Chemical Program Optimization through Drawdown and Dosage Testing

By Sean P Murtagh

About Me

Water Treatment Specialist *(Professional Jar Spinner)*

I am an experienced water treatment specialist who got my start as a licensed industrial wastewater and drinking water operator. I have over 20-years of professional experience and am specialized in the chemistries used for water / wastewater treatment. These include specialty chemicals such as coagulants, flocculants, metals precipitation, defoamers, and odor control. I focus on providing solutions, especially with difficult, complex, or hard to treat wastewater.

My approach is to understand a plants needs and provide the right solution and service tailored to that situation through operational experience, analytical evaluation, and chemical jar testing.

I currently work as an Account Manager for Water Tech, Inc. and am responsible for the Northeast US region.

Contact Info

Work Email: smurtagh@watertechinc.net

Work Cell: 484.942.1554

linkedin.com/in/seanpmurtagh/

What to Know About Jar Testing

Chemical Program Optimization through Drawdown and Dosage Testing

The Stages of Chemical Dosage Program Identification

Planning	• Before the chemical dosage program is implemented.
Proactive	• Maintaining the chemical dosage program for optimal results.
Reactive	• Adjusts the chemical dosage program when plant operation are outside normal conditions.

Jar Testing

- Determines the chemical treatment program
- Is usually performed at the planning or reactive stages
- Is not often performed during the routine stage
- And should meet the following four goals

Right Chemistry	Right Dosage	Right Performance	Right Program Cost

Jar Testing is often performed by vendors, consultants, sales individuals, and other industry personnel. It may also be performed by plant operational staff.

Effective Jar Testing is either performed routinely or based on multiple samples representing varying conditions.

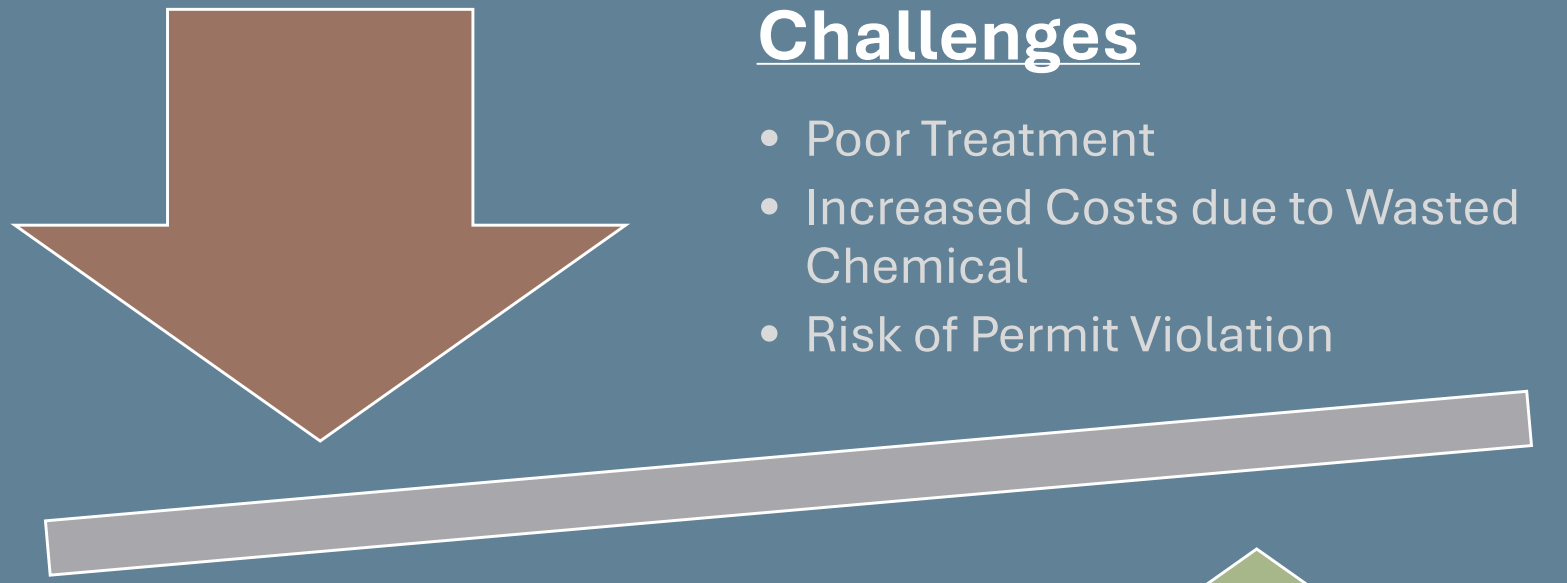
It is often the case that facilities do not perform routine jar testing, which can result in a chemical dosage program that is not optimized.

Jar Testing is only just the start of a successful chemical dosage program.

In lieu of Jar Testing, Pump Drawdowns and Dosage Testing should be used for the routine monitoring of the chemical dosage program.

