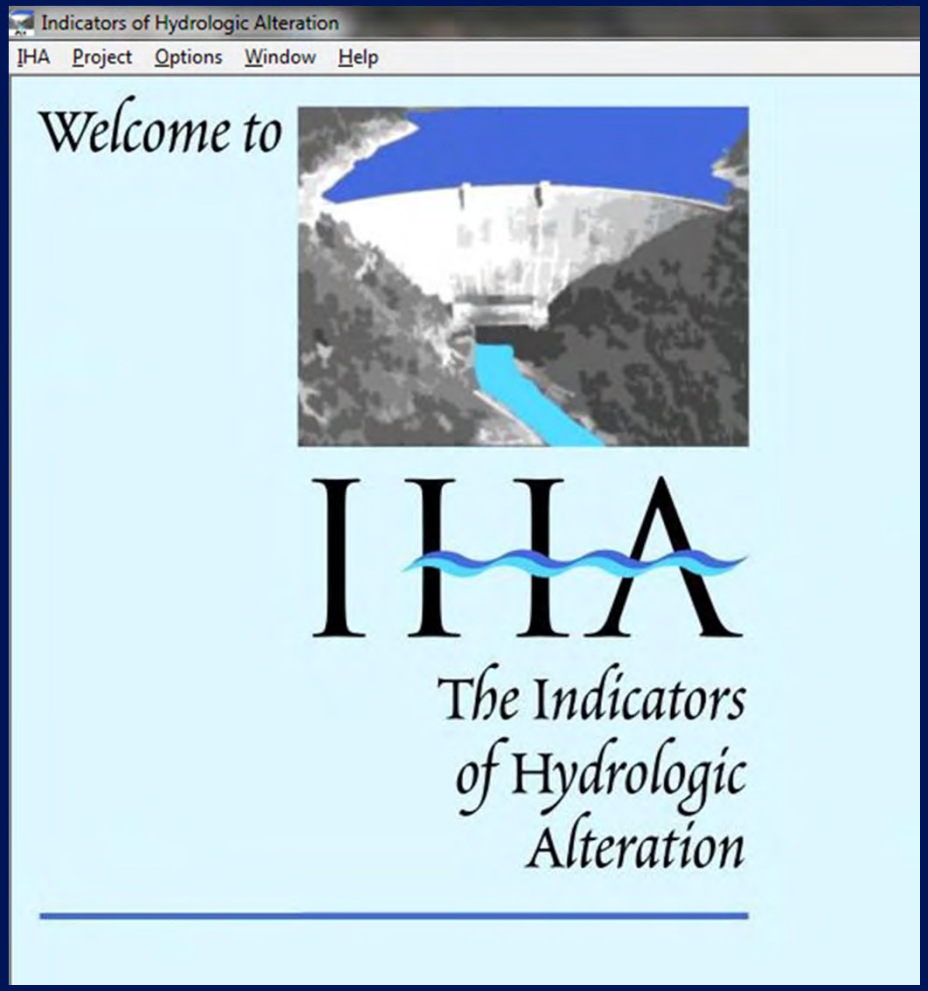


Indicators of Hydrologic Alteration (IHA) software, Version 7.1

IHA Software

- Analyzes hydrologic characteristics and their changes over time.
- Computes 67 ecologically-relevant flow statistics using daily hydrologic data along with Flow Duration Curves
- Designed to be a user-friendly, flexible tool, applicable to a variety of hydrologic systems

Role of IHA Software

IHA statistics can be used to:

- Characterize the natural flow regime
- Assess how flow regime has changed over time
- Analyze flows provided by different management scenarios
- Aid in developing environmental flow recommendations (in conjunction with biological info)

Improvement in Version 7 of the IHA

- Improved interface, tables, graphics, and help system
- Greater capability to import different data types
- 34 additional flow statistics (Environmental Flow Components) and improvement of the default EFC algorithm
- Ability to compare two datasets
- Annual and monthly flow duration curves

Analysis Options

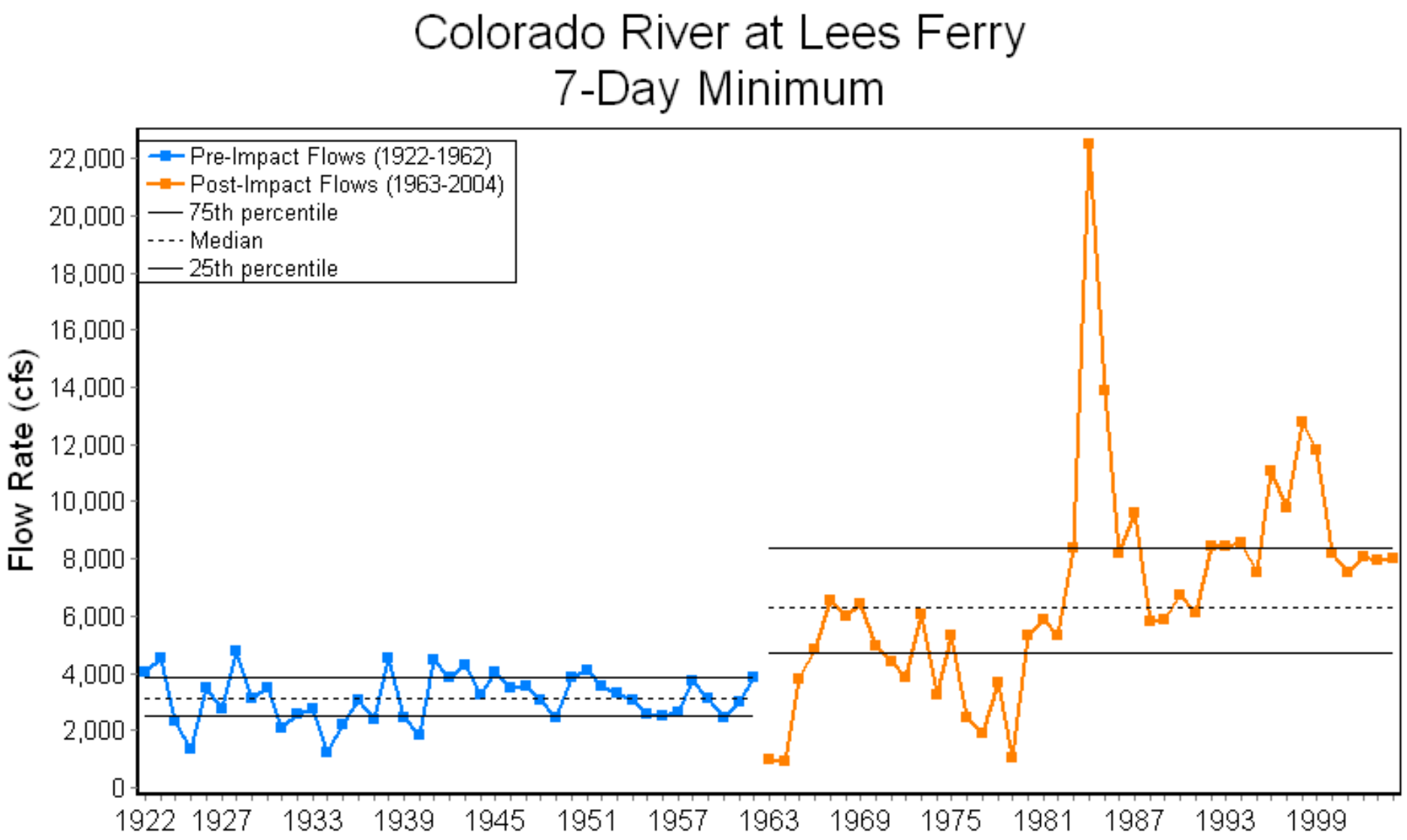
Type of analysis and statistics:

- Two period (before and after) analysis or trend analysis
- Parametric or non-parametric statistics

Time periods to analyze:

- Can analyze a subset of water years in the period of record
- Can analyze seasonal periods (i.e. shorter than a 12-month water year).

