WWOA Annual Conference
October 8, 2015

Anaerobic Digester Rehab: Real World Trials & Tribulations

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Eau Claire, WI Wastewater Utility

- Located ~ 85 miles East of Twin Cities, in Heart of Wisconsin
- Wastewater Utility
  - Serves Cities of Eau Claire and Altoona
    - Service Population ~75,000
  - WWTP
    - Average Daily Flow 5 mgd
    - 2030 Design ADF 6.8 mgd
    - Last Major Upgrade 1980

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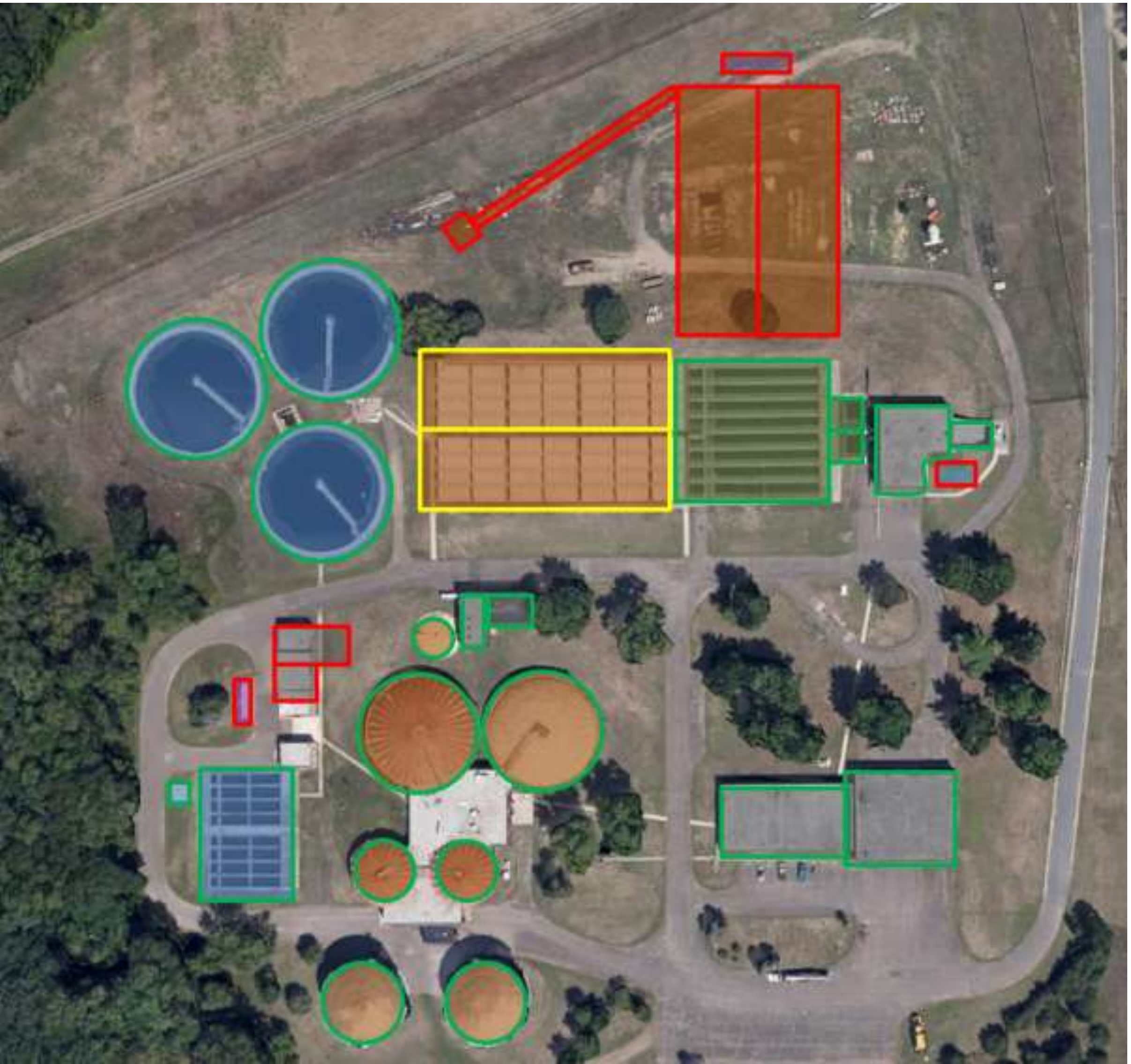
Eau Claire WWTF



Facility treats an average daily flow of 6 MGD with an average capacity of 11.5 MGD and peak capacity of 30 MGD

RED = New

GREEN = Existing

YELLOW = Removed

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2006-2007 Facility Planning

- Recommendation: Phased Upgrade
  - Phase 1: Address Critical Needs
    - Additional Biosolids Storage Tank
    - Major Pump Station Upgrade
    - Effluent pH Adjustment System
    - ~$4.5 M Cost, Constructed 2007-2008
    - Allow City to Adjust User Rates for Phase 2 Upgrade
  - Phase 2: Address 20 Year Planning Period Needs
    - "expected to be required within next 5-10 years due to age of and potential failure of RBC units"

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Phase II of Project

- The facility improvements were as follows:
  - Odor control using a self-sustaining bio-filter
  - Replace RBC process with activated sludge
  - Upgrade solids handling and digestion process
  - Digester gas utilization for electrical energy production
  - Heat recovery from effluent and gas engines
  - Automation of facilities for process efficiency and daytime operation
  - Security and fire alarm systems
  - Efficient lighting of site with management control
  - Energy management system
  - Upgrade laboratory, process buildings and administration/maintenance facilities.
  - Upgrade heating and ventilation systems
  - Replacement of pumps air blowers and motors with more efficient units.
  - Replacement of electrical power system and add standby power generation

Major Elements of Phase 2

- Nitrifying Activated Sludge
  - With Biological Phosphorus Removal
  - Rehab Secondary Clarifiers
- Sludge Thickening Improvements
  - New GBTs & Sludge Pumps
- Anaerobic Digestion Improvements
  - Covers, Mixing, Heating
  - New Biogas Engine Generators
- Design Complete & Construction Began 2013

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Major Players

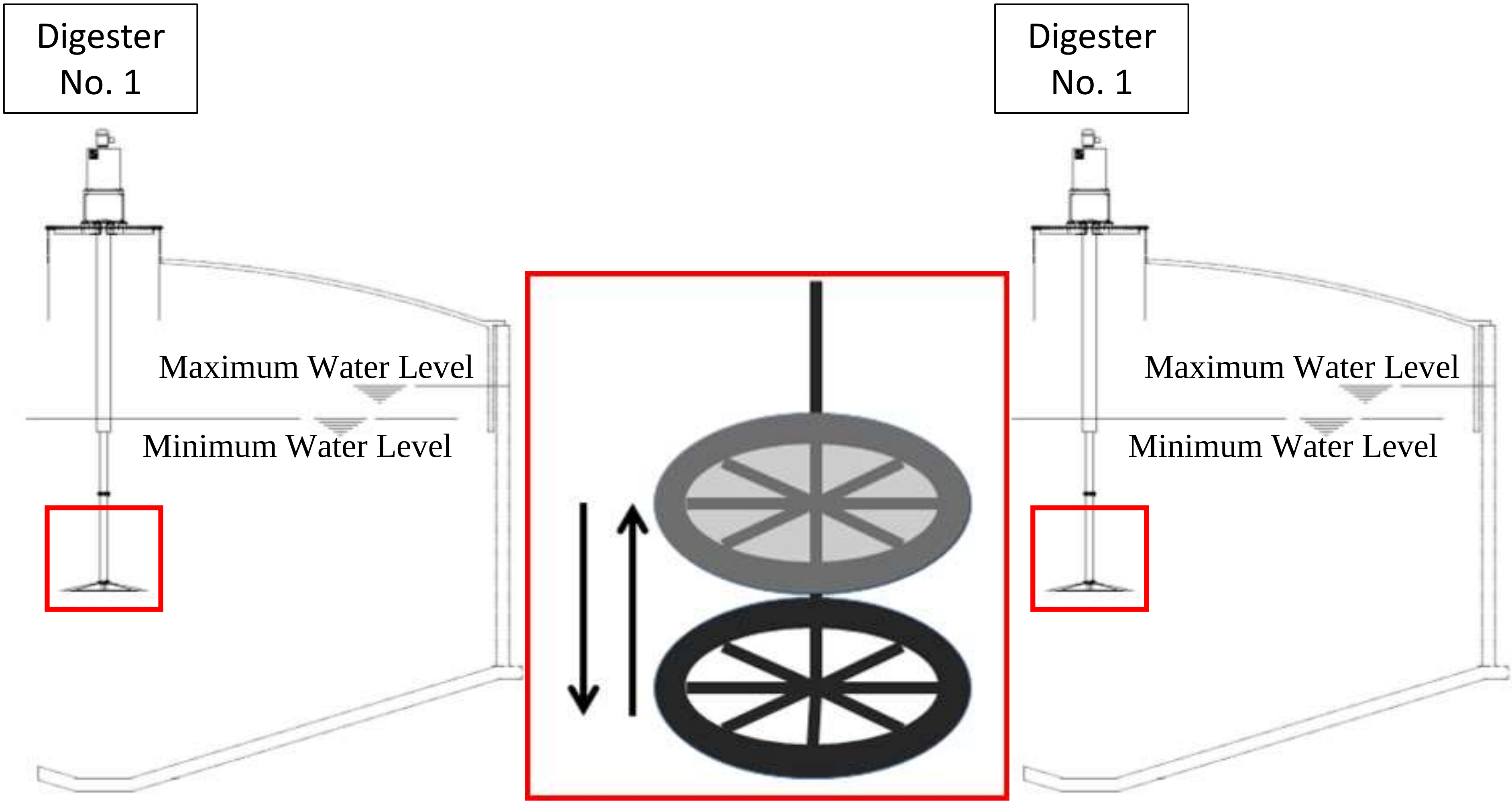
- CD Smith – General
- JF Ahearn – Mechanical
- Total Electric – Electrical
- Precision – Underground
- City of Eau Claire – Owner
- Donohue - Engineer

- 3 year project
- Weekly meetings
- Monthly meetings
- Good relationship

Digester Work

- In the order of 3, 1 and 2, then 4
- This included the following components associated with each digester:
  - Digester cleaning.
  - Digester cover “rehab”.
  - All interior piping removals and installations.
  - Digester mixing systems.
  - Digester Recirculation Pump.
  - Digester Heat Exchanger.
  - Digester gas piping.

