



NEW MEXICO ENVIRONMENT DEPARTMENT  
**UTILITY OPERATOR CERTIFICATION PROGRAM**

## Conversion Factors and Formulas

### ABBREVIATIONS

***English***

**A** = area  
**ac ft.** = acre-foot or acre-feet  
**b** = base (of right triangle)  
**°C** = degrees Celsius  
**cfs** or **ft<sup>3</sup>/sec** = cubic feet per second  
**cfm** or **ft<sup>3</sup>/min** = cubic feet per minute  
**cfd** or **ft<sup>3</sup>/day** = cubic feet per day  
**d** = diameter (circle)  
**°F** = degrees Fahrenheit  
**fps** or **ft./sec** = feet per second  
**ft.** = feet  
**ft<sup>2</sup>** or **sq. ft.** = square feet  
**ft<sup>3</sup>** or **cu. ft.** = cubic feet  
**gpd** = gallons per day  
**gpg** = grains per gallon  
**gpm** = gallons per minute  
**gps** = gallons per second  
**h** = height  
**hrs/day** = hours per day  
**in** = inches

**in<sup>2</sup>** = square inches  
**in<sup>3</sup>** = cubic inches  
**lbs.** = pounds  
**mi** = miles  
**MG** = million gallons  
**mgd** or **MGD** = million gallons per day  
**ppm** = parts per million  
**ppt** = parts per trillion  
**psi** = pounds per square inch  
**Q** = flow  
**r** = radius (circle)  
**W** = watts  
**A** = amps  
**V** = volts  
***Metric***  
**cm** = centimeters  
**g** = gram  
**Ha** = Hectare  
**kg** = kilogram  
**km** = kilometer  
**kW** = kilowatt  
**L** or **l** = liters

**m** = meter  
**m<sup>3</sup>** = cubic meter  
**mg** = milligram  
**mg/L** or **mg/l** = milligrams per liter or parts per million  
**mL** = milliliter  
**mm** = millimeter

***Metric Prefixes***

**mega (M):** x 1,000,000  
**kilo (k):** x 1,000  
**hecto (h):** x 100  
**deka (da):** x 10  
**deci (d):** x 0.10  
**centi (c):** x 0.01  
**milli (m):** x 0.001  
**micro (µ):** x 0.000001  
**micro to milli:** x 0.001  
***meter.*** linear measurement  
***liter.*** volume measurement  
***gram.*** weight measurement

### VOLUME

***English***

1 acre-ft. = 325,828.8 gllons  
 1 acre-ft. = 43,560 ft<sup>3</sup>  
**1 cfs = 0.646 MGD Flow not volume**  
 1 ft<sup>3</sup> = 7.48 gallons  
 1 gallon = 231 in<sup>3</sup>  
 1 gallon = 0.1337 ft<sup>3</sup>  
 1 gallon = 3.785 liter  
 1 gallon = 0.000001 MG  
**1 MGD = 1.55 cfs Flow not volume**  
**1 MGD = 694gpm Flow not volume**

***Metric***

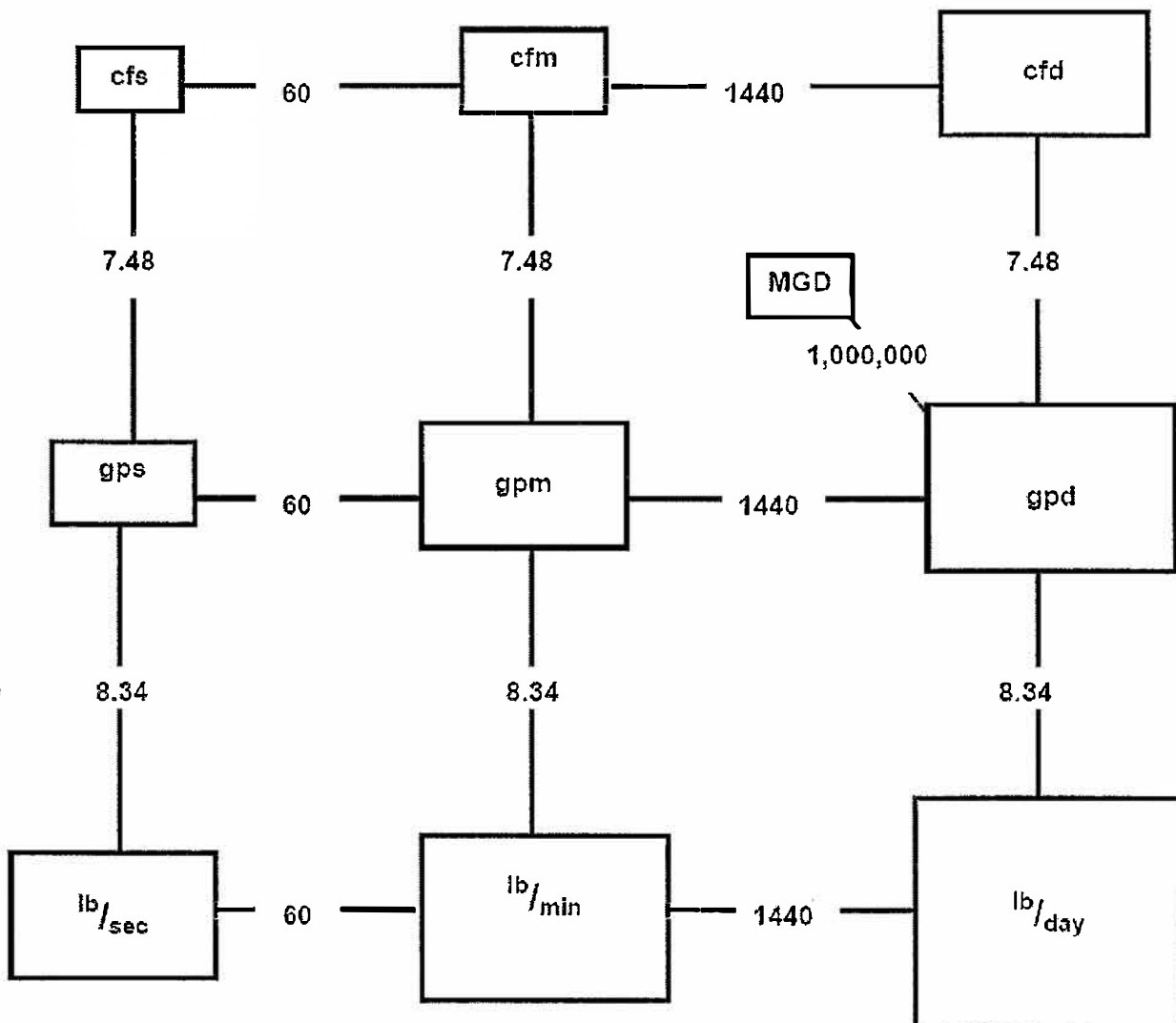
1 liter = 1,000 mL  
 1 liter = 0.2642 gallons  
 1 m<sup>3</sup> = 264.2 gallons  
 1 m<sup>3</sup> = 35.315 ft<sup>3</sup>

