Water Quality Laboratory, Heidelberg College
http://wql-data.heidelberg.edu/index2.html 9/27/05

2.c. Concentration Exceedency Curves

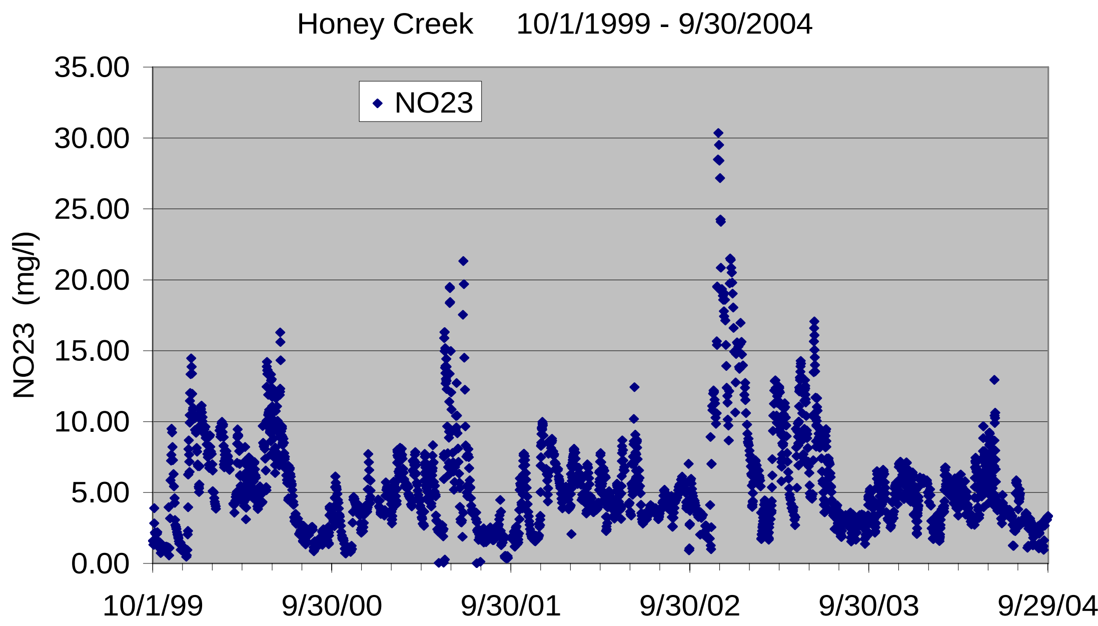
Introduction

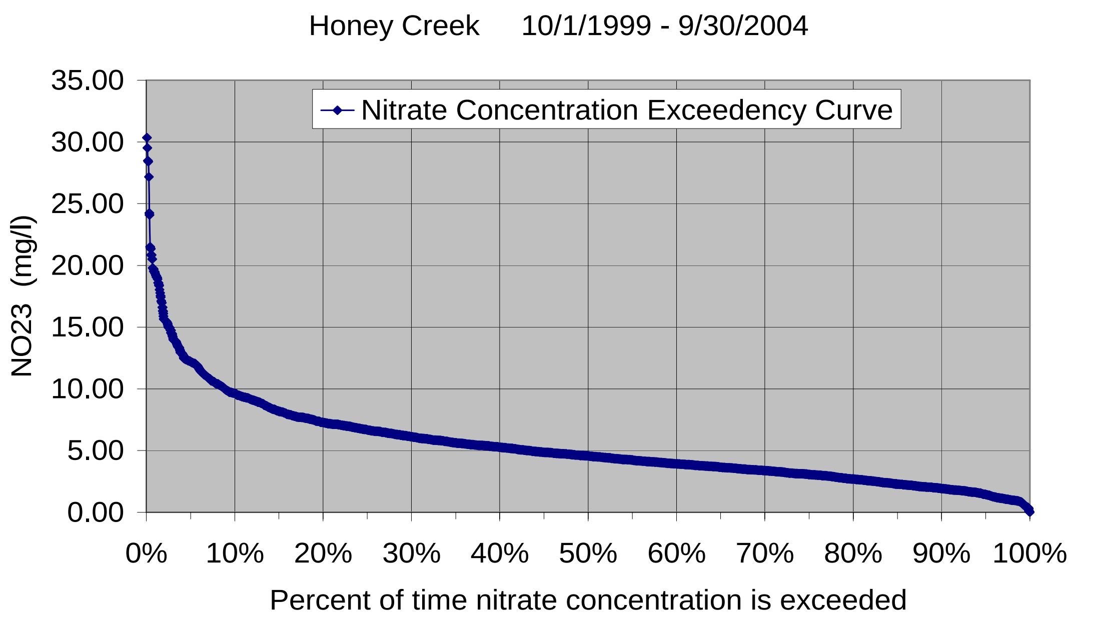
This five-year chemograph for nitrate concentrations in Honey Creek indicates that the drinking water standard of 10 mg/L was frequently exceeded. It is reasonable to ask, “What percentage of the time did nitrate concentrations exceed 10 mg/L in Honey Creek?” It is rather difficult to estimate this percentage of time by examining the five-year chemograph. A much easier procedure is to construct a concentration exceedency curve, using the same data that are included in the five-year chemograph.