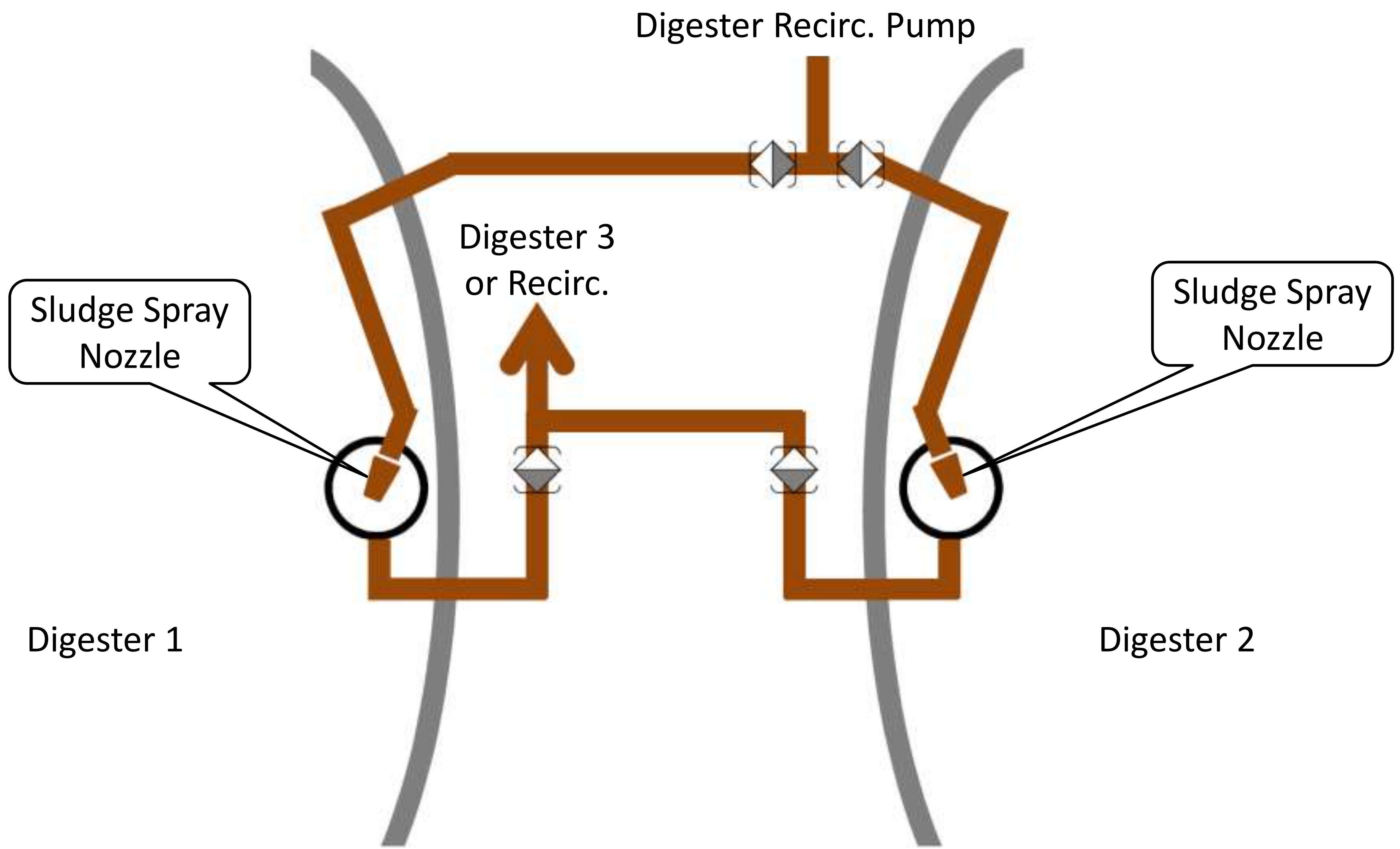
Digesters 1 & 2



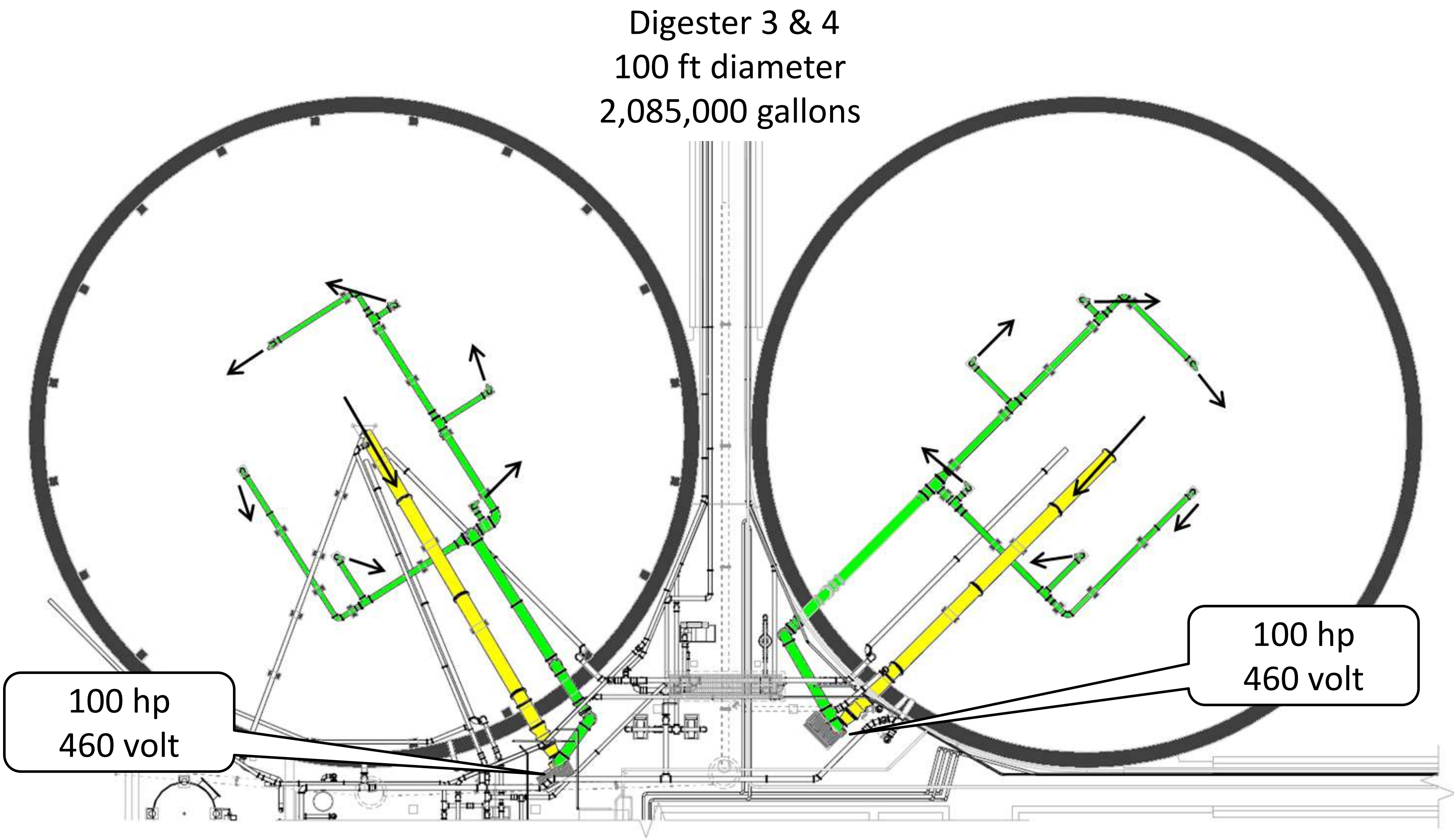
Linear Motion Mixer

Digester 1 & 2
60 ft diameter
500,000 gallons

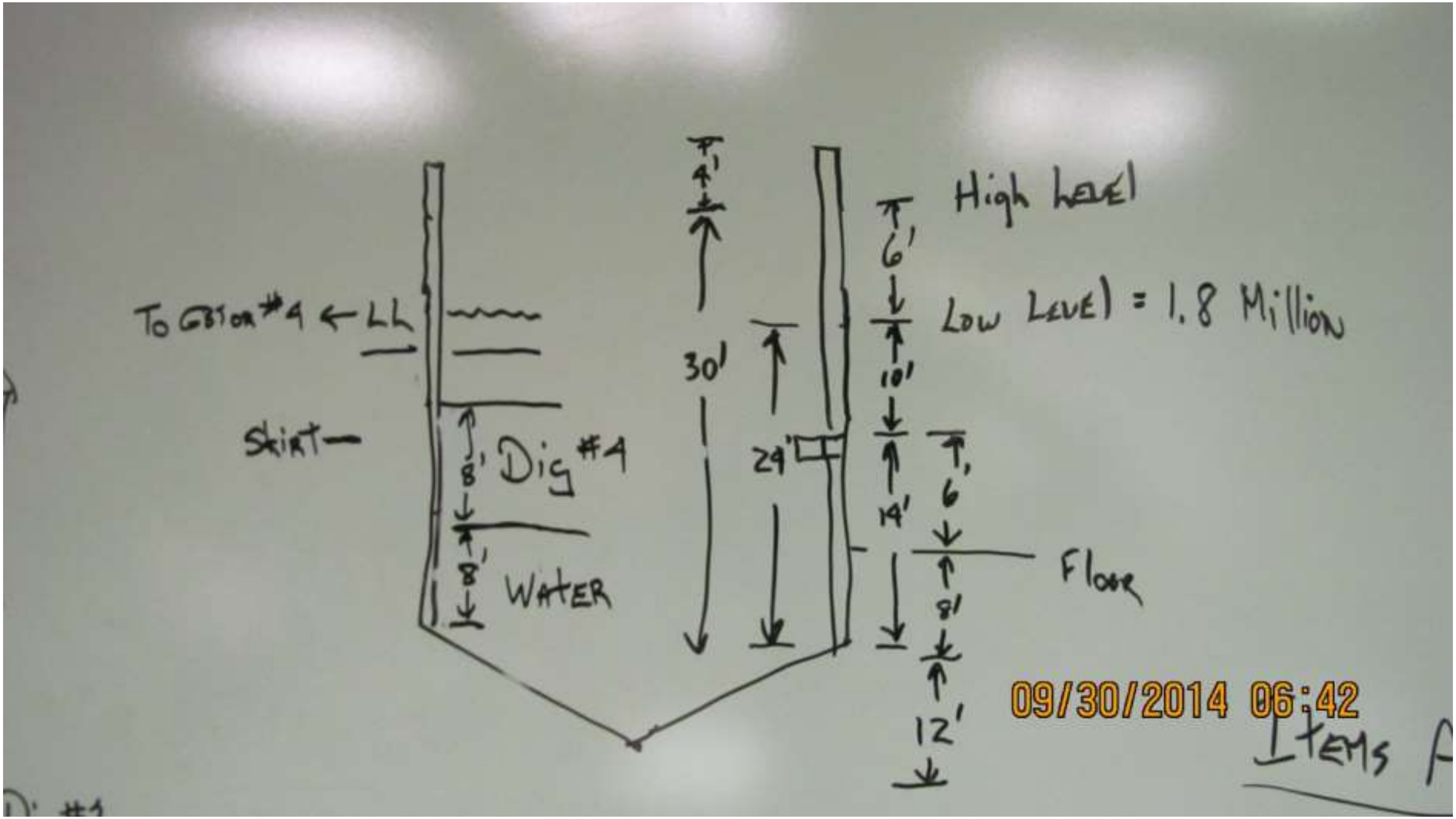
Digester 1 & 2


Digester Recirc. Pump
Digester 3
or Recirc.
Sludge Spray
Nozzle
Sludge Spray
Nozzle
Digester 1
Digester 2

Digesters 3 & 4

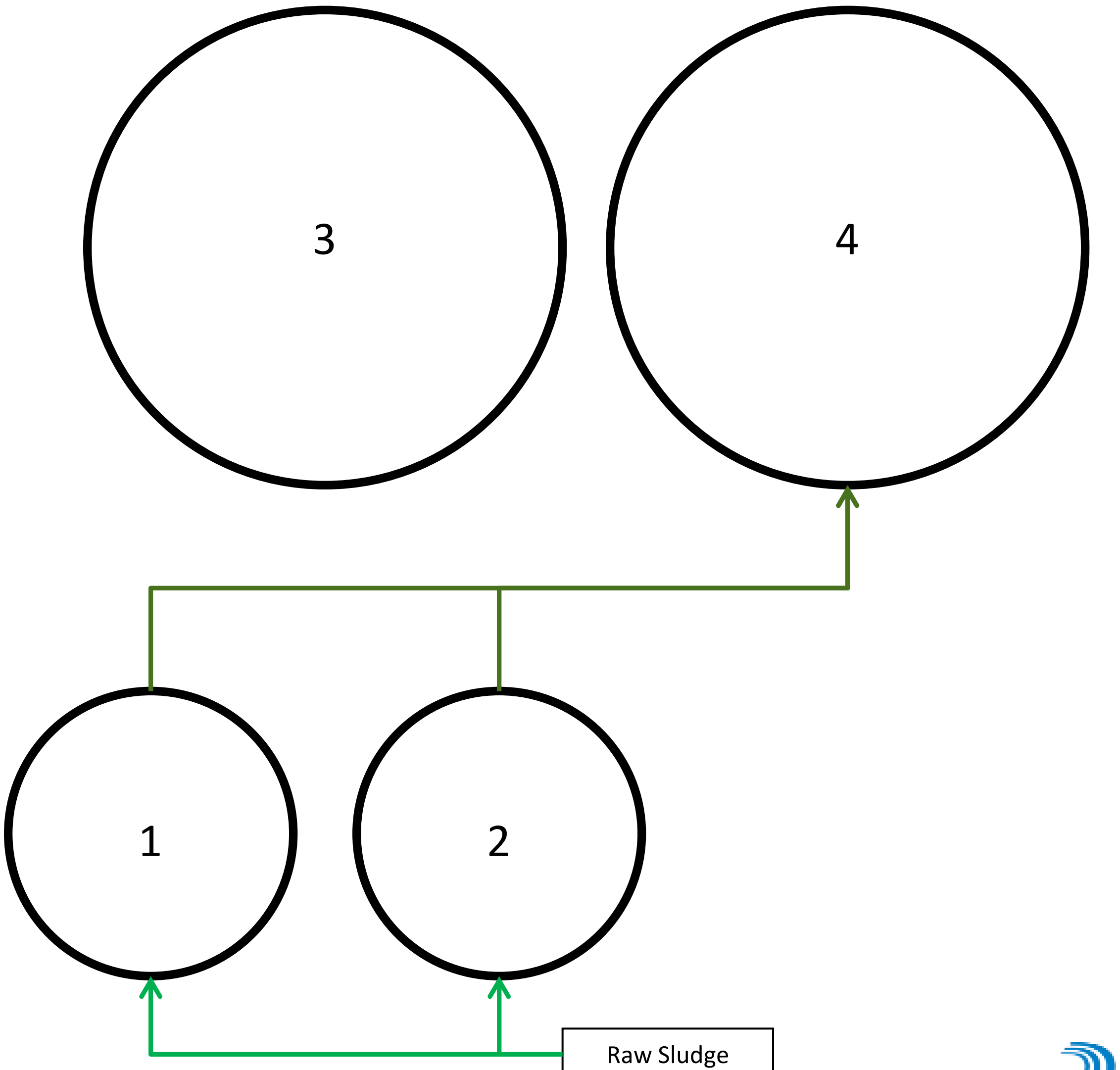


Planning



High Level
Low Level = 1.8 Million
To GBTon #4 ← LL
Skirt
Dig #4
Water
Floor
4'
30'
29'
6'
10'
14'
6
8'
8'
8'
12'
09/30/2014 06:42
Items

