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WELCOME!

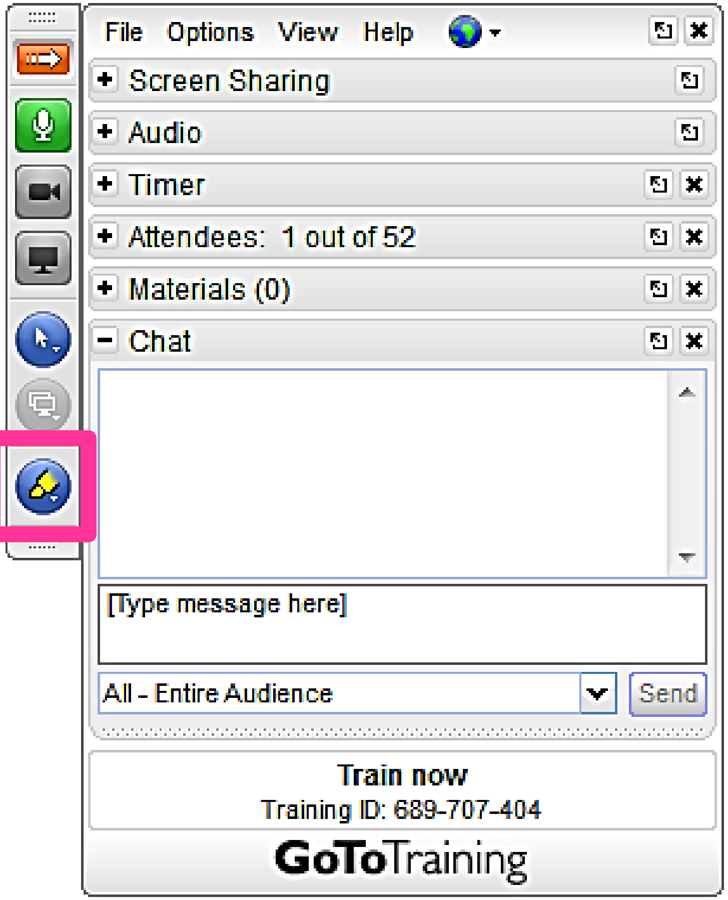
Water Treatment Math

Having Audio or Tools difficulties?

Click on the Purple Flower and change your viewing format.

It may help!

Marking Tool



M	F	K	O	S	K	C	I	G	P	A	R	K	V	M	D	M	U	S	C
O	U	Z	V	Y	I	N	P	V	N	E	J	W	P	T	U	N	A	V	H
L	S	M	N	E	J	F	B	N	O	I	T	A	L	I	T	N	E	V	C
U	K	O	I	E	N	O	A	D	I	N	N	C	C	S	N	S	A	G	K
P	R	N	C	X	Y	T	N	T	S	P	I	L	H	Y	T	U	E	L	O
X	M	T	R	G	A	P	U	E	E	A	A	L	T	L	V	V	A	S	T
D	O	R	H	U	L	M	I	R	B	C	W	O	C	J	O	T	R	M	N
R	L	X	V	S	S	U	I	C	I	P	N	E	Y	E	G	R	A	Q	E
L	E	A	K	K	M	S	S	S	J	D	E	M	L	O	E	T	I	I	G
F	W	C	H	R	T	A	O	K	U	J	G	R	I	C	W	W	L	N	A
S	R	R	J	A	A	D	R	R	V	A	F	X	N	X	S	X	C	Y	E
R	Z	E	L	P	I	L	R	G	R	W	U	U	D	Y	G	M	A	B	R
Z	Z	T	P	U	E	L	E	H	I	M	E	J	E	C	T	O	R	L	O
Z	I	E	M	A	W	O	P	B	Q	L	P	V	R	Q	I	F	P	V	E
C	K	M	Q	Z	W	A	W	L	Q	C	L	P	M	N	S	B	I	I	X
T	M	O	T	C	I	D	N	D	R	E	S	I	D	U	A	L	C	F	S
R	G	T	N	D	D	S	S	R	S	A	S	V	M	B	O	E	Z	E	W
L	L	O	R	E	T	I	L	M	E	Z	B	A	K	Q	N	D	Y	J	N
J	R	R	F	E	D	P	B	I	T	I	F	D	Z	F	E	Y	U	T	B
A	I	N	O	M	M	A	H	E	E	Y	I	L	Y	N	H	O	Q	M	O

AMMONIA	CALCIUM	CHLORINE
CYLINDER	DIAPHRAGM	EJECTOR
FIFTY	GAS	INJECTOR
LEAK	LITER	MAXIMUM
MILLIGRAMS	MRDL	ONE
PER	PERISTALTIC	PPM
RAILCAR	REAGENT	RESIDUAL
ROTOMETER	SCBA	SODIUM
TON	VENTILATION	VENTURI

Addition
Area
Calculate
Conversions
Converting
Cubic
Cylinder
Decimal
Detention
Dimension
Distance
Division
Dosage
Equal
Factor
Flow
Fraction
Gallon
Liter
Math
Measure
Milligrams
Multiply
Percent
Percentage
Pi
Pounds
Ratio
Rectangle
Square
Storage
Subtraction
Supply
Units
Velocity
Volume

Water Treatment Word Search

A	D	H	L	O	E	H	F	M	B	R	M	M	S	T	G	G	C	Y	E
S	E	O	V	E	A	P	U	Z	A	E	B	W	O	N	N	F	A	L	R
W	N	R	S	J	R	L	E	T	S	F	Q	R	K	I	L	R	L	P	U
O	I	O	A	A	T	A	I	R	Z	Z	E	U	T	M	I	A	C	P	S
L	E	L	I	I	G	O	U	V	C	D	S	R	A	P	T	C	U	U	A
F	K	E	P	S	S	E	Z	Q	N	E	E	I	V	L	E	T	L	S	E
N	X	L	L	F	R	H	H	I	S	V	N	S	M	R	R	I	A	N	M
O	Y	B	S	G	M	E	L	X	N	N	T	T	G	C	M	O	T	U	A
I	K	A	X	S	N	Y	V	O	W	O	N	H	A	H	Z	N	E	Q	W
T	C	U	B	I	C	A	C	N	M	I	L	L	I	G	R	A	M	S	D
I	Y	S	T	I	N	U	T	B	O	T	L	H	T	O	E	G	T	E	D
D	I	S	T	A	N	C	E	C	D	C	T	A	U	H	A	E	T	E	T
D	Y	T	I	C	O	L	E	V	E	A	D	I	M	L	Z	E	O	N	F
A	S	T	O	R	A	G	E	D	M	R	L	I	L	I	N	V	E	R	A
B	S	D	N	U	O	P	E	N	A	T	U	O	V	T	C	C	Y	E	C
S	I	M	H	L	Z	G	C	Z	U	B	N	Y	I	I	R	E	M	V	T
N	O	I	S	N	E	M	I	D	S	U	Z	O	J	E	S	U	D	C	O
R	F	Q	M	U	F	Y	T	S	M	S	N	G	P	Z	L	I	Z	B	R
N	G	C	Z	D	N	E	N	O	O	P	Z	C	I	O	E	R	O	E	T
E	C	R	F	E	I	P	W	M	W	V	W	K	V	K	N	B	J	N	F

Word Search

AGENCY
BACTERIA
CERTIFICATION
COLIFORM
CONTAMINANT
DRINKING
EPA
INORGANIC
MAXIMUM
MONITORING
NITRATE
NOTIFICATION
OPERATOR
ORGANIC
OUTBREAK
PESTICIDE
PUBLIC
QUALITY
RADIONUCLIDE
REGULATIONS
RULE
SAFE
SAMPLING
TRIHALOMETHANE
VIRUS
WALKERTON
WATER

P	C	U	O	D	R	I	N	K	I	N	G	M	I	W
R	I	E	Y	P	O	U	T	B	R	E	A	K	D	N
E	N	A	H	T	E	M	O	L	A	H	I	R	T	O
G	A	O	E	L	U	R	M	S	M	P	E	D	Y	I
U	G	C	I	T	A	A	A	O	A	D	E	T	A	T
L	R	I	J	T	X	I	N	T	I	F	I	R	G	A
A	O	L	N	I	A	I	R	L	O	L	E	N	E	C
T	N	B	M	I	T	C	C	E	A	R	I	D	N	I
I	I	U	K	O	T	U	I	U	T	L	I	N	C	F
O	M	P	R	P	N	R	Q	F	P	C	Y	Y	Y	I
N	U	I	C	O	N	T	A	M	I	N	A	N	T	T
S	N	V	I	R	U	S	A	T	H	T	L	B	V	O
G	K	D	X	P	W	S	S	Z	E	I	R	Z	U	N
L	A	N	O	T	R	E	K	L	A	W	P	E	I	N
R	E	T	A	W	P	M	R	O	F	I	L	O	C	Z

