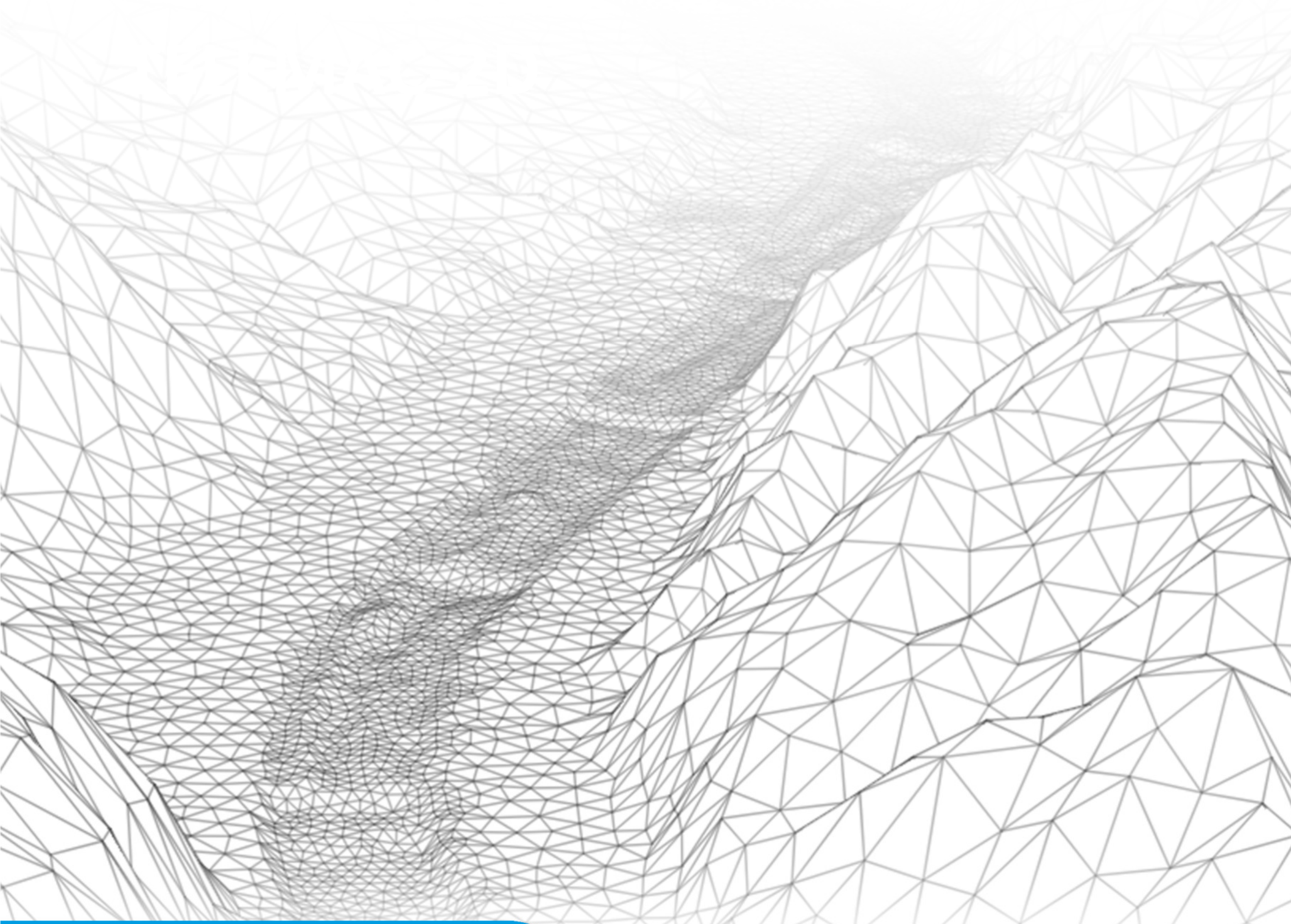

# HEC-SSP

Flood Frequency Analysis - Step by Step tutorial

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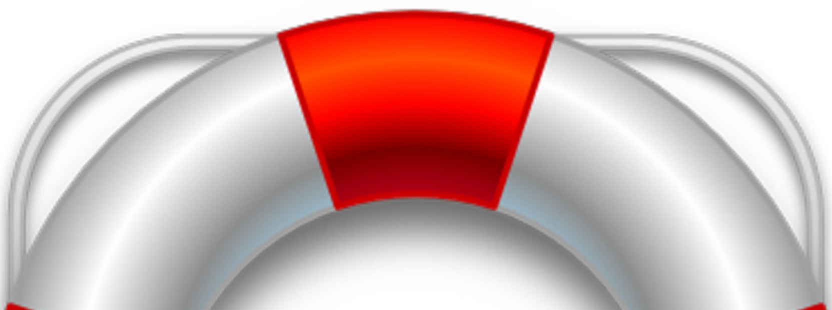


## 1. Introduction

HEC-SSP is designed to perform statistical analyses of hydrologic data. Similarly to other members of HEC software family, HEC-SSP originates from US Army Hydrologic Engineering Centre. Details of Flood Frequency Analysis (FFA) are usually a subject of national standards. Therefore HEC-SSP is in general adjusted to perform calculations according to US regulations.

This step by step tutorial is intended to show you the general concept of using HEC-SSP, a typical workflow and main elements of the interface are presented. FFA procedure with HEC-SSP is really fast, however in order to keep your focus on a real problem, this tutorial contains several open questions about your results, which we would like you to answer in your report. Try rather to think critically about your results and answer the questions than to google for the answer.
HEC-SSP can be downloaded from:
http://www.hec.usace.army.mil/software/hec-ssp/
To complete this tutorial, you need the file with data *Colorado_metric.xls* which should be available somewhere at HydroEurope webpage.

## 2. Importing your data to HEC-SSP

First thing you need to do after starting HEC-SSP is to create a new study. From the top menu of HEC-SSP window select: *Select File → New Study*.

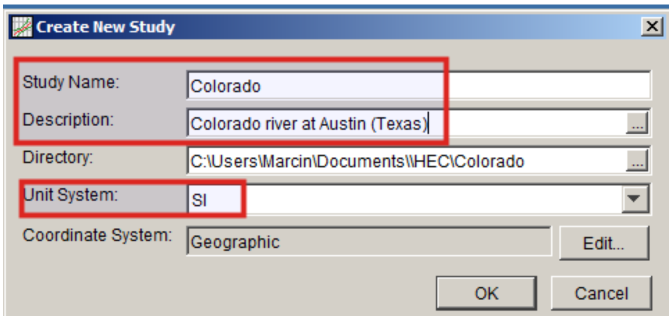



**Figure 1 Creating new study**

Fill in the study name, description, set the Unit system to SI (metric system) and click OK.

After creating a new study we need to import some historical data, which we are going to use in FFA. From the top menu of main window select *Data→ New*. This should open the *Data Import* window (fig.2). HEC-SSP offers several importing capabilities including HEC-DSS (a data storage system, used for sharing data with other HEC programs), direct import from USGS website, manual data entry and parsing text or MS Excel file.

Switch to MS Excel, click the "browse button" and select *Colorado_metric.xls*, highlight all rows, except the header and click OK. Back in the Data importer window, enter data units “cms” (cubic meters per second). HEC-SSP is quite sensitive to data format, thus your Excel file must be an old xls (not xlsx!) and the date/time column must keep a specific format. If your block selection followed the provided Excel file, block range A2,B112 should be provided. Click *Import to Study DSS file* to import the data file. The time series data should appear in the data of your study. Click *Plot* to check if the data were properly imported. A plot of time series 1900-2011 should appear.

**Question 1**: Examine the plotted data. How do you think, are they homogenous? Do they come from the same probability distribution? What might have happened within the watershed around the year 1940?

Close the plot window and the Data Importer window.

