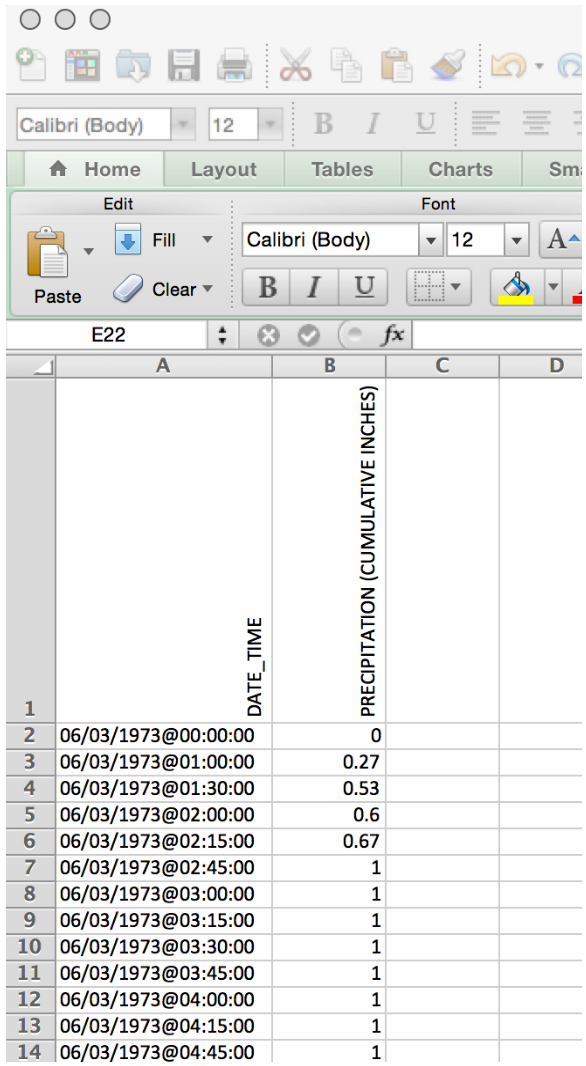
ES3 Exercise 1

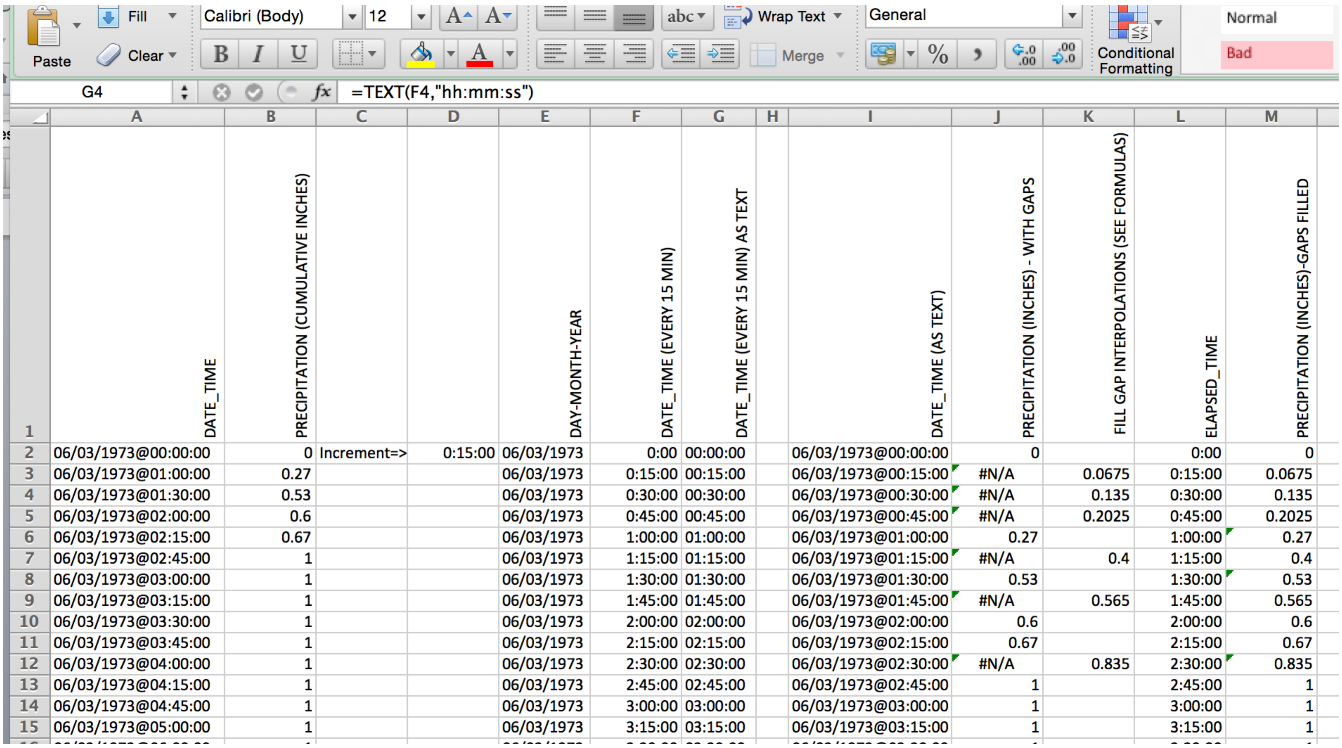
Figure 1 is a portion of the spreadsheet named RainfallData.xlsx that contains cumulative rainfall for a gage in Dallas, Texas. Convert/interpolate the data into 15-minute cumulative rainfall (amount of rainfall every 15 minutes). Be aware the cumulative data is irregular in time (there are variable Δt values in the data).



	A	B
1	DATE_TIME	PRECIPITATION (CUMULATIVE INCHES)
2	06/03/1973@00:00:00	0
3	06/03/1973@01:00:00	0.27
4	06/03/1973@01:30:00	0.53
5	06/03/1973@02:00:00	0.6
6	06/03/1973@02:15:00	0.67
7	06/03/1973@02:45:00	1
8	06/03/1973@03:00:00	1
9	06/03/1973@03:15:00	1
10	06/03/1973@03:30:00	1
11	06/03/1973@03:45:00	1
12	06/03/1973@04:00:00	1
13	06/03/1973@04:15:00	1
14	06/03/1973@04:45:00	1

Figure 1. Rainfall Data

Solution:



G4 =TEXT(F4,"hh:mm:ss")

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	DATE_TIME	PRECIPITATION (CUMULATIVE INCHES)			DAY-MONTH-YEAR	DATE_TIME (EVERY 15 MIN)	DATE_TIME (EVERY 15 MIN) AS TEXT		DATE_TIME (AS TEXT)	PRECIPITATION (INCHES) - WITH GAPS	FILL GAP INTERPOLATIONS (SEE FORMULAS)	ELAPSED_TIME	PRECIPITATION (INCHES)-GAPS FILLED
2	06/03/1973@00:00:00	0	Increment=>	0:15:00	06/03/1973	0:00	00:00:00		06/03/1973@00:00:00	0		0:00	0
3	06/03/1973@01:00:00	0.27			06/03/1973	0:15:00	00:15:00		06/03/1973@00:15:00	#N/A	0.0675	0:15:00	0.0675
4	06/03/1973@01:30:00	0.53			06/03/1973	0:30:00	00:30:00		06/03/1973@00:30:00	#N/A	0.135	0:30:00	0.135
5	06/03/1973@02:00:00	0.6			06/03/1973	0:45:00	00:45:00		06/03/1973@00:45:00	#N/A	0.2025	0:45:00	0.2025
6	06/03/1973@02:15:00	0.67			06/03/1973	1:00:00	01:00:00		06/03/1973@01:00:00	0.27		1:00:00	0.27
7	06/03/1973@02:45:00	1			06/03/1973	1:15:00	01:15:00		06/03/1973@01:15:00	#N/A	0.4	1:15:00	0.4
8	06/03/1973@03:00:00	1			06/03/1973	1:30:00	01:30:00		06/03/1973@01:30:00	0.53		1:30:00	0.53
9	06/03/1973@03:15:00	1			06/03/1973	1:45:00	01:45:00		06/03/1973@01:45:00	#N/A	0.565	1:45:00	0.565
10	06/03/1973@03:30:00	1			06/03/1973	2:00:00	02:00:00		06/03/1973@02:00:00	0.6		2:00:00	0.6
11	06/03/1973@03:45:00	1			06/03/1973	2:15:00	02:15:00		06/03/1973@02:15:00	0.67		2:15:00	0.67
12	06/03/1973@04:00:00	1			06/03/1973	2:30:00	02:30:00		06/03/1973@02:30:00	#N/A	0.835	2:30:00	0.835
13	06/03/1973@04:15:00	1			06/03/1973	2:45:00	02:45:00		06/03/1973@02:45:00	1		2:45:00	1
14	06/03/1973@04:45:00	1			06/03/1973	3:00:00	03:00:00		06/03/1973@03:00:00	1		3:00:00	1
15	06/03/1973@05:00:00	1			06/03/1973	3:15:00	03:15:00		06/03/1973@03:15:00	1		3:15:00	1

Figure 2. Data conversion spreadsheet

First need to deal with the time step. We want data every 15 minutes, so build a column that has a row every 15 minutes.[1]

Column F in the above spreadsheet has its first numeric row set as "00:00:00" Cell D2 has its numeric value set as "00:15:00". Column F3 has the formula "=F2 + $D$2". The rest of the cells below F3 are simply this formula copied which returns in the column an HH:MM:SS value every 15 minutes.

