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.
 - o Go to http://oregon.usgs.gov
 - o Select Historical Water Data
 - o Select Surface Water
 - o Select Peaks
 - o Check box under Site Identifier for Site Name and Submit
 - o Type in Alsea under Site Name and select match any part and Submit
 - o Select gage at TIDEWATER (140306500)
 - o 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)

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	14306500	2/24/94		10400		13.06									
	14306500	1/14/95		16600		16.73									
	14306500	2/7/96	14:30	32100		23.88									1
	14306500	11/19/96	10.30	28200		22.28									1
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Step 2: Organize the information in a table.

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A	B	C	D	E	F	G	H	(II)	1	K.	L
			PEAK FLOW VALUE, Q, (CFS)				_				
USGS	14306500	11/25/90	6600								
USGS	14306500		11700		-						
	14306500		10100								
	14306500		10400								
USGS	14306500		16600				_				
	14306500	2/7/96	32100						-		
	14306500		28200				_				
	14306500		10200				-			-	
	14306500		32500				_				
USGS	14306500	11/26/99	23200								
	-								-		
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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).

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Τ.	01								
	A	Ð	С	D	E	F	G	H	1
Da		Peak Flow Value, O, (cfs)			Rank 0		Ranked Peak Flow Values, Q, (cls)		
0	11/25/90	6600			1	11/26/99	23200		
8	2/20/92	11700			2	12/28/98	32500		
	1/20/93	10100			3	12/17/97	10200		
	2/24/94	10400			- 4	11/19/96	26200		
8	1/14/95	16800			5	2/7/96	32100		
1	2/7/96	32100			5 6 7	1/14/95	16600		
1	11/19/96	28200				2/24/94	10400		
1	12/17/97	10200			8 9	1/20/93	10100		
	12/28/98	32500			9	2/20/92	11700		
	11/26/99	23200			10	11/25/90	8600		
1									
6									
2									
1									
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Step 4: Create a column with the log of each max or peak streamflow using the Excel formula {log (Q)} and copy command.

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A	B	C	D	E	F	G	H	. E	1	K	12	
Rank		Ranked Peak Flow Values, Q, (cfs)										
-	11/26/99	23200	4.365			-						
2	12/28/98	32500	4.512 4.009			-	-					
4	12/17/97				-	-						
5	2/7/96	26200	4.450 4.507									
6	1/14/95	16600	4.507		-	-						
7	2/24/94	10400	4.220			-	-					
8	1/20/93	10400	4.004			-	-					
9	2/20/92	11700	4.068				-					
10	11/25/90	8600	3.934									
10	11120/00	0000	3.534			-						
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Step 5: Calculate the Average Max Q or Peak Q and the Average of the log (Q)

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A	8	C	D	E	F	G	म		1	K	1
Rank		Ranked Peak Flow Values, Q, (cfs)									
1	11/26/99	23200	4.365								
2	12/28/98	32500	4.512								
3	12/17/97	10200	4.009								
4	11/19/96	26200	4.450								
5	2/7/96	32100	4.507								
6	1/14/95	16600	4.220								
7	2/24/94	10400	4.017								
8	1/20/93	10100	4.004								
9	2/20/92	11700	4.068								
10	11/25/90	8600	3.934								
		Average 18360.000	Average 4.209								
								-			

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

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A	B	C	D	E	F.	G	H	1	- 2/ 4	K	1	1
Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)	log Q (cfs)	(log Q - avg(logQ))^2								
1	11/26/99	23200	4.365	0.0246								
2	12/28/98	32900	4.512	0.0919								
3	12/17/97	10200	4.009	0.0400								
- 4	11/19/96	28200	4.450	0.0584							-	
5	2/7/96	32100	4.507	0.0887						_		_
6	1/14/95	16600	4.220	0.0001		-		-	-		-	_
7	2/24/94	10400	4.017	0.0367						_		_
8	1/20/93	10100	4.004	0.0418						_		
9	2/20/92	11700	4.068	0.0197								-
10	11/25/90	8600	3.934	0.0752						_		-
		Average 19369-000	Average 4.209						-	-	-	-
		18360.000	4.209						-			-
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Step 7: Create a column with the excel formula { (log Q avg(logQ))^3

