Rural Community Assistance Corporation
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WELCOME!

Water Treatment Math

California Water Boards
State Water Resources Control Board
Regional Water Quality Control Boards

Your Moderator Today…

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Rural Development Specialist: Environmental
Gering, NE

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WELCOME!

This training is presented by RCAC with funding provided by the California State Water Resources Control Board Division of Drinking Water (DDW)

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CALIFORNIA Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

The Rural Community Assistance Partnership

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RCAC Programs

- Affordable housing
- Community facilities
- Water and wastewater infrastructure financing (Loan Fund)
- Classroom and online training
- On-site technical assistance
- Median Household Income (MHI) surveys

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Performance Assessment Rating Tool (PART)

- 4 to 6 weeks from today
- Email w/ today's workshop in subject line
- 2 questions – 3 minutes maximum
- How did you use the information that was presented today?
- Funders are looking for positive changes
- Help us continue these free workshops!

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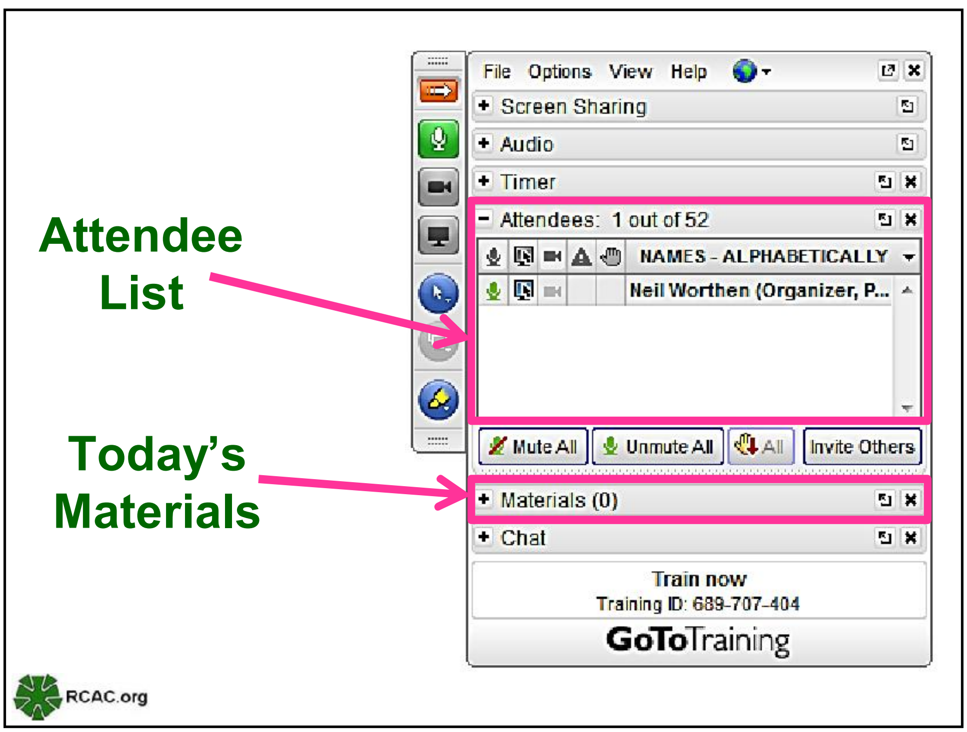
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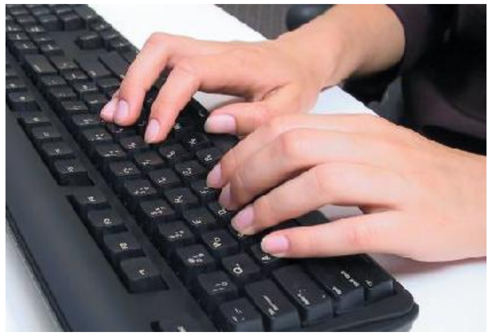
Questions?



Text your questions and comments anytime during the session

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Your Trainer Today

- John Hamner

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WELCOME!

Water Treatment Math

CALIFORNIA
Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

Water Math Topics Today

- Expected Range of Knowledge
  - Basic conversions
  - Volumes
  - Chlorination & chemical feed
  - Detention time
  - Filtration
  - Velocity
  - Misc

State Water Resources Control Board

Drinking Water Treatment Exams
Expected Range of Knowledge

Exam Content	Number of questions			
Grade	T1	T2	T3	T4
Source Water	25	25	20	15
Water Treatment Processes	25	25	35	20
Operation/Maintenance	20	20	15	15
Laboratory Procedures	15	15	15	15
Regulations/Administrative Duties	15	15	15	35

Source Water

Watershed Protection, Wells / Groundwater, Surface Water / Reservoirs, Raw Water Storage, Clear Well Storage

Water Treatment Processes

Coagulation/Flocculation/ Sedimentation, Filtration, Disinfection, Demineralization, Corrosion Control, Iron and Manganese removal, Fluoridation, Water Softening, BAT, (Best Available Technology)

Operation / Maintenance

Chemical feeders, Pumps and Motors, Blowers and Compressors, Water meters, Pressure gauges, Electrical generators, Safety, SCADA systems

Laboratory Procedures

Sampling, General Lab Practices, Disinfectant analysis, Alkalinity analysis, pH analysis, Turbidity analysis, Specific conductance, Hardness, Fluoride analysis, Color analysis, Taste and Odor analysis, Dissolved Oxygen analysis, Algae Count, Bacteriological analysis

Regulations/Administrative Duties

Planning, Organizing, Directing, Controlling, Staffing, Implementing Regulations, Record keeping, Safe Drinking Water Act and amendments, Surface Water Treatment Rule and amendments, Primary Contaminants, Secondary Contaminants, Lead and Copper Rule, Fluoride Regulations, Operator Certification Regulations

EXPECTED RANGE OF KNOWLEDGE
WATER TREATMENT EXAMS

(Items marked "T1-T4" may be on the T1 – T4 exams)
(Items marked "T2-T4" may be on the T2 – T4 exams but not on the T1 exam)

Source Water

Wells/Groundwater

T1-T4	Knowledge of the characteristics of aquifers
T1-T4	Knowledge of the chemical components of groundwater
T1-T4	Knowledge of potential contamination in groundwater
T1-T4	Knowledge of well sampling techniques
T1-T4	Knowledge of groundwater characteristics
T1-T4	Ability to analyze water quality characteristics
T1-T4	Ability to calculate well drawdown
T2-T4	Ability to recognize hydrological changes
T2-T4	Ability to calculate a disinfectant dosage in a well
T2-T4	Ability to recognize the influence of surface water on a groundwater source
T2-T4	Ability to calculate well specific capacity
T3-T4	Knowledge of the source water assessment process
T3-T4	Ability to recognize abnormal chemical characteristics of water
T3-T4	Ability to calculate well head pressure

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Water Treatment Exam Math

T1-T4	Ability to calculate well drawdown
T1-T4	Ability to calculate flow rates, water velocity
T1-T4	Ability to calculate the volume of water contained in a storage facility
T1-T4	Ability to calculate a chemical, disinfectant dosage
T1-T4	Ability to determine water level
T1-T4	Ability to calculate volumes, dilution factors, feed rates, and chemical concentrations
T1-T4	Ability to calculate a de-chlorination dosage
T1-T4	Ability to calculate chlorine residual
T1-T4	Ability to convert a head pressure to water elevation
T2-T4	Ability to calculate well specific capacity
T2-T4	Ability to calculate detention time
T2-T4	Ability to calculate chemical solution concentration
T2-T4	Ability to calculate filter-aid dosage
T2-T4	Ability to calculate filter backwash rate
T2-T4	Ability to calculate an ammonia/chlorine ratio
T2-T4	Ability to calculate a chemical feed rate (dose) for corrosion control
T2-T4	Ability to calculate a chemical dosage for Fe/Mn removal, fluoridation
T2-T4	Ability to calculate a dosage on a chemical feeder

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What are we actually doing?

