Chat question for the week

What is one of your favorite fair foods?

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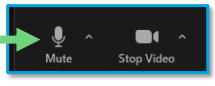
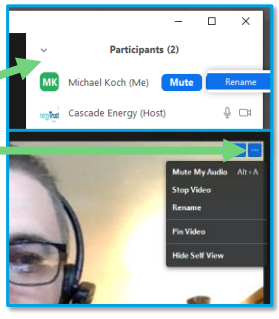
Using Zoom!

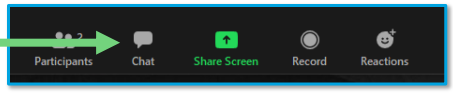
Mute yourself!
Have a question?
Use the chat feature.
Controls accessed at the bottom



Rename yourself
"Name (Company)"
Right click on your picture or 3 dots
OR
Controls accessed at the right after clicking 'Participants' at bottom.



Access Chat at the bottom



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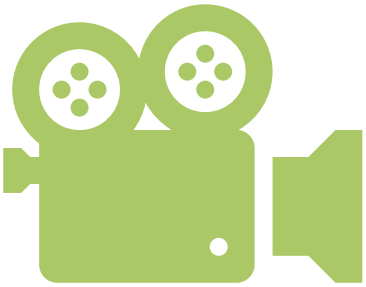
Recording

This meeting is being recorded (both audio and video)

If you do not consent to being recorded, please let the meeting moderator know ASAP and we will facilitate your participation in another way or adjust our procedure.



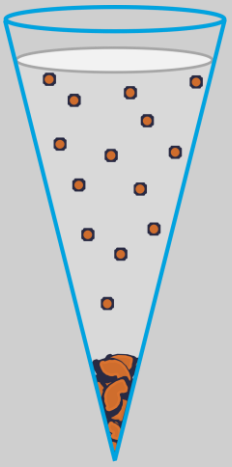
3

WASTEWATER VIRTUAL INPLT
SESSION 4

4

Chat question for the week

For those that did Imhoff cone tests on your primary effluent, what did you measure???



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Thank You!

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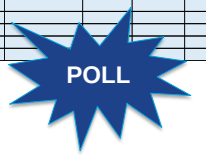
Report outs!

- Who wants to tell us about some energy saving opportunities that they have discovered?
- Have you begun to populate your opportunity register?

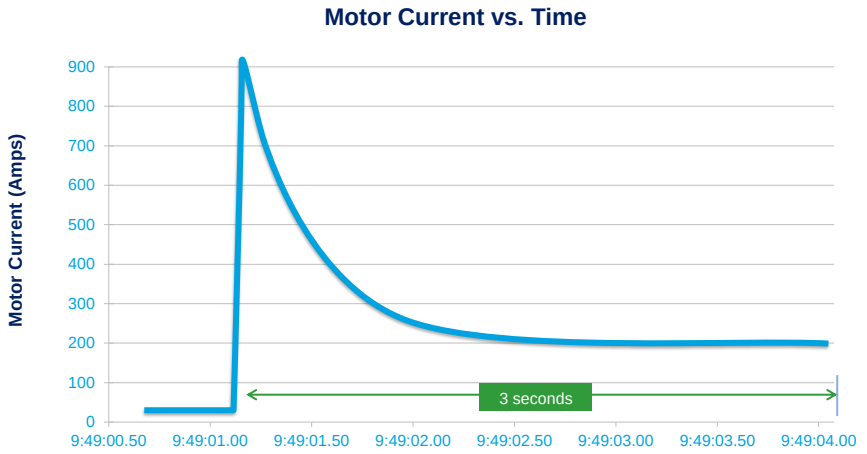
Energy Performance Improvement Action						Anticipated Reduction in Annual Energy Consumption (BEFORE Implementation)		
Action ID	Action Description	Project Initiation Date (MM/DD/YYYY)	Project Completion Date (MM/DD/YYYY)	Energy Type Impacted	Primary Energy Conversion Factor	Measurement Method	Annual Site (MMBtu/year)	Annual Primary (MMBtu/year)
Example 1	Install occupancy sensors and energy management controls	1/1/2020	2/1/2020	Electricity	3	Calculated	10,905.00	32,715.00
Example 2	Replace chilled water and process water pump motors with premium efficiency electric motors	1/1/2021	4/1/2021	Electricity	3	Calculated	12,591.00	37,773.00



Today's Agenda

Welcome and Introductions	Aeration Blower Opportunities
Plant Energy Basics	Estimating Potential Savings
Bacterial Energetics and Aeration	Kahoot
Break	Q&A

Motor Inrush Current — Concern or Not?



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Session 4
Bacterial Energetics and Aeration

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Four Requirements of Life to Live and Thrive

1	Carbon
2	Energy
3	Inorganic nutrients
4	Reducing power

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Heterotrophs Get Carbon and Energy From Organic Carbon (Like Us)

1	Carbon
2	Energy
3	Inorganic nutrients
4	Reducing power

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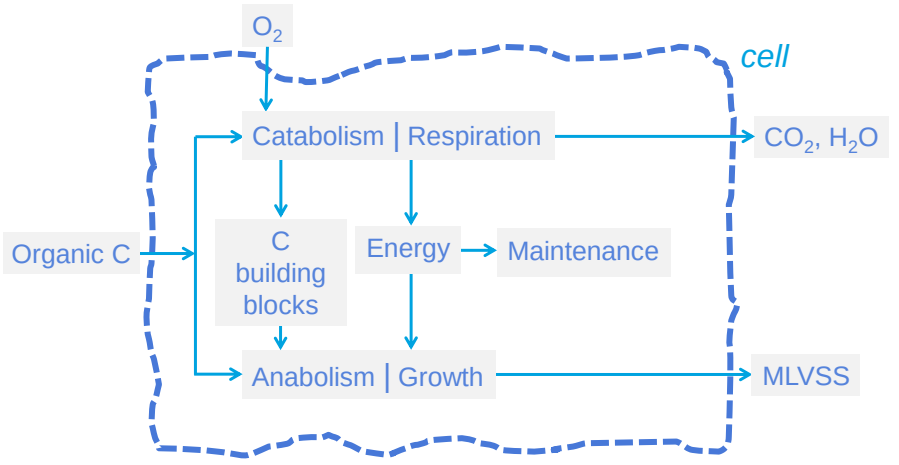
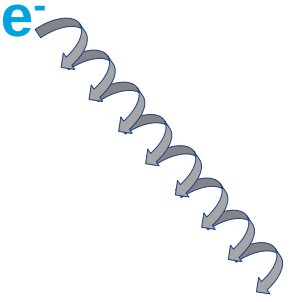
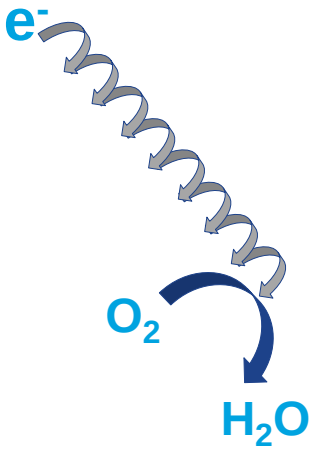
Heterotrophic Metabolism: Catabolism and Anabolism, Energy and Growth



Electron Transport Chains in Cell Membranes Extract Energy



O_2 Serves as the *Terminal Electron Acceptor* in Aerobic Respiration



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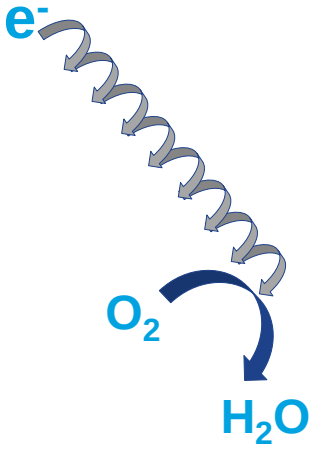
When an Atom Gains Electrons, it is Reduced



