WWTP OPERATIONS 101:

WWTP OPERATIONAL DATA

By Wessler Engineering

WWTP OPERATIONS 101: WWTP OPERATIONAL DATA

This guidebook has been put together to assist WWTP personnel in understanding calculations, trending, and data management relevant to the operations of a wastewater treatment plant. New operators may find this guide a learning tool while the more experienced operator may find this guide a handy reference.

Every WWTP operates most efficiently under different conditions. Consistent, accurate, and reliable data tracking can, over time, assist operators in finding their "ideal" control parameters and provide a method by which predictable changes in influent characteristics can be quantified for process control and optimization. Spreadsheets can be an invaluable tool in successful data recording and tracking and increase the efficiency of the process and the operator's time.

TABLE OF CONTENTS

1.0 INTRODUCTION

"You can't know where you're going if you don't know where you've been." This adage holds especially true for WWTP operators. Laboratory analyses take time to produce results, which are then used to make operational adjustments to a process. Adjustments to biological systems may take days to weeks to fully become apparent, and further laboratory processing time is required to fully gauge the effect of the initial process adjustment. This can lure operators into an inefficient state of reactive operational control. Experienced operators predict upcoming changes to the system and adjust operational parameters prior to the event. Transition to a predictive state of operational control takes time, but <u>can</u> be accomplished, and will lead to anoptimized WWTP operation and a higher quality effluent.

Most operators know that every sewer system has different characteristics and as such, every treatment plant operates best under different conditions. Text books and reference manuals offer a good starting point, but it is essential for the operator to understand that these "typical operating parameters" are based on a wide variety of data and that their particular treatment plant may be on the low or high-end, or even right outside the box, of a typical operating range. So how can an operator find their optimized operating range?

1.1 Track the Data You Need

Monthly Report of Operation (MRO) forms are standardized so that they are easy to read for the people that want to know how good of a job your plant is doing. Details needed to make predictive control decisions and even entire operational parameters are oftentimes not required on these forms. Customized spreadsheets can expand beyond the operational data included in the MRO, are typically readily available to operators, and can even make completion of the MRO form more efficient.

Each operator must choose what data is most needed to improve the efficiency of the plant. Examples of data not required on the MRO form that often help optimization efforts include:

- The F/M ratio[1] : some treatment plants do not use this ratio at all, and even those that do will often vary widely due to factors such as whether it was calculated using the MLTSS or the MLVSS, or whether you include microorganisms in the sludge blanket of the clarifiers. However, for many activated sludge plants, maintaining a proper F/M ratio can assist in optimum cBOD and nutrient removal, settlability, and filament control.

- MCRT[2] : typically becomes important for plants that require nitrification due to the slow growth rate of nitrifying bacteria.

- Volatile Acids – Alkalinity Ratio: a crucial, yet often times overlooked operational control of an anaerobic digester. Whereas pH monitoring is more common and recorded on the MRO, by the time a change in

---

[1] Food to Microorganisms; typically expressed as pounds of cBOD per pounds of mixed liquor suspended solids (total or volatile)

[2] Mean Cell Residence Time: the average amount of time a individual microorganism is retained within the activated sludge system

the pH of an anaerobic digester occurs the digester has already gone “sour” or “stuck” and requires extensive effort to restore to proper operations.

- Dissolved Oxygen (DO): Recording the minimum and/or average DO concentrations observed is required on the MRO. However, DO concentration can fluctuate widely over the course of a 24-hour period and is often the most readily available data to indicate that process control adjustments may be required. Observable patterns in DO fluctuation can be used to optimize energy usage and treatment performance, ideally using continuous (or hourly) readings over the course of a typical week.

- Waste Rate: The amount of Waste Activated Sludge removed from the activated sludge process should be reported in the MRO (in 1000 gallons per day). For optimization purposes it is beneficial to track the pounds of solids wasted per day as an additional data column, along with the rate of wasting. Plants that waste continuously may track wasting in gallons per minute; whereas plants that withdraw sludge from clarifiers through telescoping valves and waste periodically once per day, or periodically throughout the day, may track wasting through total gallons per total time of the wasting event, or by recording the interval between wasting events and the duration of each event within a single day.

1.2 Track Your Data Often

Looking at your data as you enter it once a month into the MRO only increases the lag time between the beginning of a problem event and the return to proper operations, and leads to inefficient operations and potential Permit violations. At a minimum, data should be plotted on a weekly basis, allowing the operator to observe changes in the process on a regular basis. Ideally, data entry into a spreadsheet occurs daily, allowing the operator to assimilate data as it becomes available. Daily entry of data also can become a much more efficient use of time, as it should only take a few minutes out of the day to enter the data into a spreadsheet without shuffling through a week’s or a month’s worth of paperwork. The operator will become steadily more familiar with data entry patterns over time (much like practicing the piano, a half-hour a day leads to better performance than a single four hour practice session per week).

Learn more about using excel to track your data later in this guide.

