Conversion Factors

Area

1 square foot	=	144 square inches
1 square yard	=	9 square feet
1 square mile	=	640 acres or 1 section
1 square meter	=	10.764 square feet
1 square meter	=	10,000 square centimeters
1 acre	=	43,560 square feet
1 hectare	=	2.471 acres

Length

1 inch	= 2.54 centimeters	= 25.4 millimeters
1 foot	= 12 inches	= 0.305 meters
1 yard	= 3 feet	= 0.914 meters
1 mile	= 5,280 feet	= 1,760 yards
1 meter	= 39.37 inches	= 3.281 feet
1 kilometer	= 0.621 miles	= 1,000 meters

Volume

1 cubic foot	=	1,728 cubic inches
1 cubic foot	=	7.48 gallons
1 cubic yard	=	27 cubic feet
1 acre-inch	=	27,152 gallons
1 acre-foot	=	43,560 cubic feet
1 acre-foot	=	326,000 gallons*
1 gallon	=	3.785 liters
1 gallon	=	231 cubic inches
1 gallon	=	4 quarts
1 cubic meter	=	35.318 cubic feet
1 cubic meter	=	1.308 cubic yards
1 liter	=	0.2642 gallons
1 liter	=	1,000 milliliters

**rounded off to nearest thousand gallons*

Power

1 horsepower	= 0.746 kilowatts
1 horsepower	= 33,000 ft-lbs/minute
1 kilowatt	= 1,000 watts

Flow

1 cubic foot/second	=	449 gallons/minute
1 gallon/second	=	0.134 cubic feet/second
1 gallon/second	=	8.021 cubic feet/minute
1 gallon/minute	=	0.00223 cubic feet/second
1 gallon/minute	=	1,440 gallons/day

Pressure

1 foot of water per square inch	=	0.434 pounds
1 pound per square inch	=	2.307 feet of water
1 pound per square inch	=	2.31 feet of water

Weight

1 gallon	=	8.34 pounds of water
1 cubic foot	=	62.4 pounds of water
1 pound	=	0.454 kilograms
1 kilogram	=	1,000 grams
1 liter	=	1,000 grams
1 mg/kg or 1 ppm or 1 mg/L	=	0.0022 pounds/ton or 0.0001%
1%	=	10,000 mg/L
1 mg/L	=	1,000 µg/L

Wastewater Formulas & Conversion Factors

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Metric System

The metric system is a decimal system based on units of tens – similar to our currency. If you think of the dollar as the basic unit, we can break it down this way:

- Dime = 0.10 dollars
- Cent = 0.01 dollars
- Mill (used in levying taxes) = 0.001 dollars

Occasionally we may want an extremely small (*micro*) number. If we want to talk about larger amounts – like 1000 watts of electricity – we use the prefix *kilo* (kilowatt). And sometimes we may need an extremely large (*mega*) number.

The metric system has three basic units of measurement:

- **Length** is measured in **meters.**
- **Volume** is measured in **liters.**
- **Weight** (mass) is measured in **grams.**

Like dollars, each can be broken into smaller units and expanded into larger units as shown in Table 1. (The most commonly used units are bolded.)

Table 1: Comparing the Metric System

				Basic Unit		
0.000001	0.001	0.01	0.1	**1**	1,000	1,000,000
	Mill	Cent	Dime	**Dollar**		
				Watt	Kilowatt	
Prefix:	**Micro**	**Milli**	**Centi**	**Deci**	**Kilo**	**Mega**
	Micrometer	**Millimeter**	**Centimeter**	Decimeter	**Kilometer**	**Megameter**
	Microliter	**Milliliter**	Centiliter	Deciliter	Kiloliter	Megaliter
	Microgram	**Milligram**	Centigram	Decigram	**Kilogram**	Megagram

One other useful term is a measurement of area. A square of land measuring 100 meters by 100 meters is called a *hectare,* after the prefix for 100 – *hecto*.

Table 2: Prefixes used in the Metric System

Prefix	Meaning
Micro	0.000001 (1/1,000,000)
Milli	0.001 (1/1,000)
Centi	0.01 (1/100)
Deci	0.1 (1/10)
Deka	10
Hecto	100
Kilo	1,000
Mega	1,000,000

Trivia:

- A centimeter is about the width of your little finger.
- The "hand" (used for measuring horses) is about 10 centimeters, or a decimeter.
- By the original definition of the meter in the eighteenth century, the circumference of the earth is 40 megameters.

