Sidney's Big Book of Water and Wastewater Math

Indigo Water Group

Unit Conversions to Know by Heart

1 inch = 2.54 centimeters
1 meter = 3.28 feet
1 mile = 5280 feet

1 acre = 43,560 ft^2
1 m^2 = 10.76 ft^2

1 gallon = 3.785 liters
1 ft^3 = 7.48 gallons
1 m^3 = 35.31 ft^3

1 ft water = 0.433 psi

1 gallon = 8.34 lbs when specific gravity is 1.0
1 kg = 2.2 lbs

1% = 10,000 mg/L
1 mg/L = 1 ppm
1 µg/L = 1 ppb

1 day = 1440 minutes
1 hp = 0.746 kW

1 gram = 15.43 grains
1 grain per gallon = 17.1 mg/L

Water Formulas

pounds per day = (concentration in mg/L)*(flow rate in mgd)*(8.34)

chlorine dose = demand + residual

$$\text{velocity} = \frac{\text{flow}}{\text{area}} \qquad V = \frac{Q}{A}$$

$$\text{flow rate} = \frac{\text{volume}}{\text{time}} \qquad Q = \frac{V}{t}$$

$$\text{overflow rate} = \frac{\text{flow rate}}{\text{area}}$$

$$\text{weir loading rate} = \frac{\text{flow rate}}{\text{feet of weir}}$$

(concentration 1)*(volume 1) = (concentration 2)*(volume 2) $\qquad C_1V_1 = C_2V_2$

(conc. 1)*(volume 1) + (conc. 2)*(volume 2) = (conc. 3)*(volume 3)

$$C_1V_1 + C_2V_2 = C_3V_3$$

$$\text{horsepower} = \frac{(\text{flow in gpm})*(\text{lift in feet})}{3960}$$

Hydraulic Retention Time

HYDRAULIC RETENTION TIME

EXAMPLE:

PLANT A HAS A 2.5 MG FLOW EQUALIZATION TANK. WATER IS BEING PUMPED INTO THE TANK BY A POSITIVE DISPLACEMENT PUMP WITH THE FOLLOWING CHARACTERISTICS:

PUMP CAVITY = 4.2 ft^3

STROKES PER MINUTE = 40

HOW LONG DOES IT TAKE TO FILL THE TANK?

I know that the hydraulic retention time is a measure of how much water is moving through the tank over a certain amount of time.

$$Q = \frac{\text{Volume}}{\text{Time}}$$

I know that V is 2.5 MG, but I don't know the flow rate of the pump. Plus, I need the units to match. Lets convert.

HAVE: $\frac{4.2\ ft^3}{stroke}$ | WANT: $\frac{MG}{day}$

FILL IN UNITS, MULTIPLY THROUGH

$$\frac{4.2\ ft^3}{stroke} \left| \frac{10\ strokes}{1\ min} \right| \frac{60\ min}{1\ hour} \left| \frac{24\ hours}{1\ day} \right| \frac{7.48\ gallons}{1\ ft^3} \left| \frac{gallons}{day} \right.$$

$$= 452390.4\ \frac{gallons}{day}$$

$$= 0.452390\ MGD$$

Put things back into the formula above and solve for time.

$$Q = \frac{V}{t}$$

$$0.4523904 \text{ MGD} = \frac{2.5 \text{ MG}}{\text{time}} \quad \} \text{ step 1}$$

$$(\text{time} \times 0.4523904 \text{ MGD}) = 2.5 \text{ MG} \quad \} \text{ step 2}$$

$$\text{time} = \frac{2.5 \text{ MG}}{0.4523904 \text{ MGD}} \quad \} \text{ step 3}$$

$$\text{time} = 5.53 \text{ days} \quad \} \text{ step 4}$$

We'll learn more about solving equations in the next sections of the book.

HRT

30. What is the average detention time in a basin given the following: diameter = 30' depth = 15' flow = 700 gpm
a) 1hr. 34min.
b) 1hr. 53min.
c) 1hr. 47min.
d) 2 hrs. 3 min.

31. What is the average detention time in a basin given the following: diameter = 80' depth = 12.2' flow = 5 MGD
a) 2.2 hrs.
b) 1.68 hrs.
c) 2.4 hrs.
d) 1.74 hrs.