1.3 A Day’s Datum Does Not a Trend Make

Over-reactive process adjustments can often do more harm than reactive process adjustments. It is important for the operator to recognize the potentials for errors and sporadic anomalies. Many factors play into the data an operator receives; sample time, sample location, differences between the way one operator grabs a sample vs. another operator, automated sampler problems such as worn tubing or pump rollers, unusual weather conditions, unusual influent characteristics, equipment malfunctions or hiccups, laboratory techniques, etc. With the vast multitude of variables, each with its own influence towards error, even if very small, the chance exists that even a valid datum point may not warrant process control adjustment. For this purpose, certain parameters are best monitored using “period-averaging”. For example; a five-day average trend line can be used to more accurately trend the mixed liquor concentration in an activated sludge system, as this will buffer sporadic growth from an unusually hot day, high loading, or chance encounter with a less than homogeneous portion of the basin’s contents.

1.4 Annual vs. Monthly Data Tracking

Tracking data on an annual-based spreadsheet, instead of a monthly-based spreadsheet such as the MRO, allows the operator to trend events through one month and into the other. Data from the end-of-the-month is just as relevant to the next month, as the data from the beginning of the month is relevant to the middle of the month.

Tracking data over an annual period can also display seasonal and holiday patterns that can be just as important as diurnal and weekly patterns. As time passes and the amount of available data grows, an operator will know more about not only their treatment plant, but also the community it serves.

1.5 One Case Study of Optimized MLTSS Concentrations

While working on my undergraduate degree I worked at a Class IV WWTP that experienced persistently elevated sludge blanket levels in the secondary clarifiers two times per year. Blanket issues were found to be tied to settleability issues stemming from filamentous bacteria over-abundance. Plant data was tracked through the use of a detailed spreadsheet developed in-house, and through these tracking efforts several parameters of note were identified:

MLTSS concentrations had previously been adjusted based primarily on Sludge Volume Index (SVI) levels. Trending found that SVI levels indeed correlated to the elevated sludge blanket issue; however, changes in the SVI became apparent without the necessary time to adjust the MLTSS concentration to avoid filament dominance.

Filament issues appeared to begin a few weeks to a month after the beginning of the fall semester of the local university, appeared to get better in the late-fall to early-winter, and then reemerged a few weeks to a month after the beginning of the spring semester.

Influent cBOD and ammonia data were trended in conjunction with university events such the beginning of the spring, summer, and fall semesters, 3-day weekends, spring break, fall break, thanksgiving break, and winter break. Although it was known that the university contributed a large portion of the loading to the treatment plant, a study found that the status of academic activities at the university contributed one-half to two-thirds of the influent cBOD loading to the plant, whereas its flow contribution was only about one-third of the total plant flow.

An analysis was done to determine at what point in the year effluent quality was exceptional and filament problems were negligible or non-existent. Previous studies indicated that the filament of primary concern was strain 021N. Reference manuals indicated that 021N does not compete well at low F/M ratios and the data analysis confirmed this to be a viable control, as the plant F/M was lowest during the late summer and filament problems were non-problematic during this time.

The F/M ratio was then utilized as the main MLTSS control parameter in conjunction with past experiences where increases in cBOD were correlated with the academic calendar at the university. After some further optimization that involved narrowing the ideal F/M ratio of the plant, problems with filament growth became non-existent and plant staff were able to spend more time on other efforts.

2.0 SAMPLING & ANALYSIS RESULTS

Data doesn't simply appear; individual data points come from direct observations and measurements, laboratory analysis, or they are calculated. This section will focus on the types of data useful in operating a WWTP.

2.1 Observations & Measurements

Observations and measurements are parameters that can typically be taken out in the plant and sometimes be monitored on SCADA systems. As with all data, good record keeping is essential and even simple observations should be promptly and accurately recorded on log sheets. Due to weather or convenience, it's not uncommon for operators to write field observations down on scrap paper, pocket notebooks, etc. These practices are fine as long as the information is transferred to more permanent log sheets.

At the treatment plant I first worked at, we measured the dissolved oxygen and temperature in each of four aeration tanks and in the final effluent every four hours, twenty-four hours a day, rain or shine. Clip boards and even pocket notebooks were less than ideal in the rain and cumbersome to use while holding a DO meter in one hand and carrying the probe in the other so we would keep a role of ½-inch masking tape next to the DO meter calibration station. The meter would be calibrated and a calibration record log book was filled out before each use. A strip of the masking tape was placed on the meter above the read-out screen and then the operator would go out to the tanks to gather the data. At each tank, the operator would simply mark down the DO level and temperature on the masking tape - but once back in the office that information was immediately transferred to the daily observation log sheet along with the operator's initials and the time the observations were taken.

One key item to Observation measurements that is commonly overlooked: timing. If you report your daily flow rate, does that flow rate apply to one particular date (midnight to midnight), or does it apply 8 am the day before to 8am the date reported, or 8am the date reported to 8am the next? What if you want to know if the 2-inches of rain that occurred had a significant effect on your plant flow? Maybe the flow was reported in a timely fashion but weather observations are taken at 6am every day - if the rain occurred between midnight and 6am, that 2-inch rain may then appear to have occurred the day before your high flow day, raising eyebrows at the department of environmental management.

