SESSION 3:
CHAT QUESTION OF THE DAY:

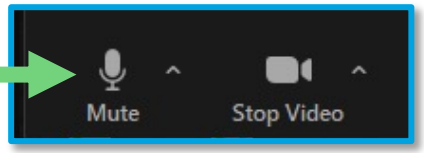
WHAT IS YOUR FAVORITE THING ABOUT SPRINGTIME??

Using Zoom!

Mute yourself!

Have a question?
Use the chat feature.

Controls accessed at the bottom



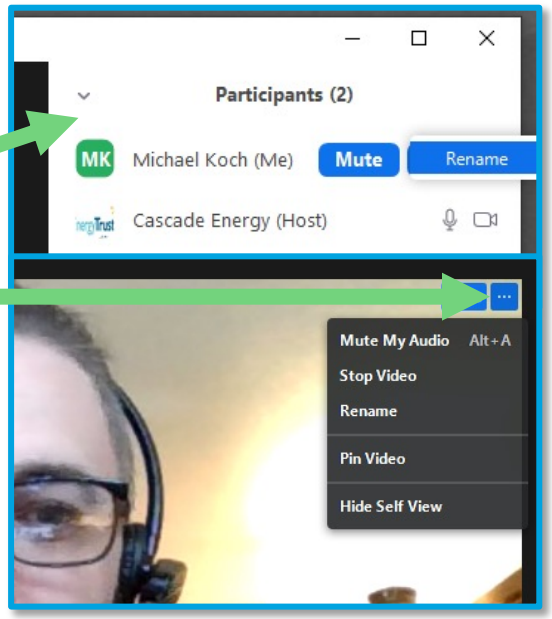
Rename yourself

"Name (Company)"

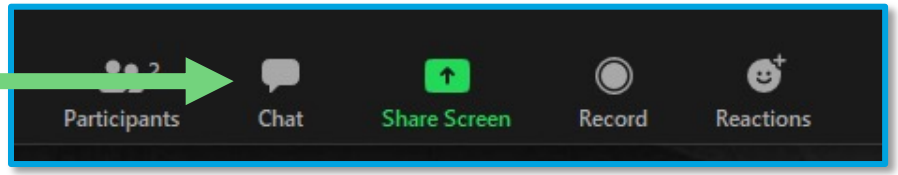
Right click on your picture or 3 dots

OR

Controls accessed at the right after clicking 'Participants' at bottom.



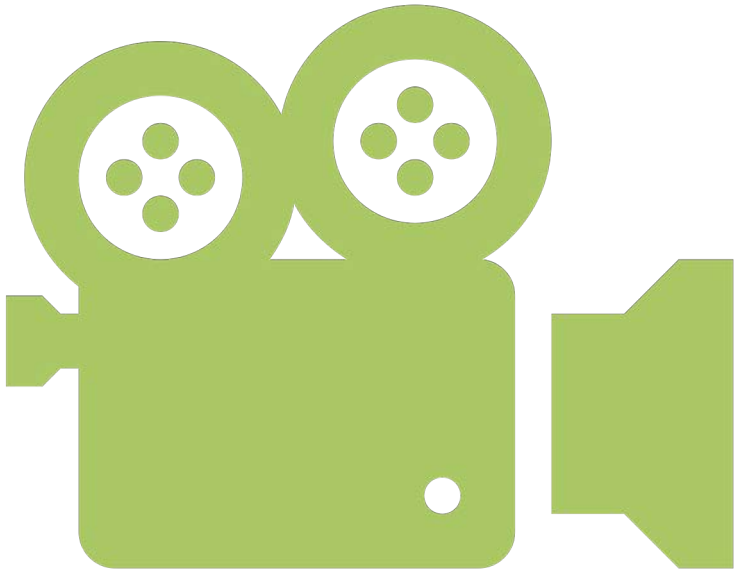
Access Chat at the bottom



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.



Better Plants
U.S. DEPARTMENT OF ENERGY

VIRTUAL WASTEWATER INPLT
SESSION 3

UNDERSTANDING PRIMARY CLARIFICATION

U.S. DEPARTMENT OF ENERGY

Thank You to Our Sponsor!

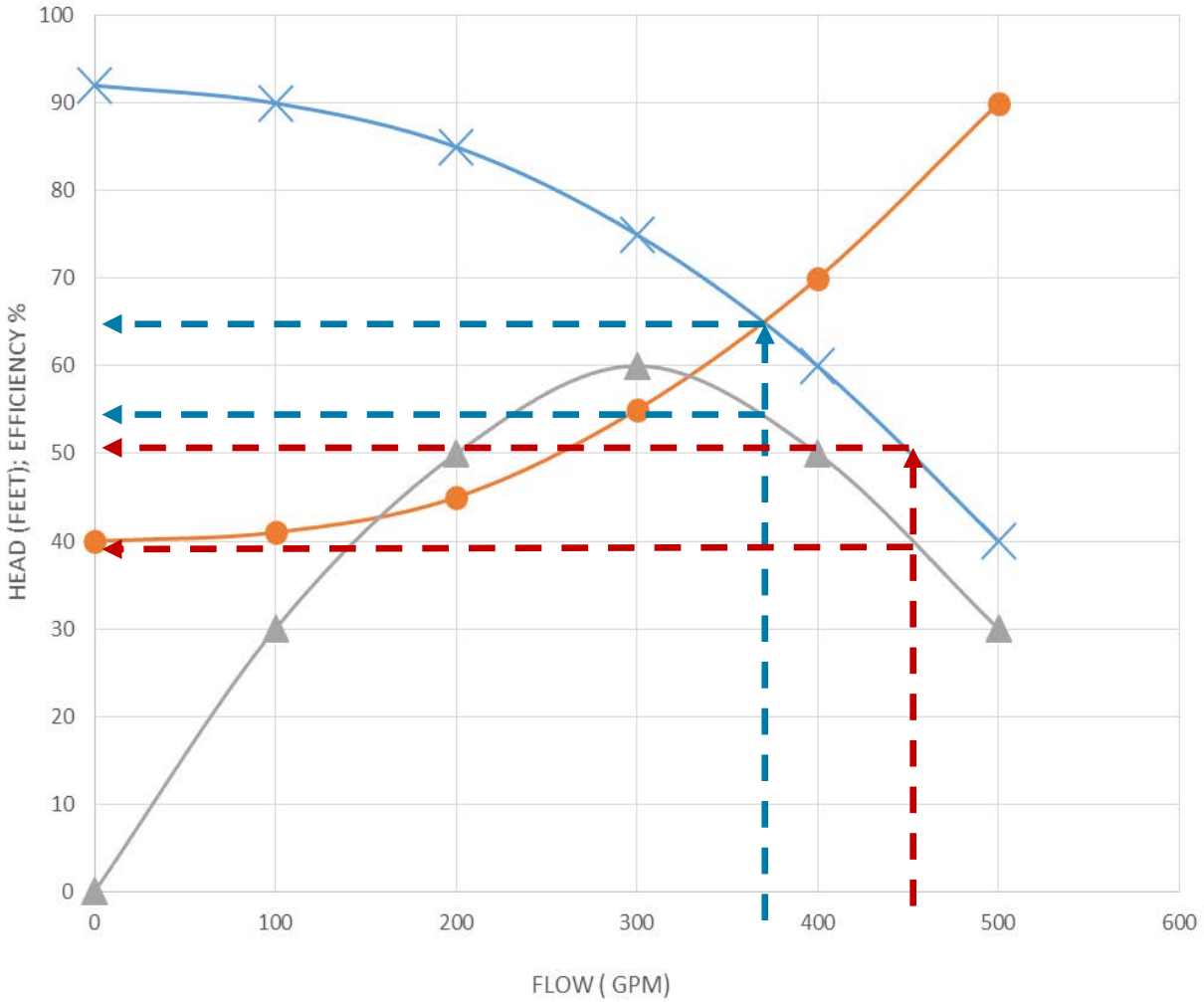
Today's Agenda

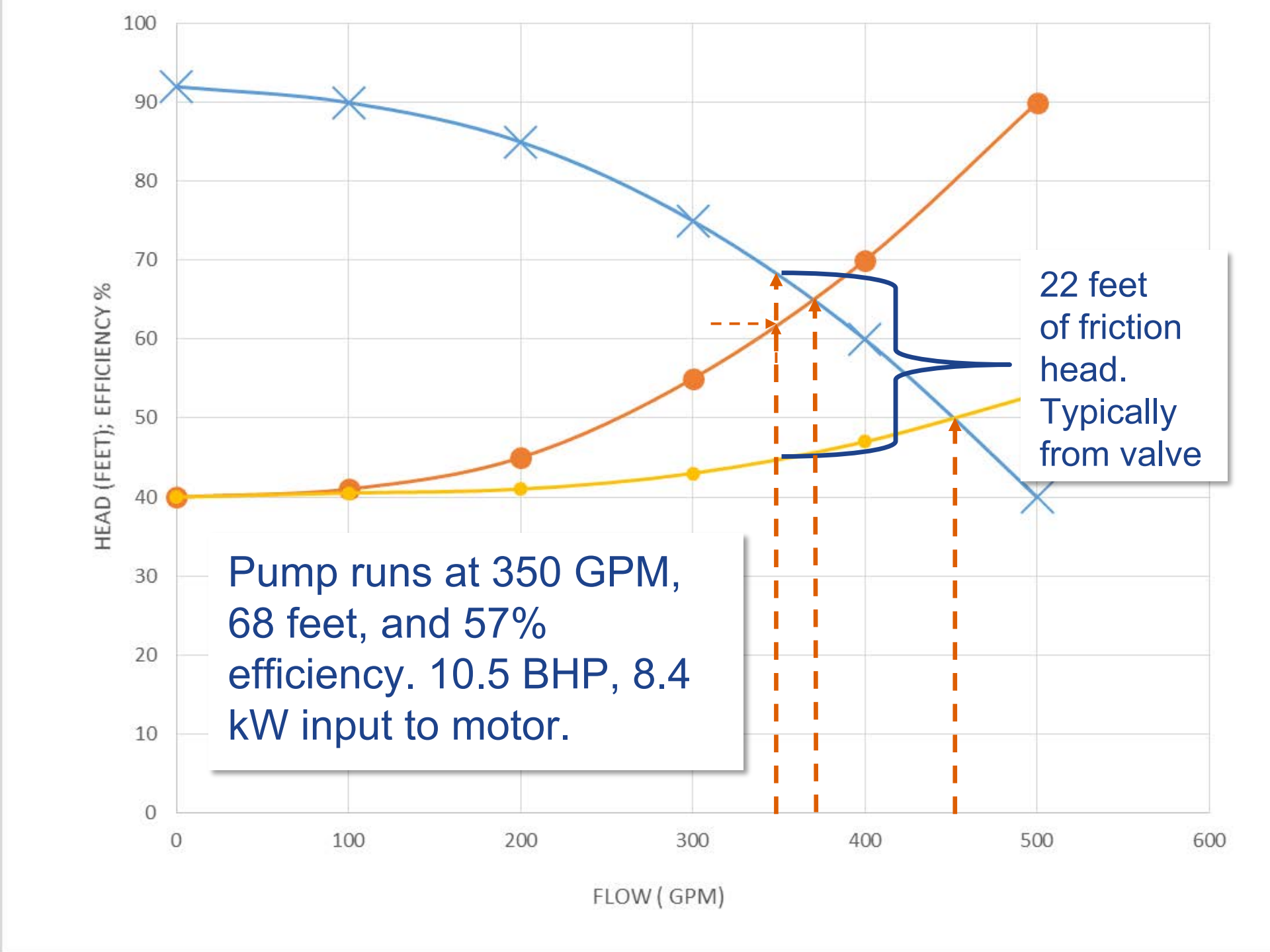
- Welcome/Opening
- Old Homework Review
- Headworks & Disenfection
- Break
- Primary Solids & Clarification
- New Homework Review
- Energy & PD Blowers
- Wrap-up

Desired Flow Rate: 350 GPM
Discharge elevation 475 ft.
Wet-well water level: 435 ft

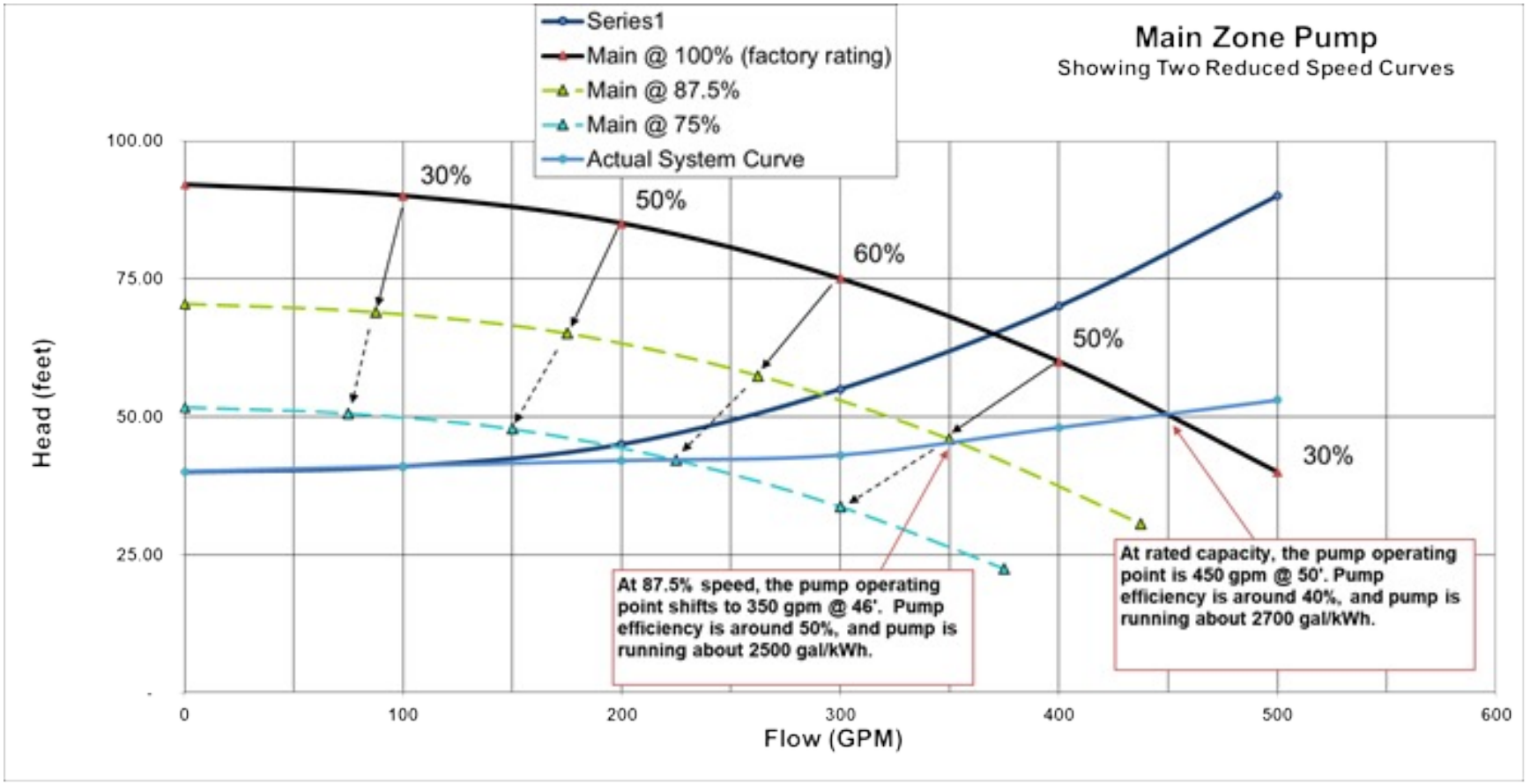
Frictional Headloss calculations

150 GPM = 3 foot
250 GPM = 9 feet
350 GPM = 20 feet
450 GPM = 40 feet
500 GPM = 50 feet




100
90
80
70
60
50
40
30
20
10
0
HEAD (FEET); EFFICIENCY %
0
100
200
300
400
500
600
FLOW (GPM)
22 feet of friction head. Typically from valve
Pump runs at 350 GPM, 68 feet, and 57% efficiency. 10.5 BHP, 8.4 kW input to motor.