Two Period Analysis

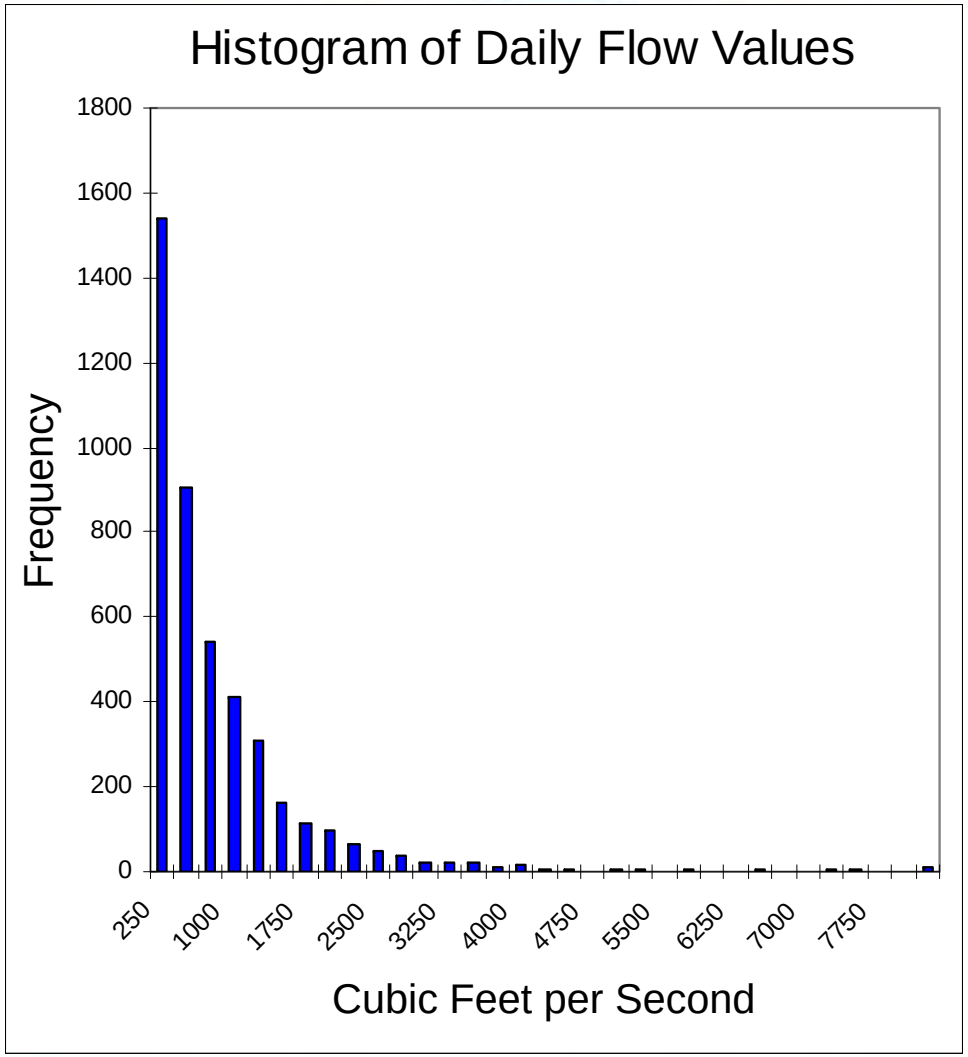


Parametric vs. non-parametric statistics

Non-parametric statistics are default, because of non-normal nature of most hydrologic data.

But parametric statistics can be useful in certain situations:

(1) Flood frequencies
(2) Comparison of climatic trends



Scorecard Table

Non-parametric version:

- For pre- and post-impact periods:
  - Median
  - Coefficient of Dispersion: $\frac{\text{75}^{\text{th}}\text{ percentile} - \text{25}^{\text{th}}\text{ percentile}}{\text{Median}}$
- For both the median and the CD, contains:
  - Deviation factor: $\frac{|(\text{Post-impact value}) - (\text{Pre-impact value})|}{\text{Pre-impact value}}$
  - Significance count for deviation factors

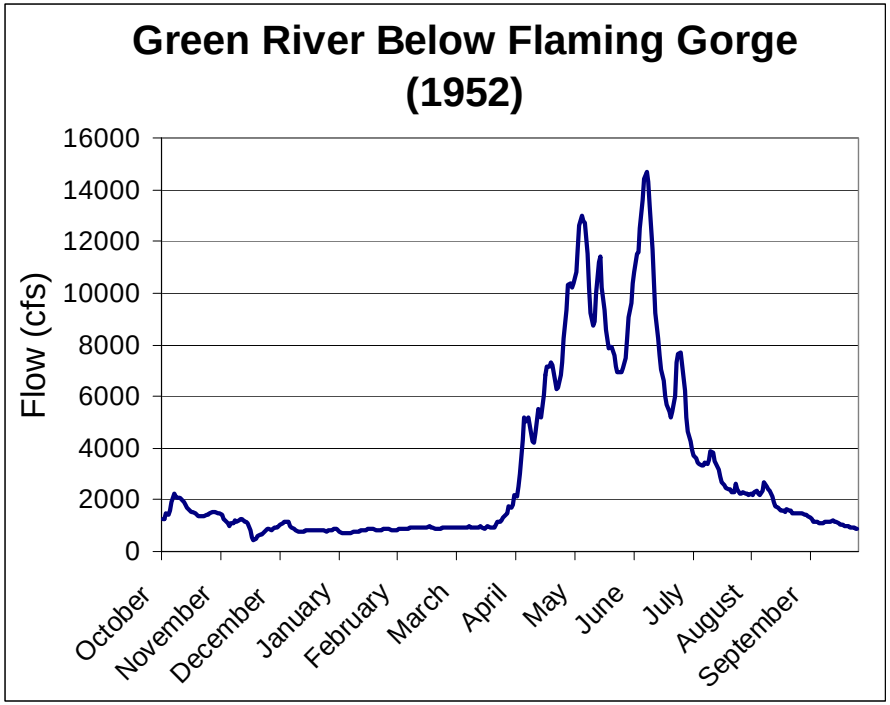
Scorecard Table

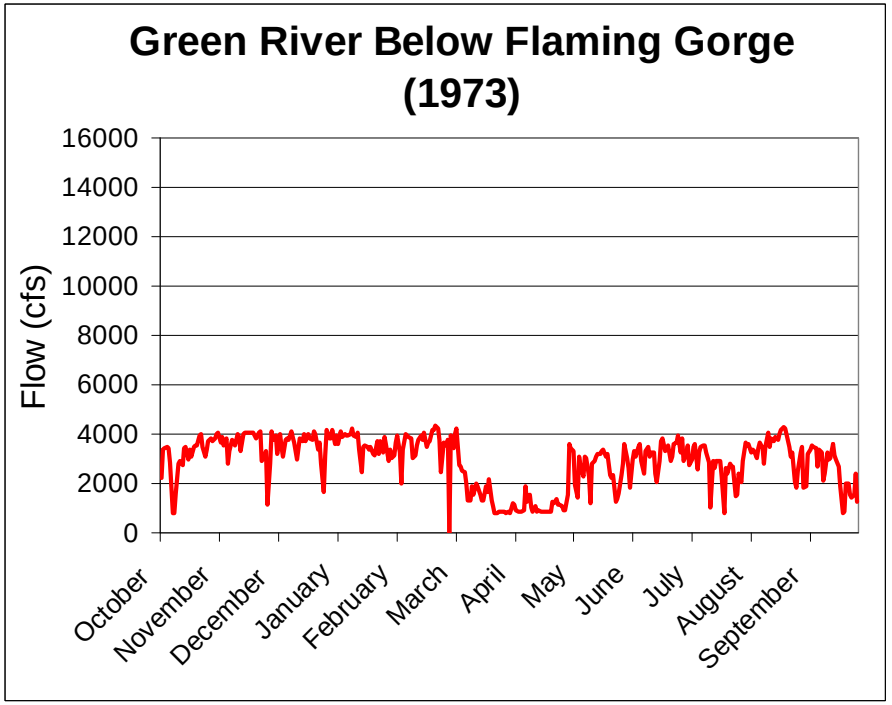
Parametric version:

- For pre- and post-impact periods:
  - Mean
  - Coefficient of Variation: $\frac{\text{Standard deviation}}{\text{Mean}}$

- For both the median and the CV, contains:
  - Magnitude of change from pre- to post-impact periods
  - Percent change

