Lake County East WTP Pre-Treatment Systems

OTCO Class III and IV Workshop
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Lake County East Facility
9 mgd Conventional WTP Serving Eastern portions of Lake County, Ohio

- **Conventional Treatment**
- **Oxidation with Potassium Permanganate**
- **Coagulation with Alum/Polymer Blend**
- **T&O/HAB Control with Powdered Activated Carbon**
- **Disinfection with Chlorine Gas**
- **Corrosion Control with Zinc Orthophosphate**
- **Filter Aid (as needed) with Cationic Polymer**
- **Application of Fluoride Ion with H_2SiF_6**
- **Polymer for Sludge Thickening - Lagoons**

Lake County Staff at the AWWA Annual Conference Receiving the Partnership for Safe Water Director's Award Plaque

Important Info About the Lake County East WTP

- This WTP was constructed as a 6 mgd conventional facility in 1982
- In the 2010-11 the WTP increased its treatment capacity to 9 mgd by:
  - installing new higher rate filtration media
  - Installing tube settlers into sedimentation basins
- The mixing and flocculation stages were not altered in any way

The use of mechanical mixing in water treatment

RAPID MIXING

- This process introduces waves of energy that are short but powerful bursts that *promote coagulation*
- The coagulant is added here so that it gets dispersed throughout the water quickly – chemical interaction creates flocs
- The goal is to get in and back out of the mixing box in a matter of seconds (15-45)

FLOCCULATION

- This process introduces waves of energy that are long and gentle pulses
- The flocs formed in rapid mixing will begin to grow in size here through physical collisions
- The goal is to flow slowly through the flocculator for 15-45 minutes so that flocs toughen and grow in size

Coagulation of particles

- In most cases, particles in suspension (colloids) come to the water plant with negative electrostatic charges
  - A multitude of these charges makes for a “stable” suspension
    - It won’t quickly change on its own – so particles remain suspended
  - Adding a coagulant with a multitude of positive charges will “destabilize” the suspension

Rapid Mix

The WTP has two units that were rated at 3 mgd each but are now part of overall pre-treatment

Rapid mixing is the quick dispersion of coagulant into the source water to create flocs

At 6 mgd, the detention time is 30 seconds, at 9 mgd it is 20 seconds

Alum/polymer blend is added here to:

- **Reduce TOC**
- **Reduce turbidity**

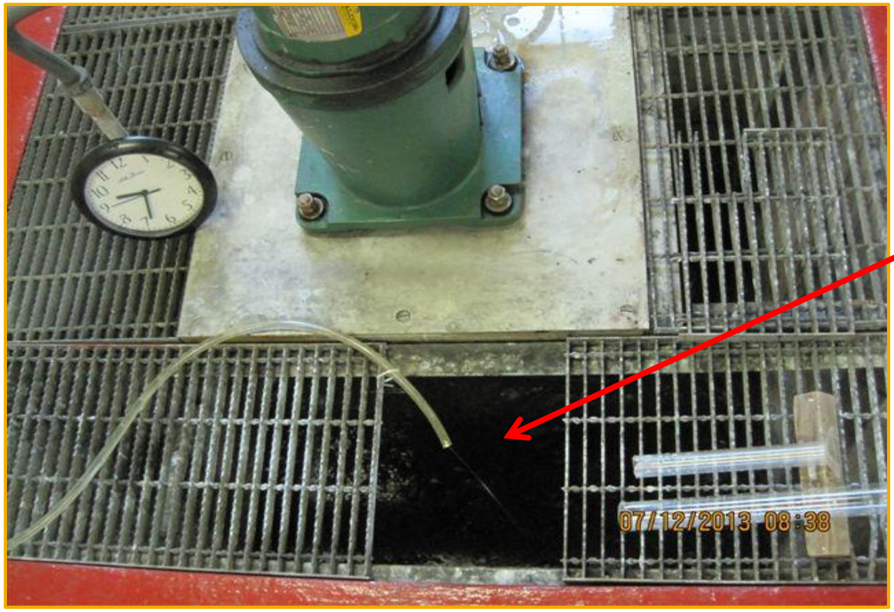
More coagulant is needed to remove TOC than is needed to remove turbidity

Operators need to capture the flow of coagulant going into mixer to be sure of a the proper dosage

- The D/DBP Rule requires that 25% of the incoming TOC be removed based on your incoming alkalinity
  - When not met, use SUVA value to comply
- The IESWTR requires that finished water turbidity levels be < 0.3 ntu 95% of time
- Lake County goals require sedimentation basin turbidity be < 1 ntu when raw water turbidity is less than 10 ntu
  - < 2 ntu when raw turbidity is greater than 10 ntu
- Lake County plants use a metallic coagulant and "sweep flocculation" to accomplish these goals

Bacon Road WTP Treatment Units

- Rapid Mixers
  - 2 units,   1,060 gallons each or 142 cubic feet
  - DT@ 6 mgd = 30 seconds, 9 mgd = 20 seconds
  - G value ≈ 300 sec^{-1}

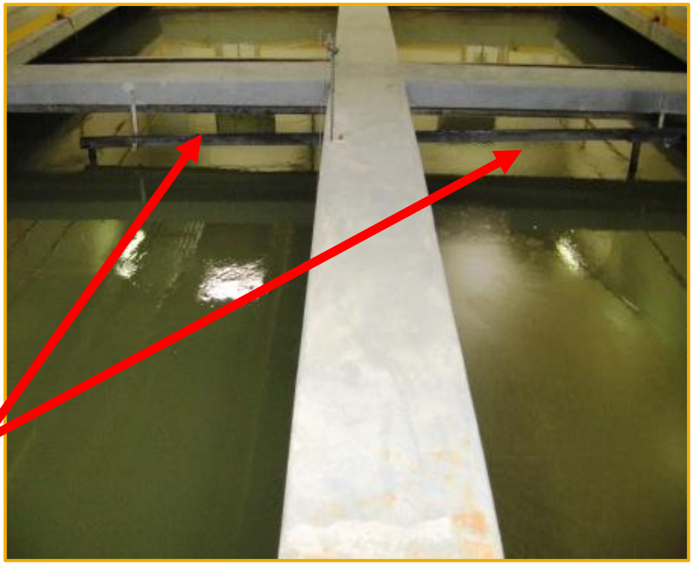


Note: alum/polymer blend feed point

Bacon Road WTP Treatment Units

- Flocculators
  - 2 units,   62,000 gallons each, DT@ 6 mgd = 30 minutes
  - Three compartments / tapered paddle mixing
  - G value ≈ 60, 50, 40 sec^{-1}

