

MasterDrain  
SW



<http://www.mstdrain.co.uk>

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Job No.		
Sheet no.		1
Date		
24/09/10		
By	Checked	Approved
IJ		

Project	
Title	Evapotranspiration calculations

## Design data:-

Location = BRACKNELL	National Grid = SU8769	Latitude ( $\phi$ )= 51° 21' 16.36"
Elevation = 30 m	Month = September	Day = 22
Maximum temp. = 17.0°C	Minimum air temp. = 12.00°C	Mean air temp = 14.50°C
Wind speed (2m) = 2.30 m/s	Sunshine hours = 6	Albedo ( $\alpha$ )= 0.23

## Calculated data:-

### Constants:

Specific heat ( $C_p$ ) of air	= 1.005kJ/kg/°K
Latent heat of vapourisation ( $\lambda$ )	= 2.450MJ/kg
Day of year (J)	= 265

### Air values:

Atmospheric pressure (P) at 30 m	= 100.9 kPa
Air density ( $\rho$ ) for 30 metres at 14.5°C	= 1.216kg/m <sup>3</sup>

### Vapour pressures:

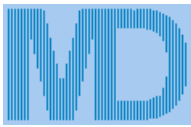
Saturation Vapour pressure ( $e_s$ ) at 14.5°C	= 1.651 kPa/°C
Calculated actual vapour pressure ( $e_a$ )	= 1.40 kPa
Calculated actual vapour pressure ( $e^{\circ}[T_{max}]$ )	= 1.94 kPa
Calculated actual vapour pressure ( $e^{\circ}[T_{min}]$ )	= 1.40 kPa
Mean calculated actual vapour pressure ( $e_{s\_mean}$ )	= 1.670 kPa/°C
Slope of vapour pressure curve ( $\Delta$ ) at 14.5°C	= 0.11 kPa
Psychrometric constant ( $\gamma$ ) for 30 metres	= 0.067

### Sun values:

Solar declination ( $\delta$ )	= -0.012 rads
Sun hour angle ( $\omega$ )	= 1.555 rads
Daylight hours	= 11.882 hours

### Radiation values

Extraterrestrial radiation ( $R_a$ )	= 22.791MJ/m <sup>2</sup> /day
Shortwave radiation ( $R_{so}$ )	= 17.23MJ/m <sup>2</sup> /day
Calculated Solar radiation ( $R_s$ )	= 14.33MJ/m <sup>2</sup> /day
Net shortwave radiation ( $R_{ns}$ )	= 11.03MJ/m <sup>2</sup> /day
Net longwave radiation ( $R_{nl}$ )	= 4.52MJ/m <sup>2</sup> /day
Net radiation ( $R_n$ )	= 6.51MJ/m <sup>2</sup> /day
Equivalent evaporation	= 2.66mm/day
Outgoing radiation ( $R_o$ )	= 8.44MJ/m <sup>2</sup> /day



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### Calculation of ET<sub>o</sub> (FAO Penman-Monteith / ASCE) :-

$$ET_{ref} = \frac{0.408\Delta(R_n - G) + \gamma(C_n/T+273) U_2(e_s - e_a)}{\Delta + \gamma(1 + C_d U_2)}$$

where :-

ET<sub>ref</sub> = reference evapotranspiration in mm/day.

Δ = Slope of vapour pressure curve at 14.5°C

R<sub>n</sub> = Net radiation

G = Soil heat flux density.....ignored in this calculation

γ = Psychrometric constant for 30 metres

T = mean daily air temperature at 2m

U<sub>2</sub> = wind speed at 2 metres

e<sub>s</sub> = saturation vapour pressure

e<sub>a</sub> = actual vapour pressure

C<sub>n</sub> = numerator constant ..... 900 for short grasses (<= 0.12m)

C<sub>d</sub> = denominator constant ..... 0.34 for short grasses (<= 0.12m)

substituting :-

$$ET_{ref} = \frac{0.408 \times 0.11 (6.51 - 0) + (0.067 \times \{900/[14.50 + 273]\} \times 2.30 (1.67 - 1.40))}{0.11 + 0.067 \times (1 + [0.34 \times 2.30])}$$

giving :-

$$ET_{ref} = 1.82 \text{ mm/day (1.82 l/m}^2\text{/day)}$$

NOTES :-

- 1) The mean air temperature is average of maximum and minimum daily values.
- 2) The actual vapour pressure assumes dewpoint temperature is the same as the minimum temperature.
- 3) If no measured sunlight value is entered, the working value is assumed to be 50% of daylight hours.
- 4) The numerator constant is a function of the time-step, and aerodynamic resistance.
- 5) The denominator constant is a function of the time-step, bulk surface resistance, and aerodynamic resistance.

For further information, refer to the ASCE or FAO documents.