2.

Given
$\mu_q$ = 800 mm/yr.
$\mu_p$ = 1047 mm/yr.
$\sigma_{\mu q}$ = 65 mm/yr.
$\sigma_{\mu p}$ = 57 mm/yr.

a. From water balance equation -
$\mu_{et} = \mu_p - \mu_q$ = 1047 mm/yr. – 800 mm/yr. = 247 mm/yr.

b. Principle of random uncertainty gives us the uncertainty for dependent variable in relation to the uncertainty for the independent variable, which is

$$\sigma_{\mu et} = [\sigma_{\mu p}^2 + \sigma_{\mu q}^2]^{1/2} = [57^2 + 65^2]^{1/2} = 86.4 \text{ mm/yr.} \rightarrow 86 \text{ mm/yr.}$$

c. The 95% confidence interval for $\mu_{et}$. The 95% confidence interval relates to 1.96 standard deviation under the Normal Distribution, i.e., k(p)=1.96 for p=0.95. Thus, the absolute error for p=0.95 is given as
$\delta_{et} = k(p) * \sigma_{\mu et}$ = 1.96 * 86 = 168.6 mm/yr. → 169 mm/yr.

Therefore, we are 95% sure that the average annual evapotranspiration is between (247 – 169) = 78 mm/yr. and (247 + 169) = 416 mm/yr.

d. The relative error for $\mu_{et}$ is given as
$\varepsilon_{et} = \delta_{et} / \mu_{et}$ = 86 / 247 = 0.35

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3.
The full script is available at https://github.com/biplovbhandari/ess-690-hydrology/blob/main/Homework_1_Question_3.ipynb

