Analysis Techniques: Annual Analysis Example

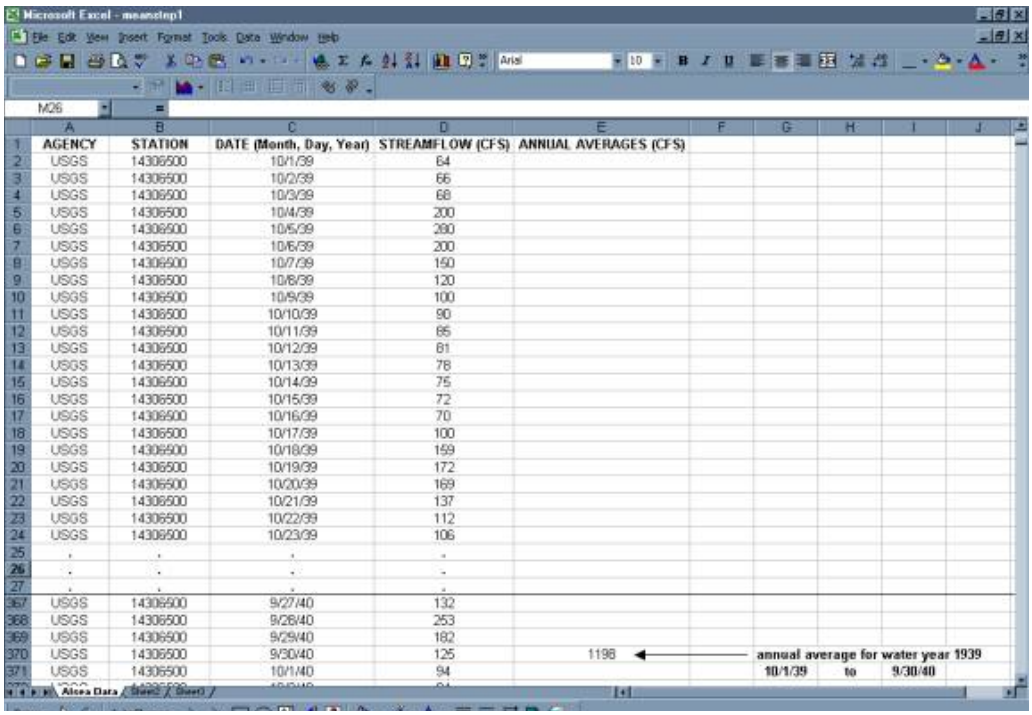
Information to get started:

- The lesson below contains step-by-step instructions and "snapshots" of what each step looks like when carried out in a Microsoft Excel workbook. Blue shading of information in the Excel illustrations denotes changes made from the previous step. Dots placed in three consecutive rows indicate that a portion of data is hidden from sight.
- You can download an Excel workbook containing the complete data set by clicking on the "Download Data" link below. It contains each calculation step on a separate worksheet. To move between steps, click on the tabs at the bottom of the excel window.
- When you download the file, it may open in your browser window. You may wish to use the "save as" function to save the file to a local drive and then reopen it in Excel. This will make it easier to flip between the online lesson and the example workbook.
- Finally, we want to remind you that the techniques explained on this site are statistically based; therefore results must be viewed as predictions and not as facts. Please use the techniques and the information obtained from them responsibly!

Download Data

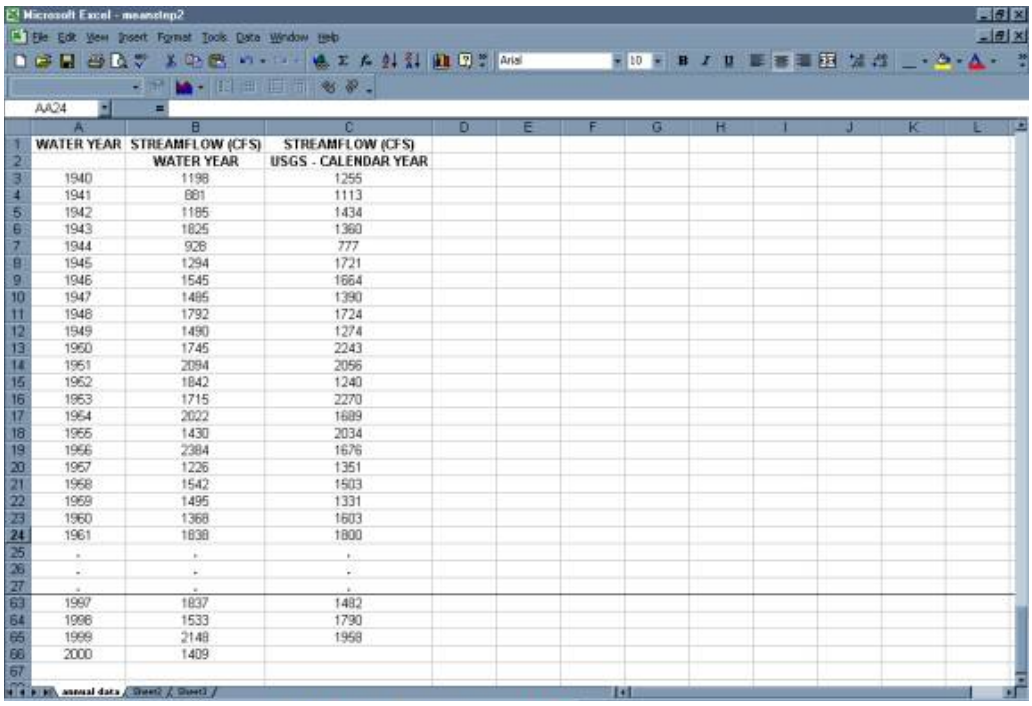
Step 1: Calculating Mean Annual Flow

- You can use the average function in Excel to obtain the average streamflow for each water year in the period of record. The averaging will involve 365 or 366 daily values in each water year (366 days accounts for leap year). See the **Data Manipulation** section for a more detailed explanation of how to obtain data and to calculate mean annual flow.