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- Í	A	B	C	0	Ē	(F)	G	н	- 3	J.	K
1	Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)	Commencer and	(log Q - avg(logQ))^2	(log Q - avg(logQ))^3					
2	1	11/26/99	23200	4.365	0.0246	0.0039					
3	2	12/28/98	32500	4.512	0.0919	0.0279					
4	3	12/17/97	10200	4.009	0.0400	-0.0080					
5	4	11/19/96	26200	4.450	0.0584	0.0141					
	5	2/7/96	32100	4.507	0.0837	0.0264					
	б	1/14/95	16600	4.220	0.0001	0.0000					
	7.	2/24/94	10400	4.017	0.0367	-0.0070					
3	8	1/20/93	10100	4.004	0.0418	-0.0065					
0	9	2/20/92	11200	4.068	0.0197	-0.0028					
1	10	11/25/90	8600	3.934	0.0752	0.0206					
23			Average	Average							
3 4			18360.000	4.209							
5											
6											
6 7											
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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.

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	A	B	С	D	E	F	G	H	T	() ja	P
	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	32900	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	0.0687	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	157				
-	8	1/20/93	10100	4.004	0.0418	-0.0085	1.38				
-		11/25/90	8500	3.934	0.0197	-0.0206	1.22				
	10	11/25/90	Average	Average	0.0752	-0.0206	1.10				
-			18360.000	4,209							
			10,300,000	4.209							
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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.

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-	Z28	=	Carlo Inc.							
	A	B	C	D	E	(Fill	G	(H)	- 1-	1
	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)		
2	1	11/26/99	23200	4.365	0.0245	0.0039	11.00	0.091		
3	2	12/28/98	32500	4.512	0.0919	0.0279	5.50	D 182		
4	3	12/17/97	10200	4.009	0.0400	-0.0080	3.67	0.273		
5	4	11/19/96	28200	4.450	0.0584	0.0141	2.75	0.364		
5	5	2/7/96	32100	4.507	0.0687	0.0264	2.20	0.455		-
501.	6	1/14/95	16600	4.220	0.0001	0.0000	1.83	0.545		-
8	- Z	2/24/94	10400	4.017	0.0367	-0.0070	1.57	0.636		
88	B	1/20/93	10100	4.004	0.0418	-0.0085	1.38	0.727		-
0	9	2/20/92	11700	4.068	0.0197	0.0028	1.22	0.618		
1	10	11/25/90	8600	3.934	0.0752	-0.0206	1.10	0.909		
2			Average	Average						
3			18360.000	4.209						
4										-
5										
6										
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0										
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4		1								
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Step 10: Calculate the Sum for the $\{(\log Q - avg(\log Q))^2\}$ and the $\{(\log Q - avg(\log Q))^3\}$ columns.

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12	A	B	C	D	E	F	G	NHS.	E.	14	1 3
	lank	Date of Peak Flow	Ranked Peak Flow Values, O, (cfs)	log Q (cfs)	(log Q - avg(logQ))^2	(log Q - avg(logQ))^3	Return Period (Tr) [(n+1)/m]	Exceedence Probability (1/Tr)			
8	1	11/26/99	23200	4.365	0.0246	0.0039	11.00	0.091			
8	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			1
8	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			1
Į.,	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			-
1	9	2/20/92	11700	4.068	0.0197	-0.0028	1.22	0.618			1
	10	11/25/90	8600	3.934	0.0752	-0.0206	1.10	0.909	-		-
			Average 400c0 000	Average	Sum	Sum					-
			18360.000	4.209	0.477	0.025					-
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Step 11: Calculate the variance , standard deviation , and skew coefficient as follows:

variance =

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

standard deviation =

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

skew coefficient =

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

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

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	Z22	B	= C	D	Ē	F	G	्रम	201	18
		Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)		(log Q - avg(logQ))^2		Return Period (Tr) [(n+1)/m]	Exceedence Probability (1/Tr)		2
2	1	11/25/99	23200	4.365	0.0245	0.0039	11.00	0.091		
10	- 2	12/28/98	32500	4.512	0.0919	0.0279	5.50	0.182		
4	3	12/17/97	10200	4.009	0.0400	-0.0080	3.67	0.273		
5	- 4	11/19/96	28200	4.450	0.0584	0.0141	2.75	0.364		
6	5	2/7/96	32100	4.507	0.0897	0.0264	2.20	0.455		
7	6	1/14/95	16600	4,220	0.0001	0.0000	1.83	0.545		
8.	7	2/24/94	10400	4.017	0.0367	-0.0070	1.57	0.636		
1	8	1/20/93	10100	4.004	0.0418	-0.0085	1.38	0.727		
0	9	2/20/92	11700	4.058	0.0197	-0.0028	1.22	0.818		
1	10	11/25/90	8600	3.934	0.0752	-0.0206	1.10	0.909		
12	11.00		Average	Average	Sum	Sum		0000000		
3			18360.000	4.209	0.477	0.025				
4										
5				EXCEL						
6				FUNCTIONS						
7				VAR	variance	0.0530				
8				STDEV	standard deviation	0.2303				
9				SKEW	skew coefficient	0.2875				
20										
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Skew	coefficier	rt (Ca) t	based o	on log(values	for instanta	aneous pea	kflows					
compu	ted using	the sa	ample d	ata for	the Alse	a at Tidev	vater gage s	station		C.	0.2875		
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The sk	ew coeffi	icient (0	C _m) bas	ed on	the regio	onal data fi	rom the map	b provided			1		
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vv = v((Cn)/[V((-s) + VI	(Cml)										
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Step 12: Calculate weighted skewness

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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.

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ľ,	A	B Date of Peak Flow	C Ranked Peak Flow Values, Q. (cfs)	D log Q (cfs)	E (log Q - avg(logQ))^2	F (log Q – avg(logQ))^3	G Return Period (Tr) [(n+1)/m]	H Exceedence Probability (1/Tr)	1	3	K
ľ	1	11/26/99	23200	4.365	0.0246	0.0039	11.00	0.091			
ľ	2	12/28/98	32500	4.512	0.0919	0.0279	5.50	0.182			
ľ	3	12/17/97	10200	4.009	0.0400	-0.0090	3.67	0.273			
ľ	4	11/19/96	28200	4.450	0.0584	0.0141	275	0.364			
ľ	5	2/7/96	32100	4.507	0.0667	0.0264	2.20	0.455			
ľ	6	1/14/95	16600	4.220	0.0001	0.0000	1.83	0.545			
ľ	7	2/24/94	10400	4.017	0.0367	-0.0070	1.57	0.636			
ľ	8	1/20/93	10100	4.004	0.0418	-0.0095	1.38	0.727			
ľ	9	2/20/92	11700	4.068	0.0197	-0.0029	1.22	0.818			
ľ	10	11/25/90	9600	3.934	0.0752	-0.0206	1.10	0.909			
ľ			Average	Average	Sum	Sum					
l			18360.000	4.209	0.477	0.025					
ł				EXCEL							
L				FUNCTIONS	and a state of the state of the						
L				VAR	variance	0.0530					
ľ				STDEV	standard deviation	0.2303					
ľ				SKEW	skew coefficient	0.2875					
					weighted skew coefficient	0.0762					
	-			Tr	K(0.0)	K(0.1)	slope	K(0.0762)	Q (cfs)		-
t				2	0.000	-0.017	-0.17	-0.013			
ŀ	-			5	0.842	0.836	-0.06	0.837			
ŀ	-			10	1.292	1.292	0.1	1,290	-		
ŀ	-			25	1.751	1.785	0.34	1.777	_		
ŀ	-			25 50	2.054	2.107	0.53	2094			
ŀ	-			100	2.326	2.400	0.35	2.382	-		
ŀ	-			200	2.576	2.670	0.94	2648	_		-
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Step 14: Using the general equation, list the discharges associated with each recurrence interval