Oxygen is reduced

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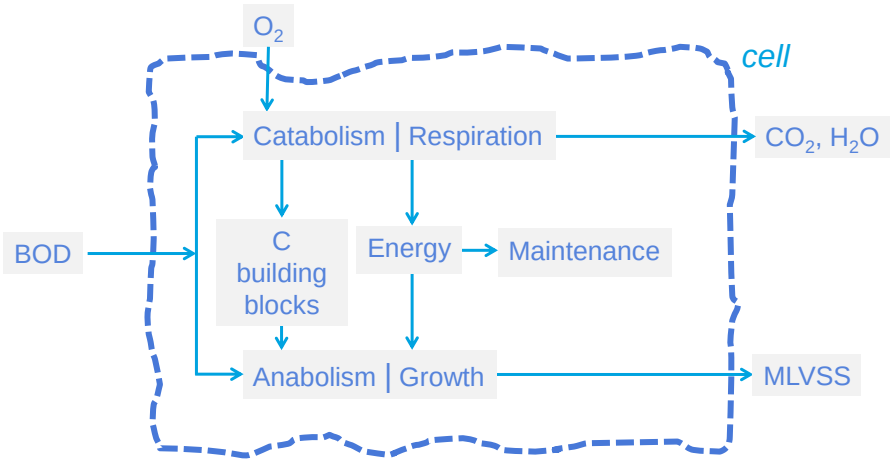
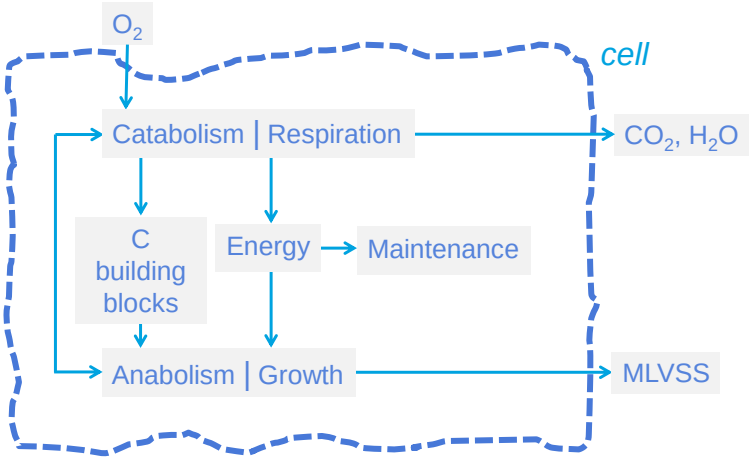
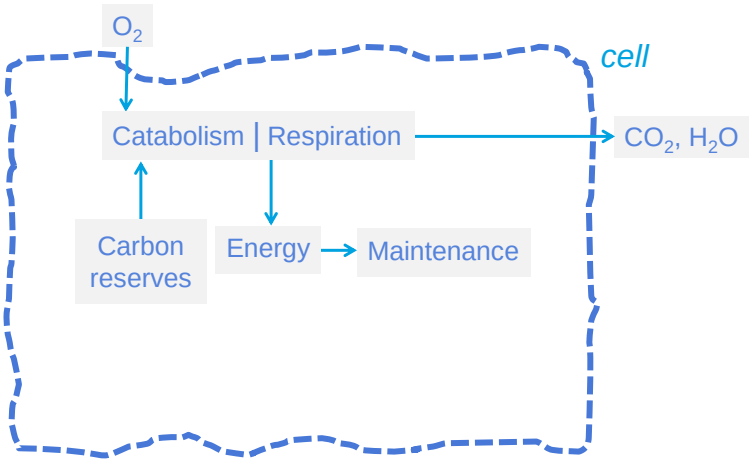
BOD Decreases Until Gone (That's the Goal) What Happens Then?



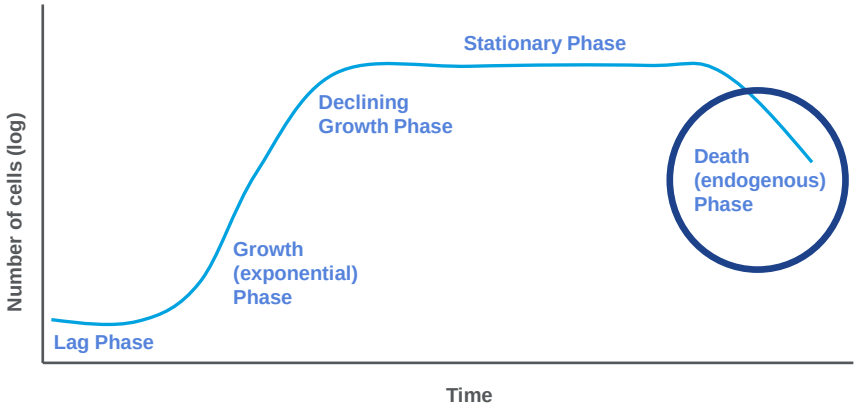
Anabolic Metabolism Shuts Down Energy Still Needed to Maintain Cell Integrity



Endogenous Respiration Begins When the Cell Starts Using its Own Carbon Reserves

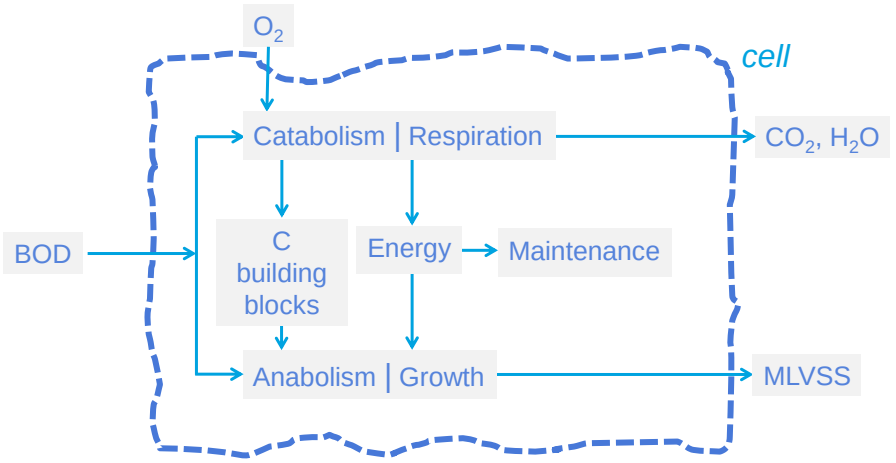


This Graphic is Wrong: Death and Endogenous are Not Synonymous



Bacterial Growth Curve from Auralene Glymph

When the BOD is Gone, the Biomass Goes Endogenous; it Does Not Die



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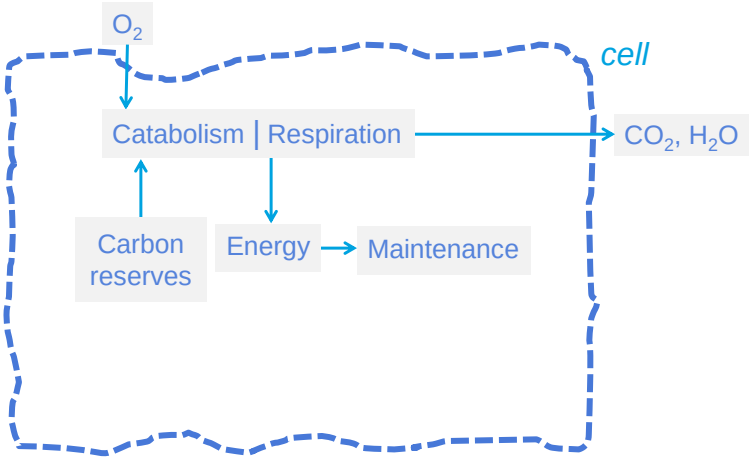
When the BOD is Gone, the Biomass Goes Endogenous; it Does Not Die



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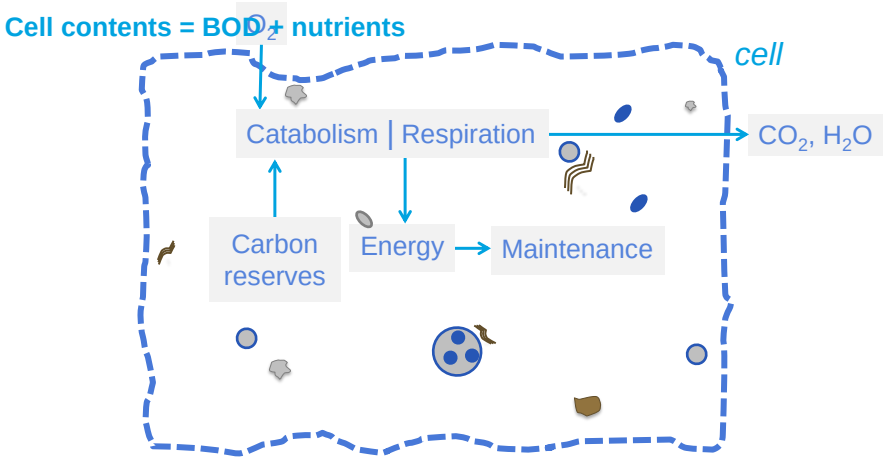
A Different Story When Carbon Reserves Run Out