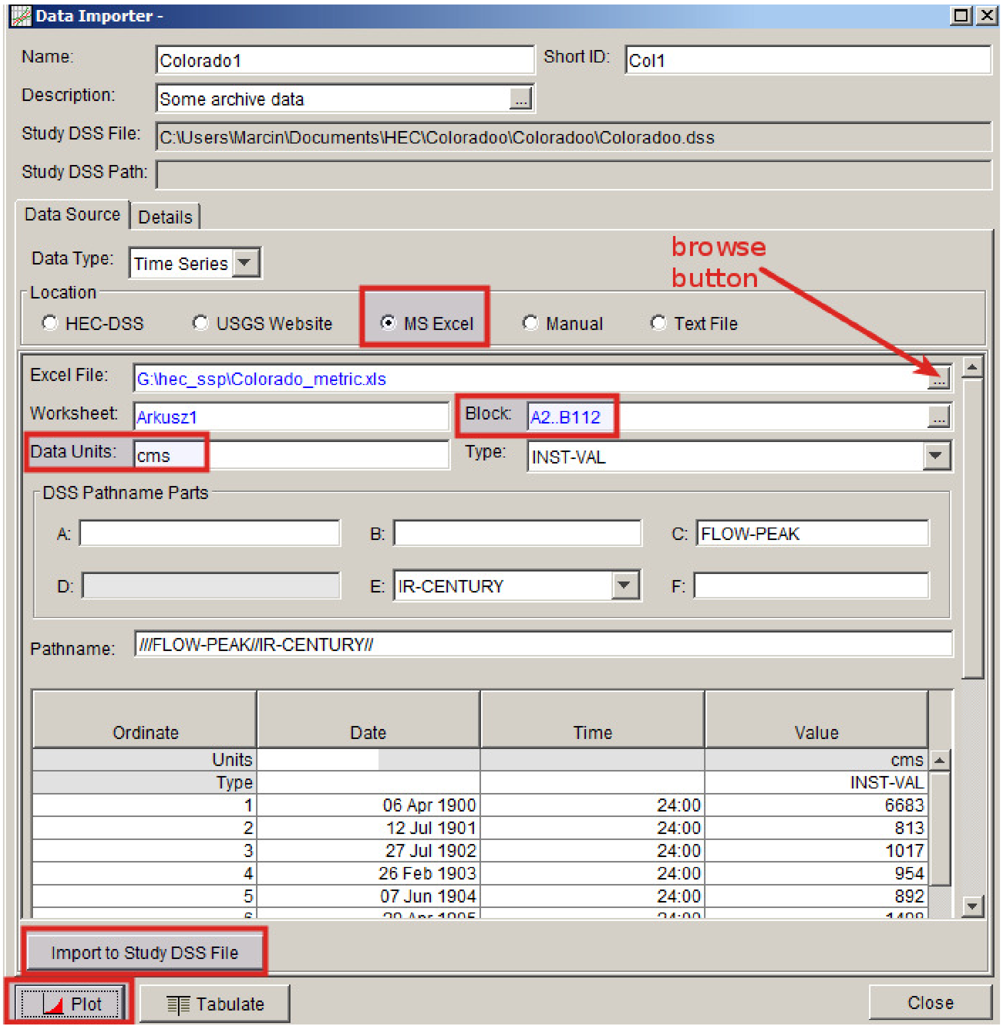



Figure 2 Importing new data to HEC-SSP

## 3. Performing Frequency Analysis

From the top menu select *Analysis* → *New* → *General Frequency Analysis Editor*. In the General Frequency Analysis Editor window enter the name of your analysis and select the data set (Hint: HEC-SSP allows you to keep multiple calculations, based on the same data set). For the first calculation, keep the confidence limits and time window as default. Switch the tab to *Analytical* (fig. 3), select *Log-Normal* as distribution type and click *Compute*. The computation is usually almost instantaneous.

Click *Plot Analytical Curve* to see the results. The fitted distribution is plotted as an exceedance function curve (fig. 4). Moreover, the horizontal axis is directed left (the more you go to the right, the lower probabilities you see, but larger return periods). Blue points are the observed historical flows from the imported data, plotted against the empirical probabilities of exceedance. Vertical axis is set to logarithmic scale, horizontal axis is set to normal probability scale, which means that an exceedance function of normal distribution would be seen as a straight line.