Column G then converts these numeric values into TEXT for assembly into a DATE_TIME_AS_TEXT which is used to find the data gaps.

Column I is the result of CONCATENATE(E2,"@",G2) and so on copied down. Column I is compared to Column A to find the missing data.

Column J is where the compare is made.

For example J2 contains the formula "=INDEX($B$2:$B$69,MATCH(I2,$A$2:$A$69,0))"
This formula returns the value in the array $B$2:$B$69 from row determined by MATCH(I2,$A$2:$A$69,0). If I2 does not appear in the array $A$2:$A$69, then the result is #N/A

[1] Alternatively one can process the data in a Jupyter Notebook. Herein we are using Excel as a visual alternative.

which identifies the locations in time of missing values. The formula is copied down to complete the column.

The gaps are filled by linear interpolation. For example there are 3 blocks of missing values in rows 3-5. Thus the linear interpolation model would take the difference between the two known values and divide that by 4 (3+1) then add this value to construct the filled gap interpolations.

D14

	I	J	K	L	M
1	DATE_TIME (AS TEXT)	PRECIPITATION (INCHES) - WITH GAPS	FILL GAP INTERPOLATIONS (SEE FORMULAS)	ELAPSED_TIME	
2	=CONCATENATE(E2,"@",G2)	=INDEX($B$2:$B$69,MAT(		0	=J2
3	=CONCATENATE(E3,"@",G3)	=INDEX($B$2:$B$69,MAT(	=(1/4)*(J6-J2)+J2	=L2+$D$2	=K3
4	=CONCATENATE(E4,"@",G4)	=INDEX($B$2:$B$69,MAT(	=(2/4)*(J6-J2)+J2	=L3+$D$2	=K4
5	=CONCATENATE(E5,"@",G5)	=INDEX($B$2:$B$69,MAT(	=(3/4)*(J6-J2)+J2	=L4+$D$2	=K5
6	=CONCATENATE(E6,"@",G6)	=INDEX($B$2:$B$69,MAT(		=L5+$D$2	=J6
7	=CONCATENATE(E7,"@",G7)	=INDEX($B$2:$B$69,MAT(	=AVERAGE(J6,J8)	=L6+$D$2	=K7
8	=CONCATENATE(E8,"@",G8)	=INDEX($B$2:$B$69,MAT(		=L7+$D$2	=J8

Figure 3 Interpolation Calculation

Exercise 2.

Convert the 15-minute cumulative rainfall into 15-minute incremental rainfall.

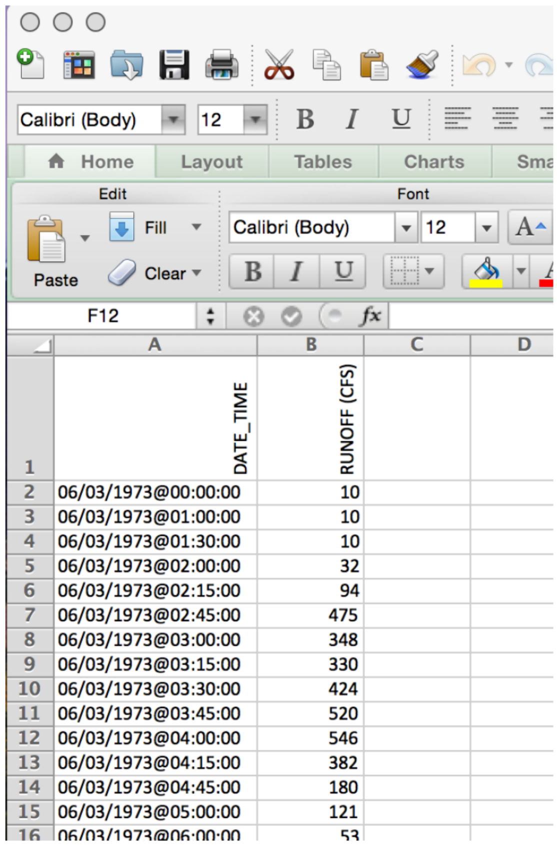
Once the data are in 15-minute intervals the conversion from cumulative to incremental is by differencing as shown below.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	DATE_TIME	PRECIPITATION (CUMULATIVE INCHES)			DAY-MONTH-YEAR	DATE_TIME (EVERY 15 MIN)	DATE_TIME (EVERY 15 MIN) AS TEXT		DATE_TIME (AS TEXT)	PRECIPITATION (INCHES) - WITH GAPS	FILL GAP INTERPOLATIONS (SEE FORMULAS)	ELAPSED_TIME	PRECIPITATION (INCHES)-GAPS FILLED	PRECIPITATION INCREMENTAL (INCHES/15MIN)	=(M3-M2)
2	06/03/1973@00:00:00	0	Increment=	0:15:00	06/03/1973	0:00	00:00:00		06/03/1973@00:00:00	0		0:00	0	0.0675	
3	06/03/1973@01:00:00	0.27			06/03/1973	0:15:00	00:15:00		06/03/1973@00:15:00	#N/A	0.068	0:15:00	0.0675	0.0675	
4	06/03/1973@01:30:00	0.53			06/03/1973	0:30:00	00:30:00		06/03/1973@00:30:00	#N/A	0.135	0:30:00	0.135	0.0675	
5	06/03/1973@02:00:00	0.6			06/03/1973	0:45:00	00:45:00		06/03/1973@00:45:00	#N/A	0.203	0:45:00	0.2025	0.0675	
6	06/03/1973@02:15:00	0.67			06/03/1973	1:00:00	01:00:00		06/03/1973@01:00:00	0.27		1:00:00	0.27	0.13	
7	06/03/1973@02:45:00	1			06/03/1973	1:15:00	01:15:00		06/03/1973@01:15:00	#N/A	0.4	1:15:00	0.4	0.13	
8	06/03/1973@03:00:00	1			06/03/1973	1:30:00	01:30:00		06/03/1973@01:30:00	0.53		1:30:00	0.53	0.035	

Figure 4. Differencing to obtain incremental rainfall

Exercise 3

Figure 2 is a portion of the spreadsheet named RunoffData.xlsx that contains runoff for a gage in Dallas, Texas as specific moments in time. Convert/interpolate the data into 15-minute cumulative runoff. The drainage area is 6.92 miles. Express the result in watershed inches of runoff. Be aware the data is irregular in time (there are variable Δt values in the data).



	A	B	C	D
1	DATE_TIME	RUNOFF (CFS)		
2	06/03/1973@00:00:00	10		
3	06/03/1973@01:00:00	10		
4	06/03/1973@01:30:00	10		
5	06/03/1973@02:00:00	32		
6	06/03/1973@02:15:00	94		
7	06/03/1973@02:45:00	475		
8	06/03/1973@03:00:00	348		
9	06/03/1973@03:15:00	330		
10	06/03/1973@03:30:00	424		
11	06/03/1973@03:45:00	520		
12	06/03/1973@04:00:00	546		
13	06/03/1973@04:15:00	382		
14	06/03/1973@04:45:00	180		
15	06/03/1973@05:00:00	121		
16	06/03/1973@06:00:00	53		

Figure 2: Portion of Runoff Data spreadsheet.

Using the same kind of computations and table searches as Exercise 1 the result is shown below. The only substantial difference is the meaning of the data –this data is runoff in CFS rather than cumulative rainfall.

