

The unit conversion coefficient in the Hazen-Williams Equation

After reviewing the textbook material on the Hazen-Williams Equation (H-W), we've realized that some of the values given for the unit conversion coefficient  $C_u$  do not agree with the units given for them. I have verified all of the information below.

In its fundamental form, the H-W equation is (Liou 1998):

$$V = 0.849 C R_h^{0.63} S^{0.54}$$

where  $V$  is pipe flow velocity (m/s),  $C$  is the H-W roughness value,  $R_h$  is hydraulic radius (m), and  $S$  is slope of the energy grade line ( $= H_f / L$ ). Hydraulic radius is defined as the ratio of flow cross-sectional area to wetted perimeter, which is equal to  $D/4$  for a circular pipe flowing full. Replacing  $V$  with  $Q/A$ , and implementing the other substitutions listed above:

$$Q = 0.278 C D^{2.63} \left( \frac{H_f}{L} \right)^{0.54}$$

for  $[Q] = m^3/s$ ,  $[D] = m$ ,  $[H_f] = m$ , and  $[L] = m$ . The value 0.278 is commonly noted as  $C_u$ , the unit conversion coefficient. The appropriate value of  $C_u$  can be determined for any combination of units using the following:

$$C_u = \frac{\left( \frac{Q \text{ units}}{m^3/s} \right) \cdot \left( \frac{L \text{ units}}{m} \right)^{0.54}}{\left( \frac{D \text{ units}}{m} \right)^{2.63} \cdot \left( \frac{H_f \text{ units}}{m} \right)^{0.54}} \times 0.278$$

where  $Q \text{ units}$  is the unit conversion factor from  $m^3/s$  to the desired system (e.g., to use gallons per minute,  $\left( \frac{Q \text{ units}}{m^3/s} \right) = 15850$ ), etc.

The table below gives  $C_u$  values for some common unit choices.

Flow units	Diameter units	Head Loss units	Pipe Length units	$C_u$
$m^3/s$	m	m	m	0.278
gal/min	in	ft	ft	0.281
gal/sec	in	ft	ft	0.00468
MGD	ft	ft	ft	0.279
gal/min	ft	ft	ft	194
gal/day	in	ft	ft	405
$ft^3/sec$	in	ft	ft	0.000626
$ft^3/sec$	ft	ft	ft	0.431