32. Two 50-ft diameter, 10-ft deep sedimentation basins operating in parallel handle a flow of 2 mgd. What is the detention time in hours (assume the basins have flat floors)?
a) 3.5 hrs
b) 6.7 hrs
c) 7.0 hrs
d) 2.0 hrs
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33. Your finished water storage tank is 35 feet in diameter and 65 feet high. With no water entering it the level dropped 4' in 5 hours. How many gallons of water were used in this period?
a) 7,193
b) 71,930
c) 467,542
d) 28,772
e) 62,506

34. If two pumps will pump 120 gpm each, how long will it take to fill a tank 50' long, 20' wide, and 8' deep?
a) 2 hours, 27 minutes
b) 4 hours, 42 minutes
c) 4 hours, 9 minutes
d) 1 hour, 49 minutes

35. Given the following information, what is the water tank detention time? Diameter = 80 ft Depth = 25 ft Flow rate = 25000 gpd

a) 47.8 days
b) 25.2 days
c) 37.6 days
d) 15.7 days

36. Compute the detention time in hours in a final sedimentation basin given: Diameter = 95' Depth = 11' Flow rate = 7.0 MGD

a) 1 hr. 59 min
b) 2 hrs 10 min
c) 4 hrs 10 min
d) 1 hr

37. A settling basin 60' by 12' and 12' deep is used to treat a flow of 2.4 MGD. What is the detention time?

a) '15 min.
b) '39 min.
c) '1.1 hrs
d) '2.3 hrs

38. What is the detention time in a reservoir if the influent flow rate is 0.785 MGD, the reservoir depth is 22 feet, and the reservoir covers 17 acres?

a) 97 days
b) 56 days
c) 155 days
d) 180 days
e) 420 days

39. Your filters fill your clearwell at a rate of 375 gpm. The clearwell measures 10' wide x 80' long x 12' deep. If it had 5' of water in it how long would it take to fill completely?

1.9 hours
111.7 minutes
19.1 minutes
11.1 hours
191 minutes

Hydraulic Retention Time

30. $Q = \frac{V}{t}$ From the information I'm given, I can find the volume in ft^3. The flow rate is in gpm. One of these must be converted.

$$\text{Volume} = \pi r^2 d$$
$$V = (3.14 \times 15\,ft \times 15\,ft \times 15\,ft)$$
$$V = 10597.5\ ft^3$$

$$10597.5\ ft^3 \left| \frac{7.48\ \text{gallons}}{1\ ft^3} \right| = 79269.3\ \text{gallons}$$

$$Q = \frac{V}{t}$$
$$\frac{700\ \text{gallons}}{\text{min}} = \frac{79269.3\ \text{gallons}}{t}$$
$$700t = 79269.3$$
$$t = 113\ \text{minutes}$$

OR 1 hour 53 minutes

31. $\text{Volume} = \pi r^2 d$
$$V = (3.14 \times 40\,ft \times 40\,ft \times 12.2\,ft)$$
$$V = 61292.8\ ft^3$$

$$\frac{5\ \text{mg}}{\text{day}} \left| \frac{1\ \text{day}}{24\ \text{hours}} \right| \frac{1{,}000{,}000\ \text{gallons}}{1\ \text{mg}} \left| \frac{1\ ft^3}{7.48\ \text{gallons}} \right| = 27852.0\ ft^3/\text{hour}$$

now that all of our units match, we can use our formula for HRT

31 (cont.) $Q = \frac{V}{t}$

$$\frac{27852.0\ ft^3}{hr} = \frac{61292.8\ ft^3}{t}$$

$$27852.0\ t = 61292.8$$

$$t = 2.2 \text{ hours}$$

32. This problem is similar to #31 except that we have two basins on-line.

$V = \pi r^2 d$

$V = (3.14)(25\ ft)(25\ ft)(10\ ft)$

$V = 19625\ ft^3$ per tank

total volume $= (2) \cdot (19625\ ft^3)$

$= 39250\ ft^3$

$$\left| \frac{2\ mg}{day} \right| \left| \frac{1\ day}{24\ hrs} \right| \left| \frac{1000000\ gal}{1\ mg} \right| \left| \frac{1\ cuft}{7.48\ gal} \right| = 11140.8\ ft^3/hour$$

