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Troubleshooting Activated Sludge Results in Operational Tools at the City of Waterloo

WWOA October 17, 2018

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Outline

- Overview of Microthrix Parvicella
- Overview of Nitrification
- Overview of Waterloo WWTP
- Review of Troubleshooting
 - Issues
 - Responses
- Summary and Future Steps

Microthrix parvicella:

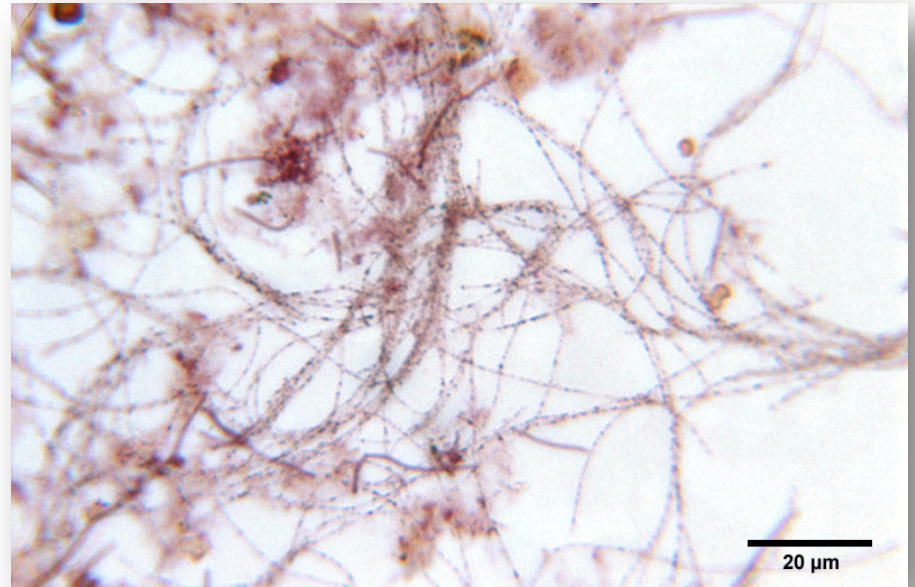
the bête noire (black beast) of filaments

“Microthrix parvicella, a gram positive, unbranched filament, can confidently be said to be the most troublesome filamentous bacterium in activated sludge”

- Elizabeth Seviour and Robert Seviour Australian microbiologists with the Biotechnology Research Centre at La Trobe University, Bendigo

M. Parvicella Characteristics

- Associated with
 - Low F:M Ratios
 - High Fat and Grease
 - Low Temperatures
 - Selectors

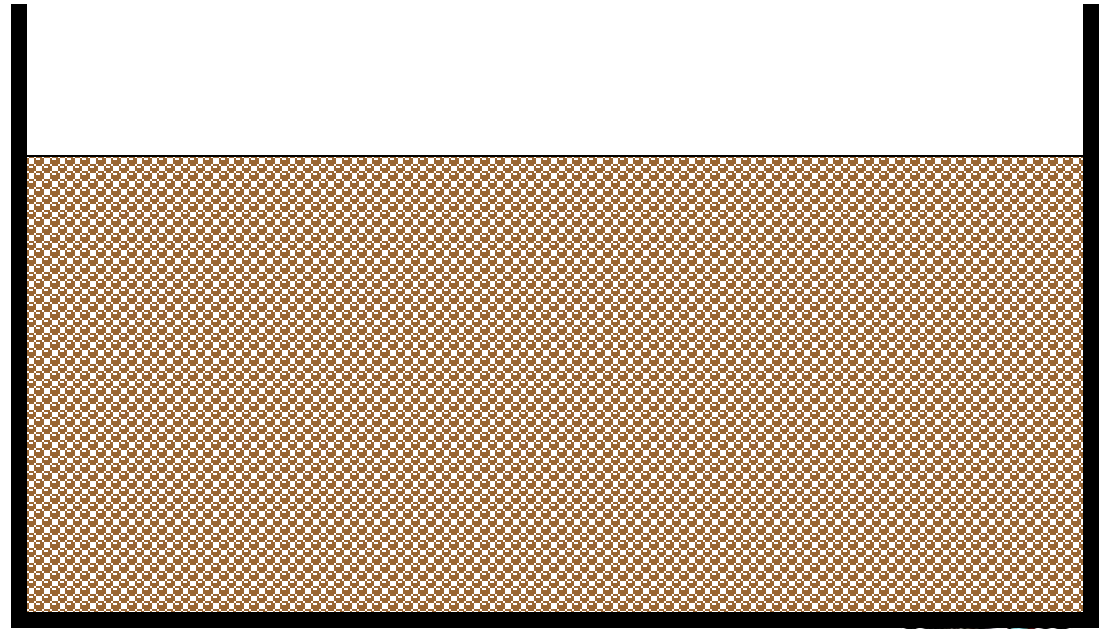


Aesthetics



Inventory Management

Good Day
No Foam
Consistent ML

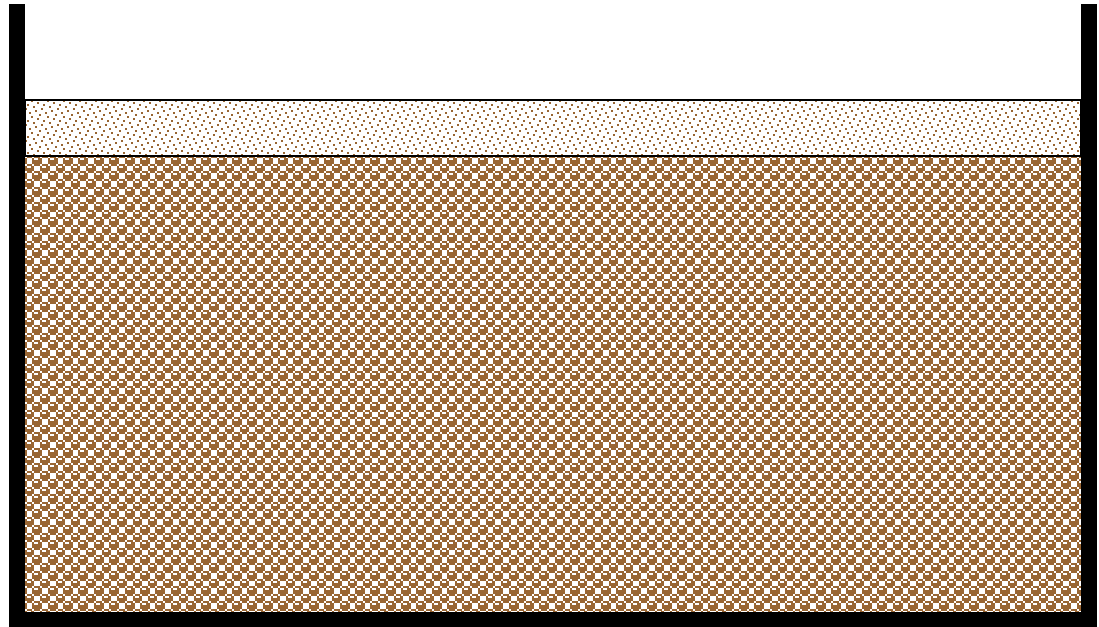
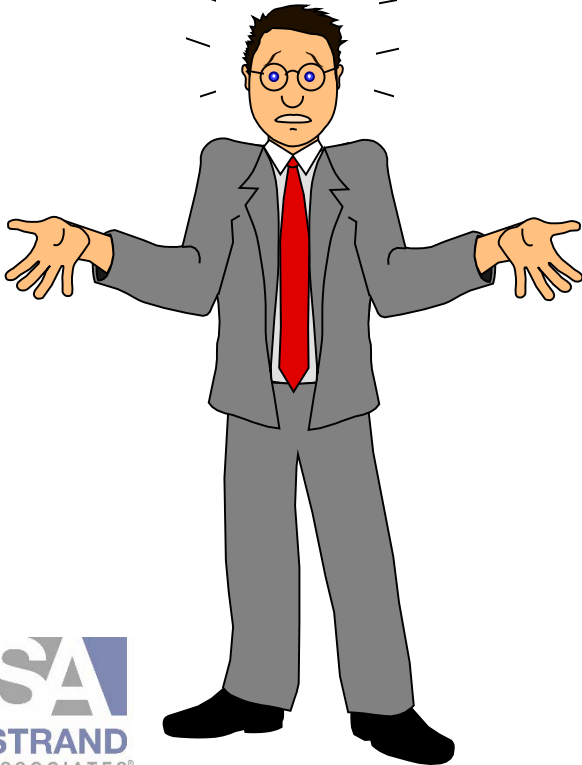


Aeration Tank

Profile View

Inventory Management

What percentage of my biomass is in the foam?