M147 | fx =K147

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	DATE_TIME	RUNOFF (CFS)			DAY-MONTH-YEAR	DATE_TIME (EVERY 15 MIN)	DATE_TIME (EVERY 15 MIN) AS TEXT		DATE_TIME (AS TEXT)	RUNOFF (CFS) - WITH GAPS		ELAPSED_TIME (MINUTES)	RUNOFF (CFS)-GAPS FILLED	
2	06/03/1973@00:00:00	10	Increment=>	0:15:00	06/03/1973	0:00	00:00:00		06/03/1973@	10		0.00	10	
3	06/03/1973@01:00:00	10			06/03/1973	0:15:00	00:15:00		06/03/1973@	#N/A	10	15.00	10	
4	06/03/1973@01:30:00	10			06/03/1973	0:30:00	00:30:00		06/03/1973@	#N/A	10	30.00	10	
5	06/03/1973@02:00:00	32			06/03/1973	0:45:00	00:45:00		06/03/1973@	#N/A	10	45.00	10	
6	06/03/1973@02:15:00	94			06/03/1973	1:00:00	01:00:00		06/03/1973@	10		60.00	10	
7	06/03/1973@02:45:00	475			06/03/1973	1:15:00	01:15:00		06/03/1973@	#N/A	10	75.00	10	
8	06/03/1973@03:00:00	348			06/03/1973	1:30:00	01:30:00		06/03/1973@	10		90.00	10	
9	06/03/1973@03:15:00	330			06/03/1973	1:45:00	01:45:00		06/03/1973@	#N/A	21	105.00	21	
10	06/03/1973@03:30:00	424			06/03/1973	2:00:00	02:00:00		06/03/1973@	32		120.00	32	
11	06/03/1973@03:45:00	520			06/03/1973	2:15:00	02:15:00		06/03/1973@	94		135.00	94	
12	06/03/1973@04:00:00	546			06/03/1973	2:30:00	02:30:00		06/03/1973@	#N/A	284.5	150.00	284.5	
13	06/03/1973@04:15:00	382			06/03/1973	2:45:00	02:45:00		06/03/1973@	475		165.00	475	
14	06/03/1973@04:45:00	180			06/03/1973	3:00:00	03:00:00		06/03/1973@	348		180.00	348	
15	06/03/1973@05:00:00	121			06/03/1973	3:15:00	03:15:00		06/03/1973@	330		195.00	330	
16	06/03/1973@06:00:00	53			06/03/1973	3:30:00	03:30:00		06/03/1973@	424		210.00	424	
17	06/03/1973@06:15:00	47			06/03/1973	3:45:00	03:45:00		06/03/1973@	520		225.00	520	

Figure 5. Runoff Data processed into 15-minute increments

The next step is to convert the values into cumulative watershed inches.

Generally the approach is to take the runoff in CFS and convert into cubic inches per second, then take the cubic inches per second and divide by the area in inches squared to recover runoff in watershed inches per second. Lastly multiply by the time interval length (15 minutes) and accumulate to obtain the runoff in cumulative watershed inches.

The result is shown in Figure 6 and the formulas in Figure 7.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	DATE_TIME	RUNOFF (CFS)			DAY-MONTH-YEAR	DATE_TIME (EVERY 15 MIN)	DATE_TIME (EVERY 15 MIN) AS TEXT		DATE_TIME (AS TEXT)	RUNOFF (CFS) - WITH GAPS		ELAPSED_TIME (MINUTES)	RUNOFF (CFS)-GAPS FILLED	RUNOFF (CUBIC INCHES/SEC)	RUNOFF/AREA (INCHES/SEC)	CUM RUNOFF (INCHES)
2	06/03/1973@00:00:00	10	Incre	######	06/03/1	0:00	00:00:00		06/03/	10		0.00	10	17280	6.22024E-07	0
3	06/03/1973@01:00:00	10			06/03/1	######	00:15:00		06/03/	#N/A	10	15.00	10	17280	6.22024E-07	0.00055982
4	06/03/1973@01:30:00	10			06/03/1	######	00:30:00		06/03/	#N/A	10	30.00	10	17280	6.22024E-07	0.00111964
5	06/03/1973@02:00:00	32			06/03/1	######	00:45:00		06/03/	#N/A	10	45.00	10	17280	6.22024E-07	0.00167947
6	06/03/1973@02:15:00	94			06/03/1	######	01:00:00		06/03/	10		60.00	10	17280	6.22024E-07	0.00223929
7	06/03/1973@02:45:00	475			06/03/1	######	01:15:00		06/03/	#N/A	10	75.00	10	17280	6.22024E-07	0.00279911
8	06/03/1973@03:00:00	348			06/03/1	######	01:30:00		06/03/	10		90.00	10	17280	6.22024E-07	0.00335893
9	06/03/1973@03:15:00	330			06/03/1	######	01:45:00		06/03/	#N/A	21	105.00	21	36288	1.30625E-06	0.00391875
10	06/03/1973@03:30:00	424			06/03/1	######	02:00:00		06/03/	32		120.00	32	55296	1.99048E-06	0.00509438
11	06/03/1973@03:45:00	520			06/03/1	######	02:15:00		06/03/	94		135.00	94	162432	5.84703E-06	0.00688581
12	06/03/1973@04:00:00	546			06/03/1	######	02:30:00		06/03/	#N/A	284.5	150.00	284.5	491616	1.76966E-05	0.01214813
13	06/03/1973@04:15:00	382			06/03/1	######	02:45:00		06/03/	475		165.00	475	820800	2.95462E-05	0.02807506
14	06/03/1973@04:45:00	180			06/03/1	######	03:00:00		06/03/	348		180.00	348	601344	2.16464E-05	0.0546666

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Figure 6. Runoff in watershed inches

	F	G	H	I	J	K	L	M	N	O	P
1	DATE_TIME (EVERY 15 MIN)	DATE_TIME (EVERY 15 MIN) AS TEXT		DATE_TIME (AS TEXT)	RUNOFF (CFS) - WITH GAPS		ELAPSED_TIME (MINUTES)	RUNOFF (CFS)-GAPS FILLED	RUNOFF (CUBIC INCHES/SEC)	RUNOFF/AREA (INCHES/SEC)	CUM RUNOFF (INCHES)
2	0	=TEXT(F2,"hh:n		=CONCATENAT	=INDEX($B$2		0	=J2	=M2*(12*12*12)	=N2/(6.92*640*43560*144)	0
3	=F2+$D$2	=TEXT(F3,"hh:n		=CONCATENAT	=INDEX($B$2	=(1/4)*(J$6-J$	=15+L2	=K3	=M3*(12*12*12)	=N3/(6.92*640*43560*144)	=O2*(15*60)+P2
4	=F3+$D$2	=TEXT(F4,"hh:n		=CONCATENAT	=INDEX($B$2	=(1/4)*(J$6-J$	=15+L3	=K4	=M4*(12*12*12)	=N4/(6.92*640*43560*144)	=O3*(15*60)+P3
5	=F4+$D$2	=TEXT(F5,"hh:n		=CONCATENAT	=INDEX($B$2	=(1/4)*(J$6-J$	=15+L4	=K5	=M5*(12*12*12)	=N5/(6.92*640*43560*144)	=O4*(15*60)+P4
6	=F5+$D$2	=TEXT(F6,"hh:n		=CONCATENAT	=INDEX($B$2		=15+L5	=J6	=M6*(12*12*12)	=N6/(6.92*640*43560*144)	=O5*(15*60)+P5
7	=F6+$D$2	=TEXT(F7,"hh:n		=CONCATENAT	=INDEX($B$2	=AVERAGE(J6,	=15+L6	=K7	=M7*(12*12*12)	=N7/(6.92*640*43560*144)	=O6*(15*60)+P6
8	=F7+$D$2	=TEXT(F8,"hh:n		=CONCATENAT	=INDEX($B$2		=15+L7	=J8	=M8*(12*12*12)	=N8/(6.92*640*43560*144)	=O7*(15*60)+P7
9	=F8+$D$2	=TEXT(F9,"hh:n		=CONCATENAT	=INDEX($B$2	=AVERAGE(J8,	=15+L8	=K9	=M9*(12*12*12)	=N9/(6.92*640*43560*144)	=O8*(15*60)+P8
10	=F9+$D$2	=TEXT(F10,"hh:		=CONCATENAT	=INDEX($B$2		=15+L9	=J10	=M10*(12*12*12)	=N10/(6.92*640*43560*144)	=O9*(15*60)+P9
11	=F10+$D$2	=TEXT(F11,"hh:		=CONCATENAT	=INDEX($B$2		=15+L10	=J11	=M11*(12*12*12)	=N11/(6.92*640*43560*144)	=O10*(15*60)+P10
12	=F11+$D$2	=TEXT(F12,"hh:		=CONCATENAT	=INDEX($B$2	=AVERAGE(J1	=15+L11	=K12	=M12*(12*12*12)	=N12/(6.92*640*43560*144)	=O11*(15*60)+P11
13	=F12+$D$2	=TEXT(F13,"hh:		=CONCATENAT	=INDEX($B$2		=15+L12	=J13	=M13*(12*12*12)	=N13/(6.92*640*43560*144)	=O12*(15*60)+P12
14	=F13+$D$2	=TEXT(F14,"hh:		=CONCATENAT	=INDEX($B$2		=15+L13	=J14	=M14*(12*12*12)	=N14/(6.92*640*43560*144)	=O13*(15*60)+P13
15	=F14+$D$2	=TEXT(F15,"hh:		=CONCATENAT	=INDEX($B$2		=15+L14	=J15	=M15*(12*12*12)	=N15/(6.92*640*43560*144)	=O14*(15*60)+P14

Figure 7. Formulas to convert various values

Exercise 4

Plot the 15-minute cumulative rainfall and the 15-minute cumulative runoff (in watershed inches) on the same time axis. What do these plots look like?