### AREA

1 acre (ac) = 43,560 ft<sup>2</sup>  
 1 acre = 0.405 Hectare (Ha)  
 1ft<sup>2</sup> = 144 in<sup>2</sup>  
 1 in<sup>2</sup> = 6.45 cm<sup>2</sup>  
**1yd<sup>3</sup> = 27 ft<sup>3</sup> Volume not area**

(metric)  
 1 hectar = 2.47 acres

## Flow Conversions



cfs = cubic feet per second

cfm = cubic feet per minute

cfd = cubic feet per day

gps = gallons per second

gpm = gallons per minute

gpd = gallons per day

To use this diagram: First, find the box that coincides with the beginning units (i.e. gpm). Then, find the box that coincides with the desired ending units (i.e. cfs). The numbers between the starting point and ending point are the conversion factors. When moving from a smaller box to a larger box, multiply by the factor between them. When moving from a larger box to a smaller box, divide by the factor between them.



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**FLOW**

1 ft<sup>3</sup>/sec = 0.6463 MG **MGD**  
 1 ft<sup>3</sup>/sec = 449 gpm  
 gpm = 0.00144 MGD  
 1 MGD = 694.4 gpm  
 1 MGD = 1.547 cfs  
 MGD = 3.07 acre-ft/day

**WEIGHT & MASS**

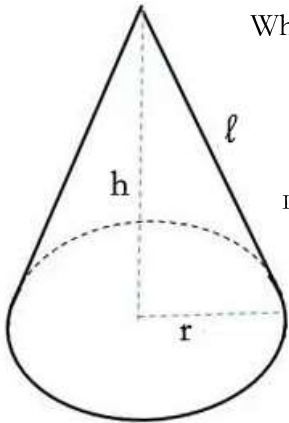
**English**

1 ft<sup>3</sup> water = 62.4 lbs.  
 1 gallon water = 8.34 lbs  
 1 gpg = 17.118 mg/L  
 1 lb. = 453.6 g

**Metric**

1 g = 1,000 m **mg**  
 1 kg = 1,000 g  
 1 mg/L = 0.0584 gpg  
 1 kg = 2.2 lbs  
 1% = 10,000 mg/L

**Area of a Cone**



Where:  $l$  = slant height or hypotenuse

$h$  = height

$r$  = radius

$\pi r(l + r)$  or  $\pi r l + \pi r^2$

If  $h$  and  $r$  are give then  $l$  will have to be solved for.

$l^2 = h^2 + r^2$

**LENGTH**

**English**

1 foot = 12 in  
 1 foot = 0.305 m  
 1 inch = 2.54 cm  
 1 mile = 5,280 ft  
 1 mile = 1.609 km

**Metric**

1 centimeter = 0.3937 in.  
 1 kilometer = 0.6214 mi  
 1 meter = 39.37 in  
**1 yard = 3 ft** **English not metric**

For the operator's convenience, both equation formulas and pie wheel formulas are included in this document.

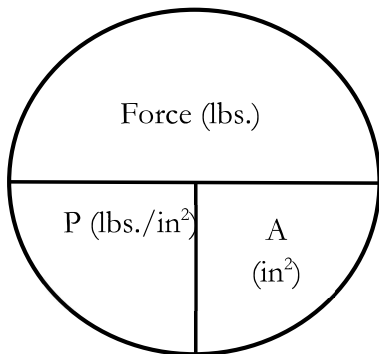
When using the pie wheel formula to solve a problem, multiply together the pie wedges below the horizontal line to solve for the quantity above the horizontal line. To solve for one of the pie wedges below the horizontal line, cover the pie wedge for which you are solving and divide the remaining pie wedge(s) below the horizontal line into the quantity above the horizontal line.

