Water Units, Data Conversions, and Constants

Prefix (Metric)	Abbreviation	Multiple	Prefix (Metric)	Abbreviation	Multiple
deka-	da	10	deci-	d	0.1
hecto-	h	100	centi-	c	0.01
kilo-	k	1000	milli-	m	0.001
mega-	M	10^6	micro-	μ	10^{-6}
giga-	G	10^9	nano-	n	10^{-9}
tera-	T	10^{12}	pico-	P	10^{-12}
peta-	P	10^{15}	femto-	f	10^{-15}
exa-	E	10^{18}	atto-	a	10^{-18}

LENGTH (L)

1 micron (μ)	$= 1 \times 10^{-3}$ mm	**10 hectometers**	$= 1$ kilometer
	$= 1 \times 10^{-6}$ m	**1 mil**	$= 0.0254$ mm
	$= 3.3937 \times 10^{-5}$ in		$= 1 \times 10^{-3}$ in
1 millimeter (mm)	$= 0.1$ cm	**1 inch (in)**	$= 25.4$ mm
	$= 1 \times 10^{-3}$ m		$= 2.54$ cm
	$= 0.03937$ in		$= 0.08333$ ft
1 centimeter (cm)	$= 10$ mm		$= 0.0278$ yd
	$= 0.01$ m	**1 foot (ft)**	$= 30.48$ cm
	$= 1 \times 10^{-5}$ km		$= 0.3048$ m
	$= 0.3937$ in		$= 3.048 \times 10^{-4}$ km
	$= 0.03281$ ft		$= 12$ in
	$= 0.01094$ yd		$= 0.3333$ yd
1 meter (m)	$= 1000$ mm		$= 1.89 \times 10^{-4}$ mi
	$= 100$ cm	**1 yard (yd)**	$= 91.44$ cm
	$= 1 \times 10^{-3}$ km		$= 0.9144$ m
	$= 39.37$ in		$= 9.144 \times 10^{-4}$ km
	$= 3.281$ ft		$= 36$ in
	$= 1.094$ yd		$= 3$ ft
	$= 6.21 \times 10^{-4}$ mi		$= 5.68 \times 10^{-4}$ mi
1 kilometer (km)	$= 1 \times 10^5$ cm	**1 mile (mi)**	$= 1609.3$ m
	$= 1000$ m		$= 1.609$ km
	$= 3280.8$ ft		$= 5280$ ft
	$= 1093.6$ yd		$= 1760$ yd
	$= 0.621$ mi	**1 fathom (nautical)**	$= 6$ ft
10 millimeters	$= 1$ centimeter	**1 league (nautical)**	$= 5.556$ km
10 centimeters	$= 1$ decimeter		$= 3$ nautical miles
10 decimeters (dm)	$= 1$ meter	**1 league (land)**	$= 4.828$ km
			$= 5280$ yd
10 meters	$= 1$ dekameter		$= 3$ mi
10 dekameters (dam)	$= 1$ hectometer	**1 international nautical mile**	$= 1.852$ km
			$= 6076.1$ ft
			$= 1.151$ mi

Water Units, Data Conversions, and Constants *(continued)*

AREA (L^2)

