Analysis Techniques: Flood Analysis Tutorial with Instaneous Peak Flow Data (Log-Pearson Type III Distribution)

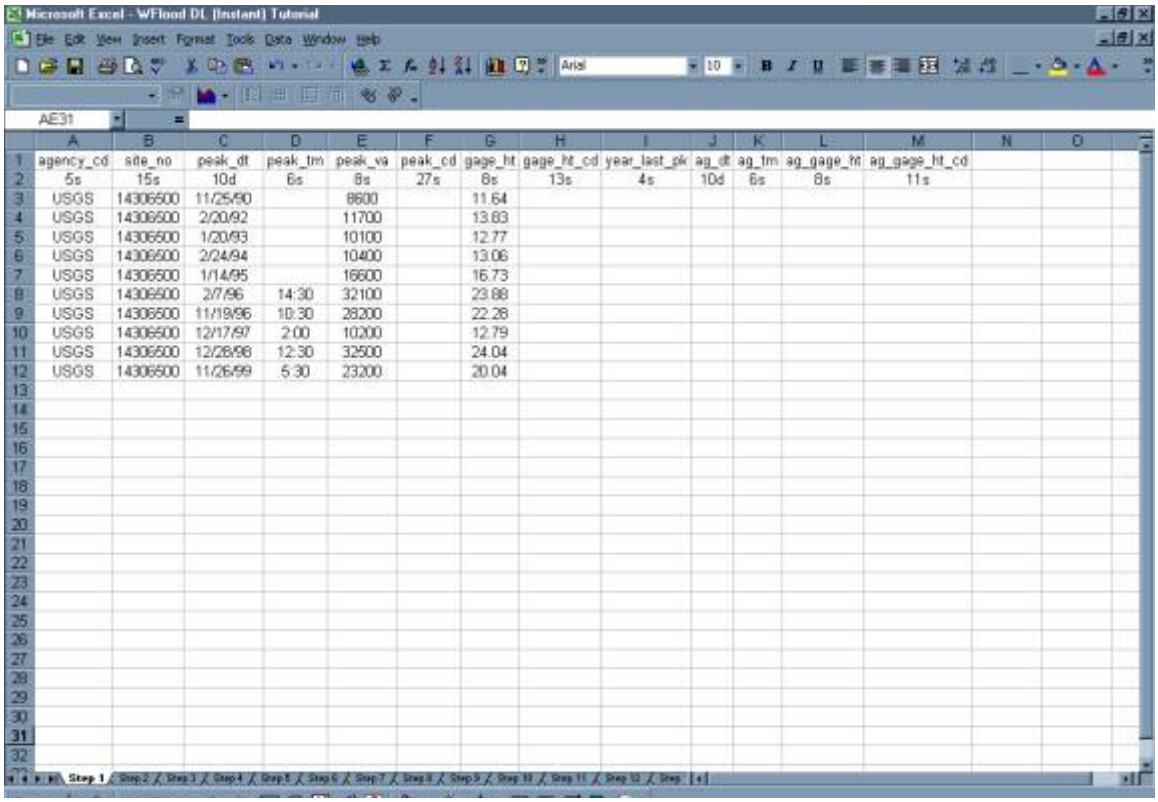
Information to get started:

- 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

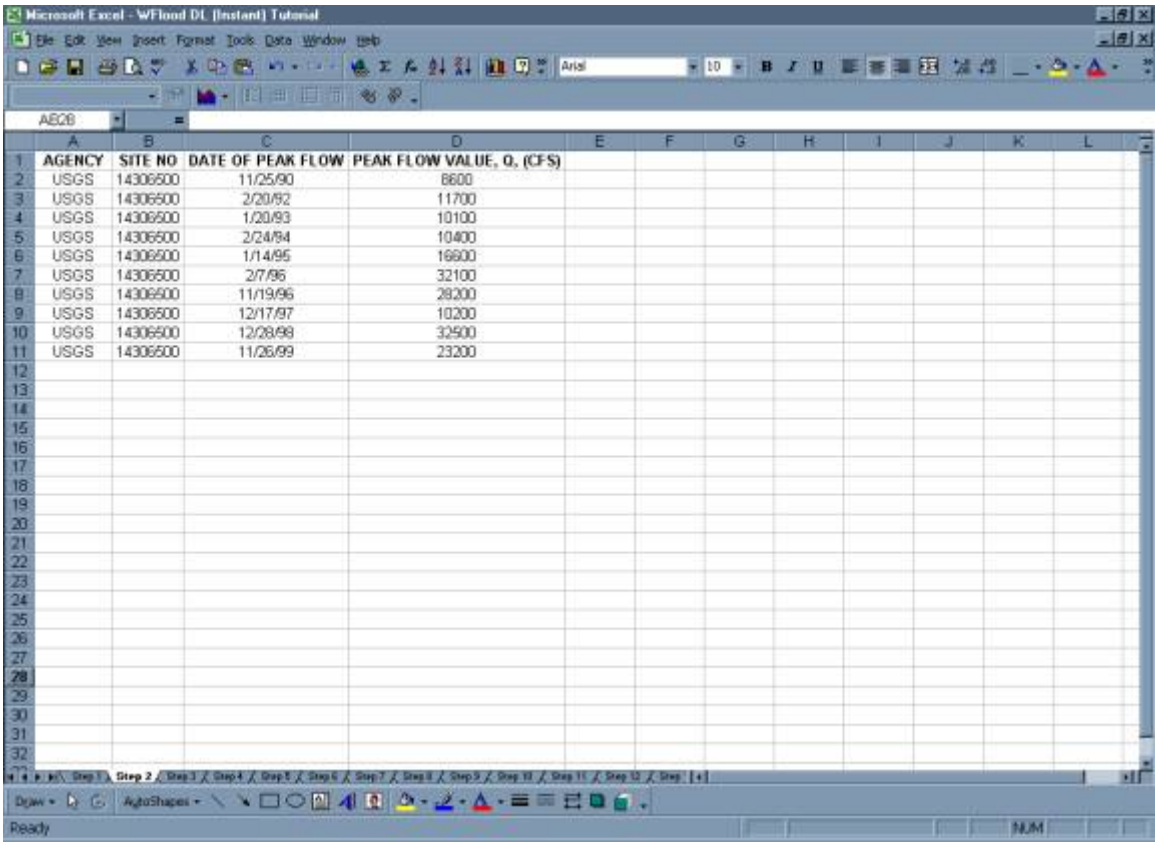
Step 1: Obtain streamflow data

- Obtain instantaneous peak streamflow data from the USGS web site.
  - Go to **http://oregon.usgs.gov**
  - Select Historical Water Data
  - Select Surface Water
  - Select Peaks
  - Check box under Site Identifier for Site Name and Submit
  - Type in Alsea under Site Name and select match any part and Submit
  - Select gage at TIDEWATER (140306500)
  - Select Tab-separated data
  - For the tutorial, copy the data for water years 1990 through 2000 into an Excel worksheet
  - Paste special as text (this will separate the data into columns)