Electromotive Force (EMF) =  $I \times R$

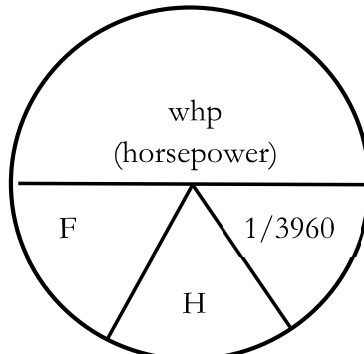
WHERE: EMF=electromotive force(volts)

I=current(amps)

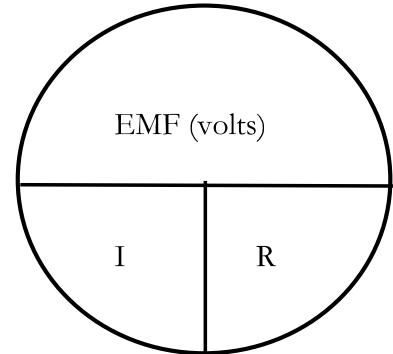
R=resistance(ohms)



$F=(P) \times (A)$   
 F=force(lbs)  
 P=pressure(psi)  
 A=area(in<sup>2</sup>)



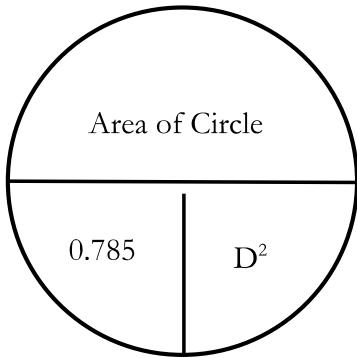
$whp = \frac{F \times H}{3,960}$   
 whp = water horsepower  
 F = flow (gpm)  
 H = head (ft)



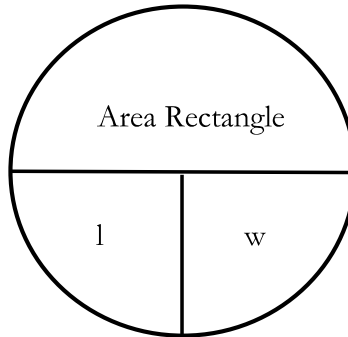


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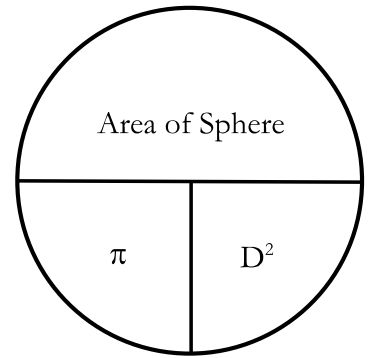
Where:  $\pi = 3.1416$   
 $r$  = radius of circle  
 $D$  = diameter of circle



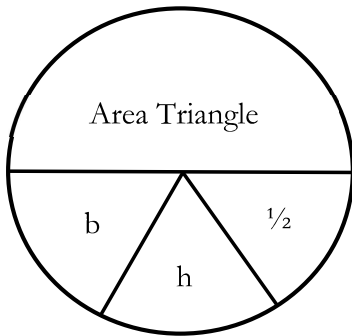
$$A = \pi r^2$$



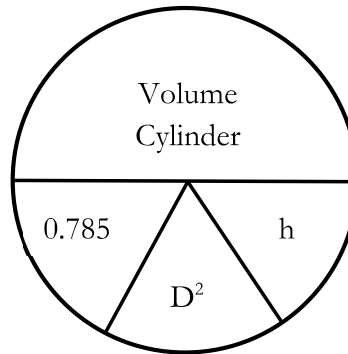
$l$  = length of rectangle  
 $w$  = width of rectangle



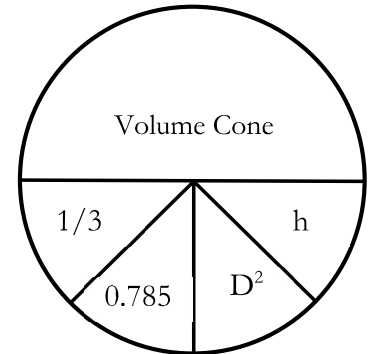
$$S = 4\pi r^2$$



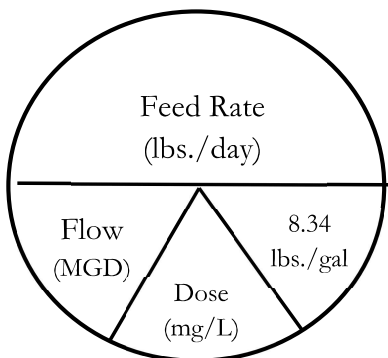
Triangle (area) =  $[(b) \times (h)]/2$   
 $b$  = base of triangle  
 $h$  = height of triangle



