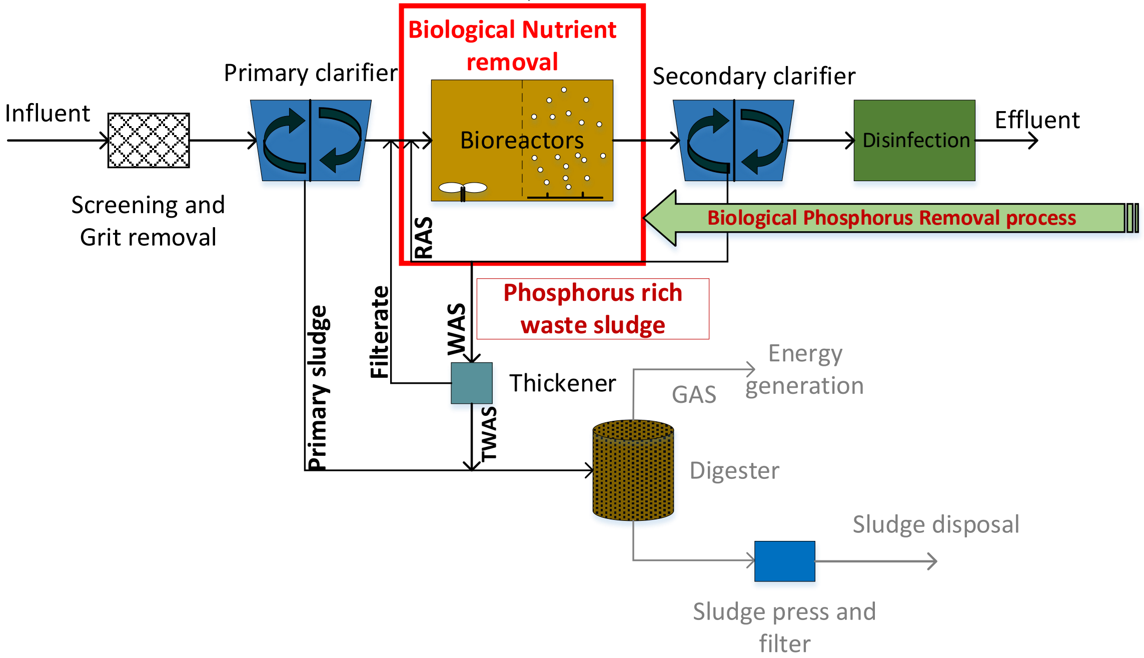
ENHANCED BIOLOGICAL PHOSPHORUS REMOVAL (EBPR)

Not the only carbon source available

Key element for PAO growth (common knowledge)



- EBPR process rejected as the sole removal system
- Require Carbon addition



What is lacking for a sustainable and efficient EBPR process?

Indication of good BPR:

- Influent VFA and RBCOD
- VFA production through hydrolysis, and fermentation

- **COD < 400 mg/L, F_{ana} = 0.20-0.25**
- **400 < COD < 700, F_{ana} = 0.15-0.20**
- **COD > 700 mg/L, F_{ana} = 0.10-0.15**

Controls the Fermentation/hydrolysis

Missing link

Existing plants

- Overshadowed by aerobic SRT and plant size
  - Mediation/optimization plan
- Adequate Anaerobic mass fraction

Future implementations

- Consider anaerobic mass fraction in design of the total plant
- Recognize the importance of hydrolysis/fermentation

EXISTING PLANT WITH INADEQUATE ANAEROBIC SIZING

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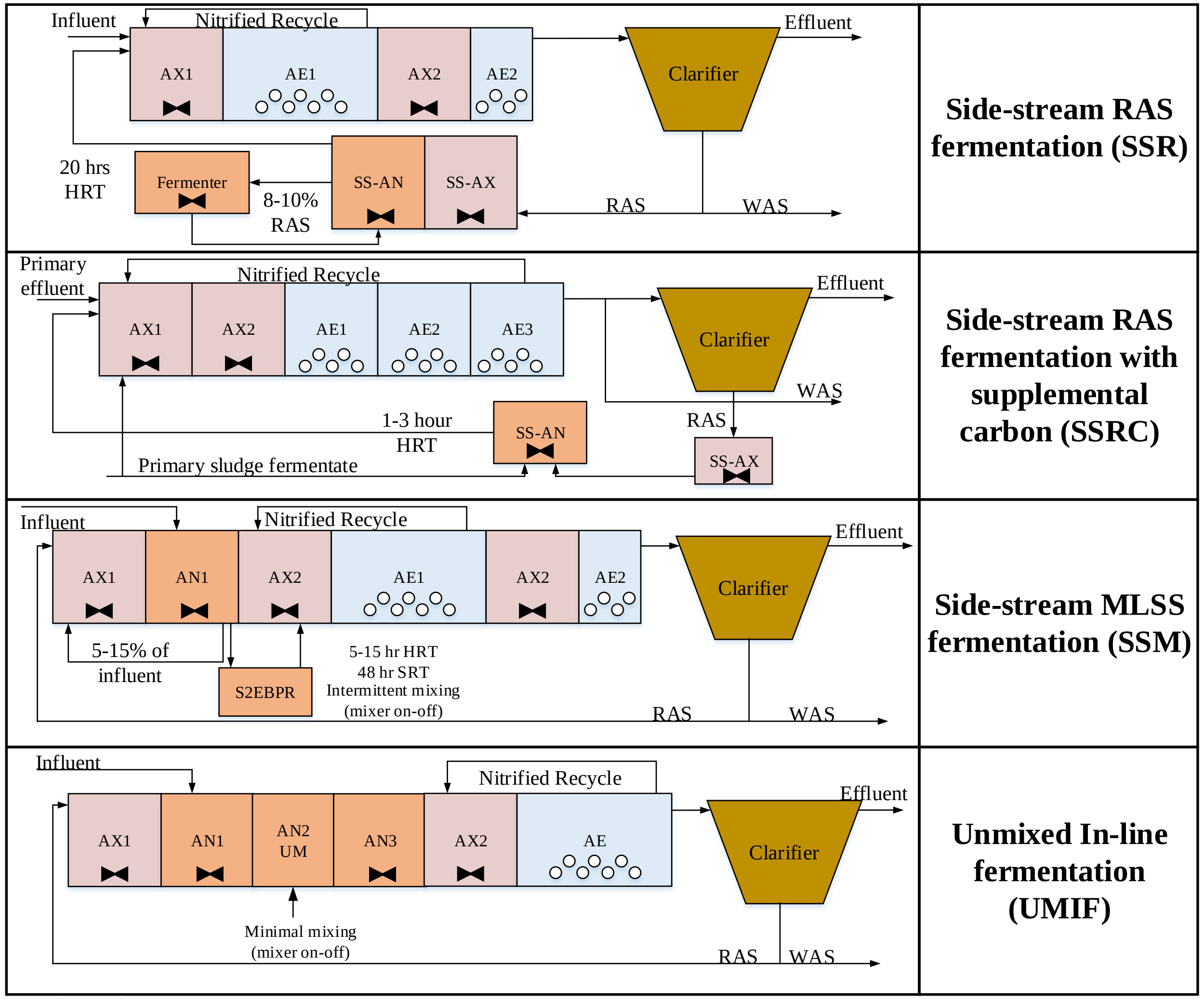
SIDE STREAM EBPR (S2EBPR)