Changes to the Chemical Dosage Program may be required due to:

Changes in Conditions	Abnormal or Upset Processes	Equipment Breakdown or Failure	Other
• Flow • Loadings • pH • Temperature	• Local or Upstream	• Local or Upstream	• Hydraulic Overloading • Toxicity • Any number of other events



Challenges

- Poor Treatment
- Increased Costs due to Wasted Chemical
- Risk of Permit Violation

Goals

- Improved Performance
- Lowest Operational Cost
- 100% Permit Compliance

This presentation will include MATH!

Let’s keep it SIMPLE

All Equations are calculated using:

- Volume
- Active Concentration
- Pounds (Mass-Based)
- Dry Weight Equivalence

For this presentation, all equations will be calculated based on volume.

What are Drawdowns

And why they should be performed?

Chemical Program Optimization

through Drawdown and Dosage Testing

How do we determine chemical usage

SCADA / PLC /Controller Report

- Either a signal from a flow meter or a calculation

Chemical Tank Change of Level

- Actual chemical consumption over a set time period

Dosage Pump Drawdown

- Instantaneous dosage based on current flow and plant conditions

Chemical Program Optimization

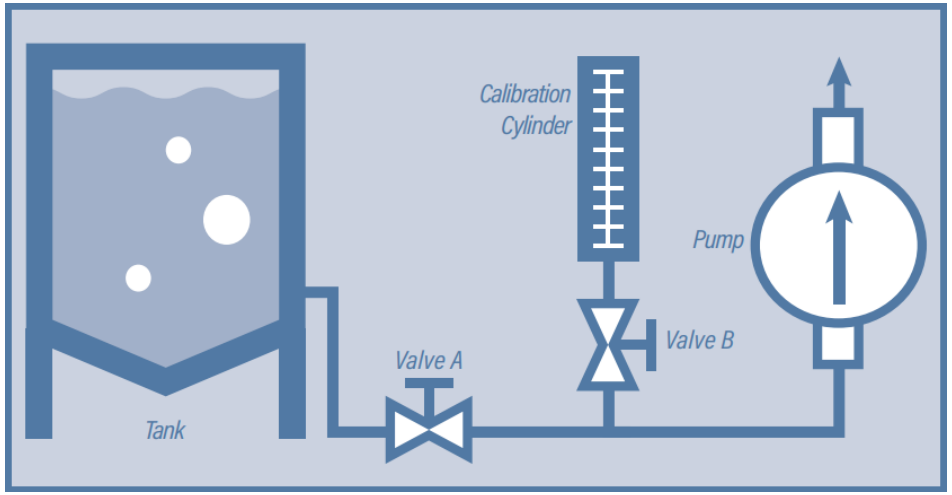
through Drawdown and Dosage Testing

Pump Drawdowns:

- Determine Instantaneous Pump Output
- Verifies Pump Operation
- Used for System Calibration
- Will Identify Potential Pump and Dosage System Issues

Chemical Program Optimization

through Drawdown and Dosage Testing



(Graphic From Washington State Dept of Health 331-592)

Open Valve B
- Fill the Drawdown Cylinder

Close Valve A
- Isolate the chemical feed tank

Drawdown
- Record the mL drawdown in 1-min

Open Valve A
- Connect to chemical feed tank

Close Valve B
- Isolate the Drawdown Cylinder

WARNING MATH AHEAD!

Chemical Program Optimization

through Drawdown and Dosage Testing

STEP 1

Convert to GPD

1. Convert drawdown to mL/min (the standard drawdown units of measurement)

$$\frac{60}{\text{Drawdown Period (seconds)}} * \text{mL Drawdown} = \frac{\text{mL}}{\text{min}}$$

2. Convert mL/min to Gallons per Day (gpd)

$$\frac{\text{mL}}{\text{min}} * 0.38 = \textbf{gpd}$$

(0.38 is the standard conversion from 1-mL/min to gals as 1,440-mL equals 3,785.4-gals)

Chemical Program Optimization

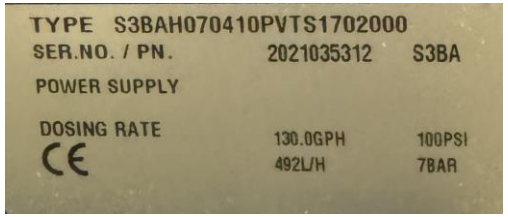
through Drawdown and Dosage Testing

STEP 2

Confirm Pump Curve

Dosage Pumps are typically rated in gph.

Multiply gph X 24 to determine gpd.



Calculate Pump Output

% Speed	*	*% Stroke*	*	*pump rating (gpd)*	=	*pump output (gpd)*

Drawdown gpd SHOULD EQUAL gpd Pump Output.

- If these numbers do not match, troubleshoot the dosage pump and/or the dosage system (tank, suction tubing, pump, discharge tubing, injection quill).
- If these numbers match, continue to Step 3.