Homework Review



Review

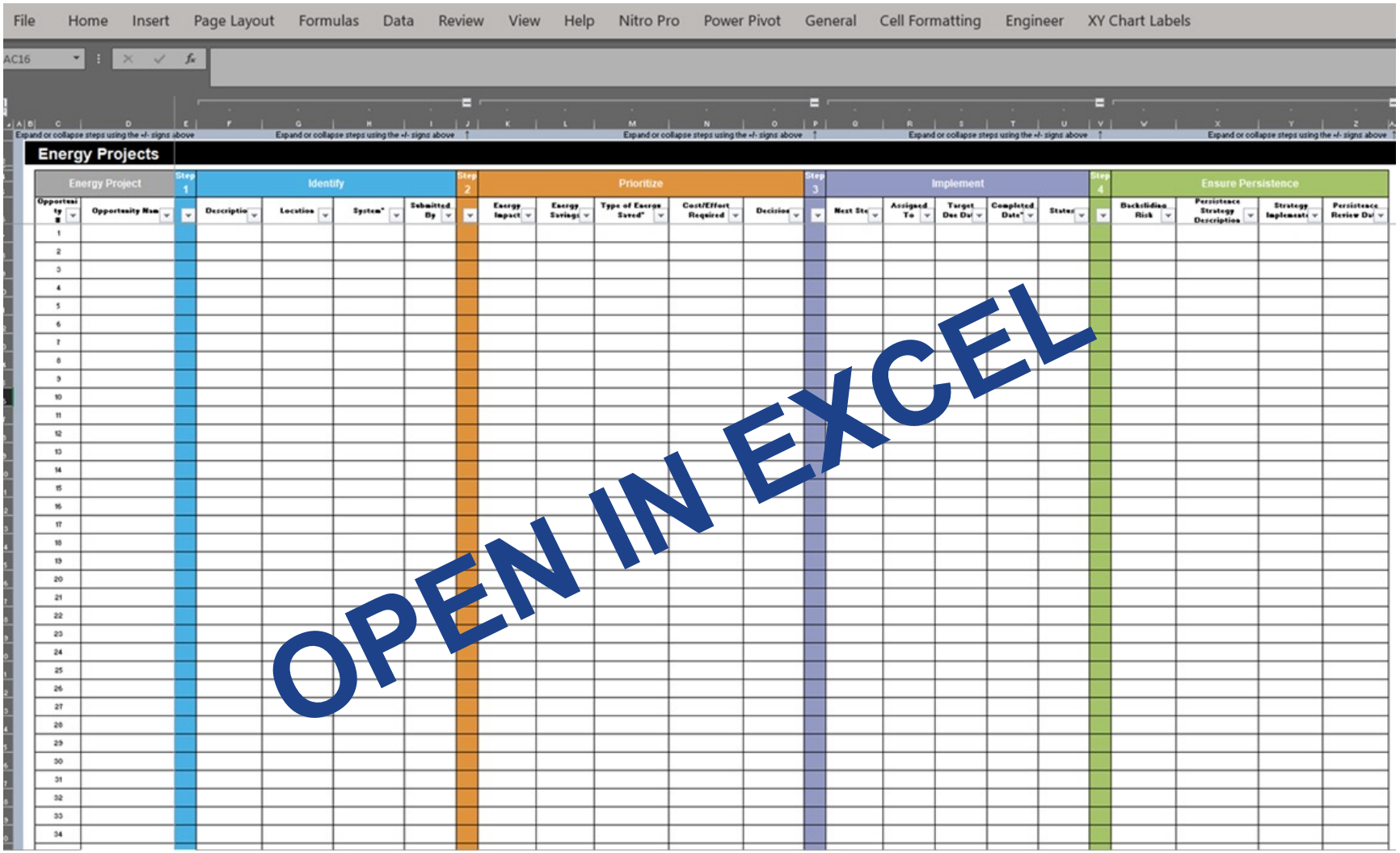
Condition	Flow (gpm)	Head (ft)	Operating kW	kWh/MG	GPM / kW
Desired	350	62			
Selected	370	65			
Installed	450	50			
Throttled	350	68			
VFD	350	46			

$$BHP = \frac{Q * H}{3960 * \eta}$$

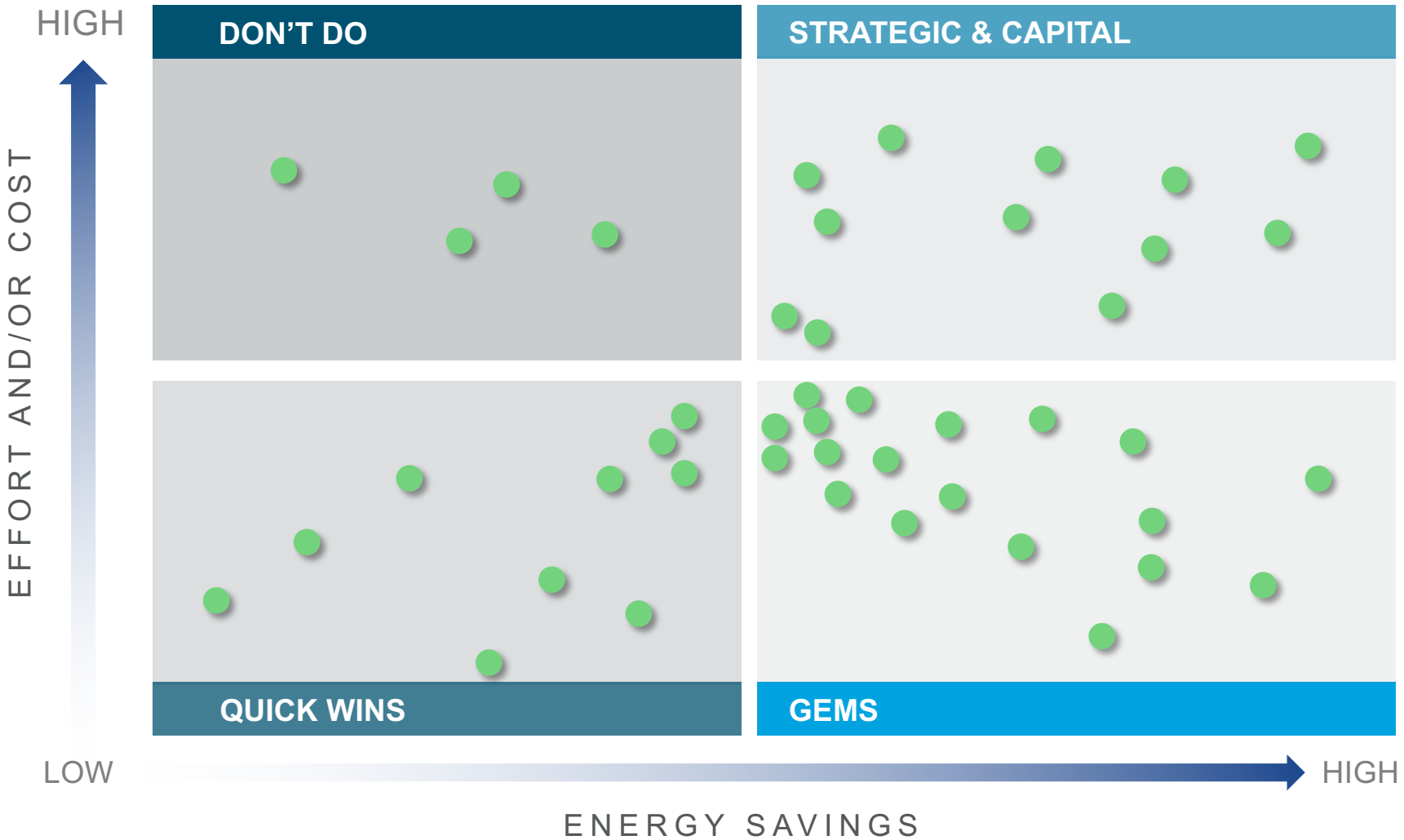
$$\text{MotorPower(kW)} = \text{MotorPower(hp)} * \frac{0.746\ \text{kW}}{\text{hp}}$$

$$MotorPower\,(hp) = \frac{Power\,(BHP)}{\eta_{motor}}$$

Opportunity Register



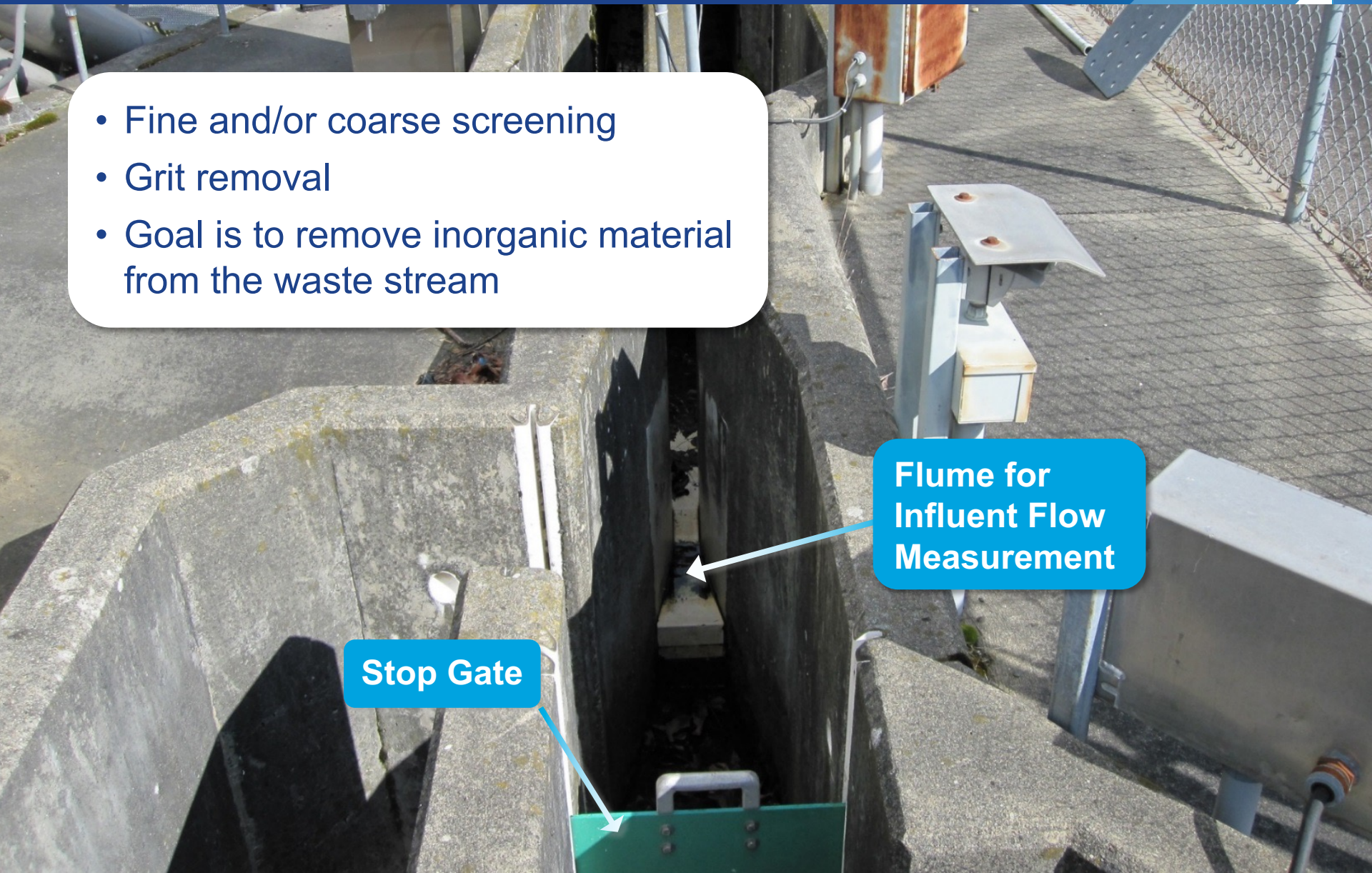
Value Matrix



HEADWORKS

Headworks

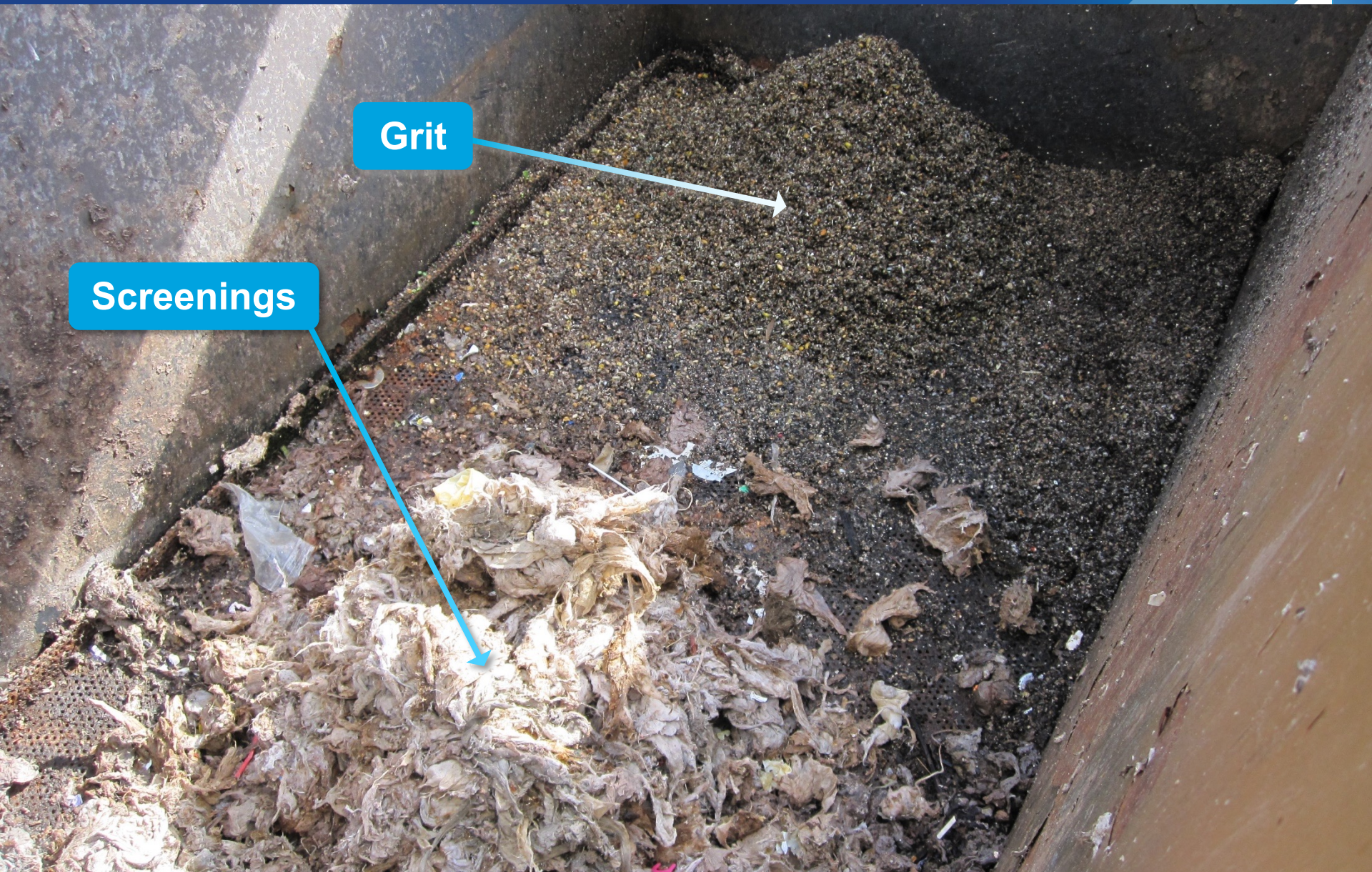
- Fine and/or coarse screening
- Grit removal
- Goal is to remove inorganic material from the waste stream



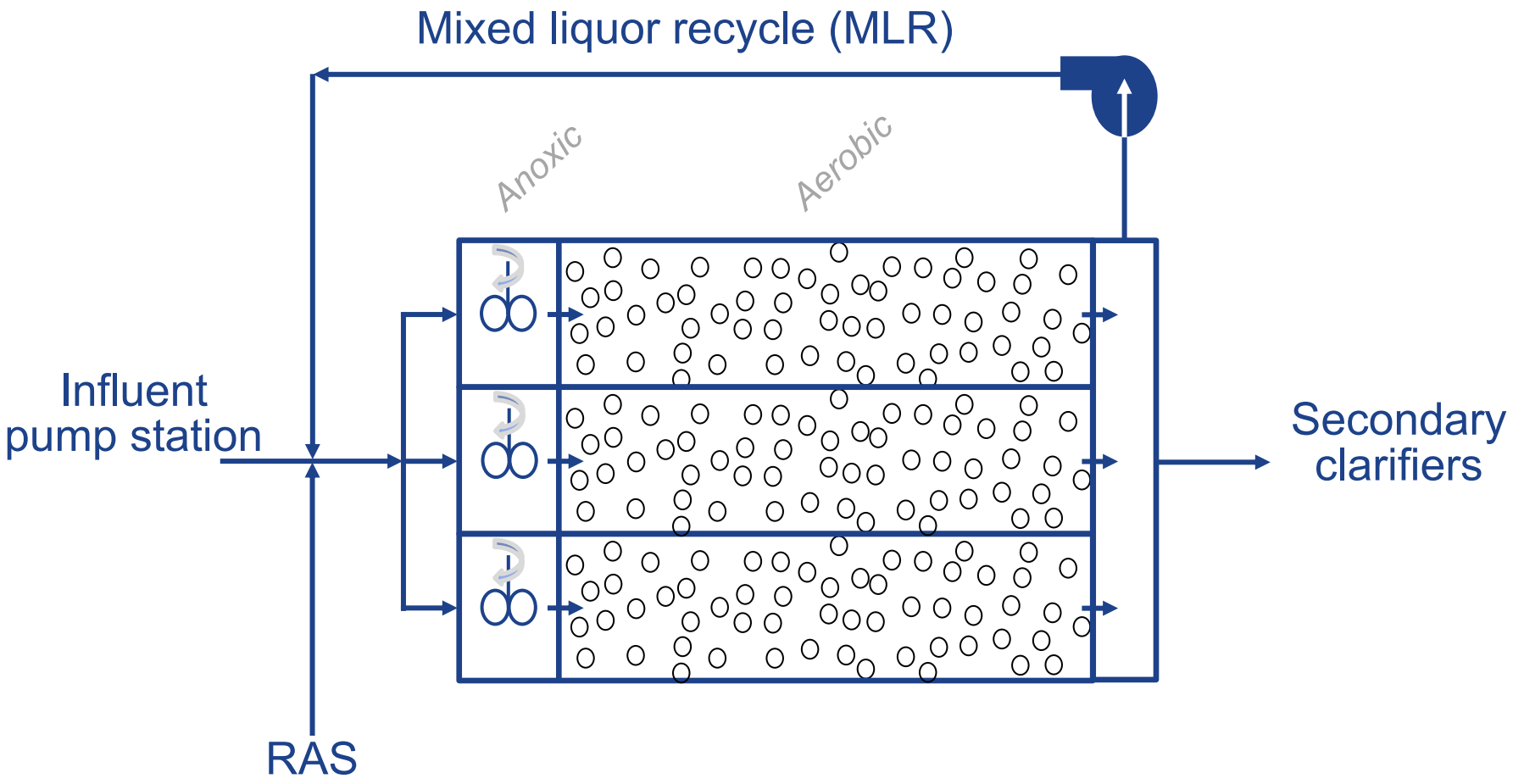
Screening

Grit Removal

Grit Removal



Grit Removal – It Matters A Lot



Headworks – What You Can Control to Save Energy

Process

→ Good capture saves $ and energy in downstream process

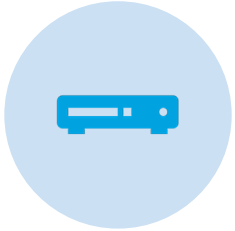
Mechanical

- Aeration (for aerated grit)
- Minimize plant water use (e.g. sluice water)
- Timing cycle
- Interlocks on ancillary equipment

Other Headworks Considerations

How much channel agitation air do you need (really)?

