Water balance of a polder

Exercise 3.11.2c

Polder area = 5 km^2: 2 km^2 is open water and 3 km^2 is land.

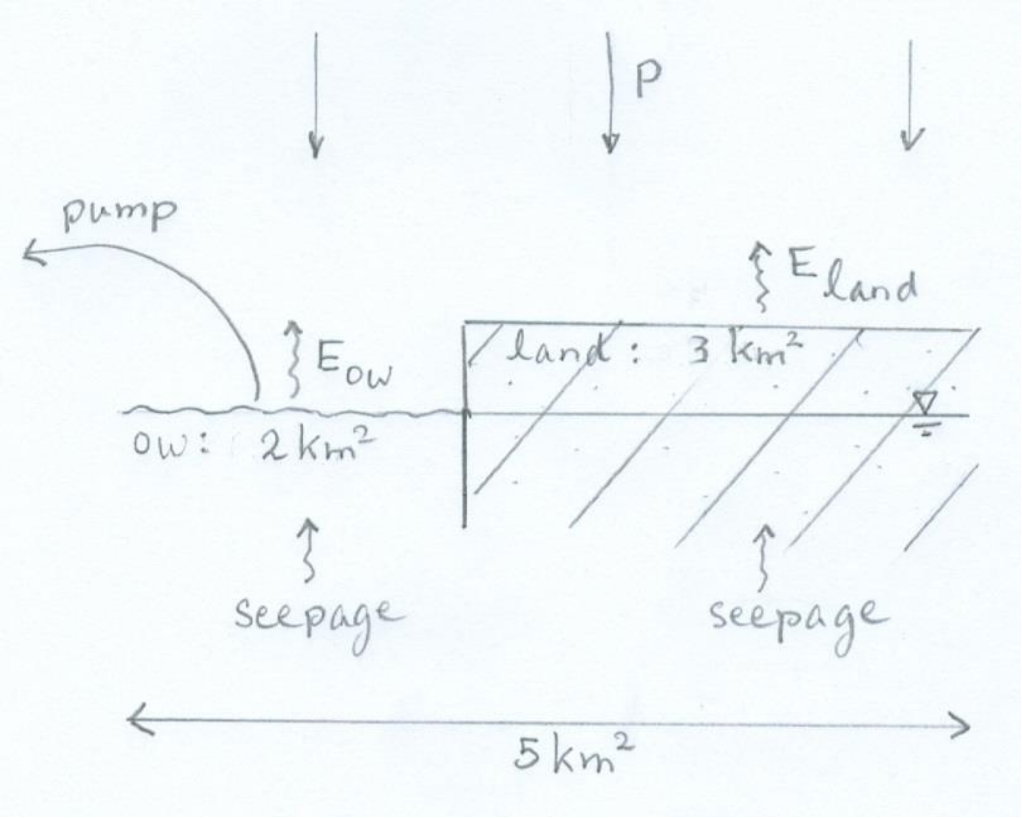
P = 750 mm $year^{-1}$; E_{ow} = 600 mm $year^{-1}$; E_{land} = 420 mm $year^{-1}$

$pump = 2 \times 10^6$ m^3 $year^{-1}$; storage coefficient = 0.4

The **storage coefficient** for the polder (sub)soil is the ratio of added or extracted water depth (mm) and the accompanying change in water table level (mm).

Determine the seepage (mm day^{-1}) for a year in which the water table and open water level have risen by 200 mm.

