Process Control Testing©

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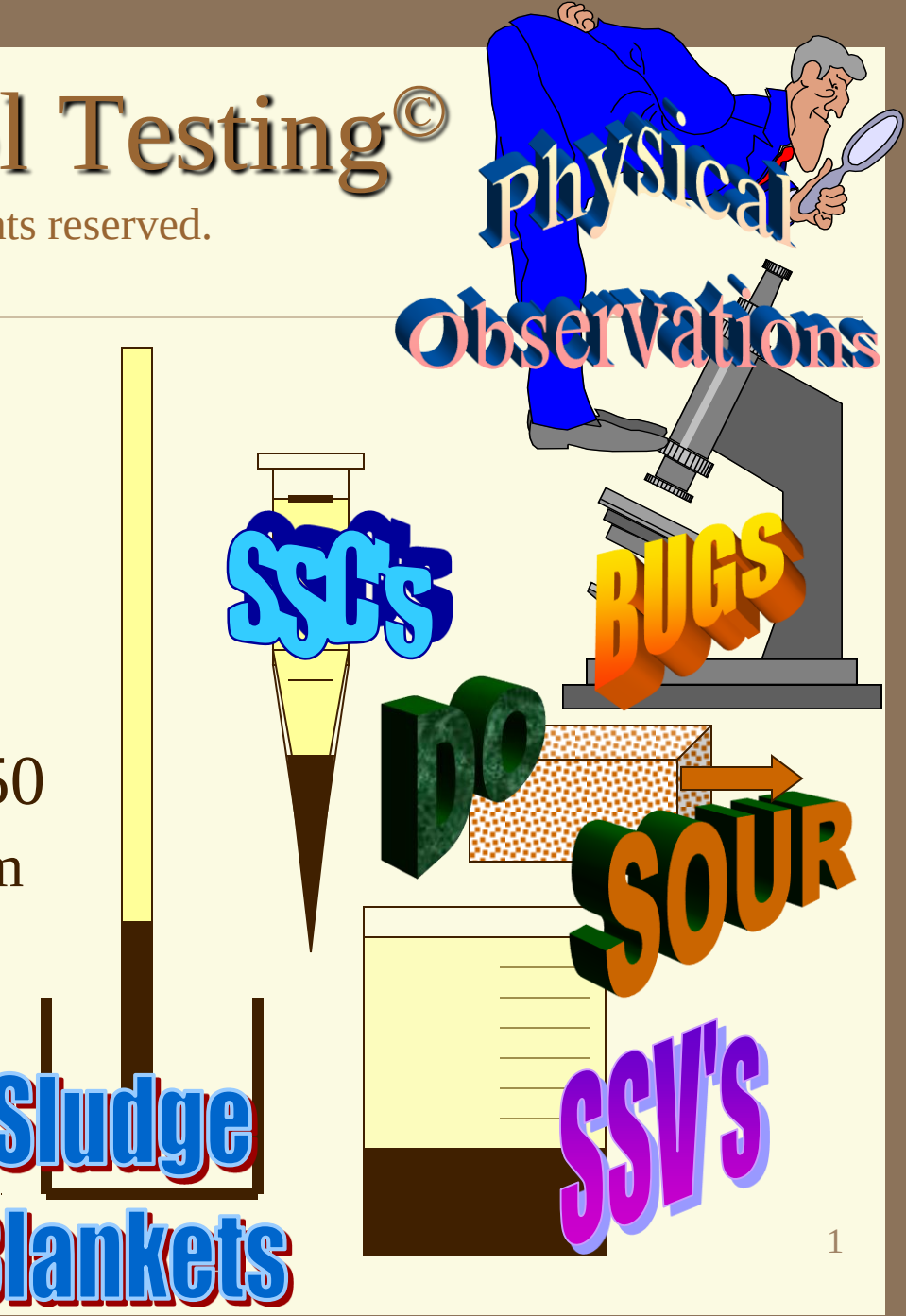


Typical WWTP Monitoring

BOD_5: Data is 5 days old

TSS: Analytical test is time consuming

FOG: INF not looked at much

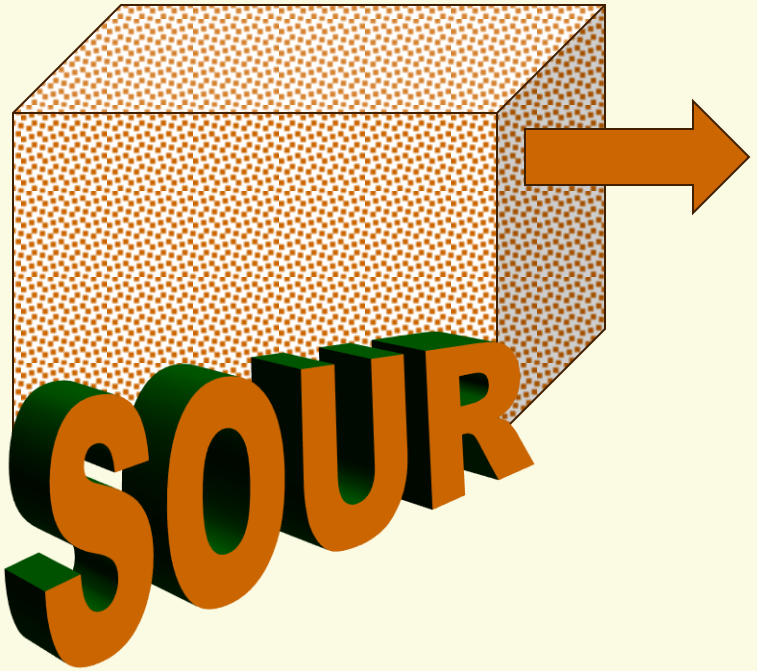
pH: INF not usually measured continuously

- Never measure pH on a composite sample!

NH_3-N: INF not required or examined much

- EFF is required at most plants for permit

Other important tests not covered



See PowerPoint presentations:

Microorganisms Growth and Oxygen Uptake Testing

Other important control tests

Dissolved Oxygen (mg./L. DO)

Oxidation-Reduction Potential (ORP in mV)

pH (1/log [H^+])

Nitrogen series

- Ammonia, NH_3-N (mg./L.)
- Nitrite, NO_2^{-1}-N (mg./L.)
- Nitrate, NO_3^{-1}-N (mg./L.)
- Organic, R-N (mg./L.)

Solids Inventory Control- KEY!

"You can't control what you don't measure!"

- Solids move continuously throughout plant
- You need to account for them daily!
  - Where are the solids?
  - How much is there?
  - For how long?
- Plants that comply routinely do this
- Compliers that don't are usually way under design

Solids Inventory Control Tests

Settleometer

- Simulates clarifier settling
- Settled Sludge Concentration (SSC_t)

TSS meter- Concentration by wt. (mg/L.)

Centrifuge- Concentration by vol. (%)

Core Sample- Average Clarifier Depth

- Verifies sludge blanket level
- Used to measure clarifier concentration

Focusing on the SQ tests that give numbers for AIR, RAS and WAS adjustments

RAS: Settlometer and the Centrifuge data

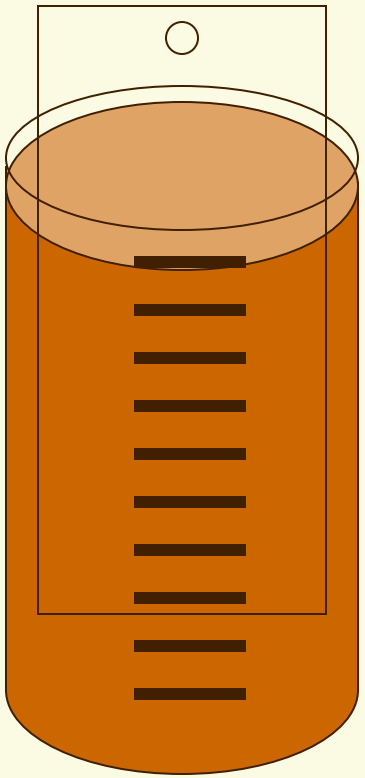
WAS:

- Tank volumes and Centrifuge data to determine the inventory.
- Flow rates and Centrifuge data to determine pumping rates and loadings

AIR: DO and ORP measurements

Settleometer Test

- Sample- Mixed Liquor
- Record start time
- Read Settled Sludge Volume (SSV) every 5 min. for 1st half hour
- Read SSV every 10 min. for 2nd half hour
- For slow settling read SSV_{90} & SSV_{120}



