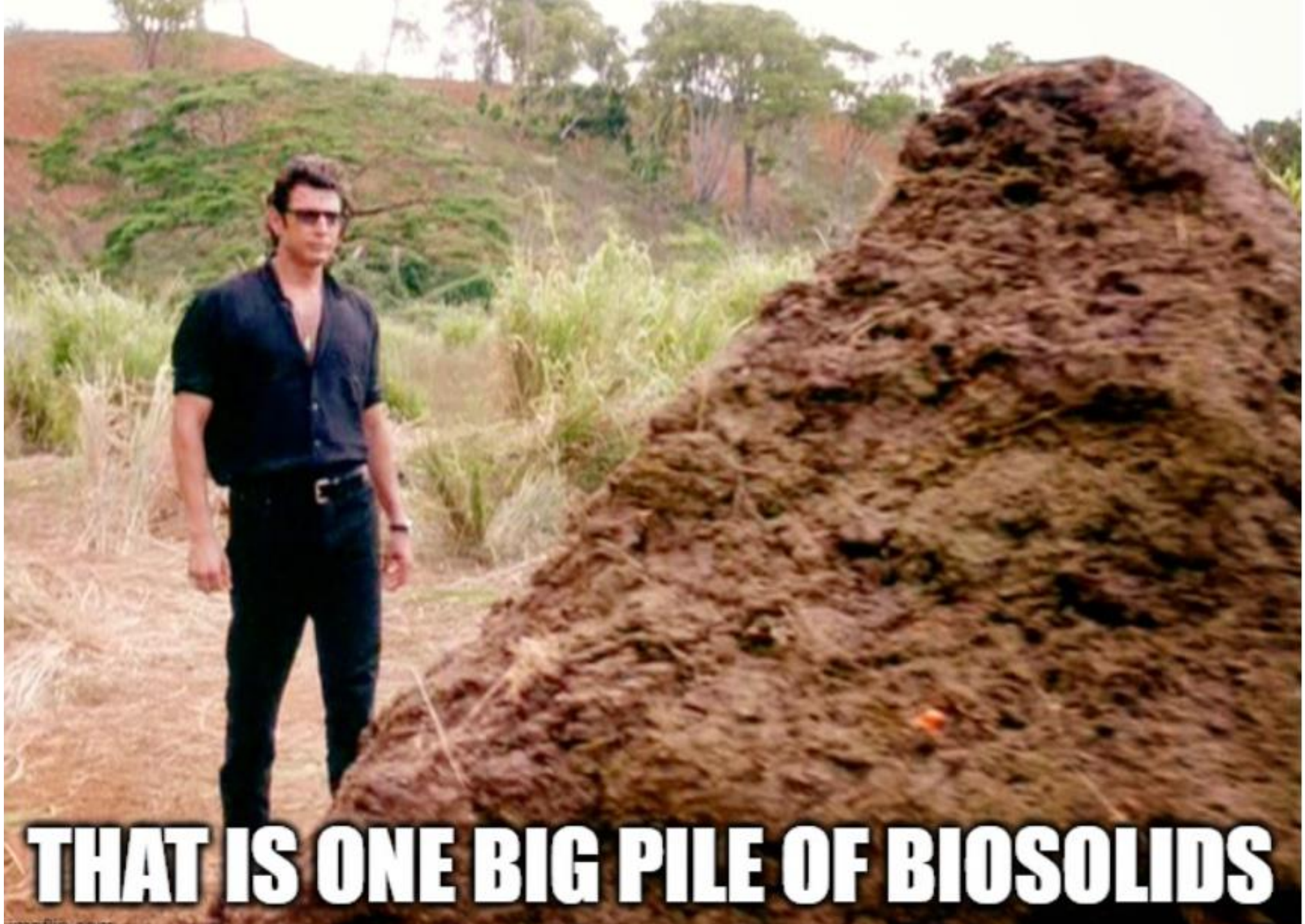

THAT IS ONE BIG PILE OF BIOSOLIDS

A Solid Case for Solids Management

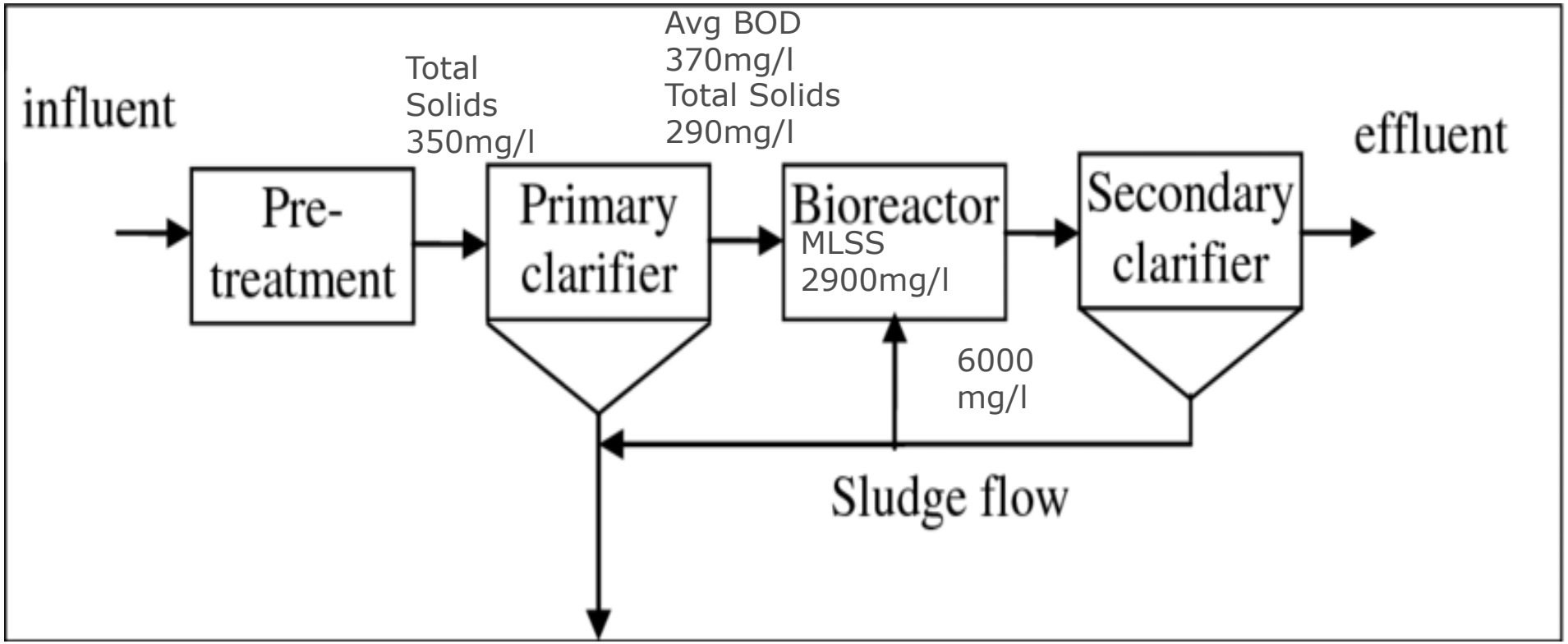
April 2023 OTCO Ohio

Dave Rutowski– Wastewater Application Development Manager

Agenda

- Activated Sludge process Review
- MLSS & SRT
  - Independent Operations
- System overview and insight

Where are all the solids coming from?



Wastewater Microbiology

Bacteria	Protozoa	Metazoa
Nutrient removal, indicator of conditions	Consumption of algae and bacteria, clarification and indicator of conditions	Consumption of bacteria and protozoa, indicator of conditions

Wastewater Treatment is a Biological Process

- Various Micro-organisms are “doing the work”
- Mechanical systems are the care and conditioning:
  - Pumps
  - Blowers
  - Valves
  - Filters

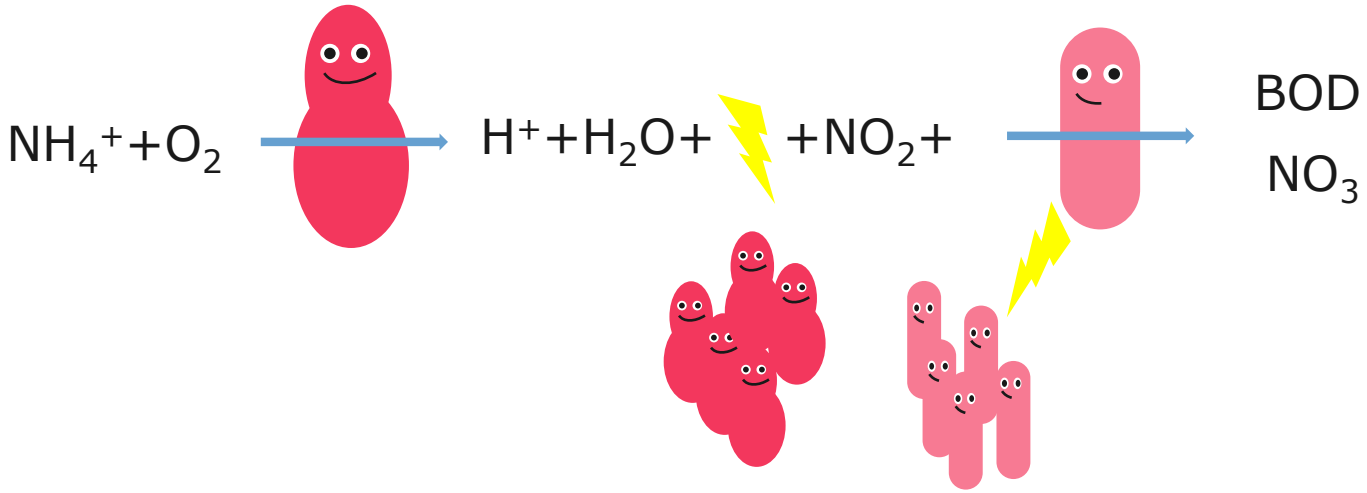
Operators should act like coaches and athletic trainers