Comparing Hydrographic Time Series

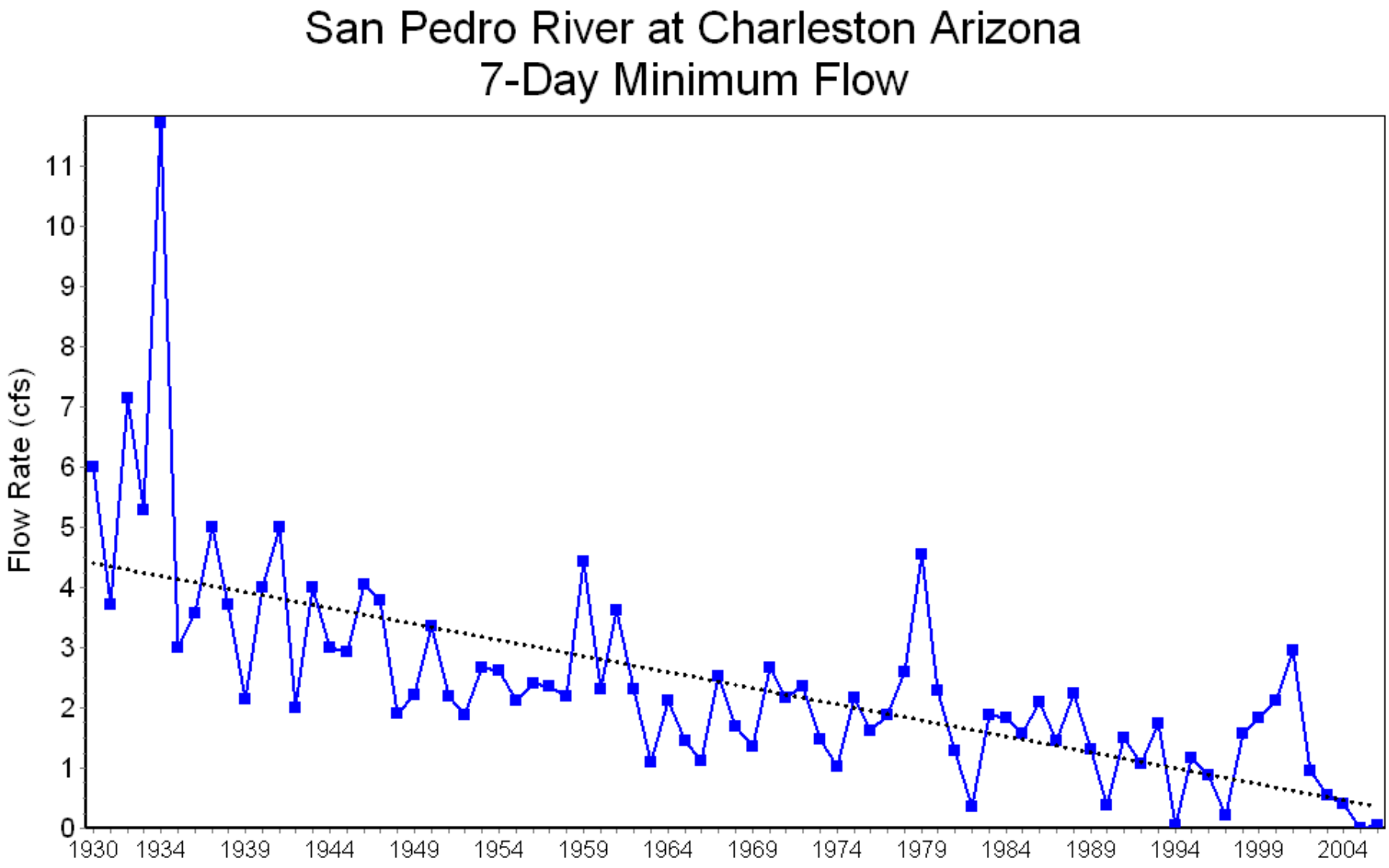




Before

After

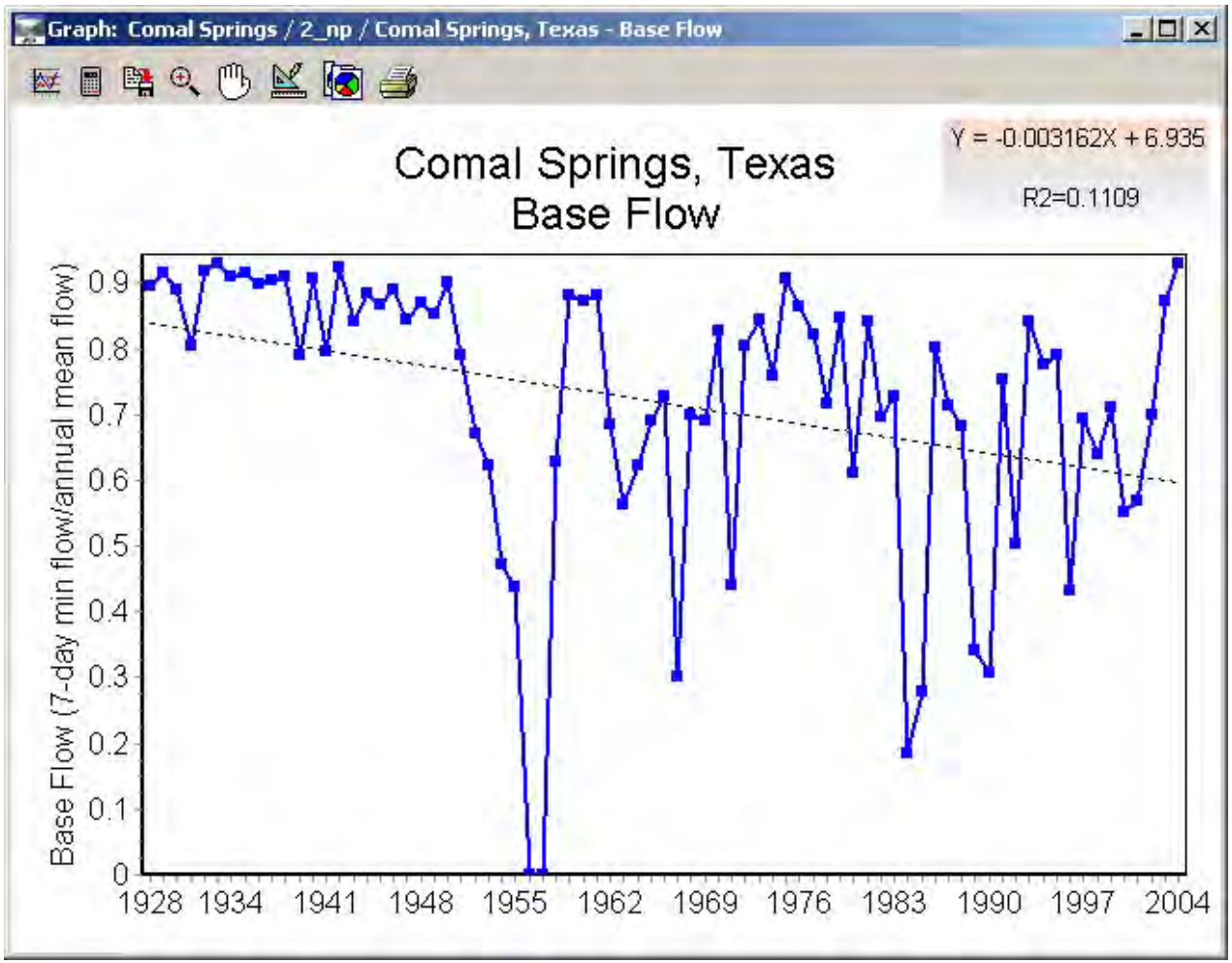
Trend Analysis



Linear Regression outputs

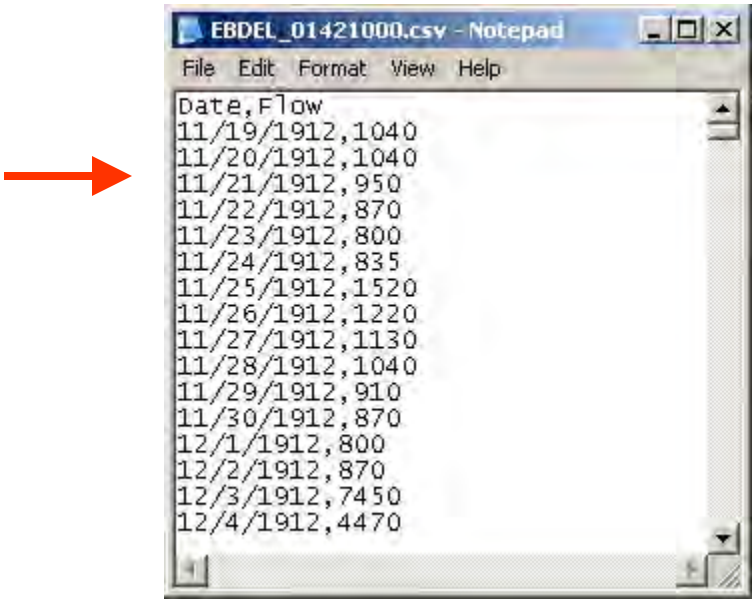
Annual data graphs and table showing regression line:

- Slope
- Y-intercept
- Standard error (sigma)
- Correlation coefficient
- P-value
- F statistic
- R^2



IHA Input Data

- Can import daily data from three text-file formats:
  - ➢USGS NWIS website
  - ➢Generic two column format (calendar date, flow value)



- IHA also has batch import capability

IHA Input Data

Number of years of data needed:

- Richter et al (1997): Recommends using at least 20 years of data.
- Taylor et al. (2003): 20 years of data was sufficient to characterize inter-annual variability for some parameters, but for others 35 or more years were needed.
- Huh et al. (2005): 20 years of pre- and post-impact data are needed to detect a 1 standard deviation shift in high flows, but 30 years were needed for low flows.

