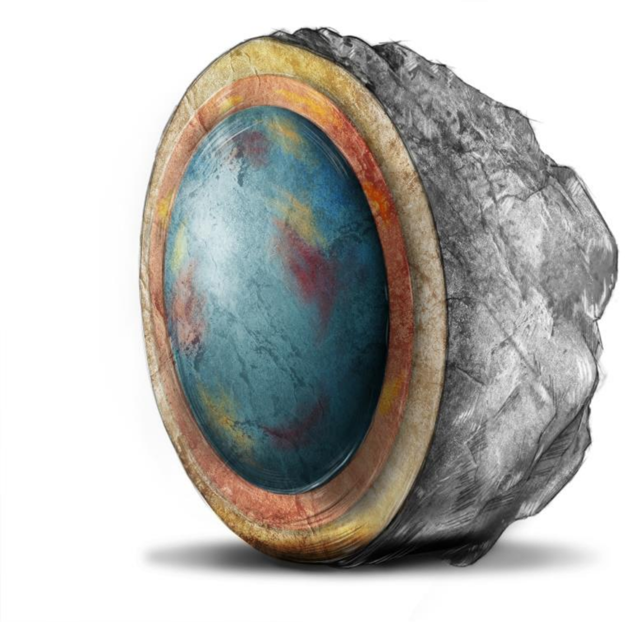
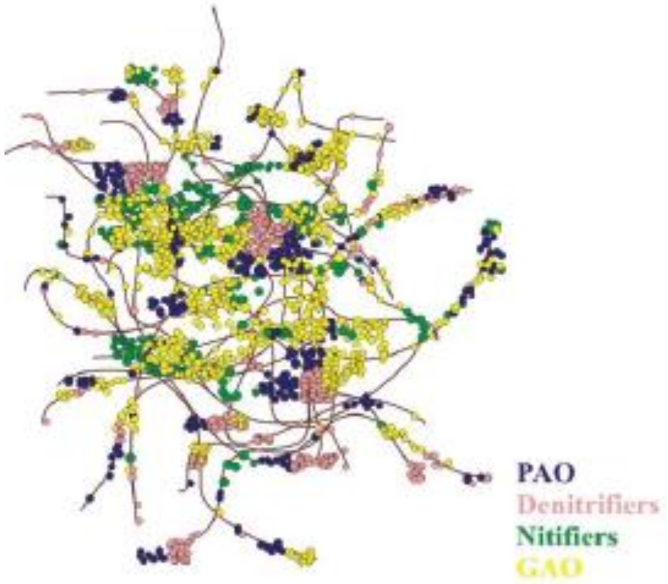
Hazen





The Value of Metabolic Selection in the Pursuit of Densified Activated Sludge

TACWA January 31, 2020

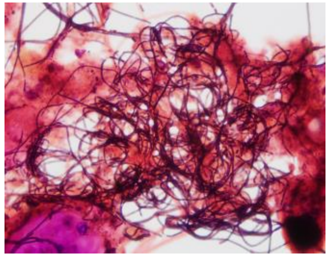
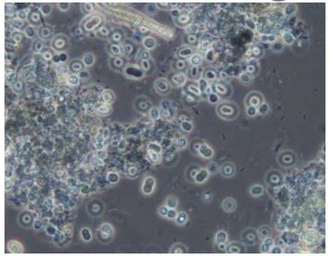
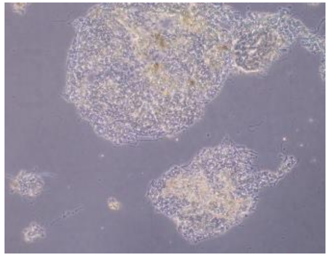
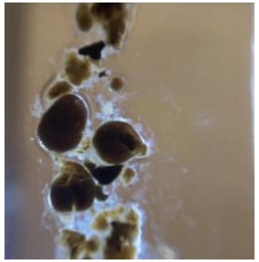
Outline

- What is densified sludge?
- Metabolic selection
- Benefits of densification
- How can we achieve densification?
- Case studies
- How densification impact plant capacity?
- Conclusions

What Is Densified Activated Sludge (DAS)?

Flocculant AS

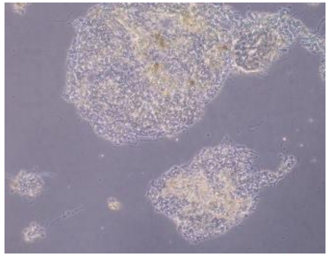
Densified AS

bulking	***dispersed/ non-bulking***	***compact***	***granular***
			
SVI_{30} > 150 mL/g	SVI_{30} ~ 120 to 150 mL/g	SVI_{30} 80 to 120 mL/g	SVI_{30} < 50 mL/g

Continuum of Densification

How Does DAS Compare with Granular Sludge?

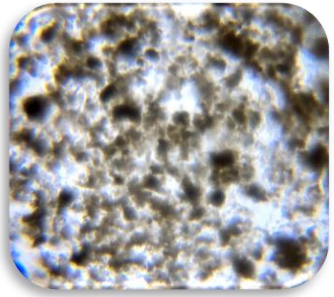
Compact AS (non-granular)



non-patented AS

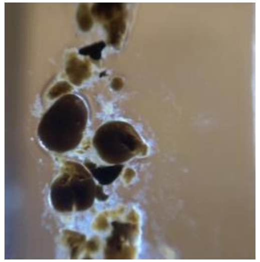
Conventional Selector Design

Densified AS (non-granular)



non-patented AS*

Densified AS (granular)



AquaNEREDA™

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How do we Bridge the Gap?