	A	B	C	D	E
1	AGENCY	STATION	DATE (Month, Day, Year)	STREAMFLOW (CFS)	ANNUAL AVERAGES (CFS)
2	USGS	14306500	10/1/39	64	
3	USGS	14306500	10/2/39	66	
4	USGS	14306500	10/3/39	68	
5	USGS	14306500	10/4/39	200	
6	USGS	14306500	10/5/39	280	
7	USGS	14306500	10/6/39	200	
8	USGS	14306500	10/7/39	160	
9	USGS	14306500	10/8/39	120	
10	USGS	14306500	10/9/39	100	
11	USGS	14306500	10/10/39	90	
12	USGS	14306500	10/11/39	85	
13	USGS	14306500	10/12/39	81	
14	USGS	14306500	10/13/39	78	
15	USGS	14306500	10/14/39	75	
16	USGS	14306500	10/15/39	72	
17	USGS	14306500	10/16/39	70	
18	USGS	14306500	10/17/39	100	
19	USGS	14306500	10/18/39	159	
20	USGS	14306500	10/19/39	172	
21	USGS	14306500	10/20/39	169	
22	USGS	14306500	10/21/39	137	
23	USGS	14306500	10/22/39	112	
24	USGS	14306500	10/23/39	106	
367	USGS	14306500	9/27/40	132	
368	USGS	14306500	9/28/40	253	
369	USGS	14306500	9/29/40	182	
370	USGS	14306500	9/30/40	125	1198 ← annual average for water year 1939
371	USGS	14306500	10/1/40	94	10/1/39 to 9/30/40

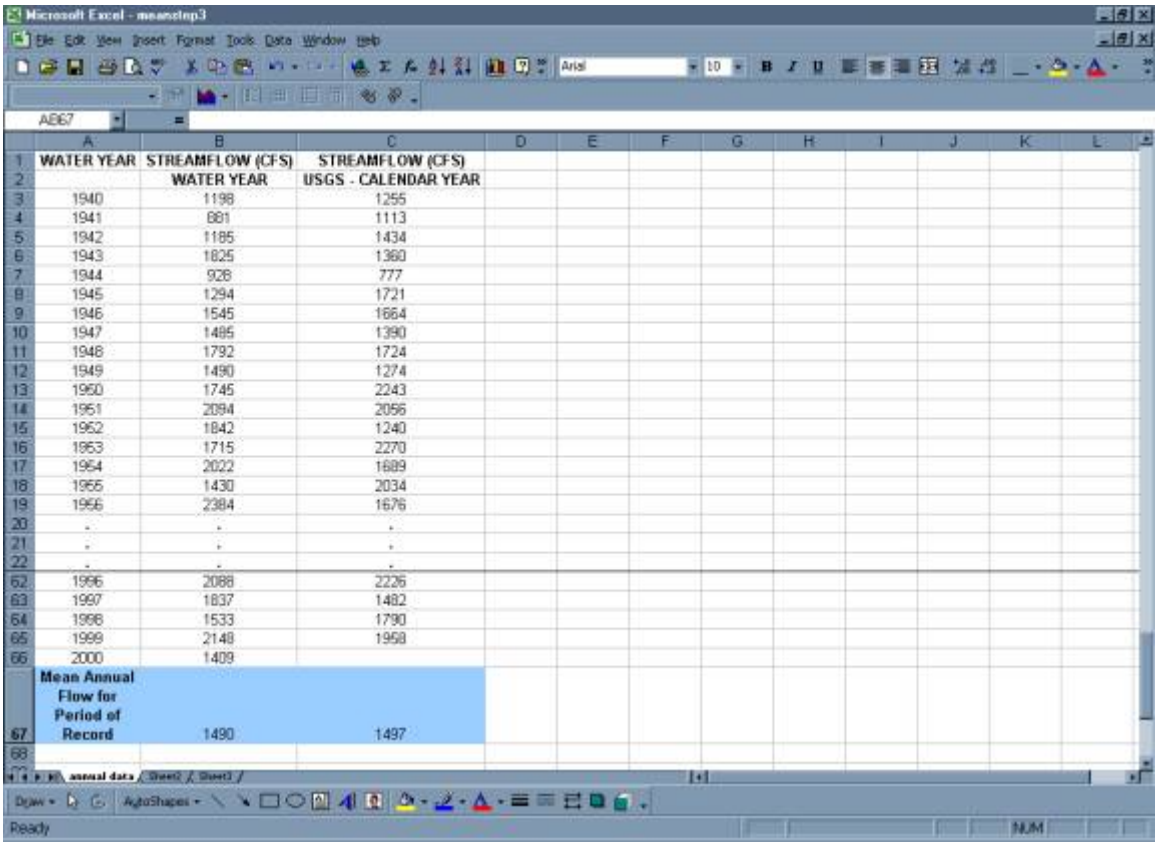
- Copy your mean flow for each year into a new table.



	A	B	C
1	WATER YEAR	STREAMFLOW (CFS)	STREAMFLOW (CFS)
2		WATER YEAR	USGS - CALENDAR YEAR
3	1940	1198	1255
4	1941	881	1113
5	1942	1185	1434
6	1943	1825	1360
7	1944	928	777
8	1945	1294	1721
9	1946	1545	1664
10	1947	1485	1390
11	1948	1792	1724
12	1949	1490	1274
13	1950	1745	2243
14	1951	2094	2056
15	1952	1842	1240
16	1953	1715	2270
17	1954	2022	1689
18	1955	1430	2034
19	1956	2384	1676
20	1957	1226	1351
21	1958	1542	1503
22	1959	1495	1331
23	1960	1368	1603
24	1961	1838	1800
63	1997	1837	1482
64	1998	1533	1790
65	1999	2148	1958
66	2000	1409	

Step 2: Calculating the Mean Annual Flow for Period of Record

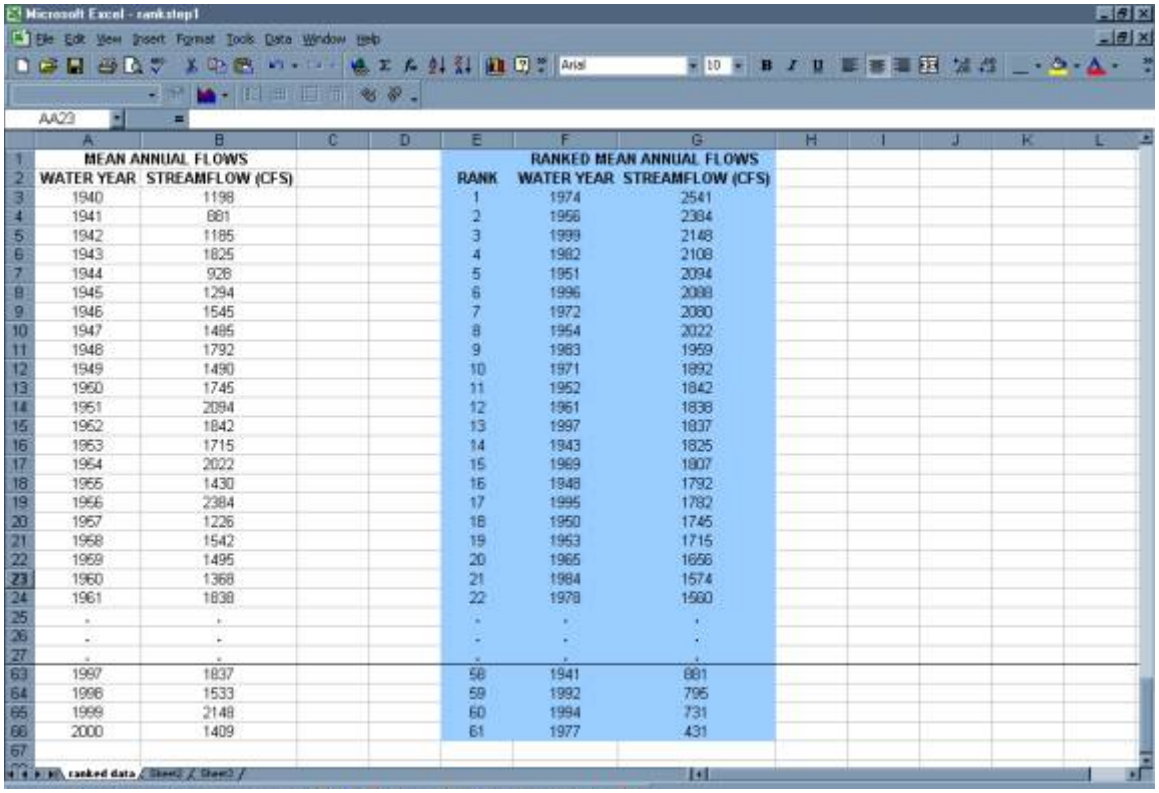
- Use the average function to calculate the mean annual flow for the period of record. For this example, the period of record is 10 years.
- Column C in the table below contains the mean annual flow for "calendar years". It is interesting to compare how the value changes when the mean is calculated for "calendar years" instead of "water years".