Symbols & Abbreviations

Symbols

π = pi or 3.14
/ = per (as gallons/day)
% = percent
µL = microliters

Abbreviations

A = area
ac-ft = acre-feet
B = base
C = circumference
°C = degrees Centigrade
CBOD = carbonaceous biological oxygen demand
CEC = cation exchange capacity
cfm = cubic feet per minute
cfs = cubic feet per second
cu in = cubic inches or inches^3
cu ft = cubic feet or feet^3
D = diameter
ft = foot or feet
ft^2 = square feet
ft^3 = cubic feet
°F = degrees Fahrenheit
F/M = food to mass ratio
gal = gallons
gal/min = gallons per minute
gal/sec = gallons per second
GPD = gallons per day
GPM = gallons per minute
GPS = gallons per second
H = height
hr = hour
HRT = hydraulic retention time
in = inch
in^2 = square inch
in^3 = cubic inch
L = length or liter
lb = pound
mi = mile
mi^2 = square mile
min = minute
mg = milligrams
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
Mgal *or*
MG = million gallons
MGD = million gallons per day
ml = milliliters
MLSS = mixed liquor suspended solids
MLVSS = mixed liquor volatile suspended solids
N = nitrogen
NH$_3$-N = ammonia nitrogen
NO$_2$ = nitrite
NO$_3$ = nitrate
Org. N = organic nitrogen
P = perimeter
PE = population equivalent
pi or π = 3.14
ppb = parts per billion
ppm = parts per million
psi = pounds per square inch
Q = flow
R = radius
RAS = return activated sludge
rise = vertical distance or height
RPM = revolutions per minute
run = horizontal distance or length
S = side of a rectangle
sec = seconds
sq in = square inches
sq ft = square feet
SVI = sludge volume index
SRT = solids retention time
SS = suspended solids
TKN = Total Kjedahl Nitrogen
TSS = total suspended solids
V *or* **vol** = volume
vel = velocity
W = width
WAS = waste activated sludge
yd = yard
yr = year

Stabilization Ponds/Spray Irrigation

Organic Loading on Primary Cell(s) *(pounds per day per acre)* =

$$\frac{\textbf{influent BOD } \textit{(mg/L)} \textbf{ x flow } \textit{(MGD)} \textbf{ x 8.34 } \textit{lbs/gallon}}{\textbf{total surface area of primary(s) } \textit{(acres)}}$$

Storage Volume of a Pond *(gallons)* =
average surface area *(acres)* **x depth** *(feet)* **x 326,000** *gallons per acre-feet*

Volume of Pond Discharged *(gallons)* =
depth discharged *(feet)* **x pond size** *(acres)* **x 326,000** *gallons per acre-feet*

Discharge Flow Rate *(gallons per day)* =
depth discharged in one day *(feet per day)* **x pond size** *(acres)* **x 326,000** *gallons per acre-feet*

Detention Time = $\frac{\textbf{volume of pond between maximum and minimum depth}}{\textbf{flow rate}}$

Total Feet Needed to Discharge or Spray:

1. **Storage volume needed** *(acre-feet)* = $\frac{\textbf{flow rate } \textit{(gallons per day)} \textbf{ x storage time needed } \textit{(days)}}{\textbf{326,000 gallons per acre-feet}}$
2. **Storage volume available** *(acre-feet)* =
   [maximum depth *(feet)* **– actual depth** *(feet)*] **x size of pond** *(acres)*
3. **Total volume needed to discharge or irrigate** *(acre-feet)* =
   storage volume needed *(acre-feet)* **– storage volume available** *(acre-feet)*
4. **Total feet needed to discharge or spray** *(feet)* =
   $\frac{\textbf{total volume needed to discharge or spray } \textit{(acre-feet)}}{\textbf{size of pond being discharged or sprayed } \textit{(acres)}}$

Digestion

Volatile Acid/Alkalinity Ratio = $\frac{\textbf{volatile acids concentration } \textit{(ml/L)}}{\textbf{alkalinity concentration } \textit{(ml/L)}}$

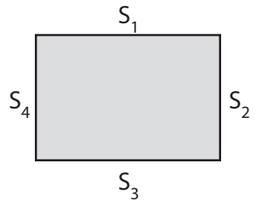
Total Solids Loading *(lbs/day)* = $\frac{\textbf{percent total solids x raw sludge } \textit{(gal/day)} \textbf{ x 8.34 } \textit{(lbs/gal)}}{\textbf{100}}$