Chemical Program Optimization

through Drawdown and Dosage Testing

The actual chemical dosage rate is calculated from the drawdown results and the process/plant flowrate at the time of the drawdown.

STEP 3

Calculate Chemical Dosage

$$\left(\frac{\text{gpd (chemical dosage)}}{\frac{\text{gpd (plant flow)}}{1{,}000{,}000}}\right) = \textbf{ppm}$$

(Note, this is a volumetric dosage rate based on 1-gal chemical dosed into every 1-million gal of flow for every 1-ppm)

If the dosage guidelines for your plant are not provided as volumetric, then additional calculations will be necessary to convert to the appropriate dosage recommendations.

Chemical Program Optimization

through Drawdown and Dosage Testing

Pump Drawdown equal Pump Output

- Yes: Proceed
- No: Troubleshoot

Is the Chemical Dosage Rate Optimized

- Plant Observations
- Proceed to Dosage testing

Chemical Dosage Program

A quick review

Chemical Program Optimization

through Drawdown and Dosage Testing

The chemical dosage program at your facility is instrumental in achieving successful permit compliance, plant performance, and has an impact on your facility's budget.

Chemical Program Optimization

through Routine Drawdown and Dosage Testing

There are three approaches to the chemical dosage program:

Planning

Proactive

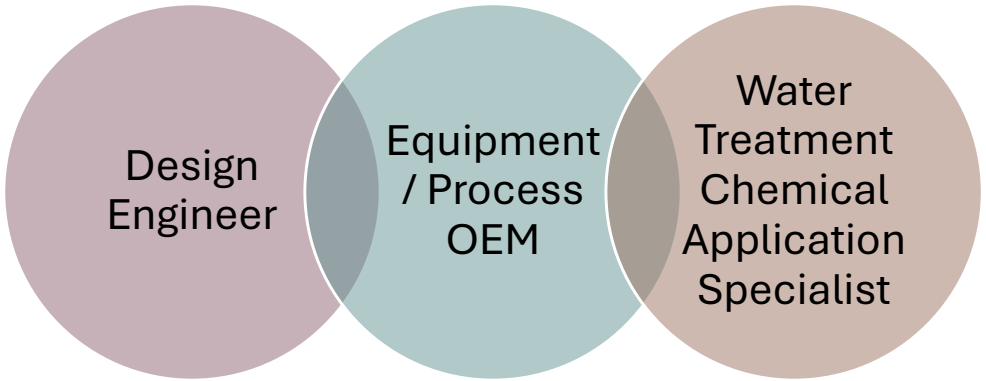
Reactive

Chemical Program Optimization

through Drawdown and Dosage Testing

Planning Stage

Development of the Chemical Dosage Program, prior to startup, by at least one of the following:



Jar Testing was likely performed, and your facility should have been provided with either a jar testing report or other report detailing the chemical dosage program, chemistries used, and recommended dosages.

Chemical Program Optimization

through Drawdown and Dosage Testing

Reactive Stage

Occurs during equipment failures or system upsets. Adequate treatment is not occurring and a change to the chemical program may be beneficial.

Will generally include Jar Testing performed by Water Treatment Chemical Application Specialists and will focus on responding to current plant conditions through a modified chemical dosage program.

Chemical Program Optimization

through Drawdown and Dosage Testing

Proactive Stage

The Proactive stage could also be described as routine operation. During this period, plant processes are functioning well, and the system is operating as designed and within permit.

While the chemical dosage program is typically not evaluated in this stage, this is the ideal time to dosage test and optimize the program.

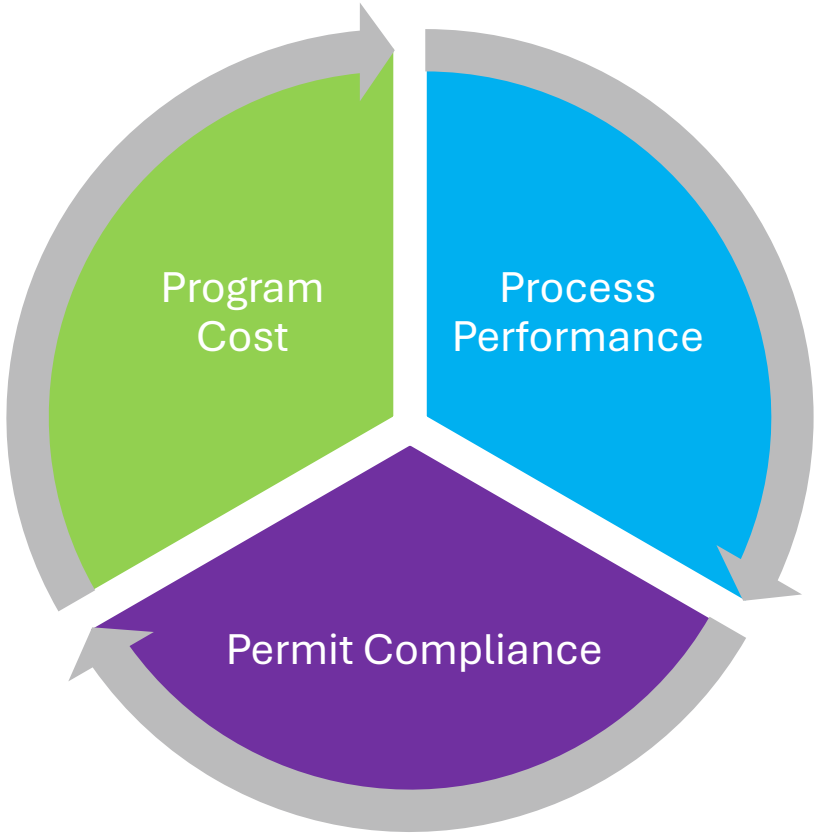
Optimization is the action of making the best and most effective use of a situation or resource.