	A	B	C
1	WATER YEAR	STREAMFLOW (CFS)	STREAMFLOW (CFS)
2		WATER YEAR	USGS - CALENDAR YEAR
3	1940	1198	1255
4	1941	881	1113
5	1942	1185	1434
6	1943	1825	1360
7	1944	926	777
8	1945	1294	1721
9	1946	1545	1664
10	1947	1485	1390
11	1948	1792	1724
12	1949	1490	1274
13	1950	1745	2243
14	1951	2094	2056
15	1952	1842	1240
16	1953	1715	2270
17	1954	2022	1689
18	1955	1430	2034
19	1956	2384	1676
20	.	.	.
21	.	.	.
22	.	.	.
62	1996	2088	2226
63	1997	1837	1482
64	1998	1533	1790
65	1999	2148	1958
66	2000	1409	
67	Mean Annual Flow for Period of Record	1490	1497
68			

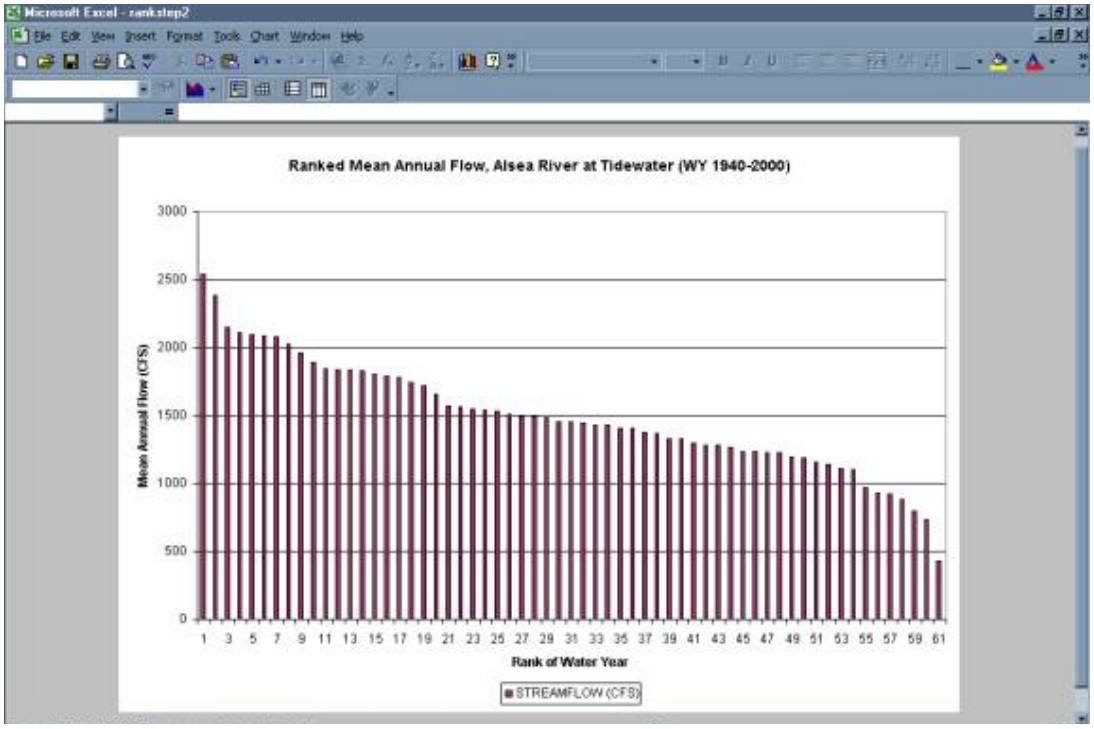
Step 3: Ranked Annual Flow

- Use the sort option (under the Data menu) to sort mean annual flows in descending order.



	A	B	E	F	G
1	MEAN ANNUAL FLOWS			RANKED MEAN ANNUAL FLOWS	
2	WATER YEAR	STREAMFLOW (CFS)	RANK	WATER YEAR	STREAMFLOW (CFS)
3	1940	1198	1	1974	2541
4	1941	881	2	1956	2384
5	1942	1185	3	1999	2148
6	1943	1825	4	1982	2108
7	1944	928	5	1951	2094
8	1945	1294	6	1996	2088
9	1946	1545	7	1972	2080
10	1947	1485	8	1954	2022
11	1948	1792	9	1983	1959
12	1949	1490	10	1971	1892
13	1950	1745	11	1952	1842
14	1951	2094	12	1961	1838
15	1952	1842	13	1997	1837
16	1953	1715	14	1943	1825
17	1954	2022	15	1969	1807
18	1955	1430	16	1948	1792
19	1956	2384	17	1995	1782
20	1957	1226	18	1950	1745
21	1958	1542	19	1953	1715
22	1959	1495	20	1965	1656
23	1960	1368	21	1984	1574
24	1961	1838	22	1978	1560
25	.	.	.	.	.
26	.	.	.	.	.
27	.	.	.	.	.
63	1997	1837	58	1941	881
64	1998	1533	59	1992	795
65	1999	2148	60	1994	731
66	2000	1409	61	1977	431

- Plot ranked data.