Your Moderator Today…

Jim McVeigh CET
Rural Development Specialist – Drinking Water

jmcveigh@rcac.org

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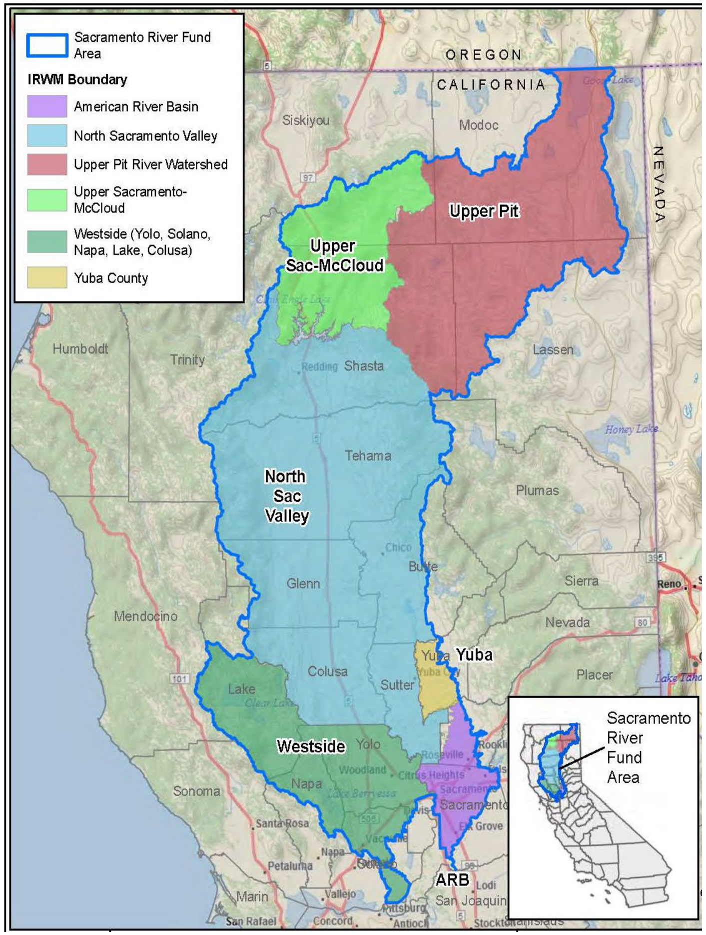
WELCOME!

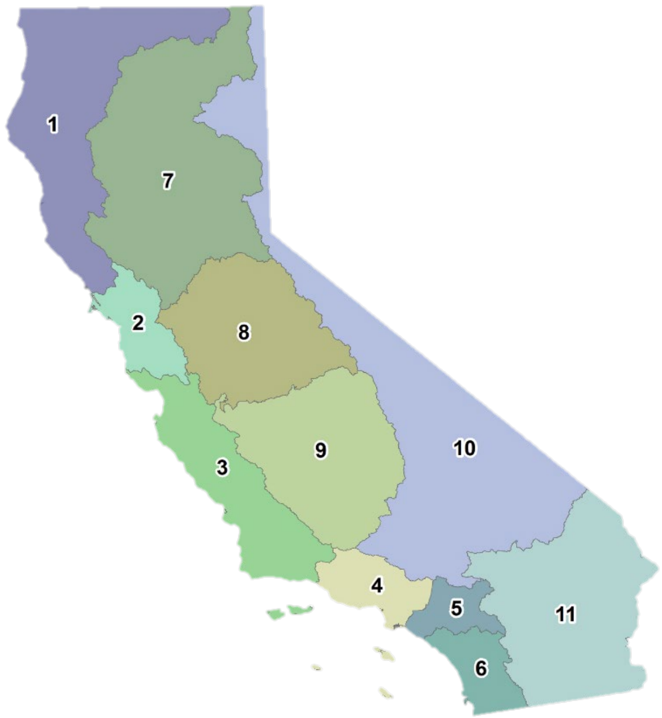
Water Treatment Math

This workshop is sponsored by the <u>Sacramento River Funding Area Disadvantaged Community Involvement Program</u>, a grant funded program supported by the California Department of Water Resources' Integrated Regional Water Management Program



For more information on the DWR DACI-Program go to:
https://water.ca.gov/Work-With-Us/Grants-And-Loans/IRWM-Grant-Programs/Proposition-1/DAC-Involvement-Program

Prop 1 Funding Areas



1 North Coast
2 San Francisco Bay Area
3 Central Coast
4 Los Angeles Sub-Region
5 Santa Ana Sub-Region
6 San Diego Sub-Region
7 Sacramento River
8 San Joaquin River
9 Tulare/Kern
10 North/South Lahontan
11 Colorado River Basin

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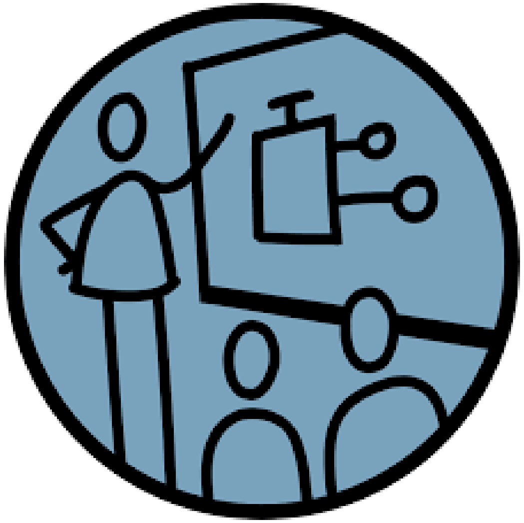
Sacramento River Funding Area Disadvantage Community Involvement Program

The goals of the SRFA-DACI-Program:

1. Engage DAC organizations, water purveyors and stakeholders in IRWM
2. Identify the water and wastewater management needs of DACs
3. Develop strategies and solutions for DAC water management needs.



This workshop was developed to address key needs that have been identified for DAC communities and/or water providers in this region.

For questions on the SRFA DACIP Program and how to engage with your IRWM please contact: JoAnna Lessard (jlessard@yubawater.org)

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Rural Community Assistance Partnership

RCAP National Office
1701 K St. NW, Suite 700
Washington, D.C. 20006
www.rcap.org

Western RCAP
Rural Community Assistance Corporation
www.rcac.org

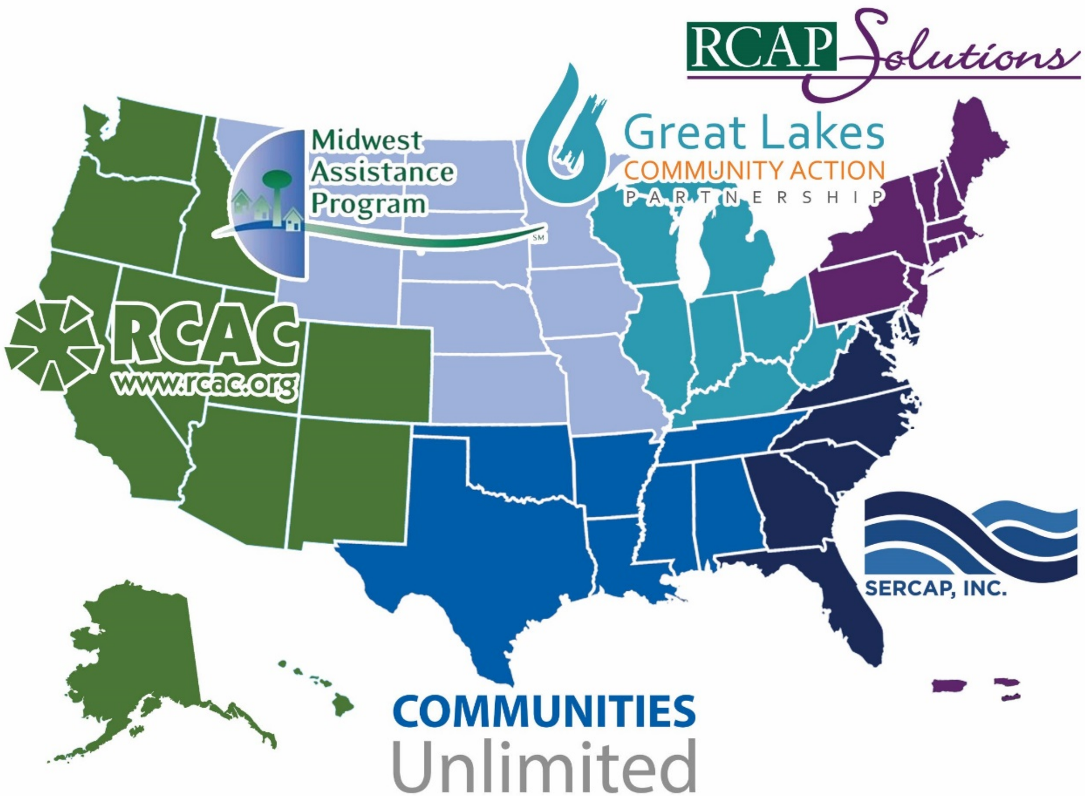
Midwestern RCAP
Midwest Assistance Program
www.map-inc.org