Metabolic Selection For Improving Settleability Is Not New…

- Chudoba et al. (1973, 1984)
  - Presented kinetic selection theory based on monod
- Van Niekerk et al. (1988)
  - Eq. to determine selector hydraulic detention time
- Multitude of publications
- Design guidelines target F:M ratios and HRTs
- In absence of historical data ***an SVI of 150 mL/g should be used if the facility uses selectors***

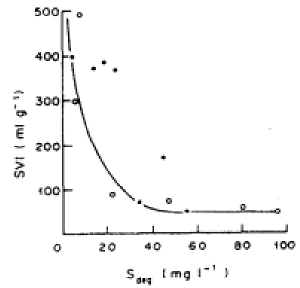
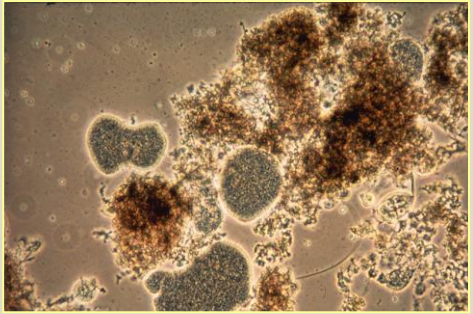


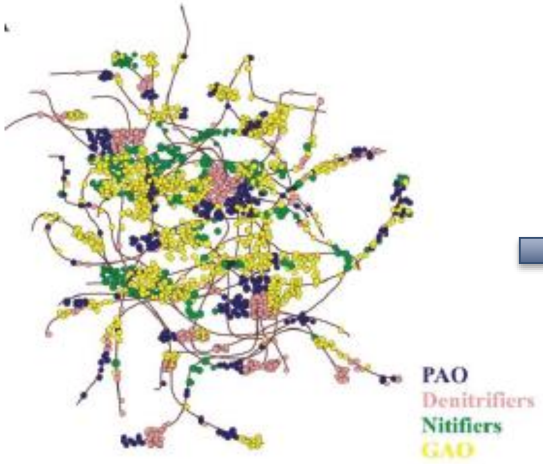
Fig. 7. Relationship between SVI and soluble degradable COD in the first selector compartment. ○ Chudoba *et al.* (1973a, b); ● Lee *et al.* (1982).



Why Achieve Densification?

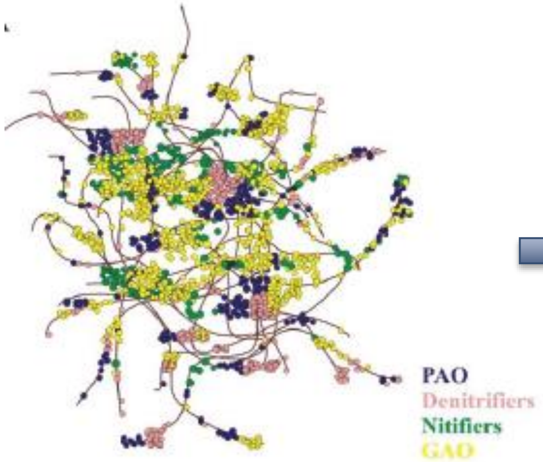
Hazen

DAS Is An Enhancement to Activated Sludge that Facilitates Rapid Settling



Underlying benefit is due to <u>improved settleability</u>

DAS Is Key to Unlocking Capacity at WRRFs



Increase capacity

Reduce Footprint

Utilize Existing Assets

Reduce Energy

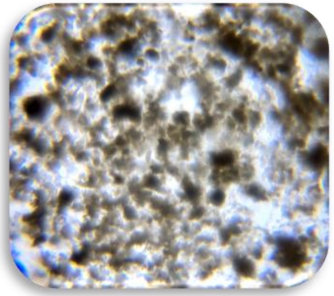
Reduce Chemicals

How Do We Achieve Densification?

Hazen

Non-granular DAS Possesses Enhanced Settling Properties Versus Conventional Activated Sludge