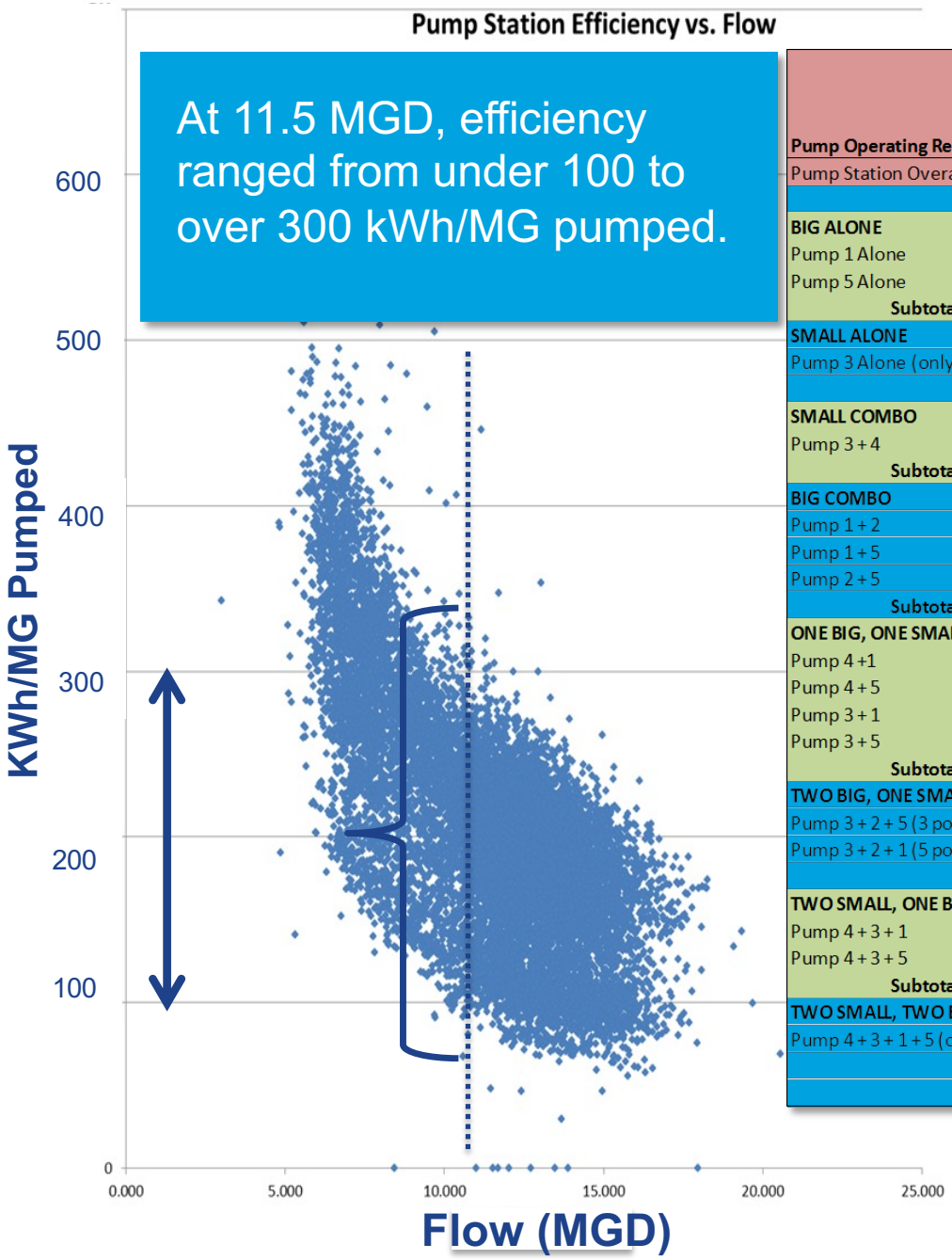
Can you run fewer trains? Perhaps seasonally?



The better your screens, the less you need to worry about downstream equipment. Consider semi-open impellers rather than full open for sludge pumps, ML recirc., etc.

Are you taking advantage of NFPA allowance for reduced airflow in cold weather?

Pump Station Considerations



At 11.5 MGD, efficiency ranged from under 100 to over 300 kWh/MG pumped.

Pump Operating Regime	Total operating time (HOURS)	Percent of Total Runtime	Average flow (MGD)	Average kWh/MG Pumped	Flow % Offset from Ave	Eff % Offset from Ave
Pump Station Overall	1156.3		11.5	204.3	0.0%	0.0%
BIG ALONE						
Pump 1 Alone	63.8	5.5%	10.9	140.2	-5.9%	31.4%
Pump 5 Alone	143.8	12.4%	12.2	126.8	6.0%	37.9%
Subtotal / average		**17.9%**	**11.5**	**133.5**	**0.1%**	**34.7%**
SMALL ALONE						
Pump 3 Alone (only 4 points)						
SMALL COMBO						
Pump 3 + 4	38.2	3.3%	12.9	100.3	12.2%	50.9%
Subtotal / average		**3.3%**	**12.9**	**100.3**	**12.2%**	**50.9%**
BIG COMBO						
Pump 1 + 2	19.8	1.7%	11.6	222.3	0.8%	-8.8%
Pump 1 + 5	234.8	20.3%	11.5	246.1	-0.7%	-20.4%
Pump 2 + 5	24.0	2.1%	11.4	243.3	-1.6%	-19.1%
Subtotal / average		**24.1%**	**11.5**	**237.2**	**-0.5%**	**-16.1%**
ONE BIG, ONE SMALL						
Pump 4 +1	90.3	7.8%	11.7	202.4	1.4%	0.9%
Pump 4 + 5	182.6	15.8%	11.3	209.3	-1.9%	-2.5%
Pump 3 + 1	73.6	6.4%	11.6	200.6	0.3%	1.8%
Pump 3 + 5	117.8	10.2%	11.1	208.7	-3.6%	-2.1%
Subtotal / average		**40.1%**	**11.4**	**205.3**	**-0.9%**	**-0.5%**
TWO BIG, ONE SMALL						
Pump 3 + 2 + 5 (3 points)						
Pump 3 + 2 + 1 (5 points)						
TWO SMALL, ONE BIG						
Pump 4 + 3 + 1	34.6	3.0%	13.3	206.1	15.3%	-0.9%
Pump 4 + 3 + 5	128.7	11.1%	10.9	260.0	-5.8%	-27.3%
Subtotal / average		**14.1%**	**12.1**	**233.1**	**4.7%**	**-14.1%**
TWO SMALL, TWO BIG						
Pump 4 + 3 + 1 + 5 (only 5 points)						

Some pump combinations should be avoided.

Pump Operating Regime	Total operating time (HOURS)	Percent of Total Runtime	Average flow (MGD)	Average kWh/MG Pumped
Pump Station Overall	1156.3		11.5	204.3
BIG ALONE				
Pump 1 Alone	63.8	5.5%	10.9	140.2
Pump 5 Alone	143.8	12.4%	12.2	126.8
Subtotal / average		**17.9%**	**11.5**	**133.5**
SMALL ALONE				
Pump 3 Alone (only 4 points)				
SMALL COMBO				
Pump 3 + 4	38.2	3.3%	12.9	100.3
Subtotal / average		**3.3%**	**12.9**	**100.3**
BIG COMBO				
Pump 1 + 2	19.8	1.7%	11.6	222.3
Pump 1 + 5	234.8	20.3%	11.5	246.1
Pump 2 + 5	24.0	2.1%	11.4	243.3
Subtotal / average		**24.1%**	**11.5**	**237.2**

Pump Operating Regime	Total operating time (HOURS)	Percent of Total Runtime	Average flow (MGD)	Average kWh/MG Pumped
Pump Station Overall	1156.3		11.5	204.3
ONE BIG, ONE SMALL				
Pump 4 +1	90.3	7.8%	11.7	202.4
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Pump 3 + 1	73.6	6.4%	11.6	200.6
Pump 3 + 5	117.8	10.2%	11.1	208.7
Subtotal / average		**40.1%**	**11.4**	**205.3**
TWO BIG, ONE SMALL				
Pump 3 + 2 + 5 (3 points)				
Pump 3 + 2 + 1 (5 points)				
TWO SMALL, ONE BIG				
Pump 4 + 3 + 1	34.6	3.0%	13.3	206.1
Pump 4 + 3 + 5	128.7	11.1%	10.9	260.0
Subtotal / average		**14.1%**	**12.1**	**233.1**
TWO SMALL, TWO BIG				
Pump 4 + 3 + 1 + 5 (only 5 points)				

Pump Operating Regime	% of Total Runtime	Average Flow (MGD)	Average kWh/MG Pumped
BIG ALONE	18%	11.5	134
SMALL ALONE	0		
SMALL COMBO	3.3%	12.9	100
BIG COMBO	24%	11.5	237
ONE BIG, ONE SMALL	40%	11.4	205
TWO BIG, ONE SMALL	0		
TWO SMALL, ONE BIG	14%	12.1	233
TWO SMALL, TWO BIG	0		

DISINFECTION – POLLING QUESTION!

Does your plant have, or is your plant moving towards, installing or upgrading a UV system?

a. Yes
b. No
c. Do not know

Chlorination vs. UV (Energy Perspective)

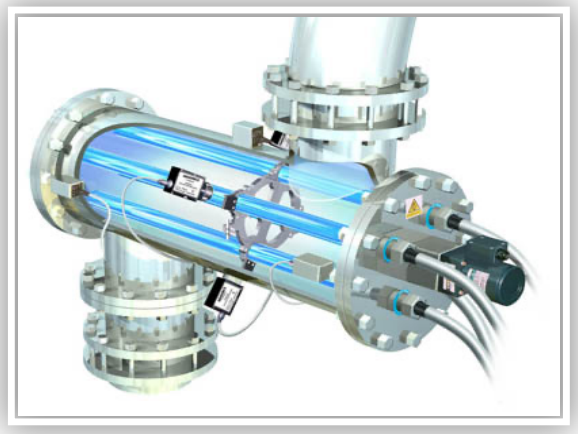
Chlorination

- Chlorine's energy footprint is invisible to the plant
- Over-chlorination is expensive and prohibited by regulations

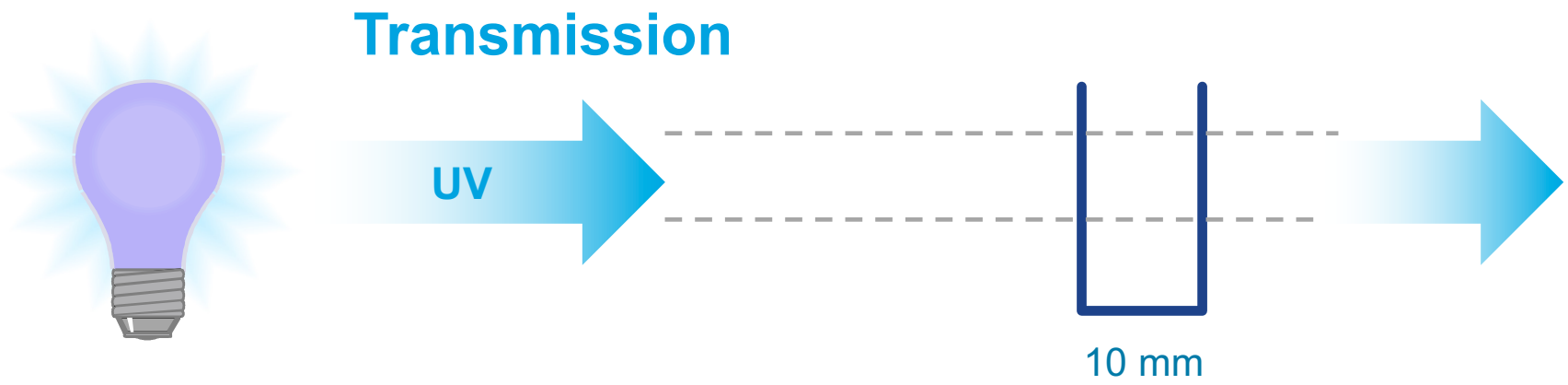
UV

- UV is a known "energy hog"
- Overkill is rampant
- Regulators promote overkill

UV Disinfection



UV Dose



UV Dose = Intensity x Exposure time

Expressed as: mWsec/cm^2 or mJ/cm^2

UV Transmission (UVT) is a measurement of the ability of UV light to penetrate water

Acknowledgement: Cynthia Bratz, Tetratech

Typical Transmittance Values

Wastewater	UV Transmittance, %
Primary	28 to 50
Secondary	45 to 70
Nitrified secondary	56 to 79
Filtered secondary	56 to 86
Microfiltration	79 to 91
Reverse osmosis	89 to 98

Lower % UTV requires higher UV energy input equal UV dose

*Acknowledgement: Cynthia Bratz, Tetratech

Factors Affecting Performance

Factors affecting intensity

- UVT
- Suspended solids
- Dissolved organics, humic materials, dyes
- Metals (particularly iron and manganese)
- Particle size
- Lamp and sleeve condition

*Acknowledgement: Cynthia Bratz, Tetratech

Factors Affecting Performance

Lamp and sleeve conditions

- Quartz sleeve fouling
  - Effluent total hardness
  - Metals
  - Other fouling
- Lamp age
- Lamp temperature
- Power supply

*Acknowledgement: Cynthia Bratz, Tetratech

Miminizing the “Hog” in the UV Energy Hog

Start now Collect UVT data

Get involved with the consultants during planning through design. . . Ask hard questions!

Designate one UV ops expert

Opportunity Register Thoughts?

Energy Projects

Energy Project		Step 1	Identify				Step 2	Step 3	Step 4
Opportunity #	Opportunity Name		Description	Location	System*	Submitted By			
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									

Break

Understanding Primary Clarification

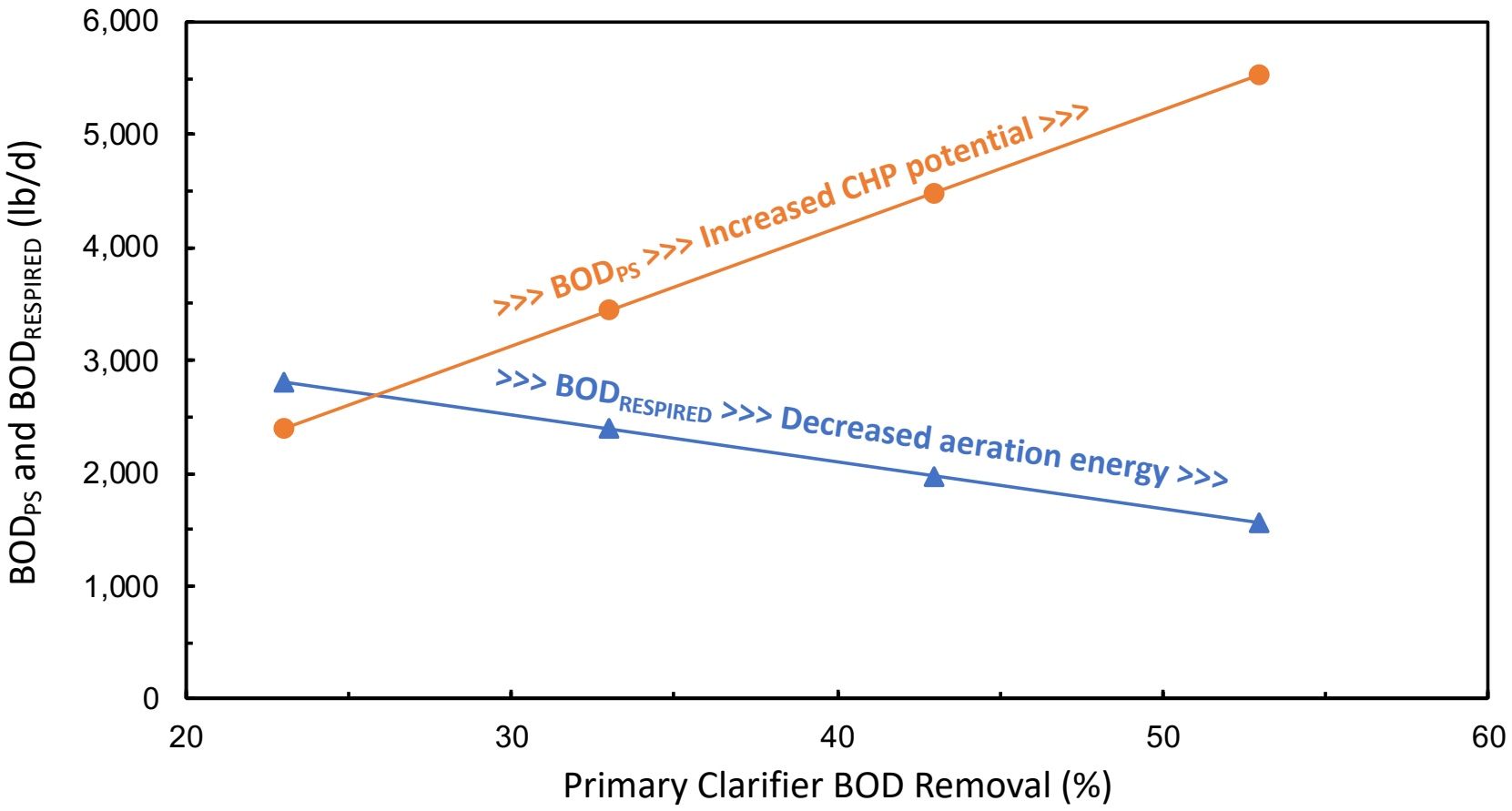
Primary Clarifiers: Why We Care

Primary clarifiers remove more BOD for less operating expense than any other treatment process

An Optimized Primary Clarifier is an Optimized Plant

Primary clarifier BOD removal (%)	BOD_{PS} (lb BOD/d)	BOD_{PE} (lb BOD/d)	BOD_{WAS} (lb BOD/d)	$BOD_{RESPIRED}$ (lb BOD/d)	BOD_{PS}/BOD_{WAS}
23	2,398	8,027	4,816	2,811	0.50
33	3,440	6,985	4,191	2,394	0.82
43	4,483	5,942	3,565	1,977	1.26
53	5,525	4,900	2,940	1,560	1.88

Increasing BOD Removal Efficiency in Primary Clarifiers Gives Double Whammy



Primary Clarifier Removal Efficiencies All Operators Have Committed to Memory

>95% settleable solids

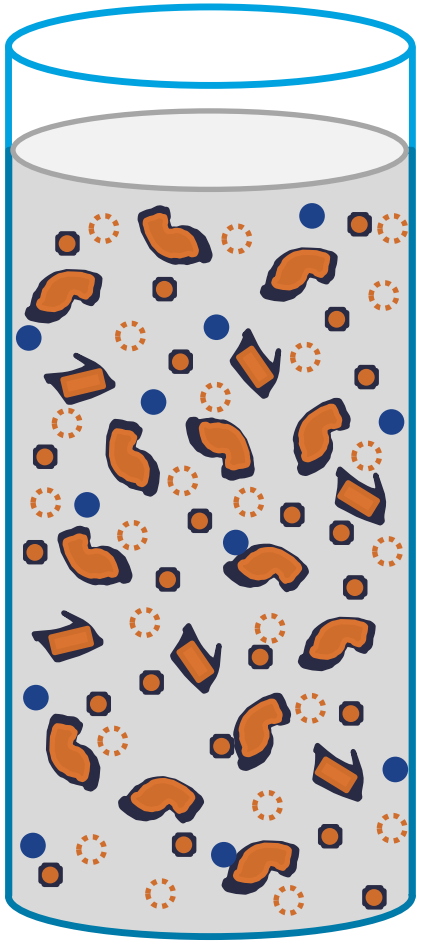
40−60% TSS

20−40% BOD

Where do these numbers come from?

Are they in our control?