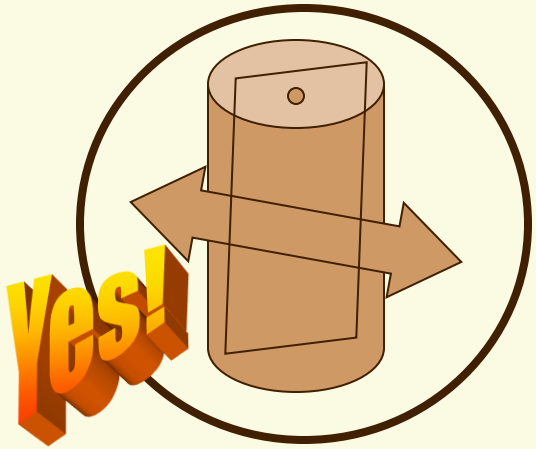
Example: SSV_0 = 1000

Settleometer Test Procedure

- **Fill** to 1000 mark
- **Mix** with wide paddle
- **Stop** all the currents
- **Remove** the paddle very slowly
- **Record** initial time
- **Start** timer
- **Observe first five minutes of settling!**

Raven Settleometer with curdled (Goldilocks) floc

Mixing the Settleometer



- Don’t use the old washing machine technique, but rather a gentle back and forth rocking action. This imparts good mixing without the potential for floc shear, especially with chemical flocs.

Example Readings

Settleometer Readings

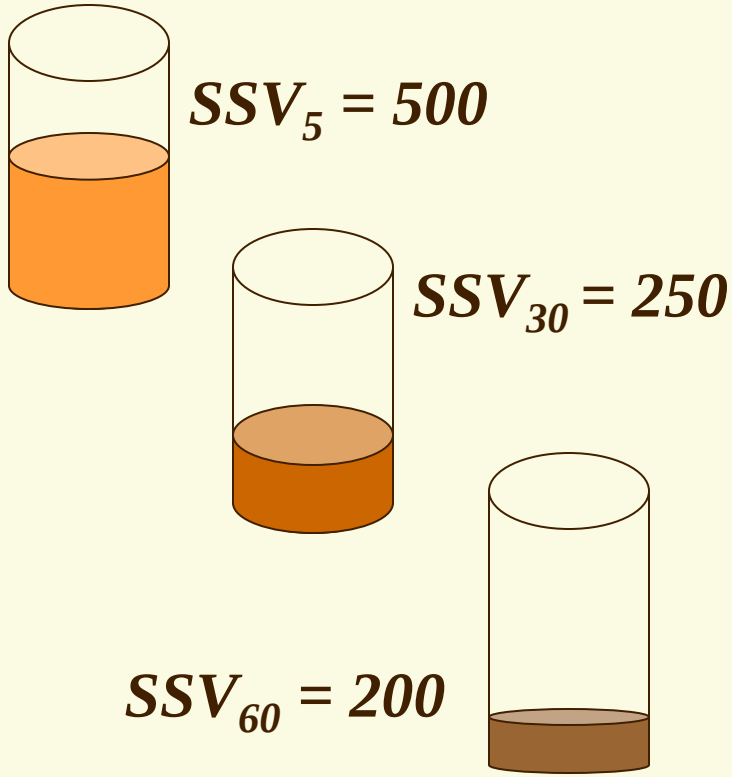
- 5 minute = 500

(5, 10, 15, 20, 25 & 30)

- 30 minute = 250

(30, 40, 50 & 60)

- 60 minute = 200
- Don't forget: If it's slow settling, read SSV_{90} & SSV_{120}



Dilution Test

Multiple Dilution Settleometer Test at WWTP. Classes for State being held with students in background.

Note that diluted sludge samples settle faster and leave a lower sludge blanket. This is very important at this plant since the clarifiers are only 10 ft. shallow!

Multiple Dilution Test Variation

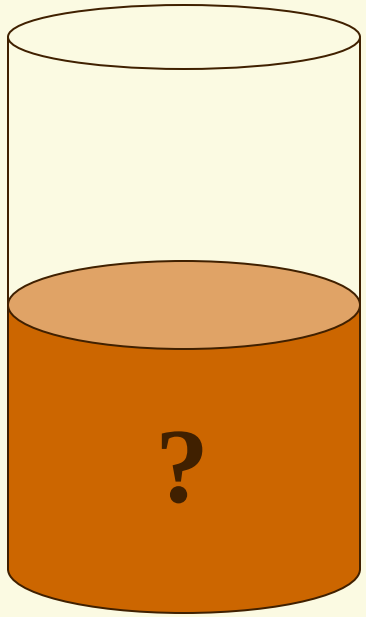
Used for slow settling sludge

- Young, under-oxidized particle settles slowly
- Old, over-oxidized particle settles fast
- Glutted old sludge settles slowly from hindered settling

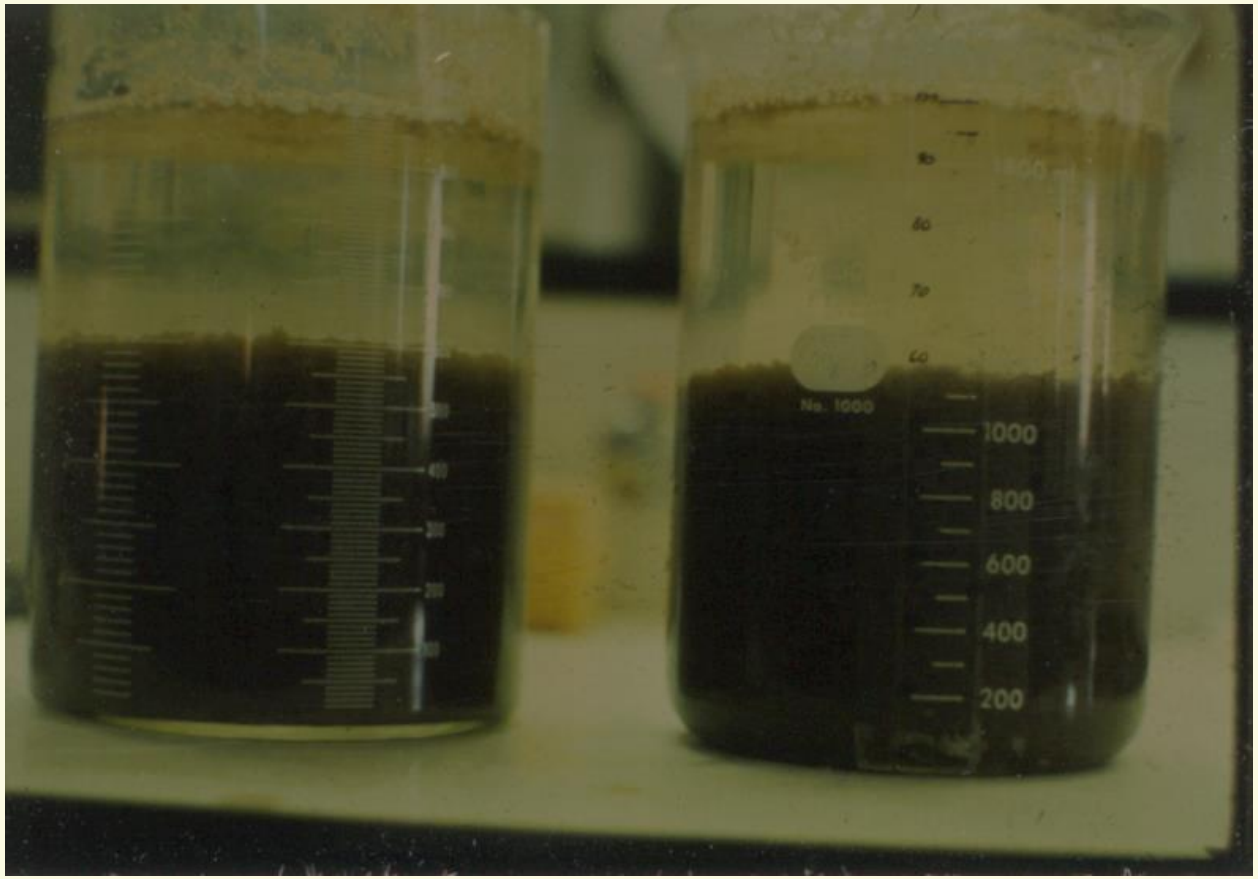
Example: SSV_{60} = 500

Is it young or old?

Waste: more or less?



Slow Settling Sludge



Settleometers from each aeration tank after 20 min., SSV_{20} = 600 cc./L.

