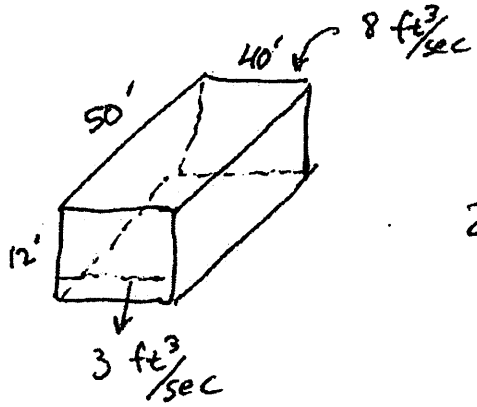
PROBLEMS

1. A water plant clear well is 40 feet wide, 50 feet long, and 12 feet deep. If water is flowing into the clear well at a rate of 8 cfs and being pumped out at a constant rate of 3 cfs, how many hours will it take to fill the clear well if there were 2 feet of water in the clear well?



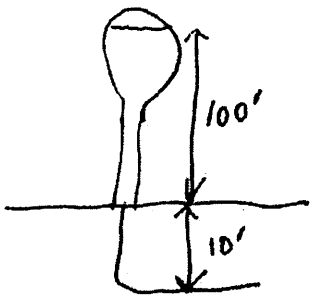
hours? (time)

Volume = 50' x 40' x 10' = 20,000 ft³

$$20{,}000\,ft^3 \times \frac{1\,sec}{5\,ft^3} \times \frac{1\,min}{60\,sec} \times \frac{1\,hr}{60\,min}$$

= 1.1 hours

2. The overflow of a water tower is 100 feet above ground. The water line is 10 feet below ground level. If the water tower is filled to a level 2 feet below the overflow point, what is the pressure in the water line?



pressure? (in psi)

$$98' + 10' = 108\ feet \times \frac{1\ psi}{2.31\ feet}$$

= 46.75 psi

3. A cylindrical rapid mix tank is 8 feet in diameter and 10 feet high. The flow rate through the plant is 8,000,000 gallons per day. What is the detention time (in seconds) of the rapid mix tank?

Time? (seconds)

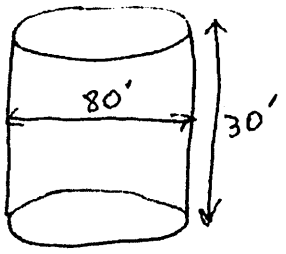
$V = \pi R^2 \times h = 3.14\ (4')^2 \times 10'$

$= 502.4\ ft^3 \times \frac{7.48\ gal}{1\ ft^3} = 3{,}758\ gal$

$$3{,}758\ gal \times \frac{1\ day}{8{,}000{,}000\ gal} = .0004697\ day$$

$$.0004697\ day \times \frac{24\ hours}{1\ day} \times \frac{60\ min}{1\ hour} \times \frac{60\ sec}{1\ min} = 40.6\ seconds$$

4. A pretreatment basin is 80 feet in diameter and 30 feet deep. The water flow is 7.0 MGD. Calculate: A) basin volume in gallons, B) detention time in hours, and C) how many pounds of alum must be fed per day to give a dosage of 3 mg/L.



A) gallons? (volume) $= \pi R^2 h$

$= 3.14 (40)^2 \times 30 = 150{,}720 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3}$

$= \underline{1{,}127{,}385.6 \text{ gallons}}$

B) hours? (time)

$\frac{7{,}000{,}000 \text{ gal}}{\text{day}} \times \frac{1 \text{ day}}{24 \text{ hrs}} = 291{,}667 \text{ gal/hr}$

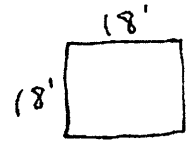
$1{,}127{,}385.6 \text{ gal} \times \frac{1 \text{ hr}}{291{,}667 \text{ gal}} = \underline{3.86 \text{ hours}}$

dosage = 3 mg/L (ppm)

pounds? (weight)

C) $7{,}000{,}000 \text{ gal} \times \frac{8.34 \text{ lbs}}{\text{gal}} = 58{,}380{,}000 \text{ lbs} = 58.38 \text{ ppm (lbs)} \times 3 = \underline{175.14 \text{ lbs.}}$