Note: Activated Carbon feed



Coagulant

- East WTP uses an Alum-Polymer blended product for a coagulant
  - It's a combination of liquid alum and a cationic polymer
  - The liquid alum portion forms flocs by combining with naturally occurring alkalinity
  - The polymer portion toughens the flocs and makes them more dense
  - Product weighs 10.8 pounds per gallon
    - Approximately 45% of the product is dry basis alum
    - **1 mg/L dry basis alum will use 0.5 mg/L alkalinity and produce 0.26 mg/L sludge**

Coagulant Feed System

North and South Mixer Motors

Motors are constant speed and drive the mixers in each compartment

Mixers are paddle mixers

Original literature that we found at the plant says that the mixing energy is small by today's standards

Mixing energy is rated as a "G value"

G value for this mixer, according to your original operation manual, is 100 sec^{-1}

G value Calculation

- G value = $\sqrt{\frac{P_w}{\mu V t}}$ where, $P_w = \frac{k}{g} w N^3 D^5$
  - K = impeller constant 1
  - W = 62.4 lb/ft^3
  - N = revolutions per second @233 rpm, so 3.88 rps
  - D = impeller diameter 16.4 inches, or 1.37′
  - g = acceleration due to gravity, 32.2 ft/sec^2

  - μ = 3.76 x 10^{-5} lb-sec/ft^2 in cold water
  - V_t for Bacon Rd is 142 ft^3
- G calculates to a range of about 280 to 345 sec^{-1}

Determining Dose

Using formulas for calculating dosage

First – capture the flow of coagulant for 1 minute

Second – use formula to calculate dosage

Third – make adjustments

- Example: at a plant flow of 3.5 mgd, what is the coagulant dosage when the captured amount is 175 mLs, and the product weighs 10.8 pounds per gallon?
- Answer:
  - 175 mLs/min ÷ 3,785 mLs/gal X 1,440 min/Day X 10.8 lbs/gal = 719 lbs/Day
  - 719 lbs/Day ÷ 8.34 lbs/MG/1 mg/L ÷ 3.5 MGD = 24.6 mg/L
  - This would be approximately (24.6 X 45%) = 11 mg/L dry basis alum

Sweep Flocculation

Flocculation is a physical process where the floc particles collide gently with one another and stick together

Sweep flocculation is the practice of adding much more coagulant than is necessary to reach charge neutralization in source water particles

Tip speed of the flocculator is controllable and should be set to rotate at somewhere around 1 fps

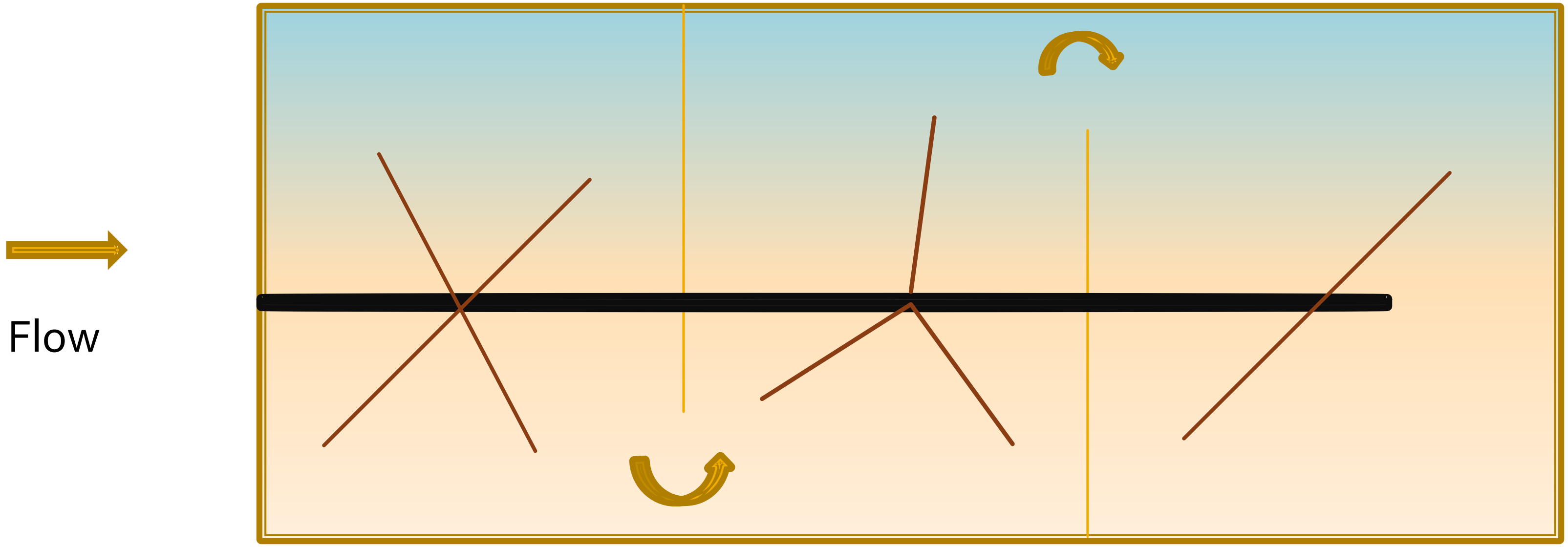
During periods of high lake turbidity, the flocculator paddles should run faster

During periods of low Lake turbidity, the paddles can run more slowly

Note: carbon fed into troughs

Flocculators

- The flocculators at Bacon Road are compartmentalized, and have paddle mixers



Flocculation

Two units were originally rated at 3 mgd each

At 6 mgd, the detention time is 30 minutes

Flocculators impart smaller amounts of energy to the water, and tapers the energy down by using compartments and fewer paddles

Lake East plant flocculators have three compartments with 4, 3 and 2 paddles in them

Activated Carbon is added to them here at Lake East plant

Flocculator tip speed

The flocculator drive mechanisms are equipped with a hand wheel which can be rotated to increase or decrease shaft speed