In a concentration exceedency curve, the data from the selected time interval are ranked from the highest to the lowest concentration. For each sample, the percentage of time that its concentration was exceeded is calculated. The concentration exceedency graph is plotted showing the nitrate concentrations on the y-axis and the percentage of time the concentration was exceeded on the x-axis. In general, the resulting graphs show that high concentrations are exceeded a low percentage of the time and low concentrations are exceeded a high percentage of the time.

The adjacent graph for nitrate shows that a concentration of 10mg/L (y-axis) is exceeded about 9% of the time (x-axis). From the Excel files used to generate the graph, a more exact figure of 9.09% of the time can be determined. The graph also shows that the nitrate concentration exceeded 50% of the time (x-axis) is about 4.5 mg/L (y-axis). From the files used to generate the graph, a value of 4.59 is indicated.

Concentration exceedency curves serve many purposes. They show not only the percentage of time concentrations exceed a particular value, but also the percentage of time concentrations fall within a particular range of values. They can also be used to compare concentrations among various rivers.



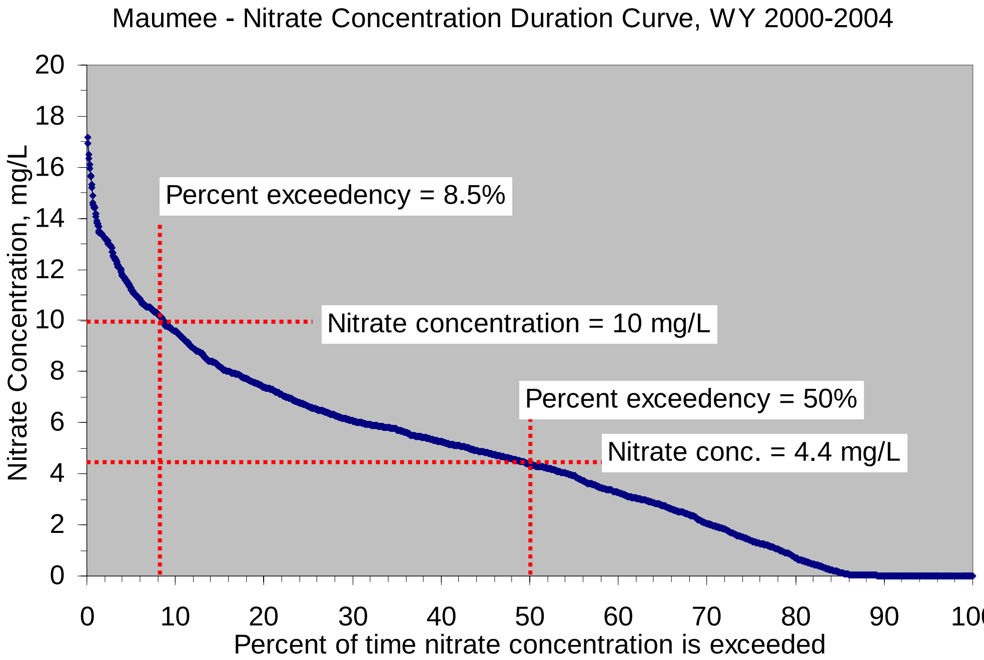


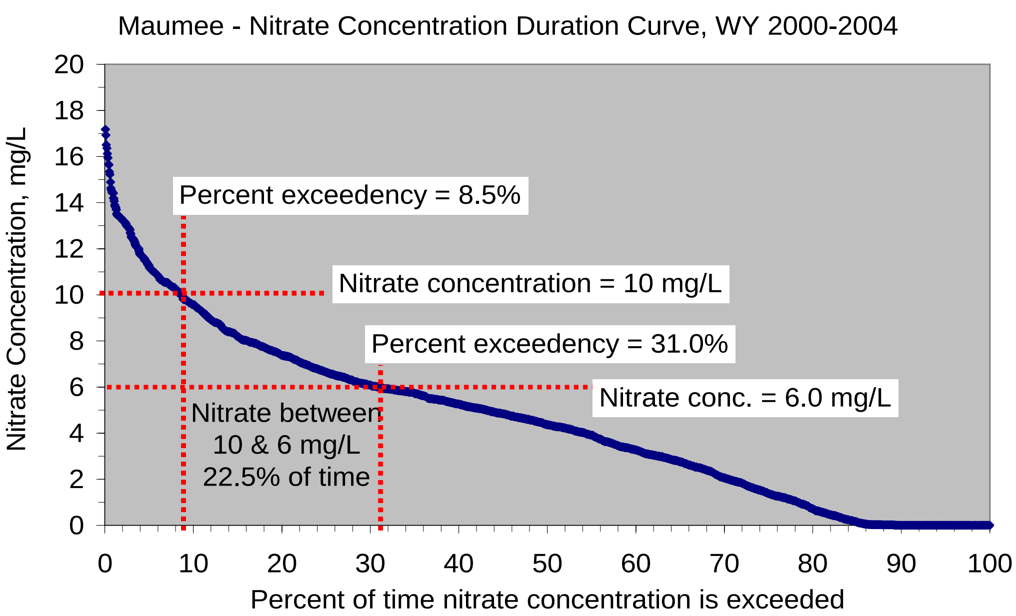
Interpreting Concentration Exceedency Graphs

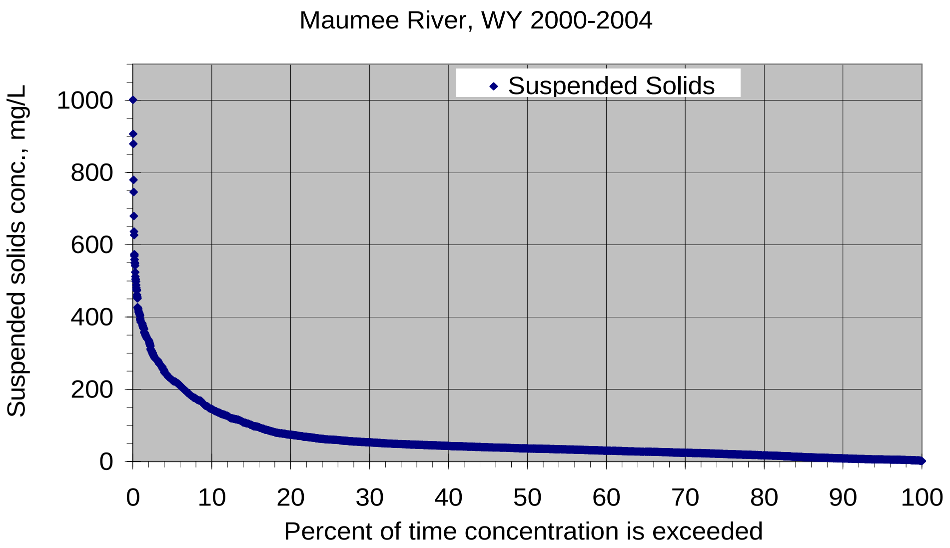
A nitrate concentration exceedency graph for the Maumee River for the five year period including water years 2000 to 2004 is shown on the adjacent graph. During this time period, nitrate concentrations exceeded 10 mg/L about 8.5% of the time. The graph illustrates that concentrations greater than 10 mg/L occurred 8.5% of the time and that concentrations were below 10 mg/L about 91.5% of the time (100% - 8.5%).