Volatile Solids Loading *(lbs/day)* = $\frac{\textbf{percent volatile solids x total solids loading } \textit{(lbs/day)}}{\textbf{100}}$

Volatile Solids Loading *(lbs VS/cu ft of digester capacity)* = $\frac{\textbf{volatile solids loading } \textit{(lbs/day)}}{\textbf{digester volume } \textit{(cu ft)}}$

Dry tons = $\frac{\textbf{gallons x percent total solids}}{\textbf{240}}$

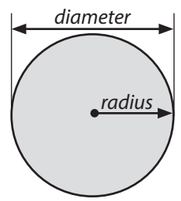
Perimeter /Circumference



The *Perimeter* (P) is the sum of the four *Sides* (S).

Rectangle or Square

$P = S_1 + S_2 + S_3 + S_4$

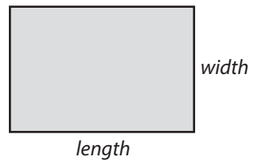


The *Circumference* (C) is *pi* (π, 3.14) times the *Diameter* (D).
(The diameter is two times the radius: **D = 2 x R**)

Circle

C = π x D

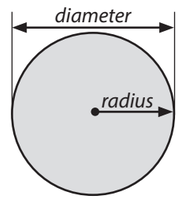
Area



The *Area* (A) is equal to the *Length* (L) times the *Width* (W).

Rectangle or Square

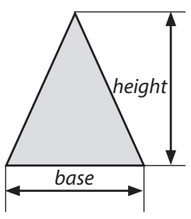
A = L x W



Area (A) of a circle is equal to 0.785 times the *Diameter squared* (D^2).
Area (A) of a circle is also equal to *pi* (**π** , 3.14) times the *Radius squared* (R^2).
Remember: the diameter is 2 times the radius (**D = 2 x R**)

Circle

$A = 0.785 \times D^2$
$A = \pi \times R^2$



The *Area* (A) of a triangle is equal to the length of the *Base* (B) times the *Height* (H) divided by 2.

Triangle

$A = \frac{B \times H}{2}$

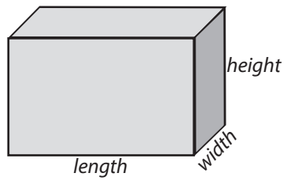
Volume

Rectangle

V = A x H

V = L x W x H

The *Volume* (V) of a rectangle equals its *Area* (A) times its *Height* (H).
Since the *Area* (A) of a rectangle is its *Length* (L) times its *Width* (W), *Volume* (V) can also be expressed as *Length* (L) times *Width* (W) times *Height* (H).

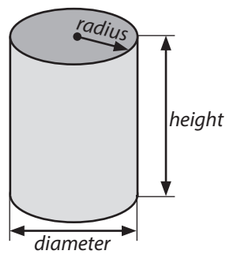


Cylinder

V = Area x H

V = 0.785 x D^2 x H
or
V = π x R^2 x H

The *Volume* (V) of a cylinder equals its *Area* (A) times its *Height* (H).
Since its *Area* (A) equals 0.785 times the *Diameter squared* (D^2), *Volume* (V) equals 0.785 times the *Diameter squared* (D^2) times its *Height* (H).
Remember: the diameter is 2 times the radius (**D = 2 x R)**
Note: 0.785 comes from dividing π by 4 when you use diameter instead of radius.

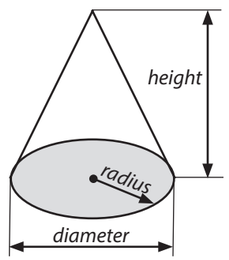


Cone

$$V = \frac{A \times H}{3}$$

$$V = \frac{0.785 \times D^2 \times H}{3}$$

The *Volume* (V) of a cone equals its *Area* (A) times its *Height* (H) divided by 3.
Since its *Area* (A) equals 0.785 times the *Diameter squared* (D^2), *Volume* (V) equals 0.785 times the *Diameter squared* (D^2) times its *Height* (H) divided by 3.
Remember: the diameter is 2 times the radius (**D = 2 x R)**



To convert volume from cubic feet to gallons: multiply cubic feet x 7.48 gallons per cubic feet

If using goal posts to convert cubic feet to gallons, use the factor $\frac{7.48 \text{ gallons}}{\text{cubic ft}}$

Rotating Biological Contactors

Hydraulic Loading Rate
(HLR – *in gallons per day per square foot***) =** **flow rate** *(gallons/day)* / **total surface area of media** *(square feet)*