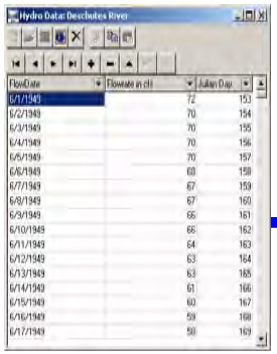
IHA Input Data

Number of years of data needed:

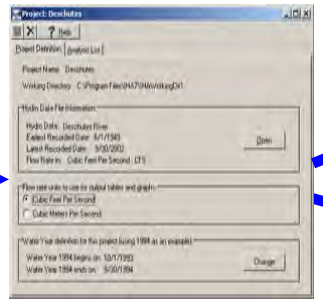
20 years seems to be a good baseline requirement, but the number of years of data needed may vary depending on:

- Climate variability
- Frequency or variability of the particular parameter
- Whether you are characterizing central tendency or range of inter-annual variability
- Severity of alteration you are trying to detect

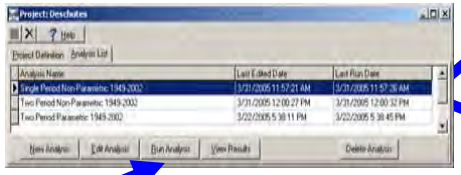
IHA Workflow

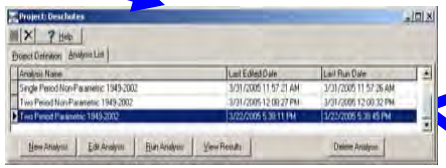


Hydro Data file

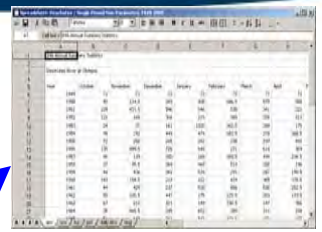


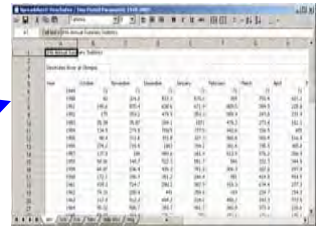
Project

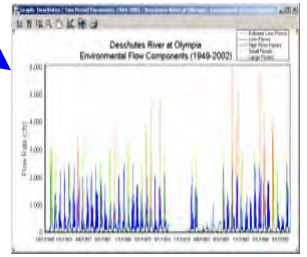




Analyses







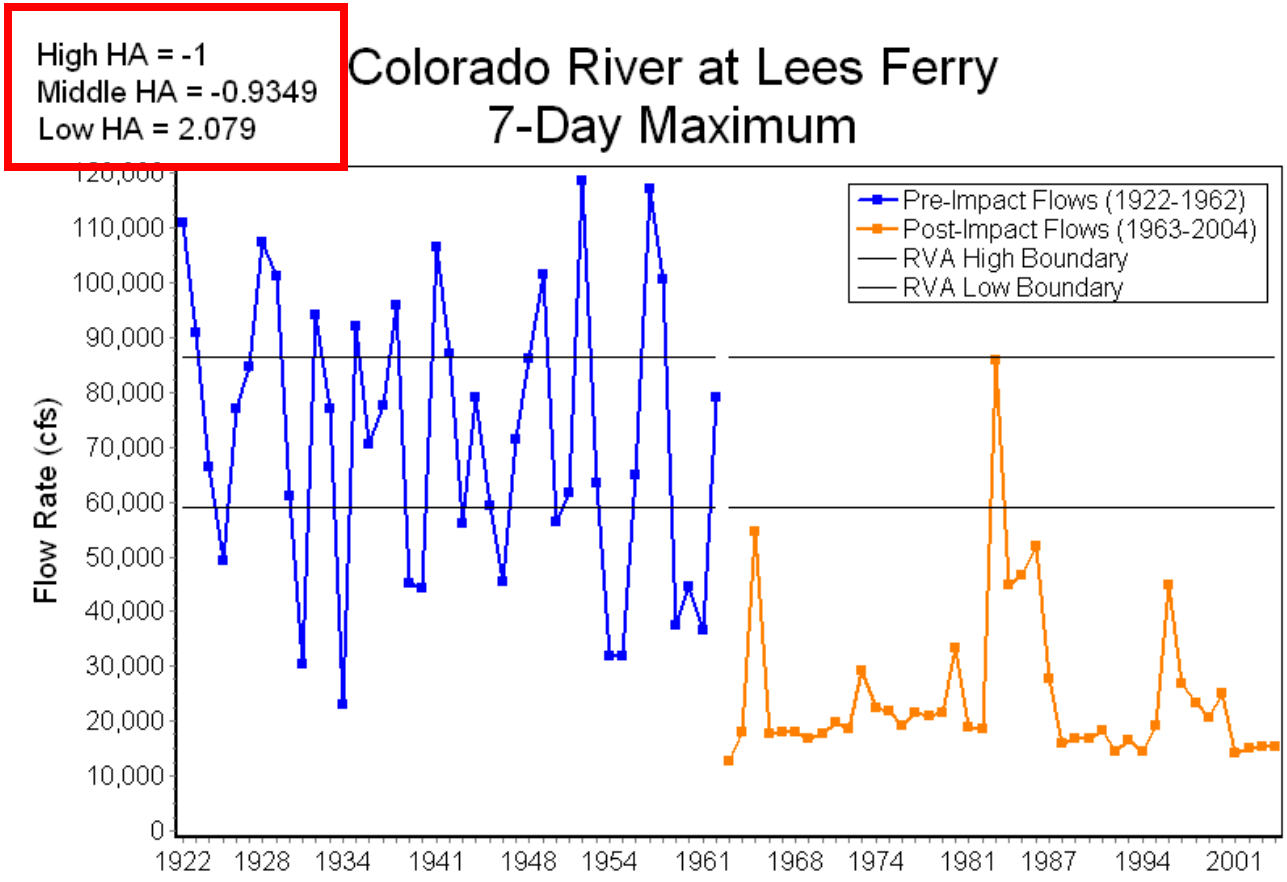
Outputs (tables and graphs)

IHA Annual Statistics (33 different parameters)

- Monthly average flows
- Magnitude of annual extremes (1-, 3-, 7-, 30-, and 90-day minimums and maximums)
- Timing of annual extremes (1-day max and min)
- Zero flow days
- Frequency and duration of high and low pulses
- Rates of flow changes and reversals
- Base flow index