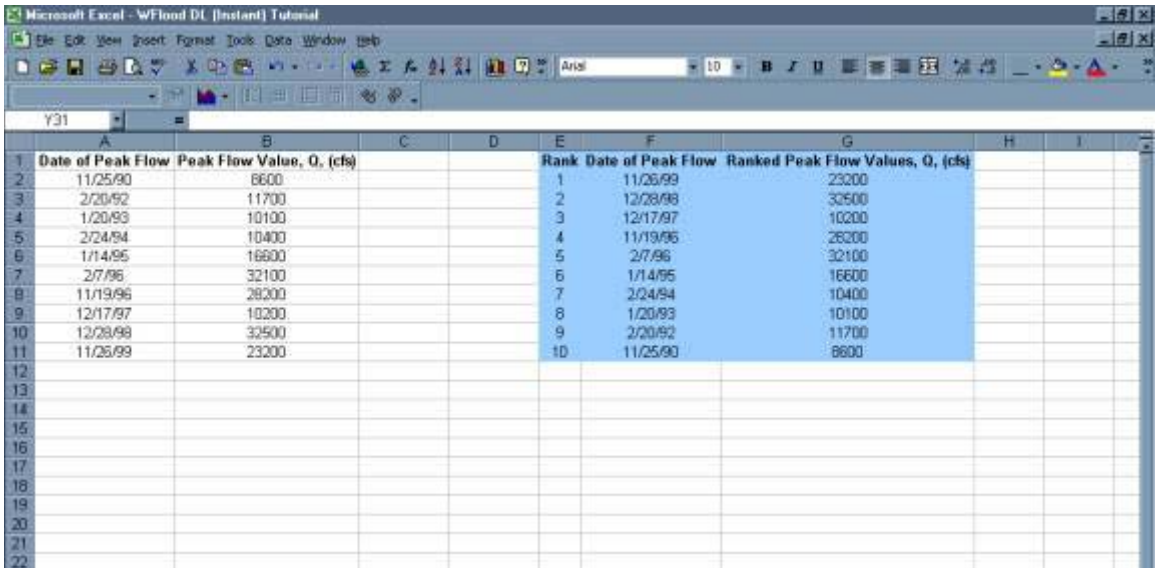
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	agency_cd	site_no	peak_dt	peak_tm	peak_va	peak_cd	gage_ht	gage_ht_cd	year_last_pk	ag_dt	ag_tm	ag_gage_ht	ag_gage_ht_cd		
2	5s	15s	10d	6s	8s	27s	8s	13s	4s	10d	6s	8s	11s		
3	USGS	14306500	11/25/90		8600		11.64								
4	USGS	14306500	2/20/92		11700		13.83								
5	USGS	14306500	1/20/93		10100		12.77								
6	USGS	14306500	2/24/94		10400		13.06								
7	USGS	14306500	1/14/95		16600		16.73								
8	USGS	14306500	2/7/96	14:30	32100		23.88								
9	USGS	14306500	11/19/96	10:30	28200		22.26								
10	USGS	14306500	12/17/97	2:00	10200		12.79								
11	USGS	14306500	12/28/98	12:30	32500		24.04								
12	USGS	14306500	11/26/99	5:30	23200		20.04								

Step 2: Organize the information in a table.



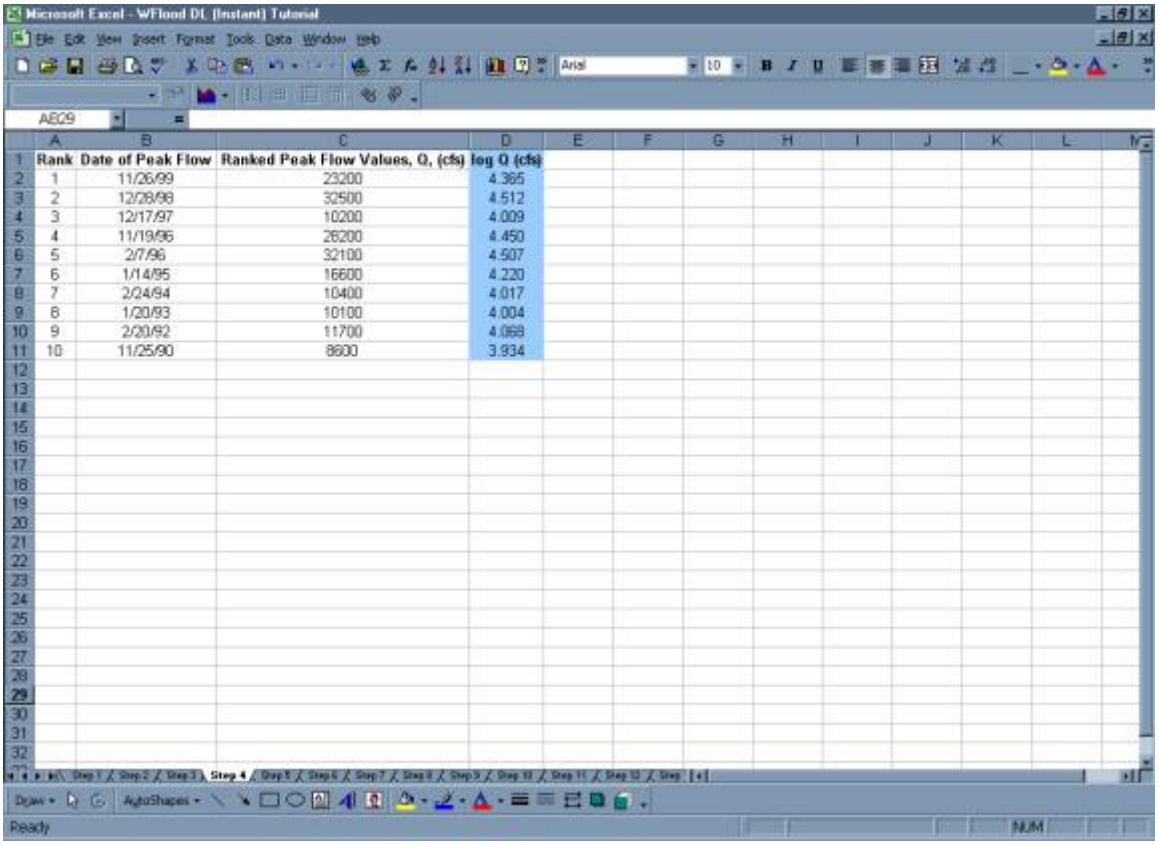
	A	B	C	D	E	F	G	H	I	J	K	L
1	AGENCY	SITE NO	DATE OF PEAK FLOW	PEAK FLOW VALUE, Q, (CFS)								
2	USGS	14306500	11/25/90	8600								
3	USGS	14306500	2/20/92	11700								
4	USGS	14306500	1/20/93	10100								
5	USGS	14306500	2/24/94	10400								
6	USGS	14306500	1/14/95	16600								
7	USGS	14306500	2/7/96	32100								
8	USGS	14306500	11/19/96	28200								
9	USGS	14306500	12/17/97	10200								
10	USGS	14306500	12/28/98	32500								
11	USGS	14306500	11/26/99	23200								

Step 3: Rank the data from largest discharge to smallest discharge using the "sort" command. Add a column for Rank and number each streamflow value from 1 to n (the total number of values in your dataset).



