North Central/Eastern Kentucky Water and Wastewater Operators Association
Annual Fall Conference

October 23, 2013

MLSS Constituents and Solids Balance
Session 2

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HAZEN AND SAWYER
Environmental Engineers & Scientists

Agenda

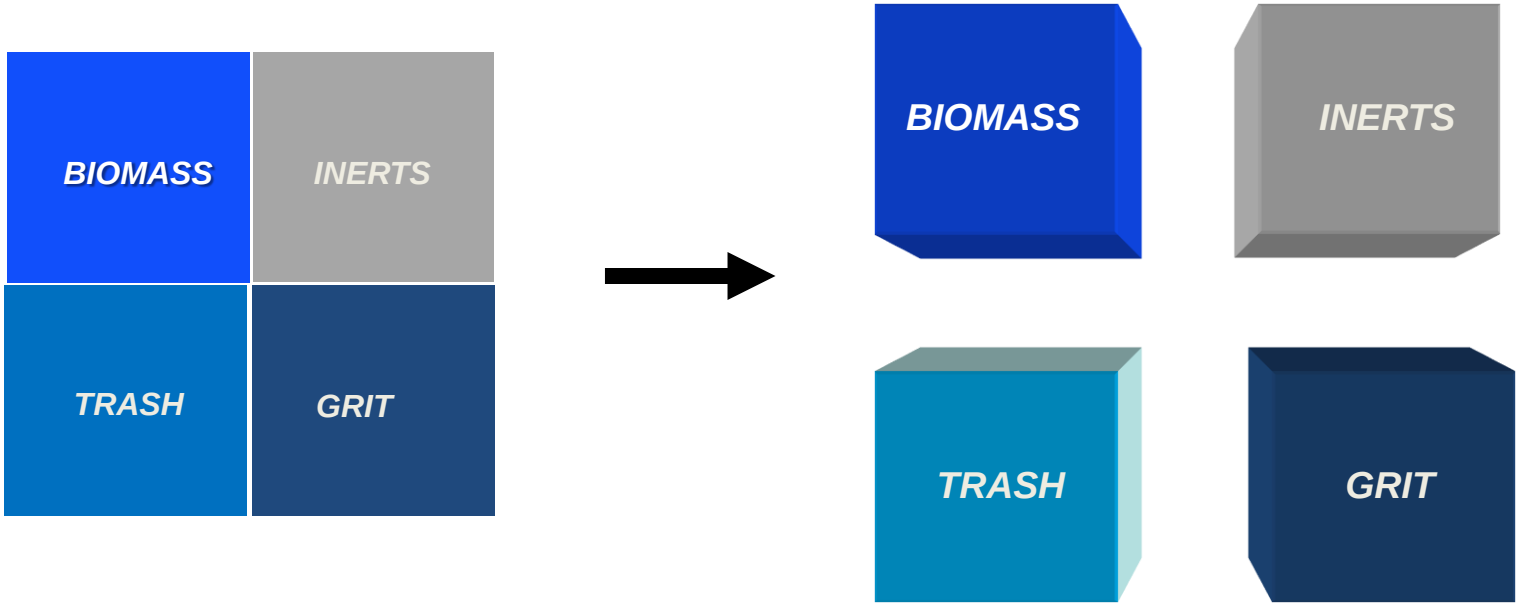
- What is in the MLSS
  - Trash/Grit/Inerts and Biomass
  - Inventory Control
- Ballasted Settling
- Estimating the Portion of MLSS that is Biomass
- Solids Movement in a Plant
  - Simplified Mixing Formulas
- Questions


Biological Solids
I Wonder How Much of that MLSS is Biomass?

Mixed Liquor Biological Content

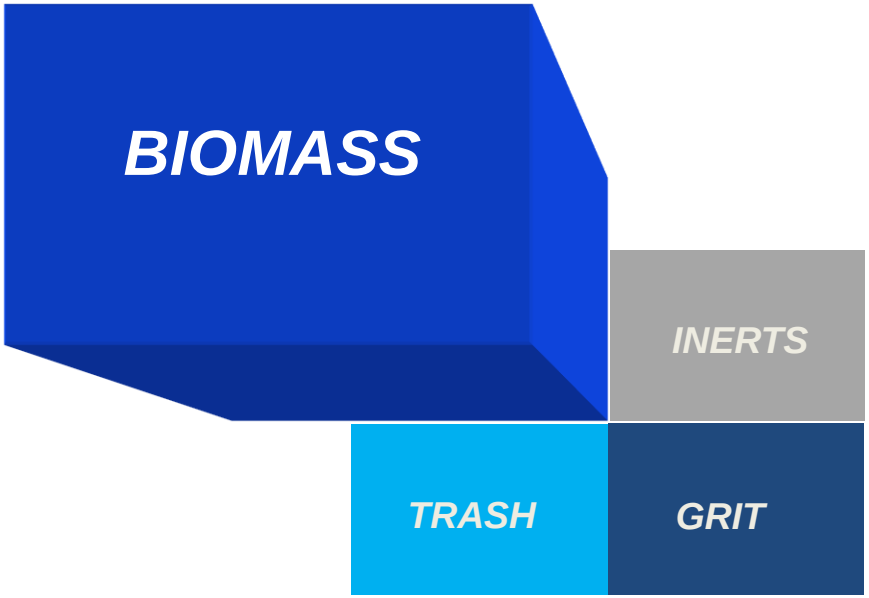
- What is in 240 gallons (1 wet ton) of 3,000 mg/L Mixed Liquor?
  - 2,000 pounds of MLSS including water and solids (approximately 240 gallons).
  - 0.003 or 0.3% solids is 6 pounds of solids
  - 0.997 or 99.7% water is 1,994 pounds of water
- Biological cells are approximately 80% water and 20% solids. Therefore, on a dry basis, if all 6 pounds of solids were biological:
  - 0.0006 or 0.006% solids - 1.2 pounds of solids and 0.024% cell moisture (4.8 pounds of water)
  - Biological content can vary and is likely to be less than 40% of the MLSS - less than 0.6 pounds.

