This study guide is intended to help students become more familiar with the variety of math equations within the Wastewater Treatment manual and exam.

Below is a chart of where math can be found in the training manual.

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Work through each problem introduced in each chapter and the math questions (if any) at the end of each chapter.
Class I & II

1. A town with a population of 4,500 people has a treatment pond with a surface area of 200 acres. What is the population loading in persons/acre?
   A. 22.5 persons/acre
   B. 45 persons/acre
   C. 60 persons/acre
   D. 75 persons/acre

2. The flow to three 800 feet long by 450 feet wide lagoons is 1.2 MGD. These lagoons serve a population of 1,250 people. What is the loading in persons/acre?
   A. 16.6 persons/acre
   B. 33 persons/acre
   C. 50.4 persons/Acre
   D. 65 persons/Acre

3. What is the organic loading for a facility that has a flow rate of 750,000 gallons per day and a BOD concentration of 125 mg/L? The area of the pond is 12.5 acres.
   A. 31.25 lbs BOD/Day/Acre
   B. 62.55 lbs BOD/Day/Acre
   C. 72.6 BOD/Day/Acre
   D. 89.4 BOD/Day/Acre
4. What is the organic loading for a facility that has a flow rate of 500 gpm, a BOD concentration of 62 mg/L, and the area of the pond is 490,500 ft²?

A. 5.6 lbs BOD/day/Acre  
B. 11.2 BOD/day/Acre  
C. 23.5 BOD/day/Acre  
D. 33.1 lbs BOD/day/Acre

5. How many lbs of Total Suspended Solids (TSS) does a plant receive that has a flow rate of 72,000 gpd at a concentration of 210 mg/L?

A. 15.12 lbs  
B. 126.1 lbs  
C. 151.2 lbs  
D. 277 lbs

6. The effluent flow from a wastewater treatment facility is 675,000 gallons per day. From the DMR, 92 pounds of BOD₅ were discharged daily. What is the BOD₅ concentration in the plant effluent?

A. 16.34 mg/L  
B. 1.63 mg/L  
C. 0.5 mg/L  
D. 0.01 ppm

7. What is the capacity of a plant that was designed to handle 125 pounds of BOD with a BOD concentration of 42 mg/L?

A. 0.2 MGD  
B. 3,570 gpd  
C. 35,700 gpd  
D. 357,000 gpd
8. The initial DO of a 25 ml sample was 9.6 mg/L and the final DO after 5 days of incubation at 20°C in a 300 ml sample bottle was 3.1 mg/L. What was the BOD in mg/L?
   A. 37 mg/L
   B. 78 mg/L
   C. 115 mg/L
   D. 152 mg/L

9. A plant with an average influent BOD of 215 mg/L produces an effluent BOD of 48 mg/L. What is the percent removal for this plant?
   A. 22.3%
   B. 77.7%
   C. 85%
   D. 93.2%

10. What is the food to microorganism ratio (F/M) of a plant with the following operational parameters? 2,450 pounds of MLVSS in the aeration tank of the plant. The average BOD concentration is 220 mg/L and the plant flow averages 0.9 MGD.
    A. 0.40
    B. 0.67
    C. 1.2
    D. 1.8

11. What is the food to microorganism ratio (F/M) of a plant with the following operational parameters? The aeration basin holds 1.2 MG and the MLVSS concentration in the basin is 350 mg/L. The average BOD concentration is 220 mg/L and the plant flow averages 750,000 gpd.
    A. 0.39
    B. 0.8
    C. 1.1
    D. 1.6
12. What is the weir overflow rate of a weir that is 70 feet long with a flow rate of 0.11 MGD?
   A. 658 gpd/ft
   B. 967 gpd/ft
   C. 1240 gpd/ft
   D. 1571 gpd/ft

   Note: Weir length may be given in inches or as the size of the basin. The basin could be rectangular or circular. Flow rate may be given in gpm or gallons per day.

13. A basin measures 45 feet wide by 90 feet long and 15 feet deep services a treatment plant. An average flow of 0.2 MGD goes through the plant. What is the detention time in days?
   A. 0.13 days
   B. 0.76 days
   C. 2.27 days
   D. 3.4 days

   There are two formulas on the sheet, one for days and one for hours. Use the appropriate one based on units of the answers.

14. What is the sludge age of a plant where an aeration basin contains 51,500 pounds of MLSS and the influent TSS is calculated at 1,960 pounds per day?
   A. 20.2
   B. 26.3
   C. 35.5
   D. 52.8
You may also be given flow, volume and concentration data to determine lbs.

15. A wastewater treatment plant is serving a population of 185,000. How much phosphorus would be removed from this plant on a daily basis assuming 100% conversion of the phosphorus?
   A. 888 lbs
   B. 3145 lbs
   C. 3700 lbs
   D. 8880 lbs

This question may ask for any population equivalents. Be aware of the units of the answers.