Plant-wide Energy Impacts Require Understanding Solids

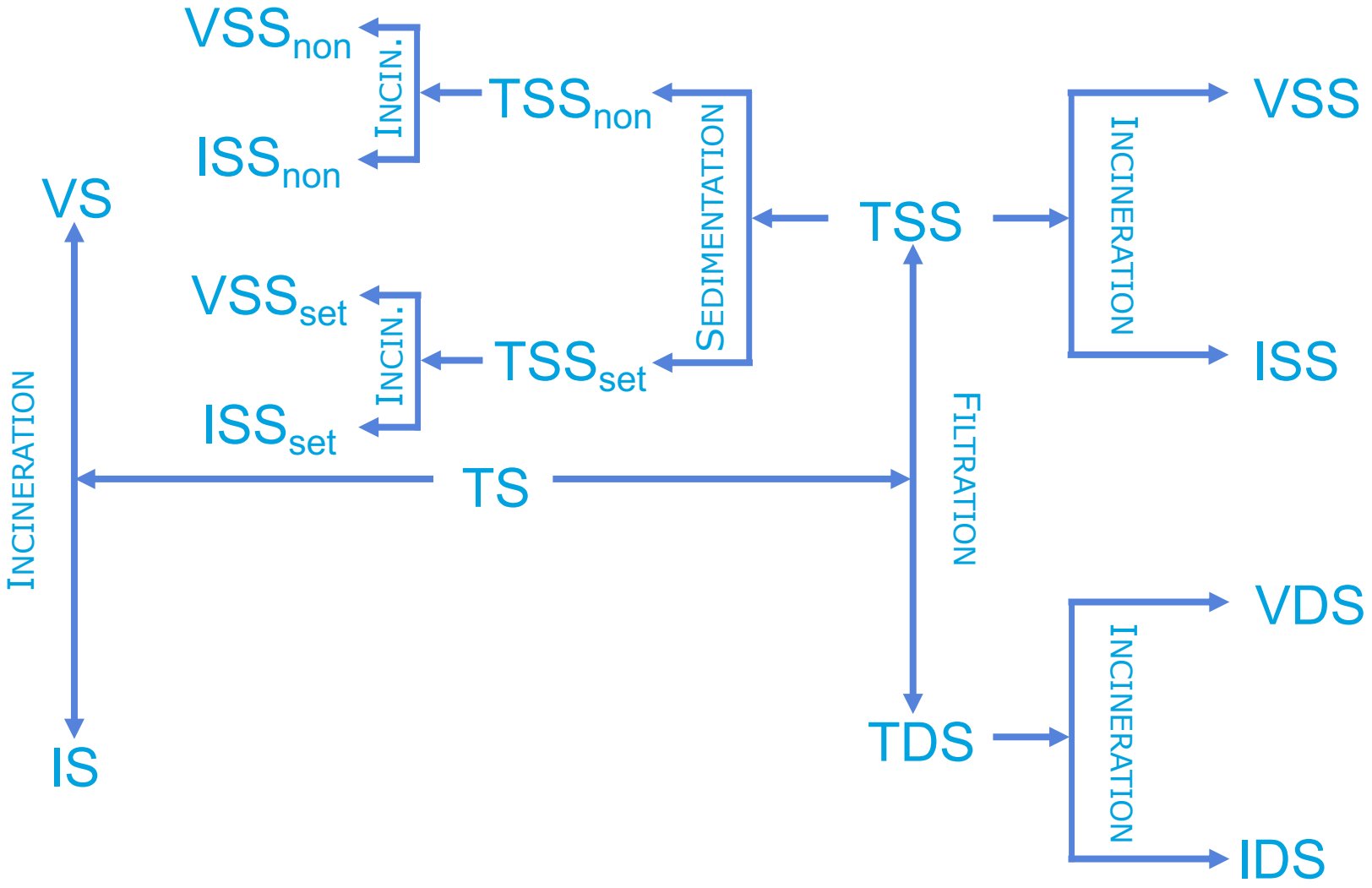


Primary clarifier performance defined by two kinds of solids

Those that settle

Those that don't

Wastewater Treatment Universe Explained!



Total Solids (TS) Measures All Solids: Visible, Too-Small-To-See, Dissolved

Carefully measured volume or mass

Credit: https://www.certifiedmtp.com/evaporating-dish-120ml/#&gid=1&pid=1

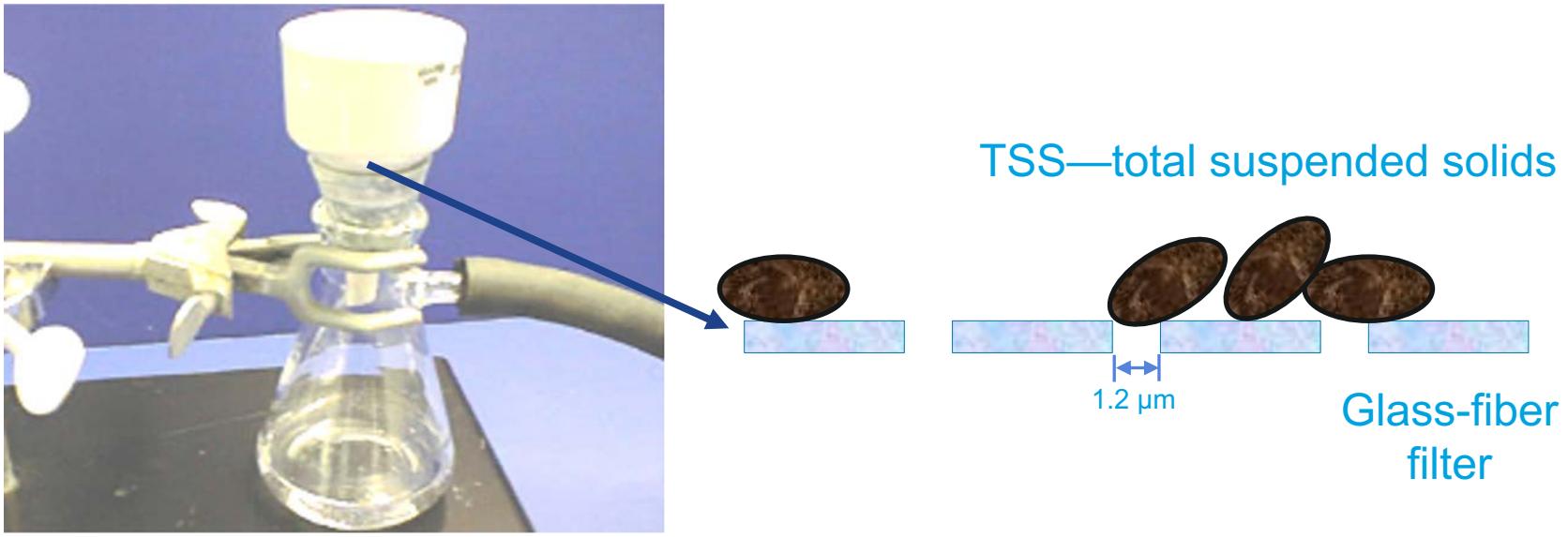
Tared evaporating dish

https://www.amazon.com/Nalgene-Wide-Mouth-Sample-Bottle-Economy/dp/B00T2PVMLA

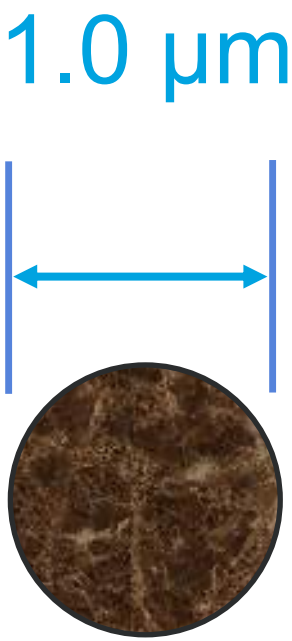
Wastewater Treatment Universe Explained!

TS

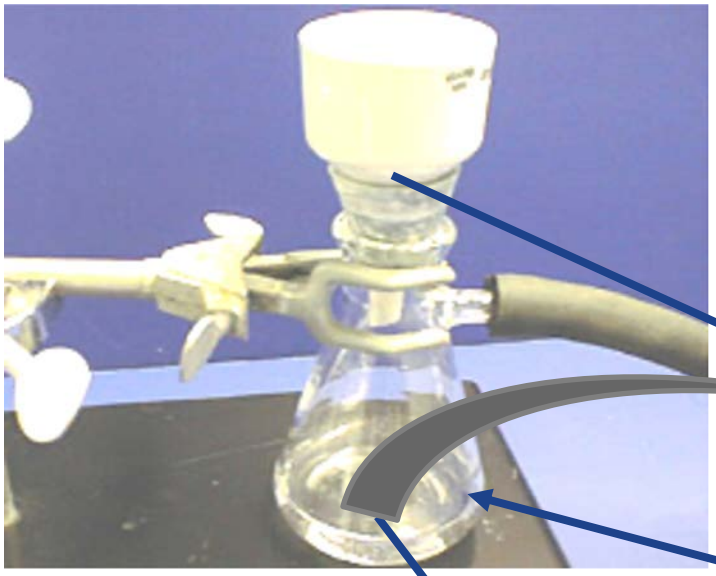
Filtration Separates TS into TSS and TDS



Colloids Are Particles with a Maximum Dimension Between 0.001 and 1.0 µm



Filtration Separates TS into TSS and TDS



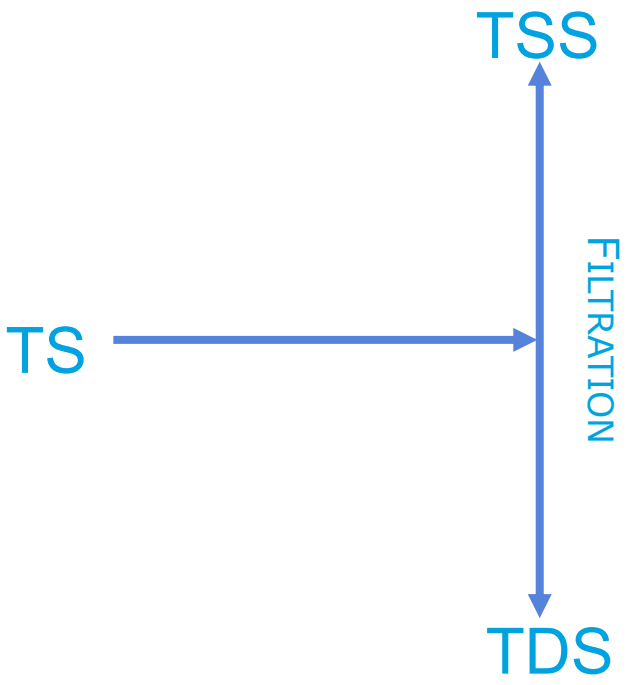
TSS—total suspended solids

Glass-fiber filter

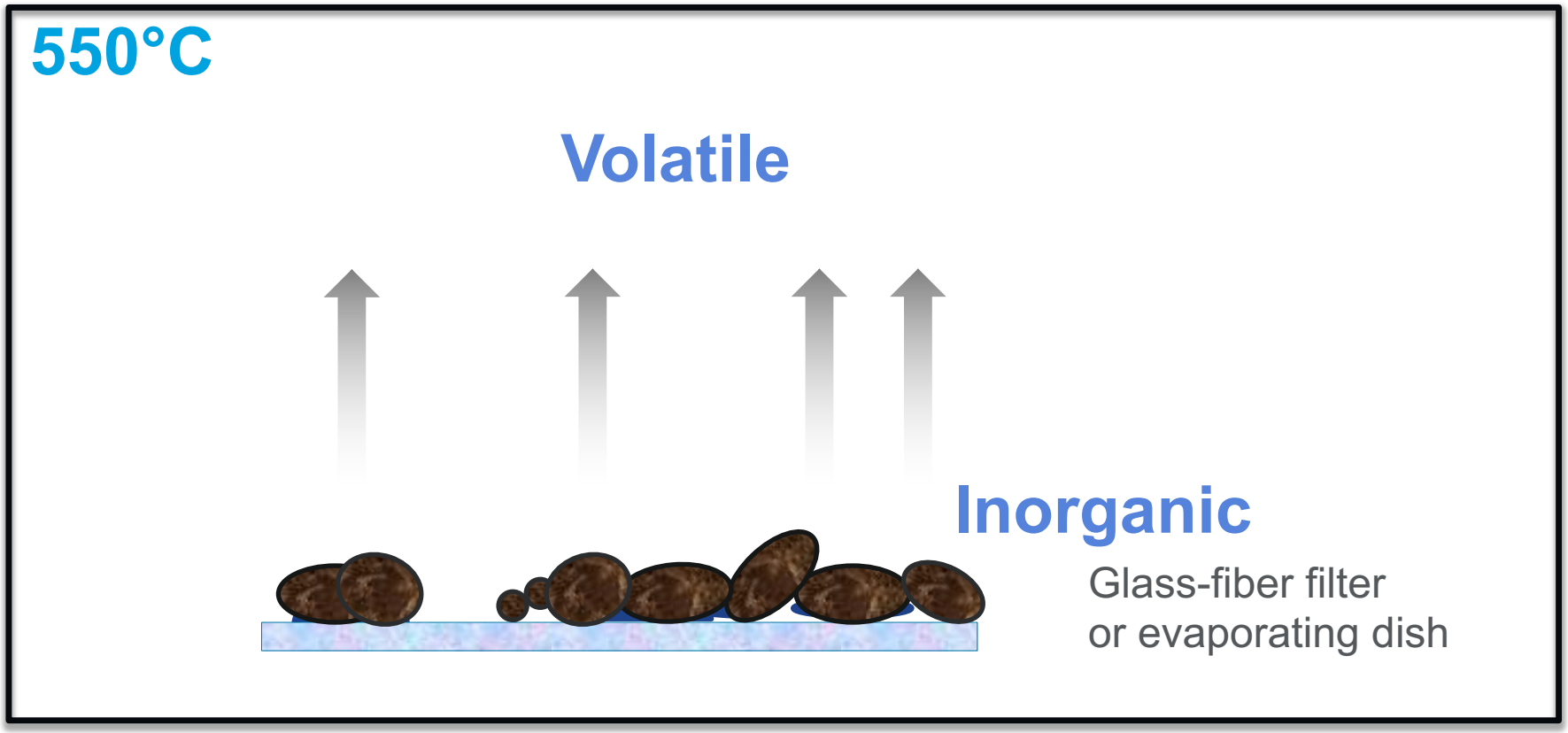
Carefully measured volume

TDS—total dissolved solids

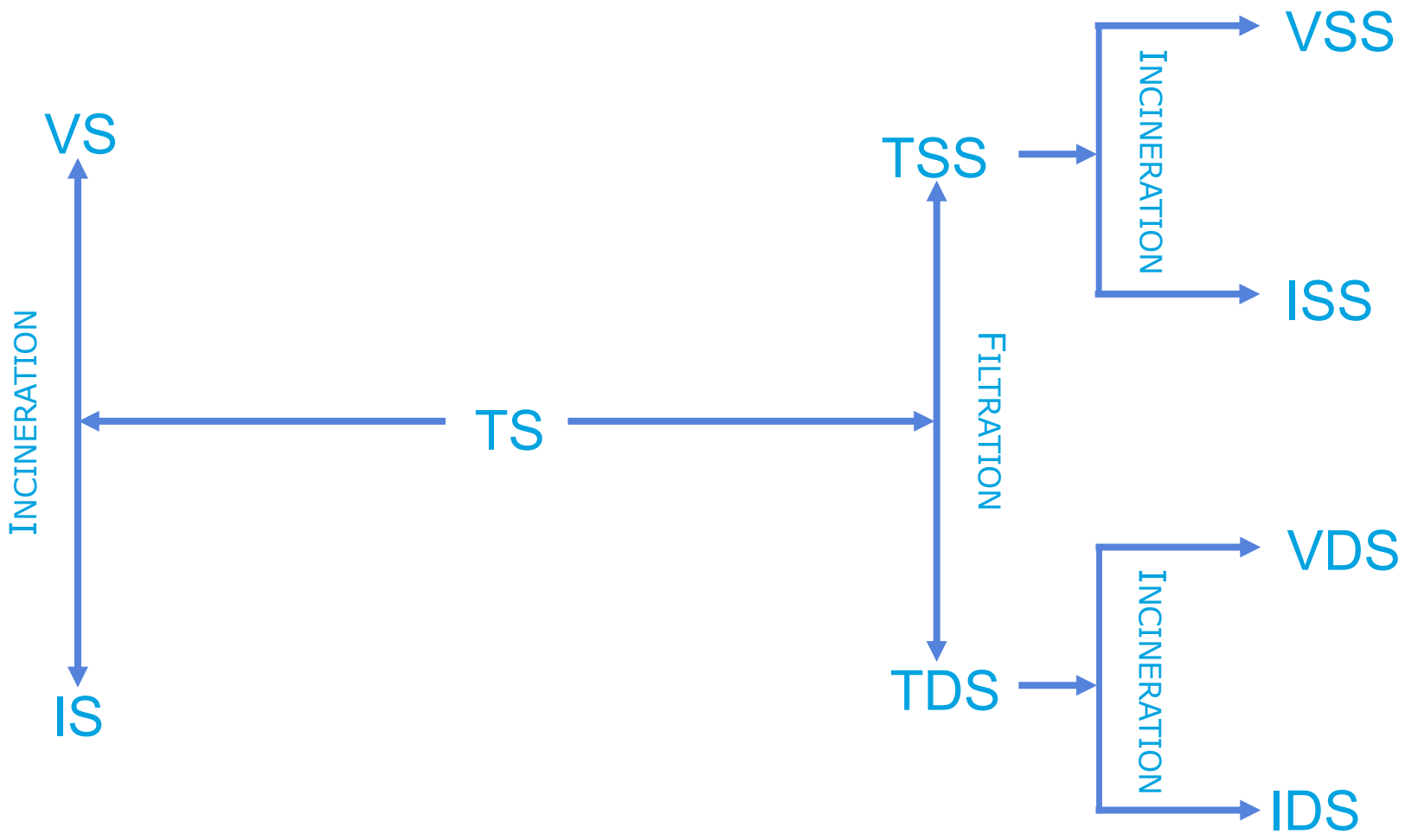
TS = TSS + TDS



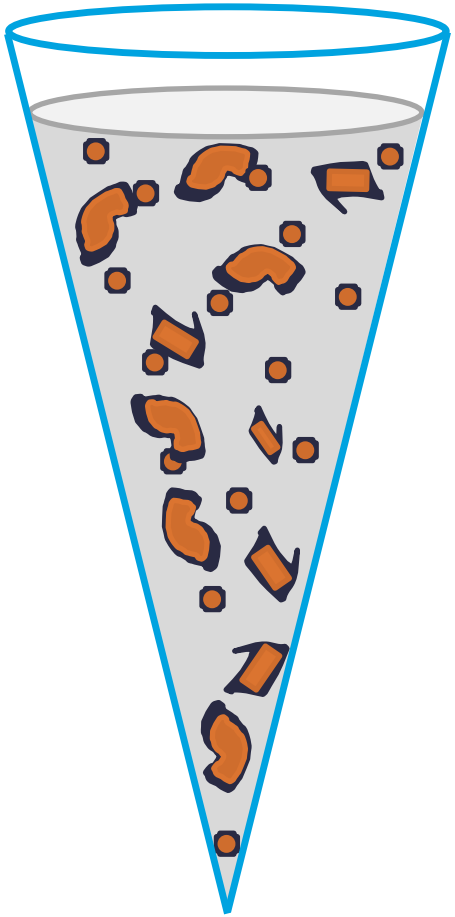
Incineration = 550°C



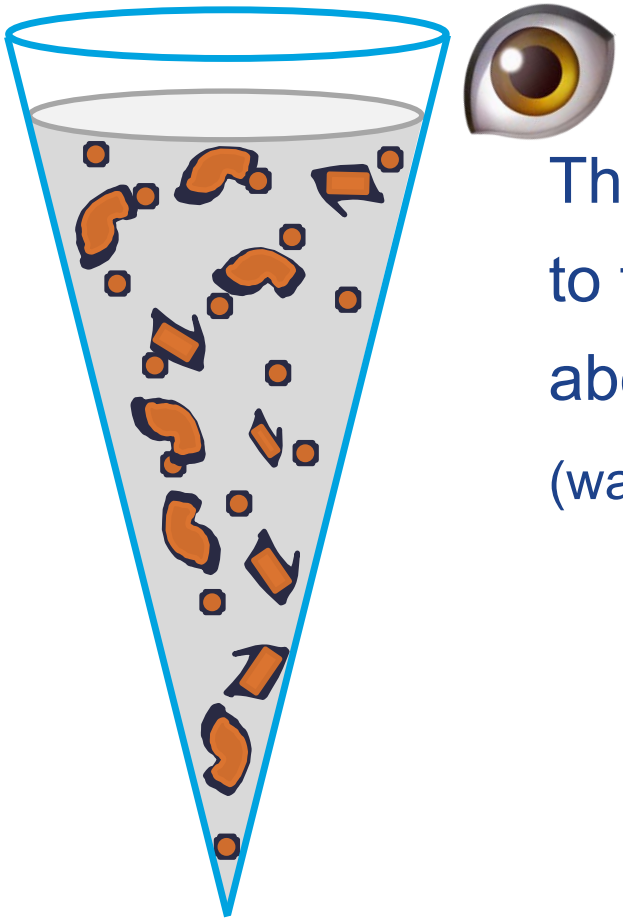
Incineration Separates TS into VS and IS; TSS into VSS and ISS; TDS into VDS and IDS