Biological Nitrogen Removal is a Two-step Process

STEP ONE

NITROSOMONAS

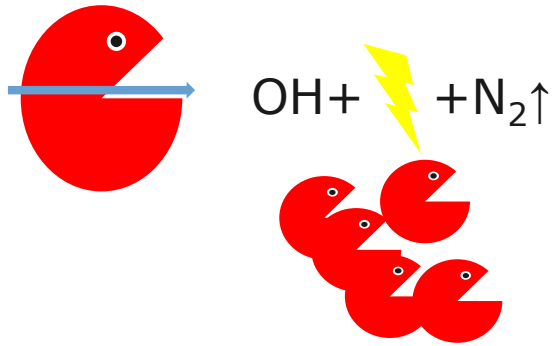
NITROBACTER



NITRIFICATION

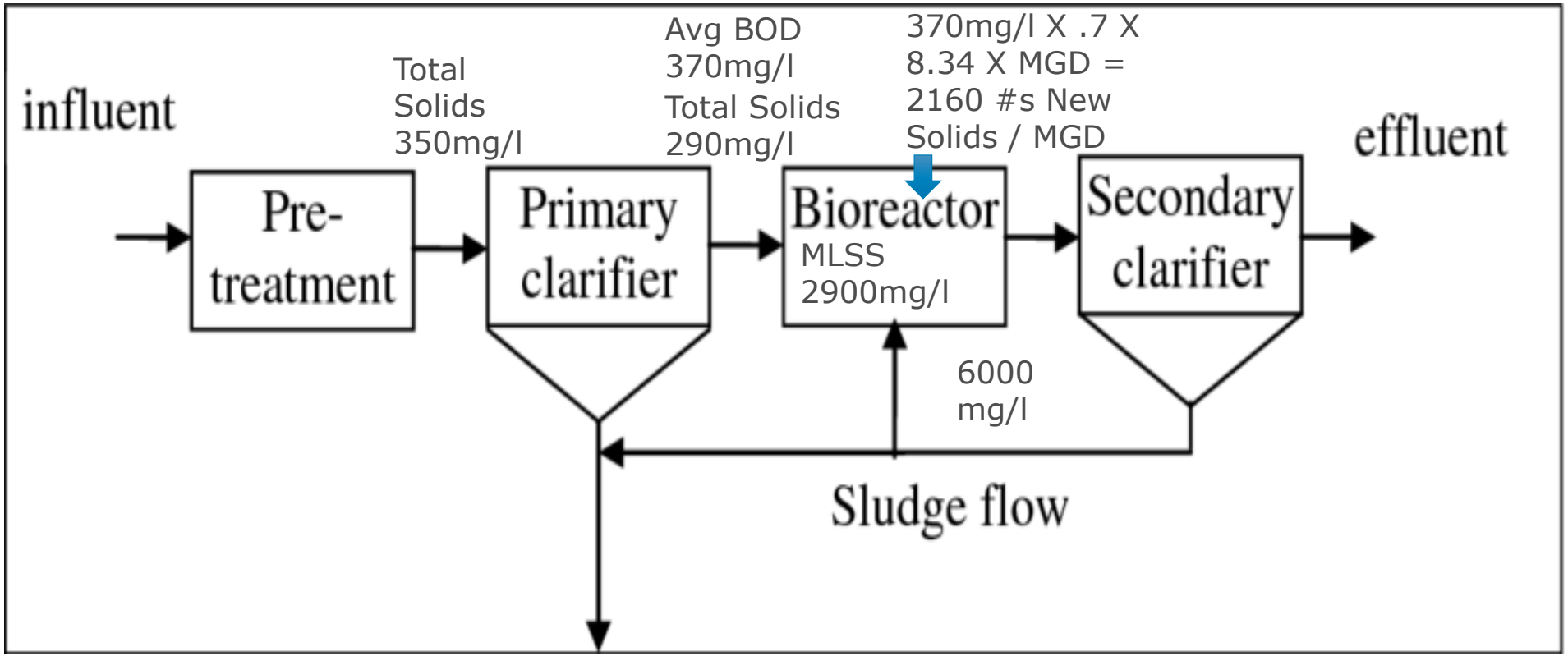
STEP TWO

PSEUDOMONAS



DENITRIFICATION

Food + Oxygen + Microbes + Time = GROWTH



USA: WAS Waste Activated Sludge
Europe: SAS Surplus Activated Sludge

RETURN ACTIVATED SLUDGE, IN THE BOOK VS IN THE BASIN

- **Return Activated Sludge Return Activated Sludge (RAS)** ***Definition***

The biological solids (mixed liquor solids) that settle in the secondary clarifier and are continuously returned back to the aeration tank.

These organisms are the major component of the treatment system.

RAS brings active, hungry microorganisms back into the aeration tank where they can multiply their populations and again feed on incoming wastes.

- What RAS is REALLY made from?

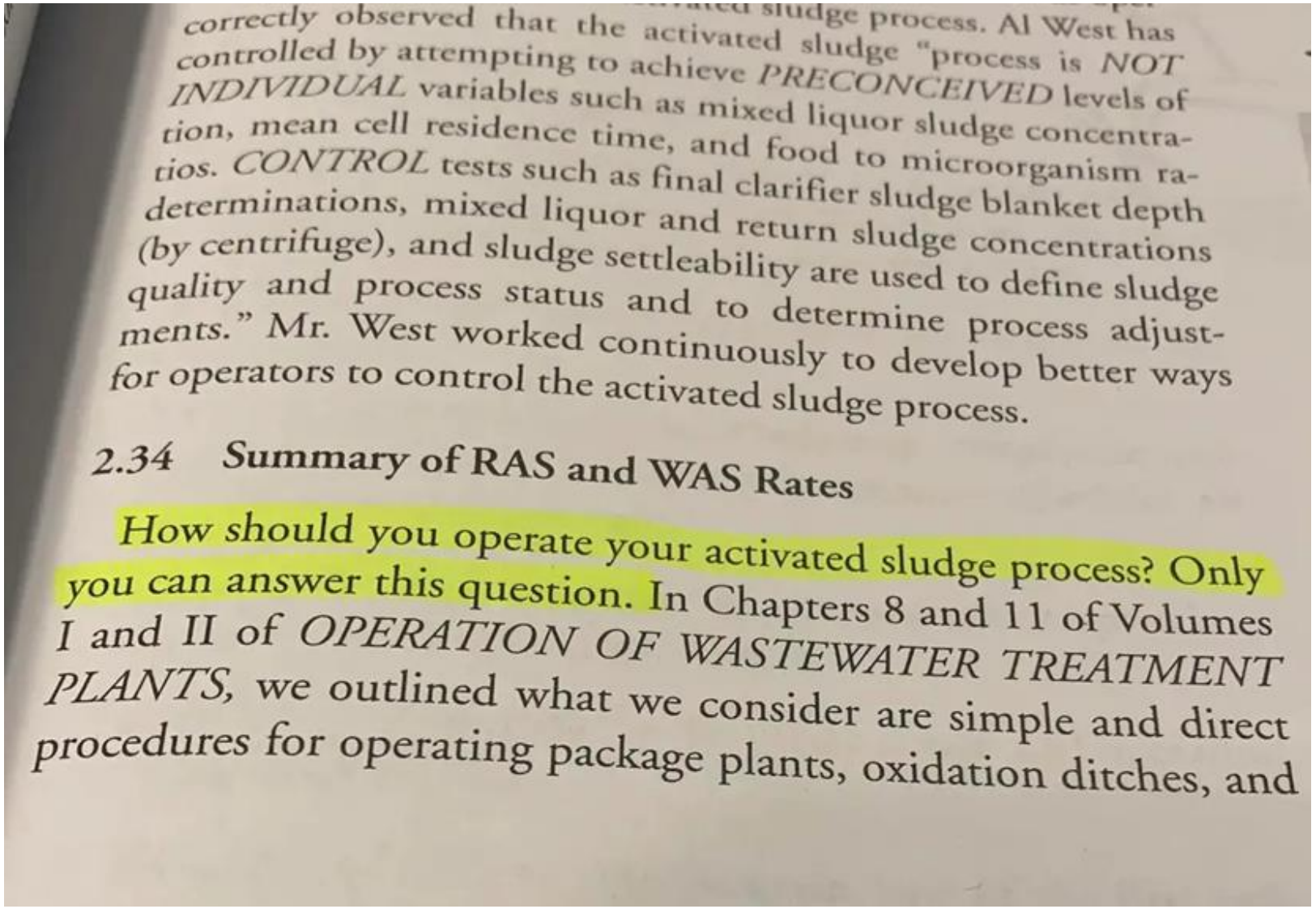
  A certain percentage of whatever settles out of the clarifier that is pumped back into the aeration system