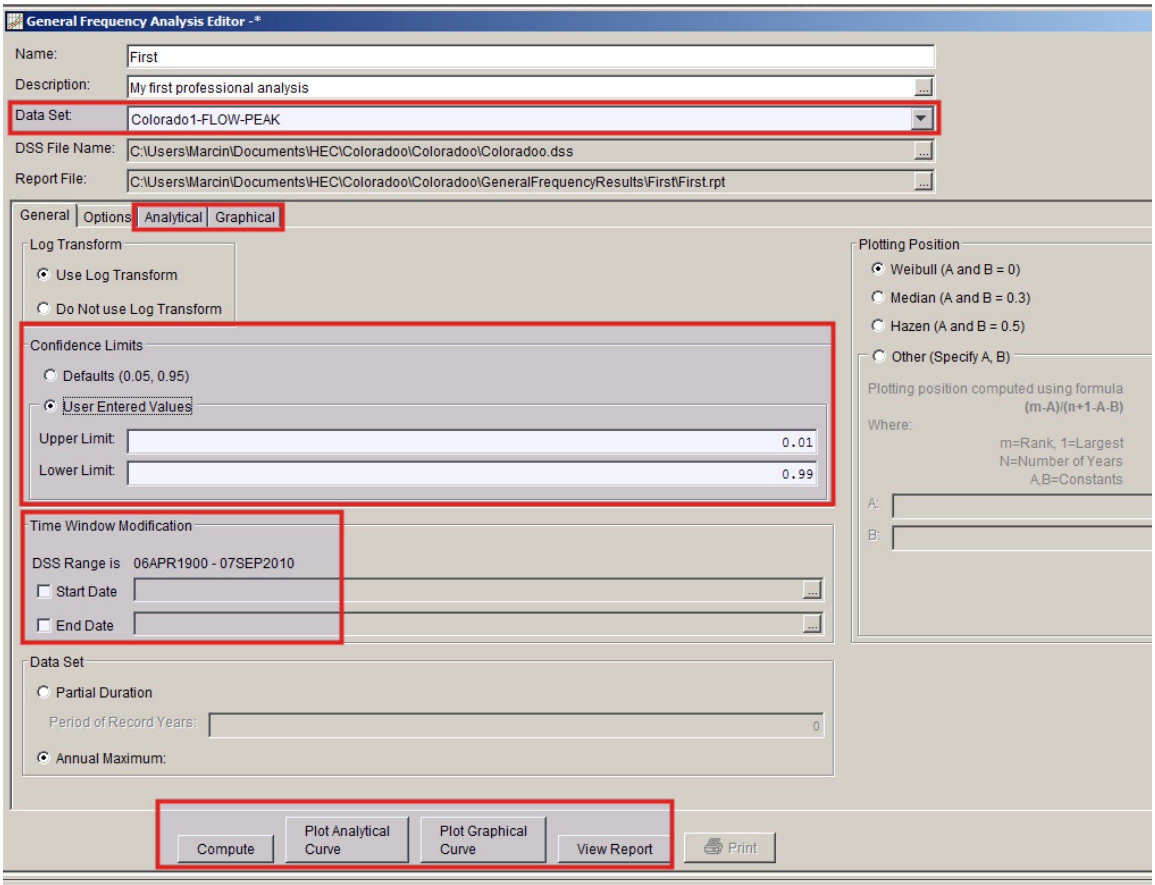



**Figure 3 General Frequency Analysis**

The results, we are usually interested in - quantiles, are flows with high return periods (e.g. 100 years). You can read them from the graph (fig. 4), but it's not a very accurate method. To get the precise values click *View Report* button at bottom of the General Frequency Analysis window.