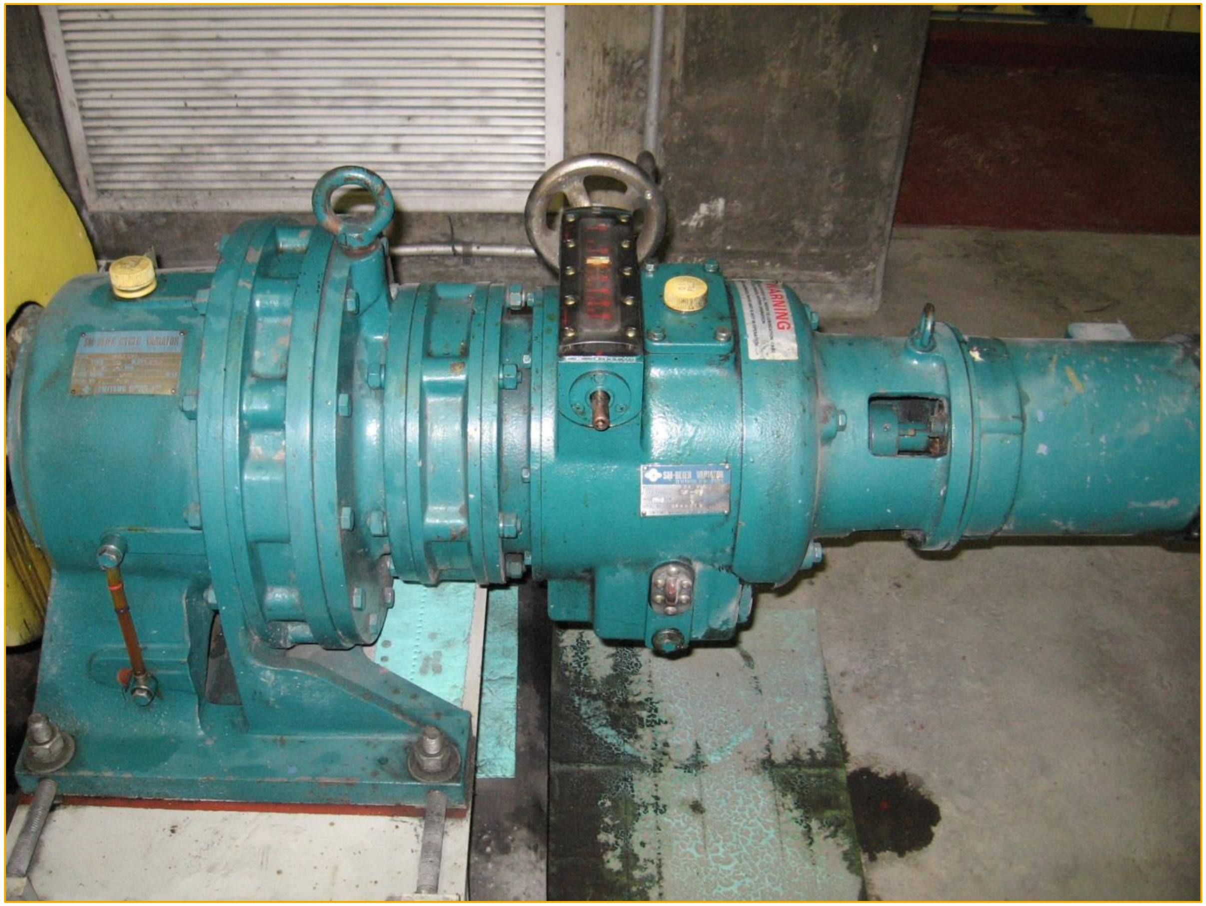
The circle that the tip of the paddle travels has a perimeter of 37.68 feet

View the travel of the paddle in the water, and use a watch to measure the amount of time it takes for 1 complete revolution