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South Cary-SSR

16% Anaerobic mass fraction increase

Westside regional-SSRC

15% Anaerobic mass fraction increase

Cedar Creek-SSM

19% Anaerobic mass fraction increase

Henderson-UMIF

3-4% Anaerobic mass fraction increase

EXISTING PLANT WITH ADEQUATE EBPR

Indication of good BPR:

- Influent VFA and RBCOD
- VFA production through hydrolysis, and fermentation

- **Evaluate anaerobic design**
- **Verify anaerobic hydrolysis and fermentation rate**

In Bonnybrook WWTP

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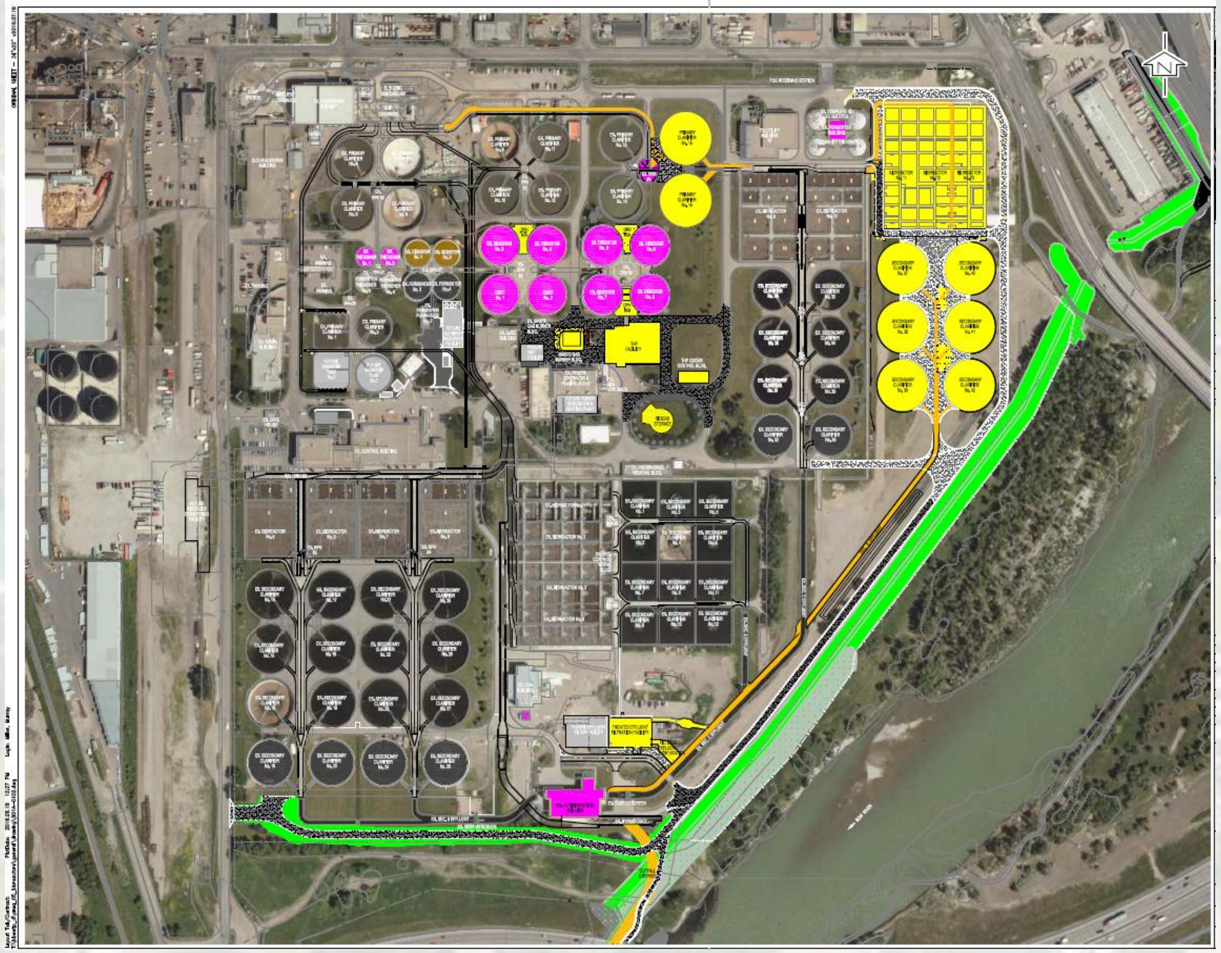
City of Calgary Plant Background

City of Calgary Plant Background

BONNYBROOK WASTEWATER TREATMENT PLANT (BBWWTP)

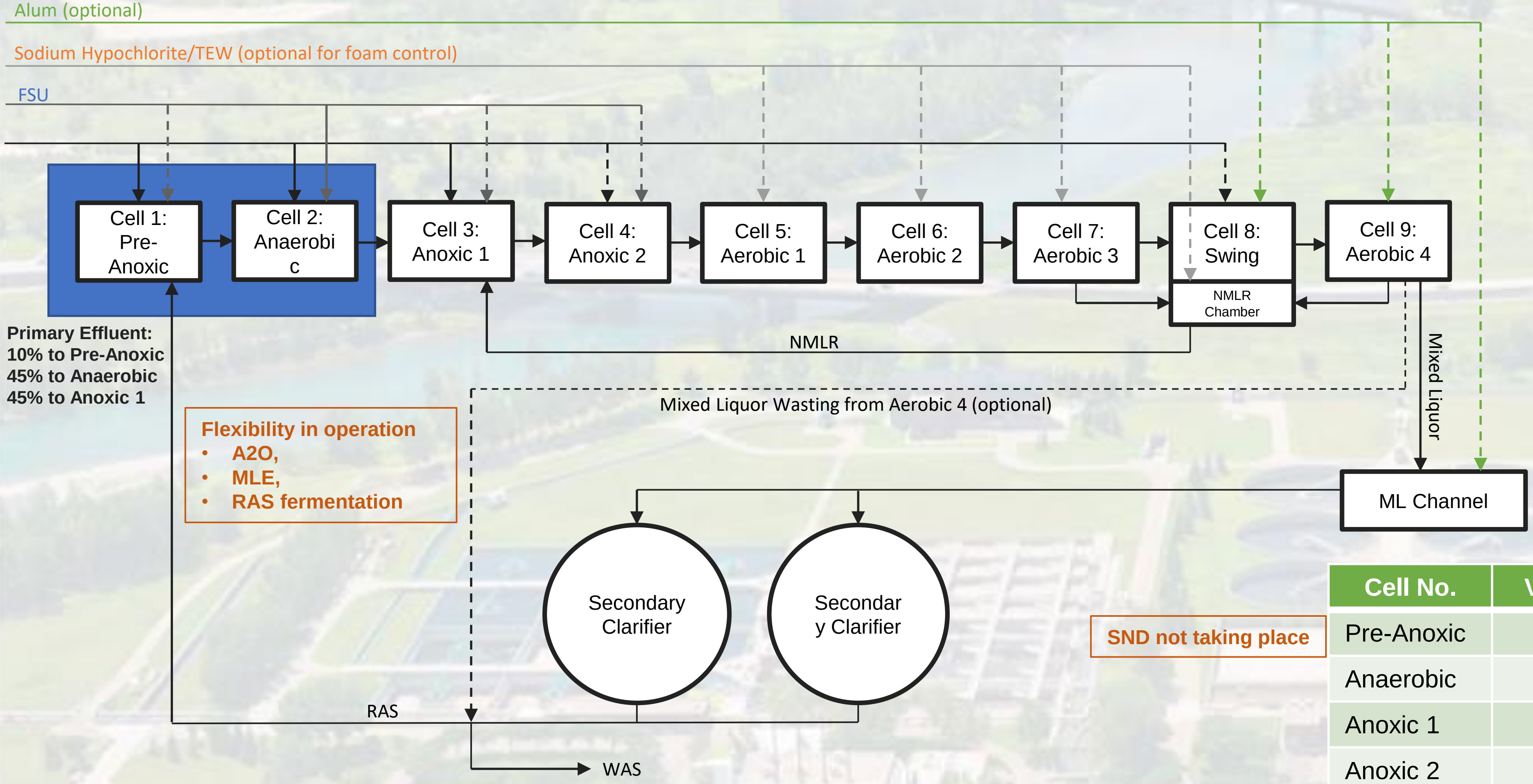


BBWWTP effluent requirements (plant D addition) monthly average	Concentration (mg/L)
TSS	20
$cBOD_5$	15
Total phosphorus	1
Ammonia (Summer)	5
Ammonia (Winter)	10
Total Nitrogen (Plant D)	15