-Google

Chemical Program Optimization

through Drawdown and Dosage Testing

An Optimized Chemical Dosage program is a balanced program that will perform at the lowest cost while meeting your performance needs and achieving permit compliance.



The Dosage Test

And how do you perform it?

Chemical Program Optimization

through Drawdown and Dosage Testing

Dosage Testing

- Is a type of jar testing that is used to identify, confirm, or optimize a chemical dosage for optimum performance in the plant process.
- Ensures that you are dosing the correct amount of chemical to meet your water treatment requirements without underdosing or overdosing.
- Is the easiest type of jar testing to perform.

Chemical Program Optimization

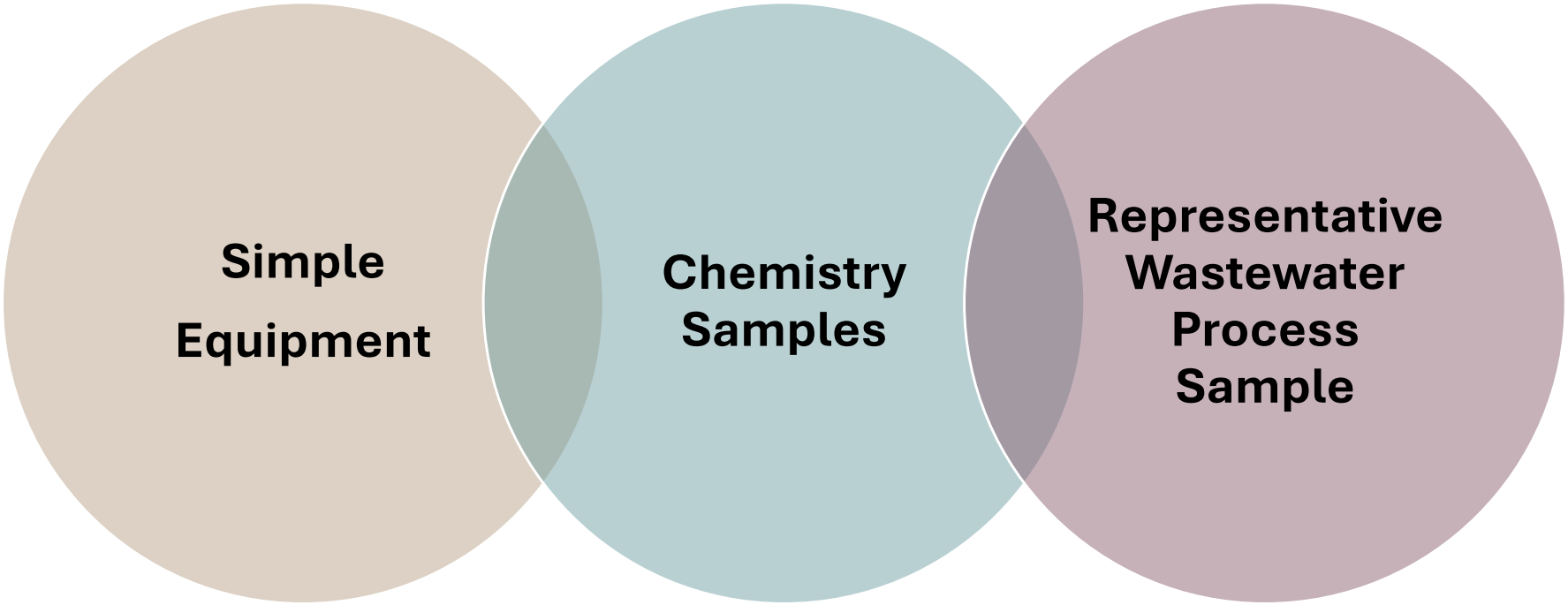
through Drawdown and Dosage Testing

Dosage testing is performed by collecting a representative sample of the process you want to test, then adding your target chemistry in known dosages to identify the optimum dosage for the desired results, and then reacting the sample to evaluate the result.