Test Procedure

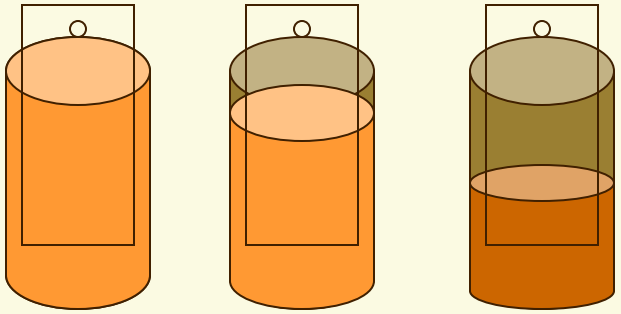
Samples:

- Mixed Liquor
- Final Effluent (no Cl_2)

Fill 3 settleometers

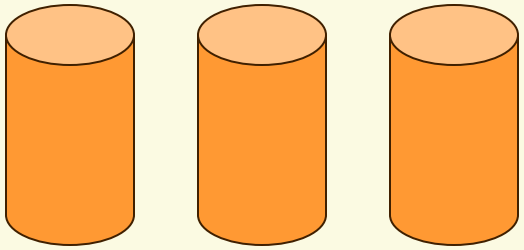
- 1-100 % mixed liquor
- 2- 75 % mixed liquor
- 3- 50 % mixed liquor

Dilute 2 & 3 to 100% mark with effluent



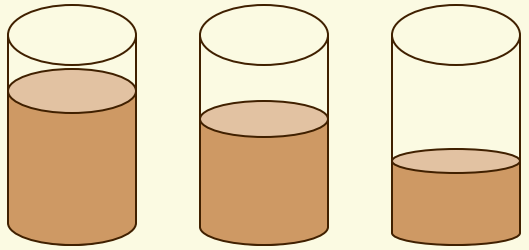
Mix all three samples with wide paddles, stop the currents and start them all at the same time: (SST = 0)

What happens?



Young Sludge (bulky sludge):

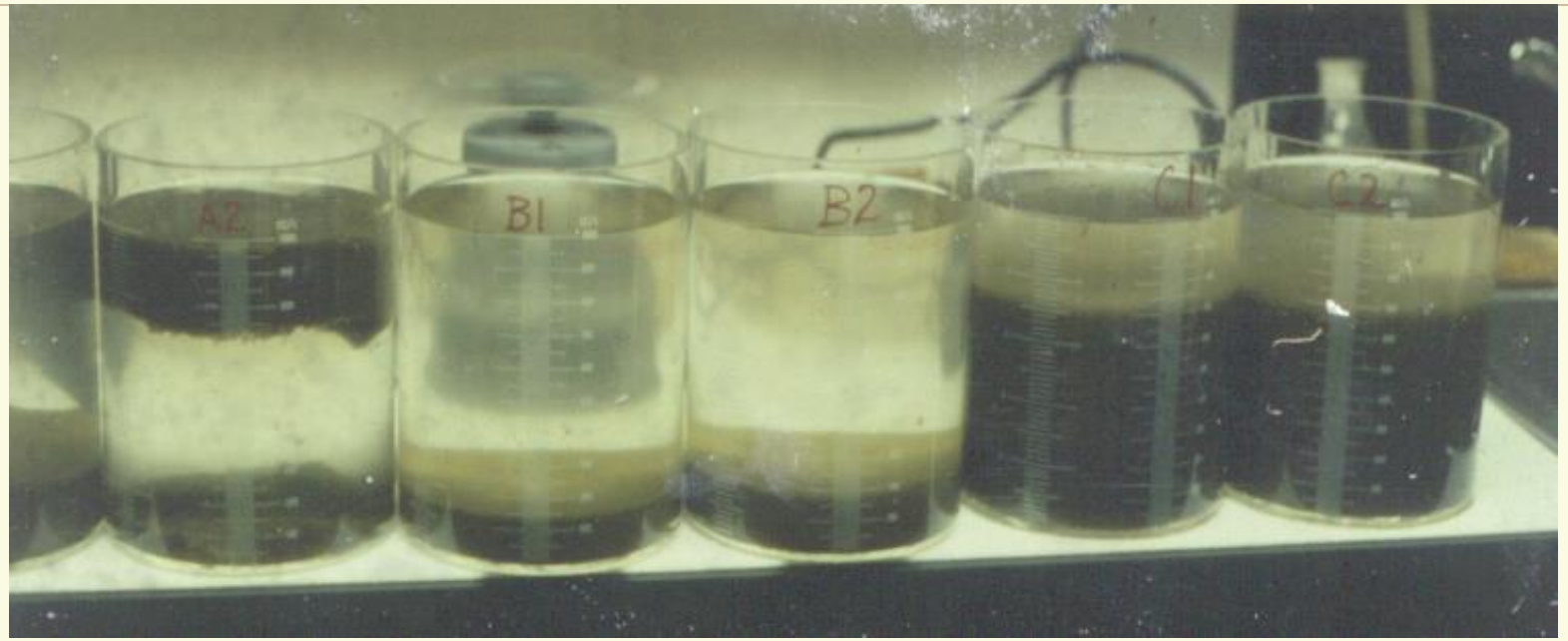
The particles dictate the settling rate so all 3 samples will settle about the same



Old glutted sludge (hindered settling):

The concentrations dictate the settling rate and the settling rate increases in the more dilute samples

3 Different Trains with 2 Tanks



- Does it look like A, B & C differ in their concentrations? That's why we use the centrifuge; to measure 6 samples in 15 min.

Suspended Solids Tests

Solids Inventory & Balance©

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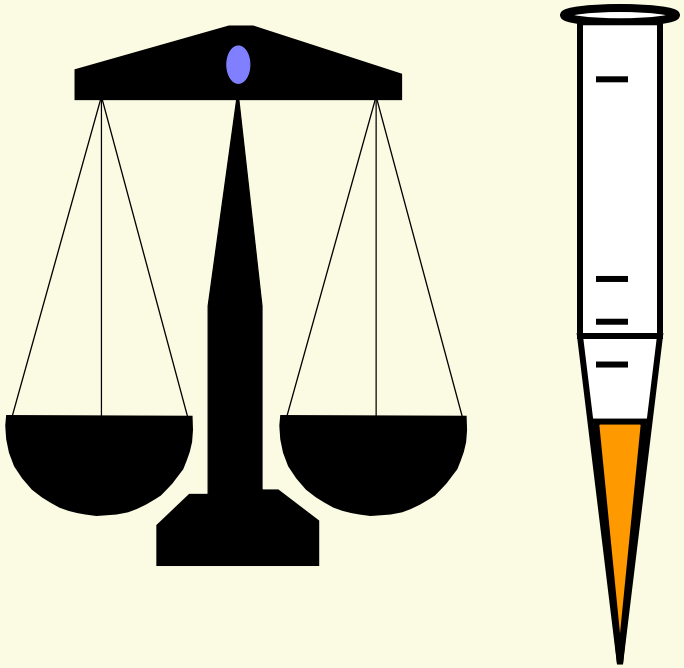
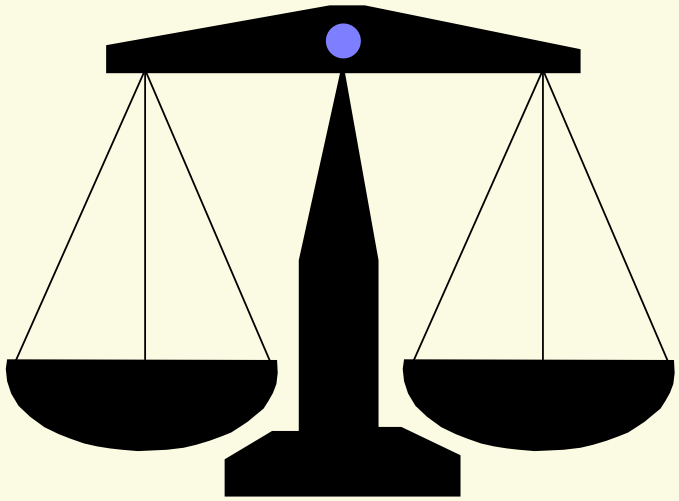


Gravimetric Determination, TSS

- Total Suspended Solids (TSS) has been conventionally used to determine the solids concentration (by weight) in sludge samples.



Portable TSS Meters

- The simplest and fastest way to obtain TSS (mg./L.)
- Some of these instruments provide more reliable measurements than do gravimetric procedures

7 day payback period!