We are CONVERTING!

- Pay attention to the units of measure…

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Examples…

24 hr/day x 60 min/hr x 60 sec/min = sec/day

MGD x 8.34 lbs/gal x ppm = lbs/day

50 ft x .433 psi/ft = psi

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Water Math – Terms, Definitions and Water Measurements

- Square feet = sq ft (ft2)
- Cubic feet = cu ft (ft3)
- Acre feet = ac ft
- Gallons per acre foot = gal/ac ft
- Inches per foot = in/ft
- Mile = mi
- Feet per mile = ft/mi

Water Math – Terms, Definitions and Water Measurements

- Gallons per cubic ft = gal/cu ft
- Pounds per gallon = lbs/gal
- Pounds per square inch = psi
- Gallons per day = gpd
- Gallons per minute = gpm
- What about percentages?

What would 75% be in the form of a decimal?

75

.75

7.5

75.0

.075

75.0

What would 5% be in the form of a decimal?

5

.05

5.0

5.00

.005

005.0

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC HEALTH
DRINKING WATER OPERATOR CERTIFICATION PROGRAM

Units and Conversion Factors

1 cubic foot of water weighs 62.3832 lb
1 gallon of water weighs 8.34 lb
1 liter of water weighs 1,000 gm
1 mg/L = 1 part per million (ppm)
1% = 10,000 ppm
ft^2 = square feet and ft^3 = cubic feet
1 mile = 5,280 feet (ft)
1 yd^3 = 27 ft^3 and 1 yard = 3 feet
1 acre (a) = 43,560 square feet (ft^2)
1 acre foot = 325,829 gallons
1 cubic foot (ft^3) = 7.48 gallons (gal)
1 gal = 3.785 liters (L)
1 L = 1,000 milliliters (ml)
1 pound (lb) = 454 grams (gm)
1 lb = 7,000 grains (gr)
1 grain per gallon (gpg) = 17.1 mg/L
1 gm = 1,000 milligrams (mg)
1 day = 24 hr = 1,440 min = 86,400 sec
1,000,000 gal/day ÷ 86,400 sec/day ÷ 7.48 gal/cu ft = 1.55 cu ft/sec/MGD

CHLORINATION

Dosage, mg/l = (Demand, mg/l) + (Residual, mg/l)

(Gas) lbs = Vol. MG x ppm or mg/L x 8.34 lbs/gal

HTH Solid (lbs) = (Vol. MG) x (ppm or mg/L) x 8.34 lbs/gal / (% Strength / 100)

Liquid (gal) = (Vol. MG) x (ppm or mg/L) x 8.34 lbs/gal / (% Strength /100) x Chemical Wt (lbs/gal)

PRESSURE

PSI = (Head, ft) / 2.31 ft/psi   PSI = Head, ft x 0.433 PSI/ft

lbs. Force = (0.785) (D, ft)^2 x 144 in^2/ft^2 PSI

VOLUME

Rectangular Basin Volume, gal = (Length, ft) x (Width, ft) x (Height, ft) x 7.48 gal/cu ft

Cylinder Volume, gal = (0.785) x (Dia, ft)^2 x (Height, Depth, or Length in ft) x 7.48 gal/ft^3

Time, Hrs = Volume, gallons / (Pumping Rate, GPM, x 60 Min/hr)

Supply, Hrs = Storage Volume, Gals / ((Flow In, GPM − Flow Out, GPM) x 60 min/hr)

SOLUTIONS

Lbs/Gal = (Solution %) / 100 x 8.34 lbs/gal x Specific Gravity

Lbs Chemical = Specific Gravity x 8.34 lbs/gallons x Solution (gal)

Specific Gravity = Chemical Wt (lbs/gal) / 8.34 (lbs/gal)

% of Chemical in Solution = (Dry Chemical, Lbs) x 100 / ((Dry Wt Chemical, Lbs) + (Water, Lbs))

GPD = (MGD) x (ppm or mg/L) x 8.34 lbs/gal / ((% purity) x Chemical Wt (lbs/gal))

GPD = (Feed, ml/min x 1,440 min/day) / (1,000 mL x 3.785 L/Gal)

Two – Normal Equations:
a) $C_1V_1 = C_2V_2$ $\frac{Q_1}{V_1} = \frac{Q_2}{V_2}$
b) $C_1V_1 + C_2V_2 = C_3V_3$

C = Concentration, V = Volume, Q = Flow

PUMPING

1 horsepower (Hp) = 746 watts = 0.746 kw = 3960 gal-min/ft

Water Hp = (GPM) x (Total Head, ft) / (3960 gal-min/ft)

Brake Hp = (GPM) x (Total Head, ft) / ((3960) x (Pump % Efficiency))

Motor Hp = (GPM) x (Total Head, ft) / ((3960) x Pump % Eff x Motor % Eff)

"Wire to Water" Efficiency = (Motor % Efficiency x Pump % Efficiency)

Cost, $ = (Hp) x (0.746 Kw/Hp) x (Operating Hrs.) x cents/KW-Hr

Flow, velocity, area

Q = A x V   Quantity = Area x Velocity

Flow (ft^3/sec) = Area (ft^2) x Velocity (ft/sec)

MGD x 1.55 cu ft/sec/MGD / (.785 x pipe diameter ft x pipe diameter ft) = cu ft/sec / sq ft = ft/sec

General

($) Cost / day = Lbs/day x ($) Cost/lb

Removal, Percent = (In − Out) / In x 100

Specific Capacity, GPM/ft = Well Yield, GPM / Drawdown, ft

Gals/Day = (Population) x (Gals/Capita/Day)

GPD = (Meter Read 2 − Meter Read 1) / (Number of Days)

Volume, Gals = GPM x Time, minutes

SCADA = 4 mA to 20 mA analog signal

(live signal mA − 4 mA off set) x process unit and range / (16 mA span)

4 mA = 0   20 mA full range

FILTRATION

Filtration Rate (GPM/sqft) = Filter Production (gallons per day) / ((Filter area sq ft) x (1,440 min/day))   sq ft = square feet

Loading Rate (GPM/ sq ft) = (Flow Rate, GPM) / (Filter Area, sq ft)

Daily Filter Production (GPD) = (Filter Area, sq ft) x (GPM/ sq ft x 1,440 min/day)

Backwash Pumping Rate (GPM) = (Filter Area, sq ft) x (Backwash Rate, GPM/ sq ft)

Backwash Volume (Gallons) = (Filter Area sq ft) x (Backwash Rate, gpm/ sq ft) x (Time, min)

Backwash Rate, GPM/ sq ft = (Backwash Volume, gallons) / ((Filter Area, sq ft) x (Time, min))

Rate of Rise (inches per min) = (backwash rate gpm/sq ft) x 12 inches/ft / 7.48 gal/cu ft

Unit Filter Run Volume (UFRV) = (gallons produced in a filter run) / (filter area sq ft)

C• T CALCULATIONS

C•t = (Chlorine Residual, mg/L) x (Time, minutes)

Time, minutes = (C• t) / (Chlorine Residual, mg/L)

Chlorine Residual (mg/L) = (C• t) / (Time, minutes)

Inactivation Ratio = (Actual System C• t) / (Table "E" C• t)

C• t Calculated = T_{10} Value, minutes x Chlorine Residual, mg/L

Log Removal = 1.0 − (% Removal / 100) x Logkey x (−1)

SEDIMENTATION

Surface Loading Rate (GPD/ sq ft) = (Total Flow, GPD) / (Surface Area, sq ft)

Detention Time = Volume / flow

Detention Time hours = volume (cu ft) x 7.48 gal/cu ft x 24 hr/day / Gal/day

Flow Rate = Volume / Time

Weir Overflow Rate, GPD/L.F. = (Flow, GPD) / (Weir length, ft)