Components of MLSS

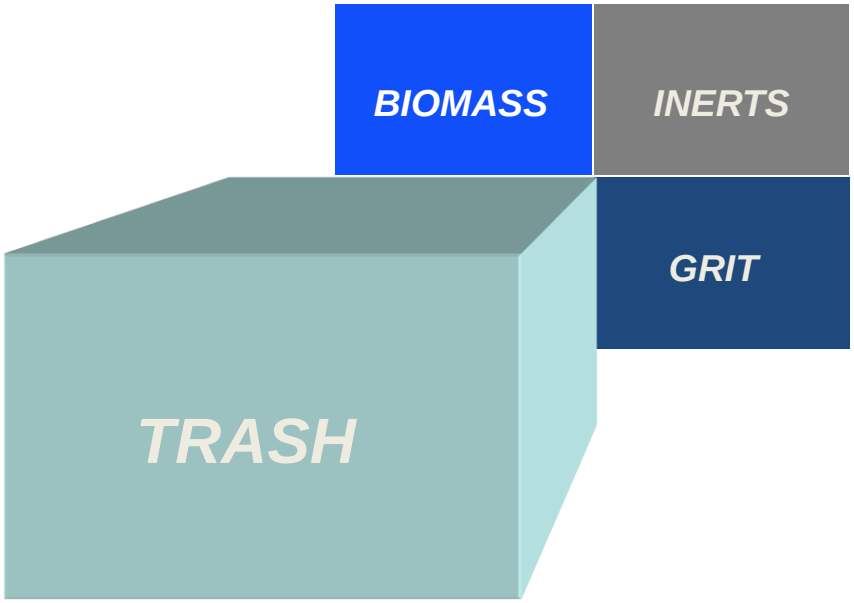


Components of MLSS

The biological growth generated by the removal of soluble organic wastes.



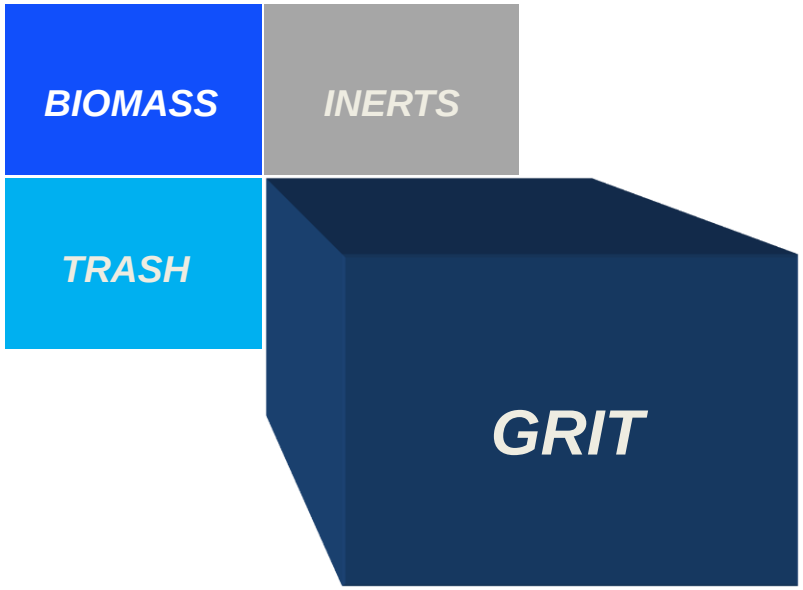
Components of MLSS



The non-biodegradable organic material present in the raw influent:

lint ,
hair,
synthetic fibers,
and plastics.