Chemical Program Optimization

through Drawdown and Dosage Testing

Dosage Testing Requires:



Chemical Program Optimization

through Drawdown and Dosage Testing

Dosage Testing can be performed with minimal equipment:

- Testing Container
  - Beaker, Cup, or (Mason) Jar
- Means to Dose
  - Syringe or Pipettor
- Ability to Stir
  - Manual stirrer or a stir plate with magnetic stir bar

Note: Advanced bench top testing equipment, included a gang-stirrer, analytical equipment, and other items can also be used.

Chemical Program Optimization

through Drawdown and Dosage Testing

Chemistry Samples

Unless otherwise available, these are obtained from your chemical inventory

If your make-down polymer concentration is known, you can use that sample or prepare you own

Samples are made-down with water to allow for easier dosing

Make down concentrations are equal to the volume you add to water for a total of 100-mLs

- For example, 5-mL of a coagulant with 95-mL of water will equal a 5% solution

Make down concentrations are typically:

- 1% to 5% for Coagulants
- 0.1% to 1.0% for polymers

Chemical Program Optimization

through Drawdown and Dosage Testing

Jar Testing Equation

$$ppm = \text{mL (dosed)} * \text{Chemical Conc.} * \frac{10{,}000}{\text{mL sample volume}}$$

Dosage Chart

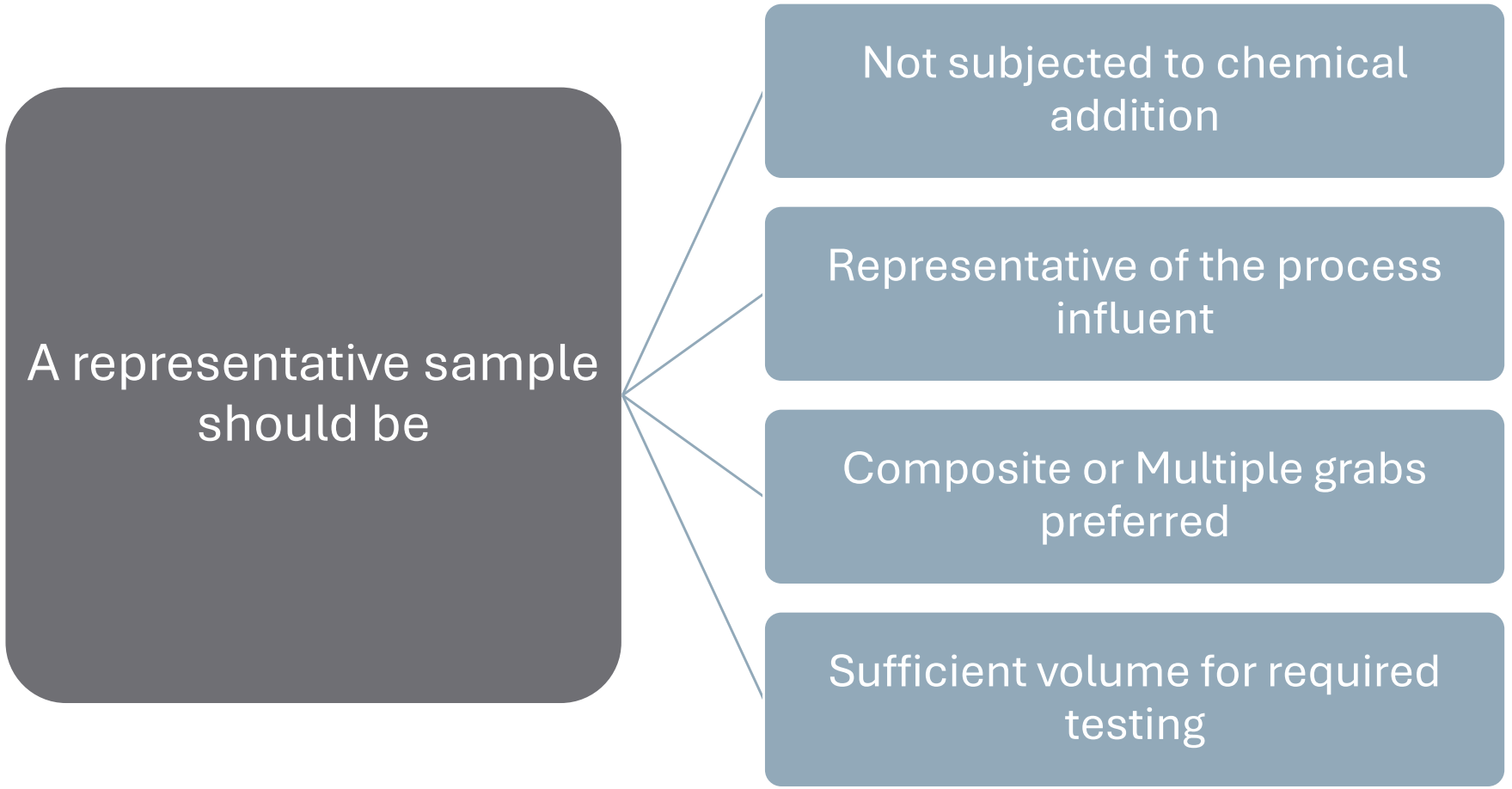
1-mL is:	0.10%	0.50%	1%	5%
250-mL	4-ppm	20-ppm	40-ppm	200-ppm
500-mL	2-ppm	10-ppm	20-ppm	100-ppm
1,000-mL	1-ppm	5-ppm	10-ppm	50-ppm

