SECTION 13: Forms and Reference

The most CURRENT version of forms are available electronically on the University of Minnesota OSTP website at: **septic.umn.edu/ssts-professionals/forms-worksheets**

Most of the forms found on website are interactive and include:

OSTP Design Forms
Inspection Forms
Installation Forms
Maintenance Forms
Management Plans
Community Septic System Owner's Guide - H20andM.com
Septic System Improvement Estimator

Table IX and IXa: loading rates and absorption ratios from MN Rules Chapter 7080.2150, subp. 3 (E) 13-1

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TABLE IX: Loading rates for determining bottom absorption area and absorption ratios using detailed soil descriptions.

USDA soil texture	Soil structure and grade	Treatment Level C		Treatment Level A, A-2, B, B-2	
		Absorption area loading rate (gpd/ft²)	Mound absorption ratio	Absorption area loading rate (gpd/ft²)	Mound absorption ratio***
Sand, coarse sand, loamy sand, loamy coarse sand, fine sand, very fine sand, loamy fine sand, loamy very fine sand, 35 to 50% rock fragments	Single grain, granular, blocky, or prismatic structure; weak grade	**	1.0	**	1.0
Sand, coarse sand, loamy sand, loamy coarse sand, <35% rock fragments	Single grain, granular, blocky, or prismatic structure; weak grade	1.2	1.0	1.6	1.0
Fine sand, very fine sand, loamy fine sand, loamy very fine sand, <35% rock fragments	Single grain, granular, blocky, or prismatic structure; weak grade	0.6	2.0	1.0	1.6
Sandy loam, coarse sandy loam, fine sandy loam, very fine sandy loam	Granular, blocky, or prismatic structure; weak to strong grade	0.78	1.5	1.0	1.6
Sandy loam, coarse sandy loam, fine sandy loam, very fine sandy loam	Platy with weak grade or massive	0.68	1.8	0.87	1.8
Loam	Granular, blocky, or prismatic structure; weak to strong grade	0.6	2.0	0.78	2.1
Loam	Platy with weak grade or massive	0.52	2.3	0.68	2.4
Silt loam, silt	Granular, blocky, or prismatic structure; weak to strong grade	0.5	2.4	0.78	2.1
Silt loam, silt	Platy with weak grade or massive	0.42	2.9	0.65	2.5
Clay loam, sandy clay loam, silty clay loam	Granular, blocky, or prismatic structure; moderate to strong grade	0.45	2.6	0.6	2.7
Clay, sandy clay, silty clay	-	**	**	**	**

* Only includes soil horizons with <50% rock fragments, with very friable and friable consistence, and loose noncemented sands. All USDA sands and loamy sands with 35% or more rock fragments or any soil horizons with >50% rock fragments must not come in contact with soil dispersal system media.
** Conduct percolation test and size under Table IXa. May need to be designed under part 7080.2300.
*** Assume a hydraulic loading rate to the sand at 1.6 gpd/ft².

Table IXa: Loading rates for determining bottom absorption area and absorption ratios using percolation tests

Percolation rate (MPI)	Treatment level C		Treatment levels A, A-2, B, and B-2	
	Absorption area loading rate (gpd/ft²)	Mound absorption ratio	Absorption area loading rate (gpd/ft²)	Mound absorption ratio
<0.1	-	1.0	-	1.0
0.1 to 5	1.2	1.0	1.6	1.0
0.1 to 5 (fine sand and loamy fine sand)	0.6	2.0	1.0	1.6
6 to 15	0.78	1.5	1.0	1.6
16 to 30	0.6	2.0	0.78	2.0
31 to 45	0.5	2.4	0.78	2.0
46 to 60	0.45	2.6	0.6	2.6
61 to 120	-	5.0	0.3	5.3
>120	-	-	-	-

