FORMULA SHEETS

CONVERSION FACTORS

Pi (π) = 3.14
1 gallon of water = 8.34 pounds
1 gallon of water = 4 quarts = 8 pints = 3.785 liters
1 Population Equivalent (PE) = 0.17 pounds BOD/capita/day
  " = 0.20 pounds SS/capita/day
  " = 100 gallons water/capita/day
1 day = 24 hours = 1440 minutes
1 square foot (ft²) = 144 square inches (in²)
1 square yard (yd²) = 9 square feet (ft²)
1 cubic foot (ft³) = 7.5 gallons = 1728 cubic inches (in³)
1 cubic yard (yd³) = 27 cubic feet (ft³)
1 acre = 43560 square feet (ft²)
1 horsepower (HP) = 33,000 foot-pounds/minute (ft-lb/min) = 746 watts = 0.746 kilowatts (kw)
1 foot of water = 0.433 pounds/square inch (psi)
1 pound/square inch (psi) = 2.31 feet of water

VOLUMES, AREAS, & PERIMETERS

**GIVEN:** V = Volume, L = Length, H = Height, W = Width, r = radius, d = diameter, δ = Pi,
  b = base, P = Perimeter, C = Circumference

**VOLUMES**

Rectangular Solid: \( V = L \times W \times H \)
Cylinder: \( V = \pi r^2 H = \pi d^2 H = 0.785 \frac{d^2 H}{4} \)
Sphere: \( V = \frac{4}{3} \pi r^3 \)
Cone: \( V = \frac{1}{3} \pi r^2 H \)
Pyramid: \( V = \frac{1}{3} L \times W \times H \)

**PERIMETER**

Polygon: \( P = L_1 + L_2 + L_3 + \ldots + L_n \)
Circle: \( C = \pi d \)

**AREA**

Rectangle: \( A = L \times W \)
Triangle: \( A = \frac{1}{2} b \times H \)
Circle: \( A = \pi r^2 = \pi d^2 = 0.785 d^2 \)
Trapezoid: \( A = \frac{1}{2} (b_1 + b_2) H \)
PROCESS FORMULAS

TEMPERATURE

\[ ^\circ F = \frac{9}{5} \times ^\circ C + 32 \quad ^\circ C = \frac{5}{9} (^\circ F - 32) \quad ^\circ K = ^\circ C + 273 \]

FLOW MEASUREMENT

90° V-notch weir: \( Q = 2.5H^{2.5} \)  
Cippolletti weir: \( Q = 3.367LH^{1.5} \)  
Parshall flume: \( Q = 4WH^{1.52W^{0.026}} \)  
Sharp-crested weir: \( Q = 3.33LH^{1.5} \)  
Proportional weir: \( Q = 7.57mH \)

ELECTRICITY

Power = Current x Voltage  
Voltage = Current x Resistance

Average Current = \( \frac{\text{Line 1 Current} + \text{Line 2 Current} + \text{Line 3 Current}}{3} \)

Current Imbalance = \( \frac{\text{Average Current} - \text{Maximum Deviation}}{\text{Average Current}} \times 100 \)

MISCELLANEOUS

Efficiency = \( \frac{(\text{In} - \text{Out})}{\text{In}} \times 100\% \)  
Velocity = \( \frac{\text{Distance}}{\text{Time}} \)

Detention Time = \( \frac{\text{Volume}}{\text{Flow Rate}} \)

Application Rate = Concentration x Flow x Conversion Factor  
Loading Rate = Concentration x Flow x Conversion Factor / Area

LABORATORY

BOD₃ (mg/l) = (Initial DO - Final DO) x \( \frac{\text{Bottle Volume}}{\text{Sample Volume}} \)
SS Concentration (mg/l) = \( \frac{\text{Weight of Solids (gr)}}{\text{Amount of Sample (ml)}} \) x Conversion Factor(s)

(Laboratory Continued)

\[
\% \text{ Capture} = \frac{\text{Sludge SS} - \text{RAS SS}}{\text{Wet Sludge}} \times 100
\]

\[
\% \text{ Solids} = \frac{\text{Dry Sample}}{\text{Wet Sample}} \times 100
\]

\[
\% \text{ Moisture} = \frac{\text{Wet Sludge} - \text{Dry Solids}}{\text{Wet Sludge}} \times 100
\]

\[
\% \text{ Volatile Solids} = \frac{\text{Dry Sample} - \text{Ash}}{\text{Dry Sample}} \times 100
\]

\[
\% \text{ Reduction in Volatile Matter} = \frac{\text{In} - \text{Out}}{\text{In} - (\text{In} \times \text{Out})} \times 100
\]