Components of MLSS

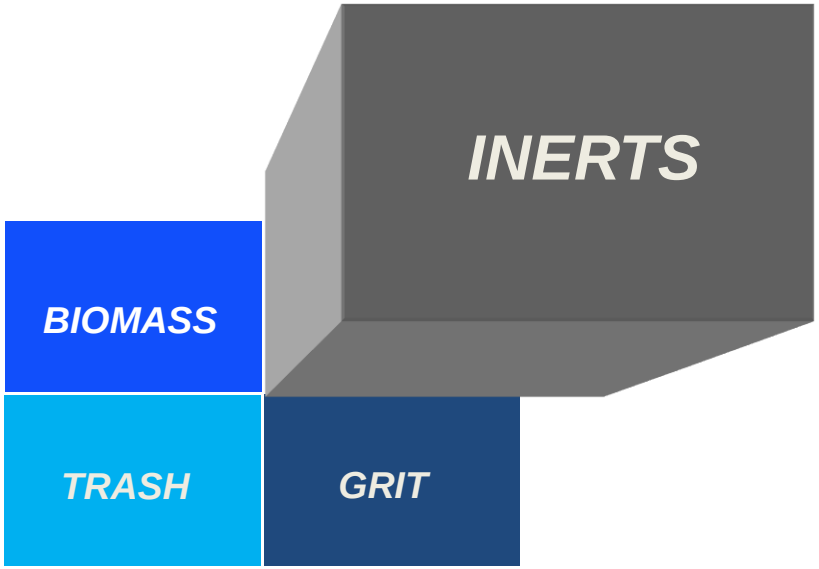


Part of the larger inert particulate material commonly known as grit:

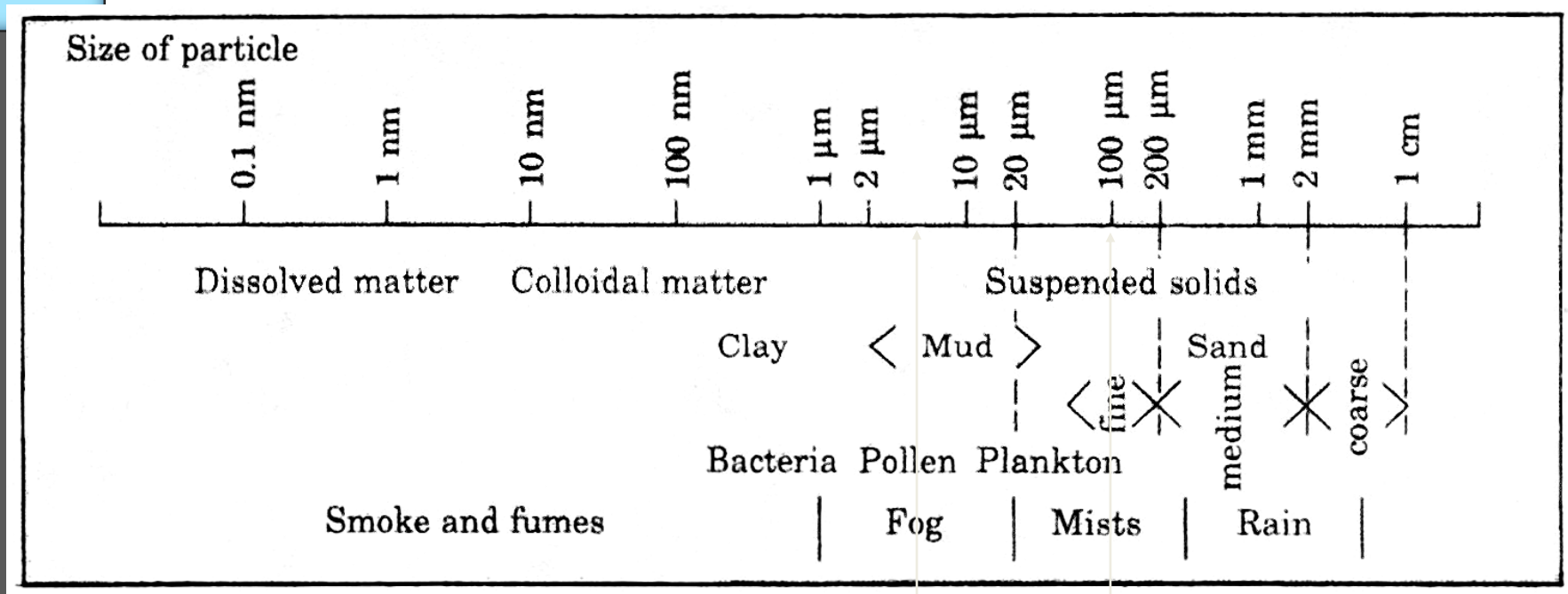
not degradable,
not organic.

Components of MLSS

Inorganic salts and fine sand similar in size to the biological solids.