2.1.1 Flow Rates

Flow rate records are essential to WWTP operations. Flows should be recorded on a daily basis for reporting purposes and should be recorded more often in many cases.

> NPDES Permit requirements specify that flow meters are calibrated at least once annually. Calibration is essential to gather accurate data.

If composite samples have to be created manually, it is essential that the process flow be marked on each sample aliquot[3] to accurately flow-proportion the composite sample.

Flow rates are also essential for many operational calculations used to control the activated sludge and other processes. And remember that the time the measurement is taken can affect the way you use this data.

2.1.2 Weather Observations

The United States Geological Survey, National Oceanic and Atmospheric Administration, and the National Weather Service often rely on weather stations and river gauges located at WWTPs and operated by plant personnel to gather and record data for a multitude of purposes.

River and creek levels can be critical to many WWTP's. Flood events can affect the plant discharge, and since many WWTP's reside in low lying areas, flooding can be a major concern.

Precipitation data is also important when determining Infiltration and Inflow (I&I) issues and reporting Combined Sewer Overflows (CSOs). Reliable and relevant precipitation data is difficult to find unless you gather it yourself or use an automated weather station. Airports typically operate weather stations as well, but the difference between the rain intensity and timing at the airport versus that at your WWTP could be significant, and is impossible to determine even if the airport is as little as a mile or two away. And, once again, the timing of the measurements can be crucial when trying to use weather data productively.

2.1.3 Electrical Measurements

Electrical measurements can provide great information when trying to optimize your treatment plant and reduce operating costs. They can also flag problems and equipment requiring maintenance; but only when electrical readings are taken on a regular and consistent basis.

2.1.4 Additional Observations and Measurements

Other observation and measurement data essential to proper operational control of your plant can include:

- Sludge Blanket Depths
- Tank Levels
- UV Intensity
- Dissolved Oxygen (DO) Concentration & Temperature
- Oxidation-Reduction Potential (ORP)

Good record keeping of these parameters allows others to determine how and why you make process adjustments. They also provide you and others a record of where you have been in the past and what happens when you adjust the system in specific ways. If nothing else, they are handy files to pull when the IDEM inspector shows up and wants to see that you have a methodology to how you run your plant.

[3] An aliquot is a portion of a total amount of a solution or a "snapshot sample" representing the process flow at that particular moment it is taken; whereas a composite sample is representative of the average condition of the process flow and is made up of many aliquots.

2.2 Laboratory Analysis Parameters

Laboratory analysis parameters include many of the parameters you are required to report to on your MROs and DMRs, while others include operational control parameters. Either way, proper record keeping remains essential; not only in how the testing was performed (tracked through good bench sheets) but also how, when and who took the samples used in the analysis.

Bench sheets should be kept updated to reflect the actual methods used in the laboratory and separate bench sheets should be kept for every kind of analysis performed. Laboratory analysis often includes:

- Total Suspended Solids (TSS)
- Percent Total Solids (%TS)
- Volatile Solids (VSS & %VS)
- carbonaceous Biochemical Oxygen Demand (cBOD5)
- Ammonia
- Phosphorus
- Total Residual Chlorine
- pH
- Alkalinity
- Volatile Acids
- Bacteriological *(e-coli.* or fecal coliform*)*

2.3 Calculated Data

Calculated data is generated from all the observations, measurements, and laboratory analyses compiled. This data is essential for reporting and for operational control, but you have to realize that if the data being used in your calculations is less than accurate, your calculated result could be doubly inaccurate. Thus, it is essential for everyone in your WWTP to understand the importance of good sampling and data recording; after all, those staff members are your eyes and ears when you are not there or have other duties to attend to.

There are numerous references for the calculations used in a WWTP, and I'll be working on expanding this section in the near future.

2.4 Standard Operating Procedures; Include a Data Management Plan

Standard Operating Procedures are great training tools and often required to have on-hand when IDEM shows up at your door, but most importantly, they provide a method to pass along knowledge and information you have gained through trial-and-error, personal insight, and experience onto those that will follow you; whether they are following as you retire or just following you on the next shift!

Sitting down to write out your Data Management Plan can be intimidating, or maybe it just seems so incredibly boring to sit at a computer typing it out when you could be out in the plant enjoying the sunshine. Just take it a little bit at a time and keep working on it, maybe start with the list of parameters earlier in this chapter. List out which of the parameters you observe, measure, analyze, or calculate; then, for each parameter list:

- **Where**: where <u>exactly</u> samples are taken. Perhaps sludge blankets are supposed to be taken at the taped handrail 12-ft from the center of the clarifier, this keeps everyone on the same page so you don't get conflicting data; if the night operator takes his sludge blankets 6-ft from the clarifier center you could be scratching your head as to why the blanket seems to be 2-ft deep every day and 3-ft deep every night!