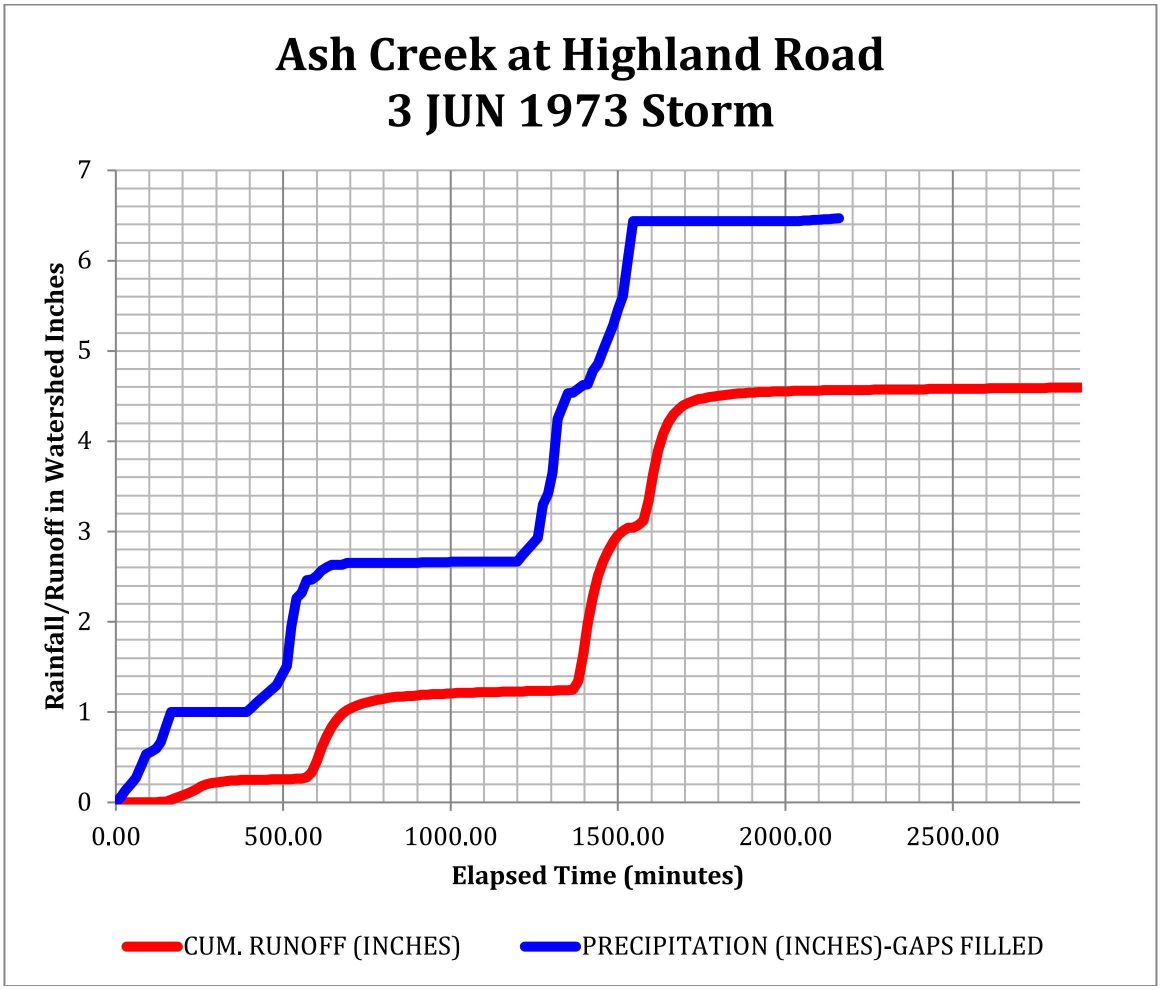


Figure 8. Plot of Rainfall and Runoff in Watershed Inches

The plots have similar shape. The runoff lags the rainfall (i.e. rainfall happens before runoff responds). Also, the total depth of runoff is less that total depth of rainfall (as anticipated because the rainfall must at least equal or exceed the runoff).

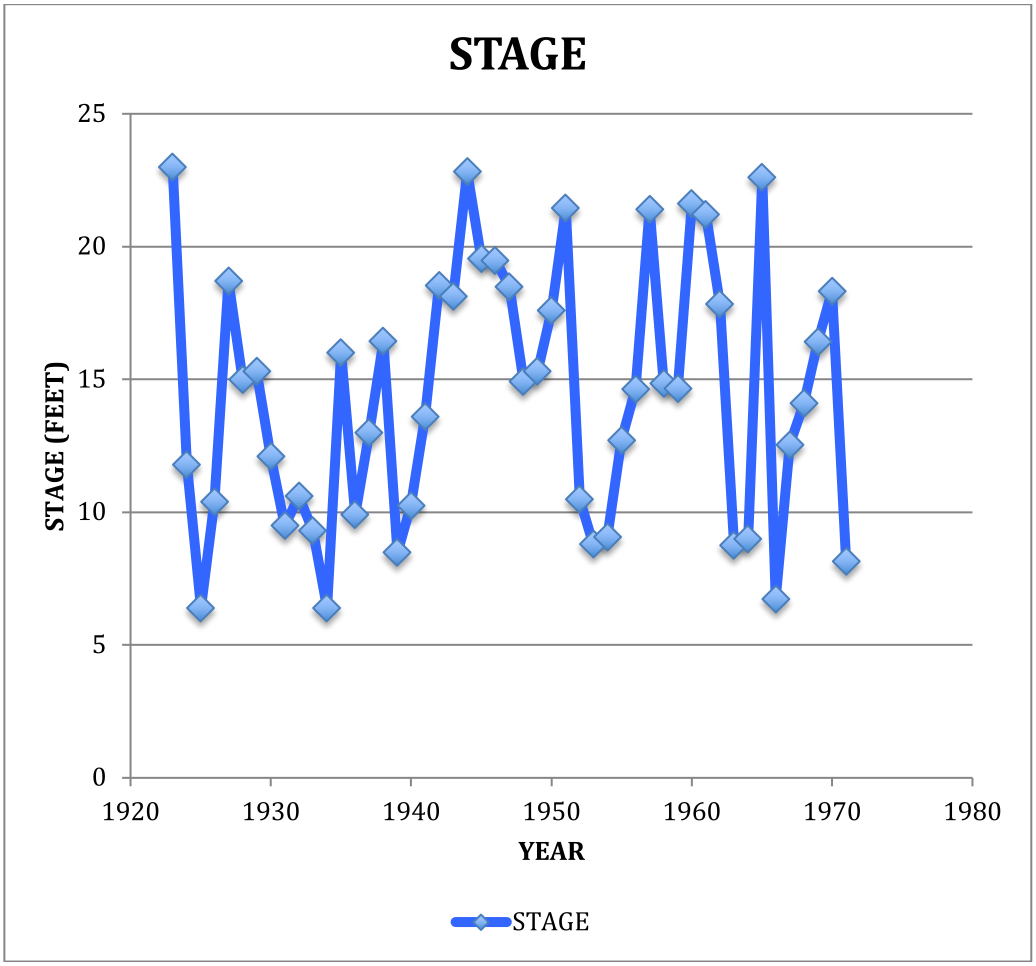
Exercise 5.

The following data represent gage height and annual peak discharge for some gaging station in Oklahoma. The stage is in feet and the discharge is in cubic feet per second. The data are sequential from 1923 through 1971.