Basic Components of Activated Sludge Mixed Liquor Particle Size Comparison

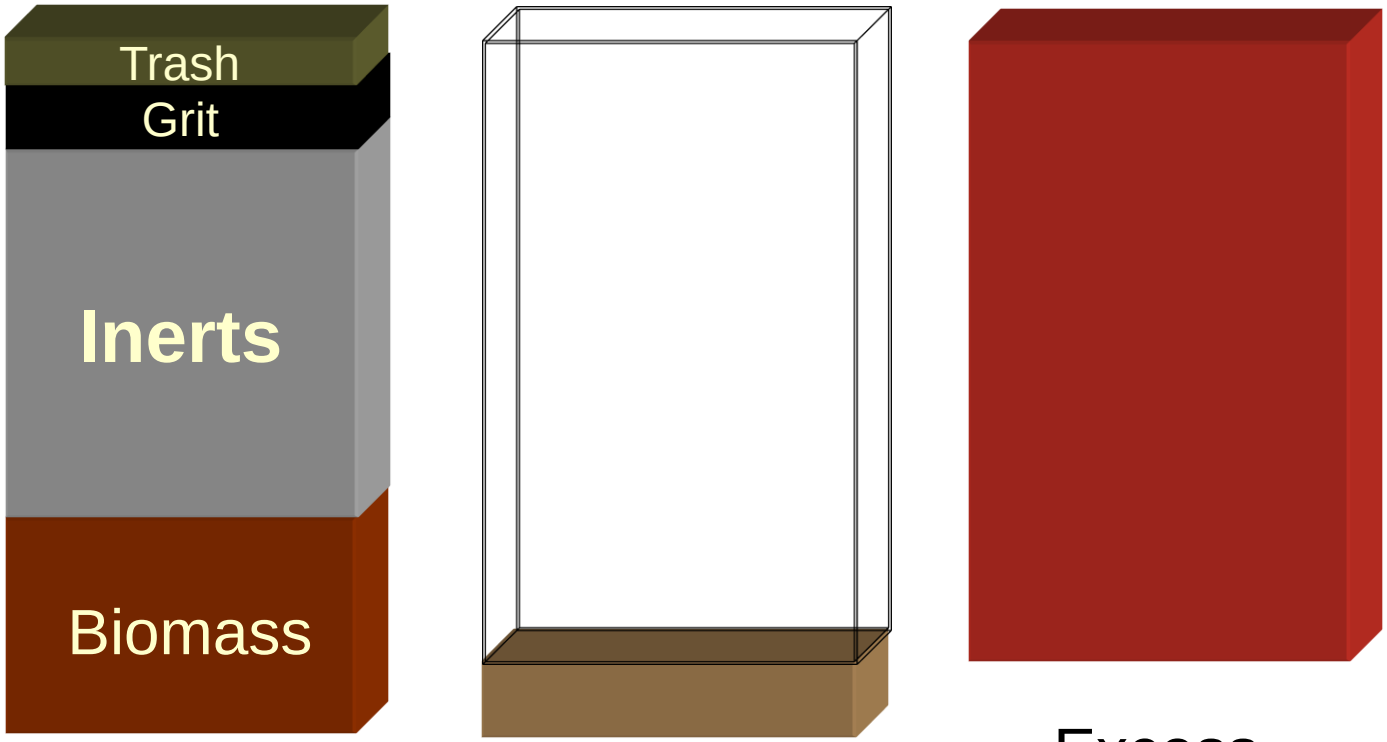


High Efficiency Cyclone removal with <u>Optimized Flow</u> and Inert Solid <u>Conditioning</u> ⟵ ⟶ **Limits to Range of Typical Influent Grit Removal**

MLSS Viability and Non-degradable Concentration

- Two (2) factors can change the balance of non-degradables and biomass in the MLSS
  - Longer sludge age would result in more decay and increase the concentration of more inerts and trash
  - Chemical addition for Phosphorus compliance will re-balance the MLSS with more inerts given the same growth and decay pressures on the biomass
- Some plants operate with a different balance of inerts/trash due to industrial loading, chemical addition to balance pH or inerts can be added to improve settling.

Solids Balance with Lime Addition to a pH of 8.0 S.U. (Discharger using Lime for Nitrification)



Solids Production

Solids Destruction

Excess Solids to Disposal

Restoring Alkalinity for Nitrification

- In our example of high inerts in the MLSS, lime is being used for pH adjustment.
- Lime is very basic and the hydroxide ion removes the hydrogen ion (acid) in solution in the plant and raises the pH.
- The free calcium ions also react with the excess carbon dioxide and form an insoluble milky product, calcium carbonate
- If too much lime is added, a significant amount of insoluble calcium carbonate is formed. Those inert solids become incorporated in the MLSS and begin to crowd out the biology.

Using Calcium Carbonate Solubility to Control Settling?

- Since calcium carbonate solubility loads the MLSS with fine inerts with a high specific gravity and dense structure, the MLSS settling is affected.
- The result is like adding sand to feathers. As expected, as the insolubility of the calcium carbonate increased, the settling rate increased (the SVI decreased).
- The graph shows settling correlates closely to the MLSS pH (5 minute and 30 minute settling).
- As biological viability increases, the SVI increases and settling slows.