Digester Operation Prior to Project



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Digester Operating Data

Digester Operation
2013 Monthly Average Data

	Digester 1		Digester 2	
	HRT days	VS Ld lb/d/cf	HRT days	VS Ld lb/d/cf
January	18.0	0.048	18.0	0.047
February	17.8	0.044	17.8	0.044
March	17.2	0.059	17.2	0.066
April	16.5	0.058	16.5	0.056
May	16.0	0.057	16.0	0.051
June	17.8	0.043	17.8	0.045
July	17.8	0.049	17.8	0.049
August	18.3	0.050	18.3	0.047
September	18.4	0.054	18.4	0.051
October	18.4	0.053	18.4	0.046
November	17.1	0.050	17.1	0.042
December	18.1	0.046	18.1	0.046

Theoretical Digester Data

	Single Primary Digester Data	
	HRT Days	VS Ld lb/d/cf
Avg	8.8	0.102
Min/Max	8	0.132

Recommended minimum HRT is **12 days**

=> Max Month Loading Conditions

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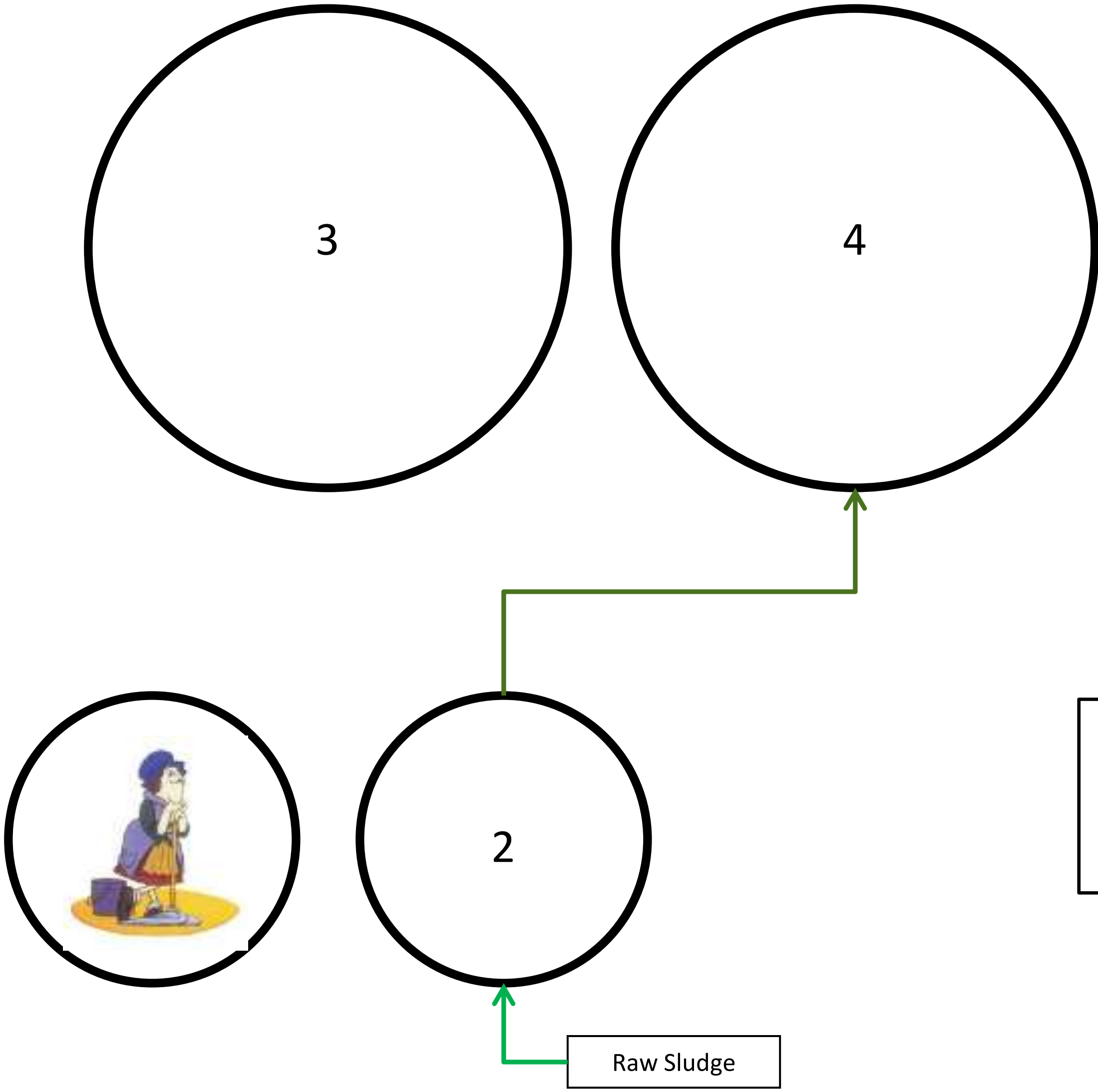
Original Digester 1 Work Plan



Theoretical Primary Digester Data

	HRT Days	VS Ld lb/d/cf
Avg	8.8	0.102
Min/Min	8	0.132

Insufficient Primary Digester HRT Will Result in Sour Digester, Use Revised Approach

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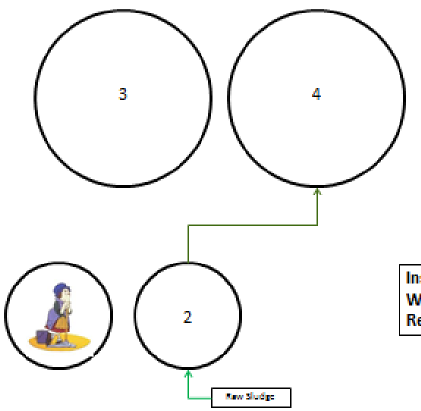
Hmmm & Haw

Original Digester 1 Work Plan



Theoretical Primary Digester Data	HRT Days	VS Ld lb/d/cf
Avg	8.8	0.102
Min/Min	8	0.132

Insufficient Primary Digester HRT Will Result in Sour Digester, Use Revised Approach

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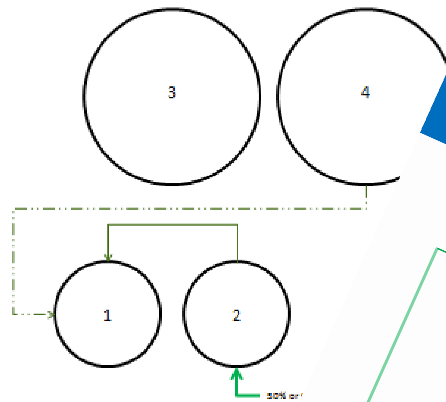
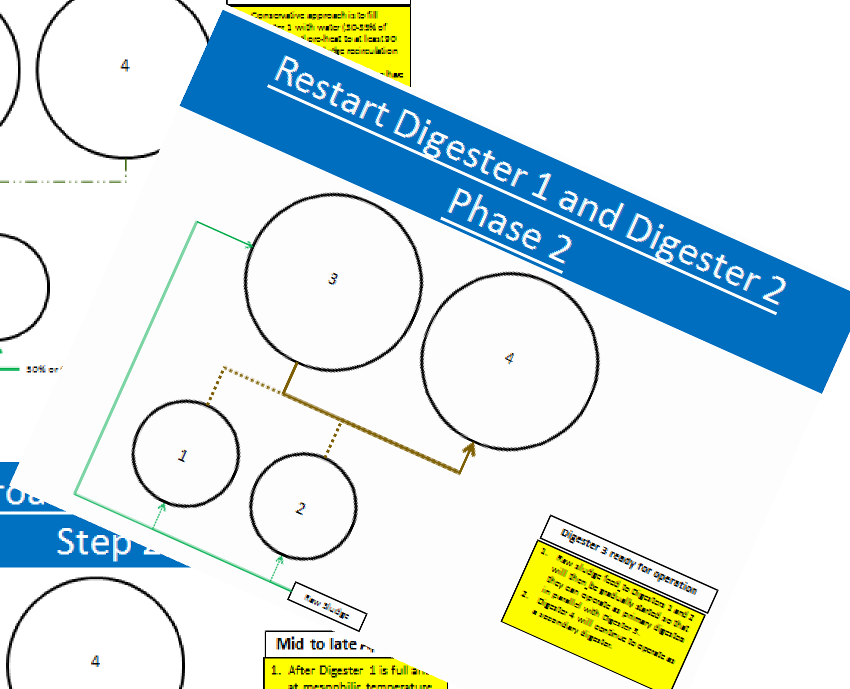
Revised Approach – Restart Digester 1 Step 1

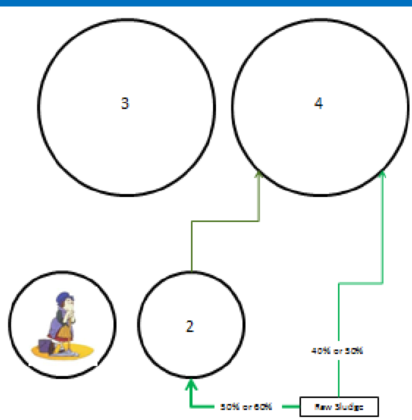


Mid to late April 2014

Conservative approach is to fill



Revised Approach –Digester 1 Work Plan



Theoretical Primary Digester Data @ 40 / 60 Split	HRT Days	VS Ld lb/d/cf
Avg	14.6	0.061
Min/Min	13.3	0.079

Theoretical Primary Digester Data @ 50 / 50 Split	HRT Days	VS Ld lb/d/cf
Avg	17.6	0.061
Min/Min	16.0	0.079

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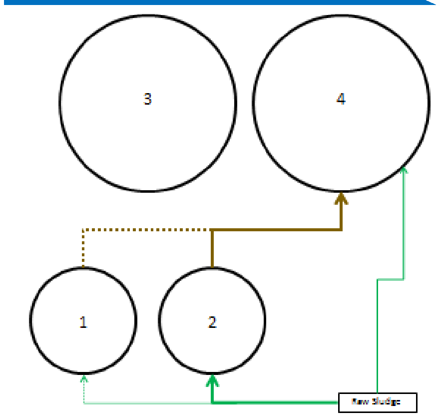
Revised Approa… Step 2



Mid to late A…

1. After Digester 1 is full an… at mesophilic temperature, begin to feed raw sludge in parallel with Digesters 2 & 4, and gradually shift raw sludge feed from Digester 2 to Digester 1.
2. Throughout transition transfer digested sludge from Digesters 1 and 2 to Digester 4 as needed to make room for raw sludge feed.

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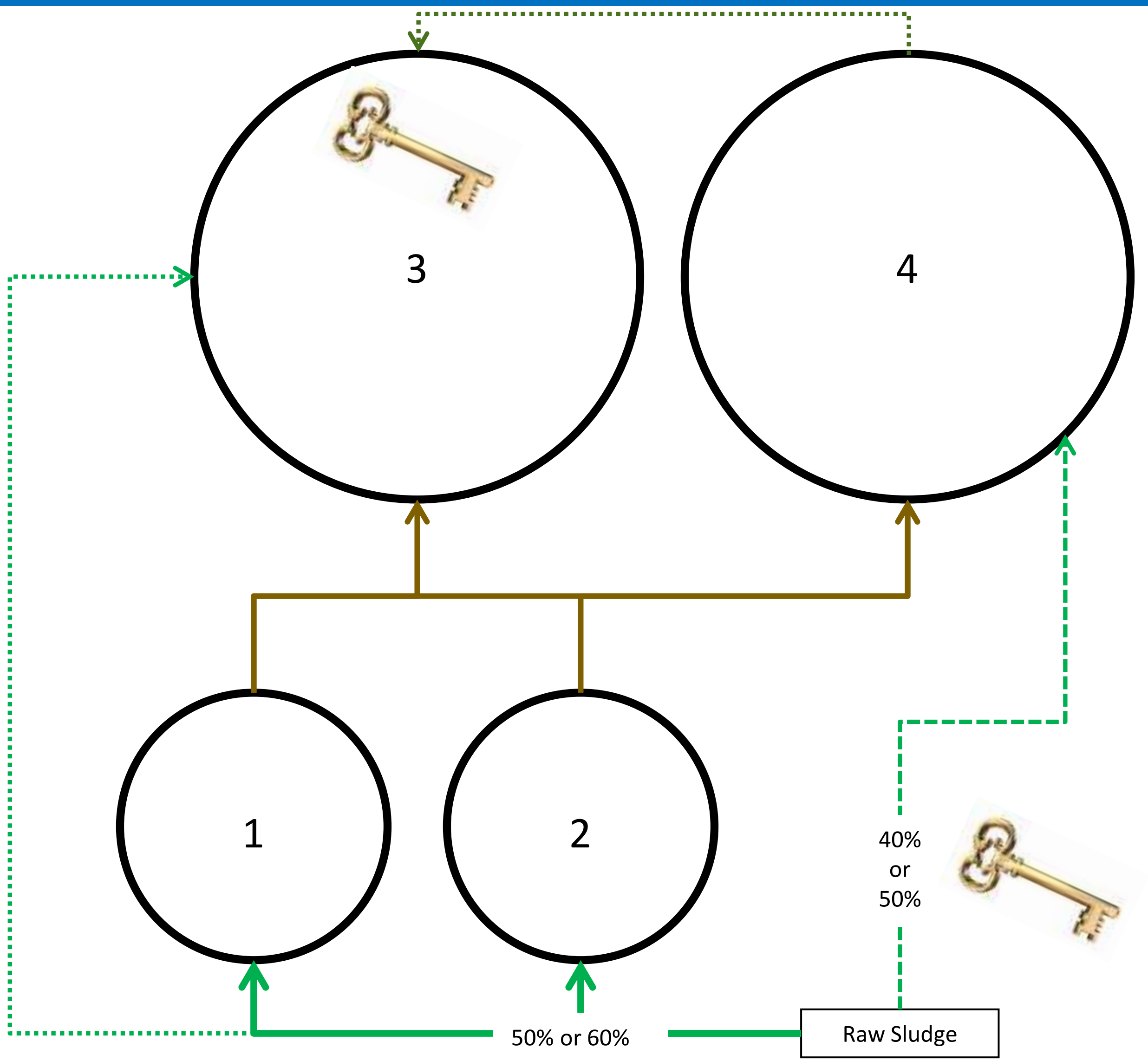
Final Approach