  ✓Autotrophic bacteria
  ✓Heterotrophic bacteria
  ✓Other organism (filaments, amoeba, tartigrades)
  ✓Silt / grit not captured in Grit chamber or primary clarifier
  ✓Precipitated phosphorus sludge i.e. $AlPO_4$

$$Al_2(SO_4)_3 \cdot 14H_2O + 2H_3PO_4 \rightarrow$$

$$2AlPO_4 + 3H_2SO_4 + 18H_2O$$

RETURN ACTIVATED SLUDGE, IN THE BOOK VS IN THE BASIN

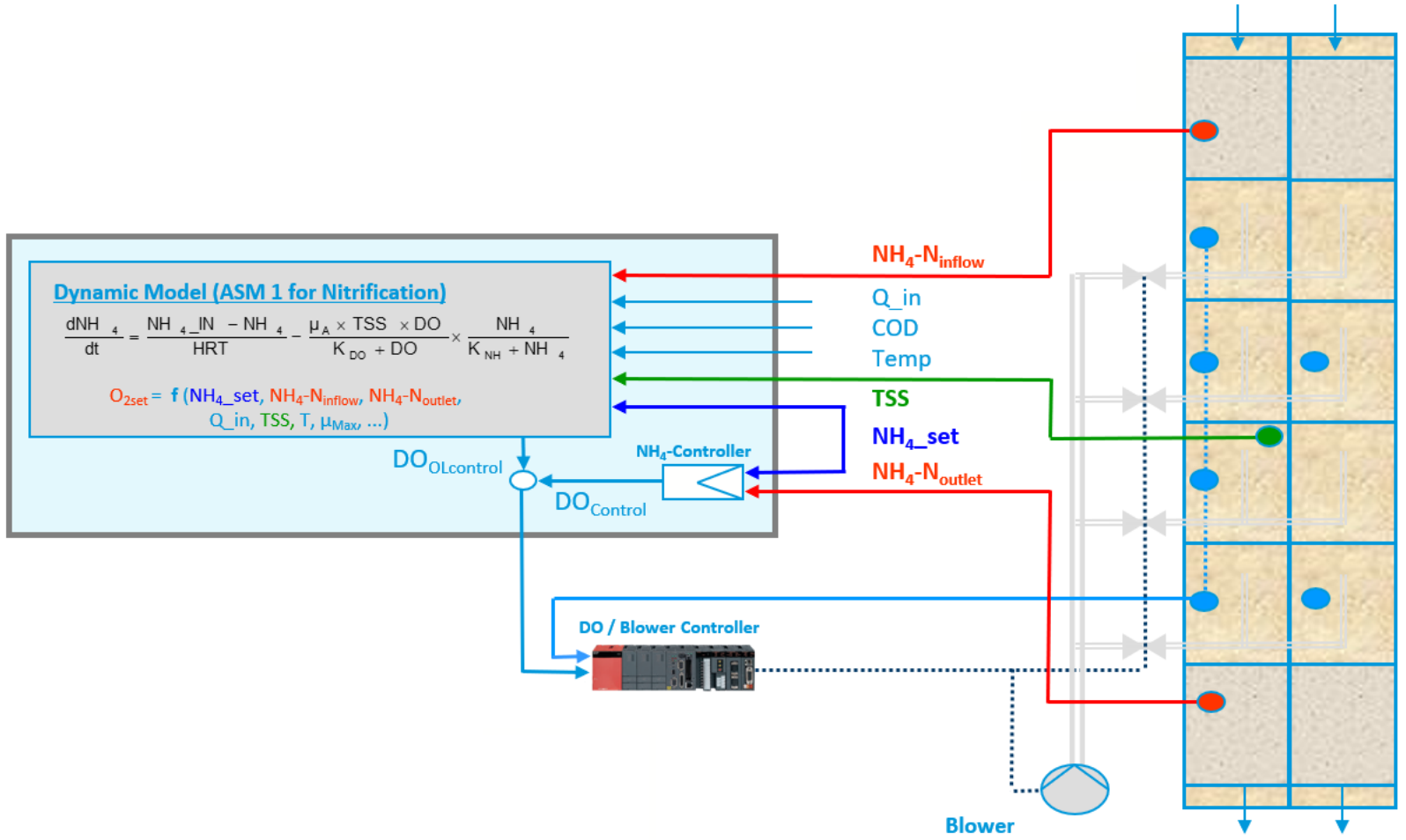


correctly observed that the activated sludge process. Al West has controlled by attempting to achieve *PRECONCEIVED* levels of *INDIVIDUAL* variables such as mixed liquor sludge concentration, mean cell residence time, and food to microorganism ratios. *CONTROL* tests such as final clarifier sludge blanket depth determinations, mixed liquor and return sludge concentrations (by centrifuge), and sludge settleability are used to define sludge quality and process status and to determine process adjustments." Mr. West worked continuously to develop better ways for operators to control the activated sludge process.

2.34 Summary of RAS and WAS Rates

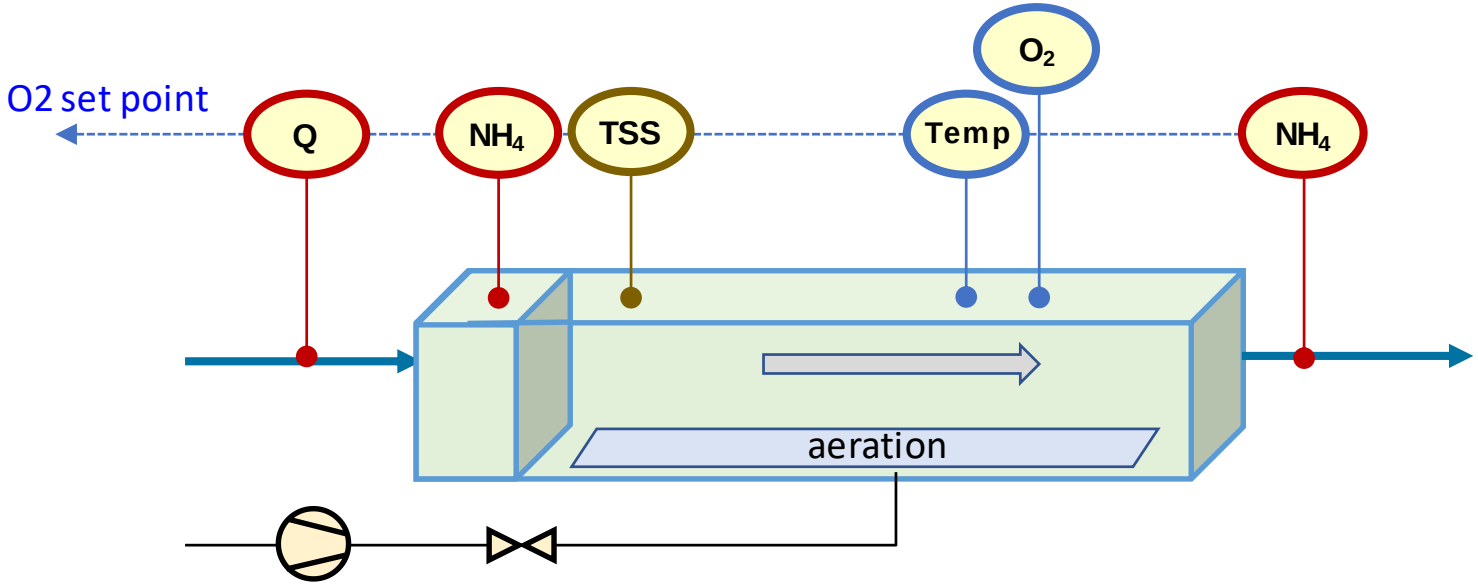
How should you operate your activated sludge process? Only you can answer this question. In Chapters 8 and 11 of Volumes I and II of *OPERATION OF WASTEWATER TREATMENT PLANTS*, we outlined what we consider are simple and direct procedures for operating package plants, oxidation ditches, and

Claros Process Management for Nitrification Process



Claros Process Management for Nitrification Process

- Aeration Influent & Effluent Ammonia Concentration
- TSS Concentration, Temperature, Flow, pH
- Use existing DO Control system
- Process Management Software onboard IPC with integrated HMI



Creating the "RIGHT" Sludge – All about the "BUGS"

Wasting Control:

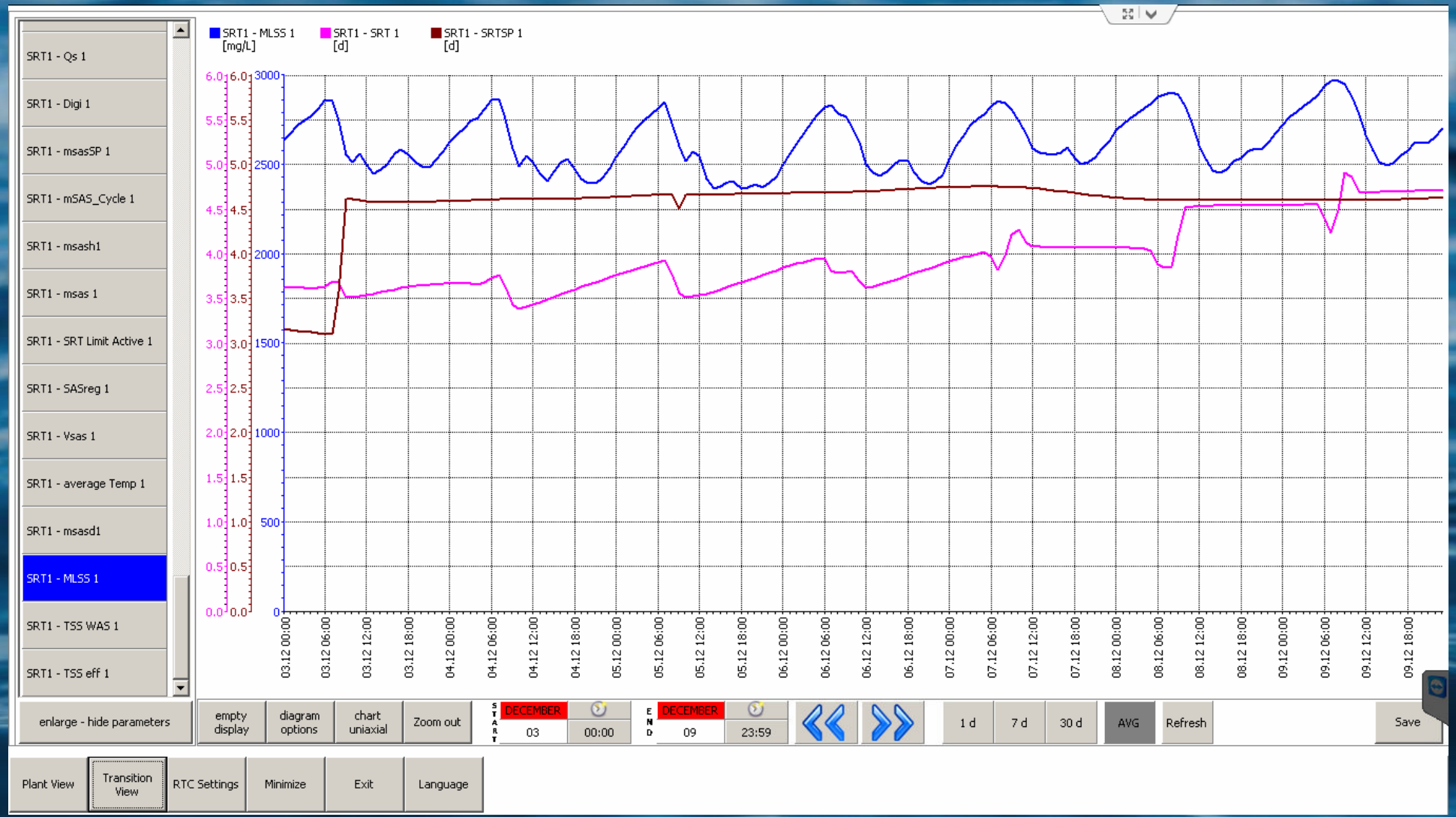
- Establishes the growth rate in the system for the given influent loading
- Provides the largest system pressure
- Waste Pounds – NOT Gallons

  lbs = conc (mg/L) *Flow (MGD)*8.34

- **Do NOT Assume** your WAS concentration remains constant

  "It has been shown this can be the problem upwards of 80% of the time when troubleshooting" – Ronald G. Schuyler, PE, BCEE, WEF Fellow, CWP

- Most common Process Control Error
  - Incorrect Data
  - Inaction by operational staff

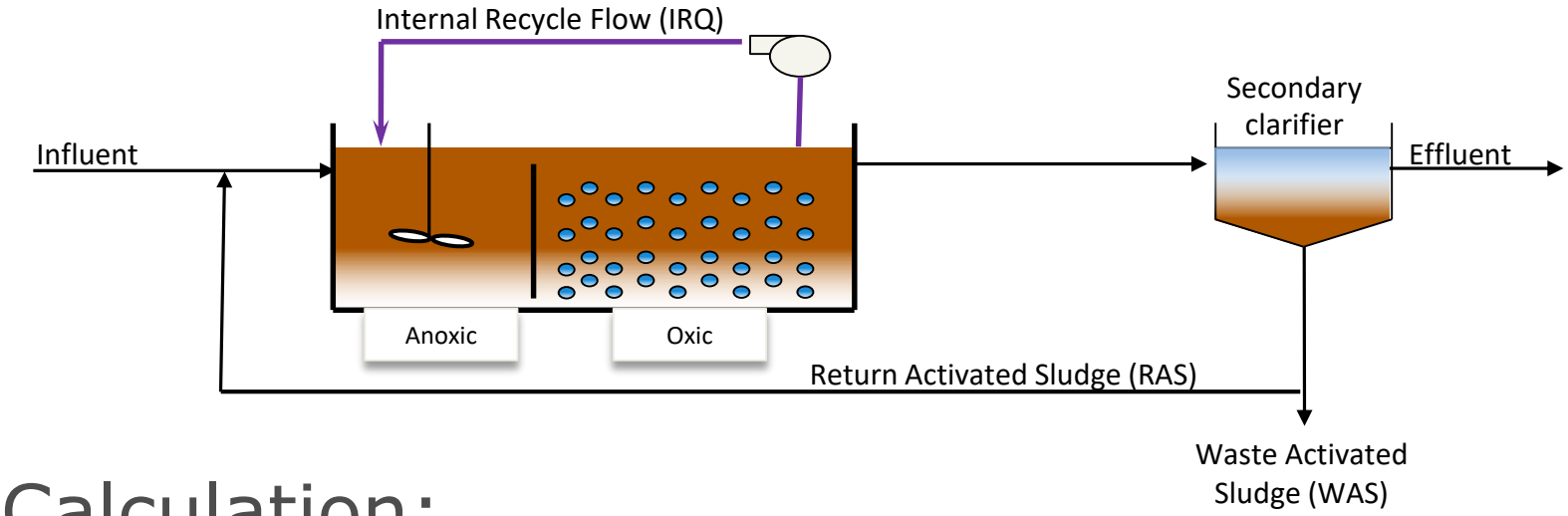

SRT1 - Qs 1
SRT1 - Digi 1
SRT1 - msasSP 1
SRT1 - mSAS_Cycle 1
SRT1 - msash1
SRT1 - msas 1
SRT1 - SRT Limit Active 1
SRT1 - SASreg 1
SRT1 - Vsas 1
SRT1 - average Temp 1
SRT1 - msasd1
SRT1 - MLSS 1
SRT1 - TSS WAS 1
SRT1 - TSS eff 1
SRT1 - MLSS 1 [mg/L]
SRT1 - SRT 1 [d]
SRT1 - SRTSP 1 [d]
enlarge - hide parameters
empty display
diagram options
chart uniaxial
Zoom out
START
DECEMBER
03
00:00
END
DECEMBER
09
23:59
1 d
7 d
30 d
AVG
Refresh
Save
Plant View
Transition View
RTC Settings
Minimize
Exit
Language

Why Sludge Retention Time?

The most important fundamental operational parameter for a biological wastewater treatment plant

- Defines what organisms can grow in the aeration basin
- Incorrect or inconsistent SRT can lead to growth of filamentous bacteria that cause foam and settleability problems
- Determines F:M Ratio
- Determines floc formation and settleability

What is Sludge Retention Time (SRT)?