16. A 2.5 MGD extended aeration plant is at full capacity with an influent BOD of 235 mg/L. What is the organic loading on this facility in pounds BOD/1,000 ft$^3$?
   A. 1.46 lbs BOD/1,000 ft$^3$
   B. 7.3 lbs BOD/1,000 ft$^3$
   C. 14.6 lbs BOD/1,000 ft$^3$
   D. 21.7 lbs BOD/1,000 ft$^3$

17. Two drying beds measuring 45 feet wide by 80 feet long are filled with 18 inches of sludge from a digester in 2 hours and 45 minutes. What is the pump rate in gal/min?
   A. 48.9 gpm
   B. 244.8 gpm
   C. 326.4 gpm
   D. 489.6 gpm
18. What is the SOUR in mg/g VSS/hr at a facility where the MLVSS was measured at 1,760 mg/L. During the analysis the initial DO was 8.9 mg/L and 3 minutes later the DO is 5.2 mg/L.
   A. 42.0 mg/g VSS/hr  
   B. 59.1 mg/g VSS/hr  
   C. 101.1 mg/g VSS/hr  
   D. 126.1 mg/g VSS/hr

19. To calculate a Sludge Volume Index, the thirty minute settled sludge volume was 295 ml and the MLSS is 3640 mg/L. What is the SVI?
   A. 0.81  
   B. 8.1  
   C. 81  
   D. 810

20. What is the hydraulic loading rate on a clarifier that is 65 ft in diameter and 12 ft deep and receives a daily average flow of 890,000 gallons per day?
   A. 268.3 lbs BOD/1000 ft²  
   B. 1,610 lbs BOD/1000 ft²  
   C. 2,683 lbs BOD/1000 ft²  
   D. 3,220.1 lbs BOD/1000 ft²
## Answer Key

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Class III & IV

Math questions for class III and class IV require a better understanding of the math in the manual and of the formulas on the formula sheet. The exams also introduce a different way of displaying the data needed to solve the problem (See question 21) for this change in question format. Questions will also require a greater skill level for what could be called “bank balance math”, in that they are not associated with a specific formula on the formula sheet or covered specifically in the manual.

Class III and class IV exams will include questions that were covered for class I and class II exams. Be aware of the units for data in the question and the units of the answer. Don’t forget the importance of conversions.

21. Given the following information, what is the cost of removal per 1,000 pounds of total suspended solids, assuming 100% removal?

Data:
Average flow = 4.9 MGD
TSS removed = 190 ppm
Operating costs = $68,250 per year

A. $24.08
B. $28.63
C. $32.98
D. $36.50
22. The flow to a plant is 1.75 MGD. The influent BOD₅ concentration is 275 mg/L. If the primary treatment process removes 25% of the incoming BOD₅ and the aeration F/M is 40 pounds of BOD₅ per 100 pounds MLVSS, how many pounds MLVSS should be maintained in the aeration basin?
   A. 2,508.5 lbs
   B. 7,525.5 lbs
   C. 10,034 lbs
   D. 7,525.5 lbs

Clue: Aerator F/M is 40 pounds of BOD₅ per 100 pounds MLVSS. BOD is food (F) and MLVSS is bacteria (M). Rearrange formula.

23. What is the weir overflow rate in gallons per day per foot of weir, if the flow is 165 gpm and the radius of the clarifier is 22 feet and 6 inches?
   A. 3,262 gpd/ft of weir
   B. 2,456 gpd/ft of weir
   C. 1,963.5 gpd/ft of weir
   D. 1,681.5 gpd/ft of weir

24. What is the detention time for two clarifiers that are 60 feet in diameter and 10 feet deep with a flow of 12.2 cubic feet per second?
   A. 0.13 hours
   B. 0.9 hours
   C. 1.3 hours
   D. 2.6 hours
There are many conversions in this problem. There are many ways to solve it too.

25. The desired sludge age for a particular extended aeration plant is 19 days. The daily flow is 1.95 MGD with an influent suspended solids concentration of 210 mg/L. If the 2.5 MG aeration basin has a MLSS concentration of 3,450 ppm, how many gallons will be wasted if the waste sludge flow is concentrated to 1.35%?
   A. 62,550 gallons
   B. 64,889 gallons
   C. 71,932 gallons
   D. 86,250 gallons

26. What is the mean cell residence time for a 2.6 MGD oxidation ditch with a flow of 1.5 MGD, a MLSS of 2,980 mg/L? The plant wastes sludge at a rate of 49,500 gal per day at 7,000 mg/L TSS and has an effluent TSS concentration of 12.5 mg/L.
   A. 19 days
   B. 21 days
   C. 24 days
   D. 28 days
27. Using the following data calculate the mean cell residence time (MCRT) for an activated sludge oxidation ditch.

