Class II

Wastewater Workbook Mathematical Solutions

WEST VIRGINIA
RURAL WATER
ASSOCIATION

Every drop counts.

Presented by

West Virginia Rural Water Association

1) If you have an 8" pipe with a velocity of 3.2 fps, what is the flow in CFS? $Q = V \times A$

$Q = 3.2 \times \frac{8}{12} \times \frac{8}{12} \times .785$

$Q = 3.2 \times .349 = 1.12$ CFS

2) Given a 12" pipe with flow of 600 GPM, Find the Velocity in FPS.

$Q = V \times A$

$\frac{600 \times 1446}{1000000} = V \times 1 \times 1 \times .785$

$V \times .785$

$.86 \times 1.545 \times .785$

$1.33 \div .785 =$

1.69 FPS

3) You have a pipe 6" pipe with a velocity of 2.3 FPS, Find the flow in MGD. $Q = V \times A$

$Q = 2.3 \times \frac{6}{12} \times \frac{6}{12} \times .785$

$Q = 2.3 \times 0.196$

$Q = .451$ CFS

$\frac{.451}{1.545} = 0.29$ mgd

4) You have a 16" pipe that is ½ Full. The velocity is 3 fps. What is the flow in MGD?

$Q = V \times A$

$Q = 3 \times \frac{16}{12} \times \frac{16}{12} \times .785$

$Q = 3 \times 1.39$

$3 \times 1.39 = 4.19$ CFS

$\frac{4.19}{1.545} = 2.71$ mgd

$\frac{2.71}{2}$ 1.35 mgd

5) You are given a Rectangular Channel that is 4' by 3'. The flow is 0.33 MGD. What is the Velocity in FPS?

$Q = V \times A$

$3 = V \times 4 \times 3$

$V \times 12$

$\frac{.051}{12} =$ 0.042 FPS

$.33 \times 1.545 = 0.51$

6) Given a flow of 0.44 MGD and a 8" pipe, what is the velocity in FPS?

$Q = V \times A$

$.44 \times 1.545 = V \times \frac{8}{12} \times \frac{8}{12} \times .785$

$.68 = V \times .349$

$\frac{.68}{.349} = 1.95$ FPS

Pumping

1) Your system has a lift station which cycles 5 times per hour for 3.5 minutes per cycle. It contains a triplex pump which produces 35 strokes per minute with a 5" BORE and an 8" STROKE. What is the pump capacity in: $3 \times \frac{5}{12} \times \frac{5}{12} \times .785 \times \frac{8}{12} \times 7.48 \times 35 =$

GPM $3 \times \frac{5}{12} \times \frac{5}{12} \times .785 \times \frac{8}{12} \times 7.48 \times 35 = 71.35$

GPH $3.5 \times 5 \times 71.35 = 1248.8$

GPD $1248.8 \times 24 = 29,971.2$

2) A one cylinder piston pump with an 8" bore and a 6" stroke pumps one cycle per second. How long must the pump operate to pump 2000 gallons of liquid?

$\frac{8}{12} \times \frac{8}{12} \times .785 \times \frac{6}{12} \times 7.48 \times 60 =$ 78.29 GPM

$\frac{2000}{78.29} =$ 25.55 minutes

3) What is the capacity in GPD of a duplex pump with a 5" stroke and a 2.5"diameter bore? It makes 55 cycles per minute.

$2 \times \frac{2.5}{12} \times \frac{2.5}{12} \times .785 \times \frac{5}{12} \times 7.48 \times 55 = 11.68$ GPM

$11.68 \times 1440 = 16,820.26$ GPD

4) What is the capacity in GPD of a duplex pump with a 6" stroke and a 2.5" Do 60 cycles per minute

$2 \times \frac{2.5}{12} \times \frac{2.5}{12} \times .785 \times \frac{6}{12} \times 7.48 \times 60 = 15.29$

$15.29 \times 1440 = 22019.25$ GPD

Geometric Mean

To find the Geometric Mean you need the results of four fecal tests. Multiply the four Numbers together and get an answer. Hit the Square root key twice, this is the Geometric Mean.
What if the numbers are too large to run through the calculator? Look at how large the numbers are and divide all four numbers by 10, 100, or 1000. Divide all four by the same number to get four numbers small enough to be run through your Calculator. Then multiply the four numbers together. Hit the square root key twice. Than multiply the number you came up with back by the number you divided by ***ONCE!***

1) Find the Average of the Following four Numbers: 33, 12, 45, and 267.

$33 + 12 + 45 + 267 = 357$

$\frac{357}{4} =$ 89.25 cts per 100 ml

2) Find the geometric mean of the above four numbers.