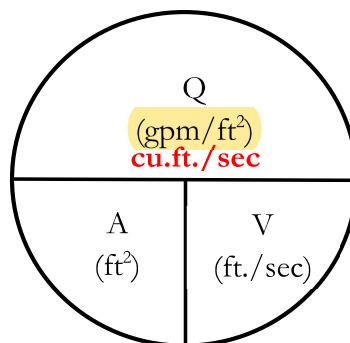
$$\text{Cylinder} = (0.785) \times (D^2) \times (h)$$



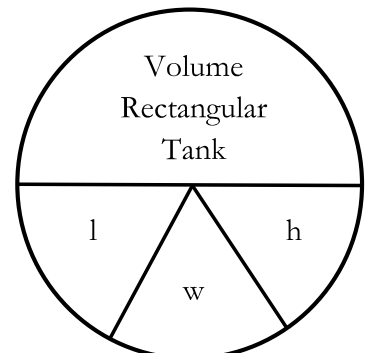
$$\text{cone} = (1/3) \times (0.785) \times (D^2) \times (h)$$



Where: feed rate = lbs./day  
 $d$  = dose (mg/L)  
 $Q$  = flow (MGD)  
 Feed Rate (lbs./day) = Chemical purity of 100%  
 For chemical purity of less than 100% see formulas on page 6.



$$Q = (A) \times (V)$$



$$\text{Rectangular Tank} = (l) \times (w) \times (h)$$

### Circumference of Circle

$$\text{Circumference} = (\pi) \times (D)$$

Where:  $\pi = 3.1416$   
D = diameter of circle

$$\text{Circumference} = (2) \times (\pi) \times (r)$$

Where:  $\pi = 3.1416$   
r = radius of circle

### Flows

$$Q = (w) \times (d) \times (V)$$

Where: Q = flow in channel (ft<sup>3</sup>/sec)  
w = width (ft.)  
d = depth (ft.)  
V = velocity (ft./sec)

$$Q = (0.785) \times (D)^2 \times (V)$$

Where: Q = flow in full pipe (ft<sup>3</sup>/sec)  
D = diameter (ft.)  
V = velocity (ft./sec)

$$Q = \{1.333 \times (h)^2 \times \sqrt{(D/h) - 0.608} \times (V)$$

Where: Q = flow in partially full pipe (ft<sup>3</sup>/sec)  
h = height (ft.)  
D = diameter (ft.)  
V = velocity (ft./sec)

$$Q = AV \quad \text{or} \quad Q = (\text{Area})(\text{Velocity})$$

$$V = (Q) / \{(0.785) \times (D)^2\}$$

Where: V = velocity (ft./sec)  
Q = flow (ft<sup>3</sup>/sec)  
D = diameter (ft.)

$$V = (d) / (T)$$

Where: V = velocity (ft./sec)  
d = distance (ft.)  
T = time (sec)

$$Q = (\sum Q_{\text{daily}}) / (n_{\text{daily}})$$

Where: Q = avg. daily flow (MGD)  
 $\sum Q_{\text{daily}}$  = sum all daily flows (MGD)  
 $n_{\text{daily}}$  = number of daily flow

$$Q = (\text{Water used}) / (\text{Population})$$

Where: Q = daily flow (gal/capita/day)  
water used or produced = gal/day  
population = total # people served(gpd/ft)

$$\text{Overflow rate} = (Q) / (L)$$

Where: overflow rate = weir overflow rate  
Q = flow (gpd)  
L = weir length (ft.)

$$\text{Change in Velocity} = (A1V1) = (A2V2)$$

Where: A=area  
V=velocity

## Dosage Formulas

$$\text{Dosage} = \frac{\text{Feed rate}}{(Q) \times (8.34 \text{ lbs./gal})}$$

Where: dosage = mg/L  
feed rate = chemical feed rate (lbs./day)  
Q = flow rate (MGD)

$$\text{Dosage} = \frac{(\text{Feed rate}) \times (\text{Purity})}{(Q) \times (8.34 \text{ lbs./gal})}$$

Where: dosage = mg/L  
feed rate = chemical feed rate (lbs./day)  
purity = chemical purity, % expressed as decimal  
Q = flow rate (MGD)

$$\text{Dosage} = \frac{(\text{Feed rate}) \times (1,000 \text{ mg/g})}{(Q) \times (3.785 \text{ L/gal})}$$

Where: dosage = mg/L  
feed rate = chemical feed rate (lbs./day)  
Q = flow rate (MGD)

$$\text{Dose} = \text{Demand} + \text{Residual}$$

## Chemical Feed/Feed Rate Formulas (lbs.)

$$\text{Chemical feed} = (d) \times (V) \times (8.34 \text{ lbs./gal})$$

Where: chemical feed = lbs.  
d = dose (mg/L)  
V = volume (MG)

$$\text{Chemical feed} = \frac{(d) \times (V) \times (8.34 \text{ lbs./gal})}{\text{Chemical purity}}$$

Where: chemical feed = lbs.  
d = dose (mg/L)  
V = volume (MG)  
Chemical purity = %, expressed as decimal

$$\text{Feed rate} = (d) \times (Q) \times (8.34 \text{ lbs./gal})$$

Where: feed rate = lbs./day  
d = dose (mg/L)  
Q = flow (MGD)

$$\text{Feed rate} = \frac{(d) \times (Q) \times 8.34 \text{ lbs./gal}}{\text{Chemical Purity}}$$

Where: feed rate = lbs./day  
d = dose (mg/L)  
Q = flow (MGD)  
Chemical purity = %, expressed as decimal

$$\text{Feed rate} = \frac{(C) \times (V) \times (1,440 \text{ min/day})}{(T) \times (1,000 \text{ mg/g}) \times (453.6 \text{ g/lb.})}$$

Where: feed rate = lbs./day  
C = concentration (mg/mL)  
V = volume pumped (mL)  
T = time pumped (min.)