**DATA:**
- Oxidation Ditch = 1.7 MGD
- MLVSS = 1,720
- Flow = 1.2 MGD
- Return sludge flow = 70%
- Influent BOD5 = 285 mg/L

**Options:**
A. 3.9 days  
B. 6.9 days  
C. 8.2 days  
D. 12.3 days

*Note the extra information given in the question. Be aware of information you do not need.*

28. Calculate the mean cell residence time (MCRT), in days, for an oxidation ditch.

**DATA:**
- Plant flow = 0.82 MGD
- Waste sludge flow = 12,000 gpd
- Aeration tank volume = 1.1 MG
- Return sludge flow MLSS concentration = 9,000 mg/L of MLSS
- Aeration MLSS = 2,900 mg/L
- Plant discharge to stream = 18 mg/L of SS
- Return sludge flow = 75%

**Options:**
A. 18.2 days  
B. 25.9 days  
C. 29.3 days  
D. 31.5 days
29. Calculate the organic loading rate on a trickling filter in pounds of BOD$_5$/1,000 sq.ft.

DATA:
Influent BOD$_5$ = 255 ppm
Filter diameter = 65 feet
Plant flow = 1.3 MGD
Filter depth = 7 feet
Plastic Media = 24 ft$^2$ per ft$^3$ volume

A. 2.59 gpd/ft$^2$
B. 3.89 gpd/ft$^2$
C. 4.96 gpd/ft$^2$
D. 6.32 gpd/ft$^2$

30. What is the organic loading rate in pounds of BOD$_5$ per day per 1,000 cubic feet for a trickling filter that is 120 feet in diameter and 7 feet deep? The primary effluent flow is 2,140 gpm and the BOD$_5$ is 190/mg/L?

A. 61.68 lbs BOD$_5$/1,000 ft$^3$
B. 106.9 lbs BOD$_5$/1,000 ft$^3$
C. 120.6 lbs BOD$_5$/1,000 ft$^3$
D. 190.2 lbs BOD$_5$/1,000 ft$^3$

31. A sample of sludge going to an aerated digester has a MLVSS of 1,960 mg/L. An analysis for Specific Oxygen Uptake Rate (SOUR) indicated the initial dissolved oxygen was 7.9 mg/L and 5 minutes later the dissolved oxygen was 5.2 mg/L. What is the SOUR in mg/g VSS/hr?

A. 13.9 mg/g VSS/hr
B. 15.8 mg/g VSS/hr
C. 16.5 mg/g VSS/hr
D. 24.2 mg/g VSS/hr
32. Given the following information regarding a treatment plant sample, calculate the mg/L of mixed liquor suspended solids (MLSS) in the aeration basin.
DATA:
Sample Size = 25 ml
Weight of dish (tare wt.) = 15.2153 g
Before burning, ash weight of sample and dish = 15.2456 g
After burning, ash weight of sample and dish = 15.2412 g
A. 176 mg/L
B. 572 mg/L
C. 1,036 mg/L
D. 1,212 mg/L

33. Calculate the sludge volume index from the following information.
DATA:
Mixed liquor suspended solids = 2,950 mg/L.
Five minute settleometer reading = 640 ml/L.
Thirty minute settleometer reading = 420 ml/L.
Sixty minute settleometer reading = 330 ml/L.
A. 111 ml/mg
B. 142 ml/mg
C. 217 ml/mg
D. 7023 ml/mg

34. A wastewater plant is receiving 2,500 pounds of total suspended solids each day. Industrial facilities contribute 15% and 85% is domestic and commercial. Calculate the population equivalent of the industrial contribution.
A. 1,875 people
B. 2,205 people
C. 2,500 people
D. 10,625 people
35. A rectangular dissolved air floatation unit is 15 feet long and 12 feet wide. What is the solids loading rate in pounds per hour per square foot if the unit receives 55 gpm of sludge from a clarifier with a solids content of 0.75%?
   A. 0.72 lbs/hr/ft$^2$
   B. 0.9 lbs/hr/ft$^2$
   C. 1.0 lbs/hr/ft$^2$
   D. 1.14 lbs/hr/ft$^2$

   Note the units...

36. Calculate the solids loading rate on the final clarifier in pounds of suspended solids per day per square foot.
   Clarifier diameter = 60 ft.
   Plant Flow = 1.2 MGD
   Side wall depth = 12 ft.
   MLSS = 2,550 ppm
   Return sludge flow = 80%
   A. 8.7 lbs/day/ft$^2$
   B. 16.3 lbs/day/ft$^2$
   C. 24.0 lbs/day/ft$^2$
   D. 31.6 lbs/day/ft$^2$

   Note the units in the question!