Organic Loading Rate
(OLR – *in pounds per day per 1,000 sq ft***) =** **pounds/day applied to RBC** / **total surface area of media** *(in 1,000 sq ft units)*

Activated Sludge

Organic Loading *(in pounds per day per 1,000 cubic feet)* **=**
CBOD concentration *(mg/L)* **x flow** *(MGD)* **x 8.34** *lb/gal* / **aeration tank volume(in 1,000 cubic feet units)**

Food to Mass Ratio (F/M) =
CBOD concentration* *(mg/L)* **x flow** *(MGD)* **x 8.34** *lb/gal* / **MLVSS concentration** *(mg/L)* **x aeration tank volume** *(MG)* **x 8.34** *lb/gal*
**Note: CBOD concentration entering aeration tank*

Sludge Volume Index (SVI) = **30-minute sludge settleability reading** *(ml)* **x 1,000** / **MLSS** *(mg/L)*

SRT *(Solids Retention Time)* **=**
MLVSS concentration *(mg/L)* **x total volume**** *(MG)* **x 8.34 lb/gal** / **[waste sludge conc** *(mg/L)* **x waste sludge flow** *(MGD)* **x 8.34** *lb/gal***] + [effluent TSS conc** *(mg/L)* **x flow** *(MGD)* **x 8.34** *lb/gal***]**
***of aeration tank and clarifier*

Wasting Rate *(lbs/day)* **=** **MLVSS in aeration tank and clarifier** *(lbs)* **–** **TSS lost** *(lbs/day)* / **SRT** *(days)*

Return Rate (MGD) = **Total flow (MGD) x MLSS concentration (mg/L)** / **RAS conc (mg/L) – MLSS conc (mg/L)**

Gal/day to MGal/day

To convert gallons/day to million gallons per day:
Million Gallons/Day *(MGD)* **=** **gallons/day** / **1,000,000**

Solids

Total Solids (%) = $\frac{\text{weight of dry sludge x 100}}{\text{weight of wet sludge}}$

Total Suspended Solids *(mg/L)* **= $\frac{\text{weight of suspended solids } (mg)}{\text{volume of sample } (liter)}$**

Volatile Solids (%) = $\frac{\text{weight of material lost by burning x 100}}{\text{weight of dry sludge}}$

Volatile Suspended Solids *(mg/L)* **= $\frac{\text{weight of material lost by burning } (mg)}{\text{volume of sample } (liter)}$**

Organic Nitrogen = Total Kjeldahl Nitrogen (TKN) – Ammonia Nitrogen

Clarifiers

Surface Settling Rate (SSR) = $\frac{\text{flow rate}}{\text{surface area}}$

Weir Overflow Rate (WOR) = $\frac{\text{flow rate}}{\text{weir length}}$

Detention Time (DT) = $\frac{\text{volume of tank}}{\text{flow rate to or from tank}}$

Percent Removal (PR%) = $\frac{\text{influent - effluent x 100}}{\text{influent}}$

Trickling Filter

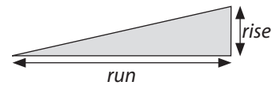
Hydraulic Loading Rate (HLR) = $\frac{\text{total flow to filter*}}{\text{surface area of filter}}$

*(*where total flow = influent flow + recirculation flow)*

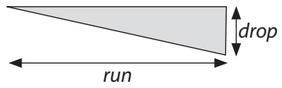
Organic Loading Rate (OLR) = (OLR – *in pounds per day per 1,000 cu ft***) $\frac{\text{pounds per day applied to the filter}}{\text{volume of filter media } (in\ 1{,}000\ cubic\ feet\ units)}$**

Recirculation Ratio (RR) = $\frac{\text{Recirculated flow}}{\text{Influent flow}}$

Slope



Slope equals the *Rise or Drop* (elevation) divided by the *Run* (distance).



To get the *Percent Slope* (Slope %), multiply the *Rise/Run* by 100.

Slope = $\frac{\text{Rise } (or\ drop)}{\text{Run}}$

Slope (%) = $\frac{\text{Rise x 100}}{\text{Run}}$

Rise = $\frac{\text{Slope (\%) x Run}}{100}$

Velocity/Flow Rate

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

Velocity = $\frac{\text{Flow rate}}{\text{Area}}$

Flow rate = Velocity x Area

Temperature

To change Fahrenheit to Celsius:

- Subtract 32 from the Fahrenheit temperature
- Divide the answer by 9.
- Multiply that answer by 5.