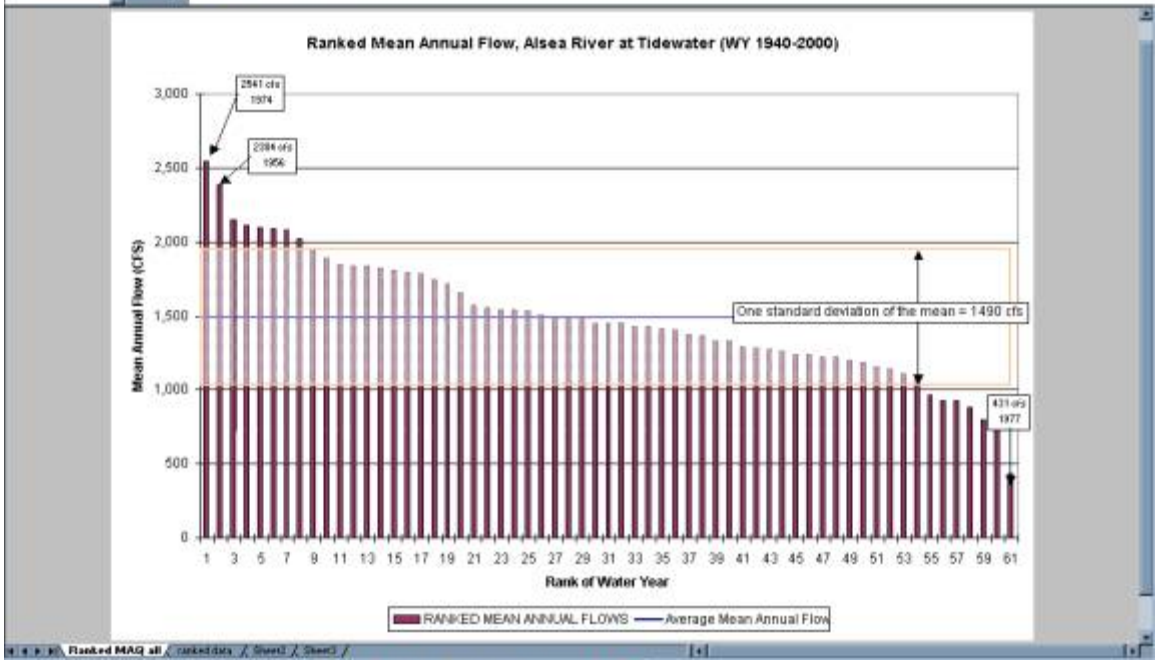


- It may be helpful to plot on the chart the mean annual flow and one standard deviaton of the mean.

Microsoft Excel - rankstep3

	A	B	C	D
1		RANKED MEAN ANNUAL FLOWS		
2	RANK	WATER YEAR	STREAMFLOW (CFS)	MEAN ANNUAL FLOW FOR PERIOD OF RECORD (CFS)
3	1	1974	2541	1490
4	2	1956	2384	1490
5	3	1999	2148	1490
6	4	1982	2108	1490
7	5	1951	2094	1490
8	6	1996	2088	1490
9	7	1972	2060	1490
10	8	1954	2022	1490
11	9	1983	1959	1490
12	10	1971	1892	1490
13	11	1952	1842	1490
14	12	1961	1838	1490
15	13	1997	1837	1490
16	14	1943	1825	1490
17	15	1969	1807	1490
18	16	1948	1792	1490
19	17	1995	1782	1490
20	.	.	.	.
21	.	.	.	.
22	.	.	.	.
64	59	1992	795	1490
65	60	1994	731	1490
66	61	1977	431	1490
67	Standard Deviation		410	
68	Mean + One STDEV		1900	
69	Mean - One STDEV		1080	