Digester 3 ready for operation June 2014

1. Fill Digester 3 with water (30-35% of volume) and heat to at least 90 degrees F using sludge recirculation heating loop.
2. When Digester 3 is ready for operation it will receive digested sludge from Digester 1 until it is full and operating stably.
3. Raw sludge feed to Digester 3 will then start and slowly be increased until both Digesters 1 & 3 are operating in parallel and receiving raw sludge in daily amounts proportional to their volumes.
4. Gradually decrease and discontinue feeding raw sludge to Digester 4.

Digester 3 Start Keys

1. Temperature dependent – June/July?
2. Sludge hauling window closes mid-May

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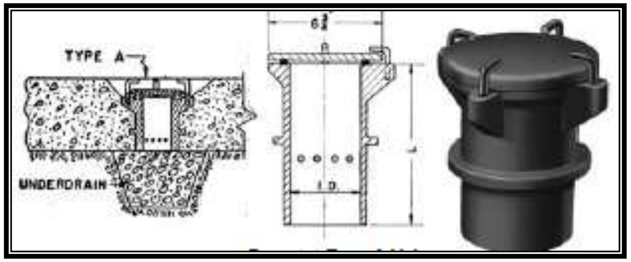
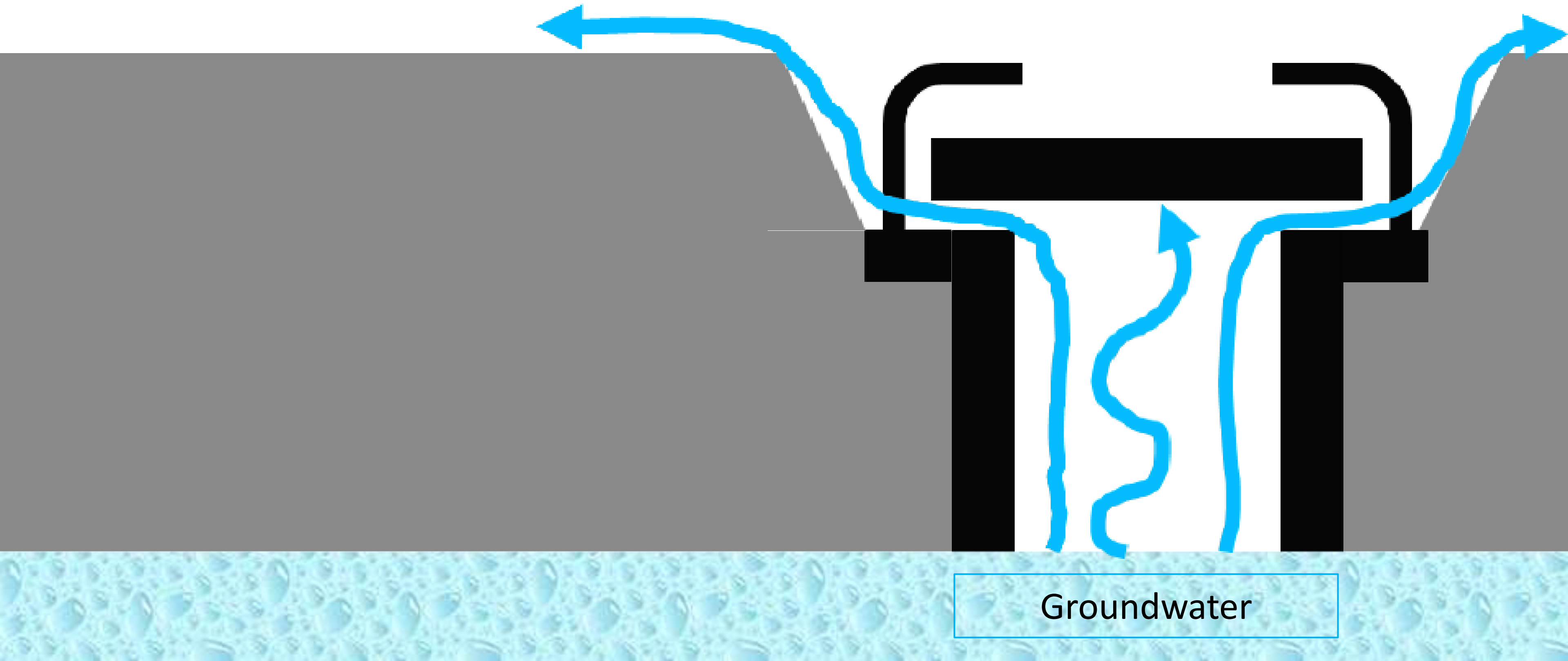
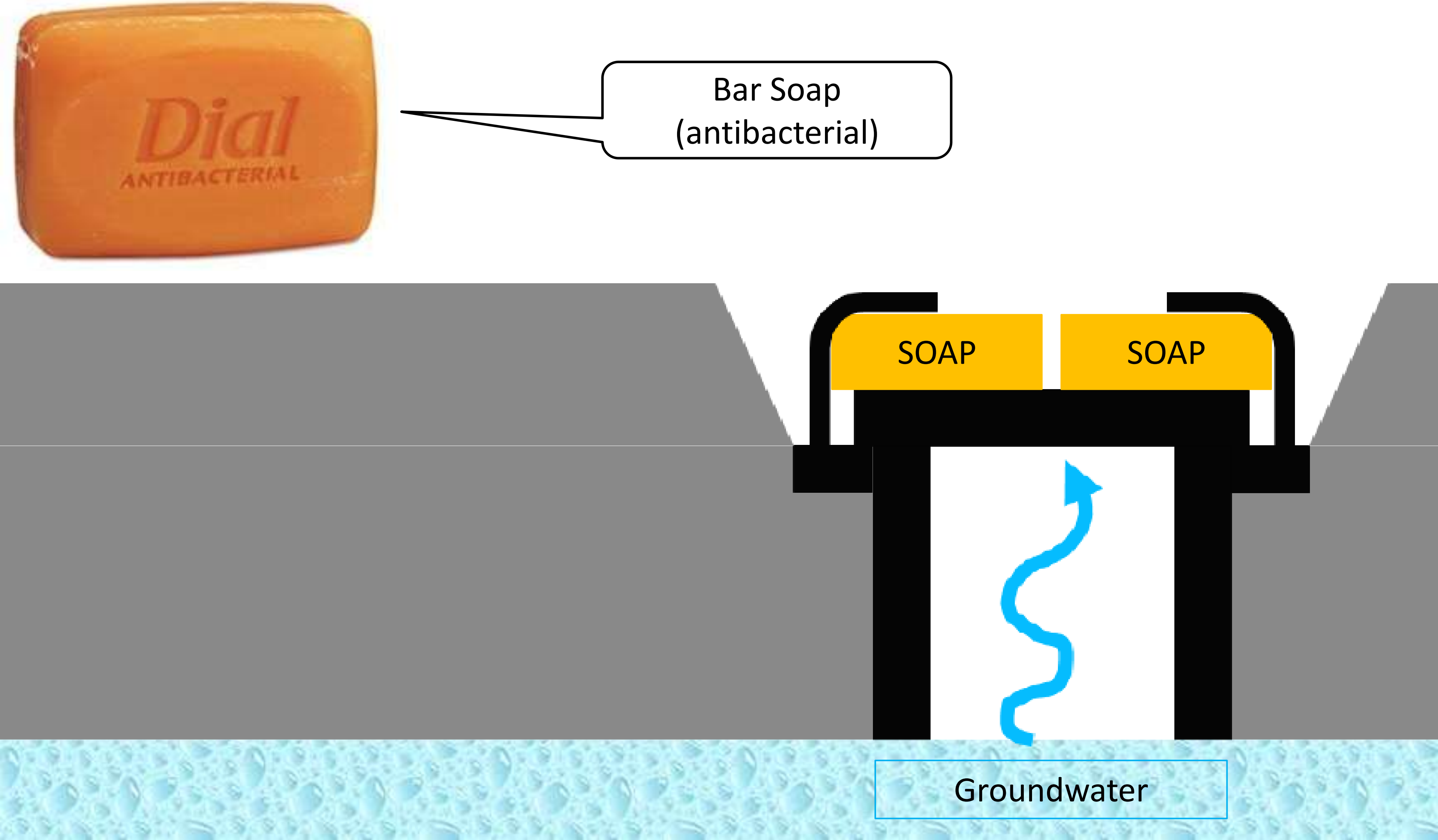
Digester Filling Issue



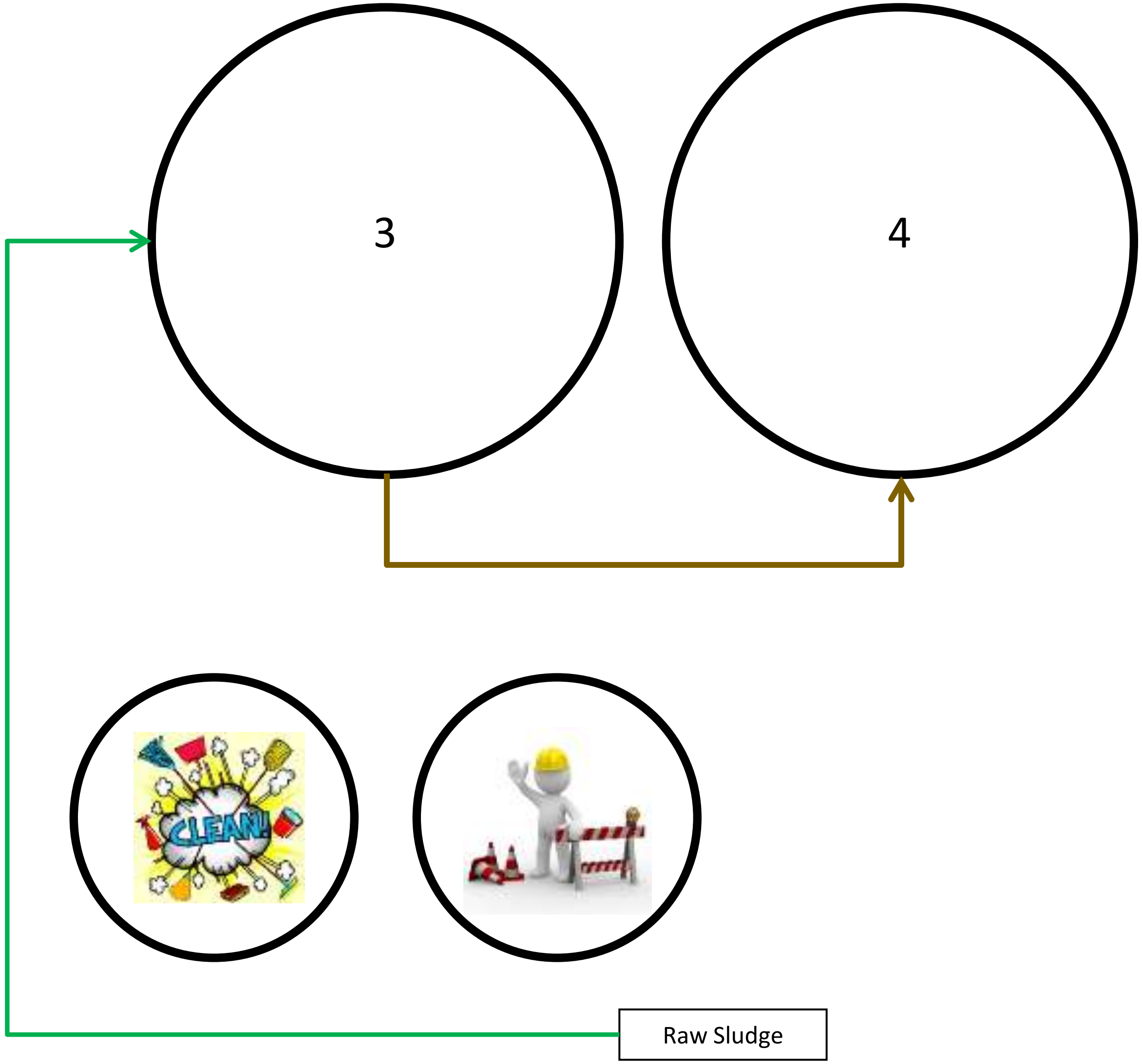
Hydrostatic Pressure Relief Valves



Digester Filling Issue Resolved



Digester 3 Operating/Release Digesters 1 & 2 For Work



Digester 3 ready for operation

1. With Digester 3 operating stably raw sludge feed will gradually be increased until it is receiving all raw sludge.
2. Digester 1 can be taken out of service and cleaned to make it available for construction.
3. Digester 3 will be the only operating primary digester and Digester 4 will continue to operate as a secondary digester.