Answer 3.11.2c



Water balance: $P + seepage = E_{actual} + pump + (\Delta S/\Delta t)$

Volume per time units

Total area = 5×10^6 m^2; area open water = 2×10^6 m^2; area land = 3×10^6 m^2

Calculation using volume per time units:

P = 750 mm year^{-1} = 0.75 m year^{-1} $\times$ 5 $\times$ 10^6 m^2 = 3.75 $\times$ 10^6 m^3 year^{-1}

E_{ow} = 600 mm year^{-1} = 0.6 m year^{-1} $\times$ 2 $\times$ 10^6 m^2 = 1.2 $\times$ 10^6 m^3 year^{-1}

E_{land} = 420 mm year^{-1} = 0.42 m year^{-1} $\times$ 3 $\times$ 10^6 m^2 = 1.26 $\times$ 10^6 m^3 year^{-1}

$E_{actual} = E_{ow} + E_{land}$ = 2.46 $\times$ 10^6 m^3 year^{-1}

$pump$ = 2 $\times$ 10^6 m^3 year^{-1}

Volume per time units

Open water and the water table have risen by 200 mm year^{-1} = 0.2 m year^{-1}.

$(\Delta S/\Delta t)_{ow} = 0.2 \text{ m year}^{-1} \times 2 \times 10^6 \text{ m}^2 = 0.4 \times 10^6 \text{ m}^3 \text{ year}^{-1}$

Storage coefficient = 0.4 = 4/10

4 mm of added (precipitation) water causes a 10 mm rise of the water table.

80 mm of added (precipitation) water causes a 200 mm rise of the water table.

$(\Delta S/\Delta t)_{land}$ = storage coefficient × P mm year^{-1}

$(\Delta S/\Delta t)_{land} = 0.4 \times 200 \text{ mm year}^{-1} = 80 \text{ mm year}^{-1} = 0.08 \text{ m year}^{-1}$

$(\Delta S/\Delta t)_{land} = 0.08 \text{ m year}^{-1} \times 3 \times 10^6 \text{ m}^2 = 0.24 \times 10^6 \text{ m}^3 \text{ year}^{-1}$

$(\Delta S/\Delta t) = (\Delta S/\Delta t)_{ow} + (\Delta S/\Delta t)_{land} = 0.64 \times 10^6 \text{ m}^3 \text{ year}^{-1}$

Water balance of a polder

P + *seepage* = E_{actual} + *pump* + $(\Delta S/\Delta t)$

seepage = E_{actual} + *pump* + $(\Delta S/\Delta t) - P$

seepage = $2.46 \times 10^6 + 2 \times 10^6 + 0.64 \times 10^6 - 3.75 \times 10^6$ m^3 $year^{-1}$

seepage = 1.35×10^6 m^3 $year^{-1}$ / $(5 \times 10^6$ $m^2)$ = 0.270 m $year^{-1}$ = 270 mm $year^{-1}$

***seepage* =** 270 mm $year^{-1}$ / (365 day $year^{-1}$) **= 0.7 mm day^{-1}**

Length per time units

Calculation using length per time units:

P = 750 mm year^{-1}

E_{actual} = ((2/5) × 600) + ((3/5) × 420) mm year^{-1} = 492 mm year^{-1}

$pump$ = 2 × 10^6 m^3 year^{-1} / (5 × 10^6 m^2) = 0.4 m year^{-1} = 400 mm year^{-1}

Open water and the water table have risen by 200 mm year^{-1}.

$(\Delta S/\Delta t)_{ow}$ = 200 mm year^{-1}

Storage coefficient = 0.4 = 4/10

$(\Delta S/\Delta t)_{land}$ = 0.4 × 200 mm year^{-1} = 80 mm year^{-1}

$(\Delta S/\Delta t) = ((2/5) \times (\Delta S/\Delta t)_{ow}) + ((3/5) \times (\Delta S/\Delta t)_{land})$

$(\Delta S/\Delta t)$ = ((2/5) × 200) + ((3/5) × 80) mm year^{-1} = 128 mm year^{-1}

Water balance of a polder

$P + seepage = E_{actual} + pump + (\Delta S/\Delta t)$

$seepage = E_{actual} + pump + (\Delta S/\Delta t) - P$

$seepage$ = 492 + 400 + 128 – 750 mm year^{-1} = 270 mm year^{-1}

seepage = 270 mm year^{-1} / (365 day year^{-1}) **= 0.7 mm day^{-1}**