1 square centimeter (cm²)	$= 1 \times 10^{-4} m^2$	**1 square foot (ft²)**	$= 929.0 \ cm^2$
	$= 0.1550 \ in^2$		$= 0.0929 \ m^2$
	$= 1.076 \times 10^{-3} \ ft^2$		$= 144 \ in^2$
	$= 1.196 \times 10^{-4} \ yd^2$		$= 0.1111 \ yd^2$
1 square meter (m²)	$= 1 \times 10^{-4}$ hectare		$= 2.296 \times 10^{-5}$ acre
	$= 1 \times 10^{-6} \ km^2$		$= 3.587 \times 10^{-8} \ mi^2$
	$= 1$ centare (French)	**1 square yard (yd²)**	$= 0.8361 \ m^2$
	$= 0.01$ are		$= 8.361 \times 10^{-5}$ hectare
	$= 1550.0 \ in^2$		$= 1296 \ in^2$
	$= 10.76 \ ft^2$		$= 9 \ ft^2$
	$= 1.196 \ yd^2$		$= 2.066 \times 10^{-4}$ acres
	$= 2.471 \times 10^{-4}$ acre		$= 3.228 \times 10^{-7} \ mi^2$
1 are	$= 100 \ m^2$	**1 acre**	$= 4046.9 \ m^2$
1 hectare (ha)	$= 1 \times 10^4 \ m^2$		$= 0.40469$ ha
	$= 100$ are		$= 4.0469 \times 10^{-3} \ km^2$
	$= 0.01 \ km^2$		$= 43,560 \ ft^2$
	$= 1.076 \times 10^5 \ ft^2$		$= 4840 \ yd^2$
	$= 1.196 \times 10^4 \ yd^2$		$= 1.5625 \times 10^{-3} \ mi^2$
	$= 2.471$ acres	**1 square mile (mi²)**	$= 2.590 \times 10^6 \ m^2$
	$= 3.861 \times 10^{-3} \ mi^2$		$= 259.0$ hectares
1 square kilometer (km²)	$= 1 \times 10^6 \ m^2$		$= 2.590 \ km^2$
	$= 100$ hectares		$= 2.788 \times 10^7 \ ft^2$
	$= 1.076 \times 10^7 \ ft^2$		$= 3.098 \times 10^6 \ yd^2$
	$= 1.196 \times 10^6 \ yd^2$		$= 640$ acres
	$= 247.1$ acres		$= 1$ section (of land)
	$= 0.3861 \ mi^2$	**1 feddan (Egyptian)**	$= 4200 \ m^2$
1 square inch (in²)	$= 6.452 \ cm^2$		$= 0.42$ ha
	$= 6.452 \times 10^{-4} \ m^2$		$= 1.038$ acres
	$= 6.944 \times 10^{-3} \ ft^2$		
	$= 7.716 \times 10^{-4} \ yd^2$		

(continues)

Water Units, Data Conversions, and Constants *(continued)*

VOLUME (L^3)