Divide 37.68 feet by the time in seconds for one revolution

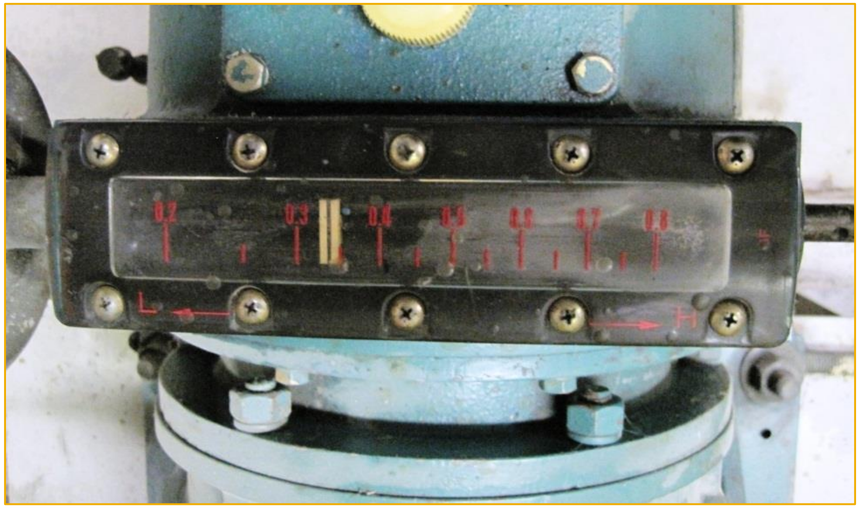
This will give you the tip speed in fps

Make adjustments when necessary

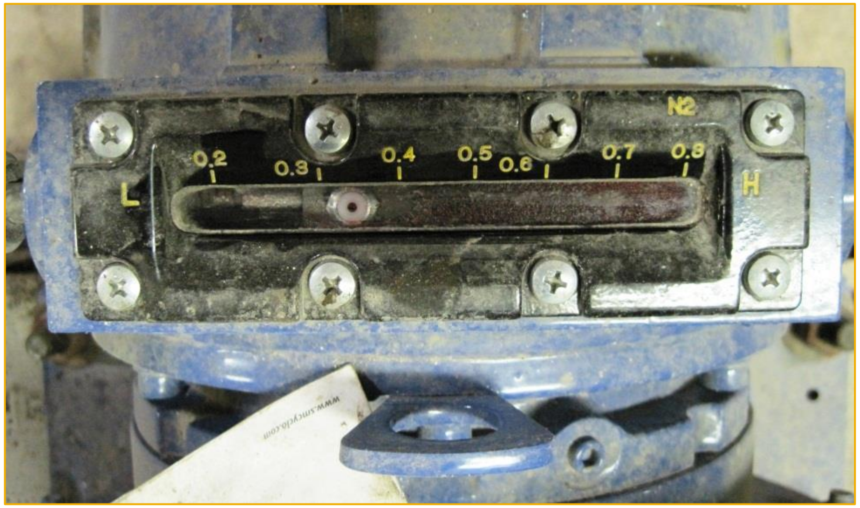


Floc Drive Settings

SOUTH DRIVE



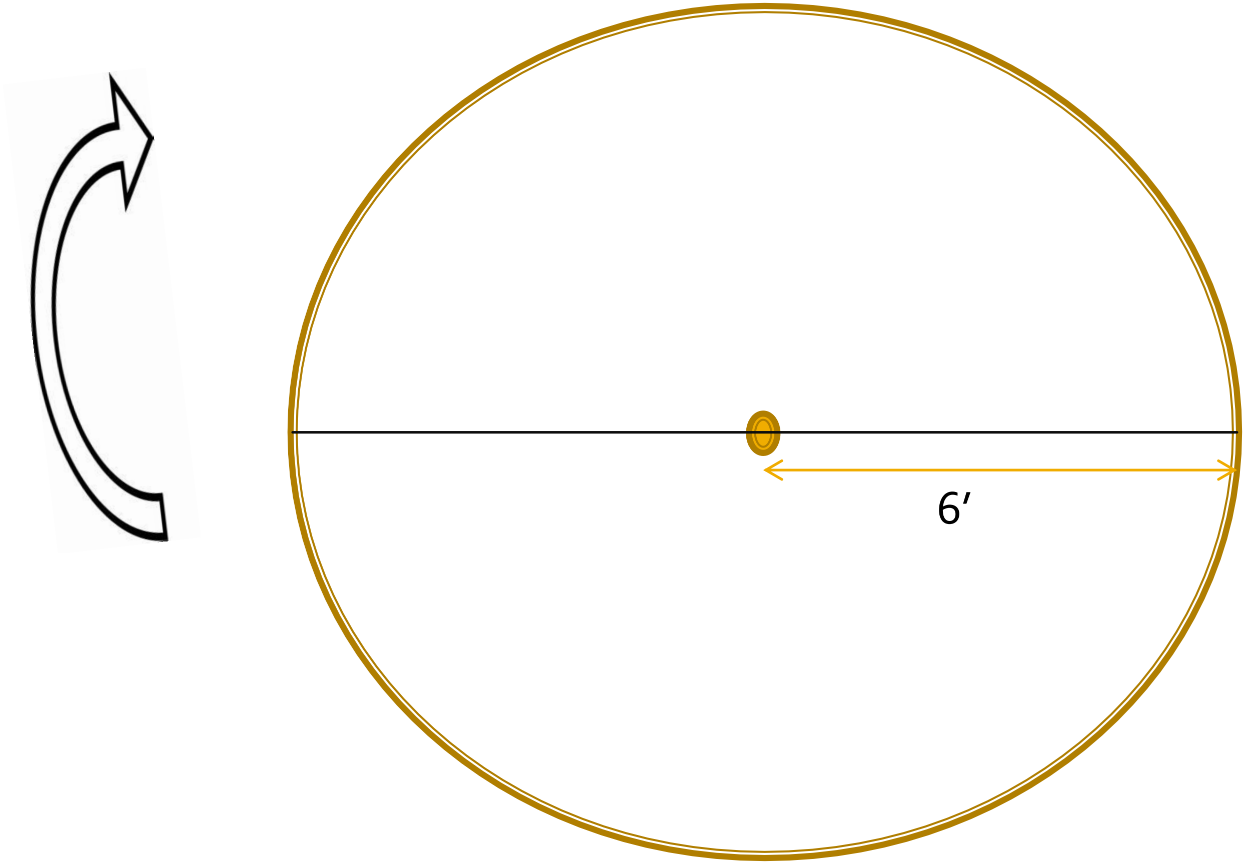
NORTH DRIVE



Within the span of 0.2 to 0.8, the mechanism will drift the shaft at a speed of 1.22 to 3.65 rpm
This corresponds to a tip speed of 0.76 fps to 2.3 fps

Flocculator travel distance

Perimeter of a circle cut out by the travel of the paddle is = to 3.14 X Diameter



Therefore, 1 rotation is 3.14 X 12′ = 37.68 feet.

Tip speed calculation

- 1 rotation is 37.68 feet
  - Step 1 – determine the desired tip speed
  - Step 2 – measure the actual tip speed
    - Step 3 – measure the time it takes to travel around once
    - Step 4 – divide 37.68 by the number of seconds you measured
    - Step 5 – adjust speed as necessary
- Example: you want 1 fps. You measure 1 rotation at 40 seconds. (37.68 ft/rotation)/40 seconds/rotation) = 0.94 fps.
  - You must increase speed at the motor downstairs

Sedimentation

- Sedimentation is a solids separation process
- In a conventional WTP it is the process that allows the majority of the larger particles created in the mixing processes to settle out of the flow of water prior to filtration
  - It relies on gravity
  - Temperature of the water plays a role
- Basins used for sedimentation accumulate the majority of the sludge produced – this sludge must be taken away periodically

Sedimentation Basins

The WTP has two units with dimensions of:
37.75′ X 120′ X 14.8′ W.D.

Surface area of the basin is 37.5′ X 120′ = 4,500 square feet

Three double-sided weirs per basin

Spaced inlets allow water to enter and flow evenly across basins

Weir overflow rate (WOR) is calculated by dividing the pumpage in gpm by the weir length in feet

Keeping the WOR low is key to producing a settled water turbidity that will filter well and produce longer filter runs

Weirs should be re-leveled when necessary as they can become warped

- Each weir is 48′ long, and has two sides which allow water to overflow
- Weirs capture water from the upper one inch or so of the basin, and in that way they get only the clearest water
- Discuss SOR and WOR
  - These are up-flow <u>velocities</u>

Sludge piping being constructed

Basin collector/tube system

Sedimentation Basins

Each unit is equipped with tubes that greatly increase the amount of water that can be processed per unit time