Estimate of Waste Strengths from Other Establishments

Type of Facility	BOD_5 (mg/L)	BOD_5 (lbs/unit/day)
Airports		
Per passenger	400 - 500	0.02
Per employee	400 - 500	0.05
Apartment houses	240 - 400	0.175/multiple family
Assembly hall (no kitchen)	240 - 400	0.01/seat
Boarding school	240 - 400	0.208/student
Bowling alley (no kitchen)	240 - 400	0.15/lane
Camps		
Construction (Semi-permanent)	400 - 500	0.140
Country club (member)	400 - 500	0.052/member
Country club (resident)	240 - 400	0.208/resident
Day (no meals)	400 - 500	0.031
Luxury	400 - 500	0.208
Church (no kitchen)	240 - 400	0.02/seat
Country club	400 - 800	0.208/member
Personnel addition	240 - 400	0.04/employee
Day school	240 - 400	0.031/student
Add for showers	240 - 400	0.011/student
Add for cafeteria	500 - 700	0.031/meal
Factory		
No showers	240 - 400	0.073/employee
With showers	240 - 400	0.083/employee
Food service		
Ordinary restaurant	600 - 1500	0.35/seat
24-Hour restaurant	600 - 1500	0.50/seat
Freeway restaurant	600 - 1500	0.70/seat
Tavern (limited food)	400 - 800	0.10/seat
Carry-out (single service)	600 - 800	0.70/100 sqft
Carry-out	200 - 600	0.04/employee
Fast food chain	1000 - 2000	0.80/seat
Kitchen Waste	600 - 1500	0.015/meal
Toilet and Kitchen Waste	600 - 1500	0.021/customer
Additional for bars & cocktail lounges	600 - 1500	0.01/customer
Hospital (not including personnel)	400 - 600	0.518/bed
Laundromat	600 - 800	2.0/machine
Mobile home park	240 - 400	0.40/space
Mobile home park	240 - 400	0.140/person
Motel, Hotel	240 - 400	0.083/bed
Motel, Hotel	240 - 400	0.14/person
Nursing home (not including kitchen or laundry)	400 - 600	0.26/bed
Office building (per 8 hour shift)	240 - 400	0.05/employee
Park, toilets only	400 - 600	0.01/person
Park, bathhouse and flush toilets	240 - 400	0.021/person
Resort hotel, cottage	240 - 400	0.15/room
Add for self-service laundry	600 - 800	2.0/machine
Service station	240 - 400	0.50/toilet or urinal
Service station	240 - 400	0.021vehicle served
Shopping center (no food service or laundry)	400 - 600	0.30/1000 sqft
Shopping center (no food service or laundry)	400 - 600	0.050/employee
Sports Stadium	400 - 600	0.20/person

Equations and Constants

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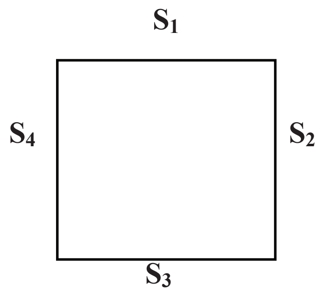
PERIMETER/CIRCUMFERENCE

1. Rectangle or Square:

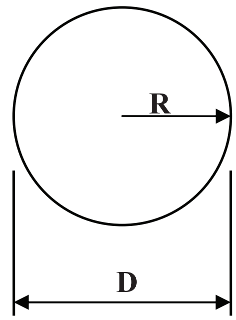
$P = S_1 + S_2 + S_3 + S_4$



2. Circle:

$C = \pi$ x D

Where: π = 3.14
D = 2 x R

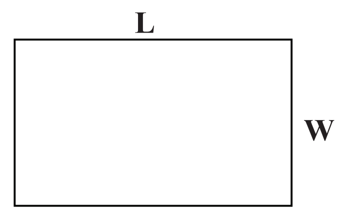


LENGTH CONVERSION FACTORS

1 inch	=	2.54 centimeters	=	25.4 millimeters
1 foot	=	12 inches	=	0.31 meters
1 yard	=	3 feet	=	0.91 meters
1 mile	=	5,280 feet	=	1,760 yards
1 meter	=	39.37 inches	=	3.28 feet
1 kilometer	=	0.62 miles	=	1,000 meters