Calculation:

$$\text{SRT (d)} = \frac{\text{Pounds of Solids in the Bioreactor}}{\text{Pounds of Solids in Leaving the System per day}}$$

$$\text{SRT (d)} = \frac{\text{MLSS Concentration x Bioreactor Volume x 8.34 lb/gal}}{\text{WAS Concentration x WAS Volume/day x 8.34 lb/gal}}$$

WAS = Waste Activated Sludge
MLSS = Mixed Liquor Suspended Solids

Issues with SRT

- Delayed Results
  - Assumes MLSS is unchanged
  - Ignores effects of rain or industrial dischargers. Most common upsets for plants
- Time Consuming and labor intensive
- Not accurate or repeatable
  - Accuracy vary between 1 and 33%
  - Dynamic process
  - Varies throughout the basins
  - Two samples from the same spot can vary as much as 300 mg/l

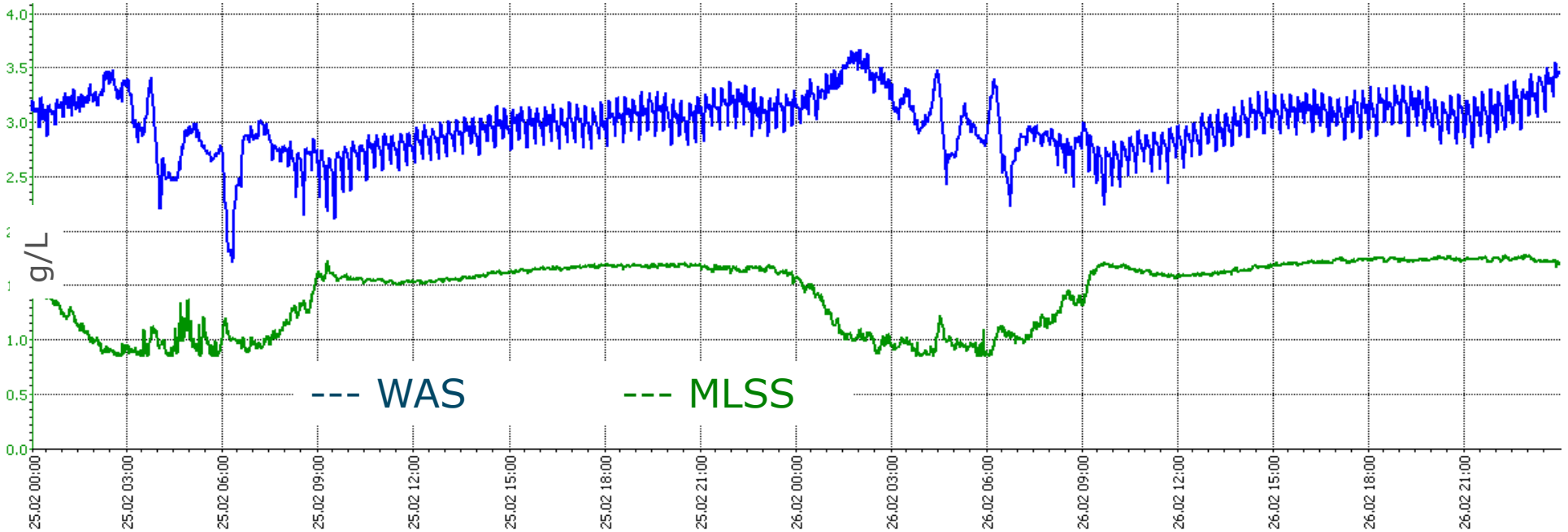
Did You Know?
Accurate & Precise SRT Control Can:

- Increase secondary system capacity up to 30%[3]
- Reduce Aeration Energy Consumption[4,7]
- Decrease SVI up to 39% while preventing Pin Floc[3,8]
- Eliminate Nocardia and M. parvicella foam[3,1]
- Avoid of Bio-P Failure while maximizing PAO/GAO ratio[2,6]
- Stabilize BNR Operations[5,7]
- Create consistent Solids Yield and Growth Rate[5,7]
- Increased MLSS stability[8]

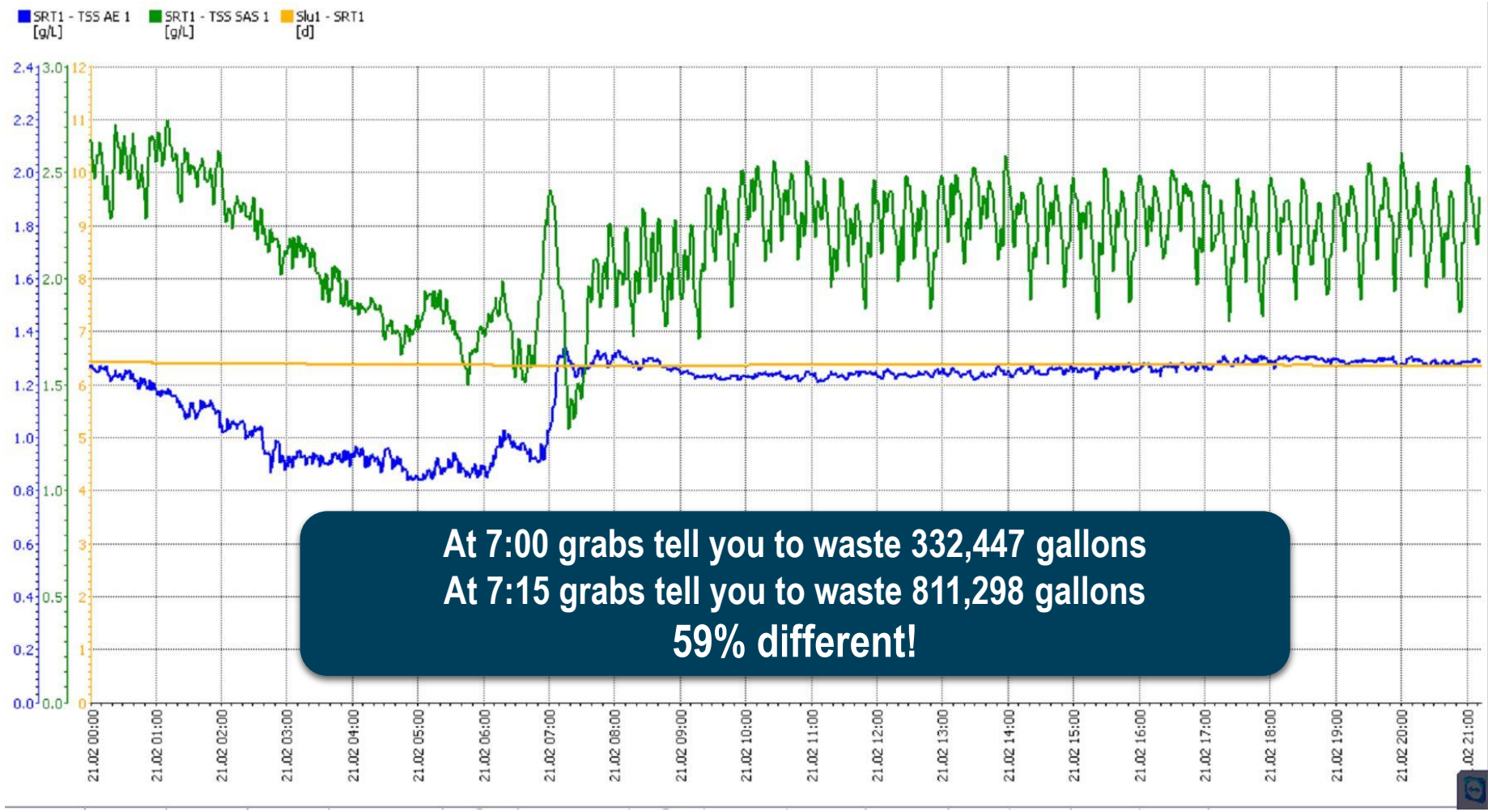
What's the problem?

Real World Data – notice how the MLSS and WAS concentrations change over 24 hours!

- When is the best time to pull a sample?
- Is that the best time every day or does it change?



When to Sample?



- Grab sample analyzed and entered into a spread sheet to calculate wasting rate.
- Sample time has a major impact on actual SRT.

			9:00 AM
WAS gpm	53		
MLSS	3400		
AB in service	4		
AB volume	0.422		
WAS conc.	8000		
Actual SRT =		9.39	
Desired SRT		**9.00**	
WAS for Desired SRT		55.35	

			6:00 PM
WAS gpm	53		
MLSS	3108		
AB in service	4		
AB volume	0.422		
WAS conc.	9300		
Actual SRT =		7.39	
Desired SRT		**9.00**	
WAS for Desired SRT		43.52	

A LOT of work to be wrong!

What are the Alternatives?

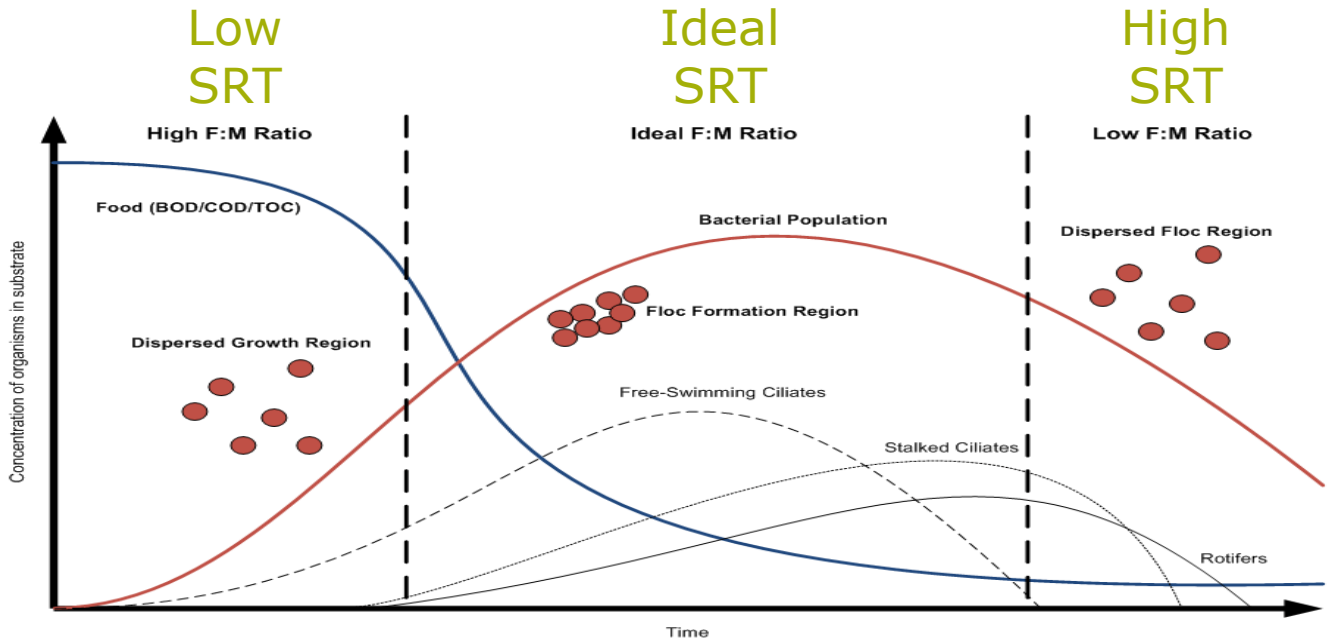
- More frequent grab samples
  - How many? How frequent? Specifically when?
  - Still have to wait for the results!
  - When should I make a change?
- 24 Hour Composite Samples (24-hour delay…at least!)
  - Delays decision making
  - Doesn't tell you what is happening right now
  - What if there was a significant load yesterday but not today? (Industrial? Is it regular or random?)
- Average your daily SRT calculation over the last 7 days
  - Only masks the problem of inconsistency!
  - Introduces more lag time