$Q = \frac{V}{t}$

$$\frac{11140.8\ ft^3}{hr} = \frac{39250\ ft^3}{t}$$

$(11140.8)(t) = 39250$

$t = 3.5$ hours

33. We are only interested in the volume lost, not the total volume of the tank.

$V = \pi r^2 d$

$V = (3.14)(17.5\text{ ft})(17.5\text{ ft})(4\text{ ft})$

$V = 3846.5\text{ ft}^3$

$$3846.5\text{ ft}^3 \left| \frac{7.48\text{ gallons}}{1\text{ ft}^3} \right| = 28772\text{ gallons}$$

34. $V = (l)(w)(h)$

$V = (50\text{ ft})(20\text{ ft})(8\text{ ft})$

$V = 8000\text{ ft}^3$

$$8000\text{ ft}^3 \left| \frac{7.48\text{ gal}}{1\text{ ft}^3} \right| = 59,840\text{ gallons}$$

$$Q = \frac{V}{t}$$

$$240\text{ gpm} = \frac{59,840\text{ gallons}}{t}$$

$240t = 59,840$

$t = 249.3\text{ minutes}$

$$249.3\text{ minutes} \left| \frac{1\text{ hr}}{60\text{ minutes}} \right| = 4.16\text{ hours}$$

$$0.16\text{ hours} \left| \frac{60\text{ minutes}}{1\text{ hr}} \right| = 9\text{ minutes}$$

4 hours 9 minutes

35. $V = \pi r^2 d$

$V = (3.14)(40\text{ ft})^2(25\text{ ft})$

$V = (3.14)(40\text{ ft})(40\text{ ft})(25\text{ ft})$

$V = 125600\text{ ft}^3$

$125600\text{ ft}^3 \left| \frac{7.48\text{ gallons}}{1\text{ ft}^3} \right| = 939488\text{ gallons}$

$Q = \frac{V}{t}$

$25{,}000\text{ gpd} = \frac{939488\text{ gallons}}{t}$

$25{,}000t = 939488$

$t = 37.6\text{ days}$

36. $V = \pi r^2 d$

$V = (3.14)(47.5\text{ ft})^2(11\text{ ft})$

$V = (3.14)(47.5\text{ ft})(47.5\text{ ft})(11\text{ ft})$

$V = 77931\text{ ft}^3$

$77931\text{ ft}^3 \left| \frac{7.48\text{ gallons}}{1\text{ ft}^3} \right| = 582922.9\text{ gallons}$

$Q = \frac{V}{t}$

$7{,}000{,}000\text{ gpd} = \frac{582923\text{ gallons}}{t}$

$7000000t = 582923$

$t = 0.083\text{ days}$

$0.083\text{ days} \left| \frac{24\text{ hrs}}{1\text{ day}} \right| = 1.99\text{ hours} = 1\text{hr } 59\text{ minutes}$

37. $V = (l \times w \times h)$

$V = (60\,ft \times 12\,ft \times 12\,ft)$

$V = 8640\,ft^3$

$8640\,ft^3 \left| \frac{7.48\,gallons}{1\,ft^3} \right| = 64,627\,gallons$

$Q = \frac{V}{t}$

$2,400,000\,gallons = \frac{64,627\,gallons}{t}$

$2400000t = 64627$

$t = 0.0269\,days$

$0.0269\,days \left| \frac{24\,hrs}{1\,day} \right| \left| \frac{60\,min}{1\,hr} \right| = 39\,minutes$

38. $17\,acres \left| \frac{43,560\,ft^2}{1\,acre} \right| = 740520\,ft^2$

an acre is an area
area is the
same as length
multiplied by width

$V = (l \times w \times h)$

$V = (740520\,ft^2)(22\,ft)$

$V = 16291440\,ft^3$

$16291440\,ft^3 \left| \frac{7.48\,gallons}{1\,ft^3} \right| = 121859971\,gallons$

38. (cont) $Q = \frac{V}{t}$

$$785000\ gpd = \frac{12185997\ gallons}{t}$$

$$785000t = 12185997$$

$$t = 155\ days$$

39. The volume of the clearwell is only the volume that needs to be filled — not the whole volume.

$V = (l \times w \times h)$

$V = (10\ ft \times 80\ ft \times 12 - 5\ ft)$

$V = (10ft \times 80ft \times 7\ ft)$

$V = 5600\ ft^3$

$$5600\ ft^3 \left| \frac{7.48\ gallons}{1\ ft^3} \right| = 41888\ gallons$$

$Q = \frac{V}{t}$

$$375gpm = \frac{41888\ gallons}{t}$$

$375t = 41888$

$t = 111.7\ minutes$

Hydraulic Retention Time

18. The wet well holds 5 million gallons and the finished water production rate at peak hour is 2800 gpm. What is the hydraulic retention time of the wet well in minutes?