AREA

1. Square or Rectangle:

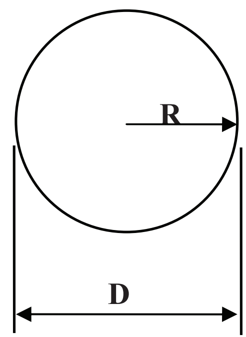


A = L x W

2. Circle:

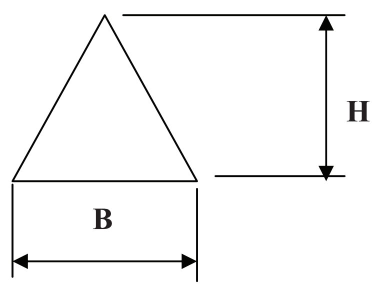
$A = \pi \times R^2$

Where: $D = 2 \times R$



3. Triangle:

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



AREA CONVERSION FACTORS

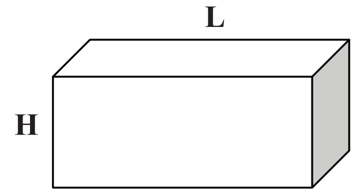
1 square foot	=	144 square inches
1 square yard	=	9 square feet
1 square mile	=	640 acres or 1 section
1 square meter	=	10.76 square feet
1 square meter	=	10,000 square centimeters
1 acre	=	43,560 square feet
1 hectare	=	2.47 acres

VOLUME

1. Rectangle

   Volume = Area x Height

   V = L x W x H



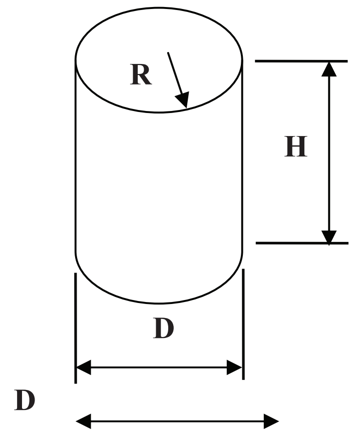
W

2. Cylinder:

   Volume = Area x Height

   $V = \pi \times R^2 \times H$

   Where : D = 2 x R



VOLUME CONVERSION FACTORS

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	=	3.79 liters
1 gallon	=	231 cubic inches
1 gallon	=	4 quarts
1 cubic meter	=	35.3 cubic feet
1 cubic meter	=	1.3 cubic yards
1 liter	=	0.26 gallons
1 liter	=	1,000 milliliters

TEMPERATURE

1. Fahrenheit to Celsius:

$$°C = \frac{5\,(°F - 32)}{9}$$

2. Celsius to Fahrenheit:

$$°F = \frac{(°C \times 9)}{5} + 32$$

VELOCITY

1. $$\text{Velocity} = \frac{\text{distance traveled}}{\text{time}}$$

2. $$\text{Velocity(C)} = \frac{\text{flow rate}}{\text{area}} = \frac{Q}{A}$$

FLOW/PUMPING RATE

1. Flow Rate (Q) = velocity (V) x area (A)

2. $$\text{Pumping Rate} = \frac{\text{volume pumped}}{\text{time pumped}}$$

3. Calibrated Pumping Rate (gallons per minute):

$$= \frac{\text{drawdown volume (gallons)}}{\text{time to drawdown (minutes)}}$$

$$= \frac{\text{(Reading 1 in inches - Reading 2 in inches) x gallon per inch of tank}}{\text{Time (min)}}$$

FLOW CONVERSION FACTORS

1 cubic foot/second	=	449 gallons/minute (GPM)
1 gallon/second	=	0.13 cubic feet/second (CFS)
1 gallon/second	=	8.03 cubic feet/minute (CFM)
1 gallon/minute	=	0.002 cubic feet/second (CFS)
1 gallon/minute	=	1440 gallons/day (GPD)