5. A filter has a sand area of 18 feet by 18 feet. When the influent valve is shut, the water level drops 5 inches per minute. What is the rate of filtration in million gallons per day? MGD? volume/time (filtration rate)



level drops $\frac{5 \text{ inches}}{\text{minute}} \times \frac{1 \text{ foot}}{12 \text{ inches}} = .417 \text{ ft/min}$

Area = 18x18 = 324 ft²

$324 \text{ ft}^2 \times \frac{.417 \text{ ft}}{\text{min}} = 135 \text{ ft}^3/\text{min}$

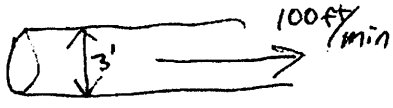
$135 \frac{\text{ft}^3}{\text{min}} \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{24 \text{ hrs}}{1 \text{ day}} = 1{,}454{,}112 \text{ gal/day}$

or

$\underline{1.45 \text{ MGD}}$

6. A pipe has a diameter of 3.0 feet and is full of water. If the flow velocity through the pipe is 100 feet per minute, what is the flow rate through the pipe in cubic feet per second?

Flow rate? ft^3/sec $Q = V \times A$



Area $= \pi R^2$

$= 3.14 \times (1.5)^2 = 7.065 \text{ ft}^2$

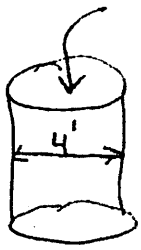
$Q = V \times A$

Q = Flow rate, V = velocity, A = area

$= 100 \frac{\text{ft}}{\text{min}} \times 7.065 \text{ ft}^2 = 706.5 \frac{\text{ft}^3}{\text{min}} \times \frac{1 \text{ min}}{60 \text{ sec}}$

$= 11.8 \text{ ft}^3/\text{sec}$

7. A pump discharges into a 4.0 foot diameter barrel. If the water level in the barrel rises 30 inches in 30 seconds, what is the flow into the barrel in gallons per minute?



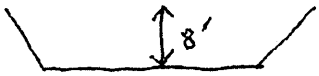
flow rate? (gallons/min) $Q = V \times A$

$\text{Area} = \pi R^2 = 3.14 \times (2)^2 = 12.56\ ft^2$

$\frac{30\ \text{inches}}{30\ \text{seconds}} \times \frac{1\ \text{foot}}{12\ \text{inches}} \times \frac{60\ \text{seconds}}{1\ \text{minute}} = 5\ ft/min$

$\frac{5\ ft}{min} \times 12.56\ ft^2 = 62.8\ \frac{ft^3}{min} \times \frac{7.48\ gal}{1\ ft^3} = \underline{469.7\ gal/min}$

8. If a stabilization pond is 8 feet deep and 6.0 acres in area, and is filled to the top, how many gallons does it hold? Assuming a discharge rate of 2 cfs, how many hours would it take to bring the level down to 4 feet?



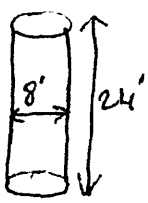
gallons? (volume) $6\ \text{acres} \times \frac{43{,}560\ ft^2}{1\ \text{acre}} = 261{,}360\ ft^2$

$261{,}360\ ft^2 \times 8\ ft = 2090{,}880\ ft^3 \times \frac{7.48\ gal}{1\ ft^3} = \underline{15{,}639{,}782\ gal}$

hours? (time) $1{,}045{,}440\ ft^3$ to discharge

$1{,}045{,}440\ ft^3 \times \frac{sec}{2\ ft^3} \times \frac{1\ min}{60\ sec} \times \frac{1\ hr}{60\ min} = \underline{145.2\ \text{hours}}$

9. The wet well of a lift station is in the form of a cylinder with a diameter of 8 feet and a depth of 24 feet. One pump starts up when the wastewater is 9 feet deep and pumps at a rate of 420 gpm. When the wastewater is 1 foot deep the pump shuts off.
A) If wastewater is entering the wet well at an average rate of 180 gpm, how long will the pump run?
B) What is the rest period between pump shut down and start up?