Recommendation

- One of the three city-owned plants
- Installed capacity: 140 MGD
- Effluent received by Bow River

BBWWTP SECONDARY D (VERSATILE PROCESS CONFIGURATION)



SND not taking place

Cell No.	Volume fraction	Mass fraction	HRT (min)
Pre-Anoxic	5.1%	8%	34.6
Anaerobic	8.4%	8.7%	37.8
Anoxic 1	11.6%	10.5%	14.7
Anoxic 2	11.6%	9.8%	14.7
Aerobic 1	14.5%	15.0%	18.3
Aerobic 2	14.5%	14.7%	18.3
Aerobic 3	19.8%	19.7%	25
Swing	5.6%	5.5%	7
Aerobic 4	8.9%	8.1%	11.3

- Each bioreactor is designed for an annual average flow capacity of 12.5 MGD

Study Framework

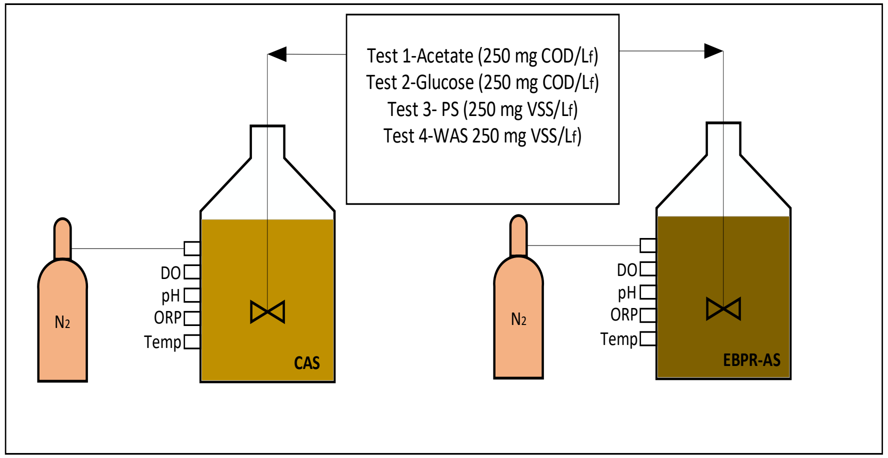
City of Calgary Testing

STUDY FRAMEWORK

Full-scale testing

Effluent Secondary-D Performance Data	Monitored/ measured	Notes
Daily flow	✔	
Solids	✔	
Carbonaceous compounds	✔	BOD5 not on daily basis
Nitrogen compounds	✔	Not on daily basis
Phosphorus	✔	TP not on daily basis
Alkalinity/pH	✔	