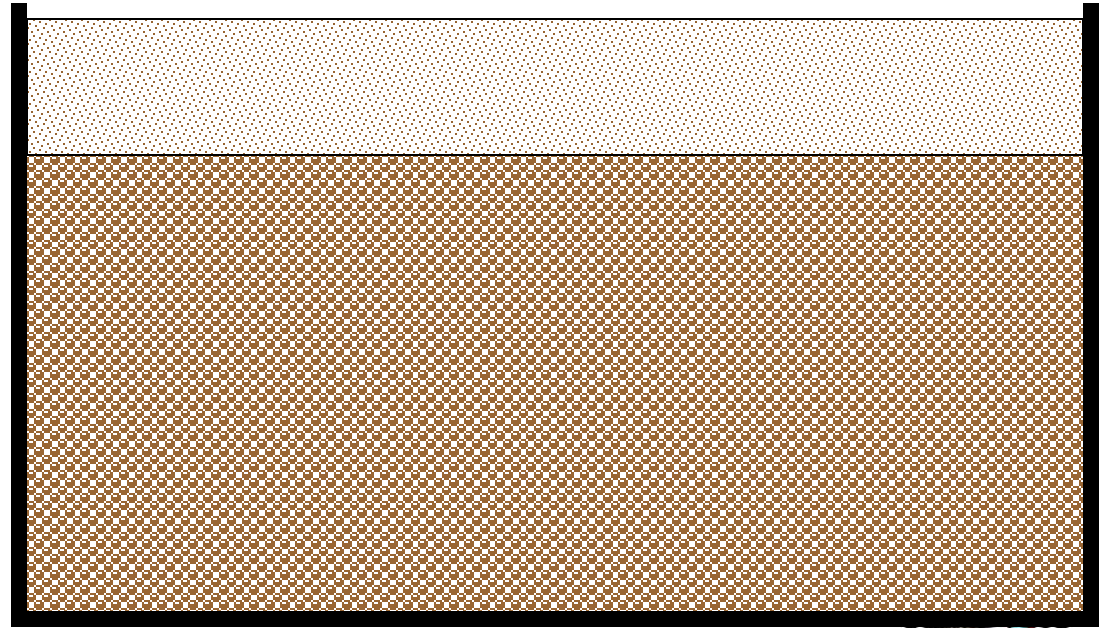


Aeration Tank

Profile View

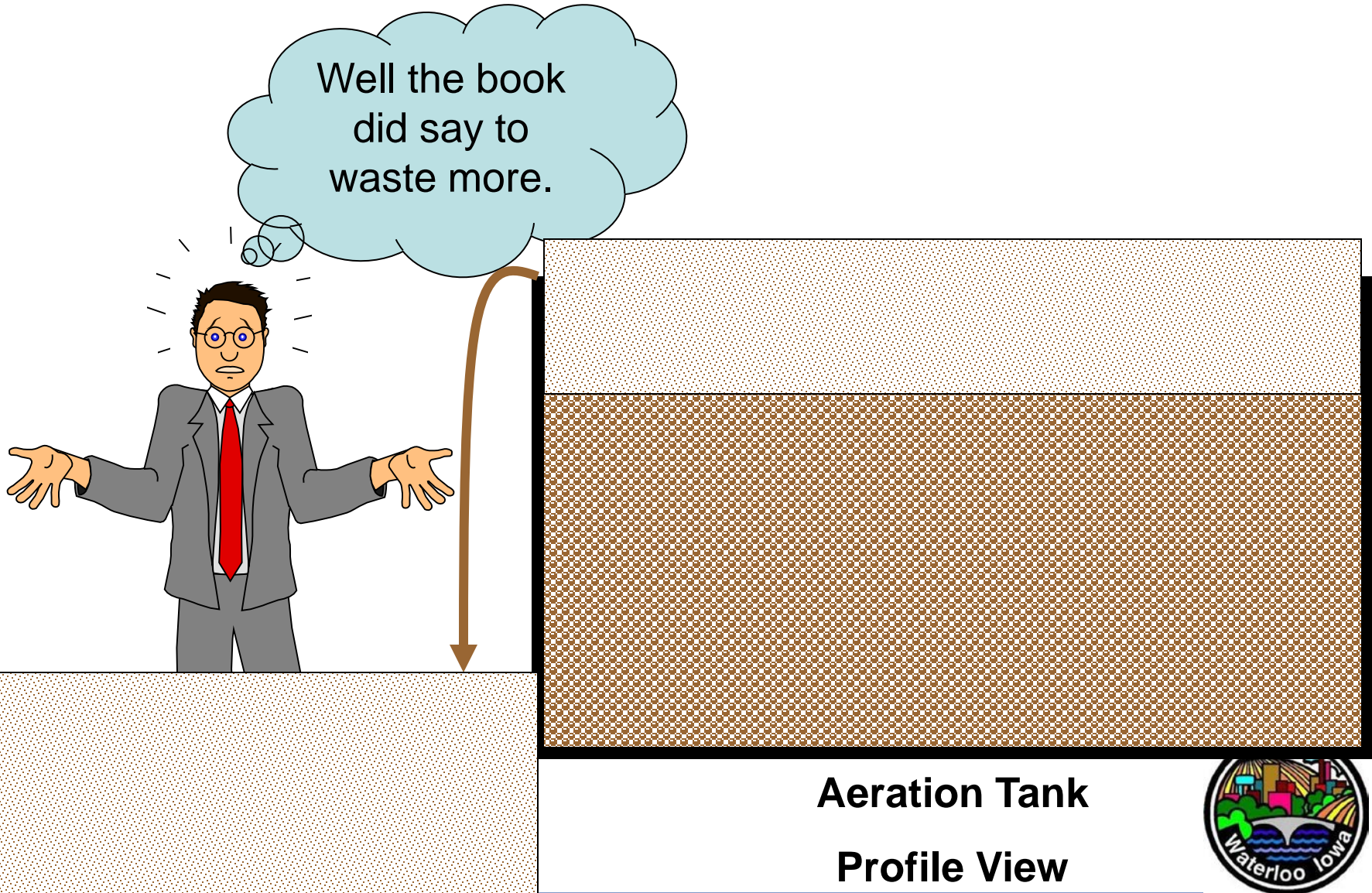
Inventory Management

How about now?