The unit has three double-sided weirs that are 48′ long

The total weir length is 3 X 48′ X 2 sides X 2 basins = 576′

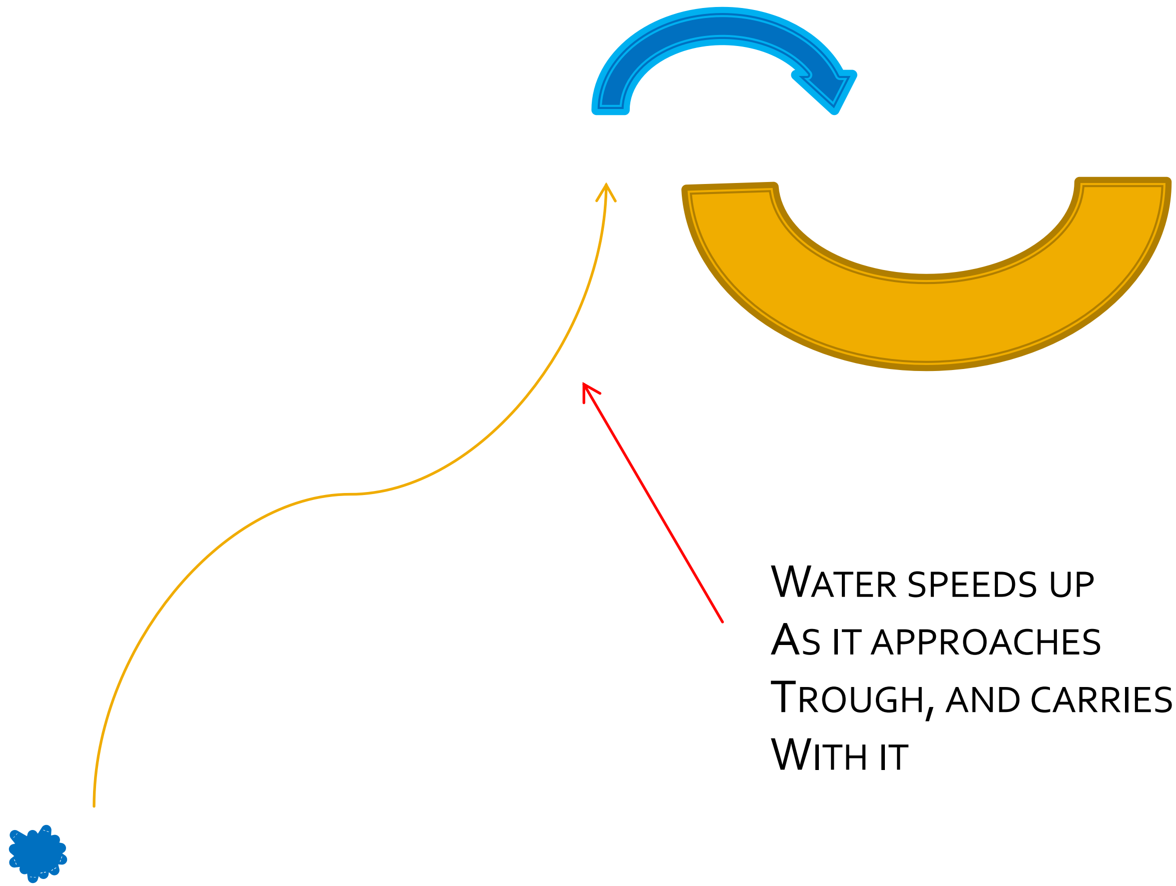
Lake County East Plant has a goal for sedimentation basin effluent turbidity: if the turbidity is greater than 2 ntu, use a filter-aid polymer

Standard Sedimentation

Flow pushes particle across

Viscosity plays a role

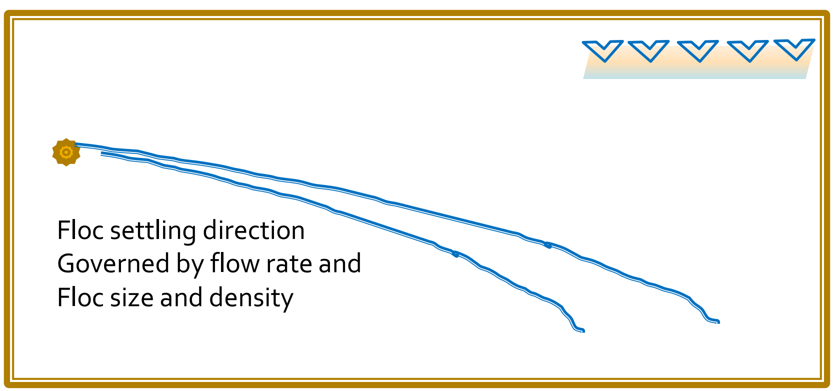
Gravity pulls particle down

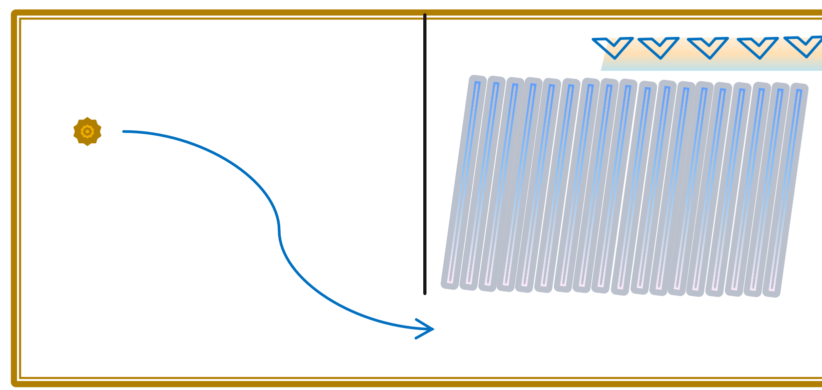


WATER SPEEDS UP
AS IT APPROACHES
TROUGH, AND CARRIES FLOC
WITH IT

Sedimentation Basins: Conventional vs. Tubes

- Conventional: flow is straight across; with tubes, flow is baffled to go upwards
- Discuss particle size and abundance
- Discuss particle travel forces





