APPENDIX A.

The following text is a description of the steps needed to estimate reference evapotranspiration for a 0.12 m tall reference surface using daily weather data as adopted by the American Society of Civil Engineers (Allen et al., 2005).

STEP 1: Extraterrestrial radiation (R_a) is calculated for each day using the following equations from Duffie and Beckman (1980).

G_{SC} = 0.082 MJ m^{-2} min^{-1} = solar constant

σ = 4.90 × 10^{-9} MJ m^{-2} d^{-1} K^{-4} = Steffan-Boltzman constant

$\phi = \frac{\pi L}{180}$ = latitude in radians converted from latitude (L) in degrees

$d_r = 1 + 0.033\, cos\left(\frac{2\pi}{365} i\right)$ = correction for eccentricity on day i of the year

$\delta = 0.409\, sin\left(\frac{2\pi}{365} i - 1.39\right)$ = declination of the sun in radians on day i of the year

$\omega_s = cos^{-1}\left[-tan\phi\, tan\delta\right]$ = sunrise hour angle in radians

$R_a = \left(\frac{24 \cdot 60}{\pi}\right) G_{SC} d_r \left[\omega_s \sin\delta \sin\phi + \cos\phi \cos\delta \sin\omega_s\right]$ = extraterrestrial rad. (MJ m^{-2} d^{-1})

STEP 2: Calculate the daily net radiation (R_n) expected over grass in MJ m^{-2} d^{-1} using equations from Allen et al. (1994).

$R_{so} = R_a \left(0.75 + 2.0 \times 10^{-5} E_l\right)$ = clear sky total global solar radiation in MJ m^{-2} d^{-1}

$R_{ns} = (1 - 0.23) R_s$ = net solar radiation for measured solar radiation (R_S) in MJ m^{-2} d^{-1}

$f = 1.35\frac{R_s}{R_{so}} - 0.35$ = a cloudiness function of R_s and R_{so}

For maximum daily air temperature (T_X) and minimum daily air temperature (T_n) in °C,

$e_s(T_x) = 0.6108\exp\left(\frac{17.27T_x}{T_x + 237.3}\right)$ = saturation vapor pressure (kPa)

$e_s(T_n) = 0.6108\exp\left(\frac{17.27T_n}{T_n + 237.3}\right)$ = saturation vapor pressure (kPa)

For maximum relative humidity (RH_x) and minimum relative humidity(RH_n) in (%),

$e_a = \frac{e_s(T_x)\frac{RH_n}{100} + e_s(T_n)\frac{RH_x}{100}}{2}$ = actual vapor pressure (kPa)

For daily mean dew point temperature (T_d) in °C,

$e_a = 0.6108\exp\left[\frac{17.27T_d}{T_d + 237.3}\right]$ = actual vapor pressure (kPa)

$\varepsilon' = 0.34 - 0.14\sqrt{e_a}$ = apparent 'net' clear sky emissivity

$R_{nl} = -f\,\varepsilon'\,\sigma\left[\frac{(T_x + 273.15)^4 + (T_n + 273.15)^4}{2}\right]$ = net long wave radiation in MJ m^{-2} d^{-1}

$R_n = R_{ns} + R_{nl}$ = net radiation over grass in MJ m^{-2} d^{-1}

STEP 3: Calculate variables needed to compute ET_h, ET_o and ET_r.

For elevation (E_L) in meters,

$\beta = 101.3\left(\frac{293 - 0.0065\,E_L}{293}\right)^{5.26}$ = barometric pressure (kPa)

$\lambda = 2.45$ = latent heat of vaporization in (MJ kg^{-1})

$\gamma = 0.00163\,\frac{\beta}{\lambda}$ = psychrometric constant in kPa $^{o}C^{-1}$

$$T_m = \frac{T_x + T_n}{2}$$ = mean daily temperature in °C

$$e^o = 0.6108 \exp\left(\frac{17.27 T_m}{T_m + 237.3}\right)$$ = saturation vapor pressure (kPa) at T_m

$$\Delta = \frac{4099\, e^o}{(T_m + 237.3)^2}$$ = slope of the saturation vapor pressure curve (kPa °C^{-1})

$$G \approx 0$$ = soil heat flux density in MJ m^{-2} d^{-1}

$$e_s = \frac{e_s(T_x) + e_s(T_n)}{2}$$ = mean daily saturation vapor pressure (kPa)

STEP 4: Calculate ET_o using the ASCE-EWRI standardized equation for short canopy reference *ET* (Allen et al., 2005)

For U_2 the wind speed at 2 m height and temperature and relative humidity measured between 1.5 and 2.0 m height,

$$R_o = \frac{0.408\,\Delta(R_n - G)}{\Delta + \gamma(1 + 0.34U_2)}$$ = radiation term (mm d^{-1})

$$A_o = \frac{\left(\frac{900\gamma}{T_M + 273}\right) U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)}$$ = aerodynamic term (mm d^{-1})

$$ET_o = R_o + A_o$$ = Standardized Reference Evapotranspiration for short canopies (mm d^{-1})