**CLARIFIER**

\[
\text{Detention Time} = \frac{\text{Volume}}{\text{Flow Rate}}
\]

\[
\text{Weir Overflow Rate} = \frac{\text{Flow}}{\text{Length}}
\]

\[
\text{Surface Settling Rate} = \frac{\text{Flow}}{\text{Surface Area}}
\]

**PROCESS CONTROL**

\[
\text{F/M} = \frac{\text{lbs of BOD}}{\text{lbs of MLSS}}
\]

\[
\text{(Q +RQ) MLSS} = \text{RQ} \times \text{RAS}
\]

\[
\text{MLSS (mg/l)} = \frac{\text{MLSS (lbs)}}{\text{Volume} \times \text{Conversion Factor(s)}}
\]

\[
\text{SDI} = \frac{\text{Settled Sludge Volume (ml) (30 minutes)}}{\text{MLSS (mg/l)}} \times 10 \quad \text{or} \quad 100
\]

\[
\text{SVI} = \frac{\text{Settled Sludge Volume (ml) (30 minutes) \times 1000}}{\text{MLSS (mg/l)}}
\]

\[
\text{Gould's Sludge Age} = \frac{\text{lbs of MLSS [Aeration Tank(s)]}}{\text{lbs of TSS (Influent)}}
\]

\[
\text{MCRT} = \frac{\text{lbs of MLSS (Aeration Tank) + lbs of Solids (Clarifier)}}{\text{______}}
\]
[(RAS(mg/l) x WAS Flow) + (Effluent SS(mg/l) x Flow)] x Conversion Factor

Mixed Concentration =
(Upstream Flow x Upstream Concentration) + (Effluent Flow x Effluent Concentration)
Downstream Flow

**SLUDGE LAND APPLICATION**

lb/ton = mg/l x 0.002

1 mg/kg = 0.002 lbs/ton

gal/acre = wet tons x 2000 lbs x \( \frac{1 \text{ gal}}{\text{acre}} \times \frac{\text{ton}}{8.34 \text{ lbs}} \)

mg/l (dry) = mg/l (wet) x \( \frac{100}{\text{% Total Solids}} \)

Dry Tons = Wet Tons x \( \frac{\text{% Total Solids}}{100} \)

Plant Available Nitrogen(PAN)(mg/kg) = Ammonia Nitrogen(mg/kg) + Organic Nitrogen(mg/kg)

Organic Nitrogen(mg/kg) = Total Kjeldahl Nitrogen(TKN)(mg/kg) - Ammonia Nitrogen(mg/kg)

**WEST PROCESS CONTROL METHOD FOR ACTIVATED SLUDGE**

\( F = 31.2 \text{ lbs/ft}^3 \times H^2 \times L \)

\( R_Q = \frac{\text{MLSS} \times Q}{1 - \text{MLSS}} \)

\( R_Q = \frac{Q \times M}{1,000,000 - M} \frac{\text{SVI}}{\text{SVI}} \)

\( \text{WCR} = \frac{\text{MLTSS}}{\text{ATC}} \)

\( \text{RSP} = \frac{\text{ATC} - \text{PEC}}{\text{RSC} - \text{ATC}} \)

\( \text{SLU} = \frac{\text{Volume} \times \text{Centrifuged Concentration}}{100} \)

\( \text{CFP} = \frac{\text{ATC} - \text{FEC}}{\text{RSC} - \text{ATC}} \)

\( \text{ATC} = (\text{CFP} \times \text{RSC}) + \text{FEC} \frac{\text{CFP} + 1.0}{\text{CFP} + 1.0} \)

\( \text{RSC} = \frac{\text{ATC} + (\text{ATC} - \text{FEC})}{\text{CFP}} \)