Southern RCAP
Communities Unlimited
www.communitiesu.org

Great Lakes RCAP
Great Lakes Community Action Partnership
www.glcap.org

Southeastern RCAP
Southeast Rural Community Assistance Project
www.sercap.org

Northeastern RCAP
RCAP Solutions
www.rcapsolutions.org



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RCAC Programs

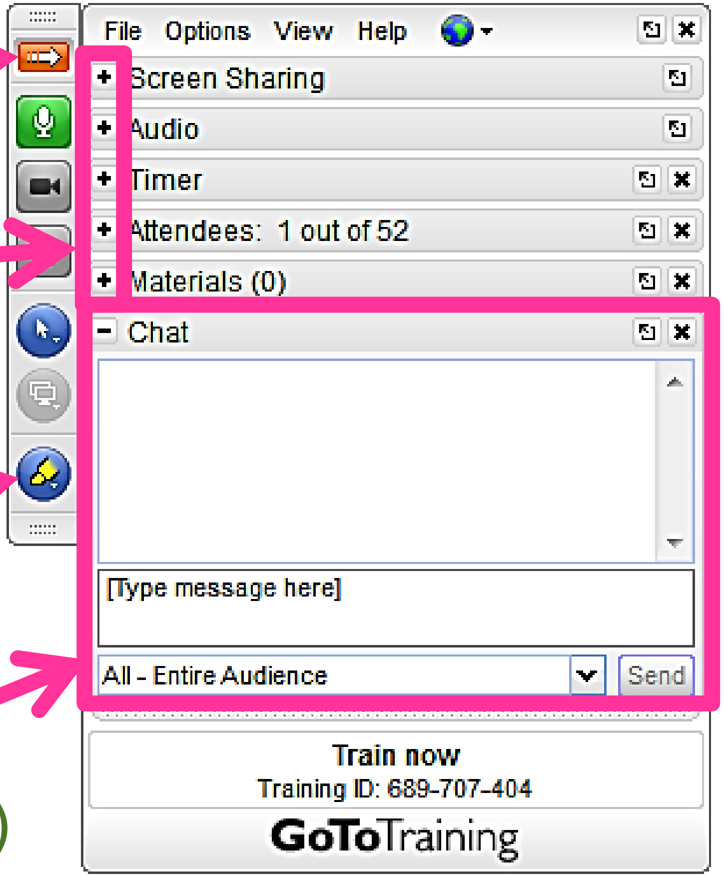
- Affordable housing
- Community facilities
- Water and wastewater infrastructure financing (Loan Fund)
- Classroom and online training
- On-site technical assistance
- Median Household Income (MHI) surveys

Hide/Restore Control Panel

Control Tabs
(Click "+" to open)

Marking Tool
(Will appear when needed)

Chat Box
(Send to "Entire Audience")



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Audio Controls

Click here to test your audio

Attendee List

Today's Materials

Where is my certificate for attendance?

Certificates for attendance can be downloaded and self-printed. Certificates for ***online*** attendance will ***not*** be mailed

Login *http://www.events.rcac.org/rcac/Calendar.asp*

From the **"view my profile"** page, click **history and certificates**

From the registration portal, click **"View Certificate"**

Certificates are not available until 48 hours after the completion of the class.

Questions?

Text your questions and comments anytime during the session

Your Presenter Today…

Hmmm…
You should probably start the recording now!

John Hamner

jhamner@rcac.org

Middletown, CA

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WELCOME!

Water Treatment Math

Poll #1 – Have you taken the test with the new platform yet?

Water Math Topics Today

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

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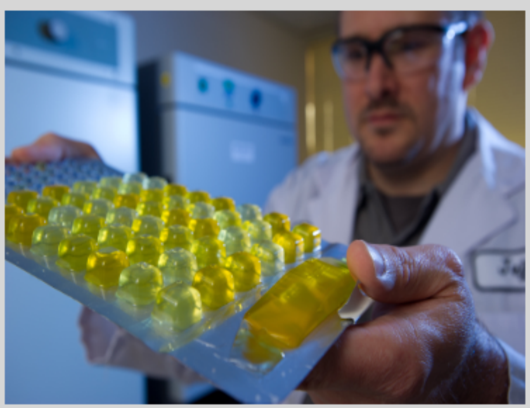
SWRCB Website Address

http://www.waterboards.ca.gov/drinking_water/certlic/occupations/DWopcert.shtml

Drinking Water Treatment & Dist ×

waterboards.ca.gov/drinking_water/certlic/occupations/DWopcert.html

Drinking Water Treatment & Distribution System Operators



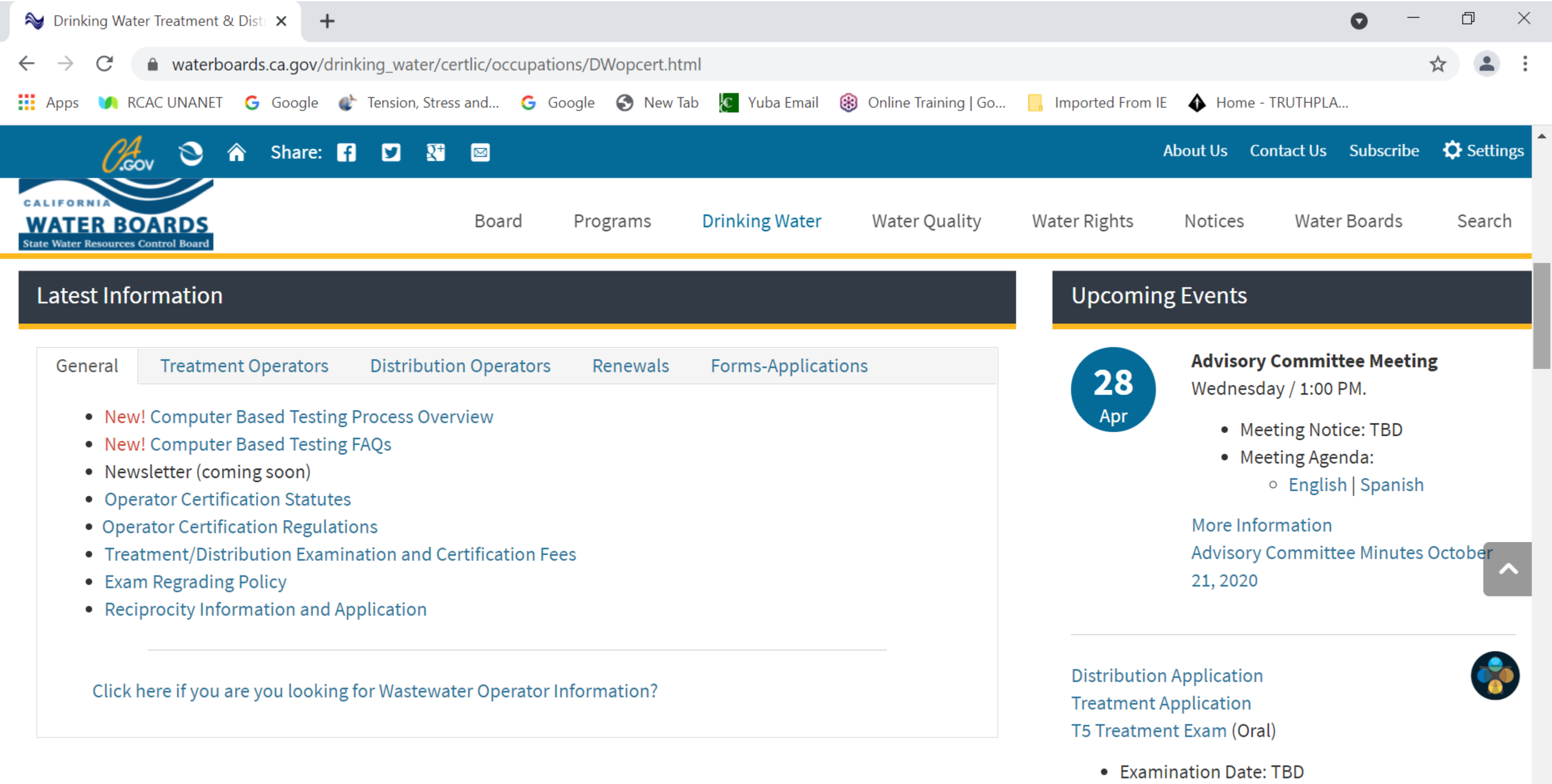
In 1971, laws and regulations governing the certification of potable water treatment facility operation were enacted. The regulations establish at what level these facilities should be manned, the minimum qualifications for testing at each of the five grade levels, and the criteria for the renewal and revocation of operator certificates.

In 1998, the United States Environmental Protection Agency (USEPA) established guidelines for the certification and re-certification of operators of community and non-transient non-community public water systems. On January 1, 2001, new state regulations were adopted to comply with these guidelines and the existing water treatment operator certification program was modified accordingly. The new regulations also established a water distribution operator certification program. This program became the Drinking Water Operator Certification Program (**DWOCP**).

The DWOCP was originally under the Department of Health Services and then the California Department of Public Health. In 2014, the DWOCP was transferred to the State Water Resources Control Board (SWRCB) in the Division of Financial Assistance.

SWRCB Website Address

http://www.waterboards.ca.gov/drinking_water/certlic/occupations/DWopcert.shtml



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

What are we actually doing?

We are CONVERTING!

- Pay attention to the units of measure…
- You don’t have to show your work, but it helps keep order

Units of Measure 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 0.433 psi/ft = psi

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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?