Overflow rate calculation for tubes

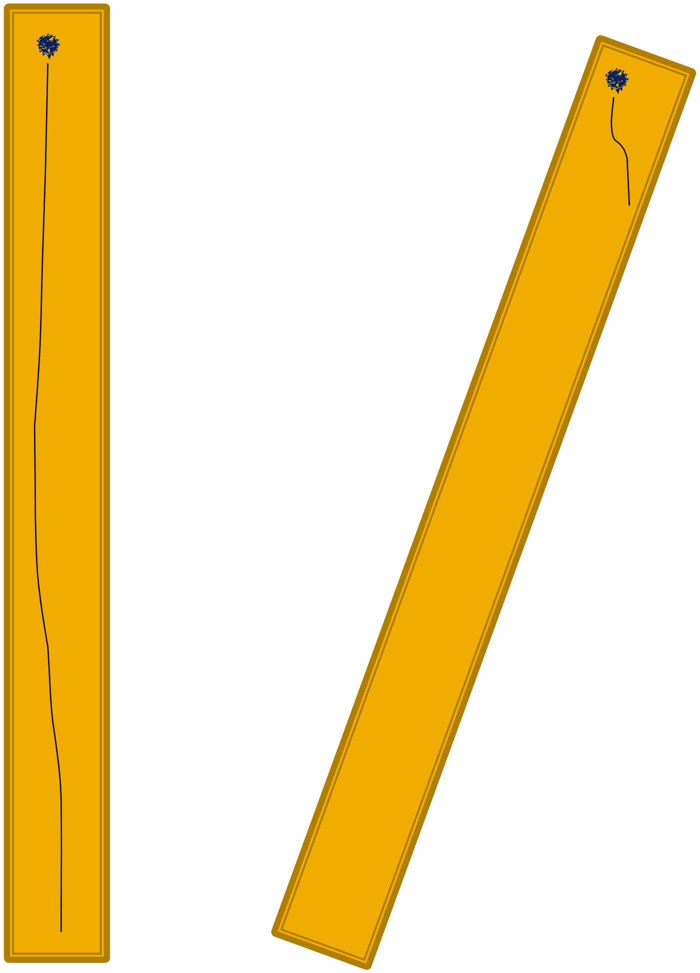
- Basin dimensions: 120′ X 37.67′ = 4,520.4 ft^2
- Overflow rate desired = 2 gpm/ft^2
  - …and each basin needs to handle 4.5 mgd, or 3,125 gpm
- So they needed to install tubes that provided a surface area of (3,125 gpm x 2 gpm/ft^2)= 1,562.5 ft^2 of tubes
- And 1562.5 / 4520.4 = 0.35, or 35% of basin needed to be covered
  - They actually covered 40% for added insurance

Sedimentation

- Overall surface area of the basin has a lot to do with the ability to settle particles
- For the same flow rate, a larger surface area will allow more particles to settle
- For the same surface area, a smaller flow rate will allow more particles to settle

Particle Capture in Tubes

- Tubes greatly increase the overall surface area of basin
- In a slanted tube, particles don't have to fall very far to be captured
- Gravity pulls the particle downwards
- Particles come in all sizes and densities



Using Filter Aid Polymer

Filter aid is added to the settled effluent water in the flume at the end of the basins - use the ntu goal

When using a filter aid polymer:

- Limit the feed time
- When finished, run some clean water through the feed pump otherwise the polymer will gum it up
- Don't try to store diluted polymer as it will break down

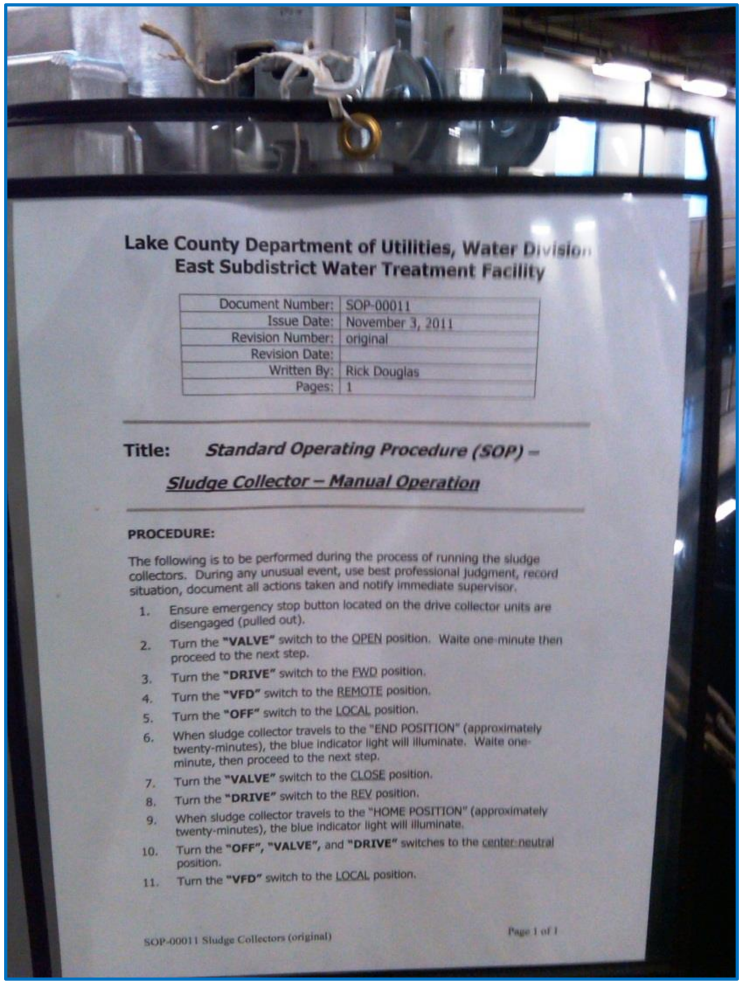
Flow rate of water to be treated, gpm	Feed rate of 1% polymer, mLs/min
1,400	26.6
1,600	30.4
1,800	34.2
2,000	38.0
2,200	41.8
2,400	45.6
2,600	49.4

Table shows the amount of 1% polymer needed to achieve a dosage of 0.05 mg/L in the flow of water going over to the filters

Basin Maintenance

- In spite of the sludge collectors each basin has, staff should take basins out for cleaning, inspection and maintenance
- Old sludge needs to be cleaned from corners, walls need to be blasted, and collectors should be maintained
- Tubes should be hosed down at this time

SOP available


Lake County Department of Utilities, Water Division
East Subdistrict Water Treatment Facility

Document Number:	SOP-00011
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Revision Date:	
Written By:	Rick Douglas
Pages:	1

Title: ***Standard Operating Procedure (SOP) – Sludge Collector – Manual Operation***

PROCEDURE:

The following is to be performed during the process of running the sludge collectors. During any unusual event, use best professional judgment, record situation, document all actions taken and notify immediate supervisor.