Theoretical Primary Digester Data

	HRT Days	VS Ld lb/d/cf
Avg	17.6	0.025
Min/Min	16	0.031

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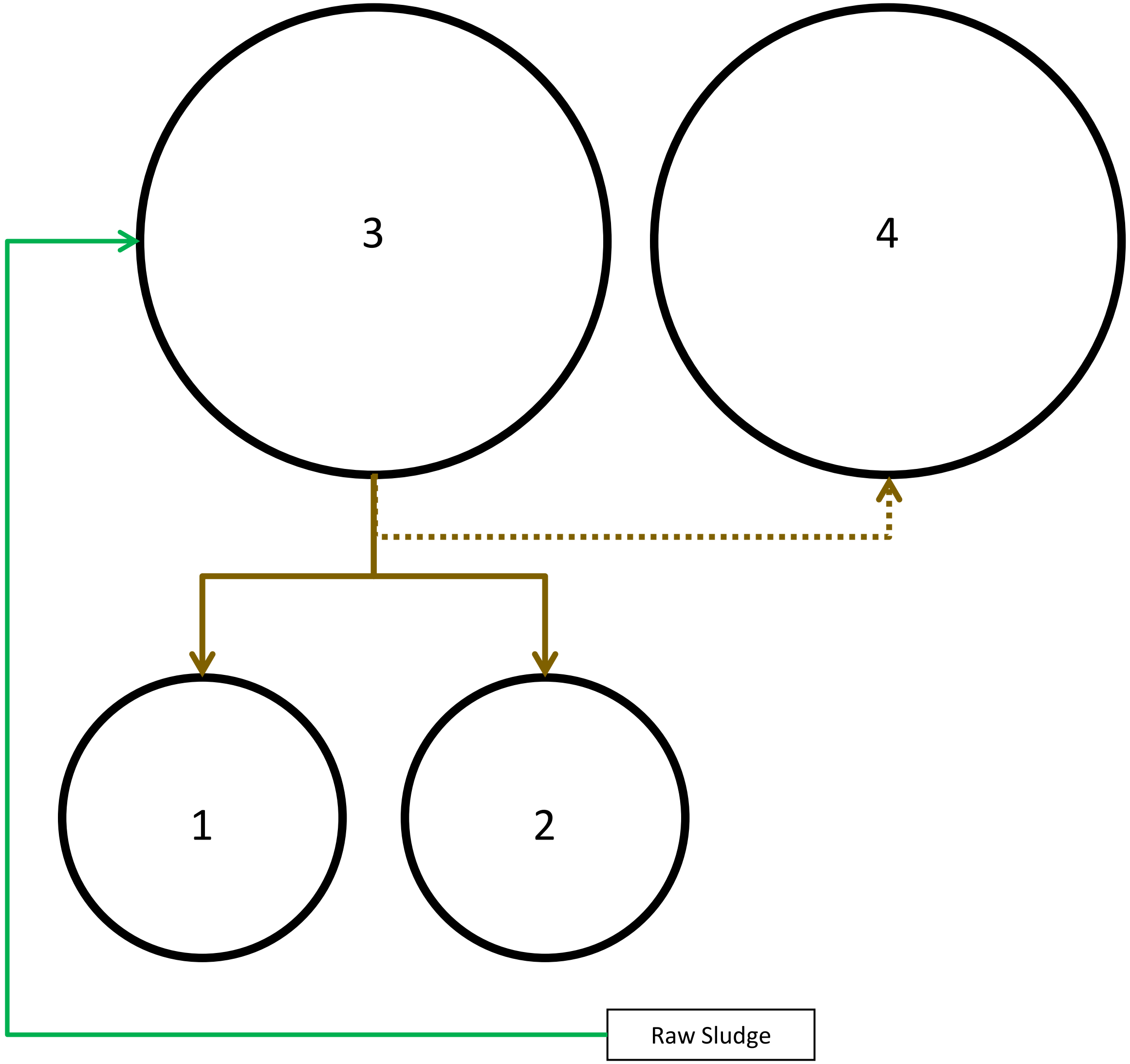
Restart Digester 1 and Digester 2 Phase 1



Digester 3 ready for operation

1. As construction is completed on Digester 2 and then Digester 1 they will be brought back on line following same protocol of first filling with water to 30-35% and heating water to at least 90 degrees F, and then filling with sludge.
2. Transfer digested sludge from Digester 3 to Digesters 1 and 2 until full.

Theoretical Primary Digester Data

	HRT Days	VS Ld lb/d/cf
Avg	17.6	0.025
Min/Min	16	0.031

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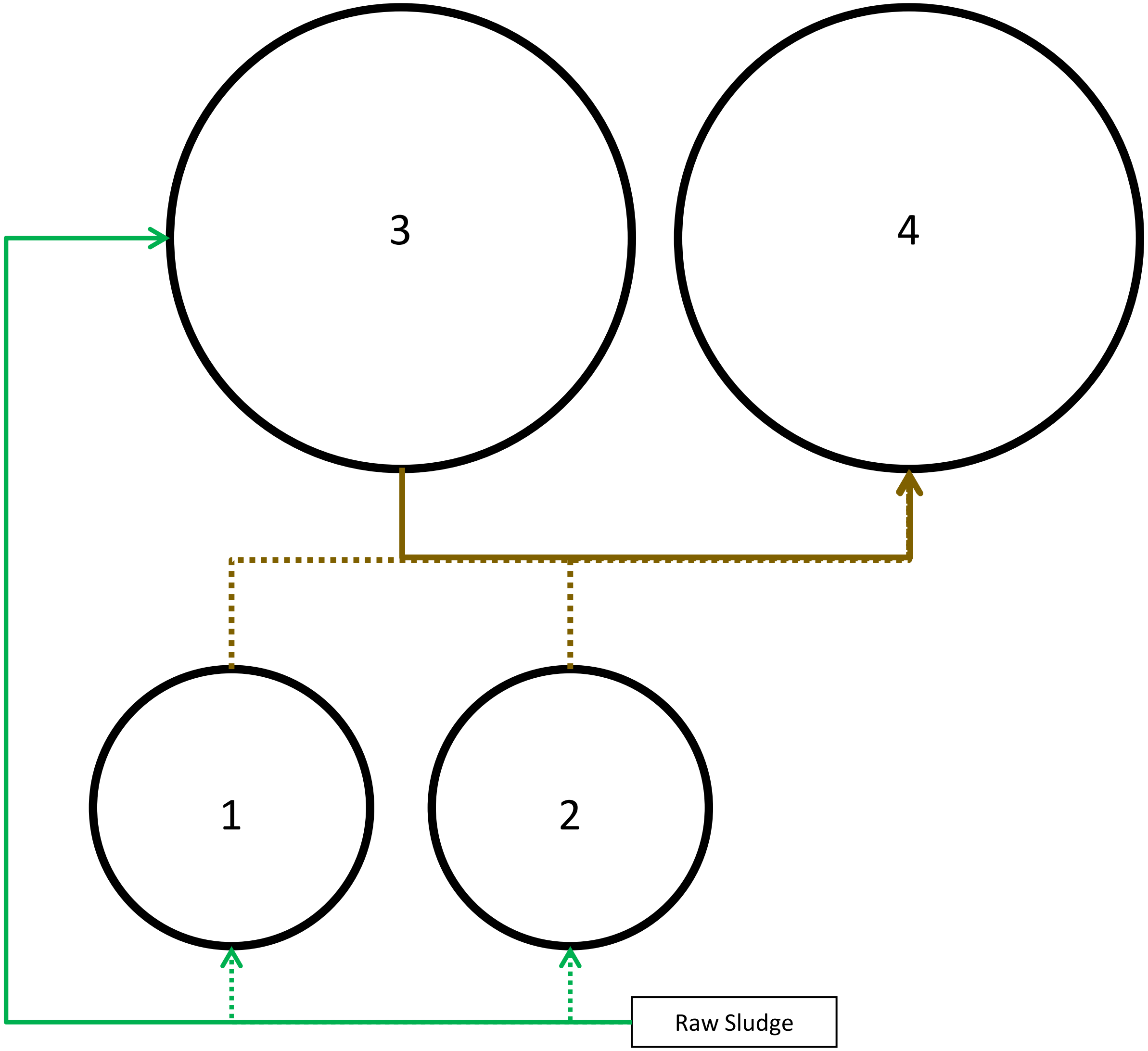
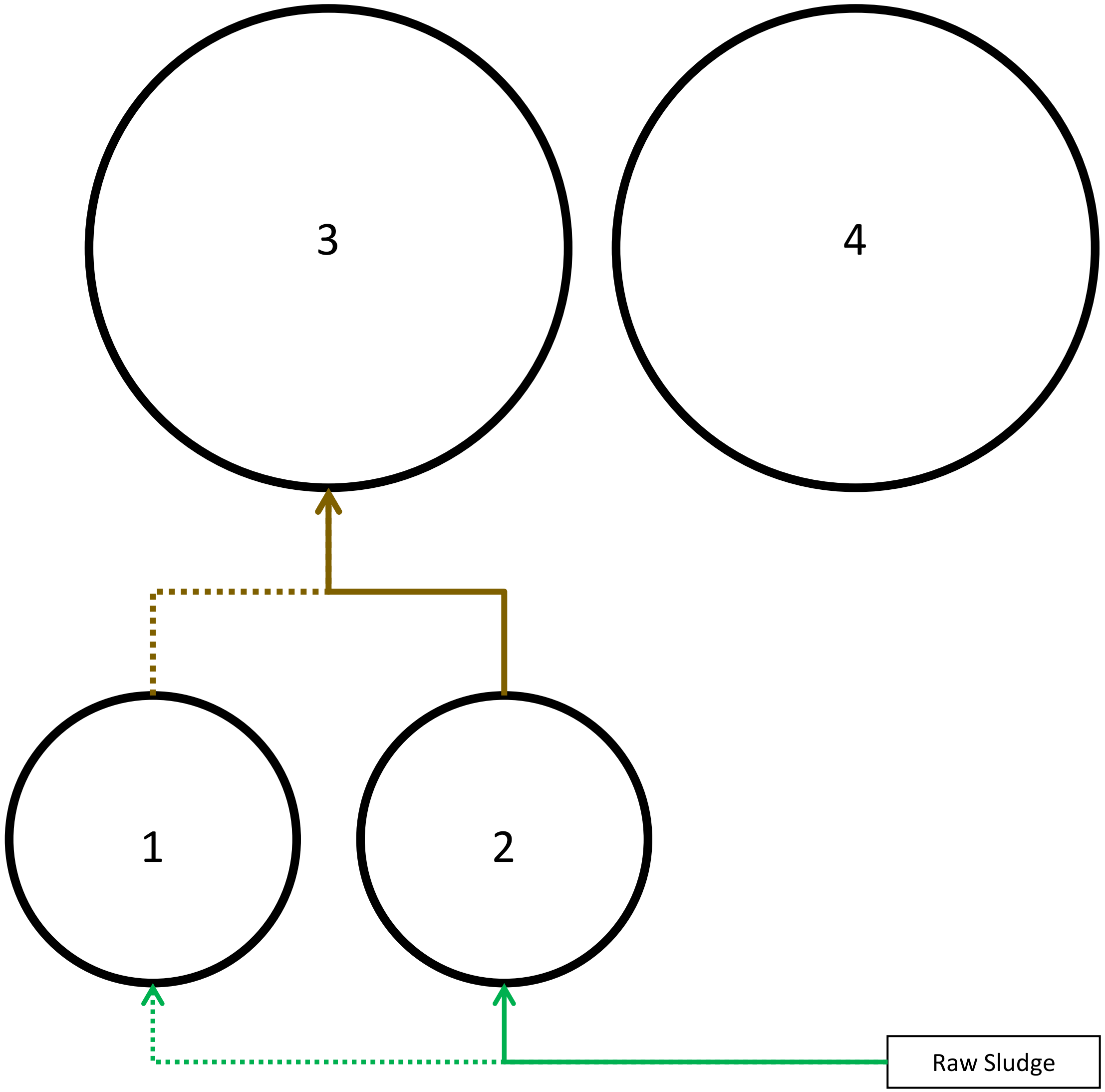
Restart Digester 1 and Digester 2 Phase 2



Digester 3 ready for operation

1. Raw sludge feed to Digesters 1 and 2 will then be gradually started so that they can operate as primary digesters in parallel with Digester 3.
2. Digester 4 will continue to operate as a secondary digester.