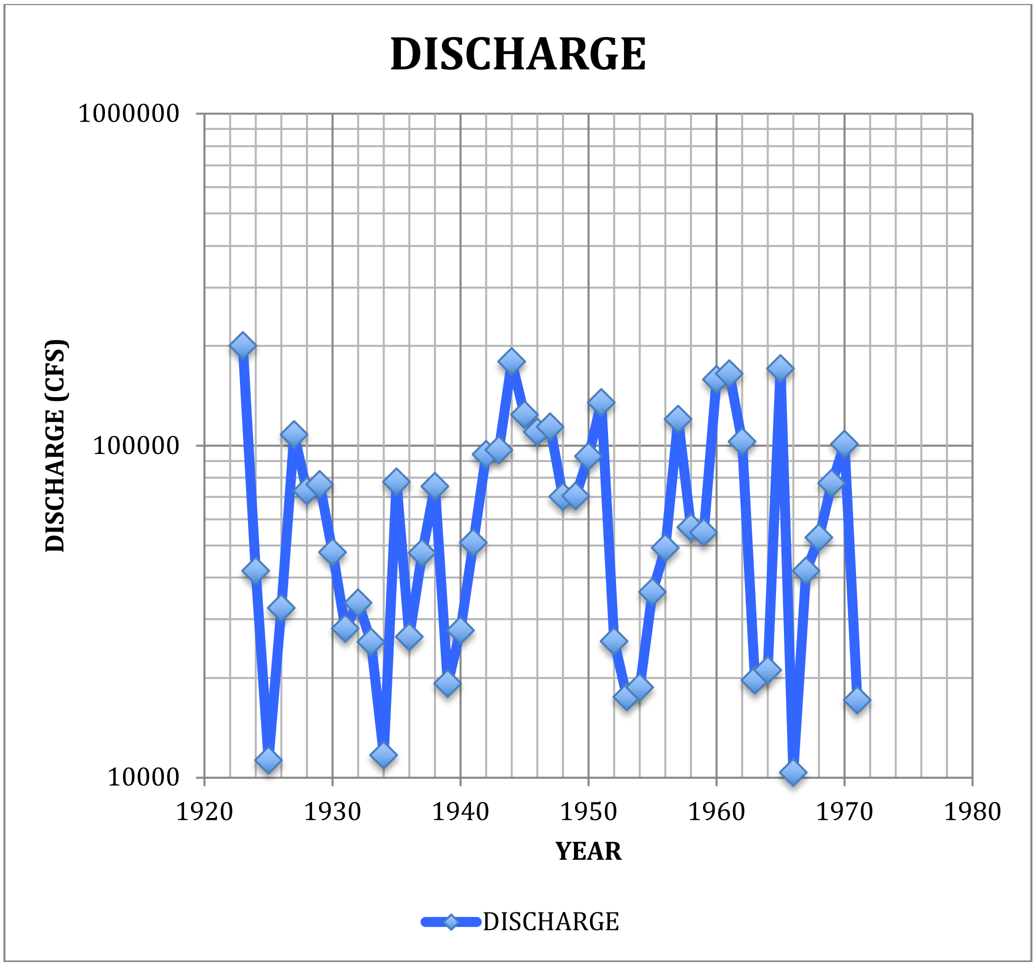
Stage	Discharge	Stage	Discharge
23.0	200,000	18.50	114,000
11.8	42,000	14.93	70,200
6.4	11,300	15.30	70,700
10.4	32,400	17.60	92,800
18.7	108,000	21.45	135,000
15.0	73,000	10.48	25,800
15.3	76,500	8.80	17,500
12.1	47,800	9.07	18,700
9.5	28,200	12.71	36,300
10.6	33,700	14.64	49,200
9.3	25,700	21.41	120,000
6.4	11,700	14.86	56,800
16.0	77,800	14.65	54,800
9.9	26,600	21.62	158,000
13.0	47,500	21.22	165,000
16.44	75,600	17.83	103,000
8.48	19,200	8.76	19,700
10.26	27,800	9.00	21,100
13.59	51,000	22.60	171,000
18.54	94,000	6.74	10,400
18.12	97,200	12.54	42,000
22.82	179,000	14.10	52,800
19.55	124,000	16.42	77,000
19.48	110,000	18.33	101,000
		8.14	17,100

From these data:

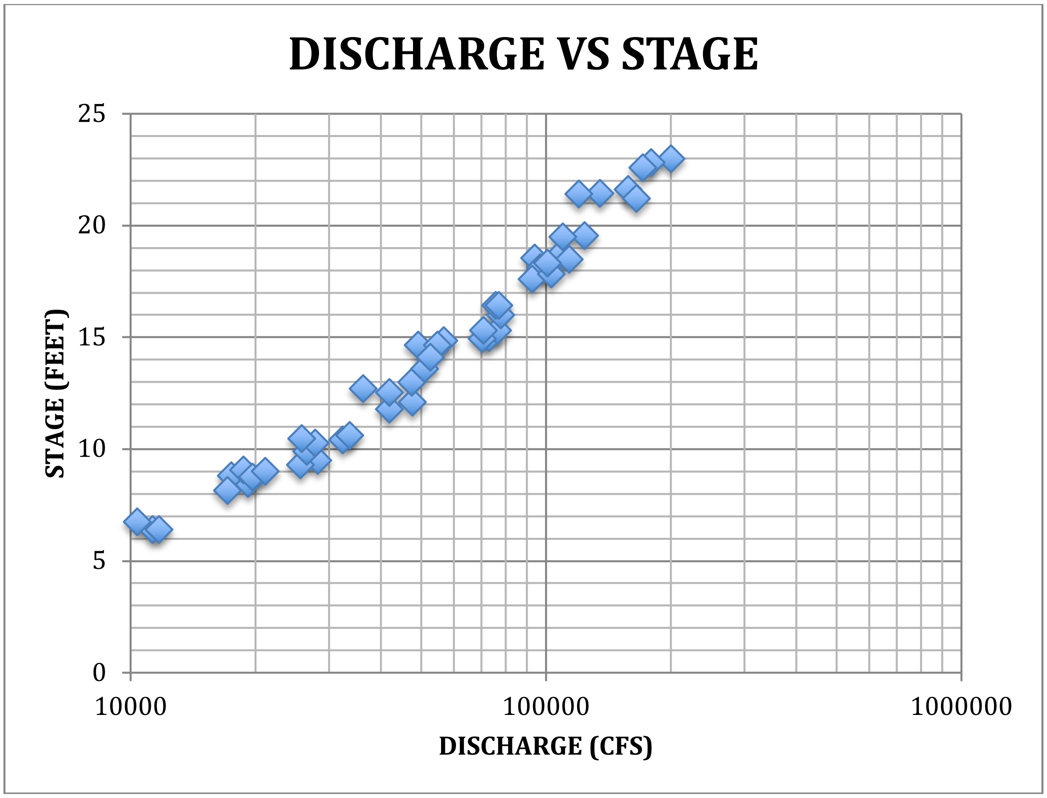
a) Plot year versus stage



b) Plot the year versus discharge.



c) Plot discharge versus stage[2]



[2] This plot is called a rating curve; stage is easy to measure, discharge is not.