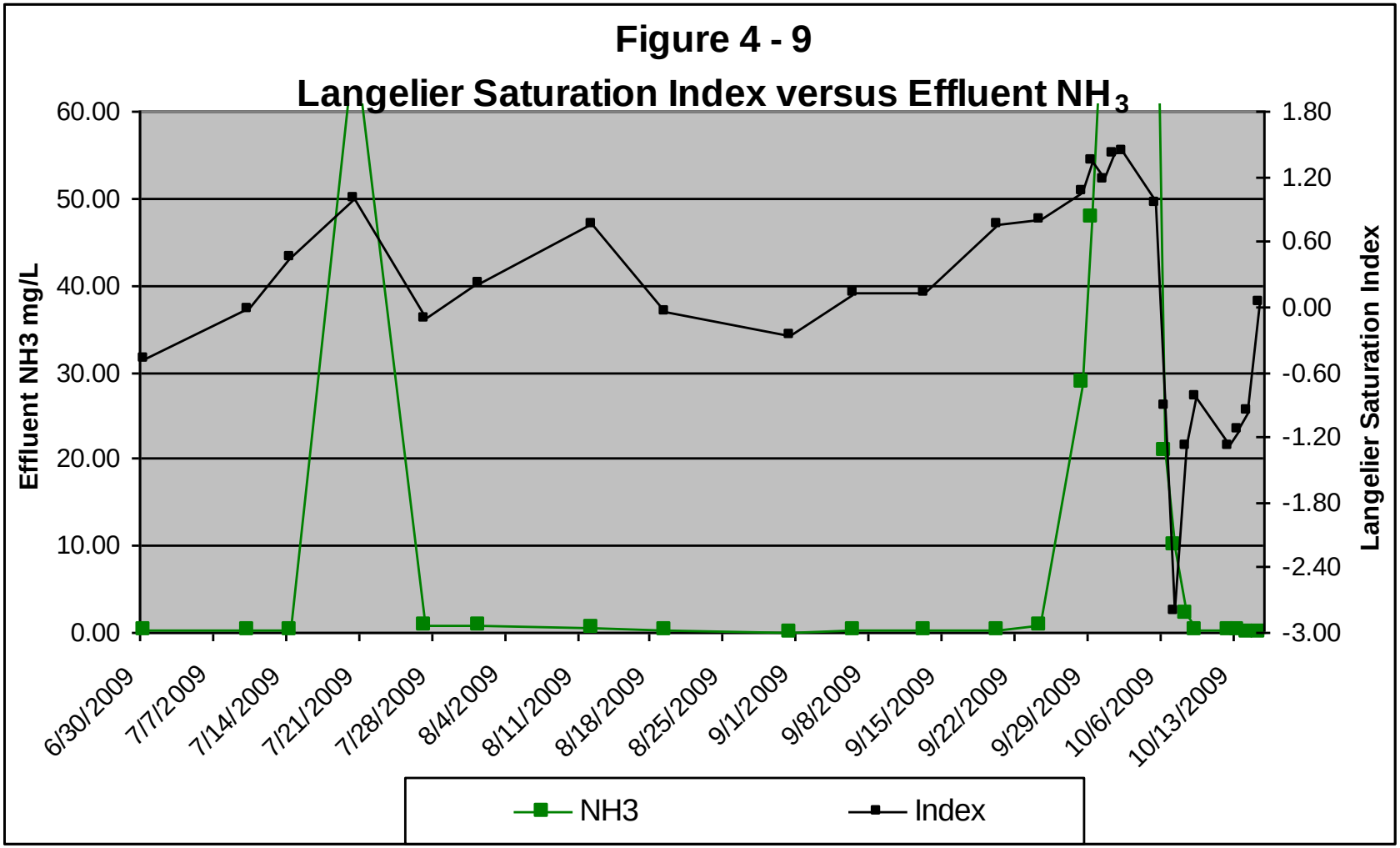


Figure 4 - 9
Langelier Saturation Index versus Effluent NH3
Effluent NH3 mg/L
Langelier Saturation Index
60.00
50.00
40.00
30.00
20.00
10.00
0.00
1.80
1.20
0.60
0.00
-0.60
-1.20
-1.80
-2.40
-3.00
6/30/2009
7/7/2009
7/14/2009
7/21/2009
7/28/2009
8/4/2009
8/11/2009
8/18/2009
8/25/2009
9/1/2009
9/8/2009
9/15/2009
9/22/2009
9/29/2009
10/6/2009
10/13/2009
NH3
Index