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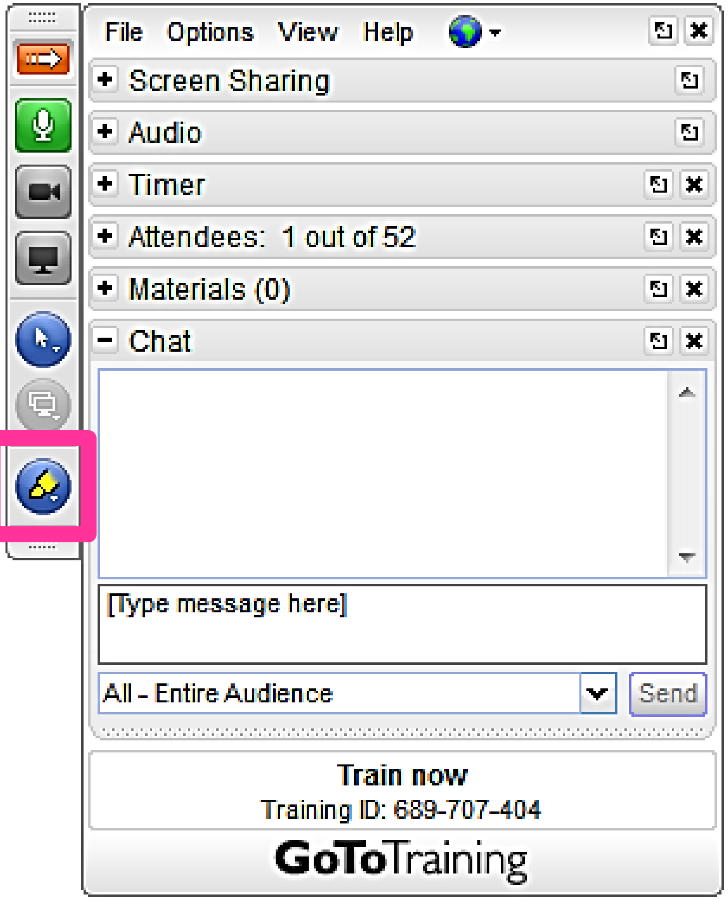
Marking Tool



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

75.75

75%

0.75

0.75

7.5

75.0

0.0075

0.075

0.75

75.0

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

5

5%

50

0.05

5.0

5.00

1$

0.005

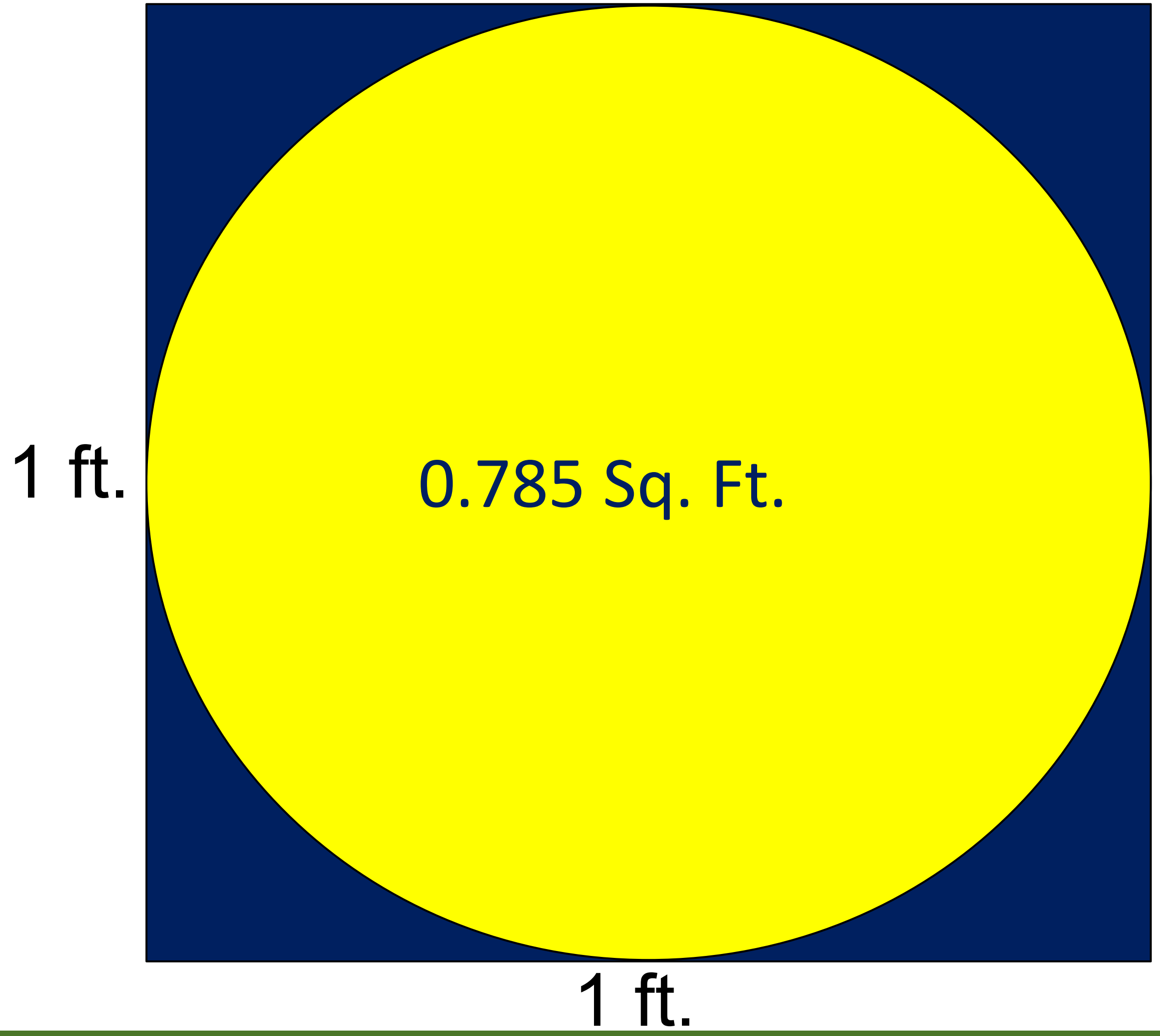
0.50

005.0

NO UNIT OF MEASURE!

- Percentages as a decimal
  - (65-70%, 0.65-0.70) (5-15%; 0.05-0.15)
- Ratios - relationship between two numbers
  - 2:1, 5/1, 10 to 1,
- Pi - π - (3.14) (radius)
  - Circumference
- 0.785 = 78.5% (diameter)
  - $(0.785) \times (\text{Dia., ft})^2$

0.785 = 78.5% of the area of a square of the same dimension



CALIFORNIA Water Boards

State Water Resources Control Board

EDMUND G. BROWN JR. GOVERNOR

MATTHEW RODRIQUEZ SECRETARY FOR ENVIRONMENTAL PROTECTION

UNITS AND CONVERSION FACTORS 1

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 = 325,851 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 2

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

Liquid (gal) = $\frac{\text{(Vol, MG) x (ppm or mg/L) x 8.34 lbs/gal}}{\text{(\% Strength /100) x Chemical Wt. (lbs/gal)}}$

PRESSURE 3

PSI = $\frac{\text{(Head, ft.)}}{\text{2.31ft./psi}}$ **PSI** = Head, ft. x 0.433 PSI/ft.

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

VOLUME 4

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

Supply, Hrs. = $\frac{\text{Storage Volume, Gals}}{\text{(Flow In, GPM - Flow Out, GPM) x 60 Min/Hr)}}$

SOLUTIONS 5

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

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

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

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

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

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

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 6

1 horsepower (Hp) = 746 watts = 0.746 kw = 3,960 gal/min/ft

Water Hp = $\frac{\text{(GPM) x (Total Head, ft)}}{\text{(3,960 gal/min/ft)}}$

Brake Hp = $\frac{\text{(GPM) x (Total Head, ft)}}{\text{(3,960) x (Pump \% Efficiency)}}$

Motor Hp = $\frac{\text{(GPM) x (Total Head, ft)}}{\text{(3,960) x Pump \% Eff. x Motor \% Eff.}}$

"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 7

Q = A x V Quantity = Area x Velocity

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

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

General 8

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

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

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

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

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

Volume, Gals = GPM x Time, minutes

SCADA = 4 mA to 20 mA analog signal 9

$\frac{\text{(live signal mA - 4 mA offset) x process unit and range}}{\text{(16 mA span)}}$

4 mA = 0 20 mA full-range

FILTRATION

10

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

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) = $\frac{\text{(gallons produced in a filter run)}}{\text{(Filter Area sq. ft.)}}$

C• T CALCULATIONS

12

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

Time, minutes = $\frac{\text{(C• t)}}{\text{(Chlorine Residual, mg/L)}}$

Chlorine Residual (mg/L) = $\frac{\text{(C• t)}}{\text{(Time, minutes)}}$

Inactivation Ratio = $\frac{\text{(Actual System C• t)}}{\text{(Table “E” C• t)}}$

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

Log Removal = 1.0 - $\frac{\text{\% Removal}}{100}$ x Log key x (-1)

CHEMICAL DOSAGE CALCULATIONS

11

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

SEDIMENTATION

13

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. = $\frac{\text{(Flow, GPD)}}{\text{(Weir length, ft.)}}$

UNITS AND CONVERSION FACTORS

1

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 = 325,851 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

2

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) =

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

$$\text{Liquid (gal)} = \frac{(\text{Vol, MG}) \times (\text{ppm or mg/L}) \times 8.34 \text{ lbs/gal}}{(\%\ \text{Strength} / 100) \times \text{Chemical Wt. (lbs/gal)}}$$