Non-granular DAS



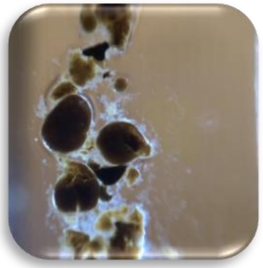
$SVI_{30} < 70$ mL/g

$SVI_{10} \sim SVI_{30}$

Particle size < 212 um

Effluent TSS < 4 to 10 mg/L

granular sludge



$SVI_{30} < 50$ mL/g

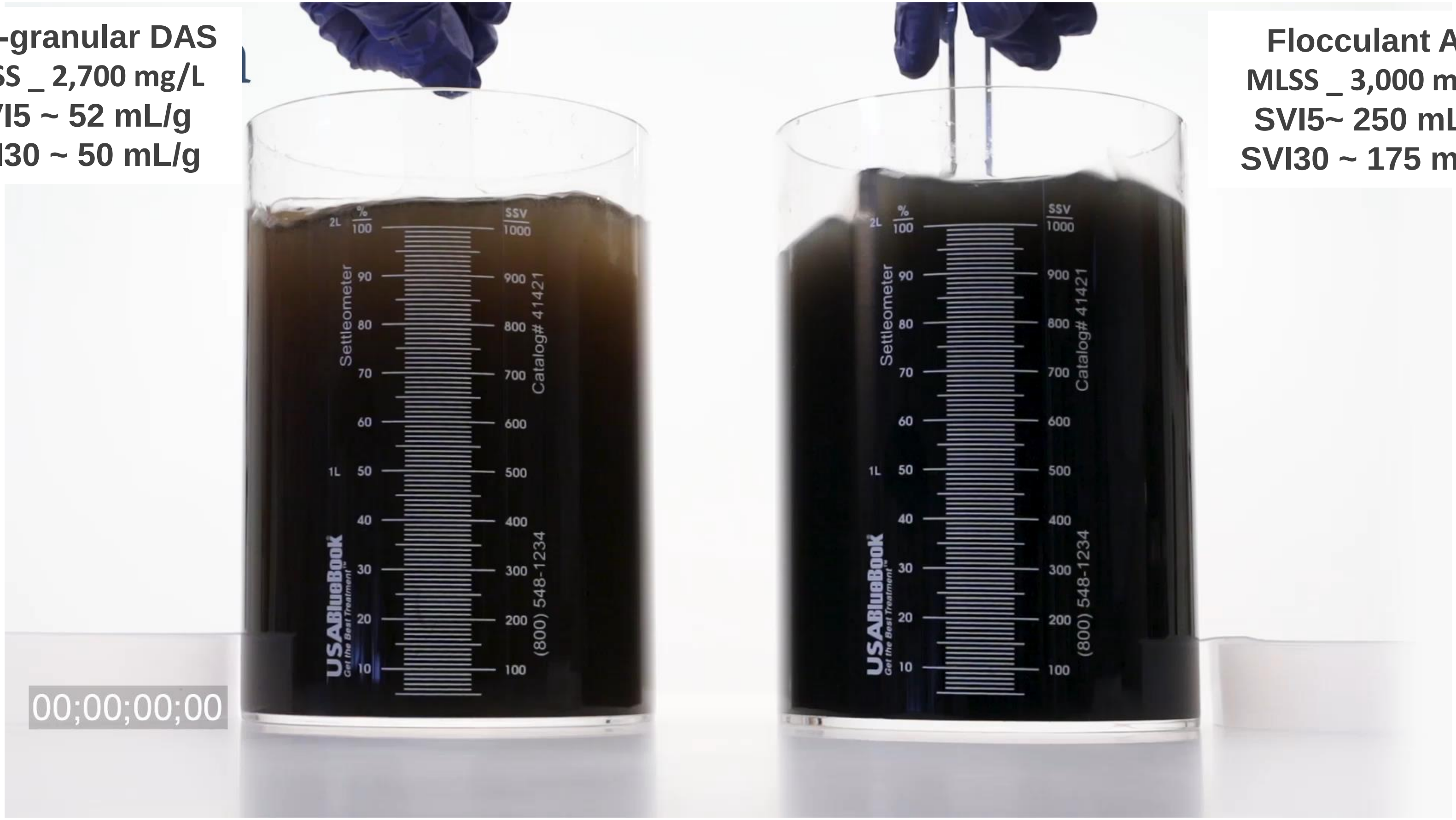
$SVI_{5} \sim SVI_{30}$

Particle size > 212 um

Effluent TSS ~ 8 to 15 mg/L

Non-granular DAS
MLSS _ 2,700 mg/L
SVI5 ~ 52 mL/g
SVI30 ~ 50 mL/g

Flocculant AS
MLSS _ 3,000 mg/L
SVI5~ 250 mL/g
SVI30 ~ 175 mL/g



What Are the Ingredients to Achieve Densified Activated Sludge (DAS)?

Promote Strong Feast Famine

Retain Dense Biomass

Washout of Slow Settling Biomass

Metabolic and Kinetic Selection

e.g., ANA selector, RAS conditioning zones, multi-compartment

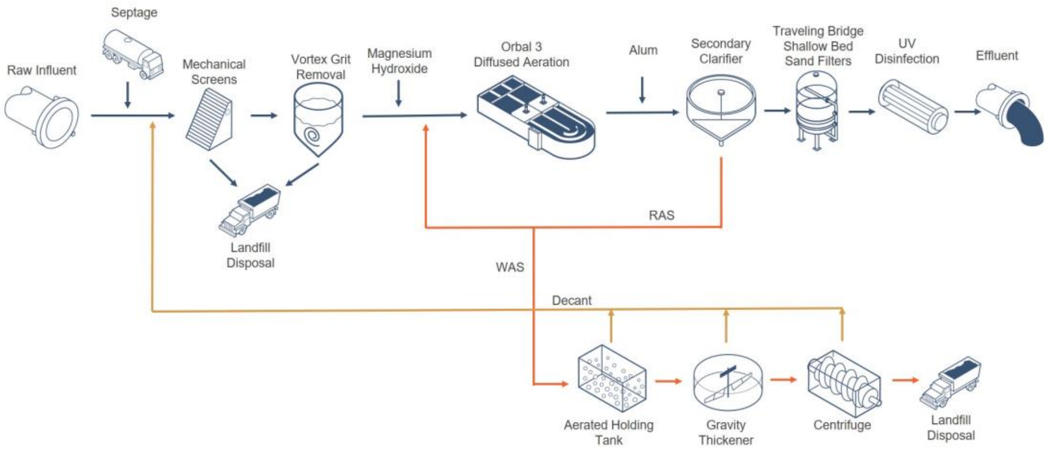
+

External (Physical) Selection

e.g., Surface wasting, hydrocyclones, screens

Lessons from DAS Facilities

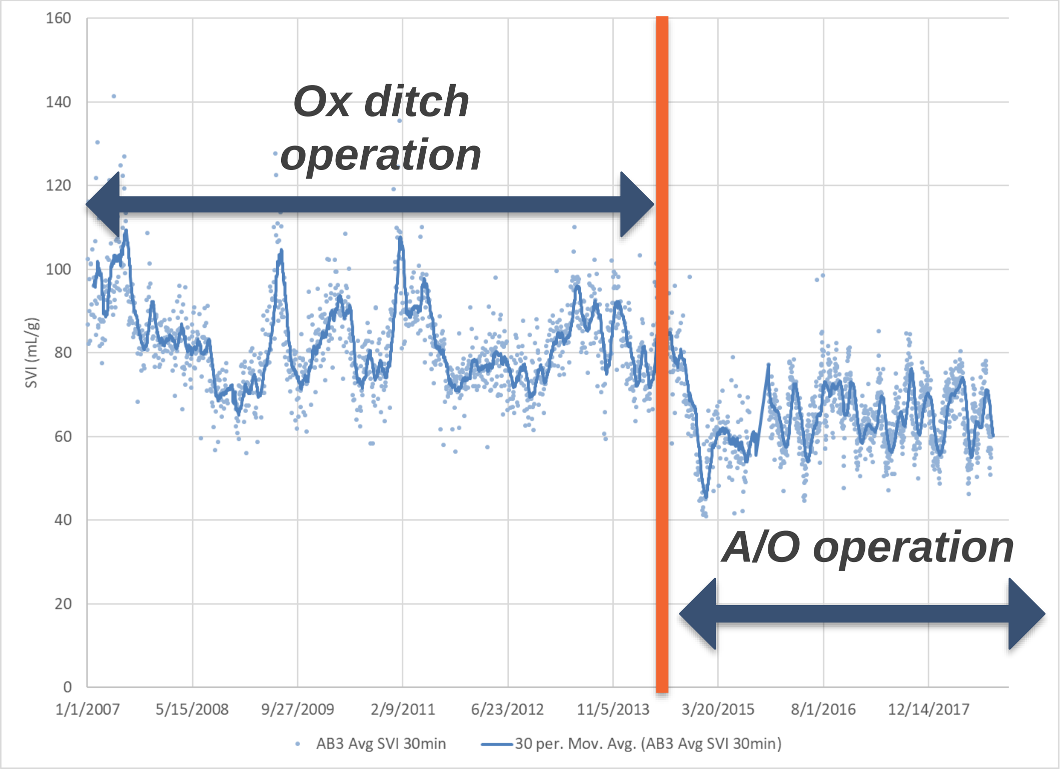
Plant A – Metabolic Selection In A/O Process