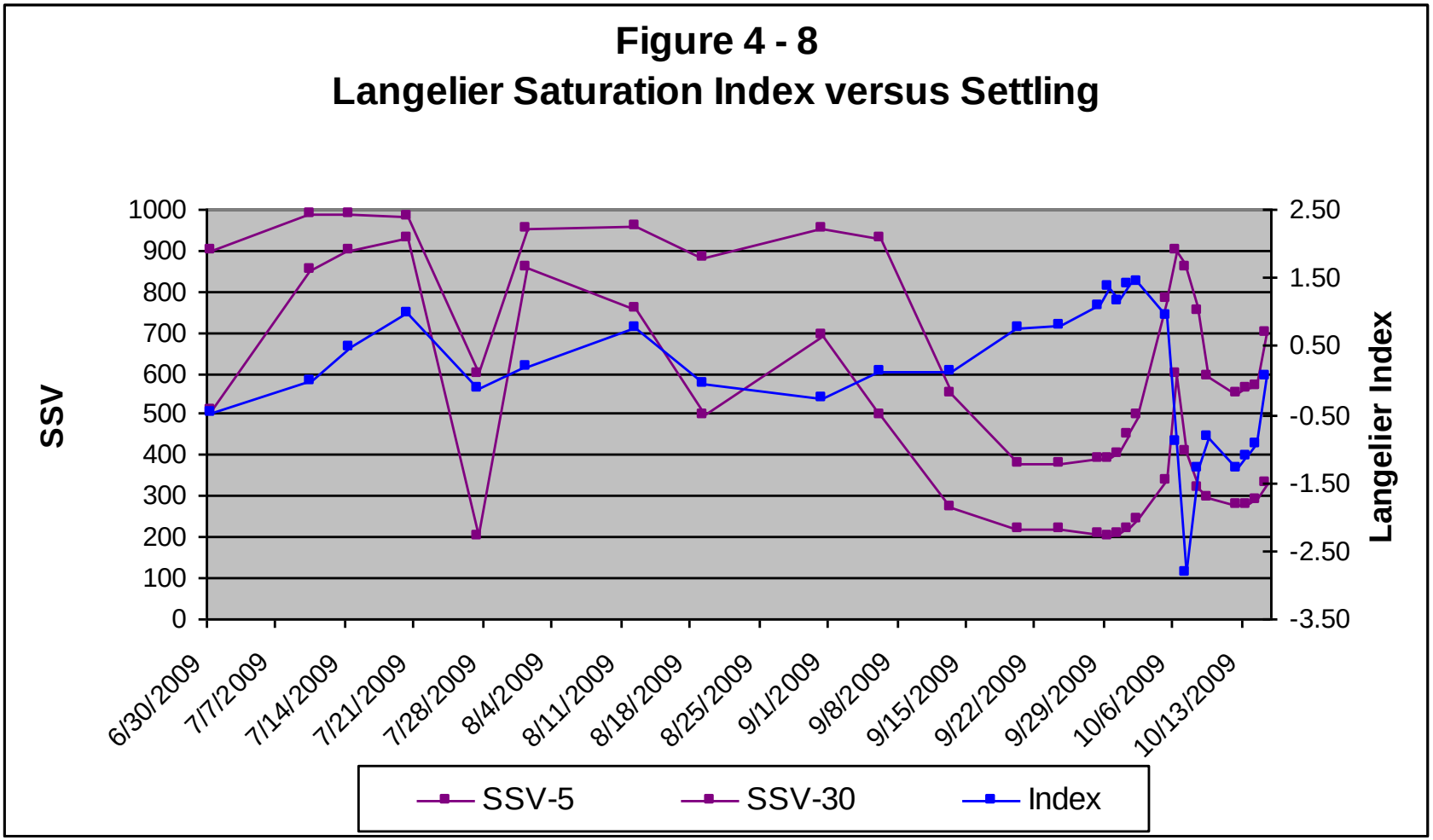
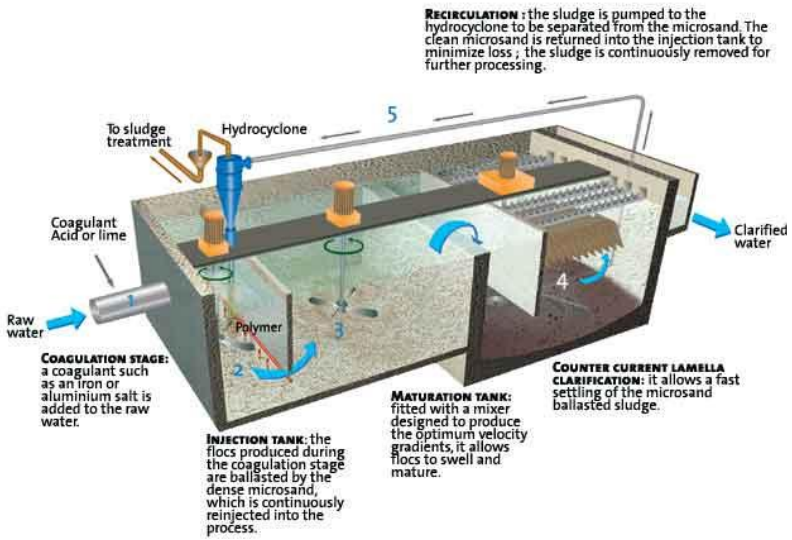
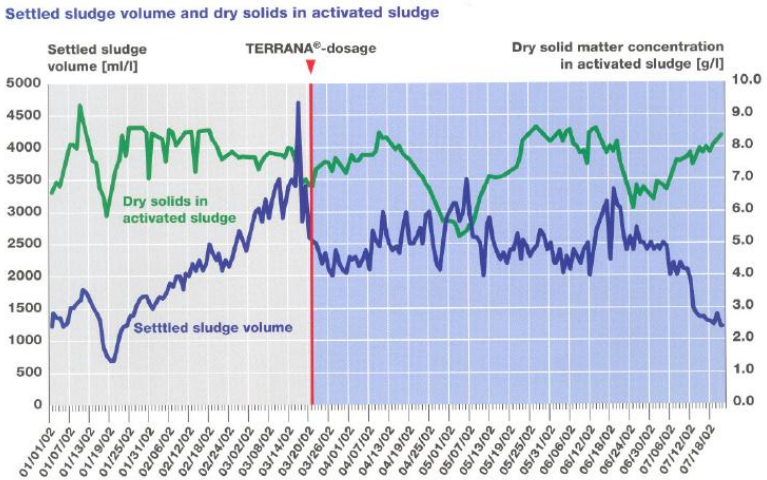


Figure 4 - 8
Langelier Saturation Index versus Settling
SSV
Langelier Index
1000
900
800
700
600
500
400
300
200
100
0
2.50
1.50
0.50
-0.50
-1.50
-2.50
-3.50
6/30/2009
7/7/2009
7/14/2009
7/21/2009
7/28/2009
8/4/2009
8/11/2009
8/18/2009
8/25/2009
9/1/2009
9/8/2009
9/15/2009
9/22/2009
9/29/2009
10/6/2009
10/13/2009
SSV-5
SSV-30
Index

Ballasted Settling

- High Rate Treatment (Actiflo) is an example of ballasted settling.
- SUD-Chemie uses Bentonite
- ~ 0.5 to 5 lb/35 cf of tank volume for filamentous control or ~250 ppm as a minimum dosage.





