Problem of the Day

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An effluent holding pond measures1,500 feet long by 950 feet wide. Over a 30-day month, the flow into the pond averaged 0.8 MGD. There were three rain events during the month starting on the 3rd, 7th and 23rd. One and a half inches (1.5 in) fell during the first event, 3.75 in during the second event and 0.5 in during the third event. During this time, there was no flow out of the pond. Ignoring evaporation and percolation, by how many feet did the level of the pond increase over the 30 days?

Introduction

The hydraulic loading rate to ponds and reservoirs always seems to throw operators for a loop, especially under the pressure of a certification exam. **The units on hydraulic loading rate to ponds is always in inches per day (in/d)**. Part of the reason that operators struggle with this calculation is these units: in/d are some of the craziest units in wastewater treatment math! It is helpful to look at in/d as a unit of length (in) divided by a unit of time (d). Length divided by time are units of velocity (think: miles per hour). It is common for wastewater treatment plant operators to have to calculate velocity in pipelines and through channels. The equation to do so is the same every time and very simple:

$$v = \frac{Q}{A}$$

where v is velocity, Q is flow rate and A is the area through which the flow passes. Not only is this the equation for calculating velocity in sewers and grit channels, it is the same equation for calculating the hydraulic loading rate in ponds and clarifiers (in clarifiers "hydraulic loading" is the same as "surface loading" and "surface overflow rate"). Another way to think about the hydraulic loading rate in ponds is as the inches per day the water surface will come up from the flow into the pond if there is no flow out of the pond. If you know in/d and how many days, then you can calculate how many inches the level in the pond or reservoir will come up. For this problem, add that result to the total inches of rain and convert to feet!

Solution

The solution to this problem requires several steps: (1) the area of the pond in acres (ac), (2) the hydraulic loading rate (in/d) to the storage pond, (3) the total number of inches the water surface elevation increases over 30 days (in), (4) the total inches added to the pond from the three rainfall events (in), and (5) the total water surface elevation rise from the wastewater flow and rainfall (ft).

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(1) Calculate the pond area in acres:

ac	=	1,500 ~~ft~~	950 ~~ft~~	**ac**
				43,560 ~~ft~~^{2}

Using the solution bridge, the units indicate whether a conversion factor is multiplied or divided. The arithmetic gives the answer to (1):

1,500 x 950 ÷ 43,560 = **<u>32.71 ac</u>**.

(2) Calculate the hydraulic loading rate to the storage pond (in/d):

in / **d**	=	Q / A	=	0.8 ~~Mgal~~ / **d**	32.71 ~~ac~~	3.069 ~~ac~~**ft** / ~~Mgal~~	12 **in** / ~~ft~~

Notice this solution bridge includes what WWTT calls the "holy grail" of all pond conversion factors, 3.069 ac·ft/Mgal, because it hugely simplifies so many pond problems. The arithmetic gives the answer to (2):

0.8 x 3.069 x 12 ÷ 32.71 = **<u>0.9 in/d</u>**.

(3) Calculate water surface level increase from the influent flow over 30 days (in):

$$\left| \textbf{in} \right| = \left| \frac{0.9\ \textbf{in}}{\cancel{\text{d}}} \right| \left| \frac{30\ \cancel{\text{d}}}{} \right|$$

The arithmetic gives the answer to (3):

0.9 x 30 = **<u>27.0 in</u>**.

(4) Calculate the total inches added to the pond from the three rainfall events.

This is simply the sum of the three rainfall events:

1.5 + 3.75 + 0.5 = **<u>5.75 in</u>**.

(5) Calculate the total water surface level increase over the 30 days (ft). The total inches of increase, from (3) and (4) is: 27.0 + 5.75 = **<u>32.75 in</u>**, which needs to be converted to feet:

$$\left| \textbf{ft} \right| = \left| \frac{32.75\ \cancel{\text{in}}}{} \right| \left| \frac{\textbf{ft}}{12\ \cancel{\text{in}}} \right|$$

The arithmetic for (5) gives the final answer:

32.75 ÷ 12 = **<u>2.73 ft</u>**.

Discussion

This is a great problem as it reviews several important concepts. As we advocate in all of WWTT's operator certification and math review classes: Learn the material, don't memorize the questions.

Happy calculating! Let us know, by leaving a comment, if you want us to do a specific problem, if you see a mistake, or if you have a question on any of the Problems of the Day you are looking at.