\( \text{RSP} = \frac{\text{ATC} - \text{PEC}}{\text{RSC} - \text{ATC}} \)
<table>
<thead>
<tr>
<th>Equation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{SSC} = 1000 \times \text{ATC}$</td>
<td>Settled Sludge Concentration</td>
</tr>
<tr>
<td>$\text{SSV} = \frac{\text{SSC}}{\text{ATC}}$</td>
<td>Settled Sludge Volume</td>
</tr>
<tr>
<td>$\text{ATC} = \frac{(\text{RSP} \times \text{RSC}) + \text{PEC}}{\text{RSP}}$</td>
<td>Aeration Tank Concentration</td>
</tr>
<tr>
<td>$\text{RSC} = \frac{\text{ATC} + (\text{ATC} - \text{PEC})}{\text{RSP}}$</td>
<td>Return Sludge Concentration</td>
</tr>
<tr>
<td>$\text{CFP} = \frac{\text{ATC}}{\text{(RSC - ATC)}}$</td>
<td>Final Clarifier Sludge Flow Percentage</td>
</tr>
<tr>
<td>$\text{ASU} = \frac{\text{AV} \times \text{ATC}}{100}$</td>
<td>Aeration Tank Sludge Units</td>
</tr>
<tr>
<td>$\text{CSU} = \frac{\text{BLV} \times \text{CSC}}{100}$</td>
<td>Sludge Blanket Volume</td>
</tr>
<tr>
<td>$\text{RSC} = \frac{\text{ATC} + (\text{ATC})}{\text{CFP}}$</td>
<td>Return Sludge Flow</td>
</tr>
<tr>
<td>$\text{RSP} = \frac{\text{RSF} \times \text{RSC}}{100}$</td>
<td>Return Sludge Percentage</td>
</tr>
<tr>
<td>$\text{ADT} \times \text{AFI} = \frac{\text{AV} \times 24}{\text{AFI}}$</td>
<td>Aeration Tank Wastewater Flow(In)</td>
</tr>
<tr>
<td>$\text{AGE} = \frac{\text{ASU} + \text{CSU}}{\text{TXU/day}}$</td>
<td>Sludge Age</td>
</tr>
<tr>
<td>$\text{CSFD} = \frac{\text{RSF} \times (\text{RSC} - \text{ATC})}{\text{SSC} - \text{ATC}}$</td>
<td>Return Sludge Flow</td>
</tr>
<tr>
<td>$\text{SCR} = \frac{\text{SSC60}}{\text{RSC}}$</td>
<td>Sludge Concentration Ratio</td>
</tr>
</tbody>
</table>

**Abbreviations:**

- AAG - Aeration Age
- ADT - Aeration Tank Detention Time
- AFI - Aeration Tank Wastewater Flow(In)
- AGE - Sludge Age
- ASU - Aeration Tank Sludge Units
- ATC - Aeration Tank Concentration
- AV - Aeration Tank Volume
- BLV - Sludge Blanket Volume
- CDT - Final Clarifier Detention Time
- CFA - Final Clarifier Area
- CFI - Final Clarifier Flow(In)
- CFO - Final Clarifier Flow(Out)
- CFP - Final Clarifier Sludge Flow Percentage
- CSC - Final Clarifier Sludge Concentration
- CSU - Sludge Blanket Volume
- CSUO - Sludge Blanket Volume (Output)
- CTD - Final Clarifier Sludge Concentration
- CSW - Sludge Blanket Concentration
- CSOE - Sludge Blanket Concentration (Outlet)
- CSUO - Sludge Blanket Volume (Outlet)
- OFR - Final Clarifier Surface Overflow Rate
- PEC - Primary Effluent Concentration
- RAS - Return Activated Sludge
- RSC - Return Sludge Concentration
- RSF - Return Sludge Flow
- RSP - Return Sludge Percentage
- SAH - Sludge Aeration Hours
- SCR - Sludge Concentration Ratio
- SLU - Sludge Units
- SSC - Settled Sludge Concentration
- SSV - Settled Sludge Volume
- SVI - Sludge Volume Index
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSDT</td>
<td>Final Clarifier Sludge Detention Time</td>
<td>TFL</td>
<td>Total Flow</td>
</tr>
<tr>
<td>CSF</td>
<td>Final Clarifier Sludge Flow</td>
<td>TXU</td>
<td>Total Excess Sludge Units to Waste</td>
</tr>
<tr>
<td>CSFD</td>
<td>Final Clarifier Sludge Flow Demand</td>
<td>VSS</td>
<td>Volatile Suspended Solids</td>
</tr>
<tr>
<td>CSU</td>
<td>Final Clarifier Sludge Units</td>
<td>WAS</td>
<td>Waste Activated Sludge</td>
</tr>
<tr>
<td>CSUO</td>
<td>Final Clarifier Sludge Units Out of Clarifier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV</td>
<td>Final Clarifier Volume</td>
<td>WCR</td>
<td>Sludge Weight to Concentration Ratio</td>
</tr>
<tr>
<td>FEC</td>
<td>Final Effluent Solids Concentration</td>
<td>XFP</td>
<td>Excess Sludge Flow</td>
</tr>
<tr>
<td>MCRT</td>
<td>Mean Cell Residence Time</td>
<td>XSC</td>
<td>Excess Sludge Concentration</td>
</tr>
<tr>
<td>MLSS</td>
<td>Mixed Liquor Suspended Solids</td>
<td>XSF</td>
<td>Excess Sludge Flow to Waste</td>
</tr>
<tr>
<td>MLTSS</td>
<td>Mixed Liquor Total Suspended Solids</td>
<td>XSU</td>
<td>Total Excess Sludge Units to Waste</td>
</tr>
<tr>
<td>MLVSS</td>
<td>Mixed Liquor Volatile Suspended Solids</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>