LOADING and SOLIDS

1. Loading (lb/day) = concentration (mg/L) x flow (gallons/day) x 8.34 lb/gallon/1,000,000

2. Organic Loading (lb/day) = population (people) x population equivalent factor (lb/person/day)

Note: **Population equivalent factors for: BOD = 0.17 lb/person/day**
TSS = 0.20 lb/person/day

WEIGHT CONVERSION FACTORS

1 gallon	=	8.34 pounds of water
1 cubic foot	=	62.4 pounds of water
1 foot of water	=	0.433 pounds per square inch
1 pound	=	0.454 kilograms
1 kilogram	=	2.2 pounds
1 kilogram	=	1,000 grams
1 pounds per square inch	=	2.31 feet of water
1 liter	=	1,000 grams
1 mg/kg or 1 ppm or 1 mg/l	=	0.0022 pounds/ton or 0.0001%
1 mg/l	=	1,000 µg/l

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

4. Organic Nitrogen = Kjeldahl Nitrogen - Ammonia Nitrogen

SOILS

1. Percolation rate = min/in
2. Ksat =
3. Contour Loading Rate (CLR) = gal/ft

TANKS & CLARIFIERS

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

2. Tank capacity in gallons $TC = L(ft) \times W(ft) \times \text{Liquid depth}(ft) \times 7.48\ gal/ft^3$

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

4. Percent Removal (PR): $PR(\%) = \frac{\text{influent - effluent}}{\text{influent}} \times 100\%$

FILTERS

1. Hydraulic Loading Rate (HLR):

$$HLR = \frac{\text{total flow to filter *}}{\text{surface area of filter}}$$

* Where total flow = influent flow + recirculation flow

2. Organic Loading Rate (OLR):
(lbs per day per 1000 cubic feet)

$$OLR = \frac{\text{pounds per day applied to the filter}}{\text{volume of filter media (in 1000 cubic feet units)}}$$

Calculating Recirculation Ratios at System Startup

To set recirculation at the time of system startup, the flowing information is needed:

- Forward flow through the system – this will be assumed from available records and/or interviews or design flow
- Pump delivery rate of the pump dosing the media filter (in gallons per minute)
- Dose volume
- Amount of pipe drainback to the pump after a dose
- Desired recirculation ratio, based upon forward flow (usually determined by the designer or manufacturer – 3:1 – 5:1)
- Number of minutes in a day = 1440

Before media filter startup occurs, it is important that the startup person understand how the regulatory jurisdiction and/or manufacturer determines recirculation volume to the filter. Most proprietary technologies use the following basic formula: [(forward flow) multiplied times (desired recirculation)] plus (forward flow) = volume to the filter. Other entities/manufacturers may calculate recirculation differently, for example [(desired recirculation) multiplied by (forward flow), so always verify before startup.

For the following example the manufacturer-determined pump dose volume per pump cycle (15 gallons) will not be altered. The pump off time needed to meet the desired recirculation ratio will be determined.

The following values will be assumed for this example:

- Forward flow = 200 gallons per day (gpd) -made by assumption
- Pump delivery rate (PDR) = 30 gallons per minute (gpm)
- Pump on time = 15 gallons/dose / 30 gpm = 0.5 minutes (min) on
- Pump dose volume = PDR X Pump run time = 30 gpm X 0.5 min = 15 gallons per dose
- No pipe drainback is assumed to simplify this example
- Desired recirculation ratio of 3:1 as required by manufacturer (Using the first formula noted above, the filter surface will see four times the amount of forward flow or [200 gpd x 3] + 200 gpd = 800 gpd

Given the above information, let’s calculate what the pump off time needs to be:

Note, that to simplify the example, the entire pump dose volume (15 gallons) reaches the media filter surface with no pipe drainback.

Number of pump dose events needed to meet the 3:1 ratio = 800 gpd ÷ 15 gallons per dose event = 53.3 dose events per day. **Because we can't have a fraction of a dose event, this is rounded down to 53 events.** Note that for each dose event there is a corresponding pump rest cycle—or 53 rest cycles a day.