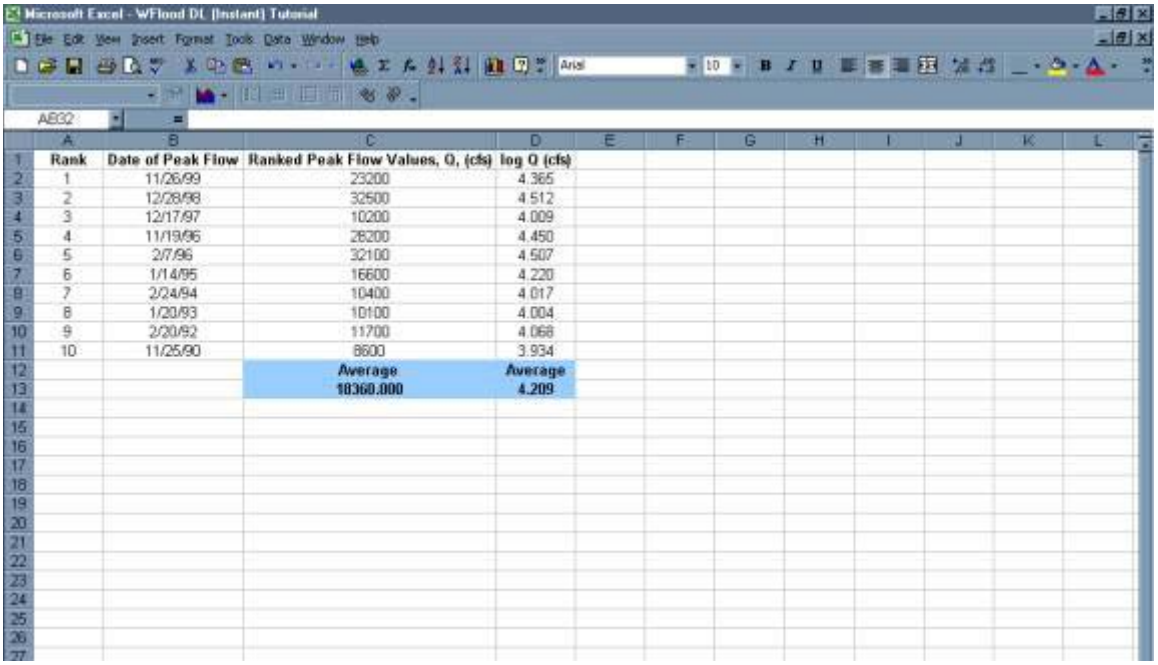
	A	B	C	D	E	F	G	H	I
1	Date of Peak Flow	Peak Flow Value, Q, (cfs)			Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)		
2	11/25/90	8600			1	11/26/99	23200		
3	2/20/92	11700			2	12/28/98	32500		
4	1/20/93	10100			3	12/17/97	10200		
5	2/24/94	10400			4	11/19/96	26200		
6	1/14/95	16600			5	2/7/96	32100		
7	2/7/96	32100			6	1/14/95	16600		
8	11/19/96	26200			7	2/24/94	10400		
9	12/17/97	10200			8	1/20/93	10100		
10	12/28/98	32500			9	2/20/92	11700		
11	11/26/99	23200			10	11/25/90	8600		

Step 4: Create a column with the log of each max or peak streamflow using the Excel formula {log (Q)} and copy command.



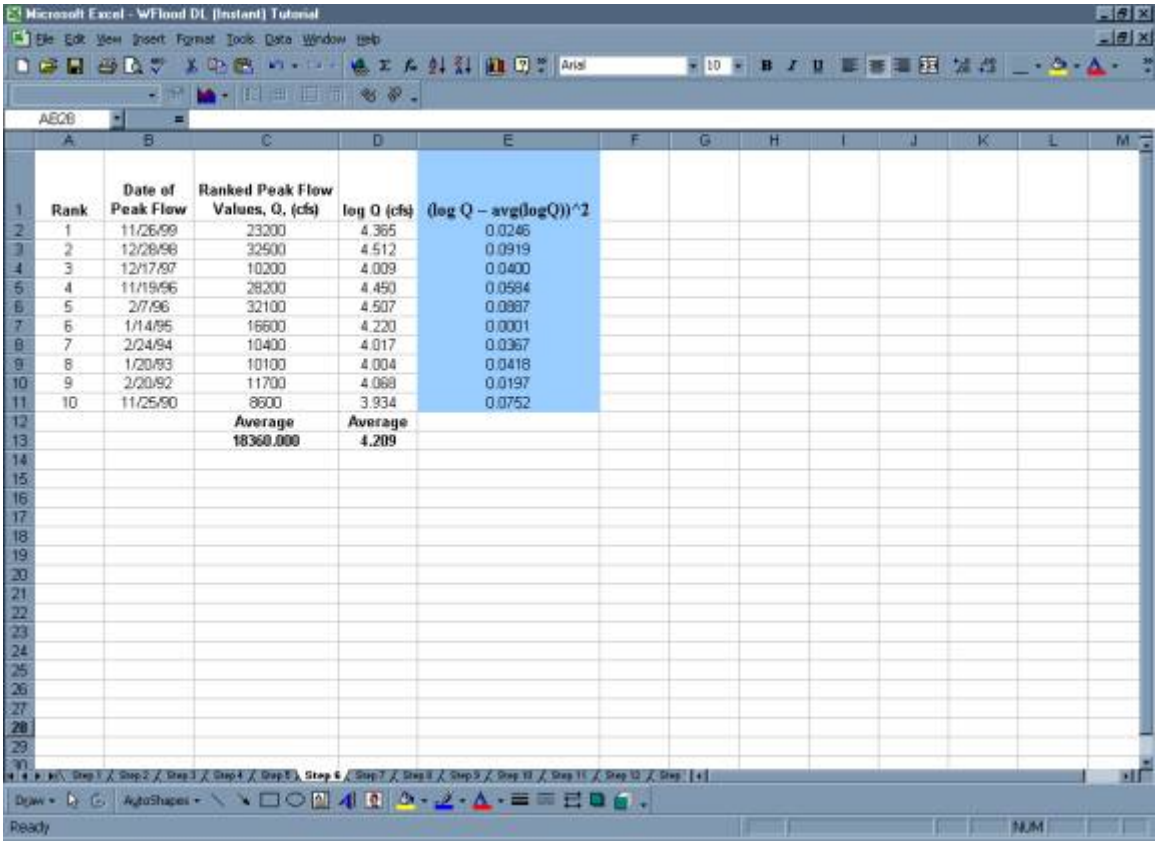
	A	B	C	D	E	F	G	H	I	J	K	L
1	Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)	log Q (cfs)								
2	1	11/26/99	23200	4.365								
3	2	12/28/98	32500	4.512								
4	3	12/17/97	10200	4.009								
5	4	11/19/96	26200	4.450								
6	5	2/7/96	32100	4.507								
7	6	1/14/95	16600	4.220								
8	7	2/24/94	10400	4.017								
9	8	1/20/93	10100	4.004								
10	9	2/20/92	11700	4.068								
11	10	11/25/90	8600	3.934								

Step 5: Calculate the Average Max Q or Peak Q and the Average of the log (Q)



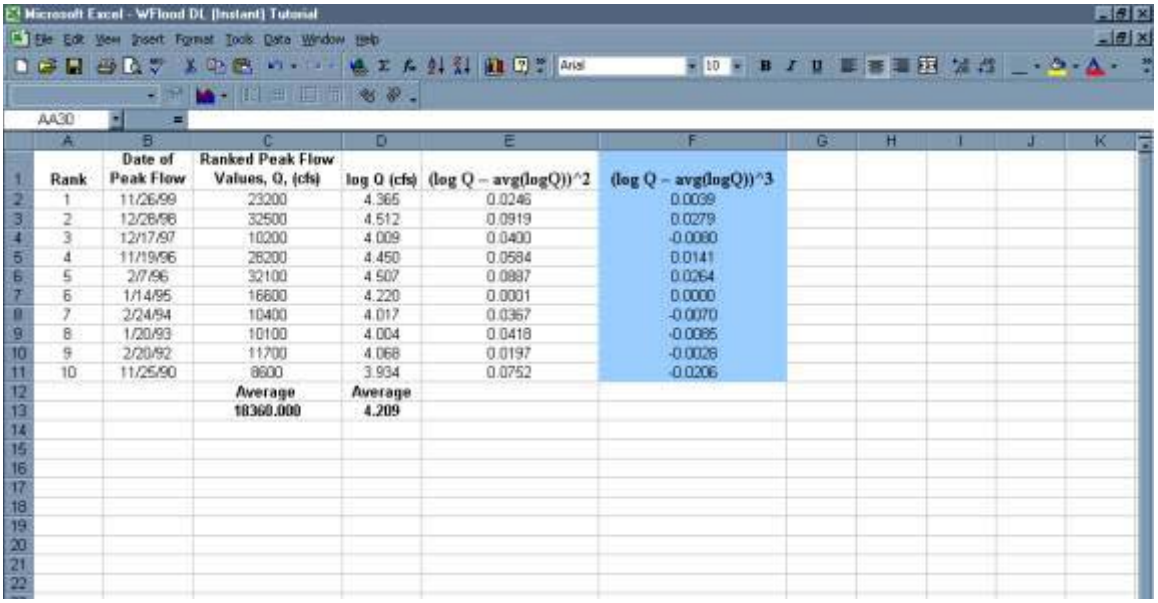
	A	B	C	D
1	Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)	log Q (cfs)
2	1	11/26/99	23200	4.365
3	2	12/28/98	32500	4.512
4	3	12/17/97	10200	4.009
5	4	11/19/96	28200	4.450
6	5	2/7/96	32100	4.507
7	6	1/14/95	16600	4.220
8	7	2/24/94	10400	4.017
9	8	1/20/93	10100	4.004
10	9	2/20/92	11700	4.068
11	10	11/25/90	8600	3.934
12			Average	Average
13			18360.000	4.209