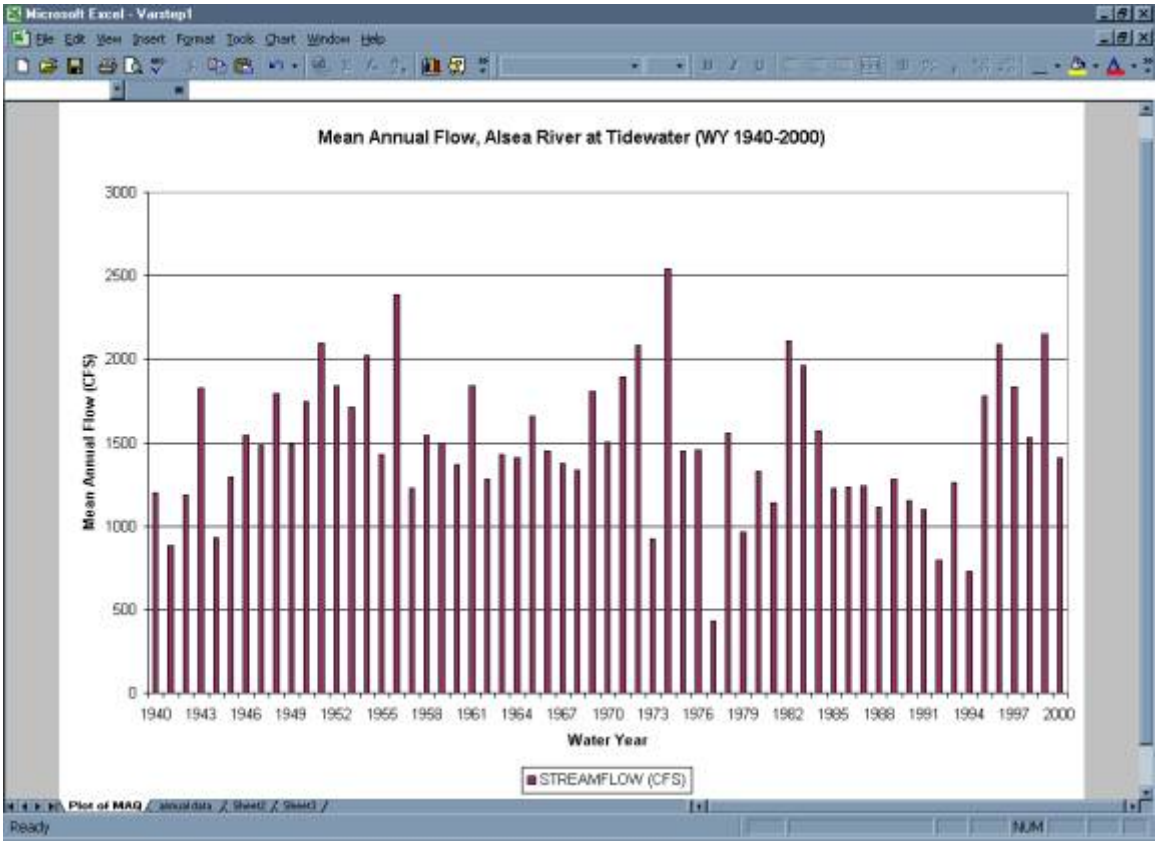
Microsoft Excel - rankstep3



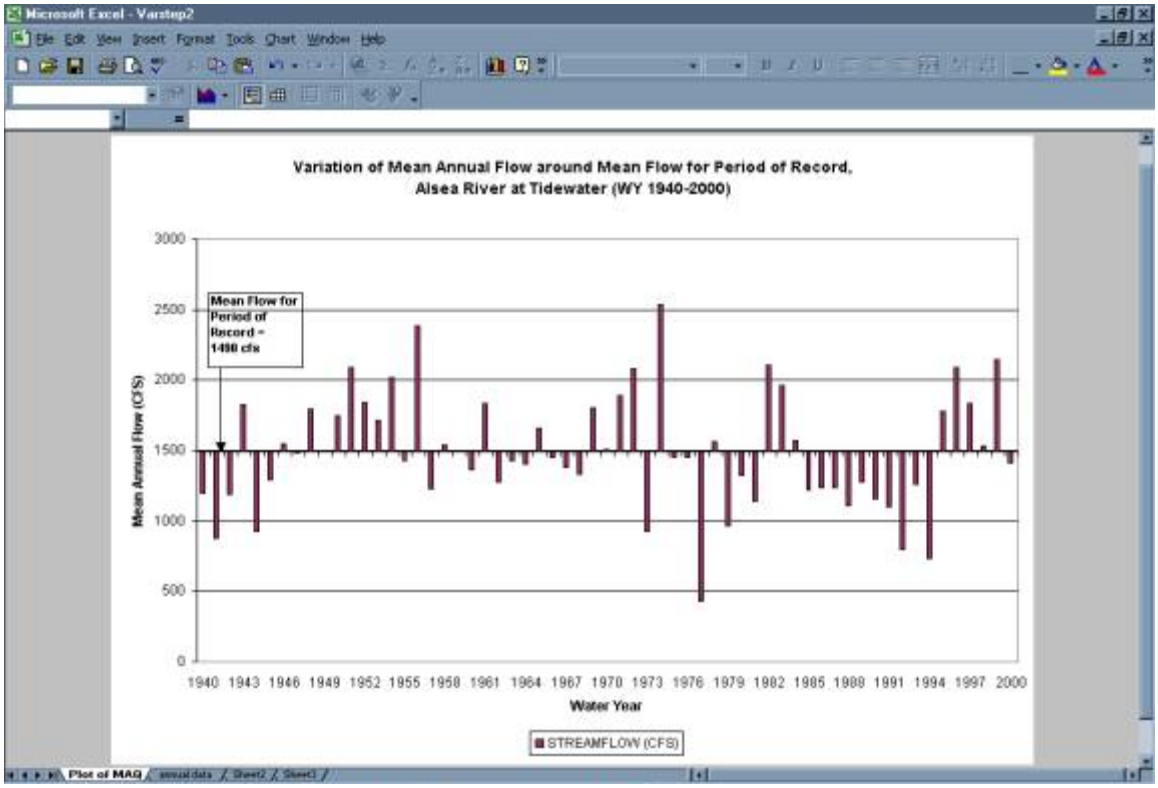
Step 4: Pattern Analysis

Step 4a: Variation of Mean Annual Flow around Mean Flow for Period of Record

- Plot mean annual flow vs. water year.

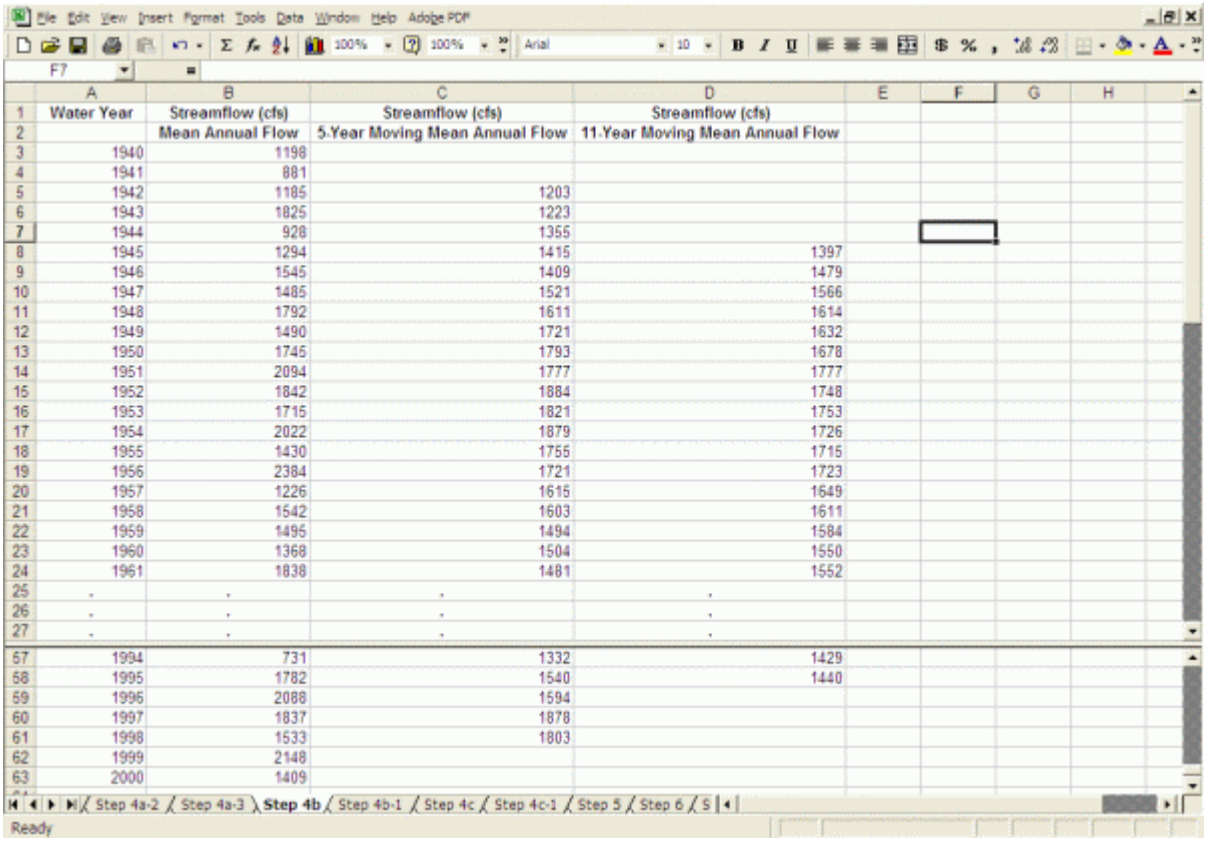


- Set the Y-axis to intersect the X-axis at the value for the mean flow for the period of record.