$33 \times 12 \times 45 \times 267 = 4,757,940$

$4,757,940$ $\sqrt{}$ $\sqrt{}$ 46.70 cts/100 mls

3) Find the Geometric Mean: 600, 325, 7011, 180.

$\frac{600}{100} = 6$ $\frac{325}{100} = 3.25$ $\frac{7011}{100} = 70.11$

$\frac{180}{100} = 1.8$ $6 \times 3.25 \times 70.11 \times 1.8 = 2460.861$

2460.861 $\sqrt{}$ $\sqrt{}$ $= 7.0432 \times 100 =$

704.32 cts/100 ml

4) Determine the geometric Mean of the following fecal results. 20,750, 33,003, 9,990, and 12,275.

$\frac{20750}{1000} = 20.75$ $\frac{33003}{1000} = 33.003$ $\frac{9990}{1000} = 9.99$ $\frac{12275}{1000} = 12.275$

$20.75 \times 33.003 \times 9.99 \times 12.275 = 83976.64298$

$\sqrt{\sqrt{17.023138 \times 1000}}$

17023.14 cts/1000 ml

17,023.14

5) Find the geometric mean of the following fecal counts all from 100 ml samples. 27, 38, 112, and 61

$27 \times 38 \times 112 \times 61 = 7,009,632$ $\sqrt{\sqrt{} = 51.45}$

51.45 cts/100 ml

6) Find the geometric mean of the following fecal counts. 99,000, 77,000, 2,000, and 57,000

$\frac{99,000}{1000} = 99$ $\frac{77000}{1000} = 77$ $\frac{2000}{1000} = 2$ $\frac{57000}{1000} = 57$

$57 \times 77 \times 99 \times 2 = 869,022$ $\sqrt{\sqrt{}}$

$30.53217 \times 1000 = 30,532.17$

cts/100 ml

7) Find the following Geometric mean of the given fecal counts. 540, 990, 2150, 2720

$\frac{540}{100} = 5.4$ $\frac{990}{100} = 9.9$ $\frac{2150}{100} = 21.5$ $\frac{2720}{100} = 27.2$

$5.4 \times 9.9 \times 21.5 \times 27.2 = 31263.408$ $\sqrt{\sqrt{}} = 13.297165$

$13.297165 \times 100 = 1329.72$

cts/100 ml

8) Find the geometric mean of the following fecal counts: 111, 6, 16, 38

$111 \times 6 \times 16 \times 38 = 404,928$ $\sqrt{\sqrt{} = 25.225}$

25.23 cts/100 ml

BOD Calculations

1) Your plant has a initial DO of 10.11 and the DO has dropped to 5.55 after the 5 day incubation period. What is the final BOD of a 100 ml sample?

$\frac{10.11 - 5.55}{100} \times 300 = 13.68$ mg/L BOD

2) Initial BOD 8.8 mg/l
   Final BOD 3.3 mg/l
   75 ml Sample
   Find the Final BOD

$\frac{8.8 - 3.3}{75} \times 300 = 22$ mg/L BOD

3) Initial BOD 12.30 mg/l
   Finial BOD 7.33 Mg/l
   120 ml Sample
   Average Monthly Flow 2.25 Mgd
   Flow on Sampling Day 3.11 Mgd
   Find the Pounds BOD you would report if this was the only sample you collected this month.

$\frac{12.3 - 7.33}{120} \times 300 = 12.42$

$3.11 \times 12.42 \times 8.34 = 322.14$ lbs BOD

4) You have an Initial BOD of 7.25 Mg/l and a Final BOD of 3.86 Mg/l. Find the final BOD in Mg/l from a 200 Ml sample with a flow of 0.55 Mgd.

$\frac{7.25 - 3.86}{200} \times 300 = 5.09$ mg/L BOD

1) You need a 2500 ml. sample for the day. The flows at sampling times were as follows: 0.53, 0.66, 0.72, 0.72, 0.83, 0.83, 0.70 and 0.61. Find the sample volume for each flow.

.53 + .66 + .72 + .72 + .83 + .83 + .70 + .61 = 5.6 $\frac{2500}{5.6} = 446.43$

0.53 X 446.43 = 236.61 ml

0.66 X 446.43 = 294.64 ml

0.72 X 446.43 = 321.43 ml

0.72 X 446.43 = 321.43 ml

0.83 X 446.43 = 370.54 ml

0.83 X 446.43 = 370.54 ml

0.70 X 446.43 = 312.50 ml

0.61 X 446.43 = 272.32 ml

2) You are told to collect an 8 hr composite sample with a total volume of 3 liters. The 8:00 am flow is 2.5 Mgd. and the 12:00 pm flow is 2.2 Mgd. If the total flow is 18.5 Mgd, how much sample needs to be collected from the 2 sample aliquots given?