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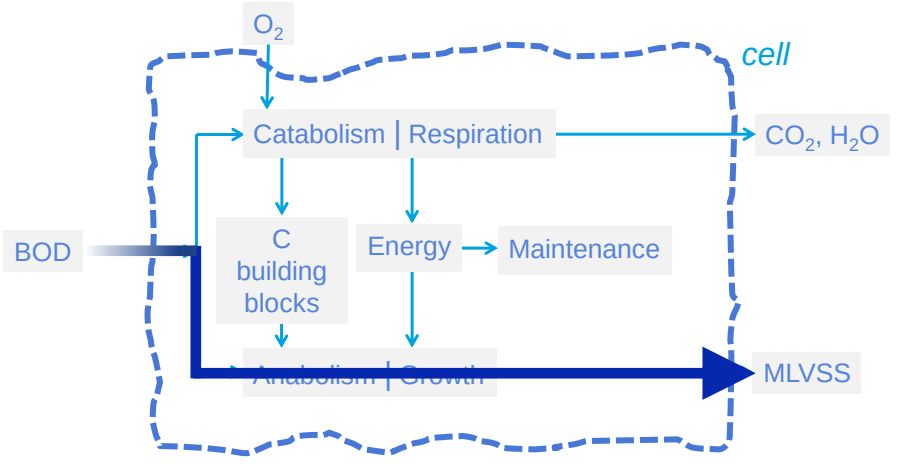
Yield: How Much Influent Organic C (BOD) is Converted to Organic C in New Cells (MLVSS)



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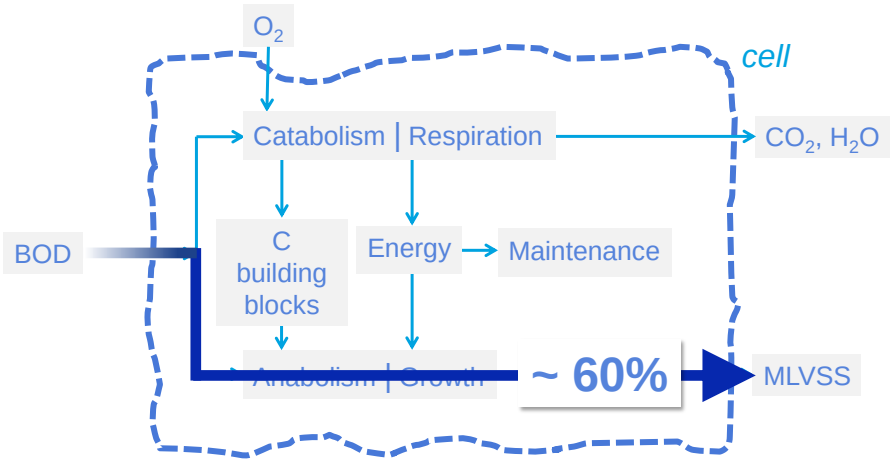
More Influent BOD is Converted to New Cells Than Oxidized for Energy (and respired)



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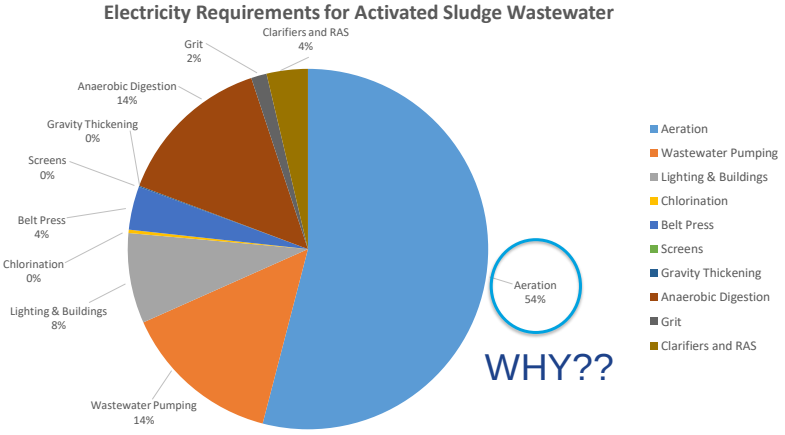
Plant Process Electricity Use Overview



Derived from data from Focus On Energy WWOA 49th Annual Conference, October 7, 2015 presentation by Joseph Cantwell, PE

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A Gallon of Milk…

Weighs ~8.34 lb

Has a BOD concentration of approximately 120,000 mg/L

How many pounds of BOD?

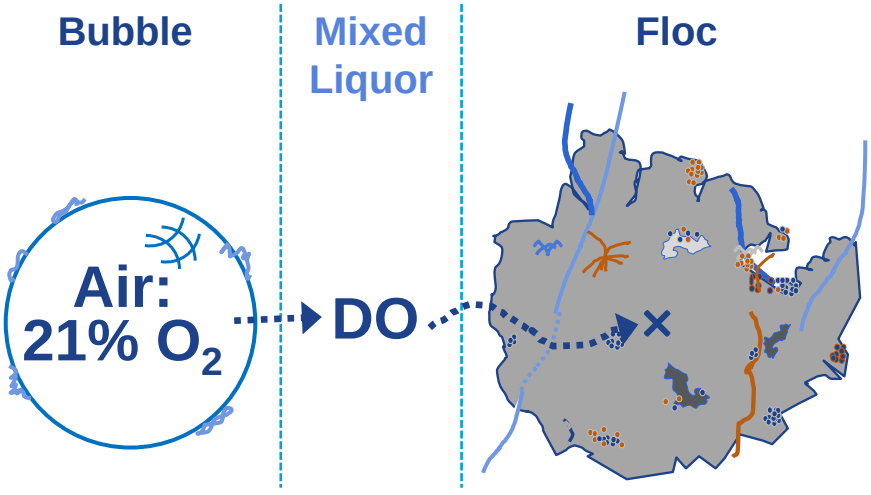
A Gallon of Milk = One Pound of BOD

What does that mean?

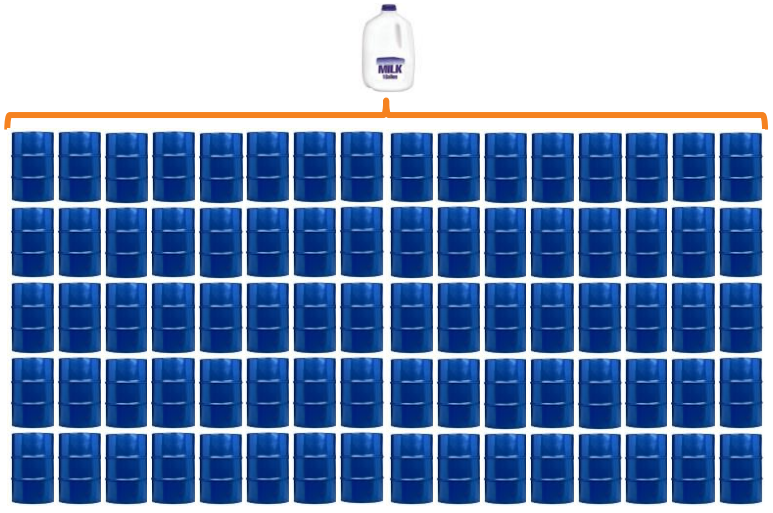
A Pound of Oxygen From the Atmosphere…

~Eight 55-gallon drums of air

The Reason so Much Aeration is Required. . . .