Batch Activity testing



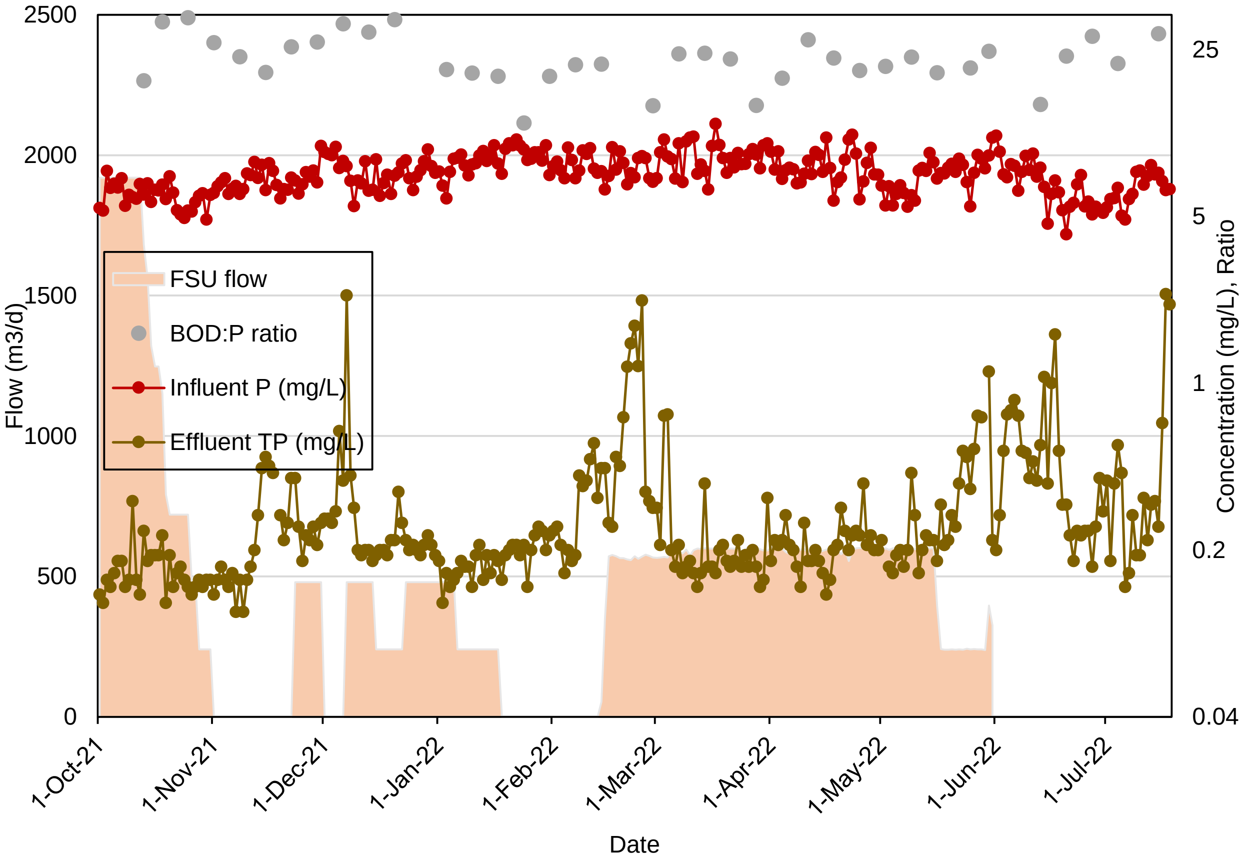
Modelling and simulation

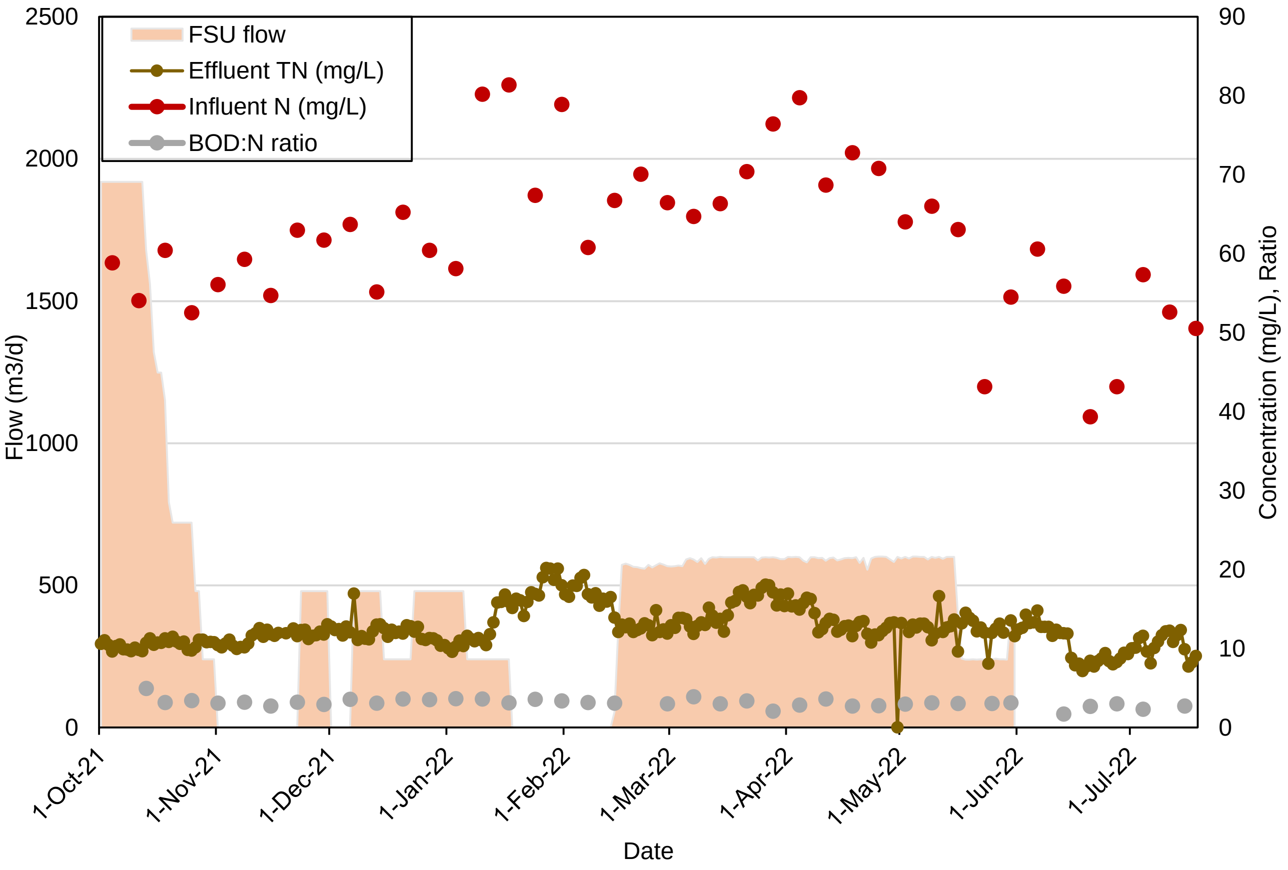
- BioWin Simulation

Results and Discussion

City of Calgary Results