$\frac{3000}{18.5} = 162.16$ 2.5 X 162.16 = 405.40 ml

2.2 X 162.16 = 356.75 ml

3) Total flow 11.75 Mgd, Sample Volume 2.5 liters 11:00 am sample is 1.55 Mgd. How much would you collect?

$\frac{2500}{11.75} = 212.77$ 212.77 X 1.55 = 329.79 ml

Billing

1) Your Sewage rate structure is 150 % of the water service rate. The water rates are $ 42.00 for the first 3500 Gallon and $ 5.00 dollars each 1000 gallons above that. If a costumer used 7500 Gallons, what should the Sewer bill be?

3500 - 42.00
4000 - 20.00
62.00

62 × 1.5 = $ 93.00

2) A costumer comes in with a bill of $ 222.00. The Sewage billing rate is 115 % of the water rates. The costumer used 8000 Gallon of water at $ 40.00 for the first 4000 Gallons and $ 25.00 per 1000 gallon thereafter. How much refund or credit is due the costumer on his sewer bill?

4000 - 40.00
4000 - 25 × 4 = 100
100 + 40 = 140

140 × 1.15 = 161.00

222 - 161 = $ 61.00
Refund or Credit

3) A meter reading shows that 11,000 Gal of water was used. The sewer rates are 125% of the water rate. The water rates are $ 50.00 for the first 3000 gallon and $ 25.00 per 1000 after that. What would this sewer bill be?

3000 = 50.00
8000 = 8 × 25 = 200
200 + 50 = 250

250 × 1.25 = $ 312.50

Efficiency

$$\frac{\text{In} - \text{Out}}{\text{In}} \times 100$$

1) If you have a Influent TSS of 280 and a Influent BOD of 316, what would the Efficiency have to be if you are required to meet a 30/30 BOD, TSS permit requirement?

$\frac{316-30}{316} \times 100 = 90.51\%$ BOD Eff

$\frac{280-30}{280} \times 100 = 89.29\%$ TSS Eff

2) If your plant has an effluent BOD of 6 Mg/l and an Influent BOD of 288 Mg/l, what is the plant efficiency?

$\frac{288-6}{288} \times 100 = 97.92\%$

3) The treatment plant has an Influent TSS of 265 Mg/l and removes 248 Mg/l, what is the plant efficiency?

$265 - 248 = 17$

$\frac{265-17}{265} \times 100 = 93.58\%$

Weir Overflow Rate

Flow (GPD)
Length of Weir (LF) = Gal/Day/LF

1) What is the Weir Overflow Rate if the flow is 1400 GPM and your have a 100' diameter Weir?

$1400 \times 1440 = 2,016,000$ G-1
$100 \times 3.14 = 314$
$\frac{2,016,000}{314} = 6420$ G-1/LF/Day

2) Find the weir overflow rate of a tank that is 40' wide, 122' long and 10' deep with a flow of 3.0 MGD.

$3 \times 1,000,000 = \frac{3000,000}{40} = 75,000$ G-1/LF/Day

3) What is the Weir Overflow Rate of a Tank with 4 double sided 10' weirs and the flow is 1.66 MGD?

$1,66 \times 1000,000 = 1,660,000$
$10 \times 4 \times 2 = 80$
$\frac{1,660,000}{80} = 20,750$ G-1/LF/Day

4) You have a tank with a 60' diameter weir taking a flow of 990,000 GPD. Find the Weir Overflow Rate.

$60 \times 3.14 =$
$\frac{990,000}{188.4} = 5254.78$ G-1/LF/Day

5) What is the weir overflow rate of a tank with 400' of total weirs and a flow of 3.1 CFS?

$3.1 \div 1,545 \times 1000,000$
$\frac{2,006,472.5}{400} = 5016.18$ G-1/LF/Day

Surface Loading Rate
Or
Surface Settling Rate

Gal/Day/ Square Foot = Flow (GPD)
Area of Tank In Sq. Ft.

1) Your system contains a tank that is 100' Long, 75', feet wide and 12' deep. The flow is 1555 GPM. Determine the Surface Loading Rate in gal/day/sq. ft.

1555 x 1440 = 2,239,200
100 x 75 = 7500
= 298.56 Gal/D-ft/Ft²

2) Your Plant contains two clarifiers each 75' diameter and 16'deep. The Plant flow is 3.5 CFS. Find the surface Loading Rate to the plant.

