

Overview of the Campbell soil hydraulic property functions

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One of the simplest sets of equations for describing soil hydraulic properties was developed by Campbell (1974). In the Campbell approach, the soil water retention curve is represented by

$$\frac{\theta}{\theta_s} = \left(\frac{\psi_e}{\psi_m} \right)^{\frac{1}{b}} \quad \psi_m < \psi_e$$

$$\theta = \theta_s \quad \psi_m \geq \psi_e$$

where θ is the volumetric water content, θ_s is the saturated water content, ψ_e is the air-entry potential, ψ_m is the soil matric potential, and b is an empirical parameter.

The corresponding hydraulic conductivity functions are

$$K(\psi_m) = K_s \left(\frac{\psi_e}{\psi_m} \right)^{2+\frac{3}{b}} \quad \psi_m < \psi_e$$

$$K = K_s \quad \psi_m \geq \psi_e$$

or

$$K(\theta) = K_s \left(\frac{\theta}{\theta_s} \right)^{2b+3} \quad \theta < \theta_s$$

$$K = K_s \quad \theta = \theta_s$$

where K_s is the saturated hydraulic conductivity. Approximate values for the parameters of the Campbell hydraulic property functions have been summarized by soil textural class in Table 1.

References:

- Campbell, G.S. 1974. A simple method for determining unsaturated conductivity from moisture retention data. *Soil Sci.* 117:311-314.
- Rawls, W.J., L.R. Ahuja, and D.L. Brakensiek. 1992. Estimating soil hydraulic properties from soils data, p. 329-340. *In* M. T. van Genuchten, et al., eds. *Indirect methods for estimating the hydraulic properties of unsaturated soils.* Univ. of California, Riverside, Riverside, California.

Table 1. Hydraulic properties of soils classified by soil texture [from Rawls et al. (1992)].

Texture	Silt	Clay	$-\psi_e$	b	K_s	$\theta_{-33 \text{ kPa}}$	$\theta_{-1500 \text{ kPa}}$
	g g^{-1}	g g^{-1}	kPa		cm hr^{-1}	$\text{m}^3 \text{m}^{-3}$	$\text{m}^3 \text{m}^{-3}$
sand	0.05	0.03	0.7	1.7	21	0.09	0.03
loamy sand	0.12	0.07	0.9	2.1	6.1	0.13	0.06
sandy loam	0.25	0.10	1.4	3.1	2.6	0.21	0.1
loam	0.4	0.18	1.1	4.5	1.3	0.27	0.12
silt loam	0.65	0.15	2.0	4.7	0.68	0.33	0.13
sandy clay loam	0.13	0.27	2.8	4.0	0.43	0.26	0.15
clay loam	0.34	0.34	2.5	5.2	0.23	0.32	0.2
silty clay loam	0.58	0.33	3.2	6.6	0.15	0.37	0.21
sandy clay	0.07	0.40	2.9	6.0	0.12	0.34	0.24
silty clay	0.45	0.45	3.4	7.9	0.09	0.39	0.25
clay	0.20	0.60	3.7	7.6	0.06	0.40	0.27