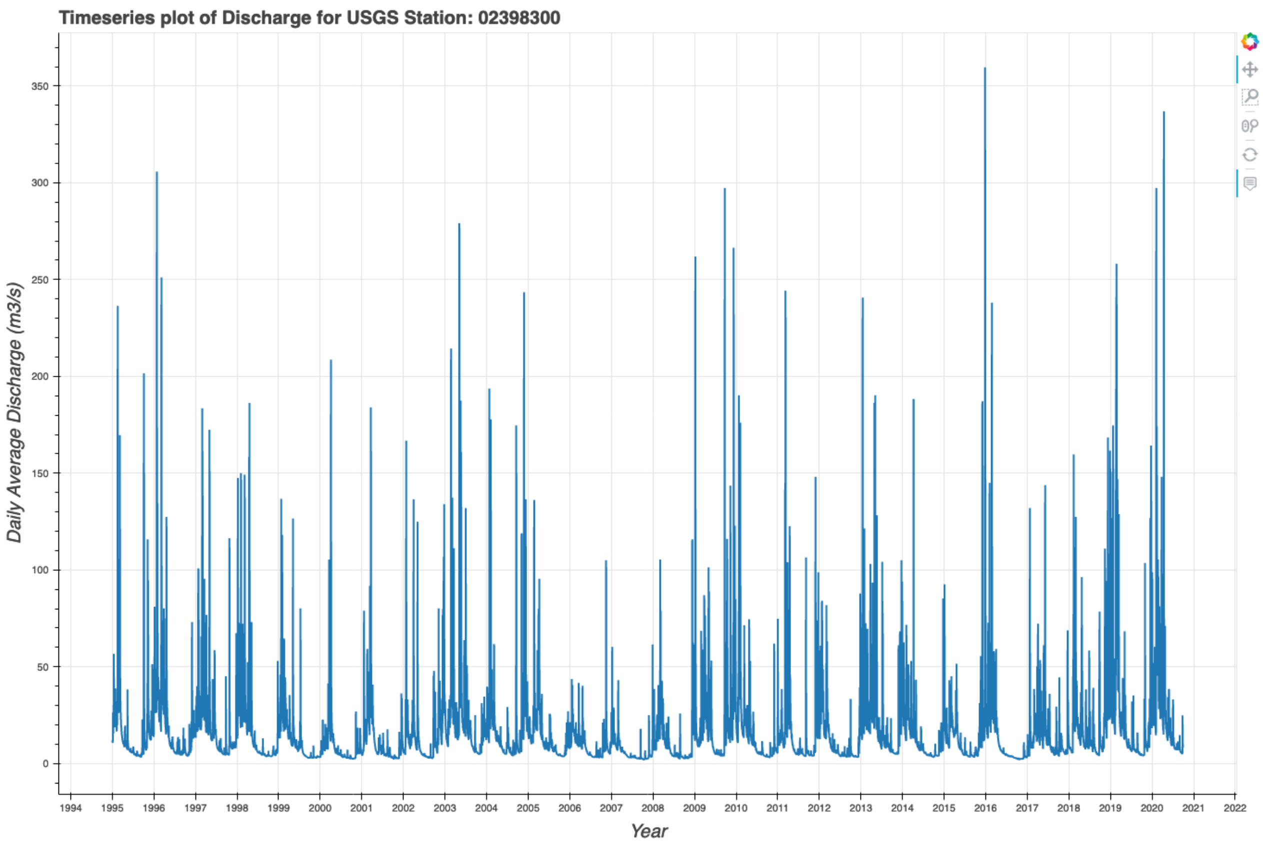
Site Number: 02398300

a. Using this information at streamstats application with the link: https://streamstatsags.cr.usgs.gov/gagepages/html/02398300.htm gives
Drainage area: 366 $mi^2$ = 1.02 x $10^{10}$ $ft^2$
Mean Annual Streamflow = $\mu_q$ = 615 $ft^3/s$
$\mu_q$ per unit length for basin = 615 / (1.02 x $10^{10}$) = 6.03 x $10^{-8}$ ft/s = 6.03 x$10^{-8}$ ft/s x 31536000 sec = 1.90 ft
$\mu_q$ = 1.90 ft
Mean Annual Precipitation = $\mu_p$ = 52 inches = 4.33 ft.

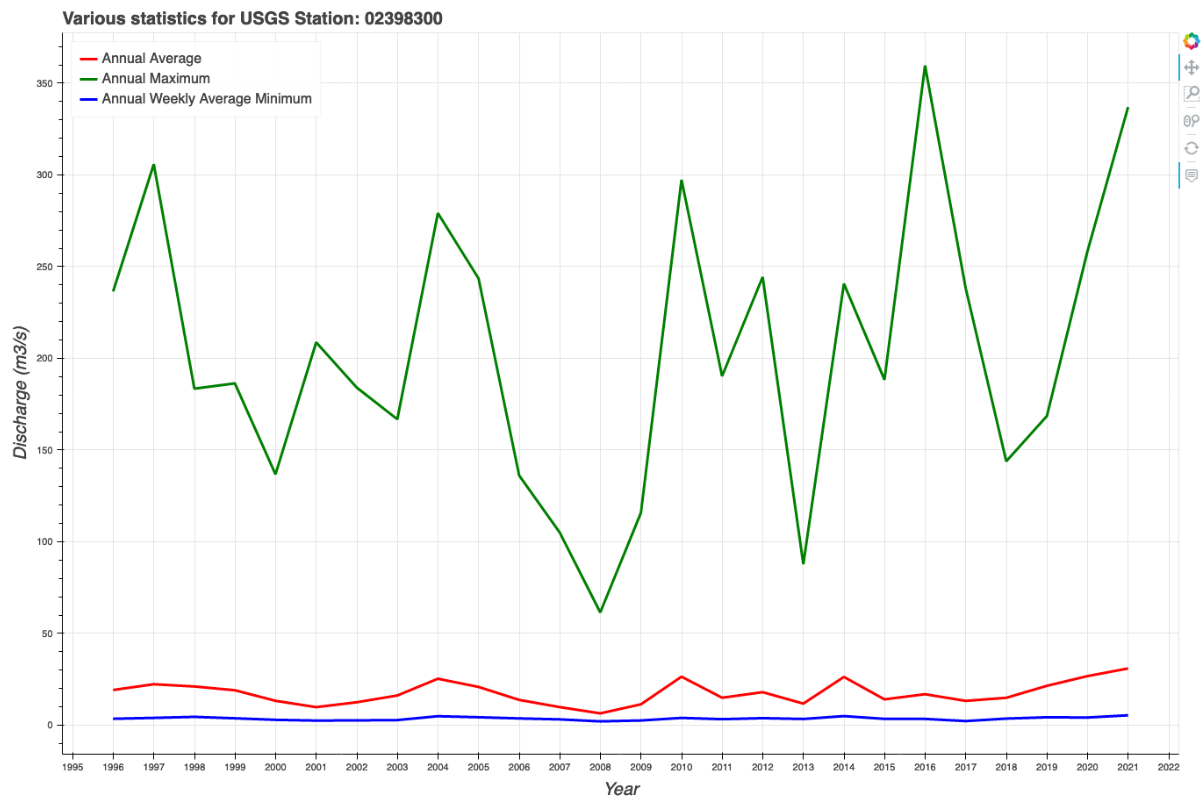
ET = $\mu_p - \mu_p$ = 4.33 – 1.90 = 2.43 ft

The underlying assuming here is that the ground water movement is negligible and assumed as zero.