Step 6: Create a column with the excel formula {(log Q – avg(logQ))^2}



	A	B	C	D	E
1	Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)	log Q (cfs)	(log Q – avg(logQ))^2
2	1	11/26/99	23200	4.365	0.0246
3	2	12/28/98	32500	4.512	0.0919
4	3	12/17/97	10200	4.009	0.0400
5	4	11/19/96	28200	4.450	0.0584
6	5	2/7/96	32100	4.507	0.0887
7	6	1/14/95	16600	4.220	0.0001
8	7	2/24/94	10400	4.017	0.0367
9	8	1/20/93	10100	4.004	0.0418
10	9	2/20/92	11700	4.068	0.0197
11	10	11/25/90	8600	3.934	0.0752
12			Average	Average	
13			18360.000	4.209	

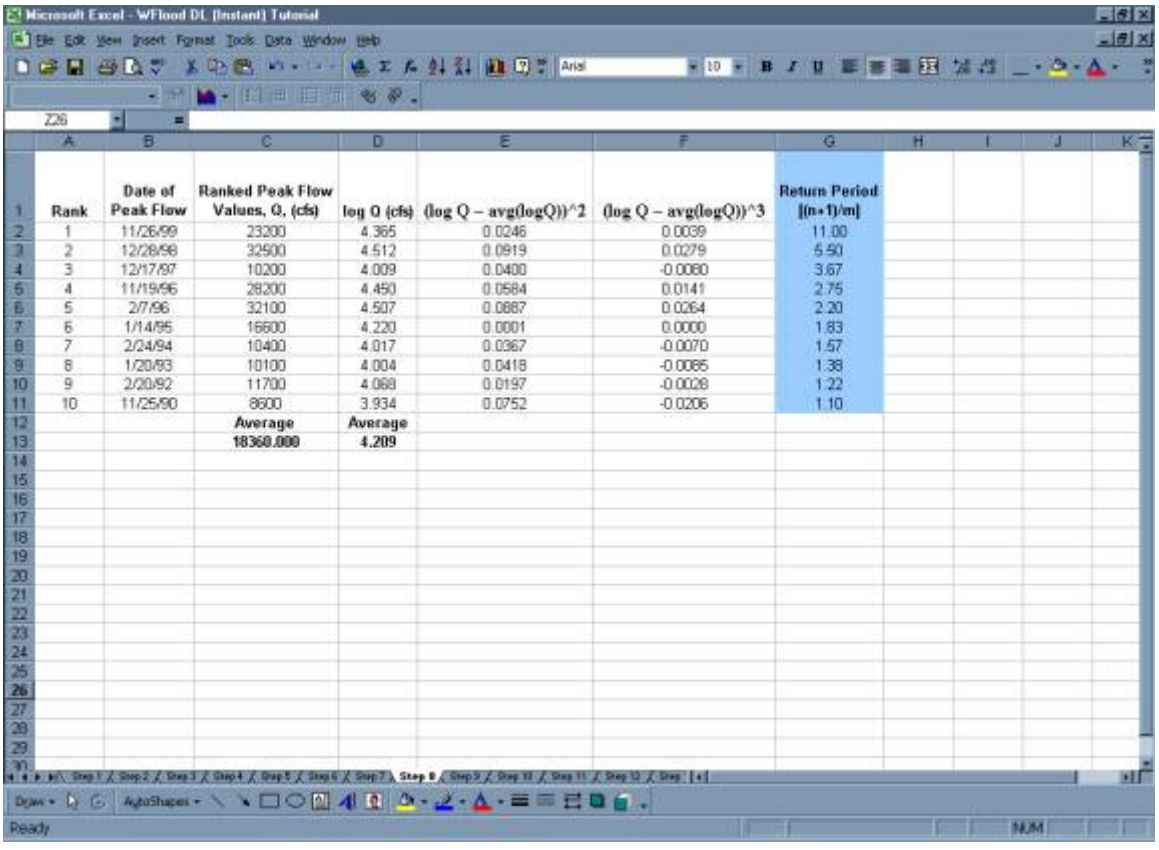
Step 7: Create a column with the excel formula {(log Q – avg(logQ))^3



Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)	log Q (cfs)	(log Q – avg(logQ))^2	(log Q – avg(logQ))^3
1	11/26/99	23200	4.365	0.0246	0.0039
2	12/28/98	32500	4.512	0.0919	0.0279
3	12/17/97	10200	4.009	0.0400	-0.0080
4	11/19/96	28200	4.450	0.0584	0.0141
5	2/7/96	32100	4.507	0.0887	0.0264
6	1/14/95	16600	4.220	0.0001	0.0000
7	2/24/94	10400	4.017	0.0367	-0.0070
8	1/20/93	10100	4.004	0.0418	-0.0085
9	2/20/92	11700	4.068	0.0197	-0.0026
10	11/25/90	8600	3.934	0.0752	-0.0206
		Average	Average		
		18360.000	4.209		

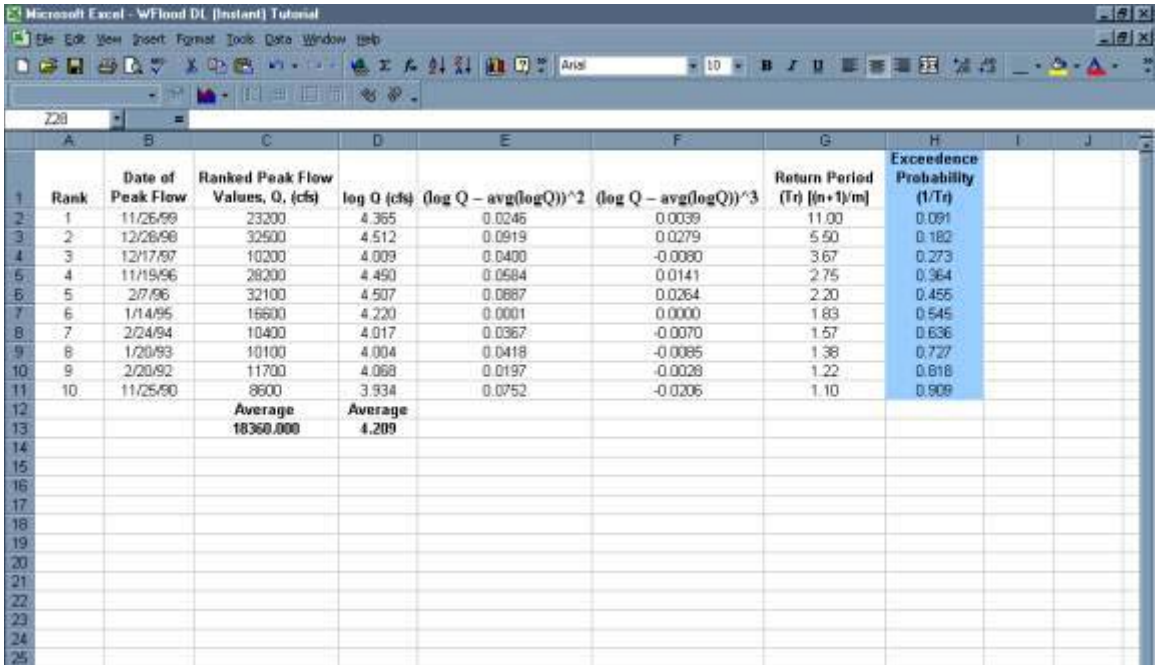
Step 8: Create a column with the return period (Tr) for each discharge using the Excel formula {(n+1)/m}.