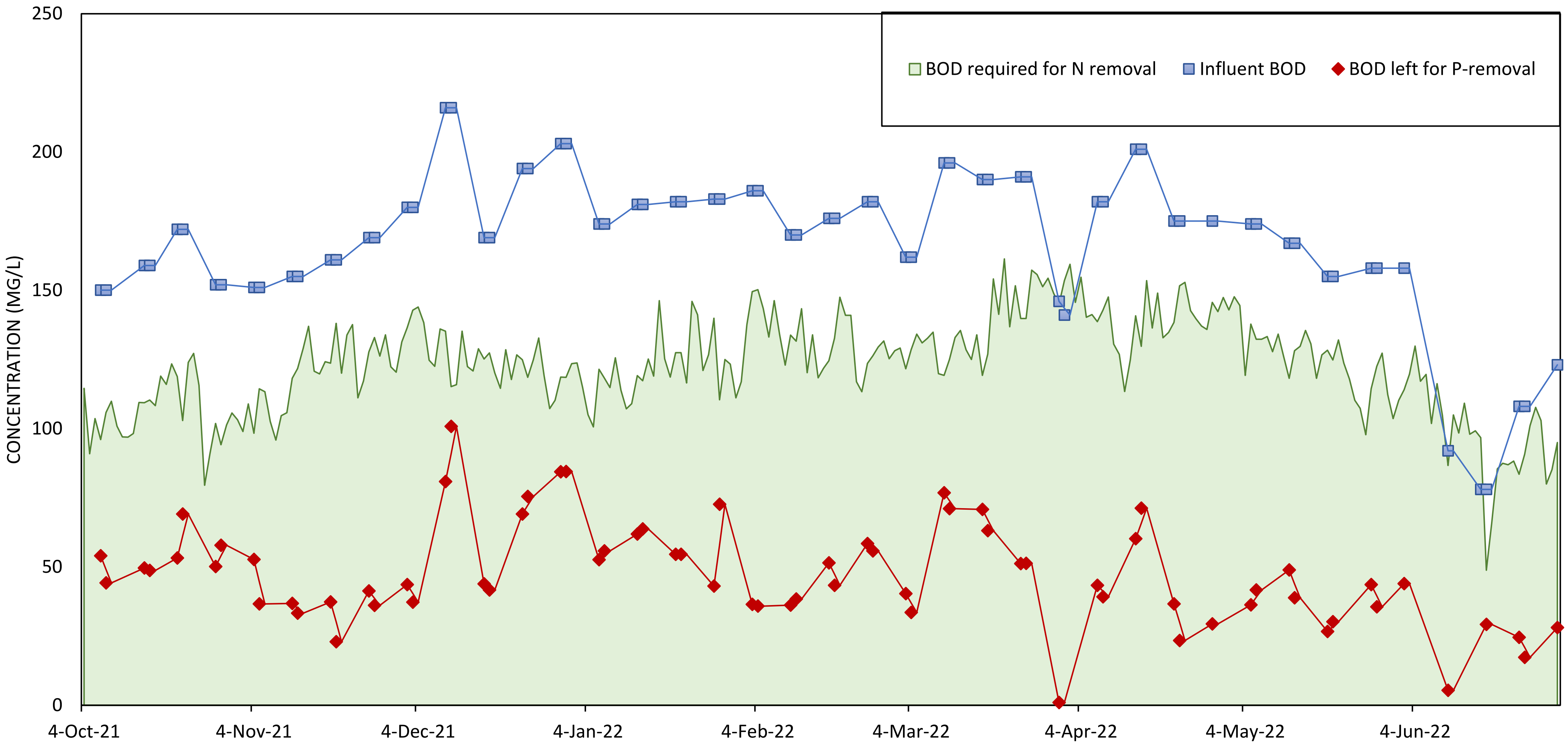
PERFORMANCE COMPARISON





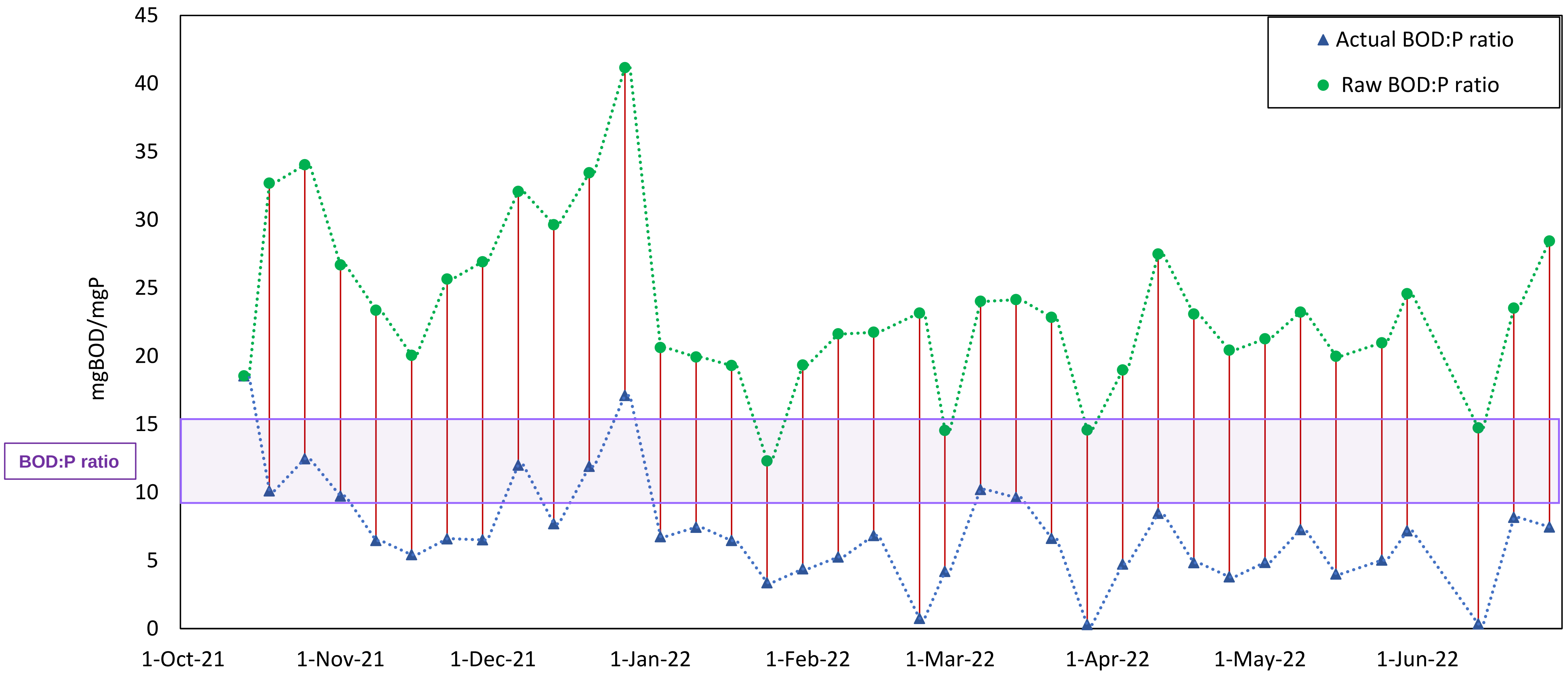
- Secondary D is running at its maximum loading
- Total SRT of Secondary D: 10.5-12 days
- Average Temperature of 59F