Number of minutes per day = 24 hours x 60 min per hour = 1440 min/day

Pump off time (minutes) = (number of minutes per day ÷ pump rest cycles per day) minus pump on time. Substituting in numbers, the math is: (1440 min/day ÷ 53 pump rest cycles) – 0.5 min = 26.7 min

Answer: 26.7 minutes off time between pump doses

To double check the math, the combined pump on and off times multiplied by the number of dose events per day should equal the total number of minutes in a day (or 1440 minutes).

Check: (0.5 min + 26.67 min) x 53 dose events = 27.2 min x 53 dose events = 1440 min

To double check the math on the timer settings; multiply the pump on time by the dose events per day, and multiply this number by the pump delivery rate (or PDR). The result should equal the total gallons needed to meet the desired recirculation ratio (or 800 gpd).

Check: (0.5 min per dose x 53 dose events/day) x 30 gpm = 795 gpd

Note that the answer above is very close to the 800 gpd needed to meet our desired recirculation ratio. The difference is because we could not utilize a portion (0.3) of a dosing event, so earlier in our calculations we decided to round down to 53 dose events per date.

COLLECTION

1. Hazen Williams Equation

$$V = 1.318*C*R^{0.63}*S^{0.54}$$

V = Velocity in feet per second
C = Hazen-Williams Roughness Coefficient = 130
D = Diameter of pipe in inches
R = D/2
$S = H_f/L$
H_f = Friction head loss (feet)
L = Length of Pipe (feet)

$$H_f = (10.5/D^{4.87}) \quad X \quad (Q/C)^{1.85} \quad X \quad L$$

Q = Flow in gallons per minute

2. Manning Equation

$V = k/n(A/P)^{2/3}S^{1/2}$ where k = 1.486, and n = 0.013

n = 0.013 should be used for PVC pipe.

Inserting the constants in the equation:

$V = 114.3\ (A/P)^{2/3}S^{1/2}$

$A = \pi D^2/4$
P = Wetted Perimeter (assume full pipe) = πD

Simplifying the equation by inserting A and P in terms of D:

$V = 114.3(D/4)^{2/3}S^{1/2}$

S = Slope (feet/foot) (usually given, and assumed 1/8 inch per foot, which equates to 0.01 feet/foot)

Manning Equation Constants

Pipe Diameter	Velocity (V) ft/s	Area (A) ft^2	Q_f (GPM)
4"	2.18	0.087	85.2
6"	2.85	0.197	253.0
8"	3.46	0.349	542.2

Other Collection Constants
Minimum slope in pipe =1/8 inch per 1 foot ~ 1%
Maximum slope in pipe = 0.2 feet/foot = 2%
Maintains velocity below 15 feet/sec

OTHER FORMULAS

1. Convert Gallons Per Minute to Gallons Per Day:

Gallons/day = gallons/minute x 1,440 minutes/day

3. $\text{Percent Removal (\%)} = \frac{\text{influent concentration} - \text{effluent concentration}}{\text{influent concentration}} \times 100\%$

5. $\text{Slope or Grade (\%)} = \frac{\text{rise or drop (difference in height)}}{\text{run (difference in length)}} \times 100\%$

SYMBOLS/ABBREVIATIONS

A = Area
Ac-Ft = Acre-feet
B = Base
BOD = Biochemical Oxygen Demand
C = Circumference
CEC = Cation Exchange Capacity
CFM = Cubic Feet per Minute
CFS = Cubic Feet per Second
Cu In. = Cubic Inches
°C = Degree Centigrade
D = Diameter
Ft = Foot or Feet
Ft^2 = Square Feet
Ft^3 = Cubic Feet
°F = Degree Fahrenheit
F/M = Food to Mass
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
In. = Inch
In^2 = Square Inch
In^3 = Cubic Inch
L = Length
lb = Pound
Mi = Mile
Mi^2 = Square Mile
Min = Minute
mg = milligrams
ml = milliliters
MG = million gallons
MGD = million gallons per day
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
MLSS = mixed liquor suspended solids
MLVSS = mixed liquor volatile suspended solids
N = Nitrogen
NH_3-N = Ammonia Nitrogen
Org. N = Organic Nitrogen
P = Perimeter
PE = Population Equivalent
ppm = Parts per Million
ppb = Parts per Billion
PSI = Pounds per Square Inch
Q = Flow
R = Radius
RPM = Revolutions per Minute
S = Side
Sec = Second
Sq. In. = Square Inches
SVI = Sludge Volume Index
SRT = Solids Retention Time
SS = Suspended Solids
TSS = Total Suspended Solids
V = Volume
Vel = Velocity
W = Width
Yd = Yard
π = pi or 3.14
/ = Per (as gallon/day)
% = Percent
μL = Microliters