- **When**: if one operator takes flow readings at 12:00 midnight and one takes them at 12:30 your data isn't going to be very accurate. If you need to take three DO grab samples every day, maybe they don't need to be taken at the exact same time, but you should at least say something along the lines of:

    Final Effluent D.O. measurements are to be taken at the end of the chlorine contact tank three times daily; once between 8am and 10am, once between noon and 2pm, and once after 4pm.

- **How**: Some parameters are pretty straight forward - "look at the flow meter readout, write the number down" - but some parameters may be fairly complex, especially the laboratory procedures. If nothing else, at least reference another resource: "TSS analyses are to be conducted per Standard Methods for Wastewater Laboratory Analyses, Version ____, Method No. ______, page ____." Then use a post-it to mark the page of that reference manual so it's easy to quickly access.

- **Information required**: Obviously you want the result recorded, but maybe you also need the meter calibration numbers recorded as well, the initials of the operator that made the observation, the time, a comment on the appearance of the tank at the time the sample was taken, whether the digester was being mixed or not at the time the blanket measurement was taken, etc.

- **Troubleshooting Info**: Maybe you don't want to get into this section the first time round, but your Data Management Plan should be a living document that is updated as things change, and this is a great section to add down the road - it can be as complicated or as simple as you like: "If MLTSS analysis is above 4,000 mg/L or below 2,000 mg/L, notify the Operations Supervisor immediately"; "If sludge blanket levels are above 5-ft, refer to Standard Operating Procedure Section____"

All Standard Operating Procedures (SOPs), including your Data Management Plan, should be considered living documents. Be sure to review them often and update them whenever needed. Have others offer suggestions and comments or at least get another set of eyes on them from time to time. The best SOPs are forged from the combined experience of your entire WWTP staff so that all that information is retained as members leave to pursue other jobs or retire.

3.0 DATA ENTRY & TRENDING

Effective data management is about more than simply filling out required reports. A comprehensive spreadsheet can give you access to historical data and can be used to predict or anticipate future conditions. When used properly, the predictions can be used to create a smoother transition through difficult operating periods, identify and correct trouble spots, and optimize your process. The following is intended as an introduction to how Microsoft Excel, a widely available spreadsheet software system, can be used to create your own data management software; this is not intended as a comprehensive guide to Excel and you should consult other manuals to learn more about Excel if needed.

This Chapter adapted from "Math Barb & Adam's Way" previously published in the IWEA Digester. Many thanks to Barb Smith of Wastewater 101 for her contributions to these articles; please check out her website at: www.wastewater101.net

3.1 Basic Equation Entry in Excel

Excel might seem kind of scary when you first look at it; but then so is operating a wastewater plant. The first thing to realize about Excel is that it's just a big game of "Battleship". The second thing to realize is that if you can operate a calculator then you can operate Excel. So here's your crash course in the basics:

Enter a value in cell A1 and a value in cell B1. Then type "=A1+B1" in cell C1.

	A	B	C
1	25	15	=A1+B1

Once you hit enter, this is what you should see:

	A	B	C
1	25	15	40

<u>Excel Tip No. 1: The equal sign is your work order.</u> Whenever you click on a cell and start by typing "=" you are telling Excel that you want it to do something; add, subtract, multiply, divide, or a whole host of more complicated mathematical functions. Play around with it; a few hours toying with Excel can save you days worth of plugging and chugging equations by hand.

<u>Excel Tip No. 2: There are multiple ways to do things.</u> You can manually type "=A2+B2", or you can type "=", then just click on A1, type "+", then click on B1 and hit enter. Again, just play around with it and it'll be as easy as turning a pump on.

3.2 Applying an Operation Equation to Excel

So let's see some of what Excel can do for us operators. Whenever I start a new spreadsheet, one of the first things I like to do is think about what it is I want to know, and how I can figure that out. Let's look at the calculation for converting a chlorine dose in mg/L into a chlorine dose in lbs/day (concentration, mg/L x flow, MGD x 8.34 lbs/gal):

	A	B	C	D	E
1	Date	D.o.W.	Flow	CL2 Dose	CL2 Dose
2			MGD	mg/L	lbs/day
3	12/1/2010	Wed	5.1	2.3	

<u>Excel Tip No. 3: label everything!</u> I devote at least the top several rows to labeling. If someone else looks at this (like another operator or IDEM), they should be able to tell what's going on without having to ask me. Without sufficient labels, I can't even tell you what is going on in my own spreadsheets a week after I write them. It may even help to get more descriptive; maybe it's the Primary Effluent cBOD and you want to shorten it to "PE BOD (mg/L)" or differentiate" MLTSS" from "MLVSS".

*<u>Excel Tip No. 4: A label isn't complete without a unit!</u> What's your BOD? 125 **<u>mg/L</u>**, not lbs/day; this may not look so important now, but when you think about the vast amount of data a WWTP really runs on, it is.*

So now we have all our known values in and we are ready to figure out how to do the equation in excel. Well it's pretty easy, remember Excel Tip No. 1? Start by selecting cell E3 and hit the "=" key and go for it. If our equation to solve is: "(5.1 ~~MG~~D) x (2.3 ~~mg/L~~) x (8.34 lb/~~gal~~) =" then in Excel we can type "=C3*D3*8.34" and just hit enter.