Insite IG TSS meter

Portable or in-situ sensors

- You can get portable instruments for TSS measurements at various locations. These sensors are valuable at plants with multiple tanks.
- You can get in-place sensors to measure TSS continuously

ROYCE TECHNOLOGIES

DATA Sheet

Total Suspended Solids Systems

Model 711
Portable MLSS/ILA System

Model 7011A
Single Channel Analyzer

Series 7100/8000
Multi Channel/Parameter
DO/TSS Systems

Model 711 Portable MLSS/ILA System Features

- Two complete analyzers in one package (TSS & Interface Level)
- Microprocessor based
- Automatic ranging
- Simple, insitu calibration
- Electronic self-diagnostics
- Nine volt battery with automatic shutoff
- Waterproof, rugged housing

Models 7100/8000 Series Continuous System Features

- Microprocessor based electronics
- Automatic ranging
- Simple to use insitu calibration
- Menu driven text help screens
- Electronic self diagnostics
- Digital communications with isolation and surge protection
- Isolated current on voltage outputs
- Up to 2 set-point relays per channel
- User selectable calibration curves
- Backlit display (7110/7120/8000 Series)
- Menu driven text help screens
- Phased array source for automatic color compensation (Model 73B Sensor)
- Automatic ambient light compensation on all sensors
- NEMA 4X (IP65) enclosure

Bulletin No. TSS-11
December 2005

ITT

Multiple functions

- Some instruments may perform more than one task
- Here's one that measures TSS and Sludge Blanket Depth
- The price may go up depending on the number of functions

Royce TSS & SID meter

Sludge Interface Detector (SID)

- This unit is designed for measuring the sludge blanket
- The LED read-out displays relative concentrations
- The unit is inexpensive when compared to the TSS meters

Raven SID meter

Instrumentation

When you measure with any instrument you must always ask yourself,

- "When was this last calibrated?"
- "Was it calibrated satisfactorily?"

The Centrifuge Test uses a calibrated tube and the equipment is much less expensive than the TSS meters are. The TSS meter is typically more accurate than the lab test used to calibrate.

Core Sampler

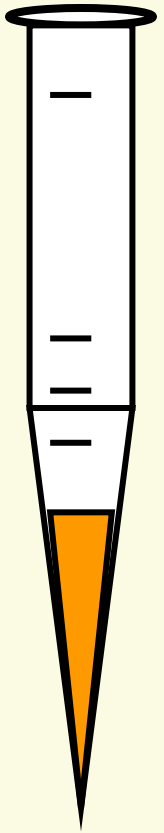
- Direct measurement of the blanket thickness
- You can see it!
- You can take a sample and measure the average clarifier concentration

Raven Centrifuge & TWC Tubes

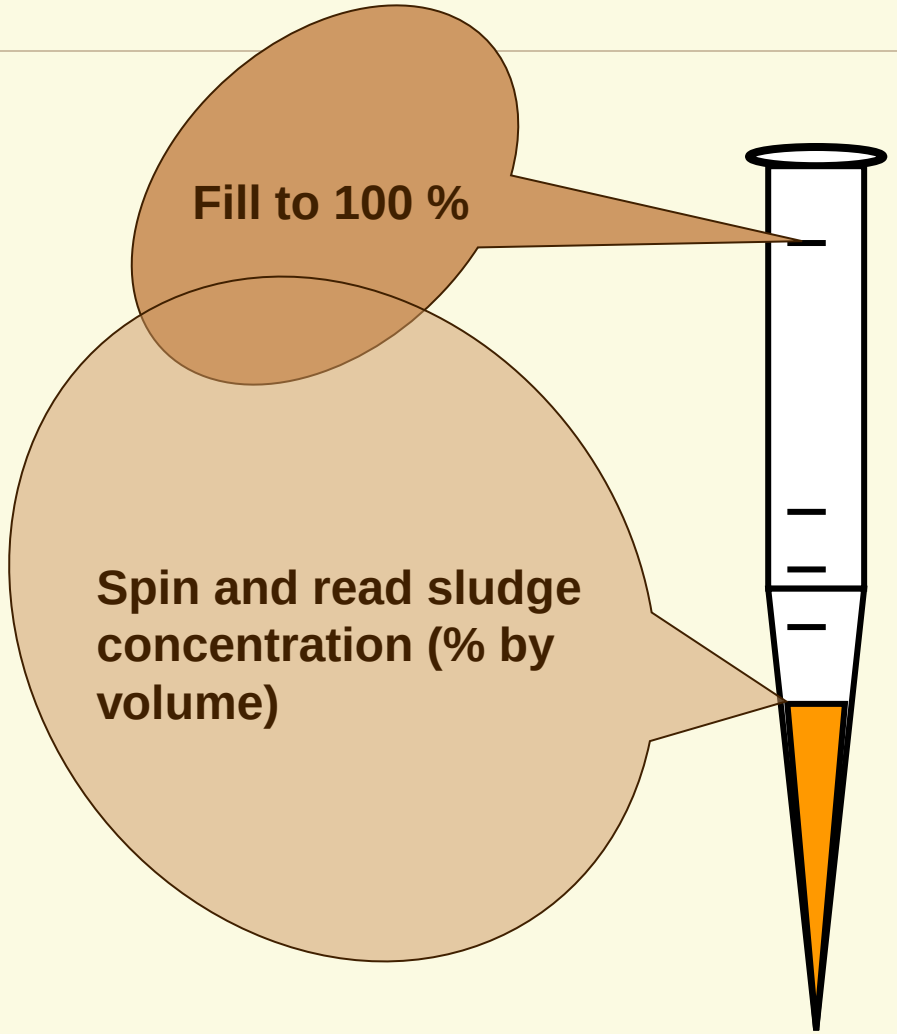
Designed for wastewater testing and used to determine concentration by volume

Centrifuge Test, % by volume

- Simple test that is used to determine solids concentration too. The concentration is expressed as % by volume rather than by weight.



Centrifuge Tube



Sludge Quality Process Control

- We are controlling a plant that is an extremely complex:
- Physical System
- Chemical System
- Biological System

- What we are looking for so that we can control:
- Simple Tests
- Timely Tests
- Inexpensive Tests

Centrifuge Test Data is used to:

- Control RAS & WAS
- Balance multiple tanks
- Determine solids inventory
- Calculate Sludge AGE
- Calculate Flow Rates
- Check Flow Meters
- Run Trim Spins
- Check OUR concentration

TSS (mg./L.) & Centrifuge (%)

Both numbers are extremely valuable operational parameters!

- MLSS is concentration by weight
- ATC is concentration by volume

Weight per unit volume is DENSITY!

- With both values we can observe changes in the density of the sludge

Weight/Concentration, WCR

Weight to Concentration Ratio:

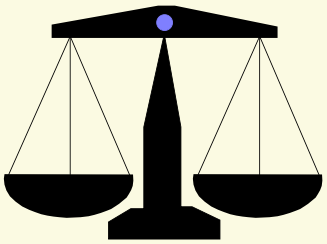
- ***MLSS/ATC***

Old, over-oxidized sludge >1000

"Properly" oxidized sludge 500-1000

Young, under-oxidized sludge <500

MLSS - Mixed Liquor Suspended Solids



ATC - Centrifuge Test on Mixed Liquor

Sludge Quality: WCR Examples

- Old, Over-oxidized Sludge

WCR= 3500/3.0 = 1166 $SSC_{60} \geq 20\%$

- "Goldilocks" Sludge

WCR= 2500/3.0 = 833 SSC_{60} 10- 20%

- Young, Under-oxidized Sludge

WCR= 1200/3.0 = 400 $SSC_{60} \leq 10\%$

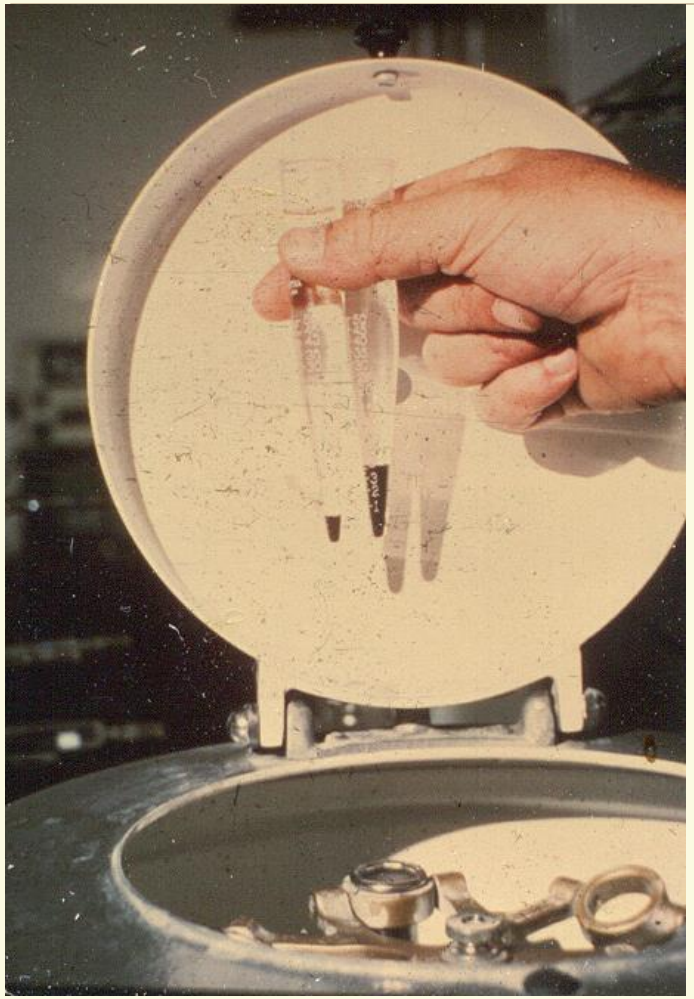
It's a density thing,….

- As sludge is oxidized from young to old, the organics are driven off. This decreases the volatile fraction and increases the inorganic (non-volatile) fraction of the sludge.
- If you run a MLSS and a spin (ATC) you can observe the increase/decrease of the volatile fraction by observing WCR.
- This provides the same type information as MLVSS does.

Summary

- Use of the centrifuge enables operators to obtain suspended solids information that is timely, simple, inexpensive
- Combining the info from the gravimetric and the volumetric tests provides density information

Centrifuge Test



Use a centrifuge to determine concentrations, balance multiple units and in operation of the Step-feed or Contact Stabilization mode.

Remember:

- ***Where are the solids?***
- ***How much is there?***
- ***For how long?***

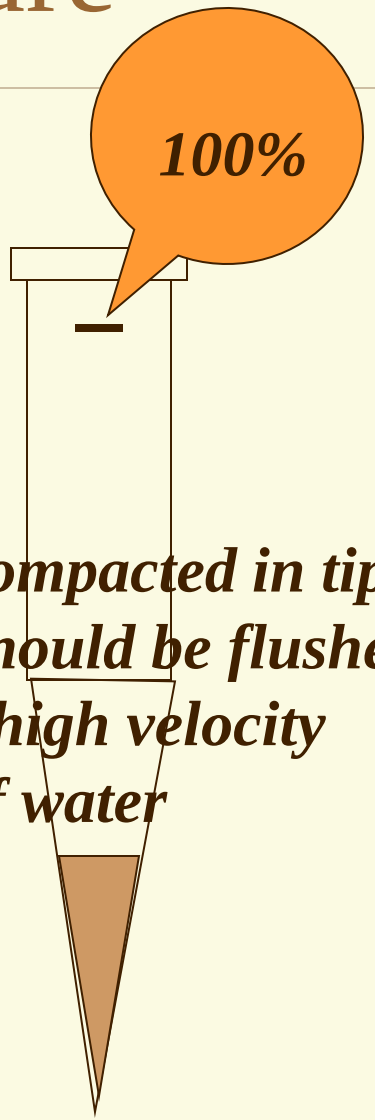
Centrifuge Test Equipment

Raven Centrifuge & TWC tube

Centrifuge Test Procedure

Raven B-10101 TWC centrifuge tube

- Calibrated directly in % by volume
- Fill to 100 % mark
- Put in balanced centrifuge
- Spin for 15 min. & read concentration
- Clean tubes & dry

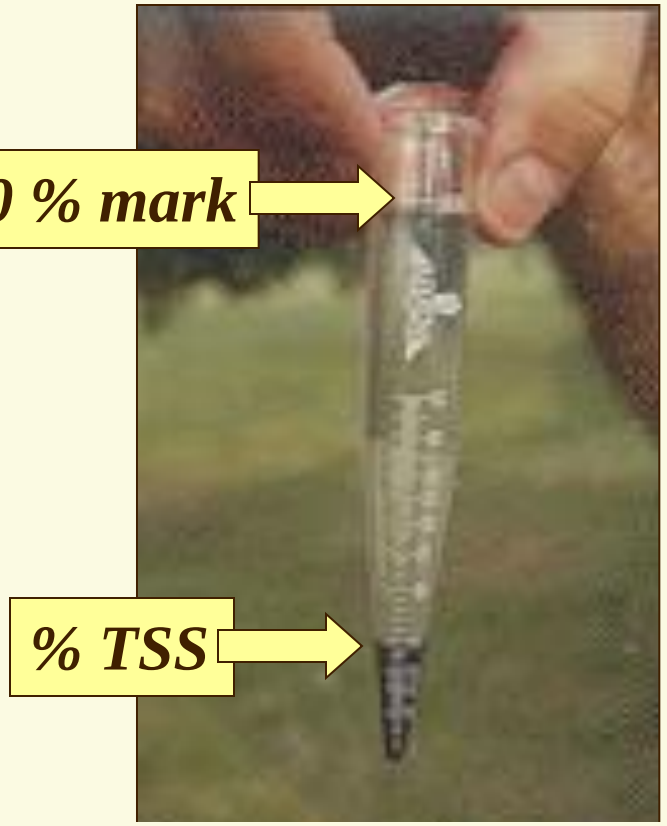


Sludge compacted in tip of tube should be flushed out with high velocity stream of water

Centrifuge tube options

- **Kimax-** API glass tube was 1st, but with breaks, cuts & co$tly
- **Nalgene-** plastic tube has no steep taper & no direct % calibration
- **Raven-** B-10101 TWC

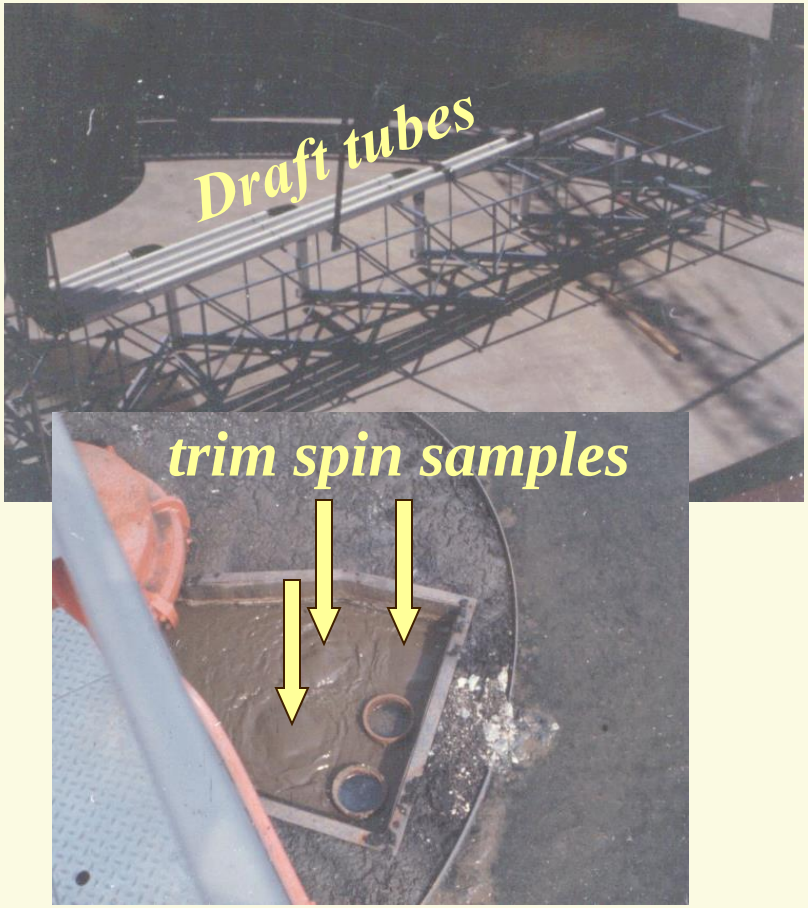
  Steep taper & direct % calibration. No breaks or cuts, it's made specifically for TWCs!