Solids Balance in the Plant

Solids Balance in the Plant

- Volumetric Analyses
  - Depth of Blanket
    - Procedures for determining average depth of blanket
    - Core Sampling
    - Common Error in Core Sampling
      - » Speed of sampler entry is determined by foot valve
    - Cloudy Versus Defined Sludge Interfaces
    - Location/Time of Sample Points
    - Sludge Detention Time
    - Troubleshooting
      - » Sludge Withdrawal Rate
      - » Flow Splitting to Settling Tanks
      - » Filamentous or sludge quality indicators

Solids Balance in the Plant

- Volumetric Analyses
  - Centrifuge
    - Volumetric Analyses in Percent (Volume to Volume Comparison Based on Centrifugal Force and Time Constant)
    - Typically used for wet stream analysis (centrate testing)
    - Location/Time of Sample Points
    - Percent Spin IS NOT EQUAL to mg/L (if used for solids)
    - Test is Based on Constant Speed/Constant Time/Variation is Sludge Mass and Quality
    - Specific Facility Sludge Units

Solids Balance in the Plant

- Volumetric Analyses
  - Centrifuge (con't)
    - Weight To Concentration Ratio

      W.C.R. = MLSS (mg/L) / ATC (%)

    - Common Errors in Application
      - » WCR is a comparison that is not constant (as is SVI)
      - » Spins can be used for sludge quality and mass calculations, but the volumetric error (expressed as a sludge quality value) should be compared to gravimetric results.
      - » SSC values can be determined with spins also. Same caution with ammonia, Phosphorus and ORP results to confirm solids concentration setting.

Solids Balance in the Plant

- Volumetric Analyses
  - Settleometer
    - Volumetric analyses in percent (Volume to Volume Comparison based on gravity and time constants)
    - Location/Time of Sample Points
    - Test is Based on Constant Separation Force (Gravity) / Constant Time. Variation is Sludge Mass and Quality
    - Settled Sludge Volume Measurement Points/Trend Points
      - » Flocculation Time (5 Minutes)
      - » Settling Rate (30 Minutes)
      - » Compaction Rate (60 Minutes)
      - » Rise Time (Sludge Detention Minimum)

Solids Balance in the Plant

- Volumetric Analyses
  - Settleometer (con't)
    - Qualitative and Quantitative Analyses
      - » Interface (readings and interface quality)
      - » Supernatant Quality (turbidity and clarity)
    - Settled Sludge Volume (SSV) and Settled Sludge Concentration (SSC) determinations.

      <u>Settled Sludge Concentration</u>

      SSC = 1,000 * (MLSS) / SSV)

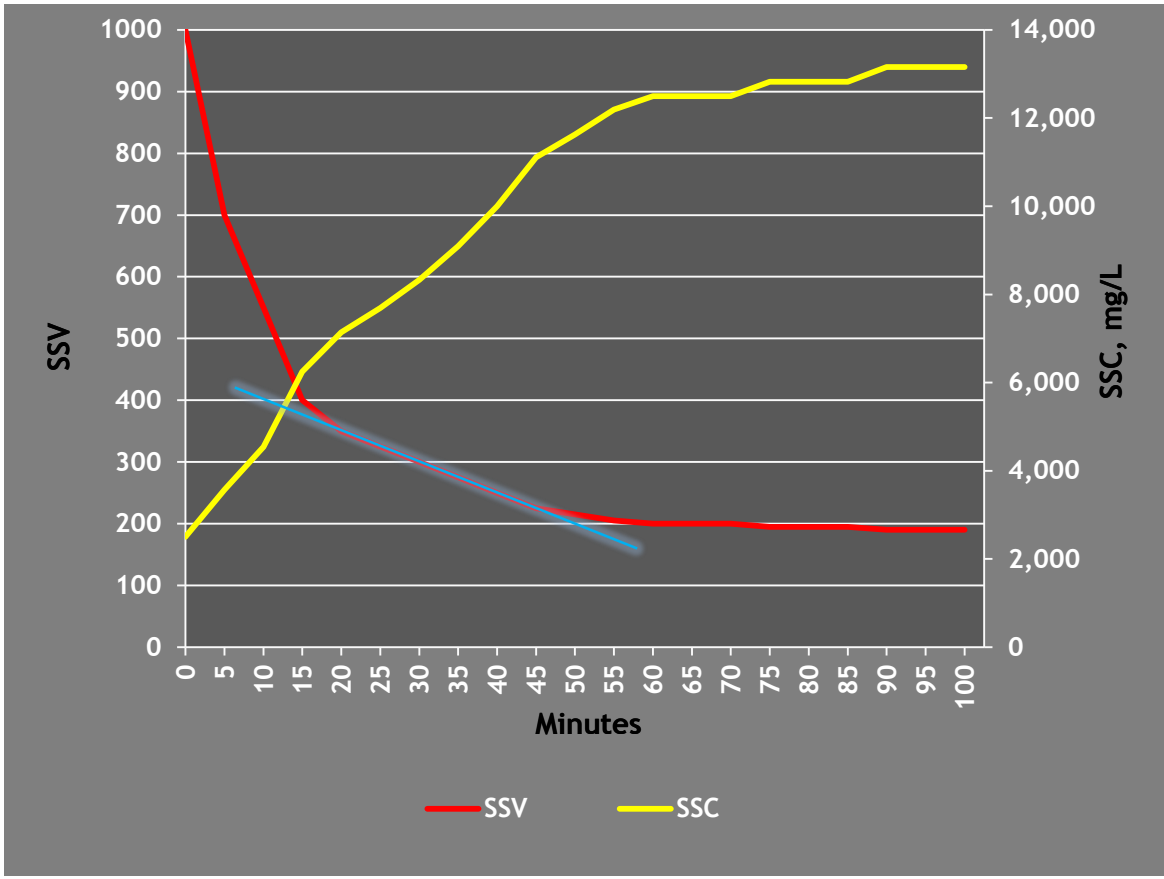
    - Diluted settling tests
    - Stirred settling test