“Settleable Solids” Measured in an Imhoff Cone



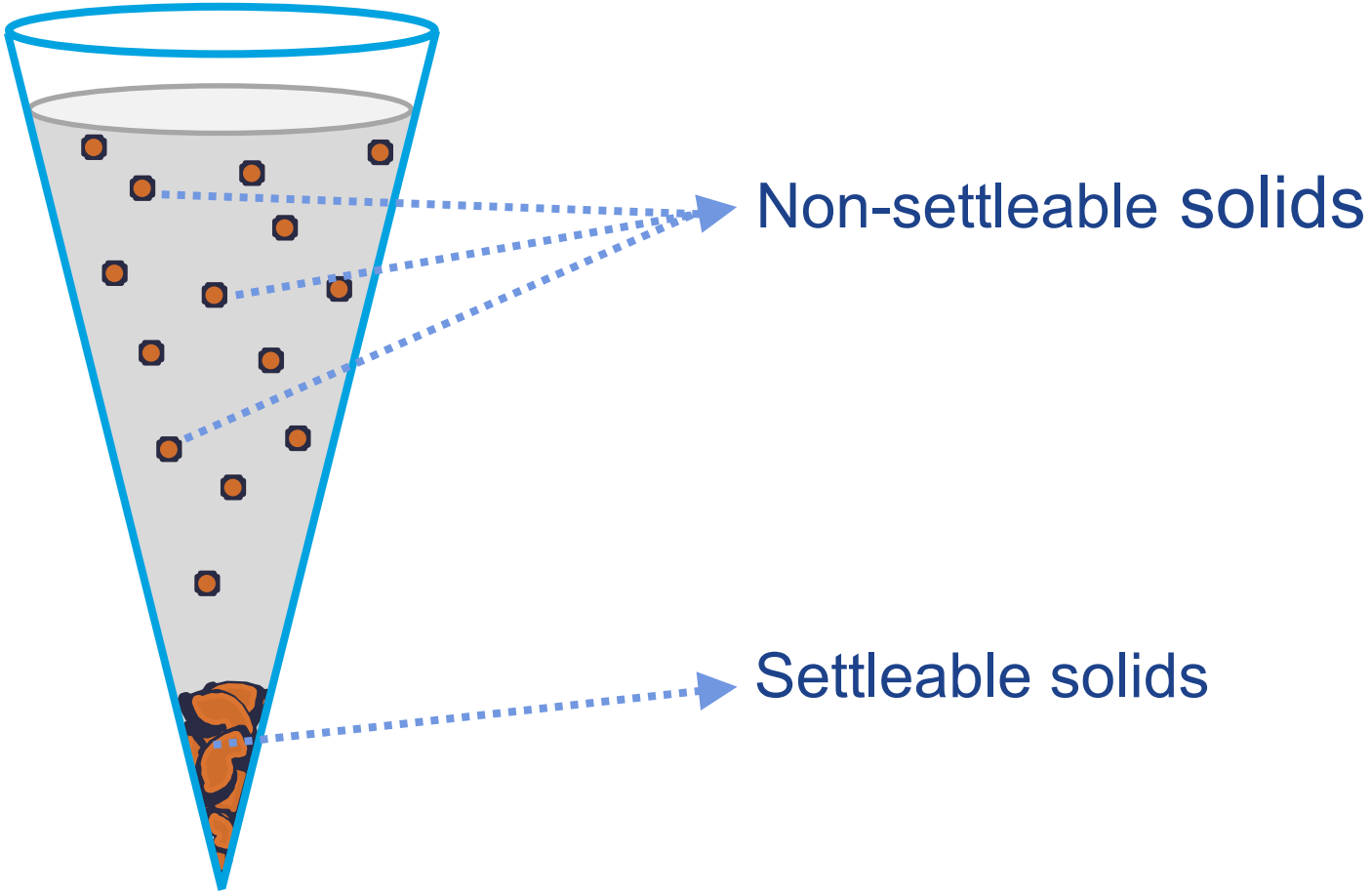
If We Can See It, It Will Be Measured as TSS



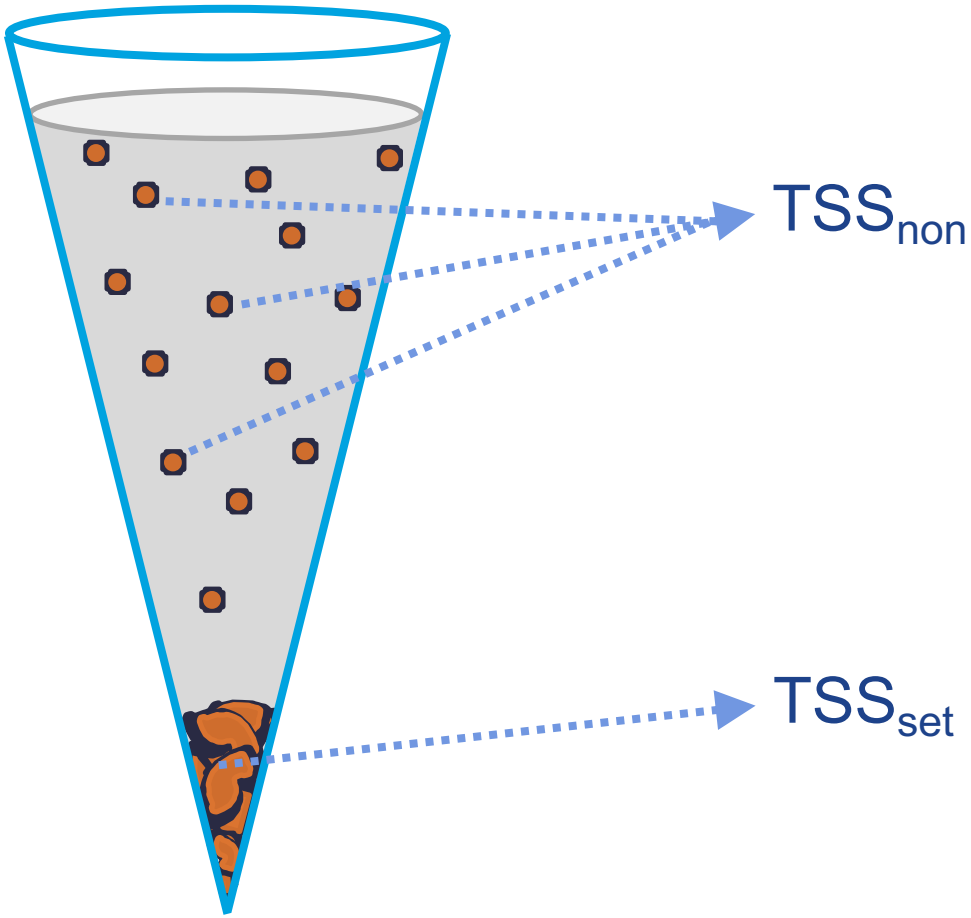
The human eye can see down to the diameter of a human hair, about **100 µm**

(way bigger than 1.2-µm pore size)

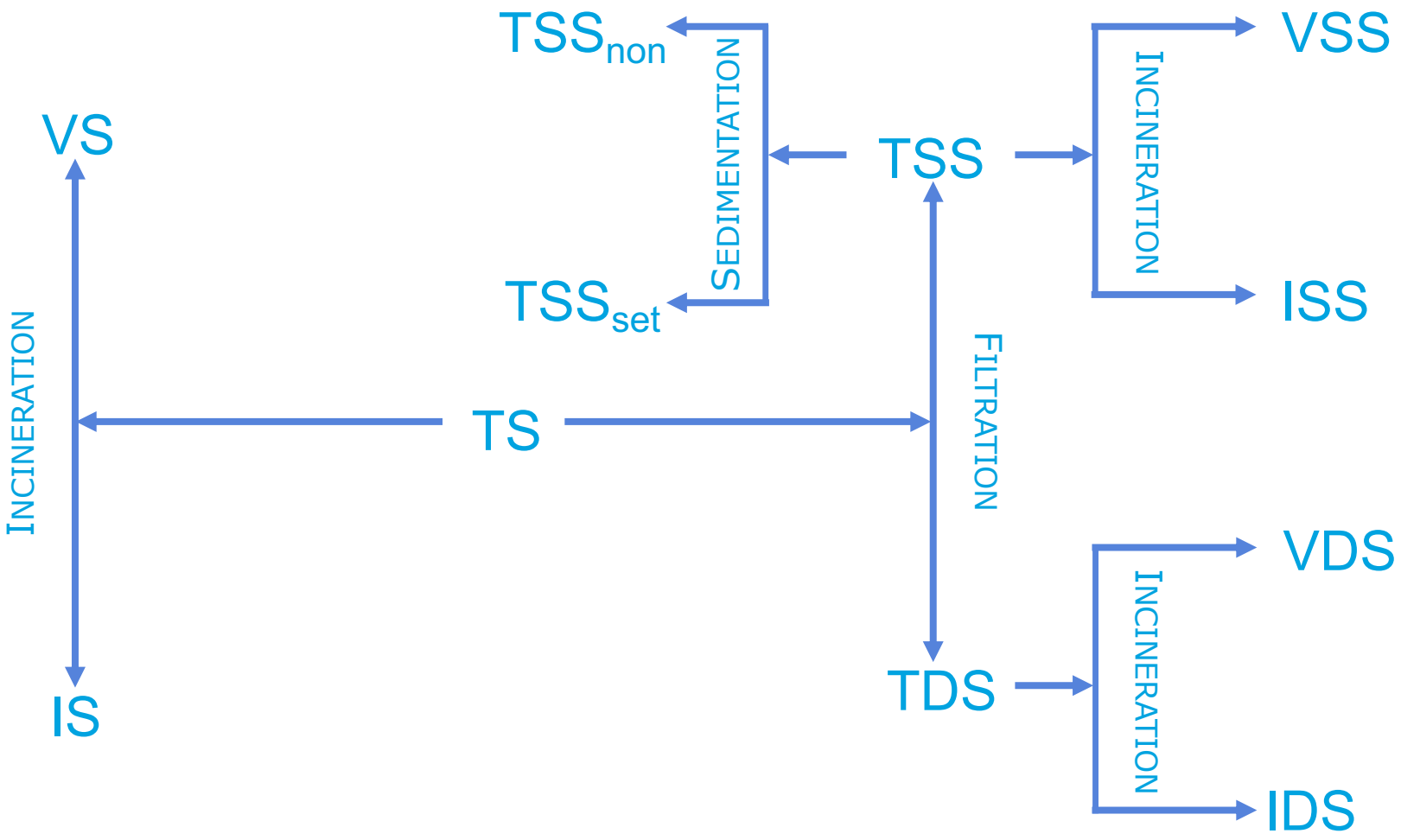
Both Settleable and Non-settleable Solids Must be TSS Because They're Visible



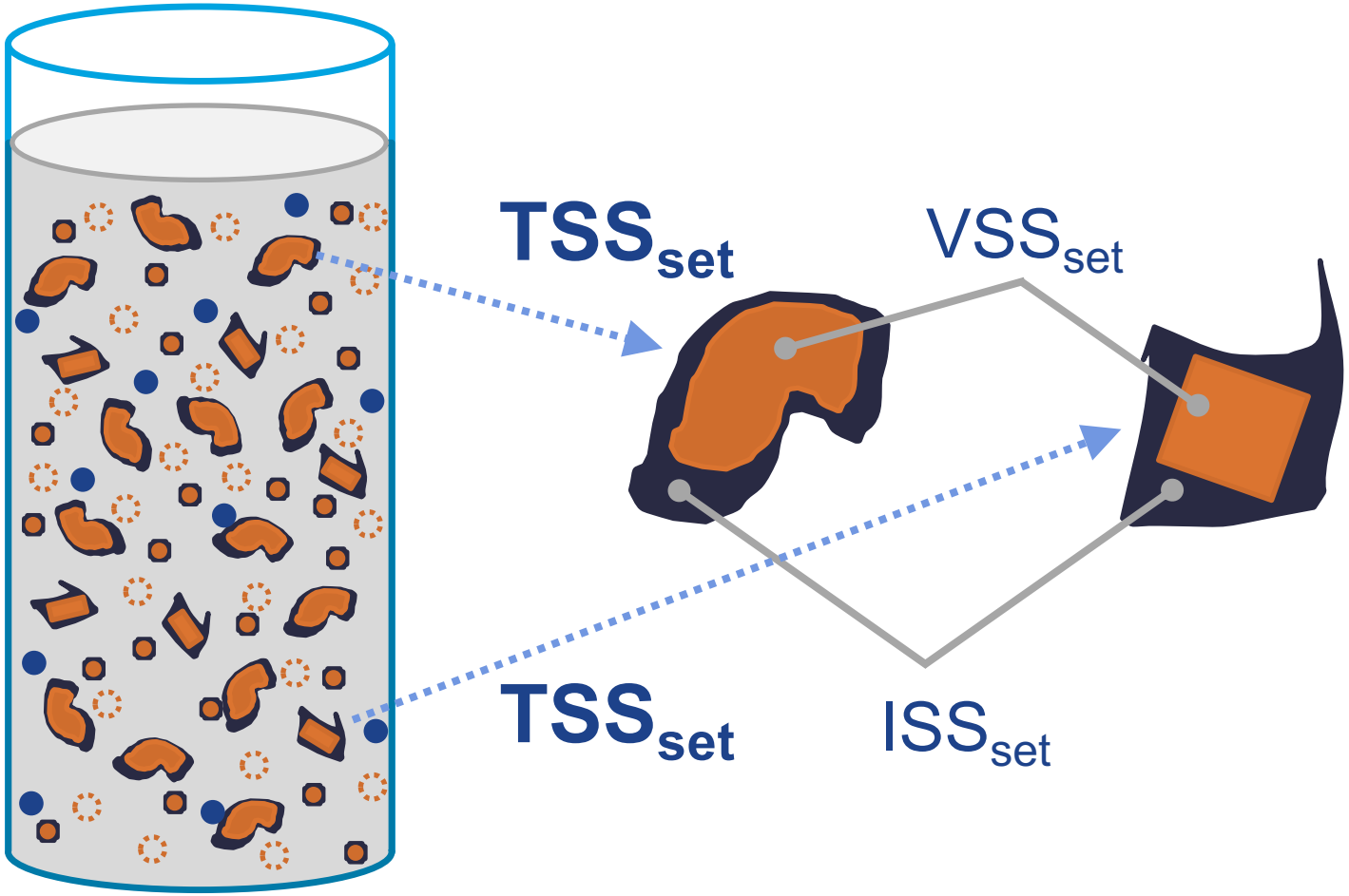
All Settleable Solids are TSS but Not All TSS are Settleable