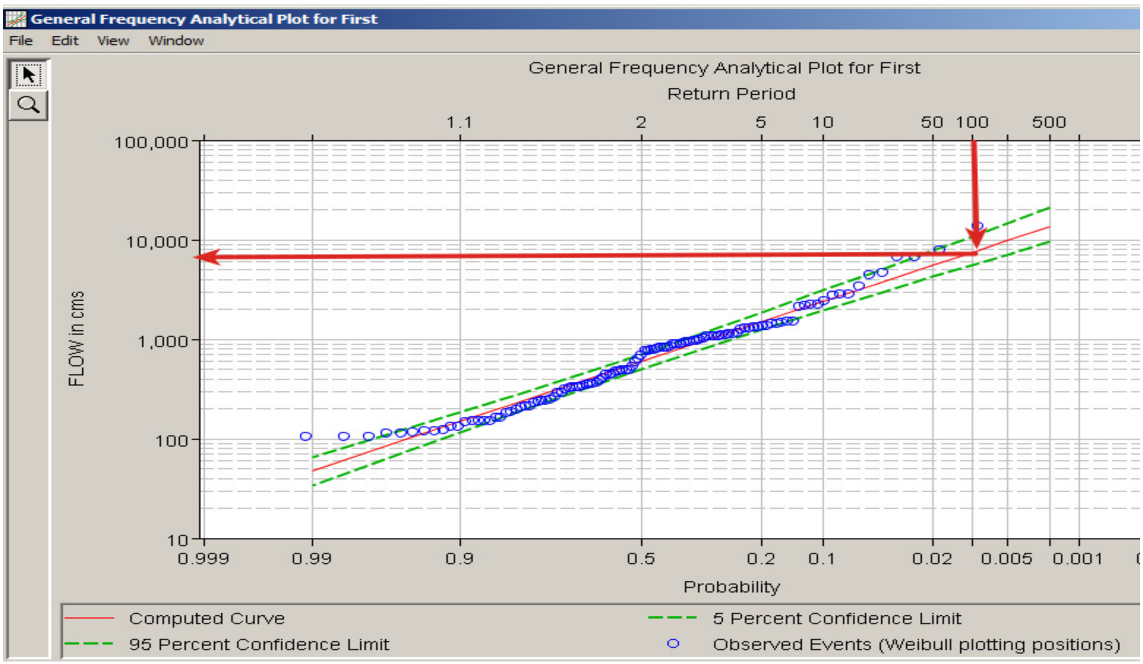
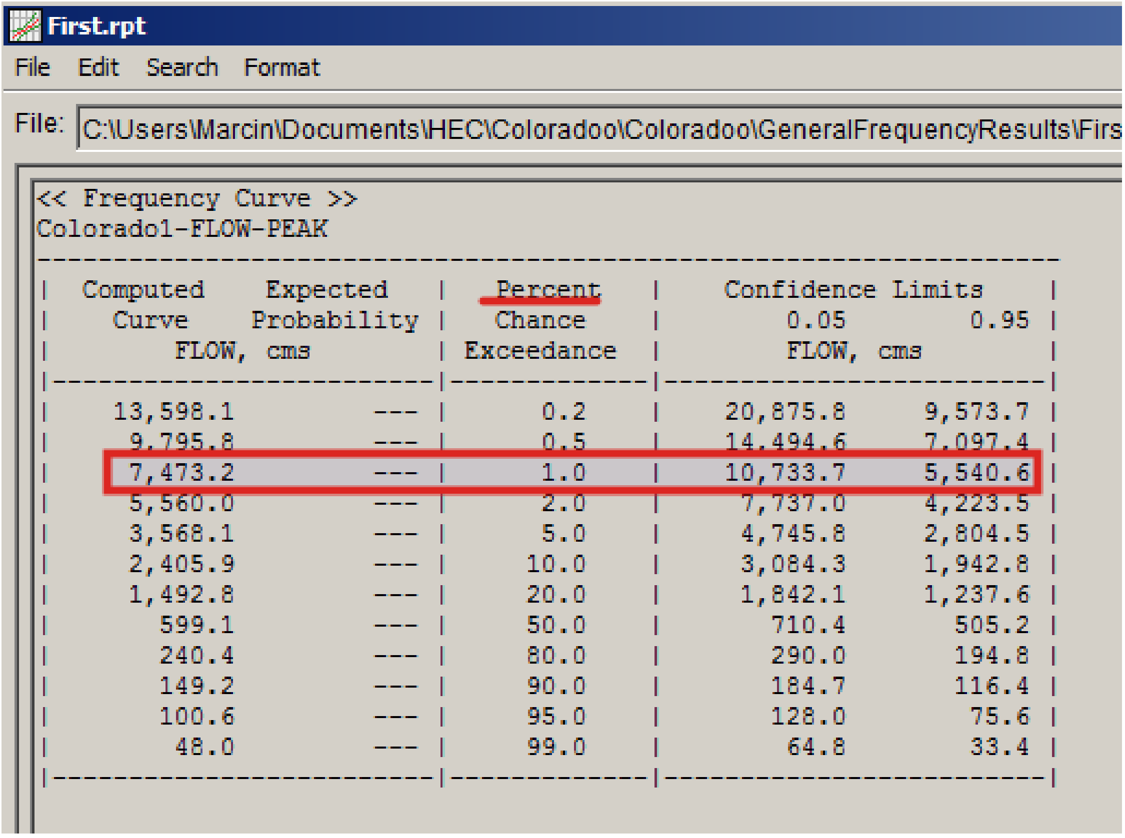