Chemical Dosage Calculations

Note (% purity) and (% commercial purity) used in decimal form

Lbs/day gas feed dry = MGD x (ppm or mg/L) x 8.34 lbs/gal

Lbs/day = MGD x (ppm or mg/L) x 8.34 lbs/gal / % purity

GPD = MGD x (ppm or mg/L) x 8.34 lbs/gal / ((% purity) x lbs/gal)

GPD = MGD x (ppm or mg/L) x 8.34 lbs/gal / ((commercial purity %) x (ion purity %) x (lbs/gal))

ppm or mg/l = lbs/day / (MGD x 8.34 lbs/gal)   or   gallons x % purity x lbs/gal / (MG x 8.34 lbs/gal)

Units and Conversion Factors	
1 cubic foot of water weighs 62.3832 lb 1 gallon of water weighs 8.34 lb 1 liter of water weighs 1,000 gm 1 mg/L = 1 part per million (ppm) 1% = 10,000 ppm ft^2 = square feet and ft^3 = cubic feet 1 mile = 5,280 feet (ft) 1 yd^3 = 27ft^3 and 1 yard = 3 feet 1 acre (a) = 43,560 square feet (ft^2) 1 acre foot = 325,829 gallons 1 cubic foot (ft^3) = 7.48 gallons (gal) 1 gal = 3.785 liters (L) 1 L = 1,000 milliliters (ml) 1 pound (lb) = 454 grams (gm) 1 lb = 7,000 grains (gr) 1 grain per gallon (gpg) = 17.1 mg/L 1 gm = 1,000 milligrams (mg) 1 day = 24 hr = 1,440 min = 86,400 sec 1,000,000 gal/day ÷ 86,400 sec/day ÷ 7.48 gal/cu ft = 1.55 cu ft/sec/MGD	**State of California Math Conversion Sheet Provided At Exam**

CHLORINATION

Dosage, mg/l = (Demand, mg/l) + (Residual, mg/l)

(Gas) lbs = (Vol, MG) x (Dosage, mgl) x (8.34 lbs/gal)

HTH Solid (lbs) =

$$\frac{\text{(Vol, MG) x (Dosage, mg/l) x (8.34lbs/gal)}}{\text{(\% Strength / 100)}}$$

Liquid (gal) =

$$\frac{\text{(Vol, MG) x (Dosage, mg/l) x (8.34 lbs/gal)}}{\text{(\% Strength /100) x Chemical Wt. (lbs/gal)}}$$

PRESSURE

PSI = $\frac{\text{(Head, ft.)}}{2.31\text{ft./psi}}$ **PSI** = Head, ft. x 0. 433 PSI/ft.

lbs Force = (0.785) (D, ft.)2 x 144 in2/ft2 PSI.

VOLUME

Rectangular Basin =

Volume, gal

(Length, ft) x (Width, ft) x (Height, ft) x7.48 gal/cu.ft.

Cylinder , Volume, gal =

(0.785) x (Dia, ft)**2** x (Height, Length, Depth, in ft.) x 7.48 gal/ft3

Time, Hrs. = $\frac{\text{Volume, gallons)}}{\text{(Pumping Rate, GPM, x 60 Min/Hr)}}$

Supply, Hrs.= $\frac{\text{Storage Volume, Gals}}{\text{(Flow In, GPM – Flow Out, GPM) x 60 min/hr.)}}$

SOLUTIONS

$$\text{Lbs/Gal} = \frac{(\text{Solution \%})}{100} \times 8.34\ \text{lbs/gal} \times \text{Specific Gravity}$$

Lbs Chemical =

Specific Gravity x 8.34 lbs/gallons x Solution(gal)

$$\text{Specific Gravity} = \frac{\text{Chemical Wt (lbs/gal)}}{8.34\ \text{(lbs/gal)}}$$

$$\text{\% of Chemical in Solution} = \frac{(\text{Dry Chemical, Lbs})}{(\text{Dry Wt Chemical, Lbs}) + (\text{Water, Lbs})} \times 100$$

$$\text{GPD} = \frac{(\text{MGD}) \times (\text{ppm or mg/L}) \times 8.34\ \text{lbs/gal}}{(\text{\% purity}) \times \text{Chemical Wt (lbs/gal)}}$$

$$\text{GPD} = \frac{(\text{Feed, ml/min} \times 1{,}440\ \text{min/day})}{(1{,}000\ \text{ml/L} \times 3.785\ \text{L/Gal})}$$

Two – Normal Equations:

a) $C_1V_1 = C_2V_2$

$$\frac{Q_1}{V_1} = \frac{Q_2}{V_2}$$

b) $C_1V_1 + C_2V_2 = C_3V_3$

C = Concentration, V = Volume, Q = Flow

Flow, velocity, area

Q = A x V Quantity = Area x Velocity

Flow (ft^3/sec) = Area(ft^2) x Velocity (ft/sec)

$$\frac{\text{MGD} \times 1.55\ \text{cu ft/sec/MGD}}{.785 \times \text{pipe diameter ft} \times \text{pipe diameter ft}} = \frac{\text{cu ft/sec}}{\text{sq ft}} = \text{ft/sec}$$

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General

($) Cost / day = Lbs/day x ($) Cost/lb

Removal, Percent = $\frac{(\text{In} - \text{Out})}{\text{In}}$ x 100

Specific Capacity, GPM/ft. = $\frac{\text{Well Yield, GPM}}{\text{Drawdown, ft.}}$

Gals/Day **=** (Population) x (Gals/Capita/Day)

GPD **=** $\frac{(\text{Meter Read 2} - \text{Meter Read 1})}{(\text{Number of Days})}$

Volume, Gals = GPM x Time, minutes

FILTRATION

Filtration Rate (GPM/sq.ft) = $\frac{\text{Filter Production (gallons per day)}}{(\text{Filter area sq. ft.}) \times (1{,}440 \text{ min/day})}$ sq. ft. = square feet

Loading Rate (GPM/ sq. ft.) = $\frac{(\text{Flow Rate, GPM})}{(\text{Filter Area, sq. ft.})}$

Daily Filter Production (GPD) = (Filter Area, sq. ft.) x (GPM/ sq. ft. x 1,440 min/day)

Backwash Pumping Rate (GPM) = (Filter Area, sq. ft.) x (Backwash Rate, GPM/ sq. ft.)

Backwash Volume (Gallons) = (Filter Area, sq. ft.) x (Backwash Rate, gpm/ sq. ft.) x (Time, min)

Backwash Rate, GPM/ sq. ft. = $\frac{(\text{Backwash Volume, gallons})}{(\text{Filter Area, sq. ft.}) \times (\text{Time, min})}$

Rate of Rise (inches per min.) = $\frac{(\text{backwash rate gpm/sq.ft.}) \times 12 \text{ inches/ft}}{7.48 \text{ gal/cu.ft.}}$

Unit Filter Run Volume, (UFRV) = $\frac{(\text{gallons produced in a filter run})}{(\text{filter area sq. ft.})}$

SEDIMENTATION

Surface Loading Rate, (GPD/sq.ft.) $= \frac{\text{(Total Flow, GPD)}}{\text{(Surface Area, sq.ft.)}}$

Detention Time $= \frac{\text{Volume}}{\text{flow}}$

Detention Time hours $= \frac{\text{volume (cu ft) x 7.48 gal/cu ft x 24 hr/day}}{\text{Gal/day}}$

Flow Rate $= \frac{\text{Volume}}{\text{Time}}$

Weir Overflow Rate, GPD/L.F. $= \frac{\text{(Flow, GPD)}}{\text{(Weir length, ft.)}}$