PRESSURE

3

$$PSI = \frac{(Head, ft.)}{2.31 ft./psi}$$

$$PSI = Head, ft. \times 0.433 PSI/ft.$$

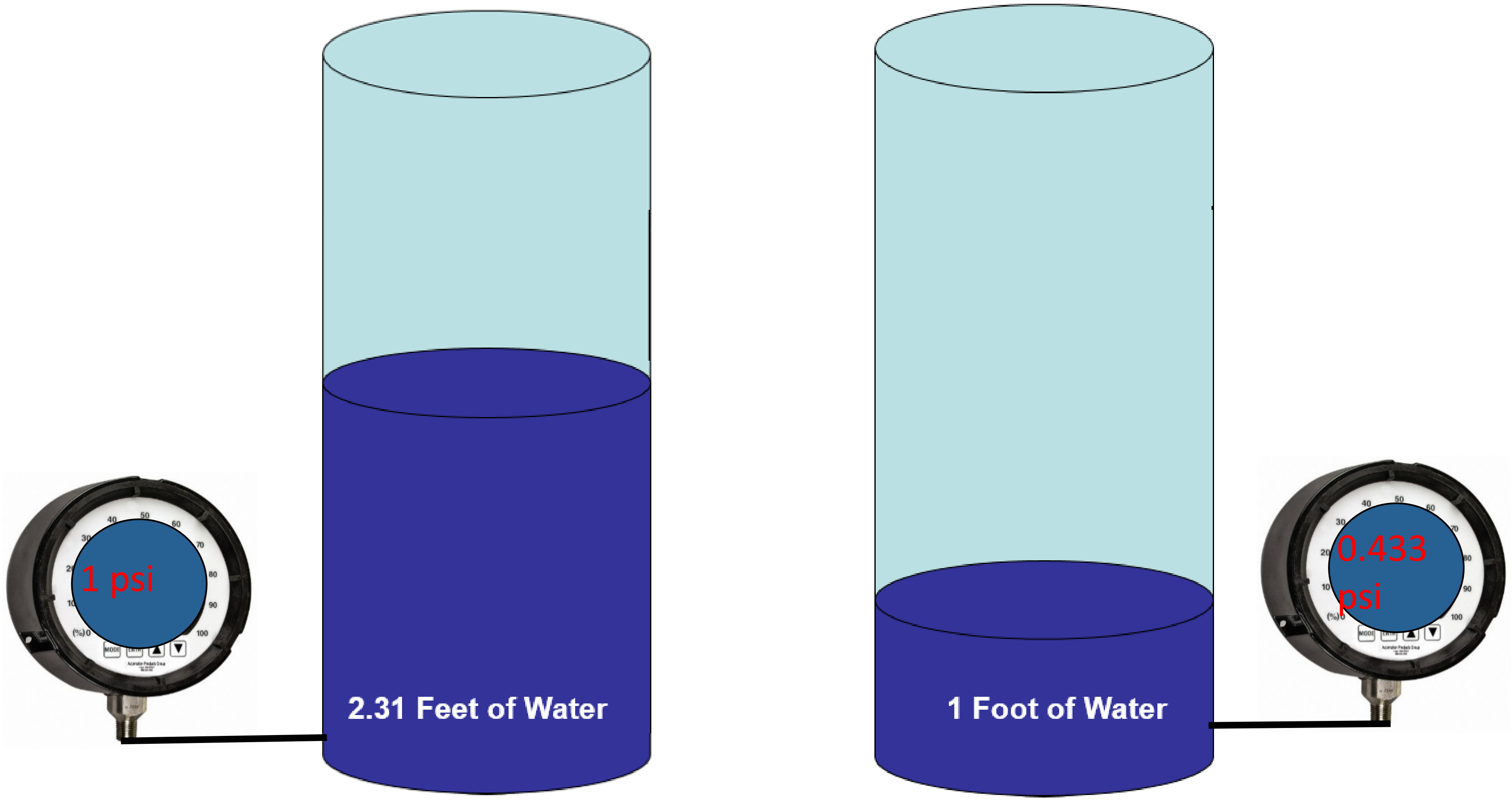
$$lbs\ Force = (0.785)\ (D, ft.)^2 \times 144\ in^2/ft^2 \times PSI.$$

Goofy, but it works.

When using 0.433…

If the answer is psi, I multiply.

If the answer is feet/head, I divide instead.



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4

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

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

$$\text{Supply, Hrs.} = \frac{\text{Storage Volume, Gals}}{(\text{Flow In, GPM - Flow Out, GPM) x 60 Min/Hr})}$$

SOLUTIONS

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

Lbs Chemical =

$$\text{Specific Gravity} \times 8.34 \text{ lbs/gallons} \times \text{Solution (gal)}$$

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

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

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

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

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

$Q = A \times V$ Quantity = Area x Velocity

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

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

General

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

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

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

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FILTRATION

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

sq. ft. = square feet

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

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

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

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

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

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

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

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

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

SEDIMENTATION

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

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

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

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

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

Questions?

Text your questions and comments anytime during the session

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Biggest tip for newcomers!

Pay attention to the cancelation of units!

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Box 2 - Formulas used to determine water at rest (gallons, MG, lbs, etc.)

CHLORINATION

$$\textbf{Dosage, mg/l} = (\text{Demand, mg/l}) + (\text{Residual, mg/l})$$

$$\textbf{(Gas) lbs} = (\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34\ \text{lbs/gal})$$

$$\textbf{HTH Solid (lbs)} = \frac{(\text{Vol, MG}) \times (\text{Dosage, mg/l}) \times (8.34\text{lbs/gal})}{(\ \%\ \text{Strength} / 100\ )}$$

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

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Box 11 - Formulas used to determine water in motion (gals/day, MGD, lbs/day, etc.)

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

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

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

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

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

What am I adding to the water to treat it/make it safe?

- 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?

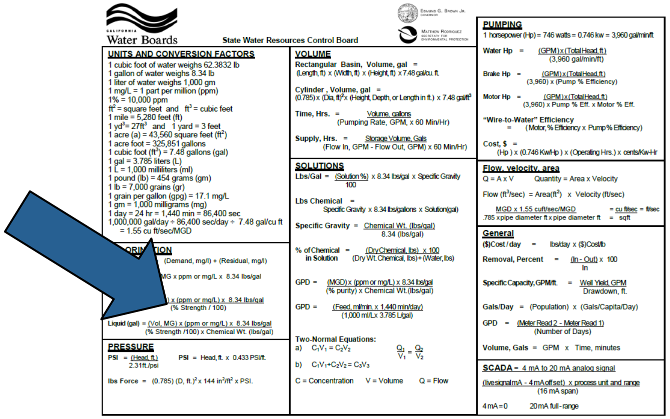
A. 2 MGD
B. 0.2 MGD
C. 0.02 MGD

What is not given in the question?

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

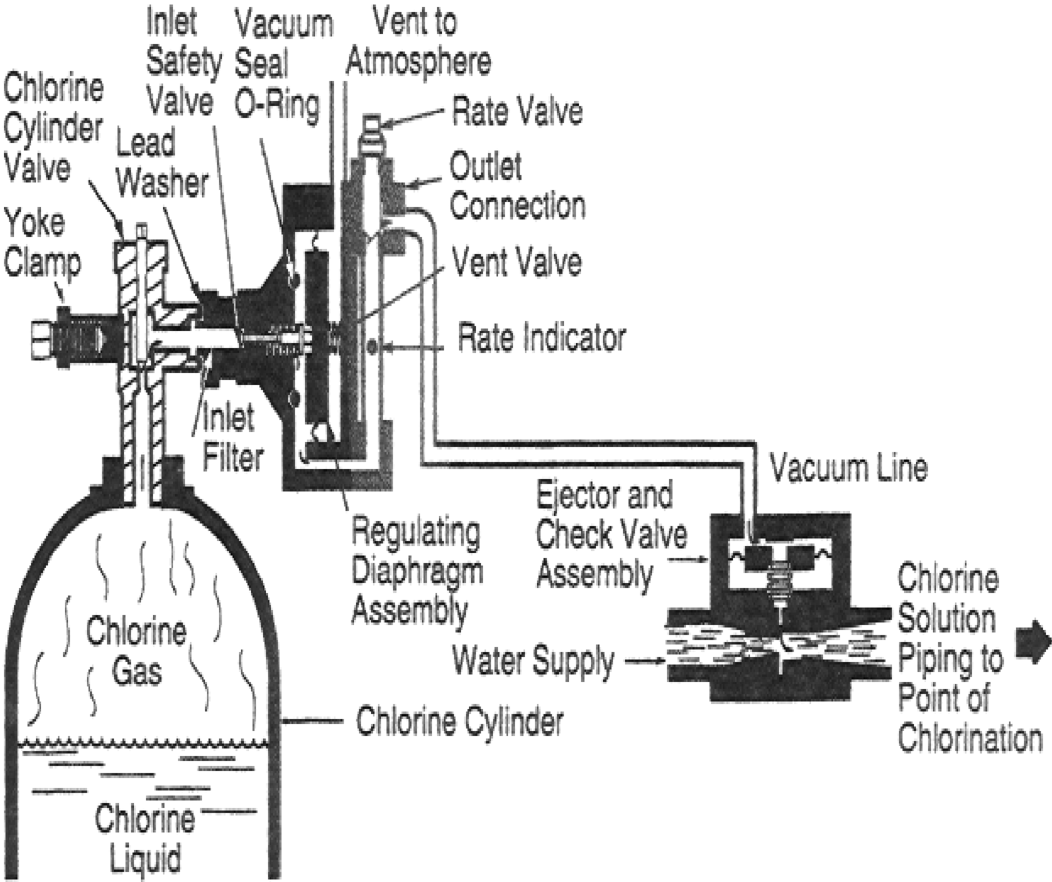
Dosage – Box 2

1. If a given water source had a chlorine demand of 3 mg/L, and you wanted a chlorine residual of 0.5 mg/L leaving the plant, what would be your dose?