Where n = the number of values in the dataset and m = the rank.



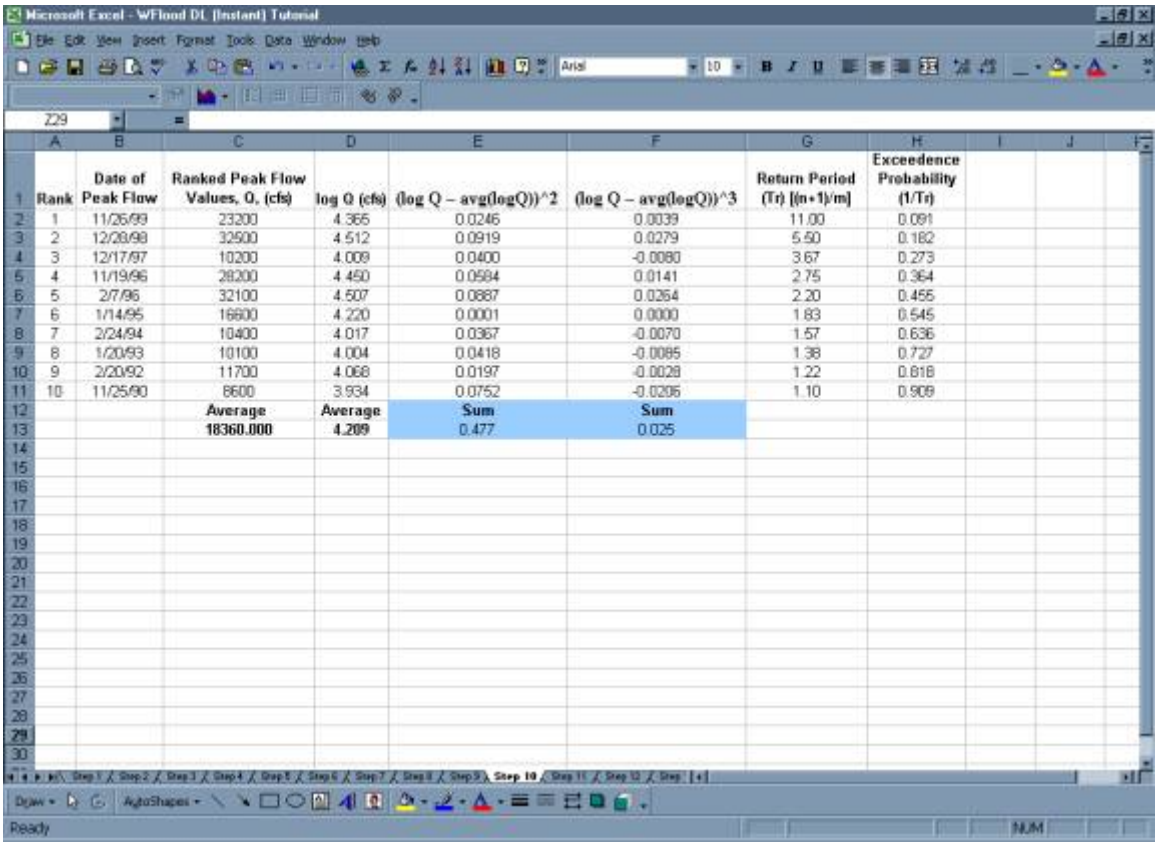
Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)	log Q (cfs)	(log Q – avg(logQ))^2	(log Q – avg(logQ))^3	Return Period [(n+1)/m]
1	11/26/99	23200	4.365	0.0246	0.0039	11.00
2	12/28/98	32500	4.512	0.0919	0.0279	5.50
3	12/17/97	10200	4.009	0.0400	-0.0080	3.67
4	11/19/96	28200	4.450	0.0584	0.0141	2.75
5	2/7/96	32100	4.507	0.0887	0.0264	2.20
6	1/14/95	16600	4.220	0.0001	0.0000	1.83
7	2/24/94	10400	4.017	0.0367	-0.0070	1.57
8	1/20/93	10100	4.004	0.0418	-0.0085	1.38
9	2/20/92	11700	4.068	0.0197	-0.0026	1.22
10	11/25/90	8600	3.934	0.0752	-0.0206	1.10
		Average	Average			
		18360.000	4.209			

Step 9: Complete the table with a final column showing the exceedence probability of each discharge using the excel formula {=1/Return Period or 1/Tr} and the copy command.



Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)	log Q (cfs)	(log Q – avg(logQ))^2	(log Q – avg(logQ))^3	Return Period (Tr) [(n+1)/m]	Exceedence Probability (1/Tr)
1	11/26/99	23200	4.365	0.0246	0.0039	11.00	0.091
2	12/28/98	32500	4.512	0.0919	0.0279	5.50	0.182
3	12/17/97	10200	4.009	0.0400	-0.0080	3.67	0.273
4	11/19/96	28200	4.450	0.0584	0.0141	2.75	0.364
5	2/7/96	32100	4.507	0.0887	0.0264	2.20	0.455
6	1/14/95	16600	4.220	0.0001	0.0000	1.83	0.545
7	2/24/94	10400	4.017	0.0367	-0.0070	1.57	0.636
8	1/20/93	10100	4.004	0.0418	-0.0085	1.38	0.727
9	2/20/92	11700	4.068	0.0197	-0.0028	1.22	0.818
10	11/25/90	8600	3.934	0.0752	-0.0206	1.10	0.909
		Average	Average				
		18360.000	4.209				

Step 10: Calculate the Sum for the {(logQ – avg(logQ))^2} and the {(logQ – avg(logQ))^3} columns.



Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)	log Q (cfs)	(log Q – avg(logQ))^2	(log Q – avg(logQ))^3	Return Period (Tr) [(n+1)/m]	Exceedence Probability (1/Tr)
1	11/26/99	23200	4.365	0.0246	0.0039	11.00	0.091
2	12/28/98	32500	4.512	0.0919	0.0279	5.50	0.182
3	12/17/97	10200	4.009	0.0400	-0.0080	3.67	0.273
4	11/19/96	28200	4.450	0.0584	0.0141	2.75	0.364
5	2/7/96	32100	4.507	0.0887	0.0264	2.20	0.455
6	1/14/95	16600	4.220	0.0001	0.0000	1.83	0.545
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9	2/20/92	11700	4.068	0.0197	-0.0028	1.22	0.818
10	11/25/90	8600	3.934	0.0752	-0.0206	1.10	0.909
		Average	Average	Sum	Sum		
		18360.000	4.209	0.477	0.025		