Chemical Dosage Calculations

Note (% purity) and (% commercial purity) used in decimal form

Lbs/day gas feed dry = MGD x (ppm or mg/L) x 8.34 lbs/gal

Lbs/day = $\frac{\text{MGD x (ppm or mg/L) x 8.34 lbs/gal}}{\text{\% purity}}$

GPD = $\frac{\text{MGD x (ppm or mg/L) x 8.34 lbs/gal}}{\text{(\% purity) x lbs/gal}}$

GPD = $\frac{\text{MGD x (ppm or mg/L) x 8.34 lbs/gal}}{\text{(commercial purity \%) x (ion purity \%) x (lbs/gal)}}$

ppm or mg/l = $\frac{\text{lbs/day}}{\text{MGD x 8.34 lbs/gal}}$ or $\frac{\text{gallons x \% purity x lbs/gal}}{\text{MG x 8.34 lbs/gal}}$

Simple conversions – box 1

1. Convert 10 cubic feet of water into pounds of weight

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Simple conversions – box 1

1. Convert 10 cubic feet of water into pounds of weight

10 cu ft x 62.38 lbs/cu ft =

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Simple conversions – box 1

2. How many pounds does 15 gallons of water weigh?

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Simple conversions – box 1

2. How many pounds does 15 gallons of water weigh?

15 gal x 8.34 lb/gal =

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Simple conversions – box 1

3. How many ppm are in 20 mg/L?

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Simple conversions – box 1

3. How many ppm are in 20 mg/L?

20 ppm = 20 mg/L

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Simple conversions – box 1

4. How many square feet does a wall have if it measures 10 feet tall and 20 feet wide?

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Simple conversions – box 1

4. How many square feet does a wall have if it measures 10 feet tall and 20 feet wide?

10 ft x 20 ft = sq ft or ft2

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Simple conversions – box 1

5. How many cubic feet of volume does a storage tank have if it measures 20 feet wide, 30 feet long and 10 feet deep?

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Simple conversions – box 1

5. How many cubic feet of volume does a storage tank have if it measures 20 feet wide, 30 feet long and 10 feet deep?

20 ft x 30 ft x 10 ft = cu ft or ft3

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Simple conversions – box 1

6. How many cubic yards (yd3) are removed from a trench that was 3 feet wide, 4 feet deep and 50 feet long?

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Simple conversions – box 1

6. How many cubic yards (yd3) are removed from a trench that was 3 feet wide, 4 feet deep and 50 feet long?

$$\frac{3 \text{ ft} \times 4 \text{ ft} \times 50 \text{ ft}}{27 \text{ cu ft/cu yd}} =$$

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Simple conversions – box 1

7. How many feet are in 2 miles?

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Simple conversions – box 1

7. How many feet are in 2 miles?

2 mi x 5280 ft/mi =

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Simple conversions – box 1

8. How many gallons of water are in 3 acre feet of water?

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Simple conversions – box 1

8. How many gallons of water are in 3 acre feet of water?

3 ac ft x 325,829 gal/cu ft =

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Simple conversions – box 1

9. How many gallons of water are in 25 cubic feet of volume?

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Simple conversions – box 1

9. How many gallons of water are in 25 cubic feet of volume?

25 cu ft x 7.48 gal/cu ft =

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Simple conversions – box 1

10. How many gallons are pumped each day if a pump is capable of pumping 50 gallons per minute and the pump runs for 9 hours a day?

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Simple conversions – box 1

10. How many gallons are pumped each day if a pump is capable of pumping 50 gallons per minute and the pump runs for 9 hours a day?

50 gal/min x 60 min/hr x 9 hr/day =

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Questions?

Text your questions and comments anytime during the session

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<u>CHLORINATION</u>

Dosage, mg/l **=** (Demand, mg/l) + (Residual, mg/l)

(Gas) lbs **=** (Vol, MG) x (Dosage, mgl) x (8.34 lbs/gal)

HTH Solid (lbs) **=**

$$\frac{\text{(Vol, MG) x (Dosage, mg/l) x (8.34lbs/gal)}}{\text{(\% Strength / 100)}}$$

Liquid (gal) **=**

$$\frac{\text{(Vol, MG) x (Dosage, mg/l) x (8.34 lbs/gal)}}{\text{(\% Strength /100) x Chemical Wt. (lbs/gal)}}$$

What am I adding to the water to treat it?

- Chemicals
- Chlorine
  - Gas
  - Calcium hypochlorite
  - Sodium hypochlorite

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Water Math Conversions – Chemical/Chorine Dosage

In dosage problems, quantities of chemical are *given* in the following increments:

- Lbs *or* lbs/day
- Gallons (chemical solution quantity) *or* Gal/day
- mg/L *or* ppm
- MG *or* MGD

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What does Miller Genuine Draft have to do with water treatment?

When working dosage, convert Q to MG or MGD!

How many MGD is 2,000,000 gal/day?

A. 2 MGD

B. .2 MGD

C. .02 MGD

What is not given in the question?

- THE CONVERSION NUMBER!
  - 8.34 lbs/gal
  - Chemical weight
  - 8.34 lbs/gal X specific gravity

Dosage

- Example: If a given water source had a chlorine demand of 3 mg/L and you wanted a chlorine residual of .5 mg/L leaving the plant, what would your dose be?

Dosage, mg/l = (Demand, mg/l) + (Residual, mg/l)

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Chlorination – box 2

1. If the chlorine dose added to drinking water equaled 10 mg/L and the chlorine demand was 9 mg/L, what is the chlorine residual in ppm?

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Chlorination – box 2

1. If the chlorine dose added to drinking water equaled 10 mg/L and the chlorine demand was 9 mg/L, what is the chlorine residual in ppm?

10 mg/L – 9 mg/L = 1 mg/L

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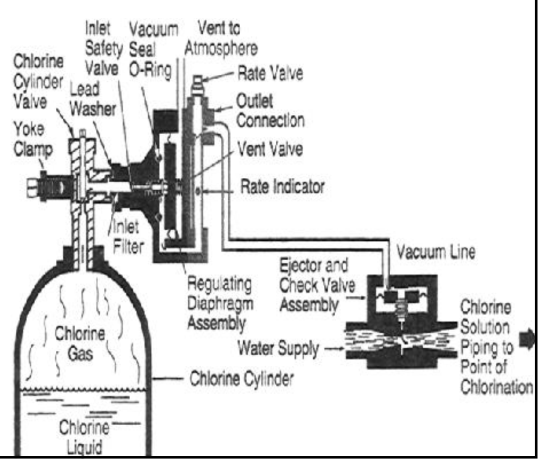
Chlorine Gas

- Chlorine gas is fed in lbs or lbs/day



Chlorination – box 2

- Example: If a chlorine gas concentration of 15 ppm were added to a storage tank holding 2.5 MG, how many lbs of chlorine would be needed?

(Gas) lbs = (Vol, MG) x (Dosage, mgl) x (8.34 lbs/gal)

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Chlorination – box 2

2. If a storage tank had 1 MG of water and it needed to be dosed with 11 mg/L of gas chlorine, how many pounds of chlorine would this take?

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Chlorination – box 2

2. If a storage tank had 1 MG of water and it needed to be dosed with 11 mg/L of gas chlorine, how many pounds of chlorine would this take?

1 MG x 8.34 lb/gal x 11 mg/L = 91.74 lb

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Chlorination – box 2

- Example: If a new storage tank measured 40 ft in diameter and were 30 ft tall, how many pounds of chlorine gas would be needed to dose this tank at 9 mg/L?

(Gas) lbs= (Vol, MG) x (Dosage, mgl) x (8.34 lbs/gal)

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Chlorination – box 2

- Example: If a new storage tank measured 40 ft in diameter and were 30 ft tall, how many pounds of chlorine gas would be needed to dose this tank at 9 mg/L?