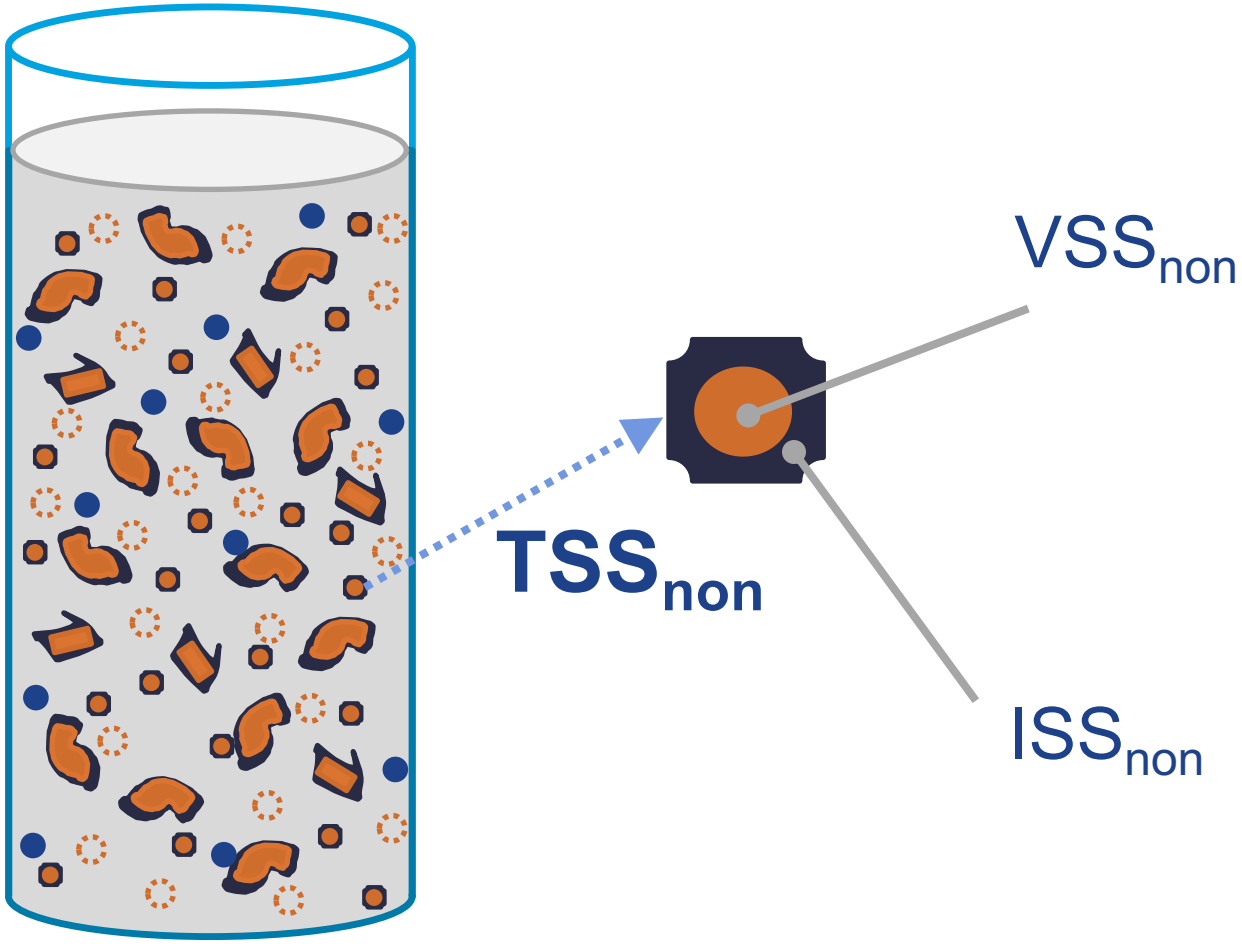
Either TSS Settle or Not



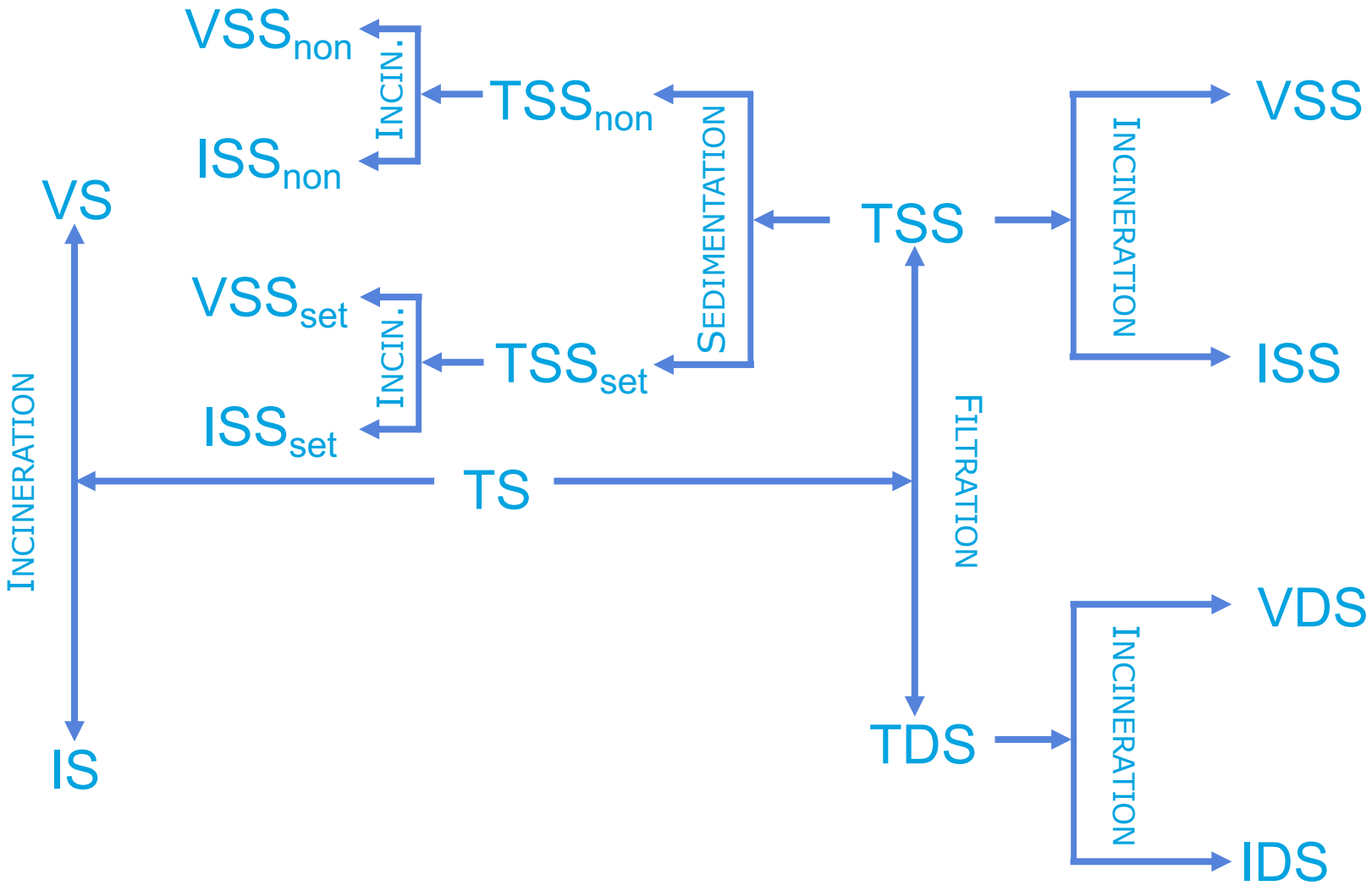
Each TSS_{set} Particle is Made Up of Volatile and Inorganic Fractions



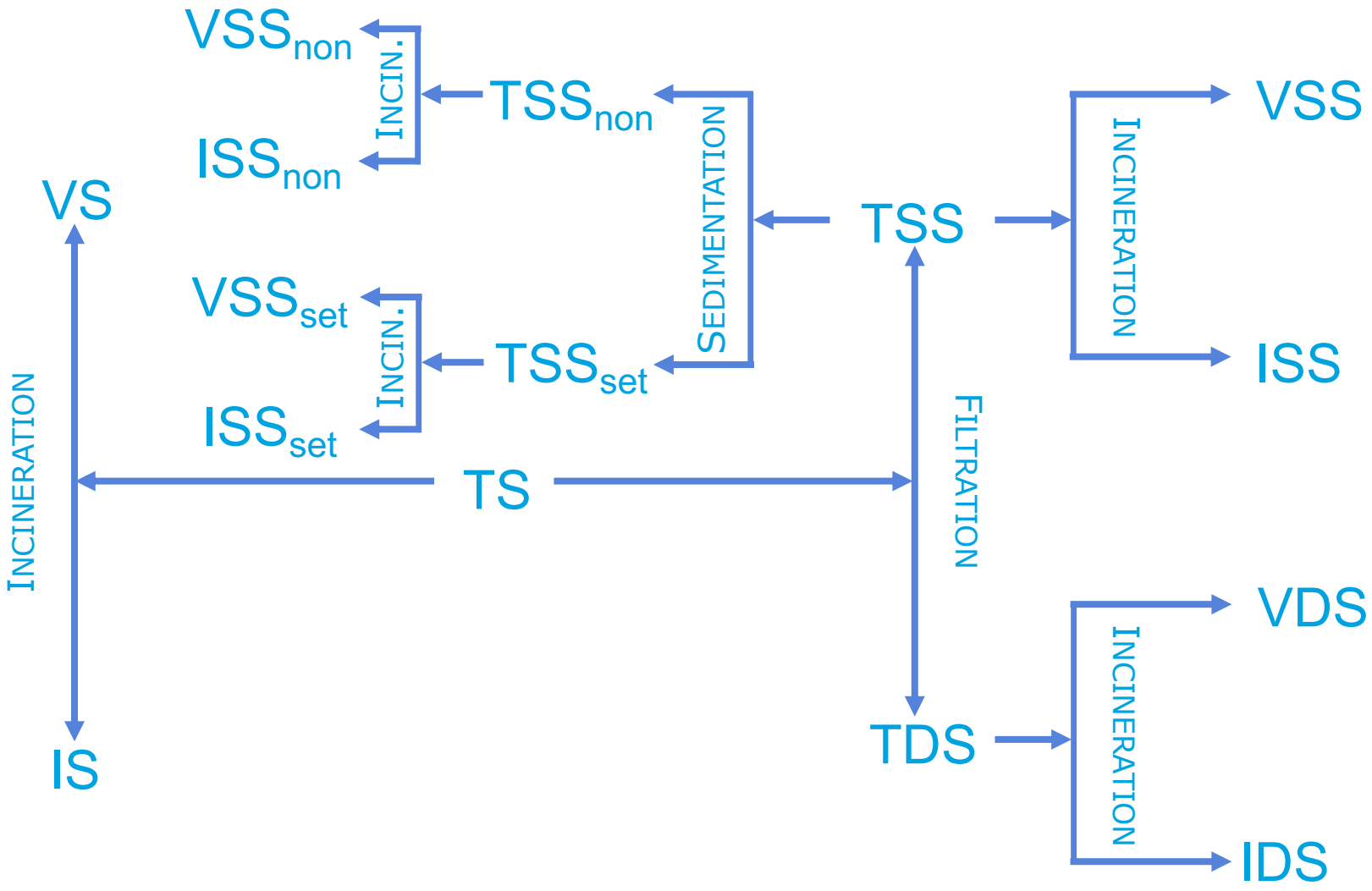
Each TSS_{non} Particle is Made Up of Volatile and Inorganic Fractions



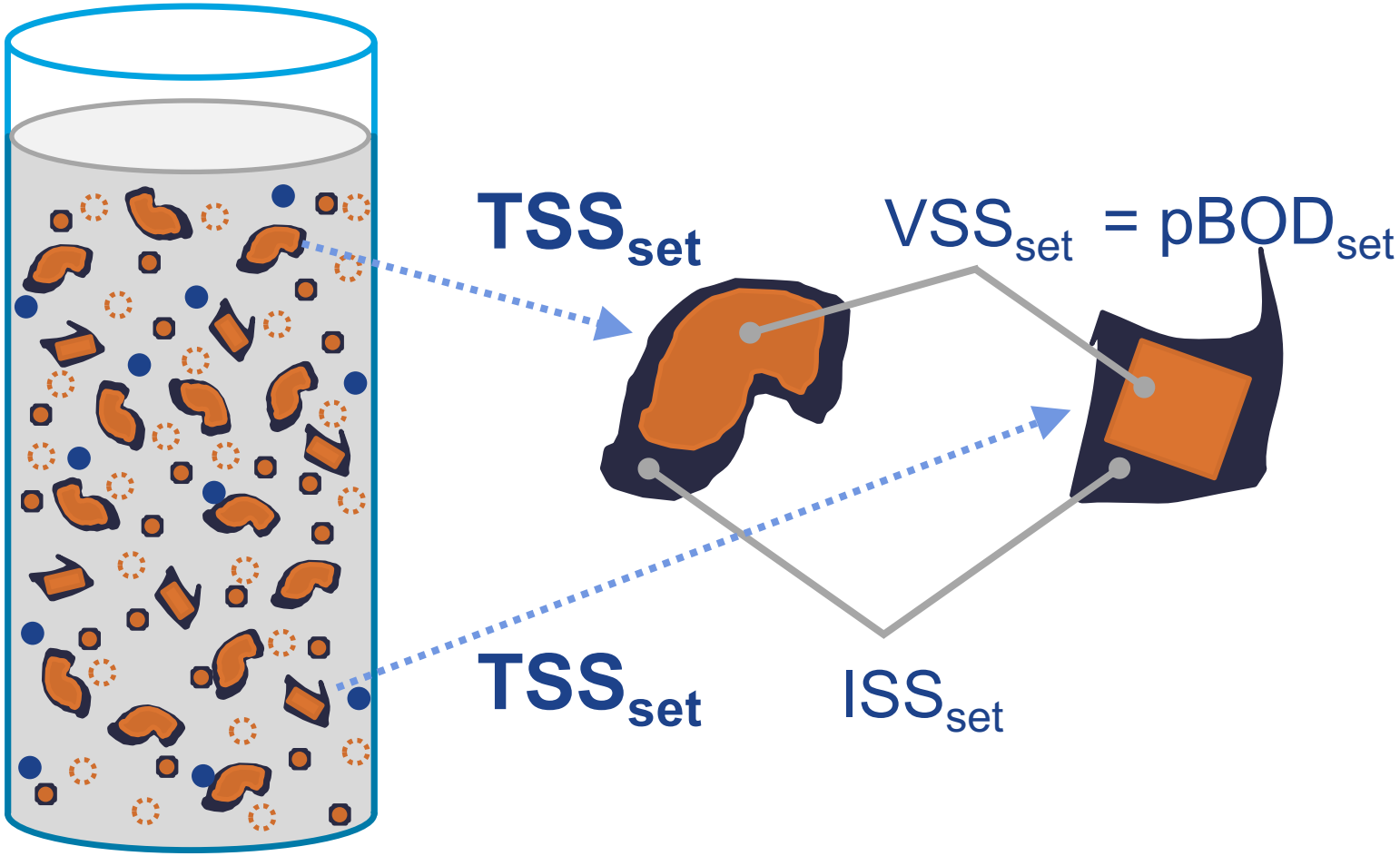
Wastewater Treatment Universe Explained!



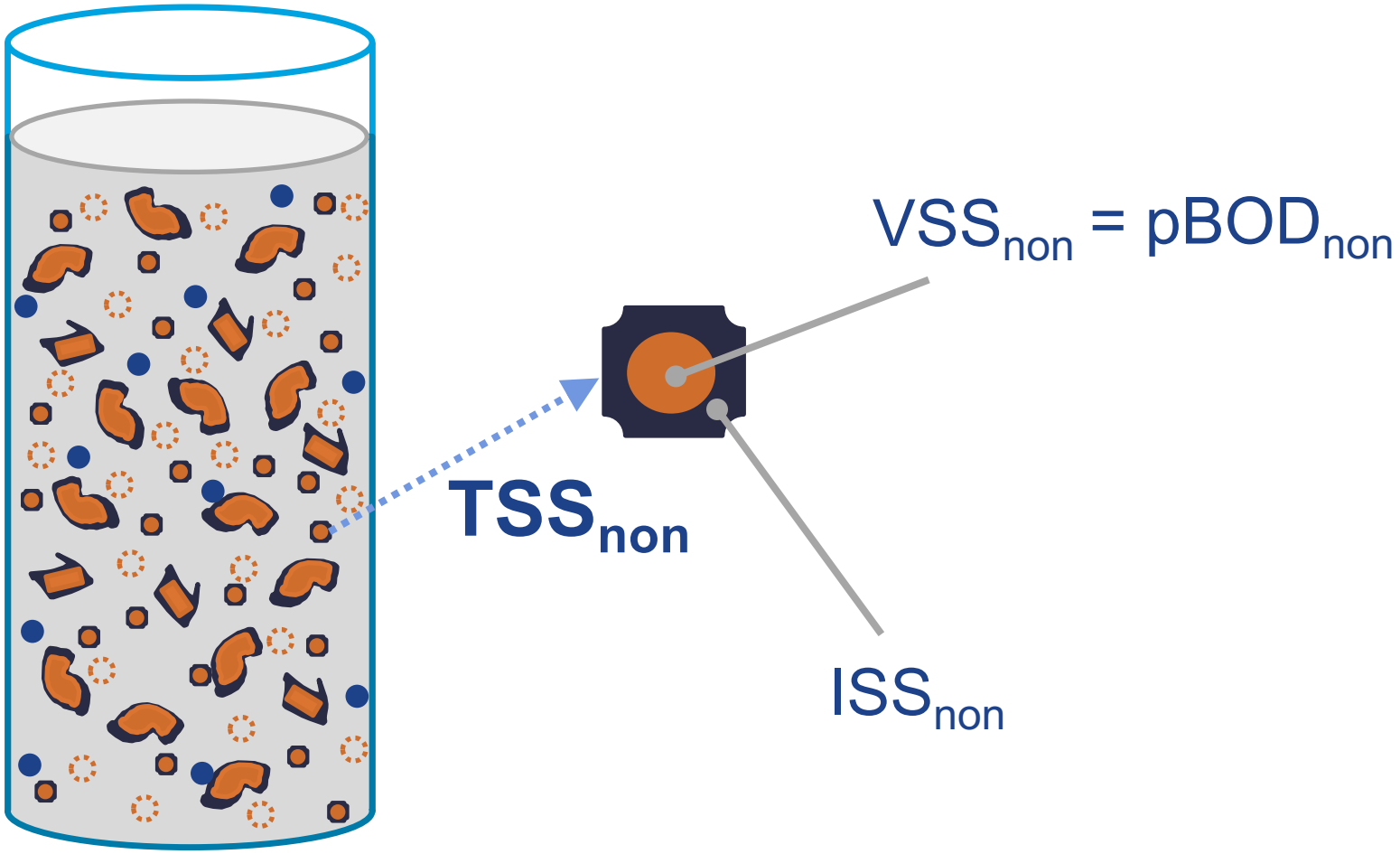
Where's the BOD?