CARBON AND NUTRIENT BALANCE



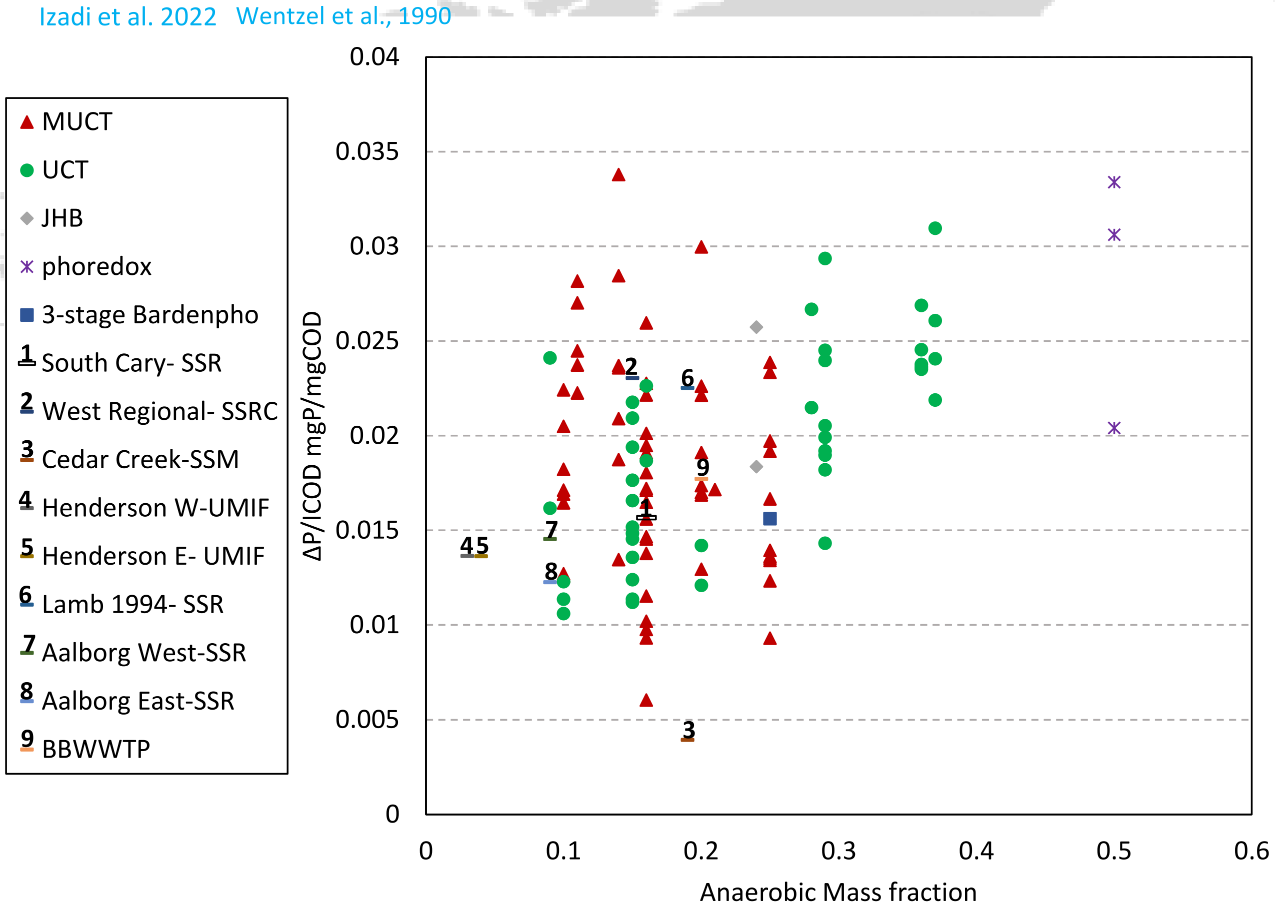
In BBWWTP, sBOD/TBOD=45%
VFA= 21 mg/L

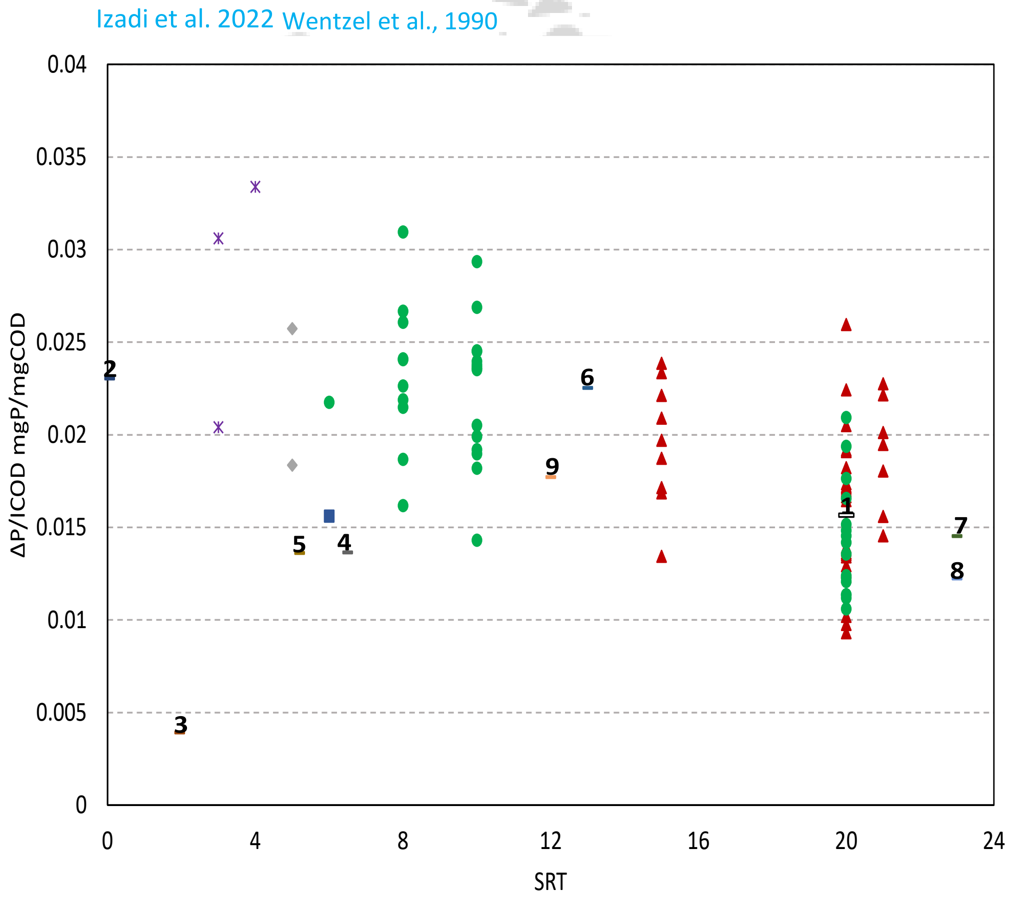
- **Available carbon (BOD) will be used for both nitrogen and phosphorus removal**
- **Actual BOD:P differs from the influent BOD:P**



Justifies other pathways of internal anaerobic hydrolysis/fermentation and VFA production
Not apparent in the COD mass balance of the system as the missing link

COMPARISON OF CONFIGURATIONS





- ***Longer SRTs shall be avoided***
- ***For a typical municipal WW an anaerobic mass fraction of 15-25% is optimal***
- ***Proper mass fraction results in improved VFA production and P-removal***
- ***Optimal AN mass fraction can insure effective P-removal of app. 0.02 mgP/mgCODin***

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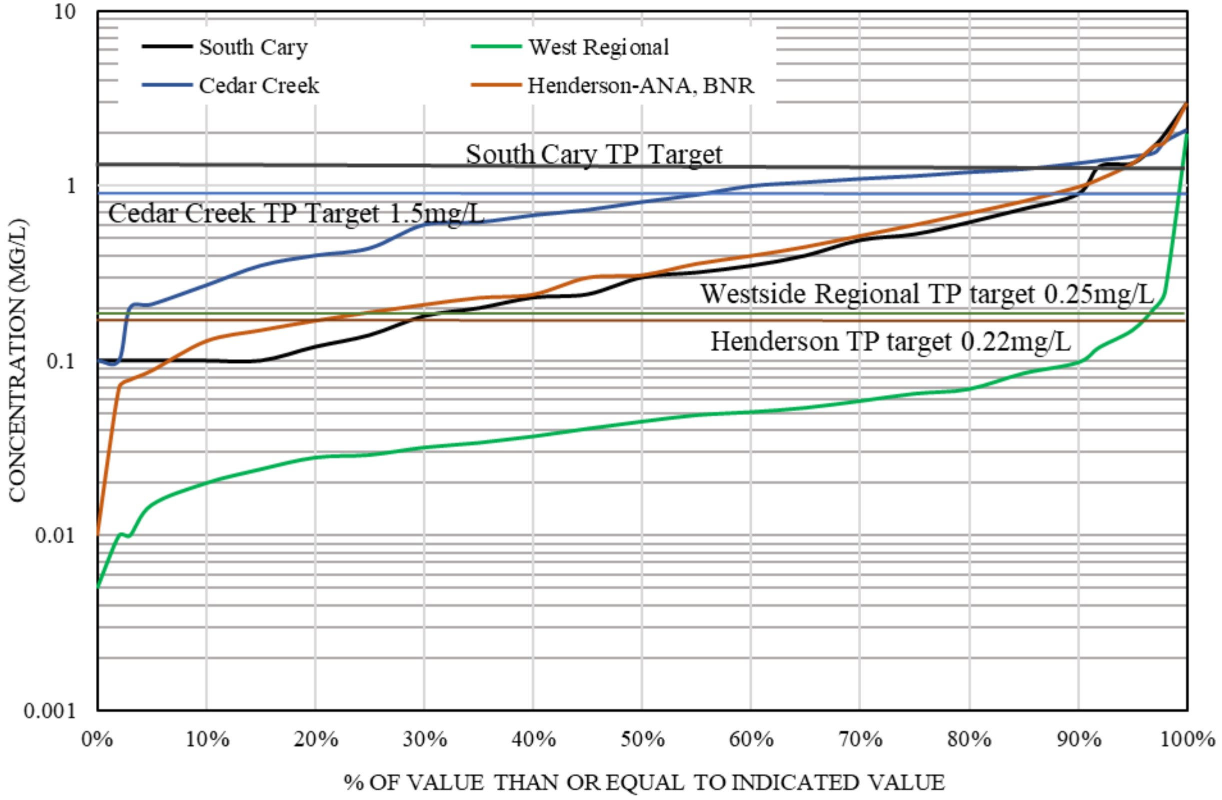
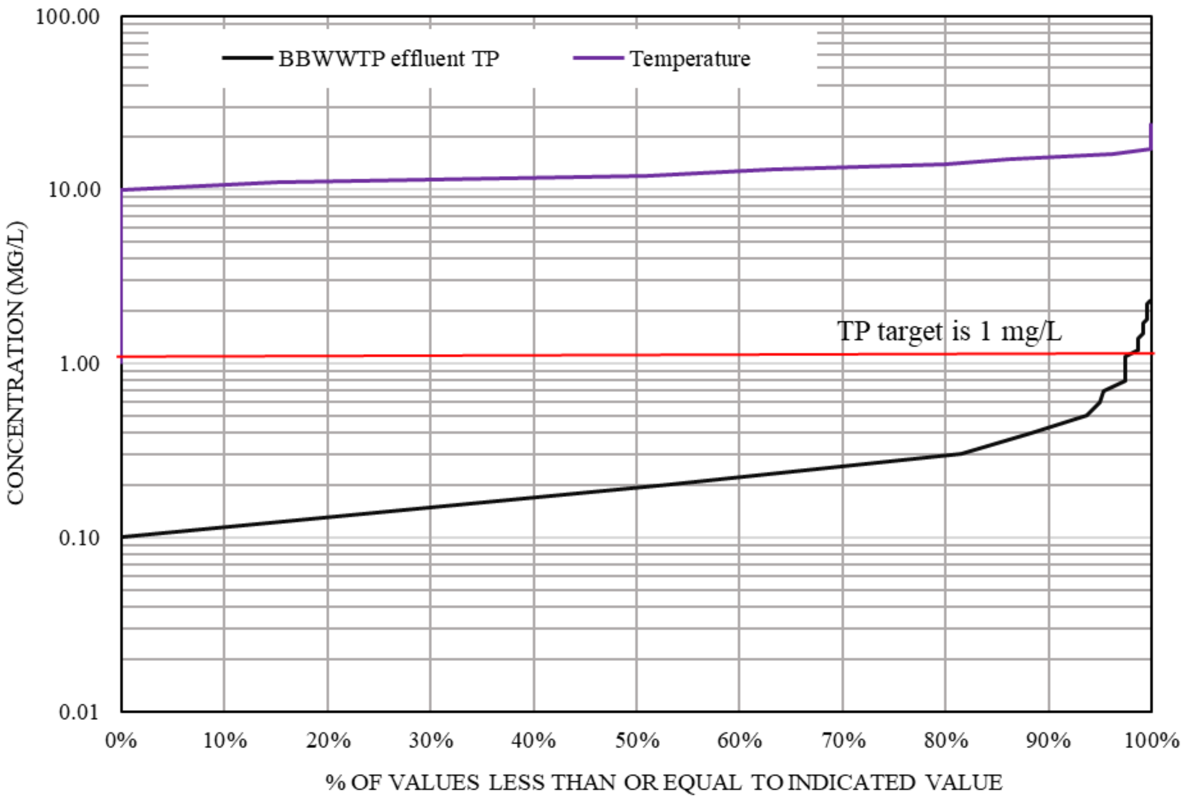