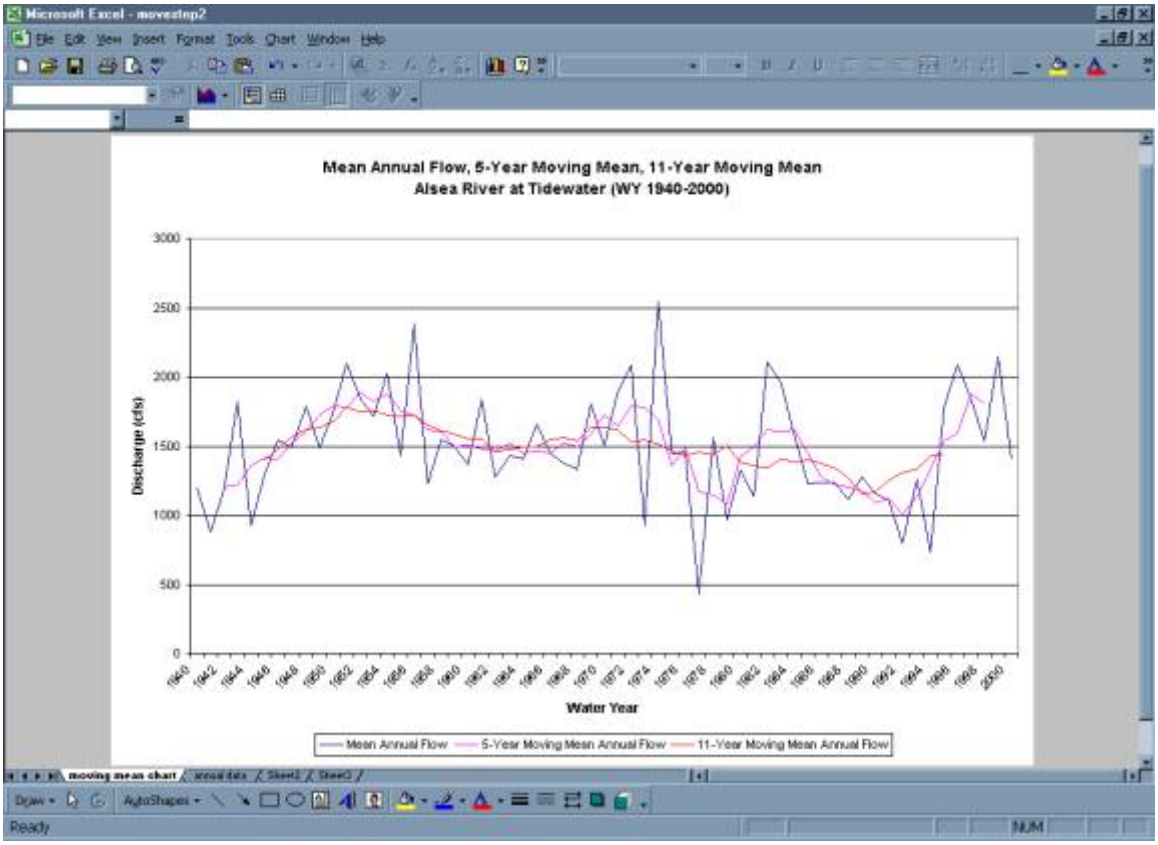
Step 4b: 5-Year and 11-Year Moving Mean

- Starting with the 3rd and 6th year of the period of record, use the average function in Excel to calculate the mean annual flow of the surrounding 5 (yr 1 to yr 5) and 11 (yr 1 to yr 11) years. Copy these formulas down the columns to calculate the mean annual flow for 5-year and 11-year intervals for the entire period of record. Note that there will be no entry for the last two years in the record for the 5-year moving mean and no entry for the last five years in the record for the 11-year moving mean.



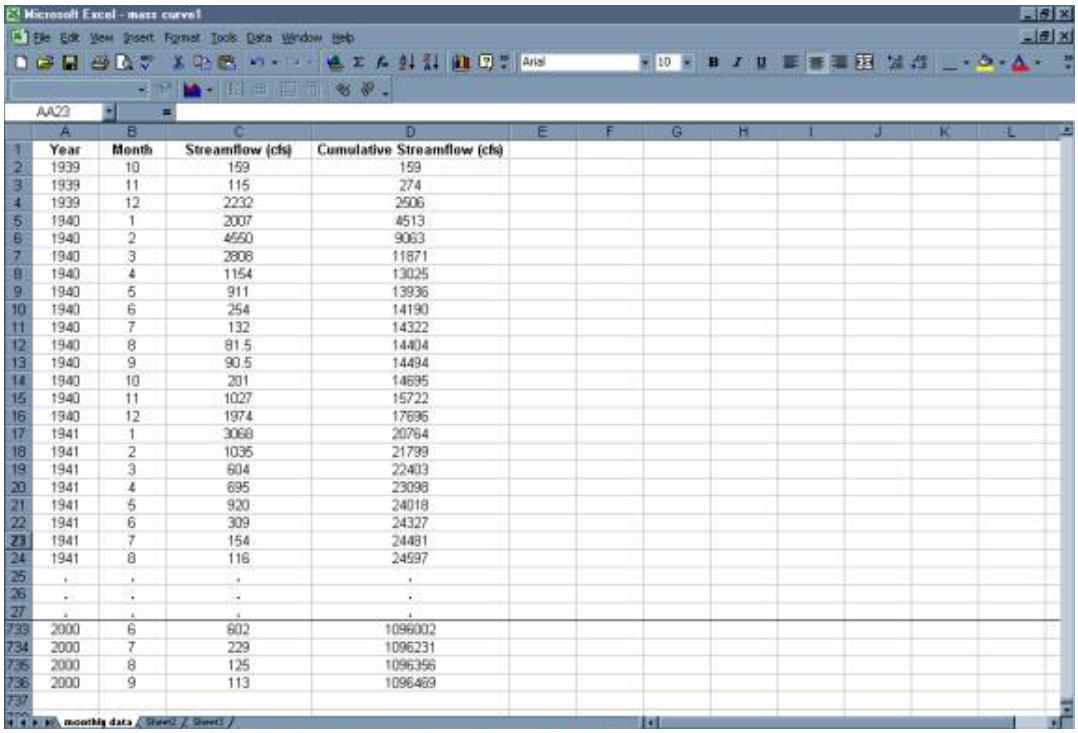
	A	B	C	D
1	Water Year	Streamflow (cfs)	Streamflow (cfs)	Streamflow (cfs)
2		Mean Annual Flow	5-Year Moving Mean Annual Flow	11-Year Moving Mean Annual Flow
3	1940	1198		
4	1941	881		
5	1942	1185	1203	
6	1943	1825	1223	
7	1944	928	1355	
8	1945	1294	1415	1397
9	1946	1545	1409	1479
10	1947	1485	1521	1566
11	1948	1792	1611	1614
12	1949	1490	1721	1632
13	1950	1745	1793	1678
14	1951	2094	1777	1777
15	1952	1842	1884	1748
16	1953	1715	1821	1753
17	1954	2022	1879	1726
18	1955	1430	1755	1715
19	1956	2384	1721	1723
20	1957	1226	1615	1649
21	1958	1542	1603	1611
22	1959	1495	1494	1584
23	1960	1368	1504	1550
24	1961	1838	1481	1552
25	.	.	.	.
26	.	.	.	.
27	.	.	.	.
57	1994	731	1332	1429
58	1995	1782	1540	1440
59	1996	2088	1594	
60	1997	1837	1878	
61	1998	1533	1803	
62	1999	2148		
63	2000	1409		

- Plot the Average mean annual flow, the 5-year moving mean annual flow, and the 11-year moving mean annual flow.