## Chemical Feed Pump Formulas

$$\text{Chemical Feed Stroke \%} = (Q_d/Q_m) \times 100$$

Where: chemical feed stroke, % expressed as a decimal  
 $Q_d$  = desired flow  
 $Q_m$  = maximum flow

$$\text{Feed pump rate} = \frac{(Q) \times (d) \times (3.785 \text{ L/gal}) \times (1,000,000 \text{ gal/MG})}{(L) \times (24 \text{ hr/day}) \times (60 \text{ min/hr})}$$

Where: feed pump rate = mL/min  
 Q = flow (MDG)  
 d = dose (mg/L)  
 L = liquid (mg/mL)

$$\text{Watts} = V \times A$$

Where: Watts = DC or AC circuit  
 V = volts  
 A = amps

**PUMPS**

**Pumping Formulas**

$$\text{Pumping Rate} = V/T$$

Where: pumping rate in gal/min  
 V = volume (gal.)  
 T = time (min.)

$$\text{Pumping Rate} = \frac{L \times W \times D \times 7.48 \text{ gal/ft}^3}{T}$$

Where: pumping rate in gal/min  
 L = length (ft.)  
 W = width (ft.)  
 D = depth (ft.)  
 T = time (min.)

$$\text{Pumping Rate} = \frac{0.785 \times d^2 \times D \times 7.48 \text{ gal/ft}^3}{T}$$

Where: pumping rate in gal/min  
 d = diameter (ft.)  
 D = depth (ft.)  
 T = time (min.)

$$\text{Time to Fill} = \frac{\text{Tank volume}}{\text{Flow Rate}}$$

Where: time to fill in min.  
 tank volume in gal.  
 flow rate in gal/min.

**Horsepower, Motor & Pump Efficiency**

$$\text{whp} = \frac{F \times H}{3,960}$$

Where: whp = water horsepower  
 F = flow (gpm)  
 H = head (ft.)

$$\text{bhp} = \frac{F \times H}{3,960 \times \text{PE}}$$

Where: bhp = brake horsepower  
 F = flow (gpm)  
 H = head (ft.)  
 PE = pump efficiency (% as decimal)

$$\text{bhp} = \text{whp}/\text{PE}$$

Where: bhp = brake horsepower  
whp = water horsepower  
PE = pump efficiency (% , as decimal)

$$\text{mhp} = \frac{\text{F} \times \text{H}}{3,960 \times \text{PE} \times \text{ME}}$$

Where F = flow (gpm)  
H = head (ft.)  
PE = pump efficiency (% , as decimal)  
ME = motor efficiency (% , as decimal)  
mbp= motor horsepower

$$\text{mhp} = \text{bhp}/\text{ME}$$

Where: mhp = motor horsepower  
Bhp = brake horsepower  
ME = motor efficiency (% , as decimal)

$$\text{ME} = (\text{bhp}/\text{mhp}) \times 100$$

Where: ME = motor efficiency (% , as decimal)  
bhp = brake horsepower  
mhp = motor horsepower

$$\text{PE} = (\text{whp}/\text{bhp}) \times 100$$

Where: PE = pump efficiency (% , as decimal)  
whp = water horsepower  
bhp = brake horsepower

$$\text{Efficiency} = \frac{\text{hp output}}{\text{hp supplied}} \times 100$$

Where: efficiency is % (as decimal)

$$\text{Overall Efficiency} = (\text{whp}/\text{mhp}) \times 100$$

Where: overall efficiency is % (as decimal)  
whp = water horsepower  
mhp = motor horsepower

$$\text{Wire to water efficiency} = \frac{\text{whp}}{\text{Power input or mhp}}$$

Where: wire to water efficiency is % (as decimal)  
whp = water horsepower  
mhp = motor horsepower  
power input is hp

$$\text{Wire to water efficiency} = (\text{PE} \times \text{ME}) \times 100$$

Where: wire to water efficiency is % (as decimal)  
PE = pump efficiency (% ) (as decimal)  
ME = motor efficiency (% ) (as decimal)

$$\text{Static Head} = \text{Suction lift} + \text{Discharge Head}$$

Where: Static Head in ft.  
Suction Lift in ft.  
Discharge Head in ft.

$$\text{Static Head} = \text{Discharge Head} - \text{Suction Head}$$

Where: Static Head in ft.  
Discharge Head in ft.  
Suction Head in ft.

$$\text{kW usage} = (\text{hp}/\text{ME}) \times (.746\text{kW})$$

Where: ME = motor efficiency % , (as decimal)  
hp = horsepower

$$\text{Friction Loss} = (0.1) \times (\text{Static Head})$$

Where: Friction Loss is ft.  
Static Head is ft.