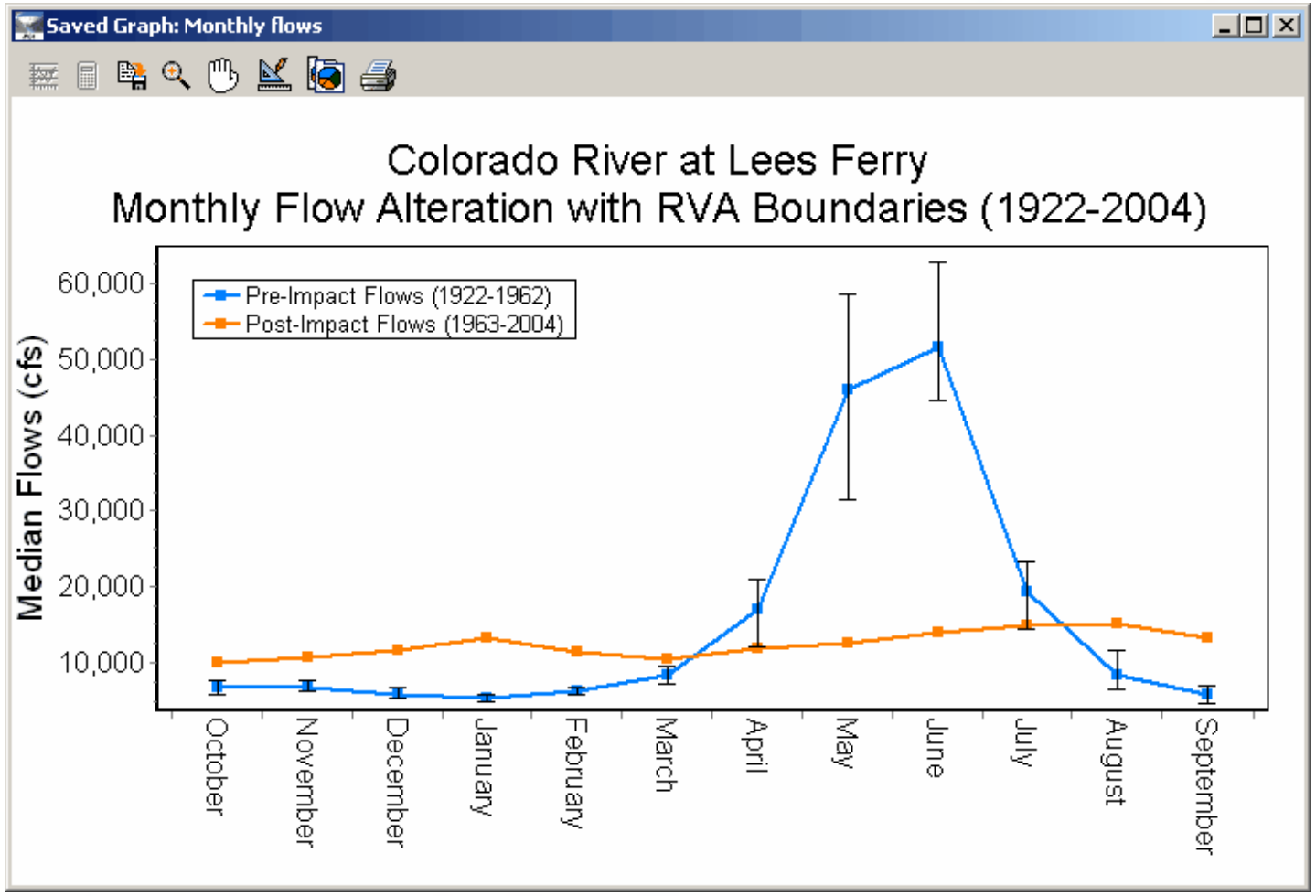
Range of Variability Analysis

- Measures the natural range of variability of these 33 flow statistics, and quantifies how this variability has been altered.



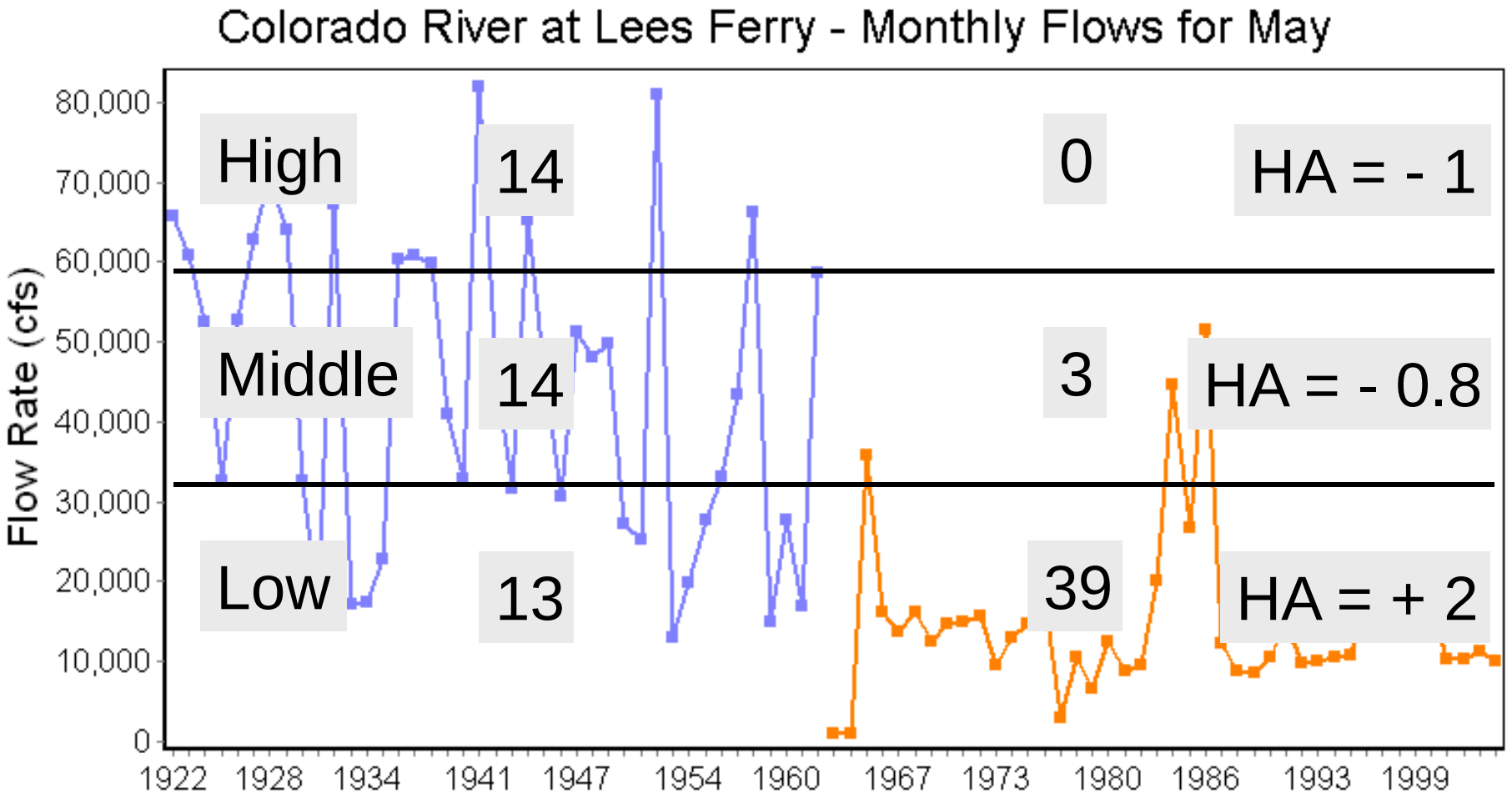
Richter et al. 1997, "How Much Water Does a River Need?" (*Freshwater Biology*)

Range of Variability Analysis

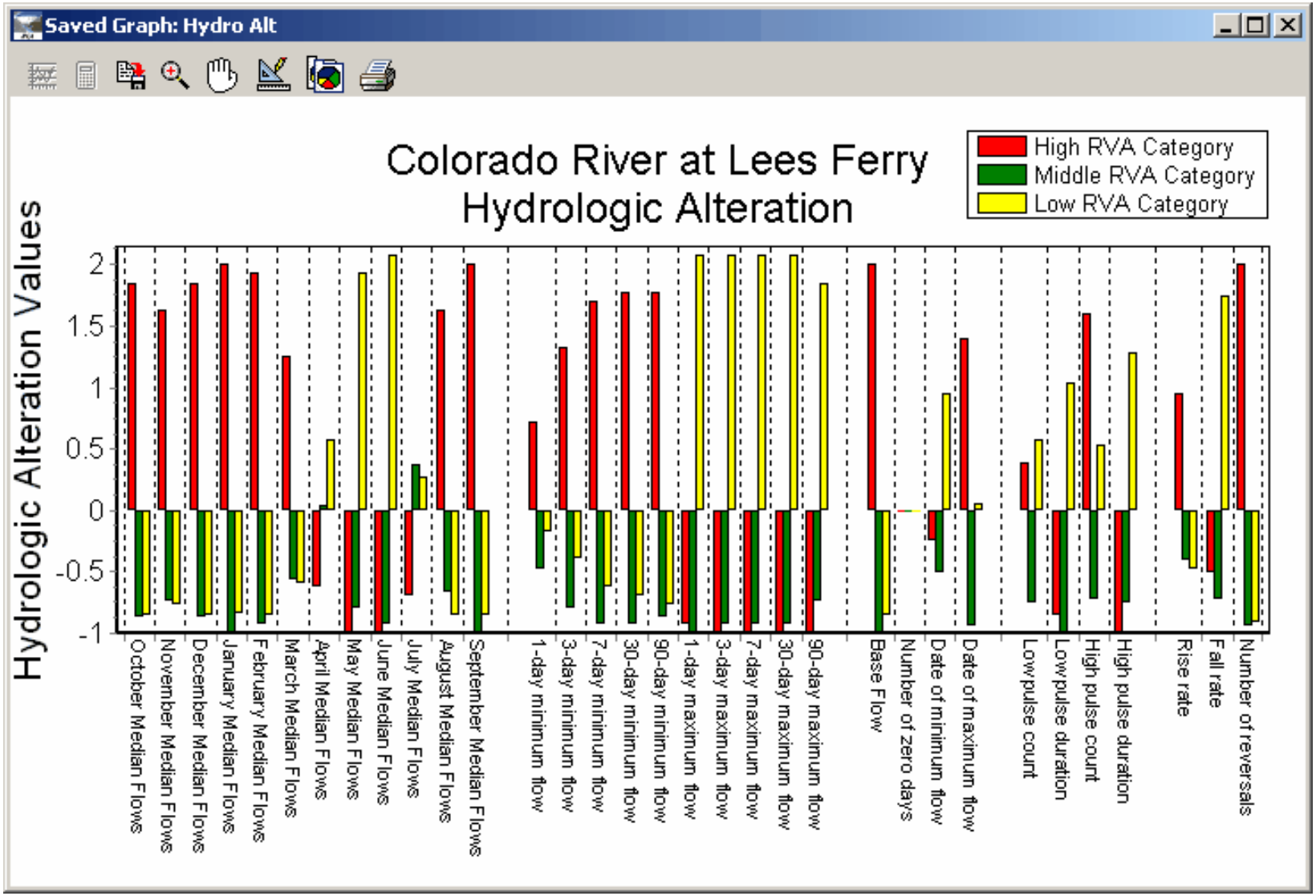


RVA Hydrologic Alteration Factors

HA = (post-alteration frequency – pre-alteration frequency) / pre-alteration frequency