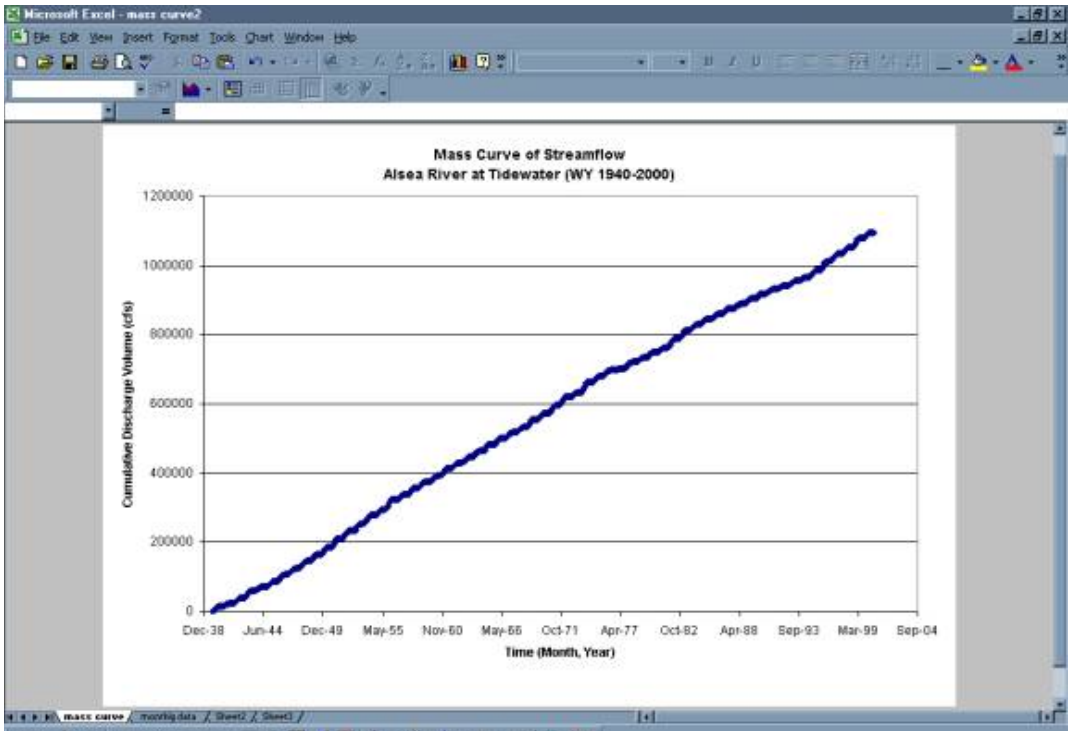
Step 4c: Mass Curve Method

- Calculate cumulative quantity of streamflow for the period of record using average monthly flows. See the **Data Manipulation** section for a more detailed explanation of how to calculate average monthly flows.



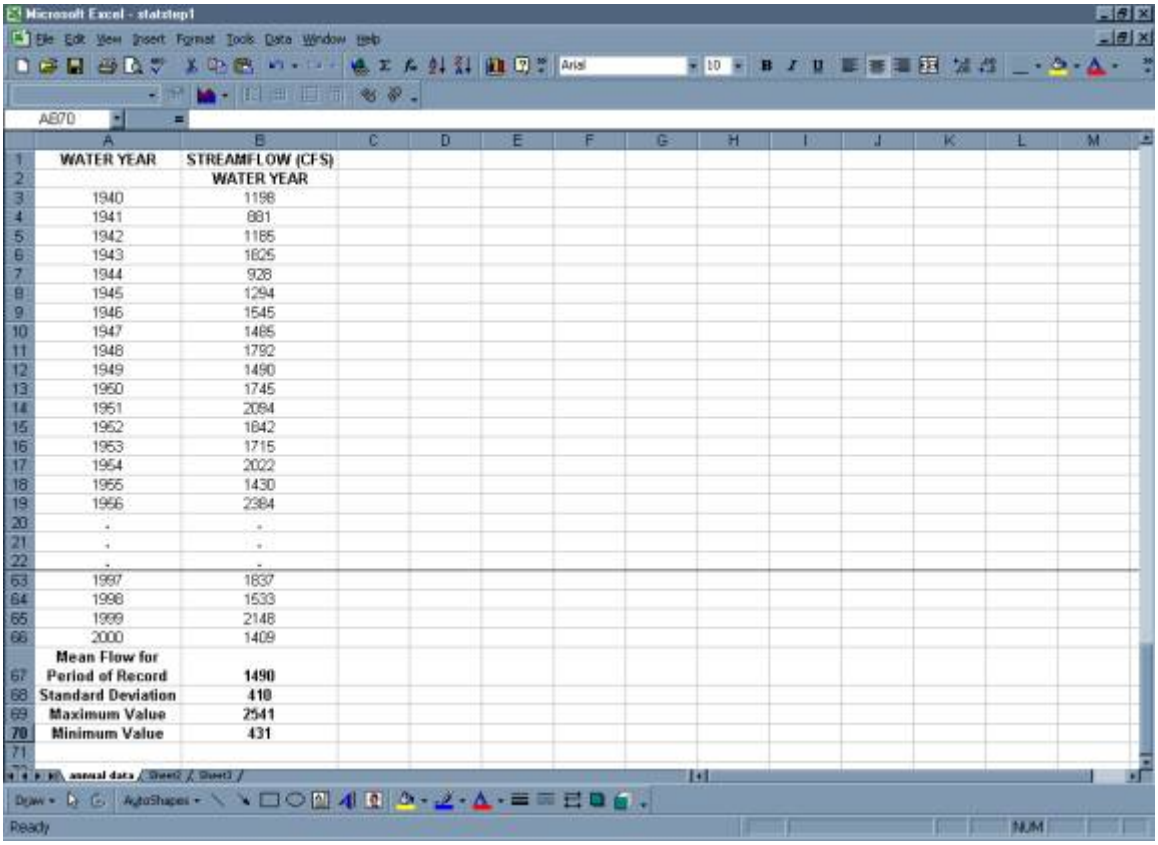
	A	B	C	D
1	Year	Month	Streamflow (cfs)	Cumulative Streamflow (cfs)
2	1939	10	159	159
3	1939	11	115	274
4	1939	12	2232	2506
5	1940	1	2007	4513
6	1940	2	4550	9063
7	1940	3	2808	11871
8	1940	4	1154	13025
9	1940	5	911	13936
10	1940	6	254	14190
11	1940	7	132	14322
12	1940	8	81.5	14404
13	1940	9	90.5	14494
14	1940	10	201	14695
15	1940	11	1027	15722
16	1940	12	1974	17696
17	1941	1	3068	20764
18	1941	2	1035	21799
19	1941	3	604	22403
20	1941	4	695	23098
21	1941	5	920	24018
22	1941	6	309	24327
23	1941	7	154	24481
24	1941	8	116	24597
25	.	.	.	.
26	.	.	.	.
27	.	.	.	.
733	2000	6	602	1096002
734	2000	7	229	1096231
735	2000	8	125	1096356
736	2000	9	113	1096469
737				