.785 x 40 ft x 40 ft x 30 ft x 7.48 gal/ft3 = 281,846

(Gas) lbs= (Vol, MG) x (Dosage, mgl) x (8.34 lbs/gal)

Chlorination – box 2

- Example: If a water pipe were 2 miles long and 8 inches in diameter, how many pounds of chlorine gas would have to be added for a dose of 6 ppm?

8 ÷ 12 = .666 ft and

2 x 5280 ft/mi = 10,560 ft, so

.785 x .666 x .666 x 10,560 x 7.48 = 27,503 gal

(Gas) lbs = (Vol, MG) x (Dosage, mgl) x (8.34 lbs/gal)

Questions?

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Dosage, Calcium Hypochlorite page 1

- An operator may be given dry chemicals (usually chlorine) that is not 100% strength
- Consider this in the dosage problem
- Remember to convert the % to a decimal (divide by 100)

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Percentages

- How would an operator enter the percentage 70% into the calculator?

A. 70

B. 7.0

C. .70

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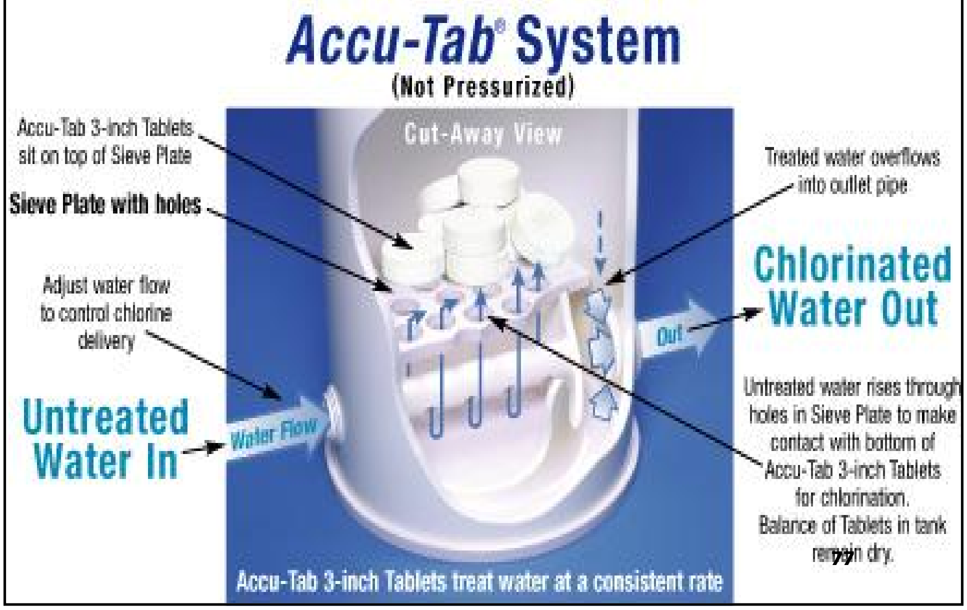
Calcium Hypochlorite

Calcium Hypochlorite



Chlorination – box 2

- Example: If a storage tank with 0.5 MG was treated with 65% calcium hypochlorite and the dose was 10 ppm, how many pounds of chemical would be needed?

HTH Solid (lbs) =

$$\frac{\text{(Vol MG) x Dosage, mg/L) x (8.34lbs/gal)}}{\text{(\% Strength/100)}}$$

Chlorination – box 2

3. If a 500,000 gallon storage tank was going to be dosed with 8 ppm of 65% HTH, how many pounds of HTH would this take?

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Chlorination – box 2

3. If a 500,000 gallon storage tank was going to be dosed with 8 ppm of 65% HTH, how many pounds of HTH would this take?

$$\frac{.5 \text{ MG} \times 8 \text{ ppm} \times 8.34 \text{ lb/gal}}{.65} = 51.31 \text{ lb}$$

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Chlorination – box 2

- Example: If a storage tank 50 feet in diameter & 40 feet tall was treated with 70% calcium hypochlorite at a dose of 10 ppm, how many pounds of chemical would be needed?

HTH Solid (lbs) **=**

$$\frac{\text{(Vol MG) x Dosage, mg/L) x (8.34lbs/gal)}}{\text{(\% Strength/100)}}$$

Chlorination – box 2

- Example: If a storage tank 50 feet in diameter & 40 feet tall was treated with 70% calcium hypochlorite at a dose of 10 ppm, how many pounds of chemical would be needed?

.785 x 50 ft x 50 ft x 40 ft x 7.48 gal/ft3 =

$$\frac{\text{.587 MG x 8.34 lbs/gal x 10 ppm}}{\text{.70}} = \text{69.9 lbs}$$

Chlorination – box 2

- Example: If 70% available HTH chlorine were added to water at a concentration of 15 ppm in a daily flow of 2.5 MGD, how many lbs would be used daily?

$$\frac{(\text{Vol MG}) \times \text{Dosage, mg/L}) \times (8.34\text{lbs/gal})}{(\text{ \% Strength}/100)}$$

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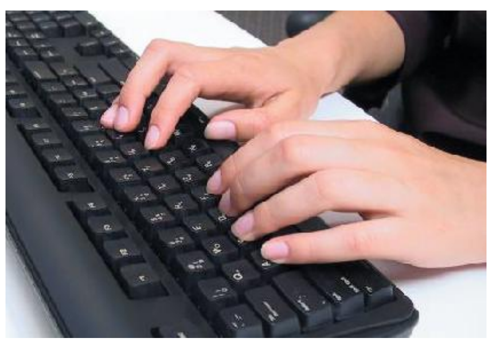
Questions?



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Disinfection with bleach

- Liquid comes in;
  - Gallon containers
  - 55 gallon drums
  - Large totes, bulk
- Does not weigh the same as a gallon of water, but…
- Assume it does if they do not mention it!

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Percentages

- How would an operator enter the percentage 5.25% into the calculator?

5.25

.525

.0525

.00525

.05

Chlorination – box 2

- Example: If .75 MG was treated with a 15% chlorine solution and a dose of 10 ppm was desired, how many gallons of solution would be required?

Liquid (gal) =

$$\frac{(\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34 \text{ lbs/gal})}{(\%\ \text{Strength}/100) \times \text{Chemical Wt. (lbs/gal)}}$$

Chlorination – box 2

4. A water storage tank with 1.2 MG is going to be chlorinated using 15% liquid chlorine at a dose of 4 ppm. How many gallons of chlorine will this take?

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Chlorination – box 2

4. A water storage tank with 1.2 MG is going to be chlorinated using 15% liquid chlorine at a dose of 4 ppm. How many gallons of chlorine will this take?

$$\frac{1.2 \text{ MG} \times 4 \text{ ppm} \times 8.34 \text{ lb/gal}}{.15 \times 8.34 \text{ lb/gal}} = 32 \text{ gal}$$

Chlorination – box 2

- Example: If 500,000 gallons was treated with a 5.25% chlorine solution weighing 9 lbs/gal and a dose of 10 ppm was desired, how many gallons of solution would be required?