Step 11: Calculate the variance , standard deviation , and skew coefficient as follows:

variance =

$$\frac{\sum_{i}^{n}(\log Q - avg(\log Q))^{\wedge}2}{n-1}$$

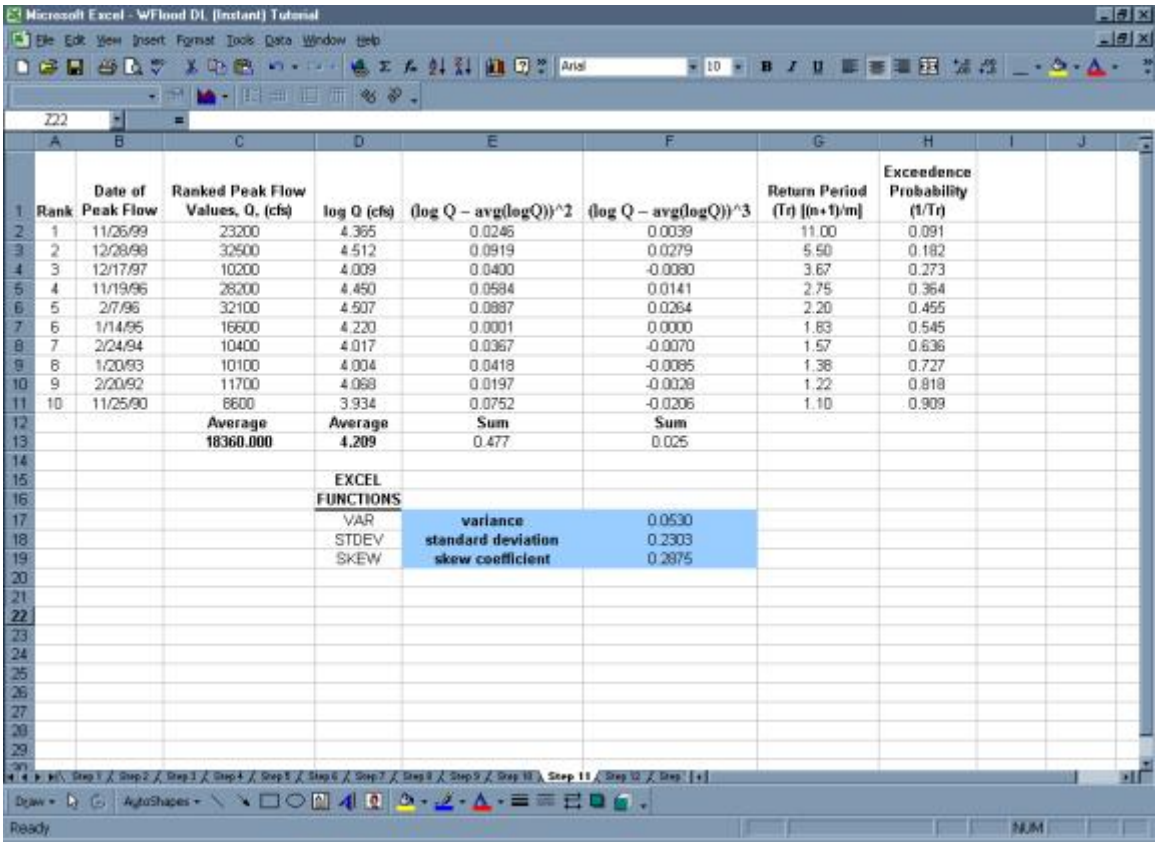
standard deviation =

$$\sigma \log Q = \sqrt{variance}$$

skew coefficient =

$$\frac{n \times \sum_{i}^{n}(\log Q - avg(\log Q))^{\wedge}3}{(n-1)(n-2)(\sigma \log Q)^{\wedge}3}$$

Excel functions can also be used to calculate the variance (=VAR( )), standard deviation (=STDEV( )), and skewness coefficient (=SKEW( )).



Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)	log Q (cfs)	(log Q – avg(logQ))^2	(log Q – avg(logQ))^3	Return Period (Tr) [(n+1)/m]	Exceedence Probability (1/Tr)
1	11/26/99	23200	4.365	0.0246	0.0039	11.00	0.091
2	12/28/98	32500	4.512	0.0919	0.0279	5.50	0.182
3	12/17/97	10200	4.009	0.0400	-0.0080	3.67	0.273
4	11/19/96	28200	4.450	0.0584	0.0141	2.75	0.364
5	2/7/96	32100	4.507	0.0887	0.0264	2.20	0.455
6	1/14/95	16600	4.220	0.0001	0.0000	1.83	0.545
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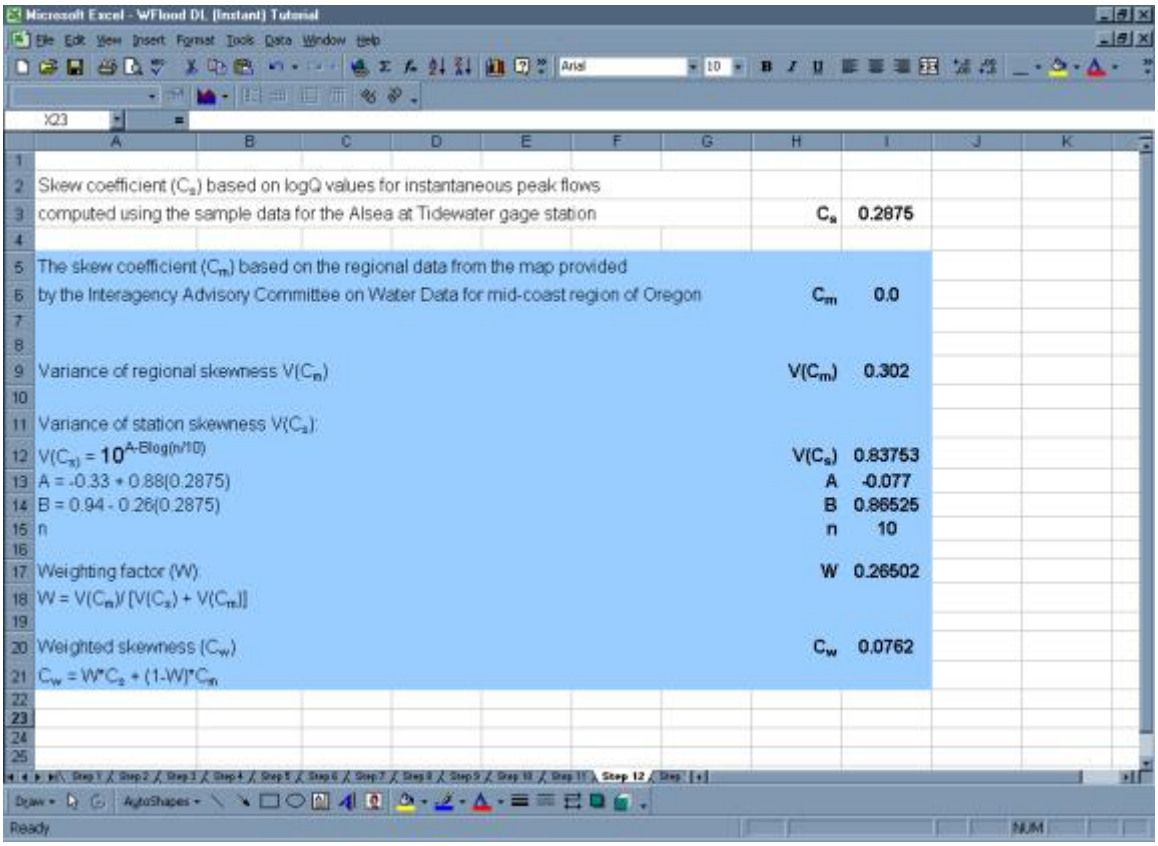
9	2/20/92	11700	4.068	0.0197	-0.0028	1.22	0.818
10	11/25/90	8600	3.934	0.0752	-0.0206	1.10	0.909
		Average	Average	Sum	Sum		
		18360.000	4.209	0.477	0.025		

EXCEL FUNCTIONS		
VAR	variance	0.0530
STDEV	standard deviation	0.2303
SKEW	skew coefficient	0.2875