Hydrologic Alteration Factors graph



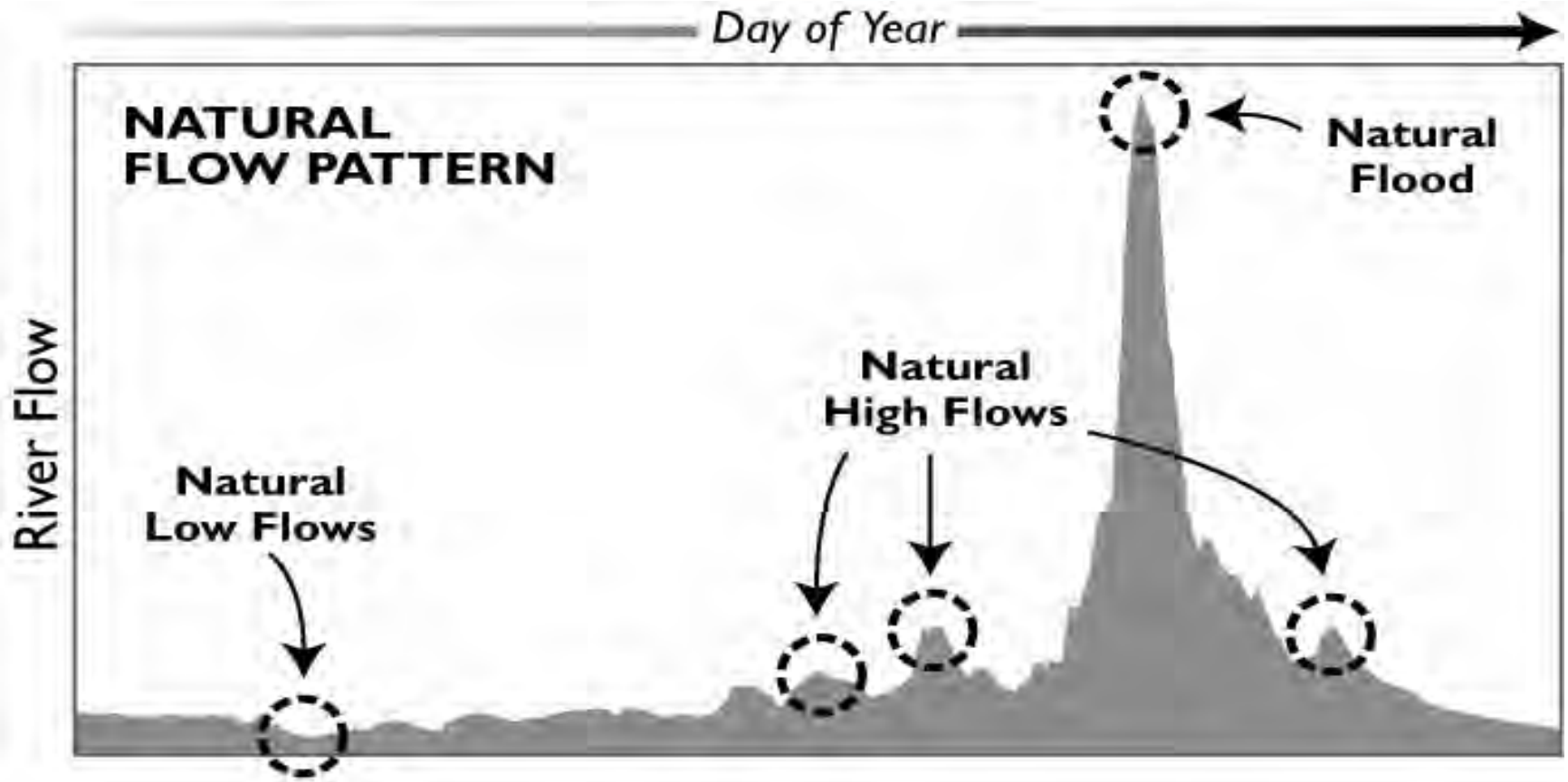
Environmental Flow Components

- IHA software segments the daily hydrograph into the following EFCs:

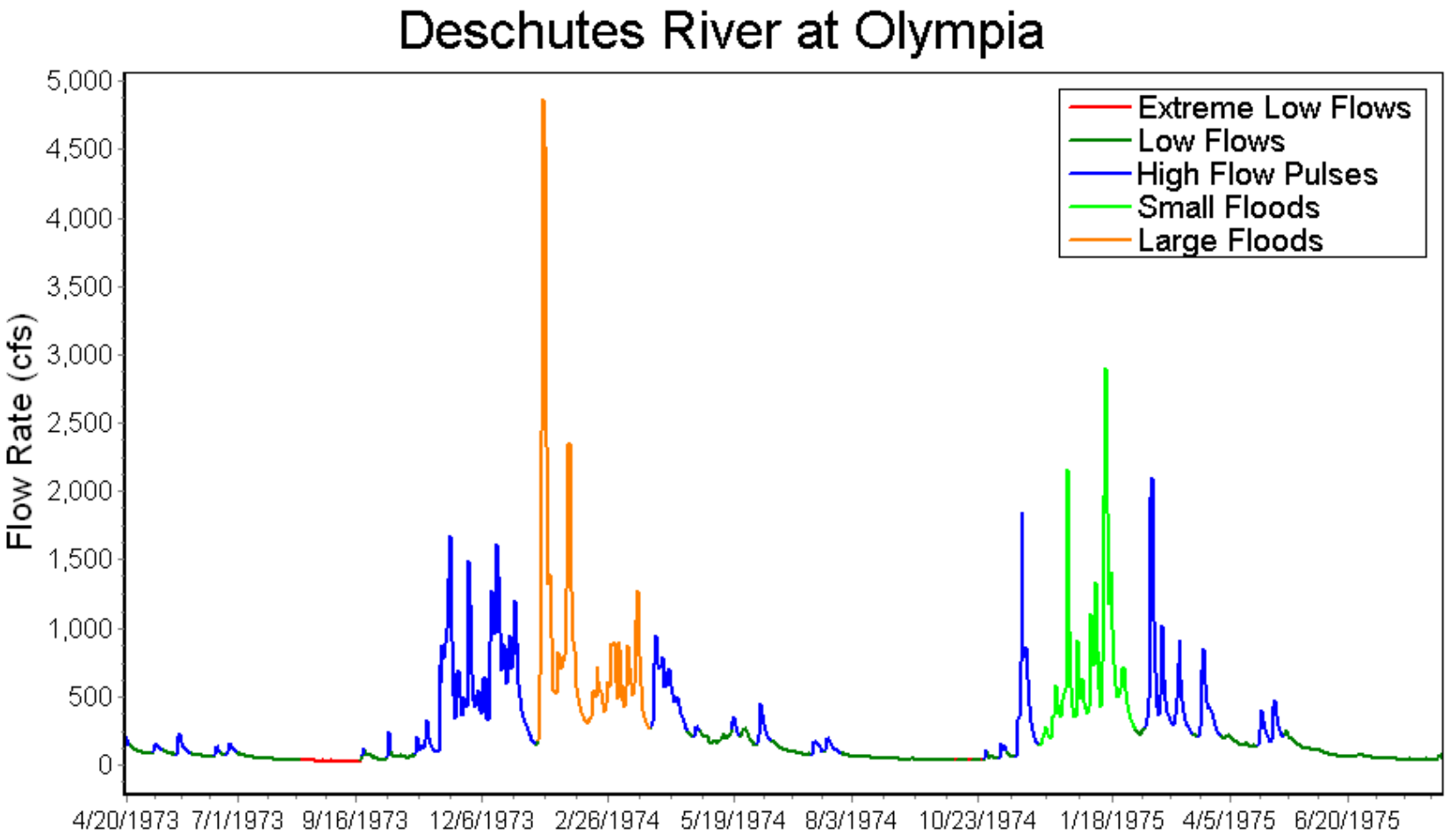
  - Low Flows
  - Extreme Low Flows

  - High Flow Pulses
  - Small Floods
  - Large Floods

Flow Events (lows, highs, floods)