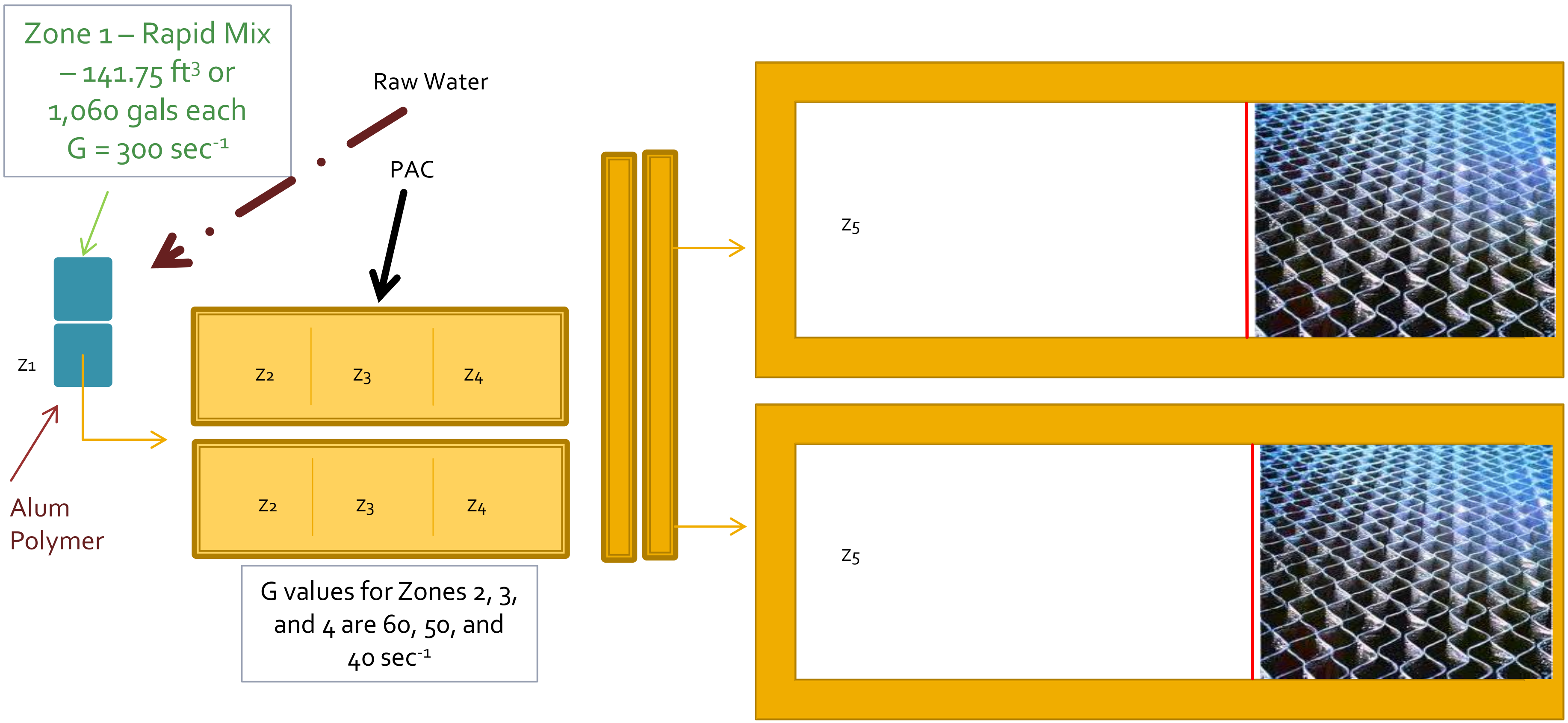
1. Ensure emergency stop button located on the drive collector units are disengaged (pulled out).
2. Turn the **"VALVE"** switch to the OPEN position. Waite one-minute then proceed to the next step.
3. Turn the **"DRIVE"** switch to the FWD position.
4. Turn the **"VFD"** switch to the REMOTE position.
5. Turn the **"OFF"** switch to the LOCAL position.
6. When sludge collector travels to the "END POSITION" (approximately twenty-minutes), the blue indicator light will illuminate. Waite one-minute, then proceed to the next step.
7. Turn the **"VALVE"** switch to the CLOSE position.
8. Turn the **"DRIVE"** switch to the REV position.
9. When sludge collector travels to the "HOME POSITION" (approximately twenty-minutes), the blue indicator light will illuminate.
10. Turn the **"OFF", "VALVE",** and **"DRIVE"** switches to the center-neutral position.
11. Turn the **"VFD"** switch to the LOCAL position.

SOP-00011 Sludge Collectors (original) Page 1 of 1

Bacon Road Jar Test Guide

Bacon Road Schematic (approximations for Bacon Road jar test)

Each Sedimentation Basin Approximately 37.75′ wide by 14.8 deep, with travel length of 120′. Because of tubes, the effective surface area is 2.33 times the old area. Therefore, SOR ÷ 2.33 = the effective SOR, or ESOR.



Zone 2 ,3 and 4 flocculation is baffled – each compartment at approximately 13.3′w.d. X 14′ wide X 15′ = 2,793 cubic feet, or 20,890 gallons each. Zones have tapered flocculation accomplished by 4,3, and 2 paddles respectively. Zone 5 is entry to Sedimentation Basins. An approximate volume of 1,400 cubic feet, or 10,500 gallons can be used for Detention Time Calculations. Use $G = 10\ sec^{-1}$.

Rules for Jar Test Calculations

Full-scale vs. Jar-scale

MIXING, COAGULATION, AND FLOC ZONES

- Full-scale Detention Times are used exactly "as is" for the jar-scale
- Full-scale mixing energy (G value) must be "scaled-down" to determine paddle speeds at jar-scale
- Where rapid mixing G value is high, use "G X T" to scale down for paddle speed

SETTLING ZONES

- Full-scale Detention Time is meaningless – do not use it
- Full-scale SOR determines the jar-scale settling time
- Convert the SOR gpm/sq ft to the settling velocity in cm/min by multiplying by 4.07
- Divide the distance of the sample port in the jar (in cm) by the settling velocity to get sample time