general equation =

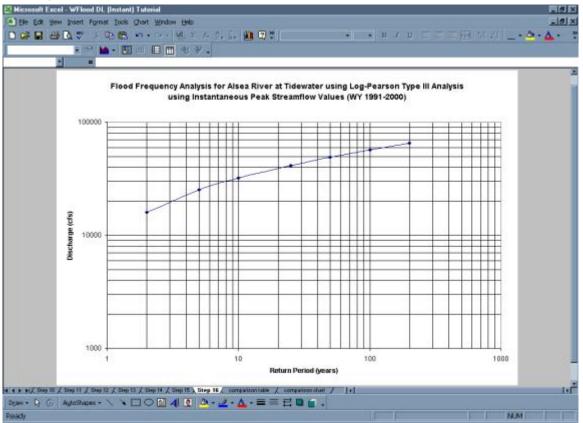
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1	S29	-								
Π	A	B	C	D	E	F	G	н	1 3	
	Rank	Date of Peak Flow	Ranked Peak Flow Values, Q, (cfs)		$(\log Q - avg(logQ))^2$		Return Period (Tr) [(n+1)/m]	Exceedence Probability (1/Tr)		
1	1	11/26/99	23200	4.365	0.0246	0.0039	11.00	0.091		-
ļ	2	12/28/98	32500	4.512	0.0919	0.0279	5.50	0.182		-
-	3	12/17/97 11/19/96	10200	4.009	0.0400	-0.0080 0.0141	3.67	0.273		-
-	4	2/7/96	28200 32100	4.450	0.0584 0.0887	0.0141	2.75	0.354		
-	6	1/14/95	32100	4.507	0.0001	0.0000	1.83	0.665		-
ŀ	3	2/24/94	10400	4.017	0.0367	-0.0070	1.57	0.636		-
ŀ	8	1/20/93	10100	4.004	0.0418	-0.0095	1.39	0.727		-
ŀ	9	2/20/92	11700	4.068	0.0197	-0.0028	1.22	0.818		-
ŀ	10	11/25/90	8600	3.934	0.0752	-0.0206	1.10	0.909		-
ŀ		11180400	Average	Average	Sum	Sum	1.10	0.000		-
ŀ			18360.000	4,209	0.477	0.025				-
Ŀ								-		-
ľ				EXCEL						
Г				FUNCTIONS						
Γ				VAR	variance	0.0530				
				STDEV	standard deviation	0.2303				
Ľ				SKEW	skew coefficient	0.2875				
					weighted skew ceefficient	0.0762				
				Tr	K(0.0)	K(0.1)	slope	K(0.0762)	O (cfs)	-
Ĺ				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	_
Į.				50	2.054	2.107	0.53	2.094	49082	-
L				100	2.326	2.400	0.74	2.382	57179	-
L				200	2.576	2.670	0.94	2.648	85813	-

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

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

30	-									
A	8	C	D.	ŧ	F	G	н	1	1	
lood Frequen	cy Calculations using I (period of record WY 199	og-Pearson Analysis III 91-2000								
Return Period	Skew Coefficient	Discharge								
(years)	K(0.0762)	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	65010								
0.00000	100.02.00	.0.150.970								

Step 16: Create Plot



Analysis Techniques: Flood Frequency Analysis Tutorial with Instantaneous Peak Data from Streamflow Evaluations for Watershed Restoration Planning and Design, http://water.oregonstate.edu/streamflow/, Oregon State University, 2002-2005. - 11 -

• 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.