Eighty 55-Gallon Drums of Air



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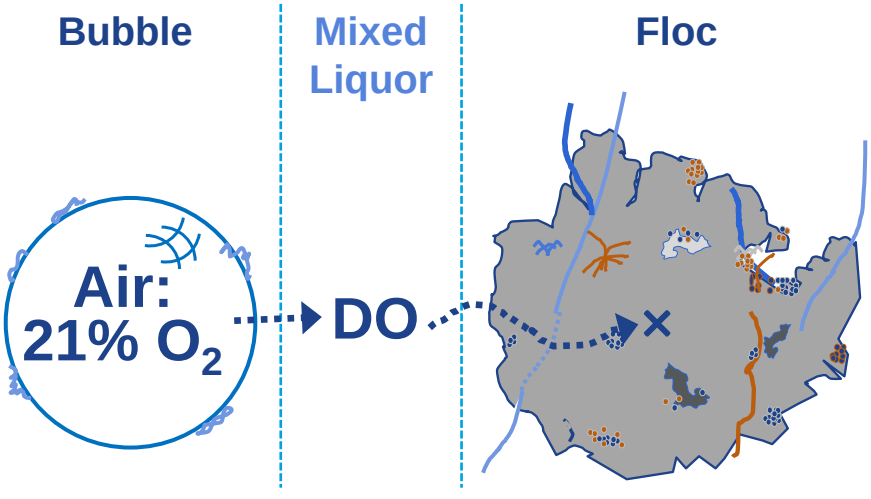
Mixed Liquor DO Concentration Must Be High Enough to Accomplish Two Things



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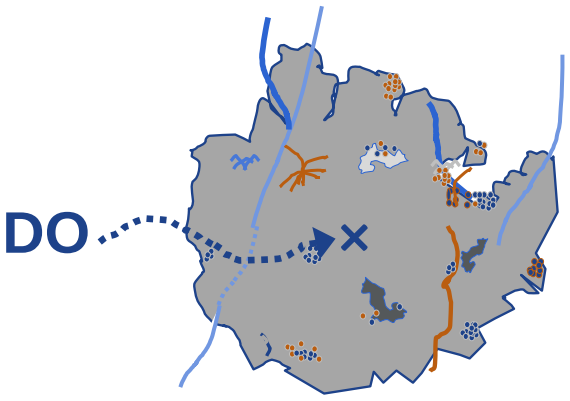
1. Must Provide Sufficient Gradient to Diffuse Oxygen Into Floc Center



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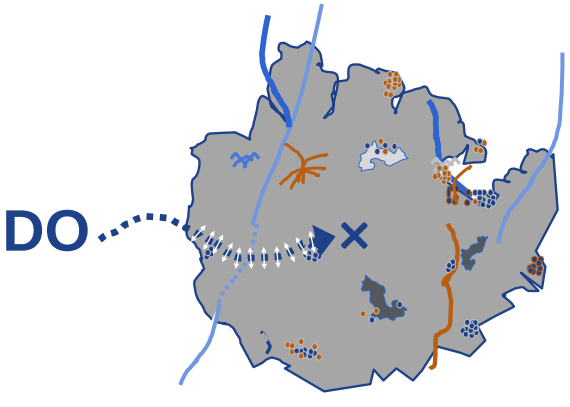
2. While Oxygen is Being Continuously Consumed for Aerobic Respiration

Oxygen Uptake Rate = OUR



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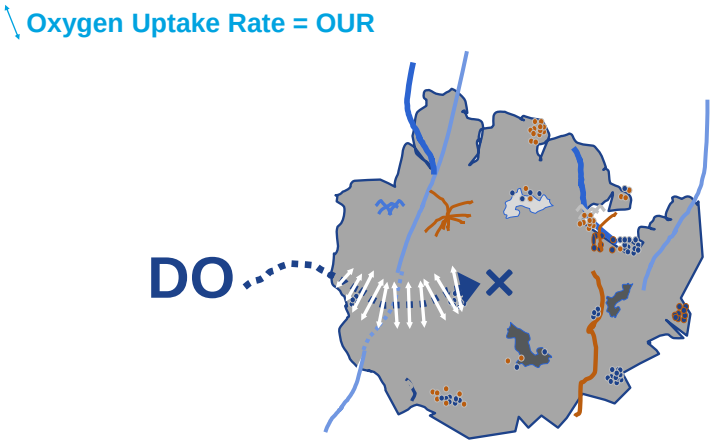
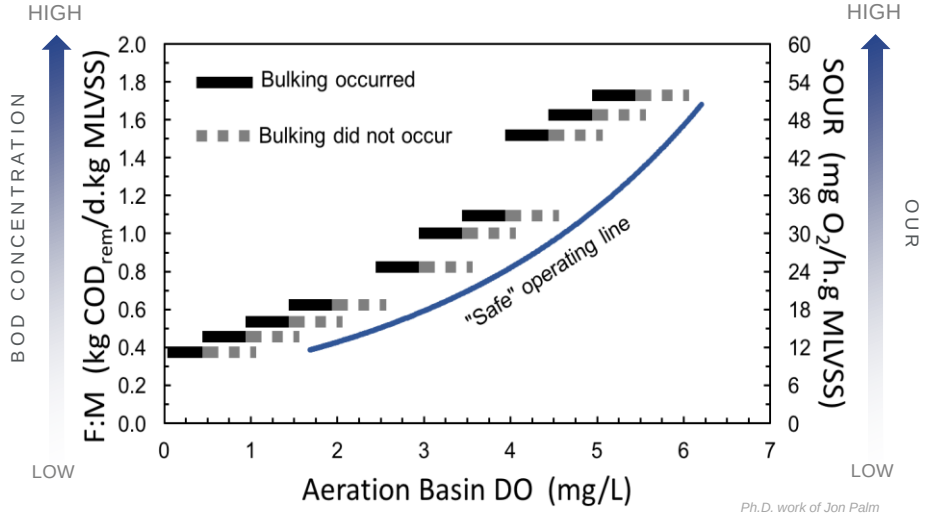
More BOD Results in Greater OUR, Requiring Higher DO Concentration in Mixed Liquor

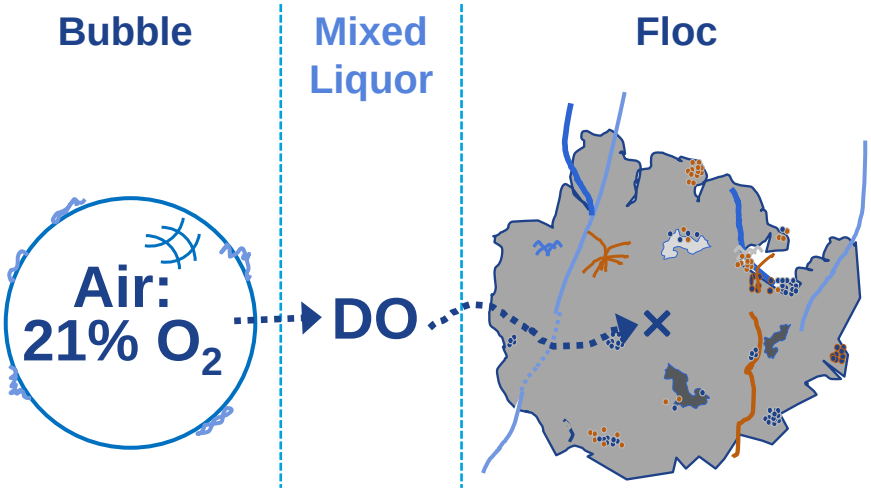


Jon Palm's Ph.D. Work: DO Set Point Depends On Organic Loading and OUR (here SOUR)



Ph.D. work of Jon Palm

Need High DO Where There's High BOD
Given Enough DO, BOD Goes Fast



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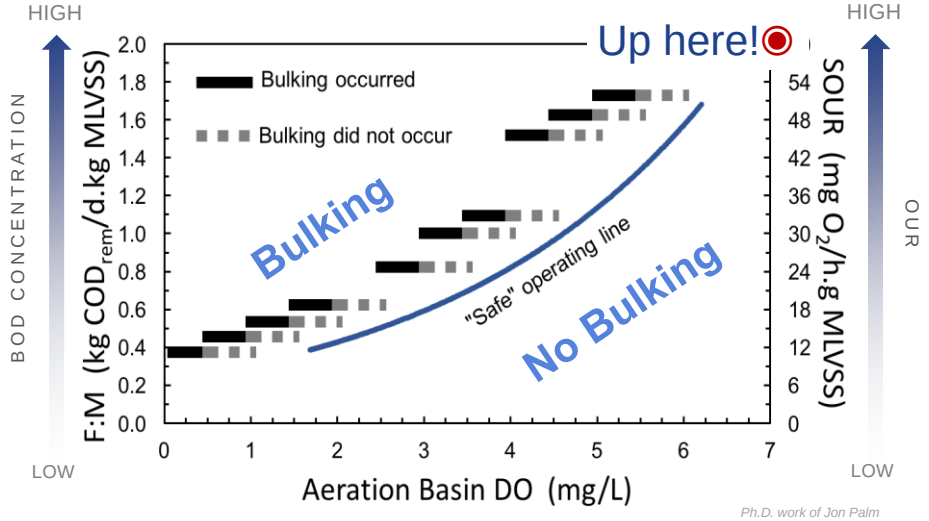
DO Requirement Greatest When Oxygen Uptake Rate is Highest (High BOD)