1 cubic centimeter (cm^3)	$= 1 \times 10^{-3}$ liter $= 1 \times 10^{-6}$ m^3 $= 0.06102$ in^3 $= 2.642 \times 10^{-4}$ gal $= 3.531 \times 10^{-3}$ ft^3	1 cubic foot (ft^3)	$= 2.832 \times 10^4$ cm^3 $= 28.32$ liters $= 0.02832$ m^3 $= 1728$ in^3 $= 7.481$ gal $= 0.03704$ yd^3
1 liter (1)	$= 1000$ cm^3 $= 1 \times 10^{-3}$ m^3 $= 61.02$ in^3 $= 0.2642$ gal $= 0.03531$ ft^3	1 cubic yard (yd^3)	$= 0.7646$ m^3 $= 6.198 \times 10^{-4}$ acre-ft $= 46656$ in^3 $= 27$ ft^3
1 cubic meter (m^3)	$= 1 \times 10^6$ cm^3 $= 1000$ liter $= 1 \times 10^{-9}$ km^3 $= 264.2$ gal $= 35.31$ ft^3 $= 6.29$ bbl $= 1.3078$ yd^3 $= 8.107 \times 10^{-4}$ acre-ft	1 acre-foot (acre-ft or AF)	$= 1233.48$ m^3 $= 3.259 \times 10^5$ gal $= 43560$ ft^3
		1 Imperial gallon	$= 4.546$ liters $= 277.4$ in^3 $= 1.201$ gal $= 0.16055$ ft^3
		1 cfs-day	$= 1.98$ acre-feet $= 0.0372$ in-mi^2
1 cubic decameter (dam^3)	$= 1000$ m^3 $= 1 \times 10^6$ liter $= 1 \times 10^{-6}$ km^3 $= 2.642 \times 10^5$ gal $= 3.531 \times 10^4$ ft^3 $= 1.3078 \times 10^3$ yd^3 $= 0.8107$ acre-ft	1 inch-mi^2	$= 1.738 \times 10^7$ gal $= 2.323 \times 10^6$ ft^3 $= 53.3$ acre-ft $= 26.9$ cfs-days
		1 barrel (of oil) (bbl)	$= 159$ liter $= 0.159$ m^3 $= 42$ gal $= 5.6$ ft^3
1 cubic hectometer (ha^3)	$= 1 \times 10^6$ m^3 $= 1 \times 10^3$ dam^3 $= 1 \times 10^9$ liter $= 2.642 \times 10^8$ gal $= 3.531 \times 10^7$ ft^3 $= 1.3078 \times 10^6$ yd^3 $= 810.7$ acre-ft	1 million gallons	$= 3.069$ acre-ft
		1 pint (pt)	$= 0.473$ liter $= 28.875$ in^3 $= 0.5$ qt $= 16$ fluid ounces $= 32$ tablespoons $= 96$ teaspoons
1 cubic kilometer (km^3)	$= 1 \times 10^{12}$ liter $= 1 \times 10^9$ m^3 $= 1 \times 10^6$ dam^3 $= 1000$ ha^3 $= 8.107 \times 10^5$ acre-ft $= 0.24$ mi^3	1 quart (qt)	$= 0.946$ liter $= 57.75$ in^3 $= 2$ pt $= 0.25$ gal
1 cubic inch (in^3)	$= 16.39$ cm^3 $= 0.01639$ liter $= 4.329 \times 10^{-3}$ gal $= 5.787 \times 10^{-4}$ ft^2	1 morgen-foot (S. Africa)	$= 2610.7$ m^3
		1 board-foot	$= 2359.8$ cm^3 $= 144$ in^3 $= 0.0833$ ft^3
1 gallon (gal)	$= 3.785$ liters $= 3.785 \times 10^{-3}$ m^3 $= 231$ in^3 $= 0.1337$ ft^3 $= 4.951 \times 10^{-3}$ yd^3	1 cord	$= 128$ ft^3 $= 0.453$ m^3

Water Units, Data Conversions, and Constants *(continued)*

VOLUME/AREA (L^3/L^2)

1 inch of rain	$= 5.610 \text{ gal/yd}^2$	1 box of rain	$= 3,154.0 \text{ lesh}$
	$= 2.715 \times 10^4$		
	gal/acre		

MASS (M)

1 gram (g or gm)	$= 0.001 \text{ kg}$	1 ounce (oz)	$= 28.35 \text{ g}$
	$= 15.43 \text{ gr}$		$= 437.5 \text{ gr}$
	$= 0.03527 \text{ oz}$		$= 0.0625 \text{ lb}$
	$= 2.205 \times 10^{-3} \text{ lb}$	1 pound (lb)	$= 453.6 \text{ g}$
1 kilogram (kg)	$= 1000 \text{ g}$		$= 0.45359237 \text{ kg}$
	$= 0.001 \text{ tonne}$		$= 7000 \text{ gr}$
	$= 35.27 \text{ oz}$		$= 16 \text{ oz}$
	$= 2.205 \text{ lb}$	1 short ton (ton)	$= 907.2 \text{ kg}$
1 hectogram (hg)	$= 100 \text{ gm}$		$= 0.9072 \text{ tonne}$
	$= 0.1 \text{ kg}$		$= 2000 \text{ lb}$
1 metric ton (tonne	$= 1000 \text{ kg}$	1 long ton	$= 1016.0 \text{ kg}$
or te or MT)	$= 2204.6 \text{ lb}$		$= 1.016 \text{ tonne}$
	$= 1.102 \text{ ton}$	1 long ton	$= 2240 \text{ lb}$
	$= 0.9842 \text{ long ton}$		$= 1.12 \text{ ton}$
1 dalton (atomic	$= 1.6604 \times 10^{-24} \text{ g}$	1 stone (British)	$= 6.35 \text{ kg}$
mass unit)			$= 14 \text{ lb}$
1 grain (gr)	$= 2.286 \times 10^{-3} \text{ oz}$		
	$= 1.429 \times 10^{-4} \text{ lb}$		