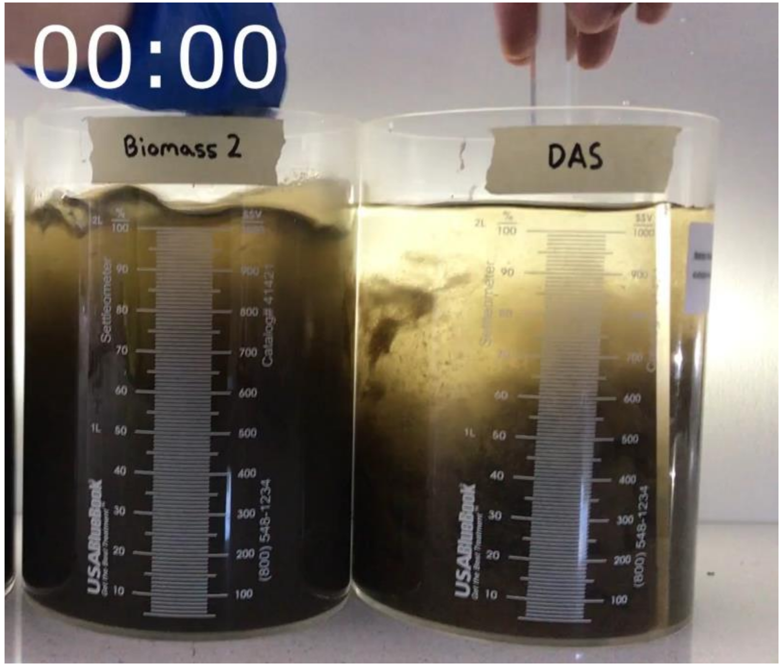
Hazen

Plant A Settling Improved Once Diffused Aeration Upgrade Completed

- 10 mgd MM capacity
- Operating at 7 mgd
- A/O process in Orbal retrofit with diffused aeration
- Current performance targets
  - *NH3-N < 1 mg/L*
  - *TP < 0.5 mg/L*



Plant A Biomass Settling Properties Approach Those Observed for Lab-Scale AGS

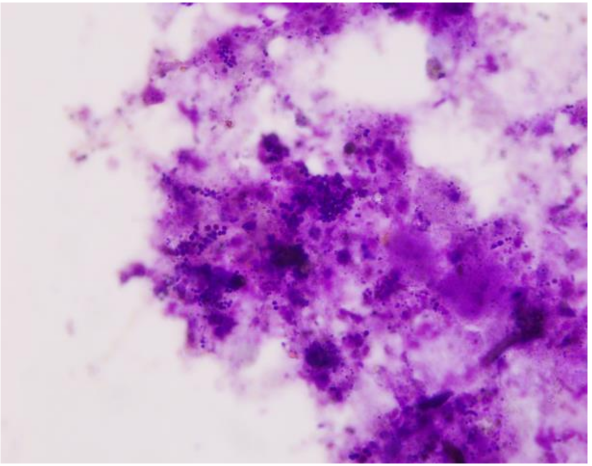
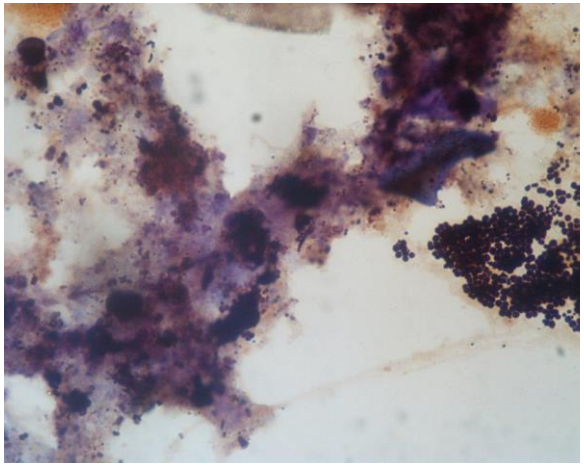


SVI5 ~ 75 mL/g
SVI30 ~ 64 mL/g

SVI5 ~ 58 mL/g
SVI30 ~ 45 mL/g

	Vo ft/hr	K L/g
Conventional Activated Sludge	30 to 38	0.4 to 0.8
Plant A DAS		

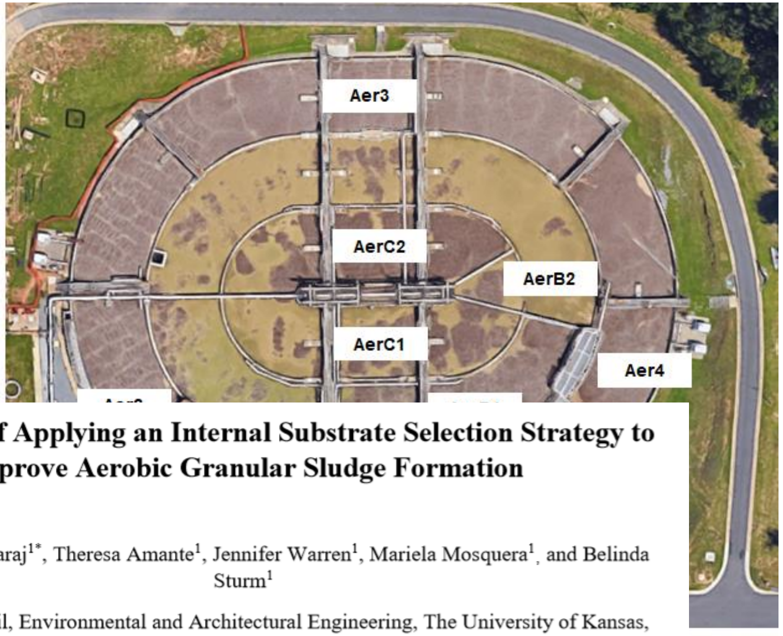
Plant A Biomass Distribution Indicates ~ 50% of Biomass > 212 um

- Strong PAO population observed
- Nocardioform type organisms also present

Influent and Recycle Characteristics

- Inf sCOD ~ 30% of influent tCOD
- Relatively high F/M experienced throughout anaerobic zone



The Impact of Applying an Internal Substrate Selection Strategy to Improve Aerobic Granular Sludge Formation

Authors: Rasha Faraj[1*], Theresa Amante[1], Jennifer Warren[1], Mariela Mosquera[1], and Belinda Sturm[1]

[1] Department of Civil, Environmental and Architectural Engineering, The University of Kansas, 1530 West 15th Street., Lawrence, KS 66045, USA
* Email: r410f839@ku.edu

Ana F/M > 0.2 g rbCOD/g VSS-day

What Might be Occurring at Plant A?