Ph.D. work of Jon Palm

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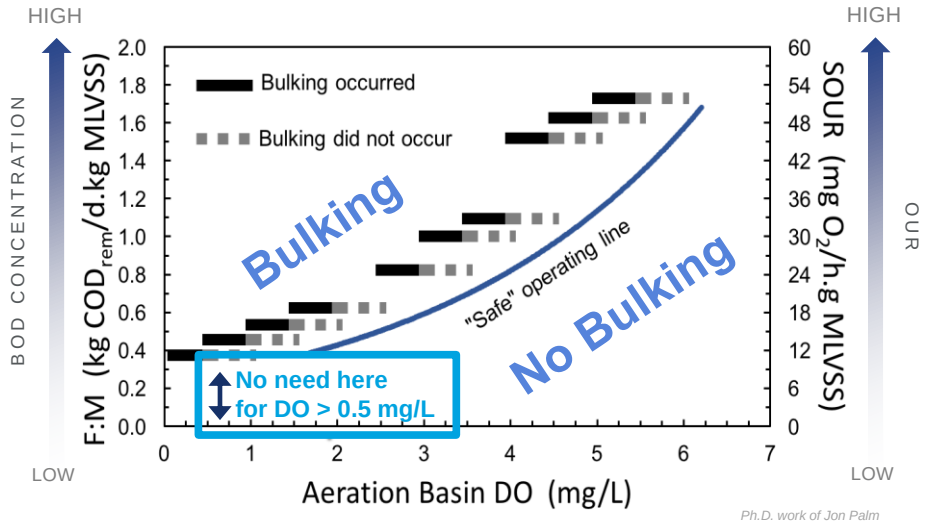
When BOD is Gone, DO Requirement Minimal—Potential for Huge Energy Savings



Ph.D. work of Jon Palm

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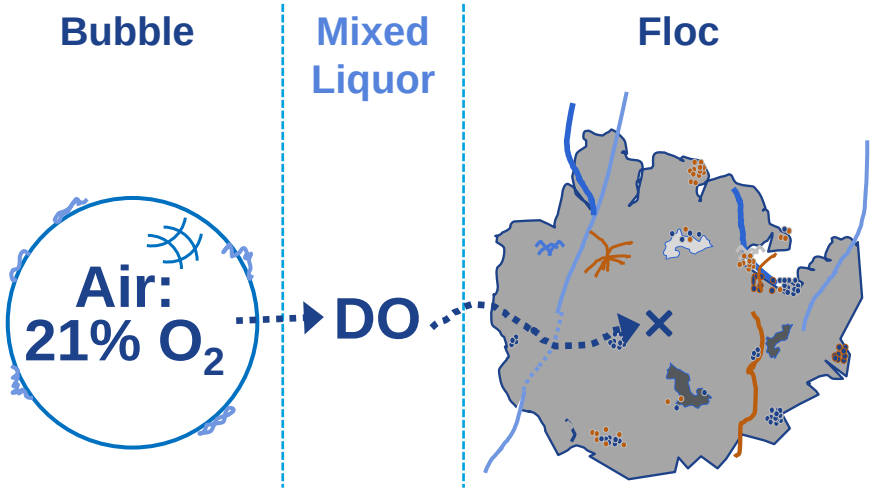
Another Problem With Inadequate DO: Small Floc Size



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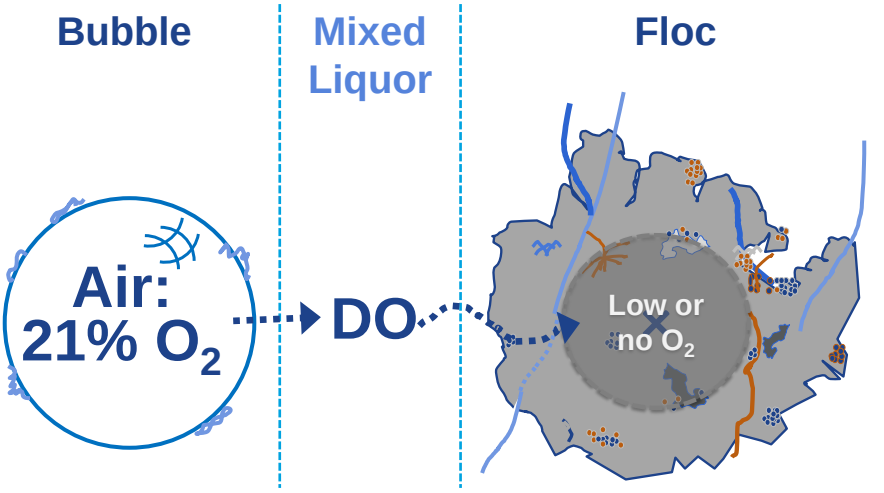
Insufficient DO to Drive Diffusion Results in Low/No DO in Center of Floc



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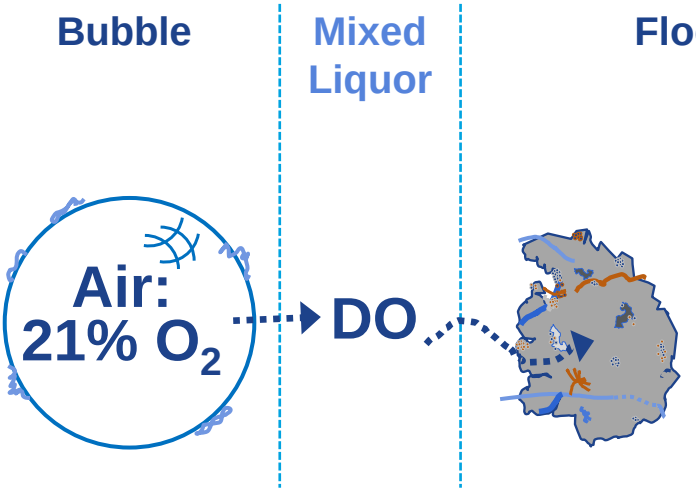
Small Floc Settle Slowly, If at All



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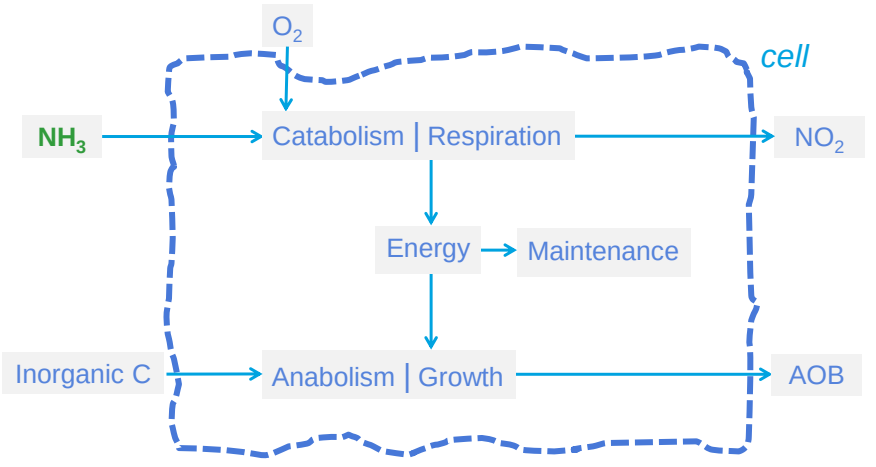
Nitrifiers are Autotrophs