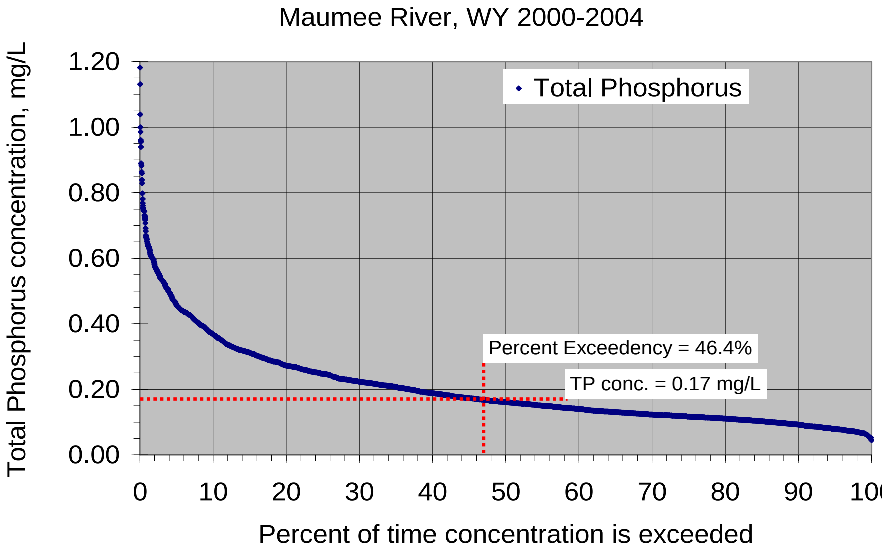
In the Maumee River for this time period, 50% of the time the nitrate concentration was above 4.4 mg/L. Any combination of nitrate concentration and percent exceedency can be read from the graph.

Concentration exceedency curves can also be used to determine the percent of time the concentrations fall within a particular range of values. For example, in the Maumee River, concentrations of 10 mg/L were exceeded 8.5% of the time. Concentrations of 6 mg/L were exceeded 31.0% of the time. Therefore concentrations fell between 10 mg/L and 6 mg/L for 22.5% of the time during that 5 year interval.