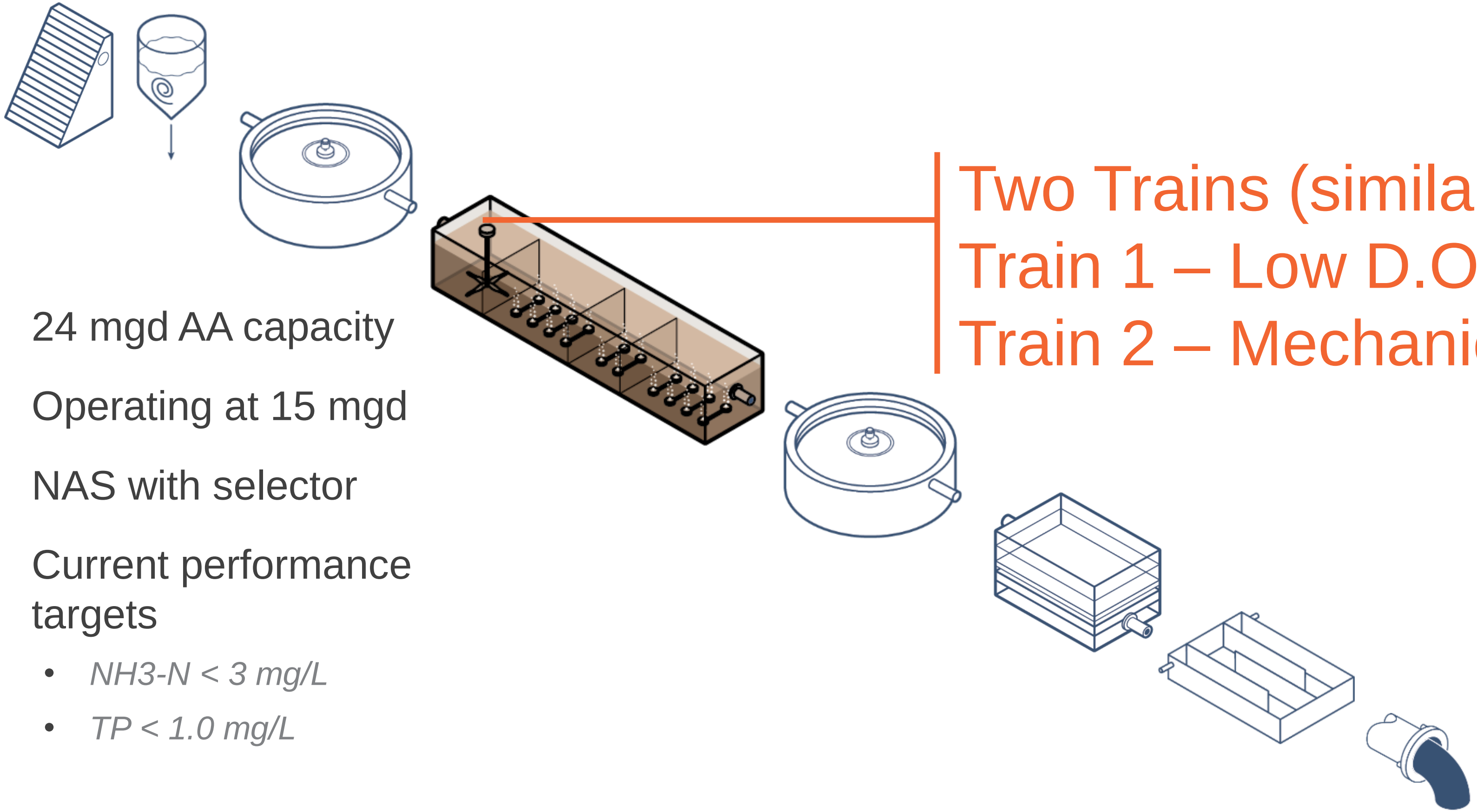
High organic loading due to favorable influent characteristics