Release Digester 4 for Cleaning



Spring 2015 Empty Digester 4

1. Digester 1 and Digester 2 operated as Primary Digesters
2. Digester 3 operated as Secondary Digester

Primary Digesters 1 & 2

- Careful, Planned Restarts
  - Preheat with hot water
  - Transfer from active digester
  - Gradual increase in feed
  - Careful monitoring of VA/Alkalinity
- Achieving 50% VSR @ VA/Alk = 0.28

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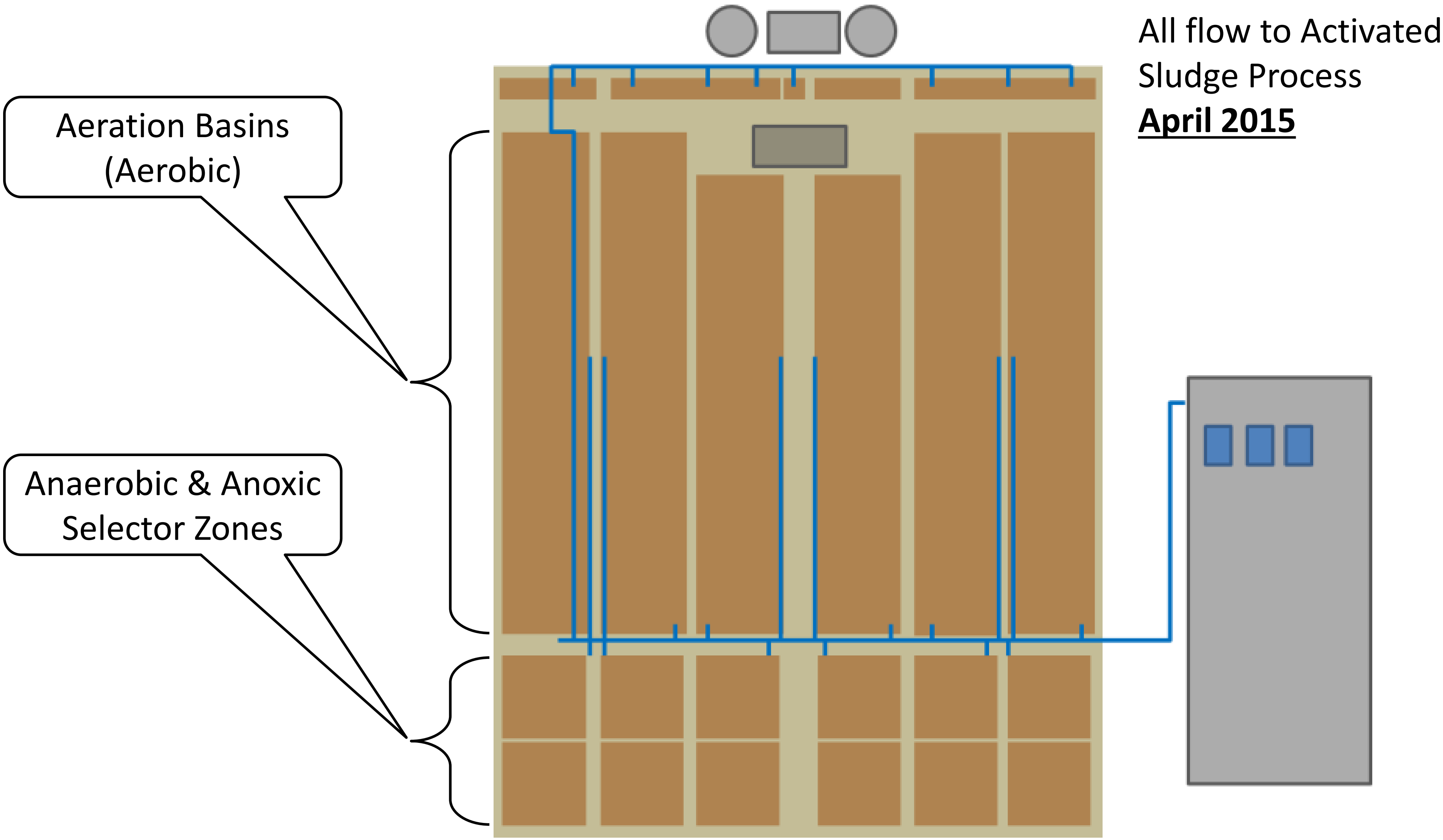
Safety Items

- Safety when dealing with open digesters:
  - Tape off area/no smoking/no sparking tools or equipment/no vehicles
  - Ventilation – contractor needs to use explosion proof fans
  - Turn off building intake fans/HVAC units in area
  - Ensure doors on all nearby buildings are kept closed at all times

Digester Monitoring

- Digester Monitoring/Contingency Considerations
  - Daily monitoring of all active digesters for TS/VS, pH, VA/alkalinity ratio, gas production and gas CO_2 content (if possible) are critical during these operations. Desire digester pH in range of 6.8-7.5 and VA/alkalinity < 0.4.
  - If a digester is showing signs of upset (gradual decrease in pH and/or gradual increase in VA/alkalinity ratio) the raw sludge feed to it will need to be reduced or stopped until it recovers.

Bio-P



Aeration Basins (Aerobic)
Anaerobic & Anoxic Selector Zones
All flow to Activated Sludge Process
April 2015

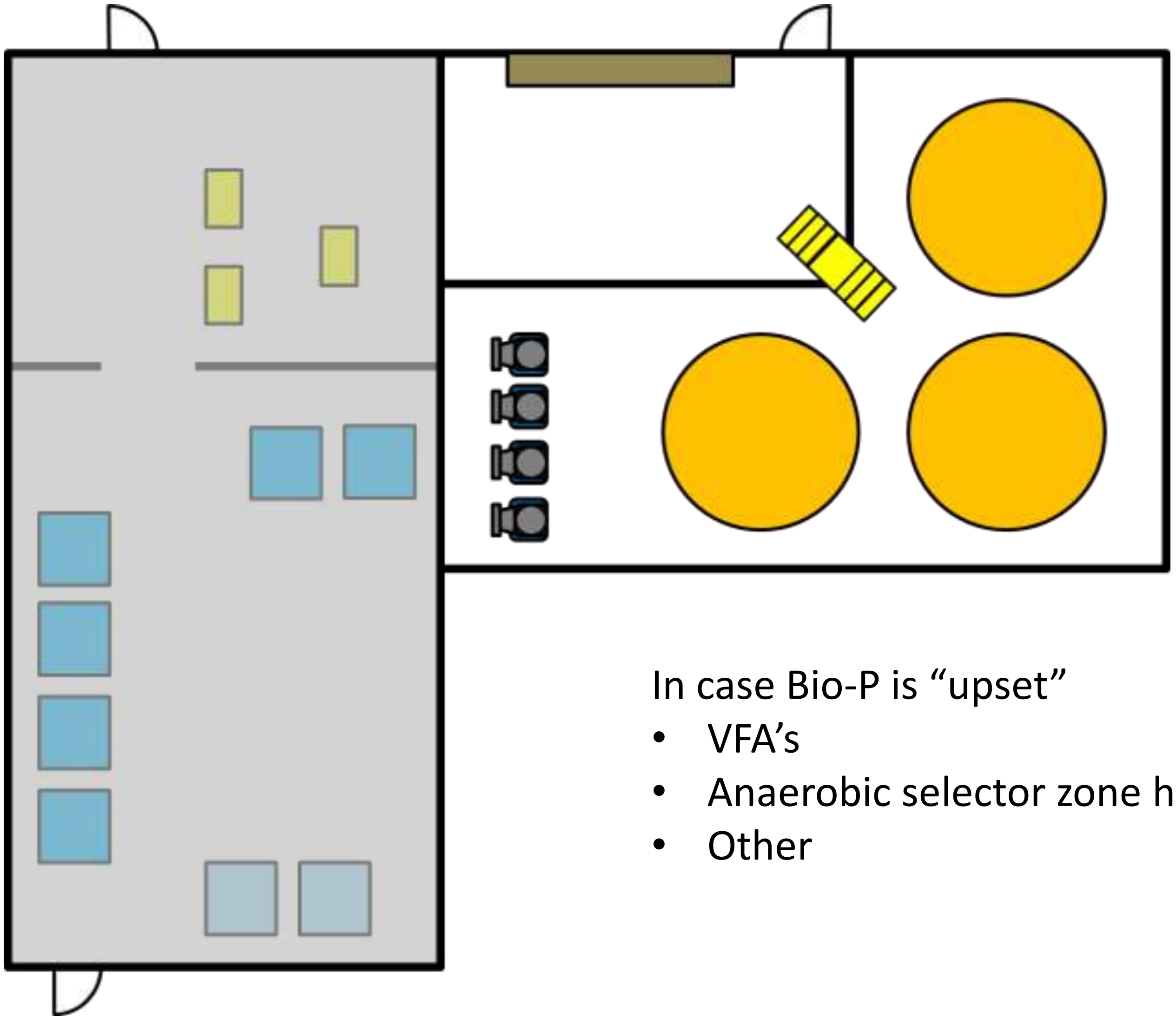
Struvite!

Other signs of struvite noticed late July 2015

Struvite!