	A	B	C	D	E
1	Date	D.o.W.	Flow	CL2 Dose	CL2 Dose
2			MGD	mg/L	lbs/day
3	12/1/2010	Wed	5.1	2.3	97.8

<u>Excel Tip No. 5: Leave a clue when you add equations!</u> I made the cell that contains an equation light blue so that when I come back to this sheet it's real easy to see what the real data is, and what I have calculated. Always use caution when copying and pasting after formulas have been entered as the reference cells (where information taken from for the equation) may or may not follow your equation depending on how you do things.

In our equation we insert 8.34 directly into the script rather than reference a cell; while we could make a column just for "8.34 lbs/gal" this creates quite a bit of clutter. 8.34 lbs/gal is an example of a mathematical **<u>constant</u>**. Constants are values that do not change and often include unit conversions (8.34 lbs/gal, 7.48 gal/cu.ft., 60 min/hr), fixed volumes (like a tank volume), and physical constants like gravity (32.2 ft/s^2).

One caution when using **<u>constants</u>**: since they are built into the equations, you won't see them in your printouts. If we treat our aeration volume as a constant and build it into the equation, this could lead to problems if you have an aeration basin offline and your constant isn't well…. constant.

3.3 Expanding the Spreadsheet to Build on Previous Calculations

Let's continue to expand the spreadsheet. If a total chlorine dosage of 8 mg/L is required to treat a particular water. If the flow is 1.6 MGD and the hypochlorite has 65% available chlorine, how many lbs/day of hypochlorite is required?

To calculate this we want to use our dose of chlorine in lbs/day and adjust for the fact that hypochlorite is only 65% chlorine by dividing by 0.65.

How can we adjust our excel spreadsheet to account for this extra twist? Of course there are several ways that we can do this, but let's start by simply using the same excel sheet we already set up and just add to that:

	A	B	C	D	E	F	G
1	Date	D.o.W.	Flow	CL2 Dose	CL2 Dose	CL2 avail.	Hypo required
2			MGD	mg/L	lbs/day	%	lbs /day
3	12/1/2010	Wed	1.6	8.0	106.75	65%	164.2

The first thing to realize here is that I did not have to start from scratch, and this is important because this is one reason Excel is such a useful tool. The equation in column E did not change, I only had to change the Known values in columns C & D. In column F, I added the conversion factor for the available chlorine (65%) and to calculate the hypochlorite required we type the following into cell G3: "=E3/F3".

Is your answer coming out wrong? Let's look at a shortcut used here: 65% = 0.65; I labeled column F as a percentage so I want it to say 65% and I used the **number format** tool to display 0.65 as 65%. I could simply use 0.65 in the spreadsheet (but I would recommend changing the column label so it doesn't say "%" because the chlorine is not 0.65% available, it's 65% available.) Another way to approach this would be to label the column %, but not use the number formatting tool:

	A	B	C	D	E	F	G
1	Date	D.o.W.	Flow	CL2 Dose	CL2 Dose	CL2 avail.	Hypo required
2			MGD	mg/L	lbs/day	%	lbs /day
3	12/1/2010	Wed	1.6	8.0	106.75	65.00	164.2

Important: this requires a different approach to the equation in cell G3! The equation for G3 used in this example is "=E3/F3*100" or "=E3/(F3/100)" because 65/100 = 0.65 or 65%. Excel is a lot like a WWTP, there are many ways do get the job done and still get it done right. You just have to focus on what is important; in this case, the important thing is that we are dividing the chlorine dose required by the chlorine available (0.65) to get the amount of hypochlorite required. I know the difference between these two examples is subtle, so if you are shaking your head, just read through it again. Soon enough it'll be as clear as the difference between raw sludge and WAS.

3.4 Calculating Pounds of Biomass Under Aeration

A WWTP has four (4) aeration tanks with a fixed volume of 0.21 Mgal per tank, the laboratory reports that the MLVSS concentration is 1,960 mg/L; how many pounds of "bugs" are in the tanks?

Our base equation is: 0.21 Mgal/tank x 4 tanks x 1960 mg/L x 8.34 lbs/gal.

	A	B	C	D	E	F
1	Date	D.o.W.	Aer. Vol.	# Tanks	MLVSS	MLVSS
2			MG/tank	in service	mg/L	lbs
3	12/1/2010	Wed	0.21	4	1960	13731

This looks suspiciously like our chemical dosage problem; however, we added an extra step. The equation in cell F3 is "=C3*D3*E3*8.34", type that in and hit enter and boom, there you go! Okay, some of you may say, "well why do I want to go through all that setup hassle just to get the answer on paper?" Let's assume for a moment that you have diligently entered your lab data every day of the week, and get something like this:

