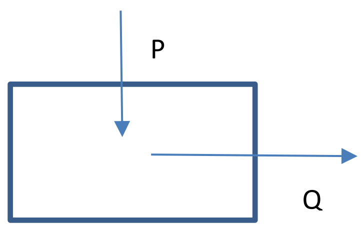
Solution for Assignment # 1

Problem 1:

$A = 4500\ Km^2$

$P = 46\ cm/month$

Solution:



Water balance equation :

$$\frac{\Delta S}{\Delta t} = I - O = (P - E)A - Q \ \ and\ \Delta S = 0\ (long\ term) \Longrightarrow Q = (P - E)A = PA - EA$$

Total volume of precipitation:

$$PA = 4500\ \times\ 10^6 \times 0.46 = 2070 \times 10^6\ m^3$$

There is a loss of 20 percent for the precipitation$P_{loss=} = 0.2PA = 0.2 \times 2070 \times 10^6 = 414 \times 10^6\ m^3$

$$Q = PA - 0.2PA = 2070 \times 10^6 - 414 \times 10^6 = 1656 \times 10^6\ m^3\ per\ month$$

Since it is a monthly precipitation to find the discharge:

$$Q = \frac{1656 \times 10^6}{30 \times 24 \times 3600} = 6.39 \times 10^2\ cms$$

Area to be irrigated:

$$\frac{639\ m3/s}{0.37\frac{m3}{s}/(1000ha)} = \mathbf{1727.3 \times 10^3 ha}$$

Problem 2:

Reservoir Area: 49776.33 m^2

Reservoir water depth: 4.0 m

Losses:

- **Evaporation:** 8 cm/week

- **Pumping:** 45.5 l/s

What is the storage after 3 weeks?

Solution:

Initial volume of water in reservoir:

$$S_1 = A \times h = 49776.33\, m^2 \times 4\, m = 199105.32\, m^3$$

Volume of evaporation each week:

$$V_e = A \times h = 49776.33\, m^2 \times 0.08\, m = 3982.1064\, m^3$$

Weekly pumping volume:

$$V_p = 0.0455 \frac{m^3}{sec} \times 7 \times 24 \times 3600 = 27518.4\, m^3$$

Weekly volume of losses:

Pumping water + evaporating water

$$Weekly\ loss = 27518.4\, m^3 + 3982.1064 = 31500.5064\, m^3$$

Total loss in three weeks:

$$Total\ loss = 31500.5064\, m^3 \times 3 = 94501.5192\, m^3$$

Final Storage in the reservoir:

$$\boldsymbol{S_2} = S_1 - Total\ loss = 199105.32\, m^3 - 94501.5192\, m^3 = \mathbf{104603.8008\, m^3}$$

Problem 3:

Figure 1.9 gives the volume to be filled (h is 50 ft to 70 ft)

Figure 1.10 gives the flow through the pipe for various elevations.

a) Estimate the surface at each elevation
b) The reservoir level=50 ft at t=0, calculate the time to get the level to 52 ft
c) Derive and plot elevation vs. time for filling the reservoir

Solution:

a) Reading storage at each elevation from Figure 1.9 and preparing a table,

$$\Delta s = A(h)\Delta h$$
$$\Delta h = 2\, ft$$

ΔS would be read from the graph in Figure 1.9,

$$Surface(h) = \frac{Storage(h + \Delta h) - storage(h)}{\Delta h}$$

Elevation (ft)	h (ft)	Storage (acre-ft) (Figure 1.9)	Surface (acre)
50	0	0	33

52	2	67	41
54	4	148	46
56	6	240	50
58	8	340	68
60	10	476	75
62	12	626	77
64	14	779	95
66	16	969	84
68	18	1138	100
70	20	1338	100

b) Apply water balance equation:

$$\frac{ds}{dt} = Q_{in} - Q_{out}$$

According to Figure 1.9, storage to be filled till h=52 ft is 66.67 acre-ft:
From Figure 1.10, Q_{in} through pipe is 65.94 cfs, therefore:

$$\Delta t = \frac{V}{Q} = \frac{66.67\ (acre - ft)}{65.44\ cfs}$$

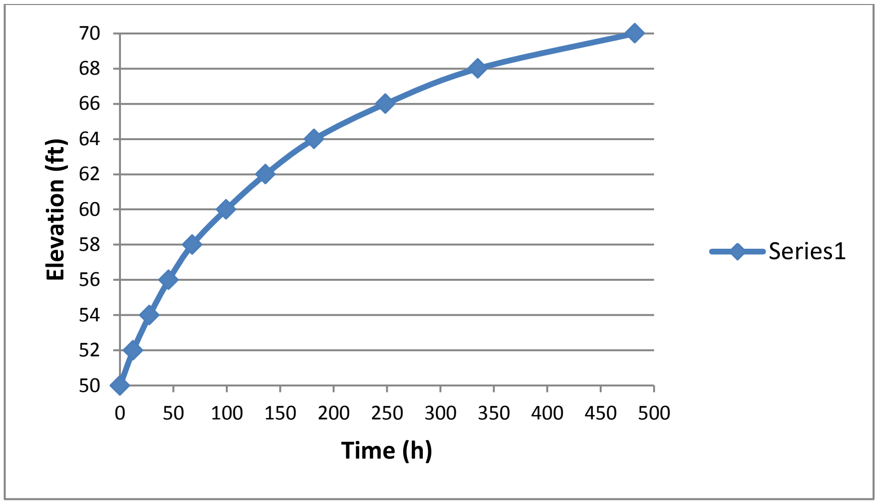
Since 1 acre-ft =43560 ft^3,

$$\Delta t = \frac{66.67 \times 43560\ ft^3}{65.44\ cfs} \times \frac{1}{3600} = \mathbf{12.33\ hour}$$

The time required to get the level to 52 ft is 12.33 hour.

c)

Elevation (ft)	h (ft)	Storage (acre-ft)	Q_{in} (cfs) (Figure 1.10)	Average (cfs)	Δt (s)	Δt (h)
50	0	0	65.94			0
52	2	**66.67**	64.93	**65.44**	44382.14	**12.33**
54	4	147.92	64.32	64.63	99704.37	27.70
56	6	240.00	62.9	63.61	164351.52	45.65
58	8	340.00	58.84	60.87	243311.98	67.59
60	10	475.86	57.01	57.93	357850.01	99.40
62	12	625.64	53.97	55.49	491131.35	136.43
64	14	779.49	49.71	51.84	654988.13	181.94
66	16	969.39	44.64	47.18	895106.06	248.64
68	18	1137.93	37.54	41.09	1206333.19	335.09
70	20	1338.24	29.62	33.58	1735965.88	482.21



Problem 4:

Reservoirs A and B are connected. The area of A is half of the area of B.

Precipitation (for both): 50 cm/yr

Evaporation (both): 30 cm/yr

A supplies 100 cms to B

a) Area of reservoir A
b) Area and volume of reservoir B, considering one year storage capacity
c) How long can B supply water for a town of 50000 people with 150 gallons/day per capita water consumption?

Solution:

a) Applying water balance equation:

$$\frac{ds}{dt} = Q_{in} - Q_{out} = 0 \qquad (long - term)$$

$$Q_{in} = 0.5\, m \times Area\ of\ A = 0.5\, A_A \ \ m^3$$

$$Q_{out} = 0.3\, m \times Area\ of\ A + 100\ cms = 0.3\, A_A + 100\frac{m^3}{s} \times 3600\frac{s}{hr} \times 24\frac{hr}{d} \times 365\frac{d}{yr}$$

$$= 0.3\, A_A + 3153.6 \times 10^6$$

$$Q_{in} = Q_{out}$$

$$0.5\, A_A = 0.3\, A_A + 3153.6 \times 10^6$$

$$\boldsymbol{A_A = 1.5768 \times 10^{10}\ m^2}$$

b) Calculating the area of reservoir B:

$$\boldsymbol{A_B} = 2\, A_A = 2 \times 1.5768 \times 10^{10}\ m^2 = \boldsymbol{3.1536 \times 10^{10}\ m^2}$$

Applying water balance equation to reservoir B, considering one year storage capacity:

$$\frac{ds}{dt} = Q_{in} - Q_{out}$$

$$Q_{in} = 0.5\,m \times Area\ of\ B + 100\ cms = 0.5 \times 3.1536 \times 10^{10} + 3153.6 \times 10^{6}$$
$$= 1.89216 \times 10^{10}$$

$$Q_{out} = 0.3\,m \times Area\ of\ B = 0.3 \times 3.1536 \times 10^{10}\ m^2 = 9460.8 \times 10^{6}$$

$$\boldsymbol{Volume\ of\ reservoir\ B} = Storage = Q_{in} - Q_{out} = 1.89216 \times 10^{10} - 9460.8 \times 10^{6}$$
$$\boldsymbol{= 9460.8 \times 10^{6}\quad m^3}$$

c) Calculating the water consumption of the town for one year:

$$Consumption = 50000\ person \times 150\ \frac{gallons}{day} \times 365 \frac{day}{yr} \times 0.00378541 \frac{m^3}{gallons}$$
$$= 10362559.88\ \frac{m^3}{yr}$$

Total storage of reservoir B = 9460.8×10^{6}

Consumption < VB, therefore the town can have water indefinitely