Struvite! 4-5 Months after Bio-P

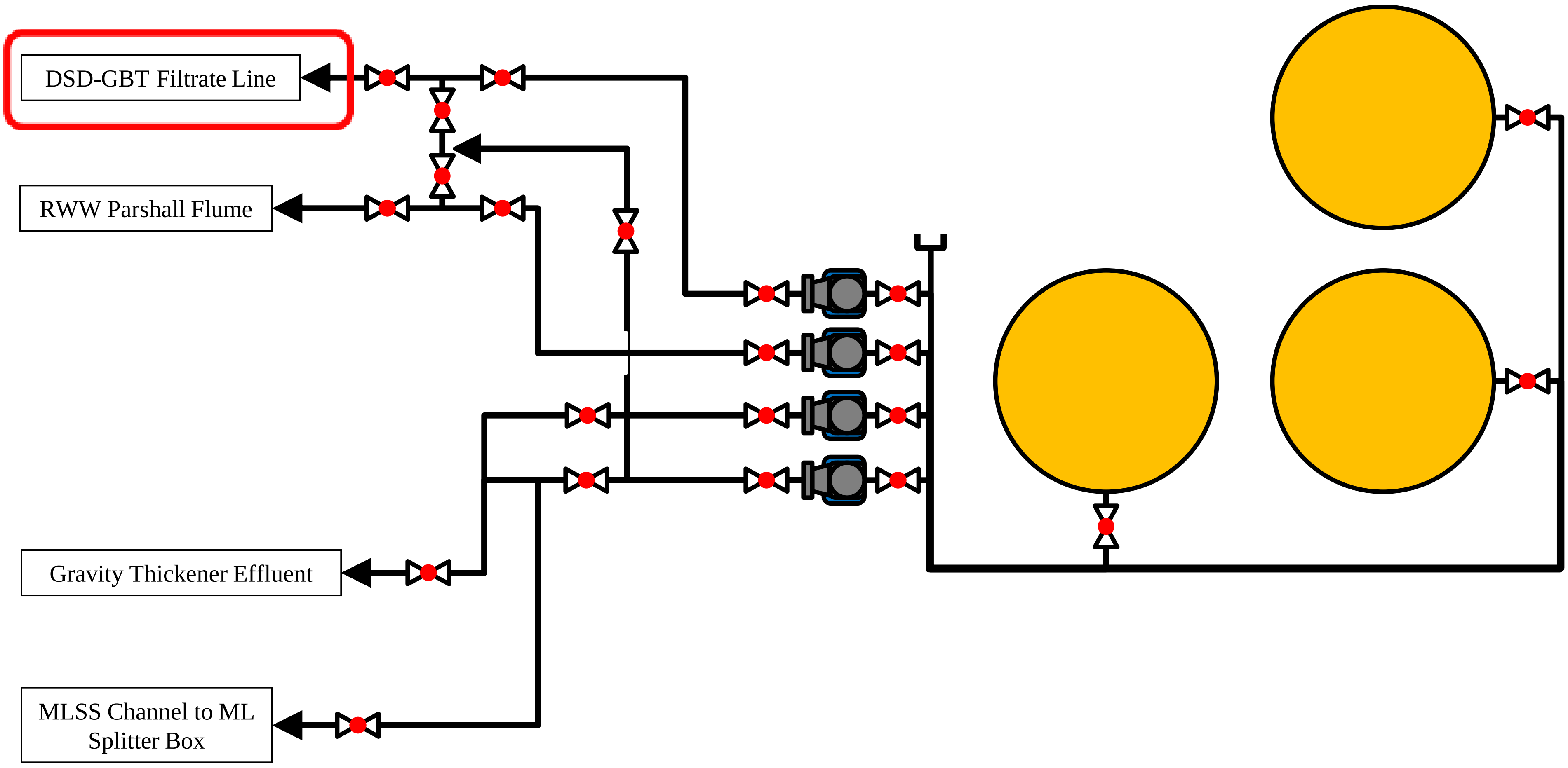
FeCl Room



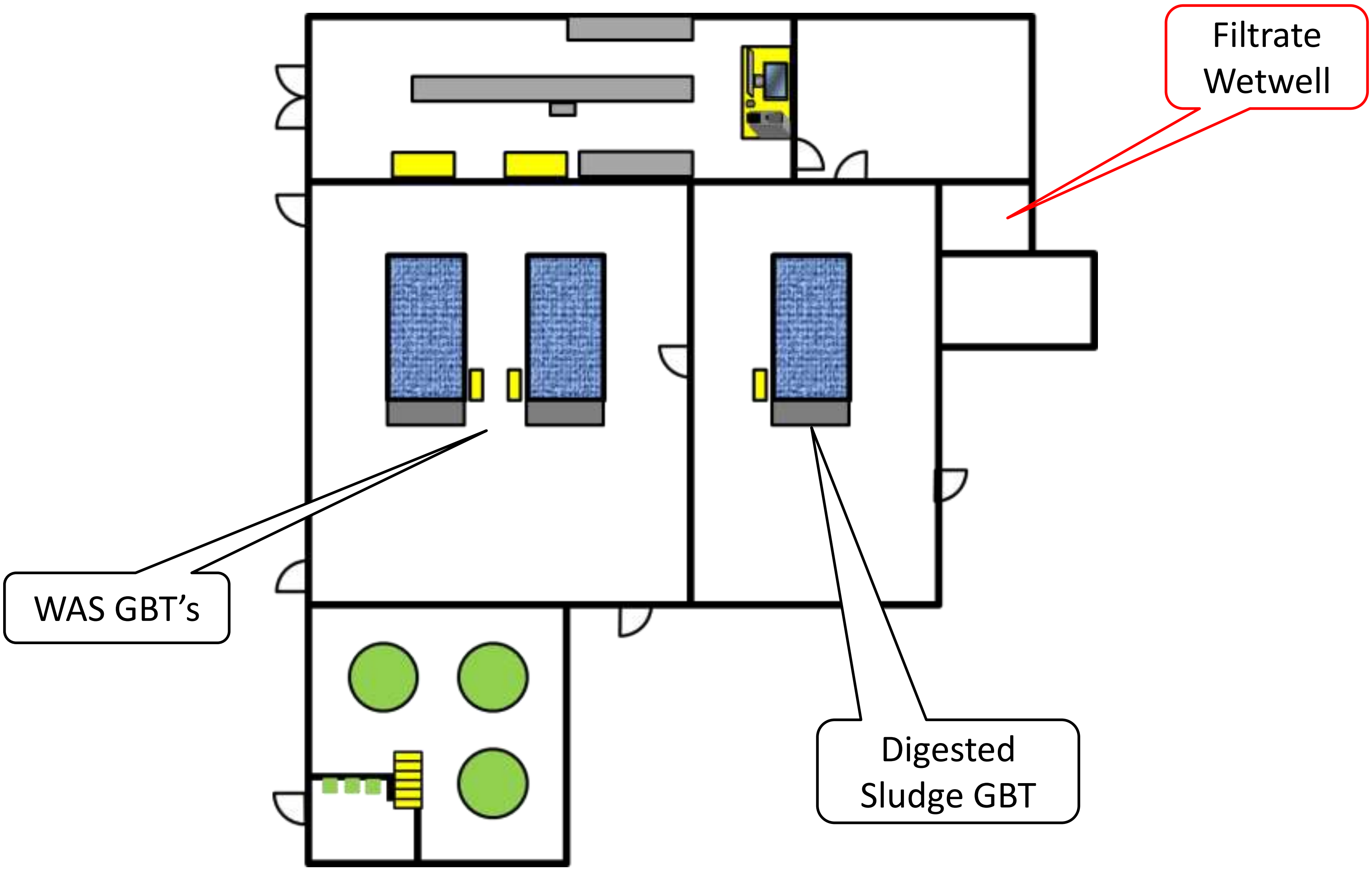
In case Bio-P is "upset"

- VFA's
- Anaerobic selector zone has oxygen
- Other

FeCl Feed Points



Sludge GBT's



FeCl Feed to DSD GBT

- Started FeCl to filtrate tank & ran mixer on August 7th at about 35 gph on a 9 hour run.
- Observed a decrease of struvite in bottom of tank after 10 days.
- Checked the filtrate pump after 2 weeks and it was clear of stuvite. Checked the other pump today and had the same result. (per the pictures).
- Only feed the FeCl & run the mixer while the DSD-GBT is operating 3x / week for avg 9 hours run

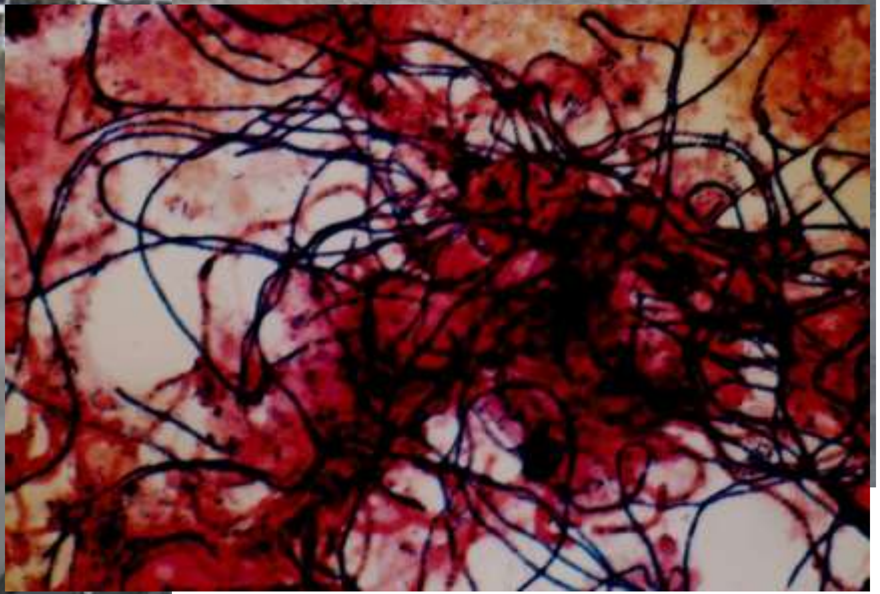
FeCl Feed Rate (to DSD GBT)

- 30 gallons/hour
  - During DSD-GBT operation

December 2014

BNR Activated Sludge Process Control

- Sludge Wasting
  - Initially – Daily SRT on Low Side – Industry Slug Load Led to Severe Digester Foaming



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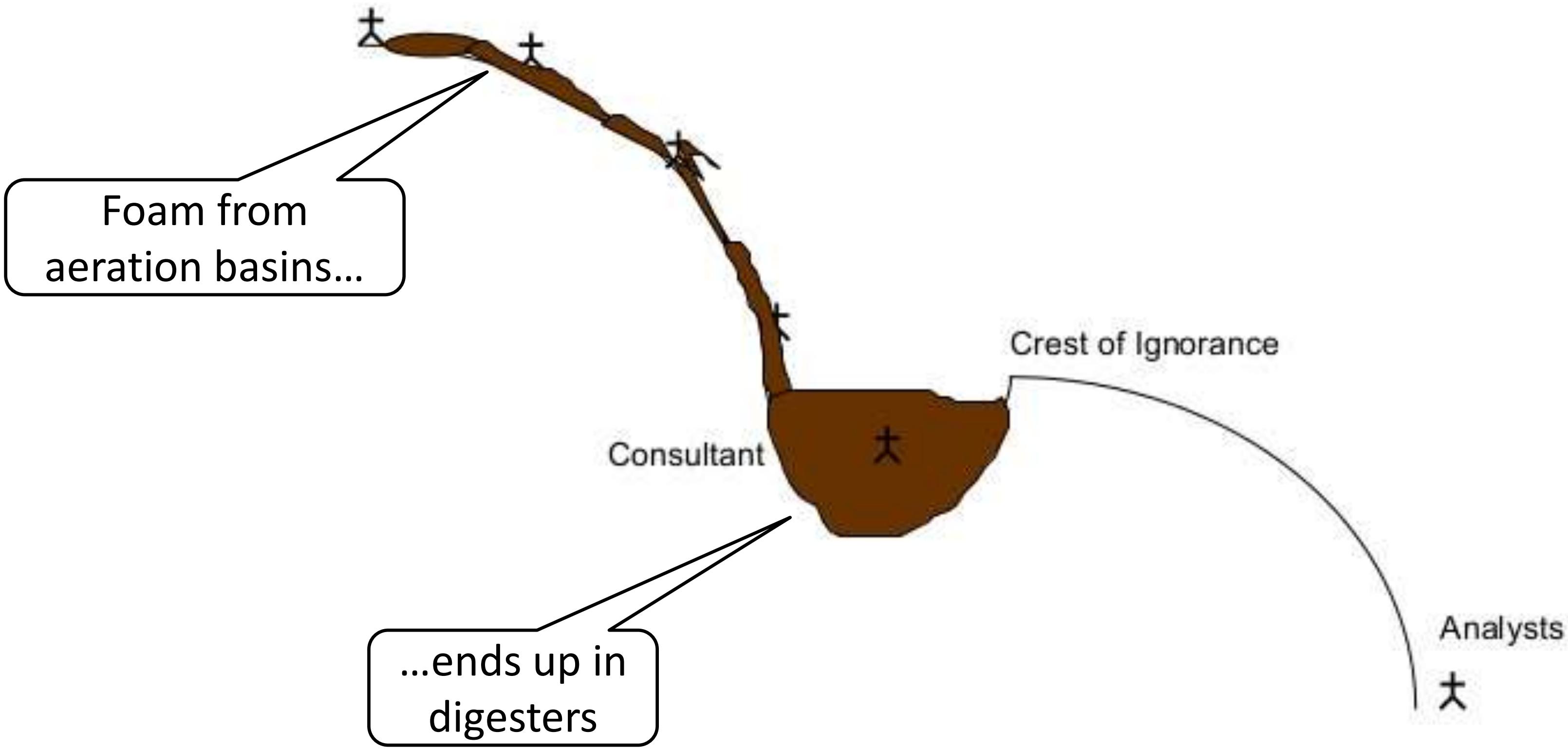
December 2014

January 2014

Foam “runs downhill”

The Analysts are shielded from the s[redacted]t by the Crest of Ignorance, which keeps s[redacted]t from rolling down on them, and ensures that the Consultant remains submerged.



Digester Foaming

Digester foaming correlated with filamentous bacteria outbreak

Digester Foaming

Identifying Problem

MLSS: This sample looked like a mixed liquor from a plant that is operating well. Rotifers and a good mix of protozoa were observed. The level of flagellated protozoa was higher than is probably optimal - this may indicate soluble organics in the system. Most of these flagellates were inside the flocs. Floc structure was good; they were mostly medium to large in size and well-formed. Dispersed bacteria were present at a moderate level.

The dominant filament in the MLSS was tentatively (~85% certainty) identified as *Microthrix*. This is a thin, Gram-positive filament that often occurs closely associated with the flocs and proliferates in high MCRT (low F:M) conditions. Using the subjective filament abundance scoring system developed by Jenkins et al. (2004), which ranges from 0 (none) to 6 (very excessive), *Microthrix* was assigned a level of 3 for the wet mount (exam of the Gram stain often results in revising the value upward).

Foam: This sample had many of the same general characteristics as MLSS regarding organisms present and floc structure. However, flocs in the foam tended to be smaller on average (there were still some large flocs present), and many were made diffuse by the presence of a thin, winding filament. This was the same filament - *Microthrix* - observed in the MLSS. *Microthrix* was assigned a value of 4.5 in the foam sample - and bear in mind this sample had been diluted 1:10. When most filaments occur at a level of 3, or greater, operational problems are likely. I am quite confident that *Microthrix* is the filament causing the foaming condition at your facility - examination of the Gram stain will most likely confirm this. There appeared to be a low level of filament type 0041 present in this sample.

