Problem of the Day

# 2014.Dec.29

## Introduction

The Chinese character meaning "crisis" is two characters superimposed on each other. The first, taken by itself, means "danger." The second, taken by itself, means "opportunity." With the drought in California, we have certainly been in crisis mode. But what amazing opportunity! **It is a good time to be in the water business**. We can live without oil but **it's impossible to live without water**.

But the water business is getting more and more sophisticated. So much of protecting environmental and public health rests on the shoulders of water and wastewater treatment plant operators. We also must do our jobs as cost effectively as possible to protect our ratepayers' hard earned money. Our jobs aren't just about "meeting permit." Consider this, or something like it, as the professional operator's credo:

> **The mission of wastewater treatment plant operators is to remove pollutants from the incoming water while complying with all permit requirements—water, land and air—and convert them to safe disposable biosolids as sustainably and cost effectively as possible.**

How do we prove to our ratepayers, regulators and ourselves that we're up for the task: **by attaining increasing levels of certification**.

At the heart of wastewater treatment is **nutrient and pathogen removal**. Let's talk about nutrients. Today when we hear "nutrients," most of us think about nitrogen (N) and phosphorus (P), but there is a third nutrient that has defined wastewater treatment from the beginning: carbon (C). Yes, carbon. The massive, indiscriminate release of carbon into our waterways—specifically, organic carbon—during the 100+ years leading up to the passage of the Clean Water Act in 1972 in the United States didn't lead to the algae blooms and euthrophication we associate with N and P pollution. Instead, the oxidation of all that carbon by resident aquatic microorganisms led to dissolved oxygen (DO) "sag," and fish suffocated. And rivers caught on fire.

We indirectly measure the presence, or absence, of organic carbon by a number of analytical tests: BOD, CBOD, COD, TOC (total organic carbon), VSS and VS. All of these tests measure "organics" in a sample. "Organic" is synonymous with "organic carbon."

Primary clarifiers remove more organics for less money than any other process unit at a wastewater treatment plant. The process objective of primary clarification is the removal of settleable total suspended solids ($TSS_{set}$). The BOD (or COD) associated with those solids is removed when the solids are removed. This is important. The reason it is important is because secondary treatment, where the remaining BOD is "removed" (I will explain "removed" in a subsequent post), is expensive, so **the more BOD removed in the primary clarifiers, the better**.

Indeed, wastewater treatment **is** expensive but it is our job to treat wastewater "as cost effectively as possible." The organic carbon captured by primary clarifiers can be converted to methane in anaerobic digesters that can then be combusted in engines driving electrical generators. Augmenting the organic carbon captured in primary clarifiers, some plants feed fats, oils and grease (FOG) to their digesters to increase methane production and electricity generation. East Bay Municipal Utilities District (EBMUD) has been so successful doing so, they produce more electricity than they use. **This is the future**.

For those of you who may be new to WWTT's Problem of the Day, we insert a page break before and after the problem statement so you can print it without looking at the solution. **See what you can do to solve the problem before looking at the solution**.

## Problem of the Day

The Running Springs wastewater treatment plant receives an average dry weather flow of 2.5 MGD. The peak wet weather flow is 8 MGD. There are two primary clarifiers, each is 60 feet in diameter with an average depth of 16.5 feet. There is a single effluent weir around the periphery of each primary clarifier. The average influent TSS and BOD concentrations during dry weather flow are 325 and 350 mg/L, respectively. The influent TSS are 72% volatile. The average primary effluent TSS and BOD concentrations during dry weather flow are 105 and 205 mg/L, respectively. Each primary sludge pump pumps 30 gpm. Find the surface overflow rate if one of the primary clarifiers is off line when a wet weather event occurs.

## Discussion

Because primary clarifiers are such treatment plant workhorses, operators really need to "get their heads around them." We're going to use this same problem statement and do every primary clarifier type problem we can think of, maybe even make up a few! We'll keep track of the types of problems in the following list so you can refer back to individual Problems of the Day if you have a question on a specific type of primary clarifier problem.

- 2014.Dec.16—TSS removal efficiency
- 2014.Dec.17—BOD removal efficiency
- 2014.Dec.18—VSS removal efficiency
- 2014.Dec.19—influent VSS concentration
- 2014.Dec.20—primary effluent VSS concentration
- 2014.Dec.21—primary sludge volatile content (VS and VSS)
- 2014.Dec.22—influent TSS pounds per day
- 2014.Dec.23—influent VSS pounds per day
- 2014.Dec.24—influent BOD pounds per day
- 2014.Dec.25—happy holidays
- 2014.Dec.26—TSS pounds per day removed
- 2014.Dec.27—VSS pounds per day removed
- 2014.Dec.28-29—Surface over flow rate (SOR)

**In today's problem we are asked to calculate the surface overflow rate (SOR).** The SOR is an important design and operational consideration for all clarifiers. The units on SOR are always **gal/d•ft$^2$**. Even if the problem doesn't state it, operators taking certification exams need to know that the units on SOR are always **gal/d•ft$^2$**. The reason the SOR is important is because it is a measure of the velocity of the flow exiting a clarifier. If the exiting flow velocity is greater than the settling velocity of the particles being removed in the clarifier, the particles will end up in the effluent rather than at the bottom of the clarifier where they are supposed to be.