Solids Balance in the Plant

- Volumetric Analyses
  - Settleometer (con't)
    - Volumetric to gravimetric comparisons: Sludge Volume Index (S.V.I.) and Weight to Concentration Ratio (W.C.R.)
    - Filament warning on settling
      - » 5 minute flocculation time is early warning for onset
    - Compaction rates after 30 minutes.
    - Maximize solids concentration while minimize Phorphorus release.
      - Knee of the curve calculation for RAS control
    - Settled Effluent Quality (quantitative? compare to field?)
    - Sludge Volume Index

Traditional Concepts – Sludge Quality

Mins	SSV	SSC	
0	1000	2,500	mg/L
5	700	3,571	mg/L
10	550	4,545	mg/L
15	400	6,250	mg/L
20	350	7,143	mg/L
25	325	7,692	mg/L
30	300	8,333	mg/L
35	275	9,091	mg/L
40	250	10,000	mg/L
45	225	11,111	mg/L
50	215	11,628	mg/L
55	205	12,195	mg/L
60	200	12,500	mg/L
65	200	12,500	mg/L
70	200	12,500	mg/L
75	195	12,821	mg/L
80	195	12,821	mg/L
85	195	12,821	mg/L
90	190	13,158	mg/L
95	190	13,158	mg/L
100	190	13,158	mg/L



– Knee of the curve. Thickened 4 times in 45 minutes. After another 45 minutes, only thickened 1.3 times.

Solids Balance in the Plant

- Volumetric Analyses
  - Settleometer (con't)

    S.V.I. = 30 minute SSV / MLSS in grams

    – Common errors in application

      » Equation changes with solids concentration.

      » 30 minute reading is for low solids concentrations and stable sludge quality. Utilize other times such as 5 minutes, 1 hour and 2 hours.

      » 80 – 120 mls/gm is based on ideals at low MLSS concentrations.

      » RAS concentration should be checked with ammonia and Phosphorus to verify RAS control setting by concentration.

Traditional Concepts – Sludge Quality

- Volumetric Analyses
  - Centrifuge (con't)
    - Weight To Concentration Ratio

$$W.C.R. = MLSS\ (mg/L) / ATC\ (\%)$$

    - Common Errors in Application
      - » WCR is a comparison that is not constant (as is SVI)
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"Math is My Friend" – Mixing Formulas

- Mass Balance Calculations
  - Solids movement in the plant
    - *Aeration and Settling by pounds formulas:*
      lbs in versus lbs out
    - *RAS Flow Rate in Equilibrium:*
      $(INF * MLSS_{tss}) / (RAS_{tss} - MLSS_{tss})$
    - *Simplified Mixing Formulas:*

<u>RAS Flow Meter Check with Solids Tests:</u>

RAS Flow Percent = $MLSS_{tss} / (RAS_{tss} - MLSS_{tss})$

<u>Maximum MLSS Concentration at a Given SSC</u>:

MLSS = $(\text{RAS Flow Percent} * RAS_{tss}) / (\text{RAS Flow Percent} + 1.0)$

"Math is My Friend" – Mixing Formulas

- Mass Balance Calculations
  - *Simplified Mixing Formulas (con't)*

RAS Sampling Check with Flow Metering:

RAS_{tss} = $MLSS_{tss}$ + ($MLSS_{tss}$ / (RAS Flow Percent))

  - *Clarifier Sludge Detention Time*

Clarifier $Sludge_{dt}$ = (Sludge Blanket lbs / RAS lbs)

  - *Clarifier Sludge Flow Demand*

CSFD = (RAS Flow * (RAS_{tss} - $MLSS_{tss}$)) / (SSC_{tss} – $MLSS_{tss}$)

Any Questions?