Step 12: Calculate weighted skewness



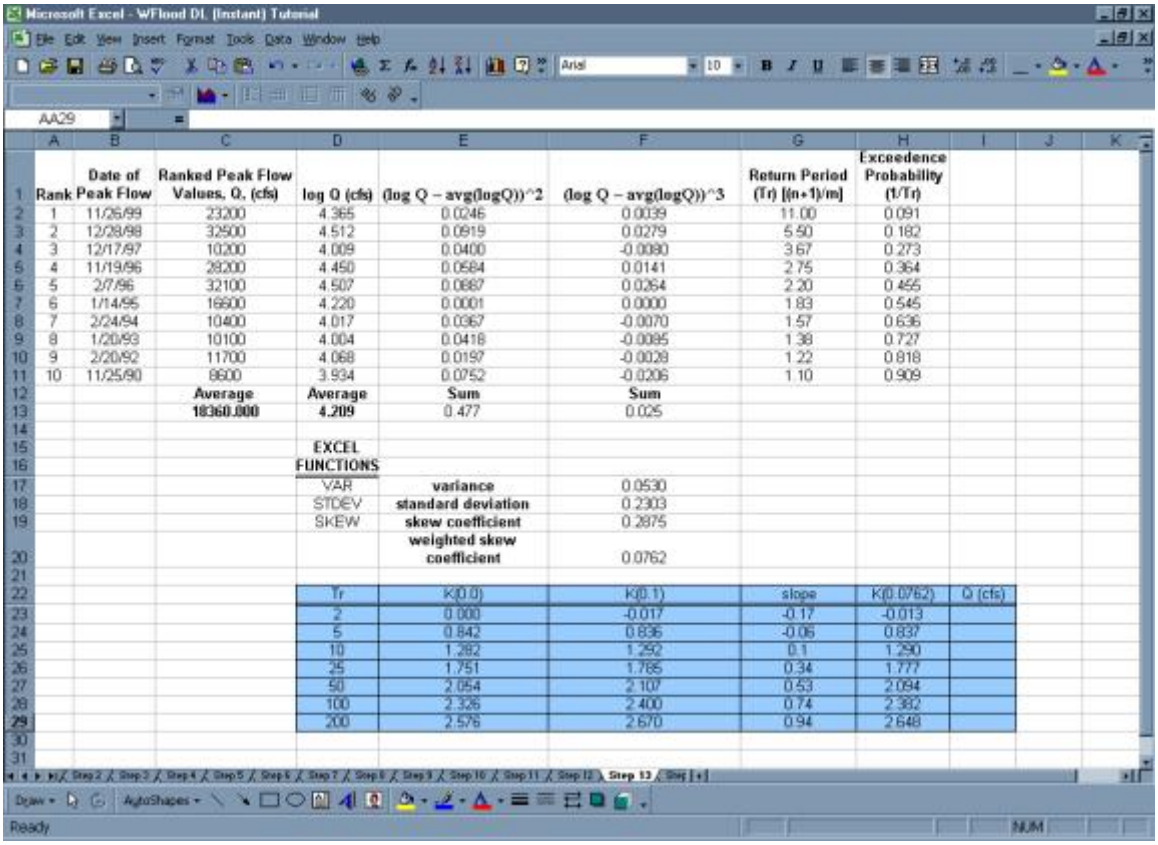
Skew coefficient (C_s) based on logQ values for instantaneous peak flows			
computed using the sample data for the Alsea at Tidewater gage station		C_s	0.2875
The skew coefficient (C_m) based on the regional data from the map provided			
by the Interagency Advisory Committee on Water Data for mid-coast region of Oregon		C_m	0.0
Variance of regional skewness $V(C_m)$		$V(C_m)$	0.302
Variance of station skewness $V(C_s)$:			
$V(C_s) = 10^{A-B\log(n/10)}$		$V(C_s)$	0.83753
A = -0.33 + 0.88(0.2875)		A	-0.077
B = 0.94 - 0.26(0.2875)		B	0.86525
n		n	10
Weighting factor (W)		W	0.26502
$W = V(C_m)/[V(C_s) + V(C_m)]$			
Weighted skewness (C_w)		C_w	0.0762
$C_w = W*C_s + (1-W)*C_m$			

Show Me

Step 13: Calculate *K* values

- Use the **frequency factor table** and the skew coefficient to find the ***K* values** for the 2,5,10,25,50,100, and 200 **recurrence intervals**.
- If the skew coefficient is between two given skew coefficients in the table than you can linearly extrapolate between the two numbers to get the appropriate *K* value. To view the frequency factor table click on the button below.

Show Me



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2	12/28/98	32500	4.512	0.0919	0.0279	5.50	0.182
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		Average	Average	Sum	Sum		
		18360.000	4.209	0.477	0.025		

EXCEL FUNCTIONS

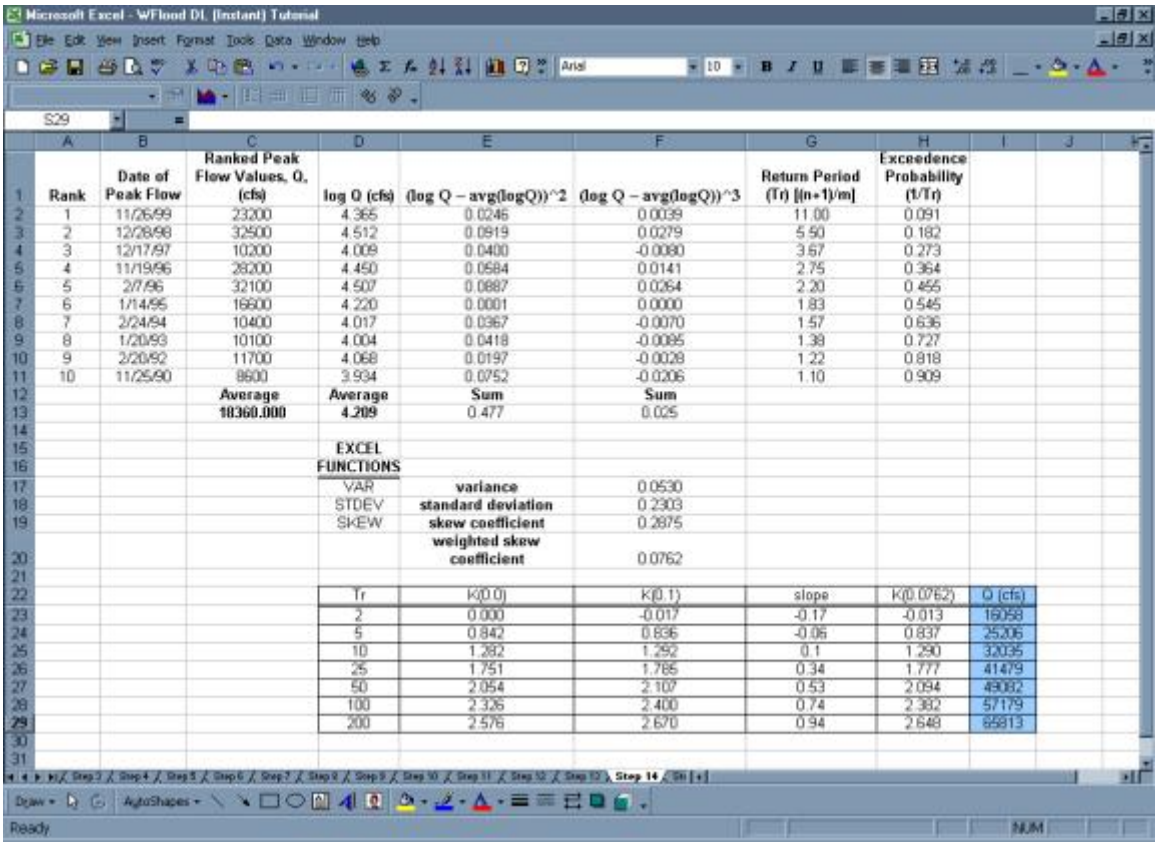
VAR	variance	0.0530
STDEV	standard deviation	0.2303
SKEW	skew coefficient	0.2875
	weighted skew coefficient	0.0762

Tr	K(0.0)	K(0.1)	slope	K(0.0762)	Q (cfs)
2	0.000	-0.017	-0.17	-0.013	
5	0.842	0.836	-0.06	0.837	
10	1.282	1.292	0.1	1.290	
25	1.751	1.785	0.34	1.777	
50	2.054	2.107	0.53	2.094	
100	2.326	2.400	0.74	2.382	
200	2.576	2.670	0.94	2.648	