TIME (T)

1 second (s or sec)	$= 0.01667 \text{ min}$	1 day (d)	$= 24 \text{ hr}$
	$= 2.7778 \times 10^{-4} \text{ hr}$		$= 86400 \text{ s}$
1 minute (min)	$= 60 \text{ s}$	1 year (yr or y)	$= 365 \text{ d}$
	$= 0.01667 \text{ hr}$		$= 8760 \text{ hr}$
1 hour (hr or h)	$= 60 \text{ min}$		$= 3.15 \times 10^7 \text{ s}$
	$= 3600 \text{ s}$		

DENSITY (M/L^3)

1 kilogram per cubic meter (kg/m^3)	$= 10^{-3} \text{ g/cm}^3$ $= 0.062 \text{ lb/ft}^3$	1 metric ton per cubic meter (te/m^3)	$= 1.0$ specific gravity $=$ density of H_2O at $4°C$
1 gram per cubic centimeter (g/cm^3)	$= 1000 \text{ kg/m}^3$ $= 62.43 \text{ lb/ft}^3$	1 pound per cubic foot (lb/ft^3)	$= 8.35 \text{ lb/gal}$ $= 16.02 \text{ kg/m}^3$

(continues)

Water Units, Data Conversions, and Constants *(continued)*

VELOCITY (L/T)

1 meter per second (m/s)	= 3.6 km/hr = 2.237 mph = 3.28 ft/s	1 foot per second (ft/s)	= 0.68 mph = 0.3048 m/s
1 kilometer per hour (km/h or kph)	= 0.62 mph = 0.278 m/s	velocity of light in vacuum (c)	= 2.9979 × 10⁸ m/s ≐ 186,000 mi/s
		1 knot	= 1.852 km/h = 1 nautical
1 mile per hour (mph or mi/h)	= 1.609 km/h = 0.45 m/s = 1.47 ft/s		mile/hour = 1.151 mph = 1.688 ft/s

VELOCITY OF SOUND IN WATER AND SEAWATER
(assuming atmospheric pressure and sea water salinity of 35,000 ppm)

Temp, °C	Pure water, (meters/sec)	Sea water, (meters/sec)
0	1,400	1,445
10	1,445	1,485
20	1,480	1,520
30	1,505	1,545

FLOW RATE (L³/T)

1 liter per second (1/sec)	= 0.001 m³/sec = 86.4 m³/day = 15.9 gpm = 0.0228 mgd = 0.0353 cfs = 0.0700 AF/day	1 cubic decameters per day (dam³/day)	= 11.57 1/sec = 1.157 × 10⁻² m³/sec = 1000 m³/day = 1.83 × 10⁶ gpm = 0.264 mgd
1 cubic meter per second (m³/sec)	= 1000 1/sec = 8.64 × 10⁴ m³/day = 1.59 × 10⁴ gpm = 22.8 mgd = 35.3 cfs = 70.0 AF/day		= 0.409 cfs = 0.811 AF/day
		1 gallon per minute (gpm)	= 0.0631 1/sec = 6.31 × 10⁻⁵ m³/sec = 1.44 × 10⁻³ mgd = 2.23 × 10⁻³ cfs = 4.42 × 10⁻³ AF/day
1 cubic meter per day (m³/day)	= 0.01157 1/sec = 1.157 × 10⁻⁵ m³/sec = 0.183 gpm = 2.64 × 10⁻⁴ mgd = 4.09 × 10⁻⁴ cfs = 8.11 × 10⁻⁴ AF/day	1 million gallons per day (mgd)	= 43.8 1/sec = 0.0438 m³/sec = 3785 m³/day = 694 gpm = 1.55 cfs = 3.07 AF/day

Water Units, Data Conversions, and Constants *(continued)*

FLOW RATE (L^3/T) (continued)

