Problem #5

Problem: *Water Balance for an Irrigation Water Supply Reservoir*

Statement:

An irrigation water supply reservoir draining flows from the Rocky Mountains has a capacity of 750,000 acre-feet. At the end of the water year, the reservoir is full. Over the next water year, the following net inflows (Q_i) into the reservoir occurred:

t (mon)	Q_i (acre-feet)
Oct	68,887
Nov	46,851
Dec	38,120
Jan	36,363
Feb	32,312
Mar	42,380
Apr	62,097
May	256,676
Jun	604,743
Jul	327,718
Aug	155,511
Sep	58,421

Predict the conditions in the reservoir for the following operating conditions. First, assume that water withdrawal demands are a constant 120,000 acre-feet each month. Also, assume that 1000 acre-feet of water must be released downstream each month to maintain sufficient river flows. Finally, if the reservoir is full, any inflow volume in excess of outflows (demands and release) is released downstream and "spilled flow" (the reservoir storage cannot exceed its capacity).

Do the following:

a. Predict the reservoir storage and spilled flow volume for each month
b. Plot the reservoir storage (in acre-feet) at the end of each time step.
c. Does the reservoir refill and spill flows? If so, when and for how long?

Note: The net inflow is the water volume for the month and accounts for local precipitation, evaporation, and seepage. Constant demands and releases for each month are not very realistic for an irrigation reservoir (but let's keep it simple). The calculations can be easily done on a spreadsheet; the only issue to account for spilled flow when the reservoir refills (you'll need to work the logic out for that).

Solution:

Problem5

February 6, 2019

1 Water Balance for an Irrigation Water Supply Reservoir

An irrigation water supply reservoir draining flows from the Rocky Mountains has a capacity of 750,000 acre-feet. At the end of the water year, the reservoir is full. Over the next water year, the following net inflows Q_i into the reservoir occurred:

```
In [41]: inflows = {
             'Oct':68887.00,
             'Nov':46851.00,
             'Dec':38120.00,
             'Jan':36363.00,
             'Feb':32312.00,
             'Mar':42380.00,
             'Apr':62097.00,
             'May':256676.00,
             'Jun':604743.00,
             'Jul':327718.00,
             'Aug':155511.00,
             'Sep':58421.00
         }

         demand = 120000.00 # for agriculture
         nature = 1000.00   # for the fishes
         res_max = 750000 #acre feet
```

A) Predict the reservoir storage and spilled flow volume for each month.
Storage volume, V, at the end of a month, i, can be defined as:

$$V_i = \max \begin{cases} V_{i-1} - D_i - N_i + Q_i \\ V_{max} \end{cases}$$

Where: - V_{i-1} is the volume of the reservoir at the end of the month prior, - D_i is the withdrawal demand, - N_i is the required releases for nature (Fishes!), - Q_i is the inflow to the reservoir, and - V_{max} is the maximum capacity of the reservoir.

For the month of October, this equation would be:

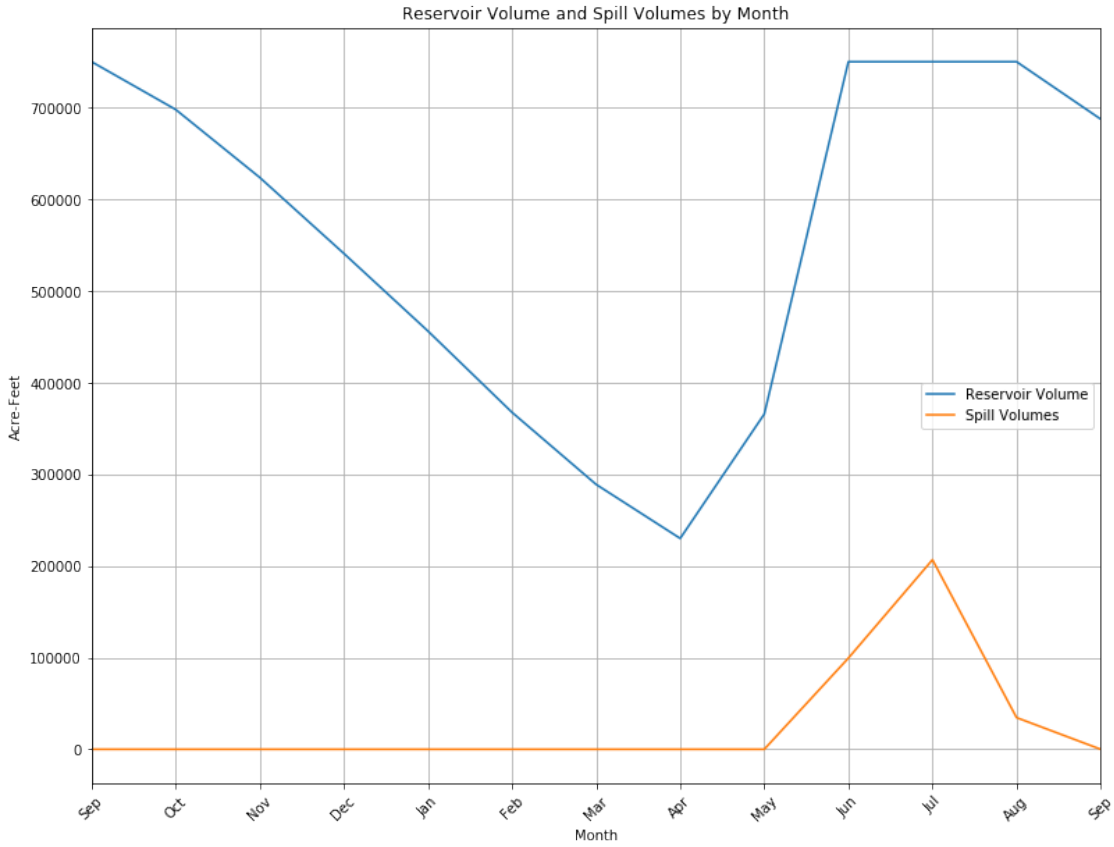
$$V_{Oct} = \max \begin{cases} V_{Sep} - D_{Oct} - N_{Oct} + Q_{Oct} \\ V_{max} \end{cases}$$

The reservoir volume at the end of the month can be calculated by stepping through a for loop. Code below.

```
In [48]: # Instantiate our lists for reservoir volume and release volumes
         reservoir_v = [res_max]
         release = [0]

         # Step through the inflows dictionary we defined above
         for i in inflows.keys():

             # Subtract Demand from last months total
             # Add supply
             # Assign value as new end of list
             reservoir_v.append(reservoir_v[-1] - demand - nature + inflows[i])

             # if theoretical total greater than capacity, release
             if reservoir_v[-1] > res_max:
                 print("release in month: " + i)
                 release.append(reservoir_v[-1] - res_max)
                 reservoir_v[-1] = res_max

             # else, release = 0
             else:
                 release.append(0)

release in month: Jun
release in month: Jul
release in month: Aug
```

B) Plot the reservoir storage (in acre-feet) at the end of each time step.

```
In [49]: import matplotlib.pyplot as plt
         import numpy as np
         labels = ['Sep','Oct','Nov','Dec','Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep'
         fig,ax = plt.subplots(figsize=(13,10))
         plt.plot(reservoir_v)
         plt.plot(release)
         plt.xticks(np.arange(len(release)), labels, rotation=45)
         plt.legend(['Reservoir Volume','Spill Volumes'])
         plt.title("Reservoir Volume and Spill Volumes by Month")
         plt.ylabel("Acre-Feet")
         plt.xlabel("Month")
         plt.grid(True)
         plt.xlim([0,12])
         plt.savefig("ReservoirStorageAndSpillVolumes.png")
         plt.show()
```



C) Does the reservoir refill and spill flow? If so, when and for how long?

Yes, the reservoir refills and release do occur. During June, July, and August the reservoir experiences releases.