Full-scale side-stream plants have different

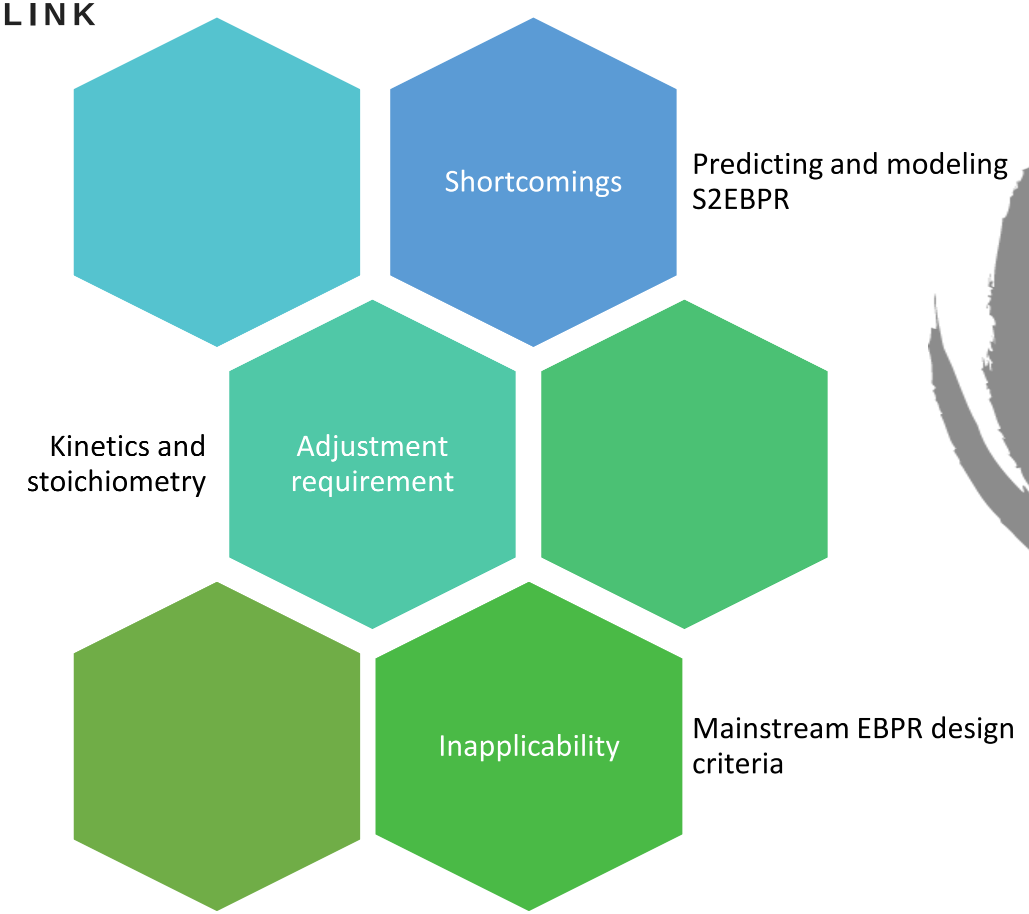
- **Influent characterization**
- **Performance goal**
- **Effluent limit**