A) how long? time $V = \pi R^2 \times h = 3.14\ (4')^2 \times 8'$

$= 401.92\ ft^3 \times \frac{7.48\ gal}{1\ ft^3}$

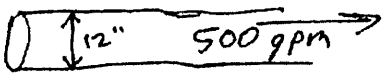
$= 3{,}006.4\ gal$

$3{,}006.4\ gal \times \frac{1\ min}{240\ gal} = \underline{12.53\ \text{minutes}}$

(B) rest period = time?

$3{,}006.4\ gal \times \frac{1\ min}{180\ gal} = \underline{16.7\ \text{minutes}}$

10. A turbine pump set at a rate of 500 gpm is pumping water through a 12 inch main. How fast is the water traveling through the pump in feet per second?



how fast? (velocity) in feet/second

$Q = V \times A$

Flow rate = velocity × area

$\text{Area} = \pi R^2$

$= 3.14 (.5')^2$

$= .785 \text{ ft}^2$

$\frac{500 \text{ gal}}{\text{min}} \times \frac{1 \text{ ft}^3}{7.48 \text{ gal}} = 66.8 \frac{\text{ft}^3}{\text{min}}$

$\frac{66.8 \text{ ft}^3}{\text{min}} = V \times .785 \text{ ft}^2$

$V = 85.1 \text{ ft/min} \times \frac{1 \text{ min}}{60 \text{ sec}} =$

1.42 ft/sec

11. A storage tank contains 50,000 gallons. How much HTH (at 65% chlorine) in pounds must be added to chlorinate the water to 12 mg/L if the water already contains 1 mg/L? pounds of HTH? (weight)

Chemical feed (lbs.) = Flow rate (MGD) or Storage (million gallons) × dosage (mg/L) × 8.34 lbs/gal

$\left(50{,}000 \text{ gal} \times \frac{1 \text{ lbs}}{\text{million lbs}} \times \frac{8.34 \text{ lbs}}{\text{gal}}\right)$

$= .05 \text{ Million gal} \times 1 \text{ mg/L} \times 8.34 \text{ lbs/gal}$

$= 4.587 \text{ lbs @ 100\% Chlorine}$

$4.587 \div .65 =$ 7 lbs. HTH

12. You are to disinfect a water storage tank by maintaining a 50 mg/L chlorine solution in the tank for 24 hours. If the tank is 40 feet in diameter and 70 feet high, how many pounds of HTH (65% chlorine) are needed? pounds of HTH? (weight)

$\text{Volume} = \pi R^2 h = 3.14 \times (20')^2 \times 70'$

$= 87{,}920 \text{ ft}^3 \times \frac{7.48 \text{ gal}}{1 \text{ ft}^3} = 657{,}642 \text{ gal}$

$.657642 \text{ mg} \times 50 \text{ mg/L} \times 8.34 \text{ lbs/gal}$

$= 274 \text{ lbs @ } 100\% \div .65$

$=$ 422 lbs HTH

13. A water plant is treating 1,000,000 gallons in 8 hours. A test for free chlorine residual of the plant indicates a level of 0.5 mg/L. Based on experience, the operator knows they must bring the free chlorine residual up to 2.0 mg/L at the plant in order to maintain a level of 1.0 mg/L free residual in the distribution system. If the rotameter on the chlorinator is set at 45, what must the new setting be? Setting on rotameter? pounds of HTH?

$3\ MGD \times 1.5\ mg/L \times 8.34\ lbs/gal = 37.5\ lbs$

$+ 45$ (original)

$82.5\ lbs/day$

14. A filter bed is 20 feet wide and 30 feet long. The operator backwashes the filter for 20 minutes and the backwash meter reads 130,000 gallons. What is the backwash rate in gpm/ft^2? backwash rate in gal/min/ft^2

$Area = 20' \times 30' = 600\ ft^2$

$$\frac{130{,}000\ gal}{20\ min} = \frac{6{,}500\ gal}{min} \div 600\ ft^2 = 10.83\ gal/min/ft^2$$

15. Calculate the volatile solids in mg/L for a 50 mL sample based on the following information:

Tared weight of crucible = 13.24 grams
Sample and crucible weight after drying = 13.68 grams
Sample and crucible weight after ignition = 13.38 grams

$13.68\ grams - 13.38\ grams = \frac{.3\ g}{50\ mL}$

$$\frac{.3\ g}{50\ mL} \times \frac{1{,}000\ mg}{1\ gram} \times \frac{1000\ mL}{1\ Liter} = 6{,}000\ mg/L$$

16. The total suspended solids in a raw wastewater sample is 500 mg/L. At a mechanical treatment plant, the primary clarifier removes 60% of the suspended solids. How many pounds of dry solids are removed each day if the flow into the plant is 1,300,000 gallons per day? lbs of solids?