**Figure 4 Plotting results as exceedance function curve**



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<< Frequency Curve >>
Colorado1-FLOW-PEAK

| Computed Curve FLOW, cms | Expected Probability FLOW, cms | Percent Chance Exceedance | Confidence Limits 0.05 FLOW, cms | Confidence Limits 0.95 FLOW, cms |
|---|---|---|---|---|
| 13,598.1 | --- | 0.2 | 20,875.8 | 9,573.7 |
| 9,795.8 | --- | 0.5 | 14,494.6 | 7,097.4 |
| 7,473.2 | --- | 1.0 | 10,733.7 | 5,540.6 |
| 5,560.0 | --- | 2.0 | 7,737.0 | 4,223.5 |
| 3,568.1 | --- | 5.0 | 4,745.8 | 2,804.5 |
| 2,405.9 | --- | 10.0 | 3,084.3 | 1,942.8 |
| 1,492.8 | --- | 20.0 | 1,842.1 | 1,237.6 |
| 599.1 | --- | 50.0 | 710.4 | 505.2 |
| 240.4 | --- | 80.0 | 290.0 | 194.8 |
| 149.2 | --- | 90.0 | 184.7 | 116.4 |
| 100.6 | --- | 95.0 | 128.0 | 75.6 |
| 48.0 | --- | 99.0 | 64.8 | 33.4 |

**Figure 5 Report view presents the most popular quantiles**

The report window(fig. 5) presents the same results as the plot (fig. 4) in a tabular form. Note that the exceedance probability is presented in percent, which means that 1 percent exceedance probability is an equivalent to 100 years return period. Copy the results with confidence limits and paste them into a text file.

**Question 2:** Go back to General Frequency Analysis window (fig. 3) and set the confidence limits to (0.01,0.99) and rerun the computation. Check how new settings influence your results. Repeat the same procedure for (0.1, 0.9). What is the consequence for confidence limits at 100 and 500 years return period? How would you interpret the confidence limits?

**Question 3:** Go back to General Frequency Analysis window (fig. 3). As you remember, there was a change in variance of the input data around 1940. This is a clear symptom, that the data does not come from the same statistical distribution. Set the time window to period 1900-1940 and repeat the computation. Do the same for period 1941-2011. Compare the results (flows with high return periods). Which of the three time windows (including 1900-2011) would you trust most? Why?

## 4. Graphical curve fitting

The analytical fitting assumes that the historical sampling of high flows was totally random. This assumption may be violated in case of small samples (just by coincidence more "dry" years might have been covered) or in case we know that some changes in flow conditions appeared (e.g. a big reservoir has been built recently). For such cases graphical fitting may be helpful.