Environmental Flow Components



Environmental Flow Components

EFC parameters:

- Low flows during each month

- Extreme low flow:
  - Frequency
  - Duration
  - Peak (minimum) flow
  - Timing

High flow pulse, small flood, and large flood:

- Frequency
- Duration
- Peak flow
- Timing
- Rise and fall rates

EFC Algorithm

Steps:

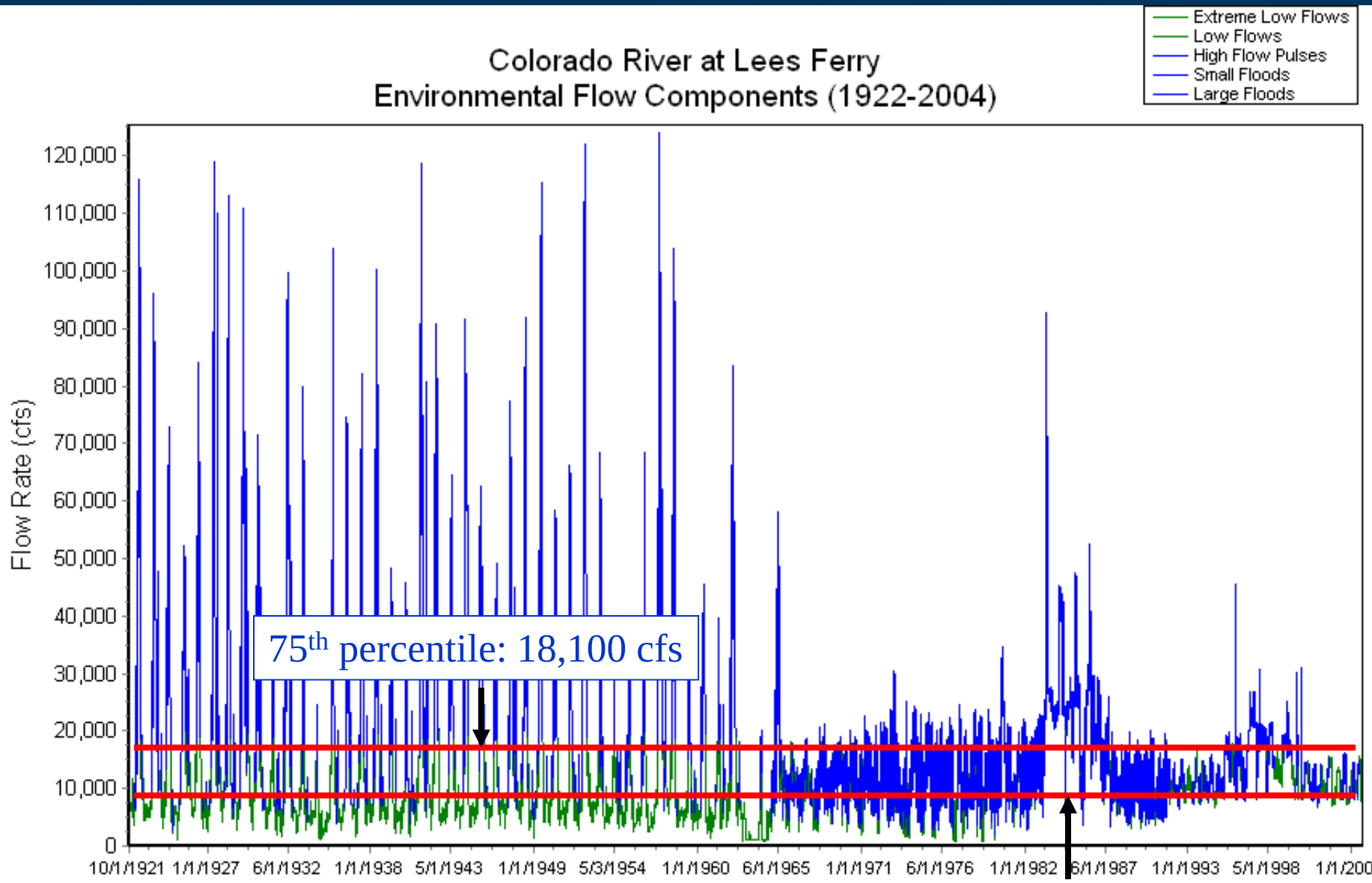
(1) Separates daily hydrograph into high flows and low flows

- *There are two ways to do this in version 7.1*

(2) Separates high flow events into high flow pulses, small floods, and large floods (based on event peak flow)

(3) Splits low flows into low flows and extreme low flows

EFC Algorithm



EFC Algorithm

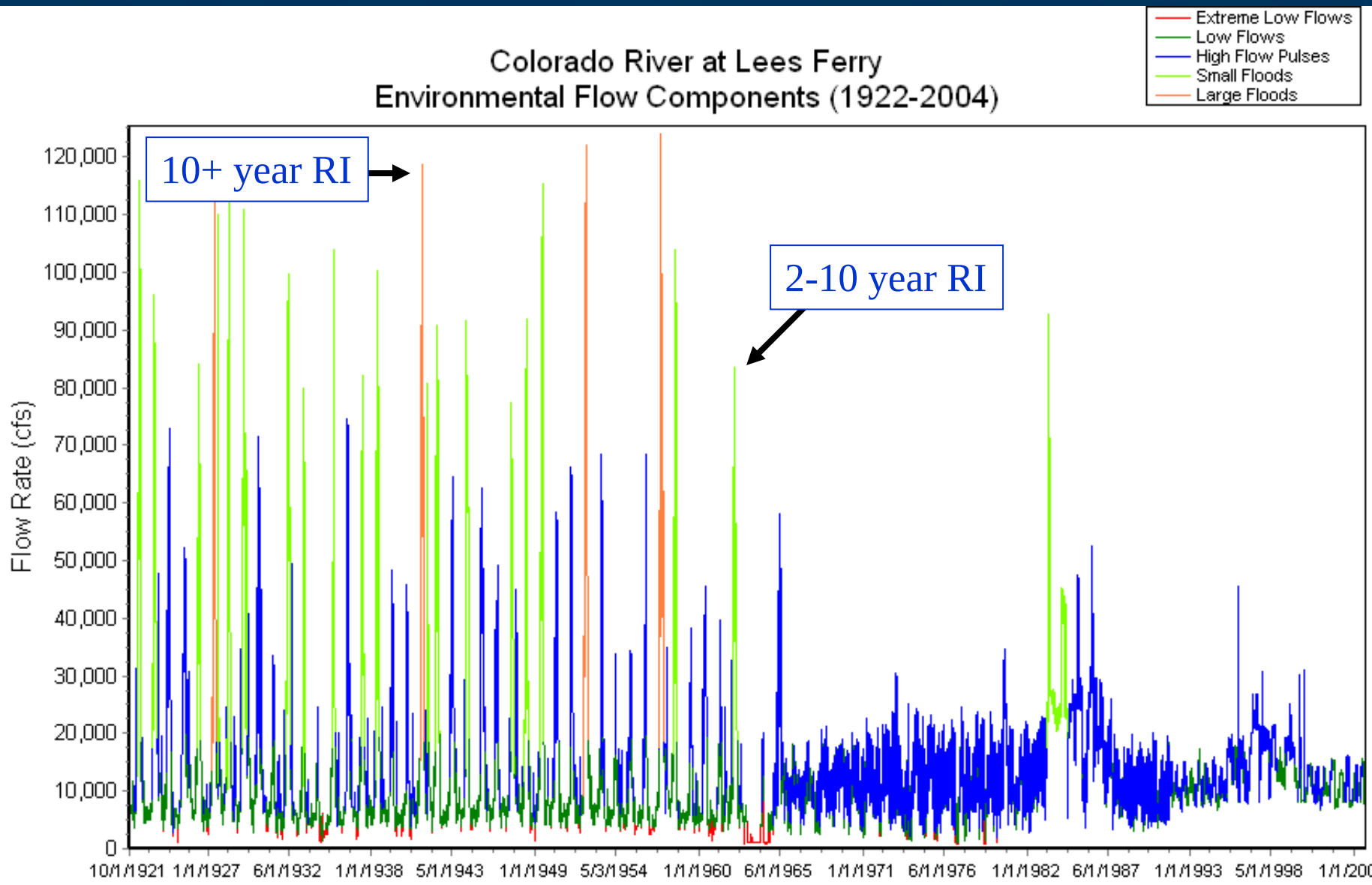
Steps:

(1) Separates daily hydrograph into high flows and low flows

(2) Separates high flow events into high flow pulses, small floods, and large floods (based on event peak flow)

(3) Splits low flows into low flows and extreme low flows

EFC Algorithm



EFC Algorithm

Steps:

(1) Separates daily hydrograph into high flows and low flows

(2) Separates high flow events into high flow pulses, small floods, and large floods (based on event peak flow)

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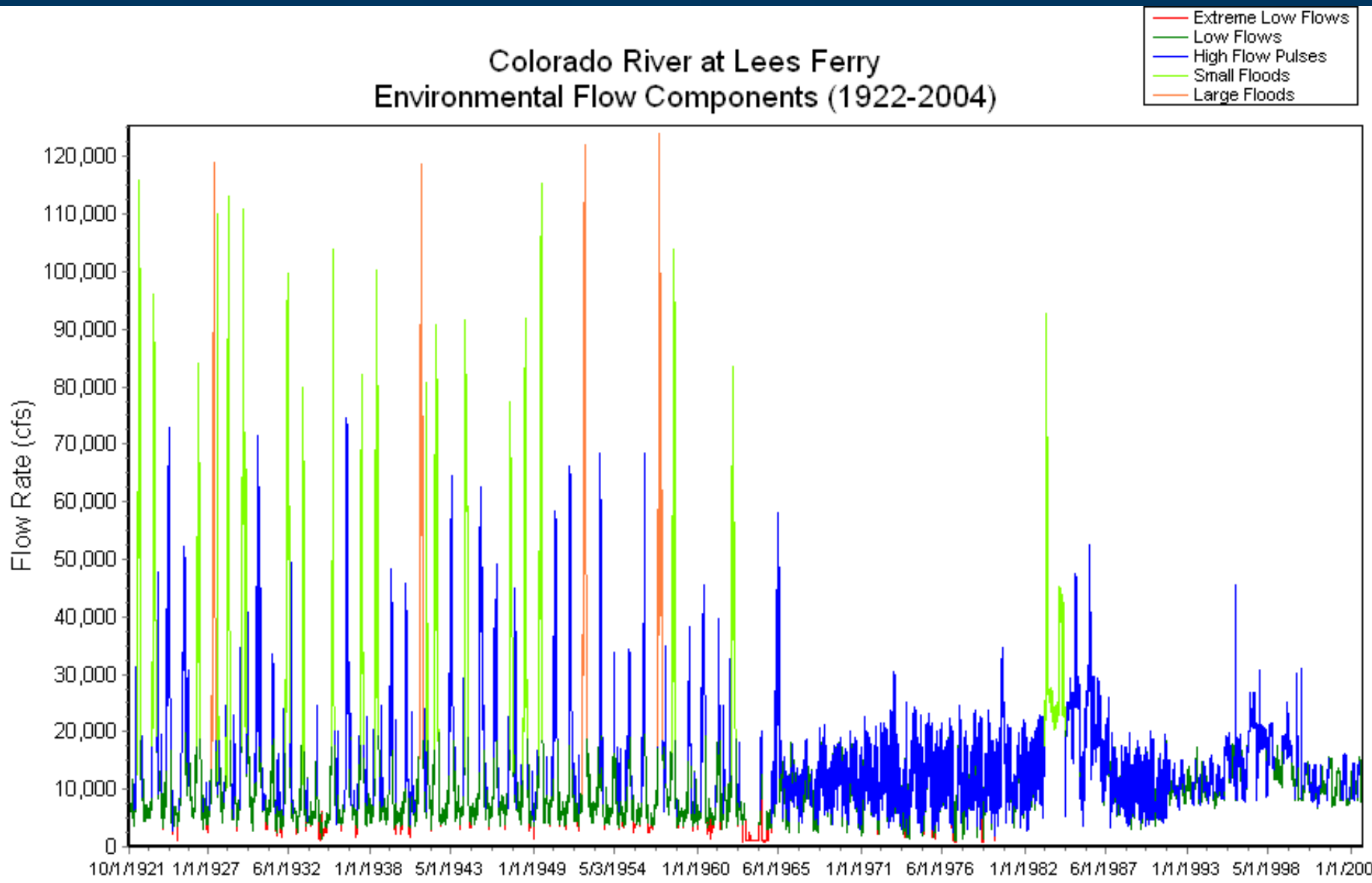
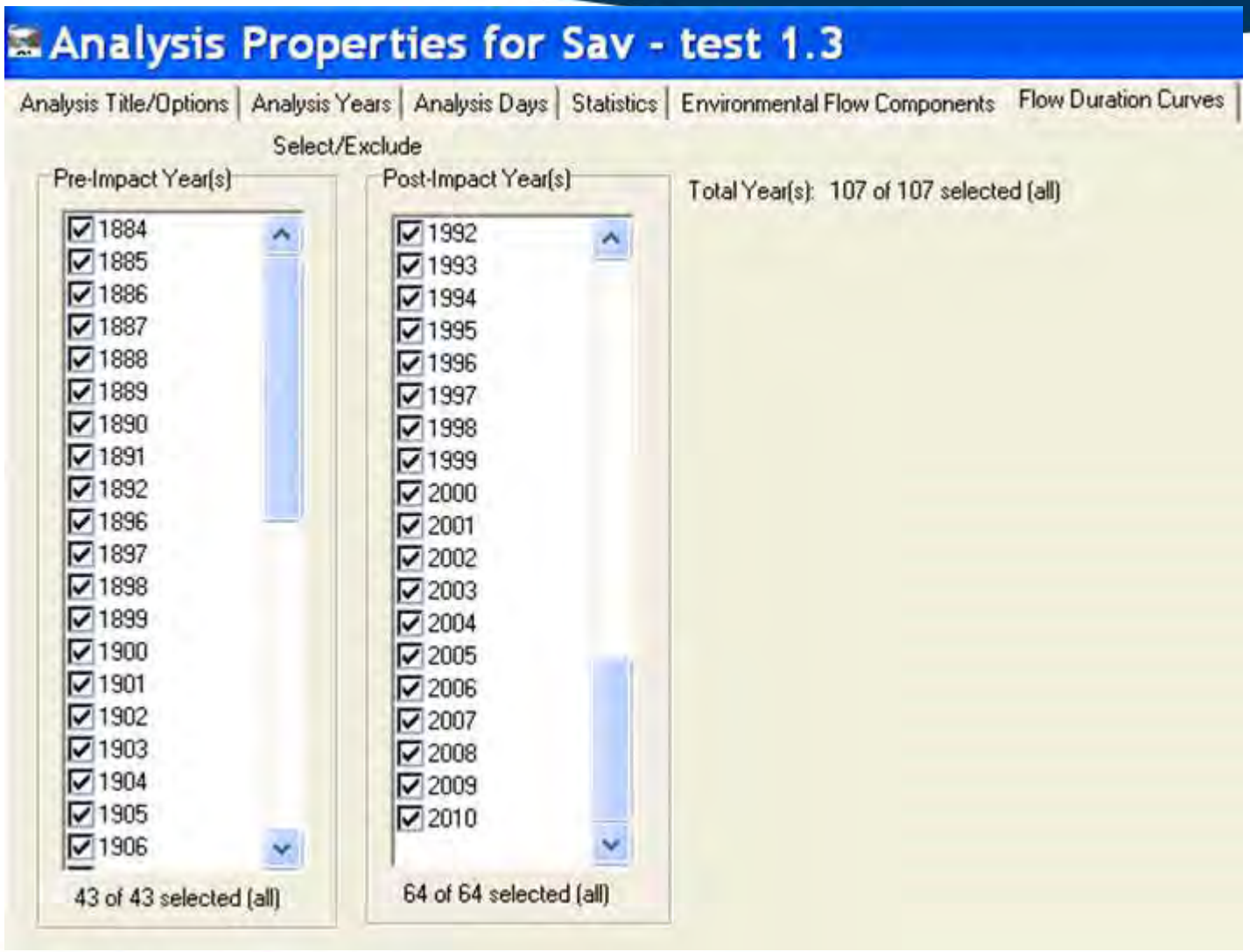
EFC Algorithm



Flow Duration Curves



IHA Outputs

IHA output tables contain:

- Annual values for each parameter (for each water year)
- Statistics calculated from these annual values
  - Will differ depending on type of statistics used (parametric, non-parametric) and whether one or two period analysis
- Daily flow values by EFC type
- List of warning messages

IHA Outputs

IHA graphs:

- Annual data graphs
- Daily data graphs
- Hydrologic alteration graph (Hydrologic Alteration factors from RVA Analysis)
- Monthly alteration graph

Other Tables

Percentile table has 10%, 25%, 50%, 75%, and 90% exceedance values (for non-parametric analysis only) for pre- and post-impact periods.

Box and Whisker table has means/medians and other statistics.

Message report has warnings and messages.

EFC daily table has daily flow values classified by EFC type (the same data as in the daily EFC graph).

Flow Duration Curve table has annual and monthly flow duration curve statistics at a range of exceedence values