METRIC SYSTEM

LENGTH	One kilometer (km)	=	1,000 meters
	One meter (m)	=	100 centimeters
	One decimeter (dm)	=	0.1 meter
	One centimeter (cm)	=	0.01 meter
	One millimeter (mm)	=	0.001 meter
WEIGHT	One kilogram (kg)	=	1,000 grams
	One gram (g)	=	1,000 milligrams
	One decigram (dg)	=	0.1 gram
	One centigram (cg)	=	0.01 gram
	One milligram (mg)	=	0.001 gram
VOLUME	One kiloliter (kl)	=	1,000 liters
	One liter (l)	=	1,000 milliliters
	One deciliter (dl)	=	0.1 liter
	One centiliter (cl)	=	0.01 liter
	One mililiter (ml)	=	0.001 liter
AREA	One hectare (HA)	=	10,000 square meters
	One square kilometer	=	1,000,000 square meters

MASTER LIST - CONVERSTION FACTORS

MULTIPLY	BY	TO OBTAIN
Acres	43560	Square Feet
Atmospheres	33.9	Feet of Water
Centimeters	0.40	Inches
Cubic Feet	7.48	Gallons
Cubic Feet	28.32	Liters
Cubic Feet/Second	449	Gallons/Minute
Cubic Meters	35.31	Cubic Feet
Cubic Meters	264.2	Gallons
Cubic Meters	10^3	Liters
Cubic Yards	27	Cubic Feet
Cubic Yards	202	Gallons
Feet	30.48	Centimeters
Feet	0.31	Meters
Feet of Water	62.43	Pounds/Square Foot
Feet of Water	0.43	Pounds/Square Inch
Gallons	3785	Cubic Centimeters
Gallons	0.13	Cubic Feet
Gallons	3.79	Liters
Gallons water	8.34	Pounds of Water
Gallons/Minute	2.2×10^{-3}	Cubic feet/Second
Gallons/Minute	1440	Gallons/Day
Gallons/ Minute	0.06308	Liters/Second
Gallons/Day	6.9×10^{-4}	Gallons/Minute
Gallons/Day/Square Foot	1.604	Inches/Day
Grams	2.21×10^{-3}	Pounds
Grams/Liter	1000	Parts/Million
Hectares	2.47	Acres
Horsepower	33,000	Foot-pounds/Minute
Horsepower	0.7457	Kilowatts
Inches	2.54	Centimeters
Inches/Day	0.62	Gallons/Day/Square Foot
Kilograms	2.21	Pounds
Kilowatts	1.34	Horsepower
Kilowatt-hours	2.66×10^6	Foot-pounds
Liters	103	Cubic Centimeters
Liters	0.04	Cubic Feet
Liters	0.26	Gallons
Meters	3.28	Feet
Milligrams/Liters	1	Parts/Million
Million Gallons/Day	1.55	Cubic Feet/Second
Parts/Million	8.34	Pounds/Million Gallons
Pounds	453.50	Grams
Pounds of Water	0.12	Gallons
Pounds/Square Inch	2.31	Feet of Water
Pounds/Square Inch	2.04	Inches of Mercury
Temperature (°C) + 17.78	1.8	Temperature (°F)
Temp. (°F) - 32	5/9	Temp. (°C)