For example, for a 500-mL sample,

- 0.1% Solution is 2-ppm for every 1-mL dosed
- 0.5% Solution is 10-ppm for every 1-mL dosed
- 1.0% Solution is 20-ppm for every 1-mL dosed
- 5% Solution is 100-ppm for every 1-mL dosed

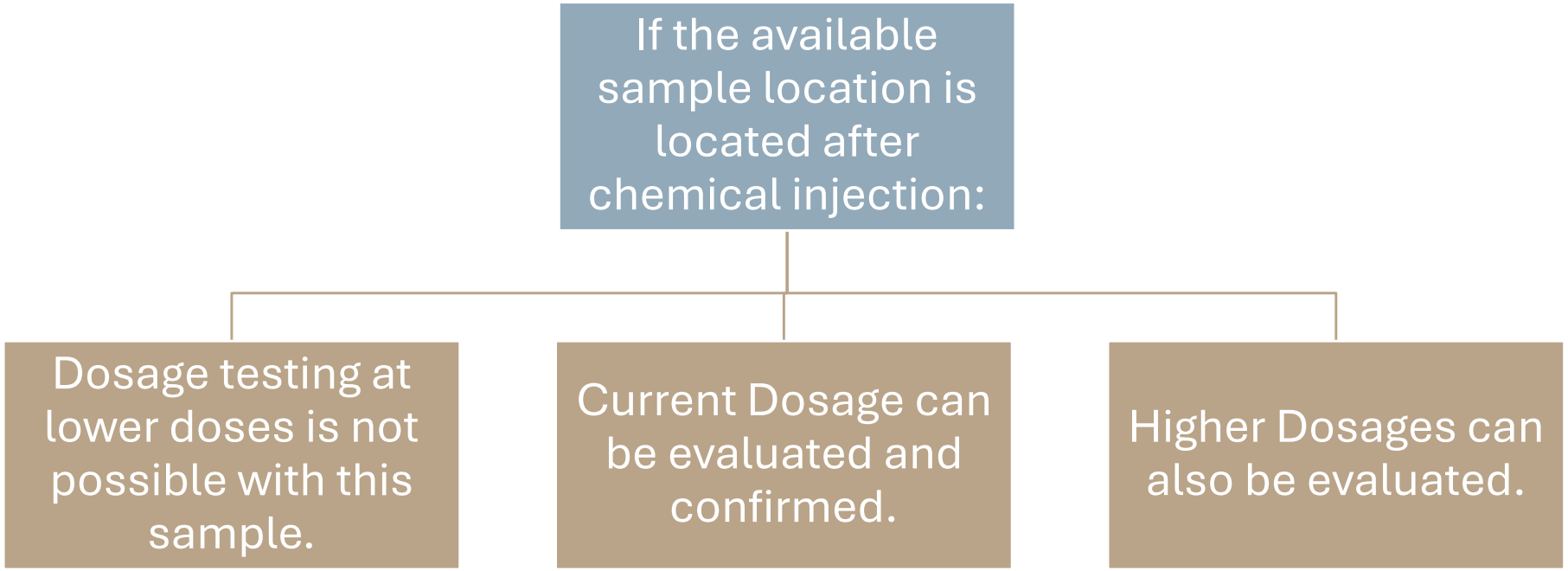
Chemical Program Optimization

through Drawdown and Dosage Testing



Chemical Program Optimization

through Drawdown and Dosage Testing



Chemical Program Optimization

through Drawdown and Dosage Testing

Step 1

- Determine Current Dosage Rate (Drawdown Testing)
- Collect a Representative Sample and Measure Sample Volume
  - •250-, 500-, or 1,000-mL sample volumes recommended

Step 2

- Following your Chemical Dosage Program, add you first chemical addition
  (pH adjustment, a coagulant, or flocculant)
- Mix the sample with high energy mixing.