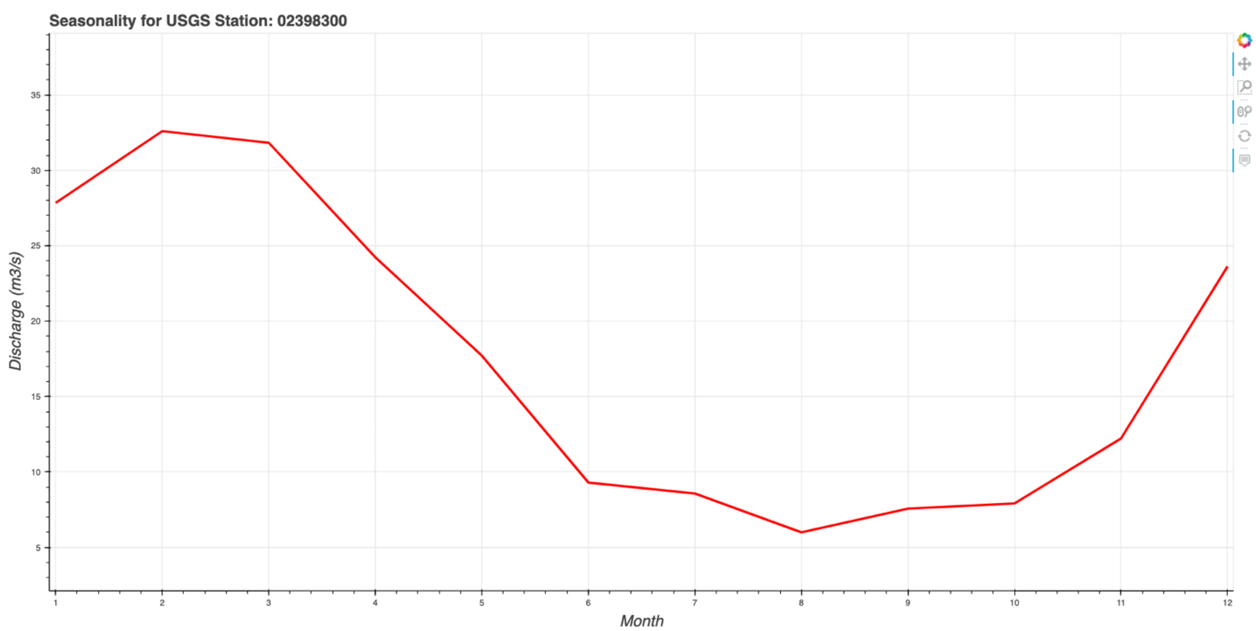
b.



c.




d.




e. The station selected is a low-flow station, with peak during the winter. There is a considerable difference between the high flow and the average as well as the weekly average minimum. Looking at the graphs from c, the annual weekly average minimum and annual average is consistent throughout the years. However, some fluctuations can be seen in the annual peak flow with low peak flow towards the latter years. The seasonality also reflects this information. The flow starts to rise from October until March and starts to drop until September. The month of August is the lowest flow, while February being the highest.

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4. The full script is available at https://github.com/biplovbhandari/ess-690-hydrology/blob/main/Homework_1_Question_4.ipynb

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5.

Location information:
Name: Summerville, Georgia, USA*
Station name: SUMMERVILLE
Site ID: 09-8436
Latitude: 34.4547°
Longitude: -85.3900°
Elevation: 639 ft

This station is inside the watershed area for question 3 above of Site Number: 02398300.
The watershed area is 366 $mi^2$ = ~948 $km^2$

a) Use figure 4.44 to determine the appropriate design-storm duration for the watershed