1 cubic foot per second (cfs)	= 28.3 1/sec = 0.0283 m^3/ sec = 2447 m^3/day = 449 gpm = 0.646 mgd = 1.98 AF/day	**1 miner's inch**	= 0.02 cfs (in Idaho, Kansas, Nebraska, New Mexico, North Dakota, South Dakota, and Utah) = 0.026 cfs (in Colorado)
1 acre-foot per day (AF/day)	= 14.3 1/sec = 0.0143 m^3/sec = 1233.48 m^3/day = 226 gpm = 0.326 mgd = 0.504 cfs		= 0.028 cfs (in British Columbia)
		1 weir	= 0.02 garcia
		1 quinaria (ancient Rome)	= 0.47–0.48 1/sec
1 miner's inch	= 0.025 cfs (in Arizona, California, Montana, and Oregon: flow of water through 1 in^2 aperture under 6-inch head)		

ACCELERATION (L/T^2)

standard acceleration of gravity	= 9.8 m/s^2 = 32 ft/s^2

FORCE (ML/T^2 = Mass × Acceleration)

1 newton (N)	= kg-m/s^2 = 10^5 dynes = 0.1020 kg force = 0.2248 lb force	**1 dyne**	= g·cm/s^2 = 10^{-5} N
		1 pound force	= lb mass × acceleration of gravity = 4.448 N

Water Units, Data Conversions, and Constants *(continued)*

PRESSURE (M/L^2 = Force/Area)		1 kilogram per sq. centimeter (kg/cm^2)	= 14.22 lb/in^2
1 pascal (Pa)	= N/m^2		
1 bar	= 1×10^5 Pa		
	= 1×10^6 dyne/cm^2	1 inch of water at 62°F	= 0.0361 lb/in^2
	= 1019.7 g/cm^2		= 5.196 lb/ft^3
	= 10.197 te/m^2		= 0.0735 inch of mercury at 62°F
	= 0.9869 atmos- phere	1 foot of water at 62°F	= 0.433 lb/in^2
	= 14.50 lb/in^2		= 62.36 lb/ft^2
	= 1000 millibars		= 0.833 inch of mercury at 62°F
1 atmosphere (atm)	= standard pressure		= 2.950×10^{-2} atmosphere
	= 760 mm of mercury at 0°C	1 pound per sq. inch (psi or lb/in^2)	= 2.309 feet of water at 62°F
	= 1013.25 millibars		= 2.036 inches of mercury at 32°F
	= 1033 g/cm^2		= 0.06804 atmosphere
	= 1.033 kg/cm^2		= 0.07031 kg/cm^2
	= 14.7 lb/in^2	1 inch of mercury at 32°F	= 0.4192 lb/in^2
	= 2116 lb/ft^2		= 1.133 feet of water at 32°F
	= 33.95 feet of water at 62°F		
	= 29.92 inches of mercury at 32°F		

TEMPERATURE			
degrees Celsius or Centigrade (°C)	= (°F–32) × 5/9	degrees Fahrenheit (°F)	= 32 + (°C x 1.8)
Kelvins (K)	= K–273.16		= 32 + ((°K–273.16) × 1.8)
	= 273.16 + °C		
	= 273.16 + ((°F- 32) × 5/9)		

Water Units, Data Conversions, and Constants *(continued)*

ENERGY(ML^2/T^2 = Force × Distance)