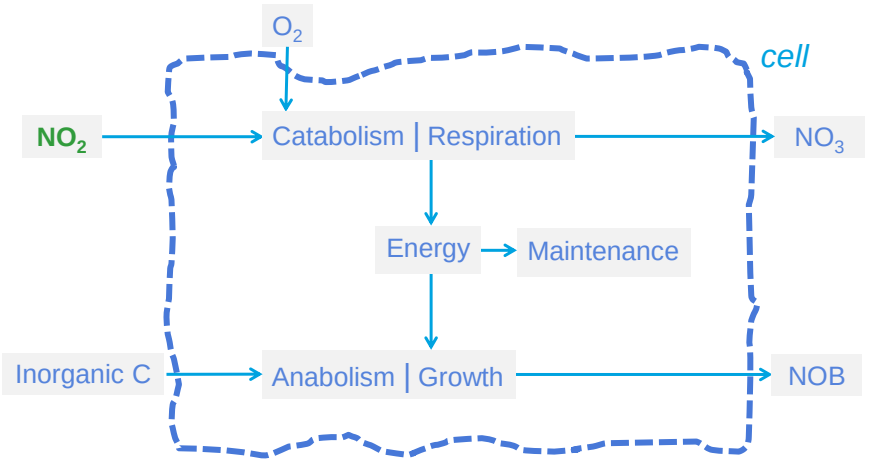
$$NH_4^+ \leftrightarrows H^+ + NH_3 \rightarrow NO_2^- \rightarrow NO_3^-$$

Ammonium Ammonia Nitrite Nitrate

Ammonia Oxidizing Bacteria (AOB)



Nitrite Oxidizing Bacteria (NOB)



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Total Oxygen Needed to Oxidize NH_4^+ to NO_2^- and NO_3^- Determined from Stoichiometry

For AOB

$$NH_4^+ + 1½O_2 \rightarrow NO_2^- + H_2O + 2H^+$$

[Every 1 lb NH_4-N requires 3.4 lb O_2]

For AOB + NOB

$$NH_4^+ + 2O_2 \rightarrow NO_3^- + H_2O + 2H^+$$

[Every 1 lb NH_4-N requires 4.6 lb O_2]

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Nitrification Proceeds as a "First-order Reaction" Two Hugely Important Consequences

$$NH_4^+ + 2O_2 \rightarrow NO_3^- + H_2O + 2H^+$$

1. **Oxygen uptake rate (OUR)**
   during nitrification is constant
2. **As a result of No. 1**
   High ammonia concentrations
   do not require high DO concentrations

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Nitrifiers are Strict Aerobes but Can't Compete When BOD Concentration is High

1. **Some inhibition**
   when DO is less than 1.5 mg/L
2. **Significant inhibition**
   when DO is less than 1.0 mg/L
3. **Complete inhibition**
   when DO is less than 0.5 mg/L
4. **Heterotrophs out-compete nitrifiers**
   for oxygen when the BOD concentration is high

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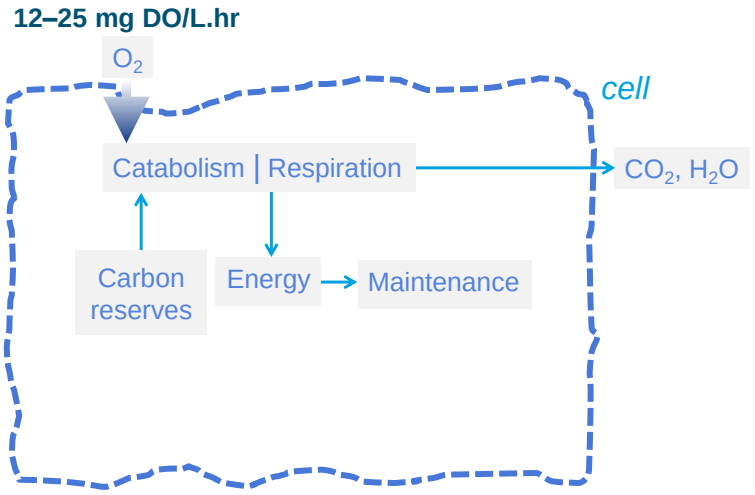
Endogenous OUR (when BOD and NH_3 are gone) is Relatively Constant and Measurable



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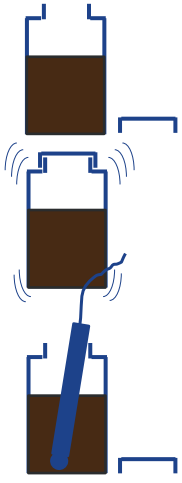
Simplified OUR Test Provides Tremendous Insight and Control



- Collect mixed liquor sample (~300 mL in 500-mL Nalgene)
- Cap and shake to aerate
- Insert DO probe
- Once DO is falling constantly, read DO as you start a stopwatch
- Read DO every 10 sec for 60 sec
- Plot DO (y-axis) as a function of seconds (x-axis) to make sure decrease is linear
- Calculate OUR, mg DO/L.hr, from slope

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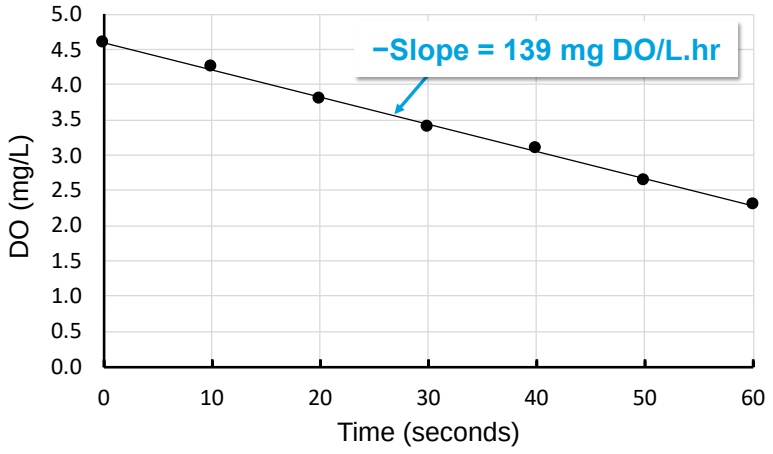
Results at the Beginning of an Aeration Basin



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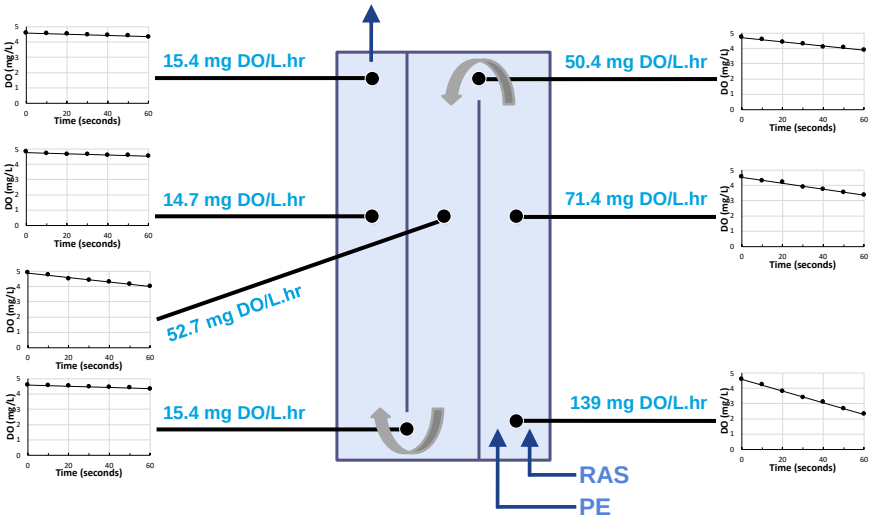
OUR Profile



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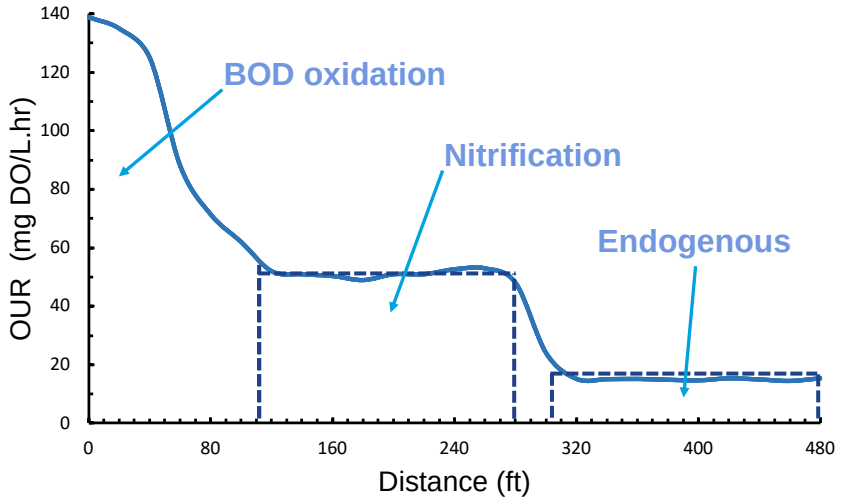
Subzones Delineated by OUR Profile