Liquid (gal) =

$$\frac{(\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34 \text{ lbs/gal})}{(\ \%\ \text{Strength}/100) \times \text{Chemical Wt. (lbs/gal)}}$$

Chlorination – box 2

- Example: If 500,000 gallons was treated with a 5.25% chlorine solution weighing 9 lbs/gal and a dose of 10 ppm was desired, how many gallons of solution would be required?

$$\frac{.5 \text{ MG} \times 8.34 \text{ lbs/gal} \times 10 \text{ ppm}}{.0525 \times 9 \text{ lbs/gal}} = 88 \text{ gal}$$

Chlorination – box 2

- Example: If 600,000 gallons was treated with a 12.5% chlorine solution with a specific gravity of 1.2 and a dose of 11 ppm was desired, how many gallons of solution would be required?

$$\frac{.6 \text{ MG} \times 8.34 \text{ lbs/gal} \times 11 \text{ ppm}}{.125 \times (8.34 \text{ lbs/gal} \times 1.2)} = 44 \text{ gal}$$

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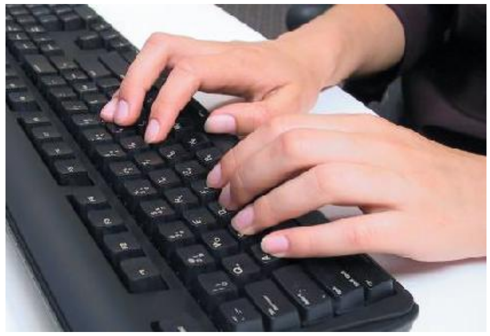
Questions?



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Chemical Dosage Calculations Part 1

Note (% purity) and (% commercial purity) used in decimal form

Lbs/day gas feed dry = MGD x 8.34 lbs/gal x (ppm/mg/L)

$$\text{Lbs/day} = \frac{\text{MGD} \times 8.34 \text{ lbs/gal} \times (\text{ppm or mg/l})}{\%\text{ purity}}$$

$$\text{GPD} = \frac{(\text{MGD}) \times (8.34 \text{ lbs/gal}) \times (\text{ppm or mg/l})}{(\%\text{ purity}) \times \text{lbs/gal}}$$

Dosage –box 13

- Example: If 70% available HTH chlorine were added to water at a concentration of 15 ppm in a daily flow of 2.5 MGD, how many lbs would be used daily?

$$\text{Lbs/day} = \frac{\text{MGD} \times 8.34 \text{ lbs/gal} \times (\text{ppm or mg/l})}{\%\ \text{purity}}$$

Dosage – box 13

- Example: If 65% available calcium hypochlorite were added to water at a concentration of 9 mg/L in a flow of 750,000 gal/day, how many lbs would be used daily?

$$\text{Lbs/day} = \frac{\text{MGD} \times 8.34 \text{ lbs/gal} \times (\text{ppm or mg/l})}{\%\ \text{purity}}$$

Dosage formula for pounds removal!

- Example: If a raw water source has an iron concentration of 50 ppm and the daily flow is 1.2 MGD, how many pounds per day are removed if the filters remove 70% of the iron in the raw water?

Pounds solids removed=
(Vol, MG) x (Dosage, mg/l) x (8.34lbs/gal) x (% removed)

Disinfection with bleach

- Liquid comes in;
  - Gallon containers
  - 55 gallon drums
  - Large totes
  - Bulk
- Does not weigh the same as a gallon of water
- Assume it does if they do not mention it!

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Dosage – box 13

- Example: If 15% chlorine bleach were added to your water at a concentration of 15 ppm, and your daily flow was 2.5 MGD, how many gallons would be needed daily?

$$GPD = \frac{(MGD) \times (8.34\ lbs/gal) \times (ppm\ or\ mg/l)}{(\%\ purity) \times lbs/gal}$$

Dosage – box 13

- Example: If 12.5% chlorine bleach were added to a flow of 850,000 gal/day at a concentration of 6 ppm, and the product weight 10 lbs/gal, how many gallons would be needed daily?

$$GPD = \frac{(MGD) \times (8.34\ lbs/gal) \times (ppm\ or\ mg/l)}{(\%\ purity) \times lbs/gal}$$

Dosage – box 13

- Example: If 75 gal/day of 15% chlorine bleach were added to a flow of 950,000 gal/day, and the product weight 10 lbs/gal, what is the dosage rate in mg/L?

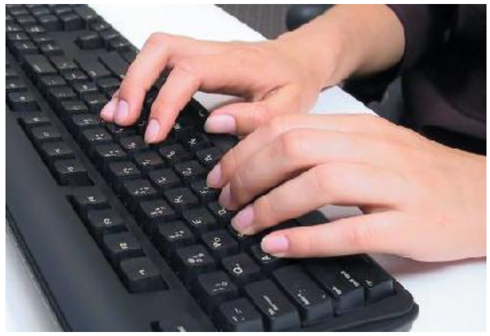
$$\text{Ppm} = \frac{\text{gallons x \% purity x lbs/gal}}{\text{MG x 8.34 lbs/gal}}$$

Dosage – box 13

- Example: If 23% coagulant were added to a flow of 650,000 gal/day at a concentration of 6 ppm, and the product was 40% pure with a commercial purity of 55%, how many gallons would be needed daily?

$$\text{GPD} = \frac{\text{(MGD) x (8.34 lbs/gal) x (ppm or mg/l)}}{\text{(\% purity) x (\% com. Purity) x 8.34 lbs/gal}}$$

Questions?



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◆POP QUIZ!

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This chlorine product is 2.5 times heavier than air.

A. Bleach

B. Powder chlorine

C. Gas chlorine

D. None of the above

What temperature does a fusible plug melt in a chlorine cylinder?

A. 158 degrees

B. 165 degrees

C. A and B

D. 175 degrees

What does SCBA stand for?

A. Supervisory Control and Data Acquisition
B. Self contained Breathing Appearance
C. Self contained Breathing Apparatus
D. Self contained Broccoli apparatus

Repair kits for one ton chlorine containers are referred to as:

A. A kit
B. B kit
C. C kit
D. B and C

What is the maximum feed rate for a 150 pound cylinder?

A. 450 lbs/day

B. 40-42 lbs/day

C. 100 lbs/day

D. 90 lbs/day

Detention Time – box 11

- Detention time refers to the time that it takes a volume of water to move through a process or vessel
- This time can be determined by dividing the vessel volume (in gallons) and time per day by the flow

Rectangular Sed Basin Example

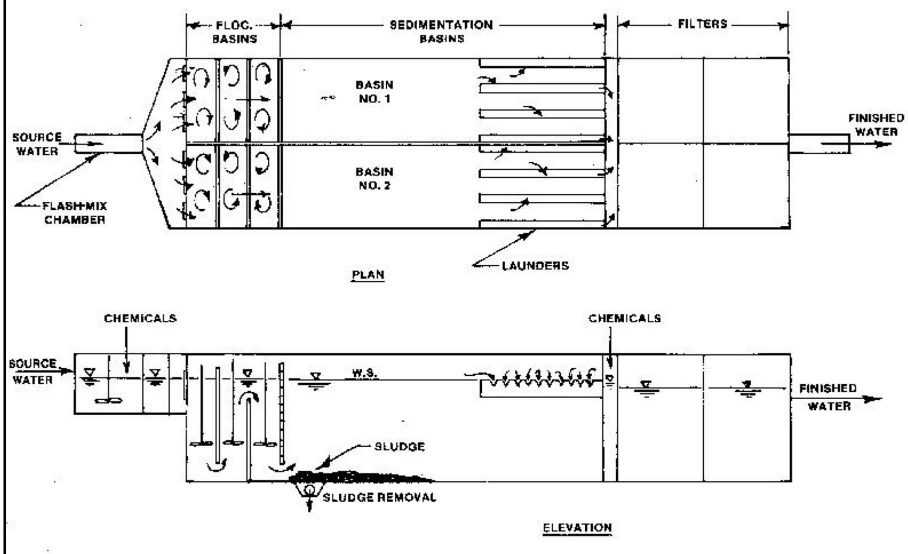

Fig. 5.21 Rectangular sedimentation basin

Factors Affecting Sedimentation

- Dissolved substances
- Flocculation characteristics
- Environmental (wind etc)
- Basin hydraulics