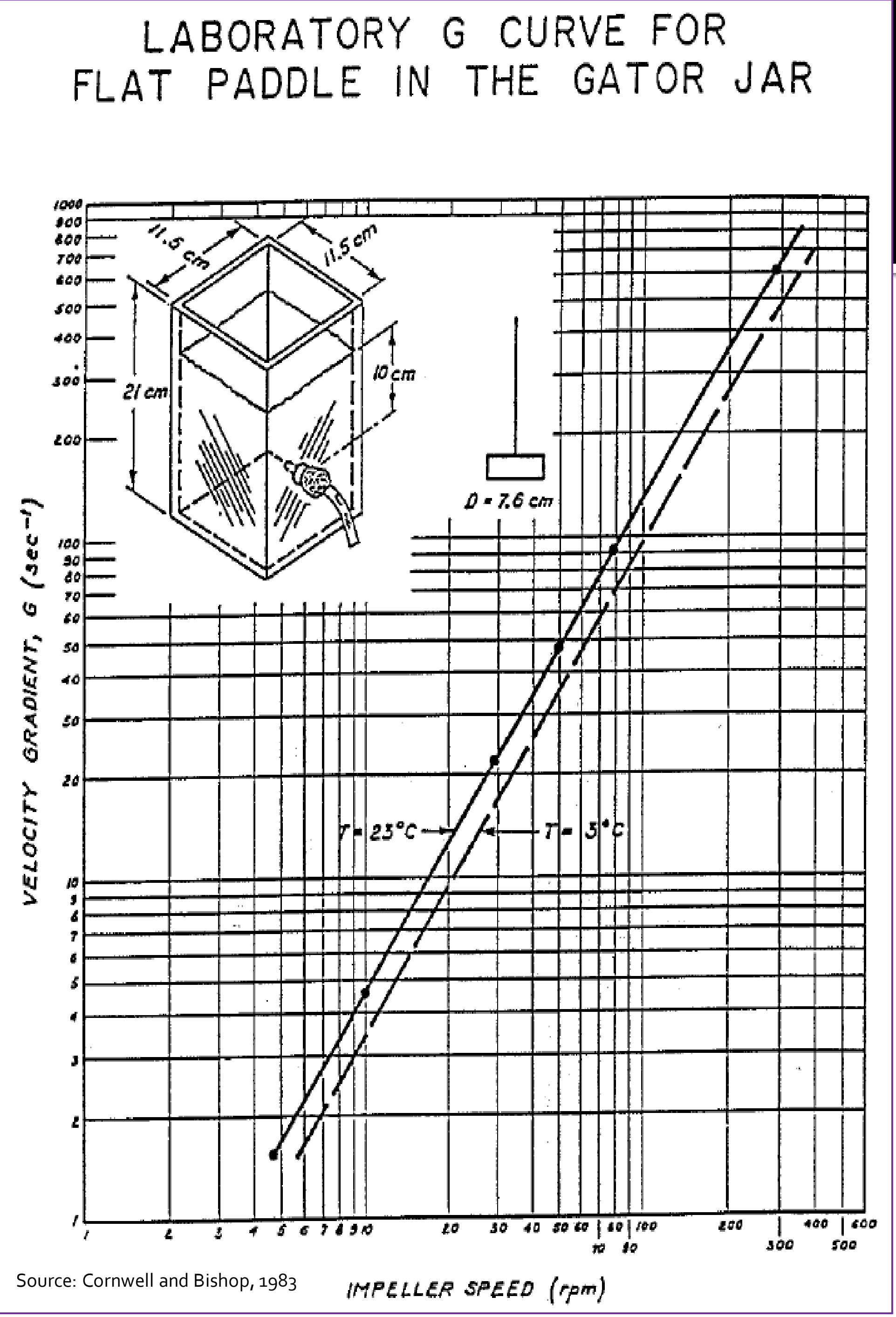
How to use G curve chart

Note: 2 lines – one for very cold water, and one for warm water.

Using the G value on the y axis, follow the horizontal line until it hits a temperature line, then go straight down to get the paddle speed.

If G value higher than the paddle speed can achieve, use G X T to increase the amount of time that you mix on the jar tester.

Remember: Jar Test Procedure depends on Raw Water Temp, Raw Water Flow Rate, # basins in service, mixers on or off, presence or absence of tubes, all the different chemicals used that day, and desired or actual dosage, so no two procedures will be the same. That is, each time you do a jar test, you will most likely do it a little differently than the time before.



Source: Cornwell and Bishop, 1983

Determine Detention Times and Paddle Speeds, and Settling Time for Jars Using Plant-Scale SOR

Mixing, coagulation, and flocculation type zones 1,2,3, 4, and 5

- Detention Times in minutes
- Zone 1 DT = (1,060 gals) (#)/ (flow rate in gpm) =

Time 1 box ☐ Paddle rpm from chart =

- Zones 2,3 and 4 DT = (20,890 gals)(2 units) / (flow rate in gpm) =

Time 2 box ☐ Paddle rpm from chart =

Time 3 box ☐ Paddle rpm from chart =

Time 4 box ☐ Paddle rpm from chart =

- Zone 5 DT = (10,500 gals) (# basins) / (flow rate in gpm)=

Time 5 box ☐ Paddle rpm from chart =

Settling type zones - 6

- SOR and Settling Time
  - Basin SOR = (gpm) / (120' x 37.75')(# basins) = ____ gpm/sq ft
  - SOR ÷ 2.33 = Effective SOR (ESOR)
  - ESOR =
  - Settling velocity = 4.07 x ESOR
  - Settling time in minutes = 10 cm / settling velocity

Settling Time = ☐

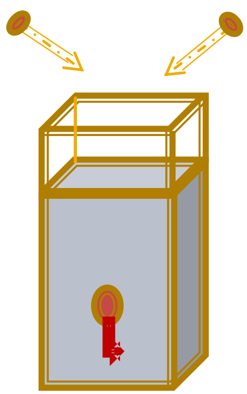
Let the jars settle for this amount of time
And then sample them simultaneously

Time 6 box

Jar Test Results Bacon Road

DATE: ________________ **REASON FOR TEST:** ____________________

Mg/L Alum | mg/L Cl_2



Jar 1

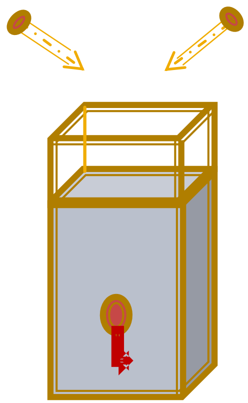
Sample

Other dose: ___________

NTU: ____________

CL2: _____________

Mg/L Alum | mg/L Cl_2



Jar 2

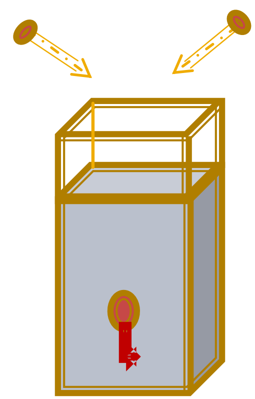
Sample

Other dose: ___________

NTU: ____________

CL2: _____________

Mg/L Alum | mg/L Cl_2



Jar 3

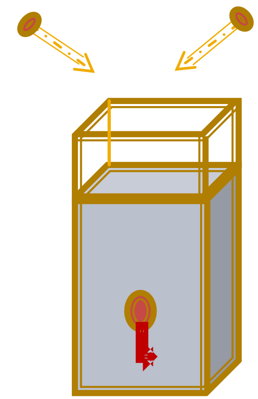
Sample

Other dose: ___________

NTU: ____________

CL2: _____________

Mg/L Alum | mg/L Cl_2



Jar 4

Sample

Other dose: ___________

NTU: ____________

CL2: _____________

Is increase or decrease of alum or warranted? Y N Action taken? ______________________________