Aeration Tank
Profile View

Inventory Management



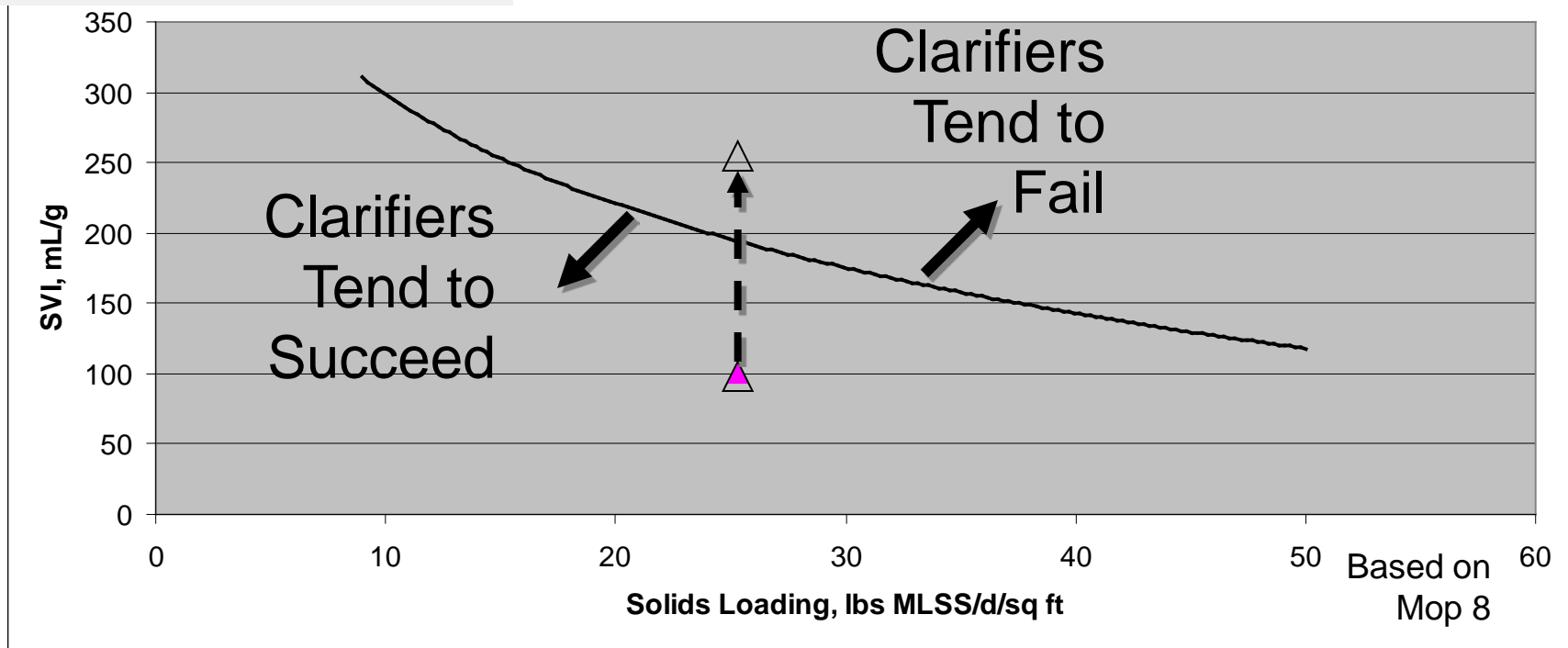
Freezing Concerns



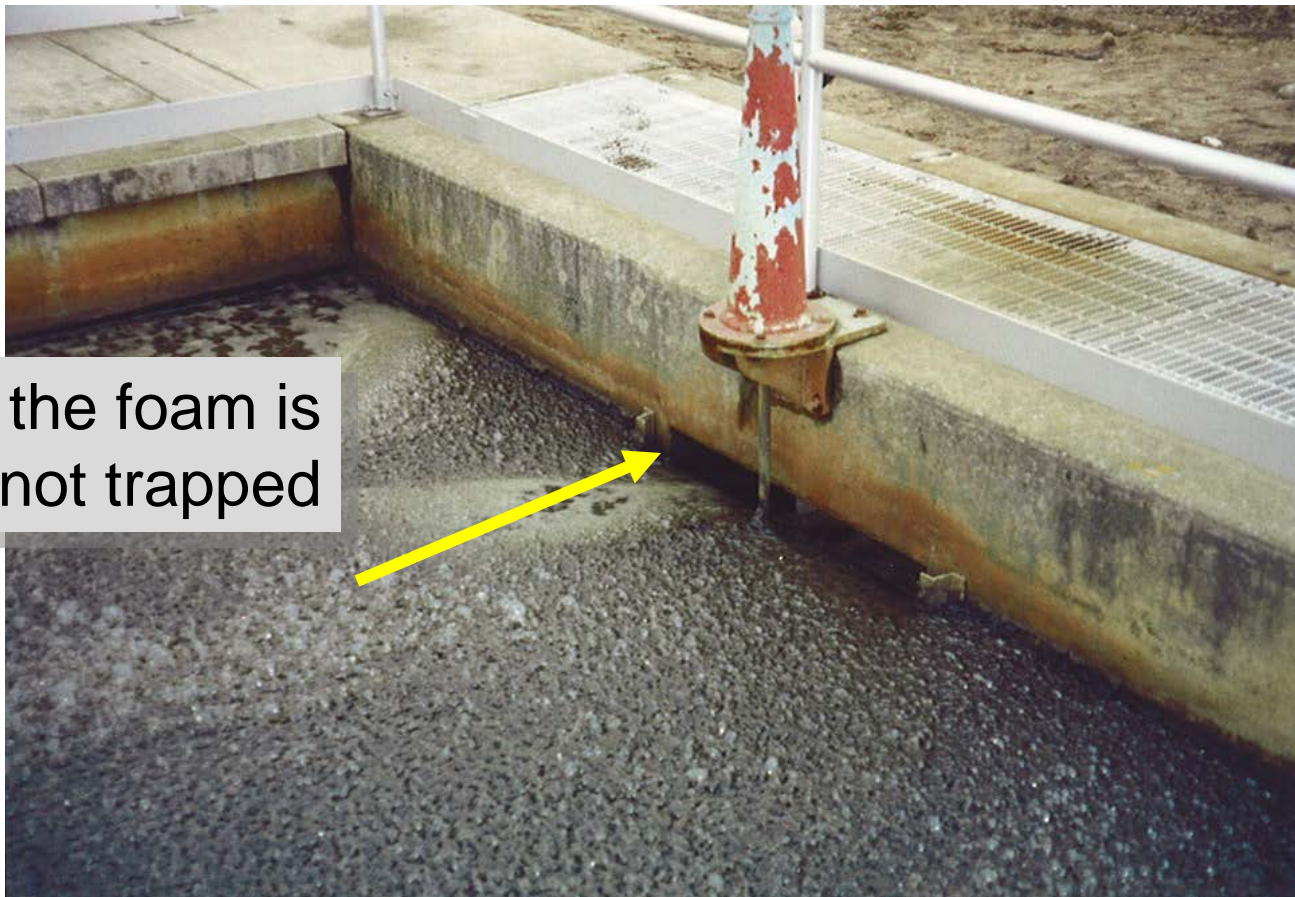
Settleability/Capacity Limitation

Clarifier Capacity is Impacted by Settling Characteristics

Final Clarifier SLR

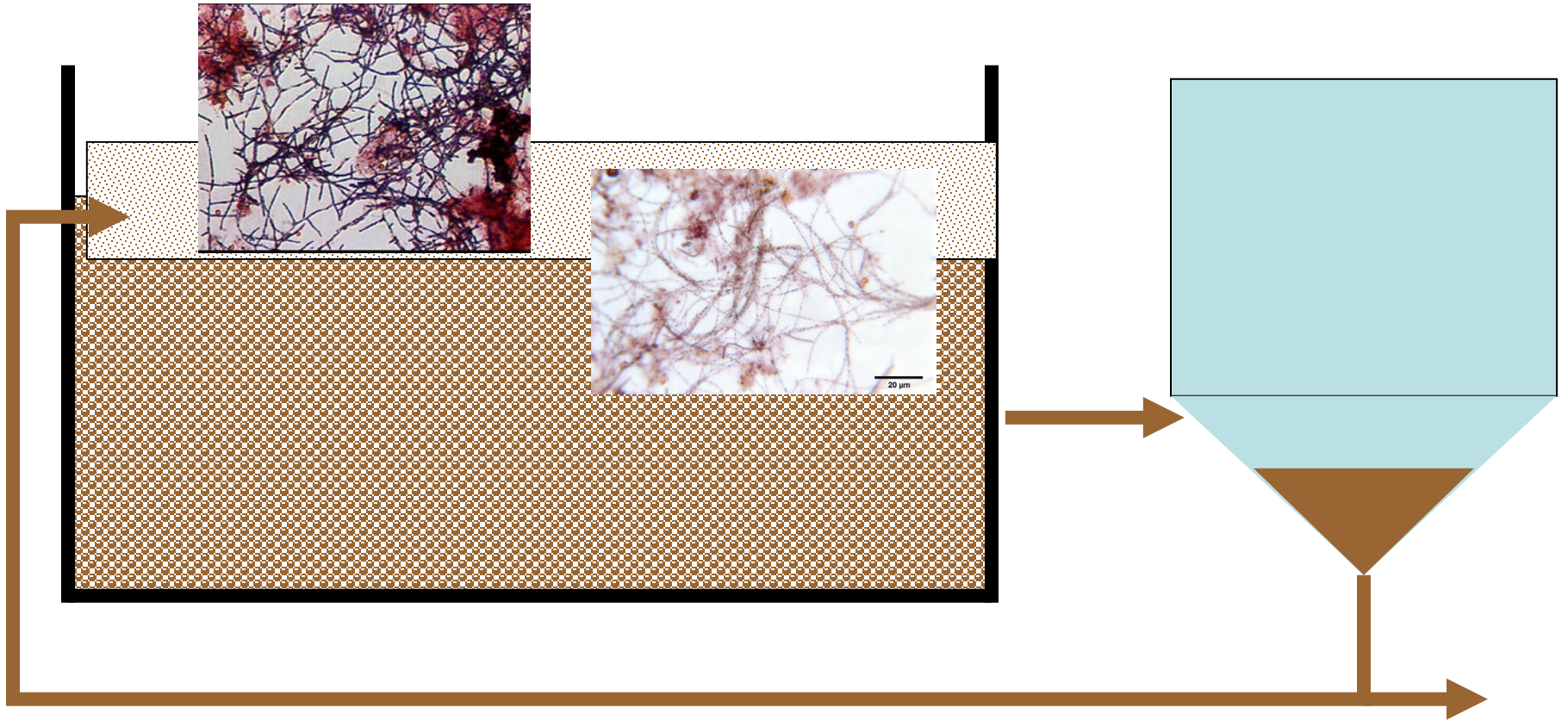


Foam Trapping

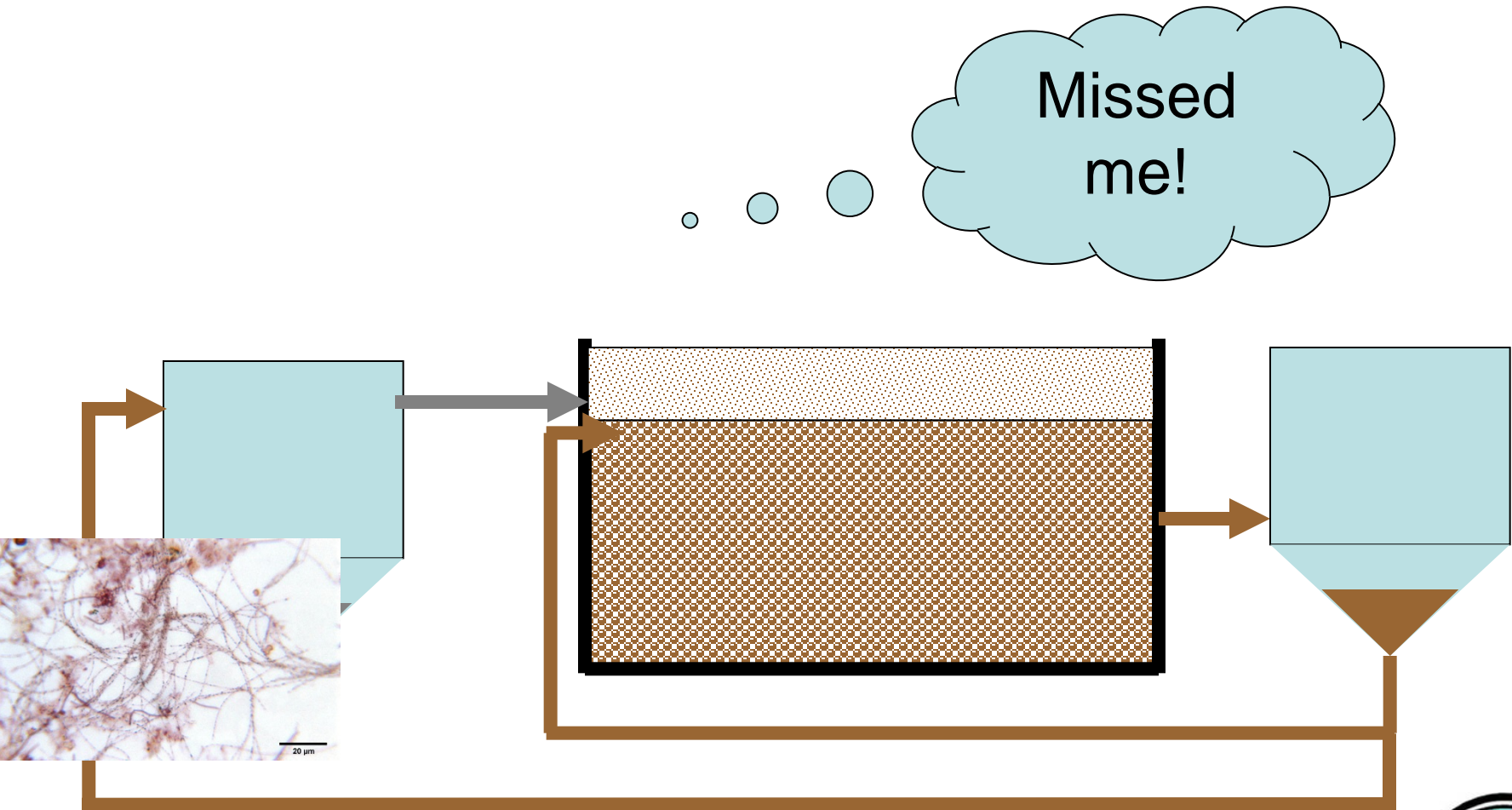


At least the foam is not trapped

Foam Trapping



Foam Trapping – Co-Thickening



Wasting

Co-Thickening

Inventory Control and Sludge Age Impacts Foaming Filaments

- Conventional Wisdom Indicates and Experience Indicate Sludge Age to be a Factor
 - Higher sludge ages allow slower growing filaments to compete
 - 12 days is a divide at some facilities

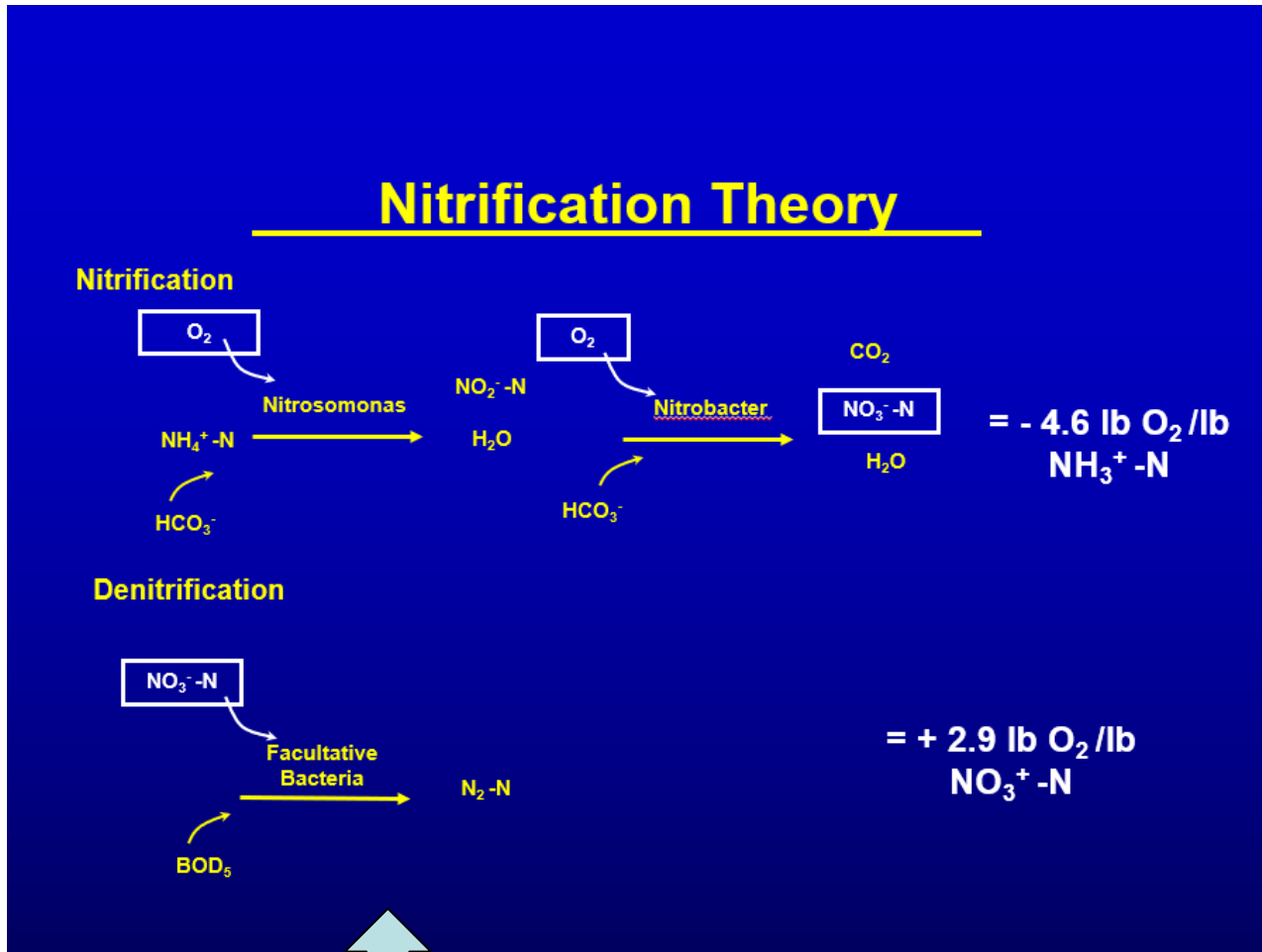
Countering the Triggers

- Eliminate Foam Trapping
- Control F.O.G.
- Reduce Sludge Age
- Provide Plug Flow Features for all zones
- Avoid low D.O. Zones
- Consider Chemical Treatment

Fundamental: Alkalinity Impacts Nitrification

- pH/ Alkalinity
 - Nitrifiers are pH sensitive (best 7.5 - 9, can nitrify down to 4.5)
 - Bicarbonate alkalinity is needed for a carbon source (7.14 mg Alk./ mg NH₃ nitrified)
 - Significant changes in pH can be toxic to nitrifiers or inhibit their ability to completely nitrify
 - Loss of alkalinity may inhibit complete nitrification