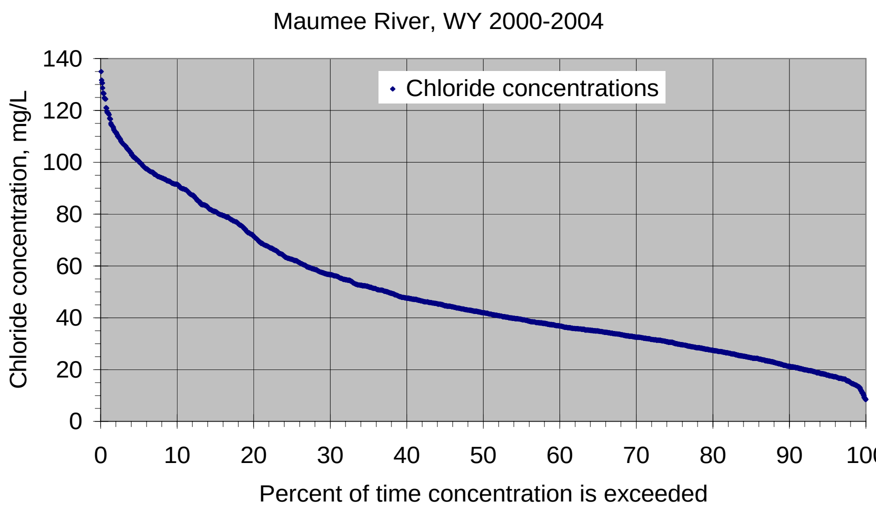




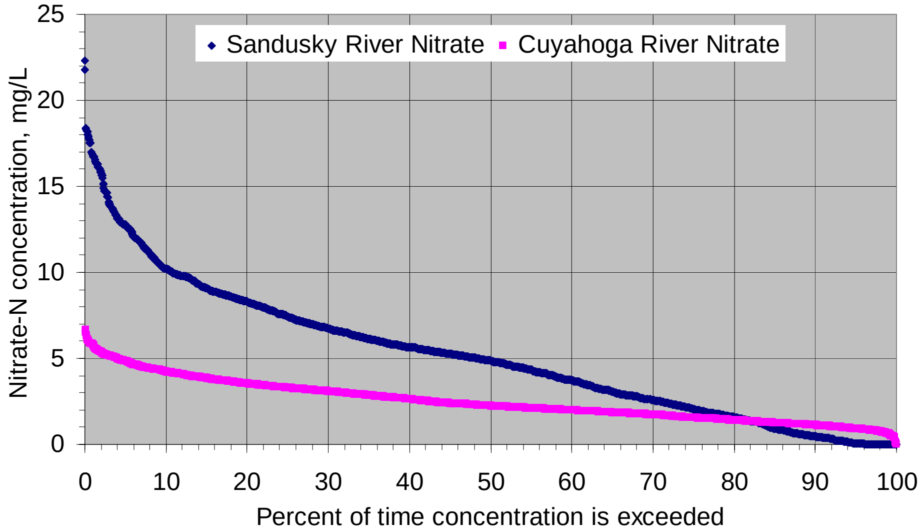
Some Examples of Concentration Exceedency Graphs

These three graphs illustrate concentration exceedency graphs for suspended solids, total phosphorus, and chloride for the Maumee River during the 5 year period, WY 2000-2004. The shapes of the three curves differ in terms of the steepness of the concentration drop during the low percent exceedency ranges. For suspended solids, the concentrations drop very quickly during the first 10% of the exceedency scale, while for chloride the drop is much less. The rate of decline for total phosphorus is intermediate relative to suspended solids and chloride. The causes of these differences will be explored elsewhere in this analysis.

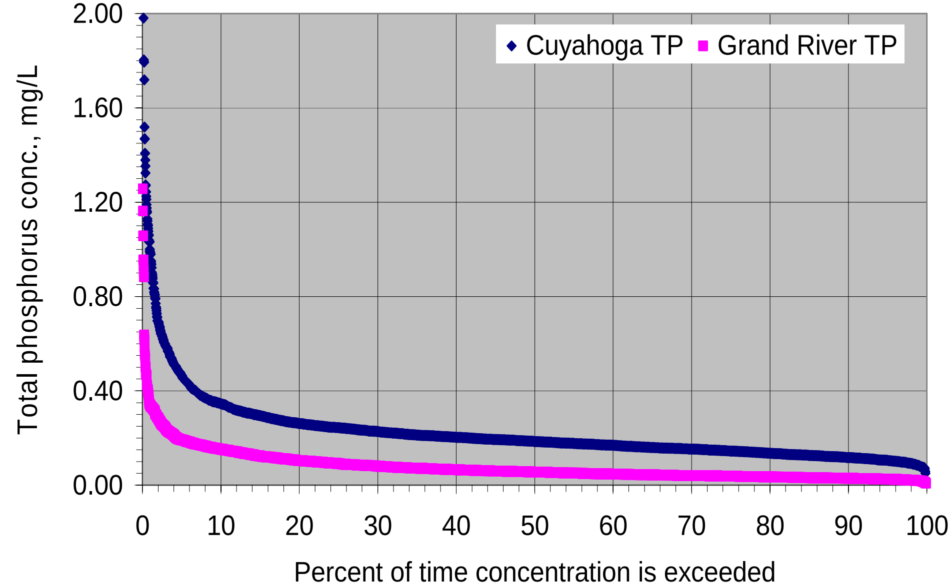
On the graph for total phosphorus, the percent of time the concentration exceeds a target level of 0.17 mg/L is shown.