Raven B-10101 TWC Centrifuge Tube

Trim spins for balanced draw-off

- With clarifiers that have RAS hoppers at the top and draft tubes we need to check that the tubes draw evenly
- Centrifuge samples are taken off each draft tube to see that they're about the same %

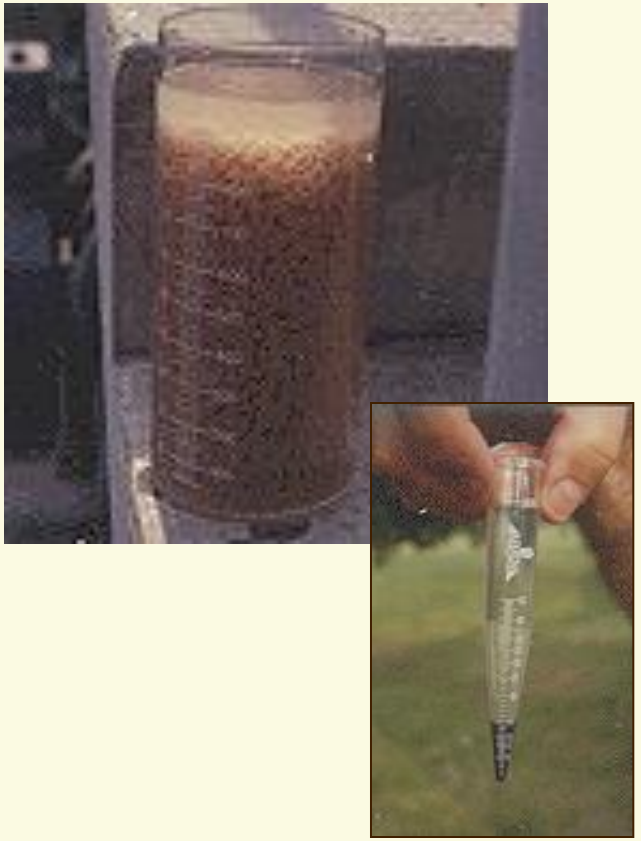


Remember!

- 1% by weight is 10,000 mg./L., e.g. a pretty heavy return or waste sludge sample
- 1% by volume is not very thick, e.g. a core sample from a clarifier or an extremely weak mixed liquor sample
- WCR = MLSS/ATC
- Goldilocks sludge quality typically has a Weight to Concentration Ratio (WCR) of 500-1000 mg./%
- This number increases with a decrease in organic fraction

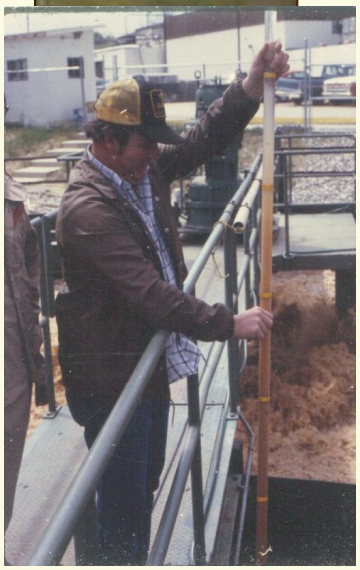
Combining data from both tests

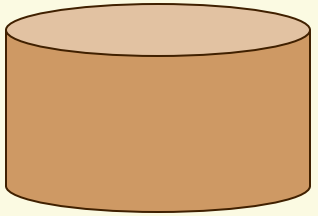
- Use to calculate Settled Sludge Concentrations(SSCs, how the sludge concentrates with time)
- Use for proper Return (RAS) adjustments
- Use to evaluate Sludge Quality



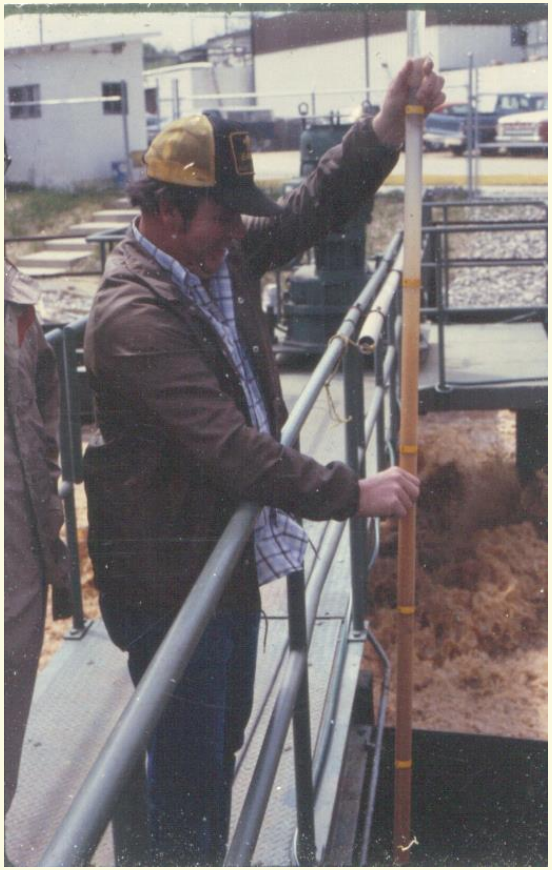
Sludge Units (SLU): Combining spin concentrations with volumes and flow rates

- Use the spin data, or collect a core sample and spin it, to multiply by the volume or flow rate
- Calculating inventory of SLU tells us how much is in a tank or how much we're pumping

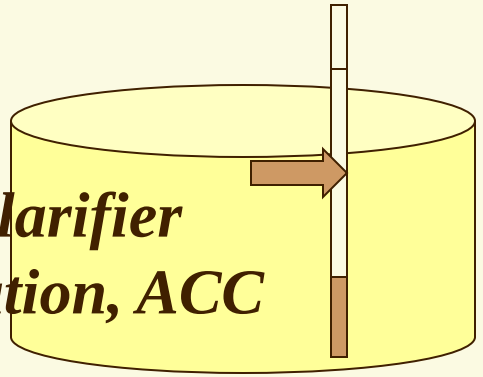




Sludge Blanket & Concentration



- Measure the blanket depth and then transfer the entire sample into a bucket for ACC (Average Clarifier Concentration) spin

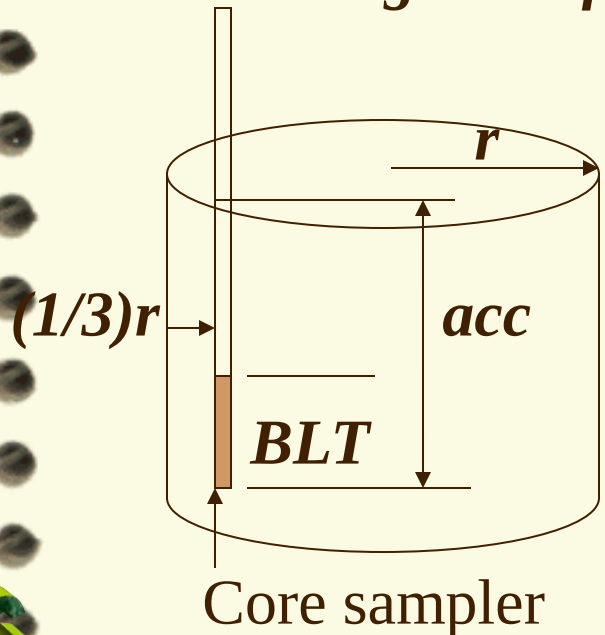


Average Clarifier Concentration, ACC

Blanket Locations & Terms

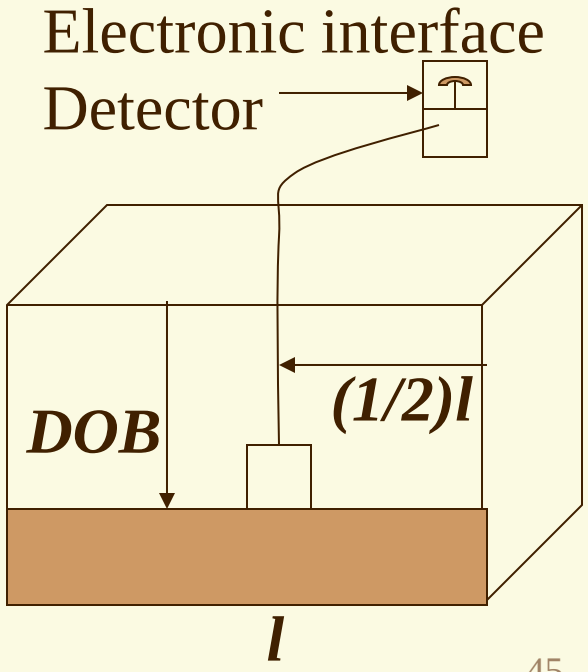
Circular Clarifiers

- ***BLT - blanket thickness***
- ***r - radius***
- ***acc - average clarifier concentration***



Rectangular Clarifiers

- ***DOB - depth of blanket***
- ***l - length***

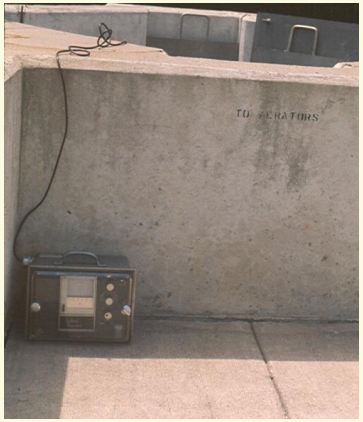


pH: ~7 for BOD & ~8 for NH_3-N

- pH problems rarely exist at municipal WWTPs but…
- A recording pH meter can be left on influent lines to monitor the wastewater
- NEVER measure pH on composite samples!