Low NO_3-N in RAS results in minimal denite demand in Ana zones

Stratification of biomass in Ana zones may result in fermentation

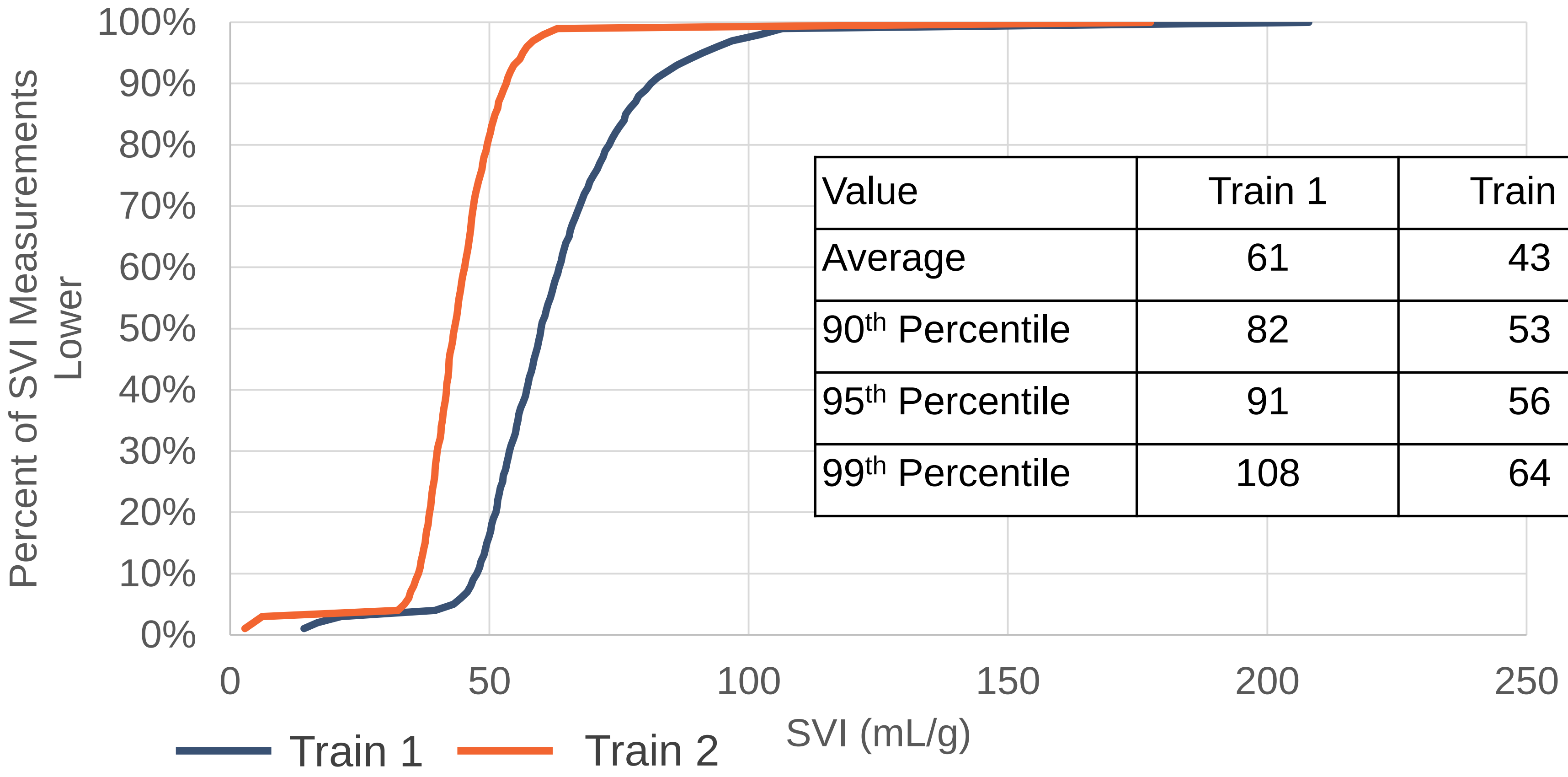
Plant C –
Nitrified Activated Sludge with Selector

Pant C Configuration



- 24 mgd AA capacity
- Operating at 15 mgd
- NAS with selector
- Current performance targets
  - *NH_3-N < 3 mg/L*
  - *TP < 1.0 mg/L*

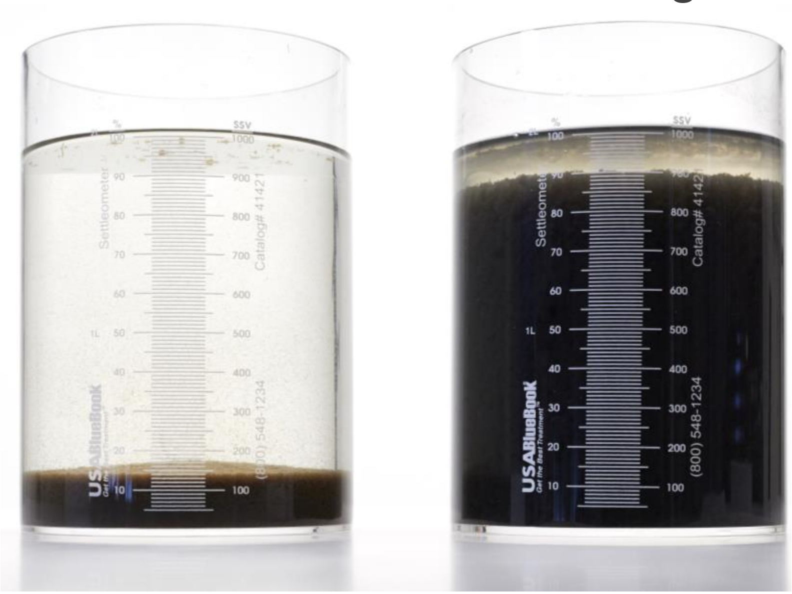
Historical SVI -Train 1 vs Train 2



Value	Train 1	Train 2
Average	61	43
90th Percentile	82	53
95th Percentile	91	56
99th Percentile	108	64

