1. A watershed receives 1000 mm/yr precipitation and has an evapotranspiration rate of 600 mm/yr. If the watershed covers 10 ha, what is the total net input of water to the watershed in m^3/y?

ANS: Net Input = P - ET = (1000 - 600) mm/y = 400 mm/y

Total Volumetric Input = $(400\ mm/y)\left(\frac{1\ m}{10^3\ mm}\right)(10\ ha)\left(\frac{10^4\ m^2}{ha}\right)$

(Net Input Rate) (Area)

$= \boxed{4 \times 10^4\ m^3/y}$ ANS

2. In the watershed above what is the heat loss associated with evaporation in units of W/m^2?

ANS. ET = 600 mm/y.

In class we noted: $1\ mm/y = 1\ \frac{kg\text{-}H_2O}{m^2 \cdot yr}$

(Because $\frac{1\ mm/y}{1\ m^2\ AREA} = 10^{-3}\ m^3/m^2 y \rightarrow \left(1\ \frac{L}{m^2 yr}\right)\left(1\ \frac{kg}{L}\right) = 1\ kg/m^2 y$) ρ_w

∴ ET Heat loss

[Evap Mass Flux, $kg/m^2 y$] [Latent Heat Vaporization J/kg]

FROM NOTES ⇒ $H_L = 2400\ J/g$ near 20°C → $H_L = 2.4 \times 10^6\ J/kg$

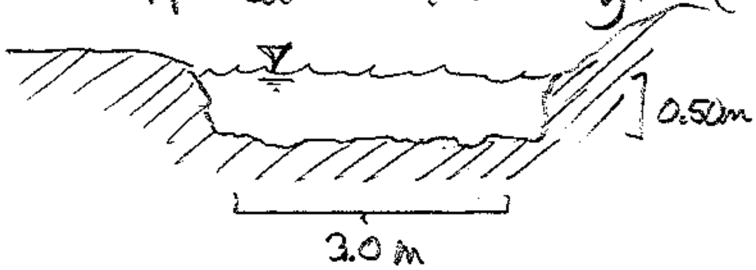
$$\phi_{evap} = (600\ mm/y)\left(\frac{1\ kg/m^2 \cdot y}{1\ mm/y}\right)\left(2.4 \times 10^6\ \frac{J}{kg}\right)\left(\frac{1\ day}{86{,}400\ s}\right)\left(\frac{1\ yr}{365\ d}\right)$$

$$\phi_{evap} = \boxed{46\ W/m^2}$$

3. A stream has a slope of 0.010 and a moderately rough bottom such that a Manning Coeff. of 0.040 is appropriate.

The stream is 3.0 m wide and has an average depth of 0.50 m. Assume the stream is approximately <u>rectangular</u> in cross section.

What is the expected mean velocity? (m/s)



<u>ANS</u> Use Manning's Eqn

$$v = \frac{R^{2/3} S^{1/2}}{n}$$

⇐ As noted in class OMIT 1.49 factor if working in meters & v = m/s

$$R = \frac{A_{xs}}{P_{wet}} = \frac{(0.5\,m)(3.0\,m)}{2(0.5) + (3.0\,m)} = 0.375\,m$$

$$v = \frac{(0.375)^{2/3}(0.01)^{1/2}}{0.040} = \boxed{1.3 \ m/s}$$

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4. A small pond has the following thermal properties

$\phi_s^{IN} = -300 \ W/m^2$

$\phi_\ell^{OUT} = +360 \ W/m^2$

$\phi_\ell^{*IN} = -200 \ W/m^2$

The temperature of the lake is <u>steady</u> (steady state).

Evaporation = 2.0 mm/day

What is the heat flux to/from the lake (ϕ_c) in W/m^2

Be sure to specify if ϕ_c is "in"(−) or "out"(+).

4 cont'd

ANS At steady state

$$\phi_s + \phi_\ell^{IN} + \phi_\ell^{OUT} + \phi_{evap} + \phi_c = 0$$

$$\therefore \quad \phi_c = \phi_s + \phi_\ell^{IN} + \phi_\ell^{OUT} + \phi_{evap}$$

Find $\phi_e = [\text{Evap Rate}] H_L$

$$= \left[2.0 \frac{kg}{m^2 \cdot d}\right]^{*} (2400 \text{ kJ/kg})\left(10^3 \frac{J}{kJ}\right)\left(\frac{1\,d}{86{,}400\,s}\right) = 56 \frac{W}{m^2}$$

$$\phi_c = (-300) + (-200) + (+360) + (+56)\,[W/m^2]$$

$$\phi_c = \boxed{84\ W/m^2}$$

5. In problem 4 ϕ_ℓ^{out} is $+360\ W/m^2$
What is the temperature of the lake? (°C)

ANS: $\phi_\ell^{out} = \sigma T^4$ ($\varepsilon \cong 1.0$ for H_2O)

$$T = \left(\frac{360\ W/m^2}{5.7 \times 10^{-8} \frac{W}{m^2 K^4}}\right)^{0.25} = 282\ K$$

$$\boxed{T = 9\,°C}$$

Sounds reasonable (~48°F)

6. At Fred Meyer, potting soil bags are sold by volume (not weight). A large bag is 2.0 cu. feet. You are curious about the weight you bought & find the bag weighs 65 kg. What is the bulk density (ρ_B) of the potting soil? (Loose soil in bag)

$$V = (2.0\ cu.ft)(0.0283\ m^3/ft^3) = 0.057\ m^3 = 57\,L$$

$$\rho_B = \frac{M_s}{V_T} = \frac{65\ kg}{57\ L} = \boxed{1.14 \frac{kg}{L}}$$

(Low for real soil but this is bagged)