Step 3

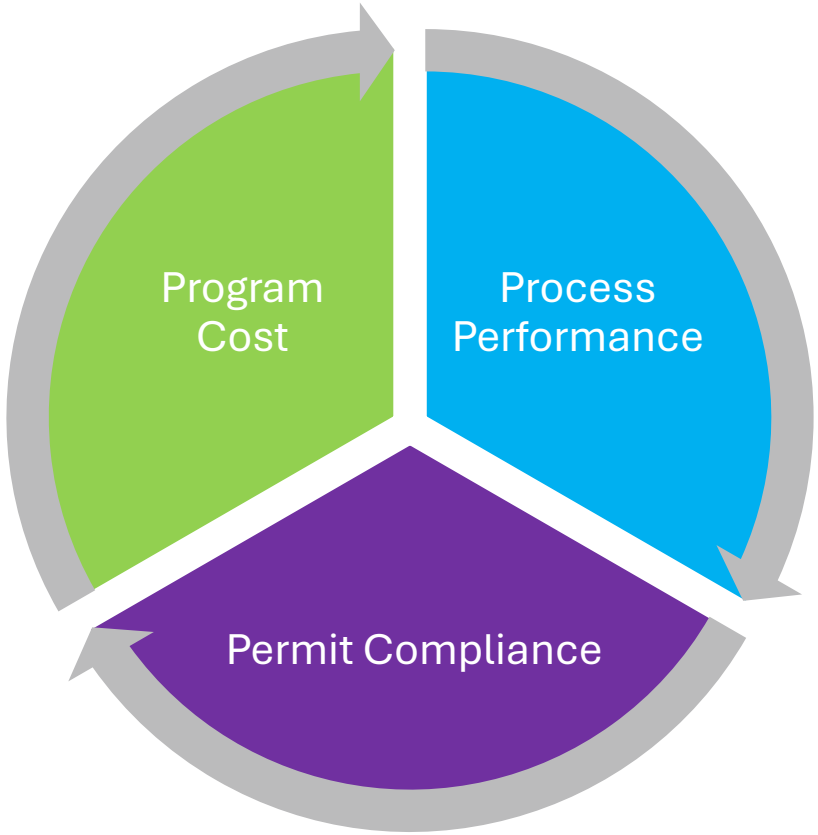
- Repeat Step 2 with each chemical addition that you process utilizes.

Evaluate the Results and Repeat with additional dosages to determine the optimum chemistry.

Chemical Program Optimization

through Drawdown and Dosage Testing

An Optimized Chemical Dosage program is a balanced program that will perform at the lowest cost while meeting your performance needs and achieving permit compliance.



Optimized Chemical Dosage Program

Operational Cost	Plant Performance	Permit Adherence
• What is the cost of the chemical dosage program	• Does the chemistry meet the plant needs	• Plant performance should equal permit compliance

Let's look at a chemical dosage program for phosphorous removal.