$^{o}C = \left({}^{o}F - 32 \right) \times \frac{5}{9}$

To change Celsius to Fahrenheit:

- Multiply the Celsius temperature by 9.
- Divide the answer by 5.
- Add 32.

$^{o}F = \left({}^{o}C \times \frac{9}{5} \right) + 32$

Detention Time

Detention Time = $\frac{\text{volume of tank}}{\text{flow rate to or from tank}}$

Pumping Rate & Power

Pumping Rate = volume pumped / time pumped

Pumping Rate$_{PISTON\ PUMP}$ *(gal/min)* **=**

volume displaced *(gallons)* **by one piston stroke x number of piston strokes / time for above number of strokes** *(minutes)*

Pumping Rate$_{CALIBRATED}$ *(gal/min)* **=**

drawdown volume *(gallons)* / **time to drawdown wet well** *(minutes)* **+** **refill volume** *(gallons)* / **time to refill wet well** *(minutes)*

Reminder: Divide before you add!

Water Horsepower = Flow *(gallons per minute)* **x Total dynamic head** *(feet)* **/ 3,960**

Brake Horsepower = Water horsepower / Pump efficiency*

** Expressed as a decimal, i.e., 85% = .85*

Note: Horsepower = kilowatts x 1.34
Kilowatts = horsepower x 0.75

Total Static Head *(feet)* **= Static discharge head** *(feet)* **+ Static suction head** *(feet)*

Total Dynamic Head *(feet)* **= Total static head** *(feet)* **+ System friction loss or head** *(feet)*

Chlorination & Chemicals

Chlorine Dosage *(mg/L)* **= chlorine demand** *(mg/L)* **+ chlorine residual** *(mg/L)*

Feed Rate *(lb/day)* **= dosage** *(mg/L)* **x flow** *(million gallons/day)* **x 8.34** *(lb/gallon)*

Chemical Dosage *(lbs)* **= Concentration** *(mg/L)* **x Volume** *(MG)* **x 8.34** *(lb/gallon)*

Detention Time = volume of tank / flow rate to or from tank

Percent Removal

Percent Removal *(%)* **= influent - effluent / influent x 100**

Geometric Mean

Table 3: Conversion of Numbers Multiplied to Its' Inverse

Numbers multiplied	Inverse
2	0.500
3	0.333
4	0.250
5	0.200
6	0.167
7	0.143
8	0.125
9	0.111
10	0.100
11	0.091
12	0.083
13	0.077
14	0.071
15	0.067

To calculate the Geometric Mean (GM):

1. Change all single digit "0" to "1"; drop all "<" symbols; and count the number of values you have. (For any "TNTC" values, contact lab for maximum number.)
2. Multiply all numbers.
3. Use one of these methods to find the Geometric Mean:
   - If you multiplied **two numbers**: push the square root key once; answer shown is the GM.
   - If you multiplied **four numbers**: push the square root key twice; answer shown is the GM.
   - If you multiplied **three or more than four numbers**: push the y^x or x^y or ^ key, then enter the inverse of the number of values you multiplied (see Table 3). Finally, push the = key; answer shown is the GM.

Loading

Loading *(lb/day)* **= concentration** *(mg/L)* **x flow** *(million gallons/day)* **x 8.34** *lb/gallon*

Loading *(kg/day)* **= concentration** *(mg/L)* **x flow** *(million gallons/day)* **x 3.78** *kg/gallon*

Loading$_{ORGANIC}$ *(lb/day)* **= population** *(people)* **x population equivalent factor** *(lb/person/day)*

Loading$_{HYDRAULIC}$ *(gal/day)* **=**
population *(people)* **x population equivalent factor** *(gal/person/day)*

Table 4: Population equivalent factors

Population equivalent factors	
BOD	0.17 lb/person/day
TSS	0.20 lb/person/day
Flow	100 gallons/person/day

Loading *(lbs)* **= Concentration** *(mg/L)* **x Volume** *(million gallons)* **x 8.34** *lb/gallon*

Loading *(lbs)* **= Percent solids** *(expressed as a decimal)* **x Volume** *(gal)* **x 8.34** *lb/gallon*

Loading$_{VOLATILE\ SOLIDS}$ *(lbs)* **=**
Total solids* x Volatile solids* x Volume *(gal)* **x 8.34** *lb/gallon*

**expressed as a decimal*