Velocity? The velocity units we are all most accustomed to are miles per hour (mi/h). Indeed, velocity is always in units of length divided by time. So how is gal/d·ft$^2$ a measure of velocity? Good question, right? We know that gal can be converted to ft$^3$ (7.48 gal/ft$^3$). So if we convert the gal in gal/d·ft$^2$ to ft$^3$, two of the three feet in the numerator (ft$^3$ = ft x ft x ft) will cancel with the two feet in the denominator (ft$^2$ = ft x ft), leaving ft/d, which are easily recognized as units of velocity, length (ft) divided by time (d). Keep in mind, too, that whenever we're calculating velocity, or SOR, in water and wastewater math problems, we divide the flow rate by the area through which the flow is passing. That area in clarifiers is the surface area. For more discussion on SOR and velocity see previous Problems of the Day (http://wastewatertechnologytrainers.com/wp-content/uploads/2014/11/2014.Nov_.17.pdf,http://wastewatertechnologytrainers.com/wp-content/uploads/2014/11/2014.Nov_.18.pdf).

## Solution

The units needed in the answer, **gal/d•ft$^2$**, are shown between heavy vertical lines followed by the equals sign and the blank track to get the problem started.

**Problem of the Day**: The Running Springs wastewater treatment plant receives an average dry weather flow of 2.5 MGD. The peak wet weather flow is 8 MGD. There are two primary clarifiers, each is 60 feet in diameter with an average depth of 16.5 feet. There is a single effluent weir around the periphery of each primary clarifier. The average influent TSS and BOD concentrations during dry weather flow are 325 and 350 mg/L, respectively. The influent TSS are 72% volatile. The average primary effluent TSS and BOD concentrations during dry weather flow are 105 and 205 mg/L, respectively. Each primary sludge pump pumps 30 gpm. Find the surface overflow rate if one of the primary clarifiers is off line when a wet weather event occurs.

Information summary, specifically labeled (**bold** indicates used in today's problem):

- Average dry weather flow = 2.5 Mgal/d
- **Peak wet weather flow = 8 Mgal/d**
- **Number of primary clarifiers = 2 PC (only 1 PC is in service)**
- **Primary clarifier diameter = 60 ft**
- Primary clarifier depth = 16.5 ft
- Primary influent dry weather TSS = 325 mg TSS/L
- Primary influent dry weather BOD = 350 mg BOD/L
- Primary influent TSS = 72% VSS = 72 mg VSS/100 mg TSS
- Primary effluent dry weather TSS = 105 mg TSS/L
- Primary effluent dry weather BOD = 205 mg BOD/L
- Primary sludge pumps, each = 30 gal sldg/min
- Calculate: **the SOR during a wet weather event with only one on-line primary clarifier**.

| gal | = | |
|---|---|---|
| d·ft$^2$ | | |

The units on SOR, **gal/d•ft$^2$**, clearly indicate flow (**gal/d**) divided by area (**ft$^2$**), so the railroad track is started by entering the wet weather flow in the numerator and the surface area (0.785 x diameter$^2$) of each primary clarifier in the denominator.

| gal | = | 8 Mgal | PC | | | |
|---|---|---|---|---|---|---|
| **d·ft$^2$** | | **d** | 0.785 | 60 **ft** | 60 **ft** | |

There is only one primary clarifier (PC) on line in this question, so it is a simple matter to cancel the PC unit in the numerator.

| gal | = | 8 Mgal | ~~PC~~ | | | | |
|---|---|---|---|---|---|---|---|
| **d·ft$^2$** | | **d** | 0.785 | 60 **ft** | 60 **ft** | 1 ~~PC~~ | |

Finally, the only thing that needs to be converted is **Mgal** to **gal**. This is done using the conversion factor, **$10^6$ gal/Mgal**.

| **gal** | = | 8 ~~Mgal~~ | ~~PC~~ | | | | $10^6$ **gal** |
|---|---|---|---|---|---|---|---|
| **d·ft$^2$** | | **d** | 0.785 | 60 **ft** | 60 **ft** | 1 ~~PC~~ | ~~Mgal~~ |

In the railroad track we now have only the units needed in the answer, **gal/d•ft$^2$**, so we **know** the math is done.

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| **gal** | = | 8 ~~Mgal~~ | ~~PC~~ | | | | $10^6$ **gal** |
|---|---|---|---|---|---|---|---|
| **d·ft²** | | **d** | 0.785 | 60 **ft** | 60 **ft** | 1 ~~PC~~ | ~~Mgal~~ |

The arithmetic gives the answer:

8 x 1,000,000 ÷ 0.785 ÷ 60 ÷ 60 = **2,831 gal/d·ft²**.

It should be noted that the operator would expect a decrease in performance at such a high SOR.

***Happy calculating. Let us know, by leaving a comment, if you want us to do a specific problem or if you see a mistake.***

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