ASSIGNMENT 1

Given date: September 20, 2010 – Due date: September 27, 2010

Problem 1.1.

A lake with a surface of 525 acres was monitored over a period of time. During a one-month period, the inflow was 30 cfs, the outflow was 27 cfs, and a 1.5 in. seepage loss was measured. During the same month, the total precipitation was 4.25 in., evaporation loss was estimated as 6.0 in. Estimate the storage change for this lake during the month.

Problem 1.2.

From the hydrologic records of over 50 years on a drainage basin of area 500 km$^2$, the average annual rainfall is estimated as 90 cm, and the average annual runoff as 33 cm. A reservoir in the basin, having an average surface area of 1700 hectares, is planned at the basin outlet to collect available runoff for supplying water to a nearby community. The annual evaporation over the reservoir surface is estimated as 130 cm. There is no ground water leakage or inflow to the basin. Determine the available average annual withdrawal from the reservoir for water supply, assuming that over a large number of years the average annual values of beginning and end of year storage will be equal.

Problem 1.3.

A city is supplied by water from a 1250-ha catchment area. The average water consumption of the community is 50,000 m$^3$/day. The annual precipitation in the region is 412 cm. A river with an average annual flow of 0.35 m$^3$/s originates in and flows out of the catchment area. If the net annual groundwater outflow from the area is equivalent to a 16-cm depth of water, what is the total evaporation loss in cubic meters per year, which if exceeded, would cause a shortage of the water supply to the community? Assume that the storages of water in the area at the beginning and at the end of the year are equal.
SOLUTION TO ASSIGNMENT 1

Solution 1.1.

1 acre-ft = 43560 ft$^3$.

\[ \Delta S = P + I - O - O_{\text{seepage}} - E = P + (I - O) - O_{\text{seepage}} - E \]

\[ \Delta S = 4.25 \text{ in.} + \left( \frac{30 \text{ ft}^3}{\text{s}} - 27 \text{ ft}^3/\text{s} \right) \left( 30 \text{ days} \right) \left( \frac{24 \text{ hrs}}{1 \text{ day}} \right) \left( \frac{3600 \text{ s}}{1 \text{ hr}} \right) \left( \frac{1 \text{ acre-ft}}{43560 \text{ ft}^3} \right) \left( \frac{1}{525 \text{ acres}} \right) \left( \frac{12 \text{ in.}}{1 \text{ ft}} \right) \]

\[ \Delta S = 0.83 \text{ in.} \]

\[ \Delta S = 0.83 \text{ in.} \left( \frac{1 \text{ ft}}{12 \text{ in.}} \right) \left( 525 \text{ acres} \right) = 36.31 \text{ acres-ft.} \]

\[ \Delta S = 36.31 \text{ acres-ft} \times 43560 \text{ ft}^3/\text{acre-ft} = 1,581,663.6 \text{ ft}^3. \]

Solution 1.2.

The continuity equation for the reservoir is

\[ \Delta S = S_2 - S_1 = I - O \]

Over the large number of years we can assume that \( S_1 = S_2 \), hence:

\[ S_2 - S_1 = I - O = 0 \]

The average annual inflow is:

\[ \bar{I} = (33 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} \times 500 \times 10^6 \text{ m}^2) + (90 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} \times 1700 \times 10^4 \text{ m}^2) = 180.3 \times 10^6 \text{ m}^3. \]

The average annual outflow is:

\[ \bar{O} = (130 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} \times 1700 \times 10^4 \text{ m}^2) + Q_{\text{withdrawal}} = 22.1 \times 10^6 \text{ m}^3 + Q_{\text{withdrawal}} \]

Hence:

\[ I - O = 180.3 \times 10^6 \text{ m}^3 - (22.1 \times 10^6 \text{ m}^3 + Q_{\text{withdrawal}}) = 0 \]

\[ \Rightarrow Q_{\text{withdrawal}} = 180.3 \times 10^6 \text{ m}^2 - 22.1 \times 10^6 \text{ m}^3 = 158.2 \times 10^6 \text{ m}^3. \]
Solution 1.3.

Assuming that the storage of water in the area at the beginning and at the end of the year are the same, then \( \Delta S = 0 \). The water balance equation is

\[
\frac{\Delta S}{\Delta t} = I - O = 0
\]

From the problem:

\( I = \) Precipitation

\( O = GWF + \) Evaporation + Watercon. + RiverOut.

\[
\Rightarrow \Delta S = \Delta t.I - \Delta t(GWF + \text{Evaporation} + \text{WaterCon.} + \text{RiverOut.}) = 0
\]

\[
\Rightarrow \Delta t.\text{Evaporation} = \Delta t.I - \Delta t(GWF + \text{WaterCon.} + \text{RiverOut.})
\]

\[
\Delta t.\text{Evaporation} = \Delta t.I - \Delta t.GWF - \Delta t.\text{WaterCon.} - \Delta t.\text{RiverOut.}
\]

\[
\Delta t.I = 412 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} \times 1250 \text{ ha} \times \frac{10^4 \text{ m}^2}{\text{ha}} = 51.5 \times 10^6 \text{ m}^3.
\]

\[
\Delta t.GWF = 16 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} \times 1250 \text{ ha} \times \frac{10^4 \text{ m}^2}{\text{ha}} = 2 \times 10^6 \text{ m}^3.
\]

\[
\Delta t.\text{WaterCon.} = (365 \text{ days}) \times (50000 \text{ m}^3/\text{day}) = 18.25 \times 10^6 \text{ m}^3.
\]

\[
\Delta t.\text{RiverOut.} = (365 \text{ days} \times 86400 \text{ s/day}) \times (0.35 \text{ m}^3/\text{s}) = 11.0376 \times 10^6 \text{ m}^3.
\]

Therefore:

\[
\Delta t.\text{Evaporation} = (51.5 - 2 - 18.25 - 11.0376) \times 10^6 = 20.2124 \times 10^6 \text{ m}^3.
\]

Or \( \text{Evaporation} = \frac{20.2124 \times 10^6 \text{ m}^3}{1 \text{ year}} = 20.2124 \times 10^6 \text{ m}^3/\text{year}. \)