Chlorine Gas

- Chlorine gas is fed in lbs or lbs/day



Chlorination – Box 2, Gas

1. If a chlorine gas concentration of 15 ppm were desired to be added to a storage tank holding 2.5 MG, how many pounds of chlorine gas would be required?

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

Chlorination – Box 2, Gas

3. 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?

Chlorination – Box 2, Gas

3. 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?

Find the volume first;

0.785 x 40 ft x 40 ft x 30 ft x 7.48 gal/ft^3 = 281,846 gal

Convert 281,846 to MG and use the formula given;

0.281 MG x 9 mg/L x 8.34 lbs/gal = 21.1 lbs

Questions?

Text your questions and comments anytime during the session

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Poll #2 - Have you ever done chlorination math and applied it to your water system?

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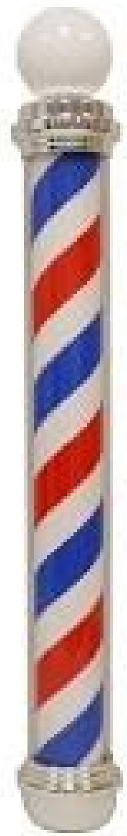
5 Minute Break

Poll #3 - Which chlorination product do you use, or have you used?



Dosage, Calcium Hypochlorite

- AKA; Dry and High Test Hypochlorite (HTH)
- 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. 0.70
D. 70%

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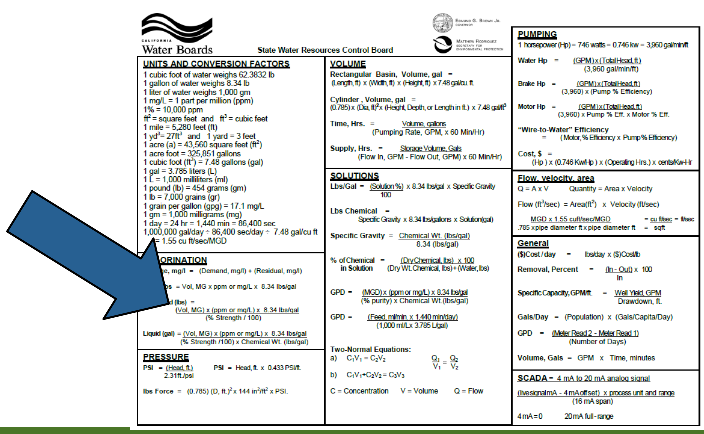
Calcium Hypochlorite

Calcium Hypochlorite

Chlorination – Box 2, HTH

1. 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?

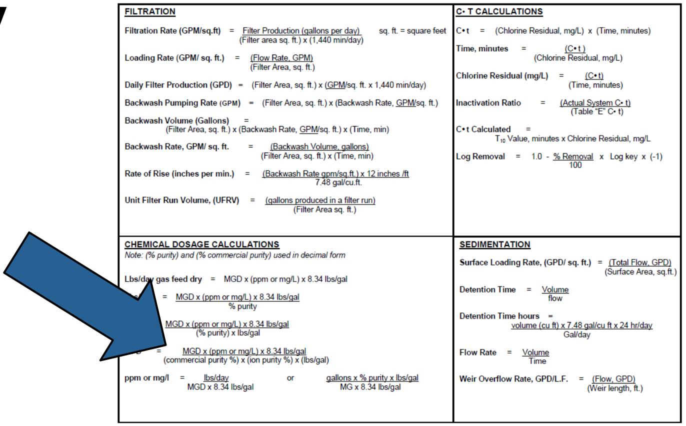
$$\text{HTH Solid (lbs)} = \frac{\text{(Vol MG) x Dosage, mg/L) x (8.34lbs/gal)}}{\text{(65\% Strength/100)}}$$



Dosage – Box 11, HTH

4. 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?

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


FILTRATION

Filtration Rate (GPM/sq.ft) = (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 Log key x (-1)

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

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

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

= (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)

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.)

Dosage – Box 11, HTH

4. 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?

Ans. 446.8

Questions?

Text your questions and comments anytime during the session

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!
- AKA; Sodium Hypochlorite

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Percentages

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

5.25

0.525

0.0525

0.00525

0.05

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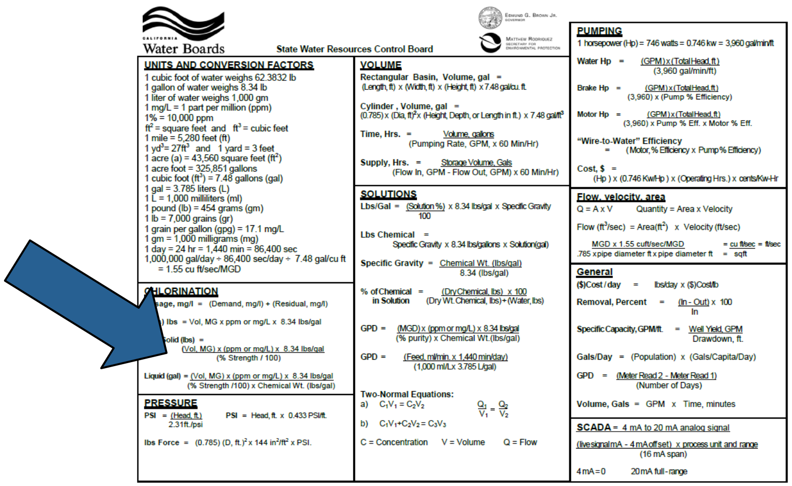
Chlorination – Box 2, Liquid

1. If 0.75 MG was treated with a 15% chlorine solution and a dose of 10 ppm was desired, how many gallons of solution would be required?

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



Chlorination – Box 2, Liquid

1. If 0.75 MG was treated with a 15% chlorine solution and a dose of 10 ppm was desired, how many gallons of solution would be required?

Chlorination – Box 11, Liquid

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

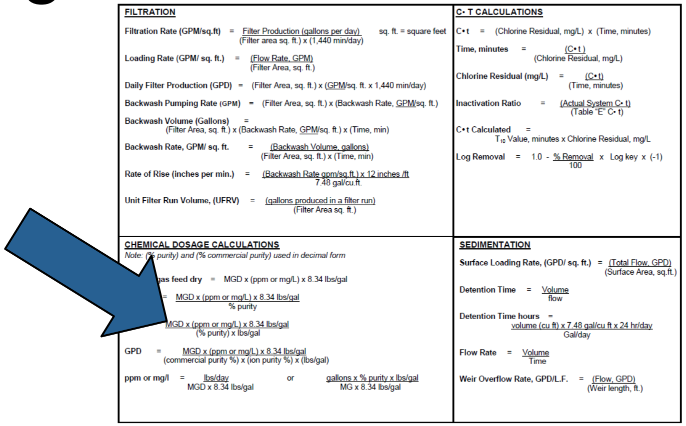
If we try to use Box 2, we would see the formula;

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

Chlorination – Box 11, Liquid

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

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



FILTRATION

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

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) = $\frac{\text{(gallons produced in a filter run)}}{\text{(Filter Area sq. ft.)}}$

C• T CALCULATIONS

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

Time, minutes = $\frac{\text{(C•t)}}{\text{(Chlorine Residual, mg/L)}}$

Chlorine Residual (mg/L) = $\frac{\text{(C•t)}}{\text{(Time, minutes)}}$

Inactivation Ratio = $\frac{\text{(Actual System C• t)}}{\text{(Table "E" C• t)}}$

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Log Removal = 1.0 - $\frac{\text{\% Removal}}{100}$ x Log key x (-1)

CHEMICAL DOSAGE CALCULATIONS

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

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

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

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

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

SEDIMENTATION

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

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

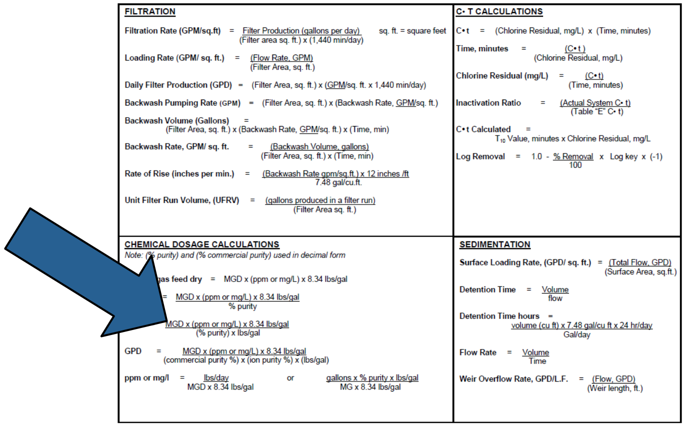
Flow Rate = $\frac{\text{Volume}}{\text{Time}}$

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

Chlorination – Box 11, Liquid

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

Ans. 14.2 ppm



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

C• T CALCULATIONS

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

Time, minutes = $\frac{\text{(C•t)}}{\text{(Chlorine Residual, mg/L)}}$

Chlorine Residual (mg/L) = $\frac{\text{(C•t)}}{\text{(Time, minutes)}}$

Inactivation Ratio = $\frac{\text{(Actual System C•t)}}{\text{(Table "E" C•t)}}$

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

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CHEMICAL DOSAGE CALCULATIONS

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

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

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

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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. = $\frac{\text{(Flow, GPD)}}{\text{(Weir length, ft.)}}$

Questions?