d) Using the Weibull plotting position formula, determine the distribution parameters that fit the data for a log-normal distribution.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1									T-year	Probabilit	Value	LogNormal	Gumbell
2									4	0.75	90514	0.750	
3									4	0.75	82200		0.750
4													
5					COUNT	49	49						
6					COUNT+1	50	50		LOGNORM	GUMBELL		GAMMA	
7					MEAN	69793.9	4.723	MU =>	4.723	54418	<=ALPHA	1.504528	<=ALPHA
8					STDEV	49537.5	0.34625	SIGMA =>	0.34625	22291	<=BETA	48525.822	<=BETA
9													
10												0.0256187	<= SSE
11	YEAR	STAGE	DISCHARGE		RANK	Q (SORTED	Log10(Q)	WEIBULL-I	LNORM-PI	GUMBELL-	GAMMA-PP		
12	1923	23	200000		1	10400	4.01703	0.02	0.02073	0.00074	0.06506	0.0020304	
13	1924	11.8	42000		2	11300	4.05308	0.04	0.02651	0.00099	0.07292	0.0010835	
14	1925	6.4	11300		3	11700	4.06819	0.06	0.0293	0.00112	0.07647	0.0002711	
	1926	10.4	32400		4	17100	4.233	0.08	0.07851	0.00482	0.12688	0.0021977	
shot	1927	18.7	108000		5	17500	4.24304	0.1	0.08285	0.0053	0.13075	0.0009455	
17	1928	15	73000		6	18700	4.27184	0.12	0.09629	0.00698	0.14243	0.0005031	
18	1929	15.3	76500		7	19200	4.2833	0.14	0.10206	0.00779	0.14732	5.365E-05	
19	1930	12.1	47800		8	19700	4.29447	0.16	0.10792	0.00868	0.15223	6.032E-05	
20	1931	9.5	28200		9	21100	4.32428	0.18	0.12476	0.01159	0.16604	0.0001949	
21	1932	10.6	33700		10	25700	4.40993	0.2	0.18295	0.0266	0.2117	0.0001369	
22	1933	9.3	25700		11	25800	4.41162	0.22	0.18425	0.02704	0.2127	5.335E-05	
23	1934	6.4	11700		12	26600	4.42488	0.24	0.19462	0.03071	0.22064	0.0003749	
24	1935	16	77800		13	27800	4.44404	0.26	0.21022	0.03686	0.23253	0.0007545	
25	1936	9.9	26600		14	28200	4.45025	0.28	0.21543	0.03909	0.23649	0.0018933	
26	1937	13	47500		15	32400	4.51055	0.3	0.26975	0.06821	0.27771	0.0004969	
27	1938	16.44	75600		16	33700	4.52763	0.32	0.2863	0.07941	0.29031	0.0008815	
28	1939	8.48	19200		17	36300	4.55991	0.34	0.31881	0.10496	0.31523	0.0006137	
29	1940	10.26	27800		18	42000	4.62325	0.36	0.38664	0.17454	0.36828	6.853E-05	
30	1941	13.59	51000		19	42000	4.62325	0.38	0.38664	0.17454	0.36828	0.0001374	
31	1942	18.54	94000		20	47500	4.67669	0.4	0.44681	0.25566	0.41708	0.0002917	
32	1943	18.12	97200		21	47800	4.67943	0.42	0.44993	0.26037	0.41967	1.104E-07	
33	1944	22.82	179000		22	49200	4.69197	0.44	0.46429	0.28259	0.43164	6.981E-05	
34	1945	19.55	124000		23	51000	4.70757	0.46	0.48223	0.3117	0.44679	0.0001745	
35	1946	19.48	110000		24	52800	4.72263	0.48	0.49958	0.3412	0.46165	0.0003368	
36	1947	18.5	114000		25	54800	4.73878	0.5	0.51818	0.37418	0.47781	0.0004924	
37	1948	14.93	70200		26	56800	4.75435	0.52	0.53607	0.40712	0.49361	0.0006964	
38	1949	15.3	70700		27	70200	4.84634	0.54	0.63916	0.61102	0.59005	0.0025047	
39	1950	17.6	92800		28	70700	4.84942	0.56	0.64249	0.61773	0.59333	0.001111	
40	1951	21.45	135000		29	73000	4.86332	0.58	0.65736	0.6476	0.60816	0.000793	
41	1952	10.48	25800		30	75600	4.87852	0.6	0.67335	0.67933	0.62437	0.0005939	
42	1953	8.8	17500		31	76500	4.88366	0.62	0.67868	0.68981	0.62985	9.694E-05	
43	1954	9.07	18700		32	77000	4.88649	0.64	0.6816	0.69551	0.63286	5.1E-05	
44	1955	12.71	36300		33	77800	4.89098	0.66	0.68622	0.70447	0.63763	0.0005002	
45	1956	14.64	49200		34	92800	4.96755	0.68	0.76	0.83633	0.71767	0.0014189	
46	1957	21.41	120000		35	94000	4.97313	0.7	0.76498	0.8442	0.72333	0.0005444	
47	1958	14.86	56800		36	97200	4.98767	0.72	0.77768	0.86354	0.73794	0.0003219	
48	1959	14.65	54800		37	101000	5.00432	0.74	0.79175	0.88363	0.75438	0.0002067	
49	1960	21.62	158000		38	103000	5.01284	0.76	0.79873	0.89306	0.76264	6.983E-06	
50	1961	21.22	165000		39	108000	5.03342	0.78	0.81502	0.91359	0.78221	4.864E-06	
51	1962	17.83	103000		40	110000	5.04139	0.8	0.8211	0.9207	0.78961	0.000108	
52	1963	8.76	19700		41	114000	5.0569	0.82	0.83257	0.93328	0.80371	0.0002653	
53	1964	9	21100		42	120000	5.07918	0.84	0.84819	0.94861	0.82323	0.0002812	
54	1965	22.6	171000		43	124000	5.09342	0.86	0.85765	0.95687	0.83522	0.0006143	
55	1966	6.74	10400		44	135000	5.13033	0.88	0.88029	0.97344	0.86435	0.0002449	
56	1967	12.54	42000		45	158000	5.19866	0.9	0.91524	0.99045	0.91024	0.0001048	
57	1968	14.1	52800		46	165000	5.21748	0.92	0.92337	0.99302	0.92095	9.017E-07	
58	1969	16.42	77000		47	171000	5.233	0.94	0.92962	0.99466	0.92914	0.0001179	
59	1970	18.33	101000		48	179000	5.25285	0.96	0.93703	0.99627	0.93879	0.0004497	

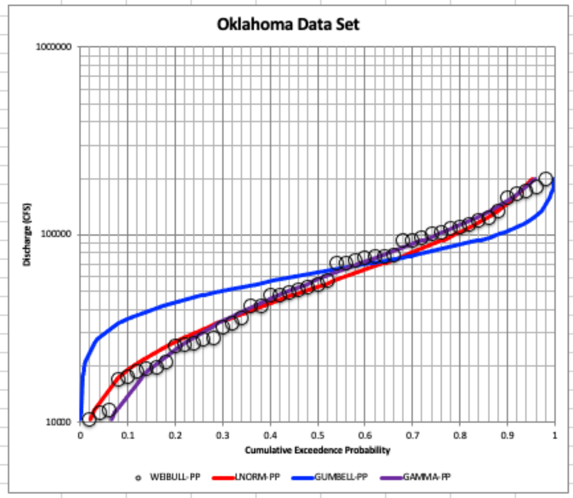


Figure 9. Plotting position and distribution fits for discharge

For log-normal, MEAN=4.72297; ST.DEV=0.346248

e) Using the Weibull plotting position formula, determine the distribution parameters that fit the data for a Gumbel distribution.

For Gumbel, ALPHA=54418; BETA=22291 (Using the approximations from Barfield, Hayes, Haan)

f) Using the Weibull plotting position formula, determine the distribution parameters that fit the data for a Gamma distribution.

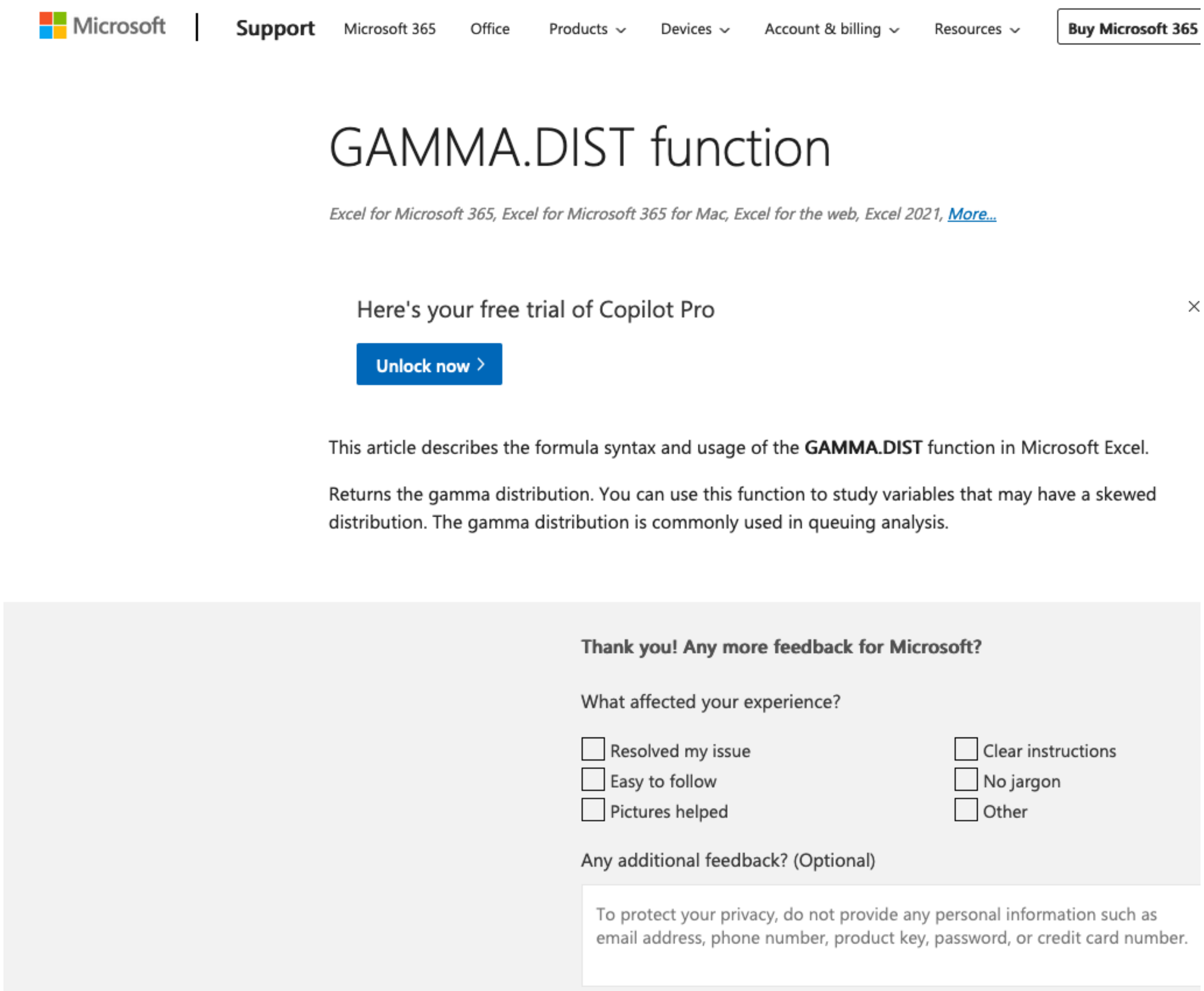


Figure 10. MS Article explaining how to access Gamma Distribution

Using the GAMMA.DIST function and solver to fit to the data (use $\alpha = 1$, β = mean(x) as initial guess)