37. Calculate the percent reduction of volatile solids.
   DATA:
   Raw VSS = 63%
   Digested VSS = 49.5%
   A. 35%
   B. 42%
   C. 51%
   D. 63%
38. If the sludge entering a digester has a volatile solids content of 55.7% and the digester effluent sludge has a volatile solids content of 42.6%, calculate the percentage of volatile solids reduction.
   A. 35%
   B. 41%
   C. 51%
   D. 63%

39. Calculate the volatile solids loading in pounds of volatile suspended solids per cubic foot on an anaerobic digester if the waste sludge flow is 10,200 gallons per day. The total suspended solids is 2.1 percent, the volatile suspended solids is 62 percent of the total suspended solids and the digester volume is 65,000 gallons.
   A. 0.08 lbs vss/ft³
   B. 0.13 lbs vss/ft³
   C. 0.21 lbs vss/ft³
   D. 0.55 lbs vss/ft³

Answer Key

27. C 34. A
1. Formula used: *Population Served, Persons ÷ Pond Surface, Acres*
   
   4,500 People ÷ 200 acres = 22.5 persons/acre

2. First calculate surface area of lagoons in acres:
   
   $3 \times 800 \text{ ft} \times 450 \text{ ft} = 1,080,000 \text{ ft}^2 \div 43,560 \text{ ft}^2/\text{Acre} = 24.79 \text{ acres}$
   
   $1,250 \text{ Persons} \div 24.79 \text{ acres} = 50.4 \text{ persons/acre}$

3. Formula used: *pounds of BOD ÷ area in acres*
   
   First calculate pounds of BOD:
   
   $125 \text{ mg/L} \times 8.34 \times 0.75 \text{ MGD} = 781.88 \text{ pounds/day}$
   
   Divide pounds of BOD by the surface area of pond in acres:
   
   $781.88 \text{ pounds/12.5 acres} = 62.55 \text{ lbs BOD/day/acre}$

4. Convert flow from gpm to MGD and surface area of pond from ft$^2$ into acres:
   
   $500 \text{ gpm} \div 694.5 \text{ gpm/MGD} = 0.72 \text{ MGD}$
   
   $490,500 \text{ ft}^2 \div 43,560 \text{ ft}^2/\text{acre} = 11.26 \text{ acres}$
   
   Calculate pounds of BOD:
   
   $62 \text{ mg/L} \times 8.34 \times 0.72 \text{ MGD} = 372.30 \text{ lbs BOD/day}$
   
   Calculate organic loading:
   
   $372.20 \text{ lbs BOD/day ÷ 11.26 acres} = 33.06 \text{ or 33.1 lbs BOD/day/acre}$

5. Formula used: *pounds = mg/L x 8.34 x Flow, MGD*
   
   First convert:
   
   gallons/day to MGD – $72,000 \text{ gal} \div 1,000,000 = 0.072 \text{ MGD}$
   
   Calculate pounds:
   
   $210 \text{ mg/L} \times 8.34 \times 0.072 \text{ MGD} = 126.1 \text{ lbs}$
6. Formula used: 

\[
ppm(mg/L) = \frac{\text{pounds}}{(8.34 \times \text{Flow, MGD})}
\]

First convert flow from gallons/day to MGD:
675,000 gallons/day ÷ 1,000,000 = 0.675 MGD
Calculate concentration:
Mg/L = \frac{92 \text{ lbs}}{(8.34 \times 0.675 \text{ MGD})} = 92 \text{ lbs ÷ 5.63} = 16.34 \text{ mg/L}

7. Formula used: 

\[
\text{Flow, MGD} = \frac{\text{pounds}}{(\text{Concentration (mg/L)} \times 8.34)}
\]

Calculate Flow, MGD:
Flow, MGD = \frac{125 \text{ lbs}}{(42 \text{ mg/L} \times 8.34)} = 125 \text{ lbs ÷ 350.28} = 0.357 \text{ MGD}
Convert to gallons/day:
0.357 \text{ MGD} \times 1,000,000 = 357,000 \text{ gpd}

8. Formula used:

\[
\text{BOD, mg/L} = \frac{(\text{Initial DO, mg/L} - \text{Final DO, mg/L}) \times \text{Bottle vol, ml}}{\text{Sample, ml}}
\]

Calculate BOD in mg/L:
BOD, mg/L = \frac{(9.6 \text{ mg/L} - 3.1 \text{ mg/L}) \times 300 \text{ ml}}{25 \text{ ml}} = \frac{6.5 \text{ mg/L} \times 300 \text{ ml}}{25 \text{ ml}} = 1,950 \div 25 = 78 \text{ mg/L}

9. Formula used: 

\[
\text{Percent Removal} = \frac{\text{(Influent – Effluent)} \times \text{Sample, ml}}{\text{Influent}} \times 100
\]

Calculate Percent Removal:
Percent Removal = \frac{((215 \text{ mg/L} - 48 \text{ mg/L}) \times 215 \text{ mg/L})}{215 \text{ mg/L}} \times 100
Percent Removal = (167 \text{ mg/L} \div 215 \text{ mg/L}) \times 100 = 0.7767 \times 100 = 77.7%