Nitrate in the Sandusky and Cuyahoga Rivers, WY 2000-0004



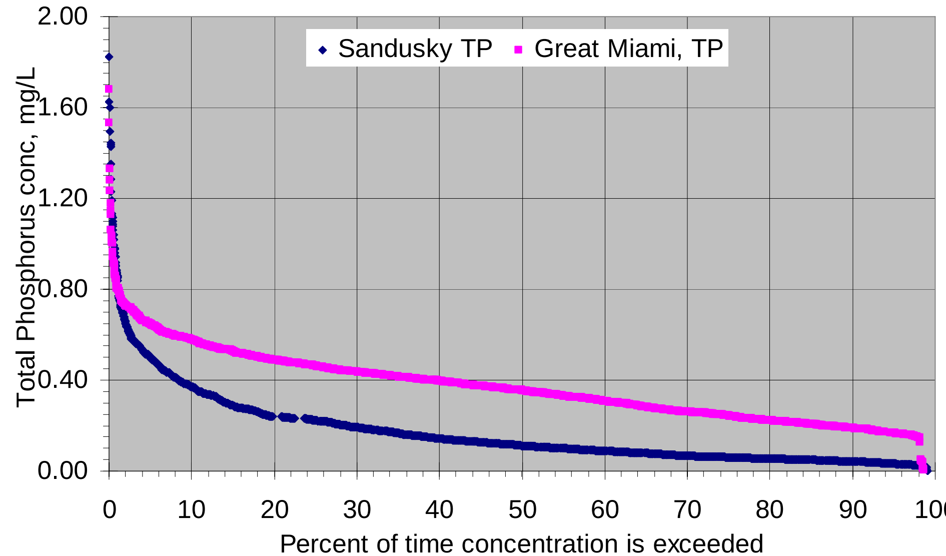
Total Phosphorus in the Cuyahoga and Grand Rivers, WY 2000-04



Using Concentration Exceedency Curves to Compare Rivers

Concentration exceedency curves can be used to compare concentrations of chemicals among various rivers. The above graph shows the nitrate concentrations for the Sandusky and Cuyahoga Rivers. The nitrate concentrations are much higher in the Sandusky River with its agricultural watershed than in the Cuyahoga River with its largely urban and forested watershed. To the right, total phosphorus concentrations are compared for two pairs of rivers -- the Cuyahoga and the Grand, and the Sandusky and the Great Miami. Watersheds of both the Cuyahoga and the Great Miami have high population densities. The Sandusky and Great Miami watersheds are dominated by agricultural land uses, while the Grand River watershed is mostly forested and has a low population density. Phosphorus removal at municipal sewage treatment plants is greater in the Lake Erie tributaries (Cuyahoga, Grand and Sandusky). These factors all contribute to the significant differences among the phosphorus concentration exceedency curves for these four rivers.

Total Phosphorus Concentrations
in the Sandusky and Great Miami Rivers



Plotting issues and instructions

If each sample represented the same length of time, such as one day, constructing concentration exceedency curves would be easy. The samples need only be ranked and the percentile distribution calculated. Since the samples included in the tributary loading program represent time windows of variable duration, calculation of exceedency curves includes additional steps. These steps are shown for the Honey Creek Nitrate Curve from the Introduction.