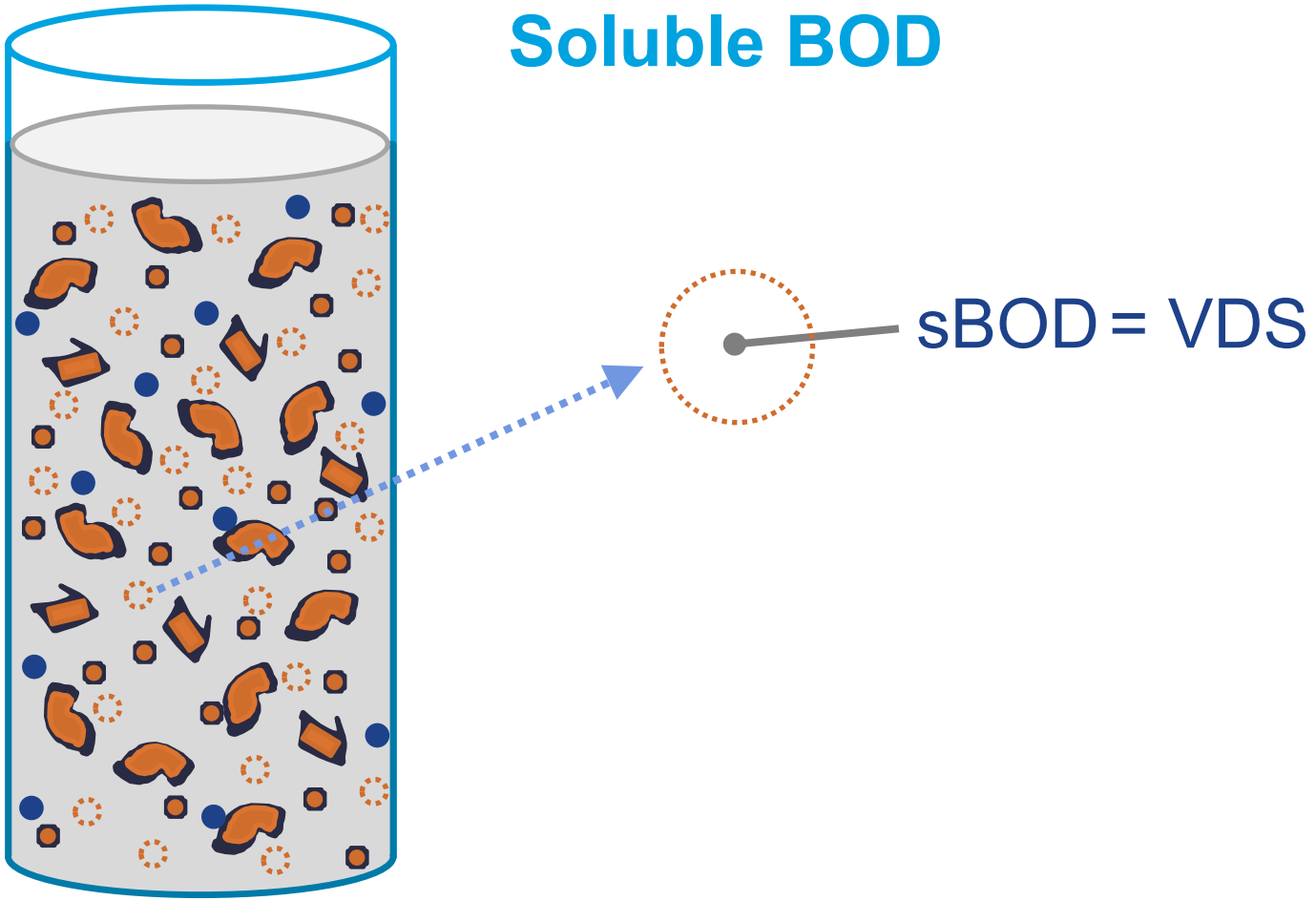
VSS Equivalent to Particulate BOD (pBOD)
Thus, $pBOD_{set}$



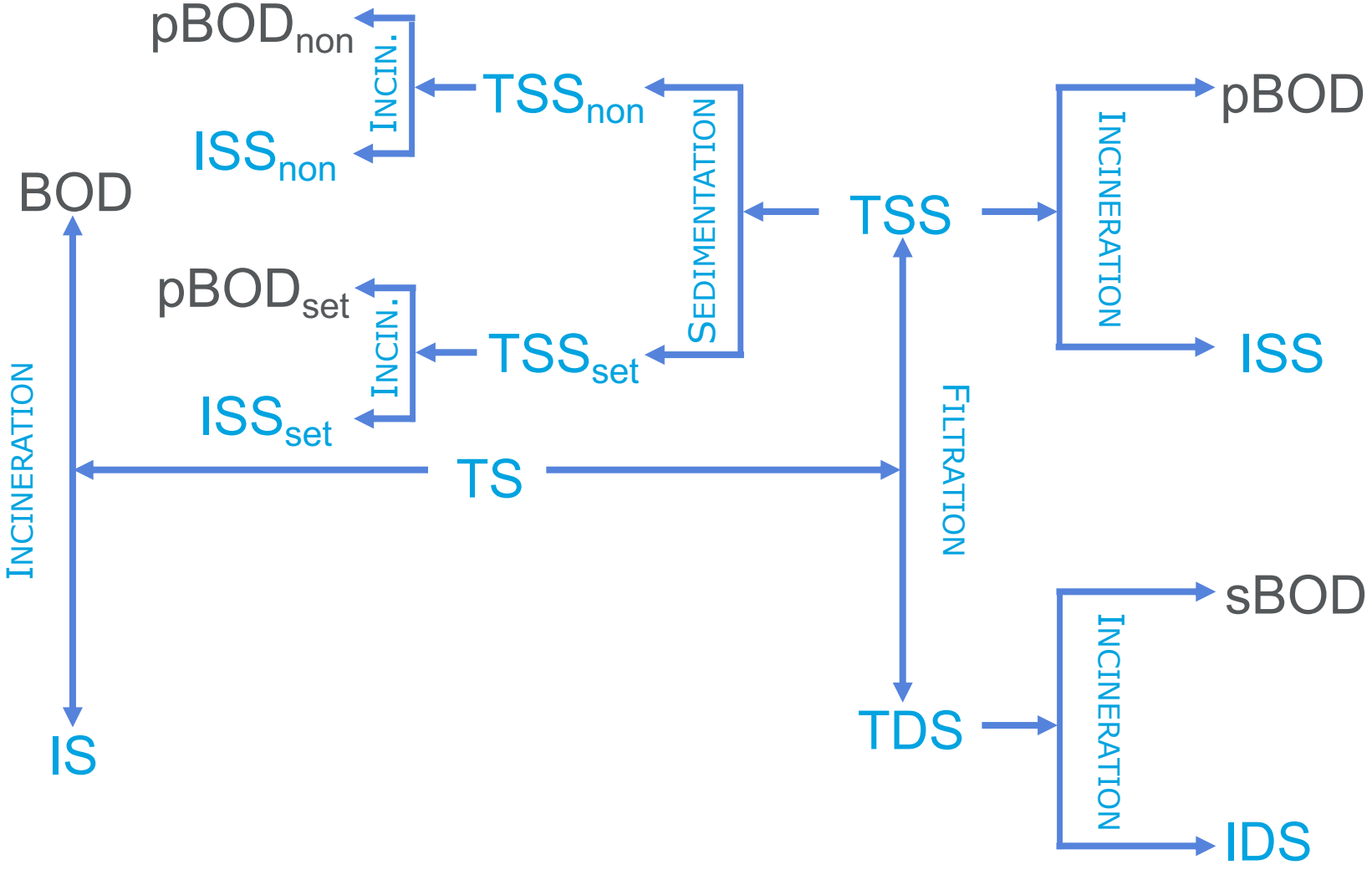
VSS Equivalent to Particulate BOD (pBOD) Thus, $pBOD_{non}$



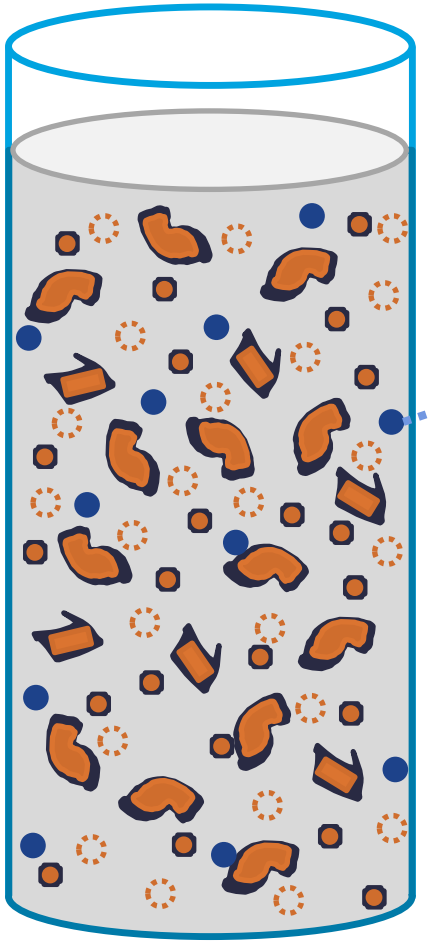
Some BOD is Soluble, Measured as VDS



BOD Measures Organics
V is for Volatile, Same as Organic



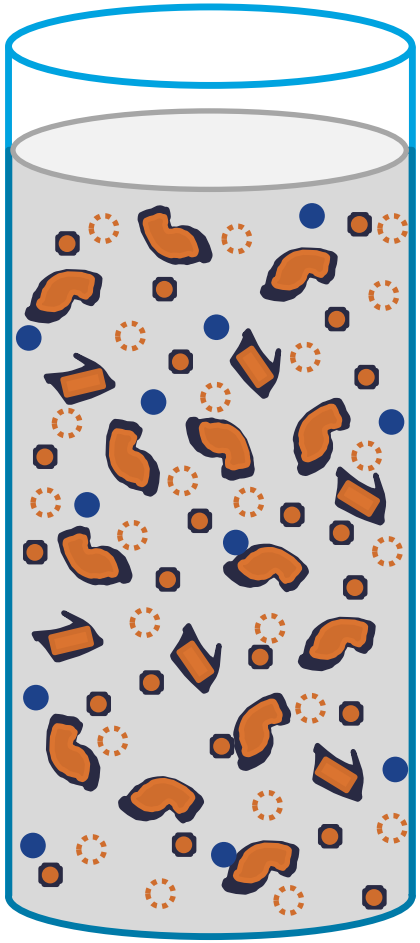
Last of the Solids, IDS Essentially Untouched Through Treatment

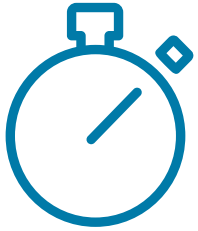


Inorganic Dissolved Solids

IDS

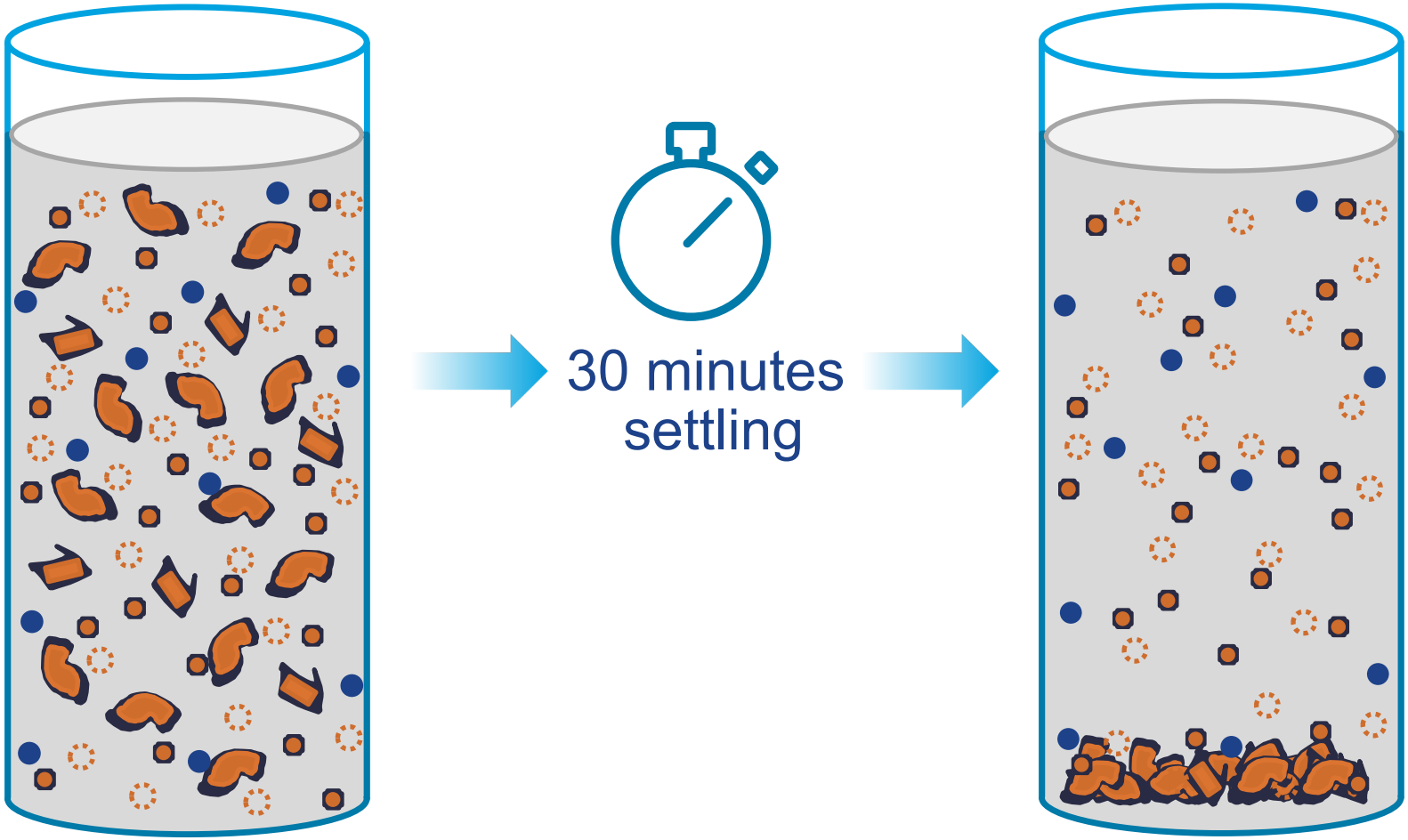
What's removed? What's remaining?



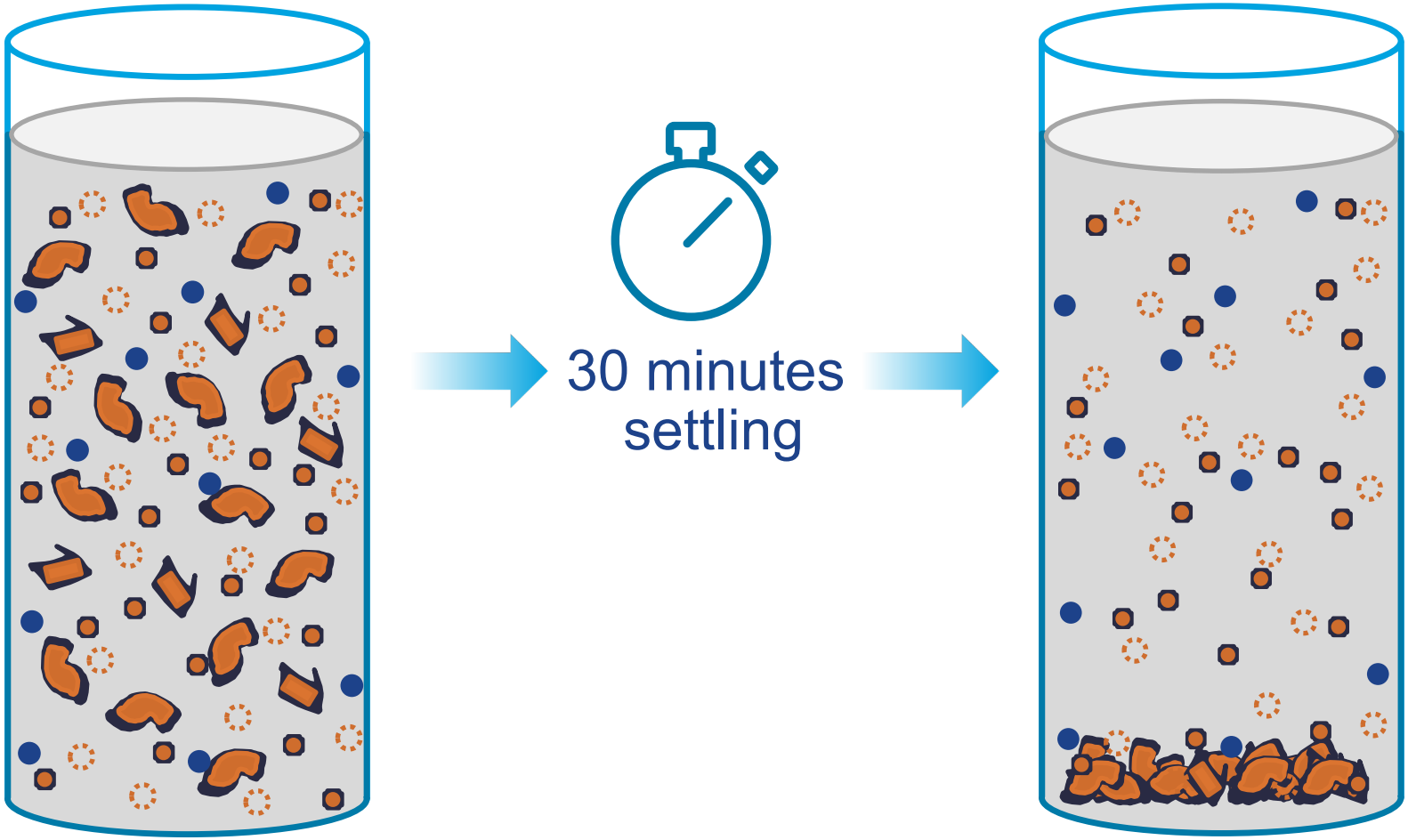


30 minutes
settling

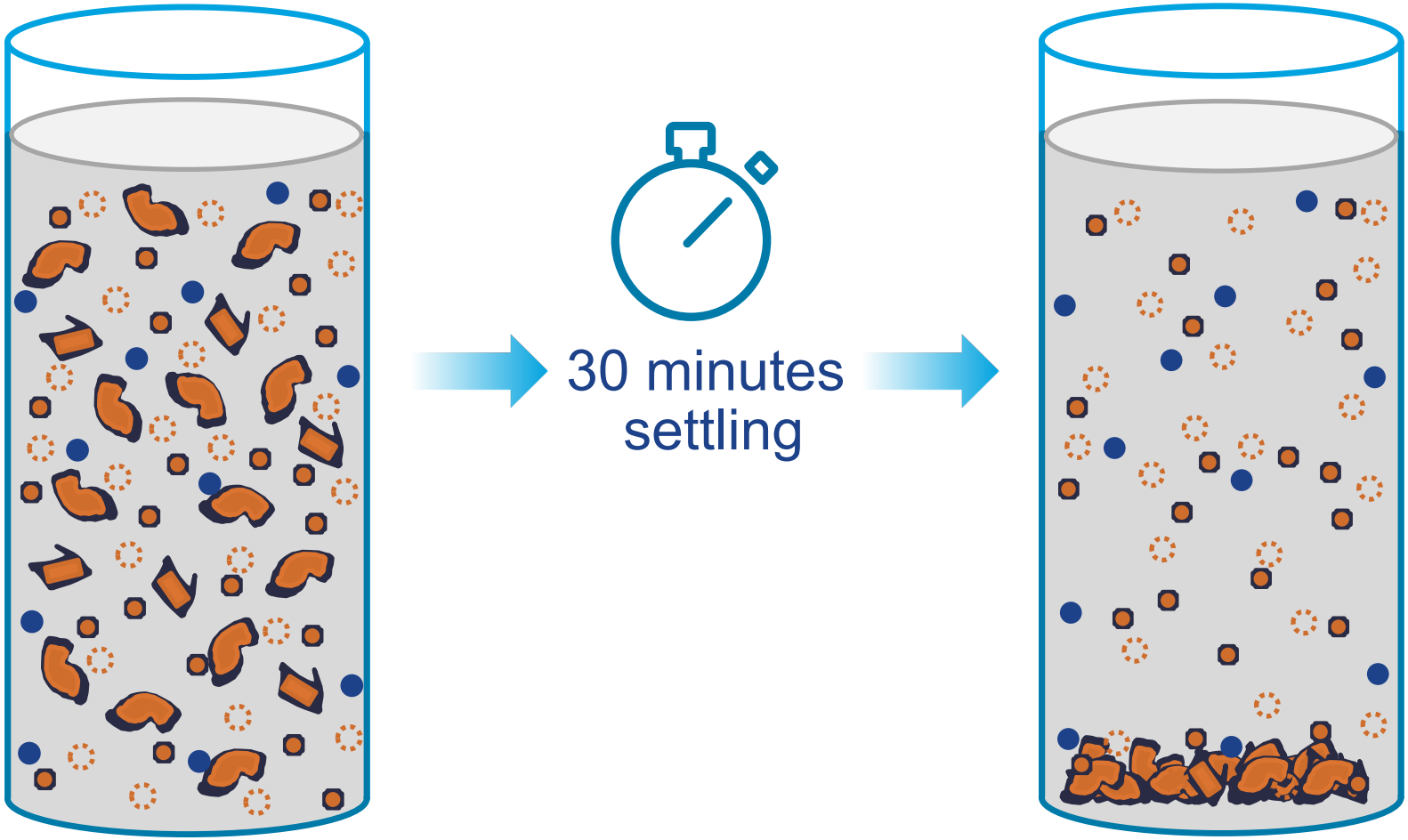
Removed: TSS_{set} (ISS_{set}, VSS_{set} = $pBOD_{set}$)