What are the Alternatives?

- Operate at a constant MLSS concentration
  - Worst way to operate – but common
    - "Constant MLSS is easy!"
    - "That's the way we've always run it."
    - "Because that's how my plant runs best."
  - Assumes Return Activated Sludge (RAS) is consistent
  - Ignores the fundamental idea that SRT controls the population, efficiency and stability of the biomass
  - Makes SRT more variable
    - ***More filaments, more foam!***

Remember It is about the Bugs?

Defines what organisms can grow in the aeration basin



Incorrect or inconsistent SRT can lead to Operational issues and or compliance violations

- The growth of filamentous bacteria that cause foam and settleability problems
- Loss of nitrification or unwanted nitrification
- Increased power requirements

Young Sludge Age

- Don’t eat much
- Leave food on the table
- Hard to settle down

Result:

- Slow settling
- Cloudy supernate
- White to gray foam
- Sludge bulking

Old Sludge Age

- Can’t eat as much
- Use a lot of air and space
- Potentially toxic to each other
- Smelly

Result:

- Poor settling
- Brown, Thick, Scummy, Stable Foam

Just Right Sludge Age "Teenagers"

- Eat every thing in sight
- No scraps
- Full of energy
- When full settle down

Result:

Stable Happiness

If SRT Control is Like Driving…

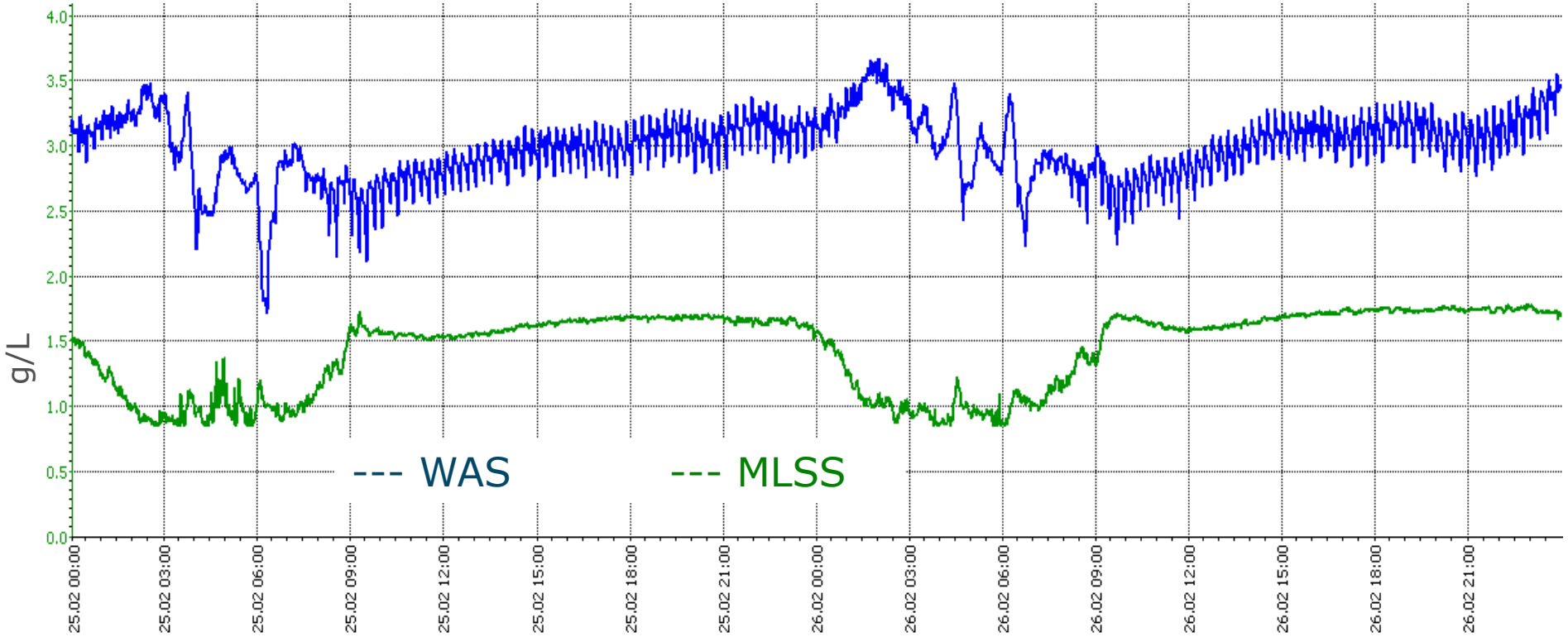
Then with manual mixed liquor and settled sludge suspended solids measurements are like…

- The driver is blindfolded
- The driver can peak at the rear-view mirrors
- The driver can only check the mirrors (concentrations) once per day for 30 seconds

Result is drastic adjustments (jerking the steering wheel) every 24 hours

What's the Solution?

- Grab samples of MLSS and WAS are NOT good enough
- Online probes & Process Management solve these problems



If SRT Control is Like Driving…

Then with automated control through suspended solids probe measurements: …

- The windshield is **clear**
- The cars GPS is driving
- The driver can check the view and the mirrors periodically to ease his mind

Result is multiple, small adjustments several times a day

Benefits of accurate & precise SRT

- Elimination of Nocardia and M. parvicella foam[3,1]
- Improved Settleability (39% reduction in SVI), Reduced Bulking[3,8]
- Increase Secondary Capacity by 30%[3]
- Prevention of Pin Floc/Dispersed Growth[3]
- Optimized PAO/GAO ratio[6]
- Avoid Loss of Bio-P[2]
- Simultaneous P release and Denitrification[6]
- Consistent Solids Yield and Growth Rate[5,7]
- Increased MLSS stability[8]
- Stable BNR Operation[5,7]
- Energy Savings through Enhanced Oxygen Transfer Efficiency[4,7]

Results:

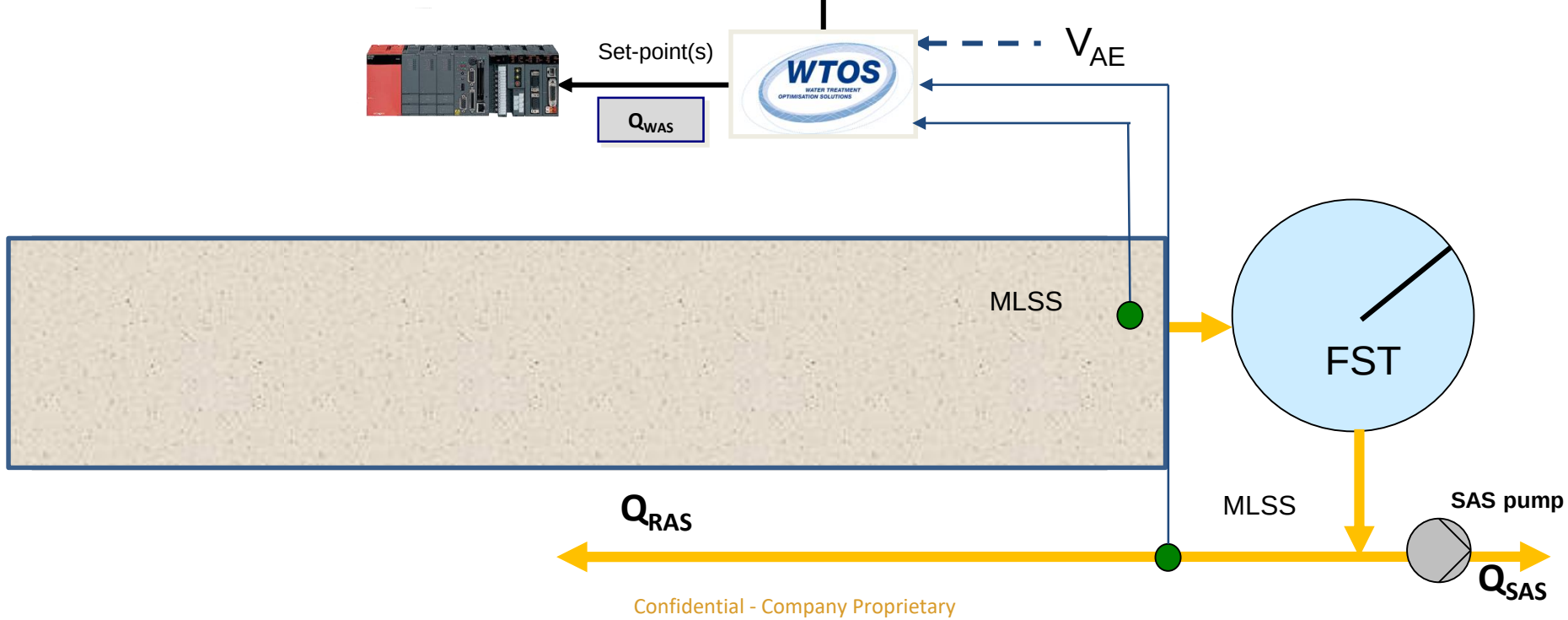
- More stable SRT
  - Consistent higher quality effluent
  - Saving money
- Consistent WAS to thickening process
- Elimination of Nocardia and M. parvicella foam
- Improved settleability (39% reduction in SVI)
- Decreased solids concentration from lower SRT increased secondary capacity
- Prevention of pin flock and solids carryover
- Consistent solids yield growth rate
- Increase MLSS stability
- Decreased energy cost due to volatile solids being treated in the anaerobic digesters
- Insight into the process
- Efficiencies allowed operators to focus on other issues

Waste Activated Sludge (SAS)

Sludge Retention Time adjusted manually by operator (monthly, seasonally)

Safety factor (SF) can be preset or chosen by the Operator

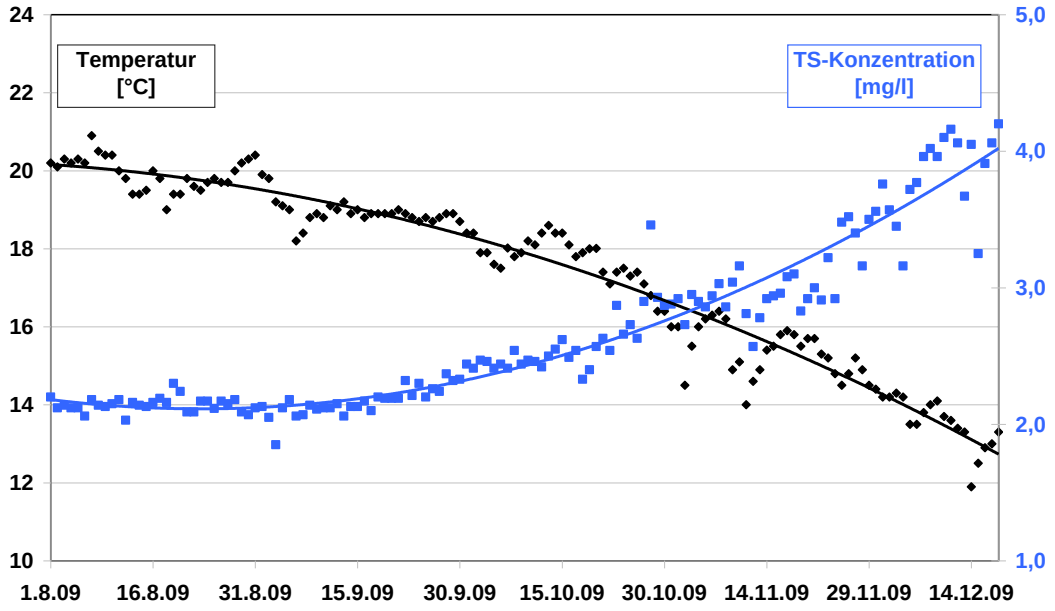
Controller calculates set-points [kg/d] for WAS to ensure **sufficient sludge age for nitrification** and to **prevent unnecessary high sludge age** concentration to save aeration costs.



Control structure

Sludge Age Controller – Sludge Retention Time-RTC

- Calculates the required volume of Waste Activated Sludge (WAS) in m^3/d
- Required:
  - MLSS concentration in the aeration basin
  - MLSS concentration in RAS/WAS stream
- The temperature is taken into account to achieve a preset sludge retention time or calculate optimal SRT with respect to the nitrification treatment target

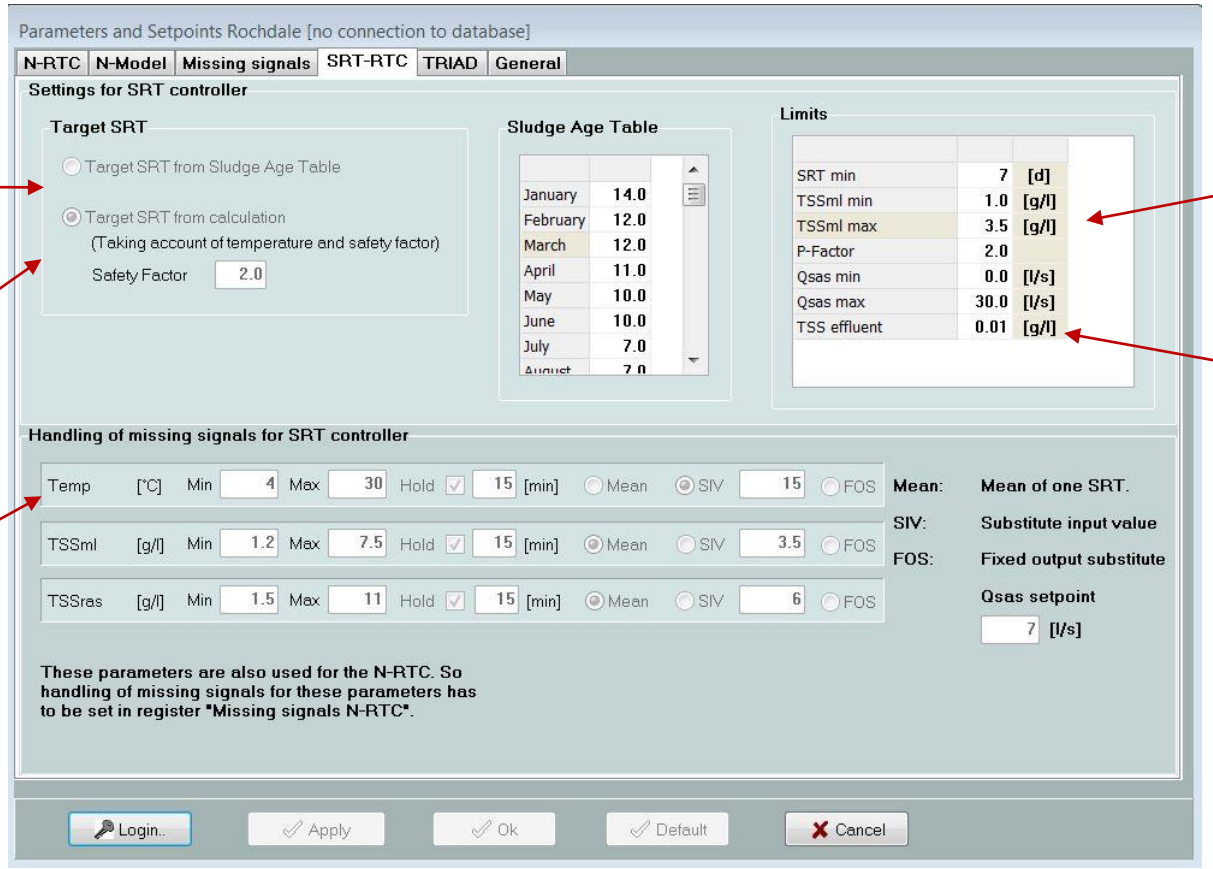


Parameters and Setpoints

Selection of calculated or defined sludge age

Only effects calculated SRT. Typical values: 1.65-2.