10. Formula used: 

\[
\text{F/M} = \frac{\text{lbs BOD, in Influent}}{\text{lbs MLVSS, in aeration basin}}
\]

First calculate lbs of BOD in the influent:
220 \text{ mg/L} \times 8.34 \times 0.9 \text{ MGD} = 1,651.32 \text{ lbs BOD}
Calculate F/M ratio:
F/M = 1,651.32 \text{ lbs, BOD ÷ 2,450 lbs, MLVSS} = 0.67
11. Formula used: \( F/M = \frac{\text{lbs BOD, in Influent}}{\text{lbs MLVSS, in aeration basin}} \)
   First convert daily flow from gallons/day to MGD:
   
   \[ 750,000 \text{ gpd} \div 1,000,000 = 0.750 \text{ MGD} \]
   
   Calculate lbs BOD in Influent:
   
   \[ 220 \text{ mg/L} \times 8.34 \times 0.75 \text{ MGD} = 1,376.1 \text{ lbs/day} \]
   
   Calculate lbs MLVSS in the Aeration Basin:
   
   \[ 350 \text{ mg/l} \times 8.34 \times 1.2 \text{ MG} = 3,502.8 \text{ lbs MLVSS} \]
   
   Calculate F/M ratio:
   
   \[ 1,376.1 \text{ lbs BOD in Influent} \div 3,502.8 \text{ lbs MLVSS in basin} = 0.39 \text{ F/M} \]

12. Formula used: \( \text{Weir Overflow rate, GPD/ft} = \frac{\text{Flow, GPD}}{\text{Length of weir, ft}} \)
   Convert flow in MGD to GPD:
   
   \[ 0.11 \text{ MGD} \times 1,000,000 = 110,000 \text{ gpd} \]
   
   Calculate Weir Overflow Rate, GPD/ft:
   
   \[ 110,000 \text{ gpd} \div 70 \text{ ft} = 1,571.4 \text{ or } 1,571 \text{ gpd/ft} \]

13. Formula used: \( \text{Detention Time, Days} = \frac{\text{Volume, MG}}{\text{Flow, MGD}} \)
   Calculate the volume of the tank in MG:
   
   \[ \text{Volume} = 45 \text{ ft} \times 90 \text{ ft} \times 15 \text{ ft} = 60,750 \text{ ft}^3 \times 7.48 \text{ gal/ft}^3 = 454,410 \text{ gal} \div 1,000,000 = 0.454 \text{ MG} \]
   
   Calculate detention time:
   
   \[ 0.454 \text{ MG} \div 0.2 \text{ MGD} = 2.27 \text{ days} \]

14. Formula used:
   
   \( \text{Sludge Age} = \frac{\text{Lbs of MLSS in Aeration basin}}{\text{Lbs/day of TSS in Influent}} \)
   Calculate sludge age:
   
   \[ \text{Sludge Age} = 51,500 \text{ lbs of MLSS} \div 1,960 \text{ lbs of TSS/day in influent} = 26.27 \text{ or } 26.3 \text{ Days} \]
15. Formula used: Population x lbs of phosphorous a person contribute per day
   Calculate lbs of phosphorous:
   \[ 185,000 \times 0.0048 \text{ lbs of phosphorus / person / day} = 888 \text{ lbs/day} \]

16. First calculate the pounds of BOD the plant receives daily:
   \[ \text{Lbs BOD} = 235 \times 8.34 \times 2.5 \text{ MGD} = 4,899.75 \]
   Find the number of \( ft^3 \) in the plant:
   \[ 2.5 \text{ MG} \times 1,000,000 = 2,500,000 \text{ gallons} \div 7.48 \text{ gal/ft}^3 = 334,224.6 \text{ ft}^3 \]
   Find the number of \( 1,000 \text{ ft}^3 \) units:
   \[ 334,224.6 \text{ ft}^3 \div 1000 = 334.22 \text{ ft}^3 \]
   Find lbs BOD per \( 1000 \text{ ft}^3 \):
   \[ 4,899.75 \text{ lbs BOD} \div 334.22 \text{ ft}^3 = 14.66 \text{ lbs BOD / 1000 ft}^3 \]

17. Calculate the volume of sludge pumped in gallons:
   Convert inches to feet: \( 18/12=1.5 \text{ ft} \)
   \[ 2 \text{ beds} \times 45 \text{ ft} \times 80 \text{ ft} \times 1.5 \text{ ft} = 10,800 \text{ ft}^3 \times 7.48 \text{ gal/ft}^3 = 80,784 \text{ gallons} \]
   Calculate the time in minutes it took to fill the beds and divide gallon by minutes to get pump rate:
   \[ 2 \text{ hours} = 2 \times 60 \text{ min} = 120 \text{ minutes} + 45 \text{ minutes} = 165 \text{ minutes} \]
   \[ 80,784 \div 165 \text{ minutes} = 489.6 \text{ gpm} \]