From figure 4.44 using the equations provided
Lower Duration (hr) = 0.26 * $A^{0.36}$ = 3.07 hr
Upper Duration (hr) = 1.23 * $A^{0.50}$ = 37.87 hr
Therefore, the duration = 37.87 – 3.07 = 34.80 hr

b) Determine and graph the 10-, 25-, 50-, and 100-yr point rainfalls for that duration.
From the data downloaded

| **by duration for AEP:** | **1/2** | **1/5** | **1/10** | **1/25** | **1/50** | **1/100** | **1/200** | **1/500** | **1/1000** |
|---|---|---|---|---|---|---|---|---|---|
| **5-min:** | 0.454 | 0.575 | 0.678 | 0.83 | 0.957 | 1.1 | 1.24 | 1.46 | 1.63 |
| **10-min:** | 0.665 | 0.841 | 0.992 | 1.22 | 1.4 | 1.6 | 1.82 | 2.13 | 2.38 |
| **15-min:** | 0.811 | 1.03 | 1.21 | 1.48 | 1.71 | 1.96 | 2.22 | 2.6 | 2.91 |
| **30-min:** | 1.13 | 1.43 | 1.68 | 2.06 | 2.38 | 2.72 | 3.09 | 3.62 | 4.05 |
| **60-min:** | 1.47 | 1.85 | 2.18 | 2.65 | 3.03 | 3.44 | 3.89 | 4.51 | 5.01 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **2-hr:** | 1.81 | 2.28 | 2.67 | 3.23 | 3.69 | 4.17 | 4.68 | 5.39 | 5.97 |
| **3-hr:** | 2.06 | 2.59 | 3.02 | 3.63 | 4.12 | 4.62 | 5.16 | 5.89 | 6.48 |
| **6-hr:** | 2.54 | 3.21 | 3.74 | 4.46 | 5.03 | 5.61 | 6.21 | 7.03 | 7.67 |
| **12-hr:** | 3.12 | 3.97 | 4.63 | 5.52 | 6.22 | 6.93 | 7.66 | 8.65 | 9.41 |
| **24-hr:** | 3.75 | 4.79 | 5.59 | 6.68 | 7.52 | 8.37 | 9.24 | 10.4 | 11.3 |
| **2-day:** | 4.41 | 5.6 | 6.52 | 7.75 | 8.7 | 9.66 | 10.6 | 11.9 | 12.9 |
| **3-day:** | 4.87 | 6.09 | 7.03 | 8.31 | 9.3 | 10.3 | 11.3 | 12.7 | 13.8 |
| **4-day:** | 5.27 | 6.51 | 7.48 | 8.79 | 9.81 | 10.8 | 11.9 | 13.3 | 14.5 |
| **7-day:** | 6.31 | 7.69 | 8.75 | 10.2 | 11.2 | 12.3 | 13.4 | 14.9 | 16 |
| **10-day:** | 7.19 | 8.7 | 9.83 | 11.3 | 12.5 | 13.6 | 14.7 | 16.2 | 17.3 |
| **20-day:** | 9.67 | 11.4 | 12.7 | 14.4 | 15.7 | 17 | 18.2 | 19.8 | 21 |
| **30-day:** | 11.8 | 13.9 | 15.4 | 17.3 | 18.7 | 20 | 21.4 | 23.1 | 24.3 |
| **45-day:** | 14.7 | 17.2 | 19 | 21.3 | 22.9 | 24.4 | 25.8 | 27.5 | 28.8 |
| **60-day:** | 17.3 | 20.3 | 22.4 | 25 | 26.8 | 28.4 | 29.9 | 31.7 | 32.8 |

So, the closest we have is the 1-day period (closer to than 2-day period), for which the 10-, 25-, 50-, and 100-yr point rainfall value is 5.59, 6.68, 7.52, and 8.37 inches respectively.

c) Using figure 4.50, determine and graph the 10-, 25-, 50-, and 100-yr rainfalls for that duration on the given watershed area.

From figure 4.50, for 366 $mi^2$, the percent of point precipitation for 24-hr duration is around 92%, which would be respectively 5.14, 6.15, 6.92, and 7.70 inches respectively.

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6. Download a spatial precipitation dataset (i.e., PRISM, NEXRAD, or GPM) and plot/display in your preferred software (gis, python, panoply). It can be a single day or a yearly or monthly average. Find a weather station with overlapping data and compare precipitation values.

The plotting of the data is done in this google earth engine script: https://code.earthengine.google.com/62d85dcf5d6d3550ee5992e936b1ce74?hideCode=true

The station used is Aldridge Creek near Farley in Alabama, USGS Station ID: 03575700. The station is also plotted in the script. The value of precipitation for the station obtained from the GPM for the month of March 2021 was 0.017 inches per hour, while the one obtained by downloading the station data from USGS and calculating the monthly average was 0.020 inches per hour. The difference can be explained by the fact that GPM data is not bias corrected with the ground station, and of the fact that GPM gives the cloud precipitation which can be different than the amount of rainfall that falls in the ground.