- Plot cumulative streamflow versus time.



Step 5: Calculate Simple Statistics

- Excel functions can be used to perform these calculations.
    - Mean -- use the AVERAGE function.
    - Standard Deviation -- use the STDEV function.
    - Maximum Value -- use the MAX function.
    - Minimum Value -- use the MIN function.



	A	B
1	WATER YEAR	STREAMFLOW (CFS)
2		WATER YEAR
3	1940	1198
4	1941	881
5	1942	1185
6	1943	1625
7	1944	928
8	1945	1294
9	1946	1545
10	1947	1485
11	1948	1792
12	1949	1490
13	1950	1745
14	1951	2084
15	1952	1842
16	1953	1715
17	1954	2022
18	1955	1430
19	1956	2384
20	.	.
21	.	.
22	.	.
63	1997	1837
64	1998	1533
65	1999	2148
66	2000	1409
67	**Mean Flow for Period of Record**	**1490**
68	**Standard Deviation**	**410**
69	**Maximum Value**	**2541**
70	**Minimum Value**	**431**
71		

Step 6: Normalization of Mean Annual Flow (Discharge per Unit Area)

- Calculate Discharge Per Unit Area.
  - To do this, you need the Station Description provided by the USGS web page. It includes the drainage area for the gage.

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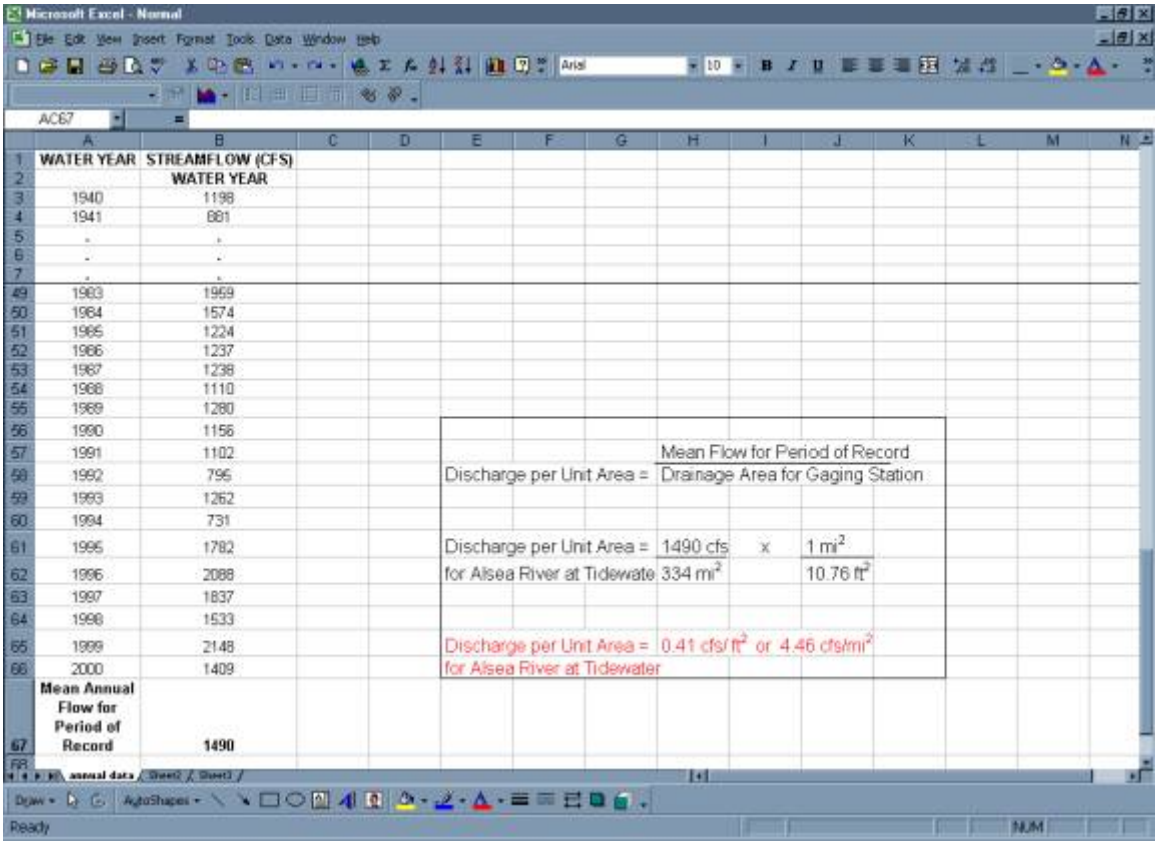
- Mean flow for the Period of Record is divided by the Drainage Area for the gage.



	A	B
1	WATER YEAR	STREAMFLOW (CFS)
2		WATER YEAR
3	1940	1198
4	1941	881
5	.	.
6	.	.
7	.	.
49	1983	1959
50	1984	1574
51	1985	1224
52	1986	1237
53	1987	1238
54	1988	1110
55	1989	1280
56	1990	1156
57	1991	1102
58	1992	795
59	1993	1262
60	1994	731
61	1995	1782
62	1996	2088
63	1997	1837
64	1998	1533
65	1999	2148
66	2000	1409
67	Mean Annual Flow for Period of Record	1490

Discharge per Unit Area = Mean Flow for Period of Record / Drainage Area for Gaging Station

Discharge per Unit Area = 1490 cfs / 334 mi^2 x 1 mi^2 / 10.76 ft^2

Discharge per Unit Area = 0.41 cfs/ft^2 or 4.46 cfs/mi^2 for Alsea River at Tidewater