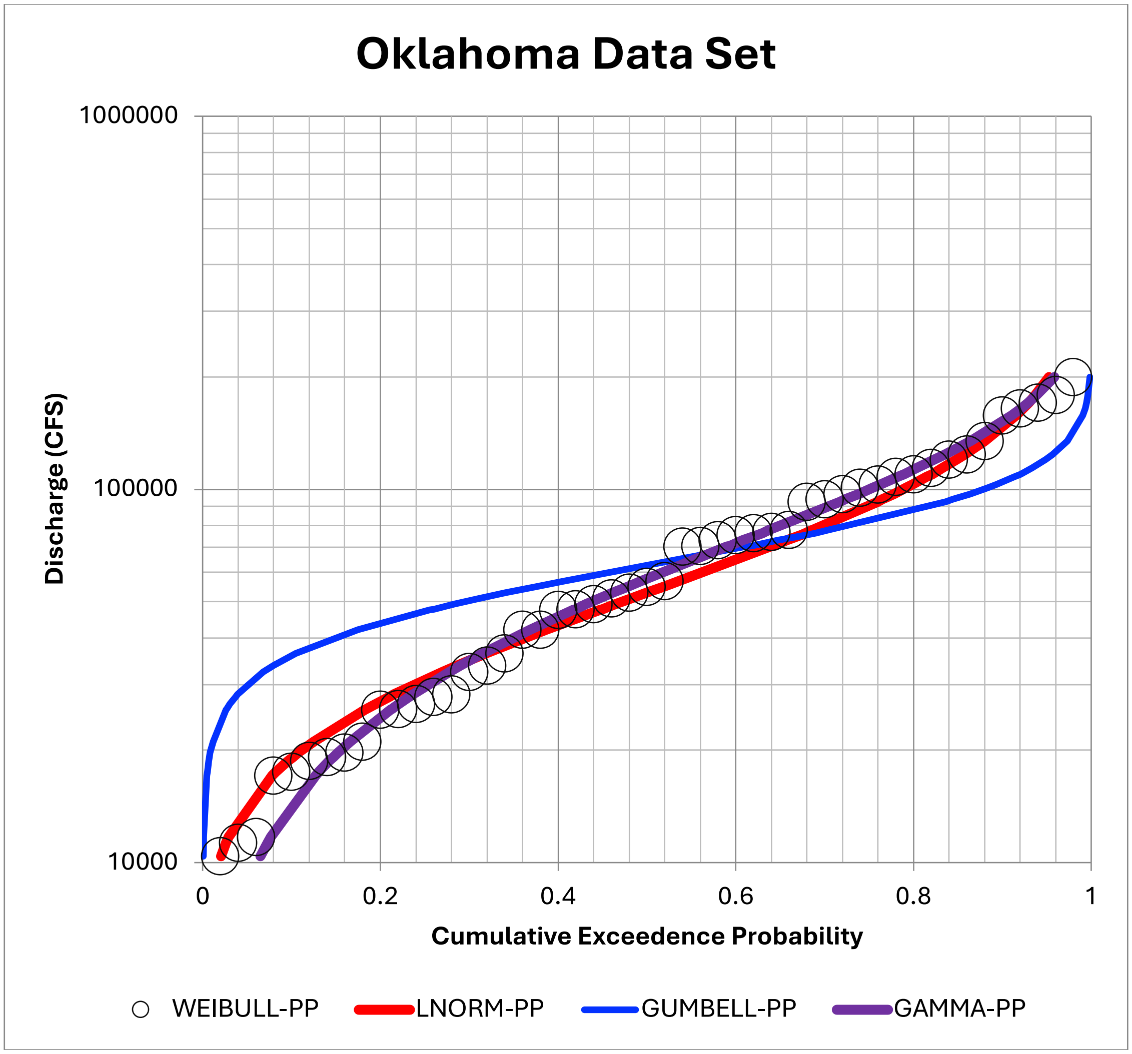
Fitted values for the data are: ALPHA=1.504528; BETA=48525.8821

g) Estimate the discharge associated with 25-percent chance exceedance probability (i.e. 1 in 4 chance in any given year)

Use the fitted values and the particular distribution to find the quantile that produces a non-exceedance probability of 0.75 (In the plots herein, the probability axis is non-exceedance)

- If log-normal is the model, Q = 90,514 cfs [=NORM.DIST(LOG10(K2),$I$7,$I$8,1)]
- If Gumbel is the model, Q = 82,000 cfs [=EXP(-EXP(-(K3-$J$7)/($J$8)))]
- If Gamma is the model, Q= 99,988 cfs [=GAMMA.DIST(K4,$L$7,$L$8,TRUE)]

The Excel function call is shown in the square brackets.



From plot the Gamma model fits this data set the bestest.

h) A resident claims that in the early 1900's a flood corresponding to a stage of 30 feet occurred at the gage location. Estimate the exceedance probability (return period) of the flow associated with this event.

   Stage =30 is beyond range of observations, so need to fit a probability distribution to stage. Use same worksheet, just change data source to stage instead of discharge.

E6

	A	B	C	D	E	F	G	H	I	J	K	L	M
1					T-year	Probability	Value	LogNormal	Gumbell	Gamma			
2					2	0.500	30	0.986	1.000	0.984			
3					75	0.987	30	0.986	1.000	0.984			
4					69	0.986	30	0.986	1.000	0.984			
5					61	0.984	30	0.986	1.000	0.984			
6													
7													
8					COUNT	49	49						
9					COUNT+1	50	50		LOGNORM	GUMBELL		GAMMA	
10					MEAN	14.41592	1.132858	MU =>	1.132858	11.24004544	<=ALPHA	6.350424881	<=ALPHA
11					STDEV	4.819566	0.155984	SIGMA =>	0.155984	2.16880489	<=BETA	2.33023861	<=BETA
shot	.176091												
13										SSE	0.045929		
14	YEAR	STAGE	DISCHARGI	RANK	STAGE (SC	Log10(STA(	WEIBULL-P	LNORM-PP	GUMBELL-	GAMMA-PP			
15	1923	23	200000	1	6.4	0.80618	0.02	0.018116	9E-05	0.04327715	0.000542		
16	1924	11.8	42000	2	6.4	0.80618	0.04	0.018116	9E-05	0.04327715	1.07E-05		
17	1925	6.4	11300	3	6.74	0.82866	0.06	0.025577	0.000348	0.053385102	4.38E-05		
18	1926	10.4	32400	4	8.14	0.910624	0.08	0.077119	0.015358	0.109057416	0.000844		
19	1927	18.7	108000	5	8.48	0.928396	0.1	0.094964	0.028151	0.125891551	0.00067		
20	1928	15	73000	6	8.76	0.942504	0.12	0.111168	0.04338	0.140655919	0.000427		
21	1929	15.3	76500	7	8.8	0.944483	0.14	0.113589	0.04594	0.142829027	8E-06		
22	1930	12.1	47800	8	9	0.954243	0.16	0.126086	0.060262	0.153925972	3.69E-05		
23	1931	9.5	28200	9	9.07	0.957607	0.18	0.130609	0.065885	0.157898958	0.000488		
24	1932	10.6	33700	10	9.3	0.968483	0.2	0.145989	0.086625	0.171265434	0.000826		
25	1933	9.3	25700	11	9.5	0.977724	0.22	0.159977	0.107455	0.183261039	0.00135		
26	1934	6.4	11700	12	9.9	0.995635	0.24	0.189505	0.156456	0.208209808	0.001011		
27	1935	16	77800	13	10.26	1.011147	0.26	0.217614	0.207782	0.231640432	0.000804		
28	1936	9.9	26600	14	10.4	1.017033	0.28	0.22888	0.229227	0.24097357	0.001523		
29	1937	13	47500	15	10.48	1.020361	0.3	0.235391	0.241787	0.246357651	0.002878		
30	1938	16.44	75600	16	10.6	1.025306	0.32	0.245252	0.260988	0.25449927	0.00429		
31	1939	8.48	19200	17	11.8	1.071882	0.34	0.347932	0.461879	0.339182312	6.69E-07		
32	1940	10.26	27800	18	12.1	1.082785	0.36	0.374101	0.510348	0.360937307	8.79E-07		
33	1941	13.59	51000	19	12.54	1.098298	0.38	0.412327	0.577442	0.392979626	0.000168		
34	1942	18.54	94000	20	12.71	1.104146	0.4	0.426979	0.60185	0.405362097	2.88E-05		
35	1943	18.12	97200	21	13	1.113943	0.42	0.451743	0.641339	0.426439158	4.15E-05		
36	1944	22.82	179000	22	13.59	1.133219	0.44	0.500925	0.71291	0.468932982	0.000837		
37	1945	19.55	124000	23	14.1	1.149219	0.46	0.541769	0.765299	0.504973763	0.002023		
38	1946	19.48	110000	24	14.64	1.165541	0.48	0.582983	0.811775	0.54214937	0.003863		
39	1947	18.5	114000	25	14.65	1.165838	0.5	0.583725	0.812554	0.542826667	0.001834		
40	1948	14.93	70200	26	14.86	1.172019	0.52	0.599116	0.82827	0.556947797	0.001365		
41	1949	15.3	70700	27	14.93	1.17406	0.54	0.604165	0.833241	0.561610245	0.000467		
42	1950	17.6	92800	28	15	1.176091	0.56	0.609174	0.838083	0.566249652	3.91E-05		
43	1951	21.45	135000	29	15.3	1.184691	0.58	0.63017	0.857427	0.585861977	3.44E-05		