**\*\* use this formula in absence of other data**

$$\text{Total Dynamic Head} = \text{Static Head} + \text{Friction Loss}$$

Where: Total Dynamic Head is ft.  
Static Head is ft.  
Friction Loss is ft.

$$\text{Cost} = (\text{Motor hp}) \times (0.746 \text{ kW/hp}) \times (\text{Cost} \$/\text{kW-hr})$$

Where: Cost is \$/hr.

**POWER**

$$1\text{hp} = .746\text{kW}; 1\text{hp} = 746\text{W}; 1\text{kW} = 1.34\text{hp}$$

**Wastewater Treatment Ponds**

$$\text{PL} = (\text{Population}) / (\text{A})$$

Where: PL = population loading (persons/acre)  
Population = population served (persons)  
A = pond area (acres)

$$\text{V} = (\text{A}) \times (\text{d})$$

Where: V = pond volume (ac-ft.)  
A = pond area (acres)  
d = pond depth (ft.)

$$\text{V (gal)} = [\text{V (ac-ft.)}] \times (43,560 \text{ ft}^2/\text{ac}) \times (7.48 \text{ gal/ft}^3)$$

Where: V = pond volume

$$\text{A} = [(\text{L}) \times (\text{W})] / (43,560 \text{ ft}^2/\text{ac})$$

Where: A = pond area (acre)  
L = length (ft.)  
W = width (ft.)

$$\text{DT} = (\text{V}) / (\text{Q})$$

Where: DT = detention time (days)  
V = volume (gal)  
Q = flow (gal/day)

$$\text{OLR} = (\text{BOD}) / (\text{A})$$

Where: OLR = organic loading rate (lbs./day/acre)  
BOD = influent BOD (lbs./day)  
A = pond areas (acres)

$$\text{OLR} = [(\text{BOD}) \times (\text{Q}) \times (8.34 \text{ lbs./gal})] / (\text{A})$$

Where: OLR = organic loading rate (lbs./day/acre)  
BOD = influent BOD (mg/L)  
Q = flow (MGD)  
A = pond areas (acres)

$$\text{HLR} = [(\text{Q}) / (\text{A})] \times 12 \text{ in/ft.}$$

Where: HLR = hydraulic loading rate (in/day)  
Q = flow (ac-ft/day)  
A = pond area (acres)

### Loading Formulas (general)

$$\text{Loading} = (\text{Concentration}) \times (Q) \times (8.34 \text{ lbs/gal})$$

Where:

Loading is TSS or BOD = lbs./day  
Concentration of TSS or BOD = mg/L  
Q = flow

$$\text{Hydraulic loading rate} = \frac{\text{Flow}}{A}$$

Where:

Hydraulic Loading = gpd/ft<sup>2</sup>  
Flow = gpd  
A = area (ft<sup>2</sup>)

$$\text{Surface loading rate or Surface overflow rate} = \frac{\text{Flow}}{A}$$

Where:

Surface Loading/Surface Overflow rate  
in gpd/ft<sup>2</sup>  
Flow = gpd  
A = area (ft<sup>2</sup>)

### Temperature Conversions

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) \times (0.556) \quad (0.556)$$

Where:

<sup>o</sup>C = degrees Celsius  
<sup>o</sup>F = degrees Fahrenheit

$$^{\circ}\text{F} = (^{\circ}\text{C} \times 1.8) + 32$$

### Formulas

Average (arithmetic mean) = (sum of all terms) / (number of terms)

$$\text{Average (geometric mean)} = \sqrt[n]{(X_1)(X_2)(X_3)(X_4) \dots (X_n)}$$

*The nth root of the product of n numbers*

$$\text{Efficiency, \%} = [(\text{In} - \text{Out}) / (\text{In})] \times 100$$

### WET WELL

$$\text{Cycle time (min)} = \frac{\text{SV}}{\text{PC} - \text{Inflow}}$$

Where:

SV = storage volume (gal)  
PC = pump capacity (gpm)  
Inflow = wet well inflow (gpm)

### COLLECTION SYSTEM

$$\text{Slope \%} = \left[ \frac{\text{Drop or rise}}{\text{Distance}} \right] \times 100$$

OR

$$\text{Slope \%} = \left[ \frac{\text{Rise}}{\text{Run}} \right] \times 100$$

$$\text{Velocity} = F/A$$

Where:

Velocity is ft./sec  
F = flow (ft<sup>3</sup>/sec)  
A = area (ft<sup>2</sup>)

$$\text{Velocity} = \frac{\text{Distance}}{\text{Time}}$$

Where:

Velocity is ft./sec  
D = distance (ft.)  
T = time (sec)

### DETENTION TIME

$$DT = \frac{(V) \times (1,440 \text{ min/day}) \times (60 \text{ sec/min})}{Q}$$

Where: DT = detention time (sec)  
V = volume (gal)  
Q = flow rate (gal/day)

$$DT = \frac{(V) \times (24 \text{ hr./day})}{Q}$$

Where: DT = detention time (hr.)  
V = volume of tank or basin (gal)  
Q = flow rate (gal/day)

$$DT = \frac{(V) \times (1,440 \text{ min/day})}{Q}$$

Where: DT = detention time (min)  
V = volume (gal)  
Q = flow rate (gal/day)

$$DT = (V)/(Q)$$

Where: DT = detention time (days)  
V = volume of tank or basin (gal)  
Q = flow rate (gal/day)

$$DT = (V)/(Q)$$

Where: DT = detention time (days)  
Q = flow (ac-ft./day)  
V = Volume (ac-ft.)