18. First calculate the Oxygen Uptake Rate (OUR):
   \[ \text{OUR} = \frac{(\text{DO}_1 - \text{DO}_2)}{(\text{Time}_2 - \text{Time}_1)} \times 60 = \frac{(8.9 - 5.2)}{3 \text{ Min}} \times 60 = 3.7 \times 60 = 1.233 \times 60 = 74 \]

   Calculate SOUR:
   \[ \text{SOUR} = \text{OUR} \times 1000 = \frac{74}{1,760} \times 1000 = 0.042 \times 1000 = 42.0 \text{ mg/m VSS/hr} \]
19. Formula used:

\[
\text{Sludge volume index (SVI), mg/L} = \frac{(SSV_{30}, mL/L \times 1,000 \text{ mg/g})}{(MLSS, mg/L)}
\]

SVI = \(\frac{(295 \text{ mL/L} \times 1,000 \text{ mg/g})}{3,640 \text{ mg/L}} = 295,000 \div 3640 = 81 \text{ mg/L}\)

20. Formula used: \textit{Hydraulic loading gpd/ft}^2 = \frac{\text{Flow , gpd}}{\text{Surface area , ft}^2}

Calculate surface area of clarifiers:

\[0.785 \times 65 \text{ ft} \times 65 \text{ ft} = 3,319.625 \text{ ft}^2\]

Divide flow, gpd by the surface area of the tank:

\[\text{Hydraulic Loading Rate} = \frac{890,000 \text{ gpd}}{3,319.625 \text{ ft}^2} = 268.3 \text{ gpd / ft}^2\]

21. Calculate how many 1000 lb units of TSS are removed per year:

\[\text{Lbs} = 190 \text{ mg/L} \times 8.34 \times 4.9 \text{ MGD} = 7,764.54 \text{ lb/day} \times 365 \text{ day/yr} = 2,834,057.1 \text{ lb/yr}\]

\[2,834,057.1 \div 1000 = 2,834.06 \text{ 1,000 lb units}\]

Divide cost per year by number of 1,000 lb units:

\[\$68,250 \div 2,834.06 \text{ 1000 lb units} = \$24.08 \text{ per 1000 pounds removed}\]

22. First calculate lb of BOD received each day:

\[\text{BOD} = 275 \text{ mg/L} \times 8.34 \times 1.75 \text{ MGD} = 4,013.6 \text{ lbs}\]

Calculate pounds not removed by the clarifier:

\[4,013.6 \text{ lbs} \times 0.75 = 3,010.2 \text{ lbs make it to the aerator}\]

For every 40 lbs of BOD, 100 lbs of MLVSS is needed so calculate how many 40 lb units of BOD are present and multiplying that number by 100 to get lbs of MLVSS needed:

\[3,010.2 \div 40 = 75.255 \times 100 = 7,525.5 \text{ lbs of MLVSS are needed}\]
23. Calculate the diameter of the tank and then calculate the circumference (length of weir):
   Diameter equal 2 x 22.5 ft = 45 ft
   Circumference = 45 ft x 3.14 = 141.3 ft
Calculate flow in gallons per day:
   165 gpm x 1440 min/day = 237,600 gpd
Divide gpd by the length of weir to get Weir Overflow Rate:
   237,600 ÷ 141.3 ft = 1,681.5 gpd/ft or weir

24. Formula used: \[ \text{Detention Time (Hrs)} = \frac{(\text{tank vol, ft}^3 \times 7.48 \text{ gal/ft}^3 \times 24 \text{ hrs/day})}{(\text{flow, gpd})} \]
   Calculate the tank size in ft\(^3\) then in gallons and the flow in gpd:
   Tank, ft\(^3\) = 2 x 0.785 x 60 x 60 ft x 10 = 56,520 ft\(^3\) x 7.48 gal/ft\(^3\) = 422,749.6 gal
   Flow, gpd = 12.2 ft/ sec x 448.8 gpm = 5475.36 gpm x 1440 min / day = 7,884,518.4 gpd
   Calculate detention time, hrs:
   Detention time, hrs = (422,769.6 gallon x 24 hr) ÷ 7,884,384.4 gpd = 10,146,470.4 ÷ 7,884,384.4 = 1.28 or 1.3 hrs

25. Calculate pounds of MLSS in the aeration basin:
   3,450 mg/L x 8.34 x 2.5 MG = 71,932.5 lbs MLSS
   Calculate the pounds of MLSS if sludge age was 19 days:
   210 mg/L x 8.34 x 1.95 = 3,415.23 x 19 days = 64,889.4 lbs MLSS at 19 day sludge age
   Calculate the number of pounds that would need to be wasted:
   71,932.5 – 64,889.4 = 7043.1 lbs wasted
   Calculate gallons to be wasted at 1.35% (13,500 mg/l) concentration:
   Flow = 7043.1 ÷ (13,500 mg/L x 8.34) = 7043.1 ÷ 112,590 = 0.06255 MGD
   0.06255 MGD x 1,000,000 = 62,550 gallons that need to be wasted
26. Formula used: \( MCRT, \text{ Days} = \frac{\text{lbs of MLSS in aeration basin}}{(\text{lbs sludge wasted} + \text{lbs TSS lost over weir})} \)