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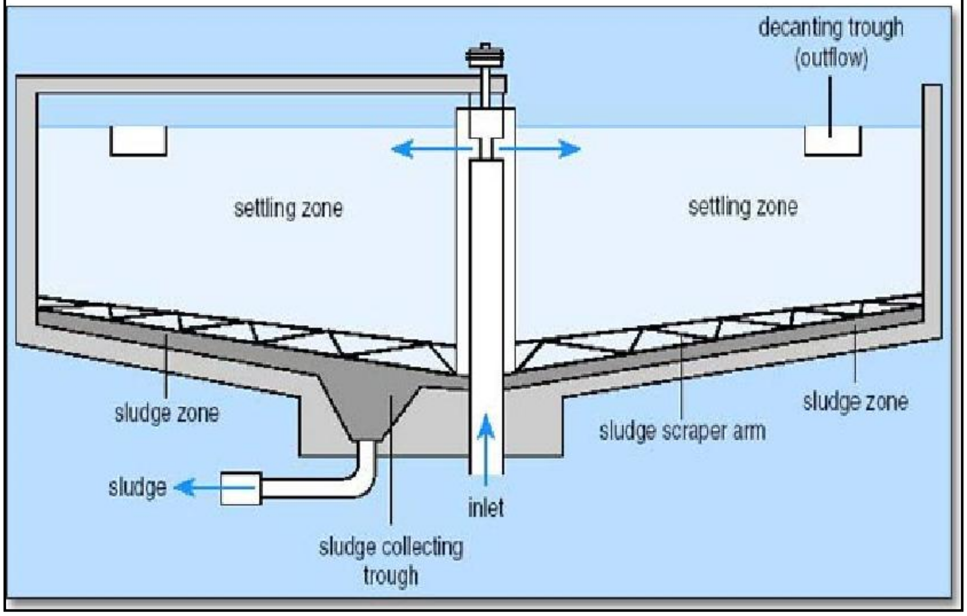
Circular Sed Basin Example



SEDIMENTATION

Surface Loading Rate, (GPD/ sq. ft.) = $\frac{\text{Total Flow, GPD}}{\text{Surface Area, sq.ft.}}$

Detention Time = $\frac{\text{Volume}}{\text{flow}}$

Detention Time hours = $\frac{\text{volume (cu ft)} \times 7.48 \text{ gal/cu ft} \times 24 \text{ hr/day}}{\text{Gal/day}}$

Flow Rate = $\frac{\text{Volume}}{\text{Time}}$

Weir Overflow Rate, GPD/L.F. = $\frac{\text{Flow, GPD}}{\text{Weir length, ft.}}$

Detention Time – box 11

- Example: What is the detention time in **hours** for a flow of 2,200,000 gal/day through a tank that measures 50 ft long, 40 ft wide and 30 ft tall?

$$\textbf{DT hours} = \frac{\text{volume (cu ft)} \times 7.48 \text{ gal/cu ft} \times 24 \text{ hr/day}}{\text{Gal/day}}$$

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Detention Time – box 11

- Example: What is the detention time in **hours** for a flow of 2,900,000 gal/day through a tank that measures 50 ft in diameter by 60 feet tall?

$$\textbf{DT hours} = \frac{\text{volume (cu ft)} \times 7.48 \text{ gal/cu ft} \times 24 \text{ hr/day}}{\text{Gal/day}}$$

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Detention Time – box 11

- Example: If 300,000 gal/day flows through a sedimentation basin that measures 60 ft in diameter and 20 ft tall, what is the detention time in days?

$$\frac{\_\_\_\text{ft x }\_\_\_\text{ft x }\_\_\_\text{ x 20 x 7.48 gal/ft}^3\text{ x 1 day}}{\_\_\_\text{gal/day}}$$

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Detention Time – box 11

- Example: How many **minutes** would it take a drop of water to pass though a contact basin 20 ft in diameter, 10 ft tall if the flow were 800,000 gal/day?

$$\frac{\_\_\text{ft x }\_\_\_\text{ft x }\_\_\_\text{ x }\_\_\_\text{ft x 7.48 gal/ft}^3\text{ x 1440 min/day}}{\text{800,000 gal/day}}$$

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What is the main operational problem with sedimentation basins?

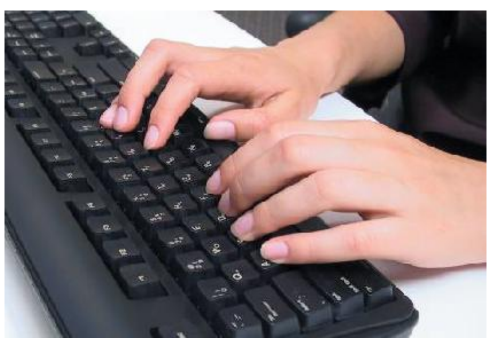
A. Short circuiting

B. Density currents

C. Wind

D. All of the above

Questions?



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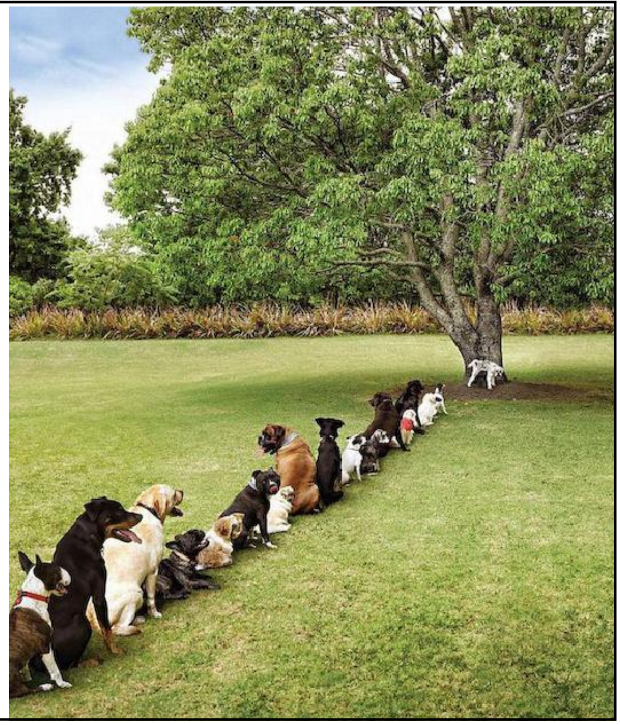
5 minute break



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Velocity

Water traveling through a pipe will need to be converted into cu ft/sec *and* divided by the square footage (area) of the pipe

$$Q \div A = V$$

OR

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Flow, velocity, area

Q = A x V   Quantity = Area x Velocity

Flow (ft^3/sec) = Area(ft^2) x Velocity (ft/sec)

$$\frac{\text{MGD x 1.55 cu ft/sec/MGD}}{\text{.785 x pipe diameter ft x pipe diameter ft}} = \frac{\text{cu ft/sec}}{\text{sq ft}} = \text{ft/sec}$$

Velocity – box 7

- Example: If a flow of 1,200,000 gpd were flowing through a 18 inch pipe, what is the velocity in ft/sec?

$$\frac{\text{MGD x 1.55 cu ft/sec/MGD}}{\text{.785 x pipe diam ft x pipe diam ft}} = \frac{\text{cu ft/sec}}{\text{sq ft}} = \text{ft/sec}$$

Velocity – box 7

Example: If the water through a 18 inch pipe were traveling at 3.5 ft/sec, how many MGD is flowing through this pipe?

MGD x 1.55 cu ft/sec/MGD = cu ft/sec = ft/sec

.785 x pipe diam ft x pipe diam ft = sq ft

Why the @#$% should I care about velocity in a water pipe?

A. Because the state says so

B. Ensures system longevity

C. Can prevent corrosion issues

D. All of the above

Questions?