Step 14: Using the general equation, list the discharges associated with each recurrence interval

general equation =

$$\log QTr = \text{avg}(\log Q) + [K\ (Tr, Cs)] \times \sigma \log Q$$



Microsoft Excel - WFlood DL (Instant) Tutorial

Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)	log Q (cfs)	(log Q – avg(logQ))^2	(log Q – avg(logQ))^3	Return Period (Tr) [(n+1)/m]	Exceedence Probability (1/Tr)			
1	11/26/99	23200	4.365	0.0246	0.0039	11.00	0.091			
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3	12/17/97	10200	4.009	0.0400	-0.0080	3.67	0.273			
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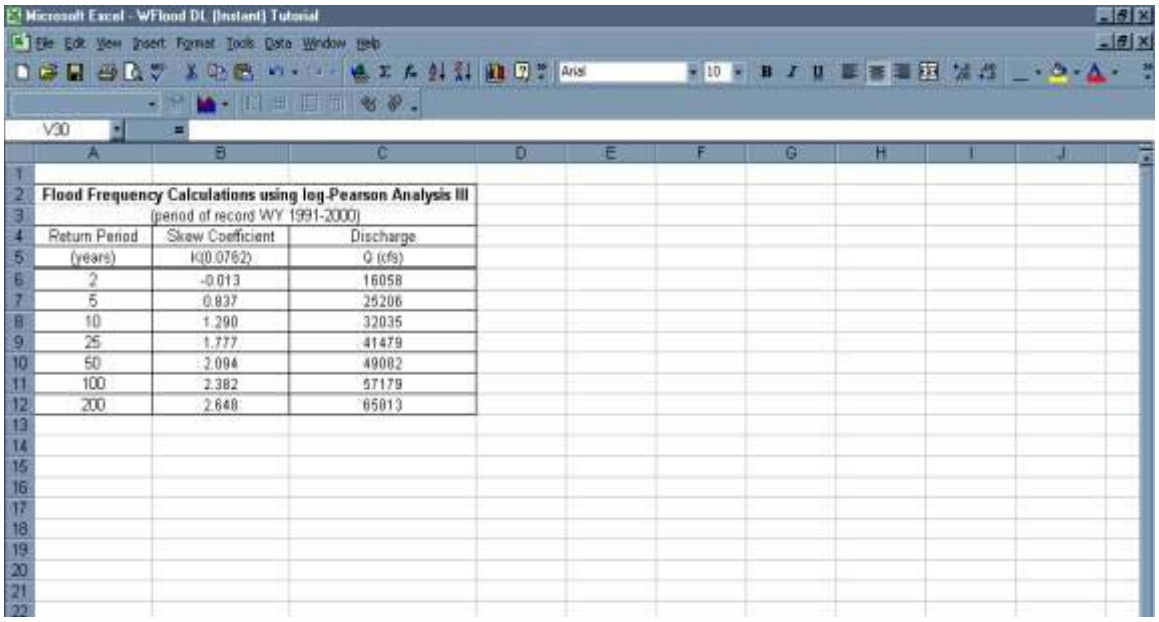
8	1/20/93	10100	4.004	0.0418	-0.0085	1.38	0.727			
9	2/20/92	11700	4.068	0.0197	-0.0028	1.22	0.818			
10	11/25/90	8600	3.934	0.0752	-0.0206	1.10	0.909			
		Average	Average	Sum	Sum					
		18360.000	4.209	0.477	0.025					

EXCEL FUNCTIONS

VAR	variance	0.0530
STDEV	standard deviation	0.2303
SKEW	skew coefficient	0.2875
	weighted skew coefficient	0.0762

Tr	K(0.0)	K(0.1)	slope	K(0.0762)	Q (cfs)
2	0.000	-0.017	-0.17	-0.013	16058
5	0.842	0.836	-0.06	0.837	25206
10	1.282	1.292	0.1	1.290	32035
25	1.751	1.785	0.34	1.777	41479
50	2.054	2.107	0.53	2.094	49082
100	2.326	2.400	0.74	2.382	57179
200	2.576	2.670	0.94	2.648	65813

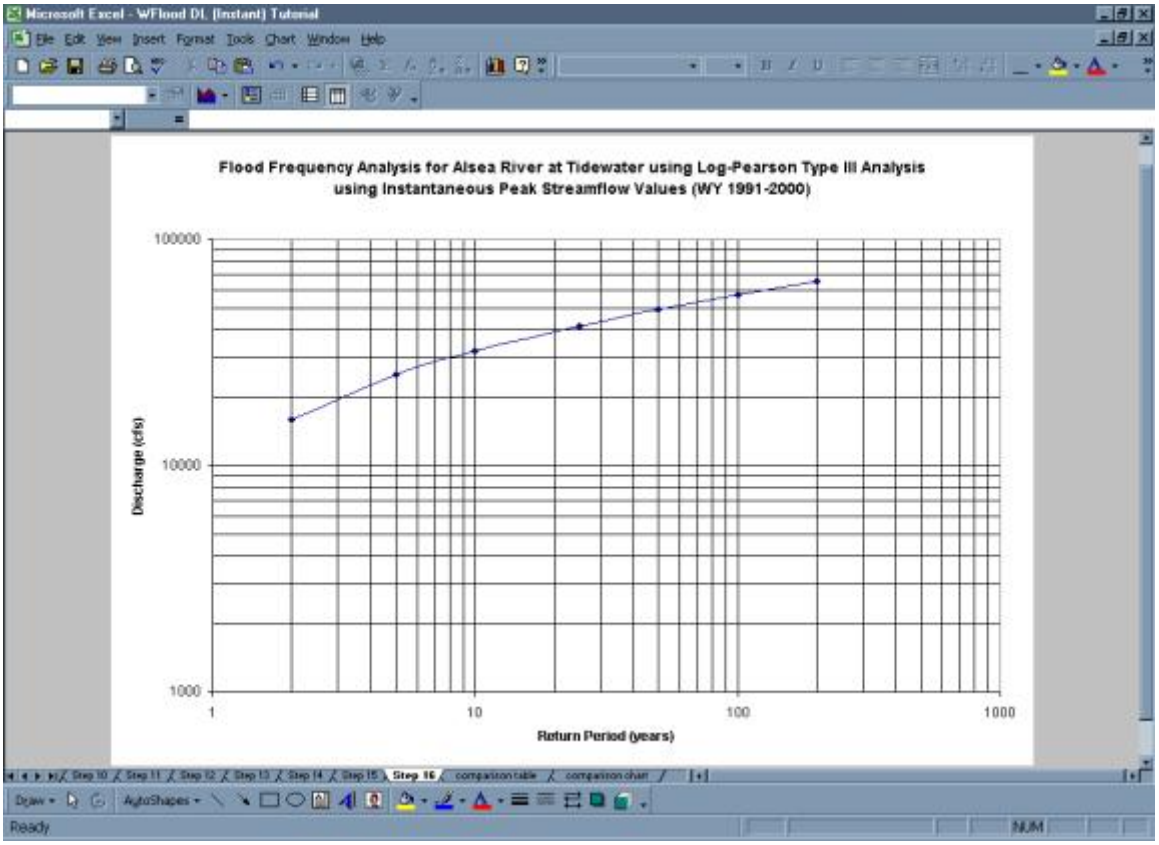
Step 15: Create table of Discharge values found using the log – Pearson analysis



Microsoft Excel - WFlood DL (Instant) Tutorial

Flood Frequency Calculations using log-Pearson Analysis III (period of record WY 1991-2000)		
Return Period (years)	Skew Coefficient K(0.0762)	Discharge Q (cfs)
2	-0.013	16058
5	0.837	25206
10	1.290	32035
25	1.777	41479
50	2.094	49082
100	2.382	57179
200	2.648	65813

Step 16: Create Plot



- Below is a comparison of flood frequency analysis completed using mean daily data versus instantaneous discharge data. As can be seen, had you completed this analysis using mean daily data, the result would have been an underestimation of the discharges associated with each return period.