### WELL FORMULAS

$$\text{Well Yield} = V/T$$

Where: Well Yield in gpm  
V = volume in gallons  
T = time in minutes

$$\text{Drawdown} = \text{PWL} - \text{SWL}$$

Where: Drawdown in feet  
PWL = pumping water level in ft.  
SWL = static water level in ft.

$$\text{Specific Capacity} = \text{Well Yield/Drawdown}$$

Where: Specific capacity = gpm/ft.  
Well Yield in gpm  
Drawdown in ft.

### PRESSURE

$$1 \text{ ft water} = 0.433 \text{ psi} \quad 1 \text{ psi} = 2.31 \text{ ft of water}$$

### ACTIVATED SLUDGE

$$SVI = \frac{(\text{SSV}) \times (1,000 \text{ mg/L})}{\text{MLSS}}$$

Where: SVI = sludge volume index (mL/g)  
SSV = settled sludge volume (mL/L)  
MLSS = mixed liquor suspended solids (mg/L)

## WATER/WASTEWATER LEVELS 3 & 4

$$\text{BOD}_5 = \frac{(\text{DO}_I - \text{DO}_F) \times 300}{V_{\text{sample}}}$$

Where: BOD<sub>5</sub> = mg/L  
 DO<sub>I</sub> = initial DO (mg/L)  
 DO<sub>F</sub> = final DO (mg/L)  
 V<sub>sample</sub> = sample volume (mL)  
 BOD bottle = 300 mL

$$\text{BOD}_5 = \frac{(D_1 - D_2) - (S) \times (V_S)}{P}$$

BOD<sub>5</sub> = lbs./day **mg/L**  
 D<sub>1</sub> = DO of sample after prep (mg/L)  
 D<sub>2</sub> = DO of sample after 5-day incubation at 20°C (mg/L)  
 S = oxygen uptake of seed  
 (S = 0 if sample not seeded)  
 V<sub>S</sub> = volume of seed in test bottle (mL)  
 P = decimal volumetric fraction of sample used. (1/P = dilution factor)

$$\text{F/M ratio} = \frac{(\text{BOD or COD})}{\text{MLVSS}}$$

Where: F/M ratio = food to microorganism ratio  
 BOD = biological oxygen demand (lbs./day)  
 COD = chemical oxygen demand (lbs./day)  
 MLSS = mixed liquor suspended solids (lbs.)  
**MLVSS = mixed liquor volatile suspended solids (lbs.)**

**MLVSS = MLSS x % volatiles as a decimal**

$$\text{F/M Ratio} = \frac{(\text{BOD or COD, mg/L})(\text{Flow, MGD})(8.34 \text{ lbs./gal})}{(\text{MLVSS, mg/L})(\text{Aerator Volume, MG})(8.34 \text{ lbs./gal})}$$

Where: MGD (flow) = Million Gallons/Day  
 MG (volume) = Million Gallons

$$\text{COD} = \frac{(\text{Amt. of FAS in Blank}) \times (\text{Molarity of FAS Titrant}) \times 8000}{\text{Amt. of Sample}}$$

$$\text{COD loading} = (\text{COD}) \times (\text{Q}) \times (8.34 \text{ lbs./gal})$$

Where: COD loading = lbs./day  
 COD = chemical oxygen demand (mg/L)  
 Q = flow (MGD)

$$\text{MLSS (lbs.)} = (\text{MLSS, mg/L}) \times (\text{V}) \times (8.34 \text{ lbs./gal})$$

Where: MLSS = mixed liquor suspended solids  
 V = aerator volume (MG)

$$\text{MLVSS (desired)} = \frac{(\text{BOD or COD})}{\text{F/M Ratio (desired)}}$$

Where: MLVSS = mixed liquor volatile suspended solids (lbs.)  
 BOD = biological oxygen demand lbs./day  
 COD = chemical oxygen demand (lbs./day)

### **SOLIDS**

$$\text{SS} = \frac{(A - B) \times (1,000,000)}{V_{\text{sample}}}$$

Where: SS = suspended solids (mg/L)  
 A = final weight of pan, filter & residue (g)  
 B = weight of prepared filter & pan (g)  
 V<sub>sample</sub> = sample volume (mL)

### Waste Activated Sludge (WAS)

$$WAS = \left[ \frac{(MLSS) \times (V_{\text{aerator}}) \times (8.34 \text{ lbs./gal})}{MCRT} \right] - [(SE \text{ SS}) \times (Q_{\text{Plant}}) \times (8.34 \text{ lbs./gal})]$$

If volume of aerator and volume of clarifier are provided the volumes will be added together and place in the formula where it say (V<sub>aerator</sub>)

Where: WAS = lbs./day  
 MLSS = mixed liquor suspended solids (mg/L)  
 V<sub>aerator</sub> = aerator volume (MG)  
 SE SS = secondary effluent SS (mg/L)  
 Q<sub>Plant</sub> = plant flow (MGD)  
 MCRT = days