Train 1 and 2 Biomass Settling Properties

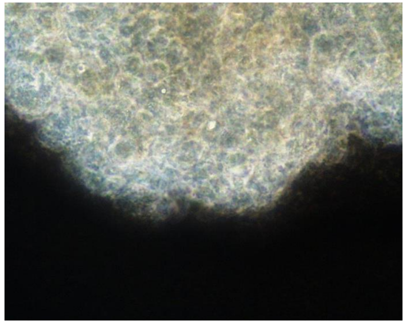
After 5 minutes of settling

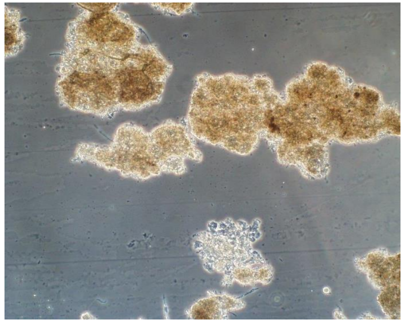


Plant C
Train 2

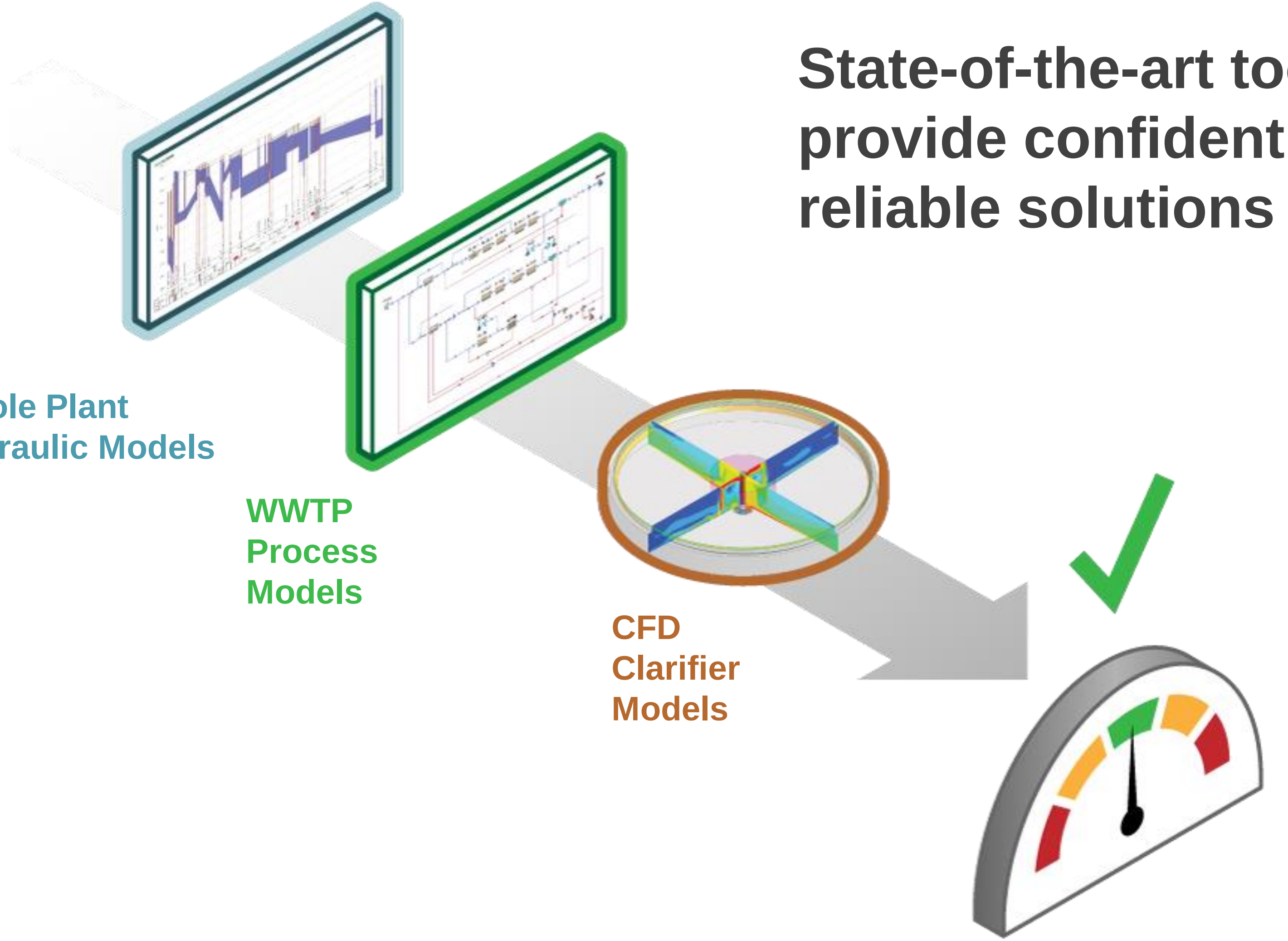
Conventional

	Vo ft/hr	K L/g
Conventional Activated Sludge	30 to 38	0.4 to 0.8
Plant A DAS		

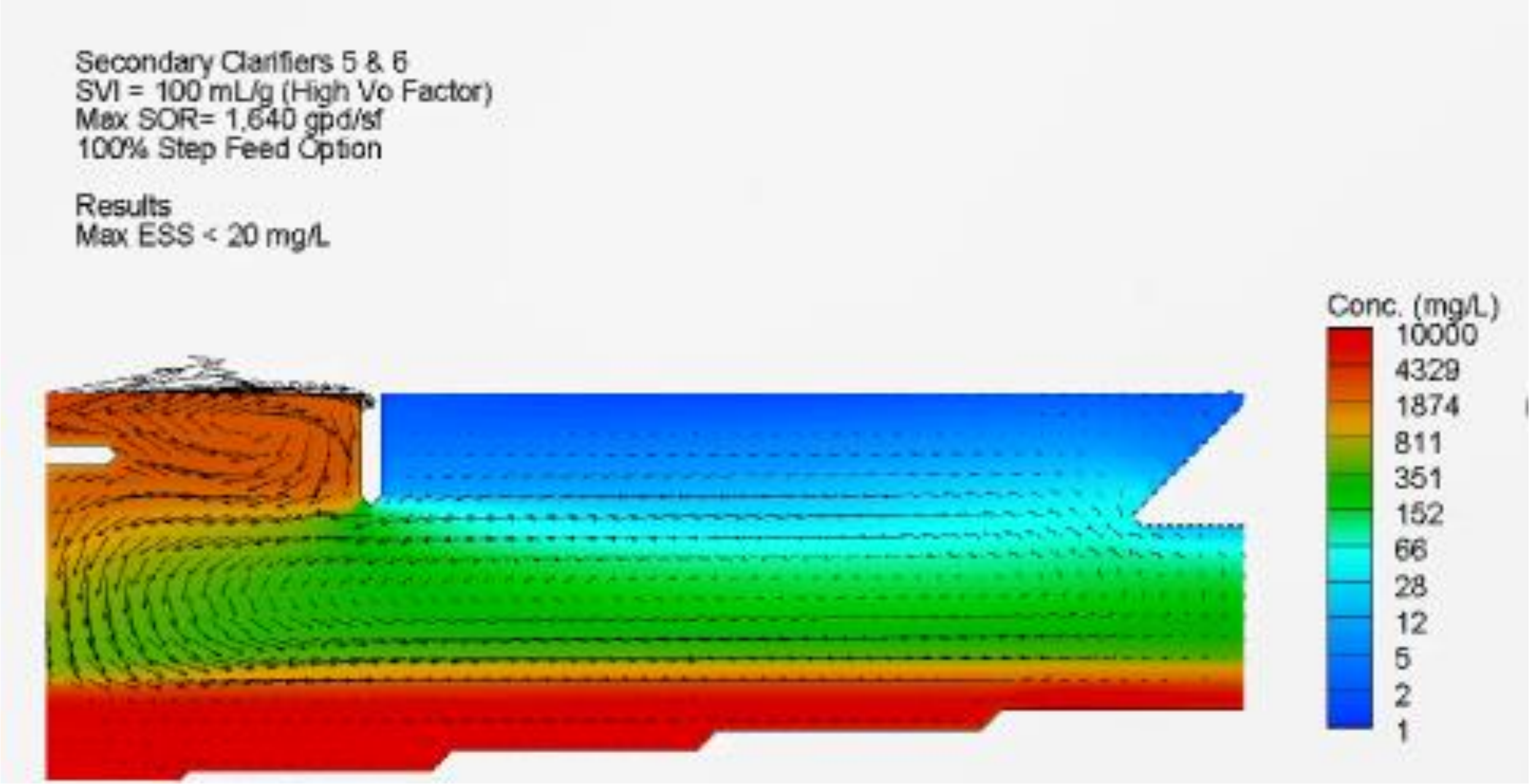




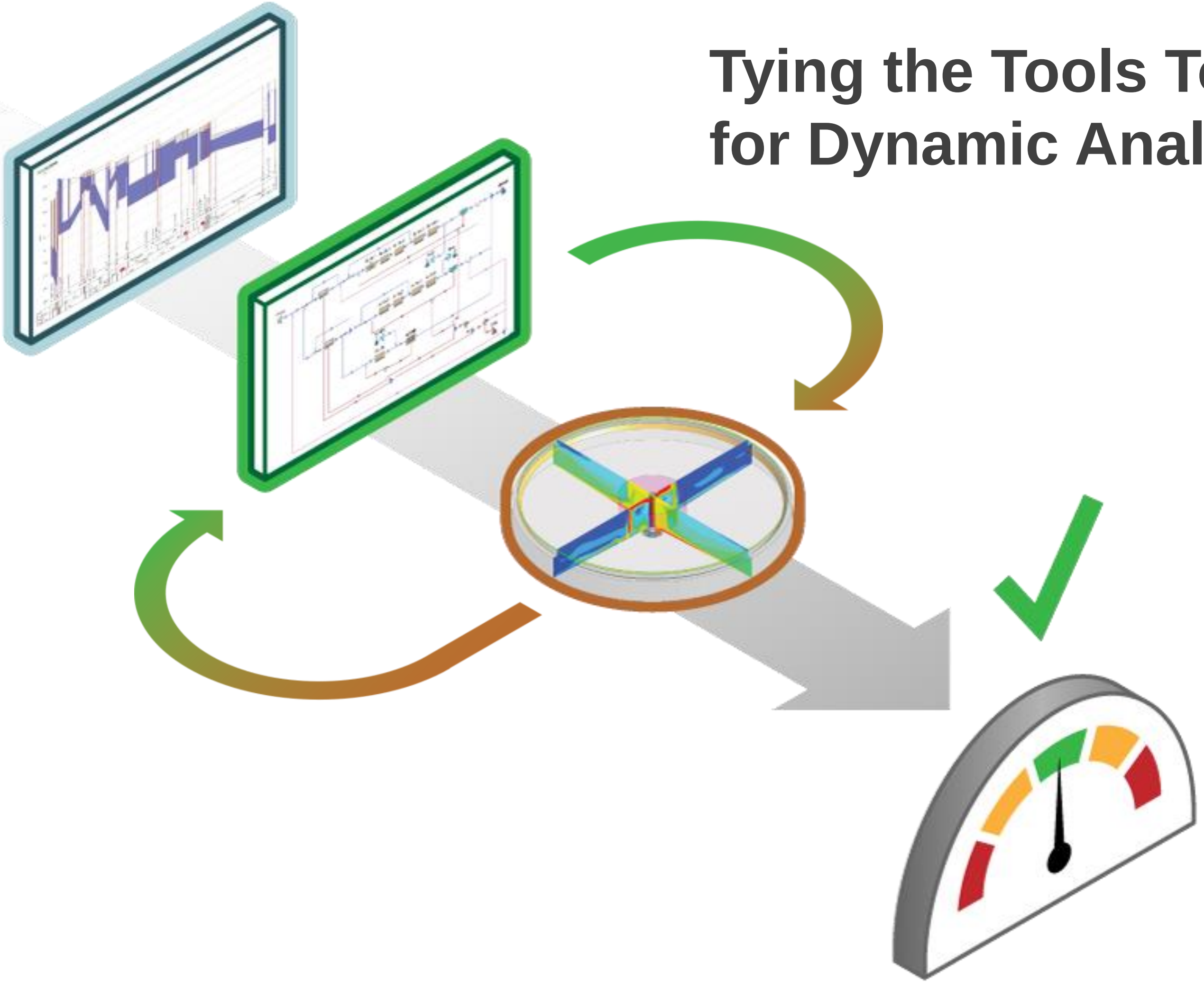
State-of-the-art tools provide confident and reliable solutions



Plant C Dynamic Clarifier Simulation



Tying the Tools Together for Dynamic Analysis



For Plant C analysis: Confidently increase process peak flow capacity by 40%

Plant C Peak Flow Capacity Alternatives

Base Case – MBR conversion

Alternative 1 – DAS configuration with step feed flexibility

Alternative 2 – Wet weather biological high rate treatment system

Cost Comparison

Alternatives	Capital Cost	20-Year O&M Present Value	Life Cycle Cost 20-Year NPV