Calculate the three pounds formulae needed:

- lbs MLSS = 2,980 mg/L x 8.34 x 2.6 MG = 64,618.32 lb MLSS
- lbs wasted = 7,000 mg/L x 8.34 x 0.0495 MG = 2,889.81 lbs wasted
- lbs TSS lost = 12.5 mg/l x 8.34 x 1.5 MGD = 156.38 lb TSS lost

Now calculate the MCRT:

\[ MCRT, \text{ days} = \frac{64,618.32 \text{ lbs}}{2,889.81 \text{ lbs} + 156.38 \text{ lbs}} = \frac{64,618.32 \text{ lbs}}{3,046.19 \text{ lbs}} = 21.2 \text{ or } 21 \text{ days} \]

27. Uses same formulae as #26. Just replace the numbers.

Calculate the three pounds formulae needed:

- lbs MLSS = 3,600 mg/l x 8.34 x 1.7 MG = 51,040.8 lbs MLSS
- lbs wasted = 11,200 mg/l x 8.34 x 0.0653 MGD = 6,099.54 lbs wasted
- lbs TSS lost = 12.6 mg/L x 8.34 x 1.2 MGD = 126.1 lbs TSS lost

Now calculate the MCRT:

\[ MCRT, \text{ days} = \frac{51,040.8 \text{ lbs}}{6,099.54 \text{ lbs} + 126.1 \text{ lbs}} = \frac{51,040.8 \text{ lbs}}{6,225.64 \text{ lbs}} = 8.19 \text{ or } 8.2 \text{ days} \]

28. Uses the same formulae as # 26. Just replace the numbers.

Calculate the three pounds formulae needed:

- lbs MLSS = 2,900 mg/l x 8.34 x 1.1 MG = 26,604.6 lbs MLSS
- lbs wasted = 9,000 mg/L x 8.34 x 0.012 MG = 900.72 lbs wasted
- lbs TSS lost = 18 mg/L x 8.34 x 0.82 MGD = 123.1 lbs TSS lost

Now calculate the MCRT:

\[ MCRT, \text{ days} = \frac{26,604.6 \text{ lb}}{900.72 \text{ lb} + 123.1 \text{ lb}} = \frac{26,604.6 \text{ lb}}{1,023.82 \text{ lb}} = 25.9 \text{ days} \]
29. First calculate the lbs of BOD entering the system:

   lbs BOD = 255 ppm x 8.34 x 1.3 MGD = 2,764.71 lbs BOD

Calculate the number of ft$^2$ of plastic media in the filter:

   Volume of filter, ft$^3$ = 0.785 x 65 x 65 x 7 = 23,216.38 ft$^3$
   Area of plastic media, ft$^2$ = 23,216.38 ft$^3$ x 24 ft$^2$/ft$^3$ = 557,193.12 ft$^2$
   # of 1000 ft$^2$ units = 557,193.12 ft$^2$ ÷ 1000 = 557.19 1000 ft$^2$ units
   Organic Loading, lb BOD/1000 ft$^2$ = 2,764.71 lbs BOD ÷ 557.19 1000 ft$^2$ units = 4.96

30. First calculate the pounds of BOD entering the filter after the Flow is converted to MGD:

   Flow, MGD = 2,140 gpm ÷ 694.5 gpm/MGD = 3.08 MGD
   lbs BOD = 190 mg/L x 8.34 x 3.08 MGD = 4,880.57 lbs

Calculate the volume of the trickling filter in ft$^3$:

   Volume of filter, ft$^3$ = 0.785 120 x 120 x 7 = 79,128 ft$^3$
   Calculate the number of 1000 ft$^3$ units in the filter:
   # 1000 ft$^3$ units = 79,128 ft$^3$ ÷ 1,000 = 79.13 1000 ft$^3$ units
   Organic loading, lb BOD/1000 ft$^3$ units = 4,880.57 ÷ 79.13 = 61.68 lbs BOD / 1000 ft$^3$

31. This formula is the same as what’s used in Class 1 & 2 #18:

   Calculate the Oxygen Uptake Rate (OUR):
   OUR = (7.9 mg/l – 5.2 mg/l) ÷ 5 min = 2.7 ÷ 5 = 0.54 x 60 = 32.4
   Calculate the Specific Oxygen Uptake Rate (SOUR):
   SOUR = (32.4 x 1000) ÷ 1,960 mg/l = 332,400 ÷ 1,960 = 16.53 or 16.5 mg/g VSS/hr