Answer: minutes

19. A number of pumps are used to fill a water tank. Each pump transfers water into the tank at a rate of 2800 gallons per minute when 4 pumps are used. The tank can be filled in 29.76 hours. What is the volume of the tank in cubic feet?

Answer: cubic feet

20. A water main feeds a subdivision. The main is 500 feet long and is 12 inches in diameter. The distribution crew is flushing the main to remove sediment. How long should they flush the line to achieve 2 pipe volumes? Express your answer in minutes. The pipe delivers 30 cfm of flow.

Answer: minutes

21. A rectangular basin measures 100 feet long, by 50 feet wide, by 12 feet deep. A pump drawing water out of the full tank is able to empty the tank in 1.24 days. What is the pump rate in gallons per minute?

Answer: gpm

22. A rectangular tank is being filled by 4 pumps. If the tank is 100 feet long by 50 feet wide by 12 feet long and takes 1.24 days to fill. At what rate is each pump moving water into the tank? Express your answer in gpm.

Answer: gpm

23. Water enters the distribution system at 4.03 mgd. The transmission line has a diameter of 12 inches and is 500 feet long. The transmission main feeds a 5000000 gallon storage tank. If water leaves the tank at the same rate that it enters, calculate the water age as it leaves the tank. Assume the tank is full. Express your answer in hours and minutes.

Answer:

24. Water leaves a full, cylindrical tank at a rate of 6.24 cfs. The tank volume is reduced by 50% after 29.76 hours. If the tank is 20 feet high, what is the diameter in feet?

Answer: feet

25. A water tank on the top of a hill holds 60000 cf of water. The tank is completely empty. The tank is fed by a booster pump station with 4 pumps. Each pump is rated at 1120 gpm. If the distribution crew needs to fill the tank in less than 29.76 hours, what is the least number of pumps that could be used? Assume that pump rates remain constant regardless of the volume of water in the tank.

Answer: pumps

26. A 12 inch pipeline needs to be flushed. If the desired length of pipeline to be flushed is 500 feet, how many minutes will it take to flush the line at 50 gpm?

Answer: minutes

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18. $Q = \frac{V}{t}$

$2800\ gpm = \frac{5\ mgd}{t}$

$2800\ gpm = \frac{3472\ gpm}{t}$

$2800t = 3472$

$t = 1.24$ minutes

$\frac{5\ mg}{day} \left| \frac{1{,}000{,}000\ gal}{1\ mg} \right| \left| \frac{1\ day}{1440\ min} \right| = 3472.2\ gpm$

19. 4 pumps → TANK

$Q = \frac{V}{t}$

$2800\ gpm = \frac{V}{29.76\ hours}$

$2800\ gpm = \frac{V}{1785.6\ min}$

$4{,}999{,}680\ gal = V$

$29.76\ hours \left| \frac{60\ min}{1\ hr} \right| = 1785.6\ min$

$4{,}999{,}680\ gal \left| \frac{1\ cf}{7.48\ gal} \right| = 668{,}406\ cf$

20. $Q = \frac{V}{t}$

$30\ cfm = \frac{785.4\ cf}{t}$

$30t = 785.4$

$t = 26.18$ minutes

$V = \pi r^2 h$

$V = (\pi)(0.5\ ft)^2(500\ ft)$

$V = 392.7\ ft^3$

$2\ volumes = 785.4\ ft^3$

21. $V = l \cdot w \cdot h$

$V = (100\ ft)(50\ ft)(12\ ft)$

$V = 60{,}000\ cf$

$60{,}000\ cf \left| \frac{7.48\ gal}{1\ cf} \right| = 448{,}800\ gal$

$1.24\ days \left| \frac{1440\ min}{1\ day} \right| = 1{,}785.6\ min$

$Q = \frac{V}{t}$

$Q = \frac{448{,}000\ gal}{1785.6\ min}$

$Q = 250.8\ gpm$

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22. Unit conversions from problem 21