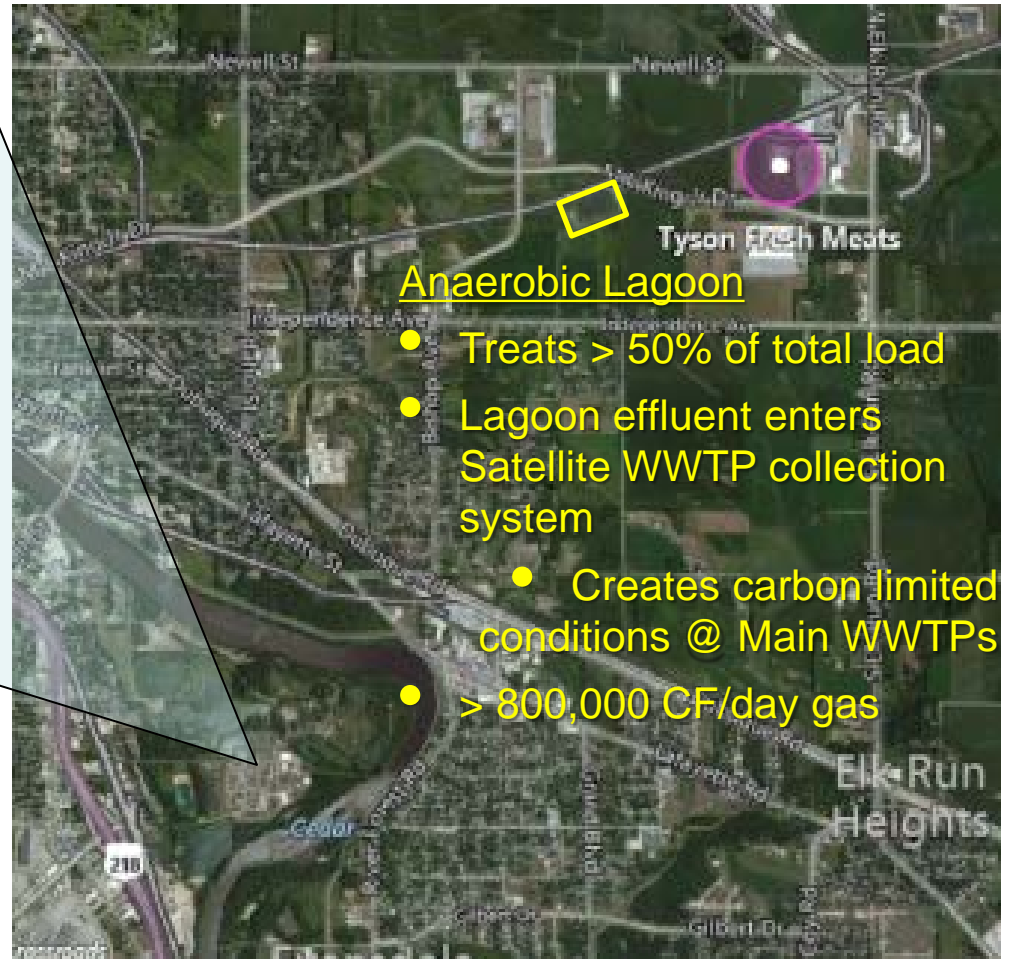
Fundamental: Nitrification and Denitrification – Historical Theory



Air Mixing Hinders
Denitrification



Waterloo Wastewater Facilities Includes Two Main WWTPs and Off-site Anaerobic Lagoon



Anaerobic Lagoon

- Treats > 50% of total load
- Lagoon effluent enters Satellite WWTP collection system
 - Creates carbon limited conditions @ Main WWTPs
- > 800,000 CF/day gas

Main WWTFs

- Easton WWTP (domestic)
- Satellite WWTP (industrial)

Two Separate Biological Units Easton & Satellite

**Satellite Facility
Designed to Accept
Designated Industrial
Waste only**



**Easton Facility
Designed to Accept
Domestic and Minor
Industrial Waste only**

**Current Mode of Operation was
To Combine the Waste and Treat
Only Thru the Easton Facility**

Existing WWTP Design Criteria

	Easton	Satellite	Combined
<u>Design Flow</u>			
Annual Average	20.4	6.7	27.1
Average Wet Weather	26.7	8.1	34.8
Peak Flow to Biological Treatment	36.0	11.1	47.1
<u>BOD Loading</u>			
Average Day	24,000	38,800	62,800
Maximum Month	30,000	58,000	88,000
<u>TKN Loading</u>			
Average Day	4,500	7,025	11,525
Maximum Month	7,500	13,550	21,050

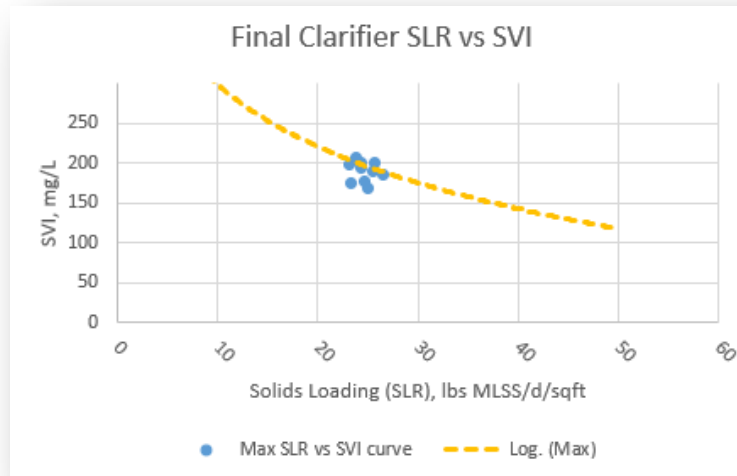
Treatment Capacity with Current Operation

	Current Value	Easton Plant Design	% of Easton Design Capacity
Combined Influent Flow, mgd			
Average Day	17.2	20.4	84%
Combined Influent Loads, lbs/day			
BOD ₅	28,645	24,000	119%
TSS	33,114	18,000	184%
TKN	8,241	4,500	183%

Satellite influent contribution:

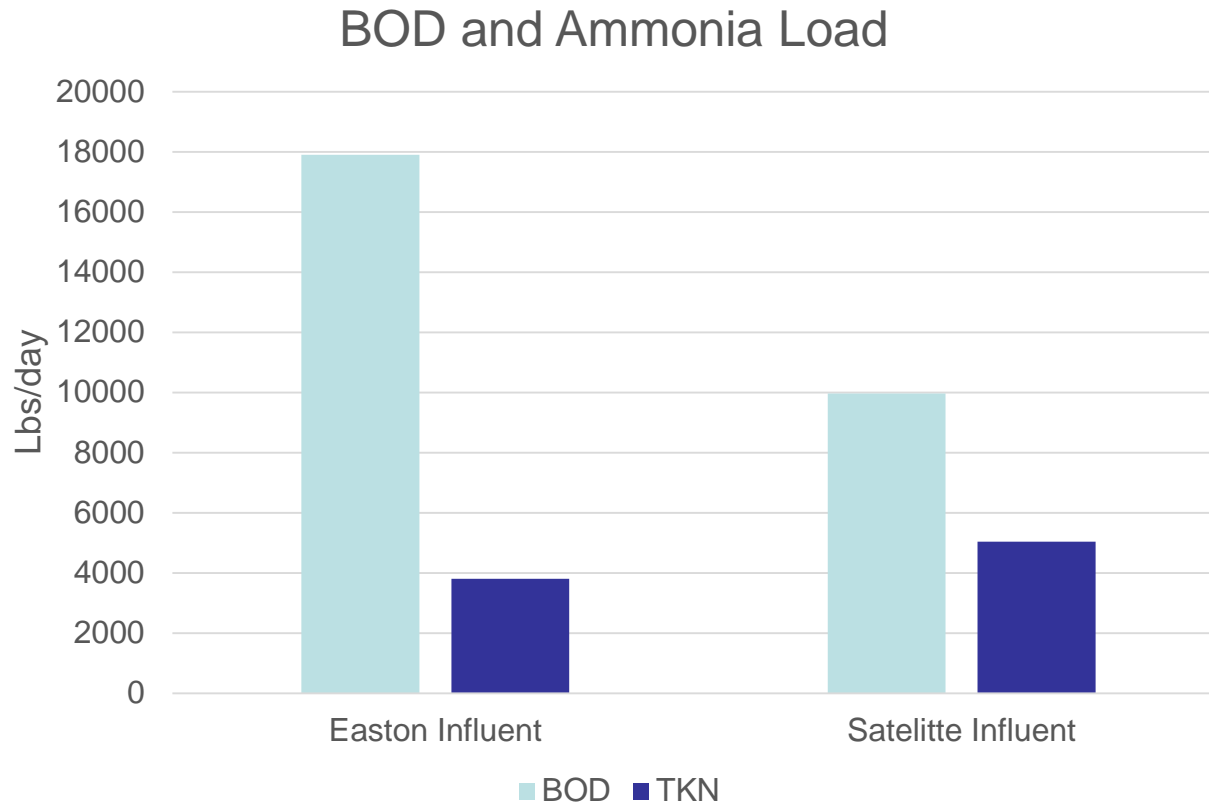
35% of BOD, 30% of TSS, and 60% of TKN

Challenges and Operational Responses



	A	B	HF	HU	HR	HI	HL	HP
5		Total	11213	86	8266	14180790	41184824	
6		Min	88.73	0.87	-4.66	0.00	0.00	
7		Max	207.60	0.69	72.61	712882.00	88888888	
8		Average	107.23	0.63	61.50	392487.31	119921.00	
9		Count	104	104	104	361	355	
10	← Click Plus to Expand							
15	Load Eff	Media Eff	RAU/WKS	Var 205	Var 207	Var 208	Var 209	Var 210
16	Set Eff	Comby Eff	Stat/Stat	Calc	Calc	Calc	Calc	Calc
17	Set Eff	Comby Eff	Stat/Stat	Calc	Calc	Calc	Calc	Calc
18	Set Eff	Comby Eff	Stat/Stat	Calc	Calc	Calc	Calc	Calc
19	Comby Eff	Stat/Stat	Calc	Calc	Calc	Calc	Calc	Calc
20	Comby Eff	Stat/Stat	Calc	Calc	Calc	Calc	Calc	Calc
200			F	%	%	%	GR	GR
801			5/9/2018					
802			5/10/2018					
803			5/11/2018					
804			5/12/2018					
805			5/13/2018					
806			5/14/2018					
807			5/15/2018					
808			5/16/2018					
809			5/17/2018					
810			5/18/2018					
811			5/19/2018					
812			5/20/2018					
813			5/21/2018					
814			5/22/2018					
815			5/23/2018					
816			5/24/2018					
817			5/25/2018					
818			5/26/2018					
819			5/27/2018					
820			5/28/2018					
821			5/29/2018					
822			5/30/2018					

Challenge: Nitrogen Load Ratio High From Industrial Sector

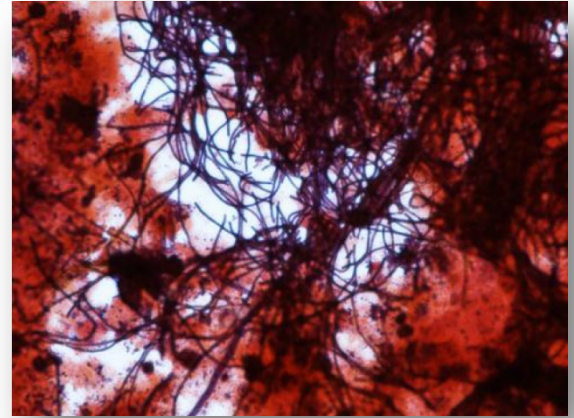


Challenge: Nitrification Alkalinity Demands Are Significant

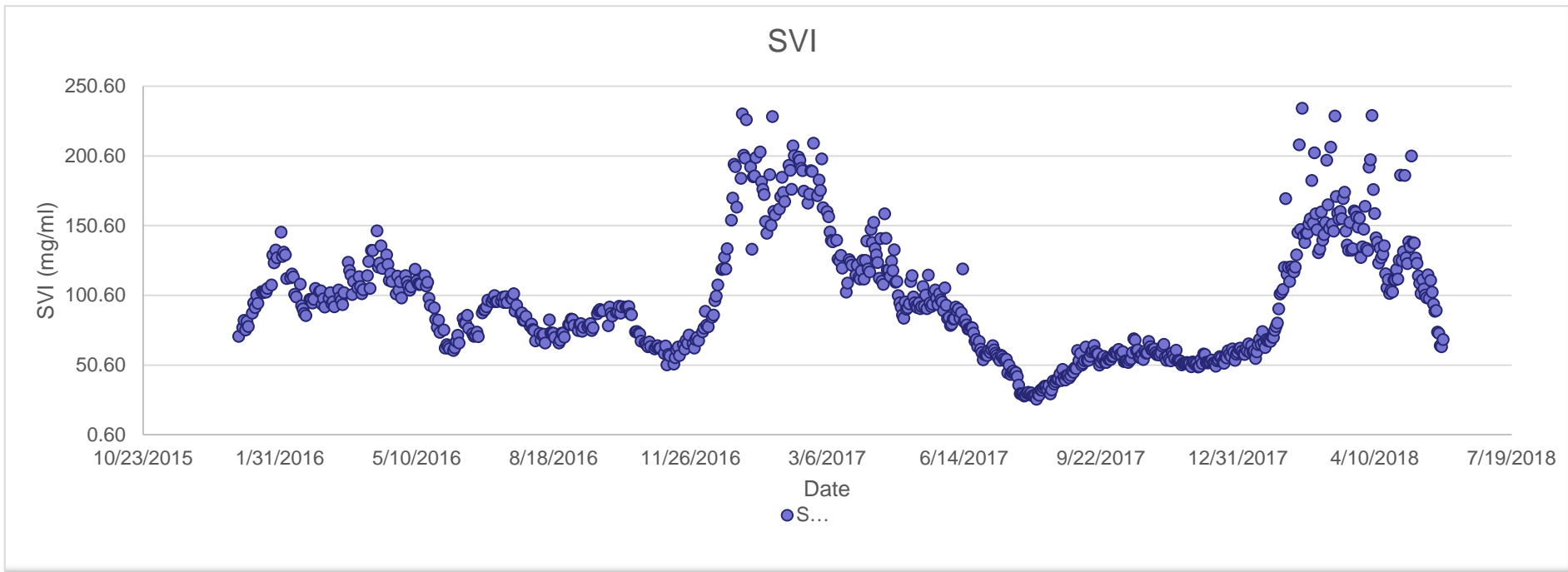
- Nitrogen Load – Alkalinity Balance Fragile
- Denitrification Rate Impacted by:
 - BOD:N Ratio
 - Aerated anoxic zone
- SOP to monitor alkalinity and supplement magnesium hydroxide necessary at times
 - pH <6.6 Add Magnesium Hydroxide
 - Alkalinity Minimums