32. Formula used:

   \[ MLSS \text{ Suspended solids, mgL} = \frac{(W_2 - W_1)}{(ml \text{ sample})} \times 1,000 \times 1,000 \]

   Where, \( W_1 = \text{Dish} \quad \) \( W_2 = \text{Dish & Dry Solids} \quad \) \( W_3 = \text{Dish & Ash} \)

   \( \text{Mg/L MLSS} = (15.2456 \text{ g} - 15.2153 \text{ g}) \div 25 \text{ ml} = 0.0303 \div 25 = 0.001212 \)
   \( = 0.001212 \times 1000 \times 1000 = 1,212 \text{ mg/L} \)
33. Formula used:

\[
\text{Sludge volume index (SVI), mg/L} = \frac{(SSV30, mL \times 1,000 \text{mg/g})}{\text{MLSS, mg/L}}
\]

\[
\text{SVI} = \frac{(420 \text{ ml/L} \times 1,000 \text{ mg/g})}{2,950 \text{ mg/L}}
\]

\[
\text{SVI} = 420,000 \div 2,950 = 142.37 \text{ or } 142 \text{ ml/mg}
\]

34. Calculate the number of pounds contributed by Industry:

- Industrial Contribution, lbs = 2500 lbs TSS x 0.15 (15%) = 375 lbs
- Calculate the population equivalent of the industrial contribution:
  - Population Equivalent = 375 lbs ÷ 0.20 lbs/person = 1,875 people

35. Calculate the surface area of the tank:

- 15 ft x 12 ft = 180 ft²
- Convert flow from GPM to MGD – 55 gpm ÷ 694.5 gpm/MGD = 0.079 MGD
- Calculate pounds of sludge per day:
  - 7500 mg/L x 8.34 x 0.079 = 4,941.45 lbs/day
- Calculate pounds of sludge per hour:
  - 7,941.45 lbs/day ÷ 24 hr/day = 205.89 lbs/hr
- Calculate sludge loading rate:
  - 205.89 lbs/hr ÷ 180 ft² = 1.14 lbs/hr/ft²

36. Calculate the surface area of the clarifier:

- 0.785 x 60 ft x 60 ft = 2,826 ft²
- Calculate the total flow to the clarifier:
  - 1.2 MGD + ( 1.2 MGD x 0.80 ) = 1.2 MGD + 0.96 MGD = 2.16 MGD
- Calculate pounds of sludge per day:
  - 2,550 mg/L x 8.34 x 2.16 MGD = 45,936.72 lbs/day
- Calculate sludge loading rate:
  - 45,936.72 lbs/day ÷ 2,826 ft² = 16.26 or 16.3 lbs/day/ft²

37. Formula used: \( \% \text{ VS reduction} = \frac{(\text{in} - \text{out})}{(\text{in} - (\text{in} \times \text{out}))} \times 100 \)

- Convert % to decimal by dividing and use decimal in equation.
- % Reduction (VS) = (0.63 – 0.495) ÷ ((0.63 – (0.63 x 0.495)) x 100
- % Reduction (VS) = (0.135 ÷ (0.63 – 0.312)) x100 = (0.135 ÷ 0.318) x 100
- % Reduction (VS) = 0.424 x 100 = 42.4 or 42%
38. Use the same formula as last problem and same conversion of % to decimal.
   \[
   \text{% Reduction (VS)} = \frac{(0.557 - 0.426)}{(0.557 - (0.557 \times 0.426)) \times 100}
   \]
   \[
   \text{% Reduction (VS)} = \frac{0.131}{0.557 - 0.237} \times 100 = \frac{0.131}{0.32} \times 100
   \]
   \[
   \text{% Reduction (VS)} = 0.409 \times 100 = 40.9 \text{ or } 41\%
   \]

39. Formula used:
   \(\text{Digester loading, lbs/day/ft}^3 = \frac{\text{(VS added, lbs/day)}}{\text{(digester vol, ft}^3)}\)
   Calculate pounds of VS loaded:
   \[
   21,000 \text{ mg/l} \times 8.34 \times 0.0102 \text{ MGD} \times 0.62 (62\% \text{ VS}) = 1,107.59 \text{ lbs}
   \]
   Calculate digester volume in ft\(^3\) = 65,000 gal ÷ 7.48 ft\(^3\)/gal = 8,689.84 ft\(^3\)
   Calculate VS loading = 1,107.59 lbs VS ÷ 8,689.84 ft\(^3\) = 0.127 or 0.13 lbs VSS/ft\(^3\)
Questions or Concerns?
The Kentucky Operator Certification Program provides training and issues certifications to ensure that individuals engaged in performing many of Kentucky's critical environmental activities are qualified and capable to perform their duties. DCA staff are available to provide on-site assistance and training.

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