Volume = 448,000 gal
t = 1785.6 min

Q = 250.8 gpm total OR $\frac{250.8}{4}$ = 62.7 gpm/pump

23. Q = 4.03 mgd $V_{PIPE} = \pi r^2 h$ V_{TANK} = 5,000,000 gal

$V_{PIPE} = (\pi)(0.5\,ft)^2(500\,ft)$

V_{PIPE} = 392.7 cf

$392.7\,cf \left| \frac{7.48\,gal}{1\,cf} \right| = 2{,}937\,gal$

TOTAL VOLUME = 5,002,937 gal

$Q = \frac{V}{t}$

$4.03\,mgd = \frac{5{,}002{,}937\,gal}{t}$

$\frac{4{,}030{,}000\,gal}{day} = \frac{5{,}002{,}937\,gal}{t}$

$4030000t = 5002937$

t = 1.24 days

$1.24\,days \left| \frac{24\,hours}{1\,day} \right| = 29.76\,hours$

$0.76\,hours \left| \frac{60\,min}{1\,hr} \right| = 46\,minutes$

} 29 hours and 46 minutes

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24. $Q = \frac{V}{t}$

$6.24\ cfs = \frac{V}{29.76\ hrs}$

$29.76\ hours \left| \frac{60\ min}{hr} \right| \left| \frac{60\ sec}{1\ min} \right| = 107{,}136\ secs$

$6.24\ cfs = \frac{V}{107{,}136\ sec}$

$668{,}528.6\ cf = V$ ← This is $\frac{1}{2}$ the volume of the tank, so the total volume is $2 \times 668{,}528.6\ cf$ OR $1{,}337{,}057.2\ cf$

$V = \pi r^2 h$

$1{,}337{,}057.2\ cf = (\pi)(r^2)(20\ ft)$

$21{,}279.88 = r^2$

$145.88' = r$

$2r$ = diameter = 292 feet

25. $60{,}000\ cf \left| \frac{7.48\ gal}{1\ cf} \right| = 448{,}800\ gal$

$29.76\ hours \left| \frac{60\ min}{1\ hour} \right| = 1785.6\ minutes$

$Q = \frac{V}{t}$

$Q = \frac{448{,}800\ gal}{1785.6\ min}$

$Q = 250.9\ gpm$ ← this is less than the flow rate of 1 pump, 50 only 1 pump needed

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26. $V = \pi r^2 h$

$V = (3.1416)(6.5\text{ ft})^2(500\text{ ft})$

$V = 392.7\text{ cf}$

$$392.7\text{ cf} \left| \frac{7.48\text{ gal}}{1\text{ cf}} \right| = 2,937.396\text{ gal}$$

$$Q = \frac{V}{t}$$

$$50\text{ gpm} = \frac{2,937.396\text{ gal}}{t}$$

$$50t = 2,937.396$$

$$t = 59\text{ minutes}$$

HYDRAULIC RETENTION TIME

1. If two pumps will pump 120 gpm each, how long will it take to fill a tank 50' long, 20' wide, and 8' deep?
   a) 2 hours, 27 minutes
   b) 4 hours, 42 minutes
   c) 4 hours, 9 minutes
   d) 1 hour, 49 minutes

2. What is the average detention time in a clarifier given the following: diameter = 30' depth = 15' flow = 700 gpm
   a) 1hr. 34min.
   b) 1hr. 53min.
   c) 1hr. 47min.
   d) 54 minutes

3. What is the average detention time in a clarifier given the following: diameter = 80' depth = 12.2' flow = 5 MGD
   a) 2.2 hrs.
   b) 1.68 hrs.
   c) 2.4 hrs.
   d) 0.94 hrs.

4. Determine the flow capacity of a pump in gpm if the pump lowers the wastewater in a six-foot square sump by 8 inches in 5 minutes.
   a) 35.9 gpm
   b) 57.6 gpm
   c) 92.4 gpm
   d) 179.5 gpm
   e) 430 gpm

5. What is the detention time in a stabilization pond if the influent flow rate is 0.785 MGD, the pond depth is 4.5 feet, and the pond covers 17 acres?
   a) 97 days
   b) 56 days
   c) 32 days
   d) 14 days
   e) 4.2 days

6. A 20-ft diameter clarifier with a depth of 8.25 ft receives a flow of 0.314 mgd. What is the detention time?
   a) 1.22 hours
   b) 1.48 hours
   c) 1.75 hours
   d) 2.25 hours

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7. Compute the detention time in hours in a final clarifier given: Diameter = 95' Depth = 11' Flow rate = 7.0 MGD
a) 1 hr. 55 min
b) 2.0 hrs
c) 2 hrs. 10 min