	Alkalinity
Units	mg/L
5/15/2017	250
5/16/2017	225
5/18/2017	175
5/21/2017	200
5/23/2017	160
5/25/2017	165
6/5/2017	115
6/6/2017	165
6/8/2017	100

Challenge – Filaments: Microthrix



Settling Issues Occur in Winter



Operational Responses – Microscopy Assistance and Training

TO: BRIAN BOWMAN
FROM: TONI GLYMPH-MARTIN
SUBJECT: WATERLOO, IA – MICROSCOPIC EVALUATION
DATE: 8/2/2017



The following samples were collected on 7/31/17 and observed on 8/1/17:

- Mixed Liquor
- RAS

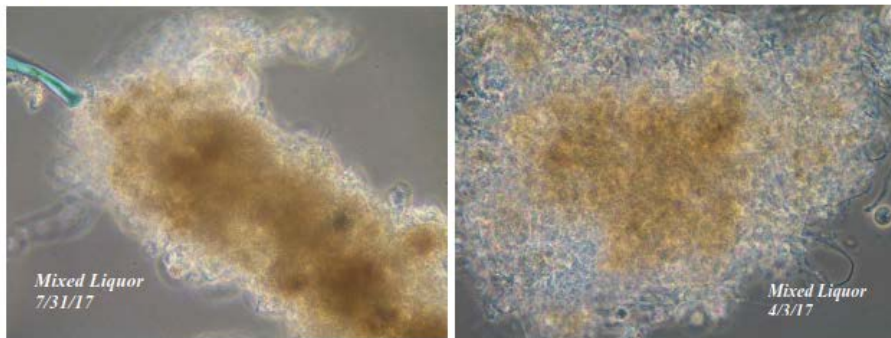
Observations:

Shelled amoebae were dominant in both the mixed liquor and the RAS samples. Only a small amount of filamentous bacteria was observed in the samples. Some exocellular lipopolysaccharide was observed within the floc in both samples however, the amount continues to decrease. Healthy active protozoa (stalked ciliates and crawling ciliates) were observed. Zoogleca was also present in both samples but not in significant amounts.

Discussion:

Exocellular lipopolysaccharide

The amount of exocellular lipopolysaccharide present in the mixed liquor and RAS samples continue to decrease when compared to the samples observed in April. Floc was a healthy brown color indicating that the plant is operating at a sufficient F/M ratio and that sufficient nutrients are present.

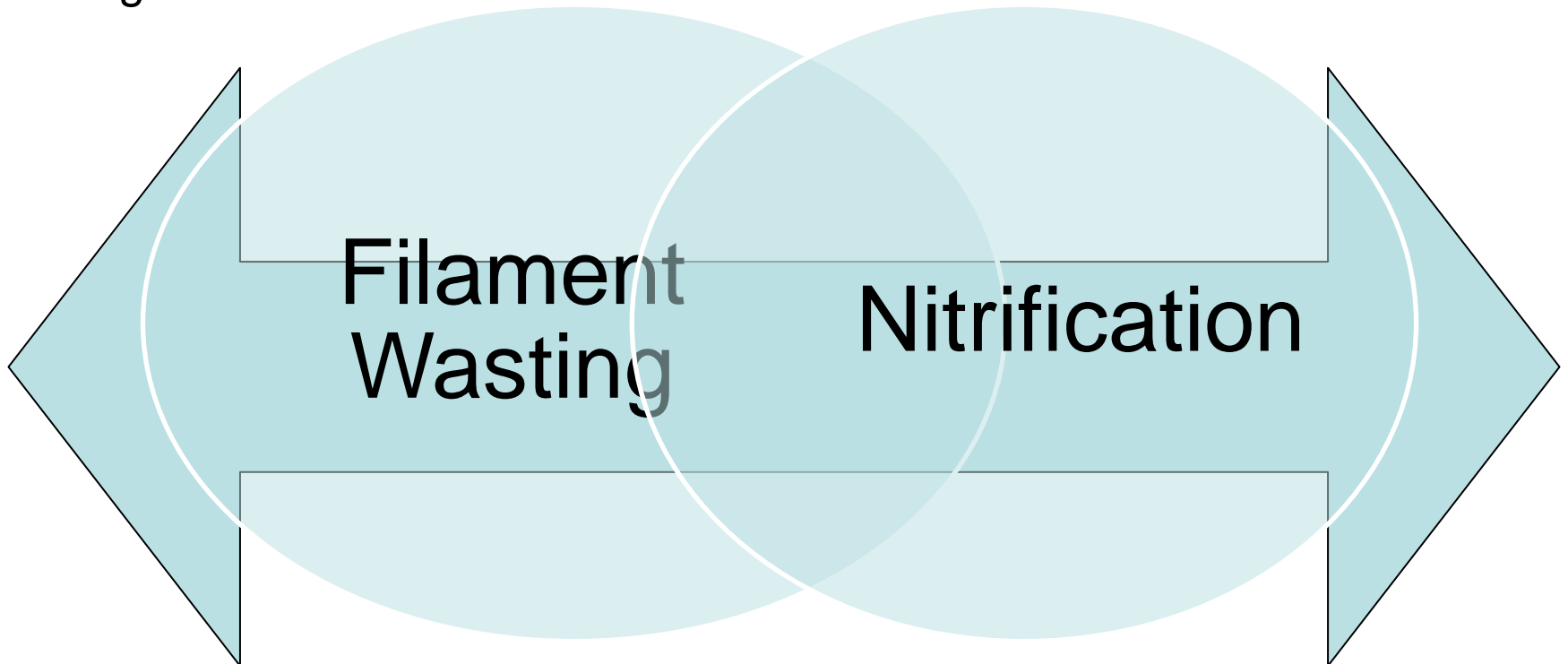


Operational Responses – Operational Adjustments

- Capacity in service
- Wasting rate sludge age based on filament elimination
- WAS decant
- FOG program continues to be a point of emphasis
- Lagoon management to equalize flows/loads as practical
- DO control an operator emphasis

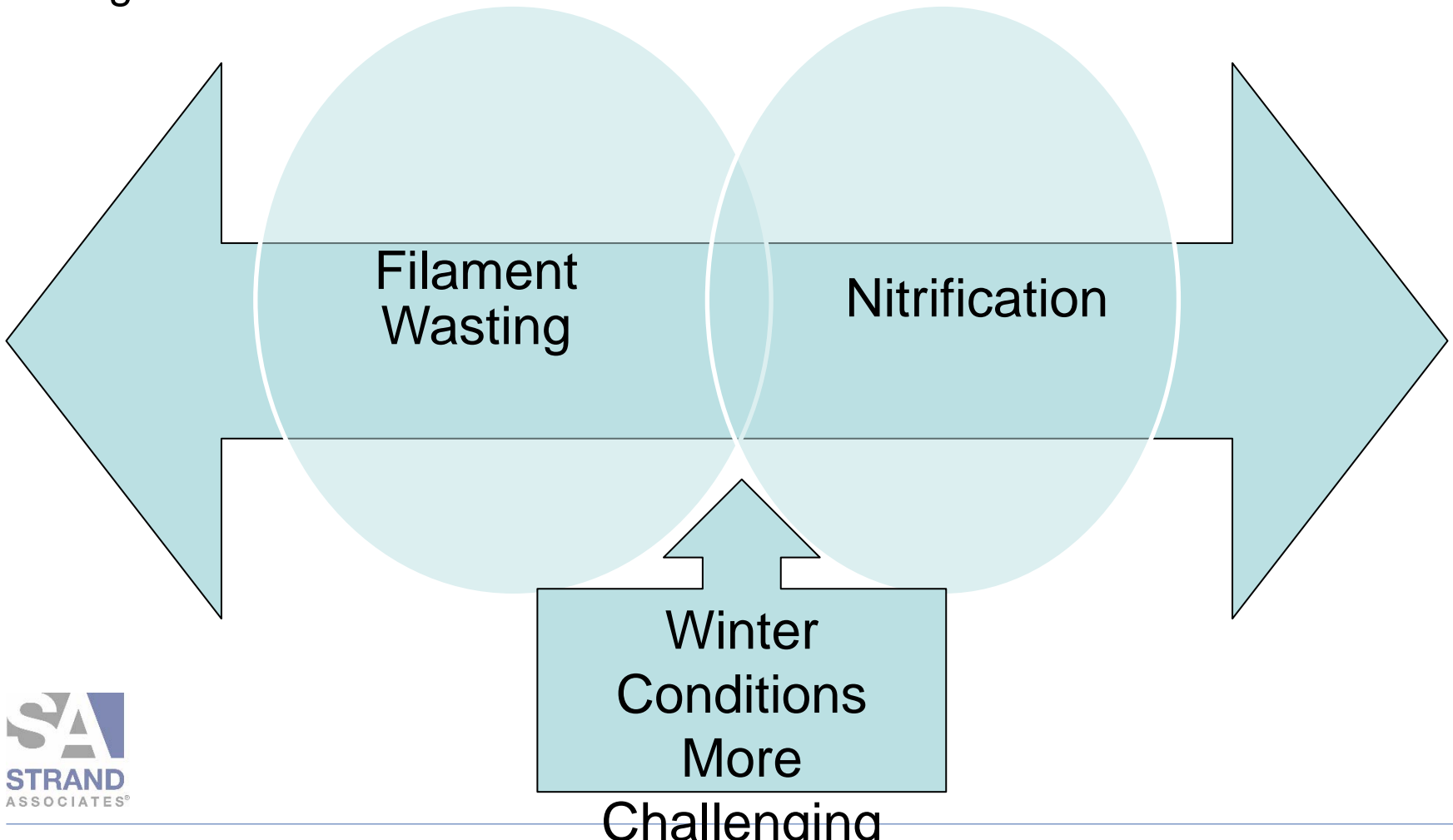
Nitrification and Filament Reduction have Different Ideal Sludge Ages