These values to be changed in missing signals tab

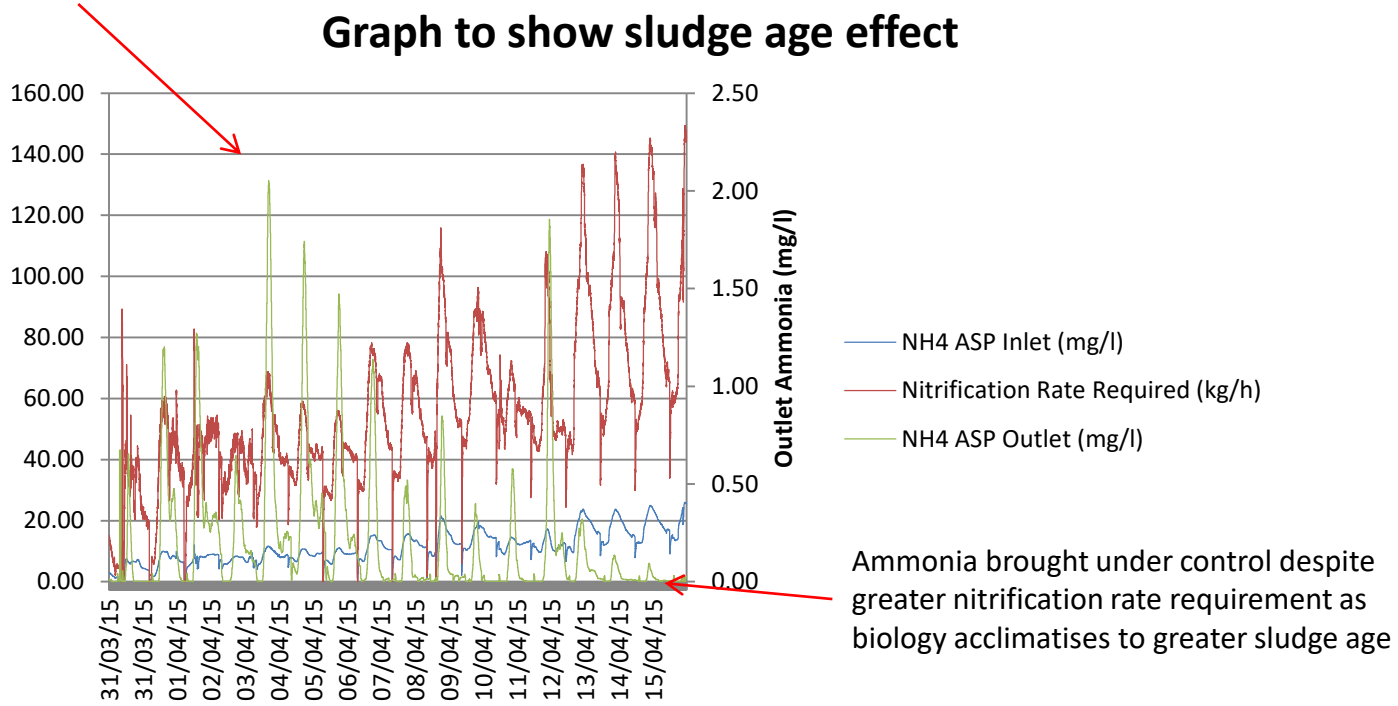


Tailor the operational range of RTC to site conditions

Used as part of sludge age calculation. If site has high solids loss in final eff. Input value here

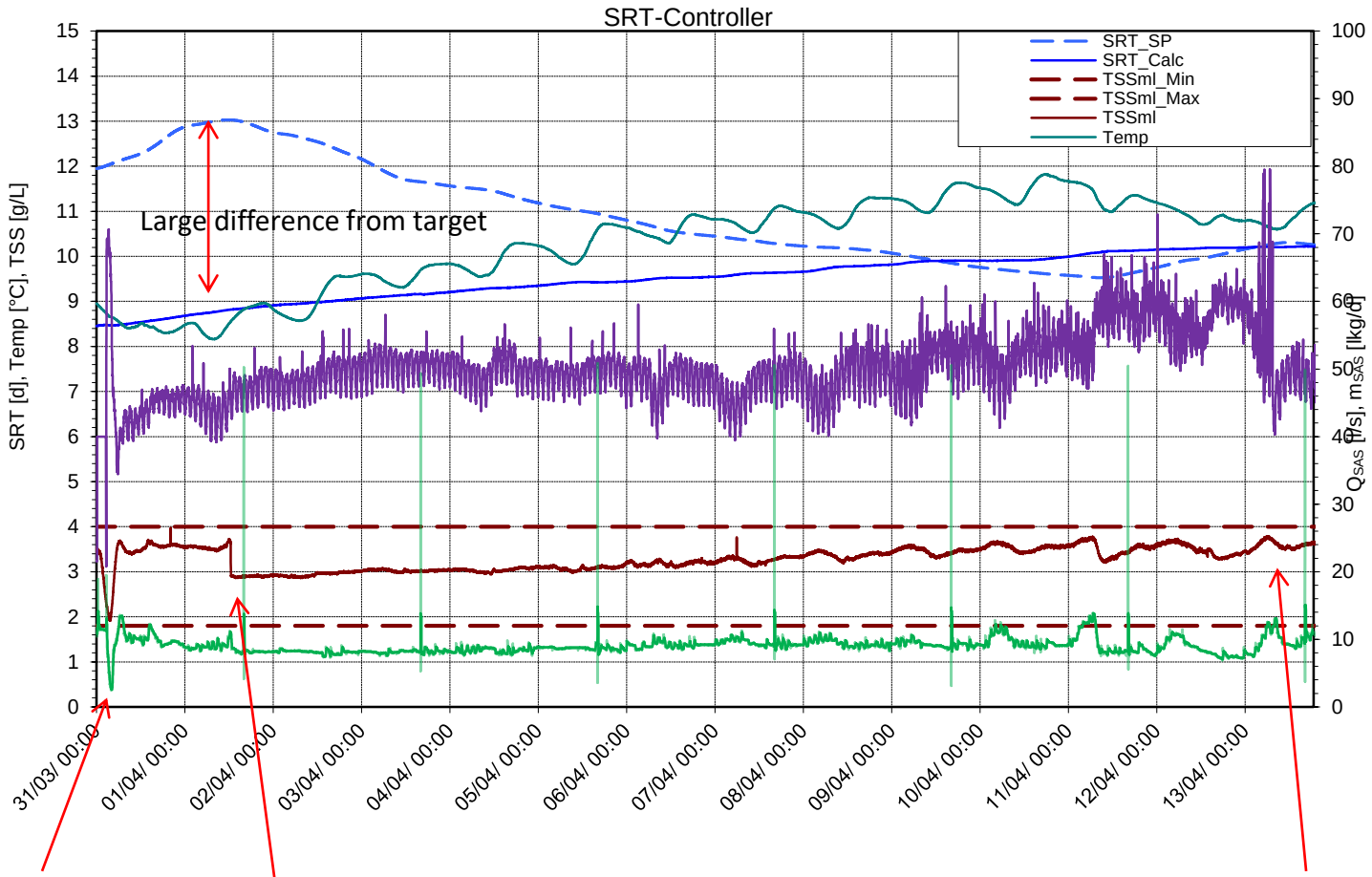
Note this visualisation is for combined solutions only. The functionality remains the same with the stand alone solutions.

Ammonia breakthrough despite dissolved oxygen >5.0 mg/l. Peak would have been considerably larger using fixed DO approach



Ammonia brought under control despite greater nitrification rate requirement as biology acclimatises to greater sludge age

Note: Commissioning Real Time Control at Rochdale WwTW



MLSS wash out event – controller significantly reduced wasted sludge to prevent loss of MLSS

Solitax calibration event

MLSS kept within operational band

Claros Process Management

YOUR process
under control

Be Right™

References

[1]Bartle, H., C. Revis. Controlling *Microtrhix parvicella* with Foam Control and "Ammonia-SRT". Proceedings of the Water Environment Federation, WEFTEC Conference, 2014.

[2]Basu, S., T. Wiesner, J. Page. Failure and Subsequent Restoration of EBPR Capability of a Small Community Wastewater Treatment Plant. Proceedings of the Water Environment Federation, WEFTEC Conference, 2008.

[3]Ekster, A., D. Jenkins, J. Hagstrom. Optimization of the microbiological population using precise sludge age (SRT) control. Proceedings of the International Water Association, Instrumentation, Control and Automation Conference, 2017.

[4]GFA Publishing Company (2001) ATV Standard Dimensioning of Single-Stage Activated Sludge Plants ATV-DVWK-A 131. German Association for Water, Wastewater and Waste.

[5]Greenwood, S., C. Anderson, M. Rieth, and T. Stein. Constant Hydraulic SRT Improves BNR Activated Sludge Performance. Proceedings of the Water Environment Federation, WEFTEC Conference, 2002.

[6]Onnis-Hayden, A., N. Majed, D. Drury, L. Risso, K. McMahon, and A. Gu. Effect of Sludge Residence Time on Phosphorus Removal Activities and Populations in Enhanced Biological Phosphorus Removal (EBPR) Systems. Proceedings of the Water Environment Federation, WEFTEC Conference, 2013.

[7]Pretorius, C., R. Appleton, S. Walker, E. Jorgensen, B. Stevenson and L. Bateman. Why SRT Control is Not More Widely Practiced and Three Ways to Fi It: Making SRT Control a Reliable Tool for Operators to Use. Proceedings of the Water Environment Federation, WEFTEC Conference, 2016.

[8]Whitlock, D., R. Wilson, D. Kinnear. An Overview of the Lincoln, NE Nitrifying Activated Sludge System, Control of Filamentous Bulking with an Anoxic Selector and Enhancing System Performance with an Automatic Solids Retention Time Control System. Proceedings of the Water Environment Federation, WEFTEC Conference, 2002.