In General Frequency Analysis window (fig. 3) switch to *Graphical* tab (fig. 6). Your observed values with empirical probabilities should be already plotted there. Enter 20 as the value of *Equivalent flow records.* Click the *Multi point edit* tool (fig. 6). Draw a polyline, which approximates the points. End drawing with a right click. The line should be smooth and points shall be given in ascending order. If you fulfilled these requirements, the probability curve, together with confidence limits should appear.

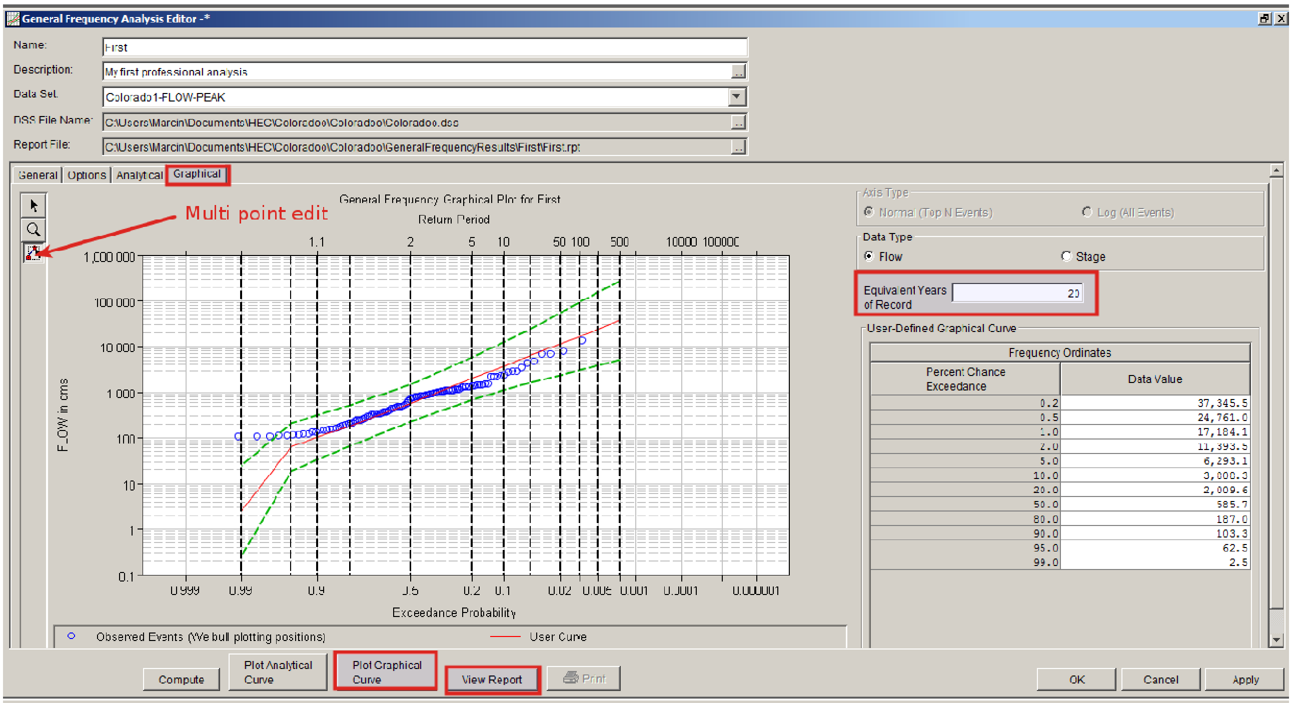


**Figure 6 Graphical curve fitting**

To check the exact results - click *View Report*. Scroll down the report window to *User-Defined Graphical Frequency Curve* to see quantiles obtained from your graphical fitting.

**Question 4:** Compare the results of graphical and analytical fitting (both plots and values of quantiles with confidence limits). Which of these two types of results would you trust more? How can you quantitatively evaluate which results of frequency analysis are better?