- Lower Benefits Filament Removal
- Higher Benefits Nitrification

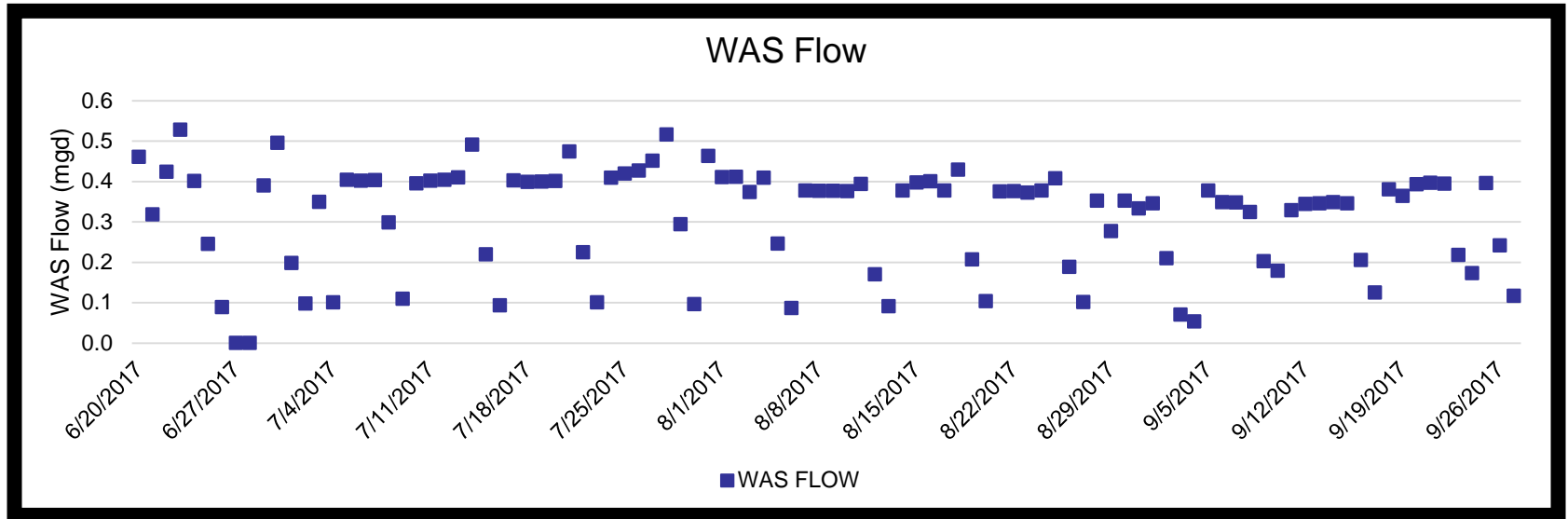


Nitrification and Filament Reduction have Different Ideal Sludge Ages

- Lower Benefits Filament Removal
- Higher Benefits Nitrification



Challenge – Wasting Limitations



**Current WAS
Storage
Limits Operations**

Operational Response: WAS Storage Tank Decant Automation



Air Valve Original



WAS Tank 3, Air Off

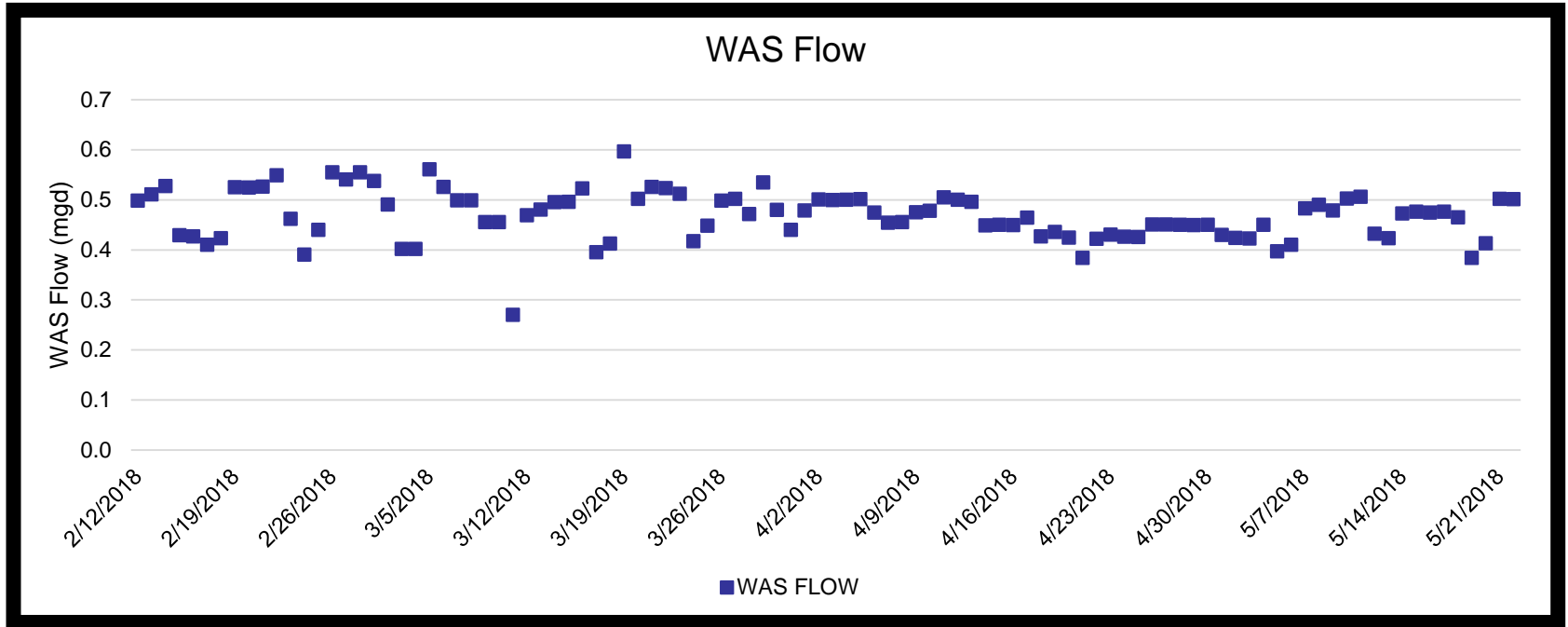


Valve Automated



Automated Valve Tied to Tank Level

Operational Response: Weekend Wasting a Priority



Challenge - Data Collected In Monthly Sheets

Reports 2009	4/25/2017 8:42 AM	File folder
Reports 2010	4/25/2017 8:42 AM	File folder
Reports 2011	4/25/2017 8:42 AM	File folder
Reports 2012	4/25/2017 8:42 AM	File folder
Reports 2013	4/25/2017 8:42 AM	File folder
Reports 2014	7/19/2017 10:40 AM	File folder
Reports 2015	2/5/2018 2:35 PM	File folder
Reports 2016	10/9/2017 3:46 PM	File folder
Reports 2017	7/3/2017 9:28 AM	File folder

DNR 2009.xls	3/12/2010 8:49 AM	Microsoft Excel 97...	535 KB
Easton Performance 2009.xls	2/15/2017 2:37 PM	Microsoft Excel 97...	724 KB
Industry 2009.xls	1/26/2010 12:06 PM	Microsoft Excel 97...	874 KB
Landfill 2009.xls	1/20/2010 10:06 AM	Microsoft Excel 97...	70 KB
Sludge 2009.xls	1/12/2010 10:11 AM	Microsoft Excel 97...	379 KB

!	5	0.101	0.000
!	5	0.146	0.000
Sept 2009	Oct 2009	Nov 2009	Dec 2009

Operational Responses - Existing Spreadsheets Combined for Comprehensive View

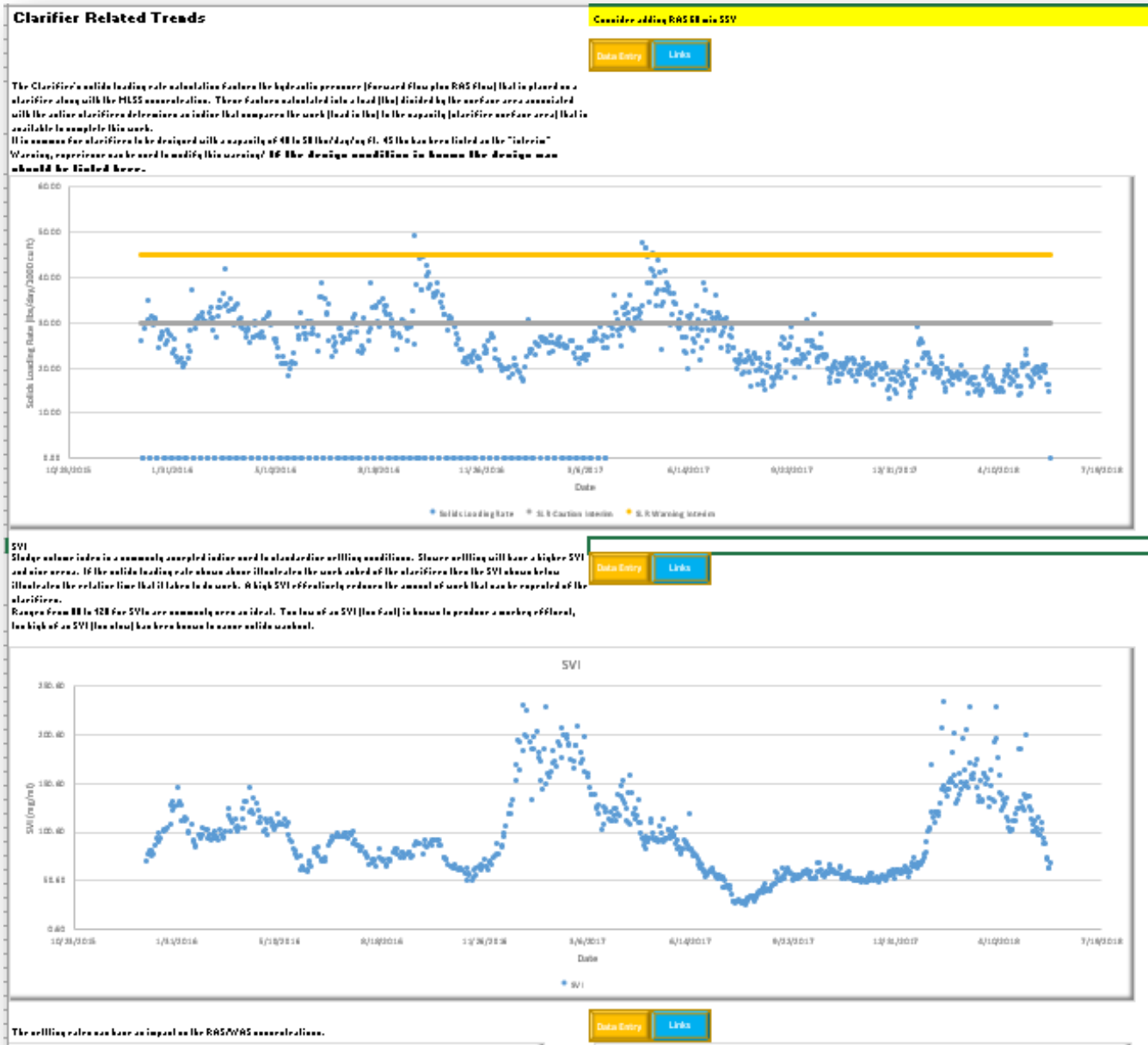
- ~200 Variables
- Buttons to minimize random searching for information.