Not Removed: sBOD, IDS, TSS_{non} (ISS_{non}, VSS_{non} = $pBOD_{non}$)



As Operations Professionals, We Have Little Control Over What's Settleable, What's Not



Primary Clarifiers Can Only Remove What's Settleable

Settleable

- TSS_{set} (ISS_{set}, VSS_{set} = $pBOD_{set}$)

Not Settleable

- TSS_{non} (ISS_{non}, VSS_{non} = $pBOD_{non}$)
- sBOD
- IDS

Primary Clarifier Removal Efficiencies All Operators Have Committed to Memory **Explained**

1. >95% settleable solids

   [All TSS_{set} are settleable]

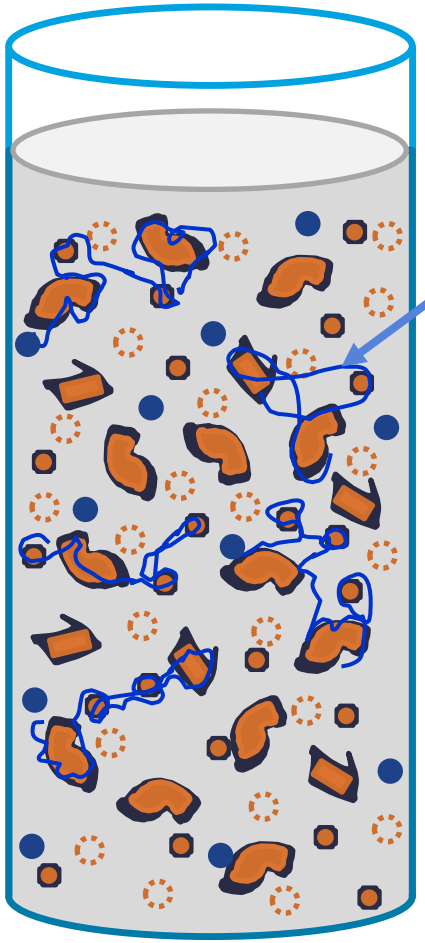
2. 40−60% TSS

   [40−60% of TSS_{INF} are TSS_{set}]

3. 20−40% BOD

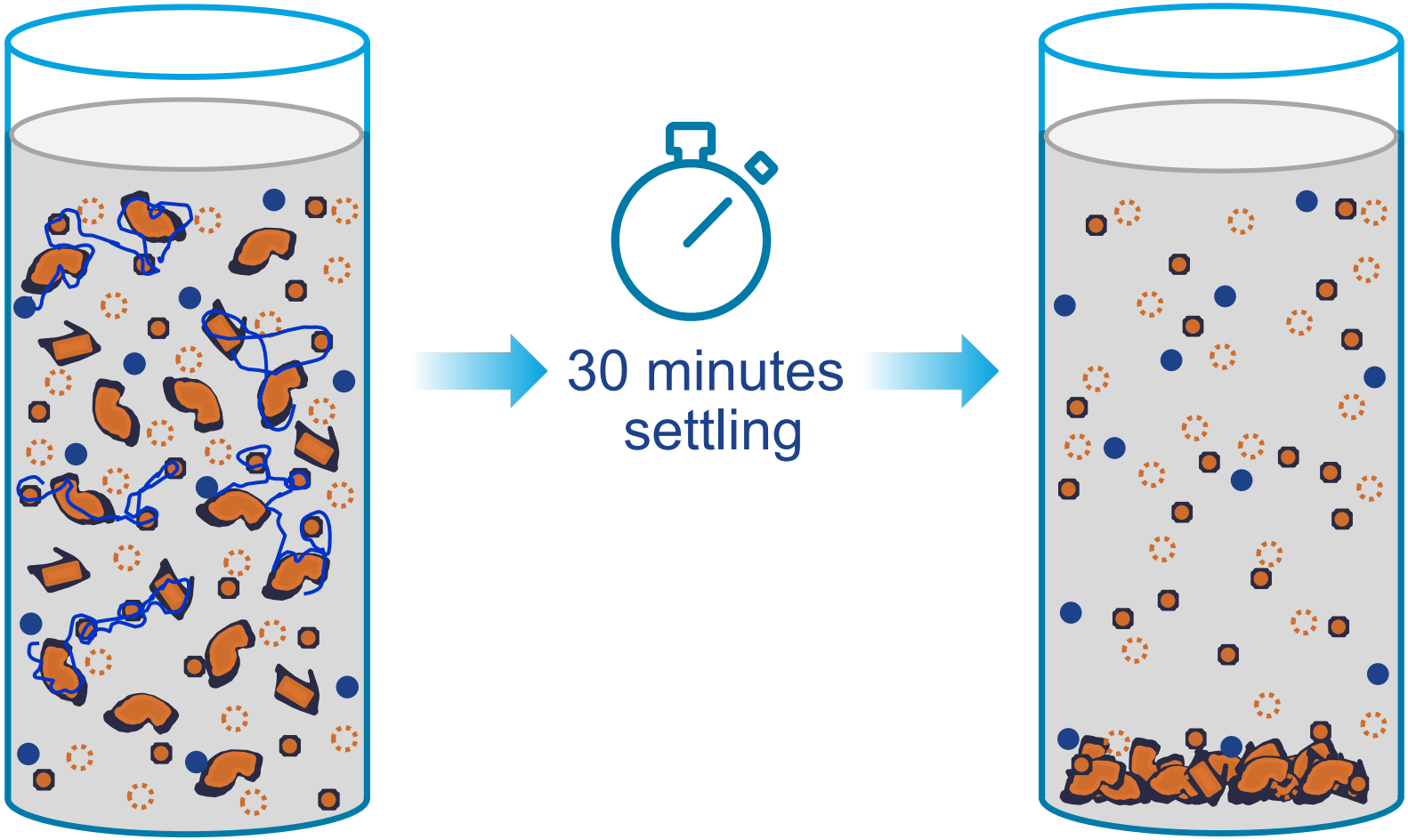
   [20−40% BOD_{INF} is $pBOD_{set}$]

Chemically Enhanced Primary Treatment (CEPT) —Two Different Objectives

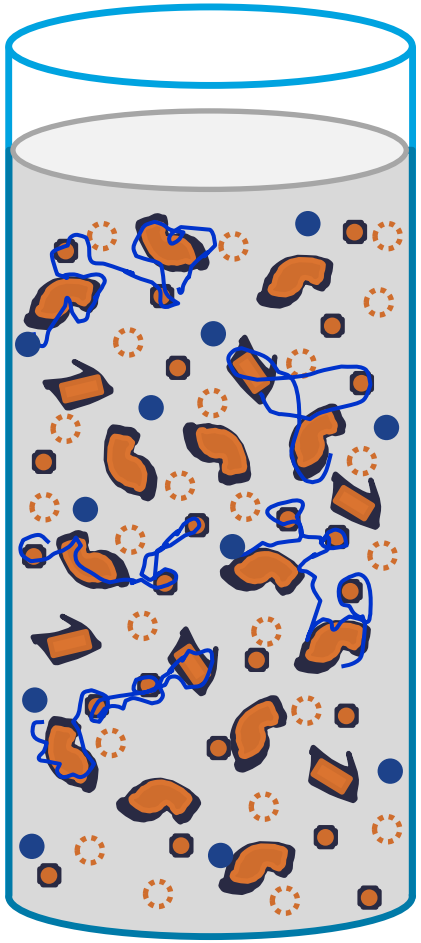


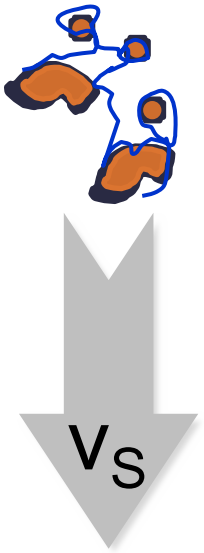
Chemicals
(coagulants and flocculants)

1. CEPT "Converts" Some TSS_{non} to TSS_{set} Increasing Removal Efficiencies

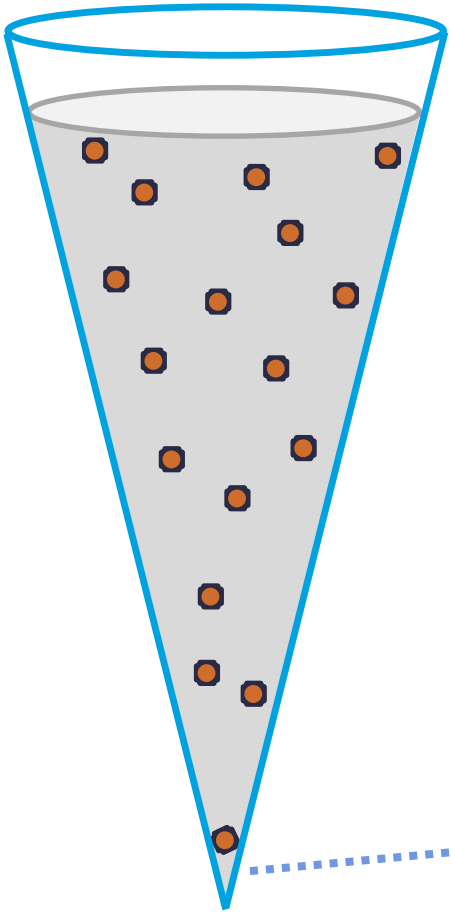


2. Larger TSS_{set} Settle Faster Maintaining Performance at High Flows





Optimum Primary Clarifier Performance Indicated by Two Test Results

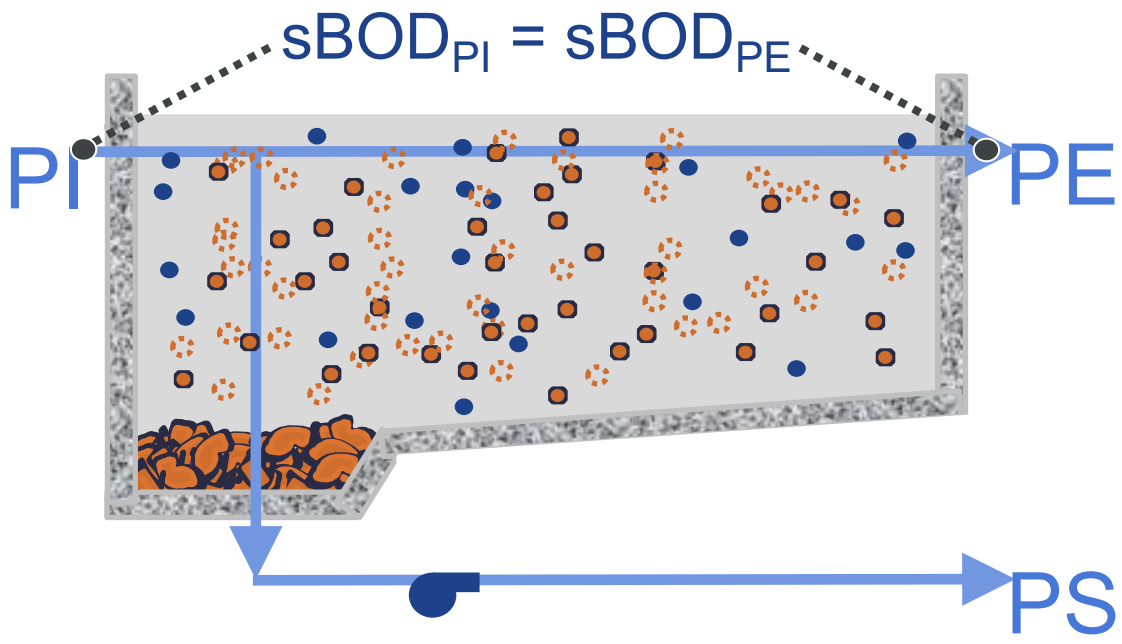


1. No TSS_{set} in Primary Effluent

$TSS_{set} = 0$

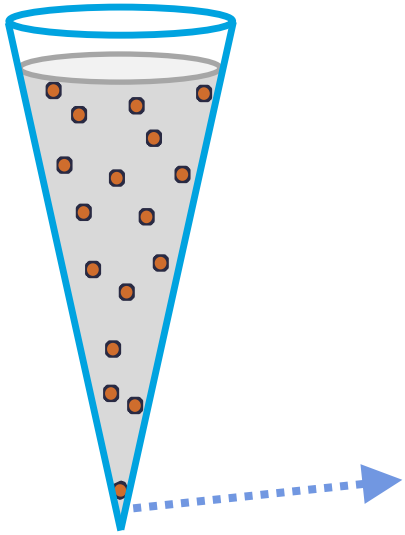
Optimum Primary Clarifier Performance Indicated by Two Test Results

2. No Increase in sBOD Influent to Effluent



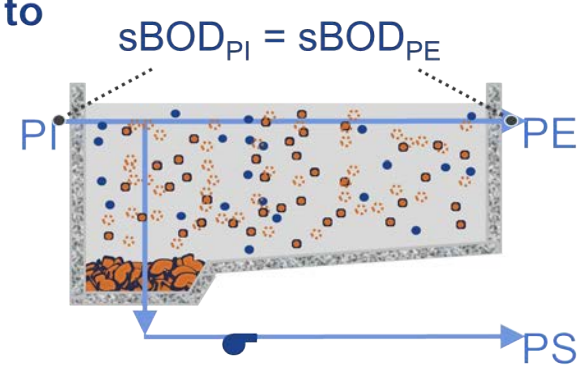
Homework Assignment 1

- Perform these 2 tests when you get back to your plant.



1. No TSS_{set} in Primary Effluent

2. No Increase in sBOD Influent to Effluent



PD Blowers


DANGER
THIS MACHINE STARTS
AUTOMATICALLY


Quarter-turn valve

@ 2500 RPM & 6 PSI

4.8 BHP & 112 CFM

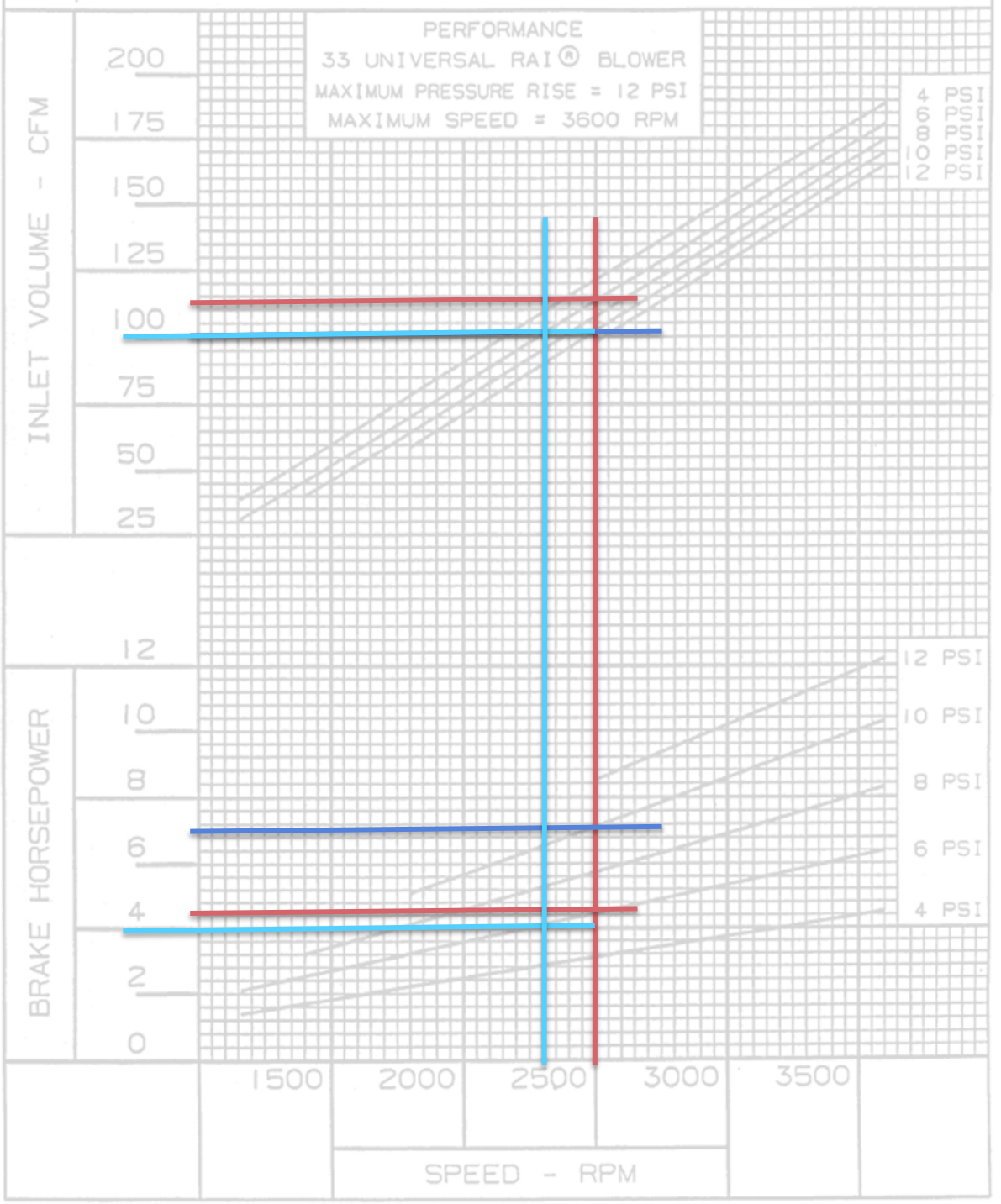
@ 2500 RPM & 10 PSI

7.1 BHP (UP 48%)
& 102 CFM (DOWN 9%)

Change the sheave
or use a VFD

@ 2300 RPM & 6 PSI

4.0 BHP (DOWN 16%)
& 102 CFM



Better Plants
U.S. DEPARTMENT OF ENERGY

Report Out

Homework

Think of three motors that are currently operating in your plant that you think you can reduce the runtime on, either through a timer or other automatic control.

List the motor equipment involved & fill in the table in your Workbook:

Equipment	HP	Current runtime	New runtime

Now, estimate the energy savings that will occur should you implement this opportunity

Closing

See You next week

Cascade Energy®

WWTT WasteWater Technology TRAINERS