Base Case: MBR Conversion	$80M	$60M	$140M
1: DAS with step feed flexibility	**$60M**	**$30M**	**$90M**
2: High rate wet weather treatment system	$70M	$35M	$105M

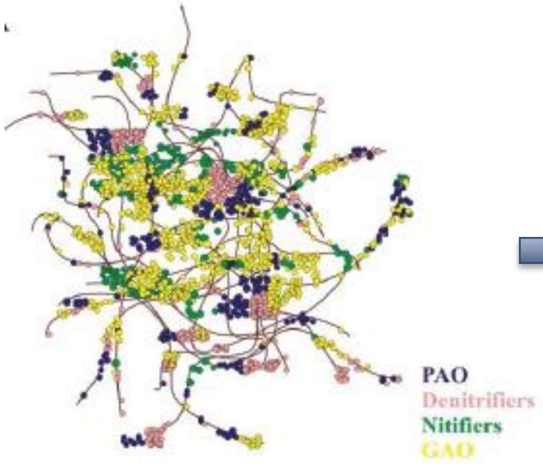
$20M savings

in liquid process improvements with recommended alternative

Concluding Thoughts

Hazen

DAS Is Key to Unlocking Capacity at WRRFs



Increase capacity

Reduce Footprint

Utilize Existing Assets

Reduce Energy

Reduce Chemicals

DAS Can Be Achieved in Continuous Flow Configurations

- Promote Strong Feast Famine
  - **Metabolic Selection might be sufficient to achieve non-granular DAS**
- Retain Dense Biomass
- Washout of Slow Settling Biomass
  - **Physical selection may be necessary for granule morphology** (applies to Retain Dense Biomass and Washout of Slow Settling Biomass)

Questions

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