	A	B	HF	HG	HH	HI	HJ	HK
5		Total	11213	66	5356	141680700	41155524	
6	Home	Links	Min	85.73	0.57	-4.66	0.00	0.00
7			Max	207.60	0.69	72.51	712582.00	#####
8			Average	107.82	0.63	51.50	392467.31	115931.05
9	<-- Click Plus to Expand		Count	104	104	104	361	355
15	East Inf	Metals Eff	RAS/WAS	Var 206	Var 207	Var 208	Var 209	Var 210
16	East Eff		Primaries	Dig Calcs	Dig Calcs	Dig Calcs	F. B Data	F. B Data
17	Sat Inf	Comb Eff Statistics	TAS	CALCULATIONS			F.B DATA	
18	Sat Eff		Digesters	AVG TEMP	TANK 2BELT VOL%	VOL % REDUCTION	THK SLDG	FB SLDG
19	Comb Inf	EQ OF	Limits					
20	Comb Eff	AB 1-4		F	%	%	Gal	Gal
880		5/9/2018						
881		5/10/2018						
882		5/11/2018						
883		5/12/2018						
884		5/13/2018						
885		5/14/2018						
886		5/15/2018						
887		5/16/2018						
888		5/17/2018						
889		5/18/2018						
890		5/19/2018						
891		5/20/2018						
892		5/21/2018						
893		5/22/2018						
894		5/23/2018						
895		5/24/2018						
896		5/25/2018						
897		5/26/2018						
898		5/27/2018						
899		5/28/2018						
900		5/29/2018						
901		5/30/2018						
902								
903								

Spreadsheet Hyperlinks Limit Issues with Spreadsheet Size

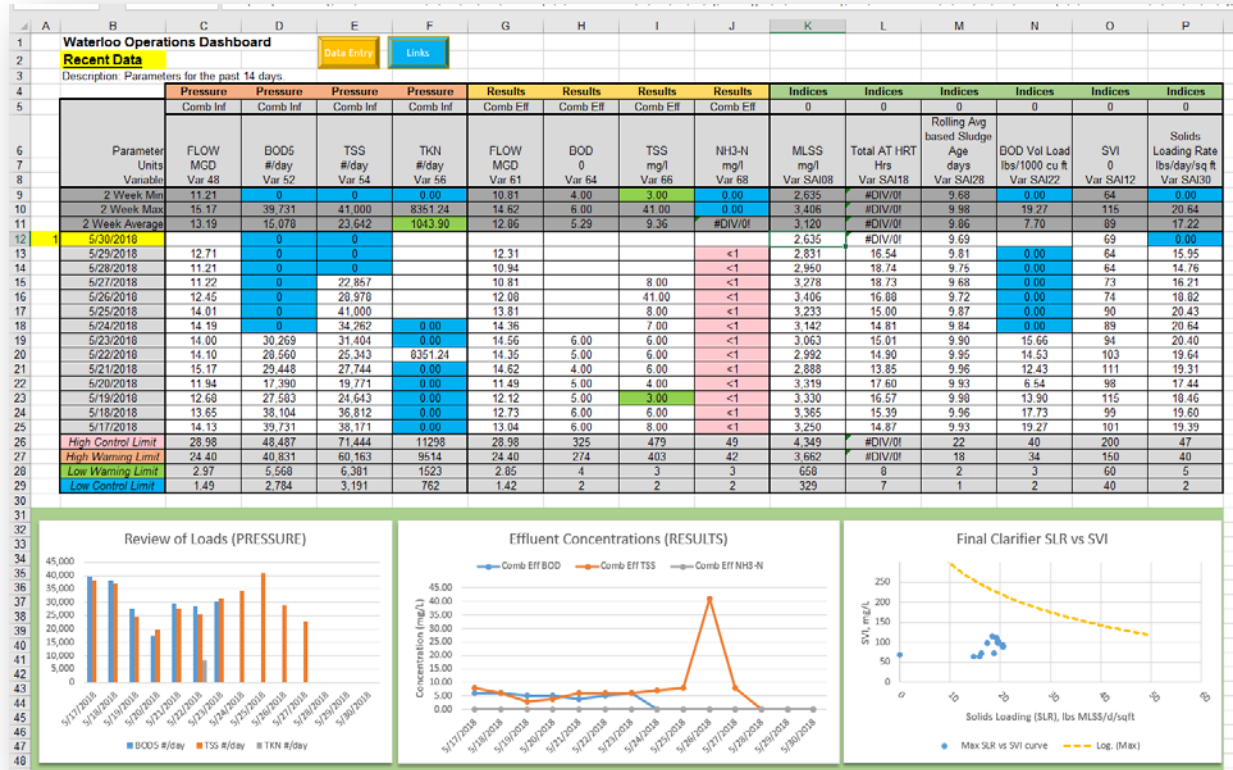
	A	B	C	D	E	F
1	Waterloo Operations Spreadsheet Hyperlink Table					
2						
3	<u>DASHBOARDS</u>	<u>DATA ENTRY</u>			<u>FIGURES</u>	
4					<i>click chart name to jump directly to specific charts</i>	
5	Dashboard	Data Entry Home		Flows and Loads	Clarifier Considerations	Performance
6	Wasting Dashboard	East Inf	EQ OF	Influent Flows and Loads	Solids Loading Rate	Effluent BOD and TSS
7	100 Day Highlights	East Eff	AB 1-4	Influent versus Effluent Flow	SVI	SVI
8		Sat Inf	RAS/WAS	Effluent, RAS, WAS Flow	RAS vs SVI	Effluent Nitrogen
9		Sat Eff	Primaries	Influent BOD Load	MLSS vs RAS SS	
10		Comb Inf	TAS	Influent TKN Load	Blanket Depth	
11		Comb Eff	Digesters	Influent BOD Load vs Influent Load		
12		Metals Eff	Limits	Units in Service		
13		Comb Eff Statistics		Wasting Considerations	Nitrification	SLR vs SVI
14				Solids Inventory	HRT vs Eff NH3	
15				Percent Volatile	Solids Inventory vs Eff NH3	
16				Sludge Age vs SVI	Sludge Age vs Eff NH3	
17				Sludge Age	pH vs Eff NH3	
18				F:M Ratio	Temperature vs Eff NH3	
19				MLSS Concentration	Influent Load vs Eff NH3	
20					Vol Load vs Eff NH3	
21					Volumetric Loading	
22						
23						
24						

Spreadsheet Develops Correlation



Dashboards Allow Quick Reference

- Key Indices
 - Performance
 - Wasting
 - 100 Day Troubleshooter
- Date Adjustable



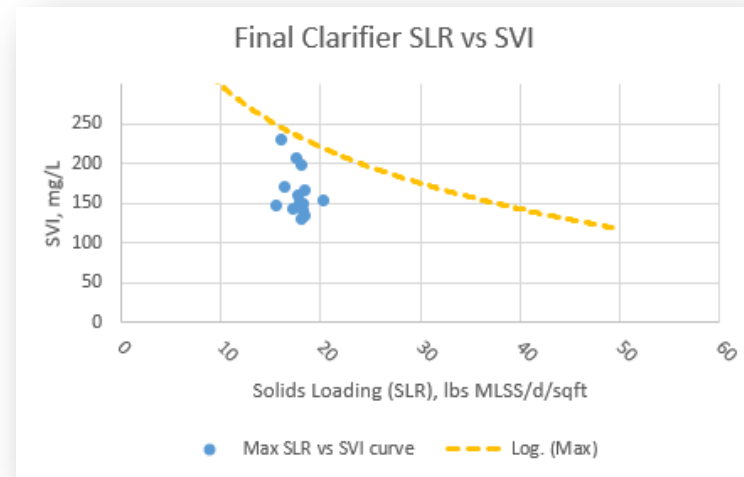
Use of Functions Allows “Dashboard” Functionality

	A	B	C
17			0
18		Parameter	BOD Vol Load
19		Units	lbs/1000 cu ft
20		Variable	Var SAI22
21		2 Week Min	6.07
22		2 Week Max	22.76
23		2 Week Average	14.90
24	Date Offset	20	5/13/2018
25			5/12/2018

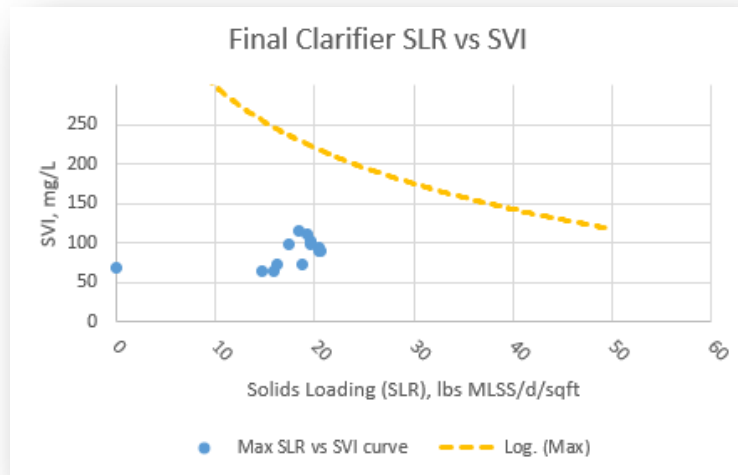
Formula in C24...

=VLOOKUP(\$B24,'Data Sheet'!\$B\$21:\$HJ\$901, MATCH(C\$20,'Data Sheet'!\$B\$15:\$HJ\$15,0),FALSE)

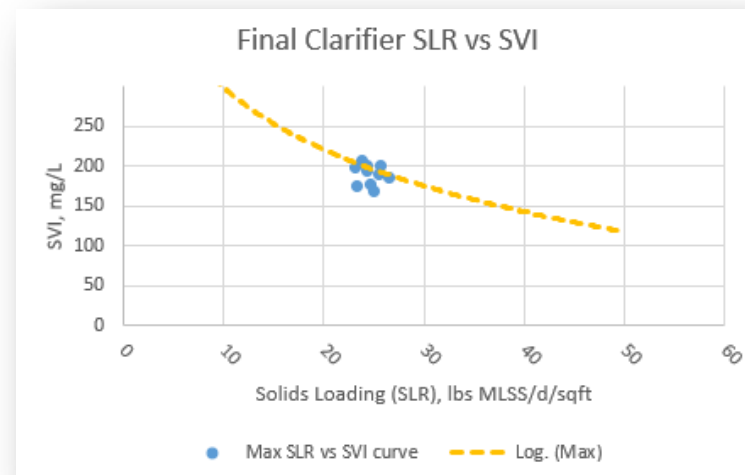
Dashboards Provide Quick Reference to Stress



March 2018

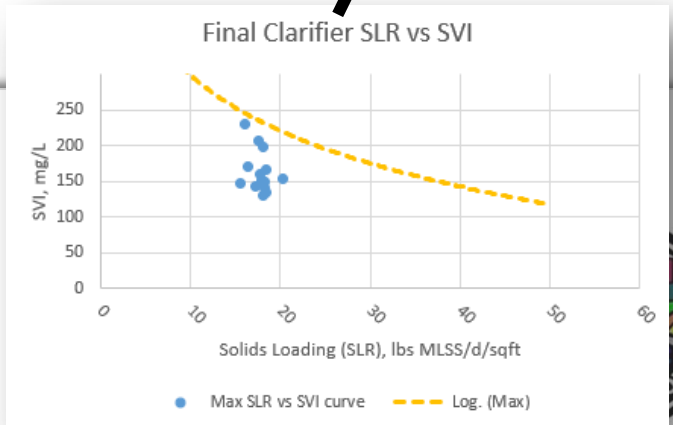
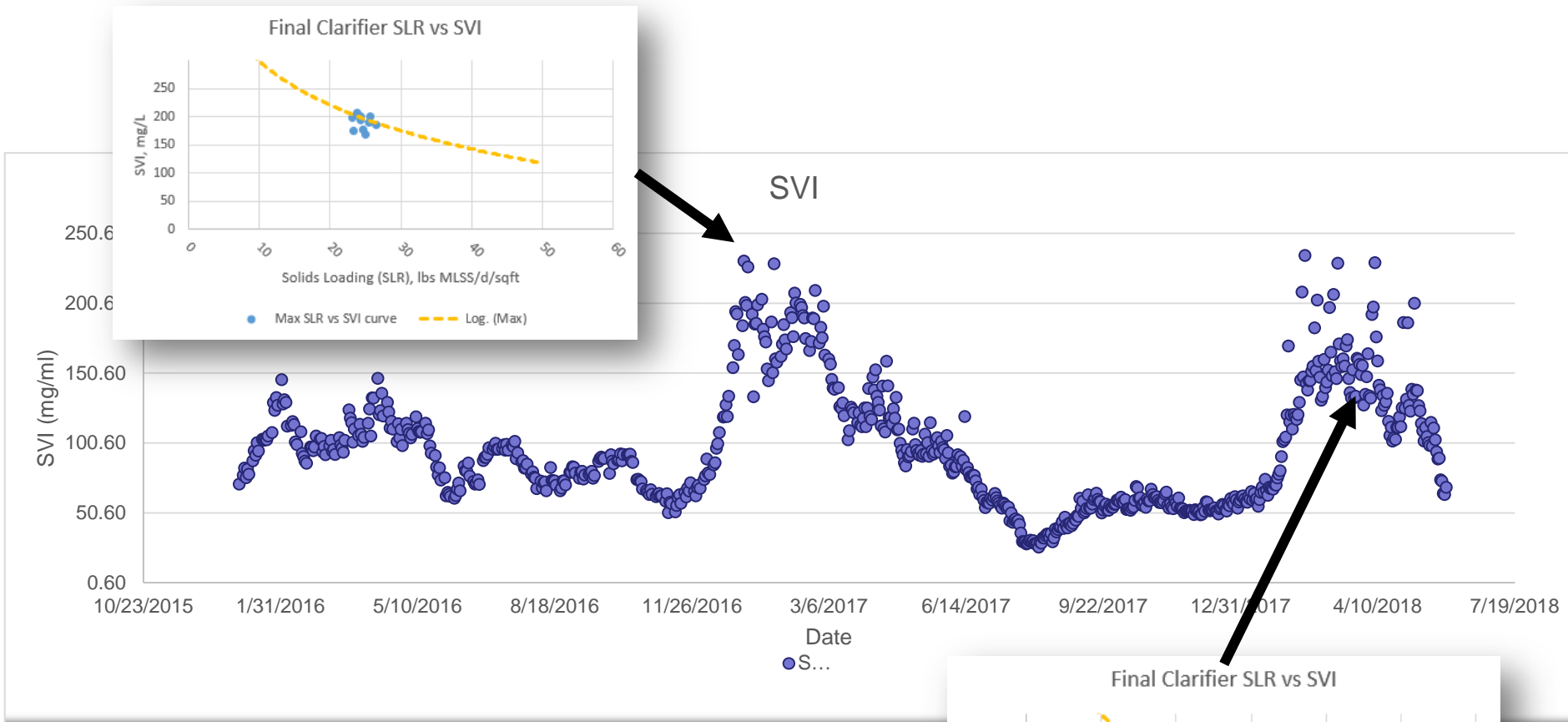