$1.3\ MGD \times 500\ mg/L \times 8.34\ lbs/gal$

$= 5,421\ lbs\ (100\%)$

$5,421\ lbs \times .6 = \underline{3,252.6\ lbs.}$

17. A lagoon system has a primary cell of 7.8 acres and one secondary cell of 7.4 acres. Assume the cells are 8 feet deep, there are 2 feet of dead storage at the bottom of the cells, and there are 3 feet of freeboard. If the population in the community is 1,464, and the daily flow is 75 gallons/capita, how many days storage does this system have? days of storage?

$7.8\ acres + 7.4\ acres = 15.2\ acres \times \frac{43,560\ ft^2}{1\ acre} = 662,112\ ft^2 \times 3\ ft$

$= 1,986,336\ ft^3$

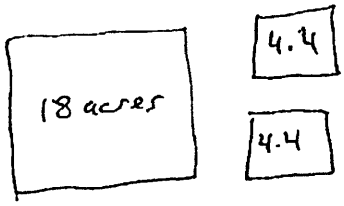
$1,986,336\ ft^3 \times \frac{7.48\ gal}{1\ ft^3} = 14,857,793\ gal$

$1,464\ people \times \frac{75\ gal}{person/day} = 109,800\ gal/day$

$14,857,793\ gal \times \frac{1\ day}{109,800\ gal}$

$= \underline{135\ days}$

18. A three cell lagoon system has a primary cell area of 18 acres and two secondary cells of 4.4 acres each. If the maximum allowable BOD_5 loading is 30 lbs/acre/day on the primary cell and 20 lbs/acre/day over the entire system, what size community is this system adequate for, based on BOD_5 loading? Assume a per capita BOD_5 contribution of 0.17 lbs/day. size community? (# of people)

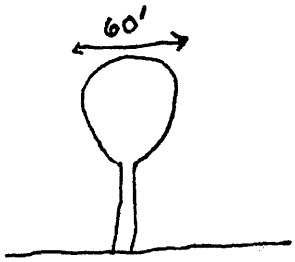


Total = $26.8\ acres \times 20\ lbs/acre/day$

$= 536\ lbs/day \div .17\ lbs/day/person$

$= \underline{3,153\ people}$

19. An elevated storage tank is sphere shaped with a diameter of 60 feet. How many gallons of water can this tank hold?



$V = \frac{4}{3} \pi R^3$

$= \frac{4}{3} \times 3.14 \times (30')^3$

$= 112,757.4\ ft^3 \times \frac{7.48\ gal}{1\ ft^3}$

(using $\frac{4}{3} = 1.33$)

$= \underline{843,425.35\ gal}$

20. A basin is 50 feet by 25 feet by 20 feet, with a flow of 2 million gallons per day through the basin. What will the detention time be?

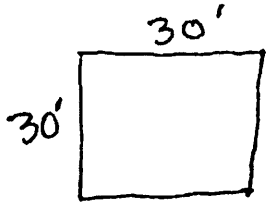
$50' \times 25' \times 20' = 25,000\ ft^3 \times \frac{7.48\ gal}{1\ ft^3} = 187,000\ gal$

$187,000\ gal \times \frac{1\ day}{2,000,000\ gal} = \underline{.0935\ day} \times \frac{24\ hrs}{1\ day}$

or

$\underline{2.24\ hours}$

21. Your plant has a 30 foot square rapid sand filter. What capacity pump may be used to produce a filter loading of 0.5 gallons per square foot per minute?



$\frac{.5\ gal/ft^2}{min} \times 30\ ft \times 30\ ft$

$= \underline{450\ gal/min}$