Table 11.2: Water Budget Examples

1. Calculate the mean annual discharge of the Oconee River below Athens in cubic feet per second (cfs). Average annual precipitation is 50 inches; average annual evapotranspiration is 35 inches; and the basin area is 783 \text{ mi}^2.

(a) Calculate the mean streamflow discharge: 
\[ Q = P - ET = 50"/\text{yr} - 35"/\text{yr} = 15"/\text{yr} \]
So, of the 50" inches of rainfall that fell on the watershed, 15" became streamflow. Some of that flow came rapidly after specific rainfall events while some of it drained slowly to the streams as ground water discharge.

(b) Determine the mean annual flow in cubic feet per second:
We have to convert that depth per year of runoff to a volume per year of runoff. The volume is simply the depth times the watershed area (using consistent units, of course). We then divide the annual runoff volume (cubic feet) by the number of seconds in a year to get cubic feet per second as an average annual flow.

(c) Calculate annual runoff volume from depth: volume = depth x area
We can think of the watershed as a large bucket, and we can determine the volume of the bucket by multiplying the area by the depth. So the annual volume (in \text{ ft}^3/\text{yr}):
\[ \frac{15"}{\text{yr}} \times \frac{1'}{12"} \times 783 \text{ mi}^2 \times \frac{640 \text{ ac}}{1 \text{ mi}^2} \times \frac{43,560 \text{ ft}^2}{1 \text{ ac}} = 27.3 \times 10^9 \text{ ft}^3/\text{yr} \]

(d) Convert \text{ ft}^3/\text{yr} to \text{ ft}^3/\text{s} (also called cfs):
\[ \frac{27.3 \times 10^9 \text{ ft}^3}{1 \text{ yr}} \times \frac{1 \text{ yr}}{3600 \text{ s}} \times \frac{1 \text{ day}}{24 \text{ hr}} \times \frac{3600 \text{ sec}}{1 \text{ hr}} = 858 \text{ ft}^3/\text{s} \]
Just imagine that you had a pool that held 27.3 billion cubic feet of water, and you wanted to release that pool at a constant rate and empty the pool in a year. You would have to drain the pool at the rate of 858 cfs. Hydrologists make this calculation faster by remembering that:
1 cfs \approx 2 \text{ acre - feet/day (AF/day)}

2. We can now ask what is the mean annual flow in the North Oconee River at a place where the basin area is 391.5 \text{ mi}^2 or exactly one half of the basin area used above? Because everything else is the same, and this area is 1/2 the area above, we can simply divide the answer by 2. So, the mean annual flow is 429 cfs.

3. Typically, water budgets are used the other way. That is, we know the mean annual flow and we know the precipitation, and we use the water budget to calculate annual actual evapotranspiration. For example, A 100 square mile basin in the Pacific Northwest has a mean annual flow of 176.8 \text{ ft}^3/\text{s}. The average precipitation is 44 inches per year. What is the average annual evapotranspiration in inches?

(a) Convert the mean annual flow into an annual volume:
\[ \frac{176.8 \text{ ft}^3}{1 \text{ s}} \times \frac{3600 \text{ s}}{1 \text{ hr}} \times \frac{24 \text{ hr}}{1 \text{ day}} \times \frac{365 \text{ day}}{1 \text{ year}} = 5.58 \times 10^9 \text{ ft}^3 \]

(b) Divide the volume of runoff by the watershed area to get a depth of runoff:
\[ \frac{5.58 \times 10^9 \text{ ft}^3}{100 \text{ mi}^2} \times \frac{1 \text{ mi}^2}{640 \text{ ac}} \times \frac{1 \text{ ac}}{43,560 \text{ ft}^2} \times \frac{12"}{1 \text{ ft}} = 24" \]

(c) Calculate the mean annual ET:
\[ ET = P - R = 44"/\text{yr} - 24"/\text{yr} = 20"/\text{yr} \]