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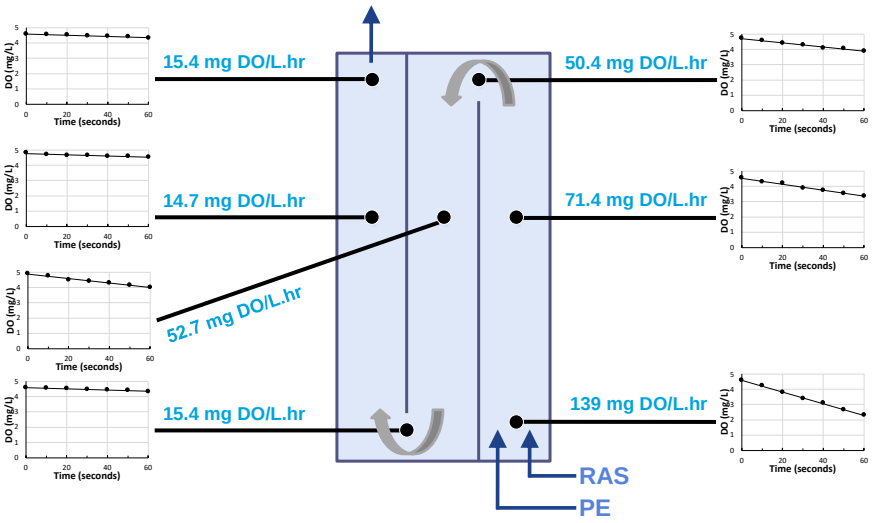
Subzones Identified



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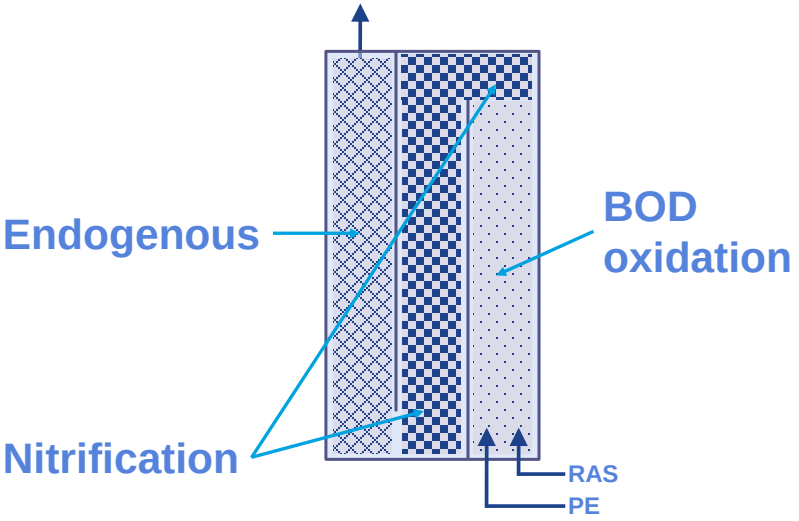
Subzones Identified



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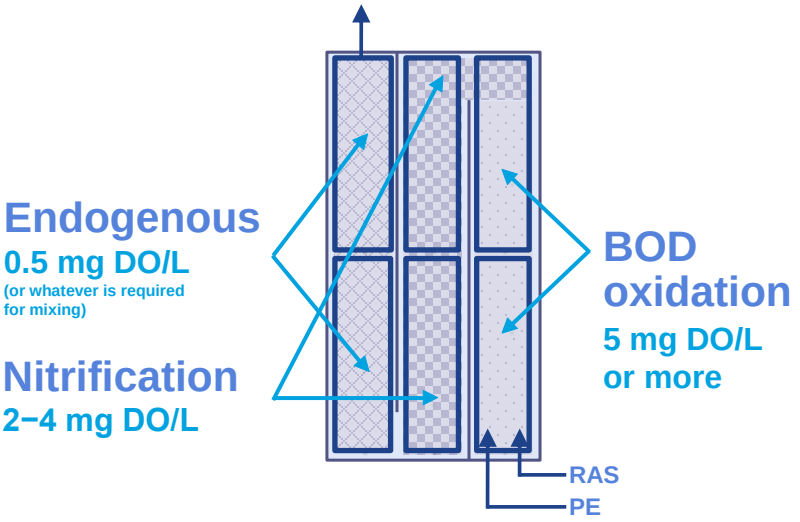
Different Subzones Have Different DO Set-Point Requirements



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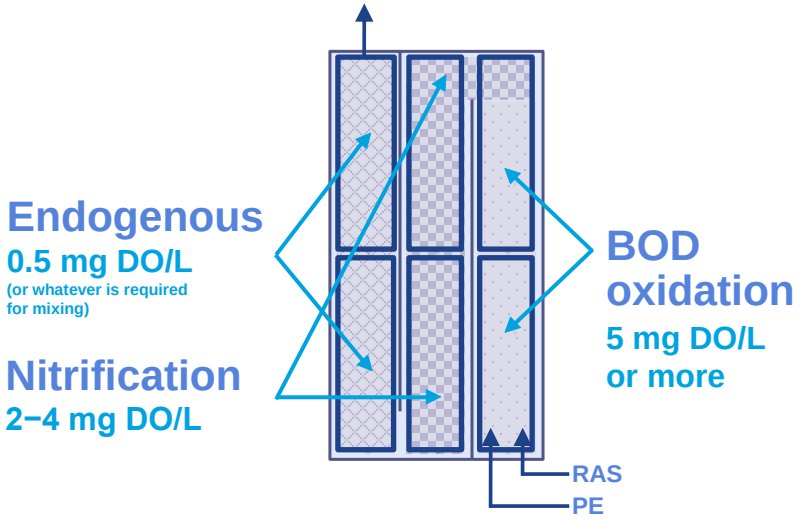
Recommendation of 2.0 mg DO/L Throughout Not Enough Sometimes, Way Too Much Others



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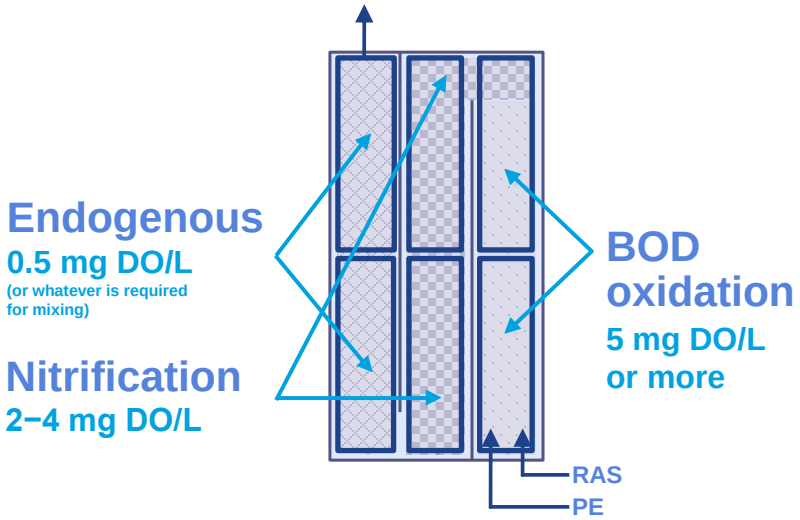
Depending on Size of Endogenous Subzone, Huge Potential for Energy Savings



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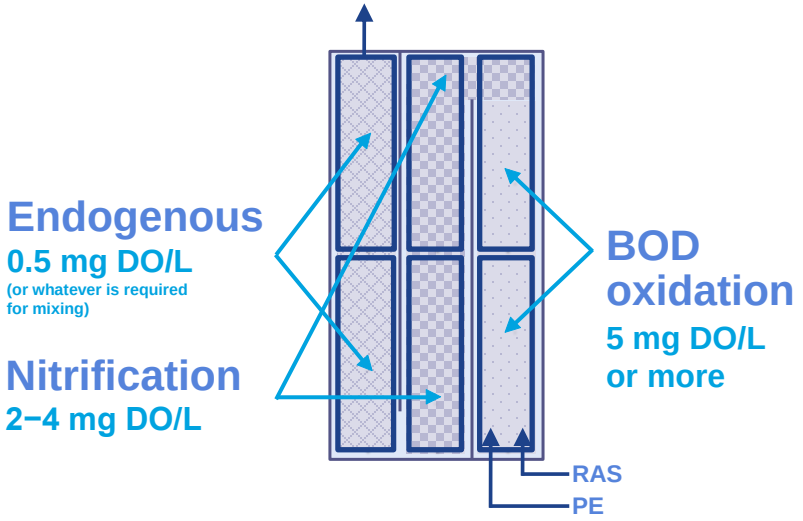
TAKEAWAY: Process Knowledge Takes Guesswork Out of Setting DO Targets