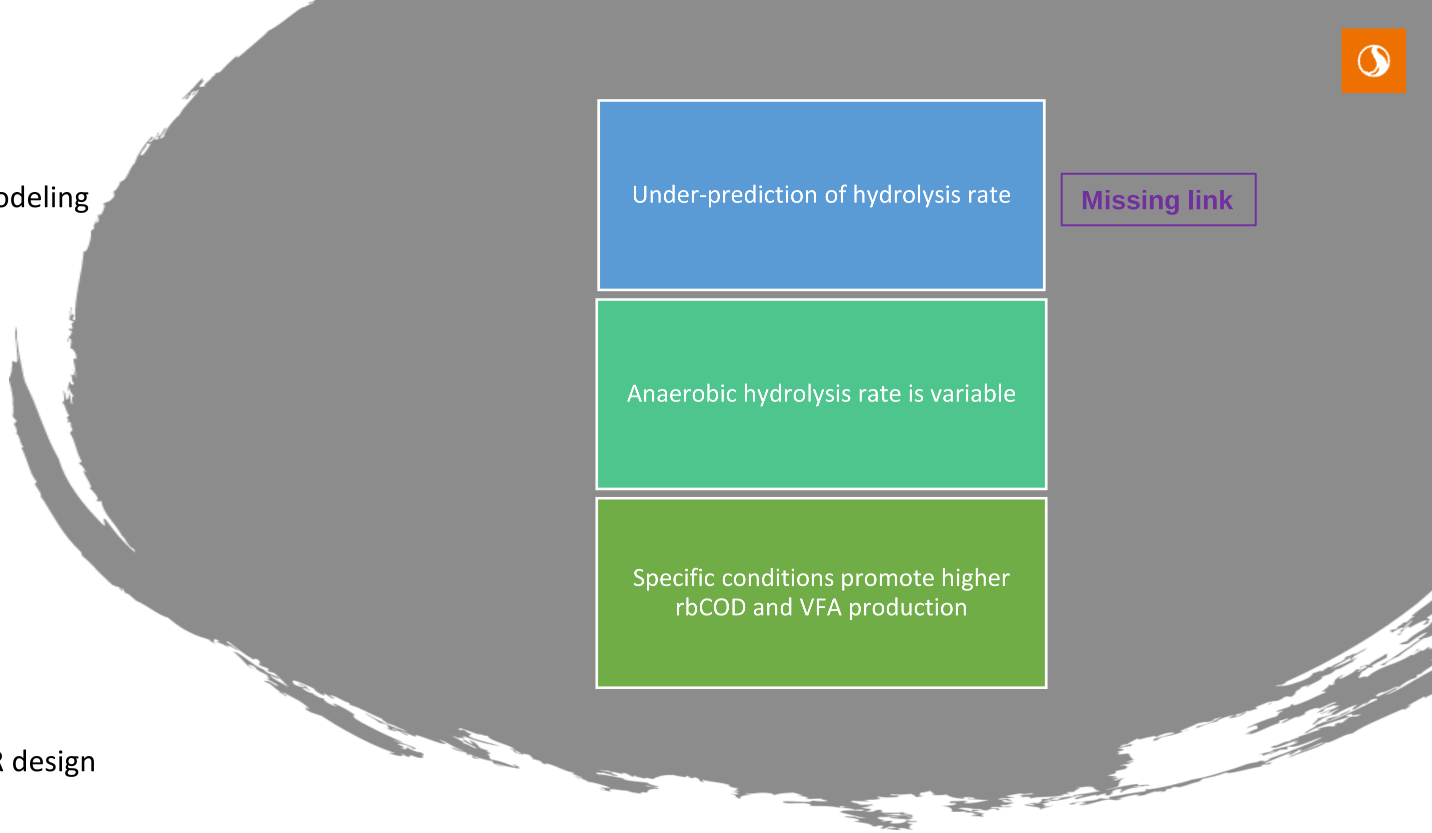
EBPR potential

Anaerobic design and operation

By understanding
Underlying mechanisms
Hydrolysis/fermentation

MISSING LINK





What is missing?

Are we underestimating the anaerobic hydrolysis and fermentation potential? How much do we know?

Next Steps and Conclusion

Next Steps

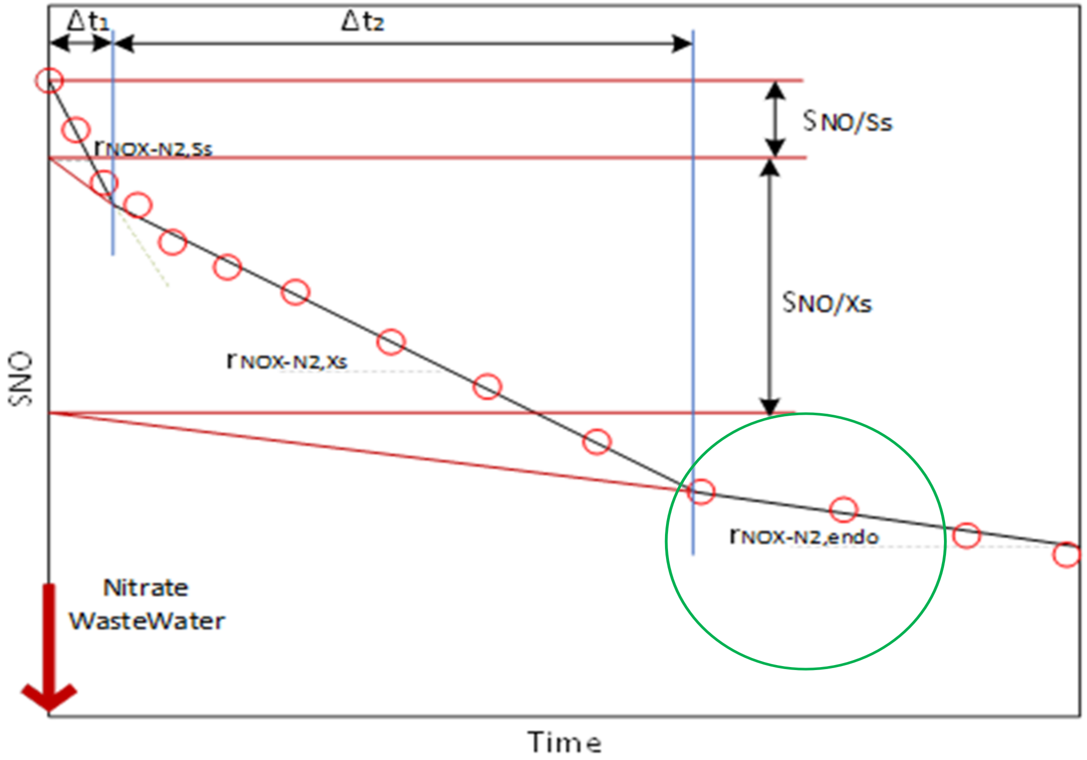
NEXT STEPS: RAS FERMENTATION/HYDROLYSIS RATE MEASUREMENT

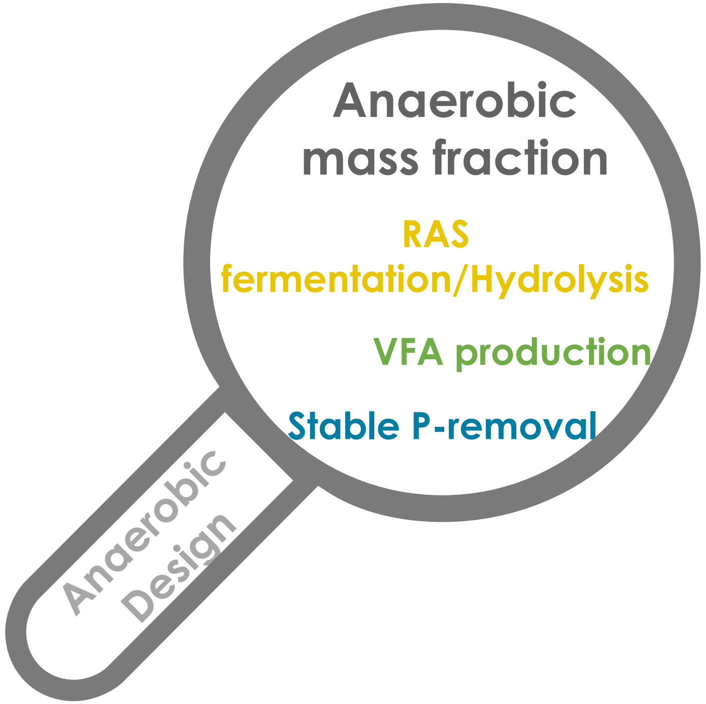
A test to directly assess the anoxic/anaerobic hydrolysis rate of a sludge sample

- Identify the effect of anaerobic intensity variation on process performance
- Quantify the anaerobic hydrolysis rate in EBPR process
- Establish understanding on kinetic and stoichiometry of EBPR

Data analysis

<u>The rate of endogenous denitrification will give us the hydrolysis rate since in reactors the cell production depends on the limiting mechanism</u>





- To understand the importance of anaerobic design and operation in the nutrient removal outcome
- Acknowledge the guidelines for anaerobic zone sizing and mass fractionation with regards to wastewater strength
- Recognize the mediation strategies to optimize the existing EBPR plants, to reach higher P-removal
- Reconsider the RAS Fermentation/Hydrolysis rate available in literature and simulation modeling

Thank you!

Discussion