	A	B	C	D	E	F
1	Date	D.o.W.	Aer. Vol.	# Tanks	MLVSS	MLVSS
2			MG/tank	in service	mg/L	lbs
3	12/1/2010	Wed	0.21	4	1960	13731
4	12/2/2010	Thu	0.21	4	2000	
5	12/3/2010	Fri	0.21	4	2040	
6	12/4/2010	Sat	0.21	4	1980	
7	12/5/2010	Sun	0.21	3	2960	
8	12/6/2010	Mon	0.21	3	3000	
9	12/7/2010	Tue	0.21	3	2940	
10	12/8/2010	Wed	0.21	4	1940	

All I have to do is select my equation box, cell F3, right click, hit "copy", then select all those empty cells, right click and hit "paste"; and voila:

	A	B	C	D	E	F
1	Date	D.o.W.	Aer. Vol.	# Tanks	MLVSS	MLVSS
2			MG/tank	in service	mg/L	lbs
3	12/1/2010	Wed	0.21	4	1960	13731
4	12/2/2010	Thu	0.21	4	2000	14011
5	12/3/2010	Fri	0.21	4	2040	14291
6	12/4/2010	Sat	0.21	4	1980	13871
7	12/5/2010	Sun	0.21	3	2960	15552
8	12/6/2010	Mon	0.21	3	3000	15763
9	12/7/2010	Tue	0.21	3	2940	15447
10	12/8/2010	Wed	0.21	4	1940	13591

Now we have a whole table of data making it easy to:

- Plot graphs and trend charts.
- Calculate averages, maximums, minimums, sums or totals, even the fabled "Geometric Mean" quickly and accurately.

<u>Tip number 6: Hire a teenager over the summer.</u> I learned Excel the hard way, by banging my head on the keyboard until it worked, because we didn't learn this stuff in school (I didn't have e-mail until I got to Purdue either); but today they are teaching this stuff in elementary. If you really want to know how to make your spreadsheets look good, pull that part-timer off of the mower and have them sit down at your computer one day and show you a few tricks. You know the equations, and they know the software.

Hopefully, Excel looks a little less scary to a few people after reading this. As an operator, I would spend 10 to 30 minutes a day entering data into spreadsheets; lab data, operator data, maintenance data, just about everything; but at the end of the month, I could prepare my DMR, my MRO, my CSO DMR, and my monthly update to the City council all within about 1 to 2 hours or less. However, the real advantage came when I wanted to make operational adjustments: when do I need to order more bleach?; should I adjust my wasting?; should I turn my RAS up or down?, etc. Everything I needed to know to make these decisions was already right there, the click of a mouse away.

3.5 Applying the F/M Ratio in Excel

Let's start with the bottom half of the F/M equation (why? Cause we've already done it in the last section!):

	A	B	C	D	E	F
1	Date	D.o.W.	Aer. Vol.	# Tanks	MLVSS	MLVSS
2			MG/tank	in service	mg/L	lbs
3	12/1/2010	Wed	0.45	4	1600	24019

Remember the equation we used last time for cell F4, "=C3*D3*E3*8.34". Now let's add the information we need to solve the top half of the F/M equation:

	A	B	C	D	E	F	G	H	I	J
1	Date	D.o.W.	Aer. Vol.	# Tanks	MLVSS	MLVSS	Flow	BOD to Aeration	BOD to Aeration	F/M ratio
2			MG/tank	in service	mg/L	lbs	MGD	mg/L	lbs/day	
3	12/1/2010	Wed	0.45	4	1600	24019	7.50	125		

Add our loading formula to cell I3: "=G3*H3*8.34":

	A	B	C	D	E	F	G	H	I	J
1	Date	D.o.W.	Aer. Vol.	# Tanks	MLVSS	MLVSS	Flow	BOD to Aeration	BOD to Aeration	F/M ratio
2			MG/tank	in service	mg/L	lbs	MGD	mg/L	lbs/day	
3	12/1/2010	Wed	0.45	4	1600	24019	7.50	125	7819	

And to solve our F/M formula, simple divide the F (BOD to Aeration) by the M (MLVSS, lbs) by inserting "=I3/F3" to get:

	A	B	C	D	E	F	G	H	I	J
1	Date	D.o.W.	Aer. Vol.	# Tanks	MLVSS	MLVSS	Flow	BOD to Aeration	BOD to Aeration	F/M ratio
2			MG/tank	in service	mg/L	lbs	MGD	mg/L	lbs/day	
3	12/1/2010	Wed	0.45	4	1600	24019	7.50	125	7819	0.33

Now, I know that was a lot of work, but remember how easy it is to do this for everyday of the week and then simply copy and pasting the equations we just made? Without reentering a single formula, I can plug in my data and quickly get:

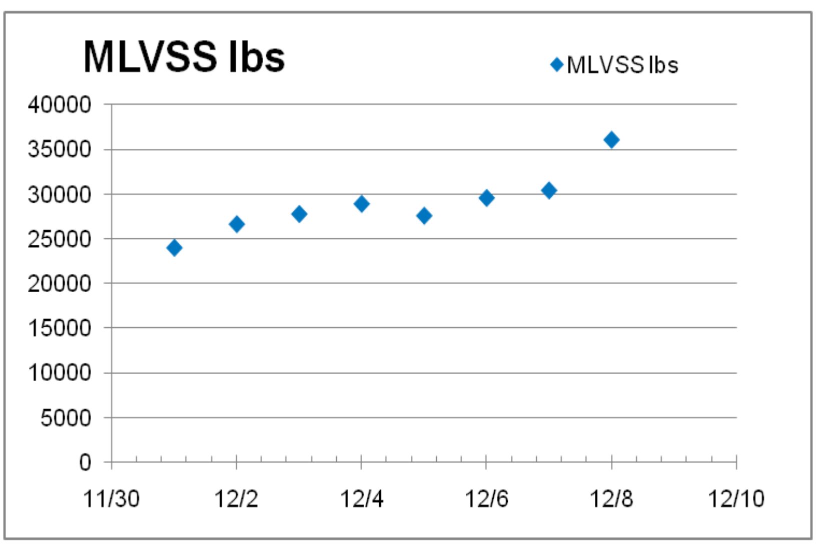
	A	B	C	D	E	F	G	H	I	J
1	Date	D.o.W.	Aer. Vol.	# Tanks	MLVSS	MLVSS	Flow	BOD to Aeration	BOD to Aeration	F/M ratio
2			MG/tank	in service	mg/L	lbs	MGD	mg/L	lbs/day	
3	12/1/2010	Wed	0.45	4	1600	24019	7.50	125	7819	0.33
4	12/2/2010	Thu	0.45	4	1775	26646	7.31	132	8047	0.30
5	12/3/2010	Fri	0.45	4	1850	27772	7.64	115	7328	0.26
6	12/4/2010	Sat	0.45	4	1925	28898	6.20	106	5481	0.19
7	12/5/2010	Sun	0.45	3	2450	27585	6.84	112	6389	0.23
8	12/6/2010	Mon	0.45	3	2625	29555	8.13	124	8408	0.28
9	12/7/2010	Tue	0.45	3	2700	30399	7.21	141	8479	0.28
10	12/8/2010	Wed	0.45	4	2400	36029	7.60	133	8430	0.23

The weekend crew took a tank out-of-service Saturday evening and it was put back online Wednesday morning, but since wasting wasn't dramatically changed we can see that while the pounds of biomass stayed pretty much the same, the concentration of the biomass under aeration went way up as the available volume was reduced.

3.6 Plotting a Simple Graph

Let's learn something new with our weekly data, like what it's really telling us. I want to adjust my wasting rate to keep a constant biomass (MLVSS, lbs), but I have trouble telling which way the numbers are really going. The pounds are up and then down, and then up and then down; which way are they really going? Well, let me say: "I love graphs" and Excel makes them pretty easy to make.

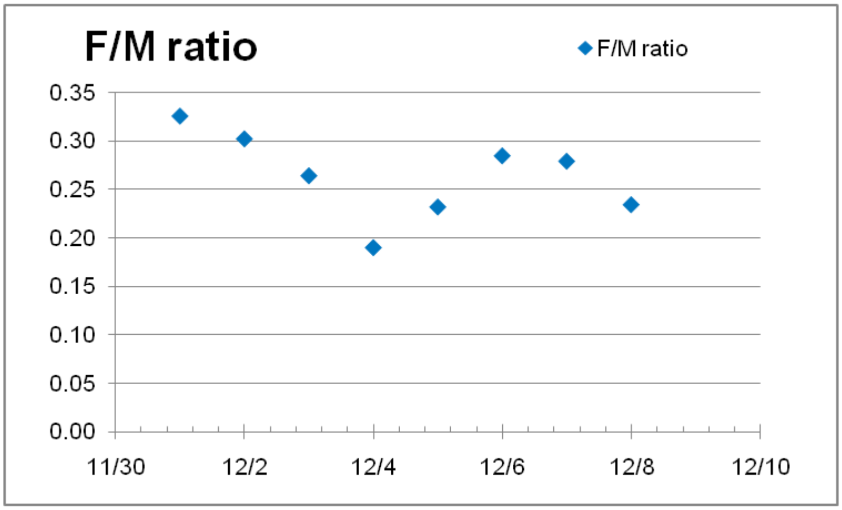
For this example, first select cells A1 through A10, then while holding the "Ctrl" button, select cells F1 through F10. In the "Insert" tab, select scatter plot and you should get something that looks like this:



I had to change the x-axis (the horizontal axis) by right clicking on it and selecting "Format axis", so I could show the dates without the year. There are a lot of ways you can make your graphs easier to read and hopefully I can give you a few tips, but play around with them long enough and you'll discover lots of options.

Even though the day-to-day data goes up and down, we can see that over the week our biomass trended towards an increase in total mass; so if I want to maintain a constant biomass, maybe I should increase my wasting slightly and see how next week looks.