1. Select and copy the nitrate concentration data and the sample time window data for the station and dates that you want. In the Honey Creek example the columns contained 2,518 samples during the 5-year period. Only the first six samples and the last sample from the file are shown here.

2. Paste those columns into a new Excel work sheet.

3. Select both columns and sort the data by decreasing nitrate concentrations. Both columns are selected so that the time window for each sample remains with that sample in the ranked data sets. Note that none of the samples shown in #2 were among the six samples (3) with the highest nitrate concentration in the data set of 2,536 samples.

4. Calculate the cumulative time through the ranked data. For each sample, the cumulative time is equal to the time for that sample plus the cumulative time for the previous samples. The equations for the calculations are shown adjacent to the cumulative time.

5. Calculate the percent time exceedency by dividing the cumulative time values (column C) by the total time (the final cumulative value ((C2519)) in the data set). The total time is 1,764.17 days. Multiply the quotient by 100 to convert to percentage. The final table indicates that a concentration of 24.25 was exceeded 0.33% of the time.

6. Plot Nitrate concentration (Column A) on Y-axis and Percent Exceed (column D) on X-axis to produce the concentration exceedency graph.

Note- The AnalysisTemplatev3 includes an exceedency plotting option.

1

Datetime	Days since 741001	Time Window ▼	Flow	SS	TP	SRP	NO23 ▼	TKN	Chloride
10/01/1999 12:00	9131.50	1.00	5.267	4.8	0.079	0.034	1.59	0.58	27.1
10/02/1999 12:00	9132.50	1.00	3.799	2.4	0.076	0.034	1.33	0.58	28.5
10/03/1999 12:00	9133.50	0.83	3.570	5.0	0.078	0.032	1.32	0.57	29.0
10/04/1999 04:00	9134.17	0.50	6.442	10.7	5.370	0.123	3.90	3.81	65.3
10/04/1999 12:00	9134.50	0.67	5.659	8.9	0.735	0.671	2.84	1.51	50.0
10/05/1999 12:00	9135.50	1.00	4.484	3.7	0.119	0.049	2.18	0.59	29.7
09/30/2004 12:00	10957.50	1.00	4.484	1.0	0.059	0.040	3.35	0.62	29.9

2

	A	B
1	NO23	Time Window
2	1.59	1.00
3	1.33	1.00
4	1.32	0.83
5	3.90	0.50
6	2.84	0.67
7	2.18	1.00
2519	3.35	1.00

3

	A	B
1	NO23	Time Window
2	30.35	1.00
3	29.51	1.00
4	28.48	1.00
5	28.40	1.00
6	27.17	1.00
7	24.25	0.83
2519	0.02	0.83

4

	A	B	C	
1	NO23	Time Window	Cum Time	C formula
2	30.35	1.00	1.00	=B2
3	29.51	1.00	2.00	=B3+C2
4	28.48	1.00	3.00	=B4+C3
5	28.40	1.00	4.00	=B5+C4
6	27.17	1.00	5.00	=B6+C5
7	24.25	0.83	5.83	=B7+C6
2519	0.02	0.83	1764.17	=B2519+C2518

5

	A	B	C	D	
1	NO23	Time Window	Cum Time	% Exceed	D formula
2	30.35	1.00	1.00	0.06	=(C2/1764.17)*100
3	29.51	1.00	2.00	0.11	=(C3/1764.17)*100
4	28.48	1.00	3.00	0.17	=(C4/1764.17)*100
5	28.40	1.00	4.00	0.23	=(C5/1764.17)*100
6	27.17	1.00	5.00	0.28	=(C6/1764.17)*100
7	24.25	0.83	5.83	0.33	=(C7/1764.17)*100
2519	0.02	0.83	1764.17	100.00	=(C2519/1764.17)*100