1 joule (J)	$= 10^7$ ergs	1 kilowatt-hour	$= 3.6 \times 10^6$ J
	$= N \cdot m$	(kWh)	$= 3412$ Btu
	$= W \cdot s$		$= 859.1$ kcal
	$= kg \cdot m^2/s^2$	1 quad	$= 10^{15}$ Btu
	$= 0.239$ calories		$= 1.055 \times 10^{18}$ J
	$= 9.48 \times 10^{-4}$ Btu		$= 293 \times 10^9$ kWh
1 calorie (cal)	$= 4.184$ J		$= 0.001$ Q
	$= 3.97 \times 10^{-3}$ Btu		$= 33.45$ GWy
	(raises 1 g H_2O	1 Q	$= 1000$ quads
	1°C)		$\approx 10^{21}$ J
1 British thermal	$= 1055$ J	1 foot-pound (ft-lb)	$= 1.356$ J
unit (Btu)	$= 252$ cal (raises		$= 0.324$ cal
	1 lb H_2O 1°F)	1 therm	$= 10^5$ Btu
	$= 2.93 \times 10^{-4}$ kWh	1 electron-volt (eV)	$= 1.602 \times 10^{-19}$ J
1 erg	$= 10^{-7}$ J	1 kiloton of TNT	$= 4.2 \times 10^{12}$ J
	$= g \cdot cm^2/s^2$	1 10^6 te oil equiv.	$= 7.33 \times 10^6$ bbl oil
	$= dyne \cdot cm$	(Mtoe)	$= 45 \times 10^{15}$ J
1 kilocalorie (kcal)	$= 1000$ cal		$= 0.0425$ quad
	$= 1$ Calorie (food)		

POWER (ML^2/T^3 = rate of flow of energy)

1 watt (W)	$= J/s$	1 horsepower	$= 0.178$ kcal/s
	$= 3600$ J/hr	(H.P. or hp)	$= 6535$ kWh/yr
	$= 3.412$ Btu/hr		$= 33,000$ ft-lb/min
1 TW	$= 10^{12}$ W		$= 550$ ft-lb/sec
	$= 31.5 \times 10^{18}$ J		$= 8760$ H.P.-hr/yr
	$= 30$ quad/yr	H.P. input	$= 1.34 \times$ kW input
1 kilowatt (kW)	$= 1000$ W		to motor
	$= 1.341$ horsepower		$=$ horsepower
	$= 0.239$ kcal/s		input to motor
	$= 3412$ Btu/hr	Water H.P.	$=$ H.P. required to
10^6 bbl (oil) /day	≈ 2 quads/yr		lift water at a
(Mb/d)	≈ 70 GW		definite rate to
1 quad/yr	$= 33.45$ GW		a given distance
	≈ 0.5 Mb/d		assuming 100%
1 horsepower	$= 745.7$ W		efficiency
(H.P. or hp)	$= 0.7457$ kW		$=$ gpm × total head
			(in feet)/3960

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Water Units, Data Conversions, and Constants *(continued)*

EXPRESSIONS OF HARDNESS[a]

1 grain per gallon	= 1 grain $CaCO_3$ per U.S. gallon	**1 French degree**	= 1 part $CaCO_3$ per 100,000 parts water
1 part per million	= 1 part $CaCO_3$ per 1,000,000 parts water	**1 German degree**	= 1 part CaO per 100,000 parts water
1 English, or Clark, degree	= 1 grain $CaCO_3$ per Imperial gallon		

CONVERSIONS OF HARDNESS

1 grain per U.S. gallon	= 17.1 ppm, as $CaCO_3$	**1 French degree**	= 10 ppm, as $CaCO_3$
1 English degree	= 14.3 ppm, as $CaCO_3$	**1 German degree**	= 17.9 ppm, as $CaCO_3$

WEIGHT OF WATER

1 cubic inch	= 0.0361 lb	**1 imperial gallon**	= 10.0 lb
1 cubic foot	= 62.4 lb	**1 cubic meter**	= 1 tonne
1 gallon	= 8.34 lb		

DENSITY OF WATER[a]

Temperature		Density
°C	°F	gm/cm³
0	32	0.99987
1.667	35	0.99996
4.000	39.2	1.00000
4.444	40	0.99999
10.000	50	0.99975
15.556	60	0.99907
21.111	70	0.99802
26.667	80	0.99669
32.222	90	0.99510
37.778	100	0.99318
48.889	120	0.98870
60.000	140	0.98338
71.111	160	0.97729
82.222	180	0.97056
93.333	200	0.96333
100.000	212	0.95865

Note: Density of Sea Water: approximately 1.025 gm/cm³ at 15°C.

[a]*Source:* van der Leeden, F., Troise, F. L., and Todd, D. K., 1990. *The Water Encyclopedia*, 2d edition. Lewis Publishers, Inc., Chelsea, Michigan.