8. Compute the lagoons detention time. Surface area = 6.0 acres, Average depth = 3.0 ft, Average daily flow = 0.25 MGD
a) 3 days
b) 8 days
c) 24 days
d) 29 days

9. A settling basin 60' by 12' and 12' deep is used to treat a flow of 2.4 MGD. What is the detention time?
a) 15 min.
b) 39 min.
c) '1.1 hrs
d) 2.3 hrs

10. Two 50-ft diameter, 10-ft deep secondary clarifiers operating in parallel handle a flow of 2 mgd. What is the detention time in hours (assume the clarifier has a flat floor)?
a) 3.5 hrs
b) 6.7 hrs
c) 7.0 hrs
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11. A chemical feed pump has been rebuilt and must be calibrated for maximum pump rate. If it takes 1 hour and 15 minutes to fill a 10-ft X 5-ft X 10-ft rectangular tank, what is the maximum pump rate in gal/min?
a) 67 gal/min
b) 50 gal/min
c) 45 gal/min
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JOB Hydraulic Retention Time JOB NO. 33
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1. $V = \text{length} \times \text{width} \times \text{length}$
$V = (50\text{ft})(20\text{ft})(8\text{ft})$
$V = 8000\ \text{ft}^3$

$8000\ \text{ft}^3 \left| \frac{7.48\ \text{gal}}{1\ \text{ft}^3} \right| = 59840\ \text{gal}$

$Q = \frac{V}{t}$

$\frac{240\ \text{gal}}{\text{min}} = \frac{59840\ \text{gal}}{\text{time}}$

Q = flow rate, in this case 120 gpm × 2 or 240 gpm since two pumps are working to fill the tank

$(240)(\text{time}) = 59840$
$\text{time} = 249\ \text{minutes}$

$249\ \text{min} \left| \frac{1\ \text{hour}}{60\ \text{min}} \right| = 4.15\ \text{hours}$

$0.15\ \text{hours} \left| \frac{60\ \text{min}}{1\ \text{hour}} \right| = 9\ \text{minutes}$ 4 hrs 9 min

2. $V = \pi r^2 h$
$V = (3.14)(15\text{ft})(15\text{ft})(15\text{ft})$
$V = 10597.5\ \text{ft}^3$

$10597.5\ \text{ft}^3 \left| \frac{7.48\ \text{gal}}{1\ \text{ft}^3} \right| = 79269.3\ \text{gal}$

$Q = \frac{V}{t}$

$700\ \text{gpm} = \frac{79269.3\ \text{gal}}{\text{time}}$

$(700)(\text{time}) = 79269.3$
$\text{time} = 113.2\ \text{minutes}$

113.2 minutes
− 60 minutes
53 minutes

1 hr 53 minutes

JOB Hydraulic Retention Time JOB NO. 34
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3. $V = \pi r^2 h$

$V = (3.14)(40\ ft)(40\ ft)(12.2\ ft)$

$V = 61292.8\ ft^3$

$61292.8\ ft^3 \left| \frac{7.48\ gal}{1\ ft^3} \right| = 458470\ gal$

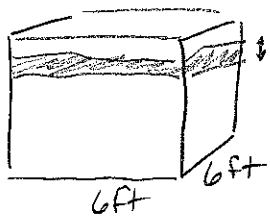
$Q = \frac{V}{t}$ $\quad Q = 5\ MGD = 5{,}000{,}000\ \frac{gal}{day}$

$5{,}000{,}000\ \frac{gal}{day} = \frac{458470\ gal}{time}$

$(5{,}000{,}000\ \frac{gal}{day})(t) = 458470\ gal$

$t = 0.092\ days$

$0.092\ days \left| \frac{24\ hours}{1\ day} \right| = 2.2\ hours$

4. 