### Mean Cell Residence Time

$$MCRT = \frac{TSS_{\text{Aeration}} + TSS_{\text{Clarifier}}}{TSS_{\text{Wasted}} + TSS_{\text{Effluent}}}$$

Where: MCRT = days  
 TSS<sub>Aeration</sub> = aeration tank TSS (lbs.)  
 TSS<sub>Clarifier</sub> = clarifier TSS (lbs.)  
 TSS<sub>Wasted</sub> = TSS wasted (lbs./day)  
 TSS<sub>Effluent</sub> = effluent TSS (lbs./day)

$$MCRT = \frac{(MLSS) \times [(V_{\text{aerator}}) + (V_{\text{clarifier}})] \times (8.34 \text{ lbs./gal})}{[(WAS \text{ SS}) \times (Q_{\text{WAS}}) \times (8.34 \text{ lbs./gal})] + [(SE \text{ SS}) \times (Q_{\text{Plant}}) \times (8.34 \text{ lbs./g})]}$$

Where: MCRT = days  
 Q<sub>Plant</sub> = plant flow (MGD)  
 V<sub>aerator</sub> = aerator volume (MG)  
 SE SS = secondary effluent SS (mg/L)  
 V<sub>clarifier</sub> = final clarifier volume (MG)  
 WAS SS = waste activated sludge SS (mg/L)  
 Q<sub>WAS</sub> = WAS flow (MGD)  
 MLSS = mixed liquor suspended solids (mg/L)

$$MCRT = \frac{(MLSS) \times (V) \times (8.34 \text{ lbs./gal})}{[(WAS \text{ SS}) \times (Q_{\text{WAS}}) \times (8.34 \text{ lbs./gal})] + [(SE \text{ SS}) \times (Q_{\text{Plant}}) \times (8.34 \text{ lbs./gal})]}$$

Where: MCRT = days  
 MLSS = mixed liquor suspended solids (mg/L)  
 SE SS = secondary effluent SS (mg/L)  
 WAS SS = waste activated sludge SS (mg/L)  
 Q<sub>WAS</sub> = WAS flow (MGD)  
 Q<sub>Plant</sub> = plant flow (MGD)  
 V = aerator volume (MG)

**CONCENTRATION/DILUTION/SOLUTIONS FORMULAS**

$$(C_1 \times V_1) = (C_2 \times V_2)$$

Where: C=concentration  
V=volume/flow

$$(N_1 \times V_1) + (N_2 \times V_2) = (N_3 \times V_3)$$

Where:  $V_1 + V_2 = V_3$   
N = normality  
V = volume or flow

**FLUORIDATION**

$$\text{Feed Rate, lbs./day} = \frac{(\text{Dose, mg/L})(\text{Flow, MGD})(8.34 \text{ lbs./gal})}{\text{AFI \% (in decimal form)} \times \text{Purity \% (in decimal form)}}$$

Where: AFI=Available Fluoride Ion

$$\text{Saturator Feed Rate, } \frac{\text{grams}}{\text{min}} = \frac{(\text{Dose, mg/L})(\text{Flow, gal/min})}{(18,000) \text{ mg/L}} \frac{\text{mg/L}}{\text{gal/min}}$$

$$\text{Calculated Dosage, mg/L} = \frac{(\text{chemical pounds}) \times (\text{AFI \% in decimal form}) \times (\text{Purity \% in decimal form})}{\text{MGD} \times 8.34}$$

**FILTRATION**

$$\text{Backwash water volume, gal} = (\text{Backwash Rate, gal/min/sq. ft}) (\text{Backwash Time, min}) (\text{Filter Area, sq. ft})$$

$$\text{Filter Production Rate, gal/min} = (\text{Filtration Rate, gal/min/sq. ft}) (\text{Filter Area, sq. ft})$$

$$\text{Filter Production Rate, gal/day} = (\text{Filtration Production Rate, gal/min.}) (1,440 \text{ min./day})$$

**CHLORINATION/HTH**

$$\text{HTH, lb.} = \frac{\text{Chlorine, lb.}}{\text{Available Chlorine, \% , expressed as decimal}}$$

$$\text{HTH, lbs.} = \frac{(\text{Desired Available Chlorine, \% , expressed as decimal}) (\text{Desired Volume, gal}) (8.34 \text{ lbs./gal})}{\text{HTH Available Chlorine, \% expressed as decimal}}$$

$$\text{Chlorine, lb.} = (\text{HTH, lb.}) (\text{Available Chlorine, \% , expressed as decimal})$$

$$\text{Chlorine, lb.} = (\text{Available Chlorine, \% , expressed as decimal}) (\text{Bleach Volume, gal}) (8.34 \text{ lbs./gal})$$

$$\text{Chlorine Dosage, mg/L} = \frac{(\text{HTH Feed Rate, lb./day}) (\text{HTH Available Chlorine, \% expressed as decimal})}{(\text{Flow, MGD}) (8.34 \text{ lbs./gal})}$$

$$\text{Chlorine Feed Rate, lbs./day} = \frac{(\text{Dosage, mg/L}) (\text{Flow, MGD}) (8.34 \text{ lbs./gal})}{\text{Chemical Purity, \% , expressed as decimal}}$$