RAISE YOUR HAND

OR SEND A TEXT MESSAGE

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Filtration Rates

- The surface area of filtration media is where most material is removed

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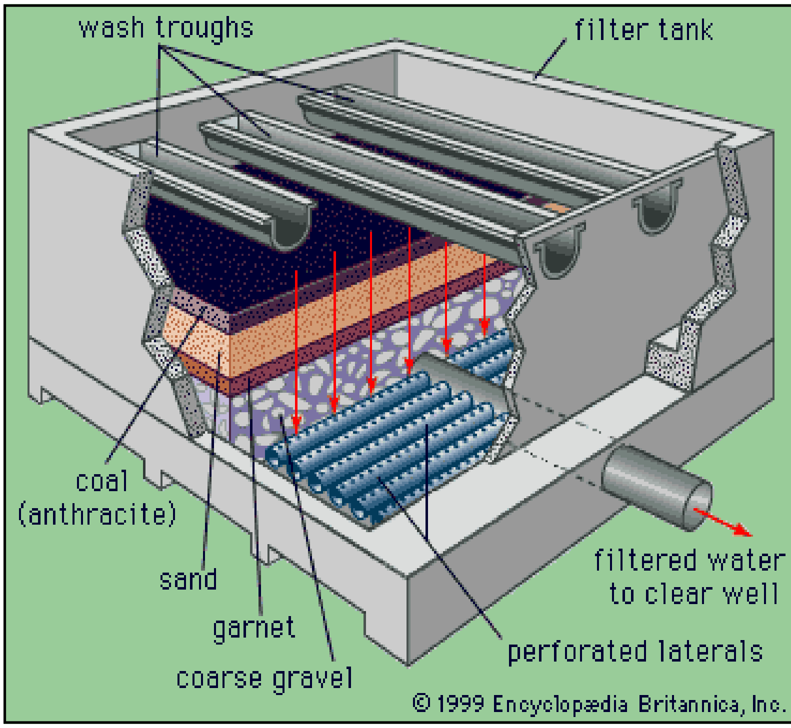

How Filters Work

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Filtration Rates

- Filtration rates are determined by dividing the flow (usually in gpm) by the square footage of the filter media material
- Gpm/sq ft

FILTRATION (number 1)

Filtration Rate (GPM/sq.ft) = $\frac{\text{Filter Production (gallons per day)}}{\text{(Filter area sq. ft.) x (1,440 min/day)}}$

Loading Rate (GPM/ sq. ft.) = $\frac{\text{(Flow Rate, GPM)}}{\text{(Filter Area, sq. ft.)}}$

Daily Filter Production (GPD) =
(Filter Area, sq. ft.) x (GPM/ sq. ft. x 1,440 min/day)

Backwash Pumping Rate (GPM) =
(Filter Area, sq. ft.) x (Backwash Rate, GPM/ sq. ft.)

FILTRATION (number two)

Backwash Volume (Gallons) =
(Filter Area, sq. ft.) x (Backwash Rate, gpm/ sq. ft.) x (Time, min).

Backwash Rate, GPM/ sq. ft. = $\frac{\text{(Backwash Volume, gallons)}}{\text{(Filter Area, sq. ft.) x (Time, min)}}$

Rate of Rise (inches per min.) = $\frac{\text{(backwash rate gpm/sq.ft.) x 12 inches /ft}}{\text{7.48 gal/cu.ft.}}$

Unit Filter Run Volume, (UFRV) = $\frac{\text{(gallons produced in a filter run)}}{\text{(filter area sq. ft.)}}$

Area in Filtration Units – Problem and Set Up

- Example: How many square feet of surface area are there in two filter units that measure 20 feet wide and 40 feet long ?

- Set up:

___ft x ___ft x ___ = sq ft

Filtration Rates

- Example: What is the filtration rate in gpm/sq ft if a flow of 1,000,000 gal/day flows through a filter measuring 20 ft by 25 ft?
- Set up:

$$\frac{\text{\_\_\_\_\_\_\_\_ gal/day} \div 1440\ \text{min/day}}{\text{\_\_\_ ft} \times \text{\_\_\_ ft}} = \frac{\text{gpm}}{\text{sq ft}}$$

Gpm ÷ sq ft = gpm/sq ft

Filtration Rate Flow

- Example: When the flow to a filter is shut off and the water drops 20 inches in 9 minutes, how fast is the water dropping in feet per minute?
- Set up:

____in ÷ 12 in/ft = ft

____ft ÷ 9 min = ft/min

Filtration Rate Flow

- Example: What is the flow through a filter in cu ft/min if the water drops .18 ft per minute and the filter is 25 ft wide and 30 ft long?
- Set up:

____ft x ____ft x ____ft/min = cu ft/min

Filtration Rate Flow

- Example: What is the flow through a rapid sand filter in gpm if flow = 135 cu ft/min?
- Set up:

____cu ft/min x 7.48 gal/cu ft =   gpm

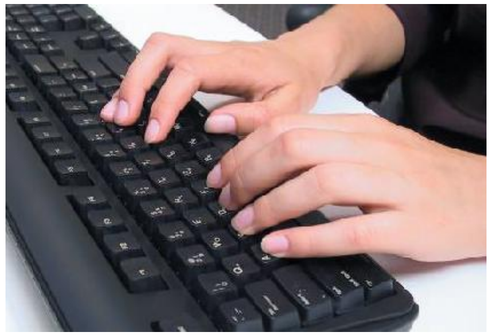
Backwash rates

- Example: What is the backwash flow required in gpm to backwash a 25 ft wide by 30 ft long filter if a backwash flow of 20 gpm/sq ft is required?
- Set up:

____ft x ____ft =   sq ft

____sq ft x ____gpm/sq ft =   gpm

Questions?



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Thank You For Attending!

We look forward to seeing you in future online classes!

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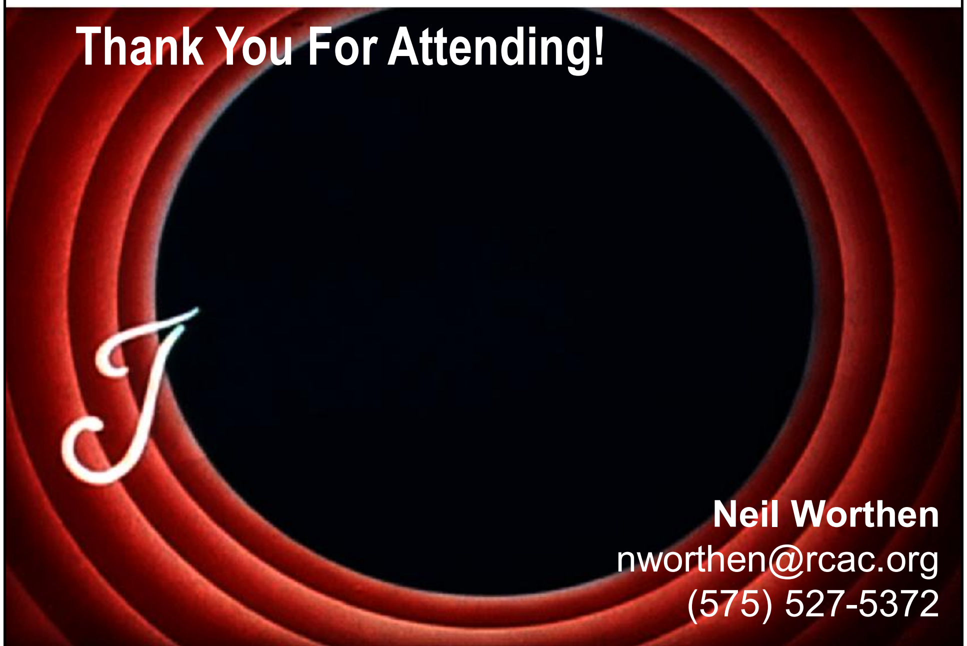
jhamner@rcac.org

Rural Community Assistance Corporation

California Water Boards
State Water Resources Control Board
Regional Water Quality Control Boards


Thank You For Attending!
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