75 x 75 x .785 x 2 = 8831.25
3.5 / 1.545 x 1,000,000 = 2,265,372.2
2,265,372.2 / 8831.25 = 256.5 Gal/D-ft²

3) Your Plant has a tank that is 40' diameter and 20' deep with a flow of 800 GPM. Determine the surface loading Rate.

40 x 40 x .785 = 1256
800 x 1440 = 1,152,000
1,152,000 / 1256 = 917.19 Gal/D-ft²

Volume/Percentages

$$\frac{V_1}{V_2} = \frac{P_2}{P_1}$$

1) 20,000 Gal of sludge is pumped to a gravity thickener at 1.2% Solids. The sludge concentration is increased to 4.55% before it is removed. How many gallons would be removed?

$\frac{20000}{V_2} = \frac{4.55}{1.2}$ $\frac{20000 \times 1.2}{4.55} = 5274.73$ G-1

2) If a drying bed is 50' Long 25' wide and contains 16" of 4.2% Sludge, if the sludge cake dries to 9%, How many inches of sludge will the bed contain?

$\frac{16}{V_2} = \frac{9}{4.2}$ $\frac{16 \times 4.2}{9} = 7.47$ inches

3) If 50,000 Gallons of 2.2% sludge is pumped and the sludge dries to 7.5%, how many gallons would be present?

$\frac{50000}{V_2} = \frac{7.5}{2.2}$ $\frac{50000 \times 2.2}{7.5}$

14,666.67 Gal

4) If 25,000 Gallons of 1.2% Sludge is pumped to a holding tank and you dry to 6.1%, how many gallons are remaining?

$\frac{25,000}{V_2} = \frac{6.1}{1.2}$ $= \frac{25000 \times 1.2}{6.1}$

4918.03 Gal

Sludge Volume Index

Sludge Volume Index = $\frac{\text{30 Minute Settling Test X 1000}}{\text{MLSS Mg/L}}$

1) If the results of the 30 Minute settling test was 520 Mg/l and the MLSS was 3350 Mg/l, determine the SVI.

$\frac{520 \times 1000}{3350} = 155.23$

2) Determine the SVI if the Settleometer settled to 380 and the MLSS are 2750.

$\frac{380 \times 1000}{2750} = 138.19$

3) The MLSS is 4175 Mg/L and the 30 minute settling test turned out to be 410, find the sludge volume index.

$\frac{410 \times 1000}{4175} = 98.21$

4) Determine the Sludge Volume Index of an sample in which the 30 minute settling test is 400 and the MLSS is 3888 Mg/L.

$\frac{400 \times 1000}{3888} = 102.88$

Pounds

1) An Aeration Tank requires 1800 Cubic foot of air per pound of BOD entering the system. The plant flow is 1.1 MGD with a 225 Mg/l BOD. How many cubic feet per day must be provided

1.1 x 225 x 8.34 = 2064.15 lbs

2064.15 x 1800 = 3,715,470 CFD

2) If a plant has a 2.25 MGD flow with an influent BOD of 200 mg/l and a 12 Mg/l effluent BOD and needs 2500 CF of air per pound of BOD, How many CFM of air is needed?

2.25 x 200 x 8.34 = 3753

3753 x 2500 = 9,382,500

9,382,500 / 1440 = 6515.63 CFM

3) Your plant needs 2000 CF of air per pound of BOD. The plant takes on 50,000 LBS. of BOD per Day. How many CFM of air is needed/

50000 x 2000 = 100,000,000

$$\frac{100,000,000}{1440} = 69,444.45 \text{ CFM}$$

4) A oxidation ditch has a flow of 250,000 Gal with a influent BOD of 280 mg/l. The ditch needs 2000 CF of air per pound of BOD. How many CFM of air is needed?

$$\frac{250,000}{1,000,000} \times 280 \times 8.34 = 583.80 \text{ lbs}$$

583.80 x 2000 = 1,167,600 CFD

1,167,800 ÷ 1440 = 810.84

Lab Math

1) Crucible Weight 25.0705 g.
2) Crucible + Ash 25.0711 g.
3) Crucible + solids 25.0722 g.
4) 50 ml sample
5) Find % Volatile
6) Find Mg/l total solids

1)

$$25.0722 - 25.0711 = .0011$$

$$25.0722 - 25.0705 = .0017$$

$$\frac{.0011}{.0017} \times 100 = 64.71\ \%\ \text{vol}$$

$$\frac{25.0722 - 25.0705}{.0017 \times 1{,}000{,}000} = 34\ \text{mg/L}$$