Text your questions and comments anytime during the session

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Detention Time – Box 13

- 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

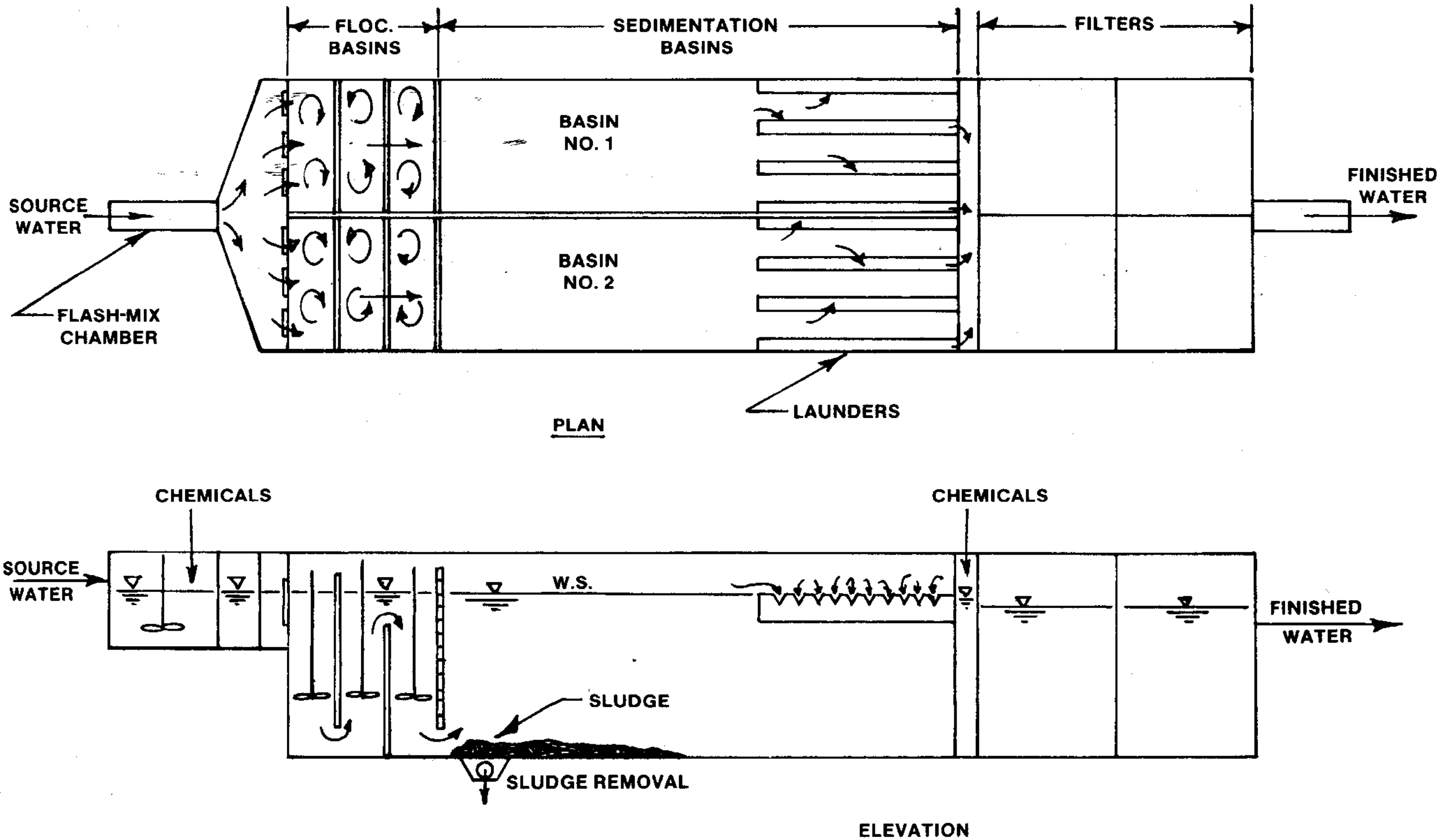


Fig. 5.21 Rectangular sedimentation basin

SEDIMENTATION

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

13

Detention Time $= \dfrac{\text{Volume}}{\text{flow}}$ $\boxed{\text{\{times time/(24 hours, 1,440 minutes)\}}}$

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

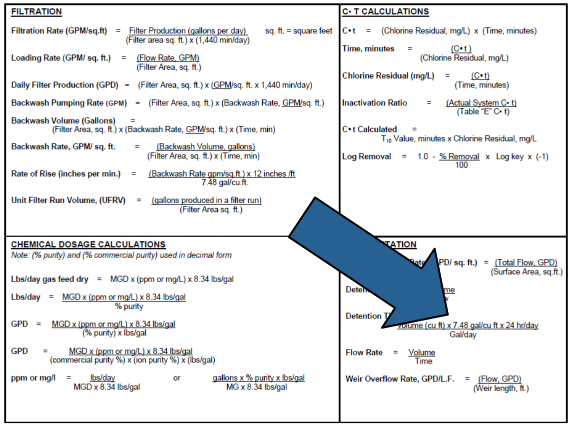
Flow Rate $= \dfrac{\text{Volume}}{\text{Time}}$

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

Detention Time – Box 13

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

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



FILTRATION

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

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) = $\frac{\text{(gallons produced in a filter run)}}{\text{(Filter Area sq. ft.)}}$

C• T CALCULATIONS

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

Time, minutes = $\frac{\text{(C•t)}}{\text{(Chlorine Residual, mg/L)}}$

Chlorine Residual (mg/L) = $\frac{\text{(C•t)}}{\text{(Time, minutes)}}$

Inactivation Ratio = $\frac{\text{(Actual System C•t)}}{\text{(Table “E” C•t)}}$

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

Log Removal = 1.0 - $\frac{\text{\% Removal}}{100}$ x Log key x (-1)

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

TATION

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

Deten me

Detention T volume (cu ft) x 7.48 gal/cu ft x 24 hr/day / 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 13

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

Ans. 4.9 hours

Detention Time – Box 13

2. What is the detention time in **hours** for a flow of 2,900,000 gal/day through a tank that measures 50 feet 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 13

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

Ans. 7.28 Hours

Questions?

Text your questions and comments anytime during the session

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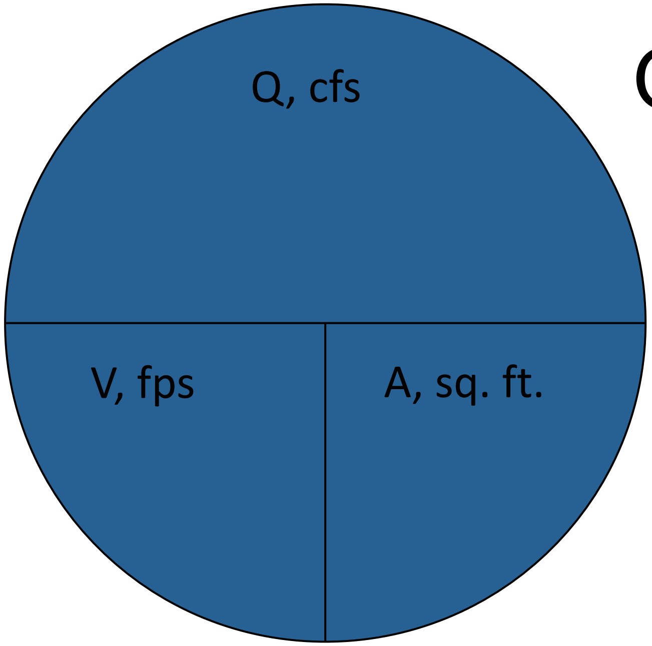
Velocity – Box 7

Water traveling through a pipe will need to be converted into cubic feet per second *and* divided by the square footage (area) of the pipe.



$$Q = V \times A$$

$$V = Q \div A$$

$$A = Q \div V$$

Flow, velocity, area

Q = A x V   Quantity = Area x Velocity   7

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

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

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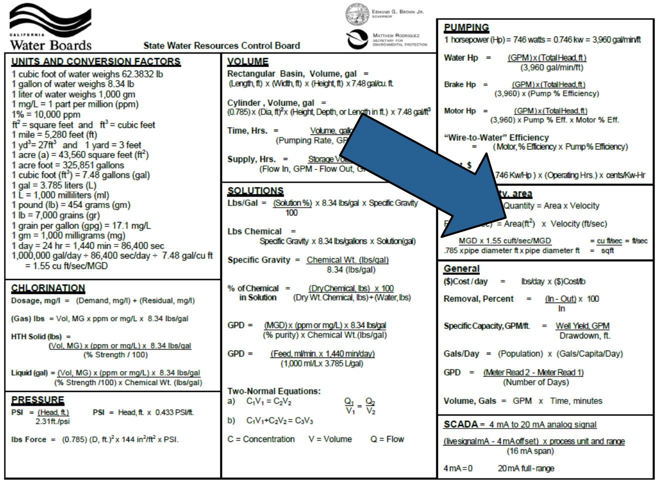
Velocity – Box 7, finding fps

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

$$\frac{\text{MGD x 1.55 cu ft/sec/MGD}}{\text{0.785 x pipe D, ft x pipe D, ft}} = \frac{\text{cu ft/sec}}{\text{sq ft}} = \text{ft/sec}$$



California Water Boards
State Water Resources Control Board
Edmund G. Brown Jr., Governor
Matthew Rodriquez, Secretary for Environmental Protection