Theoretical Plant

Facility Max Capacity

- 0.4-mgd

Phosphorous Limit

- 1.0-mg/L Monthly Average
- 2.0-mg/L Daily Max

Instantaneous Process Flow

- 175-gpm
- This is a typical flow rate

Phosphorous Reduction

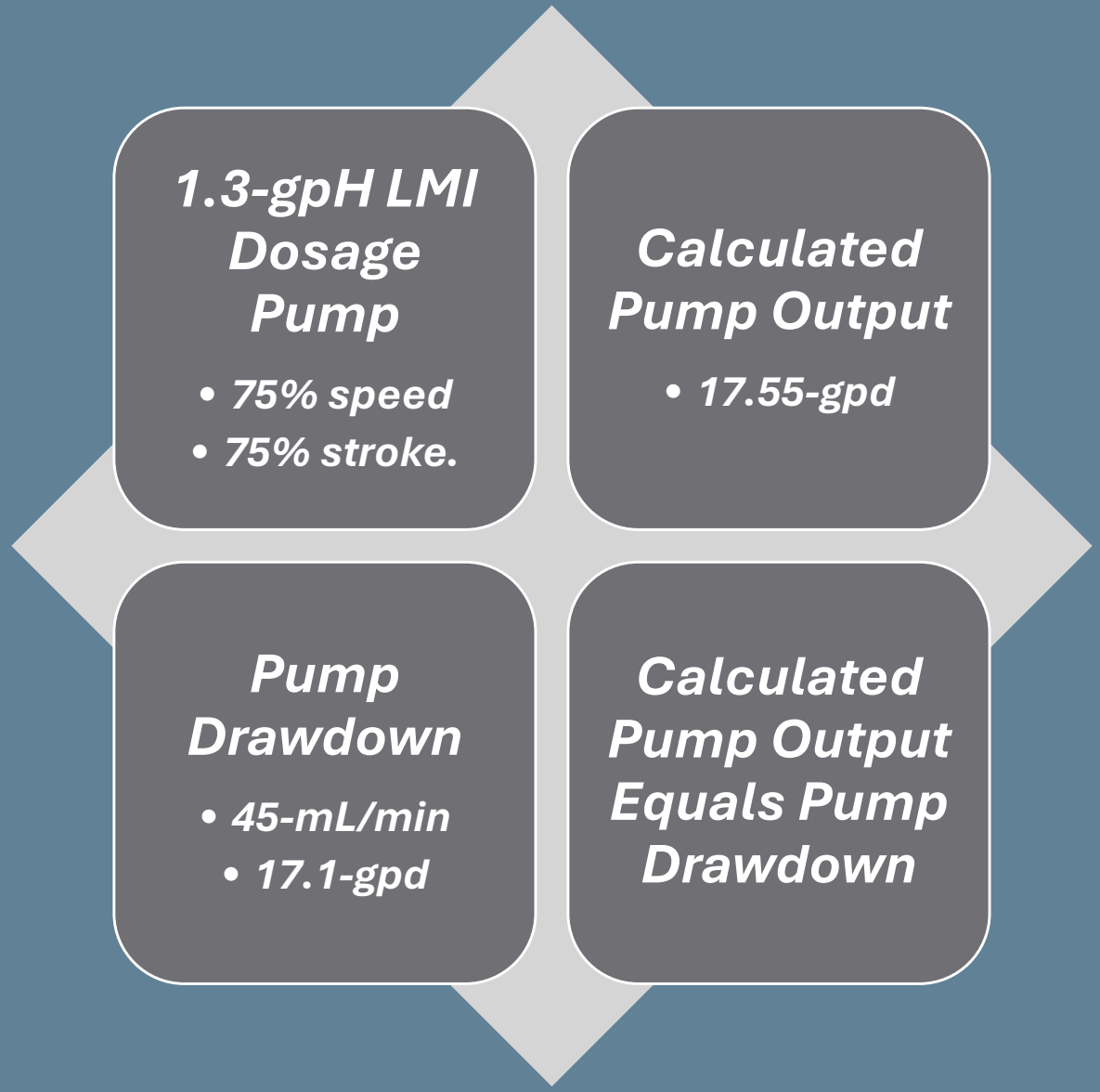
- Secondary Clarifier

Last Jar Tested was dated three (3) years prior and recommended use of a PAC at 50-ppm.

Influent Phosphorous was recorded at 30-ppm (average).

Jar Testing indicated the potential for a 98% Phosphorous Reduction to 0.65-ppm (average).

Dosage Pump Information



Chemical Dosage Program Details

0.25-Process Flow	
Jar Testing Recommendation	*Pump Drawdown*
50-ppm PAC	*68.4-pp PAC*
12-gpd	*17.1-gpd*

Current Phosphorus Details

Total Influent Phosphorous has decreased since the last jar test and now averages 25-ppm.

Total Effluent Phosphorous has been consistent at between 0.4- and 0.65-ppm and within permit requirements.

The chemical dosage should:

- Not be overdosed
- Not be underdosed
- Identify if the chemistry can perform within a large dosage range.

Chemical program optimization:

- Meets Performance Goals
- Ensures Permit Compliance
- Operates at the lowest operational cost

Is the chemical dosage program optimized?

To answer, we need to do more MATH!

Chemical Program Optimization

through Drawdown and Dosage Testing

Dosage Testing Results

Dosage	PO_4	% Reduction
40-ppm	0.65-mg/L	97.4%
50-ppm	0.625-mg/L	97.5%
60-ppm	0.6-mg/L	97.6%
70-ppm	0.55-mg/L	97.8%

Influent PO4 is 25-ppm

Dosage Testing evaluated dosages between 40- and 70-ppm.

All dosages performed similar.

All results were with the permit phosphorous limits.

Chemical Program Optimization

through Drawdown and Dosage Testing

Convert ppm to gpd

$$\text{gpd (chemical dosage)} = \frac{\text{gpd (plant flow)}}{1{,}000{,}000} * \text{ppm}$$

Convert gpd to lbs./day

$$\text{gpd} * \frac{\text{lbs}}{\text{gal}} = \text{lbs}$$

Calculate Cost per Day

$$\text{lbs} * \frac{\text{cost}}{\text{lbs}} = \text{Daily Cost}$$

Dosage	gpd	lbs/day	Cost
40-ppm	10-gpd	105.5-lbs	$52.75
50-ppm	12.5-gpd	131.9-lbs	$65.95
60-ppm	15-gpd	158.3-lbs	$79.15
70-ppm	17.5-gpd	185-lbs	$92.50

The Cost for PAC is $0.50 per pound.

Chemical Program Optimization

through Drawdown and Dosage Testing

The Chemical Dosage Program can operate at a lower dosage, meet current performance, and continue to operate with in the permit limitations.

Lowering the chemical dosage to 40-ppm can save up to $39.75 per day.

Through Drawdown and Dosage Testing, we have now optimized your chemical program and saved your facility money!

Through Drawdown and Dosage Testing, we have optimized this program to ensure performance, meet permit requirements, and reduce costs up to $40 per day.

Now go Optimize!

Sean Murtagh 484-942-1554 smurtagh@watertechinc.net