$8\ inches \left| \frac{1\ ft}{12\ inches} \right| = 0.67\ ft$

$V = length \times width \times height$

$V = (6\ ft)(6\ ft)(0.67\ ft)$

$V = 24.12\ ft^3$

$24.12\ ft^3 \left| \frac{7.48\ gal}{1\ ft^3} \right| = 180.42\ gal$

$Q = \frac{V}{t}$

$Q = \frac{180.42\ gal}{5\ min}$

$Q = 36\ gpm$

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5. $1\ ACRE = 43{,}560\ ft^2$

Volume = length × width × height
Volume = AREA × height
Volume = (17 acres × 43,560 ft^2/acre × 4.5 ft)
Volume = 3332340 ft^3

$$3332340\ ft^3 \left| \frac{7.48\ gal}{1\ ft^3} \right| \left| \frac{1\ MG}{1{,}000{,}000\ gal} \right| = 24.93\ MG$$

$$Q = \frac{V}{t}$$

$$0.785\ MGD = \frac{24.93\ MG}{t}$$

$$(0.785 \times t) = 24.93$$

$$t = 31.8\ days$$

6. $V = \pi r^2 h$
$V = (3.14 \times 10\ ft \times 10\ ft \times 8.25\ ft)$
$V = 2590.5\ ft^3$

$$2590.5\ ft^3 \left| \frac{7.48\ gal}{1\ ft^3} \right| = 19376.94\ gal$$

$0.314\ mgd = 314{,}000\ gpd$

$$Q = \frac{V}{t}$$

$$314{,}000\ \frac{gal}{day} = \frac{19376.94\ gal}{t}$$

$$(314{,}000 \times t) = 19376.94$$

$$t = 0.06171\ days$$

$$0.06171\ day \left| \frac{24\ hrs}{1\ d} \right| = 1.48\ hrs$$

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7. $V = \pi r^2 h$

$V = (3.14)(47.5\ ft)(47.5\ ft)(11\ ft)$

$V = 77930.875\ ft^3$

$77930.875\ ft^3 \left| \frac{7.48\ gal}{1\ ft^3} \right| = 582923\ gallons$

$Q = \frac{V}{t}$

$7{,}000{,}000\ \frac{gal}{d} = \frac{582923\ gal}{t}$

$t = 0.0833\ days$

$0.0833\ days \left| \frac{24\ hrs}{1\ day} \right| \left| \frac{60\ min}{1\ hr} \right| = 120\ minutes$ OR

2 hours

8. $1\ acre = 43{,}560\ ft^2$

Volume = length · width · height

Volume = AREA × height

$V = (6\ acres)(43{,}560\ ft^2/acre)(3\ ft)$

$V = 784080\ ft^3$

$784080\ ft^3 \left| \frac{7.48\ gal}{1\ ft^3} \right| = 5864918.4\ gal$

$Q = \frac{V}{t}$

$250{,}000\ \frac{gal}{day} = \frac{5864918.4\ gal}{t}$

$(250{,}000)t = 5864918.4$

$t = 23.5\ days$

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9. $V = l \times w \times h$

$V = (60\ ft)(12\ ft)(12\ ft)$

$V = 8640\ ft^3$

$$8640\ ft^3 \left| \frac{7.48\ gal}{1\ ft^3} \right| = 64627.2\ gal$$

$$\frac{2.4\ MG}{day} \left| \frac{1\ day}{1440\ min} \right| \frac{1{,}000{,}000\ gal}{1\ MG} = 1666.7\ \frac{gal}{min}$$

$$Q = \frac{V}{t}$$

$$1666.7\ \frac{gal}{min} = \frac{64627.2\ gal}{t}$$

$(1666.7)(t) = 64627.2$

$t = 38.8$ minutes

10. Find the volume of 1 tank and then multiply by 2 to find the total volume

$V = \pi r^2 h$

$V = (3.14)(25\ ft)(25\ ft)(10\ ft)$

$V = 19625\ ft^3$

$$19625\ ft^3 \left| \frac{7.48\ gal}{1\ ft^3} \right| = 146795\ gal \text{ in one clarifier}$$

293590 gal in two clarifiers

$$Q = \frac{V}{t}$$

$$2{,}000{,}000\ \frac{gal}{day} = \frac{293590\ gal}{t}$$

$t = 0.147$ days

$$0.147\ days \left| \frac{24\ hrs}{1\ day} \right| = 3.52\ hours$$

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11. $V = l \times w \times h$

$V = (10\,ft \times 5\,ft \times 10\,ft)$

$V = 500\,ft^3$

$$500\,ft^3 \left| \frac{7.48\,gal}{1\,ft^3} \right| = 3740\,gal$$

$$Q = \frac{V}{t}$$

$$Q = \frac{3740\,gal}{1hr\ 15\,min}$$

$$Q = \frac{3740\,gal}{75\,min}$$

$$Q = 49.9\,min$$