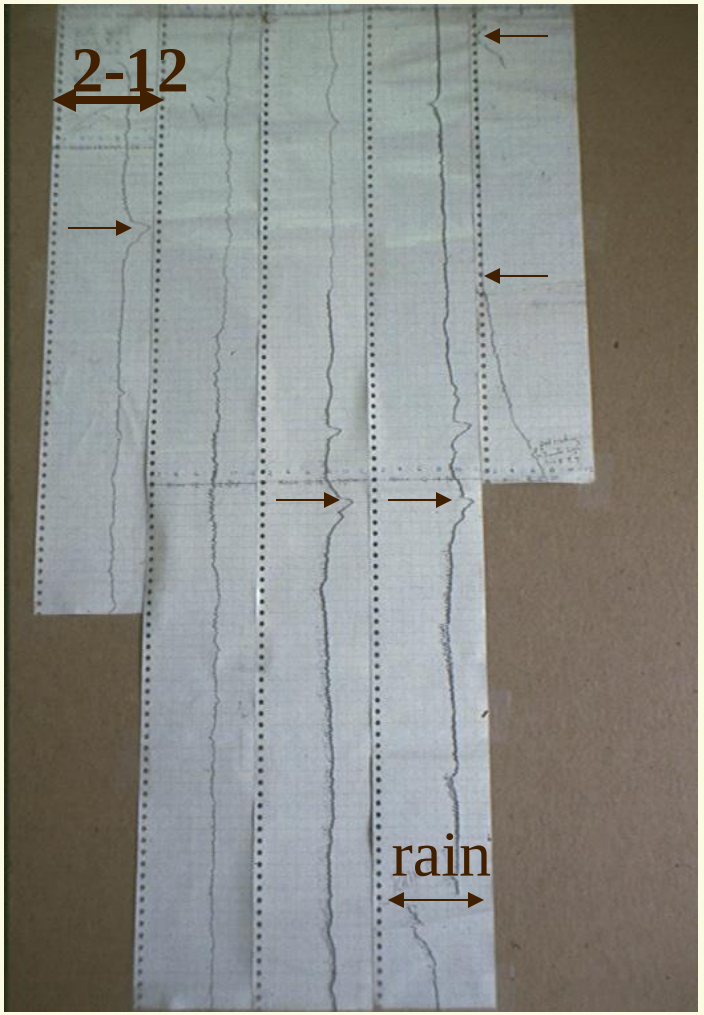
pH: Never measure composites!

- Portable recording pH meters are invaluable
- Here's an example where a battery operated pH meter was left to monitor influent into a plant in Champaign, Illinois



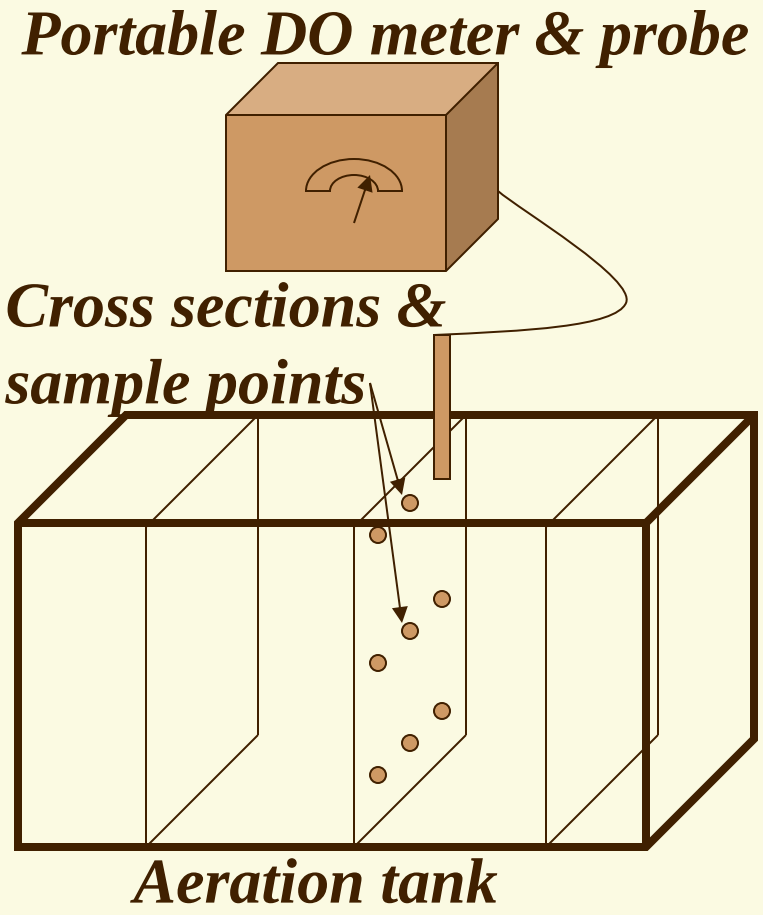
pH: Portable w/Rustrak recorder

- The pH range on the strip chart recorder is 2-12 (~ 3 week period)
- You can see from the arrows, excursions where pH varied drastically yet the plant thought they had no pH problems
- They measured the composite sample daily

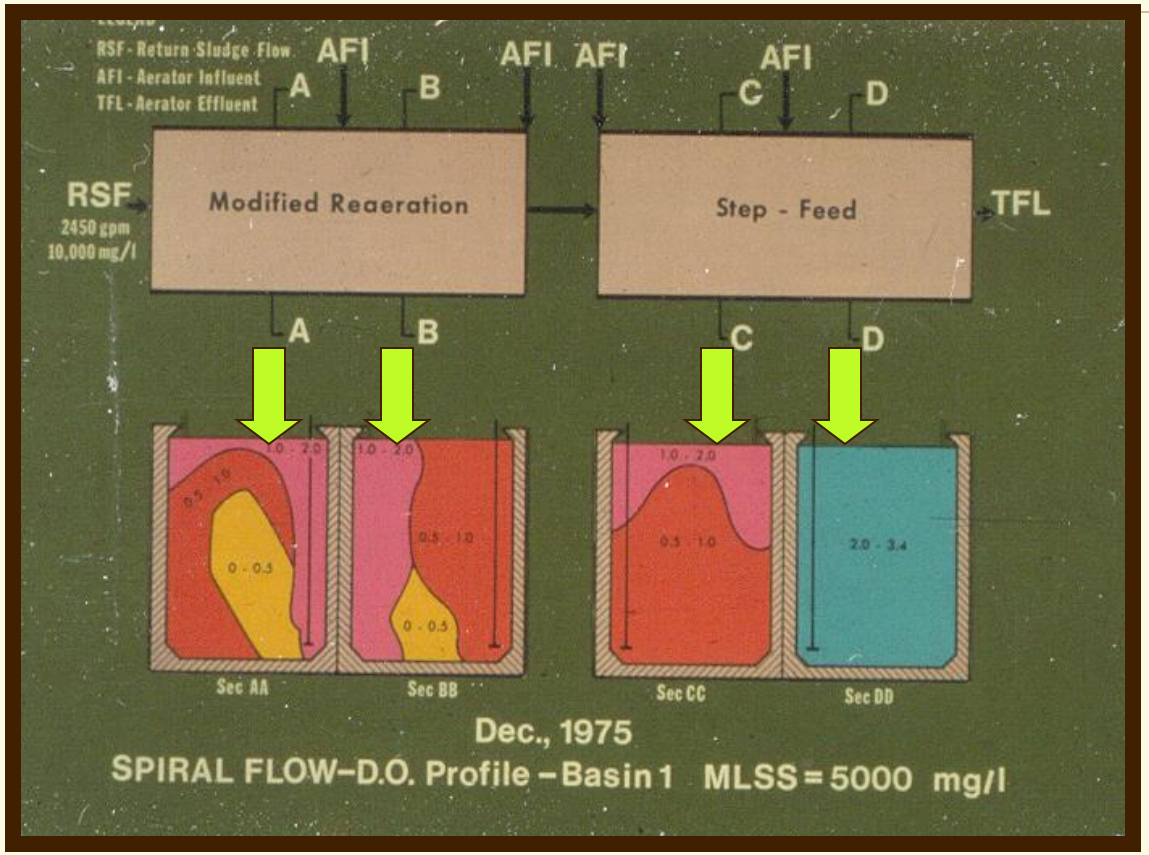


Dissolved Oxygen (DO)