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 = 325,851 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.) / 2.31ft./psi   PSI = Head, ft. x 0.433 PSI/ft.
lbs Force = (0.785) (D, ft.)^2 x 144 in^2/ft^2 x 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, gal / (Pumping Rate, GP
Supply, Hrs. = Storage Vo / (Flow In, GPM - Flow Out, G

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/L 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 = 3,960 gal/min/ft
Water Hp = (GPM) x (Total Head, ft) / (3,960 gal/min/ft)
Brake Hp = (GPM) x (Total Head, ft) / (3,960) x (Pump % Efficiency)
Motor Hp = (GPM) x (Total Head, ft) / (3,960) x Pump % Eff. x Motor % Eff.
"Wire-to-Water" Efficiency = (Motor, % Efficiency x Pump % Efficiency)
.746 Kw/Hp) x (Operating Hrs.) x cents/Kw-Hr

ty, area
Quantity = Area x Velocity
= Area(ft^2) x Velocity (ft/sec)
MGD x 1.55 cuft/sec/MGD / .785 x pipe diameter ft x pipe diameter ft = cu ft/sec / sqft = 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 offset) x process unit and range / (16 mA span)
4 mA = 0   20 mA full-range

Velocity – Box 7, finding fps

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

1.2 1.86

$$\frac{\text{MGD x 1.55 cu ft/sec/MGD}}{\text{0.785 x pipe D, ft x pipe D. ft}} = \frac{\text{cu ft/sec}}{\text{sq ft}} = \text{ft/sec}$$

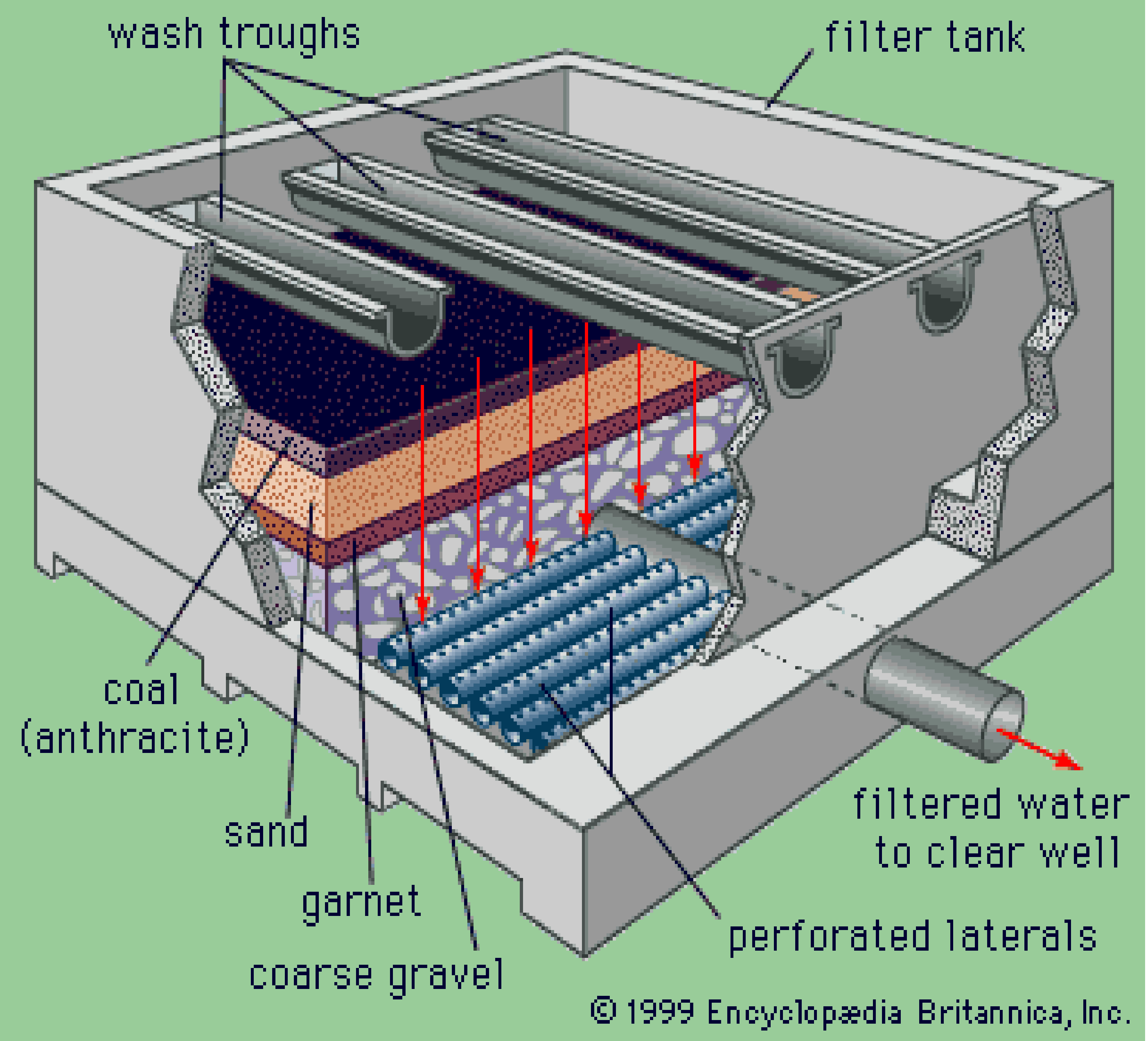
1.5’ 1.5’ 1.766

Ans. 1.05 fps

Filtration Rates

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

How Filters Work



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

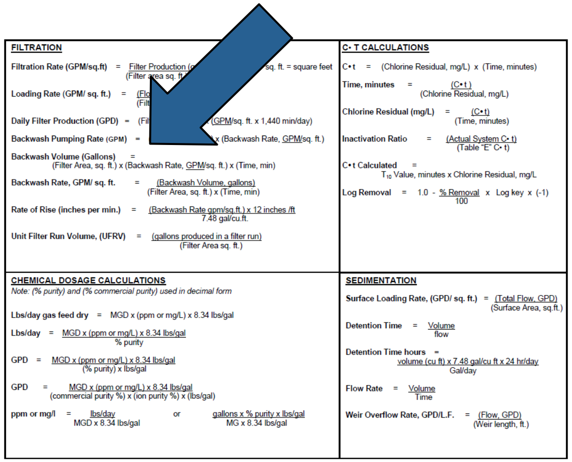
10; part 1

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

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

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

Filtration Rate (GPM/sq.ft) = Filter Production (g… / (Filter area sq. ft.… sq. ft. = square feet

Loading Rate (GPM/ sq. ft.) = (Flo… / (Filt…

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

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

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

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

C• T CALCULATIONS

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

Time, minutes = $\dfrac{\text{(C• t)}}{\text{(Chlorine Residual, mg/L)}}$

Chlorine Residual (mg/L) = $\dfrac{\text{(C• t)}}{\text{(Time, minutes)}}$

Inactivation Ratio = $\dfrac{\text{(Actual System C• t)}}{\text{(Table “E” C• t)}}$

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

Log Removal = 1.0 - $\dfrac{\text{\% Removal}}{100}$ x Log key x (-1)

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

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

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

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

SEDIMENTATION

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

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

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

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

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

FILTRATION (cont.)

10; part 2

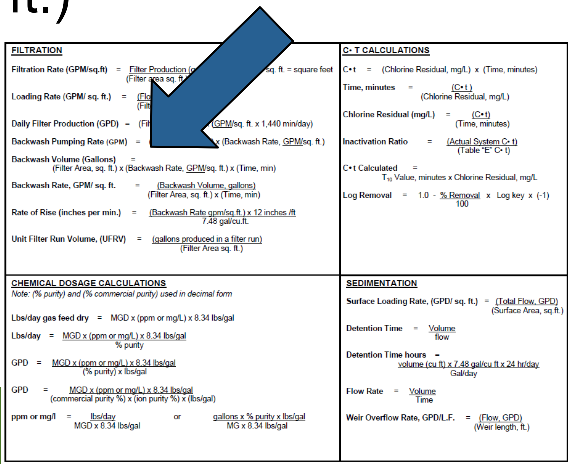
Backwash Volume (Gallons) =

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

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

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

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



FILTRATION

Filtration Rate (GPM/sq.ft) = Filter Production (g… / (Filter area sq. ft.) … sq. ft. = square feet

Loading Rate (GPM/ sq. ft.) = (Flo… / (Filt…

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

Backwash Pumping Rate (GPM) = (…) 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 Log key x (-1)

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

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.)

Filtration Rates – Box 10

- 2. 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:

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

gpm ÷ sq ft = gpm/sq ft

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Filtration Rates – Box 10

- 2. 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:

$$\frac{1{,}000{,}000 \text{ gal/day} \div 1{,}440 \text{ min/day}}{20 \text{ ft} \times 25 \text{ ft}} = \frac{694.4 \text{ gpm}}{500 \text{ sq ft}}$$

gpm ÷ sq ft = 1.388 gpm/sq ft

Filtration Rate – Box 10, Flow

- 3. 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 – Box 10, Flow

- 3. 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:

20 in ÷ 12 in/ft = 1.66 ft

1.66 ft ÷ 9 min = 0.18 ft/min

Backwash Rates – Box 10

- 6. 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:

25 ft x 30 ft = 750 sq ft

750 sq ft x 20 gpm/sq ft = 15,000 gpm

Poll #4 - What did you learn today?

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Thank You For Attending!

We look forward to seeing you in future online classes!

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