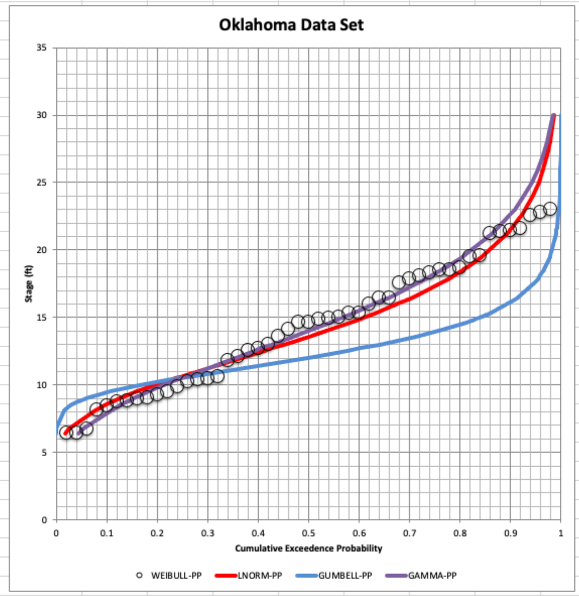


Figure 11. Analysis using Stage

From the stage analysis above, the resident's claim is plausible – it corresponds to about a 69-year event (using lognormal) or 61-year event using Gamma.

As already stated, Gamma is probably better model this data, so the residents claim would be around the **61-year** event.

Addendum

Probably would fit Log-Gamma as that is the Log-Pearson distribution. The result would look like:

E	F	G	H	I	J	K	L	M
T-year	Probability	Value	LogNormal	Gumbell	Gamma			
2	0.500	30	0.986	1.000	1			
75	0.987	30	0.986	1.000	1			
69	0.986	30	0.986	1.000	1			
23	0.957	30	0.986	1.000	0.958649686			
COUNT	49	49						
COUNT+1	50	50		LOGNORM	GUMBELL		GAMMA	
MEAN	14.41592	1.132858	MU =>	1.132858	11.24004544	<=ALPHA	40.93272752	<=ALPHA
STDEV	4.819566	0.155984	SIGMA =>	0.155984	2.16880489	<=BETA	0.028042778	<=BETA

ot .176091

A	B	C	D	E	F	G	H	I	J	K
									SSE	0.082131
YEAR	STAGE	DISCHARGI	RANK	STAGE (SC	Log10(STA(	WEIBULL-P	LNORM-PP	GUMBELL-	GAMMA-PP	
1923	23	200000	1	6.4	0.80618	0.02	0.018116	9E-05	0.018694029	1.71E-06
1924	11.8	42000	2	6.4	0.80618	0.04	0.018116	9E-05	0.018694029	0.000454
1925	6.4	11300	3	6.74	0.82866	0.06	0.025577	0.000348	0.027179169	0.001077
1926	10.4	32400	4	8.14	0.910624	0.08	0.077119	0.015358	0.08484649	2.35E-05
1927	18.7	108000	5	8.48	0.928396	0.1	0.094964	0.028151	0.104147325	1.72E-05
1928	15	73000	6	8.76	0.942504	0.12	0.111168	0.04338	0.121384536	1.92E-06
1929	15.3	76500	7	8.8	0.944483	0.14	0.113589	0.04594	0.123938678	0.000258
1930	12.1	47800	8	9	0.954243	0.16	0.126086	0.060262	0.137030042	0.000528
1931	9.5	28200	9	9.07	0.957607	0.18	0.130609	0.065885	0.141732649	0.001464
1932	10.6	33700	10	9.3	0.968483	0.2	0.145989	0.086625	0.1575906	0.001799
1933	9.3	25700	11	9.5	0.977724	0.22	0.159977	0.107455	0.17184382	0.002319
1934	6.4	11700	12	9.9	0.995635	0.24	0.189505	0.156456	0.201443694	0.001487
1935	16	77800	13	10.26	1.011147	0.26	0.217614	0.207782	0.229068484	0.000957
1936	9.9	26600	14	10.4	1.017033	0.28	0.22888	0.229227	0.240002406	0.0016
1937	13	47500	15	10.48	1.020361	0.3	0.235391	0.241787	0.246288838	0.002885
1938	16.44	75600	16	10.6	1.025306	0.32	0.245252	0.260988	0.255763591	0.004126
1939	8.48	19200	17	11.8	1.071882	0.34	0.347932	0.461879	0.351668526	0.000136
1940	10.26	27800	18	12.1	1.082785	0.36	0.374101	0.510348	0.375447837	0.000239
1941	13.59	51000	19	12.54	1.098298	0.38	0.412327	0.577442	0.409804705	0.000888
1942	18.54	94000	20	12.71	1.104146	0.4	0.426979	0.60185	0.422869019	0.000523
1943	18.12	97200	21	13	1.113943	0.42	0.451743	0.641339	0.444836585	0.000617
1944	22.82	179000	22	13.59	1.133219	0.44	0.500925	0.71291	0.488110642	0.002315
1945	19.55	124000	23	14.1	1.149219	0.46	0.541769	0.765299	0.523785606	0.004069
1946	19.48	110000	24	14.64	1.165541	0.48	0.582983	0.811775	0.559645857	0.006343
1947	18.5	114000	25	14.65	1.165838	0.5	0.583725	0.812554	0.560290698	0.003635
1948	14.93	70200	26	14.86	1.172019	0.52	0.599116	0.82827	0.573668057	0.00288
1949	15.3	70700	27	14.93	1.17406	0.54	0.604165	0.833241	0.578057167	0.001448
1950	17.6	92800	28	15	1.176091	0.56	0.609174	0.838083	0.582411118	0.000502
1951	21.45	135000	29	15.3	1.184691	0.58	0.63017	0.857427	0.600671279	0.000427

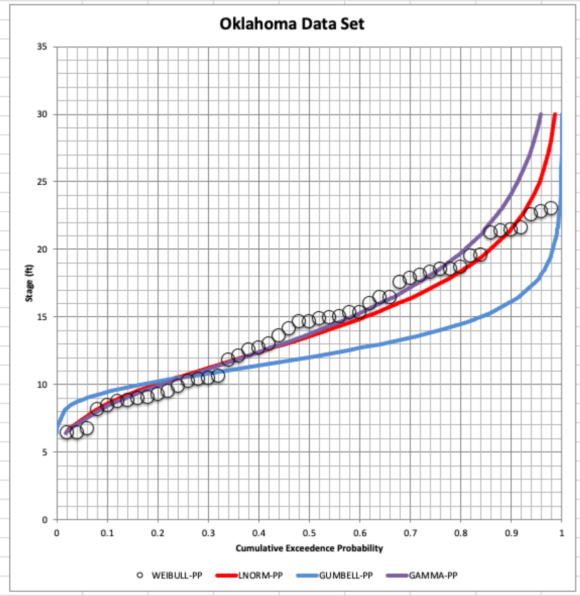


Figure 12. Log-Gamma Analysis