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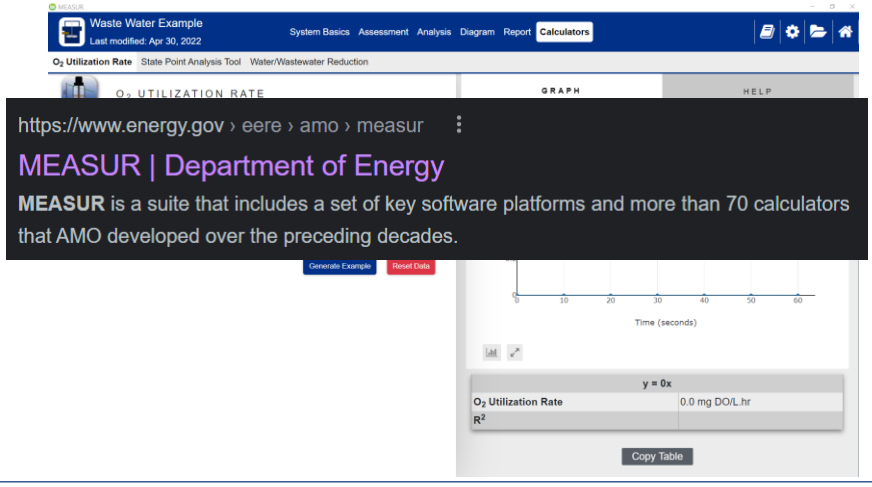
Homework - OUR Example & MEASUR



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Break

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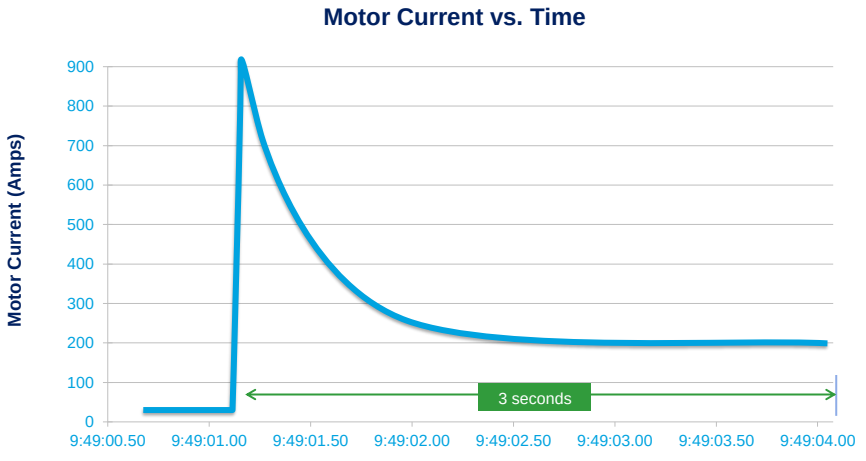
Motor Inrush Current — Concern or Not?



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Aeration/Secondary Treatment

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Coarse Bubble Aeration

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Aeration

Fine bubble diffused aeration High efficiency, moderate maintenance

Mechanical aeration Low efficiency, high maintenance

Jet aeration* High aeration efficiency, low-to-moderate maintenance

*(The pump accounts for 25 to 40 percent of the power used in a jet aeration system.)

Coarse bubble diffused aeration Low efficiency, low maintenance

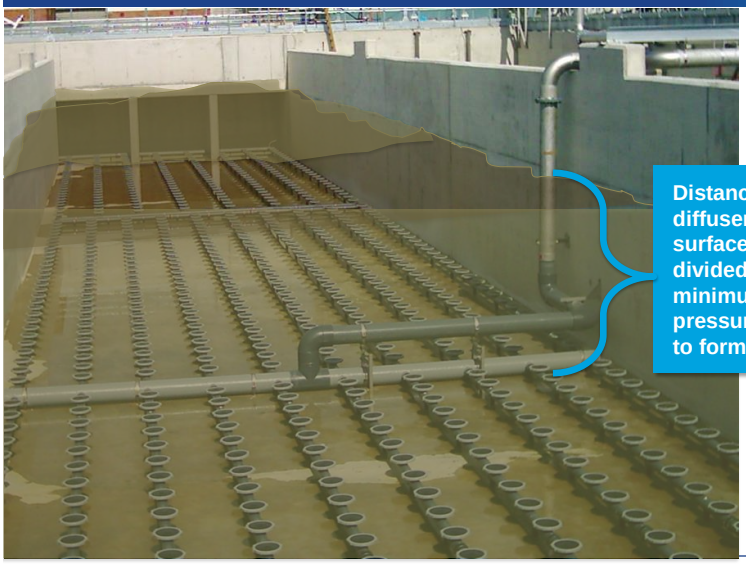
Aeration → *Priorities!*

1. **Satisfy the process need** (BOD conversion).
2. **Minimize the residual.**
3. ~~**Keep solids in suspension**.~~

***Avoid** if you can!*

This is what mixers are for!

Header Pressure



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Aeration Energy Savings

IMPACT OF AVERAGE DO LEVEL ON BLOWER ENERGY						
Mixed liquor temp		DO sat	Energy savings potential if DO reduced from __ to 2.0 mg/l			
°C	°F	mg/l	2.5	3	4	5
0	32	14.6	4.0%	7.9%	15.9%	23.8%
2	36	13.8	4.2%	8.5%	16.9%	25.4%
5	41	12.8	4.6%	9.3%	18.5%	27.8%
10	50	11.3	5.4%	10.8%	21.5%	32.3%
15	59	10.1	6.2%	12.3%	24.7%	37.0%
20	68	9.1	7.0%	14.1%	28.2%	42.3%
25	77	8.2	8.1%	16.1%	32.3%	48.4%
NOTE Higher impact as elevation increases						

(Assumes 70% motor load & 92% motor/drive eff.)

For every 0.5 mg/l reduction in DO setpoint ~ 6% blower energy savings

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Exercise - Aeration Pressure

3 IMPACT OF BLOWER PRESSURE ON ENERGY

Disch. pressure	Reduction in pressure of ___ psig				
	-0.2	-0.4	-0.6	-0.8	-1.0
12	1.3%	2.7%	4.0%	5.4%	6.7%
11	1.5%	2.9%	4.4%	5.9%	7.4%
10	1.6%	3.3%	4.9%	6.6%	8.3%
9	1.8%	3.7%	5.5%	7.4%	9.3%
8	2.1%	4.2%	6.3%	8.4%	10.6%
7	2.4%	4.8%	7.3%	9.7%	12.2%

(Assumes 70% motor load & 92% motor/drive eff.)

DO Residual Aeration Impact

2 IMPACT OF DO LEVELS ON ENERGY

Saturated DO
DO in basin = driving force for oxygen transfer
Driving force UP means Energy goes DOWN

DO rule of thumb
0.5 mg/l reduction creates ~ 6% energy savings

DO calibration & cleaning
A probe that reads 10% low (e.g. 2.0 when actual is 2.2) is costing you 2.4% at the blower.

DO level increases
As mixed liquor temp increases, the impact of elevated DO levels increases.

IMPACT OF AVERAGE DO LEVEL ON BLOWER ENERGY

Mixed liquor temp		DO sat	Energy savings potential if DO reduced from __ to 2.0 mg/l			
°C	°F	mg/l	2.5	3	4	5
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2	36	13.8	4.2%	8.5%	16.9%	25.4%
5	41	12.8	4.6%	9.3%	18.5%	27.8%
10	50	11.3	5.4%	10.8%	21.5%	32.3%
15	59	10.1	6.2%	12.3%	24.7%	37.0%
20	68	9.1	7.0%	14.1%	28.2%	42.3%
25	77	8.2	8.1%	16.1%	32.3%	48.4%

NOTE Higher impact as elevation increases

Opportunity Register Thoughts?

Opportunity #	Opportunity Name	Description	Location	System*	Submitted By

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Closing

See You Next Tuesday!

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