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More ID (Gram Stains)

Exam of Gram stains has confirmed that *Microthrix* is the dominant filament in both MLSS (4.5)and Foam (5) ('Jenkins ratings' in parentheses). Bear in mind the Foam sample was diluted 1:10, so there is an extremely high concentration of *Microthrix* in the 'raw' foam.

Also observed in the samples was a high amount of *Nostocoida limicola* II. *Nostocoida* is a tortuously coiled filament that usually occurs within the flocs (easy to overlook in a wet mount). It is usually Gram-positive to Gram-variable, however it is mostly Gram-negative in these samples. I've assigned abundance values of 4 for MLSS, and 4.5 for the Foam for *Nostocoida*. *Nostocoida* can become so tightly coiled that it forms knots in the flocs - knots were observed in these samples. This is one of the few filaments that plants can withstand a fairly high population of and not have significant operational problems. However, at the high levels in these samples, and combined with *Microthrix*, settling and foaming issues can be expected.

Other filaments were present at lower levels, the highest being type 1851 which occurred at a level of 2 in both samples.

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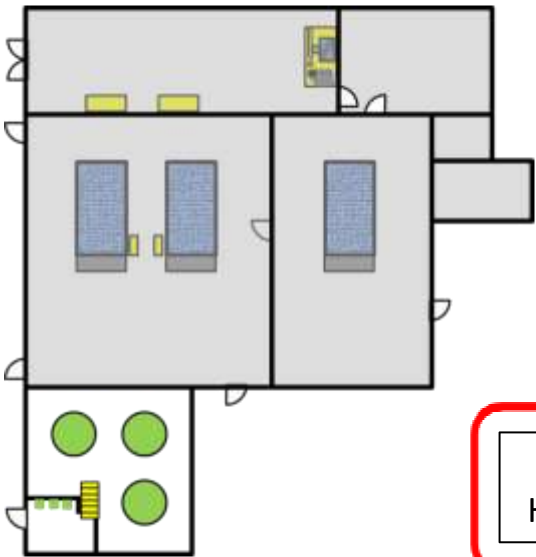
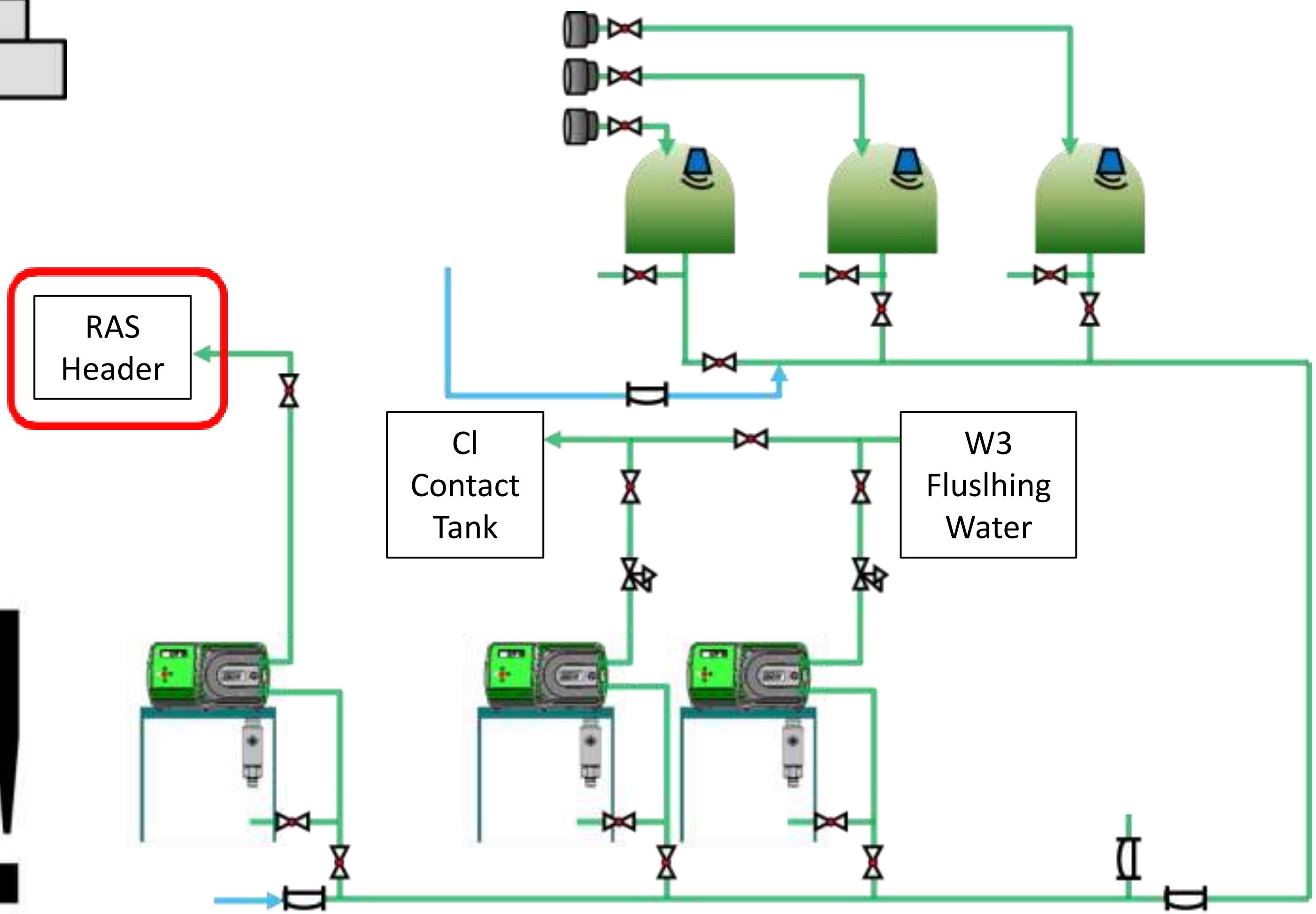
SHC System (quick, short term)





SRT (mcrt, sludge age) Long Term Key

Instructions:

Step 1: Input today's date.
Step 2: Input today's MLSS and RAS concentrations and average final clarifier blanket depth.
Step 3: Input the mixed liquor settleometer test 30 minute settling volume.
Step 4: Input the volume of WAS wasted from the system yesterday (units are gal/day).
Step 5: Input yesterday's plant flow (MGD) and final effluent TSS (mg/L).
Step 6: Check and adjust the Process Inputs as necessary (seasonal or maintenance adjustment - particularly the Target Aerobic SRT).
Step 7: Press "Ctrl" & "w" (lower case w) at the same time and the spreadsheet will update itself (only do this after entering the new values, and only do it once per day).
Step 8: Note the target volume to waste from the activated sludge system. Using this target plus judgment and experience, input the volume to waste into the control system.
Step 9: Check the values you entered and the results shown. If something looks wrong, close the file without saving, then open it again and start at Step 1. If everything looks ok, save the file and then close it.

Notes:
Cells with red bold font in yellow shading are daily inputs (cells B19 through B26).
If there is no value to report for the blue bold cells, leave the cell blank (press "delete").
Cells with red bold font in gray shading are process inputs that may change on a seasonal basis, or when basins are out of service.
Do not leave process input cells blank - must have a value entered in each of these cells.
Cell with black bold font in aqua shading gives target wasting volume for the day in gal/day.

Eau Claire WWTP Activated Sludge Wasting Calculator

SEE INSTRUCTIONS ABOVE:

Daily Inputs Date:	09/30/15	
MLSS Concentration:	1,920	mg/L
RAS/WAS Concentration:	3,650	mg/L
Ave Final Clarifier Blanket Depth:	1.2	ft
30 Minute Settling Volume:	180	mL
Today's WAS Flow:	180,000	gal/day
Yesterday's Plant Flow:	5.411	MGD
Yesterday's Plant Effluent TSS:	3	mg/L

Dailey Inputs

Process Inputs		Range of Typical Values
Target Aerobic SRT:	9.0	6-14 days
Days Per Week to Waste:	7	5-7
Selector Zones in Service:	12	2, 4, 6, 8 or 12
Aeration Basin Passes in Service:	6	1, 2, 3, 4 or 6
Final Clarifiers in Service:	3	1, 2, or 3

Seasonal & Other Inputs

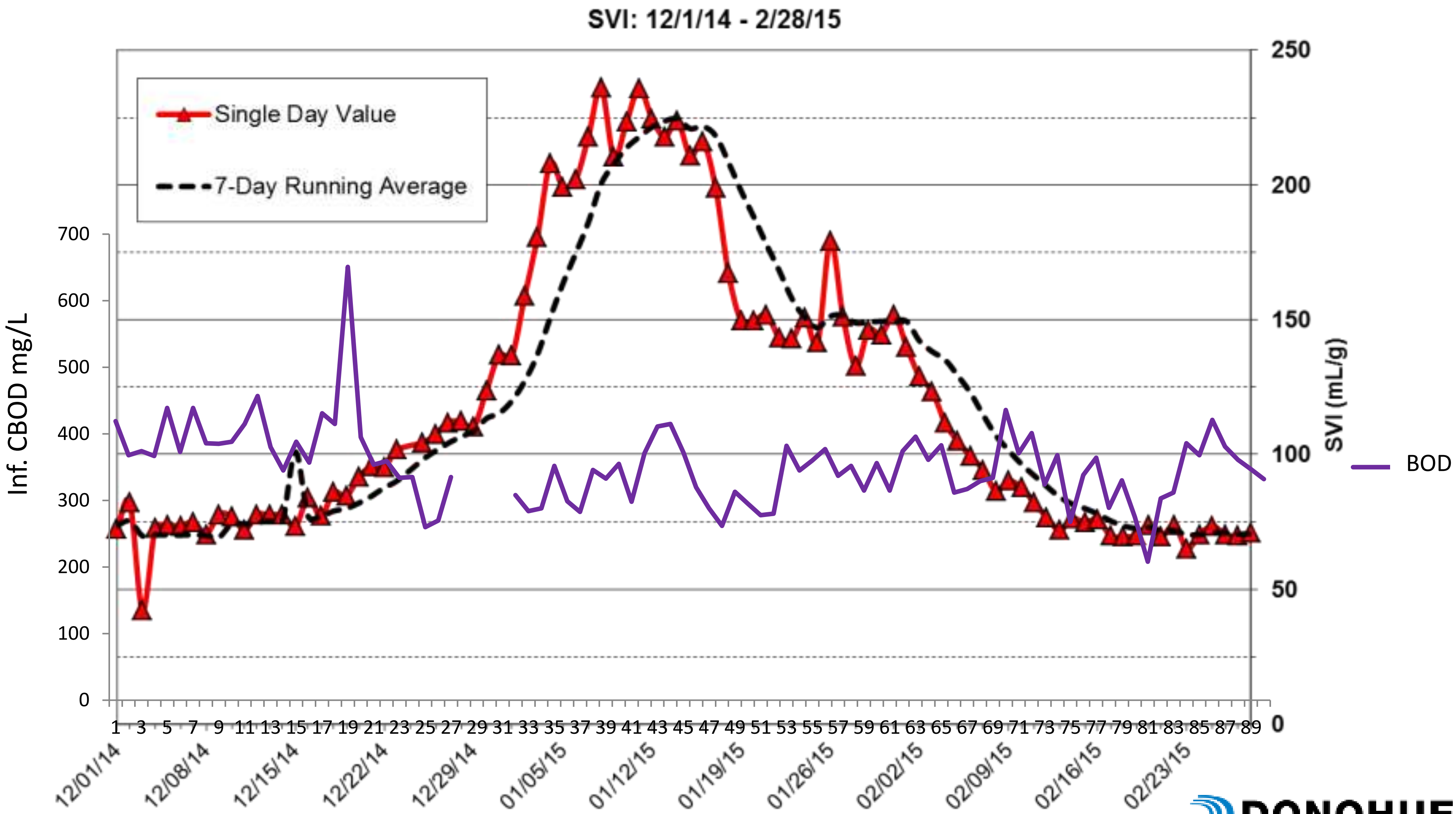
Tomorrow's Wasting Target: **196,166** gal/day

Recommended Gallons of WAS

System Monitoring	Daily	7 Day R.A.	
Aerobic SRT.:	9.3	9.6	days
Total Bioreactor SRT.:	12.3	12.7	days
Total System SRT:	12.7	13.1	days
Actual MLSS Conc:	1,920	2,129	mg/L
SVI:	94	92	mL/g

Monitoring

SVI & Influent BOD



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February 2015

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February 2015

No one is left behind!

The True Heroes in this Story…

The Eau Claire Wastewater Utility Staff, Including:

- Steve Hayden, Utility Engineer
- Kathy White, Assistant Lab Manager
- Craig Capper, Lab Manager
- Mike Thieste, Lab Tech
- Craig Hendrickson, Plant Superintendent
- Jeff Pippenger, Utility Manager
- Entire Plant O&M Staff

Questions?

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