May 2018



February 2017

Spreadsheet Develops Correlation

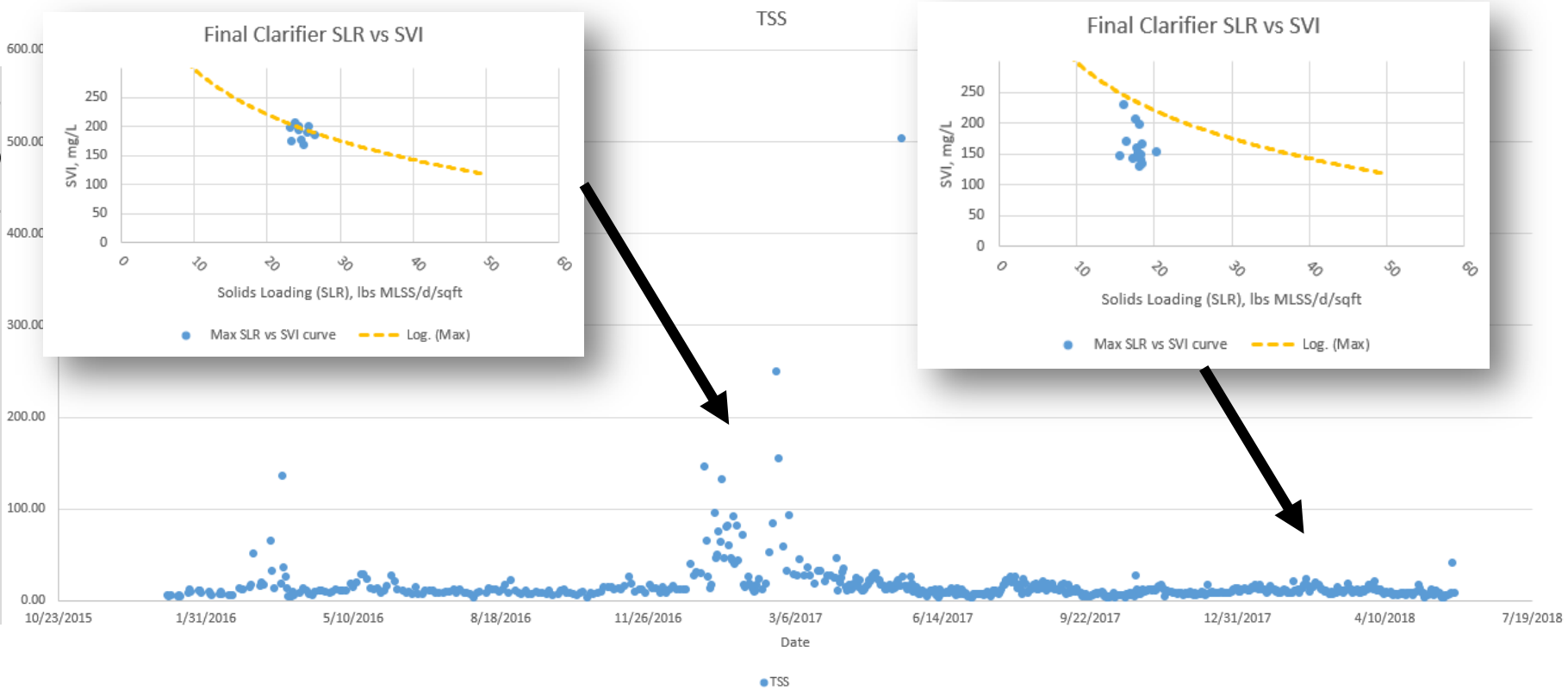


Spreadsheet Develops Correlation

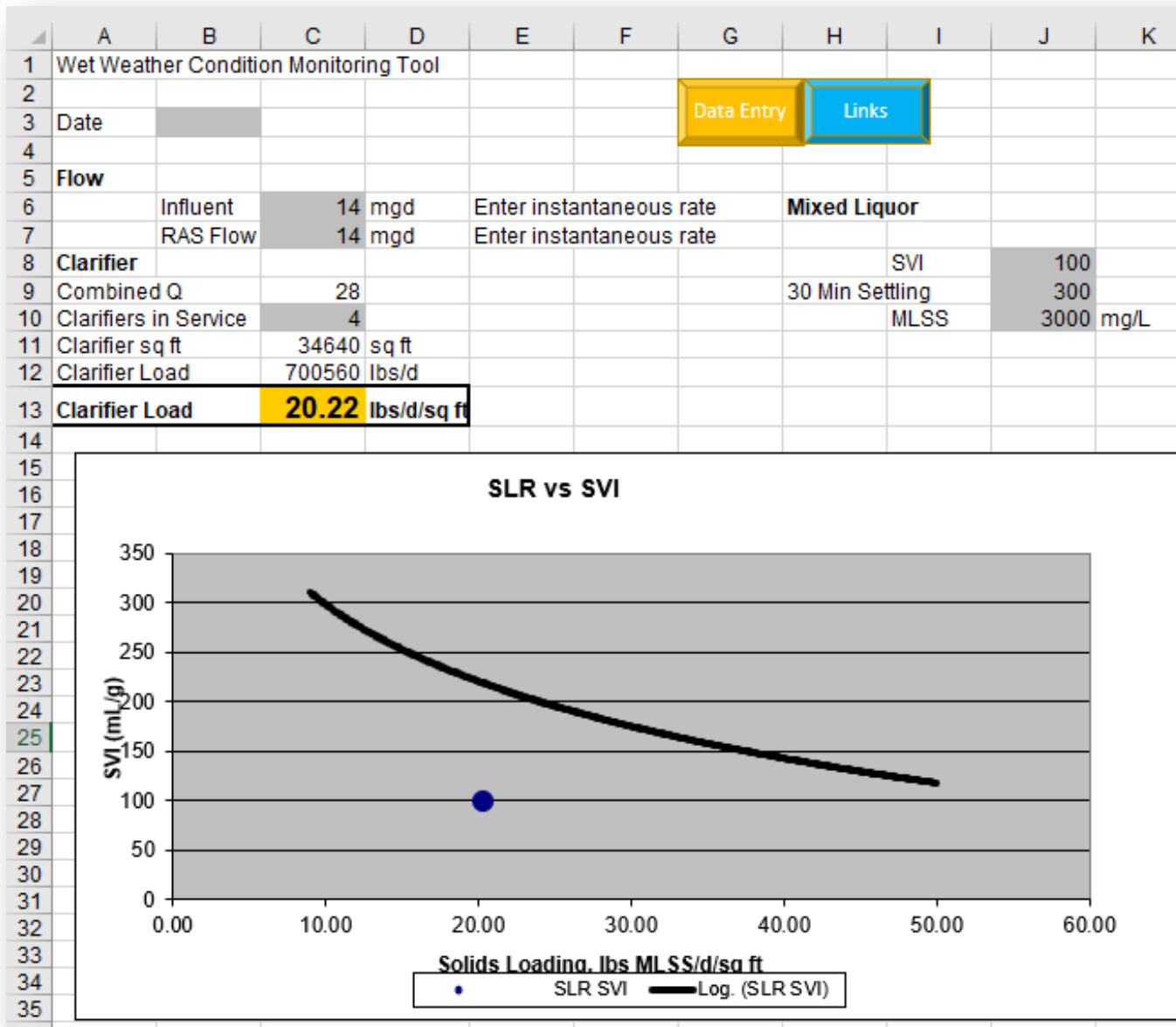
February 2017

March 2018

TSS Concentration (mg/L)

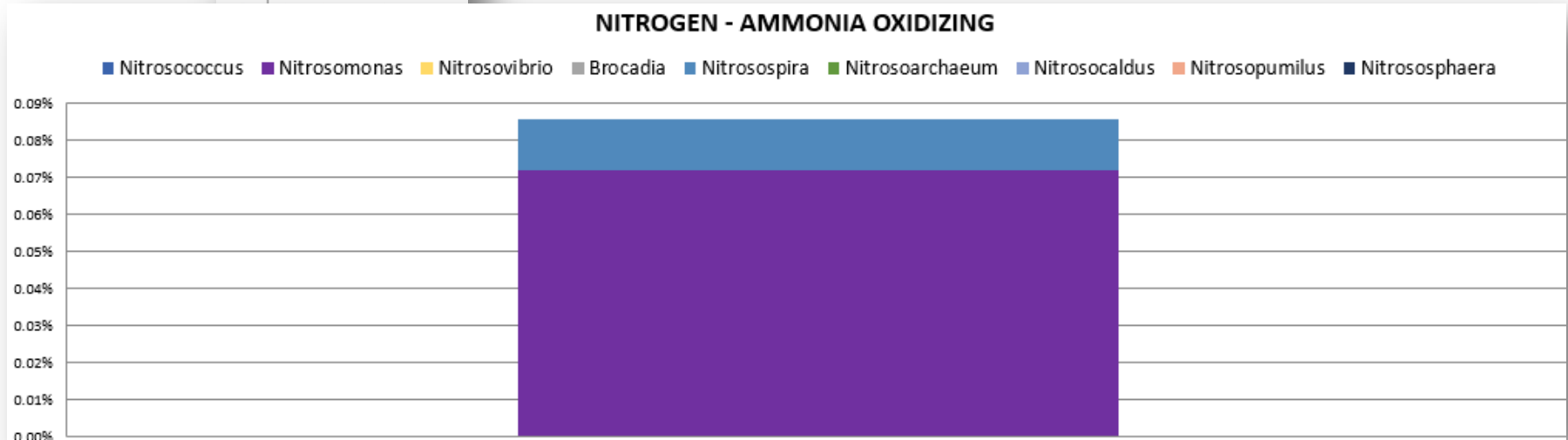


Spreadsheet Allows for “What If” Scenarios



Future Objectives Review of DNA of Activated Sludge

1	Acinetobacter
	8.79%
2	Thermomonas
	6.10%
3	Brevundimonas
	6.01%
4	Rhodobacter
	4.75%
5	Xanthomonas
	4.10%



Summary and Conclusions

- Upgrades should provide more flexibility
- Issues greater in winter
- Flows impact success
- Monitoring and data interpretation important
- Wasting key for multiple reasons



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