Ok, but if we want to use the F/M Ratio to control the plant, that graph only tells us the pounds of biomass under aeration. Select A1 to A10, hold in the "Ctrl" while we select J1 to J10, go to the insert tab and select scatter chart and the next thing we know:



3.7 What Should My Wasting Pump Rate Be?

Let's modify our Excel problem from earlier:

	A	B	C	D	E	F	G	H	I	J
1							*MLTSS*	Pounds of		WAS pump
2	Date	D.o.W.	Aer. Vol.	# Tanks	MLTSS	MLTSS	*Desired*	solids to	WAS TSS	rate
3			MG/tank	in service	mg/L	lbs	lbs	waste	mg/L	gpm
4	12/1/2010	Wed	0.370	6	2400	44,436	39,836	4,600	5970	64.16

We have three equations here, so let's look at what I put in the blue cells:

<u>Cell F4:</u> Pounds of solids under aeration or MLTSS; "=C4*D4*E4*8.34"

= (Aeration Volume per tank) * (Number of tanks) * (MLTSS, mg/L) * (8.34 lbs/gal) = (MLTSS, lbs)

<u>Cell H4:</u> Pounds of solids to waste; "=F4-G4"

= (Pounds of MLTSS) – (Pounds of MLTSS *<u>desired</u>*) = (Pounds to be wasted)

<u>Cell J4:</u> WAS pump rate; "=(H4/(I4*8.34))*(1000000/1440)"

= {(Pounds to be wasted) / [(WAS TSS, mg/l) * (8.34 lbs/gal)]} * (1,000,000 gal/MG) / (1440 min/day)

*<u>Excel tip</u>***:** parentheses allow you to tell Excel how you want an equation solved.

For example: 1+5*3=16, but (1+5)*3=18.

You might make a few errors while learning Excel so always check your equation at least once the long way until you really have it down. Here's another example of how Excel will solve a potentially confusing equation:

"=4600/(5970*8.34)" returns: 0.092; Here, Excel is dividing 4600 by (5970*8.34).

"=4600/5970/8.34" also returns: 0.092; Here, Excel is dividing 4600 by 5970 and then dividing that answer by 8.34, returning the same result but doing the problem a little differently.

"=4600/5970*8.34" returns: 6.43; because Excel works left to right, it wants to divide 4600 by 5970 and then multiply that answer by 8.34!

So be a little wary of long equations in Excel until you get really used to it. But keep playing around with it and you'll get it!

Want to learn more, contact Adam Downey at Wessler Engineering for quick tips of even to arrange on-site training for you and your staff. CEUs available with sufficient notice.

About Wessler

Wessler is an engineering firm dedicated to bringing our clients' vision to life. We strive to make our relationships
More than a Project™

WWW.WESSLERENGINEERING.COM

Wessler Engineering is headquartered in Indianapolis, Indiana with additional offices in Fort Wayne, Evansville, and West Lafayette. Our markets and services include:

- *Wastewater Treatment*
- *Wastewater Collection*
- *Drinking Water Treatment*
- *Drinking Water Distribution*
- *Stormwater*
- *Environmental Services*
- *Transportation*
- *Electrical*
- *Field Services*
- *Construction Services*
- *Airports*
- *Industrial*

About the Author

EDUCATION
Purdue University
B.S., Natural Resources & Environmental Science, 2006

M.S., in Civil Engineering
(Specialty in Environmental Engineering), 2011

REGISTRATIONS
Class IV Municipal Wastewater Operator
Class D Industrial Wastewater Operator

CERTIFICATIONS/RECOGNITION
Registered Industrial Wastewater Professional from IIOA, 2010

Watershed Management from the Indiana Watershed Leadership Academy, 2007

Water & Sewer Construction Inspection from IWEA, 2006

Greeley & Hansen Elmer F. Ballotti Memorial Fellowship, 2009

IWEA 2010 "Outstanding Paper Award"

IWEA Tumble Bug Award

PROFESSIONAL SOCIETIES
Water Environment Federation (since 2003)

Indiana Water Environment Association, IWEA

IWEA Biosolids & Residuals Committee

Air & Waste Management Association, Purdue University Chapter

D. Adam Downey, M.S. is our in-house wastewater operations specialist and joined Wessler in 2007 after serving the City of West Lafayette for 12 years at their WWTP in various capacities. He is a Certified Class IV Municipal and Class D Industrial Wastewater Operator in the state of Indiana. As an operations specialist, Adam assists clients with WWTP troubleshooting, training in facility operations, compliance with state and federal regulations, pretreatment issues, permit application preparation and permit review, drafting standard operating procedures, and process energy audits. Adam also specializes in wastewater process design, including primary and secondary treatment systems, disinfection, anaerobic digestion with supplemental waste receiving stations and heat and energy cogeneration systems, and biological nutrient removal. Adam not only provides valuable "real world" insight to our wastewater treatment designs, but he is also available to our clients who require training in facility operations or need assistance in diagnosing treatment process problems. Adam recently assisted the West Central Conservancy District in the planning of a Biosolids Facilities Master Plan.

INSIDER'S SCOOP:

Adam is an assistant coach with the Greater Lafayette Recreational Soccer Alliance. You can follow him on Twitter @dadamdowney.

144 Sagamore Parkway West
West Lafayette, IN 47906
765.463.2400
AdamD@wesslerengineering.com
WWW.WESSLERENGINEERING.COM