- Run Dissolved Oxygen (DO) Profiles on aeration tanks to evaluate mixing and adequate air supply
- Profiles should be done seasonally as temperature changes, impacting DO



Example: DO Profile



D.O. Profile on Basin 1 at MLSS = 5000 mg./L.

Note the colors:

Yellow < 0.5 mg/L

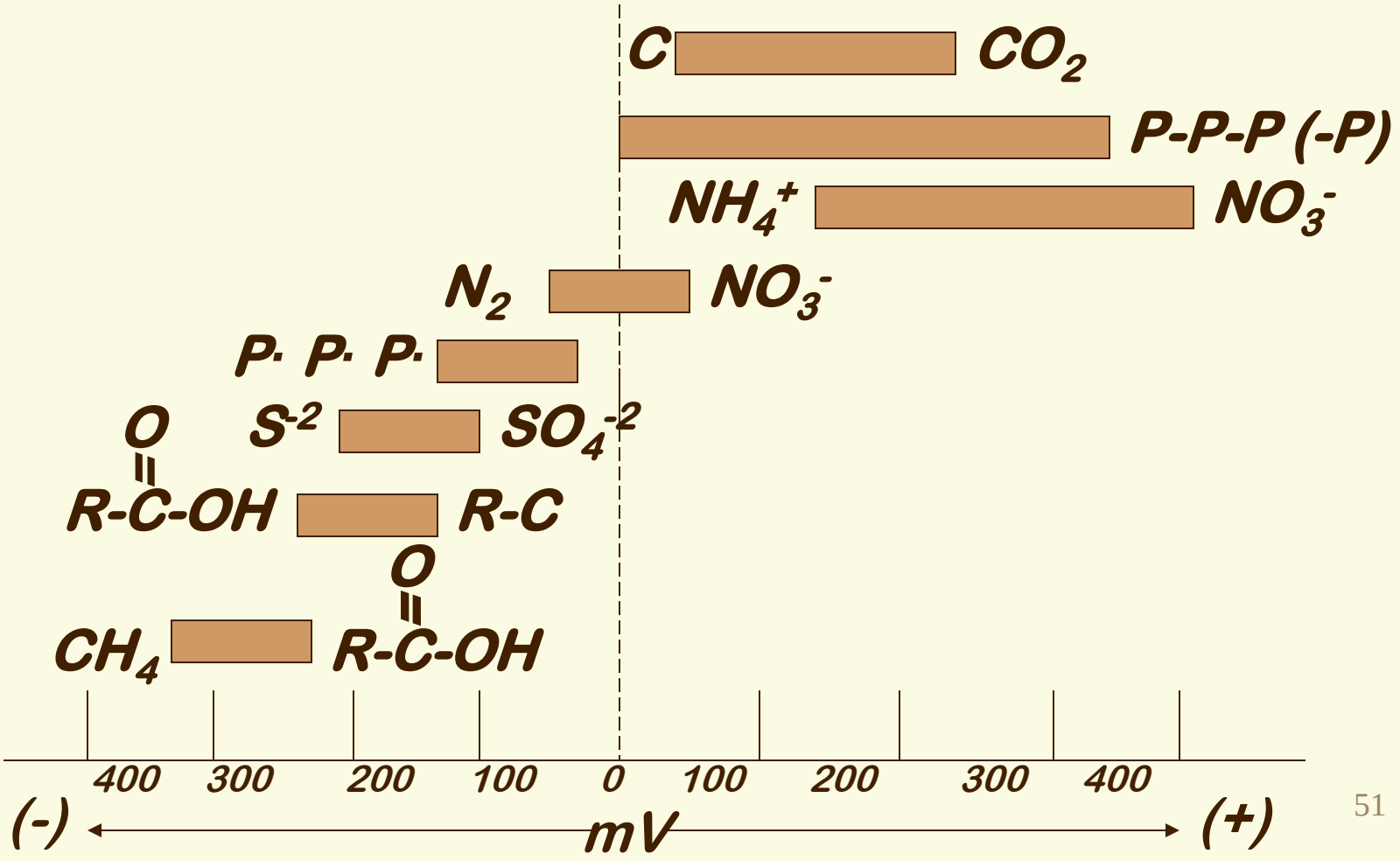
Red 0.5-1.0 mg/L

Pink 1.0-2.0 mg/L

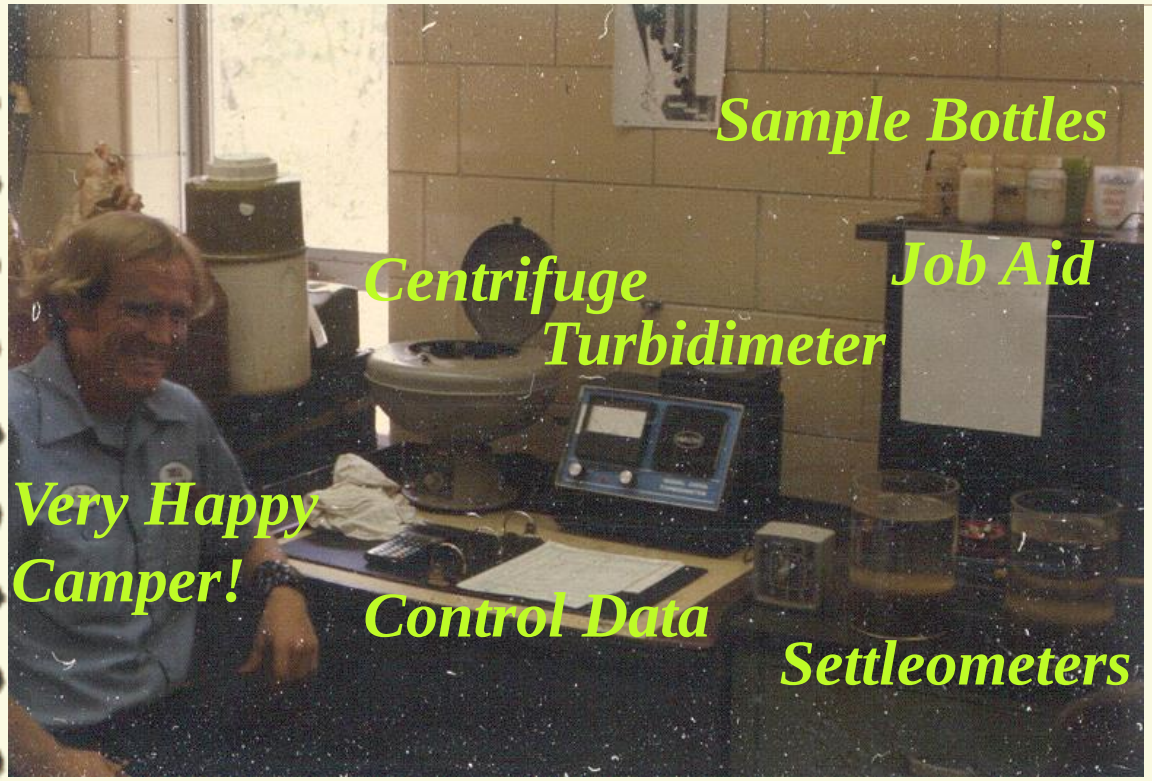
Blue 2.0-3.4 mg/L

Dissolved Oxygen Profile at WWTP - Basin 1

ORP: Oxidation Reduction Potential



Process Control Tests



Operator morale improvement through better process control and NPDES compliance at WWTP

Implement a regimented process control sampling and testing program!

How many of you had that down on your lists?